Presentation of Daniel B. Steiner[1]
Concerning San Joaquin River Hydrology
And
Alternative Flow and Quality Objectives at Vernalis

I am one of the principal developers of the revised CALSIM II model, specifically the aspects of the model that depict the San Joaquin River Basin. As such I am familiar with the model's construction, underlying hydrologic data base, assumptions for operations, and results.

My presentation will describe the current hydrologic setting of the San Joaquin River as depicted by the CALSIM II model. Subsequently I will describe how that setting changes if the water quality and flow objectives at Vernalis are modified. I am also providing hydrologic data concerning the estimation of unimpaired flow within the San Joaquin River Basin, recorded flow at Vernalis, and State Water Project and Central Valley Project diversions from the Delta.

[1] Prepared by Daniel B. Steiner, consultant to San Joaquin River Group Authority, for the California State Water Resources Control Board Periodic Review of the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary Workshop, March, 2005.

Existing Hydrologic Setting and CALSIM II

The San Joaquin River watershed is depicted in CALSIM II. CALSIM II is an application of computer software representing the State Water Project (SWP) and Central Valley Project (CVP). CALSIM II was jointly developed by the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (Reclamation), and simulates a significant portion of the water resources infrastructure of the Central Valley and Delta regions.

In modeling terms, the San Joaquin River generally enters the Delta at a modeling node depicted as "Vernalis". Geographically this location is located downstream of the confluence of the Stanislaus River with the San Joaquin River. The location is a compliance point for water quality and flow objectives contained in SWRCB Decision 1641. Long-term flow and quality records exist for this site.

Reclamation attempts to provide compliance to the quality and flow objectives at Vernalis through its operation of the New Melones Project located on the Stanislaus River. During certain periods of the year, participants of the San Joaquin River Group Authority assist Reclamation with compliance of flow objectives through aspects of the SJRA.

Hydrologic conditions at Vernalis are mostly the result of the mix of flow and quality of the San Joaquin River "upstream" of the Stanislaus River and the flow and quality of the Stanislaus River. At times, Reclamation reacts to the upstream condition with its operation of the New Melones Project. The upstream condition of the San Joaquin River is depicted in CALSIM II at a modeling node referred to as "Maze", and reflects a geographical location between the confluences of the Tuolumne River and Stanislaus River with the San Joaquin River. This location has records for flow and quality, most recently daily records for flow and periodic grab sample data for quality.

Understanding the hydrologic condition at Vernalis requires an appreciation of the upstream condition of the San Joaquin River and the operation of the Stanislaus River. The depiction of the San Joaquin River above Vernalis by CALSIM II has recently been revised through several efforts funded by Reclamation and other entities. This effort is documented by several documents under development by Reclamation.

Stream reaches, reservoirs, diversions, accretions, depletions and return flows are linked together as a network of interconnected nodes within CALSIM II. The interconnections between nodes depict the physical relationship/process that occurs between the nodes, if any. For instance, if a diversion occurs between two nodes that define a stream reach, the flow entering the reach at the upstream node will be reduced by the diversion and thus define the flow leaving the reach. As a second example of node linkage, a portion of that diversion may re-enter a reach of the same stream downstream of the diversion, or possibly enter a reach of stream on another tributary. Figure 1 illustrates the linkage of nodes within CALSIM II for the San Joaquin River Basin.

CALSIM II depicts water quality in the San Joaquin River by calculating a conservation of flow and quality (mass) within the river. Elements of flow modeled in CALSIM II are assigned an associated water quality, expressed in uS/cm (EC). As flow enters or exits the stream network, so does water quality loading. The several components of flow that occur at a modeled location in the network are mathematically blended to derive a composite flow and quality at that location. Figure 2 illustrates a general schematic of the flow and quality elements that are included in the CALSIM II depiction of the San Joaquin River.

Figure 1
Schematic of CALSIM II Depiction of San Joaquin River

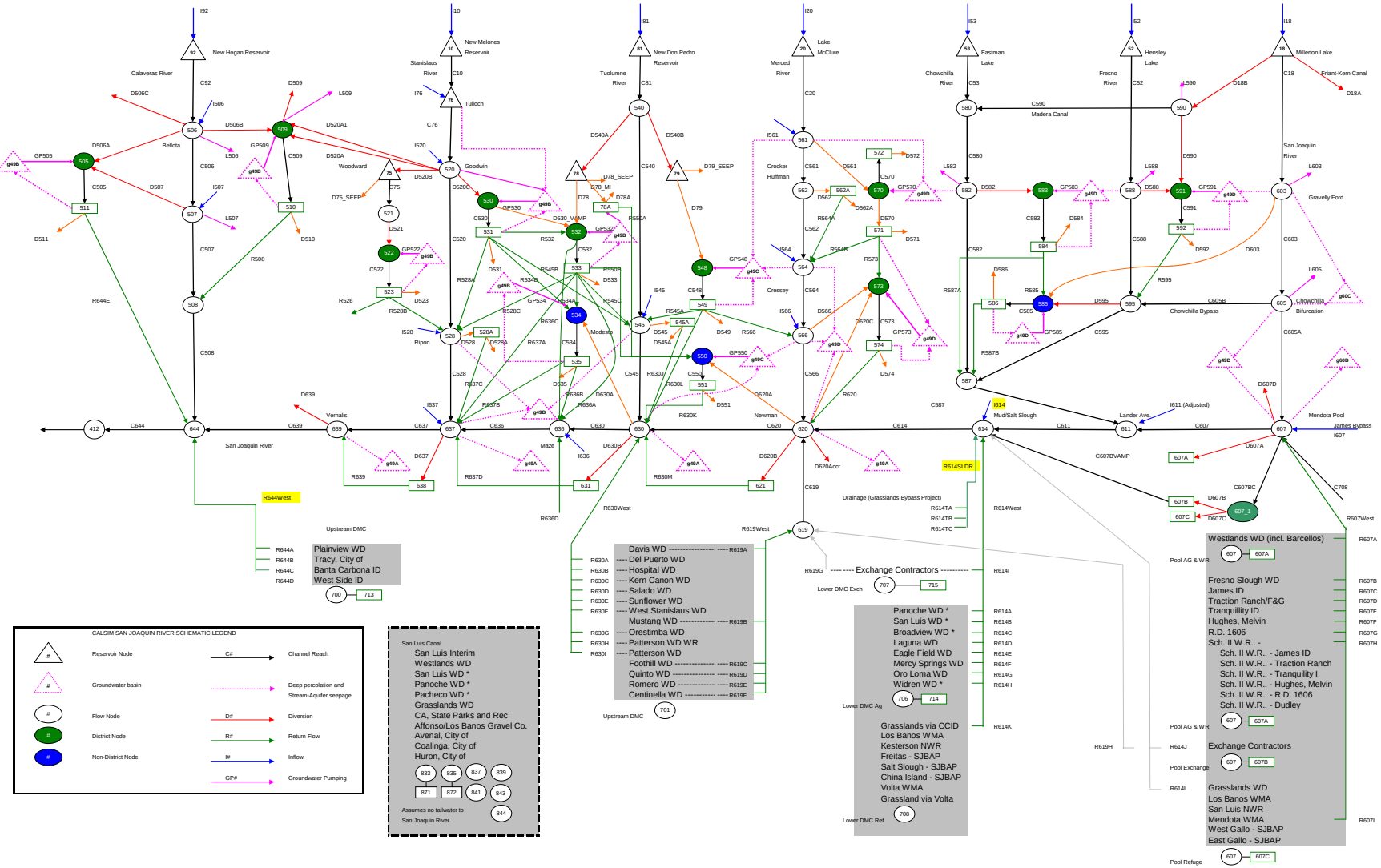
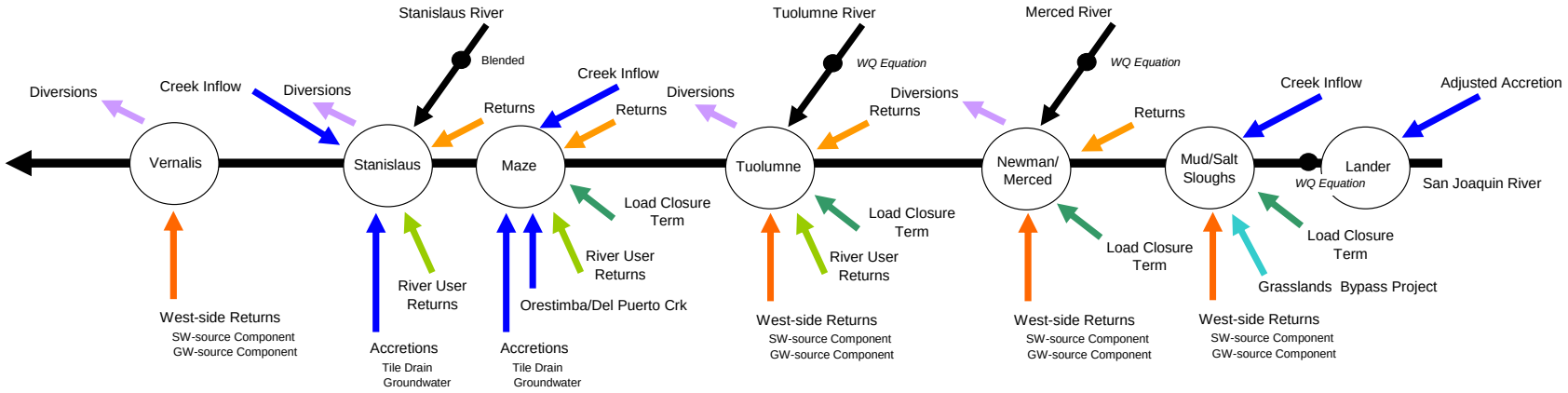


Figure 2
General Schematic of CALSIM II Depiction of San Joaquin River Flow and Quality Elements



CALSIM II currently simulates a sequential monthly operation of water project operations spanning a hydrologic period from October 1921 through September 1994 (73 water years). The simulation assumes the recurrence of historical runoff that occurred during this period, with the "current level" of water system infrastructure and water demands layered upon that hydrology as if this infrastructure and demand existed during that entire sequence of years. During this period sequences of flood and drought occur, including the droughts of 1976-77 and the prolonged 1987 through 1992 drought.

Upstream Hydrologic Condition at Maze

The hydrologic condition at Maze is affected by many aspects of hydrology and the operation of water systems. To a large extent, the runoff within the San Joaquin River Basin is controlled or affected by water systems. Major tributary water systems that affect San Joaquin River flow and quality at Maze and are modeled by CALSIM II include:

- The San Joaquin River upstream of the Mendota Pool (Friant)
- Fresno River (Hidden)
- Chowchilla River (Buchanan)
- Merced River (New Exchequer)
- Tuolumne River (New Don Pedro)
- Fresno Slough (Kings River overflow)

In addition to the operation of the major tributaries, CALSIM II depicts the occurrence of diversions, accretions and depletions, and return flows below the control of the major water systems and along the mainstem of the San Joaquin River. Contributors to the flow and quality at Maze include the major tributaries listed above, return flows/operational spills from those systems, return flows/operational spills from Westside operations, diversions and returns from riparian and appropriative diverters, and accretions from groundwater and minor streams.

The existing flow and quality of the San Joaquin River at Maze is exemplified by Figure 3A through Figure 3D. These graphs depict the simulated sequential average monthly flow and

Figure 3A

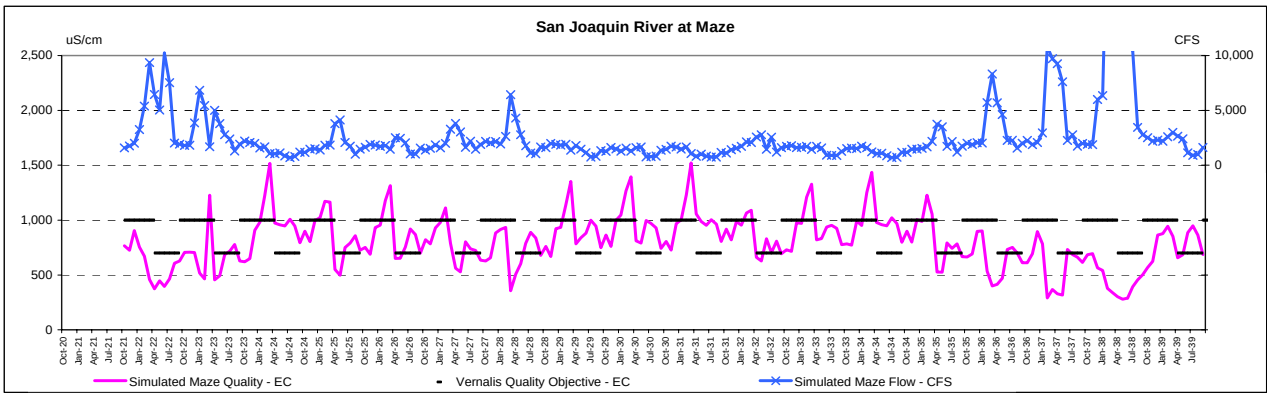


Figure 3B

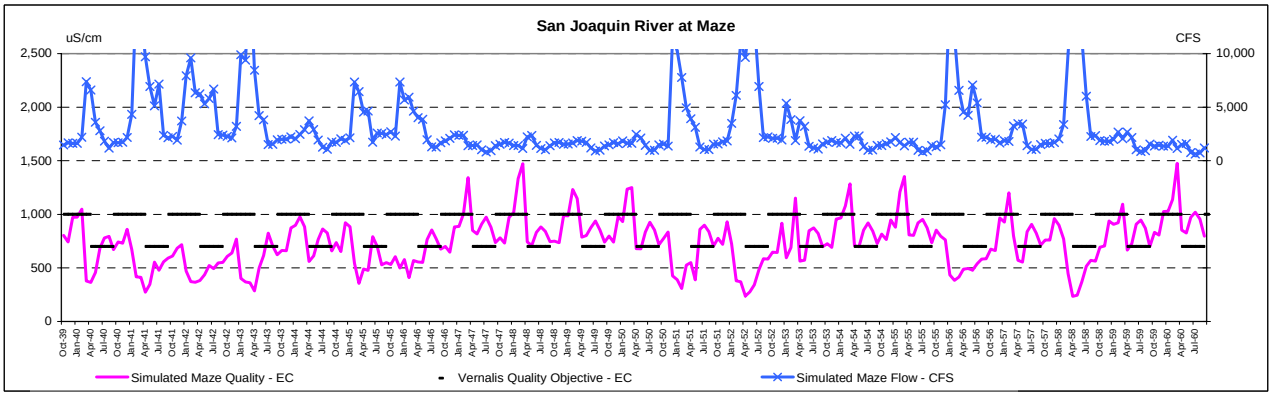


Figure 3C

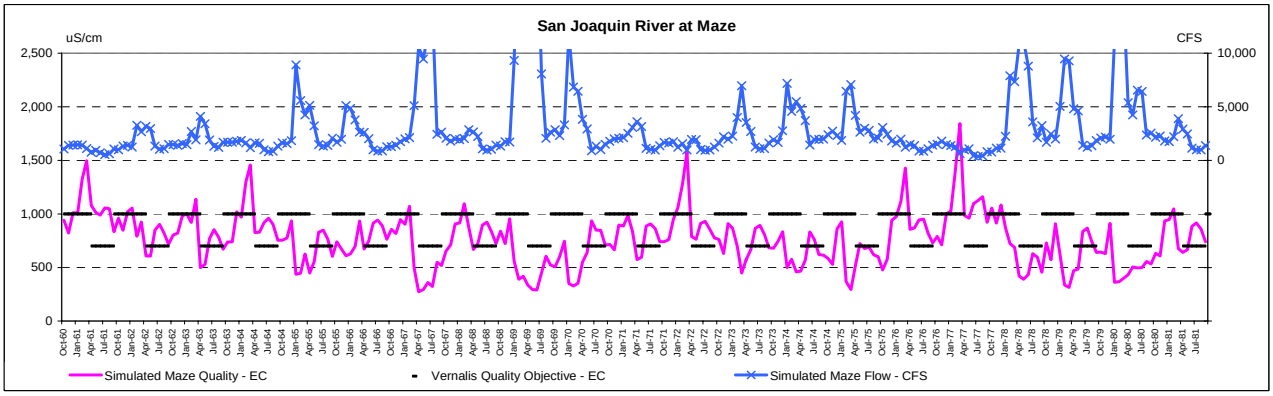
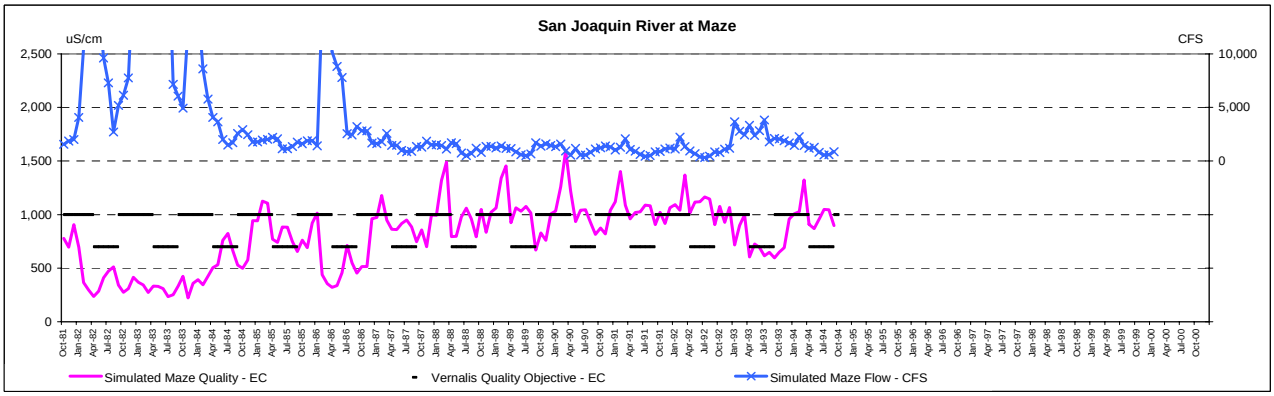


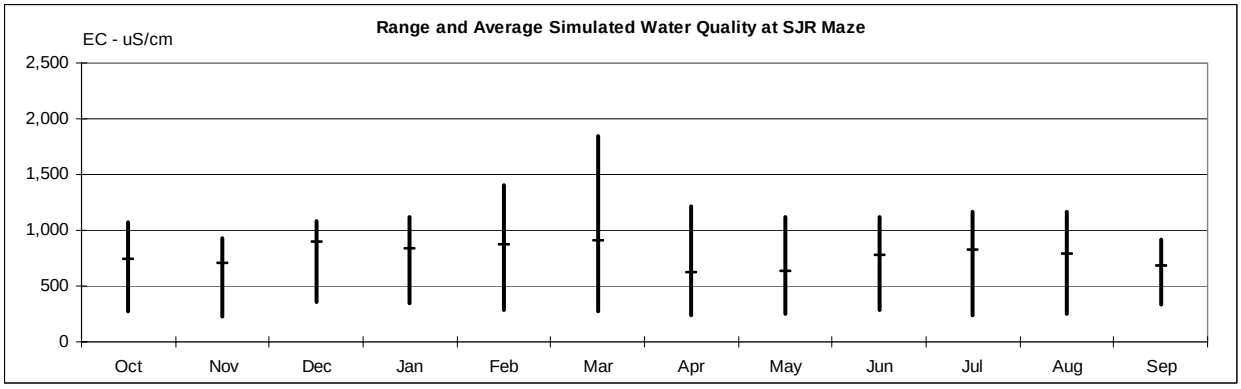
Figure 3D



and quality of the San Joaquin River at Maze as estimated by CALSIM II. Figure 3A depicts the results for water years 1922-40. Figure 3B depicts the results for water years 1941-1960. Figure 3C depicts the results for water years 1961-80, and Figure 3D illustrates the results for water years 1980-94. The seasonal downstream seasonal water quality objective at Vernalis is also shown in the graphs.

