Appendix B

Economic Consequences of Water Supply Disruption Due to Seismically Initiated Levee Breaches in the Delta

Economic Consequences of Water Supply Export Disruption Due to Seismically Initiated Levee Failures in the Delta

White Paper

by

Wendy Illingworth, Economic Insights

Roger Mann, RMecon

Stephen Hatchett, Western Resource Economics

With assistance from

Ray Hoagland, Department of Water Resources

Executive Summary

An economic work group was tasked with estimating the economic consequences of a water supply disruption to the export project areas as a result of seismically initiated levee failures in the Delta. This analysis was part of a limited seismic risk analysis intended to provide a preliminary estimate of the economic consequences of water export disruptions. This effort focused on the consequences arising in the areas served by export pumping from the Delta. A number of potential economic consequences were not explored, including the consequences to Delta agriculture, infrastructure in the Delta, the cost of repair[1] and the impact of environmental degradation in the Delta, to name a few of the more obvious. Therefore, the economic consequences reported here should be considered only a partial estimate, or perhaps a lower bound of the economic consequences for the scenarios considered.

To support the analysis to be performed by the economic work group, a number of key agencies were contacted to request their assistance in analyzing potential outcomes. Some agencies contacted were unable to respond in the time provided, but others provided extremely helpful analyses. However, it should be stressed that the analysis presented is the responsibility of the working group and does not reflect the adopted policies of any agency, although the working group has attempted to be consistent with current policies.

To manage the scope of the analysis, the selected scenarios were restricted in the following ways:

1. The analysis was restricted to two scenarios, one resulting in 50 breaches to Delta levees, and the second resulting in 30 breaches.
2. The seismic event was assumed to take place on July 1, 2003, with the water in storage at that time assumed to be available. Exchange contracts signed between that date and the end of 2004 were included.
3. The Mokelumne aqueduct, Hetch Hetchy aqueduct, and in-district facilities (Los Vaqueros reservoir and local distribution pipelines) were assumed to avoid major damage.
4. Friant Dam would not be reoperated to meet the needs of the Mendota Pool exchange contractors.
5. Water in SWP terminal reservoirs would be included in the project-wide allocation, rather than being allocated only among those agencies which have paid for the terminal reservoirs.
6. Operation restrictions at San Luis Reservoir (maximum drawdown rate, San Felipe low point) did not restrict water deliveries.

The work group was provided with the following inputs for each scenario: (1) the length of time that pumping would cease entirely; (2) the length of time that pumping would be restricted to a reduced rate, depending on the estimated need for extra carriage water to achieve acceptable salinity of water at the pumps; and (3) the amount of "opportunistic" water that would be

[1] The costs associated with levee repairs and other direct In-Delta costs were estimated separate from the analysis of this work group.

available during the period of restricted pumping. These estimates were provided for the CCWD Rock Slough intake and the south Delta export pumps.

Both the stored water and the opportunistic water were allocated to the individual project contractors. SWP supplies were allocated to contractors based on the amounts in Table A of the SWP agreements. CVP supplies were allocated for each year of the disruption period in the following manner and priority:

1. 50 percent of 2003 demands to M&I and refuges;
2. Full contract amounts to the exchange contractors;
3. Remaining supplies allocated to CVP service contractors in proportion to contract amounts.

A workshop was held on February 8 and 9 to review and assemble the information and analyses that had been developed. The analyses presented showed that Metropolitan Water District of Southern California (MWDSC) and some similar agencies could maintain supplies to all firm users under both scenarios. Similarly, Contra Costa Water District (CCWD) could draw down Los Vaqueros Reservoir and likely require only voluntary conservation efforts from its consumers.

Other M&I water agencies would incur higher shortages because they have more limited access to alternative supplies. Based on exploratory calculations for a few examples, it was assumed these agencies would experience a 20 percent shortage under the 30 breach scenario and 40 percent under the 50 breach scenario.

Agricultural agencies were analyzed under two alternative responses to the water shortages; the first assumed the agencies would be able to pump as much groundwater as they did during the 1991-1992 water shortage, and the second that they would be able to increase pumping by only a limited amount and instead would need to fallow more land. In addition, it was assumed that permanent crop plantings would be protected to the extent possible, and annual crops sacrificed. Other simplifying assumptions were used and only some categories of cost and impact were possible to estimate within the scope of this initial appraisal. For example, capital costs to rehabilitate wells and to move limited water supplies around, within, and between districts was not estimated. A number of assumptions about groundwater pumping and land fallowing patterns were based on an existing study of the 1991 drought impacts in the San Joaquin Valley.[2]

Based on the two scenarios specified and for the assumptions described, the work group estimated the economic costs and impacts of state and federal project water supply shortages associated with disruption of Delta water exports as follows:

[2] Northwest Economic Associates, **Economic Impacts of the 1991 California Drought on San Joaquin Valley Agriculture and Related Industries**. 1992.

Costs to the State
(Million $)

No. of Breaches	Agricultural Costs	Urban Costs
30 Breaches	290-300	500-620
50 Breaches	470-490	2,500-3,000
Difference	180-190	2,000-2,400

Economic Impacts (including transfer payments between parties)

No. of Breaches	Agricultural Impacts	Urban Impacts
Output (million $)		
30 Breaches	$2,200 - $3,900	$710-$870
50 Breaches	$3,400 - $6,300	$3,600-$4,400
Difference	$1,200 - $2,500	$2,900-$3,500
Job-years of employment		
30 Breaches	23,900-41,300	4,300-5,300
50 Breaches	36,300-67,500	22,500-27,500
Difference	12,400-26,200	18,000-22,000

The ranges of values shown for agricultural effects represent the two alternative responses, groundwater replacement and land fallowing. Whereas economic costs of agricultural water shortages were relatively similar for the two responses, the regional economic impacts would be much greater under the land fallowing emphasis. The assumption of a summer occurrence resulted in high losses to agriculture because of the investment in planted crops that would be lost due to the disruption.

For urban costs and impacts a range of plus or minus ten percent range has been added to reflect uncertainty in some key assumptions. The scenarios evaluated were not extremely damaging for M&I agencies, particularly for both MWDSC and CCWD. Alternative scenarios could result in higher costs.

Other impacts that were not assessed in this analysis include: environmental justice issues; increased short-term risk due to depleted local storage; the cost of replacing water in storage; the reaction of the public and business to the ‘failure’ of the water system; and the effects of lost recreation opportunities.

The results of this initial exploratory analysis of the costs and impacts of the events considered suggests further detailed studies would be required to more fully understand the range of economic consequences likely to occur as a result of seismic disruptions in the Delta. The results also show that the consequences have a non-linear relationship to the length of an outage. For example, it appears that urban users may be able to cope with disruptions of up to six months with little consequence for end-users. Disruptions that last more than one year could have significantly higher consequences, and disruptions that last for three years or more would have consequences that were much more than proportionately higher. This would suggest that actions that might shorten the extent of long disruptions would be much more beneficial than actions that might reduce the frequency of short disruptions.

Economic Consequences of Water Supply Disruption
Due to Seismically Initiated Levee Breaches in the Delta

1. Introduction

This work group was tasked with estimating the economic consequences of water supply export disruption that could result from earthquake damage to Delta island levees. If an earthquake causes several levee breaches, saline water could intrude into the Delta and prevent its use as a fresh water source for an extended period. The task reported here was limited to estimating the economic consequences that would arise from disruptions of Delta exports by the State Water Project (SWP) and the Central Valley Project (CVP). Because of the hydrology of the Delta, diversions through the North Bay Aqueduct were assumed to be unaffected by the seismic damage to the Delta levees. Thus the analysis was restricted to the consequences arising from the disruption in diversions for the Contra Costa Water District (CCWD) and the CVP and SWP export pumps in the south Delta (Banks and Tracy).

