

**CALFED Bay-Delta Program**

**Programs and Projects**

**Study Results and Data Collection**

**for**

**Alternatives Development**

January 26, 1996

## Introduction

This memorandum summarizes the data collection efforts for alternatives development for the CALFED Bay-Delta program. The purpose of this task is to identify, compile, organize, and summarize data available from recently completed and ongoing study efforts deemed likely to be useful in assembling and evaluating planning alternatives. The memorandum is organized into descriptions of 1) the **programs and projects** under which the studies were undertaken and performed, 2) a **summary of study results** generated from each effort including model runs results, where appropriate, with an emphasis on water supply reliability, water quality, ecosystem quality, and system vulnerability, 3) the various **existing models** used in the studies, and, 4) a discussion of suggested **tools for development and application for near term solutions**.

A number of agencies and decision-makers/analysts were contacted to collect relevant information. Owing to the time constraints, many reports and studies have only been referenced rather than summarized. These studies can be looked into in greater detail as necessary in the alternatives development phase.

## Programs and Projects

Several programs and projects have been identified that may provide insight to CALFED to quickly assess the ramifications and practicality of some or all of the actions presently being considered in alternative solutions.

### CVPIA PEIS

The Central Valley Project Improvement Act (CVPIA) is described in Title 34 of Public Law 102-575 which was signed into law on October 30, 1992. The CVPIA is intended to improve the authorized purposes of the Central Valley Project (CVP) and provides for a wide range of potential changes in the methods of the CVP operations. Section 3409 of Title 34 requires the Secretary of Interior to prepare a Programmatic Environmental Impact Statement (PEIS) to evaluate the direct and indirect impacts and benefits of implementing Title 34.

### Interim Reoperation of Folsom Dam and Reservoir

Sacramento Area Flood Control Agency (SAFCA) and U.S. Bureau of Reclamation prepared the *Final EIR/EA on Interim Reoperation of Folsom Dam and Reservoir*, December 1994. The goal of the project was to provide the people and property currently occupying the American River flood plain with as much immediate flood protection as possible pending federal authorization and implementation of a long-term project to improve the existing American River flood control system. The study, using PROSIM simulations, considered two alternatives over a maximum 12 year period of analysis.

## **American River Watershed Investigation**

The American River Watershed Investigation Project aims to provide long-term improvement of the current American River flood control system. Original study on Folsom Reservoir permanent reoperations, using PROSIM for analysis, was completed in January 1995. The December 1994 Bay-Delta standards superseded the earlier study assumptions. Other new pieces of information included in the final EIR/EA Interim Reoperation of Folsom Dam necessitated revision of the original study.

## **American River Water Resources Investigation**

The American River Water Resources Investigation Project (ARWRI) aims to meet the unmet water supply needs of the ARWRI study area through the year 2030. The Administrative Draft EIR/EIS is scheduled to be released in January 1996.

## **East Bay Municipal Utility District/ San Joaquin County**

East Bay Municipal Utility District (EBMUD) and San Joaquin County are currently conducting a joint study to generate improved water supply capabilities for both areas. Alternatives include conjunctive use programs, a linking of supplies available to each including those from the American, Mokelumne, Calaveras, and Stanislaus Rivers, and the potential conversion of Farmington Dam to conservation storage.

## **Interim North Delta Program**

The Interim North Delta Program aims to improve State Water Project (SWP) reliability through reduction in reverse flow and to improve flood protection in the lower Mokelumne River system. A Draft EIR/EIS for the North Delta Program was released in 1990. Since then additional studies have been conducted and a Draft EIS/EIR is under preparation for the Interim North Delta Program. The Interim North Delta Program is analyzing a no action scenario and six alternatives including 1) south Mokelumne dredging, 2) south and north Mokelumne dredging, 3) south and north Mokelumne dredging and Delta Cross Channel enlargement; 4) south and north Mokelumne dredging and screened diversion at Hood; 5) south and north Mokelumne dredging, levee setbacks, and Delta Cross Channel enlargement; and, 6) non-structural alternative.

## **Interim South Delta Program**

The Interim South Delta Project aims to improve water level and circulation in the south Delta channels for agricultural diversions. It also aims to improve south Delta hydraulic conditions to increase diversions into Clifton Court Forebay to maximize the frequency of full pumping capacity at banks Pumping Plant. A Draft EIR/EIS for the South Delta Water

Management Program was released in June 1990. The final EIR/EIS for the ISDP is tentatively scheduled to be released in January 1996. The ISDP preferred alternative is comprised of channel dredging, a new intake to Clifton Court Forebay, a fish barrier and three agricultural flow control structures.

## **Central California Water Recycling Project**

This preliminary study evaluates the technical and economic feasibility of 30 alternatives for a regional water recycling program in the San Francisco Bay area. Four alternatives are identified as potentially feasible: (1) local recycling and export to the Delta Mendota Canal, (2) local recycling and export to the Delta area, (3) local recycling and export to the Monterey Bay area, and (4) local recycling and export to the Monterey Bay and Delta areas. All four alternatives call for upgrading all local wastewater treatment facilities to tertiary levels of treatment. Projected water supply yields and unit costs for each alternative are also presented.

## **U.S. Army Corps of Engineers Delta Studies**

The U.S. Army Corps of Engineers has recently completed and is currently conducting many studies and programs involving Delta habitat restoration and mitigation as well as levee analysis.

## **Bay-Delta Oversight Council**

The Bay-Delta Oversight Council (BDOC) was formed in 1993 by State of California Governor, Pete Wilson to resolve problems associated with the current and future use of the Bay-Delta Estuary as a source of fresh water supply in California, while protecting the aquatic resources that depend on the Estuary. Several briefing papers on water supply, aquatic and terrestrial habitat, water quality, and system vulnerability were prepared under their direction and finalized in fall 1994.

## **CVP Water Augmentation Study**

Related to but separate from the CVPIA PEIS studies is the CVP Water Augmentation Study. The goal of this Study was to develop a least cost plan to replace CVP water dedicated to fish and wildlife by the Central Valley Project Improvement Act.

## Summary of Study Results

Results generated from the above studies and programs and other studies of relevance are presented in this section. Information is presented in four sections; **1) Water Supply Reliability, 2) Water Quality, 3) Ecosystem Quality, and, 4) System Vulnerability.** Modeling results, where applicable and available, are presented in the section. For ease of reference, a matrix cross-referencing the study number, by study type and CALFED super action category can be found following this page.

### 1) Water Supply Reliability Studies

#### *WS-1 -- CVPIA PEIS -- Water Supply Studies*

The PEIS team is currently preparing several alternative simulations of the CVP system as part of the study process. Reclamation's PROSIM model is being used to provide the analysis. Anticipated scenarios include 1) a base-case, 2) a case utilizing the CVP to provide up to 800,000 acre-feet of water supply per year for fishery mitigation and enhancement, and, 3) a case utilizing the CVP to provide instream flows to essentially double the fish population in Central Valley Basin rivers. At present, detailed results of the PROSIM simulations are not available.

**Action Super Category:** Bay-Delta habitat restoration, upstream habitat restoration, reduction in effects of diversions, management of anadromous fish, reduction in export reliance, water supply enhancement, increasing water supply predictability, management of water quality, improvements to system reliability

**Geographical Region:** Bay-Delta, Delta tributary watersheds

**Information Type:** PROSIM simulation model runs using December 1994 Delta standards; CVP yield impacts; monthly study results for Delta inflow and outflow, export pumping, instream fishery flows; Sacramento River temperature studies, among others.

#### *WS-2 -- CVPIA -- CVPM Economics Studies*

The Central Valley Production Model (CVPM) was used to provide economic analysis for many programs associated with the CVPIA including:

- Water Augmentation Program
- Impact of Interim Dedication and Management of 800,000 AF
- Purchase of Supplemental Water for Fish and Wildlife Restoration
- Programmatic Environmental Impact Statement (PEIS)

A summary of the economic analyses can be found in Appendix A.

**CALFED BAY-DELTA PROGRAM**  
**Programs and Projects Study Results and Data Collection**  
**for Alternative Development Matrix**

Super Category	Water Supply	Water Quality	Ecosystem Quality	Vulnerability
Bay-Delta Habitat Restoration	WS-8	WQ-1, WQ-2, WQ-9	EQ-1, EQ-2, EQ-3, EQ-4, EQ-5, EQ-6, EQ-7, EQ-9, EQ-10, EQ-11, EQ-17, EQ-18, EQ-19, EQ-20, EQ-21, EQ-22, EQ-24, EQ-25, EQ-26, EQ-27, EQ-28, EQ-29, EQ-30, EQ-31, EQ-32, EQ-33, EQ-34, EQ-35, EQ-36, EQ-37, EQ-38, EQ-39, EQ-40, EQ-41, EQ-42, EQ-43, EQ-45, EQ-46	L-3, L-4, L-5, L-6
Upstream Habitat Restoration			EQ-10, EQ-12, EQ-14, EQ-16, EQ-17, EQ-18, EQ-20, EQ-21, EQ-22, EQ-23	
Reduction in Effects of Diversions	WS-2, WS-3, WS-4, WS-6, WS-8, WS-15	WQ-1, WQ-2, WQ-5	EQ-8, EQ-16, EQ-19, EQ-20, EQ-21, EQ-22, EQ-43	
Management of Anadromous Fish			EQ-8, EQ-12, EQ-14, EQ-16, EQ-17, EQ-45, EQ-46	
Reduction in Export Reliance	WS-9, WS-15			
Water Supply Enhancement	WS-4, WS-5, WS-6, WS-7, WS-8, WS-10, WS-11, WS-13, WS-14, WS-15	WQ-1, WQ-2, WQ-4, WQ-6	EQ-8, EQ-10, EQ-16, EQ-19, EQ-22, EQ-43, EQ-44, EQ-45	L-3
Increasing Water Supply Predictability	WS-2, WS-3, WS-4, WS-5, WS-7, WS-8, WS-9, WS-12, WS-13, WS-14, WS-15		EQ-22, EQ-43	
Management of Water Quality	WS-5, WS-8, WS-9	WQ-1, WQ-2, WQ-3, WQ-4, WQ-5, WQ-6, WQ-7, WQ-8, WQ-9	EQ-10, EQ-16, EQ-19, EQ-21, EQ-22, EQ-45, EQ-46	L-3, L-4, L-5, L-6
Improvements to System Reliability	WS-3, WS-8, WS-9	WQ-1, WQ-2	EQ-1, EQ-2, EQ-4, EQ-5, EQ-19, EQ-22, EQ-43	L-1, L-2, L-3, L-4, L-5, L-6, L-7, L-8, L-9

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**Geographical Region:** Bay-Delta, Delta tributary watersheds  
**Information Type:** CVPM simulation model runs, impact analyses, costs for water transfers, and other alternative supplies, water revenue losses, and loss of water consumer surplus from Appendix A.

### ***WS-3 -- American River Watershed Investigation***

For the American River Watershed Investigation project, three alternative flood control rule curves for the Folsom Lake were analyzed with the PROSIM model. The May 1995 administrative draft report, entitled *American and Sacramento Rivers Project Task 4: Folsom Dam and Reservoir Reoperation Impact Analysis Using December 1994 Bay-Delta Standards* was prepared for the U.S. Army Corps of Engineers, Sacramento District and describes the water supply, economic and other impacts of the alternatives.

**Action Super Category:** reduction in effects of diversions, increasing water supply predictability, improvements to system reliability  
**Geographical Region:** Bay-Delta, Delta tributary watersheds  
**Information Type:** PROSIM simulation model runs, flow analysis, yield impacts.

### ***WS-4 -- American River Water Resources Investigation***

For the American River Water Resource Investigation project two action alternatives - conjunctive use and Auburn Dam were analyzed using PROSIM and spreadsheet models. The water supply and other impacts of these alternatives are described in the *Draft EIR/EIS for American River Water Resources Investigation*.

**Action Super Category:** reduction in effects of diversions, water supply enhancement, increasing water supply predictability  
**Geographical Region:** Bay-Delta, Delta tributary watersheds  
**Information Type:** PROSIM simulation model runs, flow analysis, yield analysis.

### ***WS-5 -- East Bay Municipal Utility District/ San Joaquin County***

East Bay Municipal Utility District analyzed eight conjunctive use alternatives for the Mokelumne River Aquifer Recharge and Storage Project with the Integrated Groundwater and Surface water Model for the San Joaquin County groundwater basin in California. The results of the analyses are presented in Task Report 1.6c for the Project. Preliminary design of interconnecting conveyance facilities are currently underway.

**Action Super Category:** water supply enhancement, increasing water supply predictability, management of water quality  
**Geographical Region:** Bay-Delta, Delta tributary watersheds  
**Information Type:** Used output from PROSIM, spreadsheet analysis, transfer of American River water, facility sizes, cost estimates.

### ***WS-6 -- DWRSIM Operation Simulations***

A number of DWRSIM runs were made by DWR in 1995 in support of various Statewide Planning Division projects including 1) Los Banos Grandes south of Delta storage, 2) interim North Delta conveyance improvements, 3) interim South Delta conveyance and circulation improvements and others . A brief summary of study assumptions and simulation results can be found in Table 1.

**Action Super Category:** reduction in effects of diversions, water supply enhancement

**Geographical Region:** Bay-Delta, Delta tributary watersheds

**Information Type:** DWRSIM simulation model runs, Delta outflows, yield analysis, Delta facility sizing.

### ***WS-7 -- DWR South of Delta Offstream Storage Studies***

California Department of Water Resources is presently investigating 146 potential water storage sites south of the Delta. This is an ongoing study. Detailed yield studies of each site have not been performed. However, analysis has been done on Los Banos Grandes. Yield approximations for others could be determined on a pro-rata basis or by spreadsheet analysis. Unit costs for water were not determined since yield studies have not been formally performed. Preliminary results from the first phase of the project including, reservoir size, location, distances from the Delta and the California Aqueduct, and capitalized costs expressed in dollars per acre feet of gross storage, are summarized in Table 2.

**Action Super Category:** water supply enhancement, increasing water supply predictability

**Geographical Region:** Bay-Delta, Delta tributary watersheds

**Information Type:** Delta facility location and sizing, feasibility analysis, cost for gross storage from Table 2, spreadsheet analysis, yield analysis.

### ***WS-8 -- Delta Water Transfer Alternatives***

The Department of Water Resources has conducted studies for alternatives for Delta water conveyance including through Delta improvements as well as an isolated transfer facility. Study finding including cost estimates are presented in *Alternatives for Delta Water Transfers*, November 1983, *Isolated Transfer Facility Cost Estimate*, September 1995, and *Conceptual Level Design and Cost Estimates for Various Facilities Affecting the Delta*, September 1994. Summary tables from these reports are presented in Appendix B.

**Action Super Category:** Bay-Delta habitat restoration, reduction in effects of diversions, water supply enhancement, increasing water supply predictability, management of water quality, improvements to system reliability

**Geographical Region:** Bay-Delta

**Information Type:** feasibility analysis, conveyance design, costs for water transfers from Appendix B.

### ***WS-9 -- Central California Water Recycling Project***

Table 1  
DWRSIM Model Runs -- 1995

Date Prepared	Study No.	Purpose	Level of Development	Level of SWP Demands	Facilities in Operation					Delta Standards	Annual Average Delta Inflow		Annual Average Total Delta Outflow		Annual Average Surplus Delta Outflow		Annual Average Total Delta SWP Export		Annual Average Total Delta CVP Export	
					Existing	SDI	NDI	LBG	KWB		Drought (taf)	Total (taf)	Drought (taf)	Total (taf)	Drought (taf)	Total (taf)	Drought (taf)	Total (taf)	Drought (taf)	Total (taf)
Feb '95	1995c6b-SWRCB-409.m	Dec 15 SWRCB Standards with Monterey Agreement Criteria	1995	Variable 2.6 - 3.6	Yes					Dec 15 '94 SWRCB	10375	21124	4933	14350	388	8578	1984	2872	2329	2993
Oct '95	1995c6b-SWRCB+SDI-413B.f	Study 409.m with South Delta facilities (10,300 Banks PP cap) with program correction for April-May Banks PP cap	1995	Variable 2.6 - 3.6		Yes				Dec 15 '94 SWRCB	10364	21125	4841	14299	298	8508	2051	2924	2343	2993
Mar'95	1995c6b-SWRCB.M-417	Dec 15 SWRCB Standards, SWP Monterey Agree w. 4,091 TAF SWP dmds.	1995	4.0	Yes					Dec 15 '94 SWRCB	10384	21122	4943	13938	392	8057	1991	3303	2322	2972
Mar'95	1995c6b-SWRCB.M-418	Dec 15 SWRCB Standards, SWP Monterey Agree w. 3.5 dmds-no wet yr reductions.	1995	3.5	Yes					Dec 15 '94 SWRCB	10380	21125	4945	14143	393	8322	1978	3084	2330	2988
Mar'95	1995c6b-SWRCB.M-419	Dec 15 SWRCB Standards, SWP Monterey Agree w. 3.0 dmds-no wet yr reductions.	1995	3.0	Yes					Dec 15 '94 SWRCB	10377	21121	4920	14380	394	8612	2000	2831	2330	2998
Mar'95	1995c6b-SWRCB-420	Rerun of Study 409.m, with new SWP rule curve for improved operations. Used as base for SDI Study 413.f.	1995	Variable 2.6 - 3.6	Yes					Dec 15 '94 SWRCB	10365	21123	4909	14346	384	8584	1986	2874	2344	2992
Mar'95	1995c6b-SDI+NDI-422.f	SDI Study 413 plus North Delta facilities - Altern . 2A.	1995	Variable 2.6 - 3.6		Yes	Yes			Dec 15 '94 SWRCB	10356	21123	4775	14264	325	8600	2110	2956	2344	2992
Mar'95	1995c6b-SDI+NDI-423.f	SDI Study 413 plus North Delta facilities - Altern . 3B.	1995	Variable 2.6 - 3.6		Yes	Yes			Dec 15 '94 SWRCB	10355	21123	4742	14249	347	8660	2142	2970	2344	2992
Mar'95	1995c6b-SDI+NDI-424.f	SDI Study 413 plus North Delta facilities - Altern . 5B.	1995	Variable 2.6 - 3.6		Yes	Yes			Dec 15 '94 SWRCB	10356	21123	4739	14247	356	8687	2147	2972	2344	2992
Apr'95	1995c6b-JOINTDIV-429	Study 409.mont plus SWP/CVP Joint Point of Div. (increase CVP use of SWP Banks PP).	1995	Variable 2.6 - 3.6	Yes					Dec 15 '94 SWRCB	10363	21125	4925	14321	386	8539	1985	2871	2326	3022
Apr'95	1995c6b-USCE.PER-430	Study 409.mont with change in Dec 15 - Mar 15 USCE Permit limits to Banks PP capacity.	1995	Variable 2.6 - 3.6	Yes					Dec 15 '94 SWRCB	10392	21124	4950	14350	406	8580	1986	2871	2330	2992
Apr'95	1995c6b-SDI+NDI-435.f	SDI Study 413 plus North Delta facilities - Altern. 3A-Mod. (replaces above NDI Study 425.f)	1995	Variable 2.6 - 3.6		Yes	Yes			Dec 15 '94 SWRCB	10354	21123	4713	14236	379	8709	2171	2982	2344	2992
May'95	1995c6b-SWRCB.M-436	Dec 15 SWRCB Standards, SWP Monterey Agree w. full 4,165 TAF SWP demands (rerun of Study 417 above).	1995	4.1	Yes					Dec 15 '94 SWRCB	10390	21125	4937	13915	391	8032	1989	3326	2336	2972
May'95	1995c6b-SWRCB.M-437	Dec 15 SWRCB Standards, SWP Monterey Agree w. higher variable SWP demands.	1995	Variable 3.4 - 4.1	Yes					Dec 15 '94 SWRCB	10388	21125	4937	14027	390	8161	1994	3210	2329	2978
May'95	1995c6b-SWRCB-438	G-13 Group "Study 2", Study 409.m without SWRCB inflow/export ratio limits to exports.	1995	Variable 2.6 - 3.6	Yes					Dec 15 '94 SWRCB	10374	21126	4789	14232	264	8514	2085	2919	2373	3064
May'95	1995c6b-SWRCB-439	G-13 Group "Study 3", Study 409.m without SWRCB (1) requirements at Vernalis, and (2) Apr 15 - May 15 export restrictions.	1995	Variable 2.6 - 3.6	Yes					Dec 15 '94 SWRCB	10231	14266	4933	8152	392	2852	1924	2437	2246	2707