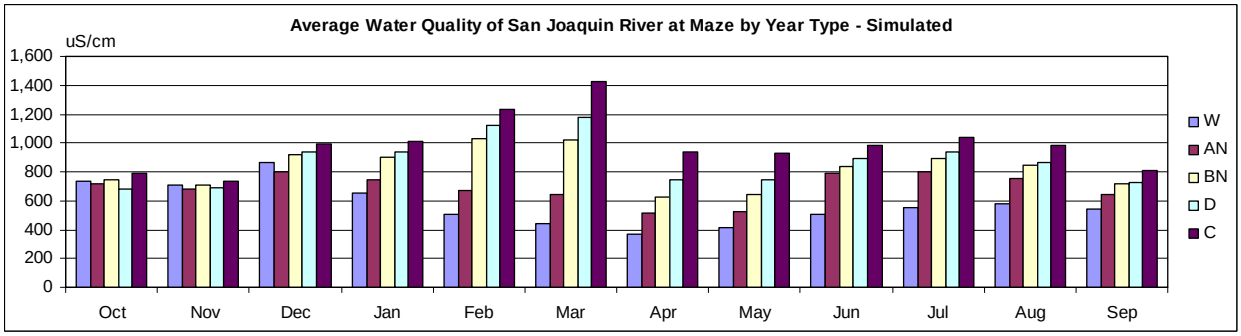
The trend of water quality at Maze is illustrated in Figure 4. Shown in Figure 4 is the range (indicated by a vertical line) in water quality that occurs within a month over the 73 years of simulated operations. Also shown is the average water quality that is simulated for a month (indicated by a bar).

Figure 4



The simulated water quality at Maze also trends by water year type, better water quality occurring during wetter years. Figure 5 illustrates the average water quality simulated at Maze by water year type (San Joaquin River Basin Index, e.g., 60-20-20).

Figure 5



Hydrologic Conditions at Vernalis

Hydrologic conditions at Vernalis are primarily affected by the flow and quality of the San Joaquin River at Maze and the flow of water from the Stanislaus River. The Stanislaus River is assumed to operate according to the 1997 New Melones Interim Plan of Operations (IPO). The IPO allocates supply to four purposes: fisheries, water quality, X2 requirement support, and water supply for Stanislaus River CVP contractors. Reclamation provides water to Oakdale Irrigation District (OID) and South San Joaquin Irrigation District (SSJID) according to a separate agreement with these agencies.

The amount of water allocated to each purpose (other than to OID/SSJID) in the IPO depends on end-of-February storage plus March-September forecasted inflow, as shown below in Table 1. CALSIM II makes releases to the Stanislaus River below Goodwin Dam in the following order:

1. Releases for the fishery according to an assumed pattern associated with the allocated volume.
2. Releases up to the amount needed above the fishery release to meet the Vernalis water quality requirement, these accumulated releases cannot exceed the annual Vernalis water quality allocation.
3. Releases for dissolved oxygen (DO) at Ripon (surrogated as a flow requirement at Goodwin), with no volume limitation except the flow requirement itself.
4. Releases for the Vernalis D-1641 Bay-Delta flow requirement. The IPO assumed that the Vernalis flow requirement release occurred as the second step; however, for modeling simplicity the release is modeled last. Results are rarely affected by the shift in order.

Table 1: New Melones Interim Plan of Operation Allocations (1,000 acre-feet)

New Melones Storage Plus Inflow		**Fishery**		**Vernalis Water Quality**		**Bay-Delta**		**CVP Contractors***	
From	To	From	To	From	To	From	To	From	To
0	1,400	0	98	0	70	0	0	0	0
1,400	2,000	98	125	70	80	0	0	0	0
2,000	2,500	125	345	80	175	0	0	0	59
2,500	3,000	345	467	175	250	75	75	90	90
3,000	6,000	467	467	250	250	75	75	90	90

* CVP Contractors: Stockton East Water District and Central San Joaquin Water Conservation District

The details of Stanislaus River modeling assumptions are provided in Attachment A of this paper. At times when not incidentally met by flows from the mainstem and non-Vernalis water quality or flow releases from Goodwin, CALSIM II will specifically make releases at Goodwin for the purpose of meeting water quality or flow objectives at Vernalis. The current water quality objective at Vernalis is a running 30-day average of 700 uS/cm for April 1 through August 31, and 1000 uS/cm for September 1 through March 31. The February through June flow objective at Vernalis is described in Table 2. Not included in Table 2 are the flow objectives during the 31-day VAMP test flow period that occurs during the April-May period.

Table 2: February through June Vernalis Flow Objective

San Joaquin Basin Index	X2 Required At or West of Chipps	X2 Required East of Chipps
Wet	3420	2130
Above Normal	3420	2130
Below Normal	2280	1420
Dry	2280	1420
Critical	1140	710

The results of the CALSIM II simulation of the upstream San Joaquin River operation in combination with the Stanislaus River operation, which is at times reactive to the upstream San Joaquin River operation, is shown in Figure 6A through Figure 6D. Illustrated are the simulated sequential average monthly flow and quality of the San Joaquin River at Vernalis for the 73-year study period. Also shown for contrast are the water quality at Maze and the Vernalis water quality objective.

The average monthly flow at Vernalis by year type (San Joaquin River Basin Index), as simulated by CALSIM II, is illustrated in Figure 7. Figure 8 illustrates the average monthly water quality at Vernalis by year type.

Under current conditions including the assumed operation of the IPO for the New Melones Project, the flow and quality at Vernalis as modeled by CALSIM II are at times is in a state of non-compliance with objectives. This simulated non-compliance is illustrated in the

Figure 6A

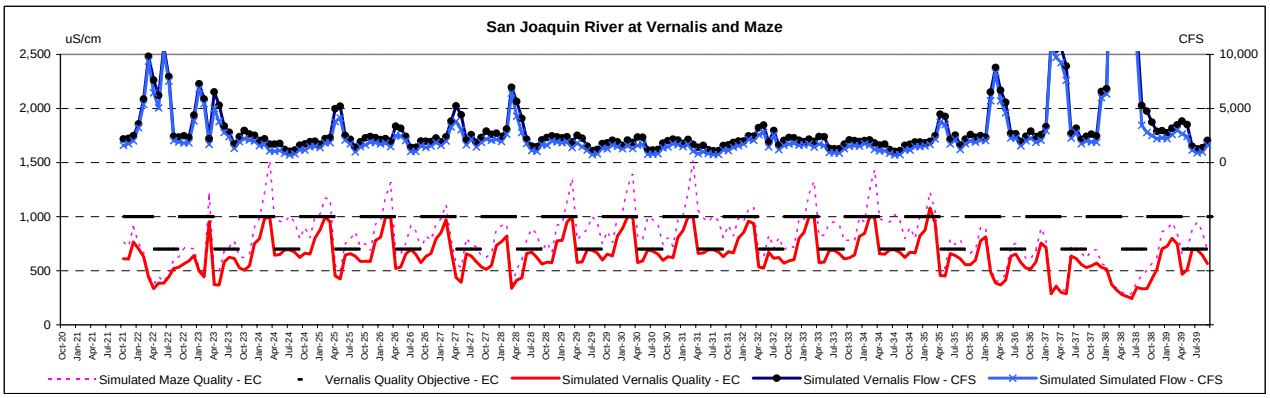


Figure 6B

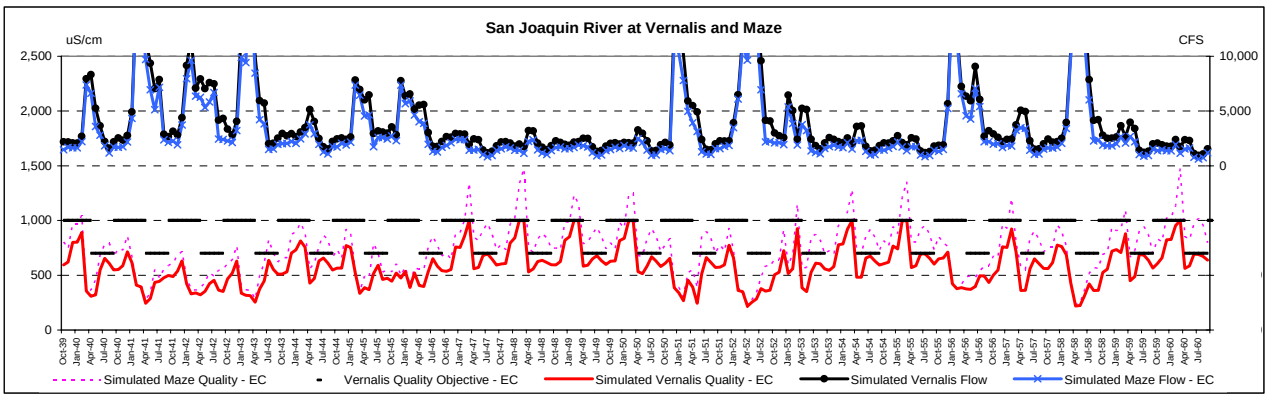


Figure 6C

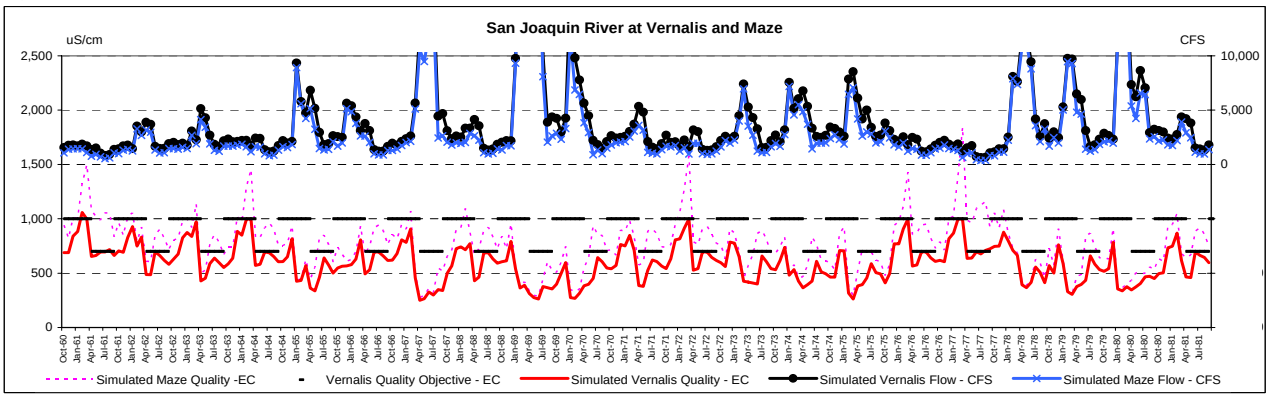


Figure 6D

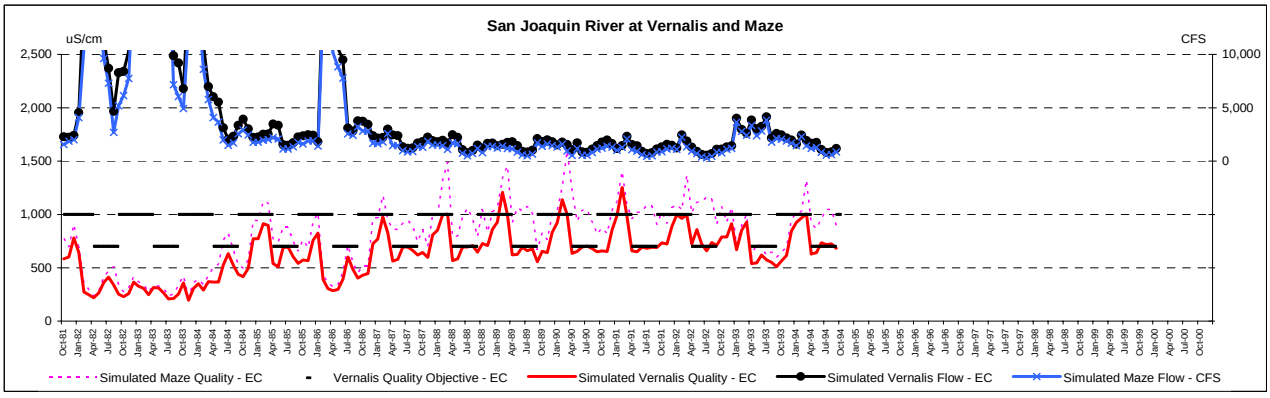


Figure 7

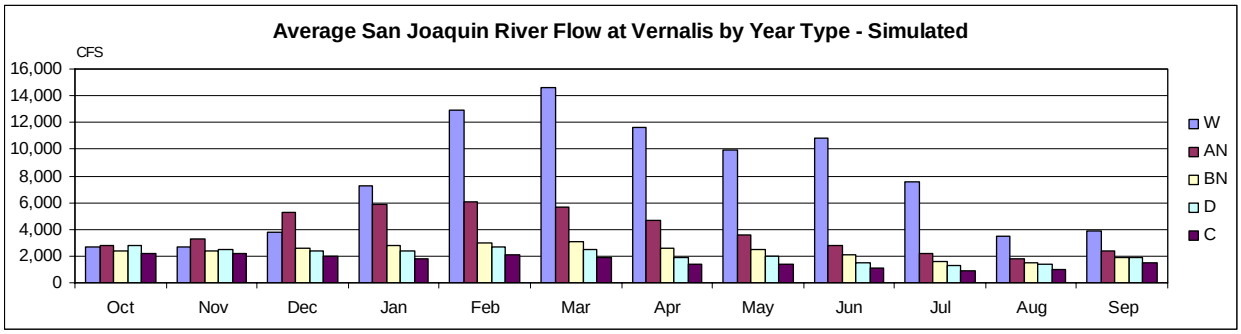


Figure 8

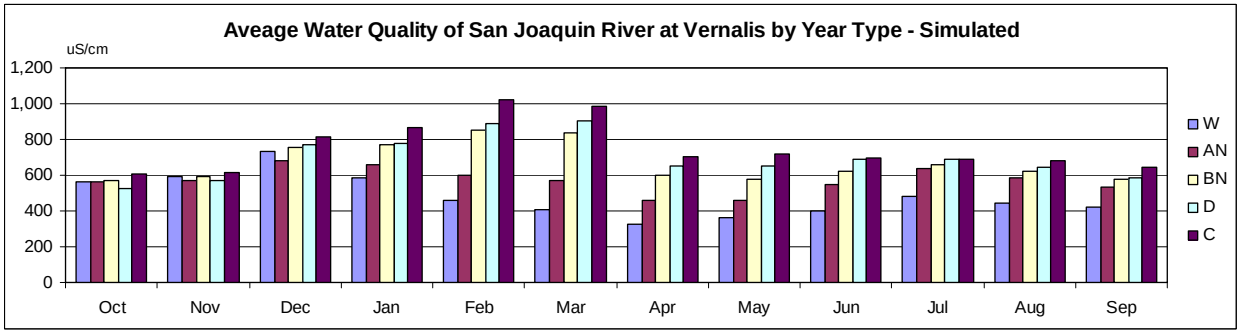


Figure 6 series when the Vernalis water quality line exceeds the line illustrating the objective. The instances when CALSIM II modeling shows water quality objective exceedences to occur are shown in Table 3. Table 3 shows that during 9 years of the 73 years of simulation at least one month of non-compliance would occur. The simulation shows a total of 15 periods of non-compliance. Table 3 also shows the storage that exists at New Melones Reservoir during these periods of non-compliance, and also the estimated amount of additional release from the Stanislaus River that would be required to achieve water quality compliance at Vernalis. The modeling results show that while water exists in New Melones to make additional releases for water quality compliance, the assumed IPO limit upon water quality allocations does not allow an additional release.

Table 4 summarized the estimated required release of New Melones water for compliance to the existing water quality objective at Vernalis. This estimate assumes the ordered-structure of releases (water quality releases subsequent to releases for the fishery) described for the IPO.

Table 3: Vernalis Water Quality Objective Compliance and Other Information – Current Conditions

Average Monthly Water Quality at Vernalis - Simulated (uS/cm)

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1935	C	C	C	C	1080	C	C	C	C	C	C	C
1961	C	C	C	C	1058	C	C	C	C	C	717	C
1977	C	C	C	C	C	C	C	C	C	C	710	C
1988	C	C	C	C	C	C	C	C	C	C	708	C
1989	C	C	C	C	1207	C	C	C	C	C	C	C
1990	C	C	C	C	1139	C	C	C	C	C	C	C
1991	C	C	C	C	1253	C	C	C	C	C	C	C
1992	C	C	C	C	C	C	749	1011	723	C	737	C
1994	C	C	C	C	C	C	C	C	735	718	725	C

Notes: "C" means water quality was within compliance for month. Exceedence during April or May is during non-pulse flow period.

Water Quality Objective - uS/cm

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1000	1000	1000	1000	1000	1000	700	700	700	700	700	1000

Estimated Additional New Melones Release Needed to Provided Water Quality Compliance - 1,000 acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1935					10							
1961					7						2	
1977											1	
1988											1	
1989					20							
1990					15							
1991					22							
1992							6	21	1		3	
1994									4	1	2	

End of Month New Melones Storage - 1,000 acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1935	584	580	583	616	640	690	820	1012	1127	1074	1001	958
1961	1201	1216	1231	1239	1243	1224	1186	1132	1079	1023	966	934
1977	1448	1444	1436	1428	1400	1339	1273	1209	1181	1124	1069	1047
1988	1443	1424	1410	1414	1404	1361	1298	1222	1182	1145	1109	1081
1989	1045	1029	1022	1020	1029	1079	1047	1002	984	932	882	886
1990	906	908	923	936	952	920	856	786	733	676	633	609
1991	598	580	589	587	584	626	594	558	521	461	404	385
1992	382	371	386	400	450	467	441	361	308	252	194	166
1994	716	738	772	802	825	775	723	675	619	552	490	455

Table 4: Estimated New Melones Release Requirements for Water Quality Compliance

Average Vernalis Required Water Quality Release within Year Type - 1,000 AF Current Conditions

SJRBI	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
W	0	0	0	0	0	0	0	0	0	0	0	0
AN	0	0	0	0	1	0	0	0	1	0	0	0
BN	0	0	0	0	3	2	2	1	1	3	1	0
D	0	0	0	0	2	7	3	2	4	7	3	0
C	0	0	0	0	8	18	7	7	13	11	5	0
All	0	0	0	0	3	5	2	2	4	4	2	0

An average of about 70,000 acre-feet of water quality releases are needed during critical years to fully comply with the existing water quality objective at Vernalis. This amount of water is in addition to water released under the IPO for fishery purposes.

Simulated compliance with the Vernalis flow objective (February through June, excluding the VAMP pulse flow period) is shown in Table 5. Shown in Table 5 is the estimated Vernalis non-pulse flow objective for the February through June period. The flow objective is

based on a combination of the San Joaquin River Base Index and the required position of X2 (see Table 2). The second set of columns in Table 5 show the calculation of flow that is above or below the objective. Positive values indicate compliance with the objective, while highlighted negative flows indicate non-compliance with the objective. Also shown in Table 5 is the New Melones Index for each year (March through following year February basis). During years when the index is less than 2,500 TAF (non-highlighted index values) the assumed operation of the IPO does not allow releases for the Vernalis flow objective. Boxed values shown in the table represent periods when Goodwin is modeled to be releasing at least 1,500 cfs, an assumed limit of release unless flood control requires greater releases. There can be instances when the index allows releases for the Vernalis flow objective but the required release is not made because Goodwin is releasing at its assumed maximum rate. Non-compliance can occur during any San Joaquin River Index year type, most often during Above Normal, Below Normal and Dry years.