This limitation in scope meant that a number of potential consequences of Delta seismic damage were not explored. These include:

- The effect on Delta agriculture of reduced diversions due to increased Delta salinity;
- The effect on Delta agriculture of flooding of croplands;
- The cost of repairing the levee breaches and dewatering islands[3];
- The effect of disruption and repair to other infrastructure in the Delta, such as roads, railways, electrical transmission towers and pipelines;
- The effect on Delta ecosystems of the increase in salinity and turbidity;
- The effect on upstream reservoirs of potential changes in operations in response to the disruption;
- The effect of these changes on Delta communities.

Given the limited time and budget available for the analysis, it was decided to conduct a preliminary analysis based primarily on information provided by:

- Operations experts at the two major projects;
- Planning personnel at some of the contracting agencies;
- Individuals at other groups, including the California Division of Tourism, California Chamber of Commerce, California Farm Bureau, and individuals with experience in real estate investment and banking;

The individuals contacted at these groups were interested in the issue, and many provided insights that were useful to the process. However, because of time limitations not all were able to provide all of the information requested by the workgroup. The information provided included results of assessments for the scenarios considered and discussions during a project workshop. These are both discussed further, below.

[3] The costs associated with levee repairs and other direct In-Delta costs were estimated separate from the analysis of this work group.

To coordinate the input from this broad range of participants, a workshop was held in Sacramento on February 8th and 9th, 2005. The following section describes the process taken to develop the analysis, including major assumptions made to move the process forward. Further sections provide details of the analyses undertaken and the resulting estimates. Final sections discuss the uncertainties in these estimates, and lessons learned that might enrich further studies.

1.1 The Seismic Scenario

The following points summarize key inputs to the economic consequence analysis:

- The analysis was performed for two scenarios, one resulting in 50 breaches to Delta levees, and the second resulting in 30 breaches.
- The seismic event was assumed to take place on July 1, 2003, with the water in storage at that time assumed to be available. Exchange contracts signed between that date and the end of 2004 were included.
- The Mokelumne aqueduct, Hetch Hetchy aqueduct, and in-district facilities (Los Vaqueros reservoir and local distribution pipelines) were assumed to avoid major damage. Thus there would be no need for the project contractors such as Santa Clara Valley Water District (SCVWD) and CCWD to supply water to assist the other Bay Area agencies. Indeed, if necessary some small supplies of water could possibly be obtained from them. In addition, any shortages experienced within the region were the result of the disruption of the Delta diversions rather than distribution limitations.

1.2 Development of the Supply Scenarios

Initially the development of the supply scenarios began on a dual track. One consisted of seismologists and hydrodynamicists modeling the effects of a specified earthquake on Delta levees, and the resultant effect on Delta salinity at CCWD's Rock Slough and South Delta export project diversion points. The other consisted of collection of data related to the inventory of south of Delta storage at the assumed time of the earthquake, and discussions with project operators of the issues that would guide their actions under a severe disruption of Delta pumping.

During the time that pumping would be totally disrupted, the agencies would need to rely on water that was south of the Delta at the time of the seismic event. When pumping was partially resumed, additional water would be available, but it could not be relied on until it had been pumped. The amount and timing of this opportunistic water could not be foreseen, particularly during the early months of the disruption. This aspect of the water availability could alter the allocation of the limited water available. For example, the CVP might keep water on hand to meet future health and safety needs of the M&I agencies, even though the agencies did not need the water at the time and other water might be available before additional water was needed. The agencies have no adopted policies to guide their decision-making under such a scenario. However, they do have policies in place for responding to much less severe conditions, including drought and short disruptions of the aqueducts. They also discussed the type of constraints under which they would be operating. Based on these discussions, rules were adopted that could be used to allocate water available south of the Delta throughout the disruption. It should be stressed that these rules are not official project policies, but operating assumptions adopted by the economic working group. The following points describe the guidelines that were adopted, and summarize some of the discussions or uncertainties related to those guidelines.

- For the SWP, water in SWP storage facilities and opportunistic water were allocated in proportion to the current version of the Table A amounts, as supplied by the State Water Contractors. Water in the terminal reservoirs in Southern California was also allocated in this way, and the water in the California aqueduct was assumed to be drawn down. However, it was suggested that the terminal reservoirs are conveyance reservoirs and not storage reservoirs. As a result, the water in them may be allocated differently than water in the San Luis Reservoir because only the Southern California contractors have paid for the terminal storage facilities. The effect of this possible change in allocations was not estimated.
- For the CVP, water was allocated in the following manner: first water was allocated to M&I and refuges equal to 50 percent of their 2003 demands for each year of the disruption. The M&I allocation was assumed to reflect health and safety levels, and may be somewhat generous for this purpose. However, determination of an appropriate health and safety level would need to be done on a district by district basis. The proportion of demands allocated to refuges was set equal to the proportion allocated to M&I. Second, in each year any remaining water was allocated to the Mendota Pool Exchange Contractors. After sufficient water supplies were available to serve the Exchange Contractors, the remaining water was allocated to the Service Contractors. This conservative allocation rule was in line with operator preferences, but it resulted in the Service Contractors not being allocated any water until after the planting season in the final year of the longer disruption. In fact, if pumping operations were being restored according to a known schedule, the operators might feel less constrained.
- The CVP was assumed not to re-operate Friant dam to provide water from Millerton to the Mendota Pool Exchange Contractors. In fact, the CVP would most likely be legally obligated to re-operate Friant Dam, but this was determined late in the process, and was not adopted because it added to the complexity of the analysis. The re-operation would result in some loss of water to rewater the San Joaquin River, and would spread the shortage over areas served by the Friant-Kern and Madera Canals. The sign of net effect on the economic consequences of changing this assumption are not obvious, but the magnitude is judged not to be great. The main effect would be to widen the region in which the losses were felt.
- There are a number of constraints on the operation of San Luis Reservoir that were ignored. For example, there are restrictions on the drawdown rate for the reservoir level. This is likely to be a constraint on the timing of deliveries to the contracting agencies. In addition, when the level of San Luis passes a known low point, deliveries of water cannot be made to Santa Clara Valley Water District. The analysis ignored the potential effect of this restriction on deliveries to Santa Clara Valley Water District.
- The California Aqueduct was assumed to be drawn down, and the water supplied to the contractors. This can be achieved so long as the drawdown is slow enough to allow for water pressure equalization inside and outside the canal. However, the amount of drawdown would be limited by the need to maintain canal water levels required to convey and deliver water, so this assumption may be optimistic.

2. Analysis of Water Supplies Within The Contractor Agencies
The invitees to the workshop were provided with the following information for each scenario:

(1) the length of time that pumping would cease entirely;

(2) the length of time that pumping would be restricted to a reduced rate, depending on the estimated need for extra carriage water to achieve acceptable salinity of water at the pumps; and

(3) the amount of "opportunistic" water that would be available during the period of restricted pumping. These estimates were provided for the CCWD Rock Slough intake and the south Delta export pumps. Both the stored water and the opportunistic water were allocated to the individual project contractors as described above. These water supply estimates were provided to a number of contractor representatives, who were asked to consider how their districts could work within these constraints.

Not all of the agencies contacted were able to prepare an analysis of their possible responses in the time available. Some agency staff, while not able to provide an analysis of their agencies' situations, were able to provide informal insights that were very useful. The key points of those analyses that were provided are summarized below.

a. Contra Costa Water District
CCWD is in a unique position because its water supply is taken directly from the Delta. It is not connected to the rest of the CVP infrastructure in the region south of the Delta, so with the Delta closed the region would need to rely completely on its own resources. These resources include the Los Vaqueros Reservoir, which provides both water quality and emergency water supply to the CCWD service territory. When the reservoir was planned, it was expected to provide a six-month supply to CCWD. However, due to conservation and changes in industrial mix it can now provide supply for a longer period.

