FINAL ENVIRONMENTAL IMPACT REPORT FOR IMPLEMENTATION OF THE 1995 BAY/DELTA WATER QUALITY CONTROL PLAN

State Clearinghouse Number 97-122056

VOLUME 1

November 1999

STATE WATER RESOURCES CONTROL BOARD

California Environmental Protection Agency

STATE OF CALIFORNIA
Gray Davis, Governor

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
Winston H. Hickox, Secretary

STATE WATER RESOURCES CONTROL BOARD
P.O. Box 2000
Sacramento, CA 95812-2000
(916) 657-2170
http://www.waterrights.ca.gov/baydelta/

PREFACE

On May 22, 1995, the State Water Resources Control Board (SWRCB) adopted the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (1995 Bay/Delta Plan or Bay/Delta Plan) which establishes objectives for the protection of municipal, agricultural, and fish and wildlife beneficial uses in the Bay/Delta Estuary. The 1995 Bay/Delta Plan includes objectives in the Bay/Delta Estuary for Delta outflow, Sacramento and San Joaquin river flows, salinity, dissolved oxygen, and State Water Project (SWP) and Central Valley Project (CVP) operations.

On July 27, 1995, the SWRCB filed a Notice of Preparation (NOP) of an Environmental Impact Report (EIR) for the development of a water right decision to implement requirements for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. The project is defined as a water right decision that (1) identifies the responsibility of water right holders in the Bay/Delta Estuary watershed to achieve the flow, operational, and water quality requirements in the 1995 Bay/Delta Plan and allocates responsibility according to established principles of water law; (2) may authorize the combined use of the CVP and the SWP points of diversion in the Delta; (3) requires actions to improve habitat conditions in the central valley; and (4) requires measures to improve water supply reliability for users of water within and from the Bay/Delta Estuary watershed. The NOP requested input from all interested parties on the scope and content of the EIR.

Public workshops were held on four days in August, September, and November 1995. Based on comments received at these workshops indicating that the NOP did not provide sufficient project detail, a revised NOP was issued in December 1995. During 1996, nine additional days of workshops were held to discuss issues arising from the revised NOP. The SWRCB staff convened a technical workshop on March 18, 1997, to review the analytical methods being used to calculate water availability when water right priorities are used to implement the 1995 Bay/Delta Plan flow objectives (Flow Alternatives 3 and 4).

The Draft EIR for Implementation of the 1995 Bay/Delta Water Quality Control Plan, Volume I (Chapters I through XII) was issued in November 1997. Volumes II (Chapter XIII - Alternatives for Implementing the Joint Points of Diversion) and III (Appendices) were issued on December 15, 1997. The Draft EIR was circulated to interested parties with a 45-day review commencing with the release of Volumes II and III, with comments to be received by January 30, 1998. Because interested parties requested additional review time, the comment period on the Draft EIR was extended to April 1, 1998.

A Notice of Public Hearing, dated December 2, 1997, was issued for the consideration of (1) alternatives to implement water quality objectives for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, (2) a petition to change points of diversion of the CVP and the SWP in the southern Delta, and (3) a petition to change places of use and purpose of use of the CVP. The petition to change places of use and purpose of use of the CVP is the subject of a separate EIR.

Volume IV of the Draft EIR, was issued on May 26, 1998. Volume IV contains revisions to Chapters V, VI, and XIII to include the provisions of the San Joaquin River Agreement (1) as an alternative for implementing the flow objectives in the 1995 Bay/Delta Plan (Flow Alternative 8) and (2) as an alternative for implementing the petition for joint use of the SWP and CVP points of diversion in the Delta (Joint POD Alternative 9). Chapters V and VI were also revised to correct errors in the original modeling of Flow Alternative 5. Volume IV was circulated for a 45-day review with comments due by July 13, 1998.

The SWRCB received 104 letters on the Draft EIR, representing the comments of 125 parties. The letters are available for review in their entirety on the SWRCB website (*http://www.waterrights.ca.gov/baydelta*). The comments and response-to-comments are included as Volume III of the Final EIR.

TABLE OF CONTENTS

LIST OF FIGURES

Figure
Number **Page**

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

LIST OF TABLES

Table
Number **Page**

LIST OF TABLES (cont.)

LIST OF TABLES (cont.)

LIST OF TABLES (cont.)

LIST OF TABLES (cont.)

LIST OF TABLES (cont.)

LIST OF TABLES (cont.)

LIST OF TABLES (cont.)

LIST OF TABLES (cont.)

LIST OF TABLES (cont.)

LIST OF TABLES (cont.)

LIST OF TABLES (cont.)

LIST OF ABBREVIATIONS AND ACRONYMS

General Terms

1978 Delta Plan	1978 Water Quality Control Plan for the Saramento-San Joaquin Delta and Suisun Marsh
1991 Bay/Delta Plan	1991 Water Quality Control Plan for Salinity for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary
1995 Bay/Delta Plan	Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary
Bay/Delta Estuary	The San Francisco Bay/Sacramento-San Joaquin Delta Estuary
Framework Agreement	Framework Agreement between the Governor's Water Policy Council of the State of California and the Federal Ecosystem Directorate
Principles Agreement	Principles for Agreement on Bay/Delta Standards between the State of California and the Federal Government

Abbreviations

BOD	Biochemical Oxygen Demand
^{o}C	degrees Celsius
CBOD	Carbonaceous Biochemical Oxygen Demand
Cfs	cubic feet per second
Cx	carbon emissions
D-1275	Water Right Decision 1275, May 31, 1967 (State Water Project Decision)
D-1422	Water Right Decision 1422, April 4, 1973 (New Melones Decision)
D-1485	Water Right Decision 1485, dated August 16, 1978 (1978 Delta Plan)
D-1630	Draft Water Right Decision 1630, April 1993
DBCP	Dibromochloropropane
DDT	the insecticide Dichlorodiphenyltrichloroethane
DO	dissolved oxygen
DS/m	deci-siemens per meter
EC	electrical conductivity

^{o}F	degrees Fahrenheit
Ft/s	feet per second
Gpcd	gallons per capita per day
JTU	Jackson turbidity units
M	meters
MAF	million acre-feet
mgd	million gallons per day
Mg/l	milligrams per liter
mm	Millimeters
mmhos/cm	micromhos per centimeter at 25 degrees centigrade (EC)
mmhos/cm	millimhos per centimeter at 25 degrees centigrade (EC); equivalent to mS/cm (millesiemens) or dS/m
msl	mean sea level
M&I	municipal and industrial
NOx	oxides of nitrogen
NTU	nephelometric turbidity units
PM10	particulate matter of less than 10 microns in diameter
POC	Particulate Organic Carbon
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
qwest	San Joaquin River downstream flow at DWRSIM node 528
ROG	reactive organic gases
RV	recreational vehicle
SNA	significant natural area
SOx	oxides of sulfur
TAF	thousand acre-feet
TCD	temperature control device
TDS	total dissolved solids
THM	trihalomethane
vpd	vehicles per day
WC	California Water Code
WQ 81-1	Water Quality Order 81-1
WR 95-6	Water Right Order WR95-6, dated June 8, 1995

Acronyms

ACID	Anderson-Cottonwood Irrigation District
ACWD	Alameda County Water District
AFB	Air Force Base
AWSC	American Water Suppliers in California
BCDC	San Francisco Bay Conservation and Development Commission
BLM	U.S Bureau of Land Management
BMP	Best Management Practice
CALFED	CALFED Bay Delta Program established under the Framework Agreement
CCR	California Code of Regulations
CCWD	Contra Costa Water District
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
COA	Coordinated Operations Agreement
CRA	California Resources Agency
CUAW	Consumptive Use of Applied Water
CUWCC	California Urban Water Conservation Council
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVPM	Central Valley Production Model
CVRWQCB	Central Valley Regional Water Quality Control Board
DD	Direct Diversion
DEIR	Draft Environmental Impact Report for Implementation of the 1995 Bay/Delta Water Quality Control Plan
DFG	California Department of Fish and Game
DHS	Department of Health Services
DMC	Delta-Mendota Canal
DPR	California Department of Parks and Recreation
DSA	DWR Depletion Study Area
DWR	California Department of Water Resources
DWRDSM	DWR Delta Simulation Model
DWRSIM	DWR Planning Simulation Model
EBMUD	East Bay Municipal Utility District
EBMUDSIM	EBMUD Planning Model
EIR	Environmental Impact Report (pursuant to CEQA)
EIR/EIS	an EIR and an EIS as a combined document

EIS	Environmental Impact Statement (pursuant to NEPA)
ER	Environmental Report, Appendix I of the 1995 Bay/Delta Plan
ESA	Federal Endangered Species Act
ETAW	Evapotranspiration of applied water
EWMP	Efficient Water Management Practices
FED	Federal Ecosystem Directorate
FEIR	Final Environmental Impact Report for Implementation of the 1995 Bay/Delta Water Quality Control Plan
FERC	Federal Energy Regulatory Commission
FO	Friant Obligation
FSSD	Fairfield-Suisun Sewer District
FWUA	Friant Water Users Association
GCID	Glenn-Colusa Irrigation District
GRCD	Grassland Resource Conservation District
GWD	Grasslands Water District
HEC	Hydrologic Engineering Center
ID	Irrigation District
IO	Inbasin Obligation
ISDP	Interim South Delta Program
LAA	Los Angeles Aqueduct
LACFCD	Los Angeles County Flood Control District
LADWP	City of Los Angeles, Department of Water and Power
LORP	Lower Owens River Project
MCWRA	Monterey County Water Resources Agency
MID	Modesto Irrigation District
MMWD	Marin Municipal Water District
MOU	Memorandum of Understanding
MWD	Metropolitan Water District of Southern California
NBA	North Bay Aqueduct
NEPA	National Environmental Policy Act
NID	Nevada Irrigation District
NMFS	National Marine Fisheries Service
NMR	New Melones Reservoir
NMWD	North Marin Water District
NPDES	National Pollution Discharge Elimination System
NRA	National Recreation Area
NWR	National Wildlife Refuge
OHV	Off-Highway Vechicle

OWID	Oroville-Wyandotte Irrigation District
PCWA	Placer County Water Agency
PEIS	Programmatic Environmental Impact Statement
PG&E	Pacific Gas and Electric Company
POD	Point of Diversion
PSA	DWR planning subarea
RWQCB	Regional Water Quality Control Board
SANJASM	USBR San Joaquin Operations Model
SCE	Southern California Edison
SCVWD	Santa Clara Valley Water District
SCWA	Solano County Water Agency
SDWA	South Delta Water Agency
SDWMP	South Delta Water Management Program
SEW	Suisun Ecological Workgroup
SFEP	San Francisco Estuary Project
SFWD	San Francisco Water District
SID	Solano Irrigation District
SJR	San Joaquin River
SJRIO	San Joaquin River Input/Output Model
SJRIO	San Joaquin River Input/Output Model
SJRMP	San Joaquin River Management Plan
SJVDP	San Joaquin Valley Drainage Program
SMPA	Suisun Marsh Preservation Agreement
SMSCG	Suisun Marsh Salinity Control Gate
SMUD	Sacramento Municipal Utility District
SR	Storage Releases
SRA	State Recreation Area
SRCD	Suisun Resource Conservation District
SRDWA	Sacramento River and Delta Water User's Association
SSWD	South Sutter Water District
SW	Supplemental Water
SWP	State Water Project
SWRCB	State Water Resources Control Board
SWTR	Surface Water Treatment Rule
TBP	South Delta Temporary Barriers Project
TCP	Traditional Cultural Property
TID	Turlock Irrigation District

UC	University of California
USBR	United States Bureau of Reclamation
USCOE	United States Army Corps of Engineers
USDOI	United States Department of the Interior
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VA	Veterans Administration
WCWD	Western Canal Water District
WD	Water District
WFP	Water Forum Proposal
WMA	Wildlife Management Area
WSCT	Western Suisun Marsh Salinity Control Test
WWTP	Stockton Wastewater Treatment Plant
YCFC&WCD	Yolo County Flood Control and Water Conservation District
YCWA	Yuba County Water Agency
YOY	Young of Year

EXECUTIVE SUMMARY

In 1995, the State Water Resources Control Board (SWRCB) adopted a water quality control plan (Bay/Delta Plan or Plan) for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay/Delta or Estuary). The Plan identifies municipal and industrial, agricultural, and fish and wildlife beneficial uses for waters of the estuary, and specifies objectives to protect these uses. The objectives consist of numeric objectives for flow; numeric objectives for water quality constituents (salinity and dissolved oxygen); numeric operational constraints for the State Water Project (SWP) and the Central Valley Project (CVP); a narrative objective for the protection of salmon; and a narrative objective for the protection of brackish tidal marshes in Suisun Marsh.

Most of the objectives in the 1995 Bay/Delta Plan are currently implemented through biological opinions issued by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service for protection of delta smelt and winter-run chinook salmon, respectively, and through SWRCB Water Right Decision 1485 (D-1485) and SWRCB Order WR 98-9. Order WR 98-9 is an interim order expiring on December 31, 1999. Under the biological opinions, D-1485, and the interim order, responsibility for meeting most of the objectives is assigned to the SWP, operated by the California Department of Water Resources (DWR), and the CVP, operated by the U.S. Bureau of Reclamation (USBR). The DWR and the USBR have agreed to implement the objectives until the SWRCB adopts a water right decision that allocates responsibility to meet the Plan objectives. The proposed project is an administrative action to implement the Plan by allocating responsibility for achieving the Plan objectives to water right holders whose diversions affect the beneficial uses of water in the estuary. The proposed project also includes consideration of whether and under what conditions combined use of the SWP and CVP points of diversion should be authorized.

As required by the California Environmental Quality Act (CEQA), the SWRCB prepared environmental documentation on the impact of adopting the Plan. The Environmental Report (ER) is a programmatic document that provides a foundation for this final Environmental Impact Report (FEIR).

This FEIR analyzes alternative actions for implementing the 1995 Plan and the environmental impacts of those alternatives. Most of the potential actions will implement one group of objectives independently of actions to implement other groups of objectives. As a result, many combinations of actions could be taken to implement the Plan. The FEIR does not identify a preferred alternative, but rather categorizes the objectives into groups and identifies various “sets” of alternatives that could be taken to implement each group of objectives. Any decision of the SWRCB to implement the 1995 Bay/Delta Plan will fall within the range of alternatives described and analyzed within this document.

The FEIR analyzes the following sets of alternatives: (1) alternatives for implementing the flow objectives, (2) alternatives for implementing Suisun Marsh salinity objectives, (3) alternatives for implementing salinity control measures in the San Joaquin River Basin, (4) alternatives for implementing southern Delta salinity alternatives (other than Vernalis), (5) alternatives for implementing the dissolved oxygen objective, and (6) alternatives for implementing combined use of points of diversion. Tables ES-1 through ES-6 summarize the important aspects of each of the alternatives in the different sets. The FEIR also analyzes the cumulative impacts of implementing the flow objectives in concert with other closely related past, present, and reasonably foreseeable future projects.

The environmental impacts associated with the different sets of alternatives are analyzed at the project level for the flow and combined use of points of diversion alternatives, and at the programmatic level for the other sets of alternatives. The base case, or “no project alternative” for this FEIR is necessarily the same as the base case for the ER because this project is a continuation of the project that resulted in the adoption of the Plan. The base case is characterized by the flow conditions that would have occurred with historical hydrology at the present level of development under regulatory requirements that most likely would be in effect if the SWRCB does not approve the project. The applicable regulatory requirements are specified in D-1485, D-1422, and the upstream biological opinion for winter run chinook salmon.

This FEIR identifies significant adverse impacts associated with the alternatives and mitigation measures to reduce impacts to less than significant levels, where possible. The alternatives to implement the dissolved oxygen objectives are not expected to have significant adverse environmental impacts; therefore, the dissolved oxygen objective is not discussed further in this summary.

A. FLOW OBJECTIVES ALTERNATIVES

Implementation of the flow objectives alternatives (Table ES-1) affects water supplies which may, in turn, cause associated environmental impacts. However, because the DWR and the USBR have voluntarily complied with the flow objectives in the Bay/Delta Plan since 1995, many of the environmental effects of implementing the flow objectives have already been experienced. In most instances, the impacts identified in the FEIR are similar to impacts already experienced.

1. Water Supply Impacts

The Bay/Delta Plan increases the quantity of water dedicated to protection of aquatic resources in the estuary. Consequently, water deliveries for municipal and agricultural uses decline. The identity of the parties subject to delivery reductions will depend on the allocation method selected by the SWRCB in its water rights decision implementing the Plan. Over the long term, annual average delivery reductions will be approximately 350,000 acre feet while in critically dry periods the annual average delivery reductions will be approximately 800,000 acre feet.

Table ES-1
Flow Objectives Alternatives

Alternative	Regulatory Requirements	Responsible Parties	Details
1	D-1485 & D-1422; Upstream BO for winter-run chinook salmon	DWR and USBR	Base Case or "No Project" Alternative. These regulatory requirements would be in effect if the SWRCB does not approve the project.
2	1995 Bay/Delta Plan	DWR and USBR	The DWR and the USBR are mutually responsible for meeting the objectives except for the Vernalis flow objectives that are the exclusive responsibility of the USBR.
3	1995 Bay/Delta Plan	Major Post-1914 Appropriative Water Right Holders in the Delta Watershed	Holders of water rights with a cumulative face value in excess of 5,000 acre-feet per year share responsibility for meeting the flow objectives based on the watershed protection statutes and water right priorities. The Friant Project is assumed to be inbasin with respect to the Delta.
4	1995 Bay/Delta Plan	Major Post-1914 Appropriative Water Right Holders in the Delta Watershed	Same as Alternative 3 except most of the deliveries through the Friant-Kern Canal are assumed to be CVP exports subject to watershed protection statutes.
5	1995 Bay/Delta Plan	Reservoir Water Right Holders identified in Tables II-7 and II-8	Monthly average flow requirements are established for each of the major watersheds tributary to the Delta. Responsibility is assigned to water right holders with storage in foothill reservoirs that control downstream flow and upstream reservoirs with capacity of at least 100 TAF where use is consumptive.
6	1995 Bay/Delta Plan	DWR and USBR	Same as Alternative 2 except the USBR meets Vernalis flow objectives by releases from the Delta-Mendota Canal into the San Joaquin River. Water is also released to meet the consumptive use requirement of the South Delta Water Agency.
7	1995 Bay/Delta Plan as modified by the Letter of Intent (LOI)	DWR and USBR; Parties to the Letter of Intent	Same as Alternative 2 except the Vernalis pulse flow objective is replaced by the target flows in the LOI. Some water users in the San Joaquin Basin provide a share of flows in the San Joaquin River as specified in the LOI.
8	1995 Bay/Delta Plan as modified by the San Joaquin River Agreement (SJRA)	DWR and USBR; Parties to the San Joaquin River Agreement	Same as Alternative 2 except the Vernalis pulse flow objective is replaced by the target flows in the SJRA. Export limits during the pulse flow period are replaced by target limits in the SJRA. Members of the San Joaquin River Group provide a share of the flows to meet the Vernalis target flows.

Table ES-2
Suisun Marsh Salinity Objectives Alternatives

Alternative	Regulatory Requirements	New Facilities	Green Valley Creek Flow Augmentation	Other Actions
1	D-1485	None	None	None
2	D-1485	Cordelia-Goodyear Ditch and Goodyear Slough Tide Gate. Minor construction on N. Bay Aqueduct.	Up to 80 cfs as needed from N. Bay Aqueduct to meet western marsh objectives.	None
3	1995 Bay/Delta Plan	None	None	None
4	1995 Bay/Delta Plan	Cordelia-Goodyear Ditch and Goodyear Slough Tide Gate. Minor construction on N. Bay Aqueduct.	Up to 80 cfs as needed from N. Bay Aqueduct to meet western Marsh objectives.	None
5	1995 Bay/Delta Plan	None	None	SMPA Amend. III management actions plus September SMSCG operations as needed
6	1995 Bay/Delta Plan	Minor construction on Putah-South Canal and N. Bay Aqueduct	As needed from all sources until objectives are met in western marsh.	None

Table ES-3
Salinity Control Alternatives in the San Joaquin Basin

Alternative	Action
1	No Water Quality Action Taken.
2	All Grasslands Water District wetland releases made during March and April are shifted to February when March Vernalis salinity objectives may be exceeded.
3	Discharge of subsurface agricultural drainage is not authorized for up to three months when assimilative capacity is not available in the San Joaquin River.
4	Combination of Salinity Control Alternatives 2 and 3.

Table ES-4
Southern Delta Salinity Objectives Alternatives

Alternative	Regulatory Requirements	Barrier Locations
1	D-1485	Temporary Barriers at Middle River, Head of Old River, and Old River at Tracy Road Bridge.
2	1995 Bay/Delta Plan	Temporary Barriers at Middle River, Head of Old River, and Old River at Tracy Road Bridge.
3	1995 Bay/Delta Plan	Permanent Barriers at Middle River, Grantline Canal, Head of Old River and Old River at Tracy Road Bridge.

Table ES-5
Dissolved Oxygen Objectives Alternatives

Alternative	Regulatory Requirements	Quantity of Stockton WWTP Discharge	Barrier Operations
1	D-1485	1996 Levels	Temporary Barrier at Head of Old River
2	1995 Bay/Delta Plan	1996 Levels	Temporary Barrier at Head of Old River
3	1995 Bay/Delta Plan	1996 Levels	Permanent Barrier at Head of Old River
4	1995 Bay/Delta Plan	1996 Discharge Quantity, CBOD & Ammonia Effluent Limits as Specified by CVRWQCB	Permanent Barrier at Head of Old River

2. Aquatic Resources

The principal purpose of implementing the flow objectives is to improve conditions for aquatic resources in the Delta. The analysis in the FEIR indicates that this purpose is achieved. The flow alternatives generally result in reduced entrainment and the adverse effects of reverse flows in the critical period for spawning, rearing, and outmigration of many aquatic species in the Delta. The abundance of many Delta species shows a significant positive relationship with Delta outflow in the spring months. In the spring months, Delta outflow under the flow alternatives is greater than in the base case which improves conditions for spawning and survival of aquatic resources. Due to changes in Delta exports and outflow, implementation of the flow alternatives is predicted to have beneficial effects on through-Delta survival of juvenile chinook salmon and steelhead, and on abundance of longfin smelt, Sacramento splittail, starry flounder, *Crangon franciscorum*, and *Neomysis mercedis*, compared to the base case.

Table ES-6
Joint Point of Diversion Alternatives

Alternative	Regulatory Requirements	Actions
1	D-1485, D-1422, and Upstream BO for winter-run chinook salmon	JPOD authorized to make up export deficiencies occurring under D-1485 in May and June. Identical to Flow Alternative Base Case.
2	1995 Bay/Delta Plan	JPOD not authorized and all water quality objectives are met.
3	1995 Bay/Delta Plan	JPOD authorized for CVP deliveries to the Cross Valley Canal, Musco Olive, Tracy Golf Course, and the Veterans' Administration cemetery. JPOD use limited by terms and conditions in SWP and CVP water right permits. SWP restrictions imposed by USCOE PN 5820-A in effect.
4	1995 Bay/Delta Plan	JPOD authorized as described in Alt. 3 and to provide a net benefit to fish and wildlife. Exports lost by either project as a result of diversion reductions to benefit fish may be made up within twelve months using either or both PODs. Modeling assumes exports are reduced during the April/May pulse flow period. Reductions made up through use of JPOD in other months.
5	1995 Bay/Delta Plan	JPOD authorized for deliveries to any SWP or CVP export area. JPOD use limited by terms and conditions in SWP and CVP water right permits. SWP restrictions imposed by PN 5820-A in effect.
6	1995 Bay/Delta Plan as modified by the Letter of Intent	JPOD authorized as described in Alt. 5 except that San Joaquin River flows at Vernalis are as specified in the Letter of Intent.
7	1995 Bay/Delta Plan	JPOD authorized as described in Alt. 5 except that restrictions imposed by PN 5820-A are not in effect. The ISDP barriers are installed and operated.
8	1995 Bay/Delta Plan	JPOD authorized as described in Alt. 7 except the SWP and CVP diversions are limited only by the combined physical capabilities of the pumping plants and by each project's annual authorized diversion. 1995 demand level modeled for the SWP and 2020 demand level modeled for the CVP.
9	1995 Bay/Delta Plan as modified by the San Joaquin River Agreement	JPOD authorized as described in Alt. 5 except the Vernalis pulse flows and export limits are replaced by the target values in the San Joaquin River Agreement.

Despite the generally positive impact of the implementation of the flow alternatives, there may be negative effects on some life stages of aquatic resources. In some months, the flow alternatives result in higher Delta exports and greater reverse flows than in the base case. Flow Alternative 5 could result in higher exports in some spring months, which may negatively affect young-of-the-year striped bass abundance. Flow Alternative 6 would increase the percentage of Sacramento River water that enters the San Joaquin River. This could adversely affect the imprinting of juvenile chinook salmon emigrating from the San Joaquin Basin in April and May. The significance of this potential impact is not known.

Implementation of the flow alternatives may result in significant impacts to reservoir fisheries at one or more upstream reservoirs, due to reduction or fluctuation in storage levels during critical time periods for warmwater fish reproduction.

Potential impacts on striped bass under Alternative 5 could be mitigated through additional stocking. If significant effects on reservoir fisheries are observed, mitigation could include additional fish planting, habitat improvement through planting of shoreline vegetation, addition of habitat structures, or improved management of shoreline grazing practices.

3. Groundwater

The decrease in surface water deliveries associated with implementation of the flow objectives will increase groundwater use. Increased groundwater use can cause land subsidence, groundwater overdraft, groundwater quality degradation, and declines in agricultural productivity.

Impacts to groundwater can be mitigated through conservation and water transfers. In addition, land subsidence impacts can be mitigated by limiting groundwater pumping and by land retirement. Overdraft and groundwater quality deterioration impacts can be mitigated by adopting groundwater management plans, establishing a groundwater management agency by statute, cropping pattern changes requiring lower consumptive water use, and conjuctive use programs. The potential for decreased agricultural productivity can be mitigated by blending groundwater supplies with surface water supplies, and shifting to different or more salt tolerant crops.

4. Energy

Implementation of the flow alternatives results in higher net hydropower generation by the SWP and the CVP because exports are reduced. The increased groundwater pumping to replace surface water supplies (described in the previous section) could lead to increased pumping lifts and increases in energy consumption. The alteration of hydroelectric power generation and consumption patterns along with increased groundwater pumping may result in the increased use of fossil-fuel generation, thereby increasing air pollution. This impact may not be entirely mitigable; however, other sources of energy generation are available including nuclear, geothermal, biomass, solar thermal, solar photovoltaic, and wind generation. Additionally, this impact can be partially mitigated through off-peak pumping operations.

5. Recreation, Scenic Quality and Cultural Resources

Implementation of the flow objectives will improve conditions for aquatic resources that live in or migrate through the Delta, increasing their populations. Such improvements may result in increased commercial and sport fishing opportunities as well as nonconsumptive recreational opportunities. The Plan requires closure of the Delta Cross Channel gates to improve migratory conditions for salmon smolts. Closure of the gates, however, impedes navigation between the Sacramento and Mokelumne rivers impacting Delta recreation. This impact is unmitigable.

Modeling results indicate that the flow alternatives could have the effect of lowering water levels in reservoirs earlier in the season, for longer periods, or below the levels than would otherwise occur at certain reservoirs compared to the base case. Consequently, recreation, scenic quality and cultural resources could be impacted at some upstream reservoirs. The significance of these modeling results is difficult to quantify because the natural hydrology already results in substantial reservoir level fluctuations. Modeled reservoir operations may not coincide with real-time operations by reservoir owners.

Recreation impacts at reservoirs can be mitigated by modification or relocation of facilities (such as boat ramps and marinas) to accommodate lower water levels. Impacts to cultural resources can be mitigated by inventorying and evaluating cultural resources at affected reservoirs, preserving and protecting the resources in place where possible, or excavating and documenting the historic values and information of the resources. Impacts to scenic quality are potentially unmitigable.

B. SUISUN MARSH SALINITY OBJECTIVES ALTERNATIVES

The 1995 Bay/Delta Plan contains salinity objectives for Suisun Marsh channels to protect the beneficial uses of the managed marsh. Suisun Marsh Alternative 5 is identified in the FEIR as the environmentally superior alternative, and its implementation is not expected to have significant adverse effects within the marsh.

Some of the Suisun Marsh alternatives (Table ES-2) include flow augmentation in the western marsh to achieve the western Marsh objectives. Such flow increases could adversely affect both terrestrial and aquatic species in the Marsh. Four terrestrial endangered species present in the marsh require brackish conditions for survival and could be affected by additional freshwater inflow. Flow augmentation with water diverted from the Sacramento River could attract salmon and delta smelt into areas of unsuitable habitat, or result in increased entrainment at the point of diversion, thus having an impact on these species.

C. SOUTHERN DELTA SALINITY OBJECTIVES

The Bay/Delta Plan contains salinity objectives for the southern Delta to protect the quality of the water available for irrigated agriculture. Southern Delta salinity concentrations can be improved by construction and operation of permanent barriers in the southern Delta (Table ES-4). Permanent barriers are a component of the Interim South Delta Program (currently part of the South Delta

Improvements Program) now under review by the DWR. Operation of permanent barriers improves water levels and water circulation in the southern Delta.

Notwithstanding the benefits, construction and operation of the barriers have the potential to cause significant impacts to water levels and salinity, aquatic resources, terrestrial biological resources, recreation, navigation and transportation. The relative magnitude of impacts to various aquatic species and habitat as a consequence of the barriers cannot be quantified. Many southern Delta locations see significant improvements in minimum water levels at certain times of the year as a result of barrier operations; however, under some circumstances, construction of permanent barriers reduces water levels.

Mitigation measures are proposed by the DWR in the Interim South Delta Program DEIR to mitigate or reduce impacts to aquatic resources, terrestrial biological resources, recreation, navigation and transportation.

D. JOINT POINTS OF DIVERSION ALTERNATIVES

The FEIR analyzes the impact of implementing the use of combined or "joint" points of diversion (JPOD) by the DWR and USBR in the southern Delta. Approval of the petition would authorize the DWR to divert water from the Delta at the CVP's Tracy Pumping Plant and would authorize the USBR to divert water from the Delta at the SWP's Banks Pumping Plant.

Implementation of the JPOD will help reduce the water supply impacts of implementing the Bay/Delta Plan and thus, lessen the environmental effects. For example, the JPOD could reduce the water supply impacts to water users in the San Joaquin Basin, thereby reducing the groundwater overdraft and subsidence impacts of implementing the Plan. Modeling studies show that the use of the JPOD can increase average annual CVP deliveries to export areas by up to 247,000 acre feet, depending on the JPOD alternative selected.

The FEIR analyzes seven alternatives to implement the JPOD and two base cases (Table ES-6). One base case assumes that the 1995 Bay/Delta Plan is not implemented and the regulatory requirements are specified in D-1485, D-1422 and the upstream biological opinion for winter-run chinook salmon. The second base case assumes Bay/Delta Plan implementation. The second base case was evaluated because the DWR and the USBR have been voluntarily complying with the Plan since 1995. Unless indicated otherwise, the impacts discussed below are in comparison to the 1995 Bay/Delta Plan base case.

1. Aquatic Resources

The JPOD can be used to improve conditions for fish by increasing operational flexibility of the projects. Project pumping can be foregone at times that are harmful to fish and the lost yield recovered at a later time when conditions for fish are more favorable. JPOD Alternative 4 will provide greater protection for aquatic resources than Alternatives 3 and 5-9 because the combined use of points of diversion is used primarily for the benefit of aquatic resources. Modeling analysis shows that exports would be reduced in the spring months under the JPOD alternatives compared to base cases, potentially reducing entrainment in the critical period for spawning, rearing, and outmigration of many aquatic species in the Delta.

Most of the JPOD alternatives will increase exports on an annual average basis. Therefore, the JPOD alternatives could result in increased entrainment and other export-related effects in the Delta in the July to January period (except September) due to increased Delta exports. Survival of yearling spring-run chinook salmon emigrating through the Delta could be reduced because their emigration period (fall and winter) coincides with the period of increased exports.

The abundance of many Delta species shows a significant positive relationship with Delta outflow in the spring months. Delta outflow is expected to change with the implementation of the JPOD alternatives but the effects are not expected to be as significant as entrainment effects. Delta outflow generally decreases compared to the Bay/Delta Plan base case between July and January and increases during February and March because of pumping shifts.

In general, the use of the JPOD is not predicted to adversely impact the through-Delta survival of juvenile chinook salmon and steelhead, or the abundance of delta smelt, Sacramento splittail, starry flounder, longfin smelt, and *Crangon franciscorum,* compared to the Bay/Delta Plan condition. However, JPOD Alternative 6 is predicted to have a slight adverse impact on survival of San Joaquin River fall-run chinook salmon smolts through the Delta compared to the Bay/Delta Plan condition. Alternatives 7 and 8 are predicted to have adverse impacts on young-of-the-year striped bass abundance compared to the Bay/Delta Plan condition.

Modeling studies indicate that implementation of the JPOD alternatives could result in significant impacts to reservoir fisheries in certain CVP reservoirs, due to reduction or fluctuation in storage levels during critical time periods. The magnitude of this adverse effect will depend on operational decisions made by the CVP.

If operations under the JPOD alternatives result in increased entrainment, the entrainment could be mitigated through regulatory constraints applied to operations on a real-time basis. Measures that could be used during critical time periods to reduce or avoid entrainment include switching diversions between SWP and CVP facilities if entrainment is high at one of the facilities, re-operation of the Delta Cross Channel gates, or reduction or termination of increased exports resulting from joint use of the SWP and CVP points of diversion. Potential impacts on striped bass under Joint POD Alternatives 7 and 8 could be mitigated through additional stocking. If significant effects on reservoir fisheries are observed, mitigation could include additional fish planting, habitat improvement through planting of shoreline vegetation, addition of habitat structures, or improved management of shoreline grazing practices.

2. Energy

The JPOD could cause a reduction in groundwater pumping and an associated increase in net energy generation. However this potential benefit could be offset by a decrease in net hydropower generation resulting from increased export pumping. Thus, the possibility exists that fossil fuel consumption could increase. If this occurs, the effect is not entirely mitigable. Off-peak pumping and other energy sources are available to partially mitigate this impact as listed in section A.4 of this summary.

3. Recreation and Cultural Resources

Modeling results indicate that the JPOD could cause lower water levels in some SWP and CVP reservoirs in the off-season during critically dry periods, which could affect recreation and cultural resources. If there are impacts, modification or relocation of facilities (such as boat ramps and marinas) to accommodate lower water levels would help to mitigate the impact to recreation at affected reservoirs. Impacts to cultural resources can be mitigated by inventorying and evaluating cultural resources at affected reservoirs, preserving and protecting the resources in place where possible, or excavating and documenting the historic values and information of the resources.

E. CUMULATIVE IMPACTS ASSESSMENT

Implementation of the flow objectives in concert with other closely related past, present and reasonably forseeable future projects was assessed for cumulative impacts. Cumulative impacts were assessed at the 2020 level of development. Under the regulatory requirements of the Plan, increased future water demands will result in higher exports and reduced Delta outflow compared to the present level of development. Consequently, aquatic resources sensitive to these parameters could be negatively affected in comparison to current demand levels.

CHAPTER I. INTRODUCTION

The San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay/Delta Estuary, Bay/Delta, or Estuary) is a large ecosystem providing habitat for numerous fish and wildlife species. Water that flows through the Bay/Delta Estuary supplies a portion of the domestic water supply for over two-thirds of the population of the State of California and irrigates several million acres of farmlands (DWR 1994).

On May 22, 1995, the State Water Resources Control Board (SWRCB) adopted the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (1995 Bay/Delta Plan or Bay/Delta Plan) which establishes objectives for the protection of municipal, agricultural, and fish and wildlife beneficial uses in the Bay/Delta Estuary (SWRCB 1995). The 1995 Bay/Delta Plan includes objectives in the Bay/Delta Estuary for Delta outflow, Sacramento and San Joaquin river flows, salinity, dissolved oxygen, and State Water Project (SWP) and Central Valley Project (CVP) operations. The SWRCB intends to implement the 1995 Bay/Delta Plan primarily through its water right authority, but water quality-related measures may also be required. The responsibility to implement the 1995 Bay/Delta Plan objectives will be assigned in an order of the SWRCB to water right holders and other parties who affect attainment of the objectives. The order will be prepared following a hearing.

