Analysis of the July 20, 2010 Draft SWRCB Delta Flow Criteria Report Appendix B and Supporting CalSim Studies

The intent of Appendix B in the Draft SWRCB Delta Flow Criteria Report (Report) was to assess potential impacts of the Delta flow criteria to water supply and reservoir storage in the Central Valley and Delta. Evaluation of impacts was performed using CalSim II. Appendix B analysis assumptions were developed by SWRCB staff and implemented with technical support from the DWR.

MBK Engineers was asked by Sacramento Valley Water Users to review the CalSim simulations supporting Appendix B, document impacts on water supply and reservoir storage, and assess the reasonableness of the impact assessments given the underlying study assumptions. SWRCB staff provided MBK Engineers with the two CalSim scenarios – Scenarios A and B – and the CalSim baseline used in the Appendix B analysis. MBK Engineers had no involvement in the development of the Scenario studies or assumptions.

Scenario Description

Scenario A includes only Category A criteria as outlined in the Report. Scenario B includes both Category A and B criteria. Both scenarios were developed using a CalSim baseline (BO baseline) that includes the Delta smelt and salmon Biological Opinion RPA's. The BO baseline was a very close approximation of the CalSim model used to support the DWR March 2010 *Draft State Water Project Delivery Reliability Report 2009*. The flow and water quality criteria contained in the baseline (D1641, Biological Opinions, etc.) remained in both Scenarios A and B. Category A and B flow criteria were implemented as additional requirements, not replacements. The impacts reported in Appendix B were measured by comparing Scenario A and B water supply and reservoir operations to the BO baseline. For further discussion of the scenario assumptions, refer to Attachment 1.

Analysis of Results

A brief summary of analytical results for some key system components is presented to demonstrate the extreme impacts of the proposed Delta flow criteria. This summary includes Delta outflow, water supply, and reservoir storage impacts. Because of the nature of the modeling performed in support of Appendix B, many of the impacts may be significantly underestimated.

Figure 1 shows, by water year type, the total average annual additional Delta outflows that would occur under Scenario A when compared to the BO baseline. On an annual average basis, outflow would conservatively be increased by 5,500,000 acre feet. It's important to note that any increase in Delta outflow must come from an equivalent reduction in consumptive use in the Delta watershed including Sacramento basin, San

Joaquin basin, the Delta, and areas of export. Therefore, the 5,500,000 acre feet increase in Delta outflow will result in a 5,500,000 acre-feet decrease in consumptive use.

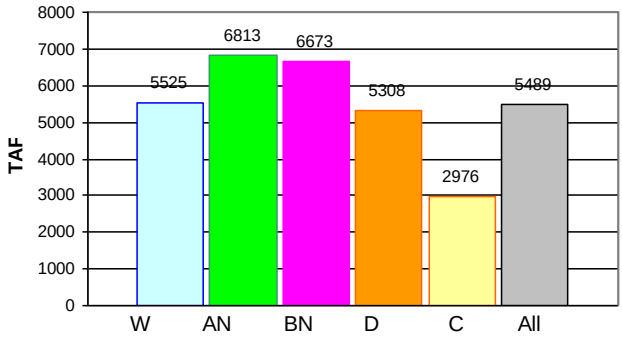

Figure 1 Scenario A Average Annual Increases in Delta Outflow over BO Baseline By Water-Year Type For 1922-2003

Sacramento and San Joaquin River Basin Water Use

Information submitted to the SWRCB by the Center for Watershed Sciences, University of California – Davis, in their report titled: *On Developing Prescriptions for Freshwater Flow to Sustain Desirable Fishes in the Sacramento-San Joaquin Delta, January 2010*, demonstrated that the annual average difference between unimpaired and historical Delta outflow for the 1986-2005 period is about 10,000,000 acre-feet. If SWRCB D1641, CVPIA, the smelt and salmon Biological Opinions, and other recent actions had been in effect for the entire 1986-2005 period of record, the difference between unimpaired and impaired outflow would have been reduced to approximately 8,000,000 acre feet. The difference between unimpaired and impaired Delta outflow represents consumptive use in the Delta watershed. So under existing laws and regulations and given the recent hydrology of 1986-2005, a rough estimate of combined annual average consumptive use and exports is 8,000,000 acre-feet. As discussed in the preceding paragraph, the proposed Delta flow criteria will cut this by 5,500,000 acre-feet on an annual average basis – a 69% reduction. This is very significant.

North-of-Delta Water Supply

Table 1 and Table 2 quantify Scenario A and B North of Delta deliveries by project and contractor type and compare them to baseline values. Key findings are:

- CVP Settlement Contractor deliveries were cut on average by 88% in Scenarios A and B.
- Deliveries to SWP Settlement Contractors were cut by 42% and 43% on average in Scenarios A and B respectively.
- Such cuts would not be allowed under existing contracts and water rights. As such, impacts of the Delta flow criteria are being underestimated elsewhere.