Table 1  
DWRSIM Model Runs -- 1995

Date Prepared	Study No.	Purpose	Level of Development	Level of SWP Demands	Facilities in Operation						Delta Standards	Annual Average Delta Inflow		Annual Average Total Delta Outflow		Annual Average Surplus Delta Outflow		Annual Average Total Delta SWP Export		Annual Average Total Delta CVP Export	
					Existing	SDI	NDI	LBG	KWVB	Drought (taf)		Total (taf)	Drought (taf)	Total (taf)	Drought (taf)	Total (taf)	Drought (taf)	Total (taf)	Drought (taf)	Total (taf)	Drought (taf)
May'95	1995c6b-SWRCB-440	G-13 Group "Study 4" Study 409,m without SWRCB (1) requirements at Vernalis, and (2) Apr 15 - May 15 export restrictions, and (3) inflow/export ratio limits.	1995	Variable 2.6 - 3.6	Yes					Dec 15 '94 SWRCB	10383	21123	4914	14332	381	8570	1987	2882	2355	2998	
Jun'95	1995c6b-SWRCB-441	G-13 Group "Study 3-A", Study 409 m without SWRCB requirements at Vernalis.	1995	Variable 2.6 - 3.6	Yes					Dec 15 '94 SWRCB	10246	21041	4914	14334	373	8558	1913	2843	2290	2955	
Sep'95	1995c6b-G13+500-445.f	For G-13 Group, Study 409 m plus 500 TAF addwater, plus special program to make Feb-Jun Banks pumping equal to S.409 m.	1995	Variable 2.6 - 3.6	Yes					Dec 15 '94 SWRCB	10791	21321	4982	14394	386	8569	2352	3024	2329	2993	
May'95	2020c9b-SWRCB-411	Dec 15 SWRCB Standards with SWP Monterey Agreement criteria.	2020	4.1	Yes					Dec 15 '94 SWRCB	10349	21135	4900	14010	343	8170	1943	3213	2384	3008	
Sep'95	2020c9b-SWRCB+SDI-414B.f	Return of Study 414 w. South Delta facilities (10,300 Banks PP cap). -w. program correction for Apr-May Banks PP capacity.	2020	4.1	Yes	Yes				Dec 15 '94 SWRCB	10349	21133	4826	13867	278	7960	2015	3354	2384	3010	
Sep'95	2020c9b-SDI/NDI/LBG-416B.f	Return of LBG Study 416.f, with program correction for Apr-May Banks PP capacity.	2020	4.1	Yes	Yes	Yes			Dec 15 '94 SWRCB	10346	21132	4846	13640	278	7721	1992	3579	2384	3010	
Sep'95	2020c9b-LBG-416B.TEST.f	Return of LBG Study 416B, w modified LBG operation for lower storage and higher SWP delivery.	2020	4.1	Yes	Yes	Yes			Dec 15 '94 SWRCB	10345	21133	4847	13609	278	7682	1990	3612	2384	3010	
Jun'95	2020c9b-SDI+NDI-431.f	SDI Study 414 plus North Delta facilities - Altern. 2A.	2020	4.1	Yes	Yes				Dec 15 '94 SWRCB	10340	21130	4772	13834	304	8064	2060	3384	2384	3010	
Jun'95	2020c9b-SDI+NDI-432.f	SDI Study 414 plus North Delta facilities - Altern. 3B.	2020	4.1	Yes	Yes				Dec 15 '94 SWRCB	10338	21131	4731	13804	327	8149	2100	3415	2384	3010	
Jun'95	2020c9b-SDI+NDI-433.f	SDI Study 414 plus North Delta facilities - Altern. 5B.	2020	4.1	Yes	Yes				Dec 15 '94 SWRCB	10338	21130	4722	13797	332	8189	2109	3422	2384	3010	
Jun'95	2020c9b-SDI+NDI-434.f	SDI Study 414 plus North Delta facilities - Altern. 3A + Hood channel (Special Program hood2).	2020	4.1	Yes	Yes				Dec 15 '94 SWRCB	10338	21130	4703	13792	355	8192	2128	3427	2384	3010	

Notes:  
SDI = South Delta Improvements  
NDI = North Delta Improvements  
LBG = Los Banos Grandes Reservoir  
KWVB = Kern Water Bank (Two studies pending. No results at this time.)  
Drought period = May 1928 through October 1934  
Total period = October 1921 through September 1992

**Table 2**  
**South of Delta Storage Offstream Storage Investigations**  
 (Source: DWR December 1995)

Offstream Reservoir Site Name	Number of Alternatives Studied	Location of Reservoir (County)	Storage Capacities (1000 AF)	Distance from California Aqueduct (miles)	Distance from Delta Pumping Plant (miles)	Range of Capital Cost (\$1000/AF)
Antelope Valley	1	Kern/San Luis Obispo	378	25	202	3.9
Arroyo Ciervo	2	Fresno	121 - 317	7	122	3.7 - 10.7
Arroyo Hondo	8	Fresno	85 - 1,009	11.6 - 14.3	137	3.8 - 10.4
Bitter Creek	3	Kern	119 - 508	6.8 - 9.8	260	4.7 - 11.7
Bitterwater Valley	3	Kern/San Luis Obispo	46 - 461	21	206	2.9 - 19
Broad Creek	1	Kern	36	5	248	9.6
Buena Vista Creek	1	Kern	67	6.5	247.5	6.6
Buena Vista Lake Bed	1	Kern	91	0.1	247	3.6
Cantua Creek	7	Fresno	94 - 1,500	5.7 - 9.4	133	2.3 - 10.8
Capita Canyon	1	Fresno	30	5.6	104	24.5
Castac Valley	5	Kern	151 - 1,300	2.3 - 6.6	292	3.7
Deep Gulch	1	San Joaquin	67	4.2	18	6
Del Puerto Canyon	5	Stanislaus	41 - 228	0.4 - 2.1	37	2.6 - 5.4
Garzas Creek	11	Stanislaus	159 - 2,000	1.9 - 5.6	57	1.1 - 2.7
Hospital Creek	6	San Joaquin/Stanislaus	20 - 1,282	3 - 8.4	25	2.1 - 12.9
Ingram Canyon	3	Stanislaus	78 - 1,113	2.3	32	1.3 - 4.9
Ingram/Kern Canyon	1	Stanislaus	1,375	2.3	33	1.8
Kellogg/Marsh Creek	1	Contra Costa	452	2.6	1	1.3
Kern Canyon	1	Stanislaus	261	2	35	6.1
Kettleman Plain	1	Kings	338	4	186	1.2
Laguna Seca Creek	4	Merced	27 - 291	.8 - 3.5	89	2.5 - 6.5
Little Panoche Creek	2	Fresno	127 - 327	5.5	97	2 - 3.2
Little Salado/Crow Cree	2	Stanislaus	149 - 289	1.3 - 3.8	46	1.9 - 2.8
Lone Tree Creek	5	San Joaquin	22 - 496	2.5 - 5.9	25	3.4 - 11.8
Los Banos Creek	5	Merced	79 - 1,323	2.8	79	0.6 - 2.8
Los Banos Grandes	1	Merced	1,728	2.8	79	0.6
Los Gatos Creek	5	Fresno	28 - 2,820	22	164	1.5 - 5.2
Los Vaqueros	1	Contra Costa	1,065	7	0.6	1
McKittrick Valley	1	Kern	105	6.5	227	4.9
Moreno Gulch	4	Fresno	41 - 683	4.8 - 5.7	103	3.3 - 14.5
Mustang Creek	1	Merced	68	1.5	59	6.1
Orestimba Creek	5	Stanislaus	84 - 1,284	3 - 5.1	51	1.2 - 3.5
Ortogonalita Creek	1	Merced	125	2.2	83	5.1
Oso Creek	2	Stanislaus	96 - 135	4.5	51	4.6 - 5.6
Packwood Creek	2	Kern	105 - 323	17.5	206	3 - 5.6
Panoche Hills	1	Fresno	100	6	97	5.8
Panoche/Silver Creek	5	Fresno/San Benito	271 - 3,100	3.3 - 8.7	109	1.1 - 1.6
Pleito Creek	6	Kern	119 - 2,609	7.5	274	3.5 - 13.6
Quinto Creek	3	Merced	129 - 434	1.9 - 3.8	64	1.6 - 2.5
Romero Creek	1	Merced	206		66	2.1
Salado Creek	4	Merced	71 - 462	2.9 - 4.8	43	2.1 - 7.4
Salt Creek	3	Fresno	134 - 448	8	136	3.0 - 5.4
Salt Creek	3	Kern	122 - 362	3.2 - 5.7	283	4.9 - 7.0
Salt Creek	2	Merced	70 - 83	2.5	82	3
San Emigdio Creek	2	Kern	120 - 814	3.2 - 8.2	268	5.6 - 13.0
San Luis Creek	6	Merced	80 - 1,342	4.6	72	1.6 - 5.3
San Luis (Enlarged)	1	Merced	2,831	0	72	N/A
Sandy Creek	1	Kern	59	1.6	254	4.7
Santiago Creek	2	Kern	167 - 514	10	264	6.5 - 11.2
Sunflower	1	Kings/Kern	600	10	186	1.3
Wildcat Canyon	1	Merced/Fresno	97	4.6	95	5.5

Total Number 146

The goal of the Central Valley Water Recycling Project was to identify projects that will provide total recycling of San Francisco Bay Area wastewater, maximize water supply benefits, maximize local reuse, maximize environmental benefits, and minimize costs and environmental damages. An evaluation of potentially viable alternatives was completed July 12, 1995.

Included among the five alternatives evaluated were the collection of recycled Bay Area water and 1) discharged into the Bay-Delta Estuary, near Chipps Island, for potential positive Delta outflow benefits, 2) delivered into the lower Delta Mendota Canal service areas in exchange for CVP deliveries, and, 3) delivered into the lower San Joaquin Valley (Westlands Water District) in exchange for CVP deliveries. Analysis was made using preliminary PEIS PROSIM model runs that included the December 15, 1994 Delta criteria as an assumption. The report, Central California Regional Water Recycling Project Step 1 Feasibility Study Administrative Draft, July 12, 1995, was prepared for the U.S. Bureau of Reclamation and Bay Area Water and Wastewater Agencies.

**Action Super Category:** reduction in export reliance, increasing water supply predictability, management of water quality, improvements to system reliability  
**Geographical Region:** Bay-Delta, Delta tributary watersheds  
**Information Type:** PROSIM simulation model runs, impact analyses, Delta Mendota Canal routing studies, southern Delta export capacity optimization, costs analysis.

#### **WS-10 -- Bay-Delta Oversight Council**

The Bay-Delta Oversight Council - Water Supply Technical Advisory Committee prepared the Draft Report on work completed by the Water Supply Technical Advisory Committee, October 1994. The report summarized action options that would assist in resolving problems associated with current and future use of the Sacramento-San Joaquin Delta as a fresh water supply source in California.

**Action Super Category:** water supply enhancement  
**Geographical Region:** Delta  
**Information Type:** status and trends assessment

#### **WS-11 -- Berrenda Mesa Water District**

Berrenda Mesa Water District prepared the report Transfer of water entitlements from Berrenda Mesa Water District for Use in the Dougherty Valley area, September 1995. This draft environmental impact report describes five use alternative scenarios which present conceptual alternatives for conveyance, storage, and treatment of the transferred water entitlements between the Berrenda Mesa Water District and the Dublin San Ramon Services District.

**Action Super Category:** water supply enhancement  
**Geographical Region:** Delta tributary watersheds  
**Information Type:** water transfers, conveyance, storage and treatment.

## WS-12 -- California Water Bank

This California Department of Water Resources' State Drought Water Bank Program Environmental Impact Report, November 1993, analyzes a drought water bank run by the State which involves short-term water transfers to meet critical water needs during severe water-short periods over the next 5 to 10 years. The proposed program is a water purchasing and allocation program whereby Department of Water Resources (DWR) will purchase water from willing sellers and remarket the water to buyers under specific critical needs allocation guidelines. Major sources for bank water are expected to be water districts, individual farmers, and reservoir operators in areas tributary to the Sacramento, Feather, Yuba, American, and San Joaquin rivers. Other potential sources are areas in the northern San Joaquin Valley that are not in groundwater overdraft conditions. Areas expected to receive water include the San Francisco Bay area, the San Joaquin Valley, and Southern California.

**Action Super Category:** water supply predictability  
**Geographical Region:** Delta, Delta tributary watersheds, Delta export areas  
**Information Type:** water banking, water transfers, conjunctive use.

## WS-13 -- California Water Supply 2020

California Water 2020: A Sustainable Vision, 1995, was prepared by Gleick, Peter H. Penn Loh, Santos V. Gomez, and Jason Morrison of the Pacific Institute for Studies in Development, Environment, and Security, Oakland, CA. The document predicts a shortage of water in California by 2020 and presents methods in which water should be managed.

**Action Super Category:** water supply enhancement, increasing water supply predictability  
**Geographical Region:** California  
**Information Type:** status and trends assessment

## WS-14 -- Monterey Agreement

The Science Applications International Corporation prepared the draft report Implementation of the Monterey Agreement. Statement of Principles by the State Water Contractors and the State of California Department of Water Resources for Potential Amendments to the State Water Supply Contracts, May 1995, for the Central Coast Water Authority, Santa Barbara, CA. This document contains an agreed Statement of Principles that is the foundation for an agreement among the Agricultural Contractors, Municipal and Industrial contractors and the Department of Water Resources that will settle their disputes over water allocations and certain operational aspects of the State Water Project.

**Action Super Category:** water supply enhancement, increasing water supply predictability  
**Geographical Region:** Delta, Delta tributary watersheds, Delta export areas

Information Type: statement of principles

**WS-15 -- CVP Water Augmentation Study**

The Bureau of Reclamation's Water Augmentation Program was tasked with the job of identifying options for augmenting the CVP water supply and the estimating the cost associated with such options. Options included new and expanded on-stream and off-stream, conjunctive use, and reservoir reoperations among others. Demand management as well as supply increase options were considered. A summary of the findings of the program can be found in Appendix C.

**Action Super Category:** reduction in effects of diversions, reduction in export reliance, water supply enhancement, increasing water supply predictability

**Geographical Region:** Delta, Delta tributary watersheds

**Information Type:** simulation model runs, impact analyses, cost analyses for conservation, reclamation, fish flows, land fallowing, and others.

## 2) Water Quality Studies

### *WQ-1 -- Interim South Delta Program (ISDP)*

In support of ISDP, DWRDSM has been used extensively to develop alternatives' components by evaluating:

1. Impacts of various south Delta barrier designs and operations (individually and in tandem) on water levels, velocities, circulation patterns, and scour potential.
2. Impacts of channel dredging on water levels, circulation patterns, and scour potential
3. Impacts of Clifton Court Forebay intake gate capacity, location, and operation strategy on sustained SWP pumping capacity, south Delta water levels, and channel scour potential.

These parameters have been evaluated under different tidal and hydrologic conditions.