A.   PURPOSE OF REPORT

The purpose of this environmental impact report (EIR) is to disclose and analyze the significant environmental effects of alternatives for implementing the objectives in the 1995 Bay/Delta Plan and to identify, where appropriate, ways to avoid, reduce, or compensate for environmental damage. This report and other evidence will be considered by the SWRCB during its preparation of an order to implement the 1995 Bay/Delta Plan. The SWRCB may also use this report in subsequent proceedings related to implementation of the 1995 Bay/Delta Plan.

The SWRCB was required to comply with the requirements of the California Environmental Quality Act (CEQA) when it adopted the 1995 Bay/Delta Plan under its water quality authority. Appendix 1 of the 1995 Bay/Delta Plan, the Environmental Report (ER), was prepared to fulfill the SWRCB's CEQA obligation. The ER, though not an EIR, is a substitute document, prepared under authority granted by the Secretary of Resources in Public Resources Code section 21080.5 and Title 14, California Code of Regulations (CCR), section 15251(g). The Deputy Secretary and General Counsel of the California Resources Agency (CRA) has advised the SWRCB that an environmental analysis prepared under section 21080.5 can be used as a programmatic document if it meets the criteria in Title 14, CCR, section 15168 (CRA 1995). The ER meets the required criteria, and therefore this EIR should be considered a tiered programmatic document, building upon and incorporating by reference the ER.

The effects of implementation of most of the 1995 Bay/Delta Plan's objectives by the SWP and the CVP are analyzed in the ER; other alternatives are not analyzed. In order to facilitate comparison of the alternatives, some of the analysis of the alternative in which the SWP and the CVP are responsible for meeting the 1995 Bay/Delta Plan's objectives is repeated in this EIR.

B. BACKGROUND

The background discussion for the proposed action is divided into two parts: (1) institutional setting and (2) recent regulatory actions affecting the Bay/Delta Estuary.

1. Institutional Setting

a. SWRCB. The SWRCB was formed in 1967 when the State Water Rights Board and the State Water Quality Control Board were merged by the Legislature. The SWRCB is composed of five full-time appointees of the Governor. Under its dual legal authority, the SWRCB allocates rights to the use of surface water and, together with the nine Regional Water Quality Control Boards (RWQCB), protects water quality in all waters of the State.

The Porter-Cologne Act is the basic water quality control law for California, and it is administered by the SWRCB and the RWQCBs (Water Code section 13000 et seq.). The SWRCB and the RWQCBs also implement portions of the federal Clean Water Act. One of the principal functions of the SWRCB and the RWQCBs is to prepare water quality control plans. Water quality control plans are blueprints for water quality control. The plans identify beneficial uses of waters, water quality objectives for the reasonable protection of beneficial uses, and programs of implementation for the water quality objectives. In most cases, water quality objectives are not directly enforceable. In order to ensure their implementation, water quality objectives usually are implemented through waste discharge requirements or water right permits. In addition, Water Code section 1258 provides that the SWRCB shall consider water quality control plans when it acts on water rights.

The SWRCB and the RWQCBs have adopted water quality control plans that cover all areas of the State. There are two types of water quality control plans: water quality control plans adopted by the SWRCB and regional water quality control plans adopted by the RWQCBs. Water quality control plans adopted by the SWRCB supersede any regional water quality control plans for the same waters to the extent that there is any conflict.

The portions of the water quality control plans that fall under the jurisdiction of the federal Clean Water Act require approval by the U.S. Environmental Protection Agency (USEPA). When approved by the USEPA, the water quality objectives and beneficial use designations become water quality standards under the federal Clean Water Act.

The SWRCB is also charged with administering the State's water right system. The principal authority the SWRCB used in the past to implement Bay/Delta Plans was its water right authority because the issues addressed in these plans were largely related to flow and water project operations.

b. Water Right System. California has established a water right system that allows for the orderly allocation and use of its water supply. Although California law recognizes several types of rights to surface water, riparian and appropriative rights are the most common.

A riparian right exists by reason of ownership of land abutting a stream or other body of water. The right allows a water user to divert from the natural flow of a stream for use on land within the watershed of the source. Seasonal storage of water is not allowed under a riparian right. Riparian rights are correlative. If there is insufficient water for the reasonable requirements of all the riparian users, the available supply must be shared relative to the needs of each user. With certain limited exceptions, riparian water users have first priority to the use of the natural flow in a river. Water remaining after riparian users have taken their share is available to appropriators. No permit or license is necessary to divert water under claim of riparian right; however, a record of water use under riparian claim should be established by filing a Statement of Water Diversion and Use with the SWRCB.

Unlike riparian rights, an appropriative right carries a priority relative to other appropriative rights. The water user who is first in time is entitled to the full quantity of water specified under the right before junior appropriators may exercise their rights. Appropriative water rights fall into two general categories: pre-1914 appropriative water rights and post-1914 appropriative water rights. No permit or license is necessary to divert water under claim of pre-1914 appropriative right; however, a record of water use under claim of pre-1914 appropriative right should be established by filing a Statement of Water Diversion and Use with the SWRCB. Since 1914, appropriative rights have been obtained by receiving a permit or license from the SWRCB or its predecessor agencies. All new appropriators must file an application with the SWRCB and obtain a permit before diverting water. In granting permits, the SWRCB determines whether the water will be put to beneficial use, how much water may be taken, when and where it can be taken, and necessary conditions to protect the environment, the public trust and prior rights. If the water is diverted and applied to beneficial use in accordance with the terms of the permit for a period of years, a license may be issued confirming the extent of the permittee's right.

The SWRCB has authority to amend an existing water right by invoking: (1) its reserved jurisdiction over certain permits under Water Code section 1394; (2) its continuing authority to prevent waste and unreasonable use, or unreasonable method of use or diversion of water under the California Constitution, Article X, section 2; or (3) its continuing authority to protect public trust uses of water.

The largest water projects in the Central Valley are the CVP, operated by the U.S. Bureau of Reclamation (USBR), and the SWP, operated by the California Department of Water Resources (DWR). The watershed protection and area of origin statutes (Water Code sections 11460 and 10505 et seq.) accord first priority to water rights for use within the watershed, and areas immediately adjacent. The water rights for the CVP and SWP are subject to these provisions, and diversions for export by these projects are restricted until the needs in the watershed, including protections for beneficial uses in the Estuary, are met. At present, these two water right holders are responsible, pursuant to Water Right Decision 1485 (D-1485), Order WR 98-09, and the federal biological opinions, for meeting Bay/Delta Estuary water quality objectives.

2. History of SWRCB Action

Regulation of the Bay/Delta Estuary has occurred through the adoption of water right decisions, water quality control policies, and water quality control plans. A brief summary of the principal decisions, policies, and plans relevant to the Bay/Delta Estuary is provided below.

In February 1961, the State Water Rights Board (predecessor to the SWRCB) adopted Water Right Decision 990, which approved water rights for the CVP. The Board did not attach specific water quality standards as terms and conditions of the CVP permits; however, it did reserve jurisdiction to impose such requirements in the future.

The development of water quality standards for the Bay/Delta Estuary began with the adoption of agricultural salinity standards as terms and conditions of Water Right Decision 1275, which approved water rights for the SWP in May 1967. In response to the concern by the Secretary of the Interior that existing standards for the Delta did not adequately protect municipal, industrial, agricultural, and fishery uses, the SWRCB (newly created by the amalgamation of the State Water Rights Board and the State Water Quality Control Board) adopted a water quality control policy for the Delta through Resolution 68-17 in 1968. This policy supplemented a water quality control policy for the Delta that was developed by the Central Valley RWQCB and adopted by the SWRCB in June 1967. In accordance with a commitment made in Resolution 68-17 to supplement the salinity standards, the SWRCB adopted Water Right Decision 1379 (D-1379) in July 1971. D-1379, which required the CVP and the SWP to meet standards for non-consumptive fish and wildlife uses in addition to agricultural, municipal, and industrial consumptive uses, was stayed by action of the court in October 1971 as a result of litigation.

In 1971, the RWQCBs adopted, and the SWRCB approved, interim water quality control plans for the 16 planning basins in the State, including the Delta and Suisun Marsh. These regional water quality control plans marked the completion of the first phase of a comprehensive statewide planning effort. Subsequently, long-term standards for the Delta and Suisun Marsh were established in the regional plans for the Sacramento-San Joaquin Delta Basin and the San Francisco Bay Basin, which were approved by the SWRCB in 1975 and 1976, respectively. Meanwhile, in April 1973, the

SWRCB adopted a water quality control plan, through Resolution 73-16, which supplemented the State water quality control policies for the Bay/Delta Estuary.

In August 1978, the SWRCB exercised its reservation of jurisdiction over the water right permits for the CVP and the SWP by adopting D-1485. At the same time, the SWRCB adopted the 1978 Water Quality Control Plan for the Sacramento-San Joaquin Delta and Suisun Marsh (1978 Delta Plan). Together, the 1978 Delta Plan and D-1485 revised existing standards for flow and salinity in the Delta's channels and ordered the USBR and the DWR to meet these standards by either reducing pumping, or releasing water stored in upstream reservoirs, or both. To address the continuing uncertainty associated with possible future project facilities and the need for additional information on the Estuary's ecosystem, the SWRCB committed to review the 1978 Delta Plan in 10 years.

Following the adoption of D-1485, the USBR and the DWR protested numerous water right applications within the Delta watershed. The protests alleged that diversions by new applicants at certain times would force the SWP and the CVP to release stored water to meet the Delta objectives in D-1485. As an interim solution, the SWRCB adopted Standard Water Right Permit Term 91 and placed it in permits issued on applications filed after August 16, 1978. Term 91 prohibits permittees from diverting water being released from project reservoirs to meet Delta water quality objectives or other inbasin entitlements. SWRCB Order 81-15 specifies a procedure for determining when this condition is occurring.

A hearing on water availability was held by the SWRCB in April 1983. Decision 1594, adopted in November 1983, extended Term 91 to all permittees whose permits are subject to the SWRCB's reserved jurisdiction for potential Delta obligations, and with direct diversion of greater than one cubic foot per second (cfs) or storage of greater than 100 acre feet (AF).

The SWRCB started the hearings to amend the 1978 Delta Plan and D-1485 in July 1987. A draft water quality control plan, which contained objectives for water quality and flow-related parameters, was issued in November 1988. The draft plan met intense opposition, and it was withdrawn in January 1989.

After withdrawing the 1988 draft plan, the SWRCB bifurcated the process. It first prepared a draft water quality control plan that did not include flow and export objectives. The plan was to be followed by a water right decision that would include flow and export objectives and allocate responsibility to meet all the of the objectives. In May 1991, the SWRCB adopted the 1991 Water Quality Control Plan for Salinity for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (1991 Bay/Delta Plan) which included objectives for salinity, dissolved oxygen, and temperature. Litigation ensued. In September 1991, the USEPA disapproved most of the fish and wildlife objectives in the plan. Meanwhile, the SWRCB began preparing an EIR to support a water right decision.

In April 1992, Governor Pete Wilson announced a new water policy. Among other provisions, the policy requested the SWRCB to initiate a hearing process to develop interim protections to stop the decline of fish and wildlife resources in the Bay/Delta Estuary.

The SWRCB conducted a water right hearing during the summer of 1992. Draft Water Right Decision 1630 (D-1630) was released in December 1992. Draft D-1630 proposed interim water right terms and conditions to protect the Bay/Delta Estuary. On April 1, 1993, the Governor requested that the SWRCB cease its work on draft D-1630 and instead work on long-term protections, and the SWRCB concurred. The SWRCB cited two reasons for withdrawing draft D-1630. First, regulatory requirements for the Bay/Delta Estuary were being established through the federal Endangered Species Act (ESA), and these requirements would benefit a broad range of species. The National Marine Fisheries Service (NMFS) issued a biological opinion under the authority of the ESA on February 12, 1993 (NMFS 1993) which included regulatory requirements to avoid jeopardy to winter-run chinook salmon. Also, the U.S. Fish and Wildlife Service (USFWS) listed the delta smelt as a threatened species under the ESA in March 1993, and it informed the SWRCB that the biological opinion would probably establish further requirements in the Estuary. The biological opinion was issued on February 4, 1994 (USFWS 1994). Second, the wet year of 1993 ended the 1987-1992 drought, which was a substantial factor in the decline of Bay/Delta aquatic resources, and uncontrolled runoff was benefiting the fishery. Under these circumstances, the interim water right decision was deemed unnecessary.

Because the SWRCB had not adopted new objectives to replace the disapproved objectives in the 1991 Bay/Delta Plan, the USEPA published draft water quality standards for the Bay/Delta Estuary on January 6, 1994 (USEPA 1994). In March 1994, the SWRCB gave notice of a series of workshops to review the 1991 Bay/Delta Plan.

In the summer of 1994, the State and federal agencies with responsibility for management of Bay/Delta resources signed a Framework Agreement (Framework 1994) in which the agencies agreed to cooperate in three areas. First, the SWRCB would update and revise its 1991 Bay/Delta Plan to meet federal Clean Water Act requirements. Next, the SWRCB would initiate a water right proceeding to implement the requirements in the plan. Second, a group would be formed, consisting of representatives of the California Department of Fish and Game (DFG), DWR, SWRCB, USFWS, NMFS, USEPA, and USBR, to facilitate the coordination of water project operations with all of the regulatory requirements in the Delta. Third, the State and federal agencies agreed to undertake a joint long-term solution finding process for the Bay/Delta Estuary.

On December 15, 1994, representatives of the State and federal governments and urban, agricultural (principally urban and agricultural water exporters), and environmental interests agreed to the implementation of an interim Bay/Delta protection plan effective for three years. The protection plan and the institutional agreements necessary to implement the plan are contained in a document, titled "Principles for Agreement on Bay/Delta Standards between the State of California and the Federal Government" (Principles Agreement) (Principles 1994). The SWRCB released the draft 1995 Bay/Delta Plan on the same day. The draft 1995 Bay/Delta Plan was consistent with, but not exactly the same as, the Principles Agreement. A hearing was held on the draft 1995 Bay/Delta Plan on February 23, 1995, and the 1995 Bay/Delta Plan was adopted on May 22, 1995.

The Principles Agreement calls for immediate implementation by the SWP and the CVP through reconsultation of the biological opinions for winter-run chinook salmon and delta smelt. The biological opinions were amended for this purpose by the USFWS and the NMFS in March 1995 and May 1995, respectively (USFWS 1995, NMFS 1995).

The USEPA published its final rule regarding water quality standards for the Bay/Delta Estuary in January 1995 (USEPA 1995a). However, the Principles Agreement states that the USEPA will withdraw the rule if the SWRCB adopts approvable water quality objectives. In September 1995, the USEPA approved the 1995 Bay/Delta Plan based on its determination that the 1995 Bay/Delta Plan protects the beneficial uses of the Bay/Delta Estuary and complies with the requirements of the Clean Water Act (USEPA 1995b). The USEPA has not yet satisfied its commitment to withdraw its January 1995 Bay/Delta standards.

On February 28, 1995, the DWR and the USBR filed a joint petition requesting the SWRCB to amend the water right permits of the SWP and the CVP in order to eliminate inconsistencies between the permits' conditions and the objectives in the 1995 Bay/Delta Plan. The SWRCB adopted Water Right Order 95-6 (WR 95-6) on June 8, 1995 for this purpose. WR 95-6 was an interim order that expired either (1) upon adoption by the SWRCB of a comprehensive water right decision that allocates final responsibilities for meeting the 1995 Bay/Delta Plan objectives or (2) on December 31, 1998, whichever came first. On December 3, 1998, the effective term of the changes approved in WR 95-6 was extended until December 31, 1999, when the SWRCB adopted Order WR 98-09.

C. LEGAL CONSIDERATIONS REGARDING PREPARATION AND USE OF THIS REPORT

This EIR is prepared under Public Resources Code section 21100 et seq. by the SWRCB. This EIR contains environmental information and analysis of a range of potential alternative actions allocating responsibility to meet the water quality objectives in the 1995 Bay/Delta Plan and other measures to protect public trust resources. No preferred alternative is identified in this EIR. Any decision of the SWRCB will fall within the range of potential alternative actions described and analyzed within this final EIR. The SWRCB intends that formulation of the decision, whether it reflects one of the alternatives in the EIR, a combination of the EIR's alternatives, or a variant of one of the EIR's alternatives, will not result in addition of "significant new information" to the EIR within the meaning of Public Resources Code section 21092.1. (See *Laurel Heights Improvement Association of San Francisco, Inc.* v. *The Regents of the University of California* (1993) 26 Cal.Rptr.2d 231, 6 Cal.4th 1112.)

This EIR is a subsequent EIR, following the ER that was prepared in connection with adoption of the 1995 Bay/Delta Plan. As is explained in the ER, the ER is a programmatic document which was prepared, not only to analyze the effects of adopting the 1995 Bay/Delta Plan, but also to analyze the then-known effects of implementing the objectives in the 1995 Bay/Delta Plan. The whole project is defined in the ER as follows:

> "The project is the review, and amendment where appropriate, of both the SWRCB's objectives for protection of fish and wildlife in the Bay/Delta Estuary and the program of implementation for achieving the objectives and protecting the beneficial uses. The program of implementation includes actions the SWRCB will undertake to achieve the objectives and recommendations to other entities for actions that will contribute to achieving the objectives and improve habitat conditions for fish and wildlife."

The SWRCB has adopted the first part of the project, which is the 1995 Bay/Delta Plan containing the water quality objectives, the plan for implementation, and the recommendations to other entities. This EIR addresses the effects of alternative measures that will implement the objectives in the 1995 Bay/Delta Plan[1] through allocation of responsibility to specific water right holders, and it builds upon and incorporates by reference the ER.

In accordance with Title 14, CCR, section 15168(d), the ER provides part of the basis for determining whether the implementation of the water quality objectives will have significant effects. It also is incorporated herein by reference repeatedly to deal with regional influences, secondary effects, certain cumulative impacts, broadly applicable actions within the alternatives, and other factors that apply to the program as a whole. (See section 15168(d), *supra*.)

[1] In addition to analyzing the effects of a range of alternatives for implementing the objectives in the 1995 Bay/Delta Plan, this EIR addresses the effects of alternatives for action by the SWRCB regarding a petition for approval of joint use of the SWP and CVP points of diversion and rediversion in the southern Delta. The SWRCB plans to consider whether and under what terms and conditions to approve the petition, when it considers allocating responsibility to implement the objectives in the 1995 Bay/Delta Plan.

Literature Cited in Chapter I

CRA. 1995. Letter from Jim Burroughs, Deputy Secretary and General Counsel of the Resources Agency, to William R. Attwater, chief counsel, SWRCB, Regarding reliance on environmental analysis under CEQA 21080.5. april 4, 1995.

DWR. 1994. California Water Plan Update. Volume 1. Bulletin 160-93. California Department of Water Resources. Sacramento, CA. October 1994. 398 pp. Volume 2. Bulletin 160-93. October 1994. 315 pp.

Framework. 1994. Framework Agreement Between the Governor's Water Policy Council of the State of California and the Federal Ecosystem Directorate. June 1994. 7 pp. plus attachments.

NMFS. 1993. Biological Opinion for the Operation of the Federal Central Valley Project and the California State Water Project for Winter-Run Chinook Salmon. National Marine Fisheries Service. February 12, 1993. 81 pp. plus attachments.

NMFS. 1995. Letter from Roland A. Schmitten, Assistant Administrator for Fisheries, NMFS, to Roger Patterson, Regional Director, USBR. May 17, 1995. 13 pp.

Principles. 1994. Principles for Agreement on Bay/Delta Standards Between the State of California and the Federal Government. December 15, 1994. 8 pp.

SWRCB. 1995. Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. 95-1 WR. May, 1995. State Water Resources Control Board. Sacramento, CA. 45 pp. Environmental Report. Appendix 1. May, 1995. 521 pp. Response to Comments. Appendix 2. May, 1995. 129 pp.

USEPA. 1994. Federal Register. Volume 59. Page 810. January 6, 1994.

USEPA. 1995a. Federal Register. Volume 60. Page 4664. January 24, 1995.

USEPA. 1995b. Letter from Felicia Marcus, Regional Administrator, USEPA, to John Caffrey, Chairman, SWRCB. September 26, 1995. 3 pp. plus enclosures.

USFWS. 1994. Biological Opinion on the Operation of the Central Valley Project and State Water Project Effects on Delta Smelt. February 4, 1994. U.S. Fish and Wildlife Service, Region 1, Portland, OR. 34 pp. plus figures.

USFWS. 1995. Memorandum from Joel Medlin, Field Supervisor, USFWS, to Roger Patterson, Regional Director, USBR. March 6, 1995. 52 pp. plus enclosures.

CHAPTER II. PROJECT DESCRIPTION

This chapter describes the project being analyzed in this EIR. The chapter includes the following sections: (A) Project Definition, (B) Statement of Goals, (C) Bay/Delta Plan Objectives, (D) Existing Conditions, and (E) Description of Alternatives.

The project analyzed in this EIR will be implemented under the SWRCB's authority to supervise the exercise of all water rights in California, under the public trust doctrine, and under Water Code section 275. Water Code section 275 implements the reasonableness doctrine set forth at California Constitution Article X, section 2. (See *National Audubon Society* v. *Superior Court* (1983) 33 Cal.3d 419 [189 Cal. Rptr. 346, 357]; *Peabody* v. *Vallejo* (1935) 2 Cal.2d 351 [40 P.2d 486]; *In re Water of Hallett Creek Stream System* (1988) 44 Cal.3d 448 [243 Cal. Rptr. 887, 901], note 16; *Imperial Irrigation District* v. *State Water Resources Control Board* (1986) 186 Cal.App.3d 1160 [231 Cal. Rptr. 283].) Based on these authorities, the SWRCB has continuing authority over all appropriations or other diversions of water for use. (SMPA 1998)

A. PROJECT DEFINITION

The project is a SWRCB decision that: (1) allocates responsibility to implement the objectives in the 1995 Bay/Delta Plan and (2) may authorize the combined use of the DWR and the USBR points of diversion in the Delta.

B. STATEMENT OF GOALS

The SWRCB's goals for the water right decision are to:

1. Implement the 1995 Bay/Delta Plan;
2. Provide meaningful regulatory stability through the administration of water rights;
3. Protect prior water rights;
4. Develop, conserve, and utilize water in the public interest;
5. Provide comprehensive, multi-species protection for the public trust resources of the Bay/Delta Estuary;
6. Equitably distribute the responsibility of meeting the objectives contained in the 1995 Bay/Delta Plan consistent with applicable law.

C. BAY/DELTA PLAN OBJECTIVES

The 1995 Bay/Delta Plan contains a description of the beneficial uses of water in the Bay/Delta Estuary, water quality objectives to protect the beneficial uses, and a program of implementation for the objectives. The following objectives for protection of municipal and industrial beneficial uses (Table II-1), agricultural beneficial uses (Table II-2), and fish and wildlife beneficial uses (Table II-3) are contained in the Plan.

Table II-1
Water Quality Objectives For Municipal and Industrial Beneficial Uses

COMPLIANCE LOCATION	INTERAGENCY STATION NUMBER (RKI [1])	PARAMETER	DESCRIPTION (UNIT)	WATER YEAR TYPE [2]	TIME PERIOD	VALUE
Contra Cosfa Canal	*C-5*	*Chloride (Cl^-)*	*Maximum mean daily 150 mg/l*			
at Pumping Plant #1	*(CHCCC06)*		*Cl^- for at least the number*			*No. of days each Calendar*
-or-			*of days shown during*			*Year £ 150 mg/l Cl^-*
San Joaquin River at	*D-12 (near)*		*the Calendar Year. Must be*	*W*		*240 (66%)*
Antioch Water Works Intake	*(RSAN007)*		*provided in intervals of not*	*AN*		*190 (52%)*
			less than two weeks duration.	*BN*		*175 (48%)*
			(Percentage of Calendar Year	*D*		*165 (45%)*
			shown in parenthesis)	*C*		*155 (42%)*
Contra Costa Canal	*C-5*	*Chloride (Cl^-)*	*Maximum mean daily (mg/l)*	*All*	*Oct-Sep*	*250*
at Pumping Plant #1	*(CHCCC06)*					
-and-						
West Canal at mouth	*C-9*					
of Clifton Court Forebay	*(CHWST0)*					
-and-						
Delta-Mendota Canal	*DMC-1*					
at Tracy Pumping Plant	*(CHDMC004)*					
-and-						
Barker Sbugh at	-----					
North Bay Aqueduct Intake	*(SLSAR3)*					
-and-						
Cache Slough at City of	*C-19*					
Vallejo Intake [3]	*(SLCCH16)*					

[1] River Kilometer Index station number.
[2] The Sacramento Valley 40-30-30 water year hydrologic classification index (see Figure II-1) applies for determinations of water year type.
[3] The Cache Slough objective to be effective only when water is being diverted from this location.

Table II-2
Water Quality Objectives For Agricultural Beneficial Uses

COMPLIANCE LOCATION	INTERAGENCY STATION NUMBER (RKI [1])	PARAMETER	DESCRIPTION (UNIT) [2]	WATER YEAR TYPE [3]	TIME PERIOD	& VALUE
WESTERN DELTA						
Sacramento River at Emmaton	*D-22 (RSAC092)*	*Electrical Conductivity (EC)*	*Maximum 14-day running average of mean daily EC (mmhos/cm)*		*0.45 EC April 1 to date shown*	*EC from date shown to Aug 15 [4]*
				W	*Aug 15*	*----*
				AN	*Jul 1*	*0.63*
				BN	*Jun 20*	*1.14*
				D	*Jun 15*	*1.67*
				C	*----*	*2.78*
San Joaquin River at Jersey Point	*D-15\ (RSAN018)*	*Electrical Conductivity (EC)*	*Maximum 14-day running average of mean daily EC (mmhos/cm)*		*0.45 EC April 1 to date shown*	*EC from date shown to Aug 15 [4]*
				W	*Aug 15*	*----*
				AN	*Aug 15*	*----*
				BN	*Jun 20*	*0.74*
				D	*Jun 15*	*1.35*
				C	*----*	*2.20*
INTERIOR DELTA						
South Fork Mokelumne River at Terminous	*C-13 (RSMKL08)*	*Electrical Conductivity (EC)*	*Maximum 14-day running average of mean daily EC (mmhos/cm)*		*0.45 EC April 1 to date shown*	*EC from date shown to Aug 15 [4]*
				W	*Aug 15*	*----*
				AN	*Aug 15*	*----*
				BN	*Aug 15*	*----*
				D	*Aug 15*	*----*
				C	*----*	*0.54*
San Joaquin River at San Andreas Landing	*C-4 (RSAN032)*	*Electrical Con-Ductivity (EC)*	*Maximum 14-day running average of mean daily EC (mmhos/cm)*		*0.45 EC April 1 to date shown*	*EC from date shown to Aug 15 [4]*
				W	*Aug 15*	*----*
				AN	*Aug 15*	*----*
				BN	*Aug 15*	*----*
				D	*Jun 25*	*0.58*
				C	*----*	*0.87*
SOUTHERN DELTA						
San Joaquin River at Airport Way Bridge, Vernalis	*C-10 (RSAN112)*	*Electrical Conductivity (EC)*	*Maximum 30-day running average of mean daily EC (mmhos/cm)*	*All*	*Apr-Aug*	*0.7*
					Sep-Mar	*1.0*
-and-					***-or-***	
San Joaquin River at Brandt Bridge site	*C-6 (RSAN073)*					
-and-						
Old River near Middle River [5]	*C-8 (ROLD69)*		*If a three-party contract has been implemented among the DWR, USBR, and SDWA, that contract will be reviewed prior to implementation of the above and, after also considering the needs of other beneficial uses, revisions will be made to the objectives and compliance/monitoring locations noted, as appropriate.*			
-and-						
Old River at Tracy Road Bridge [5]	*P-12 (ROLD59)*					
EXPORT AREA						
West Canal at mouth of Clifton Court Forebay	*C-9 (CHWST0)*	*Electrical Conductivity (EC)*	*Maximum monthly average of mean daily EC (mmhos/cm)*	*All*	*Oct-Sep*	*1.0*
-and-						
Delta-Mendota Canal at Tracy Pumping Plant	*DMC-1 (CHDMC004)*					

[1] River Kilometer Index station number.

[2] Determination of compliance with an objective expressed as a running average begins on the last day of the averaging period. If the objective is not met on the last day of the averaging period, all days in the averaging period are considered out of compliance.

[3] The Sacramento Valley 40-30-30 water year hydrologic classification index (see page 23) applies for determinations of water year type.

[4] When no date is shown, EC limit continues from April 1.

[5] The EC objectives shall be implemented at this location by December 31, 1997.

Table II-3
WATER QUALITY OBJECTIVES FOR FISH AND WILDLIFE BENIFICIAL USES

COMPLIANCE LOCATION	INTERAGENCY STATION NUMBER(RKI 1[])	PARAMETER	DESCRIPTION (UNIT) [2]	WATER YEAR TYPE [3]	TIME PERIOD	VALUE
DISSOLVED OXYGEN						
San Joaquin River between Turner Cut & Stockton	*(RSAN050-RSAN061)*	*Dissolved Oxygen (DO)*	*Minimum DO (mg/l)*	*All*	*Sep-Nov*	*6.0 [4]*
SALMON PROTECTION						
			narrative	*Water quality conditions shall be maintained, together with otehr measures in the watershed, sufficient to achieve a doubling of natural production of chinook salmon from the average production of 1967-1991, consistent with the provisions of State and federal law.*		
SAN JOAQUIN RIVER SALINITY						
San Joaquin River at and between Jersey Point and Prisoners Point [5]	*D-15 (RSAN018) -and- D-29 (RSAN038)*	*Electrical Conductivity (EC)*	*Maximum 14-day running average of mean daily EC(mmhos/cm)*	*W,AN,BN,D*	*Apr-May*	*0.44 [6]*
EASTERN SUISUN MARSH SALINITY						
Sacramento River at Collinsville -and- Montezuma Slought at National Steel -and- Montezuma Slough near Beldon Landing	*C-2 (RSAC081) S-64 (SLMZU25) S-49 (SLMZU11)*	*Electrical Conductivity (EC)*	*Maximum monthly average of both daily high tide EC values (mmhos/cm), or demonstrate that equivalent or better protection will be provided at the location*	*All*	*Oct Nov-Dec Jan Feb-Mar Apr-May*	*19.0 15.5 12.5 8.0 11.0*
WESTERN SUISUN MARSH SALINITY						
Chadbourne Slough at Sunrise Duck Club -and- Suisun Slough, 300 feet south of Volanti Slough -and- Cordelia Slough at Ibis Club -and- Goodyear Slough at Morrow Island Clubhouse -and- Water supply intakes for waterfowl management areas on Van Sickle and Chipps islands	*S-21 [7] (SLCBN1) S-42 [8] (SLSUS12) S-97 [8] (SLCRD06) S-35 [8] (SLGYR03) No locations specified*	*Electrical Conductivity (EC)*	*Maximum monthly average of both daily high tide EC values (mmhos/cm), or demonstrate that equivalent or better protection will be provided at the location*	*All but deficiency period*	*Oct Nov Dec Jan Feb-Mar Apr-May*	*19.0 16.5 15.5 12.5 8.0 11.0*
				Deficiency period [9]	*Oct Nov Dec-Mar Apr May*	*19.0 16.5 15.6 14.0 12.5*
BRACKISH TIDAL MARSHES OF SUISUN BAY						
			narrative		*[10]*	

[1] River Kilometer Index station number.
[2] Determination of compliance with an objective expressed as a running average begins on the last day of the averaging period. If the objective is not met on the last day of the averaging period, all days in the averaging period are considered out of compliance.
[3] The Sacramento Valley 40-30-30 water year hydrologic classification index (see page 23) applies for determinations of water year type.
[4] When no date is shown, EC limit continues from April 1.
[5] The EC objectives shall be implemented at this location by December 31, 1997.

Table II-3 (continued)
WATER QUALITY OBJECTIVES FOR FISH AND WILDLIFE BENIFICIAL USES

COMPLIANCE LOCATION	INTERAGENCY STATION NUMBER(RKI 1[])	PARAMETER	DESCRIPTION (UNIT) [2]	WATER YEAR TYPE [3]	TIME PERIOD	VALUE
DELTA OUTFLOW						
		Net Delta Outflow Index (NDOI) (11)	*Minimum monthly average (12) NDOI (cfs)*	*All*	*Jan*	*4,500 [13]*
				All	*Feb-Jun*	*[14]*
				W,AN	*Jul*	*8,000*
				BN		*6,500*
				D		*5,000*
				C		*4,000*
				W,AN,BN	*Aug*	*4,000*
				D		*3,500*
				C		*3,000*
				All	*Sep*	*3,000*
				W,AN,BN,D	*Oct*	*4,000*
				C		*3,000*
				W,AN,BN,D	*Nov-Dec*	*4,500*
				C		*3,500*
RIVER FLOWS						
Sacramento River at Rio Vista	*D-24 (RSAC101)*	*Flow rate*	*Minimum monthly average [15] flow rate (cfs)*	*All*	*Sep*	*3,000*
				W,AN,BN,D	*Oct*	*4,000*
				C		*3,000*
				W,AN,BN,D	*Nove-Dec*	*4,500*
				C		*3,500*
San Joaquin River at Airport Way Bridge, Vernalis	*C-10 (RSAN112)*	*Flow rate*	*Minimum monthly average [16] flow rate (cfs) [17]*	*W,AN*	*Feb-Apr 14 and May 16-Jun*	*2,130 or 3,420*
				BN,D		*1,420 or 2,280*
				C		*710 or 1,140*
				W	*Apr 15- May 15 [18]*	*7,330 or 8,620*
				AN		*5,730 or 7,020*
				BN		*4,620 or 5,480*
				D		*4,020 or 4,880*
				C		*3,110 or 3,540*
				All	*Oct*	*1,000 [19]*
EXPORT LIMITS						
		Combined export rate [20]	*Maximum 3-day running average (cfs)*	*All*	*Apr 15- May 15 [21]*	*[22]*
			Maximum percent of Delta inflow diverted [23] [24]	*All*	*Feb-Jun*	*35% Delta inflow [25]*
				All	*Jul-Jan*	*65% Delta inflow*
DELTA CROSS CHANNEL GATES CLOSURE						
Delta Cross Channel at Walnut Grove	—	*Closure of gates*	*Closed gates*	*All*	*Nov-Jan*	*[26]*
					Feb-May 20	----
					May 21- Jun 15	*[27]*

Table II-3 Footnotes

[1] River Kilometer Index station number.

[2] Determination of compliance with an objective expressed as a running average begins on the last day of the averaging period. If the objective is not met on the last day of the averaging period, all days in the averaging period are considered out of compliance.

[3] The Sacramento Valley 40-30-30 Water Year Hydrologic Classification Index (see Figure II-1) applies unless otherwise specified.

[4] If it is infeasible for a waste discharger to meet this objective immediately, a time extension or schedule of compliance may be granted, but this objective must be met no later than September 1, 2005.

[5] Compliance will be determined at Jersey Point (station D15) and Prisoners Point (station D29).

[6] This standard does not apply in May when the best available May estimate of the Sacramento River Index for the water year is less than 8.1 MAF at the 90% exceedence level. [Note: The Sacramento River Index refers to the sum of the unimpaired runoff in the water year as published in the DWR Bulletin 120 for the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total unimpaired inflow to Oroville Reservoir; Yuba River at Smartville; and American River, total unimpaired inflow to Folsom Reservoir.]

[7] The effective date for objectives for this station is October 1, 1995.

[8] The effective date for objectives for this station is October 1, 1997.

[9] A deficiency period is: (1) the second consecutive dry water year following a critical year; (2) a dry water year following a year in which the Sacramento River Index (described in footnote 6) was less than 11.35; or (3) a critical water year following a dry or critical water year.

[10] Water quality conditions sufficient to support a natural gradient in species composition and wildlife habitat characteristic of a brackish marsh throughout all elevations of the tidal marshes bordering Suisun Bay shall be maintained. Water quality conditions shall be maintained so that none of the following occurs: (a) loss of diversity; (b) conversion of brackish marsh to salt marsh; (c) for animals, decreased population abundance of those species vulnerable to increased mortality and loss of habitat from increased water salinity; or (d) for plants, significant reduction in stature or percent cover from increased water or soil salinity or other water quality parameters.

[11] Net Delta Outflow Index (NDOI) is defined in Figure II-3.

[12] For the May-January objectives, if the value is less than or equal to 5,000 cfs, the 7-day running average shall not be less than 1,000 cfs below the value; if the value is greater than 5,000 cfs, the 7-day running average shall not be less than 80% of the value.