Table 1 Comparison of Scenario A and Base NOD Surface Water Deliveries

	CVP					SWP			CVP/SWP
	AG	M&I	Refuge	Sac. SC	Total	M&I	Fea. SC	Total	Total
Base	215	195	85	1860	2356	23	949	971	3327
Scenario A	44	203	59	224	530	19	539	557	1088
Difference (Scenario A - Base)	-171	8	-27	-1637	-1826	-4	-323	-414	-2240
Percent Difference	-79%	4%	-31%	-88%	-77%	-18%	-42%	-43%	-67%

Table 2 Comparison of Scenario B and Base NOD Surface Water Deliveries

	CVP					SWP			CVP/SWP
	AG	M&I	Refuge	Sac. SC	Total	M&I	Fea. SC	Total	Total
Base	215	195	85	1860	2356	23	949	971	3327
Scenario B	43	197	58	223	522	21	530	551	1073
Difference (Scenario B - Base)	-172	3	-27	-1637	-1834	-2	-327	-420	-2254
Percent Difference	-80%	1%	-32%	-88%	-78%	-9%	-43%	-43%	-68%

Shasta Storage and Cold Water Pool

Figure 2 illustrates impacts to end-of-April Lake Shasta storage. The exceedance probability plot compares baseline, Scenario A, and Scenario B Shasta storage with the NMFS BO end-of-April Shasta storage target of 3.8 million acre-feet. Key findings include:

- Baseline Shasta storage exceeds the NMFS BO end-of-April target 77 % of simulated years.
- Scenario A and Scenario B Shasta storage exceed the target in only 24% of simulated years.
- Such a reduction in end-of-April storage would significantly reduce the availability of cold water pool for summer and fall release.

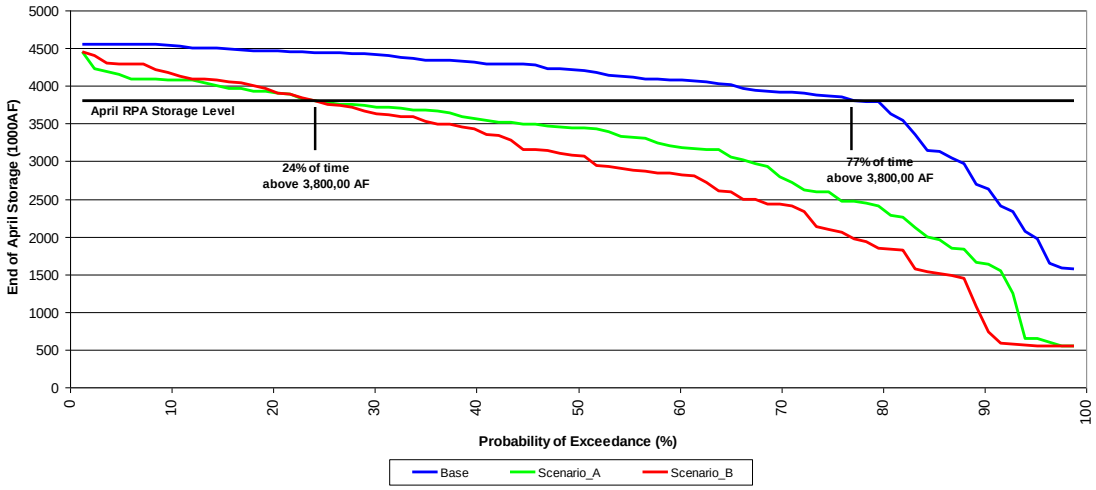

Figure 2 Probability of Exceedance Plot of Lake Shasta end-of-April storage

Figure 3 illustrates impacts to Lake Shasta carryover storage (end-of-September). The exceedance probability plot compares baseline, Scenario A, and Scenario B Shasta storage with the NMFS BO end-of-September Shasta storage target of 2.2 million acre-feet. Key findings include:

- Baseline Lake Shasta carryover storage exceeds the NMFS BO target of 2.2 million acre-feet in 81% of simulated years
- Scenario A Lake Shasta carryover storage exceeds the target in 67% of simulated years
- Scenario B Lake Shasta carryover storage exceeds the target in 57% of simulated years
- Cuts to CVP Settlement Contractor deliveries, though unreasonably large, were unable to restore Shasta carryover to baseline levels. According to SWRCB staff, the intended purpose of the delivery cuts to Settlement Contractors was to alleviate impacts to Shasta storage and cold water pool. The cuts were unsuccessful.

