Economic Impacts of Reduced Delta Exports Resulting from the Wanger Interim Order for Delta Smelt

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Executive Summary

On December 14, 2007, Judge Oliver Wanger issued an Interim Remedial Order Following Summary Judgment and Evidentiary Hearing (the "Interim Order" or the "Wanger Decision"). To protect the threatened Delta smelt, the Interim Order restricts water exports from the Delta to agricultural and urban customers of the State Water Project ("SWP") and the Central Valley Project ("CVP").

Modeling based on the California Department of Water Resources' CALSIM II framework is used to measure supply losses in different types of water years. CALSIM II predicts the change in water deliveries over the hydrologic record in California from 1922 to 2003. The supply losses presented here are for the mid-point between the low- and high-flow targets on the Old Middle River specified in the Wanger decision.

In an average water year, the Wanger decision for Delta smelt results in the loss of 586 thousand acre-feet of SWP and CVP supply. Losses can exceed 1 million acre-feet in some wet years. Generally, impacts to the SWP exceed impacts to the CVP in both absolute and proportional terms.

Table A supplies are the basic water supplies delivered by the State Water Project. The Interim Order for Delta smelt significantly reduces the reliability of Table A deliveries. The mean annual reduction in Table A deliveries is 320 thousand acre-feet. Table A deliveries are reduced in nearly all years, and decline by an average of 11%.

The Monterey Amendment stipulates that any SWP contractor is entitled to water available to the SWP when excess water to the Delta exceeds the State Water Project's operational requirements. Article 21 water supplies are severely impacted by the Wanger decision. Article 21 supplies are reduced by 96 thousand acre-feet on average, and are totally eliminated in many years.

Changes in CVP deliveries are evaluated using the same CALSIM II model runs used to calculate impacts to SWP deliveries. The Interim Order reduces CVP water supply by 170 thousand acre-feet in an average year, with an average reduction of 6%.

Generally, the water supply impacts of the Interim Order for Delta smelt are largest in above average water years. Wet year supplies are generally used to replenish groundwater and fill off-stream storage facilities. Thus, the loss of wet year water supplies can have consequences that "spill over" into subsequent dry years.

It should be emphasized that these supply loss estimates only cover restrictions resulting from conservation of the Delta smelt. There are several other species, including salmon and longfin smelt, that are candidates for additional protections that may increase the supply losses presented here. Further, other factors such as the revisions to the Long-Term Operations Criteria and Plan for the SWP and CVP will affect water supply reliability as well.

The SWP and CVP are important sources of water supplies to agricultural and urban customers in Southern California, the San Joaquin Valley and the San Francisco Bay Area. This report details the economic effects of the supply restrictions resulting from Delta pumping constraints related to conservation of the Delta smelt. The analysis shows that near term economic effects average more than $500 million annually, and can exceed $3 billion in a prolonged dry period such as the one experienced from 1987-1992.

Municipal and industrial impacts of the Interim Order are calculated using the Least Cost Planning Simulation Model (LCPSIM) developed by the California Department of Water Resources (DWR). LCPSIM measures the change in water supply cost and shortage losses for two regions in California: the San Francisco Bay Area and the South Coast. The South Coast region corresponds roughly to the service area of the Metropolitan Water District of Southern California (MWD). For the San Francisco Bay Area, the version of LCPSIM used in this report includes three South Bay agencies – Santa Clara Valley Water District, Alameda County Water District, and Zone 7 Water District.

LCPSIM allows for water agencies to invest in conservation and alternative water supply programs to cope with future shortages. The model also attempts to capture existing conservation and recycling programs, as well as existing storage and water transfer arrangements. Two configurations of LCPSIM were employed in this analysis. In the short run configuration, recycling, conservation and storage programs are set at current levels, and spot water transfers can be implemented to avoid shortages. In the long run configuration of LCPSIM, agencies can make additional investments in conservation and alternative water supply options to enhance reliability and reduce shortage losses.

The South Coast region is especially vulnerable to the water supply losses resulting from Interim Order. LCPSIM calculates these losses at $467.3 million per year on average, assuming current levels of demand, conservation, storage and recycling. These costs result from a combination of increased water rates and an increased frequency of episodes of rationing and mandatory conservation. Over a longer horizon, as water agencies in the South Coast region have time to make desired investments in conservation, recycling and alternative supplies in response to the Interim Order, average annual losses can be brought under $100 million.

The actual impacts of the Wanger decision to urban water users will depend on whether future years are wet or dry. While the average near-term impacts are $467.3 million, annual losses could exceed $3 billion should the state enter a prolonged dry period, such as the one experienced in 1987-1992. Thus, the Interim Order poses significant new risks to Southern California's water system. In the long run scenario, annual losses to South Coast water consumers can still exceed $800 million in a drought.

LCPSIM calculates generally smaller impacts to the southern San Francisco Bay Area agencies: roughly $5 million per year under the short-run scenario and $1 million per year in the long-run. In a long-term drought, annual impacts to Bay Area agencies can reach $200 million. Bay Area agencies have already made significant investments in local and San Joaquin Valley groundwater storage and recovery projects. These projects provide a water supply reserve that helps them cope with the supply losses imposed by the Interim Order.

The analysis of agricultural impacts was conducted using the Central Valley Production Model (CVPM), a standard modeling framework used to assess changes in farm water supplies in California. Combining effects across SWP and CVP service areas, CVPM calculates average economic losses as $48.4 million annually. Farmers will cope with reduced water supplies in part by reducing levels of crop production (i.e., fallowing) and job losses will occur as a result. The analysis addresses these anticipated lob losses by using the IMpact analysis for PLANning (IMPLAN) model developed by the U.S. Forest Service. IMPLAN calculates that 720 jobs will be lost in the San Joaquin Valley as a result of the Interim Order. The large majority of these farm jobs are held by low-wage workers living in economically depressed areas.

Table ES-1 summarizes the economic impacts of the water supply losses resulting from Judge Wanger's Interim Order. In the short-run, the Interim Order results in economic losses greater than $500 million per year, most of which occur in the South Coast region. Losses are, however, distributed widely across the State. Extensive preventive investments in conservation, recycling and more aggressive banking and transfer programs in urban areas reduce expected losses to around $140 million annually.

Table ES-1: Summary of Average Annual Economic Impacts

Sector	**Annual Impact (millions)**
Agriculture	$48.4
Municipal & Industrial	
South Coast	
Short Run	$467.3 (maximum $3 billion)
Long Run	$90.3 (maximum $839 million)
San Francisco Bay Area	
Short Run	$5.4 (maximum $200 million)
Long Run	$1.2 (maximum $44 million)
Total: Short Run	$521.1
Total: Long Run	$139.9

I. Introduction

On December 14, 2007, Judge Wanger of the United States District Court for the Eastern District of California issued an Interim Remedial Order Following Summary Judgment and Evidentiary Hearing (the "Interim Order" or the "Wanger Decision"). To protect the threatened Delta smelt, the Interim Order remanded the U.S. Fish and Wildlife Service's (FWS) 2005 Biological Opinion on the effects of the Central Valley Project (CVP) and State Water Project (SWP) on the Delta smelt. The conditions in the Interim Order were to remain in place until the FWS issued a new Biological Opinion on September 15, 2008. The deadline to issue the new Biological Opinion subsequently was extended to December 15, 2008.

The conditions that have the greatest affect on water exports from the Sacramento-San Joaquin Rivers Delta (the Delta) are as follows:

1. During the winter, when the average daily water turbidity in the Delta exceeds 12 nephelometric turbidity units (NTUs), the Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR) must modify "winter

pulse flow" operations of the CVP and SWP to achieve an average net upstream (reverse) flow in Old and Middle Rivers (OMR) that is less than 2,000 cubic feet per second (cfs), as long as the three-day average flow in the Sacramento River is less than 80,000 cfs. This modified operation flow remains in place for ten days, or when one of three conditions (based on environmental factors) is met.

2. By January 15th, at the conclusion of the winter flow restrictions and before the onset of Delta smelt spawning, Reclamation and DWR must operate the CVP and SWP to achieve a daily average net upstream flow in the OMR of less than 5,000 cfs, as long as the three-day average flow in the Sacramento River is less than 80,000 cfs.
3. Upon the onset of spawning and until June 20th or the entrainment risk to Delta smelt at each pumping facility is abated, Reclamation and DWR have to operate the CVP and SWP to achieve a daily reverse flow in the OMR of between 750 and 5,000 cfs.[1]

In the Courts Findings of Fact and Conclusions of Law Regarding the Interim Remedies for the Delta Smelt ESA Remand and Reconsultation (the "Court Findings of Fact"), which were issued contemporaneously with the Interim Order, the Court determined that when the flow of the OMR is negative and high (i.e. in the direction of the CVP and SWP pumping facilities) Delta smelt are at risk of being drawn toward the facilities where they are entrained. Based on testimony from FWS and DWR, the Court Findings of Fact concluded that this phenomenon is a likely cause of the smelt's record low population in recent years and that it poses a significant threat to the Delta smelt and its habitat.

The Court Findings of Fact stated that the strong negative flows in the OMR and corresponding entrainment of smelt can be mitigated by reducing diversions at the CVP and SWP export facilities. The Court Findings of Fact focused on the benefits to the pre-spawning adult smelt of reducing the winter pulse flows from the facilities and the benefits to larval and juvenile smelt of curtailing water exports from the CVP and SWP from mid-April to mid-May.[2]

II. Impacts to SWP and CVP Water Supplies

The OMR flow targets in the Interim Order will reduce the reliability of SWP and CVP water supplies. This section of the report describes the water supply changes resulting from the Court-imposed restrictions on federal and state pumping from the Delta.

The results described here are based on CALSIM II modeling runs commissioned by the Metropolitan Water District of Southern California ("MWD") in late 2007 and performed by CH2MHill. The CALSIM II framework is the standard hydrologic model used in California water planning. The model evaluates changes to project operations over the

[1] United States District Court for the Eastern District of California, "Interim Remedial Order Following Summary Judgment and Evidentiary Hearing," filed December 14, 2007, accessed at: http://www.fws.gov/sacramento/es/delta_smelt.htm.

[2] United States District Court Eastern District of California, "Findings of Fact and Conclusions of Law RE the Interim Remedies RE: Delta Smelt ESA Remand and Reconsultation," filed December 14, 2007, accessed at: http://www.fws.gov/sacramento/es/delta_smelt.htm.

historic record and uses those data to forecast changes in future deliveries. The model simulation period is 1922 to 2003.

II.A Impacts to SWP Deliveries

State Water Project Table A and Article 21 supplies were modeled under two scenarios: 1) baseline conditions, and 2) the midpoint of the high- and low-OMR flow targets in the Interim Order. It is important to note that baseline conditions used in these runs to not correspond precisely to the analysis in DWR's 2005 Reliability Report. Numerous changes to CALSIM II make the 2005 figures not directly comparable to more recent analyses. Rather, our water supply estimates are based on baseline and post-Wanger runs using the same CALSIM II configuration.

Tables 1 and 2 show the changes in Table A and Article 21 deliveries. The Interim Order significantly reduces the reliability of Table A supplies. The mean annual reduction in Table A deliveries across all simulated years is 320 thousand acre-feet (TAF). Annual Table A deliveries are reduced in nearly all years, with an average reduction of 11%. The range of annual percentage changes varies from -29% to 5%. Article 21 deliveries are more impacted, with an average annual reduction of 96 TAF, or 44%. Article 21 deliveries are totally eliminated in many years.

Figure 1 shows the likelihood of given levels of supply reductions. Figure 1a presents Table A deliveries, which will be reduced in 79 out of 82 simulated years. Article 21 deliveries are shown in Figure 1b. The Interim Order has a greater overall proportional impact on SWP Article 21 deliveries.