In addition to its normal service customers, CCWD's service area also contains some industries that obtain portions of their water directly from the Delta. These industries include the Pittsburg Power Plant and oil refineries. The outputs from these industries are often in short supply in California, and are important to the state's wellbeing, so it will be important to maintain water supplies to these industries. To the extent these industries use water for cooling, they may be able to continue to obtain water from the Delta. However, CCWD assumed that it would need to provide increased water supplies to these industries. It is not clear how much additional water will be needed for this purpose, so CCWD assumed that it would need to increase its overall deliveries by 5 percent to ensure their continued operation.

The resulting analysis suggests that CCWD could survive both scenarios by appealing for voluntary conservation. However, two caveats were given to this estimate. First, the time of the assumed event (July 1) was at a time when the water stored in Los Vaqueros is at a maximum. CCWD operates the reservoir by filling it when low salinity water becomes available in the spring, and drawing it down when the water quality in the Delta deteriorates in the late summer and fall. Thus a winter disruption would cause greater stress on the county than would one taking place in summer. CCWD also believed that it might be able to stretch its supplies further by blending water from the Delta while it was still at slightly high salinity with the low salinity water that is stored in the reservoir. In addition, CCWD has interconnections with the Mokelumne Aqueduct that it might be able to call on during emergencies. These interconnections were built during the 1991-1992 water supply shortages, but were never used. In summary, CCWD staff felt that they could endure the disruption with shortages to their customers of less than 15 percent.

The scenarios examined stretched CCWD's reserves, so that a much longer disruption would result in more serious shortages to the end-user.

b. Metropolitan Water District of Southern California

MWDSC has invested in a variety of water supply sources and in emergency water storage as a form of insurance against drought and disruption of the major aqueducts that transport the surface water imported into the region. MWDSC staff looked at the water that was available to them from those resources, and estimated that it will be able to supply all firm requirements to its member agencies under both scenarios. However, MWDSC would need to interrupt replenishment deliveries to the area's groundwater basins and curtail water supplies to one third of the interruptible agriculture within its service territory.

MWDSC staff also warned that the scenario chosen was one that would be more favorable than others, but in this case the benefit came because after a number of wet years MWDSC's local storage was full. In addition, 2003 demands were at moderate levels, not at the higher levels that might be expected under hotter weather conditions. If the seismic event had fallen during or after a period of drought the event would have been more disruptive. The following table shows the estimated probability of various levels of average end-user shortage, based on historic variety of hydrologic conditions. This shows that there is some increased probability of shortages under different hydrologies, but that the levels of those shortages are still not great. It should be further noted that these are average levels of shortages across MWDSC's service territory. There may be local variations where some users might experience higher shortages, and others lower shortages. These differences were ignored in this analysis.

Table 1
Probability of End-User Shortage
Under Seismic Scenarios (MWDSC)

	Probability of Shortage	
Severity of Shortage	*30 Breach*	*50 Breach*
0%	62%	43%
>0% to 5%	34%	43%
> 5% to 10%	4%	14%

The longer 50 breach scenario also leaves MWDSC water supplies in storage reduced by as much as three quarters. In addition, a number of MWDSC's alternative supply or interruptible demand programs are only sustainable for approximately three years, so disruptions longer than the 50 breach scenario will stress the reliability actions available to MWDSC. As a result the region would be much more sensitive to an extended disruption, or a second cause of disruption such as a series of dry years or another seismic event that disrupted other facilities.

c. San Luis and Delta Mendota Water Authority

The San Luis and Delta Mendota Water Authority (SDLMWA) provided an analysis of the crops planted within its member districts at the assumed time of the seismic event, and the amount of water supply needed to bring those crops to harvest. In addition, the Authority provided a summary of supplemental groundwater available by member agency, and indicated where those groundwater sources had water quality issues that might inhibit their use. Finally, an estimate was made of the acreage of permanent crops that could be maintained through the first year with the amount of water that was assumed available. This resulted in an assumption that approximately 70 percent of the permanent crop acreage could be maintained, assuming that water was physically and legally capable of being transferred from wells and annual crops to permanent crops within each district. The analysis developed by SLDMWA could be used to develop a more refined allocation of the available water supply, because it supports an analysis that shows that some level of water supplied to farmers in the first harvest season of the disruption is much more valuable than the same amount of water supplied during the last year of the supply disruption.

d. Tulare Lake Basin Water Storage District

Tulare Lake Basin Water Storage District (TLBWSD) provided an analysis of its region based on historic conditions. On average, over a recent 30 year period SWP supplied water has accounted for approximately 32 percent of applied water. Other supplies include King's River water (34 percent) and groundwater (17 percent). Most of the groundwater wells are owned by local farmers, rather than by the District. All of the district's crops are annual plantings (there are no permanent crops), and the major crop grown is cotton. If only high TDS water was available from the Delta in the period after the earthquake, the farmers might consider planting salt-tolerant crops rather than lose another growing season.

3. Urban Impacts

This section describes the impacts of the scenarios in terms of water shortage for urban end-users, economic cost, value of output and employment. The methods used to estimate urban economic impacts are as follows:

1. Determine if the agency type would impose water shortage on end users during the outage.
2. If, so, estimate the duration and magnitude of the shortage to the end-user (percent shortage).
3. Determine an economic area to use for modeling.
4. From the economic loss function, estimate total economic cost per year in the economic area. The economic loss function is used in DWR's LCPSIM planning model. The function uses information on the share of water use by sectors (residential, commercial, industrial, landscape) and information on relative cut-backs to estimates economic costs.
5. From the economic loss function, obtain the percent shortage for industry.
6. Conduct an economic impact analysis for manufacturing output and employment. The economic impact analysis is based on 2002 output and employment estimates, industrial loss functions based on CUWA's Cost of Industrial Water Shortages, and IMPLAN output and

employment multipliers. Estimates are based on 2002 levels because that is the date of the most current economic data.

7. Determine a scaling factor to account for other similar agencies. The scaling factor is generally the ratio of total similar agency population to the model area population.
8. Multiply the annual economic costs and impacts by the scaling factor and the duration of the shortage to obtain total cost and impact for each scenario.

The information provided is the estimated economic cost of the shortage, direct loss of manufacturing output and employment, direct and indirect loss of output and employment, for the duration of the shortage. These values are not expected annual average values because they have not considered the expected frequency of this type of event.

3.1 Information Regarding Urban Water Shortage for Scenarios

This section summarizes analysis provided by water agencies, supplemented by workgroup analysis, regarding the response of urban water agencies to the two scenarios and the amount of shortage experienced by end users in the agencies. All of the analysis provided was provided at a scoping level of detail, but the analysis was judged adequate to provide some conclusions about the likely magnitude and duration of end-user shortage in different project service areas.

This analysis includes all urban water users who obtain some of their water supply through SWP or CVP exports from the Delta. This includes the service area of Metropolitan Water District of Southern California (MWDSC), other urban SWP Table A Contract holders in the south coast, the interior south, and the Bay Area, and CVP M&I contract holders in the Bay Area and Central Valley.

To conduct this analysis, the agencies to be affected were divided into three groups: those likely to have sufficient alternative resources to minimize end-user shortage; those likely to have fewer alternative water supplies, and CCWD, whose situation is unique in that it is not connected to the project facilities south of the Delta.

<u>a. Agencies with Sufficient Alternative Resources</u>

Some agencies would have adequate supplies on hand which, when combined with opportunistic water, discretionary delivery reductions, and transfers through non-Delta facilities, would allow then to endure the entire outage with no shortage to end-users. The general characteristics of these agencies may include all or some of the following:

- SWP Table A or CVP contract water deliveries are a smaller fraction of total end-user demand or water supplies available;
- Substantial available alternative resources including surface storage and groundwater storage and pumping capacity;
- Ability to reduce discretionary deliveries with no immediate impact on end users; or
- Ability to increase water transfers though imports that do not depend on the Delta.