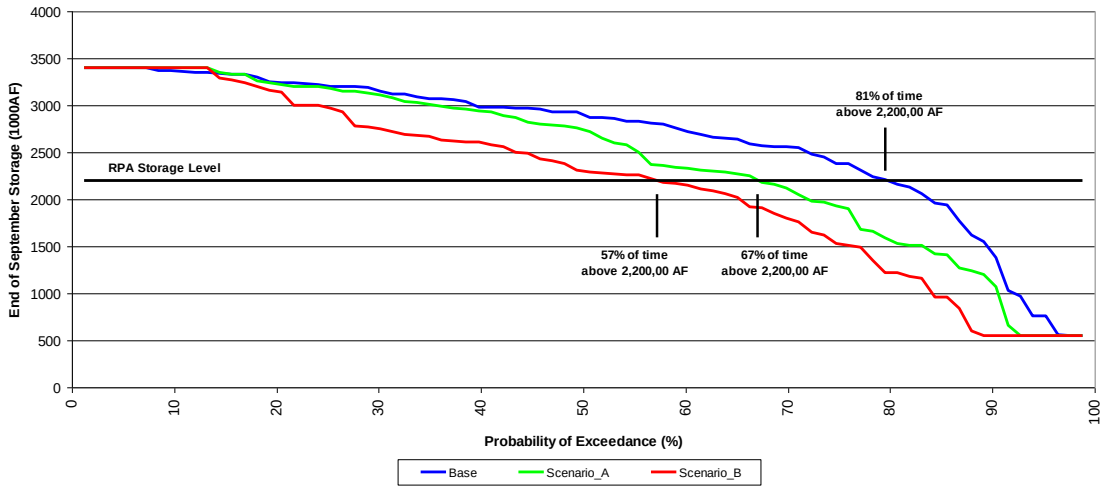

Figure 3 Probability of Exceedance Plot of Lake Shasta Carryover Storage

Keswick Dam Releases

Figure 4 shows the percent difference in Keswick Reservoir releases between Scenario A and Base by month and water year type; Figure 5 similarly illustrates the percent difference between Scenario B and Base. Key findings include:

- In both scenarios, winter and spring releases are significantly increased to meet the Delta flow criteria.
- In both scenarios, summer releases are significantly reduced in response to cuts in Settlement Contractor deliveries.
- The summer reductions in Keswick releases may not be allowable in real-time operations due to temperature impacts downstream of Keswick.
- If summer Keswick releases can not be significantly reduced from the baseline, Scenarios A and B are underestimating storage impacts of the Delta flow criteria at Shasta.

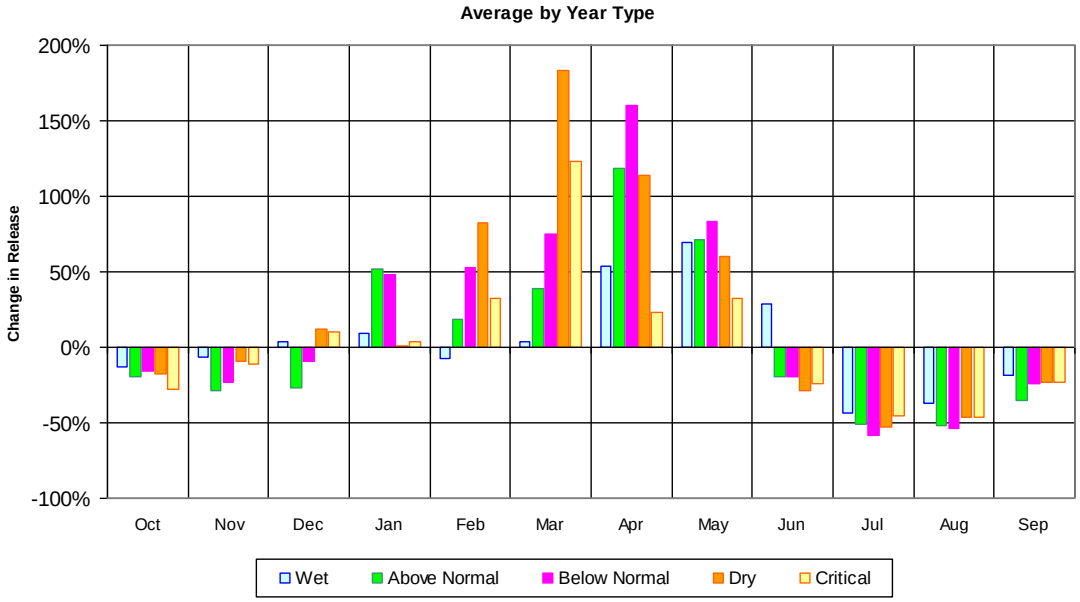

Figure 4 Percentage change in Keswick release between Scenario A and Base by month and water year type