Table 1: SWP Table A Deliveries

Year	Baseline (TAF)	Post-Interim Order (TAF)	Change	Year	Baseline (TAF)	Post-Interim Order (TAF)	Change
1922	3,255	2,948	-9%	**1963**	3,226	2,733	-15%
1923	3,317	2,685	-19%	**1964**	2,881	2,524	-12%
1924	1,383	1,377	0%	**1965**	2,679	2,459	-8%
1925	1,357	1,493	10%	**1966**	3,089	2,666	-14%
1926	2,202	2,013	-9%	**1967**	3,357	2,830	-16%
1927	3,181	2,716	-15%	**1968**	3,147	2,705	-14%
1928	3,008	2,633	-12%	**1969**	3,265	3,133	-4%
1929	1,649	1,397	-15%	**1970**	3,381	3,075	-9%
1930	2,014	1,748	-13%	**1971**	3,427	2,658	-22%
1931	1,479	1,413	-4%	**1972**	2,740	2,356	-14%
1932	1,282	1,286	0%	**1973**	2,946	2,590	-12%
1933	1,391	1,408	1%	**1974**	3,305	3,018	-9%
1934	1,484	1,404	-5%	**1975**	3,443	2,913	-15%
1935	2,581	2,261	-12%	**1976**	2,748	2,571	-6%
1936	3,323	2,764	-17%	**1977**	740	733	-1%
1937	3,105	2,669	-14%	**1978**	2,456	2,296	-6%
1938	3,332	3,157	-5%	**1979**	3,247	2,810	-13%
1939	3,116	2,829	-9%	**1980**	2,974	2,735	-8%
1940	3,188	2,684	-16%	**1981**	2,954	2,479	-16%
1941	3,464	3,014	-13%	**1982**	3,229	2,960	-8%
1942	3,446	3,021	-12%	**1983**	3,498	3,431	-2%
1943	3,171	2,845	-10%	**1984**	3,445	3,093	-10%
1944	3,062	2,503	-18%	**1985**	3,170	2,675	-16%
1945	3,065	2,550	-17%	**1986**	2,729	2,601	-5%
1946	3,171	2,743	-14%	**1987**	2,642	2,483	-6%
1947	2,568	2,410	-6%	**1988**	1,474	1,130	-23%
1948	2,351	2,071	-12%	**1989**	2,286	1,955	-14%
1949	2,255	2,158	-4%	**1990**	1,704	1,461	-14%
1950	2,449	2,084	-15%	**1991**	948	672	-29%
1951	3,273	2,764	-16%	**1992**	1,290	1,004	-22%
1952	3,431	3,020	-12%	**1993**	2,701	2,330	-14%
1953	3,385	2,948	-13%	**1994**	2,851	2,375	-17%
1954	3,325	2,705	-19%	**1995**	3,156	2,893	-8%
1955	2,105	1,824	-13%	**1996**	3,295	3,036	-8%
1956	2,720	2,554	-6%	**1997**	2,786	2,714	-3%
1957	2,969	2,510	-15%	**1998**	3,196	3,058	-4%
1958	3,211	2,935	-9%	**1999**	3,314	2,968	-10%
1959	3,122	2,820	-10%	**2000**	3,309	2,863	-13%
1960	2,579	2,045	-21%	**2001**	2,495	1,893	-24%
1961	2,403	2,253	-6%	**2002**	2,265	2,071	-9%
1962	2,542	2,479	-2%	**2003**	3,140	2,517	-20%

Table 2: SWP Article 21 Deliveries

Year	Baseline (TAF)	Post-Interim Order (TAF)	Change	Year	Baseline (TAF)	Post-Interim Order (TAF)	Change
1922	307	0	-100%	**1963**	119	0	-100%
1923	0	84	NA	**1964**	0	0	0%
1924	0	0	0%	**1965**	276	155	-44%
1925	483	66	-86%	**1966**	275	0	-100%
1926	274	0	-100%	**1967**	236	69	-71%
1927	169	0	-100%	**1968**	728	534	-27%
1928	33	0	-100%	**1969**	351	468	33%
1929	0	0	0%	**1970**	604	545	-10%
1930	383	0	-100%	**1971**	0	0	0%
1931	0	0	0%	**1972**	0	9	NA
1932	516	119	-77%	**1973**	334	128	-62%
1933	563	150	-73%	**1974**	233	166	-29%
1934	154	0	-100%	**1975**	282	0	-100%
1935	376	0	-100%	**1976**	0	188	NA
1936	106	0	-100%	**1977**	0	0	0%
1937	164	66	-60%	**1978**	956	417	-56%
1938	263	323	23%	**1979**	128	0	-100%
1939	145	77	-47%	**1980**	279	593	113%
1940	120	0	-100%	**1981**	142	0	-100%
1941	168	49	-71%	**1982**	239	386	61%
1942	215	140	-35%	**1983**	1,165	1,159	-1%
1943	472	464	-2%	**1984**	979	877	-10%
1944	1	0	-100%	**1985**	0	0	0%
1945	0	77	NA	**1986**	307	148	-52%
1946	0	0	0%	**1987**	40	0	-100%
1947	0	0	0%	**1988**	0	0	0%
1948	0	0	0%	**1989**	79	0	-100%
1949	0	0	0%	**1990**	0	0	0%
1950	75	0	-100%	**1991**	0	0	0%
1951	297	417	40%	**1992**	0	0	0%
1952	262	81	-69%	**1993**	332	0	-100%
1953	514	345	-33%	**1994**	0	0	0%
1954	76	0	-100%	**1995**	159	0	-100%
1955	0	0	0%	**1996**	588	426	-28%
1956	710	520	-27%	**1997**	306	236	-23%
1957	0	0	0%	**1998**	363	72	-80%
1958	393	442	13%	**1999**	707	606	-14%
1959	312	0	-100%	**2000**	186	0	-100%
1960	0	0	0%	**2001**	122	0	-100%
1961	281	29	-90%	**2002**	0	14	NA
1962	168	0	-100%	**2003**	0	0	0%

Change in the SWP Table A Deliveries

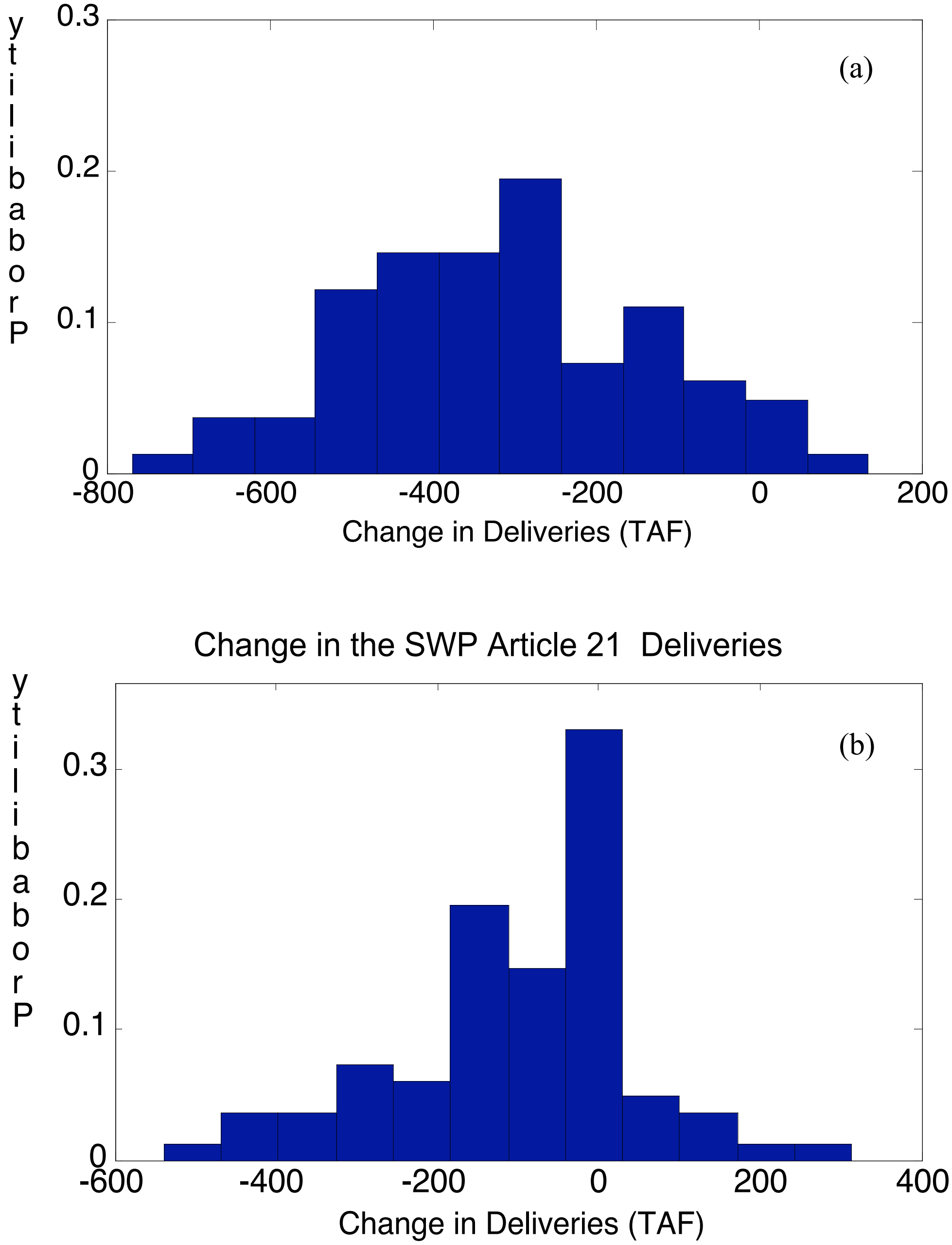


Figure 1: Change in SWP Table A and Article 21 Deliveries Resulting from the Interim Order

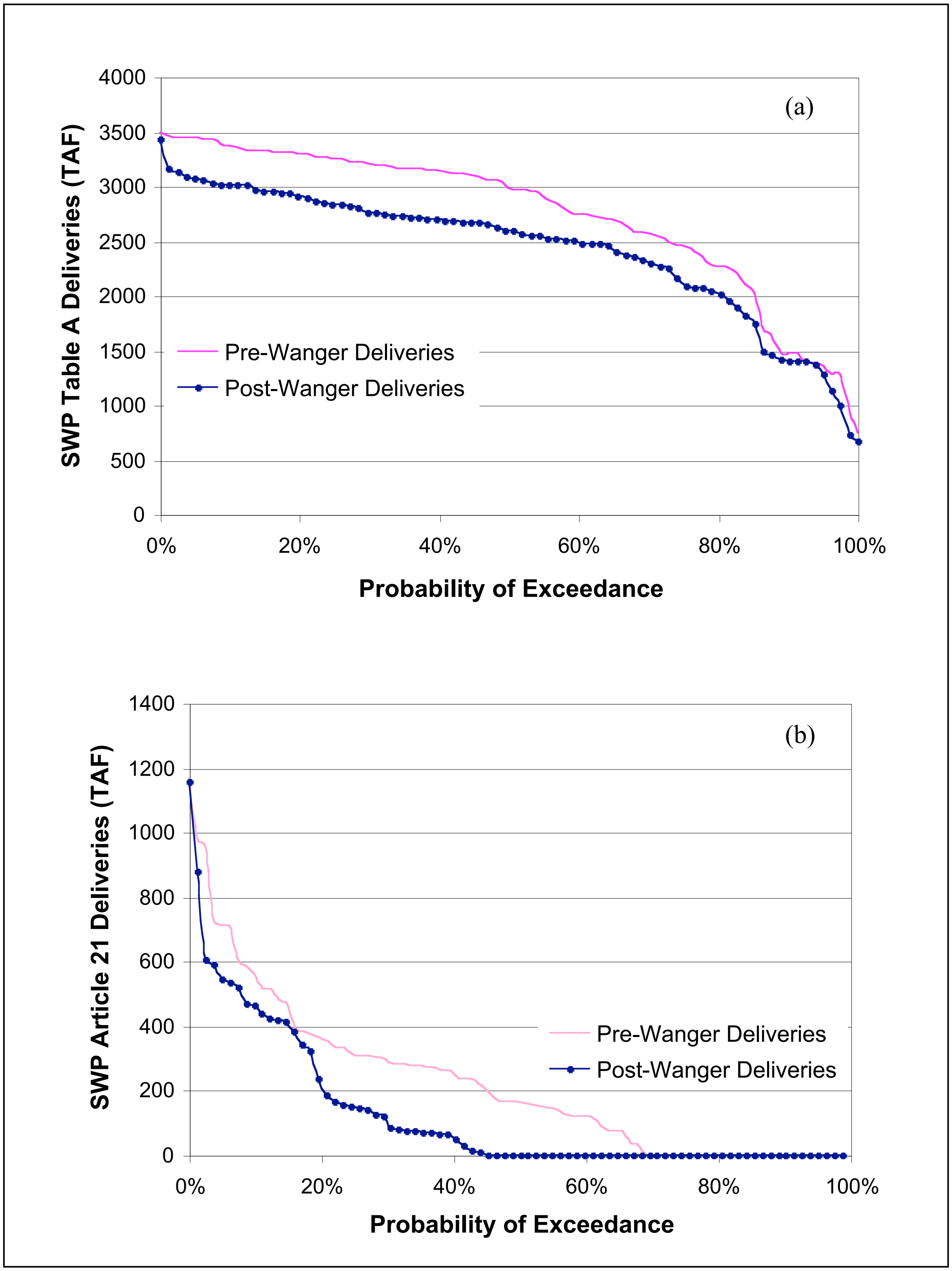


Figure 2: Probability of Exceedance for SWP Table A and Article 21 Deliveries Before and After the Wanger Decision

The Interim Order will also affect surplus deliveries. Projected deliveries from the SWP are published each year and vary depending on the amount of water available and the predicted level of precipitation. Figures 2a and 2b illustrate the probability of SWP deliveries exceeding the certain annual levels in the future.