[13] The objective is increased to 6,000 cfs if the best available estimate of the Eight River Index for December is greater than 800 TAF. [Note: The Eight River Index refers to the sum of the unimpaired runoff as published in the DWR Bulletin 120 for the following locations: Sacramento River flow at Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River flow at Smartville; American River, total inflow to Folsom Reservoir; Stanislaus River, total inflow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total inflow to Exchequer Reservoir; and San Joaquin River, total inflow to Millerton Lake.]

[14] The minimum daily Delta outflow shall be 7,100 cfs for this period, calculated as a 3-day running average. This requirement is also met if either the daily average or 14-day running average EC at the confluence of the Sacramento and the San Joaquin rivers is less than or equal to 2.64 mmhos/cm (Collinsville station C2). If the best available estimate of the Eight River Index (described in footnote 13) for January is more than 900 TAF, the daily average or 14-day running average EC at station C2 shall be less than or equal to 2.64 mmhos/cm for at least one day between February 1 and February 14; however, if the best available estimate of the Eight River Index for January is between 650 TAF and 900 TAF, the operations group established under the Framework Agreement shall decide whether this requirement will apply, with any disputes resolved by the CALFED policy group. If the best available estimate of the Eight River Index for February is less than 500 TAF, the standard may be further relaxed in March upon the recommendation of the operations group established under the Framework Agreement, with any disputes resolved by the CALFED policy group. The standard does not apply in May and June if the best available May estimate of the Sacramento River Index (described in footnote 6) for the water year is less than 8.1 MAF at the 90% exceedence level. Under this circumstance, a minimum 14-day running average flow of 4,000 cfs is required in May and June. Additional Delta outflow objectives are contained in Table II-4.

[15] The 7-day running average shall not be less than 1,000 cfs below the monthly objective.

[16] Partial months are averaged for that period. For example, the flow rate for April 1-14 would be averaged over 14 days. The 7-day running average shall not be less than 20% below the flow rate objective, with the exception of the April 15-May 15 pulse flow period when this restriction does not apply.

[17] The water year classification will be established using the best available estimate of the 60-20-20 San Joaquin Valley Water Year Hydrologic Classification (see Figure II-2) at the 75% exceedence level. The higher flow objective applies when the 2-ppt isohaline (measured as 2.64 mmhos/cm surface salinity) is required to be at or west of Chipps Island.

[18] This time period may be varied based on real-time monitoring. One pulse, or two separate pulses of combined duration equal to the single pulse, should be scheduled to coincide with fish migration in San Joaquin River tributaries and the Delta. The operations group established under the Framework Agreement will determine the time period for this 31-day flow requirement.

[19] Plus up to an additional 28 TAF pulse/attraction flow during all water year types. The amount of additional water will be limited to that amount necessary to provide a monthly average flow of 2,000 cfs. The additional 28 TAF is not required in a critical year following a critical year. The pulse flow will be scheduled by the operations group established under the Framework Agreement.

[20] Combined export rate for this objective is defined as the Clifton Court Forebay inflow rate (minus actual Byron-Bethany Irrigation District diversions from Clifton Court Forebay) and the export rate of the Tracy pumping plant.

[21] This time period may be varied based on real-time monitoring and will coincide with the San Joaquin River pulse flow described in footnote 18. The operations group established under the Framework Agreement will determine the time period for this 31-day export limit.

[22] Maximum export rate is 1,500 cfs or 100% of 3-day running average of San Joaquin River flow at Vernalis, whichever is greater. Variations to this maximum export rate are authorized if agreed to by the operations group established under the Framework Agreement. This flexibility is intended to result in no net water supply cost annually within the limits of the water quality and operational requirements of this plan. Variations may result from recommendations of agencies for protection of fish resources, including actions taken pursuant to the State and federal Endangered Species Act. The CALFED policy group will resolve disputes within the operations group. Any agreement on variations will be effective immediately and will be presented to the Executive Director of the SWRCB. If the Executive Director does not object to the variations within 10 days, the variations will remain in effect.

[23] Percent of Delta inflow diverted is defined in Figure II-3. For the calculation of maximum percent Delta inflow diverted, the export rate is a 3-day running average and the Delta inflow is a 14-day running average, except when the CVP or the SWP is making storage withdrawals for export, in which case both the export rate and the Delta inflow are 3-day running averages.

[24] The percent Delta inflow diverted values can be varied either up or down. Variations are authorized subject to the process described in footnote 22.

[25] If the best available estimate of the Eight River Index (described in footnote 13) for January is less than or equal to 1.0 MAF, the export limit for February is 45% of Delta inflow. If the best available estimate of the Eight River Index for January is greater than 1.5 MAF, the February export limit is 35% of Delta inflow. If the best available estimate of the Eight River Index for January is between 1.0 MAF and 1.5 MAF, the export limit for February will be set by the operations group established under the Framework Agreement within the range of 35% to 45%. The CALFED policy group will resolve disputes within the operations group.

[26] For the November-January period, close Delta Cross Channel gates for a total of 45 days. The operations group established under the Framework Agreement will determine the timing and duration of the gate closure.

[27] For the May 21-June 15 period, close Delta Cross Channel gates for a total of 14 days. The operations group established under the Framework Agreement will determine the timing and duration of the gate closure.

Figure II-1
Sacramento Valley
Water Year Hydrologic Classification

Year classification shall be determined by computation of the following equation:

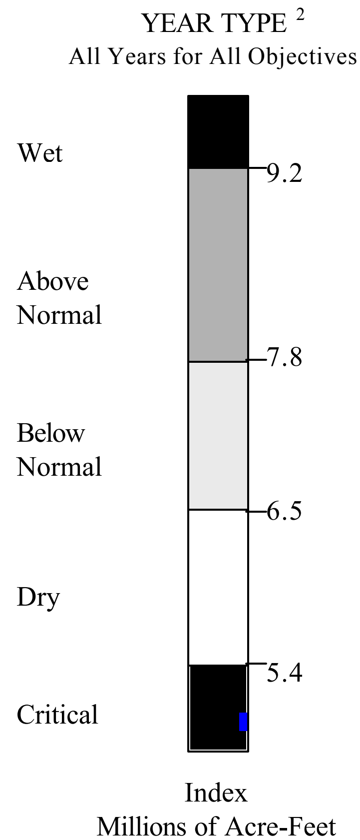
INDEX = 0.4 * X + 0.3 * Y + 0.3 * Z

Where: X = Current year's April – July Sacramento Valley unimpaired runoff

Y = Current October – March Sacramento Valley unimpaired runoff

Z = Previous year's index[1]

The Sacramento Valley unimpaired runoff for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year), as published in California Department of Water Resources Bulletin 120, is a forecast of the sum of the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir. Preliminary determinations of year classification shall be made in February, March, and April with final determination in May. These preliminary determinations shall be based on hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the water year.



Classification	Index Millions of Acre-Feet (MAF)
Wet………………	Equal to or greater than 9.2
Above Normal…..	Greater than 7.8 and less than 9.2
Below Normal…..	Equal to or less than 7.8 and greater than 6.5
Dry……………...	Equal to or less than 6.5 and greater than 5.4
Critical………..…	Equal to or less than 5.4

1 A cap of 10.0 MAF is put on the previous year's index (Z) to account for required flood control reservoir releases during wet years.

2 The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.

Figure II-2
San Joaquin Valley
Water Year Hydrologic Classification

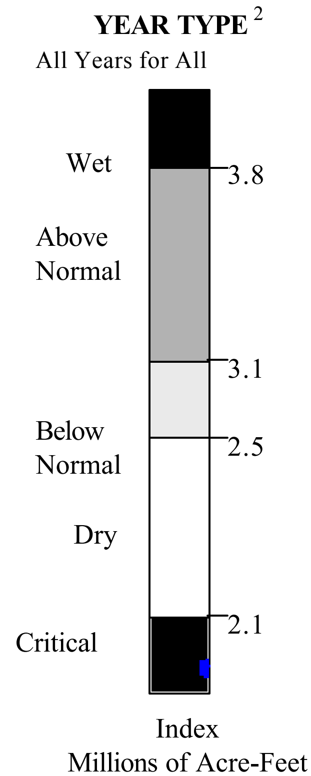
Year classification shall be determined by computation of the following equation:

INDEX = 0.6 * X + 0.2 * Y + 0.2 * Z

Where: X = Current year's April – July San Joaquin Valley unimpaired runoff

Y = Current October – March San Joaquin Valley unimpaired runoff

Z = Previous year's index[1]



The San Joaquin Valley unimpaired runoff for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year), as published in California Department of Water Resources Bulletin 120, is a forecast of the sum of the following locations: Stanislaus River, total flow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total flow to Exchequer Reservoir; San Joaquin River, total inflow to Millerton Lake. Preliminary determinations of year classification shall be made in February, March, and April with final determination in May. These preliminary determinations shall be based on hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the water year.

Classification	Index Millions of Acre-Feet (MAF)
Wet………………	Equal to or greater than 3.8
Above Normal…..	Greater than 3.1 and less than 3.8
Below Normal…..	Equal to or less than 3.1 and greater than 2.5
Dry……………….	Equal to or less than 2.5 and greater than 2.1
Critical…………..	Equal to or less than 2.1

1 A cap of 4.5 MAF is put on the previous year's index (Z) to account for required flood control reservoir releases during wet years.

2 The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.

Figure II-3
NDOI and PERCENT INFLOW DIVERTED [1]

The NDOI and the percent inflow diverted, as described in this footnote, shall be computed daily by the DWR and the USBR using the following formulas (all flows are in cfs):

NDOI = DELTA INFLOW - NET DELTA CONSUMPTIVE USE - DELTA EXPORTS

PERCENT INFLOW DIVERTED = (CCF + TPP) ¸ DELTA INFLOW

where *DELTA INFLOW = SAC + SRTP + YOLO + EAST + MISC + SJR*

SAC	=	Sacramento River at Freeport mean daily flow for the previous day; the 25-hour tidal cycle measurements from 12:00 midnight to 1:00 a.m. may be used instead.
SRTP	=	Sacramento Regional Treatment Plant average daily discharge for the previous week.
YOLO	=	Yolo Bypass mean daily flow for the previous day, which is equal to the flows from the Sacramento Weir, Fremont Weir, Cache Creek at Rumsey, and the South Fork of Putah Creek.
EAST	=	Eastside Streams mean daily flow for the previous day from the Mokelumne River at Woodbridge, Cosumnes River at Michigan Bar, and Calaveras River at Bellota.
MISC	=	Combined mean daily flow for the previous day of Bear Creek, Dry Creek, Stockton Diverting Canal, French Camp Slough, Marsh Creek, and Morrison Creek.
SJR	=	San Joaquin River flow at Vernalis, mean daily flow for the previous day.

where *NET DELTA CONSUMPTIVE USE = GDEPL - PREC*

GDEPL	=	Delta gross channel depletion for the previous day based on water year type using the DWR's latest Delta land use study.[2]
PREC	=	Real-time Delta precipitation runoff for the previous day estimated from stations within the Delta.

and where *DELTA EXPORTS* [3] *= CCF + TPP + CCC + NBA*

CCF	=	Clifton Court Forebay inflow for the current day.[4]
TPP	=	Tracy Pumping Plant pumping for the current day.
CCC	=	Contra Costa Canal pumping for the current day.
NBA	=	North Bay Aqueduct pumping for the current day.

---

1 Not all of the Delta tributary streams are gaged and telemetered. When appropriate, other methods of estimating stream flows, such as correlations with precipitation or runoff from nearby streams, may be used instead.

2 The DWR is currently developing new channel depletion estimates. If these new estimates are not available, DAYFLOW channel depletion estimates shall be used.

3 The term "Delta Exports" is used only to calculate the NDOI. It is not intended to distinguish among the listed diversions with respect to eligibility for protection under the area of origin provisions of the California Water Code.

4 Actual Byron-Bethany Irrigation District withdrawals from Clifton Court Forebay shall be subtracted from Clifton Court Forebay inflow. (Byron-Bethany Irrigation District water use is incorporated into the GDEPL term.

Table II-4

Number of Days When Maximumu Daily Average Electrical Conductivity of 2.64 mmhos/cm Must Be Maintained at Specified Location [a]

PMI [b]	Chipps Island (Chipps Island Station D10)					PMI [b]	Port Chicago (Port Chicago Station C14) [d]					PMI [b]	Port Chicago (Port Chicago Station C14) [d]				
(TAF)	FEB	MAR	APR	MAY	JUN	(TAF)	FEB	MAR	APR	MAY	JUN	(TAF)	FEB	MAR	APR	MAY	JUN
≤ 500	0	0	0	0	0	**0**	0	0	0	0	0	**5250**	27	29	25	26	6
750	0	0	0	0	0	**250**	1	0	0	0	0	**5500**	27	29	26	28	9
1000	28 [c]	12	2	0	0	**500**	4	1	0	0	0	**5750**	27	29	27	28	13
1250	28	31	6	0	0	**750**	8	2	0	0	0	**6000**	27	29	27	29	16
1500	28	31	13	0	0	**1000**	12	4	0	0	0	**6250**	27	30	27	29	19
1750	28	31	20	0	0	**1250**	15	6	1	0	0	**6500**	27	30	28	30	22
2000	28	31	25	1	0	**1500**	18	9	1	0	0	**6750**	27	30	28	30	24
2250	28	31	27	3	0	**1750**	20	12	2	0	0	**7000**	27	30	28	30	26
2500	28	31	29	11	1	**2000**	21	15	4	0	0	**7250**	27	30	28	30	27
2750	28	31	29	20	2	**2250**	22	17	5	1	0	**7500**	27	30	29	30	28
3000	28	31	30	27	4	**2500**	23	19	8	1	0	**7750**	27	30	29	31	28
3250	28	31	30	29	8	**2750**	24	21	10	2	0	**8000**	27	30	29	31	29
3500	28	31	30	30	13	**3000**	25	23	12	4	0	**8250**	28	30	29	31	29
3750	28	31	30	31	18	**3250**	25	24	14	6	0	**8500**	28	30	29	31	29
4000	28	31	30	31	23	**3500**	25	25	16	9	0	**8750**	28	30	29	31	30
4250	28	31	30	31	25	**3750**	26	26	18	12	0	**9000**	28	30	29	31	30
4500	28	31	30	31	27	**4000**	26	27	20	15	0	**9250**	28	30	29	31	30
4750	28	31	30	31	28	**4250**	26	27	21	18	1	**9500**	28	31	29	31	30
5000	28	31	30	31	29	**4500**	26	28	23	21	2	**9750**	28	31	29	31	30
5250	28	31	30	31	29	**4750**	27	28	24	23	3	**10000**	28	31	30	31	30
≥5500	28	31	30	31	30	**5000**	27	28	25	25	4	**>10000**	28	31	30	31	30

[a] The requirement for number of days the maximum daily average electrical conductivity (EC) of 2.64 mmhos per centimeter (mmhos/cm) must be maintained at Chipps Island and Port Chicago can also be met with maximum 14-day running average EC of 2.64 mmhos/cm, or 3-day running average NDOIs of 11,400 cfs and 29,200 cfs, respectively. If salinity/flow objectives are met for a greater number of days than the requirements for any month, the excess days shall be applied to meeting the requirements for the following month. The number of days for values of the PMI between those specified in this table shall be determined by linear interpolation.

[b] PMI is the best available estimate of the previous month's Eight River Index. (Refer to Footnote 13 for Table 3 for a description of the Eight River Index.)

[c] When the PMI is between 800 TAF and 1000 TAF, the number of days the maximum daily average EC of 2.64 mmhos/cm (or maximum 14-day running average EC of 2.64 mmhos/cm, or 3-day running average NDOI of 11,400 cfs) must be maintained at Chipps Island in February is determined by linear interpolation between 0 and 28 days.

[d] This standard applies only in months when the average EC at Port Chicago during the 14 days immediately prior to the first day of the month is less than or equal to 2.64 mmhos/cm

D. EXISTING CONDITIONS

CEQA requires an EIR to include "a description of the environment in the vicinity of the project as it exists before the commencement of the project" (Public Resources Code section 15125). The description of the existing conditions is the baseline against which the environmental impacts of a project and alternative actions are assessed. This section discusses the approach used in this EIR to assess the impacts of the various alternative methods of implementing the 1995 Bay/Delta Plan.

The environment of the Bay/Delta Estuary and upstream areas is the result of complex interactions and numerous changing conditions. Defining existing conditions in such a variable environment is problematic; the definition can change depending on the parameter being considered and the range of variability it exhibits. Hydrologic conditions can vary dramatically from year to year, but future conditions will likely be within the range of past events. For purposes of analysis in this EIR, parameters strongly dependent on hydrology, such as water supply, will be modeled to the extent feasible using streamflow and precipitation data from the period of record, 1922-1994, at the present level of development. Where this is not practicable, the SWRCB will model impacts for a shorter period that still exhibits significant variability.

Some parameters, such as aquatic resource conditions, exhibit annual variability, but conditions have changed substantially over time. Conditions that occurred early in the period of record are not likely to be repeated; therefore, it is not appropriate to define these years as representing existing conditions for these parameters. Also, the fluid and variable nature of hydrology does not lend itself to a strictly defined set of circumstances, but rather dictates a consideration of different water-year types together with an estimate of the demands that would be placed on the water resource during those year types. To take into account the natural variability without misstating the current demands, this EIR estimates the existing conditions for aquatic resources using recent historic conditions. The period includes a representative range of hydrology, is well documented, and describes aquatic resource conditions prior to implementation of the 1995 Bay/Delta Plan. The recent historic period used in the analysis differed for each of the aquatic species considered, depending on the availability and suitability of data to represent existing conditions.

Other parameters, such as land use, change over time but do not exhibit significant annual variability. These types of parameters are defined by the conditions in a single, recent year.

Regulatory requirements also change periodically, but show little annual variability. Currently, the SWP and the CVP operate to meet the requirements in the biological opinions for delta smelt and winter-run chinook salmon and SWRCB Order WR 98-09. In combination, these requirements are essentially the same as the objectives in the 1995 Bay/Delta Plan. However, when the SWRCB began reviewing objectives for the Bay/Delta, regulatory requirements in D-1485 and the upstream conditions in the biological opinion for winter-run chinook salmon were in effect. Accordingly, the SWRCB defined the requirements in D-1485 and the upstream conditions in the biological opinion for winter-run chinook salmon as the existing conditions for the purpose of analyzing the effects of implementing the 1995 Bay/Delta Plan. The ER, Appendix I of the 1995 Bay/Delta Plan, is a programmatic document under CEQA, and it meets the requirements for a Programmatic EIR. As explained in the ER, the project is the review of both the fish and wildlife objectives and the program of implementation for achieving the objectives and protecting the beneficial uses. Because the water right action for which this subsequent EIR is prepared will implement the objectives in the 1995 Bay/Delta Plan, it is part of the overall program that commenced with the review of the fish and wildlife objectives. To be consistent with the earlier part of this program, this EIR uses an existing condition description that varies minimally[1] from the existing condition used in the 1995 Bay/Delta Plan and contains the same regulatory requirements. D-1485 conditions will again go into effect if the SWRCB does not take action by December 31, 1999. Therefore, the existing condition with D-1485 regulatory requirements also constitutes the no-project alternative.

Environmental documents on other current projects, including the CALFED program, the Delta Wetlands Project for which the SWRCB is a lead agency, and the Central Valley Project Improvement Act implementation, are using the 1995 Bay/Delta Plan objectives as their point of reference or existing condition for CEQA analysis. The 1995 objectives describe today's regulatory conditions in the Bay/Delta, even though compliance with these objectives might not be permanent and could be replaced with either weaker or more stringent requirements in the future. The purpose of using an existing condition in a CEQA analysis is to determine the significant impacts of the proposed project. In this case, using the 1995 Bay/Delta Plan objectives as a base for comparison in addition to using the D-1485 requirements may reveal some significant impacts that otherwise would go unnoticed. The purpose of this EIR is to disclose and analyze all the significant impacts so that the SWRCB can make its water right decision knowing all of the potential impacts of the alternatives before it. Accordingly, this EIR uses the current compliance with the 1995 Bay/Delta objectives as a further point of reference against which it compares the other alternatives to determine the significant effects of the alternatives.

E. DESCRIPTION OF ALTERNATIVES

This final EIR analyzes a broad range of alternatives in order to disclose possible impacts. This EIR does not include a preferred alternative. The SWRCB's decision may differ somewhat from any of the alternatives in the EIR. The impacts of the decision, whether it is one of the alternatives in the EIR, a combination of the EIR's alternatives, variants of the EIR's alternatives, or alternatives developed through negotiations by the parties, should be adequately identified and analyzed in this report. The principal assumptions incorporated into the modeling for these alternatives are provided in Chapter IV of this report.

[1] This EIR's existing conditions differ from those in the ER by (1) not including the Cross Valley Canal deliveries since these deliveries will be considered for approval in the water right proceeding; (2) including the new flows required by the Federal Energy Regulatory Commission in the Tuolumne and Mokelumne rivers; (3) not including a 70 TAF annual limitation on deliveries from New Melones Reservoir for salinity control in the southern Delta; (4) using an updated hydrology model.

The alternatives in this report are divided into the following six, separable categories: (1) flow objectives, (2) Suisun Marsh salinity objectives, (3) salinity control actions in the San Joaquin Basin, (4) southern Delta salinity objectives (excluding Vernalis), (5) dissolved oxygen objectives, and (6) combined use of SWP and CVP points of diversion in the Delta. A separate set of alternatives is analyzed for each of these six categories.

The categories described above do not include all of the objectives in the Bay/Delta Plan. The remaining objectives, which include export limits, Delta Cross Channel gates operation, and narrative objectives are treated in the following manner. The Bay/Delta Plan establishes objectives for the operation of the SWP and the CVP export facilities in the Delta and for the Delta Cross Channel gates. Because the DWR and the USBR control the export facilities, and the USBR controls the Delta Cross Channel gates, all of the alternatives, with the exception of the No Project alternative, assume that the DWR and the USBR are responsible for complying with these objectives. In the No Project alternative, the SWP and the CVP are responsible for meeting the D-1485 standards for the operation of the export facilities and the Delta Cross Channel gates.

Alternatives for the two narrative objectives in the Bay/Delta Plan, the narrative salmon objective and the narrative Suisun Marsh objective, are not considered in this EIR. Compliance with the other objectives in the Bay/Delta Plan may be sufficient to achieve these objectives. A period of actual operation to the numerical objectives, coupled with adequate monitoring, is required before a determination can be made whether additional implementation measures are needed. If the narrative objectives are not met, the SWRCB will consider further actions under its water right and water quality authorities to meet these objectives. Such actions could include developing numerical objectives to replace the two narrative objectives. This issue will be considered in the next triennial review of the Bay/Delta Plan, and if appropriate, separate numerical objectives will be developed to replace the narrative objectives. In response to the SWRCB recommendation, the DWR has convened the multi-agency Suisun Ecological Work Group (SEW) to address, among other tasks, the Suisun Marsh narrative objective. The SEW plans to provide its recommendation to the SWRCB in time for the next triennial review.

The Vernalis salinity objectives for the protection of agricultural uses are also treated in a different manner than the other objectives. Actions to achieve these objectives are contained in two categories of alternatives: the flow objectives and the salinity control actions in the San Joaquin Basin. Presently, under the requirements of D-1422, the USBR is responsible for achieving the Vernalis salinity objectives through releases of water from New Melones Reservoir. D-1422 states that the water quality objectives in the decision will be modified to conform with the most up-to-date objectives, implying continuing responsibility of the USBR to achieve the objectives even when the objectives change. Under all of the flow objective alternatives, the USBR continues to be exclusively responsible for the release of water to meet the salinity objectives at Vernalis. This responsibility is based on the language in D-1422 and on the observation that construction of the CVP has substantially increased salinity loads and reduced flows in the San Joaquin River

(WPRS 1980, Grober 1996). However, in order to minimize the need for water releases, this EIR also analyzes alternatives for salinity control actions in the San Joaquin Basin.

1. Flow Objectives Alternatives

For purposes of the analysis in the EIR, the flow objectives include: (1) the Delta outflow objectives, (2) salinity objectives in the Delta that occasionally control Delta outflow, (3) the flow objectives on the Sacramento River at Rio Vista, (4) the flow objectives on the San Joaquin River at Vernalis, and (5) the salinity objectives on the San Joaquin River at Vernalis. Detailed descriptions of the assumptions used in the DWRSIM modeling of the Flow, Joint POD, and Cumulative Impacts alternatives are provided in Volume 2, Appendix 2.

a. Flow Alternative 1 (No Project). CEQA requires that an EIR evaluate a "No Project" alternative. Flow Alternative 1 is the "No Project Alternative." As stated in Section D, above, the existing regulatory requirements could be defined as either D-1485 requirements or as the current compliance with the 1995 Bay/Delta Plan and Order WR 98-09. However, because Order WR 98-09 is an interim document which expires on December 31, 1999, regulatory requirements will revert to those in D-1485 if the SWRCB does not approve the project and issue a decision permanently implementing the 1995 Bay/Delta Plan. Therefore, under this alternative, the SWP and the CVP are solely responsible for meeting the objectives required by D-1485 and the CVP is solely responsible for meeting the objectives required by D-1422. Condition 3 of D-1485 allows limited use of the joint point of diversion to recover pumping foregone in May and June for the protection of striped bass.

b. Flow Alternative 2. Flow Alternative 2 assigns responsibility for meeting the 1995 Bay/Delta Plan flow objectives solely to the SWP and the CVP. Vernalis flow objectives are met by releases from New Melones Reservoir, and are the exclusive responsibility of the CVP.

c. Flow Alternative 3. Flow Alternative 3 assigns responsibility for meeting the 1995 Bay/Delta Plan flow objectives to water right holders based on the water right priority system. Water right holders share responsibility to implement flow objectives; however, the SWP and the CVP are responsible for ensuring that the objectives are achieved. Junior appropriative water right holders are required to cease diversions before senior appropriative water right holders are affected. Under severe drought conditions, however, all water right holders could be directed to cease diversions if no flow is available to satisfy their rights.

In most cases, the priority of post-1914 appropriative rights is determined by the date that an application for a permit is filed, with those filing earliest receiving a more senior priority. The priority of appropriative water right holders who initiated use of water prior to December 19, 1914 is determined by either the date notice of the appropriation was filed under the Civil Code, or by the date water was first put to beneficial use. Pre-1914 appropriative water right holders and riparian water right holders would not be affected until all post-1914 appropriators ceased diversions.

Rediversions of water supplied under contract with operators of upstream storage facilities would not be directly affected by this alternative, but could be indirectly affected when the rights of the upstream provider are affected.

Alternative 3 includes the assumption that water rights for the SWP and the CVP exports of natural and abandoned flows are junior in priority to all inbasin water rights in the Central Valley because of the watershed protection statute which states:

> "In the construction and operation by the department [of Water Resources] of any project under the provisions of this part a watershed or area wherein water originates, or an area immediately adjacent thereto which can conveniently be supplied with water therefrom, shall not be deprived by the department directly or indirectly of the prior right to all of the water reasonably required to adequately supply the beneficial needs of the watershed, area, or any of the inhabitants or property owners therein." (Water Code section 11460)

The CVP serves water to users in the Tulare Lake Basin and the Kern River watershed from the San Joaquin River. Under this alternative the CVP deliveries to the Tulare Lake Basin and the Kern River watershed are assumed to be inbasin deliveries.

The impacts of imposing this alternative on the SWP and the CVP and on those water right holders identified in Table II-5 are evaluated in this report. Table II-5 identifies water right holders with consumptive, post-1914 appropriative water rights with a cumulative face value in excess of 5,000 acre feet per year. This group constitutes approximately 95 percent of the total face value of post-1914 appropriative rights. The face value is an index calculated by multiplying the direct diversion period by the maximum diversion amount and adding this figure to the maximum authorized storage. The resulting quantity is modified, if appropriate, by any maximums for these quantities specified in the permits.

Under this alternative, water right holders in Table II-5 are assigned to groups based on their priority. Groups of appropriators are directed to cease diversions to storage and direct diversions when flow is inadequate to meet outflow objectives and satisfy diversion needs. Tracking SWP and CVP reservoir releases identifies this condition. Because the SWP and the CVP export projects are junior in water right priority, all other water right holders can continue to divert until the SWP and CVP are releasing previously stored water in an amount in excess of their inbasin obligations and exports. When this condition is reached, all water right holders in a group are notified that there is no water available for diversion under their rights. Water right holders receiving such notification are required to cease diverting or to contract for supplemental water supplies. The number of groups of water right holders receiving notification is based on the amount of water necessary to ensure that the SWP and CVP storage releases do not exceed their downstream inbasin and export delivery obligations.

This procedure is similar to a process presently in effect through Standard Water Right Permit Term 91. Term 91 is included in most water right permits for the direct diversion of one cubic foot per second or more or diversion to storage of 100 acre feet per year or more of water in the Central Valley issued after 1968. Term 91 is based on the rationale that, because the SWP and the CVP export projects are junior in priority to all other water users in the basin, the downstream obligations of the projects are their exports plus carriage water. Therefore, water right holders subject to Term 91 must cease diversions when storage releases from the SWP and the CVP exceed exports plus carriage water. Under this alternative, Term 91 would be modified and added to certain post-1914 appropriative water rights. This EIR analyzes the effect of including the modified term in all water right permits in Table II-5. Extension of Term 91 to appropriators with priority dates senior to the SWP and the CVP requires modification of the term because the projects' inbasin contract deliveries become, in some cases, an additional storage release obligation. This methodology could be extended, as part of a future proceeding, to all post-1914 water rights which are presently too small for inclusion in Table II-5.

The CVP has two types of inbasin contractors: water supply contractors and settlement contractors. Settlement contractors have independent water rights and their contracts provide a supplemental supply. Water supply contractors have no independent water rights. Some water supply contracts are limited to interim water supplies. The contract specifies that water is expected to be available for only a limited time. Water supply contractors divert water under the CVP's inbasin rights at all times, and settlement contractors divert under the CVP's water rights when necessary. When uncontrolled flow is inadequate to supply the contractors' diversions and other higher priority diversions, the contractors redivert releases from CVP storage. The CVP, therefore, can have storage release obligations in excess of exports and carriage water at some times, and these obligations must be incorporated into a new water right term that can be extended to water right holders shown in Table II-5. Similar contractual obligations exist for the SWP although in smaller quantities.

Water right holders in the San Joaquin Basin are required to meet the Vernalis flow objective under this alternative. Because this alternative assumes there are no export projects subject to the watershed protection statute in the San Joaquin Basin, these users are required to cease diversion in order of priority when flow is inadequate to meet flow objectives at Vernalis. The impacts of imposing this alternative on the water right holders identified in Table II-6 are evaluated in this report. Table II-6 lists all of the water right holders in Table II-5 that are located in the San Joaquin Basin.

A detailed description of the calculations used to determine water availability under this alternative is provided in Chapter IV section F of this report.

Table II-5
Major Central Valley Water Rights by Priority Group

Priority Group	Appl Id	File Date	Status	DSA	Last Name (Company)	Max Dir Div	Total Storage	Primary DD Season	Secondary DD Season	Storage Season
1	A029471	04/20/89	P	65	KNAGGS	5.5 C	0	4/15-6/30		
1	A028453	05/15/85	P	65	UPPER SWANSTON RANCH INC	45 C	0	5/1-10/1		
1	A027853	08/29/83	P	24	ST SUPERY VINEYARDS & WINERY	11 C	0	4/1-5/31		
1	A027852	08/29/83	P	24	ST SUPERY VINEYARDS & WINERY	11 C	350	5/1-8/15		11/1-5/15
1	A027586	11/17/82	P	49	U S FISH & WILDLIFE SERVICE (Merced NWR)	9 C	0	12/15-5/31		
1	A027546	09/30/82	P	49	NEW STONE WATER DISTRICT	55 C	0	1/1-12/31		
1	A027213	02/18/82	P	12	LEON W ETCHEPARE ESTATE	29.8 C	0	2/15-6/30	9/1-11/1	
1	A027007	09/15/81	P	59	WOODBRIDGE IRRIGATION DISTRICT	3 C	0	2/1-10/31		
1	A026875	06/16/81	L	49	MENEFEE RIVER RANCH COMPANY	15.9 C	0	1/1-10/31		
1	A026757	03/19/81	P	49	MENEFEE HILL RANCH COMPANY	11 C	0	1/1-12/31		
1	A026695	01/27/81	P	65	CONAWAY CONSERVANCY GROUP	100 C	0	4/15-9/30		
1	A026492	08/13/80	P	24	MAGOON ESTATE LIMITED	0	56			11/1-4/30
1	A026098	09/25/79	P	69	GARDEN HIGHWAY MUTUAL WATER CO	0.25 C	0	4/1-6/15	9/1-10/31	
1	A025911	02/01/79	P	24	MAGOON ESTATE LIMITED	0	58			10/1-4/30
1	A025883	12/06/78	L	69	AKIN RANCH, A PARTNERSHIP	6.7 C	0	5/1-6/30	9/1-9/30	
1	A025793	07/20/78	P	12	WALLACE BROTHERS	17 C	0	7/1-8/31		
1	A025792	07/20/78	P	12	WALLACE BROTHERS	17 C	0	7/1-8/31		
1	A025751	05/31/78	P	69	CITY OF YUBA CITY	21 C	0	1/1-6/30	10/1-12/31	
1	A025727	05/01/78	P	70	NATOMAS CENTRAL MUTUAL WATER CO	168 C	0	10/1-4/1		
1	A025717	04/12/78	L	69	GORRILL LAND COMPANY	20 C	0	4/1-9/30		
1	A025616	12/22/77	P	65	CITY OF WEST SACRAMENTO	62 C	0	1/1-6/30	9/1-12/31	
1	A025516A	09/30/77	P	55	CONTRA COSTA WATER DISTRICT	115 C	9,640	1/1-12/31		1/1-12/31
1	A025231	01/04/77	L	61	CROOK	0	50			2/1-6/15
1	A025030	03/26/76	L	17	GRAEAGLE LAND & WATER CO	0.95 C	0	5/1-10/30		
1	A024961	12/29/75	P	55	RECLAMATION DISTRICT #2068	55 C	0	3/1-10/31		
1	A024646	07/19/74	L	24	ST SUPERY VINEYARDS & WINERY	0	30			11/1-4/30
1	A024635	07/03/74	P	24	MAGOON ESTATE LIMITED	0	10,000			10/1-4/30
1	A024590	04/10/74	P	69	CA DEPT OF FISH & GAME	35 C	0	3/1-6/15		
1	A024432	08/06/73	L	24	ST SUPERY VINEYARDS & WINERY	0	31			11/1-5/31
1	A024297	02/01/73	P	24	MAGOON ESTATE LIMITED	0	3,000			10/1-4/30
1	A024296C	02/01/73	P	24	MAGOON ESTATE LIMITED	0	5,350			10/1-4/30
1	A024296B	02/01/73	P	24	MAGOON ESTATE LIMITED	0	200			10/1-4/30
1	A024296A	02/01/73	P	24	MAGOON ESTATE LIMITED	0	1,450			10/1-4/30
1	A023946	12/09/71	P	12	WALLACE BROTHERS	17 C	0	4/1-6/30	9/1-9/30	
1	A023945	12/09/71	P	12	WALLACE BROTHERS	17 C	0	4/1-6/30	9/1-9/30	
1	A023838	08/11/71	L	70	SOUTH SUTTER WATER DISTRICT	1.35 C	0	4/1-6/30	9/1-9/30	
1	A023834	08/02/71	P	24	ST SUPERY VINEYARDS & WINERY	0	1,045			9/15-5/31
1	A023757	04/12/71	P	69	BROWNS VALLEY IRRIGATION DISTRICT	70 C	0	11/1-6/30		
1	A023690	01/25/71	P	70	SOUTH SUTTER WATER DISTRICT	25 C	0	4/1-6/30	9/1-10/31	
1	A023672	01/14/71	P	24	ST SUPERY VINEYARDS & WINERY	0	1,045			9/15-5/31
1	A023416	12/19/69	P	59	RANCHO MURIETA COMMUNITY SERVICES DIST	6 C	4,050	11/1-5/31		11/1-5/31
1	A023280	05/19/69	L	61	S X RANCH INC	0	4,620			10/1-3/31
1	A023249	03/19/69	L	24	ST SUPERY VINEYARDS & WINERY	0	49			11/1-5/1
1	A023248	03/19/69	L	24	ST SUPERY VINEYARDS & WINERY	0	32			11/1-5/1
1	A023247	03/19/69	L	24	ST SUPERY VINEYARDS & WINERY	0	47			11/1-5/1
1	A023246	03/19/69	L	24	ST SUPERY VINEYARDS & WINERY	0	49			11/1-4/30
1	A023201	12/26/68	P	15	RECLAMATION DISTRICT #1004	140 C	0	9/15-1/31	4/1-6/15	
1	A023045	05/15/68	L	69	GARDEN HIGHWAY MUTUAL WATER CO	32.7 C	0	4/1-4/30		
1	A023031	04/18/68	P	49	GRAVELY FORD WATER DISTRICT	0	5,000			10/1-6/1
1	A023005	03/12/68	L	12	GLENN COLUSA IRRIGATION DIST	2 C	0	4/1-6/30	9/1-12/31	
1	A022980	02/07/68	L	40	PINE MOUNTAIN LAKE ASSOCIATION	0	7,650			10/1-5/31
1	A022427	03/17/66	L	61	HOT SPRINGS VALLEY IRRIGATION DIST	0	20,000			10/1-4/30
1	A022333	11/12/65	L	69	FORAKER	40 C	340	4/1-6/15		4/1-6/15
1	A022321	10/25/65	L	69	GORRILL LAND COMPANY	25.8 C	580	4/1-6/15		4/1-6/15
1	A022309	10/08/65	L	70	NATOMAS CENTRAL MUTUAL WATER CO	14 C	0	3/1-6/30		9/1-10/31
1	A022102	04/12/65	L	70	SOUTH SUTTER WATER DISTRICT	40.3 C	0	4/1-6/15	9/1-10/31	
1	A022061	02/25/65	P	14	PARADISE IRRIGATION DIST	0	8,800			10/1-5/31
1	A022039	02/05/65	L	69	RANCHO ESQUON PARTNERS	66 C	0	4/1-6/15		
1	A021945	10/22/64	P	22	U S BUREAU OF RECLAMATION (Sugar Pine Lake)	18 C	15,400	11/1-7/1		11/1-7/1
1	A021443	08/23/63	P	17	CA DEPT OF WATER RESOURCES (Davis Lake)	0	34,000			10/1-6/30
1	A021206	03/26/63	L	69	CREPS	10 C	0	4/15-6/30	9/1-12/15	
1	A020904	08/20/62	L	61	S X RANCH INC	0	1,920			10/15-5/1
1	A020877	07/27/62	L	24	MAGOON ESTATE LIMITED	0	1,287			9/15-6/30
1	A020876	07/27/62	L	24	MAGOON ESTATE LIMITED	0	1,310			9/15-6/30
1	A020698	04/04/62	L	65	MAINE PRAIRIE WATER DIST	96 C	0	3/1-7/1	9/1-11/1	
1	A020376	08/31/61	L	65	SWANSTON	15.7 C	0	5/1-6/30	9/1-9/30	
1	A020245	06/05/61	P	55	CONTRA COSTA WATER DISTRICT	0	95,850			11/1-6/30
1	A020017	03/06/61	P	67	NEVADA IRRIGATION DIST	200 C	18,000	9/1-6/30		11/1-6/30
1	A019934	01/27/61	P	24	U S BUREAU OF RECLAMATION (Lake Berryessa)	0	7,500			11/1-5/31
1	A019890	12/21/60	L	24	MAGOON ESTATE LIMITED	0	1,381			9/15-6/30
1	A019309	03/14/60	L	61	SOUTH FORK IRRIGATION DISTRICT	0	2,240			11/1-4/15
1	A019304	03/11/60	P	39	U S BUREAU OF RECLAMATION (New Melones)	0	1,420,000			11/1-6/30
1	A019229	02/11/60	L	55	RECLAMATION DISTRICT #2068	42 C	0	11/1-3/1		
1	A019149	12/23/59	P	39	CALAVERAS COUNTY WATER DIST	365 C	79,200	3/1-7/1		11/1-6/30
1	A019145	12/23/59	L	62	GEORGE P DENNY III TRUST	0	6,400			11/1-4/1
1	A019087	11/19/59	L	65	SWANSTON	0.92 C	0	5/1-6/30	9/1-9/30	