Based on preliminary analysis, urban water providers in this group include MWDSC, most other SWP urban water users in southern California, and some CVP M&I water users in the Central Valley.

In Southern California, for example, MWDSC member agencies serve a total retail demand of about 4 million acre-feet (maf). MWDSC provides about half of the water supply needs. The other half comes from local surface and groundwater storage, imports from the Colorado River (the San Diego transfer) and Mono Lake basins, and recycling. MWDSC's supplies include the SWP, groundwater and Colorado River water. The SWP Table A contract as a share of total end-user demand is about 25%. Since 1990, MWDSC has increased its available storage for seasonal and dry year needs from about 0.5 maf to more than 2.5 maf. MWDSC's 2003 demand was 1.88 maf of which about 0.28 maf were interruptible supplies, mostly for groundwater replenishment (MWDSC presentation for workgroup).

At the beginning of the 2003 scenario, MWDSC had about 1.81 maf in surface and groundwater storage. Additional supplies included 0.69 maf of Colorado River water and 0.11 maf of water transfers through the Colorado River Aqueduct. It is assumed that all interruptible supplies would be curtailed immediately following the event. With these supplies and given the available SWP allocation and opportunistic water, MWDSC would experience no shortages to non-interruptible end users.

MWDSC would lose some sales revenue as a result of the reduction in discretionary deliveries ($170 million under the 30 breach scenario and $348 million under the 50 breach scenario). Some of this lost sales revenue should be counted as an economic cost, but the total should be reduced by the avoided cost of the water not delivered. In addition, the reduced supplies to interruptible agriculture would likely result in reduced agricultural production, but this was not included in the analysis. Otherwise, there are no substantial economic costs to report for this scenario. Impacts include lost water sales net revenues and reduced economic production, as noted above, and depleted local groundwater and surface water supplies. If hydrologic conditions were worse than assumed, economic impacts and costs might be greater.

Some users, the San Joaquin Valley CVP M&I users for example, might have substantial costs for water transfers; this could also create financial pressures. Given the size of these urban areas, the economic cost of these transfers is within the likely range of error for the lost net revenue of agricultural operations.

b. Agencies with Fewer Alternative Supplies

Some urban water agencies rely on SWP or CVP supplies for a larger share of their water supplies, they have limited local surface and groundwater supplies, and/or they have limited opportunity to increase water transfers from other sources during the outage. Most urban service areas in this situation are in the South Bay, in Santa Clara and Alameda counties. Some of the SWP Table A contract holders in Southern California also fall in this group. The South Bay group holds 188,000 af of SWP Table A contracts, plus 130,000 af of CVP contracts. Total urban water demand is about 500,000 af, so SWP and CVP contracts are about 64 percent of demand.

This group has substantial groundwater supply, but surface storage is a small fraction of demands, and there are few potential sources of water transfers into the region other than the SWP or CVP system. Since they are far upstream on the project system relative to most demand, their ability to transfer water would depend on the willingness of other agencies to exchange scarce supplies. The Hetch-Hetchy system might be able to provide some transfer water, but the amount would be constrained by the limited transfer capacity between Hetch Hetchy and other agencies.

A simple analysis of 2003 water demand and supply availability for this group suggests an average duration and magnitude of shortage of about 1.3 years and 20 percent in the 30-breach scenario, and 2.3 years and 40 percent in the 50 breach scenario.

c. Contra Costa Water District

CCWD delivers water from its Los Vaqueros Reservoir and diversions from Rock Slough and Old River intakes in the Delta. In 2003, annual sales were 111,563 af. About a third of water sold was raw water for municipal use, a quarter was treated water for residential use, and a quarter was sold to industry.

CCWD analysis of available supplies shows that CCWD could get through the 50-breach scenario outage with rationing of less than 15 percent. This rationing would require industrial shortage of 5 percent and a residential shortage of 20 percent. With Los Vaqueros storage and opportunistic water, CCWD could provide full supplies for a year (to July 2004). CCWD's ability to blend poor-quality Delta water with the available supply in Los Vaqueros might reduce this level of shortage, potentially avoiding any shortage at all.

3.2 Impact to Urban Agencies

This section presents estimates of economic cost and impacts of water shortages caused by the outage.

For the South Bay, the scenarios would result in large shortages to end users. The results from an analysis of the South Bay economy was expanded to include the effects on other, smaller water agencies that were judged to be in a similar supply position to the South Bay agencies. Other agencies were judged to be in a similar supply situation to MWDSC, and so were assumed to have minimal impacts which were excluded from the analysis.

The total economic impacts of these shortage scenarios are summarized in the table below. The workgroup judged that a range of plus or minus 10 percent, not shown in the table, should be assumed to accommodate uncertainty related to key economic assumptions. Other uncertainties also exist, related to the age of the data used and the uncertainty in the models used. The effects of these are likely to be larger than ten percent, but their size was not estimated.

Table 2
Summary of Urban Economic Impacts
Estimated for 30-Breach and 50-Breach Events

	Economic Consequences		
	30-breach scenario	50-breach scenario	Difference
Economic Costs, million $/year	$427	$1,190	$763
Duration of shortage (years)	1.3	2.3	1
Total Economic Costs	**$555**	**$2,737**	**$2,182**
% Industrial Shortage	5.4	10.8	5.4
Direct Loss of Industrial Output, million $/yr	$350	$1,000	$650
Direct Loss of Industrial Output, entire shortage	**$455**	**$2,300**	**$1,845**
Direct Loss of Employment, jobs/year	1,000	3,500	2,500
Direct Loss of Employment, entire shortage, job-years	**1,300**	**8,050**	**6,750**

Table 3 below shows some key uncertainties in the urban economic analysis.

Table 3
Summary of Key Uncertainties in the Urban Costs and Impacts Analysis

No.	Category	Approach/Assumptions	Uncertainty
1	Transfers from other south of Delta sources	None assumed.	If transfers could occur, it is likely it would reduce the costs and impacts.
2	Ability to move water within a service area, between districts and associated costs	It was assumed this could be done. The costs to do this were not estimated.	There is uncertainty as to whether agencies will be able to serve all customers, if in fact the ability to move water does not exist as assumed. This would increase costs and impacts.
3	Water Quality	Assumed opportunistic pumping at 800 EC	Little uncertainty (there would be a small change in the volume of opportunistic water if the EC level at which pumping had occurred was changed).
4	Long-term financial effects on the regional economy	Not estimated	Not applicable
5	Potential mitigating factors	Not estimated.	Not applicable
6	Scaling from major users to others	It was assumed that the estimates for the South Bay area would be scaled up to reflect other, similarly situated water agencies. Other agencies would be assumed similar to MWDSC, and would be assumed to be able to avoid serious impacts.	Agencies that are assumed to be similar to the larger areas analyzed may not be exactly equivalent to those areas. The uncertainty introduced through this process will vary from one agency to the next. The contribution to the uncertainty could be plus or minus in terms of adding to the cost and impact.
7	Water shortage assumption	20 – 40%	Local supply management is uncertain. The appropriateness of this assumption will vary between agencies placed in this category. The contribution to the uncertainty of the cost and impact estimates could be positive or negative.

4. Agricultural Impacts

An extended disruption of Delta water exports would affect large areas of irrigated acreage in the San Joaquin Valley and several other, smaller irrigated areas. Specifically, the State Water Project supplies major agricultural contractors in Kern County and Kings County: the largest contractors are Kern County Water Agency (KCWA), which provides SWP water to a number of member agencies, and Tulare Lake Basin Water Storage District. In addition, primarily urban water suppliers in the Central Coast and South Coast provide some agricultural water within their service areas.