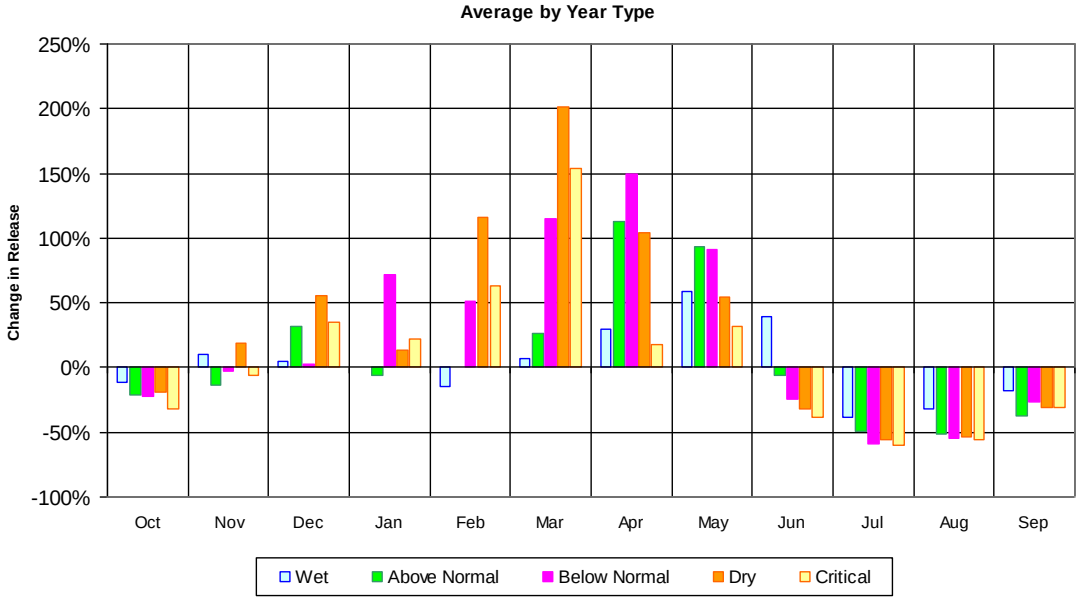

Figure 5 Percentage change in Keswick release between Scenario B and Base by month and water year type

Lake Oroville Storage

Figure 6 and Figure 7 illustrate Delta flow criteria impacts to Lake Oroville storage at the end-of-April and end-of-September, respectively. As shown in Figure 6, there could be a sizable reduction of available cold water pool going into the summer months.