Table II-5 (cont.)
Major Central Valley Water Rights by Priority Group

Priority Group	Appl Id	File Date	Status	DSA	Last Name (Company)	Max Dir Div	Total Storage	Primary DD Season	Secondary DD Season	Storage Season
1	A019086	11/19/59	L	65	SWANSTON	10 C	0	5/1-6/30	9/1-9/30	
1	A019083	11/16/59	L	69	AGRIVEST CORP	1.2 C	0	5/1-6/30	9/1-10/31	
1	A018844	07/06/59	L	17	CA DEPT OF WATER RESOURCES (Frenchman Lake)	0	4,962			11/1-6/1
1	A018812	06/19/59	P	32	U S BUREAU OF RECLAMATION (New Hogan Lake)	200 C	325,000	11/1-5/1		11/1-5/1
1	A018774	06/08/59	L	49	EL NIDO IRRIGATION DISTRICT	0	5,000			11/1-4/15
1	A018733	05/22/59	P	45	U S BUREAU OF RECLAMATION (Hidden Lake)	0	74,000			12/1-4/30
1	A018714	05/15/59	P	43	U S BUREAU OF RECLAMATION (Eastman Lk)	0	143,000			11/1-5/31
1	A018527	02/11/59	L	65	MAINE PRAIRIE WATER DIST	2.11 C	0	5/1-11/1		
1	A018488	01/26/59	L	69	AKIN RANCH, A PARTNERSHIP	1 C	0	4/15-9/15		
1	A018372	10/15/58	L	12	OLIVE PERCY DAVIS TRUST	7.6 C	0	4/1-6/15	9/1-10/1	
1	A018115	04/30/58	P	11	U S BUREAU OF RECLAMATION (Black Butte Res)	200 C	160,000			11/1-4/30
1	A018087	04/08/58	P	22	PLACER COUNTY WATER AGENCY	800 C	66,000	11/1-7/1		11/1-7/1
1	A018085	04/07/58	P	22	PLACER COUNTY WATER AGENCY	1225 C	249,000	11/1-7/1		11/1-7/1
1	A018075	03/31/58	L	55	GALEN WHITNEY & EST OF H B WHITNEY	3 C	0	6/1-10/1		
1	A018025	03/05/58	P	69	CITY OF YUBA CITY	15.6 C	0	1/1-7/1	9/1-12/31	
1	A018005	02/18/58	L	69	CA DEPT OF FISH & GAME (Gray Lodge Wildlife Area)	15 C	0	9/1-6/30		
1	A017971	02/03/58	L	55	MCCORMACK	2.2 C	0	4/15-10/1		
1	A017966	01/29/58	L	49	MCMULLIN RECL DISTRICT #2075	8.22 C	0	4/1-4/30		
1	A017948	01/17/58	L	55	SAN JOAQUIN RIVER WATER USERS CO, INC	4.75 C	0	3/1-11/15		
1	A017664	06/20/57	L	65	MAINE PRAIRIE WATER DIST	2 C	0	5/1-11/30		
1	A017605	05/14/57	P	59	JACKSON VALLEY IRRIGATION DIST	50 C	30,000	3/1-5/31		11/1-5/31
1	A017493	03/01/57	L	65	MAINE PRAIRIE WATER DIST	2 C	0	4/1-11/30		
1	A017491	03/01/57	L	65	MAINE PRAIRIE WATER DIST	2 C	0	4/1-10/31		
1	A017488	03/01/57	L	65	MAINE PRAIRIE WATER DIST	2 C	0	4/1-10/31		
1	A017487	03/01/57	L	65	MAINE PRAIRIE WATER DIST	2 C	0	4/15-11/15		
1	A017468	02/19/57	L	55	STEPHENS II	5.5 C	0	4/1-10/31		
1	A017376	11/28/56	P	58	U S BUREAU OF RECLAMATION (Whiskeytown)	3,600 C	250,000	11/1-4/1		11/1-4/1
1	A017066	05/02/56	L	12	PRINCETON-CODORA-GLENN IRRIGATION DIST	50 C	0	4/1-6/30	9/1-10/31	
1	A016985	04/03/56	L	15	TISDALE IRRIGATION & DRAINAGE CO	15 C	0	5/1-6/15		
1	A016952	03/20/56	L	17	CA DEPT OF WATER RESOURCES (Frenchman Lake)	0	30,000			11/1-6/1
1	A016950	03/20/56	P	17	CA DEPT OF WATER RESOURCES (Davis lake)	0	49,000			10/1-6/30
1	A016688	10/24/55	P	22	GEORGETOWN DIVIDE PUBLIC UTILTY DIST	30 C	4,000	11/1-8/1		11/1-8/1
1	A016677	10/20/55	L	15	SUTTER MUTUAL WATER COMPANY	7.5 C	0	4/1-6/15	9/1-10/31	
1	A016604	09/15/55	L	49	GALLO CATTLE COMPANY, A PARTNERSHIP	10 C	0	1/1-12/31		
1	A016401	05/31/55	L	69	TUDOR MUTUAL WATER COMPANY	32 C	0	4/1-10/1		
1	A016399	05/27/55	L	69	CA DEPT OF FISH & GAME (Gray Lodge Wildlife Area)	50 C	0	9/1-6/15		
1	A016362	05/05/55	P	12	RIDGE CUT FARMS	14.52 C	0	4/1-6/30	9/1-9/30	
1	A016361	05/05/55	P	12	KNAGGS	65.36 C	0	4/1-6/30	9/1-9/30	
1	A016329	04/21/55	L	49	JOSEPH GALLO FARMS	27 C	0	4/1-11/1	11/1-4/1	
1	A016219	01/26/55	L	62	HAMMOND RESERVOIR IRRIGATION ASSN	0	348			10/1-3/31
1	A016212	01/17/55	P	22	GEORGETOWN DIVIDE PUBLIC UTILTY DIST	75 C	0	11/1-8/1		
1	A016186	12/23/54	L	41	MERCED IRRIGATION DISTRICT	0	605,000			10/1-7/1
1	A016154	11/29/54	L	17	PACIFIC GAS & ELECTRIC COMPANY	0.33 C	0	1/1-12/31		
1	A016142	11/18/54	L	59	RANCHO MURIETA COMMUNITY SERVICES DIST	1.24 C	45	5/1-10/31		10/1-5/1
1	A016136	11/15/54	L	49	MENEFEE RIVER RANCH COMPANY	3.2 C	0	2/1-6/15		
1	A016060	09/22/54	P	70	CITY OF SACRAMENTO	175 C	0	11/1-8/1		
1	A015975	08/02/54	P	16	YOLO COUNTY F C & W C DIST	0	50,000			10/1-5/15
1	A015893	06/04/54	L	69	GARDEN HIGHWAY MUTUAL WATER CO	0.7 C	0	5/1-11/1		
1	A015867	05/10/54	L	69	PARROTT INVESTMENT COMPANY	5.9 C	0	3/1-7/15		
1	A015866	05/10/54	L	15	M & T INCORPORATED	5.9 C	0	3/1-7/15		
1	A015856	04/30/54	L	70	WILLIAM NICHOLAS TRUST	35.3 C	0	3/15-11/15		
1	A015795	03/24/54	L	70	OSTERLI	7.34 C	0	4/1-10/15		
1	A015748	02/25/54	L	17	PACIFIC GAS & ELECTRIC COMPANY	0.0232 C	0	1/1-12/31		
1	A015745	02/23/54	L	70	WILLEY	18.6 C	0	4/1-10/31		
1	A015734	02/18/54	L	70	OSTERLI	8.23 C	0	4/1-9/30		
1	A015710	02/02/54	L	69	MCPHERRIN LAND CO	10 C	0	4/1-6/15	9/1-10/1	
1	A015706	01/28/54	L	24	MAGOON ESTATE LIMITED	0	1,222			10/1-6/1
1	A015698	01/21/54	L	55	CECCARINI	30.2 C	0	4/1-11/1		
1	A015628	12/02/53	L	49	GALLO BEAR CREEK RANCH	38 C	0	4/1-10/31		
1	A015606	11/09/53	L	70	OSTERLI	14.54 C	0	4/1-9/30		
1	A015587	10/27/53	L	69	SUTTER EXTENSION WATER DISTRICT	35 C	0	4/15-6/30	9/1-9/30	
1	A015574	10/09/53	P	67	YUBA COUNTY WATER AGENCY	0	514,000			10/1-6/30
1	A015572	10/08/53	L	70	NATOMAS CENTRAL MUTUAL WATER CO	131 C	0	4/1-6/30		
1	A015468	08/19/53	L	69	MCGOWAN BROTHERS	25 C	0	4/1-6/15	9/1-10/31	
1	A015467	08/19/53	L	69	MCGOWAN RICE RANCH	25 C	0	4/1-6/15	9/1-10/31	
1	A015414	07/16/53	L	62	PACIFIC GAS & ELECTRIC COMPANY	0.039 C	0	1/1-12/31		
1	A015406	07/08/53	L	69	CA DEPT OF FISH & GAME	22.2 C	0	4/1-11/1		
1	A015392	06/29/53	L	65	TUTTLE	21.2 C	0	4/1-9/30		
1	A015250	03/23/53	L	55	A STEFFAN RANCH	22.7 C	0	3/1-11/30	12/1-3/1	
1	A015204	02/20/53	P	67	YUBA COUNTY WATER AGENCY	0	246,000			10/1-6/30
1	A015179	01/29/53	L	69	SUTTER EXTENSION WATER DISTRICT	31 C	0	4/1-6/30	9/1-10/1	
1	A015178	01/29/53	L	69	SUTTER EXTENSION WATER DISTRICT	15 C	0	4/1-6/30	9/1-10/1	
1	A015177	01/29/53	L	69	SUTTER EXTENSION WATER DISTRICT	20 C	0	4/1-6/30	9/1-10/1	
1	A015095	11/25/52	L	69	AKIN RANCH, A PARTNERSHIP	11.6 C	0	4/15-10/1		
1	A015017	09/15/52	L	69	CA DEPT OF FISH & GAME	6 C	0	4/15-9/15		
1	A014907	07/11/52	L	55	RECLAMATION DISTRICT #548	82 C	0	1/1-12/31		
1	A014867	06/19/52	L	69	ETCHEVERRY-IRIGOYEN	15 C	0	4/1-10/1		

Table II-5 (cont.)
Major Central Valley Water Rights by Priority Group

Priority Group	Appl Id	File Date	Status	DSA	Last Name (Company)	Max Dir Div	Total Storage	Primary DD Season	Secondary DD Season	Storage Season
1	A014858A	06/16/52	P	39	U S BUREAU OF RECLAMATION (New Melones Lk)	0	980,000			11/1-6/30
1	A014858B	06/16/52	P	39	U S BUREAU OF RECLAMATION (New Melones Lk)	2250 C	0	11/1-6/30		
1	A014804	05/12/52	L	70	SOUTH SUTTER WATER DISTRICT	330 C	58,370	5/1-9/1		10/1-6/30
1	A014803	05/12/52	P	69	FEATHER WATER DISTRICT	130 C	0	1/1-12/31		
1	A014686	02/21/52	L	69	DAVIS, HELEN	3 C	0	5/1-10/1		
1	A014665	01/31/52	L	69	SUTTER EXTENSION WATER DISTRICT	25 C	0	4/15-11/1		
1	A014649	01/21/52	L	12	CAVE	20.1 C	0	4/1-10/1		
1	A014619	01/14/52	L	12	ZUMWALT MUTUAL WATER CO	0.5 C	0	4/1-10/15		
1	A014588	11/26/51	L	69	SUTTER EXTENSION WATER DISTRICT	29 C	0	5/1-9/15		
1	A014582	11/19/51	L	49	CA DEPT OF FISH & GAME (Los Banos Wildlife Area)	47 C	0	1/1-12/31		
1	A014546	11/02/51	L	69	MCPHERRIN LAND CO	15 C	0	4/1-11/1		
1	A014544	11/01/51	L	55	ZANETTI	13 C	0	4/1-12/31		
1	A014443	08/24/51	P	69	CA DEPT OF WATER RESOURCES (Oroville)	7,545 C	3,542,100	1/1-12/31		9/1-7/31
1	A014430	08/15/51	L	70	SOUTH SUTTER WATER DISTRICT	2 C	0	4/1-11/1		
1	A014415	08/03/51	L	69	GARDEN HIGHWAY MUTUAL WATER CO	23 C	0	5/1-11/1		
1	A014378	06/28/51	L	12	MAXWELL IRRIGATION DIST	3 C	0	3/1-11/30		
1	A014354	06/20/51	L	69	MCGOWAN RICE RANCH	7.4 C	0	4/1-10/1		
1	A014316	05/21/51	L	69	U S FISH & WILDLIFE SERVICE (Butte Sink NWR)	2.4 C	0	5/1-9/1		
1	A014127	01/16/51	L	40	TURLOCK I D & MODESTO I D	0	1,046,800			11/1-7/31
1	A014113	12/28/50	P	17	OROVILLE-WYANDOTTE IRRIGATION DIST	700 C	117,300	1/1-12/31		11/1-7/1
1	A014023	10/28/50	L	55	AUGUSTA BIXLER FARMS	18.5 C	0	1/1-12/31		
1	A014022	10/26/50	L	55	AUGUSTA BIXLER FARMS	9.5 C	0	1/1-12/31		
1	A013976	10/03/50	L	58	IGO ONO COMMUNITY SERVICE DIST	0.8 C	0	4/1-11/1		
1	A013957	09/20/50	P	67	OROVILLE-WYANDOTTE IRRIGATION DIST	300 C	35,000	5/1-11/1		1/1-7/1
1	A013919	08/25/50	L	12	MAXWELL IRRIGATION DIST	11.6 C	0	5/1-12/1		
1	A013873	07/31/50	P	67	BROWNS VALLEY IRRIGATION DISTRICT	0	40,000			10/1-6/1
1	A013846	07/15/50	L	17	PACIFIC GAS & ELECTRIC COMPANY	0	60			10/1-5/1
1	A013769	06/01/50	L	17	PACIFIC GAS & ELECTRIC COMPANY	0.078 C	0	1/1-12/31		
1	A013765	05/31/50	L	17	PACIFIC GAS & ELECTRIC COMPANY	0.056 C	0	1/1-12/31		
1	A013735	05/15/50	L	12	MAXWELL IRRIGATION DIST	7 C	0	4/15-10/1		
1	A013715	05/02/50	L	55	SAN JOAQUIN RIVER WATER USERS CO, INC	22.1 C	0	1/1-12/31		
1	A013710	04/28/50	L	69	CREPS	4.7 C	0	4/15-12/15		
1	A013628	03/10/50	L	49	BROCCHINI	0.75 C	0	3/1-11/1		
1	A013590	02/20/50	L	15	OJI BROTHERS, A CO-PARTNERSHIP	2.87 C	0	4/1-10/1		
1	A013541	01/13/50	L	49	WEAVER	45 C	0	11/1-7/1		
1	A013454	11/09/49	L	15	ANDREOTTI	13.5 C	0	4/1-10/1		
1	A013452	11/09/49	L	12	PROVIDENT IRRIGATION DIST	3.25 C	0	4/1-10/1		
1	A013371	10/01/49	P	22	U S BUREAU OF RECLAMATION (Folsom)	700 C	300,000	11/1-8/1		11/1-7/1
1	A013370	10/01/49	P	22	U S BUREAU OF RECLAMATION (Folsom)	8,000 C	1,000,000	11/1-8/1		11/1-7/1
1	A013349	09/12/49	L	69	SUTTER EXTENSION WATER DISTRICT	2.66 C	0	4/15-10/15		
1	A013323	08/31/49	L	69	MCGOWAN RICE RANCH	7 C	0	4/1-10/1		
2	A013175	06/27/49	L	49	CHOWCHILLA WATER DISTRICT	90 C	50,000	3/1-7/31		11/1-5/1
2	A013156	06/16/49	P	29	EAST BAY MUNICIPAL UTILITY DIST	194 C	353,000	12/1-7/1		12/1-7/1
2	A013148	06/10/49	L	55	PETERSEN ESTATE COMPANY	18 C	0	4/15-10/15		
2	A013130	06/02/49	P	67	BROWNS VALLEY IRRIGATION DISTRICT	0	20,000			10/1-5/1
2	A013093A	05/13/49	P	39	CALAVERAS COUNTY WATER DIST	0	5,000			11/1-7/1
2	A013091	05/13/49	P	39	CALAVERAS COUNTY WATER DIST	0	63,000			11/1-7/1
2	A013031	04/18/49	L	65	KNAGGS	3 C	0	4/15-10/1		
2	A013008	03/30/49	L	69	MCGOWAN BROTHERS	14.2 C	0	4/1-10/1		
2	A013002	03/25/49	L	12	OLIVE PERCY DAVIS TRUST	1 C	0	4/1-10/1		
2	A013001	03/25/49	L	12	OLIVE PERCY DAVIS TRUST	0.27 C	0	4/1-10/1		
2	A013000	03/25/49	L	12	OLIVE PERCY DAVIS TRUST	5 C	0	4/1-10/1		
2	A012997	03/23/49	L	12	KNAGGS	2.98 C	0	4/1-10/1		
2	A012996	03/23/49	L	12	KNAGGS	2.11 C	0	4/1-10/1		
2	A012995	03/23/49	L	12	KNAGGS	1.72 C	0	4/1-10/1		
2	A012926	02/07/49	L	69	DAVIS, HELEN	3 C	0	4/1-10/1		
2	A012912	01/25/49	P	39	CALAVERAS COUNTY WATER DIST	7 C	0	11/1-7/1		
2	A012910	01/25/49	P	39	CALAVERAS COUNTY WATER DIST	400 C	0	3/1-7/1		
2	A012842	12/02/48	P	29	NORTH SAN JOAQUIN WATER CONS DIST	80 C	20,000	12/1-7/1		12/1-7/1
2	A012716	09/27/48	P	24	U S BUREAU OF RECLAMATION (Lake Berryessa)	116 C	320,000	1/1-12/31		11/1-5/31
2	A012648	08/12/48	L	59	WOODBRIDGE IRRIGATION DISTRICT	18.25 C	0	1/1-12/31		
2	A012635	08/06/48	L	49	W P RODUNER CATTLE & FARMING CO	23.4 C	0	3/1-12/1		
2	A012622	07/29/48	P	22	CITY OF SACRAMENTO	1200 C	314,000	11/1-8/1		11/1-8/1
2	A012578	06/30/48	P	24	U S BUREAU OF RECLAMATION (Lake Berryessa)	900 C	600,000	2/1-11/15		11/1-5/31
2	A012490	04/28/48	L	49	OAKDALE I D & SOUTH SAN JOAQUIN I D	0	64,500			10/1-7/1
2	A012470B	04/13/48	L	15	PELGER MUTUAL WATER COMPANY	53.5 C		4/1-11/1		
2	A012470A	04/13/48	L	15	SUTTER MUTUAL WATER COMPANY	35.9 C	0	4/1-11/1		
2	A012437	03/25/48	L	69	U S FISH & WILDLIFE SERVICE (Butte Sink NWR)	4.6 C	0	5/1-9/1		
2	A012421	03/19/48	P	22	GEORGETOWN DIVIDE PUBLIC UTILITY DIST	50 C	20,000	11/1-8/1		11/1-8/1
2	A012412	03/17/48	L	12	OLIVE PERCY DAVIS TRUST	6 C	0	4/1-10/1		
2	A012389	03/08/48	P	16	LAKE COUNTY F C & W C D	0	41,000			10/1-4/1
2	A012371	03/02/48	L	69	CORDUA IRRIGATION DISTRICT	50 C	0	4/1-11/1		
2	A012367	03/01/48	P	70	CARMICHAEL WATER DISTRICT	25 C	0	1/1-12/31		
2	A012342A	02/20/48	P	59	JACKSON VALLEY IRRIGATION DIST	60 C	6,000	11/1-5/31		11/1-5/31
2	A012321	02/13/48	P	22	CITY OF SACRAMENTO	310 C	275,000	11/1-8/1		11/1-8/1
2	A012286	02/02/48	L	55	CITY OF VALLEJO	31.52 C	0	1/1-12/31		

Table II-5 (cont.)
Major Central Valley Water Rights by Priority Group

Priority Group	Appl Id	File Date	Status	DSA	Last Name (Company)	Max Dir Div	Total Storage	Primary DD Season	Secondary DD Season	Storage Season
2	A012263	01/26/48	L	61	U S FISH & WILDLIFE SERVICE (Colusa NWR)	0	1,100			10/1-4/1
2	A012256	01/23/48	L	12	KNAGGS	9 C	0	4/1-10/1		
2	A012230A	01/06/48	L	69	SUTTER EXTENSION WATER DISTRICT	1.92 C	0	4/1-10/1		
2	A012140	10/29/47	P	70	CITY OF SACRAMENTO	500 C	0	11/1-8/1		
2	A012125	10/08/47	L	12	GLENN COLUSA IRRIGATION DIST	11 C	0	4/20-9/30		
2	A012115	09/30/47	L	12	U S FISH & WILDLIFE SERVICE (Colusa NWR)	8 C	0	4/15-11/1		
2	A012074	09/08/47	L	65	CONAWAY CONSERVANCY GROUP	9.4 C	0	4/15-10/31		
2	A012073	09/08/47	L	65	CONAWAY CONSERVANCY GROUP	165.25 C	0	4/1-10/31		
2	A011959	06/24/47	L	12	ZUMWALT MUTUAL WATER CO	15 C	0	4/1-9/15		
2	A011958	06/24/47	L	12	MAXWELL IRRIGATION DIST	13.5 C	0	4/15-10/1		
2	A011957	06/24/47	L	12	MAXWELL IRRIGATION DIST	65.5 C	0	4/15-10/1		
2	A011956	06/24/47	L	12	MAXWELL IRRIGATION DIST	8.5 C	0	4/1-10/1		
2	A011955	06/24/47	L	12	MAXWELL IRRIGATION DIST	14 C	0	4/15-10/1		
2	A011953	06/23/47	L	15	SUTTER MUTUAL WATER COMPANY	7.5 C	0	4/1-10/1		
2	A011926	06/09/47	L	12	STRAIN	22 C	0	4/15-9/15		
2	A011925	06/09/47	L	12	STRAIN	8 C	0	4/15-9/15		
2	A011910	05/29/47	L	65	RIVER GARDEN FARMS COMPANY	19 C	0	4/1-9/15		
2	A011903	05/26/47	L	12	OTTENWALTER	8.1 C	0	4/1-10/1		
2	A011902	05/26/47	L	12	GOETTE FARMS, INC & EST OF	9 C	0	4/1-10/1		
2	A011901	05/26/47	L	12	GOETTE FARMS, INC	8 C	0	4/1-9/15		
2	A011900	05/26/47	L	12	ARCH J CAMPBELL, TRUSTEE	16.4 C	0	4/1-10/1		
2	A011899	05/26/47	L	12	RECLAMATION DISTRICT #108	75 C	0	4/1-10/1		
2	A011888A	05/22/47	L	12	OTTENWALTER	6.7 C	0	4/1-10/1		
2	A011887	05/22/47	L	55	GALEN WHITNEY & EST OF H B WHITNEY	11.7 C	0	3/1-11/15		
2	A011886	05/22/47	L	12	ASH	15 C	0	4/15-10/1		
2	A011881	05/15/47	L	12	WALLACE BROTHERS	13 C	0	4/15-10/1		
2	A011878	05/13/47	L	65	ESTATE OF E L WALLACE	34 C	0	4/15-10/15		
2	A011855	05/05/47	L	12	RIDGE CUT FARMS	13.7 C	0	4/15-9/15		
2	A011854	05/05/47	L	12	RIDGE CUT FARMS	13.7 C	0	4/15-9/15		
2	A011847	04/28/47	L	55	UNION ISLAND MUTUAL WATER CO, INC	14.1 C	0	1/1-12/31		
2	A011792B	03/24/47	P	39	CALAVERAS COUNTY WATER DIST	0	78,500			11/1-7/1
2	A011688	01/08/47	L	49	U S FISH & WILDLIFE SERVICE (San Luis NWR)	20.2 C	0	1/1-12/31		
2	A011687	01/08/47	L	49	U S FISH & WILDLIFE SERVICE (San Luis NWR)	40.9 C	0	1/1-12/31		
2	A011653	12/10/46	L	49	W P RODUNER CATTLE & FARMING CO	40 C	0	12/1-6/1		
2	A011632	11/21/46	L	69	U S FISH & WILDLIFE SERVICE (Sutter NWR)	25 C	0	6/1-10/30		
2	A011618	11/14/46	L	15	ANDREOTTI	5.5 C	0	4/1-10/1		
2	A011389	05/03/46	P	16	YOLO COUNTY F C & W C DIST	0	250,000			10/1-6/30
2	A011349	03/26/46	L	69	U S FISH & WILDLIFE SERVICE (Sutter NWR)	5 C	0	4/15-10/1		
2	A011319	03/15/46	L	69	SUTTER EXTENSION WATER DISTRICT	3 C	0	5/1-10/31		
2	A011314	03/12/46	L	12	ZUMWALT MUTUAL WATER CO	11.7 C	0	4/1-10/15		
2	A011281	02/11/46	L	62	HAMMOND RESERVOIR IRRIGATION ASSN	15 C	0	4/1-10/10		
2	A011274	02/04/46	L	15	A & F BOEGER CORPORATION	15 C	0	4/15-10/15		
2	A011268	01/25/46	L	55	STEPHENS II	21 C	0	3/1-11/1		
2	A011242	12/26/45	L	12	HOLZAPFEL	22 C	0	3/15-11/1		
2	A011199	10/29/45	P	24	U S BUREAU OF RECLAMATION (Lake Berryessa)	0	1,000,000			11/1-5/31
2	A011194	10/26/45	L	55	MCCORMACK	7 C	0	4/15-10/15		
2	A011193	10/25/45	L	17	PACIFIC GAS & ELECTRIC COMPANY	0.25 C	0	1/1-12/31		
2	A011192	10/25/45	L	17	PACIFIC GAS & ELECTRIC COMPANY	0.18 C	0	1/1-12/31		
2	A011141	09/04/45	L	55	SPANOS	6.69 C	0	2/1-11/1		
2	A011105	07/13/45	L	49	OAKDALE I D & SOUTH SAN JOAQUIN I D	0	98,000			10/1-7/1
2	A011058	05/25/45	L	69	CHRISTENSON	15 C	0	4/1-10/1		
2	A011047	05/09/45	L	49	CHOWCHILLA WATER DISTRICT	11.4 C	0	2/1-11/1		
2	A011028	04/12/45	L	12	ZUMWALT MUTUAL WATER CO	96 C	0	4/1-10/15		
2	A011025	04/06/45	L	69	CREPS	2 C	0	5/1-10/1		
2	A011011	03/20/45	L	12	BALSDON RANCH	28 C	0	3/15-10/15		
2	A011003A	03/09/45	L	49	TRIANGLE T RANCH INCORPORATED	17.5 C	0	2/1-7/1		
2	A010978	02/10/45	L	49	OAKDALE I D & SOUTH SAN JOAQUIN I D	0	25,000			12/1-5/1
2	A010951	01/11/45	L	15	OJI BROTHERS, A CO-PARTNERSHIP	7.82 C	0	4/15-10/15		
2	A010905	10/26/44	L	69	DAVIS, HELEN	2.5 C	0	5/1-10/1		
3	A010872	08/30/44	L	49	OAKDALE I D & SOUTH SAN JOAQUIN I D	0	80,000			1/1-12/31
3	A010769	02/16/44	L	69	DAVIS, HELEN	0.55 C	0	4/1-11/1		
3	A010739	12/21/43	L	69	DANNA & DANNA INC	14 C	0	4/1-10/1		
3	A010658	06/16/43	L	15	SUTTER MUTUAL WATER COMPANY	7.52 C	0	3/1-10/31		
3	A010572	12/11/42	L	49	MERCED IRRIGATION DISTRICT	257 C	0	3/30-8/1		
3	A010529	08/22/42	L	69	SUTTER EXTENSION WATER DISTRICT	234 C	0	4/1-10/31		
3	A010417	03/25/42	L	15	WALLACE CONSTRUCTION INC	11 C	0	4/15-10/1		
3	A010407	03/17/42	L	61	BIG VALLEY MUTUAL WATER CO	0	2,865			10/1-6/1
3	A010363	01/16/42	L	15	WESTERMANN FARMS	9.4 C	0	2/1-12/1		
3	A010358	01/12/42	L	69	RUDD FARMING, INC	11.53 C	0	4/1-10/31		
3	A010240	07/17/41	L	59	WOODBRIDGE IRRIGATION DISTRICT	114.4 C	0	5/1-8/31	11/1-1/31	
3	A010221	06/13/41	L	70	SOUTH SUTTER WATER DISTRICT	250 C	40,000	3/1-6/30	9/1-10/31	10/1-6/30
3	A010215	06/03/41	L	55	BANDONI	8 C	0	1/1-12/31		
3	A010190	04/28/41	L	70	CAMP FAR WEST IRRIGATION DIST	0	5,000			5/1-6/1
3	A010068	11/20/40	L	55	CECCARINI	9.65 C	0	3/1-12/1		
3	A010030	10/08/40	L	69	GIUSTI	21.05 C	0	4/1-11/1		
3	A009997	09/06/40	L	49	TURLOCK I D & MODESTO I D	1200 C	0	2/1-11/30		