The Central Valley Project provides irrigation water to the west side of the San Joaquin Valley. Three major groups of contractors are Delta-Mendota water service contractors, San Joaquin River exchange contractors, and the San Luis Unit contractors (of which Westlands Water District is the largest). Additional areas served by CVP water from the Delta are the San Felipe Unit lands in San Benito and Santa Clara Counties, and Cross Valley Canal contractors in the southeastern part of the San Joaquin Valley.

The San Joaquin Valley is one of the most productive agricultural regions in the world. The three counties that encompass most of the acreage potentially affected by a Delta pumping outage, Fresno, Kern, and Kings Counties, generated over $1.3 billion in net cash farm income in 2002 (U.S. Census). The value of agricultural land in these three counties exceeded $14 billion in 2002.

4.1 Assumptions and Approach For Analysis

A complete set of data on water supplies, irrigated acreage, and other economic parameters was not available for this preliminary analysis. To develop a reasonable estimate, several key affected areas were used as indicators, and then results from those areas were scaled up to provide a representation for all affected areas. Scaling was based on the ratio of agricultural deliveries in the entire affected area to the deliveries in the indicator areas. KCWA was used to represent SWP contractors affected by irrigation water reductions. Westlands Water District (WWD) and the San Joaquin River Exchange Contractors were used to represent CVP delivery areas affected.

The year 2003 was used as a basis for the appraisal. Two alternatives were assessed to indicate the range of potential responses to a reduction in water available from the Delta. The first response alternative, Groundwater Replacement, assumed substantially higher volumes of groundwater pumping to replace much of the lost project water supply. The second response alternative, Land Fallowing, assumed that only modest increases in groundwater pumping would occur, and that the majority of the response would be to fallow land. For each of these alternatives, changes relative to the without-breach condition are estimated for a 50-breach scenario and a 30-breach scenario.

<u>a. Without-Breach Conditions</u>

According to SWP reports, about 1.3 maf of irrigation water was delivered to its San Joaquin Valley contractors in 2003; about 1 maf of that amount was delivered to KCWA for irrigation uses. Water supplies from groundwater, CVP deliveries, and other local sources were not available for 2003, so rough estimates were derived from the most recent years available.

Groundwater pumping within the KCWA service area was estimated to be 1.25 maf; other surface deliveries were estimated to be 840,000 maf (other surface deliveries were assumed not to change in the scenarios, so the estimated volume of deliveries does not affect this appraisal).

During 2003, CVP water service contractors south of the Delta (including WWD) received 75% of their contract quantity; for WWD, that delivery was about 860,000 af. Exchange contractors had no shortages imposed on their contract quantity of over 800,000 af, although CVP records report that they diverted only about 640,000 af. WWD estimated that 160,000 af of groundwater was pumped during the 2003 delivery year, and that 150,000 af of other district-acquired and grower-acquired surface water was delivered. No other sources were identified as delivered by the Exchange Contractors.

b. Water Supply Conditions for the Two Breach Scenarios

For each of the breach scenarios (50-breach and 30-breach), project water supplies were estimated and a set of assumptions were defined for each of the two response alternatives. Assumptions were made for Year 1, Year 2, and Year 3 following the breach. Specific assumptions for the two response alternatives were:

Groundwater Pumping Response Alternative:

Some of the SWP Table A contract holders in Southern California also fall in this group.

- Groundwater pumping can increase to 1991, 1992 levels. For KCWA, this is estimated to be 2 maf per year. For WWD, groundwater pumping is estimated to go as high as 600,000 af per year. Less information is known about the Exchange Contract areas, so for the analysis, 200,000 af per year is assumed. Due to the unexpected nature of the outage (assumed to occur in the middle of the irrigation season), groundwater pumping is assumed to adjust only partially in year 1.
- Minimal improvements in irrigation efficiency are possible in short run. For this appraisal, no improvements were assumed.[4]
- Growers will strive to keep orchards and vines irrigated.
- Field and row crops will be fallowed as needed.

Land Fallowing Response Alternative:

- Groundwater pumping increases by 20-25% over without-breach conditions. Pumping levels are assumed to increase up to 1.5 maf per year for KCWA, 200,000 af per year for WWD, and 60,000 af per year for the Exchange Contract area.
- Minimal improvements in irrigation efficiency are possible in short run. For this appraisal, no improvements were assumed.
- Growers will strive to keep orchards and vines irrigated.
- Field and row crops will be fallowed as needed.

[4] Some improvements in management can be implemented without significant capital investment, and could occur in the event of an outage. Such improvements are not considered as part of this appraisal.

Several other important assumptions were made for the analysis. Contractors were assumed to have received and applied half of their irrigation water for the season at the time of the outage in Year 1; project water available for the remainder of the outage was allocated from south-of-Delta storage at the time of the outage plus opportunistic pumping. The water quality of both opportunistic water and groundwater was assumed to be acceptable for irrigation uses.

Other surface water supplies (not pumped from the Delta) were assumed to remain constant – this means that no other transfers of surface water into or out of the affected areas were assumed. Transfers into WWD from north of Delta would also be curtailed by the pumping outage. For purposes of analysis, transfers into WWD were reduced from 150,000 to 20,000 af.

Substantial increases in groundwater pumping during the 1991-92 drought years resulted in significant drawdown in aquifer levels, increasing the pumping lift and cost. For this appraisal, pumping lifts under Groundwater Replacement in years 2 and 3 were assumed to increase by 60 feet in KCWA and by 100 feet in WWD and the Exchange Contract area.[5]

Water supply changes for the breach scenarios and response alternatives are summarized in Tables 4 and 5 below.

Table 4
Irrigation Water Deliveries Assumed by Scenario and Response Alternative, KCWA

Net Change in Irrigation Water Delivery
Kern Co Water Agency Service Area (AF)

		Year 1		Year 2		Year 3	
Water Source	**w/o Break**	**50-Break**	**30-Break**	**50-Break**	**30-Break**	**50-Break**	**30-Break**
SWP Delivery	1,029,853	793,827	793,827	74,000	98,000	245,000	1,029,853
Other Surface	840,000	840,000	840,000	840,000	840,000	840,000	840,000
GW - GWR	1,250,000	1,400,000	1,400,000	2,000,000	2,000,000	2,000,000	1,250,000
GW - LF	1,250,000	1,400,000	1,400,000	1,500,000	1,500,000	1,500,000	1,250,000
Net Change - GWR	0	-86,027	-86,027	-205,853	-181,853	-34,853	0
Net Change - LF	0	-86,027	-86,027	-705,853	-681,853	-534,853	0

GWR: higher GW replacement response alternative
LF: higher land fallowing response alternative

[5] These lift increases are consistent with those reported during the 1991-92 drought. See Northwest Economic Associates, "Economic Impacts of the 1991 Drought on San Joaquin Valley Agriculture and Related Industries", 1992.