As shown in Figure 2a for Table A deliveries, the probability of exceedance is greater than 80% for deliveries less than 2,000 TAF. This circumstance implies that SWP Table A deliveries in wet and average years (where deliveries are above 2,000 TAF) will be reduced more than deliveries in dry years (where deliveries are below 2,000 TAF).

II.B Impacts to CVP Deliveries

Changes to CVP deliveries are evaluated using the same CALSIM II model runs used to calculate impacts to SWP deliveries. As shown in Table 3, the Interim Order changes CVP deliveries between -24% to 5%, with an average reduction of 6%. This mean reduction is less than that predicted for the SWP.

Figure 3 depicts annual reductions in CVP supplies. The Interim Order reduces annual CVP deliveries by an average of 170 TAF. The CALSIM II runs indicate that deliveries decreased in 74 of the 82 simulated years.

Figure 4 shows the impact of the Interim Order on the probability that annual CVP supplies exceed given levels. For instance, there is roughly a 70% chance that the total CVP supply will exceed 2,500 TAF in the baseline; this probability is reduced to roughly 40% under the Interim Order.

Table 3: CVP Deliveries

Year	Baseline (TAF)	Post-Interim Order (TAF)	Change	Year	Baseline (TAF)	Post-Interim Order (TAF)	Change
1922	3,268	2,943	-10%	**1963**	2,877	2,460	-14%
1923	2,976	2,560	-14%	**1964**	2,495	2,354	-6%
1924	1,603	1,514	-6%	**1965**	2,738	2,498	-9%
1925	2,112	2,112	0%	**1966**	2,844	2,556	-10%
1926	1,960	1,964	0%	**1967**	3,229	2,866	-11%
1927	2,647	2,344	-11%	**1968**	3,042	2,715	-11%
1928	2,848	2,480	-13%	**1969**	3,401	3,339	-2%
1929	1,806	1,795	-1%	**1970**	2,978	2,882	-3%
1930	1,955	1,942	-1%	**1971**	2,652	2,295	-13%
1931	1,470	1,464	0%	**1972**	2,772	2,507	-10%
1932	1,418	1,337	-6%	**1973**	2,751	2,478	-10%
1933	1,288	1,267	-2%	**1974**	3,017	2,880	-5%
1934	1,326	1,392	5%	**1975**	2,825	2,502	-11%
1935	1,962	1,972	1%	**1976**	2,058	1,983	-4%
1936	2,495	2,388	-4%	**1977**	1,433	1,432	0%
1937	2,312	2,324	0%	**1978**	2,965	2,760	-7%
1938	3,258	3,268	0%	**1979**	2,874	2,686	-7%
1939	2,582	2,481	-4%	**1980**	3,090	2,985	-3%
1940	2,571	2,405	-6%	**1981**	2,977	2,630	-12%
1941	2,973	2,911	-2%	**1982**	3,365	3,278	-3%
1942	3,024	2,867	-5%	**1983**	3,396	3,394	0%
1943	3,178	2,911	-8%	**1984**	2,960	2,788	-6%
1944	2,480	2,441	-2%	**1985**	2,680	2,421	-10%
1945	2,760	2,448	-11%	**1986**	2,806	2,780	-1%
1946	2,725	2,461	-10%	**1987**	2,474	2,437	-1%
1947	2,452	2,360	-4%	**1988**	1,815	1,834	1%
1948	2,593	2,202	-15%	**1989**	2,098	1,862	-11%
1949	2,730	2,417	-11%	**1990**	1,604	1,544	-4%
1950	2,386	2,221	-7%	**1991**	1,468	1,441	-2%
1951	2,786	2,572	-8%	**1992**	1,926	1,473	-24%
1952	3,236	3,178	-2%	**1993**	2,542	2,394	-6%
1953	2,824	2,659	-6%	**1994**	2,843	2,473	-13%
1954	2,788	2,483	-11%	**1995**	3,225	3,153	-2%
1955	2,380	2,249	-6%	**1996**	3,250	3,159	-3%
1956	2,762	2,704	-2%	**1997**	2,865	2,817	-2%
1957	2,919	2,612	-10%	**1998**	3,255	3,247	0%
1958	3,245	3,151	-3%	**1999**	2,914	2,762	-5%
1959	2,916	2,593	-11%	**2000**	2,925	2,582	-12%
1960	2,173	2,019	-7%	**2001**	2,399	2,396	0%
1961	2,596	2,215	-15%	**2002**	2,701	2,394	-11%
1962	2,689	2,384	-11%	**2003**	2,680	2,285	-15%

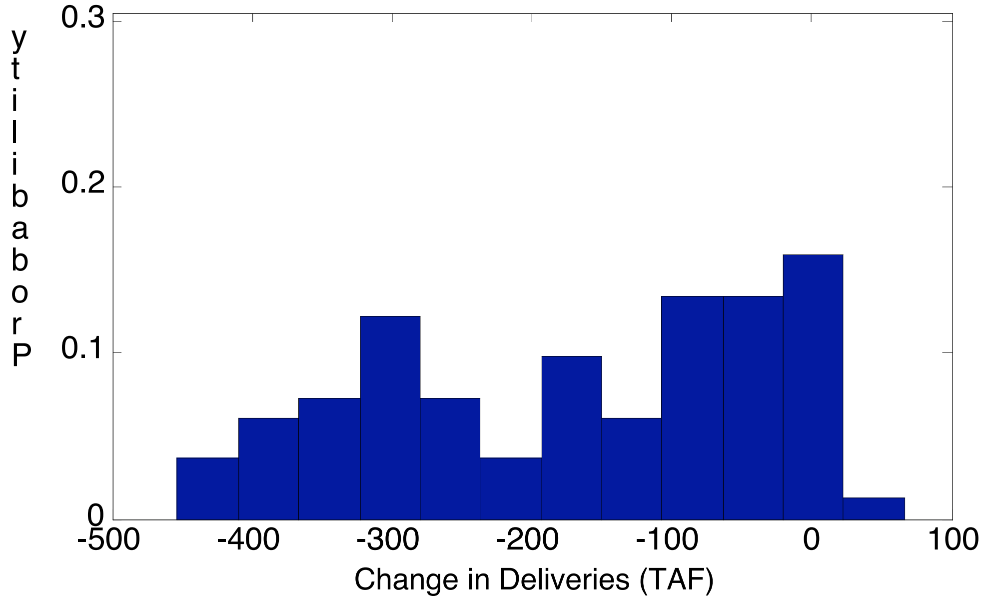


Figure 3: Change in CVP Deliveries Resulting from the Interim Order

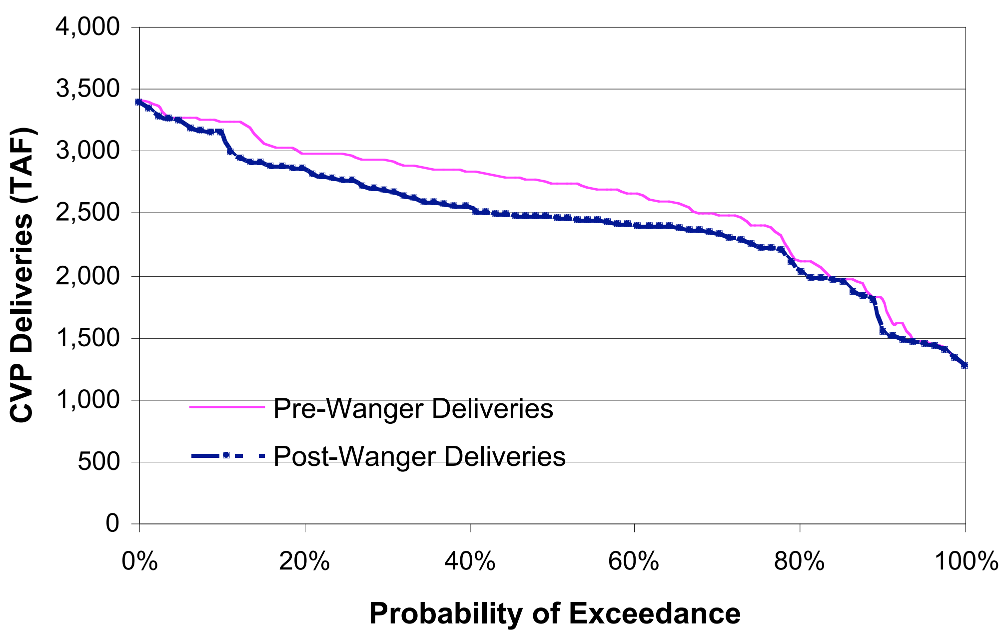


Figure 4: Probability of Exceedance for CVP Deliveries Before and After the Wanger Decision

II.C Summary of Water Supply Impacts

The Interim Order reduces the reliability of water deliveries from both the SWP and CVP. Supply effects are larger in both proportional and absolute terms for the SWP. For both state and federal projects, supply reductions resulting from Delta pumping constraints are largest in years with near-average water supplies. SWP Article 21 deliveries are significantly decreased by the Interim Order, and are eliminated entirely in many years.

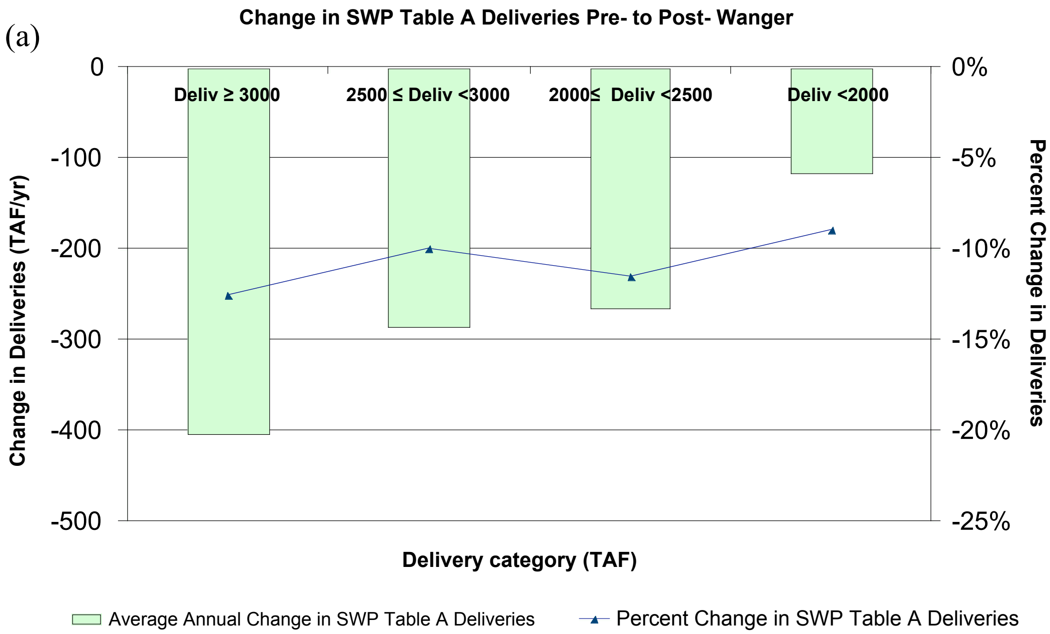
Table 4: Change in CVP and SWP Table A Deliveries for Different Water-Year Types

Delivery Project		Water-Year	Total change in deliveries (TAF/yr)	Percent change in deliveries
Delivery Project	SWP Table A	Wet	-319	-10%
		Above Average	-414	-14%
		Below Average	-399	-14%
		Dry	-277	-11%
		Critical	-183	-11%
		Average across all year types	318	-11%
	CVP	Wet	-146	-5%
		Above Average	-263	-9%
		Below Average	-238	-9%
		Dry	-146	-6%
		Critical	-86	-5%
		Average across all year types	170	-6%

Table 4 summarizes the impact of the Interim Order on SWP Table A and CVP deliveries for various water-year types. While the Interim Order results in a larger percentage reduction of SWP supplies, the absolute and proportional reductions occurring on both systems are largest in above average and below average water-years. The number of years in which Table A deliveries are less than 2,000 TAF/yr increases by 25%.

SWP and CVP deliveries were divided into various intervals and the impact of the Interim Order within each interval was evaluated. The pattern of reductions is somewhat different than that shown in Table 4 due to the difference in observing delivery amounts as opposed to water-year categories. Figure 5(a) shows that for the SWP, the largest absolute supply reductions occur in the years with the largest deliveries, and that fairly equal proportional reductions in deliveries occur across the spectrum of supply quantities. The pattern of supply reductions is different for the CVP, as shown in Figure 5(b). The largest absolute reductions in federal water deliveries occur in years with baseline deliveries between 2,500 and 3,000 TAF. In the years with the smallest baseline deliveries, the Interim Order reduces CVP supplies by less than 5%.