Table II-5 (cont.)
Major Central Valley Water Rights by Priority Group

Priority Group	Appl Id	File Date	Status	DSA	Last Name (Company)	Max Dir Div	Total Storage	Primary DD Season	Secondary DD Season	Storage Season
3	A009987	08/22/40	L	15	POUNDSTONE	7.1 C	0	4/1-10/15		
3	A009927	06/10/40	L	69	CORDUA IRRIGATION DISTRICT	40 C	0	4/1-11/1		
3	A009899	05/16/40	L	69	HALLWOOD IRRIGATION COMPANY	100 C	0	4/1-11/1		
3	A009886	04/29/40	L	17	PACIFIC GAS & ELECTRIC COMPANY	0.28 C	0	1/1-12/31		
3	A009834	02/21/40	L	49	BROCCHINI	3.89 C	0	3/1-12/1		
3	A009806	01/19/40	L	65	SWANSTON	25.4 C	0	4/1-10/1		
3	A009760	11/03/39	L	15	SUTTER MUTUAL WATER COMPANY	250 C	0	1/1-12/31		
3	A009737	09/22/39	L	15	PREMIERE FARMLAND PARTNERS III LTD PART	100 C	0	4/1-10/1		
3	A009666	07/17/39	L	49	OAKDALE IRRIGATION DISTRICT	1.68 C	0	5/1-11/1		
3	A009625	06/19/39	L	69	MCGOWAN RICE RANCH	15 C	0	4/1-10/1		
3	A009515	03/01/39	L	69	CHRISTENSON	15 C	0	3/1-10/1		
3	A009367	08/02/38	P	51	U S BUREAU OF RECLAMATION (Contra Costa Canal)	250 C	0	1/1-12/31		
3	A009366	08/02/38	P	51	U S BUREAU OF RECLAMATION (Contra Costa Canal)	200 C	0	1/1-12/31		
3	A009364	08/02/38	P	58	U S BUREAU OF RECLAMATION (Shasta)	9,000 C	1,303,000	1/1-12/31		10/1-6/30
3	A009363	08/02/38	P	58	U S BUREAU OF RECLAMATION (Shasta)	1,000 C	310,000	1/1-12/31		10/1-7/1
3	A009325	06/24/38	L	69	WESTROPE RANCHES, LTD	6.7 C	0	4/1-11/1		
3	A009320	06/14/38	L	55	LEONARDO	8.1 C	0	1/1-12/31		
3	A009182	11/20/37	L	55	PARADISE MUTUAL WATER COMPANY	6 C	0	11/1-4/1		
3	A009095	08/24/37	L	12	U S FISH & WILDLIFE SERVICE (Sacramento NWR)	8 C	0	1/1-12/31		
3	A009094	08/24/37	L	12	U S FISH & WILDLIFE SERVICE (Sacramento NWR)	17 C	0	1/1-12/31		
3	A009093	08/24/37	L	12	U S FISH & WILDLIFE SERVICE (Sacramento NWR)	23 C	0	1/1-12/31		
3	A009092	08/24/37	L	12	U S FISH & WILDLIFE SERVICE (Sacramento NWR)	12 C	0	1/1-12/31		
3	A008986	06/04/37	L	69	BROWNS VALLEY IRRIGATION DISTRICT	3 C	0	4/1-10/31		
3	A008931	04/01/37	L	15	ANDREOTTI	3 C	0	4/1-10/1		
3	A008892	02/03/37	L	49	OAKDALE IRRIGATION DISTRICT	4.54 C	0	5/1-11/1		
3	A008830	11/13/36	L	69	ROBERT LEAL & ELYSIAN FARMS, INC	12.54 C	0	4/1-11/1		
3	A008631	04/08/36	L	12	MAXWELL IRRIGATION DIST	63 C	0	3/15-11/1		
3	A008581	03/10/36	L	69	RUDD FARMING, INC	3 C	0	4/15-10/1		
3	A008496	11/14/35	L	17	GRAEAGLE LAND & WATER CO	4 C	0	1/1-12/31		
3	A008495	11/14/35	L	17	GRAEAGLE LAND & WATER CO	13.75 C	1,500	1/1-12/31		11/1-6/1
3	A008489A	11/08/35	L	55	MCCORMACK	1.65 C	0	1/1-12/31		
3	A008338	05/22/35	L	55	CHURCH OF JESUS CHRIST OF L D S (Byron Tract)	14 C	0	1/1-12/31		
3	A008238	02/11/35	L	49	EL NIDO IRRIGATION DISTRICT	0	5,066			11/1-4/15
3	A008213	01/15/35	L	15	M & T INCORPORATED	3 C	0	4/1-12/30		
3	A008188	12/01/34	L	15	M & T INCORPORATED	100 C	0	1/1-12/31		
3	A008187	12/01/34	L	69	PARROTT INVESTMENT COMPANY	100 C	0	1/1-12/31		
3	A008180	11/27/34	P	67	NEVADA IRRIGATION DIST	225 C	45,000	1/1-12/31		11/1-6/30
3	A008177	11/27/34	L	67	NEVADA IRRIGATION DIST	2.7 C	680	1/1-12/31		11/1-6/30
3	A007989	06/22/34	L	69	AGRIVEST CORP	17.82 C	0	5/1-10/1		
3	A007988	06/22/34	L	69	DAVIS, HELEN	18.75 C	0	3/1-10/31		
3	A007886	03/29/34	L	15	SUTTER MUTUAL WATER COMPANY	7.32 C	0	3/1-10/1		
3	A007860	03/05/34	L	61	SOUTH FORK IRRIGATION DISTRICT	0	17,000			11/1-4/15
3	A007641D	08/04/33	L	70	WILLIAM NICHOLAS TRUST	6.3 C	0	4/1-9/30		
3	A007641B	08/04/33	L	70	OSTERLI	9.6 C	0	4/1-9/30		
3	A007641A	08/04/33	L	70	WILLEY	26.4 C	0	4/1-9/30		
3	A007012	07/20/31	L	49	STEVINSON WATER DIST	73 C	0	3/1-11/1		
3	A006963	05/19/31	L	49	BROCCHINI	6.75 C	0	3/1-12/31		
3	A006807	09/27/30	L	49	EL NIDO IRRIGATION DISTRICT	3.8 C	0	11/1-4/15		
3	A006743	07/21/30	L	69	BUTTE SLOUGH IRRIGATION COMPANY	55 C	0	4/1-9/30		
4	A006711	06/25/30	L	49	TURLOCK I D & MODESTO I D	800 C	0	2/1-11/30		
4	A006702	06/16/30	L	67	NEVADA IRRIGATION DIST	20 C	0	4/15-9/30		
4	A006587	03/05/30	L	55	CHURCH OF JESUS CHRIST OF L D S (Byron Tract)	23.7 C	0	1/1-12/31		
4	A006582	03/04/30	L	69	WESTROPE RANCHES, LTD	34 C	0	4/1-10/31		
4	A006529	01/09/30	L	70	NEVADA IRRIGATION DIST	8 C	0	4/1-11/1		
4	A006522	01/03/30	L	59	STOCKTON EAST WATER DISTRICT	13.75 C	11,500	1/1-6/15		11/1-6/1
4	A006486	11/14/29	L	15	PREMIERE FARMLAND PARTNERS III LTD PART	55.5 C	0	4/1-10/1		
4	A006348	06/26/29	L	69	AGRIVEST CORP	12.82 C	0	4/1-10/1		
4	A006316	06/05/29	L	55	NUSS	9.25 C	0	3/1-12/1		
4	A006229	03/26/29	L	68	NEVADA IRRIGATION DIST	120 C	0	4/1-10/31		
4	A006130	12/04/28	L	39	PACIFIC GAS & ELECTRIC COMPANY	0	5,360			11/1-7/1
4	A006114	11/09/28	L	49	W P RODUNER CATTLE & FARMING CO	11 C	0	2/1-6/15		
4	A006111	11/05/28	L	49	STEVINSON WATER DIST	120 C	0	3/1-11/1		
4	A005997	07/27/28	L	17	PACIFIC GAS & ELECTRIC COMPANY	2.25 C	0	1/1-12/31		
4	A005996	07/27/28	L	17	PACIFIC GAS & ELECTRIC COMPANY	0.3 C	0	1/1-12/31		
4	A005916	05/16/28	L	15	POUNDSTONE	6.92 C	0	4/1-10/15		
4	A005807	01/20/28	L	59	WOODBRIDGE IRRIGATION DISTRICT	300 C	0	2/1-10/31		
4	A005754	11/12/27	L	69	AKIN RANCH, A PARTNERSHIP	13.7 C	0	4/1-10/1		
4	A005724	10/17/27	L	49	STEVINSON WATER DIST	163 C	0	3/1-11/1		
4	A005648D	07/30/27	P	29	CALAVERAS COUNTY WATER DIST	4 C	150	1/1-12/31		12/1-5/30
4	A005648B	07/30/27	P	59	JACKSON VALLEY IRRIGATION DIST	50 C	0			1/1-12/31
4	A005648A	07/30/27	L	49	OAKDALE I D & SOUTH SAN JOAQUIN I D	0	60,000			10/1-7/1
4	A005645A	07/30/27	L	25	U S BUREAU OF RECLAMATION (Jenkinson Lake)	32.5 C	14,800	11/1-4/14	6/16-6/30	11/1-6/30
4	A005644A	07/30/27	P	22	GEORGETOWN DIVIDE PUBLIC UTILTY DIST	100 C	20,000	11/1-8/1		11/1-8/1
4	A005638	07/30/27	P	46	U S BUREAU OF RECLAMATION (Friant)	5,000 C	1,210,000	2/1-10/31		11/1-8/1
4	A005632	07/30/27	P	67	YUBA COUNTY WATER AGENCY	1593 C	490,000	9/1-6/30		10/1-6/30
4	A005630	07/30/27	P	69	CA DEPT OF WATER RESOURCES (Oroville)	1,400 C	380,000	1/1-12/31		9/1-7/31

Table II-5 (cont.)
Major Central Valley Water Rights by Priority Group

Priority Group	Appl Id	File Date	Status	DSA	Last Name (Company)	Max Dir Div	Total Storage	Primary DD Season	Secondary DD Season	Storage Season
4	A005626	07/30/27	P	58	U S BUREAU OF RECLAMATION (Shasta)	8000 C	3,190,000	9/1-6/30		10/1-6/30
5	A005386	03/21/27	L	49	BANK OF AMERICA NT & SA	20 C	0	1/1-12/31		
5	A005359	02/17/27	L	65	CHURCH OF JESUS CHRIST OF L D S (Deseret Farms)	4.26 C	0	4/1-10/31		
5	A005316	12/24/26	L	49	MCMULLIN RECL DISTRICT #2075	48.75 C	0	1/1-12/31		
5	A005248	10/29/26	L	55	BANTA-CARBONA IRRIGATION DIST	25.14 C	0	2/1-11/30		
5	A005209B	09/15/26	L	55	CA DEPARTMENT OF CORRECTIONS	4.8 C	0	1/1-12/31		
5	A005209A	09/15/26	L	55	COSE	6.403 C	0	1/1-12/31		
5	A005193	09/08/26	P	67	NEVADA IRRIGATION DIST	0	50,000		1/1-6/30	10/1-6/30
5	A005155	08/13/26	L	55	ISLAND RECLAMATION DIST #2062	49.24 C	0	1/1-12/31		
5	A005153B	08/13/26	L	55	CA DEPARTMENT OF CORRECTIONS	5.1 C	0	1/1-12/31		
5	A005153A	08/13/26	L	55	COSE	7 C	0	1/1-12/31		
5	A005110	07/17/26	L	69	PARROTT INVESTMENT COMPANY	20 C	0	1/1-12/31		
5	A005109	07/17/26	L	15	M & T INCORPORATED	20 C	0	1/1-12/31		
5	A005092	07/10/26	L	55	GIANELLI	13.52 C	0	2/15-12/15		
5	A005047	06/08/26	L	55	GIKAS	16.68 C	0	4/1-11/1		
5	A004991	04/13/26	L	55	PESCADERO RECLAMATION DIST NO 2058	88.37 C	0	10/31-5/1		
5	A004959	03/15/26	L	69	CA DEPT OF FISH & GAME (Gray Lodge Wildlife Area)	15 C	0	4/1-12/15		
5	A004945	03/05/26	L	55	RECLAMATION DISTRICT #2039	78.6 C	0	1/1-12/31		
5	A004944	03/05/26	L	55	RECLAMATION DISTRICT #2038	71.74 C	0	1/1-12/31		
5	A004943	03/05/26	L	55	RECLAMATION DISTRICT #2037	85.45 C	0	1/1-12/31		
5	A004942	03/05/26	L	55	PALM TRACT COMPANY	30.8 C	0	1/1-12/31		
5	A004902	01/28/26	L	65	CHURCH OF JESUS CHRIST OF L D S (Deseret Farms)	8.12 C	0	4/1-10/31		
5	A004901	01/28/26	L	65	CHURCH OF JESUS CHRIST OF L D S (Deseret Farms)	22 C	0	4/1-10/31		
5	A004889	01/15/26	L	24	MAGOON ESTATE LIMITED	0	100			9/15-5/1
5	A004862	12/14/25	L	69	RANCHO ESQUON PARTNERS	18 C	0	4/1-11/30		
5	A004851	11/30/25	L	22	PACIFIC GAS & ELECTRIC COMPANY	0	300			12/1-6/30
5	A004743	08/22/25	L	70	CARMICHAEL WATER DISTRICT	10 C	0	5/1-11/1		
5	A004699	07/15/25	L	15	PREMIERE FARMLAND PARTNERS III LTD PART	2 C	0	4/15-9/30		
5	A004665	06/30/25	L	69	GORRILL LAND COMPANY	15 C	0	4/1-9/30		
5	A004664	06/30/25	L	69	GORRILL LAND COMPANY	21.7 C	0	4/1-9/15		
5	A004663	06/30/25	L	69	RANCHO ESQUON PARTNERS	13.8 C	0	4/1-9/15		
5	A004637	06/15/25	L	55	MORAN	12.44 C	0	3/15-12/1		
5	A004613	06/02/25	L	15	PREMIERE FARMLAND PARTNERS III LTD PART	0.5 C	0	4/1-10/31		
5	A004524	03/31/25	L	62	PACIFIC GAS & ELECTRIC COMPANY	1 C	0	1/1-12/31		
5	A004513	03/20/25	L	55	R & M RANCH, A PARTNERSHIP	12.72 C	0	4/1-12/31		
5	A004512	03/20/25	L	55	R & M RANCH, A PARTNERSHIP	5.79 C	0	4/1-12/31		
5	A004470	02/20/25	L	55	PARADISE MUTUAL WATER COMPANY	14.14 C	0	4/1-11/1		
5	A004460	02/14/25	L	49	RIVER JUNCTION RECL DIST NO 2064	72.29 C	0	3/1-10/1		
5	A004452	02/10/25	L	55	YAMADA BROTHERS	31.69 C	0	4/1-11/15		
5	A004432	01/27/25	L	55	DAL PORTO	16.13 C	0	3/1-11/1		
5	A004364	12/13/24	L	15	WALLACE CONSTRUCTION INC	7.25 C	0	3/1-11/1		
5	A004351	12/04/24	L	65	CHURCH OF JESUS CHRIST OF L D S (Deseret Farms)	0.37 C	0	5/1-10/1		
5	A004276	10/24/24	L	55	GRUNAUER JR	29.87 C	0	3/1-12/1		
5	A004275	10/24/24	L	55	OHLENDORF	17.5 C	0	3/1-12/1		
5	A004237	09/26/24	L	49	TWIN OAKS IRRIGATION COMPANY	21.91 C	0	2/15-10/15		
5	A004228	09/22/24	L	29	EAST BAY MUNICIPAL UTILITY DIST	310 C	209,950	1/1-12/31		10/1-7/15
5	A004124	07/31/24	L	65	SWEETWATER COMPANY	7.12 C	0	1/1-12/31		
5	A004123	07/31/24	L	65	SWEETWATER COMPANY	11.64 C	0	11/1-3/31		
5	A004101	07/18/24	L	55	RECLAMATION DISTRICT #999	12.8 C	0	5/1-10/1		
5	A004100	07/18/24	L	55	RECLAMATION DISTRICT #999	111.88 C	0	5/1-10/1		
5	A004099	07/18/24	L	55	RECLAMATION DISTRICT #999	4.82 C	0	5/1-10/1		
5	A004000	05/23/24	L	69	PACIFIC GAS & ELECTRIC COMPANY	2.5 C	0	9/1-6/1		
5	A003990	05/15/24	L	59	MCGURK	12 C	0	4/1-11/15		
5	A003914	03/21/24	L	55	MCCORMACK WILLIAMSON COMPANY	18.75 C	0	3/1-11/1		
5	A003843	02/11/24	L	70	CAMP FAR WEST IRRIGATION DIST	11.76 C	0	5/1-10/1		
5	A003795	01/10/24	L	17	PACIFIC GAS & ELECTRIC COMPANY	0.0009 C	0	1/1-12/31		
5	A003794	01/10/24	L	17	PACIFIC GAS & ELECTRIC COMPANY	0.5 C	0	1/1-12/31		
5	A003769	12/22/23	L	55	HASTINGS RECLAMATION DISTRICT 2060	45 C	0	3/1-11/1		
5	A003768	12/22/23	L	55	JERSEY ISLAND RECLAMATION DIST 830	40.22 C	0	3/1-11/1		
5	A003648	09/24/23	L	49	TURLOCK I D & MODESTO I D	100 C	0	3/1-10/31		
5	A003613	08/25/23	L	55	BRACK RECLAMATION DISTRICT #2033	49.38 C	0	3/1-11/1		
5	A003550	07/26/23	L	67	PACIFIC GAS & ELECTRIC COMPANY	0	26,662			11/1-6/30
5	A003423	05/17/23	L	65	CHURCH OF JESUS CHRIST OF L D S (Deseret Farms)	7.25 C	0	4/1-10/1		
5	A003353	04/12/23	L	61	HOT SPRINGS VALLEY IRRIGATION DIST	0	48,400			12/1-4/1
5	A003290A	03/12/23	L	15	OJI BROTHERS, A CO-PARTNERSHIP	9.39 C	0	4/1-10/31		
5	A003206	12/27/22	L	15	TAYLOR--SUTTER BYPASS PROPERTIES INC	20.3 C	0	4/1-10/15		
5	A003195	12/27/22	L	15	SUTTER MUTUAL WATER COMPANY	1.38 C	0	4/1-10/31		
5	A003091	10/19/22	L	49	OAKDALE IRRIGATION DISTRICT	0	10,754			10/1-7/1
5	A003069	10/07/22	L	24	MAGOON ESTATE LIMITED	5.35 C	1,100	4/1-6/15		9/15-5/1
5	A002979	08/12/22	P	17	OROVILLE-WYANDOTTE IRRIGATION DIST	185 C	0	1/1-12/31		
5	A002978	08/12/22	L	67	YUBA COUNTY WATER DISTRICT	21.4 C	0	4/1-10/15		
5	A002960	07/28/22	L	55	SPANOS	4.27 C	0	3/1-11/1		
5	A002959	07/28/22	L	55	DELTA FARMS R D #2044	39.18 C	0	3/1-11/1		
5	A002958	07/28/22	L	55	DELTA FARMS R D #2042	25.28 C	0	3/1-11/1		
5	A002957	07/28/22	L	55	DELTA FARMS R D #2041	13.62 C	0	3/1-11/1		
5	A002956	07/28/22	L	55	DELTA FARMS R D #2030	76.36 C	0	3/1-11/1		

Table II-5 (cont.)
Major Central Valley Water Rights by Priority Group

Priority Group	Appl Id	File Date	Status	DSA	Last Name (Company)	Max Dir Div	Total Storage	Primary DD Season	Secondary DD Season	Storage Season
5	A002955	07/28/22	L	55	DELTA FARMS R D #2029	42.83 C	0	3/1-11/1		
5	A002954	07/28/22	L	55	DELTA FARMS R D #2028	60.16 C	0	3/1-11/1		
5	A002953	07/28/22	L	55	DELTA FARMS R D #2027	61.66 C	0	3/1-11/1		
5	A002952	07/28/22	L	55	DELTA FARMS R D #2026	63.94 C	0	3/1-11/1		
5	A002951	07/28/22	L	55	DELTA FARMS R D #2025	49.25 C	0	3/1-11/1		
5	A002950	07/28/22	L	55	DELTA FARMS R D #2024	27 C	0	3/1-11/1		
5	A002949	07/28/22	L	55	FALLMAN	11.75 C	0	3/1-11/1		
6	A002948	07/28/22	L	55	RECLAMATION DISTRICT #756	71.56 C	0	3/1-11/1		
6	A002909	06/27/22	L	69	RANCHO ESQUON PARTNERS	20 C	0	4/1-6/15		
6	A002881	06/13/22	L	70	CAMP FAR WEST IRRIGATION DIST	0	5,000			3/1-5/1
6	A002805	03/24/22	L	69	RANCHO ESQUON PARTNERS	14 C	0	5/1-9/15		
6	A002778	03/06/22	P	17	OROVILLE-WYANDOTTE IRRIGATION DIST	50 C	25,000	4/1-6/1		10/1-6/1
6	A002777	03/06/22	L	69	GORRILL LAND COMPANY	15 C	0	4/1-9/15		
6	A002681A	12/08/21	L	55	MCCORMACK	0.82 C	0	5/1-9/15		
6	A002652B	11/22/21	P	68	NEVADA IRRIGATION DIST	0	65,000			11/30-6/1
6	A002652A	11/22/21	L	68	NEVADA IRRIGATION DIST	0	12,500			11/30-6/1
6	A002576	10/06/21	L	69	RANCHO ESQUON PARTNERS	6 C	0	4/15-9/15		
6	A002524	08/29/21	L	49	SOUTH SAN JOAQUIN IRRIGATION DISTRICT	0	36,000			9/1-5/1
6	A002318	04/22/21	L	55	RECLAMATION DISTRICT #2068	200 C	0	3/1-10/31		
6	A002286	03/31/21	L	55	PESCADERO RECLAMATION DIST NO 2058	88.37 C	0	5/1-10/31		
6	A002276	03/25/21	L	67	NEVADA IRRIGATION DIST	0	60,000			12/1-7/15
6	A002270	03/22/21	L	25	U S BUREAU OF RECLAMATION (Jenkinson Lake)	63.8 C	22,000	4/15-6/15		11/15-6/15
6	A002227	02/23/21	L	61	CROOK	0	5,250			12/1-6/1
6	A002212	02/17/21	L	11	U S BUREAU OF RECLAMATION (Stony Gorge Res)	0	50,200			11/1-5/1
6	A002186	02/01/21	L	17	PACIFIC GAS & ELECTRIC COMPANY	0	70,000			10/1-7/1
6	A002142	12/17/20	P	17	OROVILLE-WYANDOTTE IRRIGATION DIST	0	45,000			10/1-7/1
6	A002093	11/22/20	L	61	BIG VALLEY MUTUAL WATER CO	0	2,635			1/1-5/1
6	A001987	08/27/20	L	49	WEST STANISLAUS IRRIGATION DIST	262.15 C	0	1/1-12/31		
6	A001933	07/23/20	L	55	BANTA-CARBONA IRRIGATION DIST	179.69 C	0	2/1-11/30		
6	A001885	06/28/20	L	49	STEVINSON WATER DIST	34.4 C	0	3/1-10/31		
6	A001853	05/29/20	L	22	CITY OF SACRAMENTO	0.0111 C	0	6/15-9/15		
6	A001838	05/25/20	L	59	RANCHO MURIETA COMMUNITY SERVICES DIST	0.28 C	0	3/15-9/1		
6	A001772	04/09/20	L	15	SUTTER MUTUAL WATER COMPANY	0.31 C	0	5/1-10/1		
6	A001769	04/09/20	L	15	SUTTER MUTUAL WATER COMPANY	7.67 C	0	4/1-10/31		
6	A001765A	04/09/20	L	15	PELGER MUTUAL WATER COMPANY	4 C	0	4/1-10/31		
6	A001763	04/09/20	L	15	SUTTER MUTUAL WATER COMPANY	3 C	0	4/15-9/15		
6	A001758	04/09/20	L	15	SUTTER MUTUAL WATER COMPANY	1.5 C	0	4/1-10/31		
6	A001743	03/30/20	P	59	CITY OF SACRAMENTO	225 C	0	1/1-12/31		
6	A001739	03/25/20	L	17	THERMALITO IRRIGATION DISTRICT	0	8,200			12/1-4/1
6	A001725	03/15/20	L	12	KNAGGS	27.42 C	0	5/1-9/30		
6	A001699	03/02/20	L	69	GARDEN HIGHWAY MUTUAL WATER CO	39 C	0	4/15-10/31		
6	A001666	02/11/20	L	55	RECLAMATION DISTRICT #999	160 C	0	5/1-10/31		
6	A001659	02/09/20	L	12	OLIVE PERCY DAVIS TRUST	108.27 C	0	4/1-10/15		
6	A001656	02/05/20	L	69	RANCHO ESQUON PARTNERS	12 C	0	5/1-10/1		
6	A001651	02/02/20	P	17	OROVILLE-WYANDOTTE IRRIGATION DIST	200 C	109,012	4/1-7/1		10/1-7/1
6	A001624	01/14/20	L	12	GLENN COLUSA IRRIGATION DIST	32.01 C	0	4/15-11/1		
6	A001615	01/08/20	L	67	NEVADA IRRIGATION DIST	100 C	0	4/1-10/1		
6	A001614	01/08/20	P	67	NEVADA IRRIGATION DIST	0	60,000			1/1-12/31
6	A001589	12/26/19	L	12	RECLAMATION DISTRICT #108	255.25 C	0	5/1-10/1		
6	A001588	12/26/19	L	65	CONAWAY CONSERVANCY GROUP	14.75 C	0	4/1-9/30		
6	A001554	12/03/19	L	12	GLENN COLUSA IRRIGATION DIST	83.27 C	0	4/15-10/1		
6	A001476	10/10/19	L	49	EL SOLYO WATER DISTRICT	46.74 C	0	3/1-11/1		
6	A001465	09/26/19	P	46	U S BUREAU OF RECLAMATION (Friant)	3,000 C	500,000	2/1-10/31		11/1-8/1
6	A001413	08/27/19	L	70	NATOMAS CENTRAL MUTUAL WATER CO	120 C	0	5/1-10/1		
6	A001270	05/07/19	L	67	NEVADA IRRIGATION DIST	196 C	65,000	4/15-9/30		1/1-12/31
7	A001233	04/08/19	L	40	TURLOCK I D & MODESTO I D	0	325,000			10/1-8/1
7	A001224	03/26/19	L	49	MERCED IRRIGATION DISTRICT	1500 C	266,400	3/1-10/31		10/1-7/1
7	A001203	03/05/19	L	70	NATOMAS CENTRAL MUTUAL WATER CO	160 C	0	5/1-10/31		
7	A001199	03/01/19	L	65	CONAWAY CONSERVANCY GROUP	120 C	0	4/1-9/30		
7	A001195	02/26/19	L	49	CODDINGTON	35 C	0	3/1-10/15		
7	A001177	02/13/19	L	69	WALTON	13.66 C	0	4/1-10/31		
7	A001160	01/24/19	L	15	SUTTER MUTUAL WATER COMPANY	40.5 C	0	3/1-10/31		
7	A001150	12/31/18	L	65	SWEETWATER COMPANY	23 C	0	4/1-10/31		
7	A001081	09/20/18	L	49	OAKDALE I D & SOUTH SAN JOAQUIN I D	0	96,195			10/1-7/1
8	A001074B	09/10/18	L	15	MERIDIAN FARMS WATER COMPANY	138 C	0	3/1-11/1		
8	A001074A	09/10/18	L	15	PREMIERE FARMLAND PARTNERS III LTD PART	4 C	0	3/1-10/1		
8	A001056	08/22/18	L	70	NATOMAS CENTRAL MUTUAL WATER CO	38 C	0	3/15-10/15		
8	A001042	08/07/18	L	61	U S FISH & WILDLIFE SERVICE (Modoc NWR)	0	1,191			12/1-5/15
8	A000959	04/01/18	L	70	CAMP FAR WEST IRRIGATION DIST	13.24 C	0	4/1-10/1		
8	A000892	01/18/18	L	12	PROVIDENT IRRIGATION DIST	110 C	0	4/1-10/1		
8	A000880C	01/03/18	L	15	OJI BROTHERS, A CO-PARTNERSHIP	3.87 C	0	3/1-10/31		
8	A000880B	01/03/18	L	15	OJI BROTHERS, A CO-PARTNERSHIP	1.31 C	0	3/1-10/31		
8	A000880A	01/03/18	L	15	SUTTER MUTUAL WATER COMPANY	404.82 C	0	3/1-10/31		

Table II-5 (cont.)
Major Central Valley Water Rights by Priority Group

Priority Group	Appl Id	File Date	Status	DSA	Last Name (Company)	Max Dir Div	Total Storage	Primary DD Season	Secondary DD Season	Storage Season
8	A000879	01/03/18	L	15	SUTTER MUTUAL WATER COMPANY	25.25 C	0	3/1-10/31		
8	A000878	01/03/18	L	15	SUTTER MUTUAL WATER COMPANY	116.72 C	0	3/1-10/31		
8	A000784	09/14/17	L	58	IGO ONO COMMUNITY SERVICE DIST	0	4,800			12/1-4/1
8	A000771	09/05/17	L	15	YERXA	20 C	0	3/1-10/15		
8	A000770	09/05/17	L	12	PRINCETON-CODORA-GLENN IRRIGATION DIST	120 C	0	4/1-10/31		
8	A000763	08/27/17	L	12	RECLAMATION DISTRICT #108	500 C	0	2/1-10/31		
8	A000760	08/16/17	L	61	U S FISH & WILDLIFE SERVICE (Modoc NWR)	0	2,709			12/1-5/15
8	A000742	07/26/17	L	15	TISDALE IRRIGATION & DRAINAGE CO	29.25 C	0	3/15-10/15		
8	A000640	04/09/17	L	12	PROVIDENT IRRIGATION DIST	100 C	0	4/1-10/1		
8	A000581	02/01/17	L	15	SUTTER MUTUAL WATER COMPANY	45 C	0	3/1-10/31		
8	A000577	01/25/17	L	65	RIVER GARDEN FARMS COMPANY	35 C	0	4/1-10/15		
8	A000576	01/25/17	L	12	RECLAMATION DISTRICT #108	180 C	0	2/1-10/31		
8	A000575	01/25/17	L	65	RIVER GARDEN FARMS COMPANY	32 C	0	3/1-10/31		
8	A000534	12/13/16	L	70	NATOMAS CENTRAL MUTUAL WATER CO	42.18 C	0	4/1-10/1		
8	A000480	09/23/16	L	69	PLUMAS MUTUAL WATER COMPANY	37.3 C	0	4/1-11/1		
8	A000476	09/21/16	P	14	PARADISE IRRIGATION DIST	0	9,500			1/1-12/31
8	A000462	09/15/16	L	12	PROVIDENT IRRIGATION DIST	250 C	0	4/1-10/1		
8	A000421	08/03/16	L	61	S X RANCH INC	0	1,550			11/15-3/15
8	A000338	05/15/16	L	61	S X RANCH INC	0	550			5/1-10/1
8	A000301	04/17/16	L	55	WEST SIDE IRRIGATION DISTRICT	82.5 C	0	4/1-10/31		
8	A000244	02/03/16	L	12	PRINCETON-CODORA-GLENN IRRIGATION DIST	120 C	0	4/1-10/31		
8	A000234	01/19/16	P	46	U S BUREAU OF RECLAMATION (Friant)	3,000 C	500,000	2/1-10/31		11/1-8/1
8	A000138	09/18/15	L	70	CARMICHAEL WATER DISTRICT	15 C	0	1/1-12/31		
8	A000027	04/02/15	L	15	RECLAMATION DISTRICT #1004	166 C	0	4/1-10/15		
8	A000023	03/27/15	L	46	U S BUREAU OF RECLAMATION (Friant)	373 C	0	4/1-7/1		
8	A000018	03/03/15	L	12	GLENN COLUSA IRRIGATION DIST	110 C	0	3/1-11/1		

d. **Flow Alternative 4**. This alternative is the same as Alternative 3 except that most of the water deliveries through the Friant-Kern Canal, a component of the Friant Project, are assumed to be CVP exports subject to the watershed protection statute. Madera Canal deliveries, deliveries to areas adjacent to Millerton Lake, and deliveries within the Kings River watershed are treated as inbasin deliveries or deliveries to the area immediately adjacent to and conveniently served from the watershed of origin, and are assigned a priority based on the filing date of the permits for Millerton Lake. Because this alternative assumes that Friant-Kern is the only export facility subject to the watershed protection statutes in the San Joaquin Basin, the Friant-Kern component has a junior priority to all other water rights in the San Joaquin Basin. New Melones Reservoir is an inbasin project, and therefore, the USBR has no obligation under this alternative to release water from New Melones Reservoir to meet Delta or San Joaquin River flow objectives unless junior water right holders have ceased diversions. This alternative assumes, however, that the flow obligations of the Friant Project are met by releases from New Melones Reservoir.

A detailed description of the calculations used to determine water availability under this alternative is provided in Chapter IV section F of this report.

Table II-6

Major San Joaquin Basin Water Rights

Right Number	Appl Id	File Date	Status	DSA	Last Name (Company)	Max Dir Div	Total Storage	Primary DD Season	Secondary DD Season	Storage Season
1	A027586	11/17/82	P	49	U S FISH & WILDLIFE SERVICE (Merced NWR)	9 C	0	12/15-5/31		
2	A027546	09/30/82	P	49	NEW STONE WATER DISTRICT	55 C	0	1/1-12/31		
3	A026875	06/16/81	L	49	MENEFEE RIVER RANCH COMPANY	15.9 C	0	1/1-10/31		
4	A026757	03/19/81	P	49	MENEFEE HILL RANCH COMPANY	11 C	0	1/1-12/31		
5	A023031	04/18/68	P	49	GRAVELY FORD WATER DISTRICT	0	5,000			10/1-6/1
6	A022980	02/07/68	L	40	PINE MOUNTAIN LAKE ASSOCIATION	0	7,650			10/1-5/31
7	A019304	03/11/60	P	39	U S BUREAU OF RECLAMATION (New Melones Lk)	0	1,420,000			11/1-6/30
8	A019149	12/23/59	P	39	CALAVERAS COUNTY WATER DIST	365 C	79,200	3/1-7/1		11/1-6/30
9	A018774	06/08/59	L	49	EL NIDO IRRIGATION DISTRICT	0	5,000			11/1-4/15
10	A018733	05/22/59	P	45	U S BUREAU OF RECLAMATION (Hidden Lake)	0	74,000			12/1-4/30
11	A018714	05/15/59	P	43	U S BUREAU OF RECLAMATION (Eastman Lk)	0	143,000			11/1-5/31
12	A017966	01/29/58	L	49	MCMULLIN RECL DISTRICT #2075	8.22 C	0	4/1-4/30		
13	A016604	09/15/55	L	49	GALLO CATTLE COMPANY, A PARTNERSHIP	10 C	0	1/1-12/31		
14	A016329	04/21/55	L	49	JOSEPH GALLO FARMS	27 C	0	4/1-11/1	11/1-4/1	
15	A016186	12/23/54	L	41	MERCED IRRIGATION DISTRICT	0	605,000			10/1-7/1
16	A016136	11/15/54	L	49	MENEFEE RIVER RANCH COMPANY	3.2 C	0	2/1-6/15		
17	A015628	12/02/53	L	49	GALLO BEAR CREEK RANCH	38 C	0	4/1-10/31		
18	A014858A	06/16/52	P	39	U S BUREAU OF RECLAMATION (New Melones Lk)	0	980,000			11/1-6/30
19	A014858B	06/16/52	P	39	U S BUREAU OF RECLAMATION (New Melones Lk)	2250 C	0	11/1-6/30		
20	A014582	11/19/51	L	49	CA DEPT OF FISH & GAME (Los Banos Wildlife Area)	47 C	0	1/1-12/31		
21	A014127	01/16/51	L	40	TURLOCK I D & MODESTO I D	0	1,046,800			11/1-7/31
22	A013628	03/10/50	L	49	BROCCHINI	0.75 C	0	3/1-11/1		
23	A013541	01/13/50	L	49	WEAVER	45 C	0	11/1-7/1		
24	A013175	06/27/49	L	49	CHOWCHILLA WATER DISTRICT	90 C	50,000	3/1-7/31		11/1-5/1
25	A013091	05/13/49	P	39	CALAVERAS COUNTY WATER DIST	0	63,000			11/1-7/1
26	A013093A	05/13/49	P	39	CALAVERAS COUNTY WATER DIST	0	5,000			11/1-7/1
27	A012912	01/25/49	P	39	CALAVERAS COUNTY WATER DIST	7 C	0	11/1-7/1		
28	A012910	01/25/49	P	39	CALAVERAS COUNTY WATER DIST	400 C	0	3/1-7/1		
29	A012635	08/06/48	L	49	W P RODUNER CATTLE & FARMING CO	23.4 C	0	3/1-12/1		
30	A012490	04/28/48	L	49	OAKDALE I D & SOUTH SAN JOAQUIN I D	0	64,500			10/1-7/1
31	A011792B	03/24/47	P	39	CALAVERAS COUNTY WATER DIST	0	78,500			11/1-7/1
32	A011688	01/08/47	L	49	U S FISH & WILDLIFE SERVICE (San Luis NWR)	20.2 C	0	1/1-12/31		
33	A011687	01/08/47	L	49	U S FISH & WILDLIFE SERVICE (San Luis NWR)	40.9 C	0	1/1-12/31		
34	A011653	12/10/46	L	49	W P RODUNER CATTLE & FARMING CO	40 C	0	12/1-6/1		
35	A011105	07/13/45	L	49	OAKDALE I D & SOUTH SAN JOAQUIN I D	0	98,000			10/1-7/1
36	A011047	05/09/45	L	49	CHOWCHILLA WATER DISTRICT	11.4 C	0	2/1-11/1		
37	A011003A	03/09/45	L	49	TRIANGLE T RANCH INCORPORATED	17.5 C	0	2/1-7/1		
38	A010978	02/10/45	L	49	OAKDALE I D & SOUTH SAN JOAQUIN I D	0	25,000			12/1-5/1
39	A010872	08/30/44	L	49	OAKDALE I D & SOUTH SAN JOAQUIN I D	0	80,000			1/1-12/31
40	A010572	12/11/42	L	49	MERCED IRRIGATION DISTRICT	257 C	0	3/30-8/1		
41	A009997	09/06/40	L	49	TURLOCK I D & MODESTO I D	1200 C	0	2/1-11/30		
42	A009834	02/21/40	L	49	BROCCHINI	3.89 C	0	3/1-12/1		
43	A009666	07/17/39	L	49	OAKDALE IRRIGATION DIST	1.68 C	0	5/1-11/1		
44	A008892	02/03/37	L	49	OAKDALE IRRIGATION DIST	4.54 C	0	5/1-11/1		
45	A008238	02/11/35	L	49	EL NIDO IRRIGATION DISTRICT	0	5,066			11/1-4/15
46	A007012	07/20/31	L	49	STEVINSON WATER DIST	73 C	0	3/1-11/1		
47	A006963	05/19/31	L	49	BROCCHINI	6.75 C	0	3/1-12/31		
48	A006807	09/27/30	L	49	EL NIDO IRRIGATION DISTRICT	3.8 C	0	11/1-4/15		
49	A006711	06/25/30	L	49	TURLOCK I D & MODESTO I D	800 C	0	2/1-11/30		
50	A006130	12/04/28	L	39	PACIFIC GAS & ELECTRIC COMPANY	0	5,360			11/1-7/1
51	A006114	11/09/28	L	49	W P RODUNER CATTLE & FARMING CO	11 C	0	2/1-6/15		
52	A006111	11/05/28	L	49	STEVINSON WATER DIST	120 C	0	3/1-11/1		
53	A005724	10/17/27	L	49	STEVINSON WATER DIST	163 C	0	3/1-11/1		
54	A005638	07/30/27	P	46	U S BUREAU OF RECLAMATION (Friant)	5000 C	1,210,000	2/1-10/31		11/1-8/1
55	A005648A	07/30/27	L	49	OAKDALE I D & SOUTH SAN JOAQUIN I D	0	60,000			10/1-7/1
56	A005386	03/21/27	L	49	BANK OF AMERICA NT & SA	20 C	0	1/1-12/31		
57	A005316	12/24/26	L	49	MCMULLIN RECL DISTRICT #2075	48.75 C	0	1/1-12/31		
58	A004460	02/14/25	L	49	RIVER JUNCTION RECL DIST NO 2064	72.29 C	0	3/1-10/1		
59	A004237	09/26/24	L	49	TWIN OAKS IRRIGATION COMPANY	21.91 C	0	2/15-10/15		
60	A003648	09/24/23	L	49	TURLOCK I D & MODESTO I D	100 C	0	3/1-10/31		
61	A003091	10/19/22	L	49	OAKDALE IRRIGATION DIST	0	10,754			1/1-7/1
62	A002524	08/29/21	L	49	SOUTH SAN JOAQUIN IRRIGATION DIST	0	36,000			9/1-5/1
63	A001987	08/27/20	L	49	WEST STANISLAUS IRRIGATION DIST	262.15 C	0	1/1-12/31		
64	A001885	06/28/20	L	49	STEVINSON WATER DIST	34.4 C	0	3/1-10/31		
65	A001476	10/10/19	L	49	EL SOLYO WATER DISTRICT	46.74 C	0	3/1-11/1		
66	A001465	09/26/19	P	46	U S BUREAU OF RECLAMATION (Friant)	3000 C	500,000	2/1-10/31		11/1-8/1
67	A001233	04/08/19	L	40	TURLOCK I D & MODESTO I D	0	325,000			10/1-8/1
68	A001224	03/26/19	L	49	MERCED IRRIGATION DISTRICT	1500 C	266,400	3/1-10/31		10/1-7/1
69	A001195	02/26/19	L	49	CODDINGTON	35 C	0	3/1-10/15		
70	A001081	09/20/18	L	49	OAKDALE I D & SOUTH SAN JOAQUIN I D	0	96,195			10/1-7/1
71	A000234	01/19/16	P	46	U S BUREAU OF RECLAMATION (Friant)	3000 C	500,000	2/1-10/31		11/1-8/1
72	A000023	03/27/15	L	46	U S BUREAU OF RECLAMATION (Friant)	373 C	0	4/1-7/1		

e. <u>Flow Alternative 5</u>. Under this alternative, monthly average flow requirements are established for each of the major watersheds tributary to the Delta. For the Sacramento Basin and the eastside tributaries, the flow requirements are based on (1) the tributaries' monthly average unimpaired flow; (2) the monthly average inflow to the Delta required to meet the Sacramento Basin's share of the Delta outflow objectives; and (3) the quantity of water needed to satisfy depletions in the Delta. For the San Joaquin Basin, the flow requirements are based on (1) the tributaries' monthly average unimpaired flow; (2) the Vernalis flow objectives from February through June and in October; and (3) the monthly average inflow to the Delta required to meet the San Joaquin Basin's share of the Delta outflow objectives.