Table 5
Irrigation Water Deliveries Assumed by Scenario and Response Alternative
WWD and Exchange Contract Area

Net Change in Irrigation Water Delivery
Exchange and WWD Service Area (AF)

		Year 1		Year 2		Year 3	
Water Source	**w/o Break**	**50-Break**	**30-Break**	**50-Break**	**30-Break**	**50-Break**	**30-Break**
CVP Delivery	1,502,500	789,650	879,250	230,400	307,200	640,000	1,502,500
Other Surface	150,000	20,000	20,000	20,000	20,000	20,000	150,000
GW - GWR	160,000	350,000	350,000	800,000	800,000	600,000	160,000
GW - LF	160,000	260,000	260,000	260,000	260,000	200,000	160,000
Net Change - GWR	0	-652,850	-563,250	-762,100	-685,300	-552,500	0
Net Change - LF	0	-742,850	-653,250	-1,302,100	-1,225,300	-952,500	0

GWR: higher GW replacement response alternative
LF: higher land fallowing response alternative

4.2 Results: Agricultural Costs and Impacts

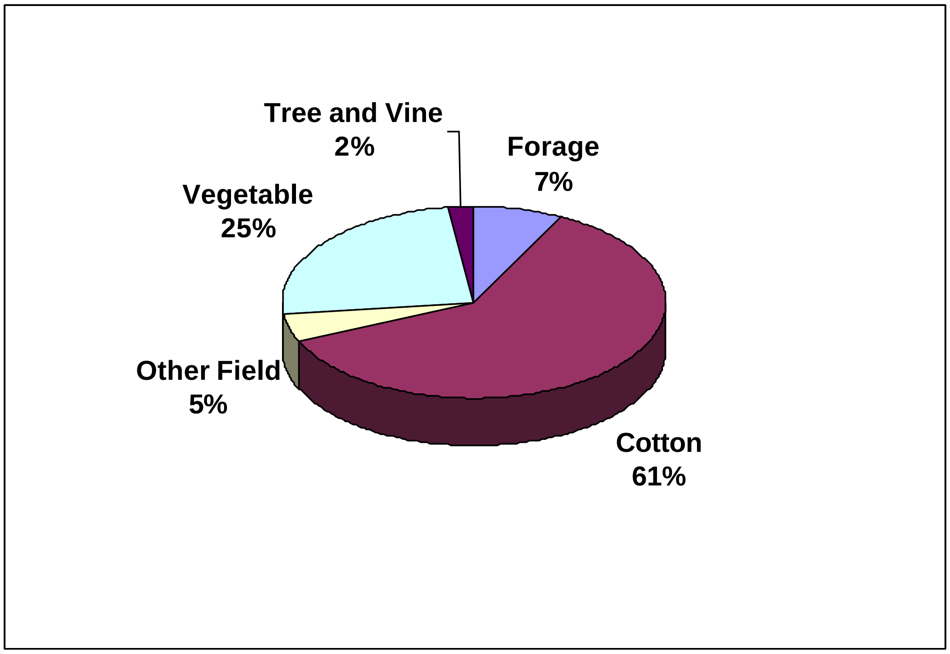
Several categories of results are summarized in the tables below: gross crop losses, net crop losses, groundwater pumping costs, well drilling and rehabilitation costs, and other costs. Only the first three of the five categories of economic effects are quantified in this appraisal. Further analysis and data are required to estimate well drilling and rehabilitation costs and other adjustment costs.

Gross crop losses are the total value of crop sales or revenue lost as compared to the without-breach scenario. These results are used to indicate the direct change in output from the local economy, and are used also to estimate indirect and induced economic impacts through economic multiplier effects. Thus, gross crop losses are one component of the economic impact of a breach scenario. Figure 1 shows the assumed crop mix affected by land fallowing. The proportions are based on estimates reported in a study of the impacts of the 1991 drought in the San Joaquin Valley (Northwest Economic Associates, 1992).

The other two quantified costs are properly viewed as economic costs that would be used in, for example, a benefit-cost analysis. Net crop losses are an estimate of the net returns lost to farming. They are the gross crop losses net of production costs that would also be avoided when crops are fallowed. Estimates are drawn from recent prices, yields, and production cost estimates for Fresno County.[6] Groundwater pumping costs are the total increase in costs for pumping groundwater, resulting both from greater volumes pumped and from increased lifts in Years 2 and 3.

[6] A more complete study would use data specific to each of the affected areas.

Figure 1
Pattern of Crops Fallowed in Response to Water Shortage.



Well drilling and rehabilitation costs would likely be needed to support significant increases in pumping under the Groundwater Replacement response. Other costs would include increased costs of irrigation management and salinity effects on crops (if applicable).

Results shown in Tables 6 and 7 are based on estimates for KCWA, WWD, and the exchange contract area, but have been scaled up to represent all of the affected areas for the SWP and CVP.

Results under the groundwater replacement response alternative (the alternative that more closely matches the experience during the 1991-92 drought) indicate a total direct crop loss of about $1 billion for the 50-breach scenario or $718 million for the 30-breach scenario. Quantified economic costs (the sum of net income losses and pumping costs) are estimated to be about $480 million for the 50-breach scenario or about $300 million for the 30-breach scenario.

Results under the land fallowing response alternative indicate a total direct crop loss of about $2 billion for the 50-breach scenario or $1.2 billion for the 30-breach scenario. Quantified economic costs (the sum of net income losses and pumping costs) are estimated to be about $470 million for the 50-breach scenario or about $290 million for the 30-breach scenario.

Table 6
Direct Economic Impacts and Costs
SWP Service Area in San Joaquin Valley (1,000$)

Category of Impact	Year 1 50-Break	Year 1 30-Break	Year 2 50-Break	Year 2 30-Break	Year 3 50-Break	Year 3 30-Break
GW Replacement Response Alternative						
Gross Crop Losses	*37,759*	*37,759*	*90,352*	*79,818*	*15,298*	*0*
Net Crop Losses	7,472	7,472	17,881	15,796	3,027	0
GW Pumping Costs	11,958	11,958	70,041	70,041	70,041	0
Well Rehab.Costs	***	***	***	***	***	***
Other Adjust. Costs	***	***	***	***	***	***
Total	19,431	19,431	87,921	85,837	73,068	0
Land Fallowing Response Alternative						
Gross Crop Losses	*37,759*	*37,759*	*309,810*	*299,276*	*234,756*	*0*
Net Crop Losses	7,472	7,472	61,311	59,227	46,458	0
GW Pumping Costs	11,958	11,958	19,930	19,930	19,930	0
Well Rehab.Costs	***	***	***	***	***	***
Other Adjust. Costs	***	***	***	***	***	***
Total	19,431	19,431	81,241	79,157	66,388	0

*** indicates not estimated

Table 7
Direct Economic Impacts and Costs
CVP Service Area in San Joaquin Valley (1,000$)

Category of Impact	Year 1 50-Break	Year 1 30-Break	Year 2 50-Break	Year 2 30-Break	Year 3 50-Break	Year 3 30-Break
GW Replacement Response Alternative						
Gross Crop Losses	*314,105*	*270,996*	*366,668*	*329,717*	*265,823*	*0*
Net Crop Losses	62,161	53,630	72,563	65,251	52,606	0
GW Pumping Costs	13,335	13,335	59,892	59,892	41,176	0
Well Rehab.Costs	***	***	***	***	***	***
Other Adjust. Costs	***	***	***	***	***	***
Total	75,496	66,965	132,456	125,143	93,782	0
Land Fallowing Response Alternative						
Gross Crop Losses	*357,406*	*314,297*	*626,477*	*589,527*	*458,275*	*0*
Net Crop Losses	70,730	62,199	123,979	116,667	90,692	0
GW Pumping Costs	7,019	7,019	7,019	7,019	2,807	0
Well Rehab.Costs	***	***	***	***	***	***
Other Adjust. Costs	***	***	***	***	***	***
Total	77,749	69,218	130,998	123,685	93,500	0

*** indicates not estimated

4.3 Discussion

Potential impacts to the regional economy are substantially greater under the land fallowing response than under groundwater replacement. However, the quantified economic costs are very similar – growers could spend (or lose) about the same amount of money by pumping more groundwater as by fallowing more land. It is unclear whether this result would hold under more careful and complete analysis.