(a)



(b)

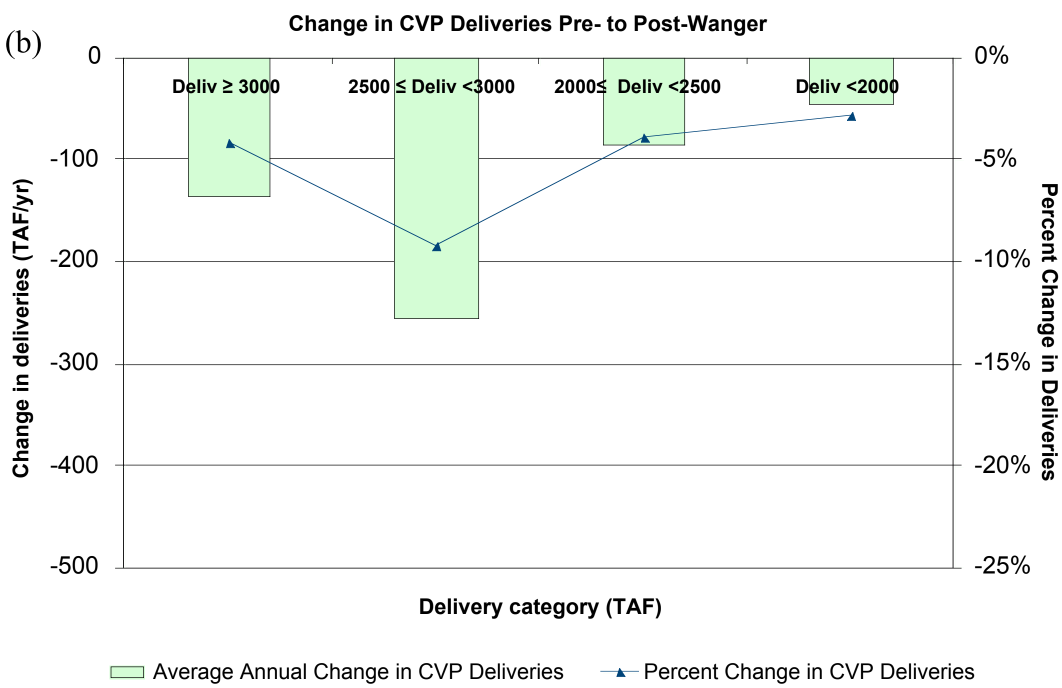


Figure 5: Average Annual and Percent Change in Various Delivery Levels (a) SWP and (b) CVP

III. Direct Economic Costs of Reductions in M&I Water Supplies

Impacts to municipal and industrial (M&I) customers receiving Delta exports are calculated using the Least-Cost Planning Simulation Model (LCPSIM) developed and maintained by the California Department of Water Resources and CH2MHill. LCPSIM is similar to load-planning models used in the electricity industry, and simulates a dynamically optimal portfolio of water supplies.

LCPSIM has been developed for two regions in California: the South Coast and the San Francisco Bay Area. In this report, we consider only the southern portion of the Bay Area to focus attention on the urban contractors receiving water via the South Bay Aqueduct. These agencies include Alameda County Water District, Santa Clara Valley Water District and Zone 7 Water District. The study regions are shown in Figure 6.

Figure 6: LCPSIM Model Regions

III.A Model Framework

LCPSIM is a yearly time-step simulation model that was developed to estimate the economic benefits and costs of improving urban water service reliability at the regional level. The primary objective of the model is to develop an economically efficient regional water management plan by minimizing the total cost of reliability management (see Figure 7 below for illustration of LCPSIM's cost minimization objective). The total cost is the sum of two categories: the cost of reliability enhancement and the cost of unreliable service associated with water shortage events.

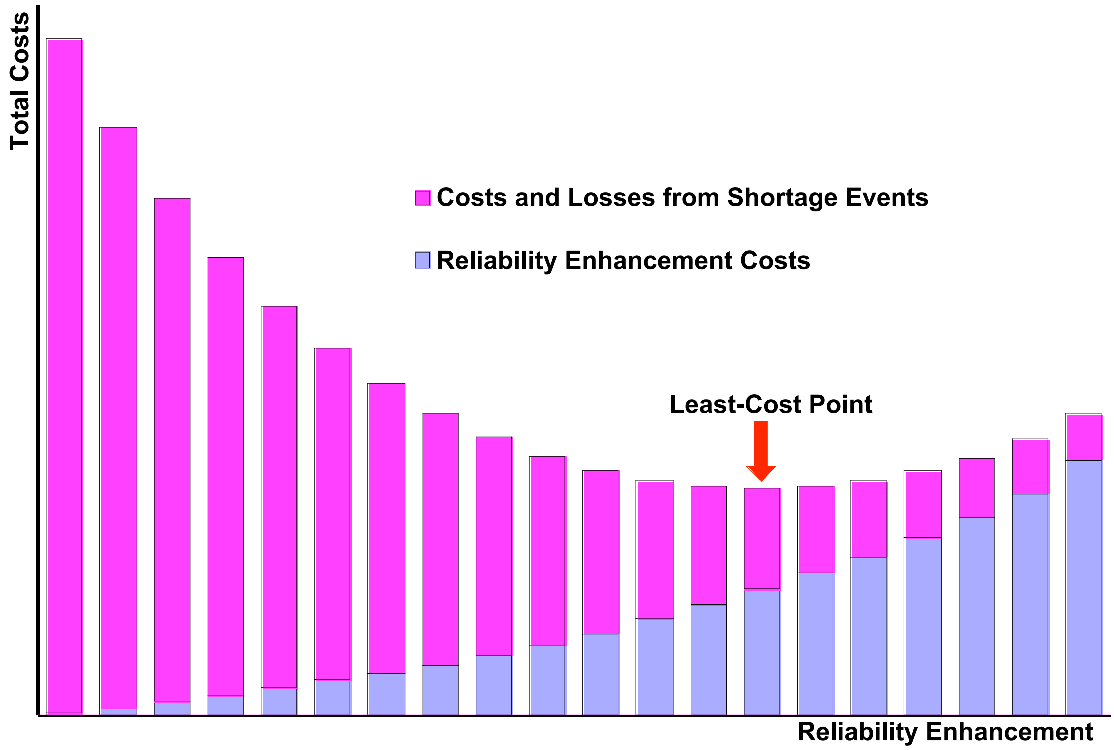


Figure 7: LCPSIM: The Effect of Increasing Reliability on Cost[3]

Water supply reliability can be achieved through demand reduction and through supply augmentation, including recycling, groundwater storage and recovery, and water transfers. The cost of reliability enhancement is comprised of three elements: the cost of reliability enhancements such as conservation and recycling, the cost of system operations, and the cost of buying and transferring water. The cost of unreliability is the welfare cost to consumers of a water shortage.[4] LCPSIM optimizes the degree of reliability over the entire simulation period by determining the portfolio of reliability-enhancing investments that minimizes the cost of these investments plus the cost of shortage in the event that demand cannot be satisfied.

LCPSIM allows for a number of conservation and recycling investments to be made to cope with water scarcity. These investments all require capital expenditures to complete, and will take a number of years to implement. The unit costs of these investments vary considerably, and are described in detail in the LCPSIM manual.[5]

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[3] LCPSIM manual- http://www.economics.water.ca.gov/downloads/Models/LCPSIM_Draft_Doc.pdf.

[4] To access these parameters in LCPSIM: (1) cost of reliability enhancement options: from the *RUN/VIEW* menu, select *VIEW SUMMARY RESULTS* and then *FULL DISPLAY*; (2) system operation costs: from the *RUN/VIEW* menu, select *VIEW LC INCREMENT RESULTS*; (3) cost of buying and transferring water: from the *RUN/VIEW* menu, select *VIEW OPERATION TRACE (Excel only)* and open the *LC Result Report* sheet; and (4) cost of a water shortage: from the *RUN/VIEW* menu, select *VIEW OPERATION TRACE (Excel only)* and open the *LC Result Report* sheet.

[5] LCPSIM manual- http://www.economics.water.ca.gov/downloads/Models/LCPSIM_Draft_Doc.pdf.

Spot water transfers from the Central Valley are also available to address potential water shortages. For the South Coast region, we set these transfers at a maximum of 600 TAF per year in the baseline. The Interim Order impacts the potential size of the spot water market because of restrictions on through-Delta conveyance. Hence we decreased the maximum water transfers to 300 TAF for the post-Interim Order scenario. For the San Francisco Bay Area region, we set water transfer limits at 50 TAF. While these transfer volumes are considerably higher than direct transfers to MWD and Bay Area water agencies in recent years, note that they are theoretical limits and LCPSIM endogenously determines how much water to transfer to minimize costs.

Direct impacts on M&I users are calculated under two scenarios which we term short-run and long-run. In the short-run scenario, it is assumed that water transfers and currently existing storage, conservation and recycling programs are available to deal with periodic shortage. In the long-run scenario, we allow for investment in the full range of conservation, recycling and groundwater storage options specified in the South Coast and Bay Area versions of LCPSIM.

Our rationale for distinguishing between short- and long-run impacts is to highlight the central role of investments in conservation, recycling and transfer/storage opportunities. While such options may be technically feasible, they take time to implement. In the case of certain recycling facilities or groundwater storage programs, for instance, the time to permit and build these options may be a decade or more. The Interim Order may have significantly larger costs should a drought occur before these options are constructed.

Moreover, the current legal climate with respect to water supplies in California is not ideal for making billions of dollars in capital investments. The Interim Order is relatively recent, and it is unclear how DWR and USBR intend to deal with the associated pumping restrictions. A state program of investment in alternative conveyance in the Delta, for example, would leave many such investments “stranded” in the sense that they would not be ex post optimal. Water agencies may wait to see how events in the Delta play out before committing their ratepayers to significant investments in new recycling, conservation, and storage projects.

III.B Results for the South Coast Region

Table 5 presents a summary of the direct economic impacts in the South Coast Region of the Delta export restrictions specified in the Interim Order. Direct impacts are defined as the sum of cost increases and shortage losses borne by customers.

Table 5: Direct Economic Impacts to the South Coast Region

Impact	Economic Impact Short Run (million $)	Economic Impact Long Run (million $)
Average Direct Impacts	$467.3	$90.3
Average Increase in Water Market Cost	$7.2	$2.7
Average Shortage Losses	$508.6	$46.6
Average Increase in System Operational Cost	-$48.5*	-$24.7*
Average Increase in Option Cost	$0**	$65.7
*The system operational cost decreases due to reduced delivery volumes. ** No options are available in the short-run scenario		

Short-run losses in the South Coast area are $467 million per year on average, according to the LCPSIM. The majority of this cost is in shortage losses experienced by consumers. This result is illustrated by Figure 8 below, which shows South Coast water shortages over the simulation period under the assumption that capital investments are not available to deal with shortages and water transfers are limited to historic quantities. The Interim Order significantly increases the magnitude and frequency of water shortages, implying that it will destabilize water supplies available to this region.

The long-run analysis of the LCPSIM indicates that recycling and conservation options can reduce the cost of the Interim Order to around $90 million annually, on average. Most of the cost under this scenario is accounted for by the investments in conservation and alternative supplies, amounting to $66 million per year. Relative to the short-run scenario, slightly less water is purchased on the transfer market. Average shortage losses are reduced from $509 million to $47 million annually. Figure 9 below compares shortages in the South Coast pre- and post-Interim Order in the long-run scenario.