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Table 5: Vernalis Flow Objective Compliance and Other Information – Current Conditions

Water	Vernalis Flow Objective - cfs					Above/Below Flow Objective - cfs					NM
Year	Feb	Mar	Apr	May	Jun	Feb	Mar	Apr	May	Jun	Index - TAF
1922	3420	3420	3334	3420	3420	2448	6409	3649	1508	7258	2269
1923	3420	3254	2689	3378	2818	2474	-1033	3316	364	569	2494
1924	784	1043	710	710	710	1415	657	676	840	507	1836
1925	2034	2280	2165	2280	1907	189	27	510	1264	594	2233
1926	1666	2280	1993	2280	1420	550	-295	122	-306	1007	1965
1927	3420	3420	3420	3420	3205	-1053	412	1280	-202	-1126	2403
1928	2250	2280	2280	2280	1535	855	4681	1850	354	637	2388
1929	802	1001	810	710	724	1583	918	930	663	787	1888
1930	1140	1140	1126	932	710	945	723	270	615	445	1747
1931	848	738	782	710	710	1286	947	511	758	488	1373
1932	3376	3420	3377	2921	3162	-915	-978	-1534	-376	-1299	1807
1933	1635	1448	2079	1448	1449	530	511	-588	193	-142	1556
1934	1140	1140	1040	710	710	966	661	158	717	505	1244
1935	3420	3420	3248	3420	3334	-1457	-943	-188	-493	-1196	1580
1936	3376	3420	3377	3420	2861	3135	5368	2844	780	-181	2154
1937	2360	3420	3420	3420	3377	8889	6811	6761	4408	-698	2374
1938	3420	3420	3420	3420	3420	21045	28440	13777	18446	17899	3476
1939	1696	1503	2079	1420	1420	1485	1976	-346	726	82	2331
1940	3376	3420	3420	3420	2947	-694	4531	4841	197	710	2698
1941	3420	3420	3420	3420	3420	12406	11281	8212	5374	3610	2879
1942	3420	3420	3291	3420	3334	8196	3662	4639	3622	4254	3100
1943	3420	3420	3420	3420	2732	8380	17982	6598	1534	2984	3090
1944	1687	2280	2108	1448	1707	1389	1202	913	1063	777	2368
1945	3420	3420	3248	3045	2947	4408	3554	1620	2632	0	2649
1946	3420	3420	3291	3378	2861	3133	1725	590	992	162	2728
1947	1604	2280	2251	1503	1420	1289	-331	-657	97	29	2206
1948	2250	1475	1850	2280	2194	-267	269	-35	-280	-135	2121
1949	1574	1642	2280	2225	1735	570	560	-578	-403	-3	1937
1950	2280	2280	2251	2280	1936	-187	-211	-342	-730	324	2112
1951	3420	3420	3377	3045	2388	6722	2490	374	-142	0	2695
1952	3376	3420	3420	3420	3420	3101	8427	7785	11215	13961	3399
1953	2280	2280	2165	2225	1735	2747	132	1072	1171	679	2695
1954	2280	2280	2280	2280	1649	254	-267	293	582	137	2427
1955	2280	1697	1621	1448	1649	-159	223	199	276	-287	2051
1956	3376	3420	3420	3378	3377	8889	3809	2190	1526	5677	3034
1957	1696	2280	2280	1614	1993	745	1446	588	1415	283	2649
1958	3420	3420	3420	3420	3420	535	7141	14757	9134	11115	3160
1959	2280	2280	2137	1531	1420	1371	368	-134	548	-19	2374
1960	918	1140	1140	863	724	1461	607	284	606	396	1952
1961	864	1140	1054	724	710	1000	565	173	661	343	1562
1962	1696	2280	2223	2280	1592	1833	728	-401	-449	73	1670
1963	3420	3420	3248	3420	3377	-350	-1143	-210	-1016	-673	2095
1964	2250	1781	1535	1448	1449	-36	0	-8	198	-96	1916
1965	3420	3420	3162	3420	2947	2374	1321	3470	0	0	2735
1966	2280	2280	2251	2225	1449	2106	838	-682	-584	-81	2293
1967	3420	3420	3420	3420	3420	-802	2228	8823	7183	10555	3168
1968	2250	2280	2251	1475	1420	1088	1056	119	753	64	2413
1969	3420	3420	3420	3420	3420	24180	19398	16830	19245	23018	3474
1970	3420	3420	3420	2130	2216	6389	4362	655	816	0	2720
1971	2280	2280	2280	2252	2108	749	1436	1178	819	0	2606
1972	2250	2280	2280	1725	1477	0	-650	-571	-42	-94	2232
1973	3420	3420	3420	3295	3334	1067	3987	1380	-432	-52	2556
1974	3420	3420	3420	3420	3334	1741	2614	3078	381	0	2947
1975	3420	3420	3420	3129	3420	4442	5117	1704	-501	1579	2927
1976	799	793	839	710	710	1749	1040	845	798	515	2195
1977	771	724	710	710	710	1103	536	273	770	9	1580
1978	3420	3420	3420	3420	3334	4678	4207	7001	7500	6124	2247
1979	3420	3420	3420	2837	3291	6348	6276	2475	2200	-172	2525
1980	3376	3420	3420	3295	2861	19696	12921	3923	2222	5780	3005
1981	2280	2280	2251	1559	1420	461	2104	255	865	89	2381
1982	3420	3420	3420	3420	3420	12321	11649	21674	13138	7998	3419
1983	3420	3420	3420	3420	3420	34344	46138	20464	20532	24128	3965
1984	3376	3420	3420	2588	2775	7556	3564	1509	1584	361	2765
1985	1727	2197	1879	2003	1420	798	348	472	320	120	2352
1986	3420	3420	3420	3337	2732	13315	24332	8747	6740	6772	3149
1987	848	1140	1126	710	710	1359	1846	495	908	642	2179
1988	1125	890	796	710	710	833	817	864	634	371	1707
1989	864	863	1140	1126	710	706	888	343	45	211	1595
1990	1140	807	1025	710	710	640	755	-144	850	154	1262
1991	741	724	1126	710	710	704	1590	271	550	208	985
1992	784	1140	1068	738	710	1679	745	166	-59	-82	741
1993	3420	3420	3420	3420	3377	-449	-810	-241	-1726	-125	1352
1994	833	1112	896	710	710	1609	829	409	801	377	1096

Notes: Boxed cells indicate Goodwin release of 1,500 cfs or more. New Melones Index: Sum of end-of-February storage plus projected M-S inflow.

Table 6 summarizes the instances of non-compliance, grouping the information by San Joaquin River Basin Index year type. Indicated in the table are the number of years within each year type that non-compliance is simulated to occur during at least one month during those years, and the range of the annual amount of release that would be required to comply with the flow objective. The frequency and range of simulated non-compliance for each month is also shown in Table 6.

Table 6: Range of Vernalis Flow Objective Non-compliance - Simulated

Wet					
Non-compliance in at least 1 month 4/20 years.					
Annual Range: 15-142 TAF					
	Feb	Mar	Apr	May	Jun
Non-compliance months	2/20	1/20	1/20	2/20	2/20
Range of Non-compliance - TAF	25-45	50	7	15-53	7-42
Above Normal					
Non-compliance in at least 1 month 10/14 years.					
Annual Range: 4-245 TAF					
	Feb	Mar	Apr	May	Jun
Non-compliance months	5/14	4/14	3/14	6/14	7/14
Range of Non-compliance - TAF	19-81	58-70	6-46	4-31	3-77
Below Normal					
Non-compliance in at least 1 month 6/12 years.					
Annual Range: 16-56 TAF					
	Feb	Mar	Apr	May	Jun
Non-compliance months	2/12	2/12	5/12	5/12	3/12
Range of Non-compliance - TAF	10-15	13-16	1-20	9-22	1-8
Dry					
Non-compliance in at least 1 month 8/11 years.					
Annual Range: 5-64 TAF					
	Feb	Mar	Apr	May	Jun
Non-compliance months	2/11	2/11	5/11	5/11	5/11
Range of Non-compliance - TAF	2-9	18-40	4-20	1-9	1-17
Critcal					
Non-compliance in at least 1 month 2/16 years.					
Annual Range: 4-7 TAF					
	Feb	Mar	Apr	May	Jun
Non-compliance months	0/16	0/16	1/16	1/16	1/16
Range of Non-compliance - TAF	0	0	4	2	5
Values shown for April/May represent non-compliance during non-pulse flow period.					

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Comparison to Previous Simulations of San Joaquin River Conditions

The above described flow and water quality depiction of the San Joaquin River differs from that previously used in SWRCB proceedings, and the differences are the direct result of approximately three years of refinement and enhancement of the model(s) used to simulate the hydrology and operations of the San Joaquin River Basin. The version of CALSIM II that is used to develop the information presented herein incorporates several advancements to earlier modeling efforts, specifically regarding the San Joaquin River Basin. These advancements include:

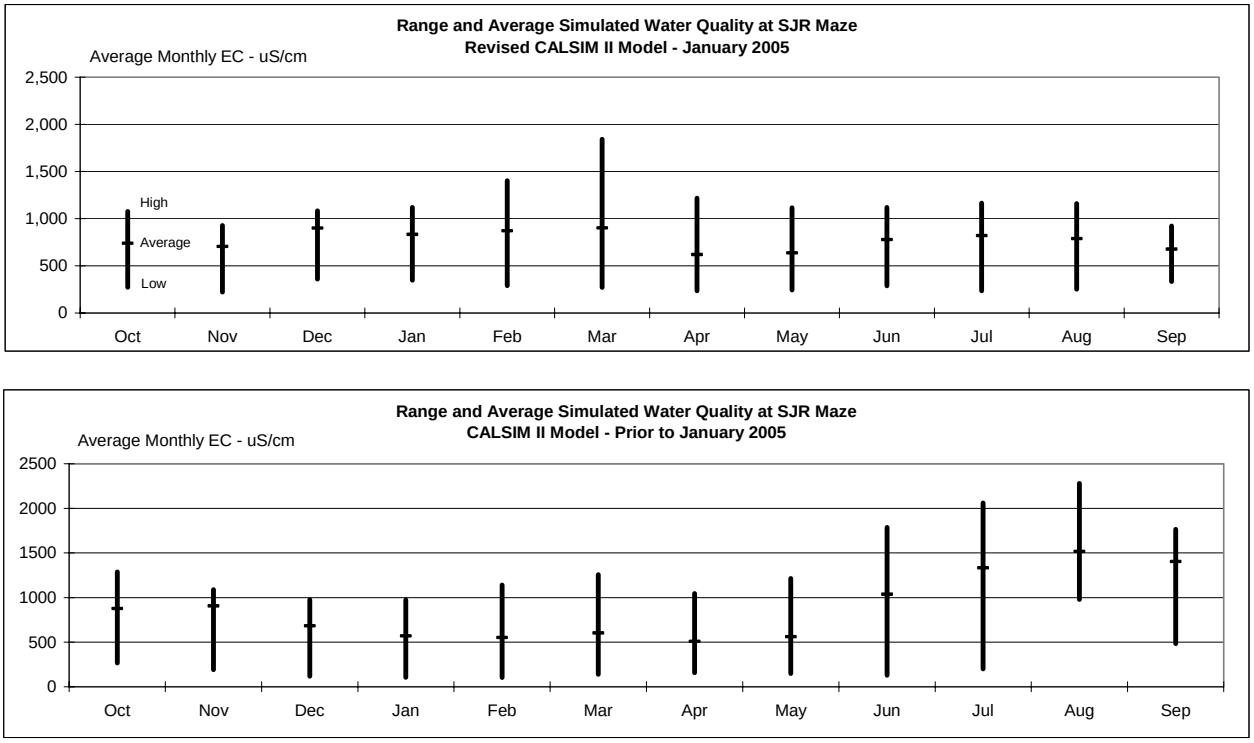
- Re-definition of San Joaquin River Basin hydrology
- Land-use based water demands for Eastside system operations
- Re-definition of Eastside system operations/interdependencies
- Re-mapping of Westside and Eastside return flows
- Development of a disaggregated water quality calculation

The current, under-review version of CALSIM II significantly changes the simulated depiction of water quality associated with San Joaquin River flow occurring from upstream of the Stanislaus River confluence. Previous models of the San Joaquin River incorporated equations relating flow and quality at Maze. The fundamental relationship between flow and quality at Maze (referred to at the Kratzer Formula) relied upon observed data for the 1981 through 1985 hydrologic period. A modification was made to the relationship in the mid-1990s in an attempt to disaggregate Westside return flows from the relationship (referred to as the Modified Kratzer Formula). Versions of SANJASM and STANMOD (predecessor models to elements now incorporated into CALSIM II, and used for previous testimony) relied upon the Modified Kratzer Formula.

As described above, the revised version of CALSIM II depicts water quality in the San Joaquin River by calculating a conservation of flow and quality (mass) within the river assigning an associated water quality with each element of flow. The use of regression equations to

describe the quality associated with flow has been greatly reduced. The change in water quality simulated by the models that has occurred is illustrated in Figure 9.

Figure 9: General Change in Simulated Water Quality at Maze



The revised version of CALSIM II incorporates a salinity "calibration" that relies upon recent, observed flow and quality data for the San Joaquin River, its tributaries, and numerous significant monitored inflows. The results of the revised version of CALSIM II reflect water quality conditions that are currently being experienced in the basin, and which have been affecting the operation of New Melones Reservoir. Recent operational experience for the New Melones Project has required water quality dilution flows in the spring-time and summer. The previous version of CALSIM II and SANJASM did not simulate the spring-time salinity condition. For the summer-time, the previous version of CALSIM II and SANJASM over-estimated salinity, well in excess of observed data.

As a second comparison of depicted water quality and flow by the models, Figure 10 illustrates the recorded and simulated conditions at Maze for the 1986 through 1992 period.

Figure 10: Recorded and Simulated Flow and Quality at Maze

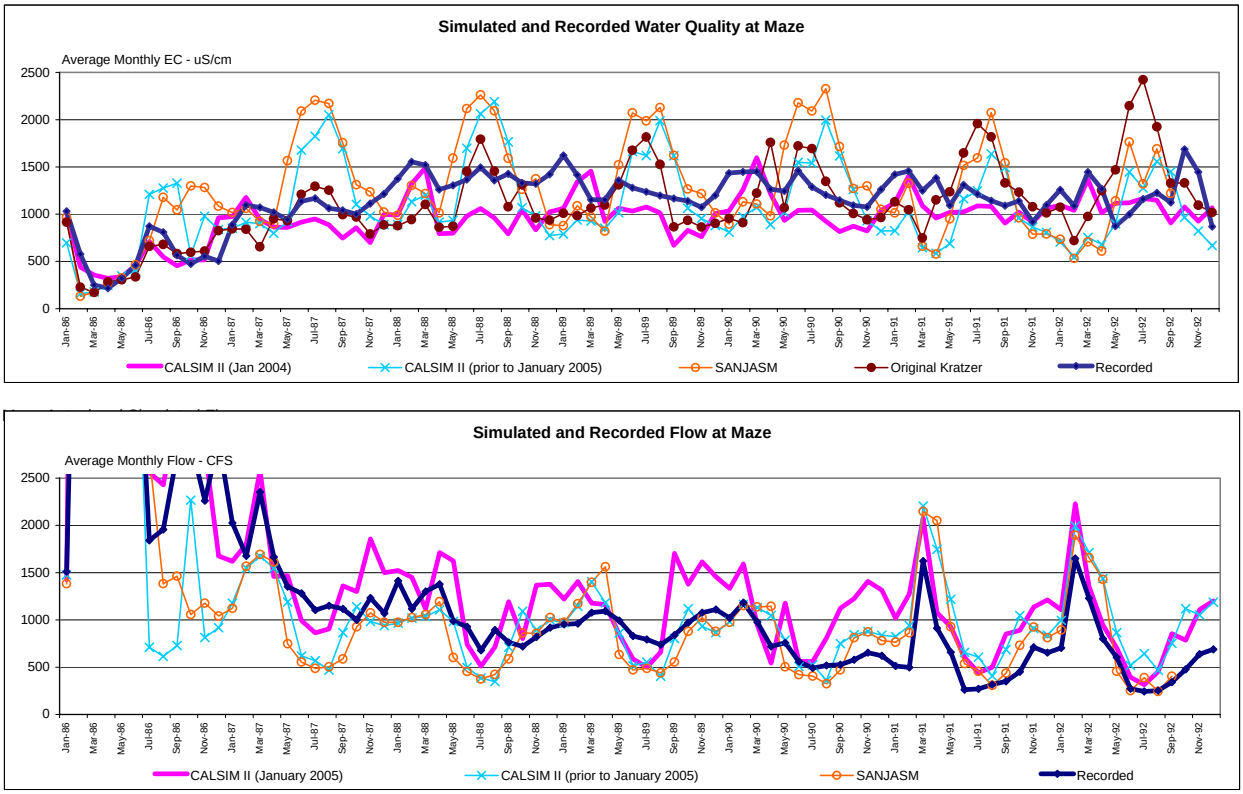


Figure 10 illustrates how the previous version of CALSIM II and SANJASM simulated water quality to be extremely high during the summer-time, much higher than was even recorded for the period. Even the original Kratzer Formula shows a high simulated water quality during the later part of the drought, when flows are simulated to be low. This type of overestimation of salinity at Maze contributed to an overestimation of the simulated water quality release needs from New Melones Reservoir, which has been prevalent in prior presentations. There is still a need for water quality releases; however, the severity of the need was exaggerated in past modeling efforts.

The revised CALSIM II results illustrate that the river is simulated to be different than those conditions actually experienced, in this illustration during the recurrence of the 1987 through 1992 period. A difference between simulated operations and historical recorded operations will typically occur due to the inability to capture anomalies between "real-time" actual operations

and systematic operations and hydrology that are incorporated into the model. However, in this case of San Joaquin River water quality and flow, the modeled difference is also the result of changes to the operations within the basin that have occurred since the early 1990s. These changes include:

- Increased water use and system efficiency actions
- Increased instream flow requirements in the Tuolumne River
- Drainage management programs by Westside irrigation districts
- Alternative water operations of Refuge areas

Each of these items, and likely others, has changed the hydrology of the San Joaquin River from those conditions that existed in the past. As described above, the revised CALSIM II model has been refined and "calibrated" against recent recorded data. When the systematic operational assumptions that represent current operations are combined with the recent water quality attributes that are associated with flows entering the river system, it is anticipated that the river will be different than previously experienced.

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Alternative Water Quality and Flow Objectives

Alternative Vernalis Water Quality Objective

The alternative Vernalis water quality objective consists of providing 1,000 uS/cm during the entire year, instead of providing 700 uS/cm during April through August and 1,000 uS/cm during the remainder of the year.

The analysis was structured to develop a reasonable "bookend" of the flow and quality effects that may occur at Vernalis if the water quality objective is modified. A series of studies were made, each with the modified water quality objective. The difference between the studies was the assumption for other release objectives of the New Melones operation. In these studies all allocations of the IPO as modeled by CALSIM II remain the same except for the required release made for Stanislaus River dissolved oxygen objectives. As described before, the assumed operation of the IPO "layers" one component of flow upon another, e.g., the fishery release is assumed to provide the first water in the river. Then, if necessary to meet the water quality objective at Vernalis, supplemental releases are made. Currently, salinity objectives at Vernalis and Stanislaus River dissolved oxygen objectives during the summer require approximately the same level of release from New Melones. Therefore, a change to the Vernalis water quality objective at Vernalis during June through August did not result in a large, regular change in release from New Melones since the water quality release was replaced with a release for dissolved oxygen objectives. Thus, this scenario did not greatly change the summer-time flow or quality at Vernalis.

In order to identify greater potential flow and quality changes that may occur due to the assumed change in Vernalis water quality objectives, an assumed modification of the Stanislaus River dissolved oxygen objective was implemented in the studies. The total removal of the dissolved oxygen objective in combination with the modified Vernalis water quality objective

would at times result in a "near-zero" release during the summer during a dry series of years. This outcome is the result of the structure of the IPO and the assumptions used to model the monthly distribution of Stanislaus River release allocations. Instead of this modeled outcome, an alternative surrogate for a minimum release at Goodwin was implemented in the model. A minimum of 100 cfs release from Goodwin was assumed required during the summer.

In terms of resulting flow at Vernalis, results of this scenario that modifies the Vernalis water quality objective in combination with a reduction in Stanislaus River release objectives is shown in Table 7. The results are provided by water year annually ranked by the San Joaquin River Basin Index (SJRBI), wettest to driest year. Table 8 illustrates the difference in flow that occurs between the alternative scenario and the "current condition" scenario. Reductions in flow at Vernalis due to the alternative scenario are shown as negative values. Increases in flow at Vernalis are shown as positive values. Generally when reductions in flow occur in the summer due to less releases being required to meet the alternative Vernalis water quality objective, a reduction of up to approximately 170 cfs may occur. Flow reductions may also occur during the non-pulse periods of April and May.