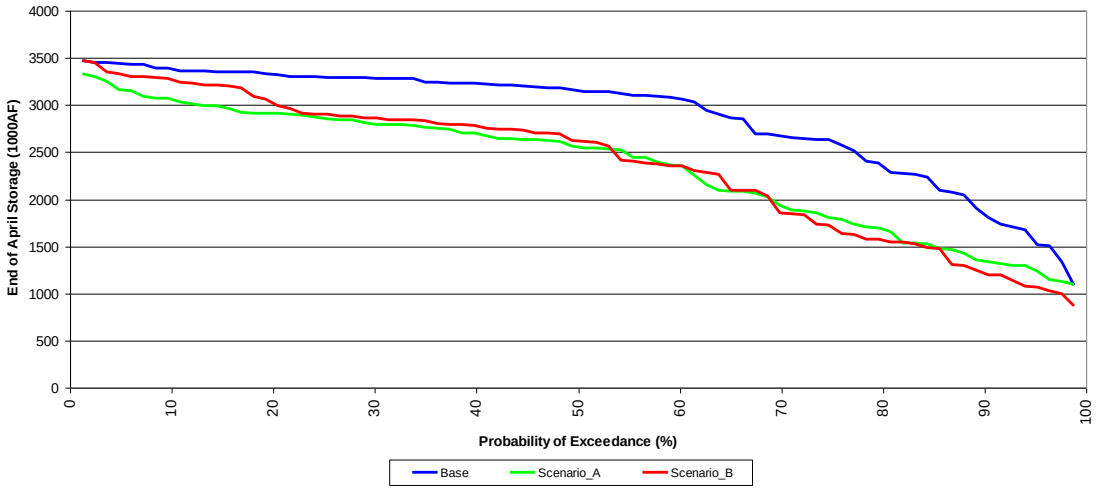

Figure 6 Probability of Exceedance Plot of Lake Oroville end-of-April storage

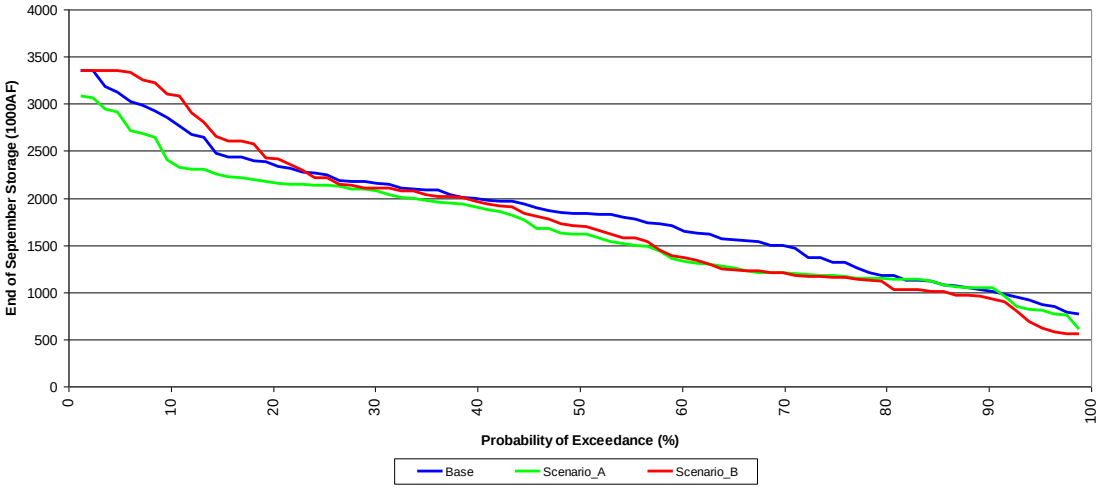

Figure 7 Probability of Exceedance Plot of Lake Oroville Carryover Storage

Folsom Lake Storage

Figure 8 and Figure 9 illustrate Delta flow criteria impacts to Folsom Lake storage at the end-of-April and end-of-September, respectively. As shown in Figure 8, there could be a sizable reduction of available cold water pool going into the summer months.