Once alternatives were selected, DWRDSM was used to estimate the alternative's potential Delta impacts for the EIR/EIS. Potential Delta impacts were assessed for the No-Action and the preferred Alternative using monthly maximum, minimum, and average water levels, flows, and velocities, and monthly average salinity (in total dissolved solids) throughout the Delta. The table below summarizes the DWRDSM simulations for the five water year types:

<b>ISDP Alternative</b>	<b>SWP Demands</b>	<b>Bay-Delta Standards</b>
No-Action	Existing	D-1485
Preferred	Existing	D-1485
No-Action	Future	D-1485
Preferred	Future	D-1485
No-Action	Existing	1995 WQ Control Plan
Preferred	Existing	1995 WQ Control Plan
No-Action	Future	1995 WQ Control Plan
Preferred	Future	1995 WQ Control Plan

**Action Super Category:** Bay-Delta habitat restoration, reduction in effects of diversions, water supply enhancement, management of water quality, improvements to system reliability

**Geographical Region:** Bay-Delta (South Delta)

**Information Type:** hydrodynamic simulation model runs, impact analyses

**WQ-2 -- Interim North Delta Program (INDP)**

Potential Delta impacts under the No-Action and five other alternatives were assessed using monthly maximum, minimum, and average water levels, flows, and velocities, and monthly average salinity (in total dissolved solids) throughout the Delta. Each INDP alternative, including the No-Action alternative, assumed the installation and operation of the ISDP preferred alternative. Delta cross-channel operations and SWP pumping reflected Bay-Delta standards. The table below summarizes the DWRDSM simulations for the INDP for wet, below normal, and critical water years.

<b>INDP Alternative</b>	<b>SWP Demands</b>	<b>Bay-Delta Standards</b>
No-Action	Existing	1995 WQ Control Plan
South Mokelumne Dredging	Existing	1995 WQ Control Plan
South & North Mokelumne Dredging	Existing	1995 WQ Control Plan
South & North Mokelumne Dredging, Delta Cross Channel Enlargement	Existing	1995 WQ Control Plan
South & North Mokelumne Dredging, Screened Diversion at Hood	Existing	1995 WQ Control Plan
South & North Mokelumne Dredging Levee Setbacks Delta Cross Channel Enlargement	Existing	1995 WQ Control Plan
No-Action	Future	1995 WQ Control Plan
South Mokelumne Dredging	Future	1995 WQ Control Plan
South & North Mokelumne Dredging	Future	1995 WQ Control Plan
South & North Mokelumne Dredging, Delta Cross Channel Enlargement	Future	1995 WQ Control Plan
South & North Mokelumne Dredging, Screened Diversion at Hood	Future	1995 WQ Control Plan
South & North Mokelumne Dredging Levee Setbacks Delta Cross Channel Enlargement	Future	1995 WQ Control Plan

**Action Super Category:** Bay-Delta habitat restoration, reduction in effects of diversions, water supply enhancement, management of water quality, improvements to system reliability

**Geographical Region:** Bay-Delta (North Delta)

**Information Type:** hydrodynamic simulation model runs, impact analyses

### *Other Studies*

**WQ-3 --** A DWRDSM study was performed for SWRCB to evaluate impacts of December 15 accord on Delta salinity. The study, which covers water years 1987 - 1992 with monthly varying hydrology, is documented in the Board's May 1995 Draft Water Quality Control Plan, Appendix 1.

**Action Super Category:** management of water quality

**Geographical Region:** Bay-Delta

**Information Type:** hydrodynamic simulation model runs, impact analyses of December 1994 standards

**WQ-4 --** U.S. Bureau of Reclamation, Mid-Pacific Region. *Draft Finding of no significant impact and supplemental environmental assessment - Grassland Bypass Channel project.* September 1995. Sacramento, CA.

This document describes a proposed interim measure for diverting salt and selenium-contaminated agricultural drainage water away from channels used to supply water to wildlife areas in the Grasslands area. The report also includes a plan for monitoring salt and selenium loads to the San Joaquin River and a discussion of long-term water quality and water supply management needs in the Grassland Area.

**Action Super Category:** water supply enhancement, management of water quality

**Geographical Region:** Delta tributary watersheds

**Information Type:** simulation model runs, impact analyses, agricultural drainage

**WQ-5 --** Bay-Delta Oversight Council - Water Quality Technical Advisory Committee. 1994. *Draft Report on work completed by the Water Quality Technical Advisory Committee.* December 1994.

A list of draft action options for the improvement of the Bay-Delta estuary's water quality is provided in this document. The effects of implementing any of the action options on Delta water quality are also evaluated.

**Action Super Category:** reduction in effects of diversion, management of water quality

**Geographical Region:** Delta

**Information Type:** status and trends assessment

WQ-6 -- San Francisco Estuary Project. 1993. Managing freshwater discharge to the San Francisco Bay/Sacramento-San Joaquin Delta estuary: The scientific basis for an estuarine standard- Conclusions and recommendations of members of the scientific, policy, and management communities of the Bay/Delta Estuary.

This report provides recommendations of using salinity and flow standards in an effort to create estuarine standards.

**Action Super Category:** water supply enhancement, management of water quality  
**Geographical Region:** Bay-Delta  
**Information Type:** technical report

WQ-7 -- California. Department of Water Resources. 1995. Sacramento-San Joaquin Delta Water Quality Surveillance Program. Monitoring Results Pursuant to Conditions Set Forth in Delta Water Rights Decision 1485. Sacramento.

This report tabulates water quality, biological, and other data collected at numerous stations throughout the Sacramento-San Joaquin Delta area during 1993. This program began in 1975 and most data are stored in STORET at the National Computer Center in North Carolina. Select data are also made available to the Department of Water Resources' Water Data Information System.

**Action Super Category:** management of water quality  
**Geographical Region:** Delta  
**Ecosystem/Habitat Type:** aquatic freshwater/riverine, aquatic estuarine  
**Information Type:** status and trends assessments, monitoring

WQ-8 -- California. Department of Water Resources, Division of Local Assistance. 1994. Five-year Report of the Municipal Water Quality Investigations Program: Summary and Findings During Five Dry Years, January 1987 - December 1991. Sacramento.

This report presents and summarizes water quality data collected from numerous channel and agricultural drainage pump stations throughout the Sacramento-San Joaquin Delta. The study focuses on water quality variables of importance to drinking water supplies, especially, specific conductance, dissolved organic carbon, bromide, and trihalomethane formation potential. The results of a simple model to estimate the impact of organic carbon from drainage and nondrainage sources are presented and discussed.

**Action Super Category:** management of water quality  
**Geographical Region:** Delta  
**Ecosystem/Habitat Type:** aquatic freshwater/riverine, aquatic estuarine  
**Information Type:** status and trends assessments, drinking water quality

WQ-9 -- U. S. Fish and Wildlife Service. 1992. Environmental impact statement, Stone Lakes National Wildlife Refuge Project, Sacramento County, California. Final. With technical assistance provided by Jones & Stokes Associates, Inc. (JSA 91-047.) Sacramento, CA.

This report analyzes the direct, indirect and cumulative impacts associated with the creation of the Stone Lakes National Wildlife Refuge. Effects of several project alternatives and the no-project alternative on climate and air quality, topography and geology, soils, hydrology and water quality, wildlife, vegetation, and wetlands, fisheries and aquatic resources, cultural resources, land use and aesthetics, recreation and public access, agricultural resources, and mosquitoes and public health are evaluated.

**Action Super Category:** Bay-Delta habitat restoration

**Geographical Region:** Delta

**Ecosystem/Habitat Type:** terrestrial, aquatic freshwater/riverine

**Information Type:** impact analyses

### 3) Ecosystem Quality Studies

#### *U.S. Army Corps of Engineers*

**EQ-1--** *Project Modification Report: Yolo Basin Wetlands Sacramento River, California*, April 1992, U.S. Army Corps of Engineers. This report describes a plan to convert agricultural land to wetland and riparian habitat at the southern tip of Liberty Island within the Yolo Bypass. An RMA2 model was used to determine the effect of the project on flood flows in the bypass. (Note: The impact was found to be negligible.)

**Action Super Category:** Bay-Delta habitat restoration

**Geographical Region:** Yolo Bypass

**Ecosystem/Habitat Type:** Wetland and riparian

**Information Type:** Cost estimates to construct seasonal wetland ponds (50-200 Acres in size), permanent wetlands (5-50 Acres in size), shorebird foraging, riparian forests and grasslands.

**EQ-2 --** *Cache Slough/Yolo Bypass Mitigation Area, Solano County, California, Office Report, Contract 42M2, Sacramento River Bank Protection Project*, October 1990, U.S. Army Corps of Engineers. The Cache Slough/Yolo Bypass mitigation site is very similar to the current study. For this site, the southern tip of Liberty Island was isolated from the northern portion of the island by constructing a cross levee. Two mounds were created in the interior of the island, and then the levees of the isolated tip were breached in two places to restore tidal action to the site. This report looks at different combinations of the habitat variables (such as topography, planting, and type of levee breach) of the mitigation site to determine the habitat value that can be realized by each combination.

**Action Super Category:** Bay-Delta habitat restoration

**Geographical Region:** Delta, Cache Slough., and Yolo Bypass

**Ecosystem/Habitat Type:** Delta riverine and wetland

**Information Type:** Preliminary cost estimates for earthwork, hydraulic, and planting options. HEP modeling results to determine annual average habitat units (AAHU). Costs ranged from \$160 to \$460 per AAHU.

**EQ-3 --** *Design and Monitoring of Wetland and Riparian Habitats Created with Dredged Materials, Deep Water Ship Channel Monitoring Programs*, September 1990, U.S. Army Corps of Engineers. This report summarized the results of 3 years of vegetation, fisheries, and wildlife monitoring on Donlon and Venice Cut Islands, two **flooded** islands along the Stockton Deep Water Ship Channel. Habitat was created on these islands by placing dredged material on the islands and allowing the created habitat to be exposed to full tidal action. The report synthesizes the results of monitoring to develop design criteria for future similar projects.

**Action Super Category:** Bay-Delta habitat restoration

**Geographical Region:** Stockton Ship Channel; Donlon and Venice Cut Islands  
**Ecosystem/Habitat Type:** Tidal marsh habitat,  
**Information Type:** Measured increases in number of breeding birds and number of fish caught over time as dredged material islands created within Donlon and Venice Cut Islands became increasingly vegetated.

**EQ-4 -- Prospect Island Fish Habitat Restoration Pilot Program, 1988, U.S. Army Corps of Engineers.** In October 1985 a Memorandum of Agreement between the Department of the Army and the NMFS was signed committing both agencies to a 3-year pilot program to demonstrate the feasibility of restoring or creating fish and wildlife habitat on Corps projects without incurring additional cost to the Corps projects selected for habitat restoration. Prospect Island was studied as part of this effort. In 1988, the Sacramento District prepared a pilot report which addressed abandoning the island's current use and accompanying levee maintenance, breaching the ship channel levee, and converting the island to wetland habitat. The economic impact of this project on the delta was quantified in this study.

**Action Super Category:** Bay-Delta habitat restoration  
**Geographical Region:** Delta, Prospect Island  
**Ecosystem/Habitat Type:** Aquatic and wildlife habitat  
**Information Type:** Levee stabilization costs were compared to the project costs. A cost savings resulted from allowing the Prospect Island lands to convert to habitat.

**EQ-5 -- Prospect Island, U.S. Army Corps of Engineers -** A follow-up study to the above study. This reconnaissance level study looks at developing freshwater tidal Marsh in the Delta by constructing interior islands within Prospect Island, reinforcing the existing perimeter levees with earth, stabilizing islands and levees using biotechnical slope stabilization and breaching the levee in two places. TTN and RMA2 models were developed to ensure a two day replacement of water through the site. A wave runoff study was also conducted to determine fetch lengths. A HEP model was also run to determine benefits and impacts to wildlife habitat.

**Action Super Category:** Bay-Delta habitat restoration.  
**Geographical Region:** Delta, Prospect Island  
**Ecosystem/Habitat Type:** Upland, riparian, SRA, tidal open marsh, and tidal tule mudflat.  
**Information Type:** Costs were estimated for developed acres of tidal marsh, mudflats, and riparian habitat. First costs ranged from \$8,000 to \$21,000 per acre.

**EQ-6 -- Northern California Streams, Sacramento River Fish Migration Study, U.S. Army Corps of Engineers .** The purpose of this ongoing reconnaissance study is to assist migration of anadromous fish, both upstream and downstream, through the Sacramento River system. Special emphasis is to be given to the possibility of using the William G. Stone Lock and ship channel for this purpose. The upstream end of the study limit is the Sacramento River at Verona; the downstream limit is at Collinsville where the San Joaquin River meets the Sacramento River. Measures being investigated include re-operation and/or modification of the lock to allow the fish to pass upstream and downstream, a fish ladder around the lock to allow for upstream migration, deflecting young out-migrants into Steamboat and Sutter

Sloughs to provide a shorter and safer migration, and habitat improvements along the river. These improvements include shaded riverine aquatic and riparian habitat, and instream cover for fish such as boulders and fish groins.

Flow splits along the ship channel were modeled by the California Department of Water Resources using DWRFLO and DWRPTM. The objective of the modeling runs was to show and analyze flow patterns generated when the ship Channels' William G. Stone Lock and Cross channel are opened and closed under various flow conditions. A further objective was to provide an understanding of how biomass is transported with various hydrologic and geometry configurations. The models generally tell how flow is distributed below the ship channel under various scenarios.

(Note: This reconnaissance level study was completed in April 1995. A final study plan, with a focus on revegetation of most of the levees between Collinsville and Verona, is currently in preparation. The Corps is currently seeking a sponsor to move forward with the study. If they find one, they estimate it can be completed by about 1998.)

**Action Super Category:** Upstream habitat restoration, management of anadromous fish.

**Geographical Region:** Sacramento River-Delta (Verona to Collinsville)

**Ecosystem/Habitat Type:** Shaded riverine, riparian, and instream cover for fish.

**Information Type:** The total first costs for the study are:

Feature	First Costs (\$)
Fish Ladder	3.1 million
Habitat Restoration	12.0 million
Acoustical Deflection into Sloughs	2.0 million
<b>Total First Costs</b>	<b>17.1 million</b>

**EQ-7 -- *Little Holland Tract Reconnaissance Investigation*, U.S. Army Corps of Engineers.** The purpose of this ongoing investigation is to determine the potential for flood control, environmental restoration, and related purposes on Little Holland Tract and Liberty Island. The area has been inundated and subject to tidal action continually since the levees failed in 1983 and has since developed and matured as a tidally influenced wetland. When flooded, Little Holland Tract provides valuable habitat for the Delta smelt and winter-run chinook salmon. This study which will investigate restoring the study area to wetland habitat, is scheduled for completion in January 1996.

The RMA2 model was used to determine possible effects of the project on flows in the Yolo Bypass. The Reclamation Board will not allow any project to significantly impact flows in the bypass. A TTN model was also used to develop the 3D topography. A wave runoff study was also conducted for this project to determine fetch lengths generated by this project.

**Action Super Category:** Bay-Delta habitat restoration.

**Geographical Region:** Delta; Little Holland Tract and Liberty Island.  
**Ecosystem/Habitat Type:** Tidal marsh, wetland habitat.  
**Information Type:** None yet.

*Bay-Delta Oversight Council*

EQ-8 -- Bay-Delta Oversight Council - Aquatic Resources Technical Advisory Committee. 1994. Draft initial report on work completed by the Aquatic Resources Technical Advisory Committee. November 1994.

This document identifies and evaluates 37 action options which address concerns to improve and sustain biological resources dependent on the estuarine ecosystem in the Delta. Action option topics include: improvement of fish production, net flow patterns improvements, diversions, operational measures, and restorative measures.

**Action Super Category:** reduction in effects of diversion, management of anadromous fish, water supply enhancement.  
**Geographical Region:** Delta  
**Ecosystem/Habitat Type:** aquatic estuarine, aquatic freshwater / riverine  
**Information Type:** status and trends assessment; Two of the 37 action options provided cost estimates and are as follows: Construction of a Restraining Channel for flow restriction in the Carquinez Strait and San Pablo Straits - \$150,000 - \$200,000; and Establishment of new hatcheries in the Central Valley rivers and tributaries - \$9.7 million (1994 dollars) with annual operation costs of \$350,000 for four staff members.

EQ-9 -- Bay-Delta Oversight Council - Plant and Wildlife Resources Technical Advisory Committee. 1994. Draft initial report on work completed by the Plant and Wildlife Resources Technical Advisory Committee. November 1994.

This document identifies 28 action options to manage existing plant and wildlife resources, manage/enhance existing land ownership, restore /manage flood plains, restore/enhance levees, and expand and create preserves within five regions of the Bay-Delta estuary.

**Action Super Category:** Bay-Delta habitat restoration  
**Geographical Region:** Delta  
**Ecosystem/Habitat Type:** terrestrial  
**Information Type:** status and trends assessment; No cost estimates are available for action options.

EQ-10 -- Bay-Delta Oversight Council. Options to protect and enhance the Estuary. May 1995. Draft. Sacramento, CA.

This document describes over 100 options to protect and enhance the Sacramento-San Joaquin Bay-Delta Estuary by addressing concerns related to water supply, water quality,

and biological resources. Each option is intended to partially address one or more resource-related problems in the Estuary. The options were developed with the expectation that they would eventually be combined into alternatives which would address the full range of problems in the Estuary.

**Action Super Category:** Bay-Delta habitat restoration, upstream habitat restoration, reduction in effects of diversions, water supply enhancement, management of water quality,

**Geographical Region:** Delta, Bay

**Ecosystem/Habitat Type:** aquatic estuarine

**Information Type:** status and trends assessment; Cost estimates were not included in this document.

### *U.S. Fish and Wildlife Service*

**EQ-11** -- U.S. Fish and Wildlife Service. 1994. Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes - Technical Agency Draft. December 8, 1994.

This report presents species accounts for seven fishes native to the Delta (Delta smelt, longfin smelt, Sacramento splittail, Sacramento perch, Green sturgeon, and Sacramento spring-run, Sacramento late fall-run, and San Joaquin fall-run chinook salmon). Each account summarizes the official status of the species, its recovery potential, and distinguishing features, its taxonomic history, distribution, habitat requirements, life history, abundance and abundance trends, the main reasons for its decline, and conservation measures currently in place to protect the species. Also included are a statement of the general objectives for restoring populations to sustainable numbers and a description of species-specific criteria that can be used to monitor the effectiveness of recovery actions and determine when the species has recovered. The report concludes with a prioritized list of tasks needed to achieve the species' recovery objectives and an estimate of associated costs.

**Action Super Category:** Bay-Delta habitat restoration

**Geographical Region:** Delta

**Ecosystem/Habitat Type:** aquatic freshwater/riverine

**Information Type:** status and trends assessments

**EQ-12**-- U.S. Fish and Wildlife Service. 1995. Working Paper on restoration needs: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. Volumes 1-3. May 9, 1995. Prepared for the U.S. Fish and Wildlife Services under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, CA.