Additions to flows at Vernalis occur during the non-summer months. The increases in flows occur due to the reaction of the IPO to an increase in carry-over storage in New Melones Reservoir (higher allocations) and occasional increased spills. The simulated New Melones Reservoir storage for the alternative scenario is shown in Table 9.

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Table 7

Average Monthly Flow at Vernalis with Modified Vernalis Water Quality Objective - CFS													SJRBI
WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	MAF
1983	8414	10325	20934	27393	37764	49558	23884	23952	27548	25925	9885	9207	7.22 W
1969	2052	2180	2170	9769	27640	22818	20250	22665	26438	10200	3891	4379	6.09 W
1938	2668	2481	6598	6862	24465	32050	17197	21866	21319	12293	5273	4763	5.89 W
1982	2278	2238	2400	4550	15816	15069	25094	16558	11418	8705	4677	8283	5.45 W
1967	1942	1810	2146	2401	2642	5648	12243	11079	13975	17348	4438	4690	5.25 W
1952	2268	2247	2276	3910	6477	11847	11205	14858	17381	9583	4140	4087	5.17 W
1958	2432	2151	2194	2501	3955	10561	18177	12554	14535	7863	4143	4213	4.77 W
1980	2878	2664	2332	11528	23814	16341	7343	6235	8641	7038	2934	3238	4.73 W
1978	1222	1438	1445	2518	8099	7670	11928	12305	9451	4130	2530	3729	4.58 W
1922	2178	2240	2481	3574	5868	9829	7623	6216	10656	7893	2361	2308	4.54 W
1956	1861	1896	5655	15919	12333	7229	6346	5918	9054	6052	2694	3978	4.46 W
1942	3149	2802	4393	9240	11616	7082	7930	7042	7588	7477	4159	4317	4.44 W
1941	2532	2333	2751	4919	15827	14702	11632	9356	7049	7861	2866	2654	4.43 W
1986	2375	2475	2416	1820	16887	27752	12167	10577	9504	3097	2825	3771	4.31 W
1993	1215	1354	1458	4016	2986	2620	3862	2899	3181	3988	1989	2447	4.20 W
1943	3350	2826	4061	12416	11800	21402	10018	5944	5716	2023	2053	2523	4.03 W
1937	2984	2470	2633	3419	11309	10260	10828	9164	3377	3180	2136	2447	3.90 W
1974	2728	2093	3178	7565	5165	6046	6766	5342	3363	2573	2492	2675	3.90 W
1975	3783	3316	2998	2584	7862	8537	6119	4197	4999	3418	2583	2721	3.85 W
1965	2195	1977	2121	9415	5803	4767	6850	5159	2947	1834	1927	2642	3.81 W
1936	2602	2341	2488	2340	6618	8877	7113	5823	2700	2645	2101	2448	3.74 AN
1984	6794	15925	24677	16894	10931	6984	6034	5535	3136	2033	2325	3352	3.69 AN
1979	2478	3046	2504	5334	9809	9702	6520	6018	3119	1671	1826	2333	3.67 AN
1945	2450	2537	2397	2624	7828	6975	6003	6472	2947	3185	3080	2980	3.59 AN
1963	2043	1831	1948	1767	3074	2326	5154	4632	2655	1752	1588	2096	3.57 AN
1927	1983	1938	2272	1910	2367	3841	5374	4493	2139	2571	1853	2337	3.56 AN
1935	1711	1937	1930	1837	2142	2485	4470	4265	2016	2386	1452	2031	3.56 AN
1923	2473	2327	4390	7288	5894	3254	6547	5326	3408	2802	1708	2383	3.55 AN
1973	2204	2591	2366	2593	4487	7410	5299	4308	3282	1546	1579	2187	3.50 AN
1932	1647	1869	2010	2010	2466	2447	3234	3468	1741	2809	1438	1902	3.41 AN
1940	2179	2162	2077	2069	2681	7952	8321	5255	3668	2217	1589	2184	3.36 AN
1946	3544	2822	7764	6381	6554	5146	5539	5587	3029	1772	1759	2210	3.30 AN
1970	4238	2979	4260	16550	9809	7782	5630	4472	2216	1824	1492	2097	3.18 AN
1951	2163	1849	14310	12537	10142	5910	5484	4907	2388	1485	1456	1991	3.14 AN
1962	1440	1708	1785	1466	3529	3012	3854	3699	1540	1311	1324	1768	3.07 BN
1953	2994	2745	2570	6437	5027	2412	5239	5136	2414	1833	1546	2080	3.03 BN
1957	2906	2584	2196	2394	2441	3726	5066	4946	2276	1506	1537	2002	3.01 BN
1925	1722	1928	1973	1685	2223	2294	4286	4975	2435	2038	1297	1821	2.93 BN
1971	2644	2430	2500	2599	3029	3716	5342	4816	2108	1598	1442	1914	2.89 BN
1950	2035	2094	1988	2129	2093	2073	3869	3563	2208	1271	1293	1844	2.85 BN
1944	2934	2728	2924	2660	3076	3482	5135	4044	2484	1697	1496	2213	2.76 BN
1954	2572	2394	2193	2121	2534	2013	3574	3631	1786	1350	1395	1830	2.72 BN
1948	2161	2207	2073	1794	1983	1744	3086	3123	1966	1556	1338	1723	2.70 BN
1928	2918	2614	2726	2423	3114	6964	5698	4144	2180	1506	1438	2104	2.63 BN
1949	2274	2161	1961	1872	2143	2202	2364	2384	1611	1136	1228	1657	2.53 BN
1966	2572	2524	5653	5429	4412	3142	4020	3362	1383	1203	1218	1667	2.51 BN
1933	2323	2294	2075	1940	2165	1959	2309	2304	1185	1116	1116	1567	2.44 D
1981	3114	2989	2433	2347	2741	4384	4204	3811	1507	1387	1313	1792	2.44 D
1985	3934	3026	2217	2260	2526	2545	3470	3352	1540	1401	1687	2244	2.40 D
1926	2283	2434	2343	2107	2208	1985	3359	3172	2317	1243	1255	1866	2.30 D
1955	2084	2066	2276	2747	2121	1921	2451	2312	1237	1009	1119	1657	2.30 D
1959	2790	2511	2519	2617	3651	2648	3967	3403	1401	1188	1294	1983	2.21 D
1968	3107	2373	2604	2511	3338	3336	4140	3563	1484	1297	1406	1849	2.21 D
1939	3734	2891	2958	2772	3181	3479	3841	3523	1491	1208	1316	2015	2.20 D
1964	2375	2105	2132	2252	2214	1781	2329	2301	1225	1003	1064	1591	2.19 D
1947	2654	2606	2940	2913	2894	1949	2360	2306	1391	1070	1214	1744	2.18 D
1972	2695	2029	2091	1694	2250	1630	3069	2951	1316	1197	1257	1566	2.16 D
1994	2469	2184	1976	1607	2452	1941	1530	1678	941	652	704	1035	2.05 C
1930	1823	2072	1910	1586	2085	1863	2317	2307	1006	990	1053	1650	2.02 C
1929	2324	2464	2373	2299	2389	1920	2433	2203	1389	938	1037	1617	2.00 C
1989	1235	1665	1693	1434	1933	1750	1710	1330	792	681	858	1979	1.96 C
1991	1782	1983	1661	1178	1852	2325	1397	1300	721	539	629	1006	1.96 C
1987	3744	3451	2390	2155	2207	2986	2357	2282	1209	1045	1125	1594	1.86 C
1960	2057	1906	1794	1773	2379	1747	2262	2210	966	768	903	1399	1.85 C
1976	3813	3128	2313	2154	2548	1834	2399	2240	1094	1023	1309	1670	1.57 C
1992	1334	1584	1511	1242	2474	1885	1202	963	504	386	539	971	1.56 C
1990	1843	1992	1813	1528	2057	1563	1009	1624	669	661	950	1307	1.51 C
1988	1834	2249	1912	1822	1958	1707	2359	2152	867	597	811	1367	1.48 C
1934	2110	2025	1950	2046	2106	1801	1557	1622	1076	864	938	1450	1.44 C
1924	2967	2649	2533	2050	2201	1699	1651	1686	1073	874	993	1456	1.42 C
1961	1551	1763	1801	1718	1985	1705	1271	1395	863	643	745	1248	1.38 C
1931	2010	2171	2076	1769	2135	1685	1341	1511	1051	909	948	1429	1.20 C
1977	2037	2221	1867	1680	1875	1260	1442	1604	548	456	486	925	0.84 C

Table 8

Change in Average Monthly Vernalis Flow - CFS					Negative values indicate reduction in flow due to alternative								SJRBI
WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	MAF
1983	0	0	0	0	0	0	0	0	0	0	0	0	7.22 W
1969	0	0	0	0	40	0	0	0	0	0	0	0	6.09 W
1938	37	28	28	28	1	190	0	0	0	0	0	0	5.89 W
1982	0	0	0	0	75	0	0	0	0	0	0	0	5.45 W
1967	0	24	24	24	24	0	0	0	0	1131	0	0	5.25 W
1952	0	0	0	-1	0	0	0	0	0	0	0	0	5.17 W
1958	0	0	0	0	0	0	0	0	0	0	0	0	4.77 W
1980	13	6	6	6	743	0	0	0	0	0	0	0	4.73 W
1978	48	4	4	2	2	42	122	128	-7	-48	-52	-25	4.58 W
1922	0	0	0	0	0	0	0	0	-22	-63	-67	-40	4.54 W
1956	0	0	0	0	69	0	0	0	0	0	0	788	4.46 W
1942	0	1	1	77	0	0	0	0	0	0	0	0	4.44 W
1941	2	1	1	1	1	1	0	0	19	0	0	0	4.43 W
1986	0	0	0	0	152	0	0	0	0	0	0	0	4.31 W
1993	98	25	25	0	15	10	5	-121	-71	-163	-167	-140	4.20 W
1943	0	0	0	0	0	0	0	0	0	0	0	0	4.03 W
1937	81	63	63	90	61	28	209	231	698	5	2	28	3.90 W
1974	7	3	3	3	3	12	0	0	29	0	0	2	3.90 W
1975	347	5	5	-10	0	0	0	0	0	0	0	0	3.85 W
1965	7	4	4	71	9	26	22	6	0	4	4	4	3.81 W
1936	6	3	3	9	107	90	429	268	20	-22	142	1	3.74 AN
1984	0	0	0	0	0	0	0	0	0	0	0	0	3.69 AN
1979	56	36	36	41	41	6	35	39	0	6	6	6	3.67 AN
1945	0	0	0	0	0	1	3	4	0	1	1	1	3.59 AN
1963	3	2	2	4	4	49	9	331	-49	-91	-94	-67	3.57 AN
1927	0	0	0	0	0	8	140	74	60	-9	-12	12	3.56 AN
1935	14	40	40	16	180	9	2	2	-122	-164	-167	-140	3.56 AN
1923	0	0	0	0	0	1033	11	12	22	2	1	2	3.55 AN
1973	0	0	0	0	0	3	19	0	0	3	3	3	3.50 AN
1932	4	6	6	5	5	5	1	1	-122	-164	-167	-141	3.41 AN
1940	0	0	0	0	0	1	6	6	11	1	1	1	3.36 AN
1946	1	1	1	1	1	1	3	3	6	1	1	0	3.30 AN
1970	0	0	0	0	0	0	0	0	0	0	0	0	3.18 AN
1951	29	-46	1136	-113	0	0	0	0	0	0	0	0	3.14 AN
1962	1	1	1	2	0	4	-36	1	-126	-162	-166	-140	3.07 BN
1953	0	0	0	0	0	0	0	0	0	0	0	0	3.03 BN
1957	0	0	0	0	0	0	0	0	0	0	0	0	3.01 BN
1925	-2	-1	-1	-3	0	-14	-691	-241	-66	-108	-111	-84	2.93 BN
1971	0	0	0	0	0	0	0	0	0	0	0	0	2.89 BN
1950	2	3	3	2	0	4	605	610	-52	-94	-97	-71	2.85 BN
1944	0	0	0	0	0	0	0	0	0	-34	-37	-11	2.76 BN
1954	0	0	0	0	0	0	0	0	0	-12	-16	0	2.72 BN
1948	1	0	0	1	0	0	-130	-62	-93	-135	-138	-111	2.70 BN
1928	10	8	8	8	8	4	45	49	8	-18	-22	5	2.63 BN
1949	9	20	20	12	0	0	-137	-104	-122	-163	-167	-140	2.53 BN
1966	8	26	26	26	26	24	256	247	16	-17	-19	7	2.51 BN
1933	4	10	10	5	0	0	-94	-86	-122	-163	-167	-140	2.44 D
1981	0	0	0	0	0	0	0	0	-1	-29	-32	-6	2.44 D
1985	0	0	0	0	0	0	0	0	0	-79	-43	-17	2.40 D
1926	-10	36	36	-14	-8	0	2	4	-110	-155	-156	-135	2.30 D
1955	0	0	0	0	0	0	-105	-127	-125	-180	-167	-140	2.30 D
1959	0	0	0	0	0	0	0	0	0	-32	-35	-9	2.21 D
1968	0	0	0	0	0	0	0	0	0	-17	-20	0	2.21 D
1939	0	0	0	0	0	0	0	0	-12	-49	-52	-25	2.20 D
1964	35	20	20	49	0	0	-90	-92	-128	-162	-166	-140	2.19 D
1947	1	1	1	1	0	0	-90	-68	-58	-103	-103	-77	2.18 D
1972	0	0	0	0	0	0	-99	-65	-67	-86	-89	-63	2.16 D
1994	8	10	10	10	10	0	-145	-74	-146	-163	-166	-140	2.05 C
1930	0	0	0	0	0	0	-41	-35	-149	-163	-167	-140	2.02 C
1929	0	4	4	4	4	0	-86	-48	-122	-164	-167	-140	2.00 C
1989	11	1	1	2	363	0	-101	-127	-129	-164	-167	-140	1.96 C
1991	8	15	15	9	407	11	-162	-145	-197	-163	-167	-140	1.96 C
1987	0	0	0	0	0	0	-106	-102	-144	-146	-121	-95	1.86 C
1960	0	0	0	0	0	0	-110	-91	-155	-163	-167	-140	1.85 C
1976	0	0	0	0	0	0	-93	-87	-132	-145	-111	-85	1.57 C
1992	10	18	18	11	11	0	-114	45	-123	-165	-168	-141	1.56 C
1990	2	1	1	3	277	0	-67	-95	-195	-163	-167	-140	1.51 C
1988	0	0	0	0	0	0	-121	-83	-214	-185	-167	-141	1.48 C
1934	5	3	3	6	0	0	-69	-82	-139	-168	-167	-140	1.44 C
1924	4	2	2	2	2	0	-63	-82	-144	-166	-167	-140	1.42 C
1961	0	0	0	0	122	0	-94	-111	-190	-191	-170	-142	1.38 C
1931	2	1	1	2	0	0	-73	-75	-148	-182	-167	-140	1.20 C
1977	0	0	0	0	0	0	-84	-127	-170	-163	-167	-140	0.84 C

Table 9

New Melones Reservoir Storage with Modified Vernalis Water Quality Objective - 1,000 acre-feet												
WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	981	985	1010	1041	1149	1223	1218	1436	1693	1658	1581	1533
1923	1506	1516	1578	1638	1685	1621	1633	1722	1732	1669	1573	1537
1924	1521	1507	1514	1524	1526	1473	1411	1337	1291	1256	1214	1210
1925	1198	1199	1207	1222	1358	1433	1461	1603	1659	1624	1546	1510
1926	1481	1467	1464	1466	1529	1534	1561	1513	1459	1392	1327	1300
1927	1281	1293	1341	1386	1525	1587	1634	1712	1798	1728	1644	1607
1928	1607	1630	1642	1651	1691	1851	1820	1853	1795	1697	1603	1560
1929	1531	1532	1534	1535	1544	1518	1484	1439	1418	1365	1312	1289
1930	1266	1251	1255	1276	1298	1338	1321	1276	1296	1242	1183	1155
1931	1146	1157	1162	1175	1179	1153	1107	1045	1008	968	919	900
1932	864	863	907	939	1048	1081	1086	1252	1399	1384	1329	1295
1933	1272	1257	1266	1276	1279	1263	1217	1188	1221	1168	1109	1081
1934	1070	1066	1081	1104	1128	1139	1089	1021	981	934	881	857
1935	824	817	817	849	864	913	1042	1229	1350	1306	1242	1207
1936	1201	1205	1214	1288	1464	1532	1598	1723	1793	1725	1640	1598
1937	1573	1555	1557	1571	1665	1759	1747	1869	1857	1764	1670	1617
1938	1584	1578	1651	1719	1902	2030	2160	2420	2420	2300	2130	2000
1939	1955	1933	1929	1937	1944	1962	1892	1785	1721	1646	1570	1543
1940	1509	1486	1487	1583	1714	1873	1941	2051	2030	1930	1837	1787
1941	1751	1734	1761	1806	1885	1985	1996	2139	2167	2108	2015	1957
1942	1925	1906	1938	1970	1970	2020	2095	2240	2348	2300	2130	2000
1943	1955	1965	1964	1970	1970	2030	2142	2190	2169	2084	1994	1937
1944	1899	1879	1869	1866	1874	1893	1819	1769	1759	1685	1601	1559
1945	1549	1579	1600	1632	1757	1833	1803	1869	1915	1846	1752	1707
1946	1702	1721	1795	1852	1902	1945	1962	2040	1996	1901	1807	1764
1947	1739	1746	1758	1766	1780	1756	1691	1629	1595	1536	1477	1451
1948	1455	1449	1445	1447	1435	1429	1417	1453	1570	1519	1453	1422
1949	1412	1404	1410	1416	1417	1443	1420	1464	1473	1422	1369	1344
1950	1312	1289	1290	1339	1393	1440	1430	1536	1613	1556	1490	1472
1951	1466	1736	1970	1970	1970	2030	2014	2009	1943	1847	1754	1703
1952	1674	1679	1723	1856	1939	2030	2095	2401	2420	2300	2130	2000
1953	1947	1941	1950	1970	1970	1979	1926	1857	1917	1869	1784	1738
1954	1706	1700	1704	1712	1728	1767	1744	1798	1769	1696	1621	1577
1955	1540	1539	1545	1571	1584	1577	1559	1517	1532	1471	1406	1370
1956	1344	1348	1593	1852	1970	2030	2039	2184	2256	2200	2108	2000
1957	1955	1939	1940	1948	1970	2003	1899	1906	1937	1849	1765	1716
1958	1678	1670	1668	1710	1783	1929	2078	2381	2420	2300	2130	2000
1959	1955	1938	1934	1950	1970	1983	1896	1764	1707	1635	1560	1556
1960	1525	1511	1511	1512	1549	1547	1514	1464	1438	1385	1334	1299
1961	1255	1270	1284	1293	1290	1271	1238	1191	1149	1103	1057	1033
1962	1000	999	1000	1008	1089	1123	1141	1185	1257	1223	1161	1125
1963	1109	1111	1127	1181	1312	1361	1373	1561	1658	1608	1534	1510
1964	1509	1535	1550	1580	1591	1562	1515	1461	1455	1400	1345	1310
1965	1301	1317	1528	1733	1838	1883	1941	2011	2041	1993	1920	1876
1966	1830	1853	1875	1903	1928	1944	1876	1848	1778	1694	1615	1566
1967	1525	1530	1604	1701	1762	1862	1934	2140	2392	2300	2130	2000
1968	1955	1951	1948	1959	1970	2011	1926	1842	1787	1704	1622	1573
1969	1557	1577	1582	1879	1970	2030	2184	2420	2420	2300	2130	2000
1970	1955	1955	1964	1970	1970	2030	1969	1966	1951	1851	1751	1709
1971	1678	1700	1758	1809	1847	1884	1829	1823	1862	1793	1701	1658
1972	1623	1630	1669	1700	1704	1702	1622	1634	1603	1541	1477	1456
1973	1446	1453	1479	1589	1732	1839	1810	1897	1850	1749	1650	1607
1974	1608	1650	1717	1824	1897	2030	2117	2237	2232	2156	2054	1998
1975	1955	1953	1964	1970	1970	2030	1995	2017	2114	2046	1964	1917
1976	1909	1912	1923	1924	1925	1865	1785	1689	1623	1573	1528	1499
1977	1487	1483	1475	1467	1439	1378	1317	1261	1242	1196	1150	1136
1978	1089	1073	1084	1162	1249	1385	1473	1589	1704	1685	1608	1603
1979	1564	1568	1577	1639	1752	1868	1841	1940	1843	1738	1640	1598
1980	1589	1598	1602	1898	1970	2030	2058	2109	2147	2124	2032	1982
1981	1955	1933	1936	1970	1970	2006	1947	1841	1757	1672	1597	1573
1982	1563	1617	1744	1945	1970	2030	2220	2357	2398	2300	2130	2000
1983	1970	1970	1970	1970	1970	2030	2094	2249	2420	2300	2130	2000
1984	1955	1970	1970	1970	1970	2030	1963	1967	1940	1869	1798	1769
1985	1769	1799	1828	1836	1867	1894	1848	1773	1707	1628	1555	1525
1986	1517	1519	1527	1602	1970	2030	2069	2101	2099	2001	1918	1891
1987	1873	1862	1863	1852	1852	1876	1802	1683	1618	1570	1527	1510
1988	1486	1466	1453	1457	1447	1404	1347	1275	1249	1222	1196	1177
1989	1139	1123	1116	1114	1102	1153	1127	1089	1078	1036	996	1008
1990	1027	1029	1044	1057	1058	1025	965	900	858	810	777	761
1991	749	730	738	736	710	751	728	701	675	623	576	565
1992	560	548	562	575	625	642	621	538	491	444	395	374
1993	339	331	346	495	599	753	801	930	1039	1015	962	939
1994	944	966	999	1028	1051	1000	954	910	862	803	750	722

The average flow and change in flow at Vernalis, by SJRBI year type, for the alternative Vernalis water quality objective scenario is shown in Table 10. The values shown for April and May are for the non-pulse period of those months.