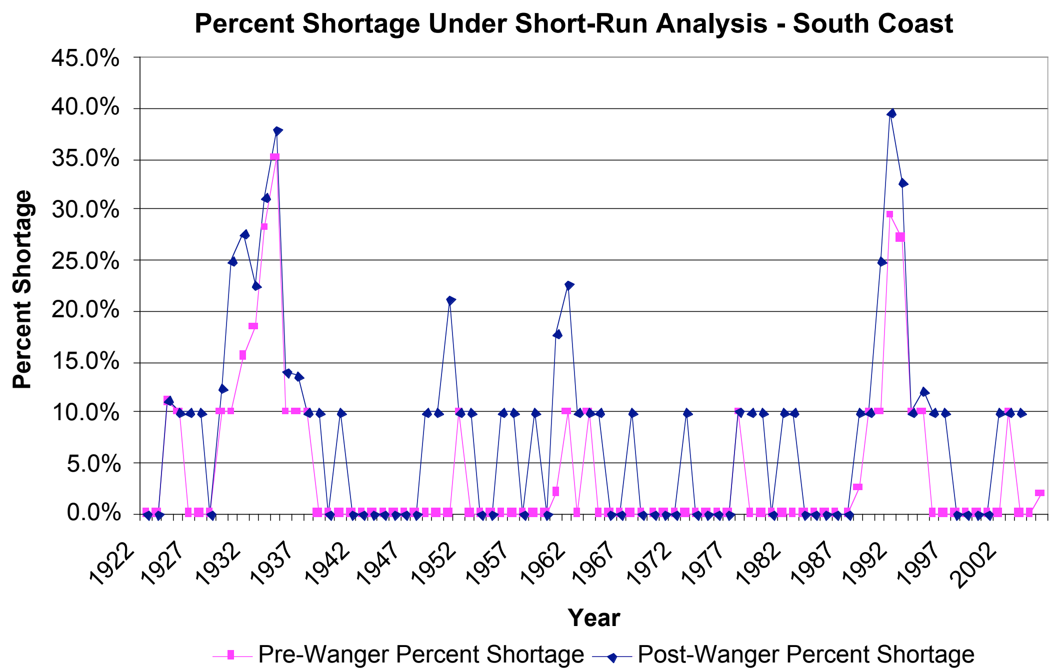

Figure 8: Annual Short-run Percent Shortage in the South Coast Region

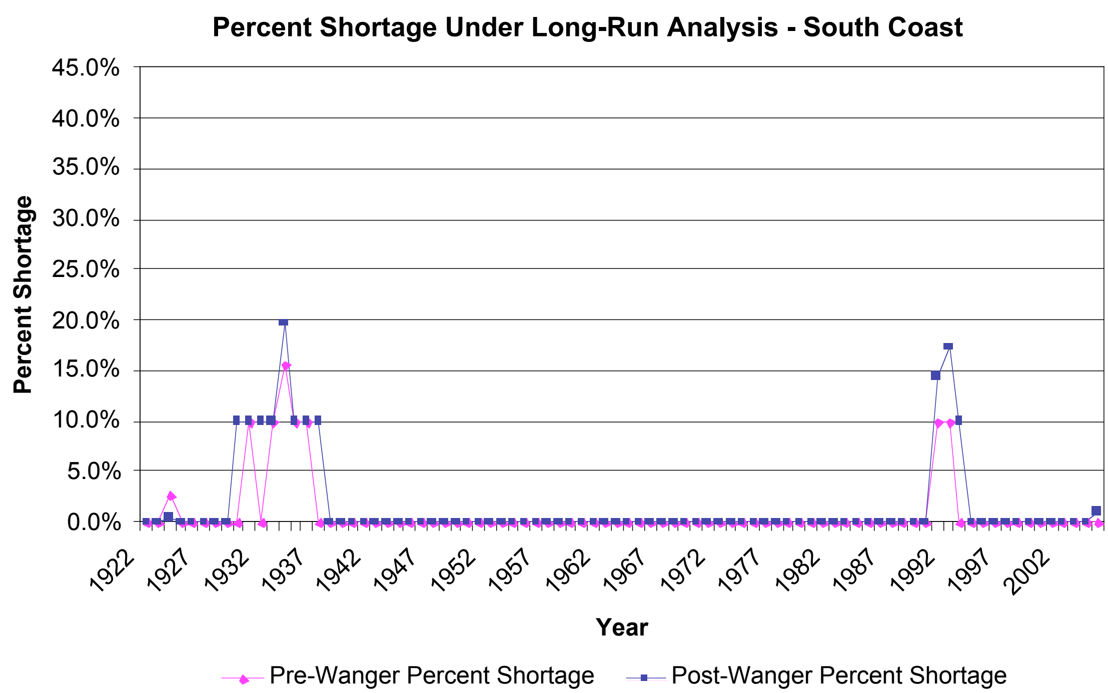

Figure 9: Annual Long-run Percent Shortage in the South Coast Region

The average annual impacts shown in Table 5 are informative. However, the average impacts mask the significant variation in losses experienced over the simulation period.

While the average annual cost to the South Coast Region is $467 million in the short-run scenario, the annual impacts in the same scenario range from -$141 million to $3.02 billion, as shown in Figure 10. Under the long run scenario the annual impacts ranges from - $160 million to $839 million, while the average annual cost to the South Coast Region is $90 million (Figure 11).

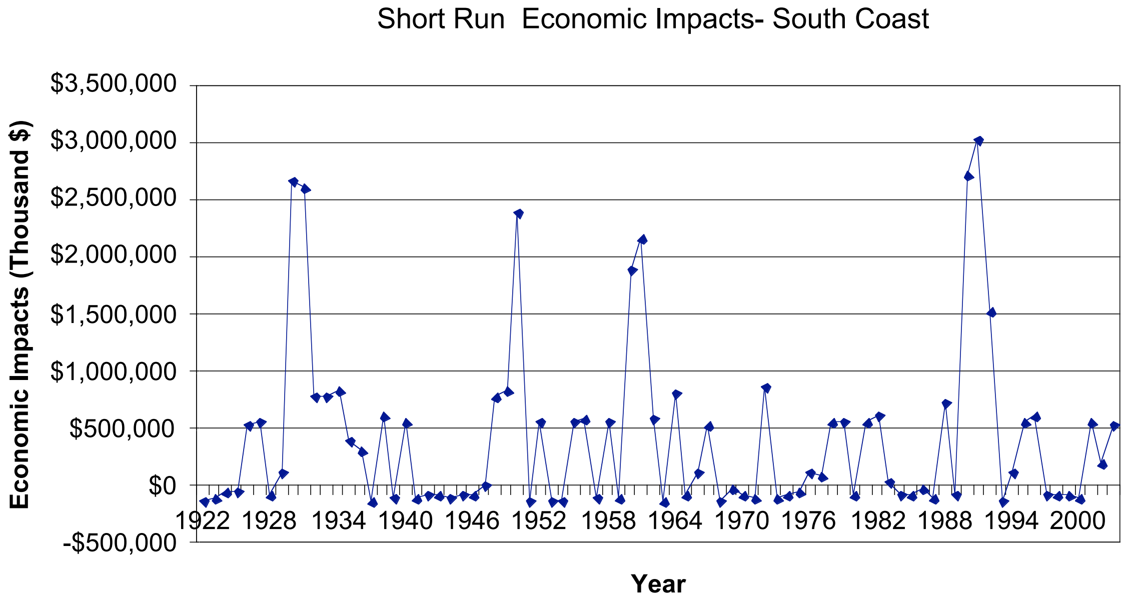

Figure 10: Annual Short-run Economic Impacts in the South Coast Region

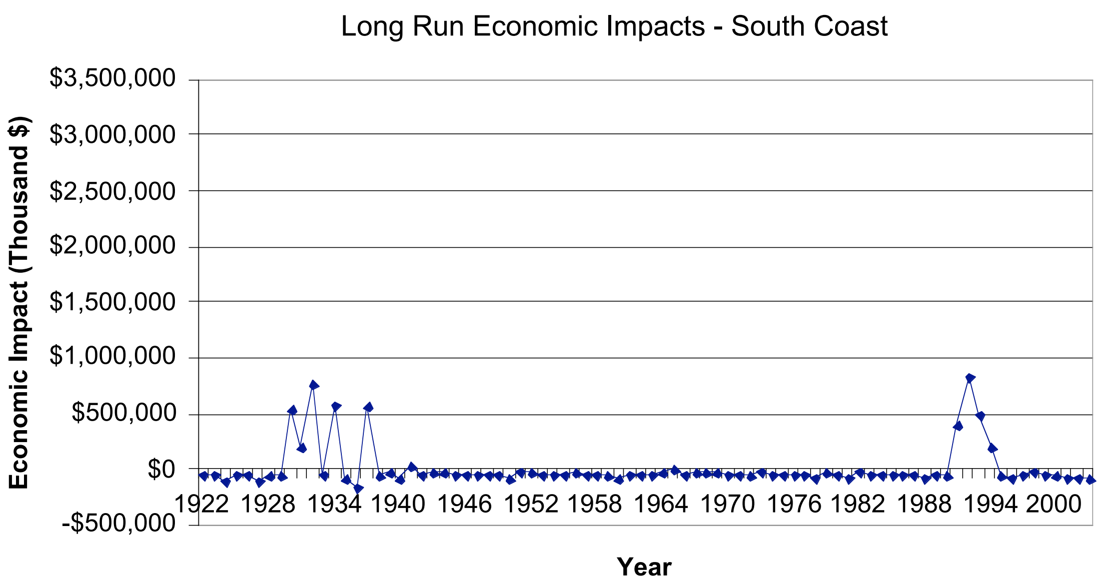

Figure 11: Annual Long-run Economic Impacts in the South Coast Region

This fluctuation in annual impacts highlights the additional risk associated with the Interim Order. If hydrologic conditions are unfavorable in a given year, the Delta export reductions would impose large costs on the South Coast region. With current levels of conservation, recycling and storage, the estimated impacts of the Interim Order exceed $3 billion during a prolonged drought. Even with significant new investments in alternative supplies and additional conservation, annual losses can exceed $800 million during a very dry period.

III.C Results for the San Francisco Bay-South Region

The economic impact of the Interim Order in the San Francisco Bay Area was also evaluated. According to the LCPSIM model, Alameda County and Zone 7 water districts will both be impacted by the restrictions on the SWP deliveries while Santa Clara Valley Water District also will be affected by CVP delivery reductions. San Francisco Bay Area supplies from the SWP were modeled by reducing the SWP Table A and Article 21 deliveries based on the percentage reductions associated with the Interim Order presented in Tables 1 and 2. The change in CVP deliveries resulting from the Interim Order were based on the CVP delivery changes presented in Table 3 and post-processing calculations provided by Santa Clara Valley Water District.

As with the South Coast model, the LCPSIM was run under short- and long-run configurations with the reliability enhancement options available in the long-run scenario. Table 6 presents the direct impacts to the San Francisco Bay Area – South region.

Table 6: Direct Economic Impacts to the San Francisco Bay Area – South Region

Impact	Economic Impact Short Run (million $)	Economic Impact Long Run (million $)
Total Direct Impacts	$5.4	$1.2
Increase in Water Market Cost	$0.5	$0.1
Shortage Losses	$5.6	$0.6
Increase in System Operation Cost	-$0.2*	- $0.8*
Increase in Option Cost	$0**	$1.3

*The system operational cost decreases due to reduced delivery volumes.
** Only current conservation and recycling options are available in the short-run scenario.

The impacts of the Interim Order, as estimated by LCPSIM, are generally smaller in the San Francisco Bay Area region as compared to the South Coast region. This finding is due in part to the fact that Bay Area water agencies have invested heavily in local and San Joaquin Valley groundwater storage facilities (e.g., Semitropic), which provides an effective buffer against the types of supply disruptions considered in this report. Nonetheless, under current conditions, annual losses to Bay Area urban customers can reach $200 million during a multi-year drought.

There are certain features of LCPSIM that may cause the model to underestimate impacts to Bay Area agencies and their customers. Notably, the model aggregates the three principal agencies receiving Delta exports into a single entity. Thus, groundwater storage available to Santa Clara is assumed to be made available to Alameda County Water District as well. In reality, the agencies are more independent, and impacts can be more severe as a result.

In the near term, with current levels of conservation and recycling, the Interim Order imposes average costs on Bay Area customers of $5.4 million annually. Again, annual impacts have a large range, and can reach $200 million during a prolonged drought such as the one experienced between 1987-1992.

Long-run economic impacts for San Francisco Bay Area- South region are illustrated in Figure 13. Even though the estimated average annual impact is $1.2 million, losses can reach over $44 million during a dry period. The sizable difference between the lowest and highest annual costs reflects the impact of the hydrologic sequence on the dynamics of system operations.