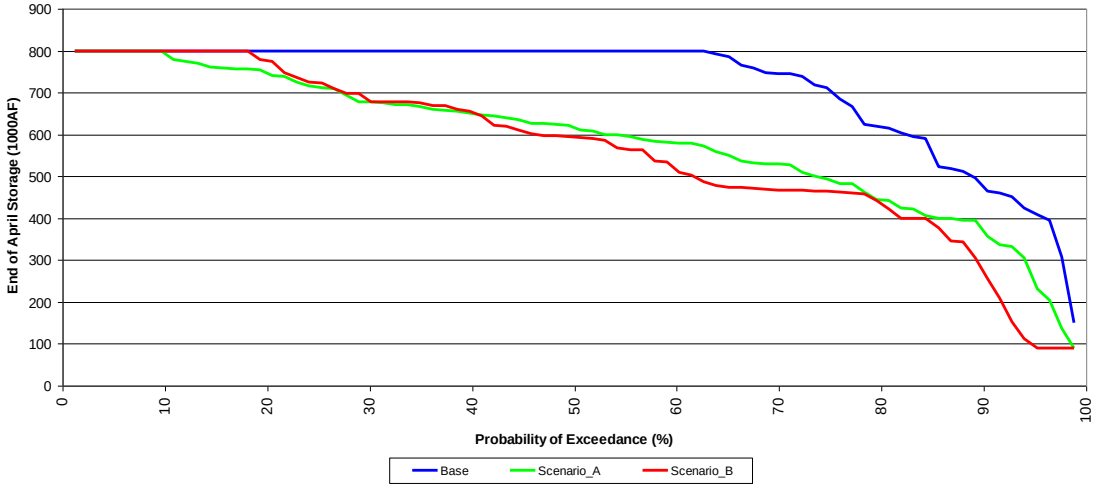

Figure 8 Probability of Exceedance Plot of Folsom Lake end-of-April Storage

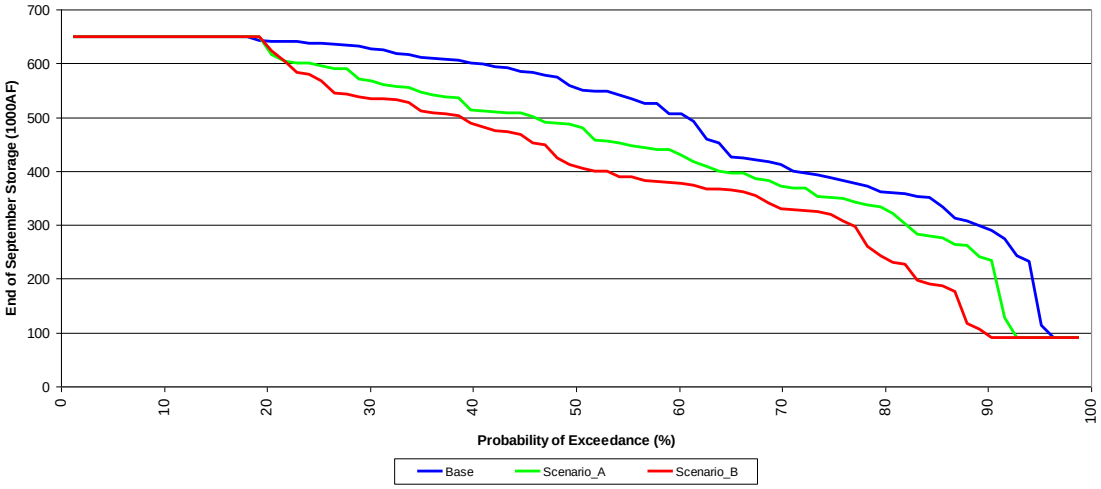

Figure 9 Probability of Exceedance Plot of Folsom Lake Carryover Storage

South-of-Delta Water Supply

Table 3 and Table 4 quantify Scenario A and B South of Delta deliveries by project and contractor type and compare those values to the baseline. Key findings:

- Cuts in South of Delta deliveries are in addition to already significant cuts caused by the FWS and NMFS BO's.
- Under the BO's, SWP Table A contractors receive approximately 60% of entitlement on average (2.5 million acre-feet of contractors' 4.2 million acre-feet entitlement).
- With the Delta flow criteria contained in the Report, SWP Table A contractors' deliveries were cut by 24% and 18% as compared to baseline in Scenario's A and B respectively.

- Deliveries in Scenarios A and B are equivalent to 45% and 50% of entitlement.
- South of Delta exporters were given lower priority than North of Delta storage in both Scenarios A and B. As such, further cuts in exports would likely have little positive impact on North-of-Delta storage.

Table 3 Comparison of Scenario A and Base SOD Deliveries

	CVP					SWP				CVP/SWP
	AG	M&I	Refuge	Exchange	Total	Table A	Art. 56	Art. 21	Total	Total
Base	874	116	273	852	2115	2492	90	50	2632	4747
Scenario A	493	78	226	816	1614	1898	24	29	1951	3565
Difference (Scenario A - Base)	-381	-38	-47	-36	-501	-594	-67	-20	-681	-1183
Percent Difference	-44%	-33%	-17%	-4%	-24%	-24%	-74%	-41%	-26%	-25%

Table 4 Comparison of Scenario B and Base SOD Deliveries

	CVP					SWP				CVP/SWP
	AG	M&I	Refuge	Exchange	Total	Table A	Art. 56	Art. 21	Total	Total
Base	874	116	273	852	2115	2492	90	50	2632	4747
Scenario B	531	79	224	793	1627	2050	35	48	2134	3761
Difference (Scenario B - Base)	-343	-37	-49	-59	-488	-442	-55	-2	-498	-987
Percent Difference	-39%	-32%	-18%	-7%	-23%	-18%	-61%	-3%	-19%	-21%

Delta Flow Criteria Report's Understatement of Impacts

Appendix B shows significant impact to both water supply and cold water pool if the recommended flow criteria were to take effect. However, due to assumptions made in the supporting CalSim studies and the lack of focus on groundwater and hydro-power it is likely that the impacts are significantly underestimated. Following are reasons for the understatement of impacts.

Trinity Imports

It was not noted in Appendix B that imports of water from the Trinity River to the Sacramento River basin were increased significantly in Scenarios A and B as compared to the baseline (48 TAF/ year and 65 TAF/year respectively). Based on CalSim operations logic, the increase was expected. As Shasta and Folsom Lake were drawn down, more water was imported from the Trinity to meet the Delta flow criteria while maintaining a storage balance between the CVP reservoirs. However, it is not realistic to expect large increases of Trinity Imports to support the new criteria because there are problems with the fishery on the Trinity River as well. Given the model is allowing additional imports, it is underestimating the impact to Shasta and Folsom storage.

San Joaquin River Flow at Vernalis

San Joaquin River Flow at Vernalis is overstated for three reasons:

i) In the model runs, SWRCB implemented a 75% unimpaired flow requirement at Vernalis from February to June rather than the recommended 60% as found in the Delta Flow Criteria Report.

ii) In Scenario B, the model mistakenly required 75% unimpaired flow at Vernalis from October to January when there was no such requirement in the Report.

iii) The San Joaquin River basin is not being reoperated from the baseline and therefore does not show the likely reduction in flow at Vernalis caused by the refilling of reservoirs in other months.

The overstatement of San Joaquin River flows at Vernalis has caused an understatement of impacts in Appendix B since the increased Vernalis flows are meeting Delta requirements that would have otherwise been met through reduced South-of-Delta exports or increased North-of-Delta reservoir releases.