Table 10

Average Vernalis Flow (non-pulse) within Year Type - cfs							Alternative Water Quality Objective Scenario					
SJRBI	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
W	2726	2666	3831	7315	12991	14586	11624	9986	10908	7622	3499	3954
AN	2750	3297	5384	5865	6119	5791	4739	3675	2746	2192	1803	2324
BN	2431	2343	2545	2750	2993	3064	2554	2513	2033	1500	1379	1885
D	2826	2484	2417	2378	2690	2510	1837	1875	1463	1192	1276	1807
C	2183	2219	1973	1752	2192	1854	1150	1220	923	752	877	1382
All	2578	2609	3297	4323	6111	6395	5042	4404	4272	3100	1916	2414
Change in Vernalis Flows within Year Type - cfs							Alternative Water Quality Objective Scenario					
SJRBI	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
W	32	8	8	15	61	15	35	21	32	43	-14	31
AN	8	3	87	-3	24	86	72	59	-12	-31	-20	-23
BN	2	5	5	4	3	2	-12	23	-36	-62	-64	-45
D	3	6	6	4	-1	0	-93	-76	-57	-96	-94	-68
C	3	3	3	3	75	1	-220	-177	-156	-166	-161	-134
All	12	5	21	5	38	21	-41	-29	-42	-55	-68	-43

Water quality at Vernalis will also change due to an alternative water quality objective. Releases from New Melones Reservoir for dilution purposes will be directly affected by an alternative objective at Vernalis, reduced in most instances during the spring and summer. Table 11 shows the average water quality at Vernalis, by SJRBI year type, for the alternative Vernalis water quality objective scenario. The April and May values are for the non-pulse flow periods of those months. A positive value indicates a reduction in water quality.

Table 11

Average Vernalis Water Quality (non-pulse) within Year Type - uS/cm							Alternative Water Quality Objective Scenario					
SJRBI	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
W	555	588	729	584	459	410	325	367	393	479	447	417
AN	560	569	678	655	592	547	458	453	555	647	594	539
BN	571	589	757	768	854	835	609	572	632	681	648	592
D	528	568	766	776	888	900	693	679	711	737	684	607
C	607	615	813	868	980	988	819	800	801	811	790	696
All	566	587	748	719	728	707	561	559	601	656	619	559
Change in Vernalis Water Quality within Year Type - uS/cm							Alternative Water Quality Objective Scenario					
SJRBI	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
W	-7	-2	-2	-1	-1	-1	-1	4	-5	1	3	-2
AN	-2	0	-4	-1	-7	-22	-4	-5	4	7	9	5
BN	0	-1	-1	-1	0	0	12	-4	11	24	25	13
D	-1	-1	-2	-1	0	0	39	30	24	47	41	20
C	-1	-1	-2	-2	-42	0	118	83	101	122	105	55
All	-3	-1	-2	-1	-11	-4	33	22	27	39	36	18

Table 12 shows the simulated water quality at Vernalis for the alternative Vernalis water quality objective scenario. Results are provided by water year annually ranked by the San Joaquin River Basin Index (SJRBI), wettest to driest year. Table 13 illustrates the difference in water quality that occurs between the alternative scenario and the "current condition" scenario. Instances of non-compliance to the alternative Vernalis water quality objective are eliminated.

Alternative Vernalis Flow Objective

The results of the alternative Vernalis water quality objective scenario were used to evaluate the viability of an alternative flow objective during the non-pulse periods of February through June. The alternative Vernalis flow objective consists of a two-component determination based on the state of the New Melones Index and the state of the SJRBI. The adjacent table illustrates the parameters of the determination. The flow objective applicable to each month during February through June is established by first determining which column of flow objectives applies for the month, either the high flow column when the New Melones Index is greater than 2,500 TAF, or the low flow column when the New Melones Index is 2,500 TAF or less. The flow objective is established by the SJRBI.

	Vernalis Flow Objective - cfs	
SJRBI	NM Index < 2,500 TAF	NM Index > 2,500 TAF
1 - W	2000	2500
2 - AN	2000	2500
3 - BN	1250	1750
4 - D	1250	1750
5 - C	700	1000

Table 14 shows the results for the determination of the alternative Vernalis flow objective post-processing the results of the alternative Vernalis water quality objective scenario. The table illustrates the shortages in compliance with the alternative objective. These shortages (less than 33 TAF in a month) could be remedied by supplemental releases from New Melones Reservoir.

Table 12

Average Monthly Quality at Vernalis with Modified Vernalis Water Quality Objective - uS/cm													SJRBI
WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	MAF
1983	230	257	367	326	309	248	315	311	265	210	211	254	7.22 W
1969	605	614	791	536	364	388	313	276	261	378	367	355	6.09 W
1938	539	567	528	513	372	322	281	262	245	347	333	334	5.89 W
1982	584	603	781	643	272	247	220	265	362	413	339	252	5.45 W
1967	621	672	798	777	900	456	249	265	326	284	348	340	5.25 W
1952	575	595	775	659	360	351	217	254	282	379	355	363	5.17 W
1958	561	615	776	763	688	428	219	224	315	421	361	362	4.77 W
1980	514	541	781	354	328	376	347	373	404	468	471	451	4.73 W
1978	720	747	877	798	710	661	390	363	414	563	516	415	4.58 W
1922	610	608	766	704	631	441	334	386	385	448	533	540	4.54 W
1956	650	657	711	423	376	387	376	371	398	495	493	367	4.46 W
1942	488	537	632	419	330	339	321	353	425	455	364	353	4.44 W
1941	552	588	714	614	409	394	244	287	436	445	479	499	4.43 W
1986	573	568	757	825	388	304	286	298	392	603	483	404	4.31 W
1993	733	777	899	669	849	925	538	595	631	594	587	533	4.20 W
1943	468	519	630	337	317	315	254	374	448	637	555	511	4.03 W
1937	505	570	739	700	286	355	295	280	525	612	558	523	3.90 W
1974	530	616	736	481	533	425	365	394	424	610	514	494	3.90 W
1975	429	462	707	708	316	262	383	395	457	588	505	493	3.85 W
1965	606	650	815	423	433	567	360	336	461	639	575	500	3.81 W
1936	555	596	775	812	481	382	352	390	631	657	558	524	3.74 AN
1984	357	195	305	351	291	371	367	367	526	633	524	438	3.69 AN
1979	557	496	751	585	328	303	375	394	434	657	581	532	3.67 AN
1945	565	566	771	755	521	335	387	369	515	591	462	473	3.59 AN
1963	628	675	824	873	836	954	426	441	596	665	625	566	3.57 AN
1927	632	660	795	851	972	691	425	386	641	639	587	535	3.56 AN
1935	668	653	807	868	997	937	455	448	694	677	667	588	3.56 AN
1923	563	591	640	497	443	680	372	367	579	625	613	527	3.55 AN
1973	596	561	787	777	650	425	417	409	401	656	603	541	3.50 AN
1932	674	664	802	851	956	935	533	527	709	646	680	604	3.41 AN
1940	595	621	800	802	892	357	309	322	546	654	610	549	3.36 AN
1946	446	520	476	536	389	521	405	397	534	651	582	543	3.30 AN
1970	399	500	598	274	268	313	385	398	451	643	604	547	3.18 AN
1951	603	670	362	342	267	457	393	245	511	663	618	571	3.14 AN
1962	705	690	829	927	749	831	500	484	743	728	681	619	3.07 BN
1953	506	527	725	516	559	926	385	351	527	611	605	557	3.03 BN
1957	503	547	759	755	923	710	360	363	560	650	606	563	3.01 BN
1925	663	654	803	880	998	957	468	433	659	687	678	608	2.93 BN
1971	539	571	764	751	847	711	386	378	524	622	607	566	2.89 BN
1950	629	632	817	836	998	997	531	488	596	708	668	597	2.85 BN
1944	513	533	703	733	814	756	428	469	632	668	624	550	2.76 BN
1954	547	579	778	787	920	998	482	482	658	680	636	594	2.72 BN
1948	603	608	796	841	999	1000	577	580	650	681	667	627	2.70 BN
1928	511	548	732	767	817	338	409	425	658	679	630	560	2.63 BN
1949	593	620	813	848	999	999	639	627	688	756	702	642	2.53 BN
1966	546	559	565	577	626	801	421	463	689	703	666	614	2.51 BN
1933	591	599	796	852	998	999	616	616	747	767	737	654	2.44 D
1981	495	503	734	747	868	615	466	458	696	675	657	597	2.44 D
1985	418	495	774	773	913	898	539	508	688	728	615	544	2.40 D
1926	589	578	770	813	998	998	520	535	683	773	722	611	2.30 D
1955	606	620	766	742	998	999	609	639	752	793	734	643	2.30 D
1959	526	556	720	734	707	879	449	489	689	698	651	569	2.21 D
1968	501	568	726	743	715	772	429	464	684	697	639	590	2.21 D
1939	425	513	703	727	801	748	467	509	700	716	666	572	2.20 D
1964	578	631	878	833	998	999	611	617	755	775	733	648	2.19 D
1947	536	552	758	755	857	999	596	597	703	748	690	615	2.18 D
1972	542	632	806	815	915	998	565	565	725	732	681	637	2.16 D
1994	561	614	840	920	963	1006	710	681	828	854	857	759	2.05 C
1930	653	637	820	890	998	999	594	601	777	768	737	637	2.02 C
1929	579	574	775	781	949	999	609	603	746	780	747	642	2.00 C
1989	723	707	859	928	997	1001	673	710	783	779	782	589	1.96 C
1991	657	649	848	985	998	979	761	745	844	831	829	771	1.96 C
1987	431	446	726	769	977	831	607	621	763	772	719	650	1.86 C
1960	609	659	823	827	954	999	616	626	784	799	769	692	1.85 C
1976	411	496	769	769	906	998	603	612	763	772	684	633	1.57 C
1992	729	715	878	989	959	999	811	826	854	846	905	794	1.56 C
1990	653	642	832	921	998	999	698	699	853	832	774	709	1.51 C
1988	644	597	810	854	998	1004	616	623	833	853	822	702	1.48 C
1934	618	645	816	842	998	999	692	695	767	797	762	672	1.44 C
1924	505	547	750	794	982	999	676	688	770	796	759	673	1.42 C
1961	690	689	840	883	999	999	708	717	815	844	840	724	1.38 C
1931	629	620	807	871	999	999	701	699	774	802	766	681	1.20 C
1977	619	604	818	868	999	999	694	699	862	850	890	815	0.84 C

Table 13

Change in Average Monthly Vernalis Quality - uS/cm					Positive values indicate reduction in water quality due to alternative								SJRBI
WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	MAF
1983	0	0	0	0	0	0	0	0	0	0	0	0	7.22 W
1969	0	0	0	0	0	0	0	0	0	0	0	0	6.09 W
1938	-6	-5	-2	-2	0	-1	0	0	0	0	0	0	5.89 W
1982	0	0	0	0	-1	0	0	0	0	0	0	0	5.45 W
1967	0	-8	-8	-7	-7	0	0	0	0	-14	0	0	5.25 W
1952	0	0	0	0	0	0	0	0	0	0	0	0	5.17 W
1958	0	0	0	0	0	0	0	0	0	0	0	0	4.77 W
1980	-2	-1	-2	0	-8	0	0	0	0	0	0	0	4.73 W
1978	-26	-2	-2	0	0	-3	-4	-3	0	5	8	2	4.58 W
1922	0	0	0	0	0	0	0	0	1	3	12	8	4.54 W
1956	0	0	0	0	-2	0	0	0	0	0	0	-68	4.46 W
1942	0	0	0	-3	0	0	0	0	0	0	0	0	4.44 W
1941	0	0	0	0	0	0	0	0	-1	0	0	0	4.43 W
1986	0	0	0	0	-3	0	0	0	0	0	0	0	4.31 W
1993	-56	-13	-14	0	-4	-3	-1	48	11	19	37	24	4.20 W
1943	0	0	0	0	0	0	0	0	0	0	0	0	4.03 W
1937	-12	-13	-16	-17	-1	-1	-4	-6	-111	-1	0	-5	3.90 W
1974	-1	-1	-1	0	0	-1	0	0	-3	0	0	0	3.90 W
1975	-34	-1	-1	2	0	0	0	0	0	0	0	0	3.85 W
1965	-2	-1	-1	-3	-1	-3	-1	-1	0	-1	-1	-1	3.81 W
1936	-1	-1	-1	-3	-7	-3	-17	-24	-4	4	-16	0	3.74 AN
1984	0	0	0	0	0	0	0	0	0	0	0	0	3.69 AN
1979	-11	-5	-10	-4	-1	0	-2	-3	0	-2	-2	-1	3.67 AN
1945	0	0	0	0	0	0	0	0	0	0	0	0	3.59 AN
1963	-1	0	-1	-2	-1	-19	-2	-12	9	27	28	14	3.57 AN
1927	0	0	0	0	0	-1	-13	-8	-15	2	3	-2	3.56 AN
1935	-5	-12	-15	-7	-83	-3	0	-4	33	36	56	31	3.56 AN
1923	0	0	0	0	0	-274	-1	-1	-3	0	0	0	3.55 AN
1973	0	0	0	0	0	0	-1	-1	0	-1	-1	-1	3.50 AN
1932	-1	-2	-2	-2	-2	-2	-1	3	38	29	57	34	3.41 AN
1940	0	0	0	0	0	0	0	0	-1	0	0	0	3.36 AN
1946	0	0	0	0	0	0	0	0	-1	0	0	0	3.30 AN
1970	0	0	0	0	0	0	0	0	0	0	0	0	3.18 AN
1951	-7	14	-24	2	0	0	0	0	0	0	0	0	3.14 AN
1962	-1	0	0	-1	0	-1	12	-1	47	65	62	38	3.07 BN
1953	0	0	0	0	0	0	0	0	0	0	0	0	3.03 BN
1957	0	0	0	0	0	0	0	0	0	0	0	0	3.01 BN
1925	1	0	0	2	0	5	16	8	14	28	44	22	2.93 BN
1971	0	0	0	0	0	0	0	0	0	0	0	0	2.89 BN
1950	0	-1	-1	-1	0	-2	-3	-26	11	39	38	18	2.85 BN
1944	0	0	0	0	0	0	0	0	0	11	12	2	2.76 BN
1954	0	0	0	0	0	0	0	0	0	5	6	0	2.72 BN
1948	0	0	0	0	0	0	47	23	24	44	51	32	2.70 BN
1928	-1	-1	-2	-2	-2	0	-4	-8	-2	7	8	-1	2.63 BN
1949	-2	-5	-7	-5	0	0	57	37	40	77	68	42	2.53 BN
1966	-1	-5	-2	-2	-3	-5	-72	-69	-6	8	8	-2	2.51 BN
1933	-1	-2	-4	-2	0	0	41	35	57	79	78	45	2.44 D
1981	0	0	0	0	0	0	0	0	1	11	13	2	2.44 D
1985	0	0	0	0	0	0	0	0	0	32	12	3	2.40 D
1926	2	-7	-11	5	3	0	0	1	27	77	71	35	2.30 D
1955	0	0	0	0	0	0	39	50	57	98	78	42	2.30 D
1959	0	0	0	0	0	0	0	0	0	14	14	2	2.21 D
1968	0	0	0	0	0	0	0	0	0	7	7	0	2.21 D
1939	0	0	0	0	0	0	0	0	4	22	20	6	2.20 D
1964	-7	-5	-7	-17	0	0	39	37	60	87	80	44	2.19 D
1947	0	0	0	0	0	0	37	26	23	53	44	22	2.18 D
1972	0	0	0	0	0	0	39	24	29	39	36	20	2.16 D
1994	-2	-2	-4	-5	-4	0	79	42	93	135	132	76	2.05 C
1930	0	0	0	0	0	0	18	11	83	87	82	42	2.02 C
1929	0	-1	-1	-1	-1	0	32	21	50	92	84	43	2.00 C
1989	-6	0	0	-1	-210	0	51	83	89	118	103	32	1.96 C
1991	-3	-4	-7	-7	-256	-4	101	93	148	148	137	79	1.96 C
1987	0	0	0	0	0	0	45	41	67	76	57	30	1.86 C
1960	0	0	0	0	0	0	54	40	89	111	96	53	1.85 C
1976	0	0	0	0	0	0	37	37	68	77	44	26	1.57 C
1992	-5	-7	-9	-8	-4	0	86	-32	131	186	168	85	1.56 C
1990	-1	0	0	-2	-141	0	63	44	157	129	93	58	1.51 C
1988	0	0	0	0	0	0	50	41	137	158	114	55	1.48 C
1934	-1	-1	-1	-2	0	0	33	43	72	103	92	50	1.44 C
1924	-1	0	-1	-1	-1	0	33	39	75	102	88	50	1.42 C
1961	0	0	0	0	-59	0	55	55	119	149	123	62	1.38 C
1931	0	0	0	-1	0	0	41	36	79	108	93	51	1.20 C
1977	0	0	0	0	0	0	59	61	166	173	180	91	0.84 C