This working paper contains instream flow requirements and other habitat restoration actions needed to double production of Chinook salmon, steelhead trout, American shad, and white and green sturgeon in mainstem or tributary reaches of the Central Valley drainage network. Volume I describes how the working paper was developed, explains the

process required for completing a final Restoration Plan, and summarizes the production goals, limiting factors, and restoration actions presented in detail in Volume III. Volume II provides descriptions of Central Valley streams and rivers, summarizes information on historic and existing conditions for anadromous fish, identifies the problems that have led to recent declines in their abundance and specifies roles and responsibilities of state and federal agencies in managing anadromous fish.

**Action Super Category:** upstream habitat restoration, management of anadromous fish

**Geographical Region:** Delta tributary watersheds

**Ecosystem/Habitat Type:** aquatic freshwater/riverine

**Information Type:** status and trends assessment. The report contains no model runs or cost estimates.

### *California Department of Fish and Game*

**EQ-13 --** The California Department of Fish and Game estimated costs for fish screens depending on diversion location, size, and complexity. The general categories used were (1) small diversions (15 cfs or less) screened for about \$2,000 per cfs, (2) medium-sized diversions (15 - 250 cfs) screened for about \$5,000 per cfs, and (3) large and/or complex diversions screened for about \$10,000 per cfs.

**Action Super Category:** upstream habitat restoration, management of anadromous fish

**Geographical Region:** Delta tributary watersheds, Delta

**Ecosystem/Habitat Type:** aquatic freshwater/riverine

**Information Type:** A list of facilities and costs can be found in **Appendix D**.

**EQ-14--** California Department of Fish and Game. 1993. *Restoring Central Valley Streams: A Plan for Action*. November 1993. Sacramento, CA.

In this action plan, Department of Fish and Game (DFG) assesses the present conditions and needs of Central Valley anadromous fish habitat, the associated riparian wetlands, and sets priorities for taking action. This plan encompasses all Central Valley waters accessible to anadromous fish, excluding the Sacramento-San Joaquin Delta. Elements of the plan include fish screening, spawning gravel enhancement, river channel modification, groundwater exchanges, and surface water purchases. Preliminary estimates of fish screening costs range from \$2,000 per cfs screened for small diversions (<15 cfs), \$5000 per cfs for medium-sized diversions (15-250 cfs), to \$10,000 for large or complex diversions. Gravel enhancement projects requiring engineering design work and retention structures cost about \$28 per square yard. River channel modification that requires modifying channel geometry, floodplain contours, levees, channel capacity or isolation of predator habitat costs about \$110 per linear foot. Well drilling for surface water exchange or supplementation of surface flow requires about \$20,000 per cfs. Cost of surface water is assumed to average about \$75 per acre-foot. Eighteen potential sources of funding are identified.

**Action Super Category:** management of anadromous fish, upstream habitat restoration  
**Geographical Region:** Delta tributary watersheds  
**Ecosystem/Habitat Type:** aquatic freshwater/riverine  
**Information Type:** status and trends assessments, habitat inventories; Costs- see above.

### *Interagency Ecological Program Technical Reports*

**EQ-15** -- Interagency Ecological Program Home Page. 1995. World Wide Web URL: <http://wwpiep.water.ca.gov/>

The IEP Home Page on the World Wide Web provides information on: 1) description and Organization of IEP, 2) listings of IEP Reports, 3) directory of contact personnel, and 4) available data. Data information includes long-term monitoring such as water quality, biological, and meteorological throughout the estuary. Near-time monitoring data includes feasibility for protecting chinook salmon, delta smelt, splittail, longfin smelt, and other species from State Water Project and Central Valley Water Project operations collected within 48 hours. Data also exists for historical short-term (special) studies.

A summary of IEP reports can be found in **Appendix E**.

### *Department of Water Resources*

**EQ-16** -- California Department of Water Resources. 1995. *San Joaquin River Management Plan*. Prepared for the Resources Agency by an Advisory Council established by Assembly Bill 3603. February 1995.

This plan describes the San Joaquin River system, problem areas such as: flood protection, water supply, water quality, recreation, fisheries, and wildlife, and lists over 70 recommended specific projects, studies, and acquisitions that would improve the conditions in and along the San Joaquin River and its tributaries.

**Action Super Category:** upstream habitat restoration, reduction in effects of diversions, management of anadromous fish, water supply enhancement,  
**Geographical Region:** Delta tributary watersheds, Delta  
**Ecosystem/Habitat Type:** aquatic freshwater/ riverine  
**Information Type:** status and trends assessment; Cost estimates and funding sources are provided for some of the recommended projects, studies and acquisitions.

The following Table -- describes some of the recommended projects and estimated costs associated with project implementation and operation for the San Joaquin River system.

Recommended Projects	Cost (Estimated)
Andrew Firebaugh Historical Park	\$1.1 million
Channel and Spawning Gravel work	\$8.0 million
Exotic Vegetation Removal	\$1.3 million / (\$69,000 for periodic costs)
In-Channel Aggradation Control (Demo Project)	\$20,000 per site
Mainstem Levee Design Correction (total cost)	\$79.0 million
Mendota Dam Replacement	\$1.6 million
Real-Time Water Quality Management Network, Phase 1	\$300,000
Real-Time Water Quality Management Network, Phase 2	\$600,000
Reservoir Flood Release Coordination	\$300,000
Restoration of Riparian Corridor	\$44.3 million
Riparian Diversion- Pilot Screening Projects*	\$5,000-\$10,000 per cubic foot/second diverted (simple screens)
Salmon-Artificial Production	\$9.5 million (Phase 1) \$400,000 annual operation budget
San Joaquin Fall Barrier at Merced River	\$350,000 / \$50,000 annual operation costs (after 5 yrs.)
San Joaquin River Overflow onto Riparian and Wetland Areas	\$6.0 million
San Joaquin River Parkway Plan	\$50.0 million
Sediment Control - Watershed and Watercourse Mgt (Total cost)	\$53.0 million
Sediment Removal from San Joaquin Mainstem	\$90,000/ \$9,000 periodic maintenance
Stanislaus River Rock Hazard Solutions	\$3,000
Tuolumne River Regional Park Plan	\$17.6 million / \$500,000 - \$3.5 million annual operation costs

Note: \*Total cost has yet to be determined.

### *Others*

EQ-17 -- Cannon, Tom. 1995. *Winter-Run Program-Suggestions and Notes for Discussion*. Tom Cannon for CUWA.

This paper includes suggestions and notes for discussion on the "new standards" and "winter-run program". This paper also discusses the key life history and population trends of the winter run chinook salmon, and an Agency Recovery Plan which includes habitat restoration, water augmentation, water quality and fish passage improvement measures.

**Action Super Category:** Bay-Delta habitat restoration, upstream habitat restoration, management of anadromous fish

**Geographical Region:** Delta, Bay, Delta tributary watersheds

**Ecosystem/Habitat Type:** aquatic estuarine, aquatic freshwater/riverine

**Information Type:** suggestions and notes for discussion paper.

EQ-18 -- Central Valley Habitat Joint Venture. 1990. *Central Valley Habitat Joint Venture Implementation Plan*. February 1990.

This implementation plan describes six objectives used to achieve the Central Valley Habitat Joint Venture's goal of protecting, maintaining, and restoring habitat to increase waterfowl populations to desired levels in the Central Valley of California. The six objectives include: protection of 80,000 acres of existing wetlands; restore and protect 120,000 acres of historic wetlands; enhance 291,555 acres of existing wetlands; secure 402,450 acre-feet of water for existing Central Valley National Wildlife Refuges and Wildlife Areas; and enhance 443,000 acres of private agricultural land for feeding and nesting waterfowl.

**Action Super Category:** Bay-Delta habitat restoration, upstream habitat restoration  
**Geographical Region:** Delta, Bay, Delta tributary watershed  
**Ecosystem/Habitat Type:** terrestrial  
**Information Type:** status trends and assessment; The following table describes the cost estimates for the six specific objectives developed by the Implementation Board of the Central Valley Habitat Joint Venture Plan in an effort to meet its goals.

Objective	Acreage	Cost
Habitat Acquisition	62,060 ac 17,940 ac	\$38.3 million (conservation easements) \$45.0 million (fee acquisitions) (Annual operation and maintenance cost are estimated to be \$1.55 and \$1.79 million, respectively.)
Water and Power	Initiate legislation to reauthorize CVP to include wildlife as a project purpose.	\$35.4 million in total capital costs based on full groundwater alternative (Annual operation and maintenance costs: \$6.9 million.)
Wetland Restoration	112,700 ac	\$315.0 million in total capital costs (Annual operation and maintenance costs: \$6.9 million)
Wetland Enhancement	291,555 ac	\$18.9 million (\$65/acre)
Agricultural Lands Enhancement	332,300 ac of grain fields (private) 110,800 ac of upland nesting habitat	\$7.2 million (Federal, State, private sectors)

EQ-19 -- Delta Protection Commission. 1995. *Land use resource management plan for the primary zone of the Delta*. February 23, 1995.

This document is a resource management plan for land uses within the primary zone of the Delta. This document includes findings, policies, and recommendations for the environment; utilities and infrastructure; land use; agriculture; water; recreation and access; levees; and marine patrol, boater education, and safety programs.

**Action Super Category:** Bay-Delta habitat restoration, reduction in effects of diversions, water supply enhancement, management of water quality, improvements to system reliability

**Geographical Region:** Delta

**Ecosystem/Habitat Type:** aquatic estuarine, aquatic freshwater/riverine, terrestrial

**Information Type:** resource management plan; No cost estimates or models were used in this document.

EQ-20 -- Joint California Water Users. 1995. Coordinated protection program for the San Francisco Bay/Sacramento-San Joaquin Delta estuary: Category III implementation plan - Proposals for the development and implementation of measures to control non-flow factors. Prepared on behalf of the Ad Hoc Category III Working Group under the sponsorship of the Joint California Water Users. July 5, 1995.

This document describes proposals for the development and implementation of measures to control non-flow factors as part of a comprehensive ecosystem protection plan for the Bay-Delta. Fifteen measures were selected for further consideration (out of 40) to provide biological benefit to the Bay-Delta. These measures (and an estimate of total project costs) include the Patterson Fish Screen Project (\$3,350,000), Parrott-Phelan Pumping Station (M&T Ranch) Project (\$2,500,000), Lower Mokelumne Screening Project (\$1,000,000), Extension of the Biologically Integrated Orchard Systems Project (\$2,000,000), Napa-Sonoma March Restoration (\$300,000), Prospect Island Restoration (\$10,000,000), Riparian Corridor Restoration on Flood-Damaged San Joaquin Tributaries (Category III costs not estimated, O&M would be \$300,000 per year), Battle Creek Restoration Proposal (\$9,500,000), Little Mandeville Restoration Project (\$1,150,000), Gravel Restoration on Mokelumne River (\$50,000 per year), Consumes River Watershed Project (\$1,275,000), Riparian Restoration-Sacramento River, Verona to Colusa (\$540,227), Clough Dam Removal Project (\$2,000,000), Captive Breeding/Artificial Propagation of Delta Smelt (\$910,000), and the Sacramento River Winter-Run Chinook Salmon Captive Broodstock Program (\$1,032,000).

**Action Super Category:** Bay-Delta habitat restoration, upstream habitat restoration, reductions in effects of diversions

**Geographical Region:** Delta, Bay

**Ecosystem/Habitat Type:** aquatic freshwater/riverine

**Information Type:** implementation plan

EQ-21 -- San Francisco Estuary Project. 1994. Comprehensive Conservation and Management Plan. June 1995.

This plan identifies nine program areas: Aquatic resources, Wildlife, Wetlands, Water Use, Pollution Prevention and Reduction, Dredging and Waterway Modification, Land Use, Public Involvement and Education, and Research and Monitoring which are of environmental concern for the Bay-Delta. Each program area discusses the existing management structure; program area goals; recommendations to approach the problem; and recommended actions for implementation to restore and maintain the chemical, physical, and biological integrity of the Bay and Delta.

**Action Super Category:** Bay-Delta habitat restoration, reduction in effects of diversions, management of water quality

**Geographical Region:** Bay, Delta

**Ecosystem/Habitat Type:** aquatic estuarine

**Information Type:** status and trends assessment; Total estimated state and federal agency costs for implementing each of the program areas over 20 years is as follows:

Program	Cost (\$)
Wildlife	442,995,000
Wetlands Management	407,021,000
Water Use	86,211,000
Pollution Prevention/Reduction	224,112,000
Dredging/Waterway Modif.	24,172,000
Land Use	38,378,000
Public Involvement/Educ.	59,450,000
Research and Monitoring	306,470,000

These estimates do not include costs to local agencies, local governments or private entities. The document also includes brief minority reports outlining objections to elements of the plan.

**EQ-22 -- Stakeholders Matrix Committee Strawman Draft - 6/27/95**

This report summarizes the initial ideas of the Matrix Committee on developing an efficient process for generating Bay-Delta solutions. Goals and objectives are presented for ecological restoration, water supply management, water quality management, and natural disaster management.

**Action Super Category:** Bay-Delta habitat restoration, upstream habitat restoration, reduction in effects of diversions, water supply enhancement, increasing water supply predictability, management of water quality, improvements to system reliability

**Geographical Region:** Bay-Delta

**Ecosystem/Habitat Type:** aquatic estuarine, aquatic freshwater/riverine

**Information Type:** report; No models or cost estimates are included in this document.

**EQ-23 -- Jones & Stokes Associates, Inc. 1993. Suitability analysis for enhancing wildlife habitat in the Yolo Basin. January 18, 1994. (JSA 90-285) Sacramento, CA. Prepared for Central Valley Habitat Joint Venture. Sacramento, CA.**

This study identifies opportunities for and constraints to the creation and management of wetland, riparian, grassland and oak woodland habitats in the Yolo Basin. In addition to background information on historical and existing physical, biological, and agricultural conditions and on existing jurisdictions and infrastructure affecting the Yolo Basin, this report describes wetland construction and enhancement projects already in place and identifies potential constraints on future restoration projects. Management guidelines and habitat suitability maps are also presented.

**Action Super Category:** upstream habitat restoration  
**Geographical Region:** Delta tributary watersheds  
**Ecosystem/Habitat Type:** terrestrial  
**Information Type:** status and trends assessments; No estimates of costs are presented.

### *Delta Ecosystem Data and Inventories*

**EQ-24** -- Botanical Research Group. 1992. *Selected Tidal and Associated Wetlands in Contra Costa County, California*. Report prepared for the Contra Costa County Community Development Department.

This document identifies and evaluates 212 sites that includes all areas of the Delta that occur within Contra Costa County and areas of the San Francisco Bay. Each site was inventoried for rare and endangered plant and animal species, wildlife habitats, and plant community types using data from the California Department of Fish and Game's Natural Diversity Database, other sources of information, and original field work. Based on the inventory data, sites were evaluated using a quantitative methodology and ranked in terms of overall habitat quality. In addition, degraded sites were evaluated for restoration potential.

**Action Super Category:** Bay-Delta habitat restoration and existing conditions  
**Geographical Region:** Delta, Bay  
**Ecosystem/Habitat Type:** Wetlands, Riparian, Shallow Water  
**Information Type:** inventory

**EQ-25** -- Botanical Research Group. 1992. *Atlas of Tidal and Formerly Tidal Wetlands in Contra Costa County, California*. Report prepared for the Contra Costa County Community Development Department.

This document is primarily an atlas of aerial photographs showing the mapping of individual sites and their habitat quality values. This document includes information that identifies and evaluates 212 sites that includes all areas of the Delta that occur within Contra Costa County and areas of the San Francisco Bay. Each site was inventoried for rare and endangered plant and animal species, wildlife habitats, and plant community types using data from the California Department of Fish and Game's Natural Diversity Database, other sources of information, and original field work. Based on the inventory data, sites were evaluated using a quantitative methodology and ranked in terms of overall habitat quality. In addition, degraded sites were evaluated for restoration potential.

**Action Super Category:** Bay-Delta habitat restoration  
**Geographical Region:** Delta, Bay  
**Ecosystem/Habitat Type:** Wetlands, Riparian, Shallow Water  
**Information Type:** inventory

EQ-26 -- Department of Fish and Game. 1995. Master Environmental Assessment for the Delta SB34 Program.

This document maps known biological resources associated with levee islands in the Delta. The inventory data includes existing rare plant and animal species from the Natural Diversity Database and vegetation associated with levees.

**Action Super Category:** Bay-Delta habitat existing conditions  
**Geographical Region:** Delta, Bay  
**Ecosystem/Habitat Type:** Wetlands, Riparian, Shallow Water, Riverine  
**Information Type:** inventory

EQ-27 -- Department of Fish and Game Natural Diversity Database. 1995.

The NDDDB is an ArcInfo geographic information system (GIS) that maintains digital and other files on the locations of rare plants, animals, and communities throughout California.

**Action Super Category:** Bay-Delta existing conditions  
**Geographical Region:** Delta, Bay  
**Ecosystem/Habitat Type:** Wetlands, Riparian, Shallow Water, Terrestrial  
**Information Type:** inventory

EQ-28 -- Jones and Stokes Associates. 1995. Delta Island Flooding EIR/EIS.

Environmental documents were prepared to evaluate the diversion of high-quality spring runoff from the Delta to four centrally-located Delta islands for temporary storage. The documents included habitat evaluation procedures (HEP) studies of the existing conditions and land use with respect to wildlife use. In addition, a water-quality study of a 50-acre demonstration wetland was monitored.

**Action Super Category:** Bay-Delta existing conditions  
**Geographical Region:** Delta  
**Ecosystem/Habitat Type:** Wetlands, Riparian, Terrestrial  
**Information Type:** environmental report

EQ-29 -- McCarten, N. University of California, Berkeley. 1990. Report on a Study of Sensitive Plant Species Occurring in Frank's Tract State Recreation Area. Report to the California Department of Parks and Recreation.