The impacts and costs to agriculture in Year 1 are especially inexact. The assumption that contractors received only half their annual water allocation at the time of the outage is overly conservative. Estimates provided by San Luis Delta Mendota Water Authority indicate that a substantial majority (up to 80% depending on the crop) of water has already been applied by the time of the assumed outage. On the other hand, the approach used to estimate available water for this appraisal implicitly allows for greater flexibility in shifting water supplies than would be the case for an outage occurring mid-season. A more complete analysis would need to take these factors into account.

A number of important considerations and potential impacts were not included in this brief appraisal. Some have been noted already, such as the unquantified costs of well rehabilitation and the effects of water quality of crop production. Other factors not considered include:

- Curtailment of deliveries to Exchange Contractors has the potential to force the re-operation of the Friant Dam to release water down the San Joaquin River. The result would be increased deliveries to Exchange Contractors but reduced deliveries on the east side of the San Joaquin Valley.
- Economic costs of flooding in the Delta, and impacts of poor Delta water quality on agriculture in the Delta have not been estimated here.
- The physical and hydrologic capacity of the groundwater to support the high pumping rates in the groundwater replacement response alternative has not been assessed.
- The ability and cost to move water within a service area or within a district is important for minimizing crop losses. This capacity and cost has not been assessed for this appraisal. Also, water transfers from other areas south of Delta have not been considered.
- Factors that could reduce the impacts and costs have not been considered. Disaster payments and low-interest loans could be provided. Farm commodity program payments are predominantly fixed payments that would be received regardless of whether the program crop were fallowed. Cotton and small grains are the important affected crops receiving commodity payments.[7] Finally, the potentially large-scale fallowing and other effects of an outage could affect the prices of some crops. Growers able to continue producing could benefit from higher prices.

[7] The structure of commodity programs changes every few years, so no long-term conclusions can be drawn about how they would affect impacts or costs of an outage.

- Various financial impacts to growers and water districts could result from an extended outage. For example, additional debt could be incurred, access to production credit may be affected, and even foreclosure or bankruptcy is possible in some cases.

Table 8 summarizes the key uncertainties associated with the brief appraisal presented here, and indicates how each uncertainty might affect the results.

Table 8
Summary of Key Uncertainties in the Agricultural Costs and Impacts Analysis

No.	Category	Approach/Assumptions	Uncertainty
1	Ground water replacement	Bracketed the economic cost/impact a. Assumed ground water could be pumped at rates comparable to those achieved during the 1991/1992 drought. b. Assumed some fallowing would occur	The bracketing approach reasonably approximates the range of uncertainty for the pumping costs. Capital costs of well drilling and rehab. have not been quantified, and these would increase the cost for groundwater replacement.
2	Transfers from other south of Delta sources	None assumed.	Friant operation would likely reduce the overall effect. There would be a distributional effect.
3	Ability to move water within a service area, between districts and associated costs	It was assumed this could be done. The costs to do this were not estimated.	There are increased costs to move water. If water could not be moved, this would increase costs and impacts.
4	Water Quality	Assumed no restrictions. There were issues raised about the impact of water quality for agriculture.	The level of restriction on water quality is not known. Restrictions would increase the impact to agriculture.
5	Long-term financial effects on the regional economy	Not estimated	Long-term effects would increase the estimated impacts. Farmers would have existing loans to pay off and may take out additional loans to pay for any capital investments need to stay in business. Bankruptcies possible.
6	Potential mitigating factors	Not estimated.	These would have a positive impact and reduce costs/impacts.
7	Scaling from major users to others	Scaled from information for some users to cover San Joaquin and San Felipe Valleys	Increases costs and impacts. Important areas of the CVP (San Felipe Unit and Cross Valley Canal contractors) have higher proportion of permanent crops, so there is expected to be a somewhat larger cost per affected acre than for the indicator areas.

5. Indirect and Induced Urban Losses

The direct losses of output in industry cause additional losses of economic activity through trade linkages with other sectors of the economy. Trade linkages are the purchases of industries for intermediate goods and factors of production such as labor (indirect effects), and IO also counts additional trade losses caused by reduced household income (induced effects). Input-Output (IO) models are designed to measure these types of effects. IMPLAN is an IO database and model building software that can be used to build an IO model for any combination of counties in the U.S. IMPLAN models were developed using 1998 data for two urban regions; the Bay Area, and Santa Clara County. Economic multipliers from these models were used to estimate additional losses of output and employment caused by the direct industrial losses. Results for the South Bay are shown below.

Table 9
Summary of Direct and Indirect Economic Impacts to M&I
Estimated for 30-breach and 50-breach events

	Economic Effect		
	30-breach scenario	50-breach scenario	Difference
Duration of shortage (years)	1.3	2.3	1
% Industrial Shortage	5.4	10.8	5.4
Direct Loss of Industrial Output, Million $/yr	$350	$1,000	$650
Direct Loss of Industrial Output, entire shortage	$455	$2,300	$1,845
Direct and Indirect Loss of Industrial Output, entire shortage	$790	$4,020	$3,230
Direct Loss of Employment, entire shortage, job-years	1,300	8,050	6,750
Direct and Indirect Loss of Employment, entire shortage, job-years	4,800	25,000	20,200

5.1 Potential Urban Impacts not Covered

There are a variety of potential economic impacts not covered. Most of these impacts occur because of particular industries not covered. All industries and water users are covered in the economic cost estimates, but only 19 industries were covered in the impact analysis of output and employment.

Landscape, nursery and garden-related industries were not counted in the analysis of output and employment. Experience from the 1987 to 1991 drought suggests that these industries are hit hard during a water shortage, but business levels are higher than normal following the drought as people seek to replace damaged landscaping.

The Census of Manufacturing shows that 734 businesses engaged in wholesale trade in flowers, nursery stock, and florists' supplies, and 792 businesses engaged in retail trade in nurseries, lawn and garden supply stores in the South Bay. These businesses did about $1.8 billion in sales in 1997. Landscape service industries are not covered by the manufacturing census, and so are not reported here. The 2002 Census of Agriculture provides data on farms and land use for nursery, greenhouse, floral, sod and vegetable seed. There were about 300 operations with 22 million square feet under glass and nearly 3,000 acres outside in the South Bay. Additional work would be needed to estimate value of output and employment losses in these industries.

5.2 Uncertainties and Concerns

This analysis has provided a first-cut level of estimation of economic costs, and output and employment losses associated with the assumed scenarios. There is a great deal of uncertainty associated with these estimates in a number of areas.

- The analysis should consider more fully the situation and response of self-supplied industries.
- Replacement cost of assets damaged or lost through the shortage have not been not included.
- Forward linkages have not been included (such as the loss to transport industries of reduced output from affected industries).
- Industry has conserved since 1991, so direct impacts may be greater.
- Impact of expected reliability on business investment decisions not included.
- How much would expenditures be reduced following reduction in output?
- There would be some offsetting increase in economic activity after returning to normal water supply conditions (nurseries/landscape).

6. Indirect and Induced Agricultural Losses

The direct losses of output in agriculture cause additional losses of economic activity through trade linkages with other sectors of the economy. An IMPLAN model (IMPLAN is described above) was developed using 1998 data for the San Joaquin Valley region. Economic multipliers from this model were used to estimate additional losses of output and employment caused by the direct agricultural losses.

In addition, losses of output and employment in forward processing of food and kindred products were included. The loss in forward processing is estimated from information about the share of crop production that goes to forward processing (36 percent) and the share of value of output in forward processing that is the value of raw crop (20 percent).

Results are shown in the following table.