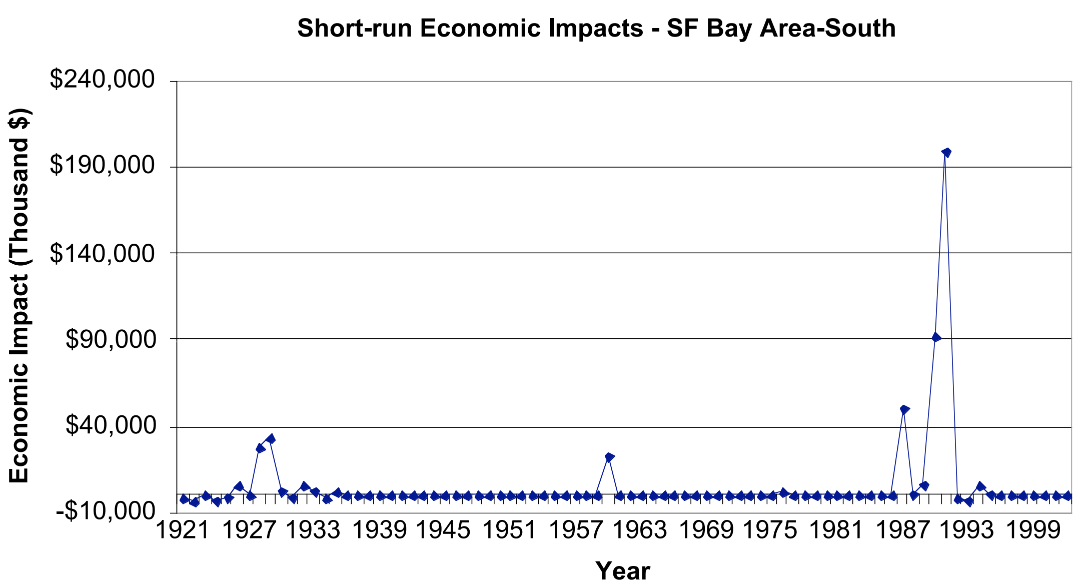

Figure 12: Annual Short-run Economic Impacts in the San Francisco Bay Area – South Region

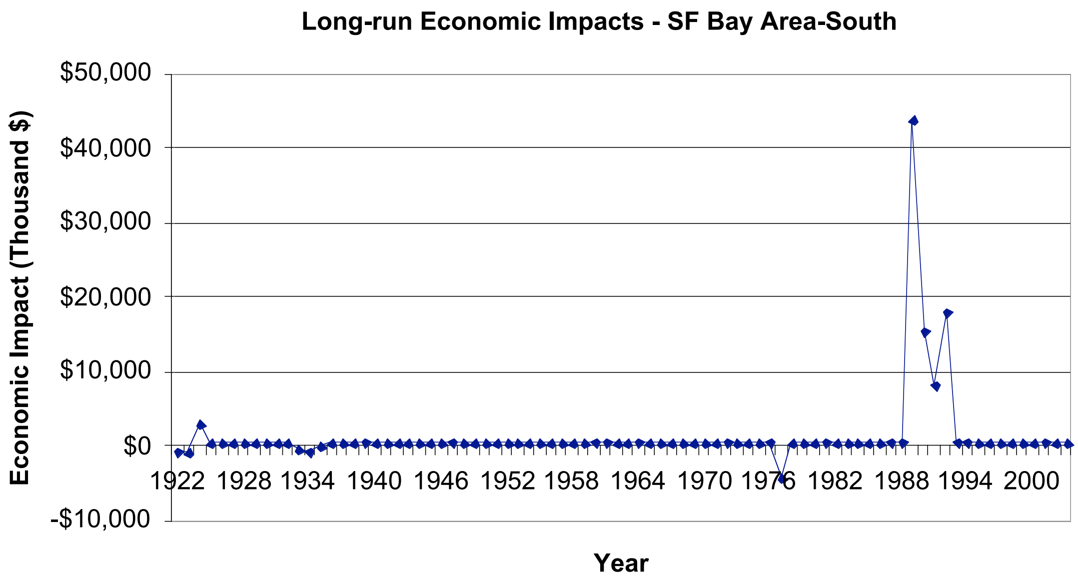

Figure 13: Annual Long-Run Economic Impacts in the San Francisco Bay Area Region

III.D. Indirect Economic Impacts

Indirect economic impacts resulting from changes in M&I deliveries are more complex than impacts resulting from changes in agricultural water supplies. As described above, one of the main responses of urban districts to reduced SWP and CVP deliveries is to increase investment in alternative water supply and conservation options. While such investments increase the cost of water supply and therefore result in an economic loss, they can also stimulate spending and employment in the region.

The changes in water supply costs in the South Coast and San Francisco Bay – South regions presented above are the result of three factors: (1) purchases of replacement water on the water market, (2) development and operation of additional water supply,[6] and (3) changes in system operational costs.[7]

The change in the cost of M&I water supply impacts statewide economic activity in several different ways. First, development and operation of new water supply by M&I water providers increases statewide economic activity. Higher costs for M&I water have the opposite effect on economic activity by reducing household disposable income, local, state, and federal discretionary spending, and potentially corporate profits. The net impact may be positive or negative depending on the import/export connections associated with increased and decreased spending activities of the different economic sectors and

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[6] Primarily recycled water and conservation.

[7] The urban sector analysis also describes changes in levels of consumer surplus resulting from water shortages. Consumer surplus provides a measure of the change in economic welfare, which cannot be directly translated into changes in economic activity. The economic welfare losses from water shortages were therefore excluded from the statewide economic impact analysis.

institutions affected.[8] IMPLAN calculations conducted as part of this study indicate that the net effect of these changes in expenditures is small measured in terms of employment or income.

The incremental water shortages resulting from the Wanger decision may have employment impacts. More frequent shortages may depress economic activity or prompt firms to locate in other regions with a more stable resource base. Calculation of these impacts would require information on how shortages are allocated at the retail level for urban water agencies receiving Delta exports. In the case of Southern California, this exercise would entail going beyond MWD and contacting its member agencies and others receiving SWP water indirectly within the MWD service area.

IV. Direct Economic Costs of Reductions in Agricultural Water Supplies

The agricultural economy in the San Joaquin Valley depends in large part on water exports from the Delta. This section of the report quantifies the direct impacts on agricultural activities resulting from Judge Wanger's Interim Order for Delta smelt.

The Central Valley Production Model (CVPM) was used to estimate the direct economic costs of the Interim Order to agricultural customers receiving water supplies from the Delta. CVPM is an optimization model that simulates the profit-maximizing decisions of growers in the Central Valley, subject to constraints on land and water availability. The analysis considers impacts to growers in both the SWP and CVP service areas. This section describes the procedure used to set up and calibrate the CVPM, and the results of the analysis.

IV.A Central Valley Production Model

This analysis uses the version of CVPM developed for DWRs Common Assumptions for Surface Storage Investigations and specifically being used by Reclamation for evaluating the San Luis Low Point Project. However, that version of CVPM uses data from the base calibration period, consisting of the three water years 1998, 2000, and 2001. All price and cost data had been indexed to 2002 levels. Three significant updates were made to the data for purposes of the analysis here.

IV.A.1 Prices and Production Costs

Real crop prices received by California growers and real input costs have risen dramatically in the last three years relative to their levels in the year 2002. Some portion of the price rise is likely to be temporary and related to droughts and commodity market uncertainty. However, most analysts believe a portion of the price rise is permanent and a result of fundamental shifts in global demand and supply. We do not attempt to identify permanent from temporary changes, but we have escalated crop prices and variable crop production costs up to 2007 levels, using prices paid and prices received indexes

[8] Import/export leakages refer to dollars that flow outside of the regional economy, in this case California, because of sector purchases and disbursements.

published by the U.S Department of Agriculture.[9] Table 7 summarizes the crop and input price escalation factors used.

Table 7: Factors Used to Escalate Crop Prices and Costs

Category	Escalation Factor 2002 to 2007
Crop	
Grain	1.79
Rice	1.79
Cotton	1.45
Sugar Beets	1.03
Corn	1.53
Dry Beans	0.98
Safflower	1.56
Other Field	1.53
Alfalfa	1.53
Pasture	1.53
Processing Tomatoes	1.11
Fresh Tomatoes	1.11
Cucurbits	1.11
Onions and Garlic	1.11
Potatoes	0.98
Other Truck	1.11
Almonds and Pistachios	1.48
Other Deciduous	1.48
Sub Tropical	1.48
Vine	1.48
Input Costs	1.33
Source: USDA National Agricultural Statistics Service, 2008. Prices Paid and Prices Received Indexes.	

IV.A.2 Crop Acreage

Cropping patterns in the San Joaquin Valley have changed substantially since 2000. In particular, the shift toward permanent crops has been large, especially in some of the CVP delivery areas. Crop acreage used for CVPM calibration is based on the detailed land and water use analysis conducted by DWR in support of the California Water Plan update (DWR, 2005). Years 1998, 2000, and 2001 were used in that report. DWR has since updated crop acreage estimates for 2003. Unfortunately, such detailed crop acreage

[9] The National Agricultural Statistics Service (NASS), Agricultural Statistics Board, U.S. Department of Agriculture, “Agricultural Prices, Indexes of Prices Received by Farmers, by Month and Annual Average,” released January 30, 2004, January 31, 2007, and April 30, 2008.

and water use estimates are not available for more recent years. In order to represent the more recent crop mix, additional data sources were used.

Westlands Water District produces and publishes its own crop survey and 2007 acreage is the most recent year available. The most striking changes between the calibration years (1999, 2000, and 2001) and 2007 are:

- Orchard and vineyard acreage increased dramatically. Almond and Pistachio acreage increased by a factor of about 2.5. Total acreage of permanent crops is now almost 120,000 acres, almost one quarter of the irrigated acres in the District (up from about 50,000 in 2000).
- Cotton acreage dropped by almost half, from over 200,000 acres to about 100,000 in 2007.[10]

The Kern County Agricultural Commissioner has also published on its website its most recent (2008) county-wide crop statistics.[11] Whereas these are not broken down by water district or CVPM region, they can be used to create update factors that will produce a better, though not precise, estimate of 2007 crop acres and crop mix. Patterns are similar to those observed for Westlands, though the percentage increase in permanent crops is not as dramatic. Cotton also fell to less than half its acreage of less than a decade earlier. Alfalfa, corn and grain silage, and other field crops also increased substantially. Permanent crops (orchards and vineyards) now represent just over one quarter of the irrigated acres in Kern County.

IV.A.3 Groundwater Pumping

One of the most important issues affecting the cost of surface water reduction is the extent to which growers can replace that loss with groundwater pumping. Unfortunately, no comprehensive and reliable data are gathered on groundwater pumping that can be used to estimate this based on actual observations. In the past, CVPM has been used iteratively with a groundwater model to assess the hydrologic effects of and limitations on groundwater replacement. DWR and others have estimated groundwater pumping based on water balance calculations and on changes in depth to groundwater in observation wells.

Recently, groundwater and agriculture experts estimated the availability of groundwater in the Delta export region to replace a loss of surface water from SWP and CVP delivery facilities.[12] The Delta Risk Management Strategy (DRMS) Phase 1 report used a combination of districts' responses to a survey, water balance and depth-to-water calculations, and groundwater model estimates to derive groundwater pumping parameters by CVPM region. For each region they provided an estimate of monthly and annual pumping capacity, cost, and drawdown. In addition, survey respondents provided an estimate of the portion of their district with access to usable groundwater.

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[10] Westlands Water District 2007 Crop Survey

[11] Kern County Agricultural Commissioner 2008 Crop Statistics

[12] The Delta Risk Management Strategy Phase 1 Report

Westlands Water District makes its own estimates of annual groundwater pumping using a water balance approach (it does not directly measure or collect data on all well pumping in the District). In addition, it provides estimates of other (non-project) surface water acquired by the District or its growers.[13] These estimates, along with irrigated acreage and CVP supply, provide a way to estimate how much of the CVP contract shortage is replaced, on average, by groundwater pumping. Using a simple regression over the 20 years of data provided yields an estimate that 55 percent of CVP contract reduction is made up by groundwater pumping. This is a simple analysis based on numbers that are, themselves, estimates from a water balance rather than direct observations. However, it is the best possible estimate that can be made given the available data.

For other regions, the data are even sparser. For the Delta-Mendota service area, San Joaquin River (SJR) Exchange Contractors and the SWP service areas in Kern and Kings Counties, there are no estimates of how much of a project delivery reduction is replaceable by groundwater pumping, other than through modeling analysis or by the combination of approaches used in the DRMS study. Therefore for these areas, the analysis relies on the DRMS information augmented by informal conversations with local water supply experts. Table 8 summarizes the groundwater assumptions used in the agricultural sector analysis.

Table 8: Groundwater pumping assumptions used for CVPM analysis

CVPM Region	Description – Primary SWP and CVP Delivery Area	Base Condition GW Pumping (TAF)[1]	Maximum Annual Pumping (TAF)[2]	Percent of Project Shortage Replaced by GW[3]
10	Delta Mendota and SJR Exchange Contractors	253	650	15%
14	Westlands Water District	259	895	55%
15	SWP Contractors in Kings County*	1,247	1,900	25%
19	Western Kern Valley Floor	354	665	50%
21	Southern Kern Valley Floor	641	965	50%
Sources: 1. CVPM/Calsim II. 2. DRMS Phase 1 Report (DWR, 2007). 3. DRMS Phase 1 Report (DWR, 2007) and estimate based on WWD data(2007). *Region also includes large areas not served by SWP.				

[13] Westlands Water District annual groundwater pumping estimates.

IV.B Modeling Framework

After CVPM was modified to incorporate the changes just described, the model was run incrementally imposing 5% project (SWP and CVP) supply reductions. CVPM estimated acres taken out of agricultural production, increased groundwater pumping, and the overall value per acre-foot of water supply lost. This last value is also referred to in economics as the marginal value of water, often termed by economists the "shadow price" of water. The shadow price is an estimate of the economic value to agricultural production of one additional acre-foot of water supply. "Economic value to agriculture" in this sense means the additional net revenue and consumer benefits gained from having the extra acre-foot of water available for crop production. Correspondingly, when agricultural water supply is reduced as a result of additional restrictions on Delta exports, the shadow price is an estimate of the economic cost per acre-foot of water supply lost.

CVPM estimates the shadow price of water for each region, based on its internal calculation (estimation) of how growers in that region will respond to a reduction in surface water delivery. In CVPM, the response can be a combination of reduced production, increased groundwater pumping, and increased irrigation efficiency.[14]

The model was run in increments of project water supply reduction in order to generate a spectrum of shadow price estimates that could be applied to different delivery years over the 82-year hydrologic sequence. The shadow price is relatively low in wet and above normal water years and becomes much larger in dry and critically dry years. The rate at which the shadow price increases with increasing shortage depends on the availability and cost of replacement supply (groundwater) and the net revenue of crops that are fallowed rather than irrigated with groundwater (for example, if groundwater is not available or usable, or is more expensive than the crop is worth).