Responsibility to achieve the requirements is assigned to (1) water users with storage in foothill reservoirs that control downstream flow and (2) water users with upstream reservoirs that have a cumulative capacity of at least 100 TAF and who use water primarily for consumptive uses. This alternative specifically identifies releases from Friant Dam as a source of water to meet the Vernalis flow and Delta outflow objectives. The tributary systems and reservoirs identified in Tables II-7 and II-8 would be affected by this alternative. If there is insufficient water in the reservoirs both to achieve the flow requirements and to meet all other downstream flow obligations, users of water downstream of the reservoirs would receive reduced deliveries. The SWP and the CVP are responsible for ensuring that the objectives are achieved and may operate the tributaries they control as a unit to meet the objectives.

If more than one party is responsible for meeting the requirements on a tributary, responsibility is shared among the parties based on each party's percentage of the total depletion of the tributary. This situation occurs in the Yuba, Bear, and Tuolumne river watersheds. In these watersheds, responsibility is assigned among parties as shown in Table II-9. The depletions of agencies that export water from these watersheds are calculated as 100 percent of average amount exported. For a more detailed explanation of the methodology used for this alternative, see Chapter 4, section H, and Volume 2, Appendix 4.

Under Alternative 5, Putah Creek and Cache Creek are assigned no obligation to help meet the Sacramento Basin's share of the Delta outflow objectives and they are not included in Tables II-7 and II-8.

f. <u>Flow Alternative 6</u>. Flow Alternative 6 assigns responsibility for meeting the Bay/Delta Plan flow objectives solely to the SWP and the CVP. Vernalis flow objectives are the CVP's responsibility and are met by releases from the Delta-Mendota Canal through the Newman Wasteway into the San Joaquin River. Water is also released from the Newman Wasteway to meet the estimated consumptive use requirements of the South Delta Water Agency as shown in Table II-10 (Alex Hildebrand, personal communication). Vernalis salinity requirements are also the CVP's responsibility and are met by dilution water releases from New Melones Reservoir.

Table II-7
Allocation of Delta Flow Objectives by Watershed and by Water-Year Type (TAF)

Watershed	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Stony Creek												
W	0.7	3.7	6.7	11.5	29.6	22.3	9.6	7.2	4.5	1.0	0.1	0.2
AN	0.7	3.7	6.7	12.3	28.5	24.2	14.1	7.1	3.9	1.0	0.1	0.2
BN	0.7	3.9	7.2	10.3	20.2	22.9	9.2	6.2	3.6	0.9	0.1	0.2
D	0.7	3.8	7.1	10.2	13.7	12.0	8.1	4.6	3.2	0.8	0.1	0.2
C	0.8	3.9	7.3	9.1	17.1	12.1	8.0	4.1	3.4	0.8	0.1	0.2
Sacramento River												
W	120.0	133.2	117.9	150.9	373.7	374.1	194.0	188.6	237.8	275.5	248.6	177.1
AN	129.2	131.8	117.3	161.4	359.4	406.2	285.7	184.9	208.2	275.4	256.6	179.5
BN	128.2	137.3	126.0	135.2	255.2	384.2	185.0	162.4	191.0	247.8	236.5	175.8
D	128.9	136.3	125.0	134.4	173.0	200.9	164.7	118.9	171.0	219.9	221.8	177.0
C	138.4	138.1	128.3	119.8	216.0	203.5	161.3	107.4	179.4	201.4	214.3	178.4
Feather River												
W	43.0	56.9	52.3	63.4	164.6	195.7	136.3	174.6	178.4	139.0	97.3	59.8
AN	46.3	56.4	52.1	67.9	158.4	212.5	200.7	171.3	156.2	139.0	100.4	60.6
BN	45.9	58.7	55.9	56.8	112.4	201.0	129.9	150.4	143.3	125.1	92.5	59.4
D	46.1	58.3	55.4	56.5	76.2	105.1	115.7	110.2	128.3	111.0	86.8	59.8
C	49.6	59.1	56.9	50.4	95.2	106.5	113.3	99.4	134.6	101.7	83.8	60.3
Yuba River at Slate Creek												
W	1.3	2.6	2.6	3.2	8.2	9.4	6.9	10.7	10.9	4.8	2.1	1.3
AN	1.4	2.6	2.6	3.4	7.9	10.2	10.1	10.4	9.5	4.8	2.2	1.3
BN	1.3	2.7	2.8	2.9	5.6	9.6	6.5	9.2	8.7	4.3	2.0	1.3
D	1.4	2.7	2.8	2.9	3.8	5.0	5.8	6.7	7.8	3.8	1.9	1.3
C	1.5	2.7	2.9	2.6	4.8	5.1	5.7	6.1	8.2	3.5	1.8	1.3
Yuba River below Drum Canal												
W	8.7	18.3	18.3	22.3	57.0	64.9	47.5	73.9	75.5	33.4	14.9	9.0
AN	9.4	18.1	18.2	23.9	54.8	70.4	70.0	72.4	66.1	33.4	15.4	9.1
BN	9.3	18.8	19.5	20.0	38.9	66.6	45.3	63.6	60.6	30.0	14.1	9.0
D	9.4	18.7	19.4	19.9	26.4	34.8	40.3	46.6	54.3	26.6	13.3	9.0
C	10.1	19.0	19.9	17.7	32.9	35.3	39.5	42.1	56.9	24.4	12.8	9.1
Yuba River at Mouth												
W	13.3	27.8	27.8	33.9	86.7	98.7	72.3	112.4	114.9	50.8	22.6	13.7
AN	14.3	27.5	27.7	36.3	83.4	107.2	106.6	110.2	100.6	50.8	23.4	13.9
BN	14.2	28.7	29.7	30.4	59.2	101.4	69.0	96.8	92.3	45.7	21.5	13.6
D	14.3	28.5	29.5	30.2	40.2	53.0	61.4	70.9	82.6	40.5	20.2	13.7
C	15.4	28.9	30.3	27.0	50.1	53.7	60.2	64.0	86.7	37.1	19.5	13.8
Bear River Inflow to Camp Far West Reservoir												
W	0.7	1.5	2.0	2.7	7.1	6.5	2.7	1.6	1.1	0.8	0.4	0.3
AN	0.7	1.5	2.0	2.9	6.8	7.0	4.0	1.5	1.0	0.8	0.4	0.4
BN	0.7	1.6	2.1	2.4	4.9	6.6	2.6	1.3	0.9	0.7	0.4	0.3
D	0.7	1.5	2.1	2.4	3.3	3.5	2.3	1.0	0.8	0.7	0.4	0.3
C	0.8	1.6	2.2	2.1	4.1	3.5	2.2	0.9	0.8	0.6	0.4	0.3
Bear River at Mouth												
W	1.9	4.3	5.7	7.8	20.4	18.5	7.7	4.5	3.2	2.3	1.2	1.0
AN	2.0	4.3	5.7	8.3	19.6	20.1	11.4	4.4	2.8	2.3	1.2	1.0
BN	2.0	4.5	6.1	6.9	13.9	19.0	7.4	3.8	2.5	2.1	1.1	1.0
D	2.0	4.4	6.0	6.9	9.4	9.9	6.6	2.8	2.3	1.9	1.0	1.0
C	2.2	4.5	6.2	6.2	11.8	10.1	6.4	2.5	2.4	1.7	1.0	1.0

Table II-7 (Continued)

Allocation of Delta Flow Objectives by Watershed and by Water-Year Type (TAF)

Watershed	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
American River												
W	10.5	26.9	28.2	37.7	95.8	114.7	87.3	137.5	146.3	59.3	15.4	8.1
AN	11.3	26.6	28.0	40.4	92.2	124.6	128.5	134.8	128.1	59.2	15.9	8.2
BN	11.2	27.7	30.1	33.8	65.5	117.9	83.2	118.4	117.5	53.3	14.6	8.0
D	11.3	27.5	29.9	33.6	44.4	61.6	74.1	86.7	105.2	47.3	13.7	8.1
C	12.1	27.9	30.7	30.0	55.4	62.4	72.6	78.3	110.4	43.3	13.3	8.1
Cosumnes River												
W	0.7	2.9	4.3	7.0	19.2	22.2	12.9	11.7	8.2	3.3	1.2	0.5
AN	0.8	2.9	4.3	7.5	18.5	24.1	19.0	11.5	7.2	3.3	1.2	0.5
BN	0.8	3.0	4.6	6.3	13.1	22.8	12.3	10.1	6.6	3.0	1.1	0.5
D	0.8	3.0	4.5	6.3	8.9	11.9	10.9	7.4	5.9	2.6	1.1	0.5
C	0.8	3.0	4.7	5.6	11.1	12.1	10.7	6.7	6.2	2.4	1.0	0.5
Mokelumne River												
W	2.2	5.7	5.4	6.4	17.6	24.0	24.5	52.9	64.3	22.1	4.2	1.8
AN	2.4	5.6	5.4	6.8	17.0	26.1	36.0	51.8	56.3	22.1	4.4	1.8
BN	2.4	5.8	5.8	5.7	12.1	24.7	23.3	45.5	51.6	19.9	4.0	1.8
D	2.4	5.8	5.7	5.7	8.2	12.9	20.8	33.3	46.2	17.6	3.8	1.8
C	2.6	5.9	5.9	5.1	10.2	13.1	20.3	30.1	48.5	16.2	3.6	1.8
Calaveras River												
W	0.2	1.3	2.3	4.0	11.9	10.7	4.2	1.7	1.1	0.7	0.3	0.2
AN	0.2	1.3	2.3	4.3	11.4	11.6	6.2	1.6	1.0	0.7	0.3	0.2
BN	0.2	1.4	2.4	3.6	8.1	11.0	4.0	1.4	0.9	0.6	0.3	0.2
D	0.2	1.4	2.4	3.6	5.5	5.7	3.6	1.1	0.8	0.6	0.3	0.2
C	0.2	1.4	2.5	3.2	6.8	5.8	3.5	1.0	0.8	0.5	0.2	0.2
Stanislaus River												
W	21.4	7.3	7.3	10.0	38.5	44.6	81.0	72.9	31.9	25.6	6.6	2.7
AN	21.5	7.0	6.9	10.7	37.4	43.4	68.6	59.9	24.2	25.6	6.9	2.7
BN	21.4	7.2	7.2	8.9	24.1	28.8	51.1	44.3	16.5	20.8	6.0	2.7
D	22.4	7.1	6.9	8.9	24.8	28.7	41.7	33.9	13.7	16.0	5.3	2.7
C	18.4	7.1	6.9	7.9	9.4	12.5	27.3	23.0	6.8	12.8	5.0	2.7
Tuolumne River Inflow to Don Pedro Reservoir												
W	7.8	2.7	2.6	3.2	12.6	14.0	24.3	24.2	13.5	12.3	2.7	1.0
AN	7.8	2.6	2.5	3.4	12.3	13.6	20.6	19.9	10.2	12.3	2.9	1.0
BN	7.8	2.6	2.6	2.9	7.9	9.0	15.3	14.7	7.0	10.0	2.5	1.0
D	8.2	2.6	2.5	2.9	8.2	9.0	12.5	11.2	5.8	7.7	2.2	1.0
C	6.7	2.6	2.5	2.5	3.1	3.9	8.2	7.6	2.9	6.2	2.0	1.0
Tuolumne River at Mouth												
W	36.9	12.7	12.3	15.2	59.9	66.3	115.1	114.5	63.9	58.5	12.8	4.8
AN	37.1	12.1	11.8	16.3	58.3	64.5	97.4	94.2	48.5	58.5	13.5	4.8
BN	36.9	12.5	12.1	13.6	37.5	42.8	72.6	69.7	33.0	47.6	11.8	4.8
D	38.7	12.4	11.8	13.6	38.6	42.7	59.3	53.3	27.3	36.5	10.3	4.8
C	31.7	12.3	11.8	12.1	14.7	18.5	38.8	36.1	13.7	29.3	9.7	4.8
Merced River												
W	15.6	5.2	6.0	8.0	34.9	35.5	61.9	62.5	31.2	26.0	6.4	2.2
AN	15.7	5.0	5.7	8.6	33.9	34.6	52.4	51.4	23.7	26.0	6.8	2.2
BN	15.6	5.1	5.9	7.2	21.8	22.9	39.1	38.0	16.1	21.1	5.9	2.2
D	16.4	5.1	5.7	7.2	22.5	22.9	31.9	29.1	13.3	16.2	5.2	2.2
C	13.4	5.1	5.7	6.4	8.5	9.9	20.9	19.7	6.7	13.0	4.9	2.2

Table II-7 (Continued)

Allocation of Delta Flow Objectives by Watershed and by Water-Year Type (TAF)

Watershed	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Chowchilla River												
W	0.1	0.4	0.8	1.5	7.5	6.3	4.9	1.0	0.2	0.1	0.0	0.0
AN	0.1	0.4	0.8	1.6	7.3	6.1	4.1	0.8	0.2	0.1	0.0	0.0
BN	0.1	0.4	0.8	1.3	4.7	4.0	3.1	0.6	0.1	0.1	0.0	0.0
D	0.1	0.4	0.8	1.3	4.9	4.0	2.5	0.5	0.1	0.1	0.0	0.0
C	0.1	0.4	0.8	1.2	1.8	1.7	1.7	0.3	0.0	0.1	0.0	0.0
Fresno River												
W	0.9	0.5	0.8	1.4	7.1	6.9	6.6	2.4	0.9	0.9	0.2	0.2
AN	0.9	0.4	0.8	1.5	6.9	6.7	5.6	2.0	0.7	0.9	0.2	0.2
BN	0.9	0.4	0.8	1.2	4.4	4.5	4.2	1.5	0.5	0.7	0.2	0.2
D	1.0	0.4	0.8	1.2	4.6	4.4	3.4	1.1	0.4	0.5	0.2	0.2
C	0.8	0.4	0.8	1.1	1.7	1.9	2.2	0.8	0.2	0.4	0.2	0.2
San Joaquin River												
W	41.8	8.6	8.3	10.3	42.2	50.3	99.5	111.7	68.2	80.6	27.1	10.0
AN	42.0	8.2	7.9	11.0	41.0	49.0	84.3	91.8	51.7	80.6	28.6	10.0
BN	41.8	8.4	8.2	9.2	26.4	32.5	62.8	67.9	35.2	65.5	24.9	10.0
D	43.8	8.4	7.9	9.1	27.2	32.4	51.3	52.0	29.2	50.3	21.7	10.0
C	35.9	8.3	7.9	8.1	10.3	14.1	33.6	35.2	14.6	40.3	20.5	10.0

Note: The 40-30-30 and 60-20-20 indices should be used in applying these objectives to the Sacramento River and the San Joaquin River watersheds respecitively in October and February through June. For the remaining months, use the 40-30-30 index for both watersheds

Combined use of the SWP and the CVP points of diversion in the Delta is allowed under this alternative, limited only by the combined physical capacities of the pumping plants and by each project's annual authorized diversion. Combined use is allowed in order to reduce the water supply impact to the export contractors caused by the use of the export facilities to meet the Vernalis flow objectives.

g. **<u>Flow Alternative 7</u>**. This alternative is similar to Flow Alternative 2, with the following exceptions. Under this alternative, the flow objectives for the San Joaquin River at Vernalis are replaced by minimum flows at Vernalis identified in the document titled "Letter of Intent among Export Interests and San Joaquin River Interests to Resolve San Joaquin River Issues Related to Protection of Bay/Delta Environmental Resources" (SJRTG 1996). The following minimum flows at Vernalis are identified in the letter of intent: (1) a base flow in all years of 1,000 cfs for the period February 15 through May 31, and 1,000 cfs during the month of October and (2) a pulse flow, inclusive of the base flow, during the April through May period equivalent to 31 days of 2,000 cfs in critically dry years, 3,000 cfs in dry years, 4,000 cfs in below normal years, and 5,000 cfs in above normal and wet years.

Table II-8
Flow Alternative 5 Responsible Parties

Watershed	Reservoir	Entity Responsible for Remaining Deficiencies
Stony Creek	Black Butte Reservoir	Local USBR Contractors
Sacramento River	Shasta Lake	CVP Contractors
Feather River	Lake Oroville	SWP Contractors and Feather River Districts
Yuba River (lower)	New Bullards Bar	Yuba County Water Agency
Yuba River (upper)	Nevada ID reservoirs	Nevada ID and Oroville Wyandotte ID
Bear River (lower)	Camp Far West Lake	South Sutter WD and Camp Far West ID
Bear River (upper)	Combie, Rollins reservoirs	Nevada ID, PG&E
American River	Folsom Lake	CVP Contractors
Cosumnes River	Jenkinson Lake	Local USBR Contractors
Mokelumne River	Camanche and Pardee lakes	East Bay MUD
Calaveras River	New Hogan Reservoir	Local USBR Contractors
Stanislaus River	New Melones Reservoir	Local USBR Contractors
Tuolumne River (lower)	New Don Pedro Reservoir	Modesto and Turlock ID
Tuolumne River (upper)	Hetch Hetchy Complex	San Francisco PUC
Merced River	Lake McClure	Merced ID
Chowchilla River	Eastman Lake	Local USBR Contractors
Fresno River	Hensley Lake	Local USBR Contractors
San Joaquin River	Millerton Lake	Friant Project Contractors

Table II-9
Flow Alternative 5 Responsibility of Parties in the Yuba, Bear and Tuolumne River Watersheds

Agency	Percent of Total Depletion
Yuba River Watershed	
Yuba County WA	24.83
PG&E	56.95
Nevada ID	8.74
Oroville Wyandotte ID	9.48
Bear River Watershed	
Nevada ID	34.90
South Sutter WD	57.55
Camp Far West ID	7.55
Tuolumne River Watershed	
City of San Francisco	21.1
Modesto ID	20.6
Turlock ID	58.3

Table II-10
Flow Alternative 6
Consumptive Use Requirements Within the Southern Delta

Month	Flow (cfs)
June	1,120
July	1,400
August	1,330
September	1,060
November	760
December	720
January	570

Table II-11 identifies the water users in the San Joaquin Basin that will provide any required flows. The table also identifies the priority under which water will be released and the quantity of water under each priority. For example, Merced Irrigation District (Merced ID) is responsible for the first 25 TAF of required water in each year. Due to modeling complexities, the exchange contractors allocated share was not modeled. Obligations of Modesto/Turlock Irrigation Districts (MID/TID) and Merced ID are met directly by reoperation of New Don Pedro Reservoir and Lake McClure.

Minimum fishery flows below Goodwin Dam on the Stanislaus River are maintained at 156 TAF in critical water years, 181 TAF in dry and below normal years, and 206 TAF in above normal and wet years. Up to 49 TAF/year is delivered to CVP contractors on the Stanislaus River above Goodwin Dam in wet and above normal years. No deliveries are made in other water years. Water quality releases from New Melones Reservoir are capped at 70 TAF/year.

h. **Flow Alternative 8**. This alternative is similar to Flow Alternative 2 with the following exceptions. Under this alternative, the April 15 to May 15 pulse flow objectives for the San Joaquin River at Vernalis are replaced by the target flows in the San Joaquin River Agreement (SJRA) (SJRGA 1998). The San Joaquin River Group Authority (SJRGA) agencies[2] will release water to meet the target flows up to a maximum of 110 TAF. In addition, the export limits in the Bay/Delta Plan during the April to May Vernalis pulse flow are replaced by export limits in the SJRA. The modeling of Flow Alternative 8 in this EIR is in accordance with the SJRA, which is similar to, but not identical with, the Vernalis Adaptive Management Plan (VAMP).

2 San Joaquin River Group Authority member agencies are: (1) Modesto Irrigation District, (2) Turlock Irrigation District, (3) Merced Irrigation District, (4) Oakdale Irrigation District, (5) South San Joaquin Irrigation District, (6) the San Joaquin River Exchange Contractors Water Authority on behalf of its member agencies, (7) the Friant Water Users Authority on behalf of its member agencies, and (8) the City and County of San Francisco.

Table II-11
Flow Alternative 7
Responsible Parties in the San Joaquin Basin (Excluding the CVP)

Priority of Release	Responsible Party	Release (TAF)
1	Merced ID	25
2	Oakdale/South San Joaquin ID	10
3	San Joaquin River Exchange Contractors	5
4	Modesto/Turlock ID	10
5	Merced ID	6
6	Oakdale/South San Joaquin ID	2.4
7	San Joaquin River Exchange Contractors	1.2
8	Modesto/Turlock ID	2.4

The SJRA provides a mechanism for conducting the VAMP, an experiment to determine the relative impact of flow in the San Joaquin River and exports in the Delta on chinook salmon in the lower San Joaquin River. The VAMP is designed to assess the effect of export pumping at various specific river flows, which range from 3,200 cfs to 7,000 cfs.

SJRA Vernalis Target Flows. The Vernalis Target Flows are to be provided as specified in Table II-12, based upon "existing flow" at Vernalis. The existing flow is the forecasted San Joaquin River flow at Vernalis that would exist in the absence of the VAMP. It takes into account minimum instream flows required by the Davis-Grundsky Act and the Federal Energy Regulatory Commission (FERC), releases from New Melones Reservoir in accordance with the Interim Operation Plan, upstream flood releases required by the U.S. Army Corps of Engineers (USCOE), and local runoff.

The target flows may be modified depending on forecasts of water-year type, using the San Joaquin Valley "60-20-20" Water Year Hydrologic Classification. Modifications are accomplished by giving each water-year type a numeric indicator as shown in Table II-13. If the sum of the current year's indicator and the previous two years' indicators is four (4) or less, the parties to the SJRGA are not required to provide flows above the existing flow. If the sum of the current year's indicator and the previous year's indicator is seven (7) or greater, the parties must provide a target flow one level higher than they normally would provide (i.e., if the sum of the indicators is 7 and the existing flow is 2,050 cfs, the parties must provide a target flow of 4,450 cfs). This is referred to as a "double step."

Table II-12 Vernalis Target Flows	
Existing Flow (cfs)	Target Flow (cfs)
0-1,999	2,000
2,000-3,199	3,200
3,200-4,449	4,450
4,450-5,699	5,700
5,700-6,999	7,000
7,000 or greater	Existing Flow

There are two principal differences in the flow targets between the VAMP and the SJRA. First, the SJRA allows minimum flow targets of 2,000 cfs, but the minimum flow targets under the VAMP are 3,200 cfs. Second, the obligation of the parties to the SJRA to provide water to meet the flow targets is limited to 110 thousand acre feet (TAF) annually. The SJRA calls for the USBR to purchase water, if possible, to meet the VAMP flow targets under these two circumstances.

In addition to the VAMP flows, the SJRA requires flows at other times of the year from individual member agencies. Merced ID must provide 12,500 AF in October to attract returning adult salmon into the tributaries to spawn. Oakdale Irrigation District (OID) has agreed to make up to 15 TAF available annually to the USBR.

Table II-13 VAMP Hydrologic Classification	
SJR Basin Classification	Indicator
Wet	5
Above Normal	4
Below Normal	3
Dry	2
Critical	1

Export Limitations Under the VAMP. In addition to the Vernalis flow targets, the VAMP requires reduced levels of export pumping at the SWP and CVP Delta pumping plants. Combined exports during the pulse flow period are set as shown on Table II-14.

The proposed export limitations called for by the SJRA may be lifted in any year if the operations plan for the year is unacceptable to the parties. This might occur if export limitations substantially reduce the amount of water available to export contractors.

The SJRA is based on several assumptions. Some of these assumptions may have direct or indirect effects on conditions in the Delta. The agreement assumes that New Melones Reservoir will be operated consistent with the USBR's Interim Plan of Operation until a long-term plan of operation is developed. The SJRA further assumes that a barrier will be constructed at the head of Old River and operated in conjunction with the flows provided during the April/May pulse flow period.

Table II-14
SJRA Operational Structure

Export Limits	Vernalis Target Flows (cfs) 2,000	3,20	4,450	5,700	7,000
1,500	X	X	X		X
2,250				X	
3,000					X

2. Suisun Marsh Salinity Objectives Alternatives

Existing modeling indicates that the eastern marsh objectives (Stations C-2, S-64, and S-49) and two of the western marsh objectives (Stations S-21 and S-42) will be met, with very limited exceptions, through Suisun Marsh Salinity Control Gates (SMSCG) operation and implementation of the Delta outflow objectives. Therefore, the EIR will not consider separate alternatives to meet these objectives. The SWP and the CVP are responsible for achieving these objectives because they control the SMSCG operation. An exception to this responsibility may be made when: (1) hydrologic conditions are such that even with full-bore gate operation and implementation of the Delta outflow objectives, the Suisun Marsh objectives cannot be achieved; or (2) the SMSCG can not be operated full bore and/or it is physically modified in response to regulatory constraints. This section of the EIR will analyze methods to meet the remaining two western marsh objectives (Stations S-35 and S-97) (see Figure VII-1 for a map of station locations).

a. **Suisun Marsh Alternative 1 (No Project a)**. The SWP and the CVP are responsible for meeting D-1485 Suisun Marsh objectives, as modified by subsequent SWRCB actions. The SMSCG are in place and operated to meet the objectives to the extent possible. The DWR and the USBR take no further action to meet the D-1485 western marsh objectives.

b. **Suisun Marsh Alternative 2 (No Project b)**. The SWP and the CVP are responsible for meeting D-1485 Suisun Marsh objectives, as modified by subsequent SWRCB actions. The SMSCG are in place and operated to meet objectives to the extent possible. In addition, the DWR and the USBR prepare and implement a plan to achieve full compliance with the western marsh objectives. For purposes of analysis, the plan is assumed to consist of flow augmentation up to

80 cfs in Green Valley Creek with water from the North Bay Aqueduct and construction of a Cordelia-Goodyear Ditch and a Goodyear Slough Tide Gate, if necessary to fully comply with the objectives. A preliminary analysis of this action, along with 17 other actions, was undertaken by the DWR and reported in a document titled "Screening Alternative Actions and Describing Remaining Actions for the Proposed Western Suisun Marsh Salinity Control Project" (DWR 1993). The analysis of this alternative will be programmatic only. A subsequent EIR would have to be done by the DWR and the USBR before implementation of this alternative.

c. **Suisun Marsh Alternative 3**. The SWP and the CVP are responsible for meeting Bay/Delta Plan Suisun Marsh objectives. The SMSCG are in place and operated to meet the objectives to the extent possible. The DWR and the USBR take no further action to meet the Bay/Delta Plan western marsh objectives.

d. **Suisun Marsh Alternative 4**. The SWP and the CVP are responsible for meeting Bay/Delta Plan Suisun Marsh objectives. The SMSCG are in place and operated to meet objectives to the extent possible. In addition, the DWR and the USBR prepare and implement a plan to achieve full compliance with the western marsh objectives. For purposes of analysis, the plan is assumed to consist of flow augmentation up to 80 cfs in Green Valley Creek with water from the North Bay Aqueduct and construction of a Cordelia-Goodyear Ditch and a Goodyear Slough Tide Gate, if necessary, to fully comply with the objectives. A preliminary analysis of this action, along with 17 other actions, was undertaken by the DWR and reported in a document titled "Screening Alternative Actions and Describing Remaining Actions for the Proposed Western Suisun Marsh Salinity Control Project" (DWR 1993). The analysis of this alternative will be programmatic only. A subsequent EIR would have to be done by the DWR and the USBR before implementation of this alternative.

e. **Suisun Marsh Alternative 5**. Bay/Delta Plan outflow objectives are in effect and the SMSCG are in place and operated to meet objectives to the extent possible. The parties to the Suisun Marsh Preservation Agreement, Amendment III (DWR, USBR, DFG, and Suisun Resources Conservation District) take management actions to protect the beneficial uses of the managed wetlands of the western marsh, including: (1) meeting channel-water salinity objectives in Order WR 98-09 (2) converting S-35 and S-97 from compliance stations to monitoring stations, (3) September operation of the SMSCG, (4) a water manager program, (5) updating existing land management plans, (6) a joint-use facilities program, (7) establishment of a managed wetland improvement fund, (8) purchase of portable diversion pumps with fish screens, (9) purchase of portable drainage pumps, (10) the realignment and stabilization of the Roaring River distribution system turnouts, and (11) a drought response fund.

Under this alternative, the two western marsh numerical salinity objectives may not always be met, but the intent is to provide approximately equivalent protection to the managed wetlands. The Bay/Delta Plan states that the numerical objectives do not have to be achieved if a demonstration of equivalent or better protection is provided at the location.

f. **Suisun Marsh Alternative 6**. Multiple parties are responsible for full implementation of the 1995 Bay/Delta Plan western marsh objectives through flow augmentation in Green Valley Creek. Water comes from: (1) the Fairfield Treatment Plant, (2) Lake Frey and Lake Madigan, and (3) Lake Berryessa. Lake Berryessa water could be repaid to the Solano Project by the DWR and the USBR through the North Bay Aqueduct unless the Solano Project has an obligation to the Delta under the outflow alternatives in which case that obligation may be met through releases into the western marsh.

3. Salinity Control Alternatives in the San Joaquin Basin

Salinity control measures can be used to achieve the Vernalis salinity objectives either alone or in combination with dilution water releases. The Central Valley Regional Water Quality Control Board (CVRWQCB) is principally responsible for implementing salinity control measures in the San Joaquin Valley. The purpose of the analysis in Chapter VIII of this EIR is to review the existing salinity control actions in the San Joaquin Valley and to analyze any new salinity control alternatives that are not presently being implemented or analyzed in some other forum. The information will be used by the SWRCB to decide whether it should recommend further evaluation and implementation of salinity control measures to the CVRWQCB. An SWRCB decision to recommend evaluation of a salinity control measure by the CVRWQCB does not require CEQA compliance. Nonetheless, the salinity control alternatives are analyzed at the programmatic-level to provide information to the SWRCB and to interested parties.

Most of the possible salinity control actions are being implemented or evaluated in some forum by either the SWRCB, the CVRWQCB, the CALFED program, the DWR, or the USBR. An exception is controlled timing of wetland and tile drain discharges to maximize use of the assimilative capacity of the river. These alternatives are analyzed in this EIR. The SWRCB and the CVRWQCB have authority, under Water Code section 13260, et seq., to require persons discharging waste that could affect the quality of the state's waters to report on the discharges and to obtain waste discharge requirements before continuing the discharges.

a. **Salinity Control Alternative 1**. In this reference case, no salinity control action is taken. The wetland and agricultural tile drain discharges continue to flow into the San Joaquin River in accordance with present practices. Present practices are described in Chapter VIII. The Bay/Delta Plan objectives at Vernalis are achieved through the provision of dilution water from New Melones Reservoir.

b. **Salinity Control Alternative 2**. Under this alternative, the CVRWQCB implements a regulatory program or coordinates a cooperative program in which wetland operators within Grasslands Water District shift their releases during the months of March and April to the month of February. This program is implemented whenever the salinity objectives at Vernalis during the month of March are likely to be exceeded. The shift of all releases from the months of March and April to February can adversely affect the diversity of waterfowl food in the managed wetlands because different plants are favored depending on when the land is drained. In order to avoid this effect, 10 TAF of additional CVPIA water is provided in both March and April to maintain a flow through system in the wetlands.

c. Salinity Control Alternative 3. Under this alternative, the CVRWQCB implements a regulatory program or coordinates a cooperative program in which parties with tile drainage systems hold the drainage for limited periods when assimilative capacity is not available in the San Joaquin River. The parties would have flexibility in deciding how to temporarily cease their discharge. For illustrative purposes, the assumption in this programmatic analysis is that the parties store their drainage in laterals, submains, sumps, and the soil column for up to three months. To model this alternative, the following criteria are used to simplify the analysis. When the Vernalis salinity objective is exceeded in January, tile drainage is stored in January, February, and March and released in April and May. When the Vernalis salinity objective is exceeded in June, July, or August, tile drainage is also held in June, July, and August and released in September and October. Actual implementation of this alternative would probably be based on real-time data and operations.

d. Salinity Control Alternative 4 (Combination of Alternatives 2 and 3). This alternative combines the operational measures in both Alternative 2 and Alternative 3. The CVRWQCB implements a regulatory program or coordinates a cooperative program in which (1) wetland operators within Grasslands Water District shift their releases during the months of March and April to the month of February, and (2) parties discharging subsurface agricultural drainage hold the drainage when assimilative capacity is not available in the San Joaquin River.

4. Southern Delta Salinity Objectives Alternatives (Excluding Vernalis)

The Bay/Delta Plan establishes agricultural salinity objectives at three locations in the southern Delta (excluding Vernalis). Salinity at these locations is affected principally by the salinity of the San Joaquin River entering the Delta, local agricultural diversions and discharges, and SWP and CVP export operations.

Implementation of the Bay/Delta Plan objectives at Vernalis will change SWP and CVP export operations and will increase flows at Vernalis. These actions will affect salinity in the southern Delta. Also, the DWR and the USBR are evaluating alternatives to implement these salinity objectives, along with other program goals, through the Interim South Delta Program (ISDP). Therefore, the program of implementation for this objective will rely, in part, on construction and operation of the barriers proposed in the ISDP. This EIR will document the effect of barrier operation on flows in the southern Delta, salinity, and minimum water levels. Environmental effects of barrier construction and operation are analyzed in the DWR's draft EIR for the ISDP and are summarized in this report. Because the program of implementation for these objectives depends on construction of a project by another agency that is independently complying with CEQA, the analysis in this EIR is programmatic.

a. **Southern Delta Salinity Alternative 1 (No Project)**. The SWP and the CVP are responsible for meeting D-1485 flow objectives. Existing temporary barriers in the southern Delta are installed and operated to improve salinity conditions in the south Delta. No further action is taken to implement the south Delta salinity objectives.

b. **Southern Delta Salinity Alternative 2**. The Bay/Delta Plan flow objectives are met by implementation of one of the flow objective alternatives. Existing temporary barriers in the southern Delta are installed and operated by the SWP and the CVP to improve salinity conditions in the southern Delta. No further action is taken to implement the southern Delta salinity objectives.

c. **Southern Delta Salinity Alternative 3**. The Bay/Delta Plan flow objectives are met by implementation of one of the flow objective alternatives. The barriers proposed in the ISDP are constructed and operated by the SWP and the CVP to achieve the southern Delta salinity objectives to the extent feasible.