This report describes three rare plant species, Mason's lilaopsis, Suisun marsh aster, and mudwort, that occur in the Delta and provides maps and population data on their location within Frank's Tract.

**Action Super Category:** Bay-Delta habitat existing conditions  
**Geographical Region:** Delta

**Ecosystem/Habitat Type:** Wetlands, Shallow Water  
**Information Type:** report

EQ-30 -- McCarten, N. University of California, Berkeley. 1989. Report on a Study of Sensitive Plant Species Occurring in Brannon Island State Park. Report to the California Department of Parks and Recreation.

This report describes three rare plant species, Mason's lilaeopsis, Suisun marsh aster, and mudwort, that occur in the Delta and provides maps and population data on their locations.

**Action Super Category:** Bay-Delta habitat existing conditions  
**Geographical Region:** Delta, Bay  
**Ecosystem/Habitat Type:** Wetlands  
**Information Type:** report

EQ-31 -- California Department of Water Resources. 1989. Biological Data Report for the West Delta Water Management Project.

This report describes the biological resources of the West Delta study area.

**Action Super Category:** Bay-Delta habitat existing conditions  
**Geographical Region:** Delta  
**Ecosystem/Habitat Type:** Wetlands, Riparian, Shallow Water, Riverine  
**Information Type:** report

EQ-32 -- McCarten, N. University of California, Berkeley. 1989-1993. Monitoring of Transplanted Mason's Lilaeopsis Populations in Barker Slough. Report to the Department of Water Resources.

This report describes changes in natural and transplanted populations of the State-Rare plant Mason's lilaeopsis in Barker Slough, Solano County, CA.

**Action Super Category:** Bay-Delta habitat existing conditions  
**Geographical Region:** Delta  
**Ecosystem/Habitat Type:** Wetlands, Shallow Water  
**Information Type:** report

EQ-33 -- California Departments of Fish and Game and Water Resources. 1988. Sherman Island Wildlife Management Plan.

This report describes wildlife habitat conditions and potential on Sherman Island, Sacramento County. It discusses current land use in relation to wildlife habitat.

**Action Super Category:** Bay-Delta habitat existing conditions  
**Geographical Region:** Delta, Bay  
**Ecosystem/Habitat Type:** Wetlands, Riparian, Terrestrial  
**Information Type:** report

**EQ-34** -- California Department of Water Resources. 1993. Initial Study and Negative Declaration for Proposed Twitchell Island Wildlife Management Plan.

This study provides habitat quality information on wildlife habitat and potential on Twitchell Island.

**Action Super Category:** Bay-Delta habitat existing conditions  
**Geographical Region:** Delta  
**Ecosystem/Habitat Type:** Wetlands, Riparian, Terrestrial  
**Information Type:** study

**EQ-35** -- California Department of Water Resources. 1994. Biological Characterization of the East Delta Properties.

This report provides preliminary information on the biological resources in the East Delta. Wildlife and habitat potential is discussed.

**Action Super Category:** Bay-Delta habitat existing conditions  
**Geographical Region:** Delta  
**Ecosystem/Habitat Type:** Wetlands, Riparian, Terrestrial  
**Information Type:** report

**EQ-36** -- California Department of Water Resources. 1990. Sensitive Species Survey Report for the North Delta Water Management Project. Prepared by ECOS.

This report describes and maps sensitive wildlife and plants in the North Delta study area.

**Action Super Category:** Bay-Delta habitat existing conditions  
**Geographical Region:** Delta  
**Ecosystem/Habitat Type:** Riparian, Wetlands  
**Information Type:** report

**EQ-37** -- California Department of Water Resources. 1992. Georgiana Slough Barrier Project.

This report is an assessment of existing fish, wildlife, and plant community resources and potential project impacts.

**Action Super Category:** Bay-Delta habitat existing conditions  
**Geographical Region:** Delta  
**Ecosystem/Habitat Type:** Wetlands, Riparian, Riverine  
**Information Type:** report

**EQ-38** -- Jones and Stokes Associates. 1993. *Final Wetland Delineation for the 100-Year Floodplain in the Northern Portion of the Sacramento-San Joaquin Delta.*

This report maps and describes the wetland areas in the North Delta that fall under the jurisdiction of the U.S. Army Corps of Engineers following wetland delineation procedures identified in the 1987 Wetland Delineation Manual. Approximately, 50,000 acres of wetlands are mapped and the types of habitat they include is described.

**Action Super Category:** Bay-Delta habitat existing conditions  
**Geographical Region:** Delta  
**Ecosystem/Habitat Type:** Wetlands  
**Information Type:** report

**EQ-39** -- California Department of Water Resources. 1995. *Conceptual Habitat Plan for the Grizzly Slough Project Area.*

This report identifies existing conditions on Grizzly Island and identifies potential changes and improvements in habitat through restoration.

**Action Super Category:** Bay-Delta habitat existing conditions and restoration  
**Geographical Region:** Delta  
**Ecosystem/Habitat Type:** Wetlands, Riparian, Terrestrial  
**Information Type:** report

**EQ-40** -- California Department of Fish and Game. 1992. *Assessment of Existing Fish, Wildlife, and Plant Community Resources and Potential Impacts.*

This report is an evaluation of existing biological resources associated with the South Delta temporary barriers project which is a water quality and fisheries improvement project.

**Action Super Category:** Bay-Delta habitat existing conditions  
**Geographical Region:** Delta  
**Ecosystem/Habitat Type:** Wetlands, Riparian, Riverine  
**Information Type:** report

**EQ-41** -- California Department of Water Resources. 1992. Draft South Delta Temporary Barriers Project Monitoring, Evaluation, and Management Program.

This report describes monitoring activities proposed for the South Delta Temporary Barriers in terms of changes to water quality, fisheries, sensitive species and wetland habitat as a result of seasonal tidal water changes due to the barriers. Proposed increases in tidal elevations due to the temporary barriers potentially will impact the wetland vegetation. The report outlines proposed monitoring activities to determine the potential changes in wetland vegetation.

**Action Super Category:** Bay-Delta habitat existing conditions  
**Geographical Region:** Delta  
**Ecosystem/Habitat Type:** Wetlands, Riparian, Riverine  
**Information Type:** report

**EQ-42** -- Botanical Research Group. 1993. Jurisdictional Wetlands Study in the South Delta Water Management Program Area.

This report documents waters of the United States, including wetlands, that fall under the jurisdiction of the U.S. Army Corps of Engineers. The report documents the types of wetland habitats and open water in the study area that may be affected by proposed project.

**Action Super Category:** Bay-Delta habitat existing conditions  
**Geographical Region:** Delta  
**Ecosystem/Habitat Type:** Wetlands, Riparian, Riverine, Shallow Water  
**Information Type:**

**EQ-43** -- Environmental impact report and environmental impact statement for the Delta Wetlands project. Draft. September 11, 1995. (JSA 87-119.) Prepared by Jones & Stokes Associates, Inc., for California State Water Resources Control Board, Division of Water Rights, and U.S. Army Corps of Engineers, Sacramento District, Sacramento, CA.

This two-volume report analyzes the direct, indirect and cumulative effects of converting at least two Delta islands from agricultural land use to water storage and managed wetlands. The project would convert surplus wet year Delta flows into a new source of central Delta water that could be used to satisfy water supply demands later in the year. The effects of three project alternatives and a fourth no-project alternative on water supply and water project operations, hydrodynamics, water quality, flood control, utilities and highways, fishery resources, vegetation and wetlands, wildlife, land use and agriculture, recreation and visual resources, traffic, cultural resources, mosquitoes and public health, and air quality in the statutory Delta region are evaluated. Effects on water supply and project operations, hydrodynamics, water quality, as well as fish species and their habitat are based primarily on simulations using the Delta Standards and Operations Simulation (DELTASOS) Model developed by Jones & Stokes Associates with inputs from the Department of Water Resources DWRSIM model (for initial water budget terms) and the RMA Delta hydraulic model. Significant impacts and mitigation measures are identified.

**Action Super Category:** Bay-Delta habitat restoration, reduction in effects of diversion, water supply enhancement, increasing water supply predictability, improvements to system reliability.

**Geographical Region:** Delta

**Ecosystem/Habitat Type:** aquatic estuarine, aquatic freshwater/riverine, terrestrial

**Information Type:** impact analyses, simulation model runs; No estimates of cost are included.

**EQ-44 -- Environmental impact report for the Los Vaqueros/Kellogg project. Stage 1.**  
Final 1986. Prepared for Contra Costa Water District, Concord. Jones & Stokes Associates, Inc.

This document analyzes the environmental impacts associated with several alternatives for increasing water quality and water supply reliability to customers of the Contra Costa Water District (three reservoir storage options, desalination, and the no action). Ability of alternatives to meet project objectives are assessed and significant impacts on soils, geology/seismicity, hydrology (ground and surface water), water quality, plant life, wildlife resources, fishery resources, cultural resources, land use, population, and housing, transportation, public services, energy, utilities, public health and safety, recreation, aesthetics, air quality, noise, public finance, agricultural economics, and customer service are identified and appropriate mitigation measures are suggested. Air quality impacts were evaluated in part using the CALINE3 model.

**Action Super Category:** water supply enhancement

**Geographical Region:** Delta export areas

**Ecosystem/Habitat Type:** terrestrial

**Information Type:** impact analyses

**EQ-45 -- California.** Department of Water Resources, California Department of Fish and Game, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S. Army Corps of Engineers, and U.S. Environmental Protection Agency. 1993. 1993 Annual Program Work Plans for the Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary.

This report, part of a series beginning in 1978, summarizes research and monitoring activities being conducted by federal and state agencies under the Interagency Ecological Studies Program. Major program areas described include Fishery/Water Quality, Delta Outflow/San Francisco Bay, Hydrodynamics, and Fish Facilities. The objectives, justification, procedures, and schedule of each program element are described. Lead persons in each agency responsible for work on a program element are also identified.

**Action Super Category:** Bay-Delta habitat restoration, management of anadromous fish, management of water quality

**Geographical Region:** Delta, Bay

**Ecosystem/Habitat Type:** aquatic estuarine

**Information Type:** status and trends assessments

**EQ-46** -- California. Department of Water Resources, California Department of Fish and Game, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S. Army Corps of Engineers, and U.S. Environmental Protection Agency. 1993. 1993 Program Element Fact Sheets for the Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary.

This report accompanies the Annual Work Plans report and provides more detailed information about each program element of the Interagency Ecological Studies Program for 1993. Each description summarizes what questions the program element is attempting to answer and what its management or policy implications might be; whether or not the element is mandated and if so by what source; what the major findings of the element have been since the element began; what has been learned most recently; what activities are currently underway or planned for the future; what agencies do the work; when did work begin and when is it scheduled to be completed; who funds the work and what is its annual cost; how are the data generated by the program element being used; and who should be contacted for further information.

**Action Super Category:** Bay-Delta habitat restoration, management of anadromous fish, management of water quality

**Geographical Region:** Delta, Bay

**Ecosystem/Habitat Type:** aquatic estuarine

**Information Type:** status and trends assessments

#### 4) System Vulnerability Studies

##### *U.S. Army Corps of Engineers -- Levees and Channel Improvements*

**L-1 -- Cache Slough/Yolo Bypass Levee, Sacramento River Flood Control Project, Biotechnical Slope Protection, Supplement No. 2, Design Memorandum 13**, November 1990 (revised June 1991) , U.S. Army Corps of Engineers. This design memorandum studies the feasibility of using biotechnical slope protection on a cross levee between Cache and Shag Sloughs at the southern tip of Liberty Island. The installation of the cross levee is to allow the existing levees below it to be breached and allow for habitat restoration. A 2 dimensional model was used to determine the breach size, location and quantity required to produce a 2 day replacement of water through the site.

**Action Super Category:** Improvements to system reliability, Bay-Delta habitat restoration.

**Geographical Region:** Delta

**Information Type:** simulation model runs, impact analyses; cost estimates for levee construction; cost comparisons between standard rip-rap technique vs. biotechnical slope protection. Rip-rap first cost estimated to be \$262,000 (.8 mile levee) vs. \$193,000 for biotechnical protection.

**L-2 -- Sacramento River Deep Water Ship Channel, General Design Memorandum and Appendix A, and Final Supplemental Environmental Impact Statement**, March 1986, U.S. Army Corps of Engineers. This design memorandum describes the selected plan for deepening and widening the existing ship channel for navigation purposes, considering economic feasibility, the local sponsor's ability to pay, and environmental effects. Construction was initiated in 1989. The work stopped in 1991. Construction is expected to continue in 1995 or 1996.

**Action Super Category:** Improvements to system reliability

**Geographical Region:** Bay-Delta

**Information Type:** Report. Detailed cost estimates for levee construction, retention dikes, and facility relocations. HEP analysis for determination of fish and wildlife habitat affected and subsequent mitigation requirements; riparian planting design; water quality analysis.

**L-3 -- Sacramento San Joaquin Delta, California, Draft Feasibility Report and Draft Environmental Impact Statement**, October 1982, U.S. Army Corps of Engineers. This report concentrates primarily on the central portion of the Delta. This report offers a comprehensive view of the Delta and investigates water resource related problems, especially salinity intrusion into the Delta, deterioration of Delta levees, lack of recreational facilities, subsidence, and the protection of fish and wildlife in the Delta.

**Action Super Category:** Bay-Delta habitat restoration, water supply enhancement, management of water quality, improvements to system reliability

**Geographical Region:** Delta

**Information Type:** Flood protection analysis at the 300 year interval; feasibility cost estimates (1981 level) to bring levees to that level of protection, by levee mile, for 47 of the 54 Delta Islands; costs for fish and wildlife habitat mitigation.

L-4 -- Feasibility Report and Environmental Impact Statement for Navigation and Related Purposes, Sacramento River Deep Water Ship Channel, California, July 1980, U.S. Army Corps of Engineers. This report investigated the need for adding deep draft channels to the Port to improve existing channels and enhance existing environmental and recreation conditions in the study area. The area included the ship channel from Avon to the Port.

**Action Super Category:** Bay-Delta habitat restoration, management of water quality, improvements to system reliability

**Geographical Region:** Delta

**Information Type:** impact analyses; better and more current data in EQ-6.

L-5 -- Sacramento-San Joaquin Delta, Western Delta Islands Study, U.S. Army Corps of Engineers. The scope of this ongoing reconnaissance study includes both flood control and environmental restoration for three western Delta islands, Twitchell Island, Jersey Island, and Webb Tract, all of which abut the Stockton Deep Water Ship Channel. They are surrounded by levees and comprise about 12,500 acres.

Damage to structures and agricultural land may result if the levees are allowed to fail. Fresh water delivery to the urban and agricultural water users including CVP and State Water Project, as well as public safety, may also be compromised by levee failure and resultant salt water intrusion. While these islands are valuable agriculturally, they also provide excellent opportunities for restoring environmental values which have diminished drastically since the turn of the century because of levee construction and farming. The report included an office report assessing the damage to water quality, water supply, agriculture and fish and wildlife resources in the event of levee failure.

**Action Super Category:** Improvements to system reliability, Bay-Delta habitat restoration, management of water quality,

**Geographical Region:** Delta

**Information Type:** Economic evaluations of flood damages to each island if flooded; habitat restoration acreage for permanent and seasonal wetlands, riparian woodlands, upland grasslands; costs for water quality impacts due to inundation; and reconnaissance level costs varying levee heights vs. incremental flood protection as shown in the following table.

Average Annual Costs (million \$) vs. Stage Exceedence						
Exceedence Interval	Webb Tract		Twitchell Island		Jersey Island	
	Cost	Benefits	Cost	Benefits	Cost	Benefits
1000 year	N/A	N/A	1.1	1.4	1.1	2.3
700 year	2.1	1.9	N/A	N/A	N/A	N/A
100 year	1.8	1.9	.9	1.2	.9	2.1
20 year	1.6	1.7	.8	.9	.8	1.1

L-6 -- *Sacramento-San Joaquin Delta, California Special Study, Initial Report*, March 1993, U.S. Army Corps of Engineers. This study is phase I of an ongoing study. This report briefly describes the study area; identifies parties interested in Delta resources; describes problems and opportunities to improve and/or provide flood protection, the restoration of flooded islands, recreation, and navigation; and presents potential solutions to resolve these problems. A final report is due out about 1998.

**Action Super Category:** Bay-Delta habitat restoration, management of water quality, improvements to system reliability

**Geographical Region:** Delta

**Information Type:** Systematic method results for levee failure probability, economics of flood damages. No cost estimates.

#### *Bay-Delta Oversight Council -- Levees and Channel Improvements*

L-7 -- Bay-Delta Oversight Council - Levee and Channel Management Committee. October 1994. *Initial report on work completed by the levee and channel management technical advisory committee-draft*. Revised February 1995.

This document provides information that may be used in developing a comprehensive program which would improve the levees and channels within the Sacramento-San Joaquin Delta. Evaluation criteria, design examples of levee and channel improvements, as well as a management framework which describe funding, environmental and regulatory mechanisms were also included in the document.

**Action Super Category:** improvements to system reliability

**Geographical Region:** Delta

**Information Type:** status and trends assessment

**L-8 -- California Department of Water Resources -- Cost of Delta Levee Improvements**

The Department of Water Resources' report entitled Delta Levee Improvements Cost Estimates and Conceptual Designs, identifies thirteen conceptual designs and cost estimates for various types of levee improvements which may be used within the Sacramento-San Joaquin Delta. Cost estimates are based on a cost per lineal mile of levee. The cost per mile must be multiplied by a factor of two if levees on both sides of the channel require repairs. The following table identifies the alternative with their respective cost.