The steps in the analysis were the following:

1. Revise CVPM to incorporate the three data updates described above.
2. Run CVPM in increments of project water reduction, saving the total project water delivered and the shadow price of water. Estimate functional relationship between shadow price and project delivery for SWP and CVP areas.
3. Estimate how much of the total annual SWP or CVP delivery predicted by the CALSIM II runs represents agricultural delivery.
4. Estimate the SWP and CVP agricultural delivery for each year in the CALSIM II pre-Interim Order condition results.
5. Use the CALSIM II-assigned water-year types to calculate an average pre-Interim Order SWP and CVP agricultural delivery by water-year type.
6. Use the functional relationship in step 2 above to calculate the implied shadow price by year type for SWP and CVP agricultural delivery by water-year type (see Figures 14 and 15 below).

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[14] CVPM does not estimate water transfers from outside a region as an endogenous calculation of the model – the quantity of any transferred water must be estimated separately and provided as an input to CVPM. Another version of CVPM does estimate interregional transfers, but that model has not been updated in recent years and is not available for use in this report.

7. Estimate the agricultural portion of delivery *reductions* (difference between pre-Interim Order and post-Interim Order CALSIM II results) by year and calculate the average by water-year type (see Figure 16 below).
8. Multiply the reductions estimated in step 7 by the shadow prices from step 6 to calculate direct agricultural economic costs of the Interim Order, by year type, for both SWP and CVP delivery areas (see Figures 17 and 18 below).

IV.C SWP Agricultural Deliveries

Based on the revisions to allocation and shortage criteria adopted as part of the Monterey Amendments, agricultural and municipal and industrial (M&I) contractors receive equal percentage allocations of their SWP Table A contract amounts.[15] According to the SWP Table A amounts listed in Bulletin 132-05 (California DWR, 2006), contract quantities to agricultural suppliers in the Delta export area are approximately 28% of the sum of SWP agricultural and M&I deliveries. Two other significant SWP delivery quantities in CALSIM II are so-called Article 21 surplus water deliveries and Article 56 voluntary carry-over deliveries. The agricultural proportion of these two categories varies from year to year. For purposes of this analysis, the SWP agricultural deliveries are estimated as a fixed proportion (28%) of total SWP deliveries reported by CALSIM II.

IV.D CVP Agricultural Deliveries

The available CALSIM II results include a time series of the percent of contract quantity delivered to CVP agricultural contractors south of the Delta (excluding San Joaquin River Exchange contract deliveries). For purposes of this analysis, we have used the following assumptions to generate a time series of CVP agricultural deliveries in the Delta export regions:

- All CVP agricultural water service contractors south of the Delta receive the same percent delivery (that is, no transfers, exchanges, or other arrangements among contractors, and no delivery restrictions that would vary the percent of contract delivery across contractors).
- Contract totals are as reported in the Bureau of Reclamation's 2005 Irrigation Rate Book (USBR, 2005).[16]

IV.E Direct Agricultural Impacts

CVPM was used to generate estimates of the marginal value, or shadow price, of water in two regions as surrogates for SWP delivery areas and CVP delivery areas respectively. CVPM Region 19 includes a significant amount of Kern County Water Agency's SWP agricultural delivery. The region includes Belridge Water Storage District, Berrenda Mesa Water District, Devil's Den WD, Lost Hills WD, Semitropic WSD, and portions of

[15] Monterey Amendments
[16] Bureau of Reclamation, Irrigation Rate Book, USBR, 2005; More recent rate books did not report contract maximum quantities as part of their projected deliveries.

Buena Vista WSD and West Kern WD. It receives no CVP delivery and has limited access to other local surface water supplies.

As illustrated in Figure 14, the estimated shadow price of water ranges from about $120 per acre-foot in wet years to just over $200 per acre-foot in critically dry years. These CVPM estimates assume that the available groundwater in the region can be used to offset some of the SWP shortage, either directly or through within-region exchanges. In reality, some areas within this region have good access to groundwater replacement at a lower cost than $200 per acre-foot, while other areas do not and would suffer an economic loss higher than $200 per acre-foot.

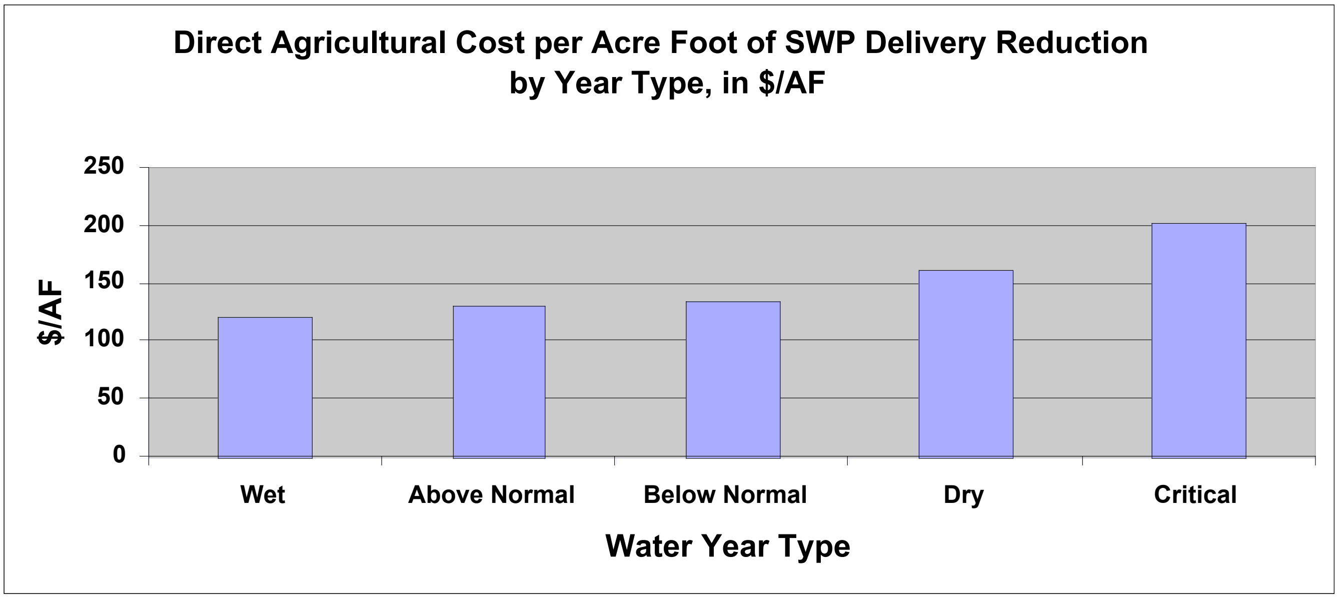

Figure 14: Shadow Price of Water in CVPM Region 19 by Water Year Type

CVPM Region 14 represents Westlands Water District, a CVP water service contractor that receives no SWP water and has limited access to other surface supplies through exchanges and transfers. As illustrated in Figure 15, the marginal value of water, as estimated by CVPM, ranges from $115 per acre-foot in wet years to over $300 per acre-foot in critically dry years. Similar to Region 19 described above, these estimates assume that some limited amount of groundwater is available to replace some of the reductions in CVP supply, either directly or through exchanges within the region. Actual price values will vary across the region.

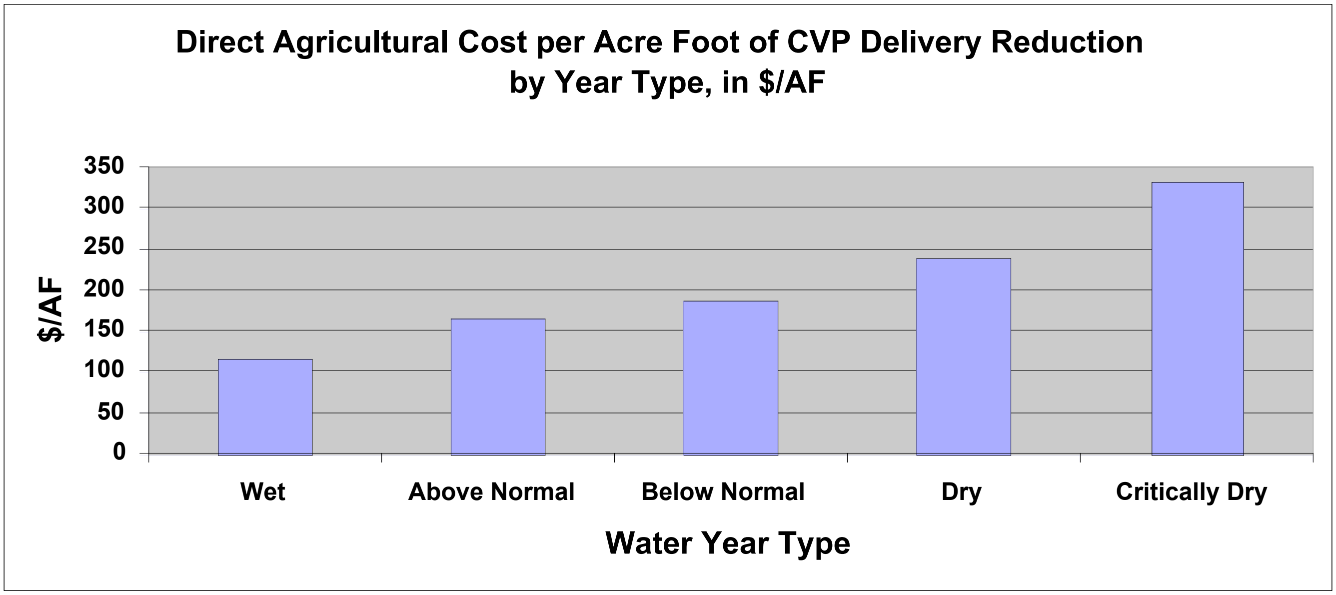

Figure 15: Shadow Price of Water in Westlands Water District by Water Year Type

IV.F Direct Impacts on Agricultural Water Users

The CALSIM II results were used to calculate the difference between deliveries in the pre-Interim Order model run versus the post-Interim Order run. Figure 16 summarizes the total reduction in SWP and CVP deliveries for Delta export irrigation, using the assumptions described above. The largest volume of reductions is in the wet, above-normal, and below-normal years.

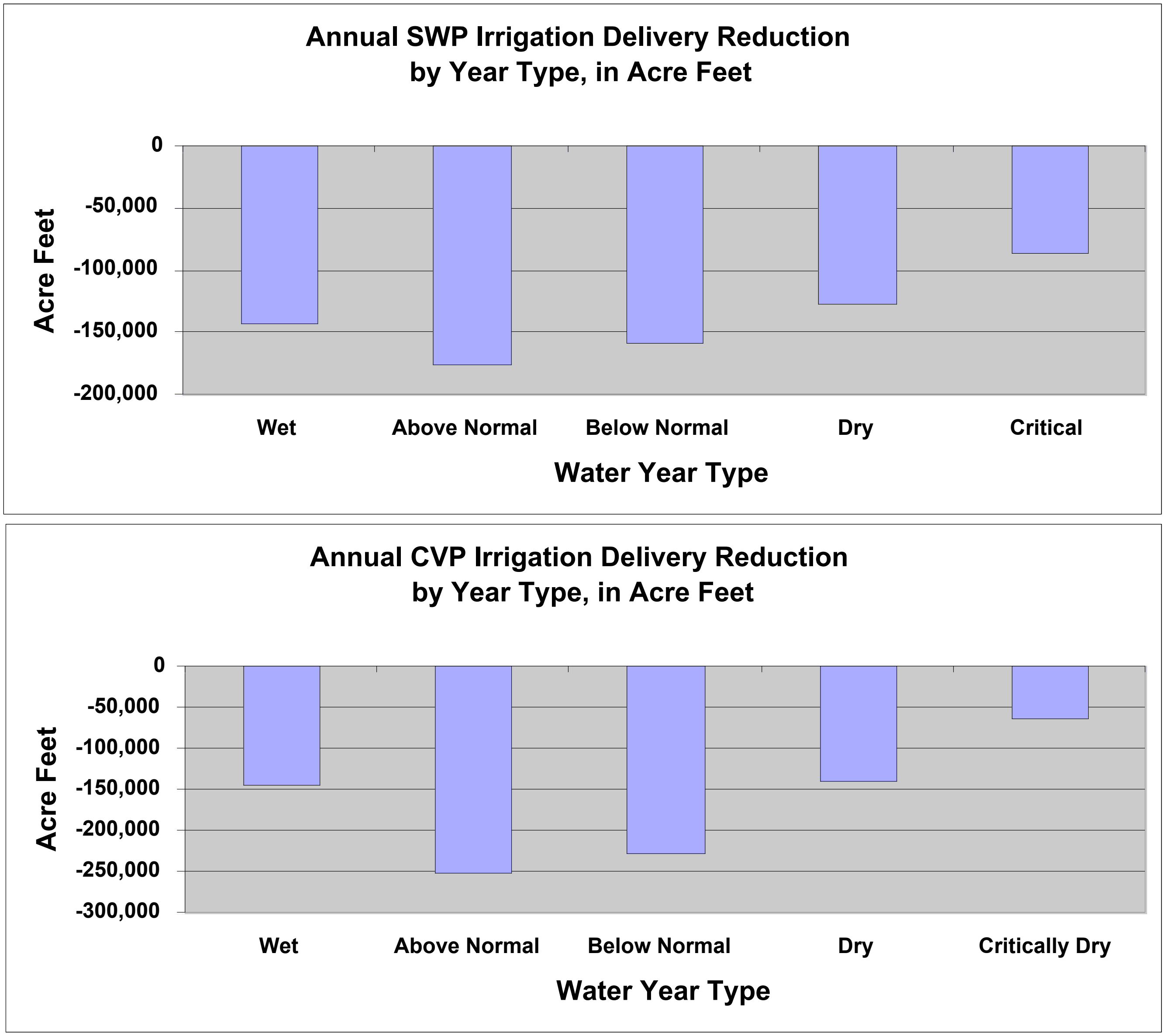

Figure 16: Estimated SWP Irrigation Delivery Reductions by Year Type

For each project and year type, the direct economic costs were calculated by multiplying the volume of reduction in irrigation deliveries by the shadow price of water. Note that, although the shadow prices were estimated for the surrogate regions, they are multiplied by the total estimated reduction in deliveries to all affected areas (not only the surrogate regions).