San Joaquin River Basin

The SWRCB does not address potential impacts in the San Joaquin River Basin. It was not modeled in Scenarios A and B. However, the impacts to the San Joaquin will be just as severe as those illustrated in the Sacramento basin. There will be significant reductions in cold water pool to maintain fisheries on the Stanislaus, Tuolumne, and Merced Rivers. Water supply diverted from the San Joaquin River and its tributaries for in-basin consumptive uses will be reduced dramatically.

Dead Pool

As reported in Appendix B, storage in Trinity, Shasta, and Folsom reservoirs are reduced to dead pool for a significant number of months in Scenarios A and B. This is referred to as a "broken system", where the model loses the ability to release water for in-basin use obligations. The same reservoirs are also reduced to dead pool storage in the baseline, but it is for a much shorter period of time. In real-time operations, such loss of control of the system must be avoided. Appendix B does not quantify the costs of having a broken system or the costs of avoiding it.

Groundwater

Effects to groundwater are not assessed in the analysis performed for Appendix B. Decreases in applied water for agriculture will result in less deep percolation to groundwater, thereby reducing groundwater contribution to stream flow. Because a significant portion of ground water recharge is due to applied irrigation water, there would likely be a significant decrease in stream accretion. This decrease is not reflected in the analysis, therefore the water supply and reservoir impacts are significantly underestimated.

In the absence of available surface water, irrigators will likely pump more ground water to compensate. A large degree of prolonged increases in groundwater pumping will likely lead to lower groundwater tables, and possibly mining of groundwater, throughout the Sacramento River basin. This increase in groundwater pumping and corresponding decrease in stream accretions is not addressed in the Appendix B analysis leading to a significant underestimate of impacts.

Lower groundwater tables will reduce groundwater contribution to stream flow in most streams and rivers throughout the Sacramento Valley. There are many smaller

streams that contain critical habitat for endangered species, this habitat may be significantly reduced with decreases in groundwater tables.

Hydro-Power

Decreases in reservoir storage, described above, will reduce hydropower production. In addition to decreases in reservoir elevations, the timing of reservoir releases required to satisfy the proposed flow criteria will result in high flows when power needs are the lowest and greatly reduced flows with power requirements are the greatest. Spring time requirements described in the proposed criteria will cause reservoir releases to exceed power plant capacities, further reducing hydropower production. In addition, low reservoir storage resulting from the proposed flow criteria will likely render power houses useless and force reservoirs to use low level outlets that bypass power houses. The loss of hydropower will require the state to use alternative energy sources, including increases in fossil fuels, which lead to increases in green house gas emissions.

Refuges

Water supply impacts to refuges have not been fully quantified in the Appendix B analysis. However, there will likely be significant reduction in refuge water supply. This may cause reductions in habitat and affect water fowl.

Attachment 1

List of Category A criteria found in the SWRCB Delta Flow Criteria Report:

1. Delta Outflow: 75% unimpaired net Delta outflow from January through June.
2. Sacramento River: 75% unimpaired flow at Rio Vista from April through June.
3. San Joaquin River: 60% unimpaired flow at Vernalis from February through June.
4. San Joaquin River: October 10 day pulse flow at Vernalis of 3600 cfs
5. Delta Exports: Maximum Vernalis flow to export ratio of 0.33 during October pulse flow

List of Category B criteria found in the SWRCB Delta Flow Criteria Report:

6. Delta Outflow: Fall X2 requirements from September through November
7. Delta Outflow: 2006 Bay-Delta Plan Delta outflow objectives
8. Sacramento River: 75% unimpaired flow at Rio Vista from November through March
9. Sacramento River: Wilkins Slough pulse flows starting in November
10. Sacramento River: Positive flows downstream of Georgiana Slough from November through March
11. Sacramento River: 2006 Bay-Delta Plan flow objectives at Rio Vista
12. San Joaquin River: 2006 Bay-Delta Plan October pulse flow at Vernalis
13. OMR Flows: Greater than -1500 cfs during March and June of dry and critical water years
14. OMR Flows: Greater than 0 or -1500 cfs in April and May of dry and critical years depending on the FMWT index for longfin smelt
15. OMR Flows: Greater than -5000 cfs in all water year types from December through February
16. OMR Flows: Greater than -2500 cfs when salmon smolts are present
17. Delta Exports: Vernalis flows to exports ratio greater than 4 when juvenile Salmon are migrating in the San Joaquin River
18. Jersey Point: Positive flows when salmon are present in the Delta
19. Delta Exports: 2006 Bay-Delta Plan export to Delta inflow ratio

Scenario A Delta Flow Criteria Implementation

Scenario A implemented criteria 1-4. However, there were differences between the Delta Flow Criteria Report specifications and the CalSim implementation of criteria 3 and 4 as follows: The third criterion, as implemented in the model, required 75% unimpaired flow at Vernalis instead of the specified 60%, and criterion 4, as implemented, required an average October Vernalis flow of 1200 cfs rather than a 10 day pulse flow of 3600 cfs. The fifth criterion was not implemented in Scenario A.