<b>Delta Levee Improvements Cost Estimates</b>	
<b>Alternative</b>	<b>Cost (\$)</b>
A. Embankment	2,518,000
B. Berm with Seepage Collection	3,720,000
C1. Concrete Slurry Wall	4,471,000
C2. Sheetpile Cutoff Wall	8,013,000
D. Berm with Filter Drain	4,351,000
E. Berm with Trench Drain	4,609,000
F. Berm with Stone Columns and Filter Drain	6,665,000
G. Concrete Wave Wall	6,613,000
H. Sheetpile Wave Wall	3,830,000
J. Levee Setback with Wetland Habitat	5,579,000
K. Levee Setback with Riparian Habitat	5,783,000
M. Sand Beach	10,265,000
O. Complete Setback with Wetland Habitat	5,052,000

**Action Super Category:** improvements to system reliability  
**Geographical Region:** Delta  
**Information Type:** design, cost analyses

**L-9 -- Reclamation District No. 2118 -- Costs of Mitigation of Levee Slope Erosion**

The Reclamation District No. 2118's, Little Mandeville Island Proposed Mitigation Plan, provides for the placement of riprap on levee slopes at ten severely eroded sites around perimeter of the island. The total length of the project sites is estimated to be 1,581 linear feet. The total low bid price is \$56,875,000. The cost per linear foot is \$36.00. The cost estimate and project details were derived from the Kjeldsen-Sinnock & Associates

September 30, 1991 response letter to Mr. James D. Messersmith (DFG) regarding the mitigation plan.

**Action Super Category:** improvements to system reliability

**Geographical Region:** Delta

**Information Type:** design, cost analyses

## Modeling Tools -- Existing

This section presents a summary and brief description of existing models used in the above mentioned programs and studies.

### DWRSIM

The Department of Water Resources Planning Simulation model, DWRSIM, is a planning model designed to simulate the operations of SWP and CVP with an emphasis on the former. The input for DWRSIM consists of reservoir inflows, instream flow requirements, other agricultural and municipal and industrial water demands, and reservoir and channel capacities. The output includes such key items such as project deliveries, CVP and SWP reservoir storages, streamflows for the major rivers entering the Delta, and Delta outflows at any timestep in the simulation period. It is a complex simulation model, and as such it takes at least 2 to 3 weeks to set up and perform a simulation using DWRSIM.

### PROSIM

PROSIM or the Projects Simulation model was developed by the Bureau of Reclamation to simulate the CVP and SWP systems. It is also a mass balance model like DWRSIM with an emphasis on CVP facilities. It has input needs, output results, and time requirements to finish a run similar to DWRSIM.

### CVGSM

The Central Valley Ground-Surface Model (CVGSM) is a finite element groundwater and surface water flow model developed for the Central Valley Basin. CVGSM, a monthly model, was developed for the Bureau of Reclamation, the Department of Water Resources, and the State Water Resources Control Board to provide analysis of the Central Valley groundwater basins with key outputs including flow in streams, stream aquifer interactions, and, groundwater level changes.

### DSM

The Department of Water Resources Delta Simulation Model (DWR-DSM) is a deterministic hydrodynamic and salt transport model developed for the Sacramento-San Joaquin delta. The model area includes Sacramento River downstream of the City of Sacramento, San Joaquin River downstream of Vernalis, and Sacramento-San Joaquin Delta east of Benicia Bridge.

## CVPM

The Central Valley Production Model (CVPM) is a regional optimization model to predict changes in irrigated crop production from changes in costs, prices, and resource conditions.

## Ecosystem Models

Several ecosystem models are available from various sources. A summary of model required inputs, potential outputs, and source for each of the following categories can be found in **Appendix F**:

- General Ecosystem Oriented Models
- Flow-Habitat Model
- Temperature-Mortality Models
- Passage and Entrainment Models
- Multiple Species Models
- Chinook Salmon
- Striped Bass
- American Shad
- Delta Smelt
- Longfin Smelt
- Sacramento Splittail
- Invertebrates and General Productivity: Neomysis, Crangon, organic carbon

## Modeling Tools -- Near-Term Solutions

This section presents an identification of models presently in use that can easily be used within the CALFED program development time frame, or if such tools do not exist, a discussion of possible methodologies to provide near-term solutions to the consequences of action for which sufficient detailed has not been provided in previous studies and programs. Methodologies could include the use of spreadsheet models, either previously developed for other purposes or ones that could easily be developed for a quick and reasonably accurate analysis. In all cases, methodologies will consider the use of readily available data from existing simulations of operations from DWRSIM, PROSIM, CVGSM, SANJASM, and other relevant models.

### Water Supply Reliability

Several monthly assessment tools are available for preliminary evaluation of CALFED alternatives. Monthly models are appropriate because many of the potential benefits of CALFED alternatives will occur as a result of seasonal management of water and fisheries resources. These tools have been developed as part of previous investigations including CVPIA PEIS, CVP Water Augmentation Program, Central California Water Recycling Project, East Bay MUD studies, and others.

A baseline simulation from DWRSIM (with supporting information from PROSIM, SANJASM, and CVGSM) that includes the 1995 WQCP Delta conditions can be used as the starting point for the CALFED preliminary assessment of alternatives. These monthly water management models provide basic information on the hydrology, water use (from both groundwater and surface diversions), reservoir operations, and Delta inflows, export pumping, and outflow conditions. The baseline conditions would then be adjusted to reflect the proposed facilities and water management for each CALFED alternative, using the hierarchy of monthly spreadsheet water models.

Excel spreadsheet models were developed to investigate offstream storage potential in the Eastern San Joaquin County area, using Delta surpluses from the Folsom Lake reoperation PROSIM run, for East Bay MUD. Another was developed to test reoperations of San Luis Reservoir for the Central California Recycling Project. This model considered PROSIM Delta surpluses, excess pumping capacity at Banks and Tracy Pumping Plants, and available conveyance capacity to optimize San Luis operations. These tools can be easily modified to investigate offstream storage potential for CALFED alternatives using either PROSIM or DWRSIM output.

Another such tool is the DELTASOS (Delta Standards and Operations Simulation) model. DELTASOS, a Lotus 1-2-3 spreadsheet model, allows the effects of various Delta outflow requirements and export operations criteria to be evaluated. The effects of inflows and exports on Delta channel flows are estimated. Operations of in-Delta storage and an isolated transfer facility (with intake diversion above Hood) can be simulated. The incremental changes in the initial Delta water budget (outflow and export) are calculated, so that the effects of various adaptive management strategies can be easily demonstrated. DELTASOS does not include upstream or export area reservoirs, so DELTASOS cannot

itself change the inflows by upstream reservoir reoperation or limit the exports because of lack of export area storage. However, DELTASOS can be linked with other models that include the water management facilities (reservoirs and diversions) in each Delta tributary, and in the export area.

The TRIBSIM (Tributary Simulation) models were developed for the CVPIA water augmentation program, and include all Delta tributaries and export areas. These spreadsheet models are available. They were used to test reoperation potential of existing major reservoirs, and to evaluate conjunctive use as well as offstream storage potential in upstream watersheds. The models were set up to respect downstream flow conditions derived from PROSIM simulations. This was essential in order to quantify additional upstream water supplies without impacting the simulated CVP and SWP operations.

These TRIBSIM models include the basic hydrology, reservoir operations, in stream flow requirements, diversion targets (demands), and downstream flow targets that are used in the DWRSIM, PROSIM, and SANJASM models. Because the spreadsheet format allows much easier manipulation and testing of revised reservoir operations, diversion targets, and in stream flows, effects of CALFED alternatives on reservoir operations can be quickly evaluated. Because the CALFED alternatives include additional facilities, but do not completely describe the associated operations of these facilities, the spreadsheet format will allow the most beneficial operations of the new facilities to be estimated. These WATER models will allow the basic "water budget" effects of proposed actions to be simulated and integrated with existing facilities and operational constraints.

## **Water Quality**

There have been numerous water quality studies performed recently by a variety of tools including Contra Costa Water District's G-Model, DWR's DSM model, RMA, and other versions of the Fisher Model. Many studies are underway. Most of the studies in progress are presented at regular Bay Delta Modeling Forum (BDMF) meetings. Considerable data is available from many sources. It is likely that no new models should be needed for CALFED alternatives water quality analyses.

## **Ecosystem Quality**

A few new models are required to cover the full range of environmental assessments that are appropriate for the CALFED program. Additional spreadsheet models would be used to estimate the corresponding environmental effects of these water management and restoration actions on water quality, habitat condition, and expected fish populations.

There are several existing models that can be used together to provide ecosystem level information and assessment, without actually developing a new comprehensive "ecosystem model". Each of these models can be implemented as spreadsheets that combine historical data, baseline simulations, and incremental changes from proposed facilities and water operations of each alternative. These models have also been developed and applied to recent Delta evaluations, including the Delta Wetlands project EIR/EIS, the CVPIA PEIS and CVP water augmentation program.

## System Vulnerability

Numerous levee analysis studies have been performed recently making available a wide range of data to provide analysis. It is not expected that any new models will be required.

## Decision Programming

Decision Programming Language, (DPL) is Windows software that is quite powerful for building influence diagram models. An influence diagram model is a way to represent the variables and causal linkages of a system in a direct, simple and very general way. For example, the nodes of the influence diagram could be amounts and direction of water flow, and habitat and species at different points in the Delta. The DPL can be applied to an underlying spreadsheet which could include a flow balance model, and the variable of interest could be a weighted sum of the performance measures. Input nodes could be actions.

An influence diagram model, based on DPL could be an attractive way to represent several interacting elements of the physical system, so that we can link actions to outcomes using elements that can be based on expert judgment for the time being, to be replaced by model runs in the future. The explicit handling of uncertainty allows us to represent expert judgment in the form of probability distributions, which is a convenient way to represent judgment between disagreeing experts, and simply any single expert estimating an uncertain variable.

# Appendices

## A. CVPIA -- CVPM Economics Studies

### *Economic Analysis of the Water Augmentation Program (Summer, 1995)*

The purpose of the Augmentation Study was to identify the yield, cost, and potential impacts of various options to replace the water supply reallocated to fish and wildlife uses.

Options included conjunctive use projects, reoperation of existing facilities, water reuse and reclamation, new storage and conveyance, and land fallowing. CVPM was used to estimate the cost of buying water from land fallowing. A linear programming model was created to provide a planning-level assessment of the least-cost options for supplying water to different CVP regions, considering costs and losses in conveyance.

The regional economic impact assessment measured losses in personal income caused by fallowing of irrigated land. The IMPLAN input-output method and database was used. The analysis accounted for backward economic linkages with businesses that supply inputs to irrigated agriculture, and farmers' propensity to spend farming net income and water transfer revenue were considered.

### *Economic Impact of Interim Dedication and Management of 800,000 AF (Summer, 1994)*

The production and income impacts were estimated for an Environmental Assessment of the interim dedicated water plan for the 1994-95 water year. Three water year types were assessed and impacts summarized for Central Valley total, CVP only, and an example CVP water service contractor. The analysis used spreadsheets to estimate water delivery impacts and CVPM to estimate resulting crop production and income impacts.

### *Analysis of the Cost of Purchasing Supplemental Water for Fish and Wildlife Restoration (Spring, 1995)*

CVPM was used to provide an estimate of the cost of purchasing various amounts of water for instream flow. Assumptions of the analysis were that instream flow must be purchased within the watershed, that no groundwater substitution would be allowed, and that land fallowing or crop switching were needed to generate real water. The model produced estimates of the minimum price needed to buy water at different levels of flow, based on the value of the water to agricultural production. The unit cost of water rises rapidly as more water is purchased.

## *Economic Analyses for the Programmatic Environmental Impact Statement (PEIS)*

### **Preliminary Options Descriptions and Screening Evaluation (1993-94)**

These descriptions provided rough cost estimates and qualitative assessment of potential impacts of options for implementing CVPIA provisions. Economic assessment was provided for tiered water pricing, water conservation, land fallowing for supplemental water, and land retirement.

### **CVPM Sensitivity Analysis and Model Testing (1994-95)**

CVPM was used to estimate, in general, how agriculture would respond to reductions in surface water available. Results indicate that if groundwater is unconstrained, nearly all reductions in surface water would be replaced by additional groundwater use. Net income to farming would be significantly reduced, but the cost of groundwater pumping does not appear to preclude its use in the near term.

If groundwater replacement is somehow prevented (although no legal mechanism currently exists to do this), then CVPM estimates that initial cutbacks in surface water are met mostly through improved irrigation efficiency. Efficiency gains are exhausted fairly quickly, after which crop switching and land fallowing occurs. Delta export regions most subject to reduction in surface supply are already at a high level of irrigation efficiency, so further efficiency savings are small. Also, the on-farm efficiency gains primarily reduce recoverable losses, so from a water balance perspective regional efficiency may change very little. On-farm efficiency gains can however reduce pesticides, nitrates, and other chemicals in return flows.

The model indicates a low potential for switching into high revenue but low water-using crops such as vegetables. These crops tend to have the least elastic demand, meaning that small percent increases in production can lead to large declines in price. In other words, the acreage of these crops is determined by demand, not by water supply. Demand for these crops (and the acreage produced) appear to be growing over time almost independently of annual fluctuations in water supply.

### **Agricultural Economic Analysis for PEIS (Winter, 95-96)**

The Central Valley Production Model (CVPM) has been revised and updated for use in assessing the impacts of reduction in water delivery, increases in water prices, and other CVPIA provisions on crop production, irrigation efficiency, acreage, and income. Revised No Action results should be available in early January, followed by action alternative results over the subsequent weeks.

### **M&I Water Supply Economic Analysis for PEIS (Winter, 95-96)**

This analysis estimates economic costs to ten groups of M&I providers and their customers caused by water shortage. Costs include water transfers and other alternative supplies, water revenue losses, and loss of water customer consumer surplus. The analysis is based on observed water prices and quantities used, water demand elasticities and data on water supply costs. The analysis accepts M&I water deliveries as input and provides water transfer demand functions for the water transfer analysis.

### **Water Supply Risk Analysis for PEIS (Winter, 95-96)**

Water supply risk and uncertainty costs are caused by variable hydrology, seasonal uncertainty and delayed timing of water allocations, and long run uncertainty in the laws and rules of water allocation. For the PEIS, we will estimate the variability of annual water supplies, economic costs to eliminate downside risk, and we will consider how new water allocation rules and their administration may affect costs of uncertainty.

### **Water Transfer Analysis for PEIS (Winter, 95-96)**

The water transfer analysis uses the Central Valley Water Transfer Model (CVWTM) to estimate prices, sources and destinations of water transfers. The model includes information on irrigation economics, feasible transfers, conveyance losses and conveyance costs. The CVWTM estimates an implicit price for irrigation water in 21 regions, adds M&I water demand functions, and mimics free trade by allowing water transfers that maximize the value of water in alternative uses.

## B. DWR -- Water Transfer Facilities and Costs

### *Delta Water Transfer Alternatives*

The Department of Water Resources' report entitled *Alternatives For Delta Water Transfers*, identifies the four alternatives considered most practical (DWR, Nov. 1983). The four alternative "through-Delta" transfer systems would increase the flow of the Sacramento River water through central Delta channels. The following table identifies the basic alternatives and their costs.

Plan A. New Hope Cross Channel and Enlarged Clifton Court Forebay					
Design Options					
North Delta	South Delta	Capital Cost in \$ million	Yield 1,000 AF/Yr	Unit Cost \$/AF	Salt Reduction Percent
Gravity Flow	Existing and New Intakes Existing Fish Screens	230	450	43	25
Tidal Flow Controllers	Existing and New Intakes Existing and New Fish Screens	340	500	57	30
Tidal Flow Controllers	Single New Intake, SWP only, with New Fish Screens	370	500	62	30
Pumping Plant with Fish Screens	Existing and New Intakes Existing Fish Screens	400	500	69	30

Plan B. New Hope Cross Channel, Dredged South Delta and New Clifton Court Forebay Intake					
Design Options					
North Delta	South Delta	Capital Cost in \$ million	Yield 1,000 AF/Yr	Unit Cost \$/AF	Salt Reduction Percent
Gravity Flow	Existing Fish Screens	210	450	39	25
Pumping Plant with Fish Screens	Existing Fish Screens	380	500	66	30

Plan C. New Hope Cross Channel and New Intake Channel to Clifton Court Forebay					
Design Options					
North Delta	South Delta	Capital Cost in \$ million	Yield 1,000 AF/Yr	Unit Cost \$/AF	Salt Reduction Percent
Gravity Flow	From Middle River, SWP only, with Existing Fish Screens	120	250	40	15
Pumping Plant with Fish Screen	From Middle River, SWP only, with Existing Fish Screens	400	500	69	30

Plan D. Enlarged North Delta Channels and Enlarged Clifton Court Forebay					
Design Options					
North Delta	South Delta	Capital Cost in \$ million	Yield 1,000 AF/Yr	Unit Cost \$/AF	Salt Reduction Percent
Gravity Flow	Existing and New Intakes  Existing Fish Screens	120	250	40	15
Tidal Flow Controllers	Existing and New Intakes  Existing and New Fish Screens	290	500	49	30
Tidal Flow Controllers	Single New Intake, SWP only, with New Fish Screens	320	500	54	30

#### *Isolated Transfer Facility Cost Estimate*

The Department of Water Resources' report entitled *Isolated Transfer Facility Cost Estimate*, identifies the cost estimate for the proposed Isolated Transfer Facility. (DWR, Sept. 1995) Environmental mitigation and right-of-way costs are not included in this estimate. There are two components of this estimate, the Peripheral Canal estimate updated to the July 1, 1995 cost with an escalation factor of 1.25 and the eight new inverted siphons at Middle River, Fourteen Mile Slough, White Slough, Sycamore Slough, Hog Slough, Beaver Slough, Lost Slough and Snodgrass Slough.

There are two alternative siphon sizes considered. One alternative uses four 25' x 25' barrels per siphon and the other alternative uses four 30' x 30' barrels per siphon. As a result of the eight different cases evaluated, a maximum design flow of 23,200 cfs can be conveyed with the twelve siphons without raising the height of the levees beyond original design. The eight additional siphons to the system are based on improved siphon efficiencies. The design details were derived from the Department of Water Resources report entitled "Isolated Transfer Facility Twelve Siphon Alternative Preliminary Analysis dated July 1995. The cost summary is described below.