Table 14

Alternative Vernalis Flow Objective Using New Melones Index and SJRBI													
	Flow Objective - cfs					NM	SJRBI	Flow Above/Below Objective - cfs					
WY	Mar	Apr	May	Jun	Follow Feb	Index	602020	Mar	Apr	May	Jun		Follow Feb
1922	2000	2000	2000	2000	2000	2269	1	7829	4983	2928	8656		3894
1923	2500	2500	2500	2500	2500	2506	2	754	3528	1267	908		-299
1924	700	700	700	700	700	1750	5	999	552	692	373		1523
1925	1250	1250	1250	1250	1250	2197	3	1044	1420	2289	1185		958
1926	1250	1250	1250	1250	1250	1970	4	735	870	733	1067		1117
1927	2000	2000	2000	2000	2000	2443	2	1841	3001	1361	139		1114
1928	1250	1250	1250	1250	1250	2408	3	5714	2975	1479	930		1139
1929	700	700	700	700	700	1901	5	1220	856	579	689		1385
1930	700	700	700	700	700	1802	5	1163	607	779	306		1435
1931	700	700	700	700	700	1468	5	985	402	594	351		1766
1932	2000	2000	2000	2000	2000	1944	2	447	-156	547	-259		165
1933	1250	1250	1250	1250	1250	1721	4	709	40	222	-65		856
1934	700	700	700	700	700	1446	5	1101	350	568	376		1442
1935	2000	2000	2000	2000	2000	1804	2	485	1064	930	16		4618
1936	2000	2000	2000	2000	2000	2400	2	6877	4741	2719	700		9309
1937	2500	2500	2500	2500	2500	2511	1	7760	8128	5775	877		21965
1938	2500	2500	2500	2500	2500	3488	1	29550	14697	19366	18819		681
1939	1250	1250	1250	1250	1250	2331	4	2229	484	896	241		1431
1940	2500	2500	2500	2500	2500	2706	2	5452	5773	1129	1168		13327
1941	2500	2500	2500	2500	2500	2885	1	12202	9132	6294	4549		9116
1942	2500	2500	2500	2500	2500	3100	1	4582	5430	4542	5088		9300
1943	2500	2500	2500	2500	2500	3090	1	18902	7518	2454	3216		576
1944	1250	1250	1250	1250	1250	2368	3	2232	1771	1261	1234		6578
1945	2500	2500	2500	2500	2500	2654	2	4475	2375	3184	447		4054
1946	2500	2500	2500	2500	2500	2733	2	2646	1387	1877	529		394
1947	1250	1250	1250	1250	1250	2209	4	699	151	218	141		733
1948	1250	1250	1250	1250	1250	2152	3	494	279	637	716		893
1949	1250	1250	1250	1250	1250	1997	3	952	159	368	361		843
1950	1250	1250	1250	1250	1250	2219	3	823	537	316	958		8892
1951	2500	2500	2500	2500	2500	2695	2	3410	1251	404	-112		3977
1952	2500	2500	2500	2500	2500	3399	1	9347	8705	12135	14881		2527
1953	1750	1750	1750	1750	1750	2695	3	662	1487	1645	664		784
1954	1250	1250	1250	1250	1250	2427	3	763	1323	1612	536		871
1955	1250	1250	1250	1250	1250	2053	4	671	344	229	-13		11083
1956	2500	2500	2500	2500	2500	3082	1	4729	3110	2404	6554		-59
1957	1750	1750	1750	1750	1750	2649	3	1976	1118	1279	526		2205
1958	2500	2500	2500	2500	2500	3160	1	8061	15677	10054	12035		1151
1959	1250	1250	1250	1250	1250	2374	4	1398	753	829	151		1129
1960	700	700	700	700	700	1957	5	1047	489	593	266		1285
1961	700	700	700	700	700	1609	5	1005	310	458	163		2829
1962	1250	1250	1250	1250	1250	1768	3	1762	494	583	290		1824
1963	2000	2000	2000	2000	2000	2225	2	326	1057	423	655		214
1964	1250	1250	1250	1250	1250	2015	4	531	84	218	-25		4553
1965	2500	2500	2500	2500	2500	2871	1	2267	4178	949	447		1912
1966	1250	1250	1250	1250	1250	2415	3	1892	867	869	133		1392
1967	2500	2500	2500	2500	2500	3238	1	3148	9743	8103	11475		838
1968	1250	1250	1250	1250	1250	2413	4	2086	1120	979	234		26390
1969	2500	2500	2500	2500	2500	3474	1	20318	17750	20165	23938		7309
1970	2500	2500	2500	2500	2500	2720	2	5282	1575	446	-284		529
1971	1750	1750	1750	1750	1750	2606	3	1966	1708	1322	358		500
1972	1250	1250	1250	1250	1250	2232	4	380	247	307	66		3237
1973	2500	2500	2500	2500	2500	2584	2	4910	2341	383	782		2665
1974	2500	2500	2500	2500	2500	2972	1	3546	3998	1301	863		5362
1975	2500	2500	2500	2500	2500	2927	1	6037	2624	128	2499		48
1976	700	700	700	700	700	2195	5	1134	784	640	394		1175
1977	700	700	700	700	700	1619	5	560	104	533	-152		7399
1978	2000	2000	2000	2000	2000	2332	1	5670	8606	9105	7451		7809
1979	2500	2500	2500	2500	2500	2577	2	7202	3471	2613	619		21314
1980	2500	2500	2500	2500	2500	3005	1	13841	4843	3017	6141		241
1981	1250	1250	1250	1250	1250	2381	4	3134	1257	1174	257		14566
1982	2500	2500	2500	2500	2500	3419	1	12569	22594	14058	8918		35264
1983	2500	2500	2500	2500	2500	3965	1	47058	21384	21452	25048		8431
1984	2500	2500	2500	2500	2500	2765	2	4484	2429	1672	636		26
1985	1250	1250	1250	1250	1250	2352	4	1295	1101	1073	290		15637
1986	2500	2500	2500	2500	2500	3149	1	25252	9667	7577	7004		-293
1987	700	700	700	700	700	2179	5	2286	694	721	509		1258
1988	700	700	700	700	700	1749	5	1007	700	483	167		1233
1989	700	700	700	700	700	1668	5	1050	540	204	92		1357
1990	700	700	700	700	700	1368	5	863	-5	640	-31		1152
1991	700	700	700	700	700	1111	5	1625	298	238	21		1774
1992	700	700	700	700	700	916	5	1185	221	8	-196		2286
1993	2000	2000	2000	2000	2000	1549	1	620	1191	-542	1181		452
1994	700	700	700	700	700	1322	5	1241	294	592	241		

Unimpaired and Measured Flow Data for the San Joaquin River Basin and State Water Project and Central Valley Project Diversions

The Department of Water Resources periodically estimates and publishes unimpaired flows for Central for Central Valley subbasins and the Sacramento-San Joaquin Delta. The latest published edition of these estimates appear in *California Central Valley Unimpaired Flow Data (October 1920 through September 1992), Third Edition*, Department of Water Resources, August 1994. These data were revised by Errata from DWR dated September 15, 1994, and extended through September 1993 during 1995. DWR is currently planning to further extend the data. In its 1994 report, DWR describes unimpaired flow to be:

> "*… runoff that would have occurred had water flow remained unaltered in rivers and streams instead of stored in reservoirs, imported, exported, or diverted. The data are a measure of the total water supply available for all uses after removing the impacts of most upstream alterations as they occurred over the years. Alterations such as channel improvements, levees, and flood bypasses are assumed to exist.*"

Table 15 presents a calculation of unimpaired flow by water year for the San Joaquin River at Vernalis which is the sum of several computational locations:

- UF 16 – Stanislaus River at Melones Reservoir
- UF 17 – San Joaquin River Floor
- UF 18 – Tuolumne River at Don Pedro Reservoir
- UF 19 – Merced River at Exchequer Reservoir
- UF 20 – Chowchilla River at Buchanan Reservoir
- UF 21 – Fresno River near Dalton
- UF 22 – San Joaquin River at Millerton Reservoir
- UF 23 – Tulare Lake Basin Outflow

The computation of each of these components of flow for the period 1921 through 1993 is described in the DWR report. The record was extended by me through water year 2004 by extraction of data from the California Data Exchange Center (CDEC). UF 17 data were extended by a procedure similarly used by DWR. Also indicated in Table 15 is the San Joaquin River Basin Index for each year. Table 16 presents the same data arranged by calendar year, rank-ordered by San Joaquin River Basin Index, from the wettest year to the driest year.

Table 15

Estimated Unimpaired Flow: San Joaquin River above Vernalis
Estimated Unimpaired Flow in CFS

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	60-20-20 MAF	60-20-20 Type
1921	1,561	2,571	3,447	9,382	8,775	11,935	13,849	22,748	23,748	5,528	1,041	521	3.23	AN
1922	390	437	4,016	4,569	14,000	10,667	14,000	40,504	42,605	10,602	2,098	739	4.54	W
1923	585	1,647	7,236	6,683	5,477	6,016	16,000	29,203	16,303	8,049	1,659	1,160	3.55	AN
1924	1,350	824	813	1,073	2,018	1,967	6,319	8,943	1,277	618	179	118	1.42	C
1925	585	2,118	2,244	2,081	11,568	8,000	17,849	26,049	16,689	5,837	1,659	487	2.93	BN
1926	829	857	1,382	1,057	5,820	6,065	20,655	16,455	5,462	1,285	358	218	2.30	D
1927	293	3,714	3,593	3,463	15,099	9,659	19,277	27,073	25,311	7,480	1,577	639	3.56	AN
1928	894	4,487	2,325	2,667	4,757	15,837	14,303	20,748	7,798	1,626	455	202	2.63	BN
1929	211	504	894	1,041	2,198	4,439	7,429	17,642	10,639	2,488	488	134	2.00	C
1930	179	218	894	1,870	3,568	7,041	12,101	12,959	13,059	2,520	569	269	2.02	C
1931	504	857	537	1,154	2,036	2,829	7,092	9,220	2,588	585	244	151	1.20	C
1932	195	387	6,650	4,943	16,414	9,285	14,218	27,886	27,630	9,203	1,854	605	3.41	AN
1933	488	319	650	1,545	1,928	4,293	9,042	12,813	20,622	4,016	878	454	2.44	D
1934	195	487	2,146	2,813	4,595	7,106	9,244	6,846	4,034	911	358	303	1.44	C
1935	537	1,882	2,293	6,293	6,108	8,000	26,336	28,959	26,353	5,707	1,480	487	3.56	AN
1936	602	891	894	4,211	24,000	11,366	22,252	28,130	18,655	6,114	1,333	370	3.74	AN
1937	423	555	1,675	2,163	22,216	13,772	18,034	37,528	22,454	5,496	1,138	353	3.90	W
1938	455	790	15,220	6,065	24,396	34,976	27,361	44,992	45,664	16,764	4,000	1,479	5.89	W
1939	2,016	2,101	1,724	2,081	3,243	6,992	14,773	10,488	4,403	1,350	569	689	2.20	D
1940	1,870	807	878	12,374	15,604	17,984	18,672	30,894	17,328	3,366	748	218	3.36	AN
1941	504	689	7,203	7,528	17,189	17,317	18,050	38,943	31,765	12,569	2,537	723	4.43	W
1942	764	1,697	8,163	9,659	9,892	9,008	19,193	27,220	34,353	12,455	2,179	588	4.44	W
1943	472	3,664	4,033	13,837	10,937	24,098	23,378	27,431	17,950	7,187	1,724	487	4.03	W
1944	569	840	1,089	1,984	4,631	7,593	8,555	22,829	13,782	5,106	992	336	2.76	BN
1945	488	4,185	3,642	2,813	20,396	10,959	16,739	26,585	24,975	8,797	1,951	622	3.59	AN
1946	2,634	4,605	10,244	6,098	4,018	8,455	19,126	25,301	13,513	3,951	992	454	3.30	AN
1947	1,203	3,731	4,423	2,423	4,541	6,634	10,353	17,252	6,235	1,447	358	286	2.18	D
1948	1,415	1,109	797	1,610	1,622	3,821	11,529	22,667	21,479	4,667	748	336	2.70	BN
1949	407	555	959	1,073	2,162	6,455	15,261	22,325	12,437	2,130	650	353	2.53	BN
1950	325	723	748	3,593	7,261	6,244	17,832	23,285	15,210	3,512	650	319	2.85	BN
1951	911	25,798	27,122	8,927	8,703	8,894	13,160	17,886	12,706	3,837	894	286	3.14	AN
1952	569	1,311	6,114	13,642	8,847	15,691	25,345	46,439	34,891	15,057	3,561	1,143	5.17	W
1953	618	891	2,846	6,959	3,532	5,041	13,681	12,976	19,025	7,854	1,106	420	3.03	BN
1954	423	857	1,073	2,049	5,135	10,260	18,370	22,569	9,597	2,618	472	235	2.72	BN
1955	276	824	2,114	3,236	3,261	4,260	7,597	18,699	15,630	2,878	618	218	2.30	D
1956	260	672	35,902	22,585	11,153	10,114	16,084	30,585	29,866	12,455	2,780	1,092	4.46	W
1957	1,073	1,294	1,187	1,610	5,586	7,333	9,294	19,772	20,471	4,081	927	420	3.01	BN
1958	732	1,042	2,244	3,041	10,180	15,756	27,714	43,398	32,403	11,854	3,577	1,261	4.77	W
1959	650	672	569	2,976	6,649	6,309	11,798	10,959	6,924	1,333	358	2,017	2.21	D
1960	569	454	537	1,154	5,856	6,764	12,084	13,967	7,513	1,252	390	235	1.85	C
1961	244	1,008	1,577	992	2,234	3,317	8,202	9,919	5,916	927	732	319	1.38	C
1962	309	555	1,122	3,089	14,577	7,285	21,109	19,951	23,008	6,976	1,350	471	3.07	BN
1963	878	538	1,089	5,171	17,820	6,163	14,134	28,163	23,513	9,431	2,114	941	3.57	AN
1964	1,008	4,571	2,293	2,537	2,559	3,577	8,571	14,878	10,353	2,228	748	403	2.19	D
1965	455	2,387	23,008	16,325	8,180	7,642	18,336	23,984	24,336	11,252	4,927	1,328	3.81	W
1966	634	6,370	4,455	4,244	4,162	7,447	16,000	17,480	5,429	1,545	683	420	2.51	BN
1967	455	2,303	12,049	7,008	7,045	16,699	21,630	40,065	44,891	26,276	5,106	1,950	5.25	W
1968	878	874	1,659	2,195	6,685	5,919	9,798	13,154	6,622	1,398	699	387	2.21	D
1969	618	3,076	3,935	33,398	26,288	21,447	33,244	57,935	44,756	19,187	4,146	1,210	6.09	W
1970	1,837	1,933	4,504	19,122	7,802	10,862	9,076	20,667	15,429	4,309	1,285	538	3.18	AN
1971	455	3,176	5,821	5,724	5,243	7,203	10,924	17,545	19,832	5,821	1,398	622	2.89	BN
1972	407	1,597	3,870	2,846	3,964	9,138	8,269	16,569	10,185	1,724	488	1,176	2.16	D
1973	797	1,748	3,496	7,236	13,351	11,301	15,261	35,512	20,824	4,000	1,350	504	3.50	AN
1974	911	7,143	6,585	10,211	4,649	14,163	18,101	30,846	23,378	6,374	2,016	706	3.90	W
1975	748	857	1,854	2,488	8,775	12,130	10,218	30,569	31,042	7,398	1,642	992	3.85	W
1976	2,862	2,353	1,561	943	2,234	3,561	5,261	9,382	2,303	1,008	959	1,042	1.57	C
1977	634	454	276	537	811	1,057	3,429	4,325	5,025	650	260	168	0.84	C
1978	146	454	4,276	11,593	16,252	22,455	26,992	38,130	38,101	16,992	4,488	5,092	4.58	W
1979	1,268	1,496	1,642	8,065	10,288	13,870	15,143	32,374	16,185	4,098	1,382	639	3.67	AN
1980	1,203	1,815	2,309	27,512	25,982	18,276	18,975	28,146	29,613	17,398	3,724	1,412	4.73	W
1981	894	706	1,333	2,732	3,622	6,179	12,672	15,886	8,168	1,561	748	555	2.44	D
1982	1,041	6,739	8,943	12,878	22,505	19,772	43,227	41,220	29,328	15,496	4,748	5,815	5.45	W
1983	6,927	11,378	18,699	21,333	30,000	42,016	24,571	44,179	63,731	34,976	11,886	4,387	7.22	W
1984	4,276	16,487	20,390	12,569	8,685	10,325	12,000	26,016	14,521	5,610	1,756	739	3.69	AN
1985	1,268	3,697	2,423	2,179	4,108	6,179	15,563	16,211	7,059	1,545	699	756	2.40	D
1986	1,106	2,487	4,049	6,146	41,640	31,951	23,261	31,561	27,613	7,772	2,260	1,361	4.31	W
1987	1,024	504	732	846	2,468	4,667	9,563	10,146	4,067	976	553	286	1.86	C
1988	569	1,277	1,691	3,138	3,045	5,041	8,387	10,195	5,664	1,707	683	319	1.48	C
1989	341	773	1,220	1,512	2,847	11,691	15,916	13,951	8,790	1,756	553	605	1.96	C
1990	1,772	1,277	1,008	1,756	2,486	5,902	10,840	8,504	5,412	1,821	407	185	1.51	C
1991	228	286	293	374	432	8,748	8,555	16,049	14,672	3,756	862	471	1.96	C
1992	732	1,160	943	1,317	6,108	5,545	11,950	10,309	2,857	2,667	715	353	1.56	C
1993	504	773	2,211	17,106	10,685	17,057	19,227	36,049	27,899	11,707	3,106	1,395	4.20	W
1994	934	676	1,016	1,166	2,837	4,686	9,112	13,315	6,189	1,377	795	484	2.05	C
1995	1,208	2,612	2,572	18,460	9,901	35,050	24,326	39,946	45,693	33,897	8,339	2,084	5.95	W
1996	936	663	3,291	6,020	20,758	15,859	19,340	31,572	19,136	6,659	1,641	620	4.12	W
1997	560	5,752	21,990	61,562	14,578	12,539	15,901	25,922	14,138	3,874	1,909	899	4.13	W
1998	686	1,143	1,790	10,342	24,297	19,461	24,353	30,420	51,091	31,557	5,462	2,796	5.65	W
1999	1,419	2,349	3,083	6,013	12,832	7,818	13,029	27,242	19,262	4,855	1,553	1,065	3.59	AN
2000	603	976	655	6,101	17,117	12,764	17,279	26,773	15,692	3,436	1,491	844	3.38	AN
2001	914	911	989	1,598	3,248	8,439	11,258	20,697	3,891	1,233	339	300	2.20	D
2002	340	1,603	4,366	4,756	4,151	6,662	15,406	17,845	10,623	1,779	484	289	2.34	D
2003	191	3,261	3,297	4,160	3,956	6,416	10,996	25,160	18,775	3,235	1,458	625	2.82	BN
2004	304	673	3,256	3,229	5,981	12,048	13,528	14,527	7,336	1,950	637	319	2.21	D

Table 16

Estimated Unimpaired Flow: San Joaquin River above Vernalis
Estimated Unimpaired Flow in CFS
Sorted by 60-20-20