Scenario B Delta Flow Criteria Implementation

Scenario B implements criteria 1-3 of Category A. Unlike Scenario A, Scenario B imposed caps on the unimpaired flow requirements. The caps were 70,023 cfs for Delta outflow (1), 40,000 cfs for Rio Vista flow (2), and 17,000 cfs for Vernalis flow (3). Scenario B does not include criteria 4 and 5 of Category A.

Scenario B implements criteria 6, 7, 8, 11, 12, 13, and 19 from Category B as numbered above. However, some of the implementations require explanation. Criterion 6, the Fall X2 requirement, is the same as the requirement in the current Delta smelt biological opinion. So while it's included in Scenario B, it's also included in Scenario A and the baseline. Criteria 7, 11, 12, and 19 are also included in the baseline and Scenario A as part of the 2006 WQCP. Criterion 8, the November through March Rio Vista unimpaired flow requirement, is limited to the same cap (40,000 cfs) as criterion 2 in Scenario B.

Many of the Category B criteria are dependent on the presence of fish. These criteria -- numbered 9, 10, 14, 16, 17, and 18 above -- are not implemented. However, there is overlap between the OMR criteria in the Delta smelt biological opinion and the OMR criteria recommended in the SWRCB Delta Flow Criteria Report. As such, there are stringent OMR criteria applied from December – March and June in the baseline and both scenarios. Furthermore, the salmon biological opinion sets a minimum Vernalis flow to export ratio of 4 in the months of April and May. As such, Scenario B implements criterion 17 in April and May, just as in the baseline, but does not in March.

Based on Scenario B input, there is another issue to address. An additional unimpaired flow requirement at Vernalis was imposed in Scenario B that was not part of the final SWRCB Delta Flow Criteria Report. The unspecified constraint calls for 75% of unimpaired flow at Vernalis from October through January. According to SWRCB staff, this was part of a previous draft of the criteria but was dropped. Scenario B was not changed to reflect the last minute edit. Therefore, in summation, the differences in flow requirements between Scenario B and the baseline are criteria 1-3 and 8 with the imposed caps on flow requirements, criterion 13, and the unspecified October-January Vernalis flow criteria.

San Joaquin River Vernalis Flow Assumption

In both Scenarios A and B, it was assumed that the necessary reservoir releases would be made and deliveries cut to meet the new San Joaquin River flow criteria at Vernalis (3 and 4). It was also assumed that the baseline flows, when in excess of the proposed criteria, would be maintained. This assumption does not account for the likely reduction in releases during non-criteria months to fill reservoirs depleted by the criteria. Therefore, Scenarios A and B are overstating the water that will be available from the San Joaquin River.

Settlement Contractor and Water Right Delivery Cuts

For both Scenarios A and B, the following reductions were imposed on CVP Settlement Contractor's contract entitlement according to water year type:

Year Type	Reduction
Wet	80%
Above Normal	90%
Below Normal	100%
Dry	100%
Critical	100%

Consumptive use in CVP settlement contractor's place of use was also reduced to prevent large increases in groundwater pumping to replace the lost surface water deliveries.

Reductions were not directly placed on SWP Settlement Contracts or Feather River Water Rights. Instead, consumptive use at the place of use was reduced by water year type:

Year Type	Reduction
Wet	30%
Above Normal	45%
Below Normal	55%
Dry	45%
Critical	45%

The intent was to both reduce surface water deliveries and groundwater pumping.

South of Delta Exports

South-of-Delta exports, except those necessary for health and safety (900 – 1100 cfs), were given a priority one step up from Delta surplus in Scenarios A and B. This means that North-of-Delta reservoirs do not release water to support Delta exports. In Scenarios A and B, exports would otherwise be Delta surplus as defined using the proposed Delta outflow criteria combined with existing flow and water quality regulations.

Other Issues

Stage 1 transfers are included in both the Scenarios and baseline. In Scenario A, there is on average 18 TAF per year more transferred from NOD to SOD. These exports do not come out of Delta surplus. They were probably created with increased groundwater pumping.

There are likely more Sacramento Basin delivery cuts implemented in Scenarios A and B than are being accounted for in Appendix B. For instance, consumptive use at node 17302 and 11306 were cut according to the same schedules listed above for SWP Settlement Contractors. This results in a 123 TAF/yr reduction in surface water diversions that isn't accounted for in Appendix B or in the North-of-Delta delivery calculations in Table 1 and Table 2 of this report.