Isolated Transfer Facility Cost Summary	
Item	Item Cost (\$)
Escalated Peripheral Canal Cost	724,121,000
Eight Additional Siphons	112,436,400
Low Bid Cost	836,557,400
S/O - Design @ 10%	83,655,700
S/O - Const. Supervision & Contingencies @ 25%	209,139,400
<b>Total Cost</b>	<b>1,129,353,000</b>

*Design and Cost of Delta Facilities*

The Department of Water Resources' report entitled Conceptual Level Design and Cost Estimates for Various Facilities Affecting the Delta, identifies the conceptual designs and cost estimates for ten facilities affecting the Delta. The total estimated cost of each facility and their alternatives are summarized in the following table.

Delta Facility Alternatives Cost Estimates	
Facility Alternatives	Cost (\$)
1. Georgiana Slough Barrier Alternative	
Alternative I - Rock Barrier	2,055,000
Alternative II - Inflatable Dam <sup>1</sup>	
Alternative III - Fish Deflector Dam	362,000
Alternative IV - Wicket Gate	4,000,000
Alternative V - Permanent Radial Gate Structure - Built Off Site	17,820,000
Alternative VI - Permanent Radial Gate Structure - Built in Place	17,426,000
2. Delta Cross Channel Three Gate Enlargement	31,962,000
3. Threemile Slough Barrier Alternatives	
Alternative I - Rock Barrier	4,305,000
Alternative II - Fish Deflector Wall	1,744,000
Alternative III - Wicket Gate	13,420,000
Alternative IV - Permanent Radial Gate Structure - Built Off Site	20,462,000
Alternative V - Permanent Radial Gate Structure - Built in Place	19,083,000
4. Deflector Walls at Steamboat and Sutter Sloughs	1,492,000
5. William Stone Lock	1,608,000
6. Delta Island Water Storage Project	
Bacon Island Reservoir	61,434,000
Webb Tract Reservoir	62,768,000
Holland Tract Habitat Area	13,237,000
Bouldin Island Habitat Area	35,748,000
7. Desalination Plant Costs <sup>2</sup>	
8. North Delta Preferred Alternative	356,000,000
9. Offstream Water Storage Projects (1.7 MAF Los Banos Grandes Dam Project)	823,208,000
10. Flood Control Storage Projects	
Latrobe Multipurpose Dam	124,000,000
Middle Bar Single Purpose Dam	155,000,000
Notes:	
<sup>1</sup> A 33-ft inflatable dam would be required for the Georgiana Slough Barrier. The manufacturer's representative indicated that the rubber dam would be impossible to construct and operate using current technology. Thus, the dam was eliminated from further consideration.	
<sup>2</sup> For the desalination cost, a graph was developed depicting the cost of desalination per 1,000 gallons of water versus plant size for various desalination processes. The graph indicates that the cost of desalination produced water decreases with increasing plant size for the different desalination processes. The information was derived from a report prepared by the Office of Technology Assessment for the U.S. Congress entitled "Using Desalination Technologies for Water Treatment", dated 1988.	

## C. CVP Water Augmentation Study

The Bureau of Reclamation's Water Augmentation Program was tasked with the job of identifying options for augmenting the CVP water supply and the estimating the cost associated with such options. Options included new and expanded on-stream and off-stream, conjunctive use, and reservoir reoperations among others. Demand management as well as supply increase options were considered.

### *Water Conservation - Agricultural and Urban*

**Agricultural Conservation.** Agricultural water conservation includes:

- ❖ reductions in conveyance losses during delivery to farm turnouts (at district and higher levels). Examples include canal lining.
- ❖ reduction in the quantity of recoverable losses (water that returns to the hydrologic system in a usable form and is not viewed as "new" water). Examples include improved on-farm irrigation performance and district delivery capabilities.
- ❖ reduction in the quantity of irretrievable losses (water that becomes unusable including percolation or surface runoff to poor-quality perched groundwater and salt sinks). Examples include improved on-farm irrigation performance and district delivery capabilities.

Cost associated with agricultural conservation are estimated to range from \$150 to over \$500 per acre-foot per year depending on site specific conditions. In general, the greater amount of on-farm conservation being attempted the higher the cost. The following amounts were determined to be conservable during investigations:

Region	Conveyance Loss (1,000 af/yr)	Recoverable Loss <sup>a</sup> (1,000 af/yr)	Irretrievable Loss (1,000 af/yr)
Sacramento Valley	575	2,500	0
San Joaquin Valley - East Side	500	3,050	220
San Joaquin Valley - West Side	215	1,200	625

a) The values shown do not reflect the associated impact to groundwater recharge, downstream users, or instream flows and need to be understood as only providing potential for timing of flow and water quality benefits.

As can be seen in the table, a fairly large potential exists as recoverable losses. However, these quantities do not necessarily reflect new sources of water. A detailed understanding

of the interrelations of surface and groundwater and how runoff and deep percolation are reused is needed to determine basin-wide water savings.

**Urban Conservation.** Urban water conservation includes reductions in the demand by residential, commercial, governmental, and industrial water users. Such reductions take the form of changes to landscaping, installation of lower water using appliances and toilets, and use of industrial water recycling systems. The analysis during the program identified the following conservation potential:

Region	Residential - indoor (1,000 af/yr)	Residential - outdoor (1,000 af/yr)	Commercial/ Industrial/ Governmental (1,000 af/yr)	Total Potential (1,000 af/yr)
Sacramento Valley	57	57	42	156
San Joaquin River Region	48	41	34	124
Tulare Lake Region	53	36	35	124
San Francisco Bay	74	44	35	154
South Coast <sup>a</sup>	370	416	106	892

a) The large potential from the South Coast area was ignored in the Water Augmentation Program because of the assumption that this area would be reluctant to sell water back to the Bureau of Reclamation and would rather keep hold of all current water supplies.

Cost associated with urban conservation are estimated at \$315 to \$390 per acre foot annually at the source.

### *Conjunctive Use - Evaluated Groundwater Storage Capacity*

Using the Central Valley Groundwater Simulation Model (CVGSM), a gross estimate was made of the storage potential of aquifers within the Central Valley. It should be noted that the model is a large scale regional model with an average element size of 14 square miles, far bigger than the practical size of an active recharge basin. The capacity as evaluated in this study is defined as the amount of water that can be recharged and extracted over the site without causing a water level fluctuation of more than 30 feet compared to historic water levels. The following values show the potential capacity as evaluated of aquifers within the indicated geographic region. Actual potential will vary from values shown based upon local aquifer characteristics. Costs shown are estimates of annualized cost for development of an active recharge basin, delivery channel, and extraction wells. The cost does not include the possible additional charge for a supply of water to recharge.

Region	Evaluated Capacity (1,000 af)	Cost at Source (\$/af/yr)
Sacramento Valley	700	95
North Delta Region and eastside Delta Tributaries	525	90
San Joaquin River Basin	725	90 - 120
Tulare Lake Basin	500	120

### *Surface Storage Potential*

The program identified several onstream and offstream surface storage locations, based primarily on past studies and some current activities. Projects identified were either enlargements of existing facilities or altogether new facilities. In addition to size and cost of specific facilities, time frames for implementation were also investigated. Cost for new or enlarged facilities are dependent on individual sites and vary widely. Estimated costs included in the Water Augmentation Program ranged from a low of around \$300/af annually to a high of nearly \$3,000/af annually. These costs include estimates of mitigation for environmental and social impacts. The following is a summary of capacity findings generalized geographically.

Region	Onstream Capacity <sup>a</sup> (1,000 af)	Offstream Capacity <sup>a</sup> (1,000 af)
Sacramento Valley	15,355 <sup>b</sup>	770
North Delta Region and eastside Delta Tributaries	150	12,030 <sup>c</sup>
San Joaquin River Basin	870 <sup>d</sup>	240
Delta Export	none ident.	1,730 <sup>e</sup>
Tulare Lake Basin	none ident.	none ident.

- a) Capacity values do not consider availability of a water supply to fill all identified sites. Rather they are representative of the total capacity available if all identified facilities were built. In some cases, construction of one facility would restrict the potential of another.
- b) Includes enlargement of Shasta Reservoir by 9,800 taf. enlargement of Folsom by 360 taf. and a 2,300 taf Auburn site as well as others.
- c) Includes enlargement of Berryessa Reservoir by 11,400 taf, enlargement of Farmington by 110 taf, and the Delta Wetlands project at 240 taf.
- d) Includes enlargement of Friant by 870 taf.
- e) Includes Los Banos Grandes at 1,730 taf.

### Land Fallowing Potential

Land fallowing potential was identified using the Central Valley Production Model (CVPM). Using this model, water supplies were decreased resulting in an estimate of values of the water associated with particular crop production. In general, the value of water increases as more water is removed from a particular geographic region (groundwater substitution was not allowed). Only consumptively used water, or evapotranspiration, of agricultural crops was included in the fallowing analysis. Results were grouped into 4 levels with each level representing 5 percent of an areas' consumptively used non-CVP surface water supply. The cost represents the minimum that may be required to purchase water away from consumptive use on crops. The following is a summary of the model results grouped geographically (actual results are more localized).

Region	Activity Level	Annual Yield (1,000 af)	Cost at Source <sup>a</sup> (\$/af/yr)
Sacramento Valley	Level 1	90	55 - 90
	Level 2	90	60 - 110
	Level 3	90	65 - 130
	Level 4	90	65 - 145
Delta Region and Eastside Tributaries	Level 1	62	60 - 95
	Level 2	62	70 - 120
	Level 3	62	80 - 145
	Level 4	62	85 - 165
Eastside of S.J. Valley	Level 1	107	55 - 105
	Level 2	107	65 - 110
	Level 3	107	75 - 130
	Level 4	107	85 - 150
Westside of S.J. Valley <sup>b</sup>	Level 1	23	55 - 80
	Level 2	23	60 - 95
	Level 3	23	75 - 110
	Level 4	23	85 - 130
Tulare Basin Area	Level 1	27	135 - 205
	Level 2	27	145 - 215
	Level 3	27	155 - 235
	Level 4	27	170 - 255

- a) The range of costs shown reflect: 1) the variation in the value of water used for irrigation on different crops, and in different areas; 2) difference among potential sellers in their willingness to sell water; and 3) variations in the transferable fraction of water purchased. Individual situations may fall outside the range of costs shown.
- b) Values shown represent CVP exchange contractors as well as other non-CVP surface water users. Westlands is not included in the values shown since this estimate is based on non-CVP surface water supplies only.

As stated in footnote "a", the range of values is based on many assumptions and does not imply that values cannot be outside of ranges. Contracts with individual water users or with districts will need to be negotiated as well as monitoring developed to ensure appropriate reductions in consumptive use. Land fallowing can be used for temporary or permanent water acquisition, however, permanent fallowing may incur greater economic impact to the local communities.

### Transport Costs

The additional cost resulting from transport and delivery of water to specific locations is referred to as the transport cost. This cost includes the operational and maintenance costs incurred in conveying water to the destination and the cost associated with conveyance and carriage water losses. Carriage water requirements are assumed to be included as a 35 percent surcharge for all deliveries that require transport through the Delta. The regions shown in the following table correspond to the regions in the figure below.

**Table IV-3 (from Least-Cost CVP Yield Increase Plan, Oct. 1995)**

**Annual Transport Cost (\$/af)**

From→ To↓	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10	Region 11
Region 1	0	34	32	15	30	-7	x	x	-7	-7	-7
Region 2	29	0	26	8	24	-10	x	x	-10	10	10
Region 3	21	20	0	-1	15	0	x	x	0	0	0
Region 4	37	36	34	0	31	8	8	8	8	8	8
Region 5	x	x	26	6	0	x	-11	x	x	x	x
Region 6	110	109	104	92	99	0	35	34	34	34	34
Region 7	x	x	x	x	x	x	0	48	x	x	x
Region 8	x	x	x	x	x	x	x	0	x	36	36
Region 9	120	119	113	101	109	43	40	39	0	39	39
Region 10	123	121	116	103	111	54	50	49	49	0	49
Region 11	126	125	119	106	114	76	72	70	70	70	0
M1	47	47	45	27	45	36	x	x	36	36	36
M2	172	170	165	154	161	123	123	123	123	123	123
M3	129	128	122	110	118	90	90	90	90	90	90
M4	232	230	225	211	220	223	223	223	223	223	223

Notes:

- 1) The transport cost includes cost for use of facilities, transaction cost, and conveyance loss. For purposes of display in this table, conveyance loss is valued at \$100 per af.
- 2) Cells marked with an x assume water transfers are not feasible.
- 3) M1 through M4 represent urban centers in the following areas: M1=North Bay areas/Sacramento Valley; M2=East and South Bay areas; M3= Central and South coast; M4= San Joaquin Valley

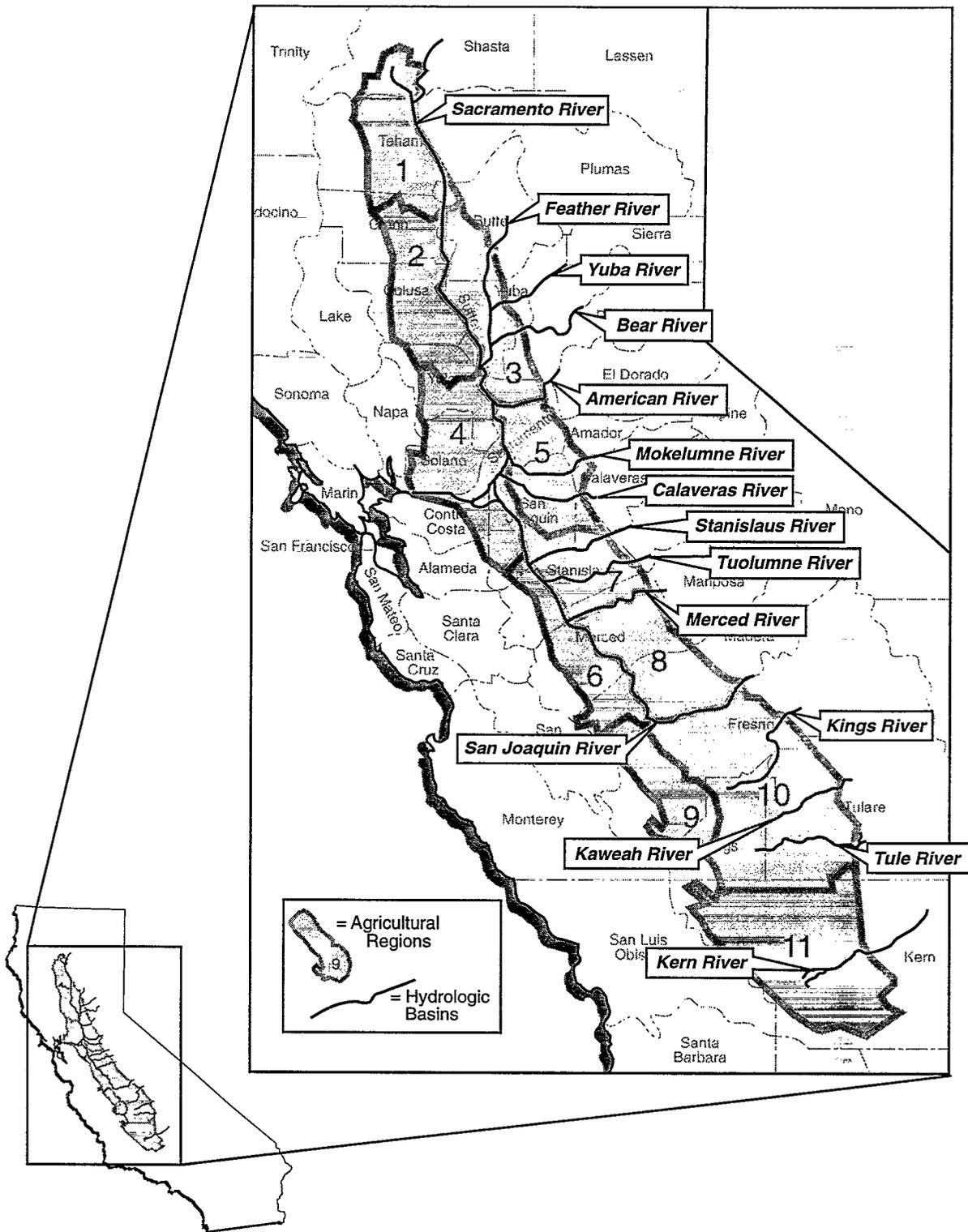


Figure: Central Valley Agricultural Regions and Hydrologic Basins Used in Development of the Least-Cost CVP Yield Increase Plan (source: Least-Cost CVP Yield Increase Plan, Oct. 1995)

## Summary of Water Augmentation Program Findings

The Program's Least-Cost CVP Yield Increase Plan (October 1995) summarized all of the demand management and supply increase options identified in the following figure. This figure shows the range of yield potential and the range of costs, including transport costs (using assumed locations for delivery north and south of the Delta).