Calendar Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	60-20-20 MAF	60-20-20 Type
1983	21,333	30,000	42,016	24,571	44,179	63,731	34,976	11,886	4,387	4,276	16,487	20,390	7.22	W
1969	33,398	26,288	21,447	33,244	57,935	44,756	19,187	4,146	1,210	1,837	1,933	4,504	6.09	W
1995	18,460	9,901	35,050	24,326	39,946	45,693	33,897	8,339	2,084	936	663	3,291	5.95	W
1938	6,065	24,396	34,976	27,361	44,992	45,664	16,764	4,000	1,479	2,016	2,101	1,724	5.89	W
1998	10,342	24,297	19,461	24,353	30,420	51,091	31,557	5,462	2,796	1,419	2,349	3,083	5.65	W
1982	12,878	22,505	19,772	43,227	41,220	29,328	15,496	4,748	5,815	6,927	11,378	18,699	5.45	W
1967	7,008	7,045	16,699	21,630	40,065	44,891	26,276	5,106	1,950	878	874	1,659	5.25	W
1952	13,642	8,847	15,691	25,345	46,439	34,891	15,057	3,561	1,143	618	891	2,846	5.17	W
1958	3,041	10,180	15,756	27,714	43,398	32,403	11,854	3,577	1,261	650	672	569	4.77	W
1980	27,512	25,982	18,276	18,975	28,146	29,613	17,398	3,724	1,412	894	706	1,333	4.73	W
1978	11,593	16,252	22,455	26,992	38,130	38,101	16,992	4,488	5,092	1,268	1,496	1,642	4.58	W
1922	4,569	14,000	10,667	14,000	40,504	42,605	10,602	2,098	739	585	1,647	7,236	4.54	W
1956	22,585	11,153	10,114	16,084	30,585	29,866	12,455	2,780	1,092	1,073	1,294	1,187	4.46	W
1942	9,659	9,892	9,008	19,193	27,220	34,353	12,455	2,179	588	472	3,664	4,033	4.44	W
1941	7,528	17,189	17,317	18,050	38,943	31,765	12,569	2,537	723	764	1,697	8,163	4.43	W
1986	6,146	41,640	31,951	23,261	31,561	27,613	7,772	2,260	1,361	1,024	504	732	4.31	W
1993	17,106	10,685	17,057	19,227	36,049	27,899	11,707	3,106	1,395	934	676	1,016	4.20	W
1997	61,562	14,578	12,539	15,901	25,922	14,138	3,874	1,909	899	686	1,143	1,790	4.13	W
1996	6,020	20,758	15,859	19,340	31,572	19,136	6,659	1,641	620	560	5,752	21,990	4.12	W
1943	13,837	10,937	24,098	23,378	27,431	17,950	7,187	1,724	487	569	840	1,089	4.03	W
1937	2,163	22,216	13,772	18,034	37,528	22,454	5,496	1,138	353	455	790	15,220	3.90	W
1974	10,211	4,649	14,163	18,101	30,846	23,378	6,374	2,016	706	748	857	1,854	3.90	W
1975	2,488	8,775	12,130	10,218	30,569	31,042	7,398	1,642	992	2,862	2,353	1,561	3.85	W
1965	16,325	8,180	7,642	18,336	23,984	24,336	11,252	4,927	1,328	634	6,370	4,455	3.81	W
1936	4,211	24,000	11,366	22,252	28,130	18,655	6,114	1,333	370	423	555	1,675	3.74	AN
1984	12,569	8,685	10,325	12,000	26,016	14,521	5,610	1,756	739	1,268	3,697	2,423	3.69	AN
1979	8,065	10,288	13,870	15,143	32,374	16,185	4,098	1,382	639	1,203	1,815	2,309	3.67	AN
1945	2,813	20,396	10,959	16,739	26,585	24,975	8,797	1,951	622	2,634	4,605	10,244	3.59	AN
1999	6,013	12,832	7,818	13,029	27,242	19,262	4,855	1,553	1,065	603	976	655	3.59	AN
1963	5,171	17,820	6,163	14,134	28,163	23,513	9,431	2,114	941	1,008	4,571	2,293	3.57	AN
1927	3,463	15,099	9,659	19,277	27,073	25,311	7,480	1,577	639	894	4,487	2,325	3.56	AN
1935	6,293	6,108	8,000	26,336	28,959	26,353	5,707	1,480	487	602	891	894	3.56	AN
1923	6,683	5,477	6,016	16,000	29,203	16,303	8,049	1,659	1,160	1,350	824	813	3.55	AN
1973	7,236	13,351	11,301	15,261	35,512	20,824	4,000	1,350	504	911	7,143	6,585	3.50	AN
1932	4,943	16,414	9,285	14,218	27,886	27,630	9,203	1,854	605	488	319	650	3.41	AN
2000	6,101	17,117	12,764	17,279	26,773	15,692	3,436	1,491	844	914	911	989	3.38	AN
1940	12,374	15,604	17,984	18,672	30,894	17,328	3,366	748	218	504	689	7,203	3.36	AN
1946	6,098	4,018	8,455	19,126	25,301	13,513	3,951	992	454	1,203	3,731	4,423	3.30	AN
1921	9,382	8,775	11,935	13,849	22,748	23,748	5,528	1,041	521	390	437	4,016	3.23	AN
1970	19,122	7,802	10,862	9,076	20,667	15,429	4,309	1,285	538	455	3,176	5,821	3.18	AN
1951	8,927	8,703	8,894	13,160	17,886	12,706	3,837	894	286	569	1,311	6,114	3.14	AN
1962	3,089	14,577	7,285	21,109	19,951	23,008	6,976	1,350	471	878	538	1,089	3.07	BN
1953	6,959	3,532	5,041	13,681	12,976	19,025	7,854	1,106	420	423	857	1,073	3.03	BN
1957	1,610	5,586	7,333	9,294	19,772	20,471	4,081	927	420	732	1,042	2,244	3.01	BN
1925	2,081	11,568	8,000	17,849	26,049	16,689	5,837	1,659	487	829	857	1,382	2.93	BN
1971	5,724	5,243	7,203	10,924	17,545	19,832	5,821	1,398	622	407	1,597	3,870	2.89	BN
1950	3,593	7,261	6,244	17,832	23,285	15,210	3,512	650	319	911	25,798	27,122	2.85	BN
2003	4,160	3,956	6,416	10,996	25,160	18,775	3,235	1,458	625	304	673	3,256	2.82	BN
1944	1,984	4,631	7,593	8,555	22,829	13,782	5,106	992	336	488	4,185	3,642	2.76	BN
1954	2,049	5,135	10,260	18,370	22,569	9,597	2,618	472	235	276	824	2,114	2.72	BN
1948	1,610	1,622	3,821	11,529	22,667	21,479	4,667	748	336	407	555	959	2.70	BN
1928	2,667	4,757	15,837	14,303	20,748	7,798	1,626	455	202	211	504	894	2.63	BN
1949	1,073	2,162	6,455	15,261	22,325	12,437	2,130	650	353	325	723	748	2.53	BN
1966	4,244	4,162	7,447	16,000	17,480	5,429	1,545	683	420	455	2,303	12,049	2.51	BN
1933	1,545	1,928	4,293	9,042	12,813	20,622	4,016	878	454	195	487	2,146	2.44	D
1981	2,732	3,622	6,179	12,672	15,886	8,168	1,561	748	555	1,041	6,739	8,943	2.44	D
1985	2,179	4,108	6,179	15,563	16,211	7,059	1,545	699	756	1,106	2,487	4,049	2.40	D
2002	4,756	4,151	6,662	15,406	17,845	10,623	1,779	484	289	191	3,261	3,297	2.34	D
1926	1,057	5,820	6,065	20,655	16,455	5,462	1,285	358	218	293	3,714	3,593	2.30	D
1955	3,236	3,261	4,260	7,597	18,699	15,630	2,878	618	218	260	672	35,902	2.30	D
1959	2,976	6,649	6,309	11,798	10,959	6,924	1,333	358	2,017	569	454	537	2.21	D
1968	2,195	6,685	5,919	9,798	13,154	6,622	1,398	699	387	618	3,076	3,935	2.21	D
2004	3,229	5,981	12,048	13,528	14,527	7,336	1,950	637	319				2.21	D
1939	2,081	3,243	6,992	14,773	10,488	4,403	1,350	569	689	1,870	807	878	2.20	D
2001	1,598	3,248	8,439	11,258	20,697	3,891	1,233	339	300	340	1,603	4,366	2.20	D
1964	2,537	2,559	3,577	8,571	14,878	10,353	2,228	748	403	455	2,387	23,008	2.19	D
1947	2,423	4,541	6,634	10,353	17,252	6,235	1,447	358	286	1,415	1,109	797	2.18	D
1972	2,846	3,964	9,138	8,269	16,569	10,185	1,724	488	1,176	797	1,748	3,496	2.16	D
1994	1,166	2,837	4,686	9,112	13,315	6,189	1,377	795	484	1,208	2,612	2,572	2.05	C
1930	1,870	3,568	7,041	12,101	12,959	13,059	2,520	569	269	504	857	537	2.02	C
1929	1,041	2,198	4,439	7,429	17,642	10,639	2,488	488	134	179	218	894	2.00	C
1989	1,512	2,847	11,691	15,916	13,951	8,790	1,756	553	605	1,772	1,277	1,008	1.96	C
1991	374	432	8,748	8,555	16,049	14,672	3,756	862	471	732	1,160	943	1.96	C
1987	846	2,468	4,667	9,563	10,146	4,067	976	553	286	569	1,277	1,691	1.86	C
1960	1,154	5,856	6,764	12,084	13,967	7,513	1,252	390	235	244	1,008	1,577	1.85	C
1976	943	2,234	3,561	5,261	9,382	2,303	1,008	959	1,042	634	454	276	1.57	C
1992	1,317	6,108	5,545	11,950	10,309	2,857	2,667	715	353	504	773	2,211	1.56	C
1990	1,756	2,486	5,902	10,840	8,504	5,412	1,821	407	185	228	286	293	1.51	C
1988	3,138	3,045	5,041	8,387	10,195	5,664	1,707	683	319	341	773	1,220	1.48	C
1934	2,813	4,595	7,106	9,244	6,846	4,034	911	358	303	537	1,882	2,293	1.44	C
1924	1,073	2,018	1,967	6,319	8,943	1,277	618	179	118	585	2,118	2,244	1.42	C
1961	992	2,234	3,317	8,202	9,919	5,916	927	732	319	309	555	1,122	1.38	C
1931	1,154	2,036	2,829	7,092	9,220	2,588	585	244	151	195	387	6,650	1.20	C
1977	537	811	1,057	3,429	4,325	5,025	650	260	168	146	454	4,276	0.84	C

A record of flow at Vernalis has been maintained by USGS for many years. Table 17 presents the record from USGS records by water year. The most recent record of flow is extracted from the Reclamation record that calculates the daily Delta Outflow Index.

Table 18 presents State Water Project and Central Valley Project diversion data. The State Water Project diversion values reflect data extracted for the DAYFLOW variable "SWP", with the values for water years after 2002 representing diversions to Clifton Court Forebay. The Central Valley Project diversion values reflect data extracted for the DAYFLOW variable "CVP, with the values for water year after 2002 representing the U.S. Bureau of Reclamation record for Tracy Pumping Plant diversions. Table 19 presents the same data as the summation of the two diversions, expressed in average monthly flow (cfs).

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Table 17

Flow at Vernalis
(Values in Average Monthly CFS)

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	60-20-20 MAF	60-20-20 Type
1924	2591	1316	1573	1478	1450	1035	1476	1275	575	420	420	417	1.42	C
1925													2.93	BN
1926													2.30	D
1927													3.56	AN
1928													2.63	BN
1929													2.00	C
1930	1407	1234	1285	1799	1702	2453	2581	2214	2754	1237	919	1433	2.02	C
1931	1668	1644	1913	1546	1603	880	389	444	392	233	228	320	1.20	C
1932	477	643	1251	3340	11158	4886	4814	11591	15101	5792	1164	1067	3.41	AN
1933	1671	1897	1869	2007	3007	1737	1147	1383	5309	1113	666	1150	2.44	D
1934	1533	1528	2408	2745	2241	1695	702	639	627	395	383	501	1.44	C
1935	849	1291	1606	3637	3537	4074	14759	16381	15778	2698	994	1350	3.56	AN
1936	2033	1939	2535	3304	12857	14168	13023	16781	11120	3047	1121	1281	3.74	AN
1937	1889	1960	2855	3290	12403	13207	14465	20048	15559	3260	1129	1396	3.90	W
1938	1898	1979	5307	6198	23440	34148	22412	28340	36653	14607	3359	2225	5.89	W
1939	2665	3799	3700	4090	4174	2026	2467	2035	991	756	715	1034	2.20	D
1940	1484	1436	1586	4130	8895	14945	16908	14297	10851	1994	1186	1688	3.36	AN
1941	1603	1715	3011	7133	13115	21164	17088	21280	22305	9141	2094	1686	4.43	W
1942	2198	2330	4775	8430	12738	8674	13415	16529	22242	7775	1684	1916	4.44	W
1943	2236	2333	4365	5646	13078	23118	18062	14970	11654	2208	1542	1689	4.03	W
1944	2108	1952	2387	2689	2966	4792	2300	3826	3384	1245	1091	1199	2.76	BN
1945	1648	2473	3787	3863	10889	9214	8988	13913	11324	3880	1779	2031	3.59	AN
1946	2758	3484	5732	9509	5959	3733	6015	13056	5784	1465	1224	1483	3.30	AN
1947	1814	2616	3616	2782	2409	2259	1488	2045	943	527	569	1074	2.18	D
1948	1314	1773	1695	1384	857	599	1393	5000	8606	1328	725	1088	2.70	BN
1949	1548	1492	1486	1740	1416	3468	2058	3529	2003	562	602	715	2.53	BN
1950	1267	1582	1571	1998	3545	2205	5367	5011	5014	687	621	946	2.85	BN
1951	1324	8103	25124	10278	10820	7768	2653	6523	3338	870	759	1035	3.14	AN
1952	1784	1763	3135	8850	11926	13745	20198	27634	23342	3497	1355	1620	5.17	W
1953	1865	2176	3663	5946	3676	1162	1520	3059	4915	1604	747	1093	3.03	BN
1954	1629	1662	1762	1656	2360	4458	5059	6715	1286	542	546	754	2.72	BN
1955	1042	1386	1814	2965	2453	1561	917	1150	1496	416	431	610	2.30	D
1956	799	1071	10903	27040	17909	7485	6262	13973	12252	3482	1902	1885	4.46	W
1957	1998	2212	2505	1921	1764	3054	1326	2581	3760	875	753	1149	3.01	BN
1958	2055	2249	2493	2420	5438	12092	27922	22415	15618	4091	1535	2243	4.77	W
1959	2835	3633	2954	2331	3270	2068	812	791	533	312	402	786	2.21	D
1960	876	1051	1183	1395	1785	595	517	618	293	222	267	385	1.85	C
1961	712	1013	1287	1338	1119	444	200	380	207	104	151	321	1.38	C
1962	410	593	711	804	5782	5931	2085	2620	3497	856	694	993	3.07	BN
1963	1453	1643	2434	1754	8191	2607	8616	9337	6664	1821	1095	1515	3.57	AN
1964	2677	3022	3532	2871	1759	929	764	703	650	383	440	900	2.19	D
1965	1411	2356	6036	14381	7933	5325	9860	5295	5651	1973	1220	1678	3.81	W
1966	2944	3644	6232	5267	4094	1914	982	863	570	440	500	725	2.51	BN
1967	1101	1330	4375	3207	6368	6535	14496	20361	20002	10448	2020	2029	5.25	W
1968	2725	3473	3634	2940	2712	3093	1436	891	592	503	768	938	2.21	D
1969	1384	1604	2532	13812	32576	30868	22119	24608	27889	5802	2324	3255	6.09	W
1970	4461	4628	4011	11114	9197	7178	1673	2393	2704	1330	1044	1319	3.18	AN
1971	1466	1655	5043	5203	4394	2589	1961	1832	2322	1066	892	1097	2.89	BN
1972	2252	1646	2398	3116	2800	1379	1037	744	587	481	543	1563	2.16	D
1973	1991	2217	2501	4058	7994	7610	4204	2936	2576	1082	1067	1471	3.50	AN
1974	2546	2281	3586	7780	5097	4816	5850	4106	3860	1636	1615	2846	3.90	W
1975	3496	3891	4161	3766	6216	5683	3957	3971	5708	1718	1680	2653	3.85	W
1976	4542	3906	3744	3326	2192	1822	1293	939	798	671	1055	1067	1.57	C
1977	1273	1136	965	1091	789	524	212	400	118	93	124	179	0.84	C
1978	246	430	506	2275	7324	11473	20032	19116	7070	1907	1418	2731	4.58	W
1979	3327	3498	2812	5232	7143	8650	3507	2523	2254	1333	1451	1841	3.67	AN
1980	2790	2312	2486	13067	19460	25292	10250	9910	5306	3383	1969	3802	4.73	W
1981	4071	3278	2949	3250	2881	3121	2533	1966	1499	1265	1269	1181	2.44	D
1982	1386	1564	1852	3888	6650	10060	22965	18650	7585	6162	4016	6130	5.45	W
1983	8178	6975	16490	19064	31625	40028	36450	31765	26086	19224	9033	11311	7.22	W
1984	13314	10676	19122	25627	11228	7500	4285	3239	2297	1904	2179	2918	3.69	AN
1985	3813	2823	4770	4064	3244	2736	2467	2132	1748	2557	2600	1925	2.40	D
1986	2072	1929	2205	2059	8750	25031	19592	8762	6234	2893	3183	4181	4.31	W
1987	3741	2809	3705	2305	2138	3414	2867	2177	1990	1632	1626	1597	1.86	C
1988	1369	1548	1278	1482	1440	2240	2146	1781	1711	1357	1557	1452	1.48	C
1989	1126	1274	1372	1255	1235	2023	1915	1949	1583	1284	1169	1353	1.96	C
1990	1402	1403	1380	1242	1366	1759	1309	1280	1116	1010	1033	876	1.51	C
1991	993	1115	918	816	758	1779	1168	1049	568	594	537	574	1.96	C
1992	788	1084	895	959	2167	1469	1418	891	481	447	483	635	1.56	C
1993	849	956	981	4119	3037	2702	3421	3609	2341	1509	1998	2771	4.20	W
1994	3040	1759	1628	1773	1989	2205	1863	1972	1109	1135	867	869	2.05	C
1995	1369	1288	1295	4598	6564	14609	19935	22183	14013	9879	3924	4735	5.95	W
1996	5691	2429	2250	2430	11891	15068	7501	8420	3739	2209	2033	2164	4.12	W
1997	2690	2715	12190	30371	35080	13032	4728	4784	2647	1756	1875	2069	4.13	W
1998	2705	1981	2116	6024	28140	19348	21939	17944	17761	13190	5441	5758	5.65	W
1999	6152	3290	4330	4729	11704	8330	6437	5550	3016	2094	1969	2037	3.59	AN
2000	2531	2158	1688	2136	7564	12096	5013	4813	2772	1898	2171	2330	3.38	AN
2001	2806	2413	2212	2457	3194	3559	3004	3642	1599	1401	1338	1374	2.20	D
2002	1886	2064	2100	2696	1896	2128	2599	2794	1424	1273	1150	1161	2.34	D
2003	1563	1619	1950	1930	1922	2188	2656	2691	2230	1481	1431	1383	2.82	BN
2004	1927	1694	1516	1684	2202	3273	2759	2683	1466	1146	1136	1125	2.21	D

Table 18

State Water Project Diversions
DAYFLOW Variable SWP - 1,000 acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1956	-	-	-	-	-	-	-	-	-	-	-	-	-
1957	-	-	-	-	-	-	-	-	-	-	-	-	-
1958	-	-	-	-	-	-	-	-	-	-	-	-	-
1959	-	-	-	-	-	-	-	-	-	-	-	-	-
1960	-	-	-	-	-	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-	-	-	-	-	-
1965	-	-	-	-	-	-	-	-	-	-	-	-	-
1966	-	-	-	-	-	-	-	-	-	-	-	-	-
1967	-	-	-	-	-	-	-	-	-	-	-	-	-
1968	8	5	10	27	3	71	88	79	17	13	47	108	476
1969	142	157	158	172	92	70	75	60	29	32	34	11	1,032
1970	17	37	45	40	21	27	52	17	34	35	51	39	416
1971	26	88	113	112	42	51	60	45	68	102	123	51	881
1972	52	34	24	33	26	160	156	125	97	36	135	168	1,046
1973	180	207	211	82	27	38	47	103	150	165	180	104	1,494
1974	151	106	109	44	111	117	90	158	262	361	283	91	1,885
1975	62	111	171	167	135	137	118	93	12	16	254	233	1,510
1976	238	245	238	254	175	228	26	42	18	19	130	209	1,822
1977	84	94	68	205	106	97	14	72	17	20	15	9	801
1978	8	51	224	365	343	108	35	59	201	212	247	211	2,063
1979	127	135	169	81	90	143	157	184	179	282	347	278	2,172
1980	224	282	360	387	188	71	87	95	178	130	276	238	2,516
1981	184	147	181	253	196	175	250	57	16	144	302	189	2,094
1982	225	188	266	211	311	384	363	177	46	59	219	183	2,632
1983	185	154	323	377	348	83	7	24	108	70	168	40	1,887
1984	21	45	26	20	113	157	215	165	178	279	299	131	1,650
1985	115	238	273	116	200	278	197	184	196	283	338	266	2,683
1986	220	207	363	307	112	45	120	184	178	240	331	375	2,681
1987	208	181	188	132	151	190	153	123	119	265	305	272	2,288
1988	104	82	298	383	333	259	255	184	167	200	245	197	2,707
1989	114	140	178	361	220	371	375	184	120	279	391	365	3,097
1990	374	361	382	389	351	389	309	21	18	150	208	147	3,099
1991	139	130	166	180	98	364	270	79	52	45	126	132	1,779
1992	208	64	79	185	203	386	71	43	56	23	91	165	1,574
1993	43	67	170	465	284	120	161	105	121	257	382	381	2,555
1994	396	154	385	213	106	115	20	43	19	104	210	215	1,980
1995	170	212	240	458	257	31	8	77	199	364	290	169	2,476
1996	181	79	0	348	171	174	106	157	296	371	380	345	2,608
1997	336	349	211	45	90	162	106	79	153	322	268	339	2,462
1998	266	293	420	197	7	14	2	43	129	213	264	266	2,115
1999	295	129	128	85	52	183	186	99	59	376	409	409	2,411
2000	304	311	234	396	422	344	189	98	252	359	377	388	3,672
2001	307	322	292	241	261	361	98	34	9	217	249	213	2,603
2002	60	192	377	397	275	239	125	38	128	383	414	246	2,873
2003	108	187	256	355	355	382	153	61	355	412	431	404	3,458
2004	176	227	263	419	368	423	127	46	101	389	408	298	3,245