Table 10
Direct and Indirect Effects in Agriculture
San Joaquin Valley

	Groundwater Replacement		Land Fallowing	
	30-breach	50-breach	30-breach	50-breach
Million $ Crop Sales to Food and Kindred Products Lost				
Year 1	$35	$40	$40	$45
2	$47	$52	$101	$107
3	$0	$32	$0	$79
36% of crops except forage and cotton				
Million $ Crop Revenue Loss, Not Sold to Food and Kindred Products				
Year 1	$274	$312	$312	$350
2	$363	$405	$788	$830
3	$0	$249	$0	$614
Million $ Value of Output in Food and Kindred Products Lost				
Year 1	$176	$200	$200	$225
2	$233	$260	$506	$533
3	$0	$160	$0	$395
20% of value of expenditure of food and kindred products is for crops				
Total Loss in Value of Output Including Indirect and Induced Effects				
Year 1	$966	$1,101	$1,102	$1,237
2	$1,282	$1,430	$2,782	$2,930
3	$0	$880	$0	$2,169
Output multipliers are 2.17 and 2.12				
Total Employment Loss (1000s jobs) Including Indirect and Induced Effects				
Year 1	10.3	11.7	11.7	13.2
2	13.6	15.2	29.6	31.2
3	0.0	9.4	0.0	23.1
Employment per million $ output is 26.6 and 17.14				

6.1 Uncertainties and Concerns

Forward processing effects in livestock industries have not been counted. These sectors would be likely to replace lost forage crops with forage and feed imported from outside of the region. Therefore, their costs would increase, but value of output would not be much affected.

7. Uncertainty in the Estimates

Any analysis estimating the economic consequences of supply disruption must be uncertain. Specifying that the economic analysis should examine particular scenarios removes the uncertainty from field of the economic analysis. For example, major sources of uncertainty of the consequences of a disruption to Delta pumping include the length of the disruption, the hydrologic situation at the time of and after the disruption, the demand levels at the time of the disruption, the season of the year in which the disruption takes place, and the water in storage south of the Delta at the time of the disruption. These were all issues that were fixed by assumption before the analysis was undertaken, so the uncertainty in the resulting analysis has been significantly reduced.

There are still a number of remaining sources of uncertainty arising from the assumptions made and the models used. At the end of the workshop, the work group attempted to evaluate subjectively the level and likely direction of this uncertainty. The resulting evaluation was that the uncertainty remaining in these estimates is of the order of plus or minus 50 percent. Although the directionality of some of this uncertainty could be evaluated, the direction of the largest sources of uncertainty could not be ascertained, so those estimates included are judged to be equally likely to be too high as to be too low.

7.1 Analyses Not Included

Because of time constraints or the lack of useful data, a full analysis could not be conducted. Those areas that were expected to be primary sources of economic consequences were investigated, and those that were thought to be of lesser consequence were set aside at this time. Some of these issues were addressed briefly in the workshop, but no meaningful analysis was conducted.

The issues that were not investigated include the following:

1. *Environmental Justice:* Many of the impacts are concentrated in the agricultural sector of the San Joaquin Valley. The scenarios would likely have a strong negative effect on farm workers and laborers in the valley, groups that are generally already underprivileged.
2. *Consolidation of Agriculture and Loss of Family Farms:* The average age of farmers is increasing, as children of farmers chose to work in cities rather than on the family farm. The loss of water and income for such an extended time would likely hasten the exit of such family farmers from the industry, leading to lowered agricultural land prices and consolidation into large agribusinesses that are more able to withstand the extended loss of income.
3. *Reduced Housing:* The northern end of the San Joaquin Valley is experiencing rapid growth in housing stocks as cities such as Tracy increasingly become dormitory suburbs for the major urban areas. Under the scenarios, questions over water supply reliability could result in increased problems with permitting of large developments, potentially increasing the shortage of affordable housing and causing real estate development companies to lose money as existing projects were delayed.
4. *Increased Short-Term Water Supply Risk:* Local agencies will have drawn down supplies in emergency and local storage, and so would have a lower ability to respond to a second supply emergency (extended drought or additional seismic or storm events) should they occur in the near future after export services have been restored.
5. *Increased Financing Costs* Water agencies, other local agencies and individuals will have had increased costs and decreased revenues as they responded to the disruption. This may have depleted financial reserve accounts. Such entities may also have had to finance or refinance borrowing because of the reduced revenues. This may impose long term costs that have not been included in the analysis.
6. *Lost Recreation Opportunities:* Both the affected part of the Delta and project reservoirs south of the Delta will have reduced recreation opportunities, both because the reservoirs will be drawn down to ensure supplies to the end-users and potentially because water quality will be more of a concern due to the lack of "flushing" in the system because of reduced water throughput. None of these recreation sites are "destination" resorts, so the majority of the

lost use will come from within California, not from a loss of tourism into the state. Therefore the losses in state income and jobs are likely to be small, although some particular regions might be hard hit. In the north of the affected region there are other opportunities for freshwater recreation, so the consumer surplus losses will be less. However, given the scarcity of freshwater body contact recreation opportunities in Southern California, the closures of Castaic and Perris in particular could cause significant consumer surplus losses.

7. *Cost of Re-operating and Replacing Water Storage:* Over the time of the disruption water agencies will be operating their facilities in a different, higher cost fashion. As a result of these operations, additional water will be pumped from storage, and after the disruption additional water will be placed in storage than would have occurred without the disruption. These actions will have additional costs, many of which have not been included in the analysis.

8. *Reaction to Lost Reliability:* After the water shortages of 1991, a number of businesses reported that any new investments in production lines, etc. would be outside California because of concerns over the reliability of the state's infrastructure. However, there are many advantages and disadvantages to being located in California, and the general consensus seemed to be that earthquakes are considered as a cost of being located in California and so would be unlikely to have a long-term effect on investment decisions. The major reservation to this opinion was that if a poorly-managed Delta disruption was one of many infrastructure problems (such as electricity unreliability) then this could be a contributing factor to a perceived problem with California infrastructure, and as part of a general picture could have a long term negative impact on the state. The potential size of this negative impact was not estimated.

8. Summary

This preliminary analysis of extended Delta water delivery disruptions has resulted in an estimate of the potential economic consequences to the state, as shown in Tables 11 and 12, below.

The analysis has also led to an increased understanding of some aspects of the potential for economic consequences arising from a disruption in the Delta. The more important of these are shown below:

1. The time (season) of the pumping disruption can have a significant effect on the economic consequences of that disruption. It may affect the level of demands that must be met, the amount of water available south of the Delta, and the period of time before pumping can be restored. In addition, a disruption that occurs *after* a crop has been planted will impose higher costs on the agricultural community than one that occurs *before* the planting season.

2. The length of the disruption has an extremely important effect on economic consequences. The size of the economic consequences is much more than proportional to the length of the disruption. A disruption of six months or less is likely to have minimum effects on urban water users, and, depending on the season, may have similar small effects on agricultural users. However, disruptions of more than a year may have significant impacts on some urban customers; Extending the disruption to longer than three years will affect even those agencies with the most extensive alternative water supplies.

Table 11
Costs to the State
(Million $)

No. of Breaches	Agricultural Costs	Urban Costs
30 Breaches	290-300	500-620
50 Breaches	470-490	2,500-3,000
Difference	180-190	2,000-2,400

Table 12
Economic Impacts (including transfer payments between parties)

No. of Breaches	Agricultural Impacts	Urban Impacts
Output (million $)		
30 Breaches	$2,200 - $3,900	$710-$870
50 Breaches	$3,400 - $6,300	$3,600-$4,400
Difference	$1,200 - $2,500	$2,900-$3,500
Job-years of employment		
30 Breaches	23,900-41,300	4,300-5,300
50 Breaches	36,300-67,500	22,500-27,500
Difference	12,400-26,200	18,000-22,000

3. The results of this initial exploratory analysis of the costs and impacts of the events considered suggests that more detailed studies should be undertaken to more fully understand the range of economic consequences likely to occur under seismic disruptions in the Delta. At the same time, planning investigations should be undertaken to identify options that may reduce the disruption time for more extreme levels of disruption. This is likely to be much more important than reducing the frequency of short disruptions.