5. Dissolved Oxygen Objective Alternatives

The factors affecting dissolved oxygen concentrations in the San Joaquin River between Stockton and Turner Cut that can be controlled are flow and biochemical oxygen demand (BOD) from point and nonpoint sources. Implementation of the Bay/Delta Plan flow and salinity objectives at Vernalis will affect dissolved oxygen concentrations. Further flow augmentation in the San Joaquin River at Vernalis to meet the dissolved oxygen objective is not proposed as an alternative; however, the sensitivity of the flow/dissolved oxygen relationship is evaluated.

Flow augmentation in the San Joaquin River in the vicinity of Stockton will occur if southern Delta channel barriers are constructed through the ISDP. Therefore, the program of implementation for this objective will rely both on flow augmentation through construction and operation of the barriers proposed in the ISDP and on enhanced wastewater treatment at the Stockton Treatment Plan to reduce the BOD loading. The analysis of these alternatives is programmatic because their implementation requires further action by other parties. Environmental effects of barrier construction and operation are analyzed in the DWR's draft EIR for the ISDP, and they are summarized in this report. The analysis of operations to implement dissolved oxygen objectives in the 1995 Bay/Delta Plan is not included in the ISDP draft EIR and has not been evaluated previously. Environmental effects of enhanced wastewater treatment must be analyzed by the City of Stockton and will be reviewed through the CVRWQCB's permitting process. Anticipated effects are summarized in this report.

a. **Dissolved Oxygen Alternative 1 (No Project)**. The SWP and the CVP are responsible for meeting D-1485 flow objectives. The quantity and quality of effluent from the Stockton Wastewater Treatment Plant (WWTP) are at present levels. The head of Old River temporary barrier is installed in September, October, and November. No further water right action is taken to implement the dissolved oxygen objective. This is the existing condition.

b. **<u>Dissolved Oxygen Alternative 2</u>**. The 1995 Bay/Delta Plan flow objectives are met by implementation of one of the flow alternatives. Effluent quantity and quality from the Stockton WWTP are at present levels. The head of Old River temporary barrier is installed in September, October, and November. No further action is taken to implement the dissolved oxygen objective.

c. **<u>Dissolved Oxygen Alternative 3</u>**. The 1995 Bay/Delta Plan flow objectives are met by implementation of one of the flow alternatives. Effluent quantity and quality from the Stockton WWTP are at present levels. The permanent barriers proposed in the ISDP are constructed and operated and the barrier at the head of Old River is closed in September, October, and November.

d. **<u>Dissolved Oxygen Alternative 4</u>**. The 1995 Bay/Delta Plan flow objectives are met by implementation of one of the flow alternatives. The permanent barriers proposed in the ISDP are constructed and operated and the barrier at the head of Old River is closed in September, October, and November. The discharge quantity from the Stockton treatment plant is at the present levels; however, the effluent meets CBOD and ammonia effluent limits as specified in the NPDES permit issued by the CVRWQCB and shown in Table X-6. Stockton complies with the permit limits by constructing enhanced treatment facilities.

6. Combined Use of SWP and CVP Points of Diversion Alternatives

Combined use of SWP and CVP points of diversion was first authorized in 1978 in condition 3 of D-1485. Condition 3 allowed the USBR to use SWP pumps to recover, later in the year, water that could not be exported during May and June because of operational constraints to minimize entrainment of striped bass. On December 7, 1981, the USBR filed a petition requesting that the SWRCB add the DWR's Banks Pumping Plant as a point of diversion and rediversion under the USBR's permits. This request was repeated in a subsequent petition filed on September 24, 1985. The SWRCB notified the USBR that it would defer action on the USBR's request until a Bay/Delta water rights hearing was held. The SWRCB approved short-term combined use of the points of diversion of the SWP and the CVP through Water Right Orders WR 95-6 and WR 98-09, subject to the condition that such use must benefit fish and wildlife and not result in increased average exports.

The following alternatives for combined use of SWP and CVP points of diversion (Joint POD) are considered. In all of the alternatives, the assumption is made that the SWP and the CVP are exclusively responsible for meeting the objectives in the Bay/Delta Plan unless specifically stated otherwise. For Alternatives 1 through 6 and 9, the assumption is made that temporary barriers are installed and operated in the southern Delta.

a. **<u>Joint POD Alternative 1 (No Project)</u>**. D-1485 objectives are in effect. The CVP is authorized to use the SWP's point of diversion in the Delta only to make up deficiencies caused by export restrictions in D-1485 in May and June.

b. **<u>Joint POD Alternative 2</u>**. The Bay/Delta Plan objectives are in effect. Combined use of points of diversion is not authorized.

c. **<u>Joint POD Alternative 3</u>**. The Bay/Delta Plan objectives are in effect. The CVP is authorized to use the SWP's point of diversion in the Delta to deliver up to 129 TAF of contract water to the Cross Valley Canal, Musco Olive, Tracy Golf Course, and the VA cemetery. Combined use of the SWP and the CVP points of diversion in the Delta is limited by the terms and conditions in SWP and CVP water right permits that specify permitted diversion rates of the projects in the Delta. USCOE Public Notice 5820-A (PN 5820-A), as amended further limits use of the SWP point of diversion.

The SWP and the CVP water right permits include instantaneous diversion and rediversion rates (10,350 cfs for the SWP at Banks Pumping Plant and 4,600 cfs at Tracy Pumping Plant) as well as rates of diversion to storage in San Luis Reservoir (10,350 cfs for the SWP and 4,200 cfs for the CVP). The SWP's Banks Pumping Plant has capacity to pump up to 10,350 cfs. However, PN 5820-A limits daily diversions into Clifton Court Forebay to 13,870 acre-feet and limits 3-day average diversions to 13,250 AF/day, except in winter when San Joaquin River flow is high. From December 15 to March 15, DWR may divert an additional amount equal to one-third of the total flow at Vernalis when flows at Vernalis exceed 1,000 cfs. The conditions of PN 5820-A effectively limit the operating capacity of Banks Pumping Plant to 6,680 cfs much of the time.

d. **<u>Joint POD Alternative 4</u>**. The Bay/Delta Plan objectives are in effect. Combined use of the SWP and the CVP points of diversion in the Delta is authorized for the purposes identified in Alternative 3. Additionally, the Joint POD is authorized if the purpose is to provide a net benefit to fish and wildlife. Any pumping losses incurred by either of the projects as a result of reductions to benefit fish will be allowed to be made up within 12 months utilizing either or both pumping plants. Combined use of the SWP and the CVP points of diversion in the Delta is limited by the terms and conditions in SWP and CVP water right permits that specify permitted diversion rates of the projects in the Delta. Use of the SWP point of diversion is further limited by PN 5820-A, as amended.

e. **<u>Joint POD Alternative 5</u>**. This alternative builds on Alternative 3, however, the use of water authorized under the Joint POD is not restricted to deliveries to the entities specified in that alternative. The Bay/Delta Plan objectives are in effect. Combined use of the SWP and the CVP points of diversion in the Delta is limited by the terms and conditions in SWP and CVP water right permits that specify permitted diversion rates of the projects in the Delta. Use of the SWP point of diversion is further limited by PN 5820-A, as amended.

f. **<u>Joint POD Alternative 6</u>**. The Bay/Delta Plan objectives are in effect except that minimum San Joaquin River flows at Vernalis are as specified in the Letter of Intent, as in Flow Alternative 7 (see section E.1.g., above). Combined use of the SWP and the CVP points of diversion in the Delta is limited by the terms and conditions in SWP and CVP water right permits that specify diversion rates of the projects in the Delta. Use of the SWP point of diversion is further limited by PN 5820-A, as amended.

g. **Joint POD Alternative 7**. This alternative builds on Alternative 5. The Bay/Delta Plan objectives are in effect. The purpose of use of the Joint POD is not restricted. Combined use of the SWP and the CVP points of diversion in the Delta is limited by the permitted diversion rates of the projects in the Delta. The SWP and the CVP permits include instantaneous diversion and rediversion rates as well as rates of diversion to storage in San Luis Reservoir. However, the restrictions imposed by PN 5820-A are not in effect. The modeling of the alternative assumes that permanent barriers as proposed in the ISDP are installed and operating in the southern Delta.

h. **Joint POD Alternative 8**. This alternative builds on Alternative 7. The Bay/Delta Plan objectives are in effect. Combined use of the SWP and the CVP points of diversion in the Delta is limited only by the combined physical capacities of the pumping plants and by each project's annual authorized diversion.

i. **Joint POD Alternative 9**. The alternative has the same regulatory conditions as Flow Alternative 8 except that combined use of SWP and CVP points of diversion in the Delta is authorized. Combined use of the SWP and the CVP points of diversion in the Delta is limited by the permitted diversion rates of the projects in the Delta. Combined use of points of diversion is further limited by PN 5820-A, as amended. This alternative assumes that temporary barriers are installed and operated in the southern Delta. The alternative further assumes that New Melones Reservoir is operated in accordance with the Interim Operations Plan.

Literature Cited in Chapter II

DWR. 1993. Screening Alternative Actions and Describing Remaining Actions for the Proposed Western Suisun Marsh Salinity Control Project. DWR and USBR. State Clearinghouse Number 90030973. May 1993. 100 pp. Plus appendices.

Grober, Leslie F. 1996. Sources and Circulation of Salt in the San Joaquin River Basin. CVRWQCB. Proceedings of the North American Border and Environmental Congress, ASCE Conference. June 24-26, 1996. Anaheim, California. (Proceedings on CDROM).

SJRGA. 1998. The San Joaquin River Agreement. San Joaquin River Group Authority.

SJRTG. 1996. Letter of Intent Among Export Interests and San Joaquin River Interests to Resolve San Joaquin River Issues Related to Protection of Bay-Delta Environmental Resources. Prepared by the San Joaquin River Tributaries Group. 10 pp.

WPRS. 1980. Report on the Effects of the CVP upon the Southern Delta Water Supply Sacramento-San Joaquin River Delta, California. Prepared Jointly by the Water and Power Resources Service and the South Delta Water Agency. June 1980. 179 pp. plus appendices.

SMPA. 1998. Draft Amendment Number 3 to the Suisun Marsh Preservation Agreement among the USBR, DWR, DFG and Suisun Resource Conservation District. June 20, 1998. 37 pp. plus attachments.

Personal Communication

Hildebrand, Alex. South Delta Water Agency, Stockton, CA. December 19, 1996. Personal Communication.

CHAPTER III. ENVIRONMENTAL SETTING

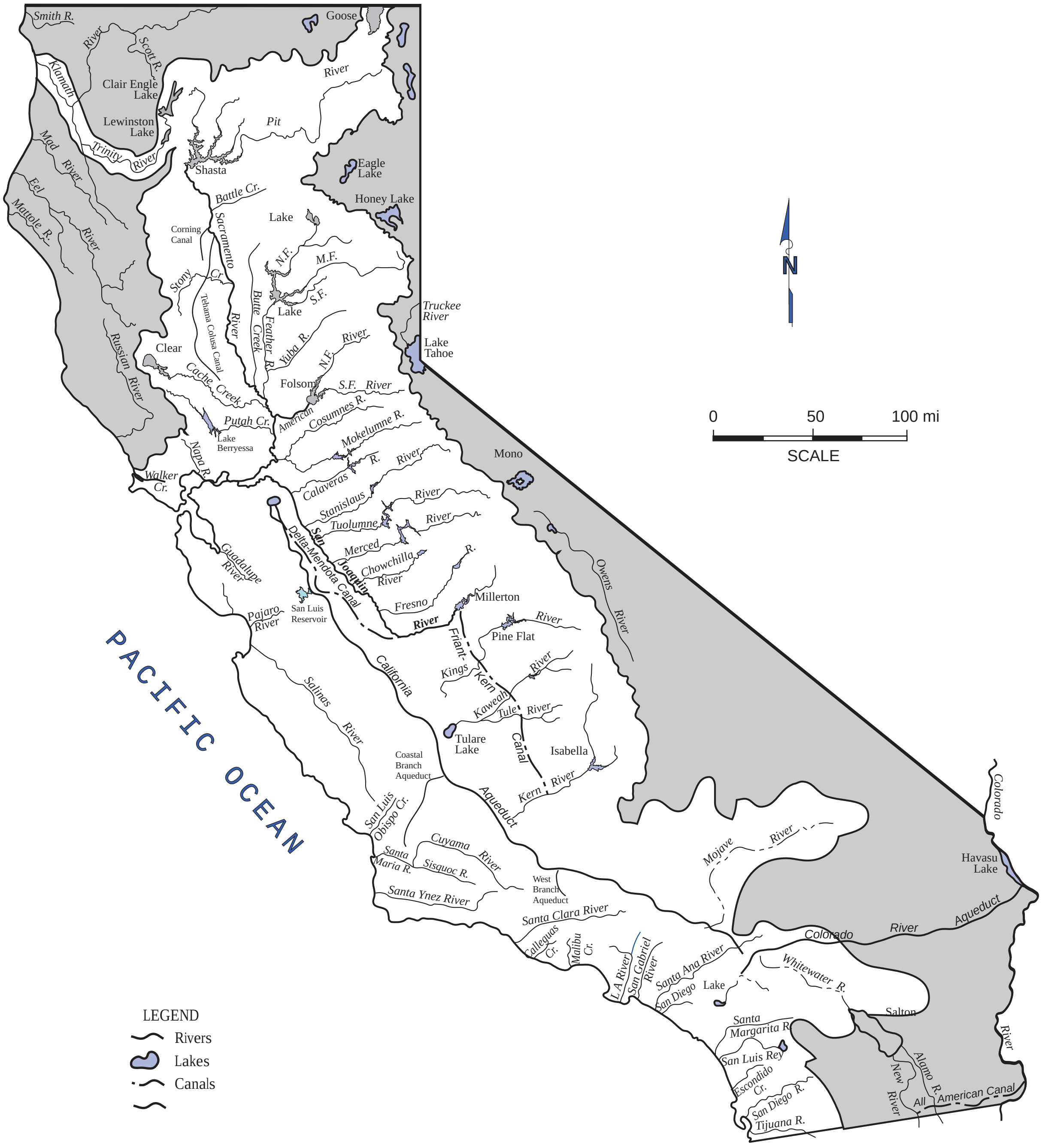
This chapter describes the environmental setting of the proposed project. The environmental setting is defined as the physical conditions that exist within the area which will be affected either directly or indirectly by the proposed project. (Public Resources Code section 15360). The purpose of the Environmental Setting chapter is to provide a baseline of the existing environmental conditions by which to determine the environmental impacts of the proposed action. The environmental setting for this project was described in Chapter IV of the ER (SWRCB 1995). The discussion here details the upstream areas and updates the discussion in Chapter IV of the ER.

Due to the significant interdependence of water supplies and uses in California, implementing the objectives for the Bay/Delta Estuary is relevant not only to the Estuary itself but also to a large portion of the State. The effects of the SWRCB's water right decision may be seen in the areas that are the source of the water for the Bay/Delta Estuary, as well as in the service areas to where water from the Central Valley is exported. The source areas include the Trinity River Basin, Sacramento River Basin, San Joaquin River Basin, the Sacramento-San Joaquin Delta, and Suisun Marsh. The export areas include the San Francisco Bay Region, the portion of the San Joaquin River Basin served by the Delta-Mendota Canal, the Tulare Lake Basin, Central Coast Region, and the portion of Southern California served by the State Water Project. The project area is shown in Figure III-1.

The discussion of the environmental setting is organized essentially by the major hydrologic regions as defined in DWR Bulletin 160-93, The California Water Plan Update (DWR 1994). The Trinity River Basin is part of the North Coast Region; however, it is unlikely that any effects of the SWRCB decision will be seen in the North Coast Region outside of the Trinity River Basin. The project area in Southern California includes the South Coast Region, as well as the Antelope Valley and Mojave areas of the South Lahontan Region and the Coachella area of the Colorado River Region. These areas were combined to represent the SWP Southern California service area.

The factors used to describe the existing environmental conditions in the affected areas include: geography and climate, population, land use and economy, water supply (including hydrology and water quality), water use, vegetation, fish, wildlife, and recreation. The source of much of the information on geography and climate, population, land use and economy, water supply, and water use is DWR Bulletin 160-93. Much of the information on hydrology, water quality, vegetation, fish, and wildlife is taken from the State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR 1996). The discussion of surface water development draws from Bulletin 160-93 (DWR 1994) and the Central Valley Project Improvement Act, Draft Programmatic Environmental Impact Statement, Technical Appendix, Volume 2, Surface Water Supplies and Facilities Operations (USBR 1997a). Information on recreation in the Sacramento River, San Joaquin River, and Tulare Lake regions comes from

Figure III-1
Map of Affected Area
(shaded area excluded)



the Central Valley Project Improvement Act, Draft Programmatic Environmental Impact Statement, Technical Appendix, Volume 4, Recreation (USBR 1997b). The discussion of aquatic resources is based in large part on the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes (USFWS 1996).

This chapter begins with an overview of the Central Valley, including the development of surface water supplies, and the aquatic resources and recreational opportunities found therein. The Central Valley overview includes a discussion of the physical components of the Central Valley Project (CVP), State Water Project (SWP), and local water supply projects. Detailed descriptions of several anadromous fish and other special-status species found in the Bay/Delta Estuary and tributary streams are also presented in the overview.

A. CENTRAL VALLEY BASIN OVERVIEW

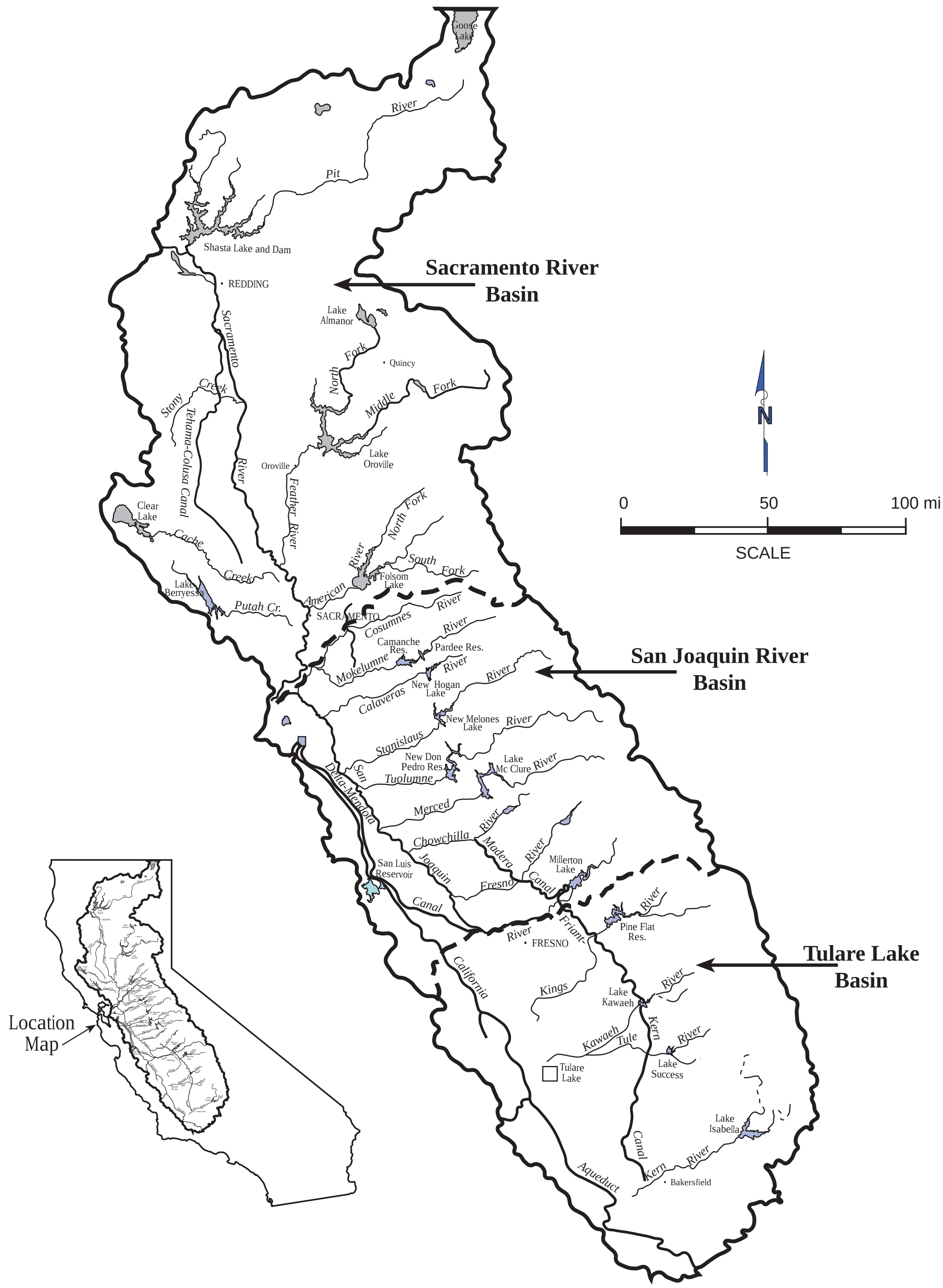
The Central Valley basin of California (Figure III-2) is comprised of the 450-mile long Central Valley and the surrounding upland and mountain areas which drain into it. The basin encompasses about 60,000 square miles and makes up about 40 percent of California. The basin is entirely surrounded by mountains except for a narrow gap on the western edge at the Carquinez Strait.

Stream flow in the Central Valley is chiefly derived from runoff from the Cascade and Sierra Nevada mountains, with minor amounts from the Coast Ranges. Precipitation totals vary annually with about four-fifths of the total occurring between the last of October and the first of April. Snow storage in the high Sierra delays the runoff from that area until the snow melts in April, May, and June. Normally, half of the annual runoff occurs in these months.

The Central Valley basin is divided into the Sacramento Valley on the north and the San Joaquin Valley on the south. The Sacramento Valley is part of the Sacramento River Basin. The San Joaquin Valley spans two sub-basins: the San Joaquin River Basin and the Tulare Lake Basin. These two basins are distinct drainage areas separated by a low divide formed by coalescing alluvial fans. The divide lies between the San Joaquin River to the north and Kings River to the south. Because the rivers and streams in the Tulare Lake Basin do not normally contribute runoff to the Delta, the environmental setting of the Tulare Lake Basin will be discussed as a separate region. The area in the center of the Central Valley where the Sacramento and San Joaquin valleys merge coincides with a break in the coastal mountains which border the basin on the west side. Here the Sacramento and San Joaquin rivers converge in the Bay/Delta Estuary, flow through Suisun Bay and Carquinez Strait into San Francisco Bay, and out the Golden Gate to the Pacific Ocean.

Water is used in the Central Valley basin primarily for growing crops. Water is used to a lesser extent to meet urban, industrial, environmental, and instream needs, and for other uses. Local irrigation districts, municipal utility districts, county agencies, private companies or corporations, and State and federal agencies have developed surface water supply projects. Flood control, water

Figure III-2
Central Valley Basin



storage, and diversion works exist on all major streams in the basin, altering the natural flow patterns. These projects also produce hydroelectric power, enhance recreation opportunities, and serve other purposes. The major surface water supply developments will be discussed in the following sections.

Groundwater is also used extensively in the Central Valley. The regional aquifer system beneath the Central Valley is contained in semi-consolidated to unconsolidated marine and continental deposits. Fresh water in these deposits extends to about 1,100 feet below land surface in the Sacramento Valley and to about 1,500 feet below land surface in the San Joaquin Valley. The storage capacity of the Central Valley regional aquifer system has been estimated by DWR to be 64 million acre-feet and the perennial yield to be 5.7 million acre-feet. Overdraft conditions exist throughout much of the aquifer system in the San Joaquin Valley. In the Sacramento Valley, overdraft conditions are limited to a few localized areas.

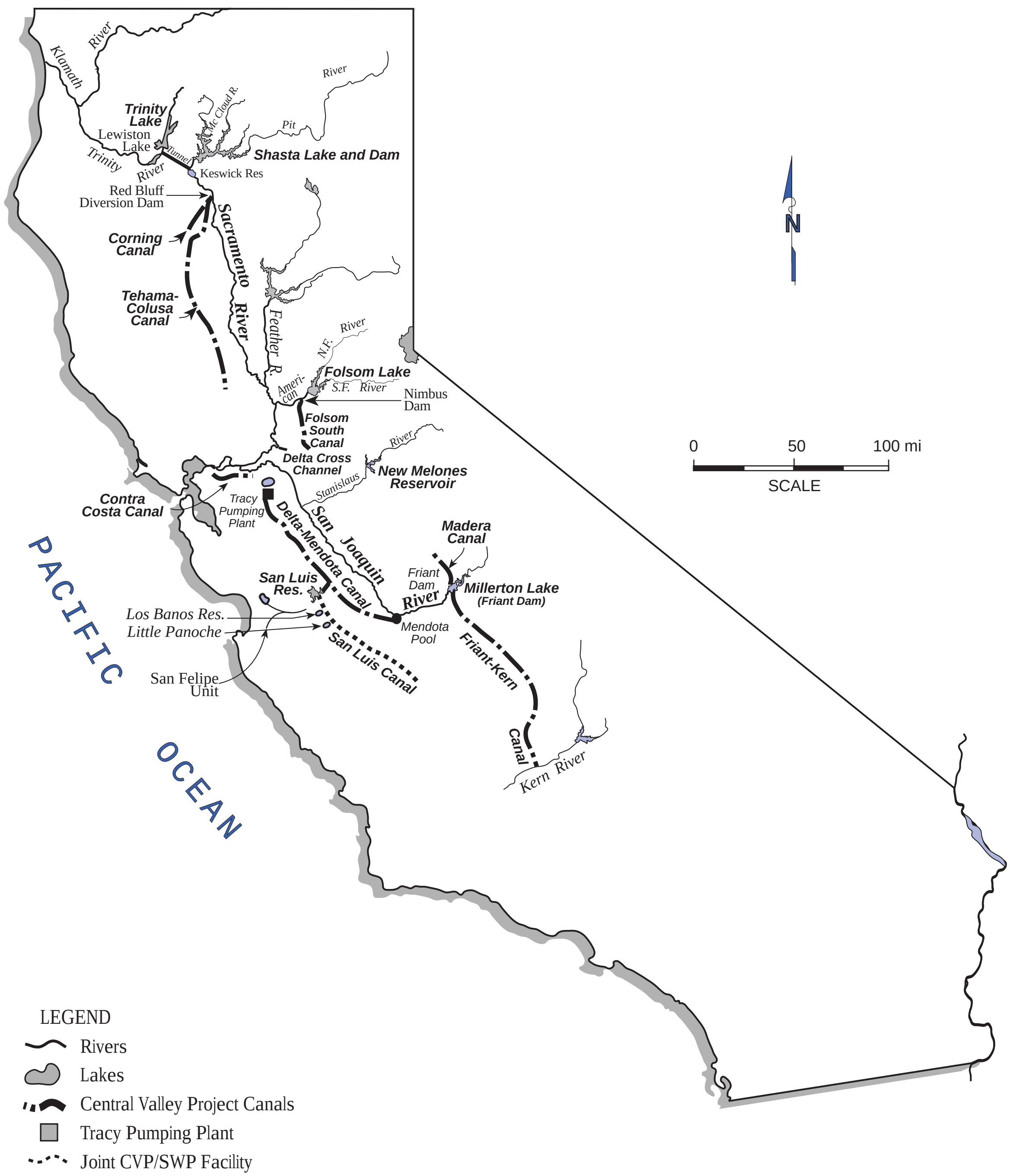
1. Surface Water Development

This section discusses the development of the surface water supplies of the Central Valley. The major developments include the CVP, other federal projects, the SWP, and several local projects.

a. Central Valley Project. The CVP is a water supply, flood control and power generation project owned by the United States and operated by the USBR. It is the largest water storage and delivery system in California. Extending from the Cascade Range to the Kern River, the CVP consists of 18 federal reservoirs, plus four additional reservoirs jointly owned with the SWP. It also includes eight hydroelectric plants, two pumping plants, two pump-generating plants, and about 500 miles of major canals and aqueducts. The project stores and controls waters of the Sacramento, Trinity, American, San Joaquin, and Stanislaus river basins. The major features of the CVP are shown in Figure III-3.

The CVP has three main storage facilities in northern California. The principal facility is Shasta Dam and the 4.5 MAF Lake Shasta on the Sacramento River near Redding. Water from the Trinity River, which drains to the Pacific Ocean, is imported into the Central Valley through tunnels connecting to the Sacramento River north of Redding. Trinity Lake is the largest storage facility in the Trinity River Division. Folsom Dam is located on the American River about 30 river miles upstream from its confluence with the Sacramento River. These main reservoirs of the CVP have a total storage capacity of about 8 MAF. The major storage facilities south of the Delta include New Melones Reservoir on the Stanislaus River, Millerton Lake on the San Joaquin River, and San Luis Reservoir. San Luis Reservoir is a pumped-storage reservoir on the west side of the San Joaquin Valley shared with the SWP. The storage facilities south of the Delta provide an additional 4 MAF storage capacity for the CVP.

Figure III-3
Central Valley Project Facilities



A number of conveyance and pumping facilities are used to distribute water throughout the CVP service area. The major conveyance facilities of the CVP include the Corning and Tehama-Colusa canals which divert water from the Sacramento River to serve the west side of the Sacramento Valley, the Contra Costa and Delta-Mendota canals which divert water from the Delta, the San Luis Canal which carries water along the west side of the San Joaquin Valley, and the Madera and Friant-Kern canals that divert water from the San Joaquin River and distribute it along the east side of the San Joaquin Valley and Tulare Lake Basin. Tracy Pumping Plant pumps most of the water that the CVP exports from the Delta.

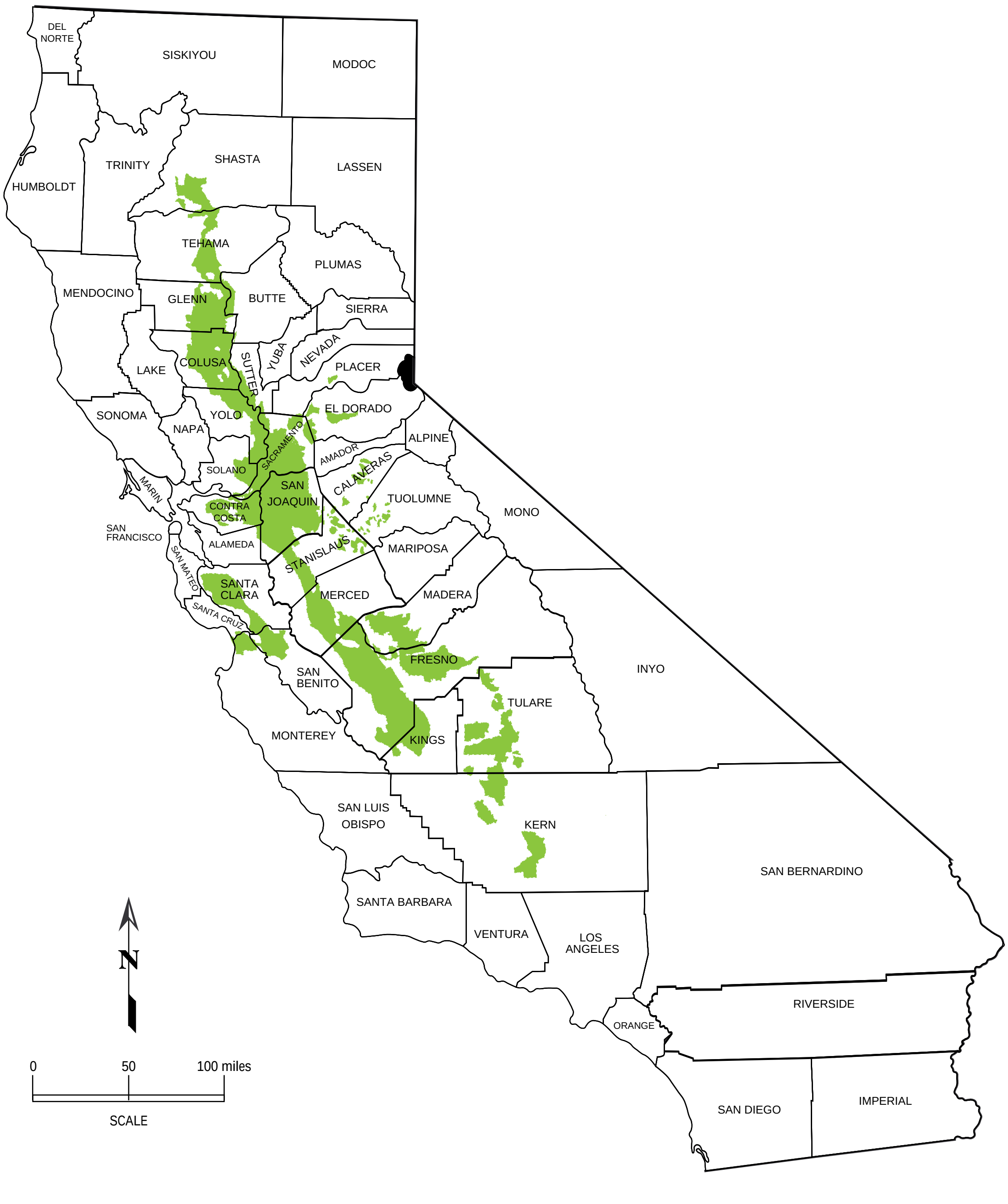
The CVP supplies water to over 250 long-term water contractors whose contracts total 9.3 MAF per year. Of the 9.3 MAF, 6.2 MAF is project water, including 1.4 MAF of Friant Division Class 2 supply in wet years, and 3.1 MAF is water right settlement water. Water right settlement water is diverted by water right holders whose diversions were in existence before the project was constructed. The diversions are made in accordance with agreements between the CVP and the water right holders. Average-year deliveries by the CVP have been around 7 MAF. Figure III-4 shows the CVP contractors' service areas. Figure III-5 shows CVP deliveries for the period 1960-1996.

About 90 percent of the CVP water has gone to agricultural uses in the recent past; this includes water delivered to prior right holders. CVP water is used to irrigate some 19,000 farms covering 3 million acres. Currently, increasing quantities of water are being served to municipal customers. Urban areas receiving CVP water supply include Redding, Sacramento, Folsom, Tracy, most of Santa Clara County, northeastern Contra Costa County, Stockton, and Fresno.

Water stored in CVP northern reservoirs is gradually released down the Sacramento River, where it helps meet contract commitments along the river and quality and flow requirements in the Delta. The remainder is exported via the Contra Costa Canal and the Delta-Mendota Canal. Excess water during the winter is conveyed to off-stream storage in San Luis Reservoir on the west side of the San Joaquin Valley for subsequent delivery to the San Luis and San Felipe units.

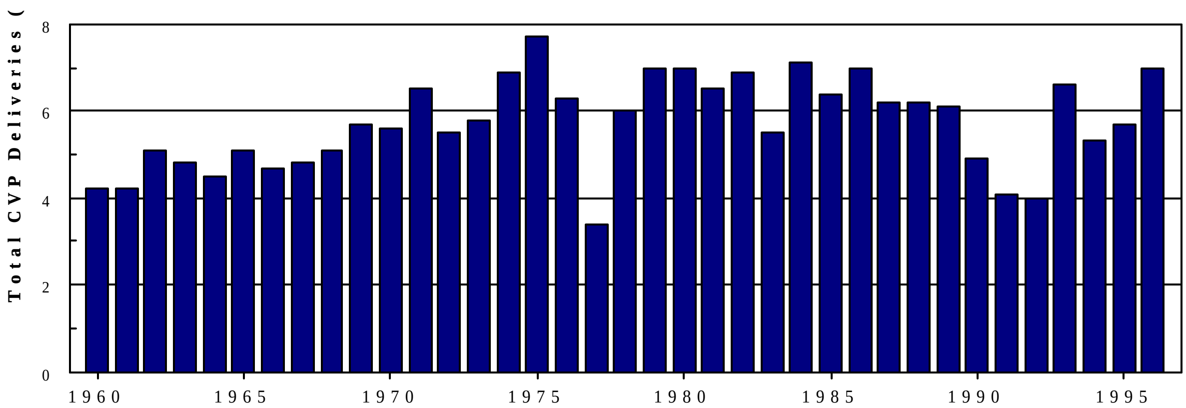
Many of the CVP contractors in the Sacramento Valley held prior rights to the waters of the Sacramento River. Since construction of the CVP altered the natural flows upon which water right holders had relied, contracts were negotiated to serve the users stored water to supplement the river flows available under their water rights. CVP contractors with prior water rights on the Sacramento River (called *settlement contractors*) receive their supply from natural flow, storage regulated at Shasta Dam, and Trinity Basin imports. Table III-1 shows base entitlement, project entitlement, and average deliveries from the main stem of the Sacramento River for some of the largest CVP contractors in the Sacramento Valley. The Tehama-Colusa and Corning canals serve an area on the west side of the Sacramento Valley. Table III-2 shows project entitlement and average deliveries for CVP contractors served by the Tehama-Colusa and Corning canals.