Central Valley Project Diversions
DAYFLOW Variable CVP - 1,000 acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1956	69	21	8	0	9	25	39	22	64	195	179	93	726
1957	40	4	3	2	56	108	136	131	189	213	188	112	1,181
1958	64	26	6	1	3	15	6	33	41	174	188	106	663
1959	71	29	6	15	32	121	159	157	203	236	202	109	1,341
1960	74	35	11	11	33	136	151	159	218	241	209	111	1,390
1961	89	30	-	15	42	123	168	167	228	275	231	120	1,489
1962	81	35	12	21	11	53	160	177	218	251	219	119	1,357
1963	83	44	0	28	42	109	70	167	204	249	227	120	1,344
1964	123	29	7	32	88	129	175	190	216	273	250	136	1,647
1965	132	39	-	10	83	132	68	190	213	259	229	116	1,472
1966	105	35	-	4	48	149	179	199	232	270	251	128	1,599
1967	109	55	26	45	38	119	68	112	122	158	256	149	1,258
1968	98	57	26	39	99	202	224	256	250	291	240	214	1,997
1969	233	137	68	177	167	136	112	134	112	166	268	134	1,844
1970	100	22	-	25	82	108	217	219	252	273	219	136	1,653
1971	126	28	0	1	128	234	199	222	264	281	269	165	1,918
1972	176	138	119	64	187	240	210	250	198	260	270	234	2,346
1973	207	-	0	90	35	39	147	275	273	285	276	226	1,855
1974	205	178	95	76	193	261	153	269	262	277	278	198	2,444
1975	212	-	1	165	233	231	251	243	238	284	276	216	2,349
1976	222	228	239	249	264	281	262	279	222	213	281	270	3,008
1977	195	150	96	223	125	125	60	102	18	22	67	98	1,281
1978	30	97	133	238	226	245	163	127	246	277	256	225	2,264
1979	182	191	195	166	68	122	189	184	178	280	280	261	2,296
1980	240	61	-	-	158	199	228	179	170	281	279	209	2,006
1981	219	229	233	251	203	119	219	193	206	268	253	197	2,590
1982	130	85	48	111	210	254	205	183	175	179	267	123	1,971
1983	138	199	193	238	219	242	218	174	177	244	262	199	2,502
1984	128	57	99	84	219	263	236	184	178	288	269	186	2,190
1985	222	232	243	237	224	243	232	184	178	281	269	244	2,790
1986	241	221	238	239	219	150	166	184	178	274	270	239	2,618
1987	246	220	247	246	224	146	258	184	178	273	281	255	2,758
1988	246	234	248	250	236	251	243	183	178	275	279	273	2,895
1989	218	214	256	257	228	253	237	184	178	291	289	263	2,870
1990	259	248	253	254	227	253	253	170	178	225	186	190	2,697
1991	68	94	140	116	145	229	172	79	53	100	102	110	1,408
1992	106	120	114	197	142	252	102	52	47	55	61	95	1,342
1993	59	76	75	246	224	251	171	94	118	265	268	261	2,108
1994	265	252	255	140	215	139	93	69	79	154	150	211	2,023
1995	152	148	217	255	234	146	198	184	242	274	270	261	2,581
1996	266	251	263	263	206	45	143	128	263	274	269	256	2,626
1997	258	245	251	124	31	267	162	107	264	270	272	257	2,510
1998	263	250	251	243	164	127	86	143	170	250	269	259	2,474
1999	256	127	2	183	240	253	102	105	199	272	270	255	2,262
2000	261	250	156	197	236	208	131	78	181	266	270	253	2,487
2001	259	242	240	168	195	116	130	53	178	254	254	243	2,332
2002	223	223	226	255	200	257	128	53	151	268	267	255	2,505
2003	251	218	205	262	237	267	113	90	262	258	264	253	2,680
2004	264	257	255	268	228	254	216	59	116	269	272	261	2,718

Table 19

State Water Project and Central Valley Project Combined Diversions - Average Monthly CFS

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1956	1,123	350	138	6	165	413	650	362	1,083	3,168	2,914	1,566
1957	657	66	56	31	1,004	1,756	2,288	2,122	3,174	3,471	3,049	1,875
1958	1,035	440	98	15	55	250	104	530	684	2,832	3,063	1,779
1959	1,149	496	96	250	584	1,962	2,667	2,545	3,418	3,841	3,289	1,833
1960	1,203	594	175	184	596	2,206	2,532	2,589	3,665	3,926	3,394	1,873
1961	1,449	503	-	245	760	2,004	2,818	2,711	3,834	4,465	3,761	2,025
1962	1,320	581	191	343	201	857	2,688	2,873	3,669	4,080	3,560	2,006
1963	1,347	746	6	454	763	1,769	1,172	2,708	3,429	4,054	3,698	2,014
1964	1,995	483	109	524	1,582	2,100	2,947	3,090	3,637	4,433	4,059	2,283
1965	2,145	655	-	170	1,501	2,149	1,136	3,090	3,579	4,219	3,725	1,943
1966	1,699	587	-	60	858	2,418	3,006	3,243	3,895	4,397	4,082	2,156
1967	1,776	924	424	735	685	1,938	1,147	1,827	2,055	2,566	4,157	2,506
1968	1,723	1,040	595	1,077	1,832	4,434	5,250	5,451	4,485	4,943	4,673	5,418
1969	6,098	4,929	3,677	5,687	4,650	3,349	3,139	3,161	2,381	3,228	4,921	2,421
1970	1,902	994	727	1,067	1,867	2,192	4,525	3,845	4,801	5,015	4,393	2,929
1971	2,468	1,952	1,851	1,841	3,076	4,630	4,351	4,337	5,588	6,214	6,377	3,632
1972	3,708	2,898	2,329	1,568	3,834	6,506	6,150	6,090	4,952	4,811	6,587	6,760
1973	6,290	3,483	3,437	2,811	1,114	1,264	3,256	6,156	7,105	7,322	7,418	5,549
1974	5,799	4,773	3,324	1,958	5,470	6,134	4,081	6,955	8,807	10,373	9,126	4,851
1975	4,450	1,865	2,787	5,400	6,630	5,987	6,189	5,468	4,203	4,880	8,612	7,561
1976	7,467	7,953	7,752	8,182	7,906	8,264	4,838	5,216	4,034	3,773	6,683	8,055
1977	4,532	4,092	2,671	6,965	4,164	3,598	1,241	2,822	598	685	1,345	1,795
1978	615	2,500	5,806	9,811	10,254	5,735	3,323	3,018	7,509	7,952	8,179	7,321
1979	5,015	5,478	5,923	4,012	2,855	4,318	5,820	5,990	5,988	9,141	10,192	9,049
1980	7,550	5,767	5,858	6,293	6,247	4,386	5,301	4,464	5,859	6,687	9,022	7,505
1981	6,558	6,325	6,733	8,189	7,190	4,782	7,889	4,061	3,723	6,695	9,023	6,488
1982	5,767	4,594	5,112	5,229	9,402	10,360	9,560	5,863	3,701	3,878	7,915	5,137
1983	5,248	5,932	8,384	9,989	10,225	5,278	3,785	3,209	4,794	5,116	6,993	4,017
1984	2,418	1,706	2,026	1,704	5,990	6,843	7,570	5,669	5,981	9,219	9,233	5,325
1985	5,482	7,898	8,396	5,738	7,637	8,469	7,208	5,983	6,286	9,171	9,876	8,561
1986	7,498	7,190	9,776	8,865	5,966	3,161	4,794	5,996	5,992	8,349	9,760	10,310
1987	7,381	6,732	7,069	6,155	6,758	5,463	6,916	4,995	4,998	8,745	9,528	8,860
1988	5,690	5,302	8,882	10,293	10,243	8,292	8,372	5,969	5,799	7,729	8,508	7,900
1989	5,405	5,950	7,056	10,056	8,059	10,138	10,292	5,992	5,013	9,274	11,054	10,560
1990	10,302	10,235	10,324	10,455	10,419	10,430	9,446	3,114	3,295	6,091	6,420	5,670
1991	3,364	3,766	4,974	4,810	4,372	9,638	7,418	2,557	1,763	2,362	3,709	4,068
1992	5,116	3,084	3,133	6,209	6,209	10,369	2,908	1,545	1,733	1,273	2,471	4,364
1993	1,661	2,400	3,985	11,564	9,141	6,025	5,587	3,237	4,015	8,483	10,571	10,783
1994	10,753	6,825	10,411	5,734	5,791	4,139	1,892	1,826	1,651	4,202	5,848	7,149
1995	5,239	6,045	7,443	11,594	8,855	2,875	3,460	4,238	7,414	10,389	9,097	7,230
1996	7,280	5,551	4,277	9,936	6,808	3,570	4,173	4,623	9,382	10,472	10,557	10,093
1997	9,662	9,982	7,517	2,757	2,185	6,984	4,495	3,026	7,017	9,637	8,787	10,028
1998	8,604	9,133	10,899	7,148	3,089	2,294	1,478	3,022	5,030	7,529	8,666	8,832
1999	8,955	4,313	2,115	4,366	5,260	7,080	4,831	3,317	4,333	10,542	11,047	11,147
2000	9,183	9,419	6,347	9,643	11,856	8,967	5,386	2,851	7,280	10,159	10,513	10,769
2001	9,194	9,477	8,662	6,662	8,222	7,749	3,833	1,407	3,148	7,658	8,171	7,656
2002	4,604	6,986	9,799	10,599	8,553	8,073	4,249	1,481	4,682	10,575	11,067	8,410
2003	5,834	6,805	7,491	10,024	10,658	10,561	4,474	2,446	10,371	10,896	11,301	11,042
2004	7,150	8,138	8,411	11,158	10,733	11,008	5,773	1,711	3,647	10,694	11,059	9,392

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Attachment A

Stanislaus River Basin Assumptions / Operating Criteria

The assumptions used to model the Stanislaus in the preliminary CALSIM II test simulation are outlined in detail below.

- **1997 New Melones Interim Plan of Operations:**

  The New Melones Interim Plan of Operations (IPO) allocates supply to four purposes: fisheries, water quality, X2 requirement support, and water supply for CVP contractors (i.e., SEWD and CSJWCD). Reclamation provides water to Oakdale Irrigation District (OID) and South San Joaquin Irrigation District (SSJID) according to a separate agreement with these agencies.

  The amount of water allocated to each purpose (other than to OID/SSJID) in the IPO depends on end-of-February storage plus March-September forecasted inflow, as shown below in Table 2. CALSIM makes releases to the Stanislaus River below Goodwin Dam in the following order:

  1. Releases for the fishery according to an assumed pattern associated with the allocated volume.
  2. Releases up to the amount needed above the fishery release to meet the Vernalis water quality requirement, these accumulated releases cannot exceed the annual Vernalis water quality allocation.
  3. Releases for DO at Ripon (surrogated as a flow requirement at Goodwin), with no volume limitation except the flow requirement itself.
  4. Releases for the Vernalis D-1641 Bay-Delta flow requirement. The IPO assumed that the Vernalis flow requirement release occurred as the second step; however, for modeling simplicity the release is modeled last. Results are rarely affected by the shift in order.

Table 2: **New Melones Interim Plan of Operation Allocations (1,000 AF)**

New Melones Storage Plus Inflow		Fishery		Vernalis Water Quality		Bay-Delta		CVP Contractors*	
From	To	From	To	From	To	From	To	From	To
0	1,400	0	98	0	70	0	0	0	0
1,400	2,000	98	125	70	80	0	0	0	0
2,000	2,500	125	345	80	175	0	0	0	59
2,500	3,000	345	467	175	250	75	75	90	90
3,000	6,000	467	467	250	250	75	75	90	90

* CVP Contractors: Stockton East Water District and Central San Joaquin Water Conservation District

Deliveries to the OID and SSJID are limited by the following equation:

Oakdale ID/South San Joaquin ID Maximum Diversion

- Annual volume equals 600 TAF unless water year inflow is less than 600 TAF.
- When less than 600 TAF the following formula is applied:

  Entitlement = Inflow + (600 – Inflow) / 3

Each district is entitled to one-half of the water available.

- **Fishery Releases - 1987 Reclamation, DFG Agreement, and U.S. Fish and Wildlife Service discretionary use of CVPIA 3406(b)(2)**

  Depending on the fishery allocation (0 - 467 TAF/yr) under the New Melones IPO, the fishery release volume at Goodwin Dam is assumed to be managed under the base and pulse flow schedules shown below. Values are interpolated between the seven discrete schedules. Fishery releases are based on a 1987 agreement between Reclamation and the California Department of Fish and Game and U.S. Fish and Wildlife Service discretionary use of the CVPIA 3406(b)(2) account to support release goals established by the Anadromous Fish Restoration Program (AFRP). Table 3 depicts the volumes and patterns used in CALSIM for the interpolation. These values are consistent with the modeling used during the finalization of the IPO.

Table 3: **Stanislaus River Base and Pulse Flow Schedules**

Annual Fishery Allocation (TAF)	**0**	**98.4**	**243.3**	**253.8**	**310.3**	**410.2**	**466.8**
Base Flow Schedules (cfs)							
January	0	125	250	275	300	350	400
February	0	125	250	275	300	350	400
March	0	125	250	275	300	350	400
April	0	250	300	300	900	1500	1500
May	0	250	300	300	900	1500	1500
June	0	0	200	200	250	800	1500
July	0	0	200	200	250	300	300
August	0	0	200	200	250	300	300
September	0	0	200	200	250	300	300
October	0	110	200	250	250	350	350
November	0	200	250	275	300	350	400
December	0	200	250	275	300	350	400
Pulse Flow Schedules (cfs)							
Apr 15 – May 16	0	500	1500	1500	1500	1500	1500

- **SWRCB D-1422 – Stanislaus River Dissolved Oxygen**

  CALSIM II does not have the ability to predict or adjust operations for dissolved oxygen in the Stanislaus River. D-1422 requires that water be released from New Melones to maintain the dissolved oxygen concentration in the Stanislaus River at a value of at least 7 mg/l as measured near Ripon. As a surrogate, specific release volumes are required from Goodwin Dam to meet this criterion. The surrogate volumes are shown in Table 4 below.

Table 4: **Surrogate Dissolved Oxygen Release Volumes (1,000 AF)**

Month	**Release Volume**
June	13.2
July	16.2
August	16.4
September	14.3

- **SWRCB D-1641 – Vernalis Water Quality**

  The salinity objective near Vernalis was originally defined in SWRCB D-1422. SWRCB D-1641 provisions have revised this requirement. CALSIM II calculates the salinity concentration at Vernalis by evaluating the blended flows and their associated assumed salinity concentrations that reach Vernalis. D-1641 requires salinity near Vernalis to be less than 0.7 electrical conductivity (EC) for April – August and less than 1.0 EC September – March. Releases are made from New Melones, as required, up to the allocation provided by the New Melones IPO, to meet this criterion.

- **SWRCB D-1641 – Bay-Delta Flow (X2 Requirement Support)**

  D-1641 also requires the flow at Vernalis to be maintained during the February through June period to support the 2 ppt isohaline (X2 position) in the Delta, as shown in Table 5. The objectives of the Vernalis Adaptive Management Plan (VAMP – see below) become the flow objective during the period April 15 through May 16. Releases are made from New Melones, as required, but are limited by the Bay-Delta allocation determined by the New Melones IPO.

Table 5: **Bay-Delta Vernalis Flow Objectives (average monthly cfs)**

San Joaquin Basin Index	X2 Required At or West of Chipps	X2 Required East of Chipps
Wet	3420	2130
Above Normal	3420	2130
Below Normal	2280	1420
Dry	2280	1420
Critical	1140	710

- **South San Joaquin Irrigation District Water Commitments**

  In addition to district-area water demands, South San Joaquin Irrigation District (SSJID) demands incorporate deliveries to the South County Project (scheduled to begin operation during 2005), commitments to the San Joaquin River Agreement (VAMP) and water sales to the Stockton East Water District (SEWD). The South County Project is modeled as a 25,000 acre-feet delivery, equally distributed during the year. SSJID's commitment to the SJRA is determined dynamically each year and can range up to 11,000 acre-feet. The sale to SEWD is modeled as one-half of a 30,000 acre-feet transfer by SSJID/OID, annually dependent upon water year inflow to New Melones (Table 6).

  Table 6: ***Total SSJID/OID Transfer to SEWD*** **(1,000 AF)**

New Melones Inflow	Total Transfer Volume
0	8
450	12.5
500	30

- **Oakdale Irrigation District Water Commitments**

  In addition to district-area water demands, Oakdale Irrigation District (OID) demands incorporate commitments to the San Joaquin River Agreement (SJRA) and water sales to SEWD. OID's commitments to the SJRA include up to 11,000 acre-feet per year towards VAMP, 15,000 acre-feet of water towards fall (October) river releases, and any portion of the VAMP water not used during the VAMP pulse flow period also for fall releases (equally during November and December). OID's sale to SEWD mirrors the sale by SSJID.

  VAMP releases by SSJID/OID are made to the Stanislaus River on top of IPO releases whenever there is capacity available below a limit of 1,500 cfs at Goodwin. If the VAMP release is limited, the increment of release not made at Goodwin is made from the Tuolumne River. An accounting is made of such a release, and subsequently water is transferred from SSJID/OID to the Modesto Irrigation District at a rate not to exceed 50 cfs (assumed conveyance limitation).

- **IPO Deliveries to SEWD and CSJWCD**

  Up to 90,000 acre-feet of water is modeled as a diversion from Goodwin to SEWD and CSJWCD.

  Table 7: ***Assumed Division of IPO Allocation to SEWD and CSJWCD*** **(1,000 AF)**

New Melones Storage Plus Inflow		SEWD plus CSJWCD	
From	To	From	To
0	1,400	0	0
1,400	2,000	0	0
2,000	2,500	0	59
2,500	3,000	90	90
3,000	6,000	90	90

- **New Melones Flood Control and Drawdown Target Storage**

  New Melones storage is limited to the USCOE flood control envelope for rainfloods as shown below in Table 8.

Table 8: ***End-of-Month Storage for Flood Control (1,000 AF)***

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1,970	1,970	1,970	1,970	1,970	2,030	2,220	2,420	2,420	2,420	2,420	2,270

Results indicate that unless otherwise modified New Melones storage would on occasion be above the September flood control envelope and thus CALSIM would produce a "spill' during the fall. Normal operations would include foresight of this event and likely distribute such a release earlier during the year. Iterative analysis to smooth this release during the

summer demonstrated that target storages of 2,300 TAF July, 2,130 TAF August, and 2,000 TAF September would accomplish an objective of not producing fall-time "spills" of water to reach flood control objectives.

Goodwin releases are limited to not exceed 1,500 cfs unless required to maintain the flood control target storages.