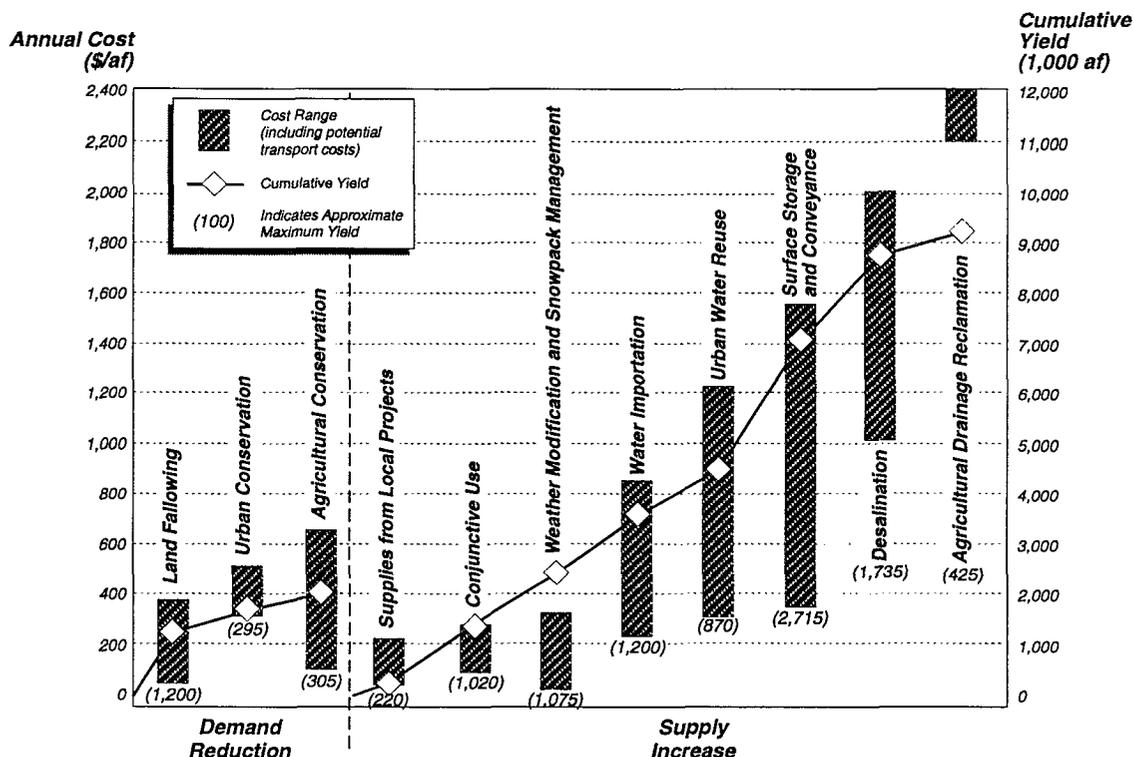


Figure: Summary of Demand Reduction and Supply Increase Options for CVP Yield Increase (source: Least-Cost CVP Yield Increase Plan, Oct. 1995)

A final screening was applied to these identified options to develop the Program's plan. Options were included in the plan based on the following screening criteria:

- ❖ **Verifiable Yield:** They provided a *verifiable* supply of water. Options that have speculative or unquantifiable yields and that include unproven technologies were not included.
- ❖ **Environmental Considerations:** They did not cause known unacceptable impacts on wildlife habitat or endangered species. Unacceptable adverse impacts are those considered unmitigable and contrary to the purposes of the CVPIA
- ❖ **Social Considerations:** They did not produce substantial negative impacts on local or regional economies.
- ❖ **Timing:** They could be implemented before October 2007. This is a stipulation of the CVPIA.

- ❖ **Cumulative Yield:** They have a cumulative yield of approximately 3 million af/yr. This cumulative yield is necessary to account for the possible effects of competition for water supply.

These screens resulted in retention of the options shown in the following table. This table shows annual yield estimates of the options and their prominent characteristics. Yields in this table differ slightly from those shown above because they take into account transport considerations.

Table IV-1 Categories of Options Included in the Least-Cost CVP Yield Increase Plan <sup>a</sup>			
Yield Increase Options	Annual Yield <sup>b</sup> (1,000 af)	Range of Cost at Source <sup>c</sup> (\$/af)	Characteristics
<b>Land Fallowing</b>			
Level 1	309	55-205	Potential social impacts can be mitigated through temporary, rotational, and dispersed fallowing; may cause divisiveness in local communities, especially at higher levels; would be implemented with local partnerships
Level 2	309	60-215	
Level 3	309	65-235	
Level 4	309	65-255	
<b>Conservation</b>			
Agricultural conservation	215	100-200	Supports the economic viability of agriculture, environmental benefits with decrease in irretrievable losses
Urban conservation	230	315-390	More efficient use of water resources; environmental benefits with decreases in irretrievable losses
<b>Supplies From Local Water Projects</b>	180	30-70	Low cost; potential environmental benefits; timely potential implementation
<b>Conjunctive Use</b>			
Active recharge	840 <sup>d</sup>	90-120	Relatively large-yield, low-cost storage alternative; makes efficient use of limited resources; operational flexibility; environmental effects of stream diversions require study
Developable perennial yield	70	60	No construction required; low cost; operational flexibility
<b>Water Reuse</b>			
Urban discharges to ponds/saline sinks	200	285-330	Potential for groundwater recharge; wholly new source of water; proximity to agricultural areas
<b>Surface Storage &amp; Conveyance</b>			
Enlarged Farmington	30	300	The facility included is offstream and operated for temporary storage only
<b>TOTAL ANNUAL YIELD</b>	<b>3,001</b>		

<sup>a</sup> Section III presents a detailed characterization of these options.  
<sup>b</sup> Includes multiple projects with differing levels of effectiveness.  
<sup>c</sup> Costs for options involving purchase of water may increase as competition for water supplies increases.  
<sup>d</sup> Yield adjusted for transport considerations.

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### D. California Department of Fish and Game -- Fish Screens

The Department of Fish and Game's estimated cost basis varies depending on the size of diversion and complexity of the fish screen system. The general categories used are (1) small diversions (15 cfs or less) screened for about \$2,000 per cfs, (2) medium-sized diversions (15 - 250 cfs) screened for about \$5,000 per cfs, and (3) large and/or complex diversions screened for about \$10,000 per cfs. The following table is a list of fish screen projects and their respective costs.

RECENT FISH SCREENING PROJECTS, THEIR APPROXIMATE CAPACITY AND DATE OF THE COST ESTIMATE			
Project	Capacity (cfs)	Total Cost (\$)	Cost per cfs (\$)
ACID (Bonneyview Pumps) - 1992	60	330,000	5,500
Contra Costa Canal - Estimate 1992	350	3,000,000	8,600
Los Vaqueros - Estimate 1992	250	500,000	2,000
MacDonald Island - 1992	12	25,000	2,100
USBR Tehama Colusa Canal - 1991	3,000	17,000,000	5,700
EBMUD Bixler Slough Intake - 1987	90	50,000	556
City of West Sacramento - 1985	45	45,000	1,000
DWR North Bay Aqueduct - 1987	180	250,000	1,400
DWR Roaring River - 1980	750	1,500,000	2,000
Glenn-Colusa Intake -1990	3,000	30,000,000	10,000
Grizzly Island Ditch - 1993	150	300,000	2,000
Bacon Island - 1993	16	27,000	1,700
Maxwell Irrigation District -1993	80	794,000	9,900
Pelger Mutual Water District - 1994	40	170,000	4,250

The estimated costs for the fish screens were derived from the Department of Fish and Game memorandum entitled Fish Screen Action Plan dated June 6, 1994.

## E Interagency Program Technical Reports

- 1982 Clogging, Cleaning, and Corrosion Study of Possible Fish Screens for the Proposed Peripheral Canal L. Smith
- 1982 An Evaluation of Predator Composition at Three Locations on the Sacramento River Pickard, Grover, Hall
- 1982 Occurrence, Abundance, and Size of Fish at the Roaring River Slough Intake, Suisun Marsh, California, during the 1980-81 and 1981-82 Diversion Season Pickard, Baracco, Kano
- 1982 Responses of Juvenile Chinook Salmon, *Oncorhynchus tshawytscha*, and American Shad, *Alosa sapidissima*, to Long-Term Exposure to Two-Vector Velocity Flows R. Kano
- 1982 Passage of Juvenile Chinook Salmon, *Oncorhynchus tshawytscha*, and American Shad, *Alosa sapidissima*, through Various Trashrack Bar Spacings Reading
- 1982 Delta Fish Facilities Program Report through June 30, 1982 D. Odenweller, R. Brown
- 1983 Effects of Freshwater Outflow on San Francisco Bay Biological Resources Herrgesell, Schaffter, Larsen
- 1983 Suspended Sediment Studies for the Sacramento River Diversion to the Peripheral Canal
- 1984 Technical Summary of Findings of the Phytoplankton Task Force Biological Committee
- 1986 Fisheries of Sacramento-San Joaquin Estuary and Adjacent Waters, California: A Guide to the Early Life Histories J. Wang
- 1987 Suisun Marsh Vegetation Survey F. Wernette
- 1987 Striped Bass Egg and Larvae Survey Low, Miller
- 1987 Benthic Monitoring C. Markmann
- 1987 Estimated Entrainment of Striped Bass Eggs and Larvae at State Water Project and Central Valley Project Facilities in the Sacramento-San Joaquin Delta, 1985-1986 P. Raquel
- 1987 The Effects of Trashrack and Bypass Design and Predator Control on Predation Losses of Juvenile Chinook Salmon at Hallwood-Cordua Fish Screen R. Kano
- 1988 Estimated Entrainment of Striped Bass Eggs and Larvae at State Water Project and Central Valley Project Facilities in the Sacramento-San Joaquin Delta, 1987 P. Raquel

- 1988 Striped Bass Egg and Larval Monitoring Near the Proposed Montezuma Slough Control Structure, 1987  
P. Raquel
- 1988 Suisun Marsh Salinity Control Gate Pre-Project Fishery Resources Evaluation  
S. Spaar
- 1988 Selenium Behavior in the Sacramento-San Joaquin Estuary, California  
G. Cutter
- 1989 Effects of Handling and Trucking on Chinook Salmon, Striped Bass, American Shad, Steelhead Trout, Threadfin Shad, and White Catfish Salvaged at the John E. Skinner Delta Fish Protective Facility  
P. Raquel
- 1989 Exhibit 25, regarding Striped Bass Abundance
- 1989 Tests on the Effect of Mesh Size on the Capture of Striped Bass Larvae in the Sacramento-San Joaquin Estuary  
R. Fujimura
- 1990 Evaluation of Selected Biological Factors That May Have Contributed to the Drought and Post-Drought Decline in Chlorophyll a Concentration
- 1990 Proceedings of the Sixth Annual Pacific Climate (PACCLIM) Workshop  
J. Betancourt, A. MacKay, editors
- 1990 Occurrence and Abundance of Predator Fish in Clifton Court Forebay, California  
R. Kano
- 1990 Results of 1988 Striped Bass Egg and Larva Study near the State Water Project and Central Valley Project Facilities in the Sacramento-San Joaquin Delta  
S. Spaar
- 1991 Proceedings of the Seventh Annual Pacific Climate (PACCLIM) Workshop  
J. Betancourt, V. Tharp, editors
- 1991 Observations on Temporal and Spatial Variability of Striped Bass Eggs and Larvae and Their Food in the Sacramento-San Joaquin River System  
R. Fujimura
- 1991 Early Life Stages and Early Life History of the Delta Smelt, *Hypomesus transpacificus*, in the Sacramento-San Joaquin Estuary with Comparison of the Early Life Stages of the Longfin Smelt, *Spirinchus thaleichthys*  
J. Wang
- 1991 *Potamocorbula amurensis*: Comparison of Clearance Rates and Assimilation Efficiencies for Phytoplankton and Bacterioplankton  
J. Hollibaugh, I. Werner

- 1991 Results of a Spatially Intensive Survey for *Potamocorbula amurensis* in the Upper San Francisco Bay Estuary  
Z. Hymanson
- 1992 Proceedings of the Eighth Annual Pacific Climate (PACCLIM) Workshop  
K. Redmond, editor
- 1992 Long-Term Trends in Zooplankton Abundance in the Sacramento-San Joaquin Estuary  
S. Obrebski, J. Orsi, W. Kimmerer
- 1992 An Evaluation of Existing Data in the Entrapment Zone of the San Francisco Bay Estuary  
W. Kimmerer
- 1993 Proceedings of the Ninth Annual Pacific Climate (PACCLIM) Workshop  
K. Redmond, V. Tharp, editors
- 1993 Observations of the Early Life Stages of Delta Smelt, *Hypomesus transpacificus*, in the Sacramento-San Joaquin Estuary in 1991, with a Review of Its Ecological Status in 1988 to 1990  
J. Wang, R. Brown
- 1994 Proceedings of the Tenth Annual Pacific Climate (PACCLIM) Workshop  
K. Redmond, V. Tharp, editors
- 1994 Delta Agricultural Diversion Evaluation 1992 Pilot Study  
S. Spaar
- 1994 Long-Term Trends in Benthos Abundance and Persistence in the Upper Sacramento-San Joaquin Estuary -- Summary Report: 1980-1990  
Z. Hymanson, D. Mayer, J. Steinbeck
- 1994 Seasonality and Quality of Eggs Produced by Female Striped Bass (*Morone saxatilis*) in the Sacramento and San Joaquin Rivers  
J. Arnold, T. Heyne
- 1995 Proceedings of the Eleventh Annual Pacific Climate (PACCLIM) Workshop  
C. Isaacs, V. Tharp, editors
- 1995 Food Habits of Several Abundant Zooplankton Species in the Sacramento-San Joaquin Estuary  
J. Orsi
- 1995 Working Conceptual Model for the Food Web of the San Francisco Bay/Delta Estuary  
Estuarine Ecology Team
- In Review Observations of Early Life Stages of Splittail (*Pogonichthys macrolepidotus*) in the Sacramento-San Joaquin Estuary, 1988 to 1994  
J. Wang

## F. Ecosystem Models

A major assumption in the list of tools that follows is that the models must be able to use output from DWRSIM. When additional information is required (i.e., water temperature simulations), the data need is noted. Unless noted, the tools can be used on personal computers and most can be incorporated into spreadsheets. Tools which require special computer needs are identified with an asterisk(\*).

### General Ecosystem Oriented Models (require information on water)

1. CPOP:Fall-Run Chinook Salmon, Sacramento River
  - input: flow, water temperature, life history information
  - output: population response
  - source: California Department of Fish and Game, National Marine Fisheries Service
2. CPOP:Winter-Run Chinook Salmon, Sacramento River
  - input: flow, water temperature, life history information
  - output: population response
  - source: National Marine Fisheries Service
3. CPOP:Fall-Run Chinook Salmon, Mokelumne River
  - input: flow, water temperature, life history information
  - output: population response
  - source: East Bay Municipal Utility District
4. EACH: Fall-Run Chinook Salmon, San Joaquin River
  - input: flow, water temperature, life history information
  - output: population response
  - source: EA Engineering, Science, and Technology (Turlock and Modesto Irrigation districts).

### Flow-Habitat Models

1. Relationships from IFIM studies on Central Valley rivers.
  - input: river flows, species life history data
  - output: habitat index
  - source: California Department of Fish and Game, U.S. Fish and Wildlife Service, various public and private water agencies.
2. Flow-Habitat Index Model
  - input: river flows, species life history data, IFIM relationships
  - output: habitat index
  - source: Jones & Stokes Associates (CVPIA-PEIS)

### Temperature-Mortality Models

1. \*Sacramento River, Feather River, American River, and Stanislaus River
  - input: river water temperature by node
  - output: mortality
  - source: U.S. Bureau of Reclamation

2. Sacramento River, Feather River, American River, and Stanislaus River
  - input: river water temperature by node
  - output: mortality
  - source: Jones & Stokes Associates (CVPIA-PEIS)

#### Passage and Entrainment Models

1. Red Bluff Diversion Dam: upstream passage
  - input: flow, gate operations
  - output: passage
  - source: U.S. Fish and Wildlife Service
2. Entrainment Index Models
  - input: acre feet pumped, fish screen efficiency
  - output: entrainment
  - source: California Department of Fish and Game, Jones & Stokes Associates (CVPIA-PEIS)

#### Multiple Species Models

1. Optimal Salinity Habitat Model: striped bass, longfin smelt, delta smelt, bay shrimp
  - input: Delta outflow
  - output: habitat area
  - source: Jones & Stokes Associates (CVPIA-PEIS, Delta Wetlands EIR/EIS)
2. Transport Index Models: striped bass, longfin smelt, delta smelt, chinook salmon, planktonic larvae, and planktonic invertebrates
  - input: Delta flows, operations, diversions, life history information, productivity relationships
  - output: transport indices, population abundance, entrainment
  - source: California Department of Water Resources (\*DWRDSM, \*Particle Tracking Model), U.C. Davis (\*Particle Tracking and Delta productivity), Jones & Stokes Associates (D30MOVE, DAYMOVE), U.S. Bureau of Reclamation (\*Fisher Delta Model), Resource Management Associates (\*RMA Link-Node Model)
3. Entrainment Models: striped bass, delta smelt, longfin smelt, Sacramento splittail
  - input: diversions, fish screen efficiency, Delta flows, life history information
  - output: entrainment indices
  - source: Jones & Stokes Associates (CVPIA-PEIS, Delta Wetlands EIR/EIS)

#### Chinook Salmon

1. Fall-Run Chinook Salmon Mortality: Sacramento River Delta
  - input: Sacramento River inflow, Delta Cross Channel and Georgiana Slough flow, water temperature, exports
  - output: mortality
  - source: U.S. Fish and Wildlife Service
2. Fall-Run Chinook Salmon Mortality: San Joaquin River Delta

- input: San Joaquin River inflow, Old River flow, water temperature, exports
- output: mortality
- source: U.S. Fish and Wildlife Service

3. Entrainment Models

- input: Delta flows, export, salvage efficiencies, life history information
- output: entrainment
- source: California Department of Water Resources

### Striped Bass

1. Striped Bass Population Model

- input: Delta outflow, Exports, life history information
- output: population abundance
- source: California Department of Fish and Game

2. Entrainment Models

- input: Delta flows, export, salvage efficiencies, life history information
- output: entrainment
- source: California Department of Water Resources, Wendt 1987

3. Juvenile Abundance

- input: Delta outflow (X2)
- output: abundance index
- source: U.S. Environmental Protection Agency

4. Juvenile Distribution

- input: Delta outflow
- output: proportion of population downstream of the Delta
- source: California Department of Fish and Game

### American Shad

1. Juvenile Abundance

- input: Delta outflow
- output: abundance index
- source: California Department of Fish and Game

### Delta Smelt

1. Juvenile Abundance

- input: Delta outflow (X2)
- output: abundance index
- source: U.S. Environmental Protection Agency

2. Juvenile Distribution

- input: Delta outflow
- output: proportion of population downstream of the Delta
- source: California Department of Fish and Game

## Longfin Smelt

### 1. Juvenile Abundance

-input: Delta outflow (X2)

-output: abundance index

-source: California Department of Fish and Game, U.S. Environmental Protection Agency

## Sacramento Splittail

### 1. Juvenile Abundance

-input: Delta inflow

-output: abundance index

-source: California Department of Fish and Game

## Invertebrates and General Productivity: Neomysis, Crangon, organic carbon

### 1. Abundance Index

-input: Delta outflow (X2)

-output: abundance index

-source: California Department of Fish and Game, U.S. Environmental Protection Agency