Figure 17 summarizes the results for the SWP Delta export agricultural deliveries, and Figure 18 summarizes the results for the CVP. Table 9 contains an overall summary of direct economic costs of the delivery reductions, for each year type and for the overall average.

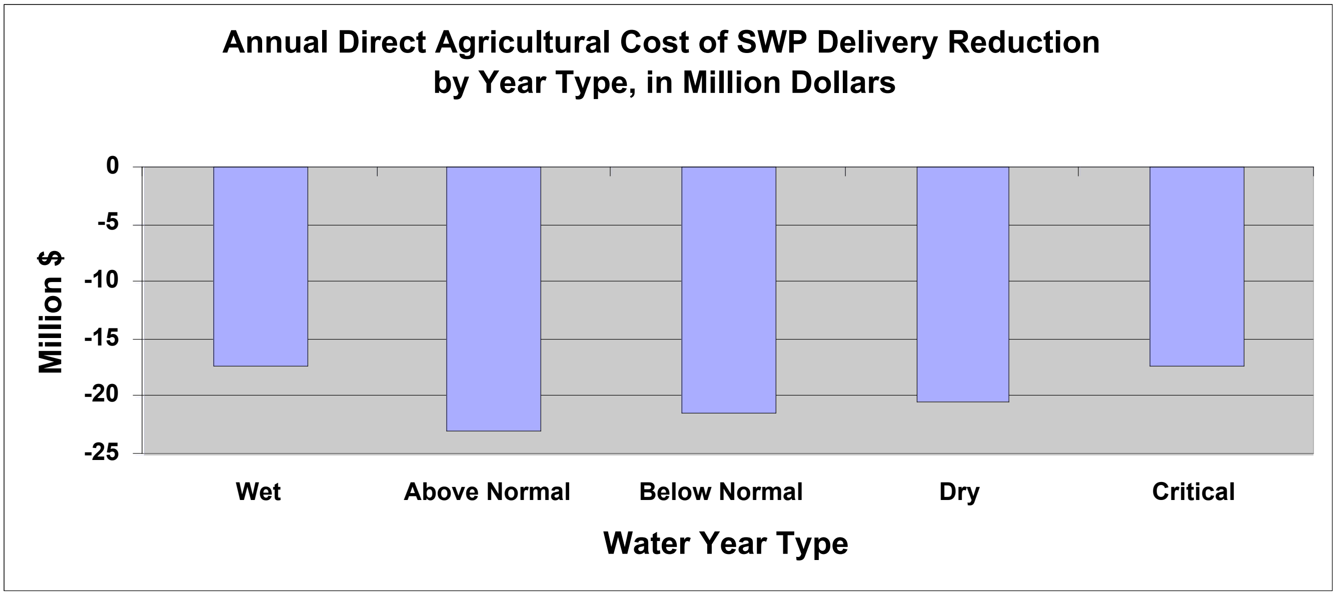

Figure 17: Estimated Direct Economic Cost of SWP Irrigation Delivery Reductions by Year Type

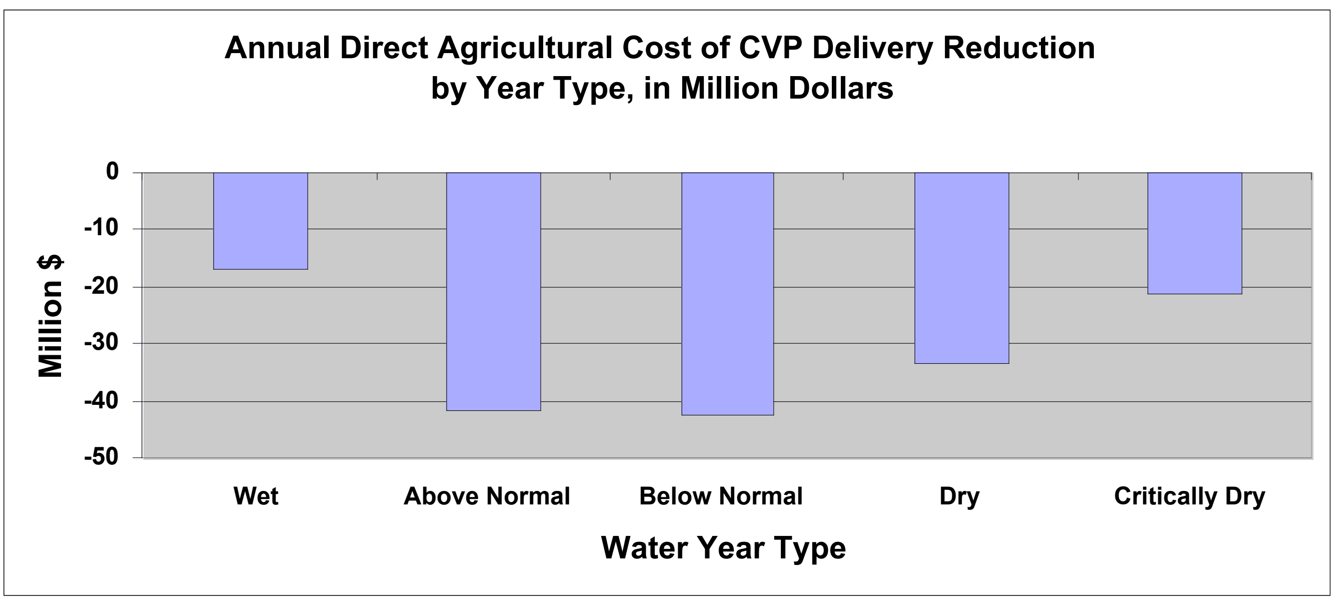

Figure 18: Estimated Direct Economic Cost of CVP Irrigation Delivery Reductions by Year Type

Table 9: Summary of Direct Agricultural Economic Costs from SWP and CVP Irrigation Delivery Reductions

		Annual Average	Wet	Above Normal	Below Normal	Dry	Critically Dry
SWP Direct Agricultural Costs							
Reduction in Delivery	TAF	139	143	175	157	127	86
Direct Cost per AF	$/AF	$ 141	$ 121	$ 130	$ 135	$ 161	$ 202
Total Direct Cost	million $	$ 19.5	$ 17.3	$ 22.8	$ 21.3	$ 20.5	$ 17.3
CVP Direct Agricultural Costs							
Change in Delivery	TAF	161	144	250	226	139	63
Direct Cost per AF	$/AF	$ 180	$ 116	$ 166	$ 187	$ 239	$ 332
Total Direct Cost	million $	$ 28.9	$ 16.6	$ 41.4	$ 42.1	$ 33.2	$ 21.0
Total Direct Agricultural Costs							
Change in Delivery	TAF	299	287	426	383	266	149
Total Direct Cost	million $	$ 48.4	$ 34.0	$ 64.3	$ 63.4	$ 53.7	$ 38.3

IV.G Dynamic Considerations Relating to Groundwater Pumping

Groundwater management involves dynamic considerations because pumping in one year can affect economic decisions in other, subsequent years. Such intertemporal effects typically occur through changes in the stock of groundwater over time. When the stock of groundwater affects profitability (usually because groundwater elevation affects pumping costs), measuring economic impacts with reference to a single year can underestimate the actual effects of a change in the water management regime.

Westlands Water District provides a good example of this phenomenon. District staff members report that the safe yield of the aquifers underlying the district is about 175,000 acre-feet annually. As described above, the CVPM incorporates the assumption that Westlands farmers may, at least temporarily, extract groundwater at a rate well in excess of the safe yield. There are several physical consequences of such groundwater depletion. First, by reducing the stock of groundwater, pumping in excess of safe yield will lower the elevation of groundwater and increase pumping costs. Second, overdraft can result in land subsidence, at least at a local scale. This circumstance may have economic consequences, involving a permanent loss of storage capacity in at least a portion of the aquifer, and damage to canals, roads, foundations and other infrastructure.

The CVPM does not incorporate these dynamic effects. Rather, the model treats groundwater as a reserve supply that is available up to some defined monthly pumping capacity. In the model, the cost of switching to groundwater is the difference between the cost of groundwater and the cost of surface supplies. If groundwater and water transfers are unable to return farmers to their original level of water use, then fallowing is assumed to occur. Growers lose net income (revenues minus variable costs) when they are forced to fallow their land.

In this context, it is important to note that the economic value of Article 21 supplies is underestimated by CVPM. Article 21 supplies are primarily available in wet years, and CVPM treats these supplies as used in the year they are delivered. This assumption is factually incorrect, as Article 21 supplies are banked for use in future years. To estimate the magnitude of the undervaluation of Article 21 supplies, consider the shadow values of water presented in Figure 6. Assuming that the marginal value of banked water is $250 per acre-foot in dry years, the cost of storage and extraction is $100 per acre-foot, Article 21 water is purchased at $28 per acre-foot, and the net value of Article 21 water is $122 per acre-foot. In years in which Article 21 water is available, the Interim Order reduces Article 21 supplies by just over 150,000 acre-feet annually. Under the assumption that agriculture receives 28% of Article 21 supplies, a static model like CVPM that treats Article 21 and Table A water the same would underestimate the value of Article 21 water by just over $5.1 million annually.

IV.H. Indirect and Employment Impacts of Delivery Reductions

The indirect and labor market impacts of the Interim Order are calculated using the IMpact analysis for PLANning (IMPLAN) framework developed by the U.S. Forest Service. IMPLAN is a standard model for measuring regional economic impacts, and is based on a Social Accounting Matrix, or input-output framework. The IMPLAN model can be used to calculate the employment losses associated with the reductions in water supplies.

Changes in farm revenues were measured using the same CVPM framework that was used to calculate producer losses in the agricultural sector. Table 10 summarizes these results by crop category. The pattern of impacts differs between the SWP and CVP service areas. In SWP districts, the largest revenue losses occur in the forage and cotton sectors due to the relative abundance of these crops and their low value per unit of water. In the CVP service area, the largest impacts are in the cotton and vegetable sectors. This finding is significant from an indirect impacts perspective because vegetable crops require much more input application per acre than field crops. Thus, the impact of fallowing on the rest of the economy can be larger.

Table 10: Average Annual Crop Revenue Losses from SWP/CVP Delivery Reductions (Mil $/Yr)

	Cotton	Food Grains	Feed Grains	Forage	Fruits /Nuts	Veg	Sugar Crops	Oil Seeds	Total
SWP Service Area	$5.63	$1.82	$2.32	$9.37	$2.78	$0.66	$0.01	$0.00	**$22.60**
CVP Service Area	$14.53	$1.86	$2.71	$4.12	$3.73	$11.32	$0.28	$0.22	**$38.75**
Total	**$20.16**	**$3.67**	**$5.03**	**$13.49**	**$6.51**	**$11.98**	**$0.29**	**$0.22**	**$61.35**

Table 11 summarizes the impacts to employment, which were calculated in IMPLAN, using the CVPM revenue losses as an input. The analysis indicates that 720 jobs are lost as a result of changes in irrigation water supplies resulting from the Interim Order. Job losses are larger for CVP impacts (even though water supply losses are less for the CVP system) because CVPM predicts that vegetable acreage is fallowed to conserve water.

Table 11: Job Losses in the San Joaquin Valley

	CVP	SWP	Total
Lost Jobs	458	262	720