Figure III-4
Central Valley Project Service Area



Source: DWR, Bulletin 160-93 (1994)

Figure III-5
Central Valley Project Deliveries, 1960 to 1996



(Millions of acre-feet)

Table III-1. CVP Deliveries to Selected Settlement Contractors

(Acre-feet)

Contractor	River Mile	Total Base Entitlement	Total Project Entitlement	Average* Deliveries
Glen Colusa I.D.	154.8 R	720,000	105,000	775,418
Sutter Mutual Water Co.	32.4 L	172,900	95,000	205,377
Anderson Cottonwood I.D.	240.5 L	165,000	10,000	144,955
Reclamation District #108	43.1 R	199,000	33,000	136,384
Natomas Central Mutual Water Co.	2.15 L	98,200	22,000	89,376
Reclamation District #1004	85.3 L	56,400	15,000	63,849
Princeton-Codora-Glen I.D.	112.3 R	52,810	15,000	54,942
Provident I.D.	124.2 R	49,730	5,000	39,064
Conaway Conservancy	112.0 R	50,190	672	29,481
Olive Percy Davis Trust	77.8 R	22,000	9,800	26,636
Meridian Farms Water Co.	71.1 L	23,000	12,000	25,777
River Garden Farms Co.	34.5 R	29,300	500	18,900
Pleasant Grove-Verona MWC	19.6 L	23,790	2,500	14,186
Colusa Drain MWC**	NA	0	100,000	12,517
City of Redding	246.0 L	6,889	1,216	10,721
Total, Fifteen Major Contractors				1,647,584
Total, 124 Other Settlement Contractors				91,291
Majors as % of Grand Total				94.75%

*Period of record for determining average deliveries is 1982-1989, excluding 1983.

**Colusa Drain MWC has an exchange contract with the CVP which enables them to divert water from the Colusa Basin Drain. The CVP makes up the impact of that diversion to downstream senior water right holders. No water is delivered directly to CDMWC by the CVP.

Table III- 2. CVP Deliveries to Tehama-Colusa Canal Contractors
(Acre-feet)

Contractor	Total Project Entitlement	Average* Deliveries
Orland-Artois Water District	53,000	70,529
Colusa County Water District	62,000	44,404
Kanawha Water District	45,000	38,000
Westside Water District	25,000	25,481
Corning Water District	25,300	24,521
Glide Water District	10,500	13,083
Dunnigan Water District	19,000	11,965
Westside Water Dist. (from Colusa Co.)	40,000	8,604
Thomes Creek Water District	8,400	7,295
Proberta Water District	5,500	5,630
Davis Water District	4,000	5,310
La Grande Water District	5,000	5,136
4-M Water District (from Colusa Co.)	5,700	2,814
Holthouse Water District (from Colusa Co.)	2,450	1,999
Cortina Water District (from Colusa Co.)	1,700	1,645
Colusa Co. Water Dist (from Colusa Co.)	5,965	1,572
La Grande Water Dist. (from Colusa Co.)	2,200	1,433
Glenn Valley Water District	1,730	879
Kirkwood Water District	2,100	495
Myers-Marsh MWC (from Colusa Co.)	255	438
Total		271,235

*Period of record for determining average deliveries is 1982-1989, excluding 1983.

Settlement contractors on the San Joaquin River (called *exchange contractors*) receive Delta water via the Delta-Mendota Canal. A portion of the water exported from the Delta via the Delta-Mendota Canal is placed into the San Joaquin River at Mendota Pool to serve, by exchange, water users who have riparian and pre-1914 rights to use of San Joaquin River flow. The exchange agreement has annual and monthly limitations on the water to be provided by the USBR to the exchange contractors and the annual amount to be provided is based on forecasted runoff into Shasta Reservoir. This exchange enabled the CVP to build Friant Dam on the San Joaquin River, northeast of Fresno, and divert a major portion of the flow from the river at that point. Most of the water from the upper San Joaquin River is diverted south into the Friant-Kern Canal and supplied to the Tulare Lake Basin for use in Kings and Kern counties. A portion is diverted northward in the Madera Canal to serve areas in the central San Joaquin Valley. Table III-3 lists the CVP exchange contractors and their average annual diversions.

Table III-3. CVP Exchange Contractors Average Annual Diversions
(Acre-feet)

Contractor	Average Diversion
Central California Irrigation District	430,600
San Luis Canal Company	155,600
Firebaugh Canal Water District	64,200
Columbia Canal Company	58,800

CVP facilities are grouped as operating divisions and the operation of these facilities are integrated to enable flexibility in the distribution of water and power resources throughout the project service area. The CVP divisions include the Trinity River, Shasta, Sacramento River, American River, Delta, West San Joaquin, San Felipe, East Side, and Friant divisions.

Trinity River Division. The Trinity River Division was completed in 1964 and includes facilities to store and regulate flows in the Trinity River and to transfer a portion of the flow to the Sacramento River Basin. These facilities include Trinity Lake; Trinity Dam and Powerplant; Lewiston Dam, Lake, and Powerplant; Clear Creek Tunnel and Carr Powerplant; Whiskeytown Dam and Lake; Spring Creek Debris Dam, Reservoir, Powerplant, and Tunnel.

Water is stored in Trinity Lake behind Trinity Dam, and is released for a variety of purposes. Releases from Trinity Lake are re-regulated downstream at Lewiston Lake. Lewiston Dam regulates flows in the Trinity River to meet downstream flow, in-basin diversion, and temperature requirements. Lewiston Lake provides a forebay for interbasin transfer of water through the Clear Creek Tunnel and the Judge Francis Carr Powerplant into Whiskeytown Lake on Clear Creek. Water stored in Whiskeytown Lake includes exports from the Trinity River as well as local runoff from the Clear Creek drainage area. Releases from Whiskeytown are either passed through the Spring Creek Powerplant and discharged into Keswick Reservoir on the Sacramento River, or released to Clear Creek to meet downstream flow and diversion requirements.

Shasta Division. The Shasta Division consists of Shasta Lake, Dam, and Powerplant and Keswick Reservoir, Dam, and Powerplant. These facilities are located on the Sacramento River below the confluence of the Sacramento, McCloud, and Pit rivers. Shasta Dam was completed in 1945 and regulates a drainage area of 6,600 square miles. It provides flood control and stores water for irrigation and M&I use, generation of hydroelectricity, maintenance of fish and navigation flows, and protection of the Delta from salinity intrusion. A small amount of water is diverted directly from Shasta Lake for M&I use by local communities.

Water in Shasta Lake is released through or around Shasta Powerplant to Keswick Reservoir. A temperature control device was recently installed on Shasta Dam which was designed to allow all releases at Shasta to pass through generation facilities when the system is being operated to meet a temperature standard for fishery enhancement/protection on the upper Sacramento River. A series of gates on the intake structure allows for the withdrawal of water at various lake levels.

Keswick Reservoir serves as an afterbay to regulate releases from Shasta Dam and discharges from Spring Creek Tunnel. All releases from Keswick are made to the Sacramento River. There is a migratory fish trapping facility at Keswick that operates in conjunction with the Coleman National Fish Hatchery located downstream on Battle Creek.

Sacramento River Division. The Sacramento River Division includes the Sacramento Canals Unit which was authorized in 1950 to supply irrigation water to over 200,000 acres in the Sacramento Valley, principally in Tehama, Glenn, Colusa, and Yolo counties. The Sacramento Canals Unit consists of the Red Bluff Diversion Dam, the Corning Pumping Plant, and the Corning and Tehama-Colusa canals. The Red Bluff Diversion Dam, built in 1964, is located on the Sacramento River southeast of the town of Red Bluff. Water is diverted from the Sacramento River into the Tehama-Colusa Canal, which extends southerly from the Red Bluff Diversion Dam, to provide irrigation service on the west side of the Sacramento Valley. The Tehama-Colusa Canal also provides water to the refuges under contract with the USBR. The Corning Pumping Plant lifts water from the Tehama-Colusa Canal downstream of the Red Bluff Diversion Dam into the Corning Canal. The Corning Canal provides service to areas on the west side of the Sacramento Valley at elevations too high to be served by the Tehama-Colusa Canal. Congressional authorization has been given (CVPIA, Title 34, Section 3412) to extend the Tehama-Colusa Canal into Solano and Napa counties.

American River Division. The American River Division includes Folsom Dam, Lake, and Powerplant; Lake Natoma; and Nimbus Dam and Powerplant on the American River. It also includes the Folsom South Canal, which diverts water from the American River, and Jenkinson Lake on Sly Park Creek, which is tributary to the Cosumnes River. Folsom Dam, which was completed in 1956, regulates flows on the American River for irrigation, power, flood control, M&I use, fish and wildlife, recreation, and other purposes. Lake Natoma regulates the releases from Folsom Powerplant and Nimbus Dam serves as the point of diversion for the Folsom South Canal. The Nimbus Fish Hatchery is located below Nimbus Dam and was built to compensate for the salmon and steelhead spawning areas lost due to the construction of Folsom and Nimbus dams.

Delta Division. Water released from the CVP reservoirs in northern California is conveyed to the Bay/Delta Estuary through the channel of the Sacramento River. The Delta Division facilities provide for the transport of water through the Delta and the export of water to the San Joaquin Valley and Contra Costa County. The main features of the Delta Division are the Delta Cross Channel, the Contra Costa Canal, Tracy Pumping Plant, and the Delta-Mendota Canal.

About 30 miles south of Sacramento, the Delta Cross Channel diverts a portion of the Sacramento River flow into interior Delta channels, while the remaining Sacramento River water flows westward toward Suisun Bay. The purpose of the Delta Cross Channel is to preserve the quality of water diverted from the Sacramento River by conveying it to southern Delta pumping plants through eastern Delta channels rather than allowing it to flow through more saline western Delta channels. The Delta Cross Channel, with a capacity of 3,500 cfs, can divert a significant portion of the Sacramento River flows, particularly in the fall.

In the southern Delta, the CVP diverts water at Rock Slough, Old River, and at the Tracy Pumping Plant. The Rock Slough diversion is conveyed through the Contra Costa Canal for municipal and industrial uses in Contra Costa County. The Old River intake, near the Highway 4 crossing, was completed in 1997 and diverts CVP water either directly to the Contra Costa Water District (CCWD) service area or into storage at CCWD's new Los Vaqueros Reservoir. At the Tracy Pumping Plant, water is lifted nearly 200 feet above sea level into the Delta-Mendota Canal.

The Delta-Mendota Canal serves several purposes; it delivers water to San Joaquin River water rights holders through exchange agreements, supplies water for agricultural users on the west side of the San Joaquin Valley, and conveys water for storage in San Luis Reservoir. As its name indicates, the canal conveys water from the Delta 117 miles southeast to the Mendota Pool located on the San Joaquin River west of Fresno. West of Los Banos, a turnout from the Delta-Mendota Canal conveys water to the CVP's San Luis Unit.

West San Joaquin Division. The West San Joaquin Division of the CVP includes the San Luis Unit and consists of federal as well as joint federal-State facilities, including O'Neill Dam and Forebay, San Luis Dam and Reservoir, and San Luis Canal. San Luis Reservoir is a pumped-storage reservoir primarily used to store water exported from the Delta by the SWP and CVP.

O'Neill Forebay is used as a hydraulic junction point for State and federal waters. The SWP California Aqueduct discharges directly into the forebay and CVP water is lifted from the Delta-Mendota Canal into the forebay by the O'Neill Pumping-Generating Plant. Water is pumped from O'Neill Forebay into San Luis Reservoir through the William R. Giannelli Pumping-Generating Plant. The forebay provides re-regulation storage necessary to permit off-peak pumping and on-peak power generation by the plant. Power is also generated when CVP water is released from O'Neill Forebay to the Delta-Mendota Canal.

The portion of water stored by the CVP in San Luis Reservoir is released to three locations: the San Luis Canal to serve CVP contractors, including Westlands WD; the Pacheco Tunnel to serve the San Felipe Unit of the CVP; and the Delta-Mendota Canal to serve CVP and exchange contractors on the west side of the San Joaquin Valley. The San Luis Canal conveys water southward from O'Neill Forebay along the west side of the San Joaquin Valley. The San Luis Canal is the joint federal and State portion of the California Aqueduct, extending to Kettleman City. CVP water conveyed through the Delta-Mendota Canal is released into the San Joaquin River channel at the Mendota Pool to replace the exchange contractors' entitlements which are diverted at Friant Dam.

Other facilities included in the West San Joaquin Division include the Coalinga Canal, the Los Banos and Little Panoche detention dams and reservoirs, and the San Luis Drain. The Coalinga Canal transports water from the San Luis Canal to the Coalinga area. The Los Banos and Little Panoche detention dams and reservoirs protect the San Luis Canal by controlling flows of streams crossing the canal. These facilities do not supply water to the CVP or SWP. The San Luis Drain was designed to carry agricultural subsurface drainage from collectors along the west side of the San Joaquin Valley to the Sacramento-San Joaquin Delta for discharge to the ocean, as mandated by the authorization of the San Luis Unit. However, only a portion of the drain was constructed, terminating at Kesterson Reservoir which was incorporated into the Kesterson National Wildlife Refuge. The discovery of accumulations of selenium in the drainage water and sediments at Kesterson Reservoir forced the closure of the reservoir and the drain after 1985. Ongoing actions regarding the San Luis Drain are discussed in Chapter VIII of this draft EIR.

San Felipe Division. The San Felipe Division provides CVP water to Santa Clara and San Benito counties through conveyance facilities from San Luis Reservoir. These facilities include the Pacheco Tunnel and Conduit, the Hollister Conduit, San Justo Dam and Reservoir, and the Santa Clara Conduit. The Pajaro Valley, in southern Santa Cruz County, was originally authorized to receive irrigation water from the CVP to reduce seawater intrusion caused by groundwater pumping, but no conveyance facilities have been built.

Water leaves San Luis Reservoir through the two separate reaches of the Pacheco Tunnel. The water flows through the first reach of the tunnel and is lifted up to the second reach by the Pacheco Pumping Plant. Water from the Pacheco Tunnel flows through the Pacheco Conduit where the flow is split between the Santa Clara and Hollister conduits.

East Side Division. The East Side Division of the CVP includes reservoirs on the Stanislaus, Chowchilla, and Fresno rivers. These rivers drain the western slopes of the Sierra Nevada and flow into the San Joaquin River. The major CVP facilities in the East Side Division include New Melones Dam and Reservoir, Buchanan Dam and Eastman Lake, Hidden Dam and Hensley Lake.

New Melones Dam is located on the Stanislaus River. Originally authorized for flood control in 1944, it was reauthorized in 1962 as an integral part of the CVP and construction was completed in 1979. New Melones is operated to provide flood control, satisfy water rights obligations, provide instream flows, maintain water quality conditions in the Stanislaus River and the San Joaquin River at Vernalis, and provide deliveries to local CVP contractors.

Buchanan Dam and Eastman Lake are located on the Chowchilla River; Hidden Dam and Hensley Lake are on the Fresno River. These reservoirs are operated largely for flood control, but the operations are integrated into the CVP. When possible, releases from these reservoirs are used to satisfy portions of the CVP contractual requirements on the Madera Canal.

Friant Division. The Friant Division collects water from the San Joaquin River and distributes it along the east side of the San Joaquin Valley and the Tulare Lake Basin to provide a supplemental water supply to augment the groundwater and local surface water supplies in the area. The division is an integral part of the CVP, but is hydrologically independent and, therefore operated separately from the other divisions of the CVP. The water supply to the Friant Division is made available in part through an exchange agreement and from purchase of water rights. A substitute water supply for the Exchange Contractors is transported from the Delta to Mendota Pool via the Delta-Mendota Canal. The functions of the Friant Division are to provide flood control, irrigation, and M&I water supply. Major facilities of the division include Friant Dam and Millerton Lake, the Madera Canal, and the Friant-Kern Canal.

Friant Dam is located on the upper San Joaquin River in the Sierra-Nevada foothills above Fresno. Completed in 1947, Millerton Lake has a storage capacity of 500,000 acre-feet. Water released through Friant Dam is diverted north through the Madera Canal, and south through the Friant-Kern Canal. The water supply to the Madera Canal is integrated with the operation of Hidden Dam on the Fresno River and Buchanan Dam on the Chowchilla River and serves areas on the east side of the San Joaquin Valley. The Friant-Kern Canal extends south to Kern County near Bakersfield, primarily serving areas in the Tulare Lake Basin. Additional water supplies are conveyed via the Friant-Kern Canal through coordinated operations with water supply facilities on the Kings, Kaweah, Tule, and Kern rivers and through exchange agreements between Friant-Kern and Cross Valley canal contractors. These water supplies are not associated with the CVP and the CVP merely facilitates exchanges or wheeling for CVP contractors if such actions do not affect the ability of the CVP to deliver contractual supplies.

b. Other Federal Projects. Other federal projects include those constructed by the U.S. Army Corps of Engineers (USCOE) or the USBR. These projects generally provide flood control and water supply benefits. Some of the larger projects in this category include: the Orland Project and Black Butte Reservoir on Stony Creek; the Solano Project on Putah Creek; Englebright Reservoir on the Yuba River; New Hogan Lake on the Calaveras River; and the four major reservoirs on the east side of the Tulare Lake Basin -- Pine Flat, Kaweah, Success, and Isabella.

The Orland Project includes East Park and Stony Gorge reservoirs which were built by the USBR in 1910 and 1928, respectively. They store surplus water for irrigation deliveries. Black Butte Reservoir was built in 1963 by the USCOE primarily for flood control and irrigation supply. It is financially integrated with the CVP and operations are coordinated between the CVP and the Orland Project. Black Butte Reservoir has a storage capacity of 143,000 acre-feet and East Park and Stony Gorge reservoirs each store about 50,000 acre-feet. The Solano Project, built by the USBR in 1959, stores water behind Monticello Dam in the 1.6 MAF Lake Berryessa in Napa County and conveys water through the Putah South Canal to agricultural and M&I users in Solano County. Narrows Dam (Englebright Reservoir) was built by the USCOE in 1941 as part of the Sacramento River Debris Control Project. The reservoir has a capacity of 70,000 acre-feet and is located on the Yuba River, downstream of New Bullards Bar Dam and Reservoir and Colgate Powerhouse. New Hogan Dam was also built by the USCOE and the lake, with a storage capacity of 317,000 acre-feet, provides flood control, agricultural and M&I water supplies, and recreational opportunities.

The reservoirs on the east-side tributaries to the Tulare Lake Basin were built by the USCOE to provide flood control; however, these reservoirs also provide water supply for irrigation of downstream agricultural lands. Pine Flat Dam and Reservoir on the Kings River, was completed in 1954 and has a capacity of 1.0 MAF. Success Lake stores 100,000 acre-feet on the Tule River and Lake Kaweah (Terminus Dam) stores 143,000 acre-feet on the Kaweah River. Lake Isabella, located on the Kern River northeast of Bakersfield, was constructed in 1953 and stores 568,000 acre-feet. These projects do not have federally-held water rights associated with them; local water users hold all rights.

c. State Water Project. Like the CVP, the SWP stores runoff from within the Sacramento Valley basin, releases stored water to the Sacramento River and the Delta, and pumps water out of the Delta for delivery to water users in the Bay area, the San Joaquin Valley, and Southern California. The SWP, operated by the DWR, includes 22 dams and reservoirs, 8 hydroelectric power plants, and 17 pumping plants. The major features of the SWP are shown in Figure III-6.

Plans for the SWP recognized that there would be a gradual increase in water demand and that some of the supply facilities could be deferred until later. Delta water transfer facilities were part of the original plan, and additional Sacramento and North Coast basin supply reservoirs were envisioned. Contracts were signed for an eventual delivery of 4.23 MAF. With the present level of development and current operating criteria, the SWP is capable of developing a reliable water supply of about 2.3 MAF.

The SWP delivers water to 29 long-term contractors. The service areas of these contracting agencies are shown in Figure III-7. Figure III-8 depicts the SWP water deliveries (excluding Feather River inbasin obligations) from 1967 to 1996. Generally, San Joaquin Valley use of SWP supply has been near full contract amounts since about 1980 (except during very wet years and during deficient-supply years). The San Joaquin Valley contractors are primarily agricultural users, with Kern County Water Agency having the largest contract entitlement (about 1.15 MAF/year). Southern California use, which is principally municipal and industrial, has only built up to about 60 percent of full entitlement. Metropolitan Water District of Southern California is the SWP's largest contractor, with annual entitlement of over 2 MAF.

The SWP also delivers water under negotiated settlement agreements to several agencies that are entitled to water from the Feather River under prior rights. Table III-4 shows the entitlement and average deliveries for the SWP's Feather River inbasin obligations.

The chief components of the SWP's water storage facilities are Oroville Dam and Lake Oroville which store winter and spring flows on the Feather River. Oroville Dam was completed in 1968 and the reservoir has a storage capacity of 3.5 MAF. Three smaller reservoirs, Lake Davis, Frenchman Lake, and Antelope Lake are located in the upper Feather River Basin in Plumas

Figure III-6
State Water Project Facilities

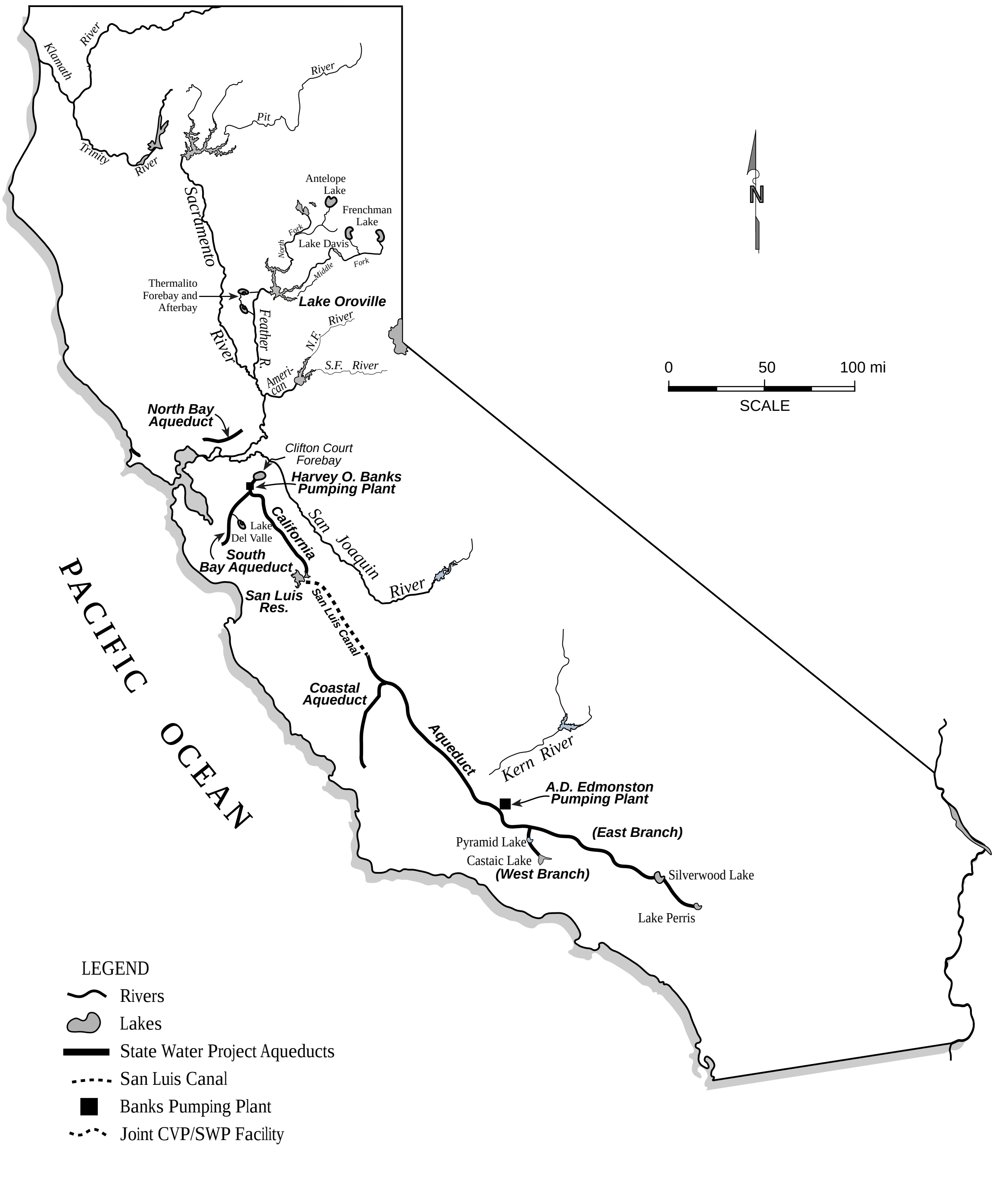


Figure III-7
State Water Project Service Area

Source: DWR, Bulletin 160-93 (1994)

County. These reservoirs are operated for recreational, fish and wildlife, and local water supply purposes. Below Oroville Dam, Thermalito Diversion Dam diverts water from the Feather River into the Thermalito Forebay for use in power generation. Water flows through Thermalito Powerplant and into Thermalito Afterbay, which regulates the return flow to the Feather River. Three of the four units at Thermalito Powerplant are reversible to allow pumping back into Thermalito Forebay.

Water stored in Lake Oroville is released into the Feather River, where it flows into the Sacramento River 21 miles above Sacramento, and from there, to the Delta. The SWP diverts a portion of this water from the Delta for export through the North and South Bay aqueducts and the California Aqueduct, and the remainder contributes to meeting minimum flow and water quality requirements.

The SWP diverts water from Barker Slough in the northern Delta, where it is pumped into the North Bay Aqueduct for municipal use in Solano and Napa counties. In the southern Delta, water is diverted into Clifton Court Forebay, then pumped at the Harvey O. Banks Delta Pumping Plant into the California Aqueduct. Clifton Court Forebay serves as a regulating reservoir for the pumping plant, allowing much of the pumping to occur at night when energy costs are lower. It also allows diversion from the Delta to be varied to minimize salinity intrusion. The John E. Skinner Delta Fish Protective Facility removes migrating fish drawn from the Delta with the pumping plant inflow.

Bethany Reservoir serves as an afterbay for discharges from the Banks Delta pumps and as a regulating reservoir for both the California and South Bay aqueducts. Water is pumped from Bethany Reservoir into the South Bay Aqueduct for delivery to urban and agricultural areas in Alameda and Santa Clara counties. Del Valle Reservoir provides 40,000 acre-feet of pumped-storage capacity for conservation and water delivery and also provides flood control and recreation benefits to the area. The lake is designed to store up to 77,000 acre-feet, but all storage above 40,000 acre-feet is reserved for floodwater encroachment.

The California Aqueduct is the main conveyance facility of the project and extends 444 miles from the Delta to Southern California. From the Delta, the California Aqueduct follows the west side of the San Joaquin Valley to the federal/State joint-use facilities of the San Luis Unit, including O'Neill Forebay and San Luis Reservoir (described previously under CVP). Water is pumped into San Luis Reservoir for storage during winter and released later when demand is greater and pumping restrictions reduce the amount of wateravailable from the Delta. From O'Neill Forebay, the joint-use portion of the California Aqueduct (San Luis Canal) extends south to the Kettleman City area. Two pumping plants (Dos Amigos and Buena Vista) provide the lift necessary for the aqueduct to continue south to the Tulare Lake Basin, where it serves most of the SWP agricultural users.

Figure III-8
State Water Project Deliveries, 1967 to 1996
(Millions of acre-feet)

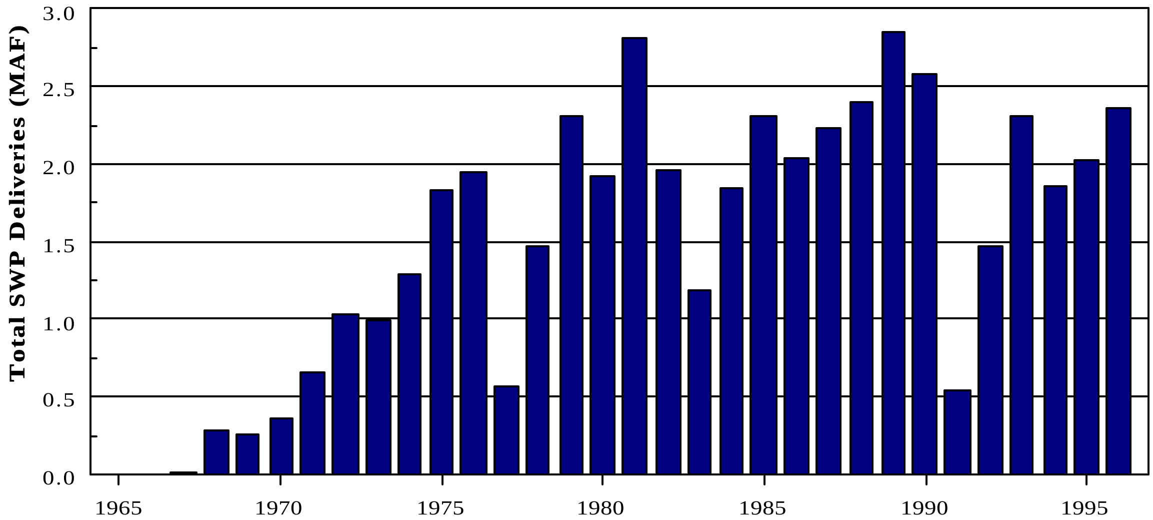


Table III-4.
SWP Feather River Inbasin Obligations

Contracting Agency	Annual Status (1)	Average Entitlement (Acre-feet)	Deliveries (2) (Acre-feet)
Joint Water District Board	WR	620,000	574,203
Western Canal Water District	WR	295,000	246,005
Garden Highway Mutual Water Co.	WR	18,000	16,260
Plumas Mutual Water Co.	WR	14,000	9,551
Oswald Water Co.	WR	3,000	0
Tudor Mutual Water Co.	WR	5,000	4,818
City of Yuba City	WS	9,600	185
County of Butte	WS	27,500	325

(1) WR - Water Settlement Contractors; WS - Water Supply Contractors
(2) Deliveries are averaged for the period 1982-1989, excluding 1983.

The Coastal Branch of the aqueduct splits from the main branch in the Tulare Lake Basin near Devil's Den. Construction of this branch was completed in 1997. It will convey water westerly over the Coast Ranges for use in the coastal areas of San Luis Obispo and Santa Barbara Counties.

Two additional pumping plants (Wheeler Ridge and Wind Gap) are required to move the water in the California Aqueduct to the southern end of the Central Valley. Water in the aqueduct is lifted nearly 2,000 feet into the Tehachapi Mountains by the A.D. Edmonston Pumping Plant and then flows through a series of four tunnels. The aqueduct then splits into the West Branch, which transports water through Pyramid Lake to Castaic Lake in Los Angeles County, and the East Branch, which delivers water to the Antelope Valley and Silverwood Lake, and terminates at Lake Perris in Riverside County.

d. Local Development. The majority of local water supply developments are in-basin diversion and storage projects. Most local surface projects are small, but there are some large local water projects constructed and operated by a wide variety of water and irrigation districts, agencies, municipalities, and companies. Initially, most local projects consisted of direct stream diversions. When these proved inadequate during the dry season, storage dams and reservoirs were built.

Some of the larger local storage projects on rivers tributary to the Central Valley include Bullards Bar Dam on the Yuba River, Exchequer Dam on the Merced, and Don Pedro Dam on the Tuolumne. Each original dam has been replaced by a new, larger version. Bullards Bar Reservoir, which is owned by Yuba County Water Agency, has a storage capacity of nearly one million acre-feet. Lake McClure, behind New Exchequer Dam, has a storage capacity of over one million acre-feet for Merced Irrigation District. New Don Pedro Reservoir, which has a storage capacity of over two million acre-feet, is owned and operated by the Turlock and Modesto Irrigation Districts.

Smaller storage projects have been built by a number of local water purveyors. Oroville-Wyandotte Irrigation District has facilities in the Feather River Basin, and South Sutter Water District operates Camp Far West Reservoir (104 TAF) on the Bear River. Nevada Irrigation District has several small reservoirs in the Yuba and Bear River Basins. Placer County Water Agency owns French Meadows (136 TAF) and Hell Hole (207 TAF) in the American River Basin, and Yolo County Flood Control and Water Conservation District stores water from Cache Creek in Clear Lake and Indian Valley Reservoir.

Numerous dams have been constructed on the Central Valley rivers primarily for hydroelectric power production. These facilities also incidentally regulate stream flows, create more usable water supplies during the dry summer months, and provide flood control and recreation benefits. Pacific Gas and Electric Company (PG&E) has facilities on the Pit and Feather river drainages, including Lake Almanor which has a storage capacity of over 1.1 million acre-feet. PG&E also operates facilities in the Yuba, American, Mokelumne, and Kings river watersheds. Southern California Edison has facilities on the upper San Joaquin River, and the Sacramento Municipal Utility District has facilities in the American River Basin. Some irrigation districts take advantage of the conservation of winter and spring runoff that is stored by the utilities and later released to meet peak summer demand for electricity.

As nearby sources of water were fully developed, urban areas began to reach out to more distant sources. In the 1920s, the East Bay cities of the San Francisco Bay Region turned to the Sierra Nevada watershed for additional water. The East Bay Municipal Utility District (EBMUD) completed the Mokelumne Aqueduct in 1929, bringing water from Pardee Reservoir and the Mokelumne River. Camanche Reservoir was added in 1963 below Pardee, and with the addition of a third barrel, the aqueduct's capacity was increased from 224,000 acre-feet per year to 364,000 acre-feet per year. The average annual import in 1990 was 245,000 acre-feet.

The City of San Francisco constructed O'Shaughnessy Dam on the upper Tuolumne River in 1923. In 1934, the City of San Francisco completed the Hetch Hetchy Aqueduct system, which diverts water from the Tuolumne River across the Central Valley to serve San Francisco, San Mateo, northern Santa Clara, and portions of Alameda counties. The current conveyance capacity of the Hetch Hetchy Aqueduct is about 330,000 acre-feet per year and average annual imports in 1990 were 267,000 acre-feet. The primary supply reservoirs are Hetch Hetchy, Lake Lloyd (Cherry Valley), and Lake Eleanor. The City of San Francisco also has exchange water storage in Don Pedro Reservoir which allows water that otherwise goes to the Turlock and Modesto irrigation districts to be diverted through the Hetch Hetchy Aqueduct.

e. Major Diversions. In addition to the surface water developments of the CVP, SWP, and local projects described above, there are substantial diversions from the Sacramento and San Joaquin river systems made by local water purveyors, irrigation districts, and individuals with water rights. Some of the diversions include elaborate facilities, such as diversion dams, pumping plants, fish screens, concrete-lined canals, and extensive distribution systems. Others are as simple as siphon tubes and irrigation ditches. Many of the major diverters listed below are covered by water right settlement contracts with the CVP and SWP.

Some of the major diverters on the upper Sacramento River include the Anderson-Cottonwood Irrigation District (ACID) and the Glenn-Colusa Irrigation District (GCID). Reclamation Districts 108 and 1004, Princeton-Codora-Glenn ID, Natomas Central Water Company, and Sutter Mutual Water Company make large diversions from the lower Sacramento River.

Western Canal Water District (WCWD) and Joint Water Board are among the major diverters from the Feather River. Joint Water Board is a consortium of four pre-1914 water right holders including Richvale ID, Biggs West Gridley WD, Butte WD, and Sutter Extension WD. Yuba County Water Agency (YCWA), South Sutter WD, Nevada ID, and PG&E have substantial rights to water from the Yuba and Bear rivers.

Urban areas within the area affected by this project receive water from a variety of sources. Most urban areas in the Central Valley rely on groundwater for municipal and industrial use. The City of Sacramento is the largest urban user of surface water supplies in the Central Valley, having water rights to the Sacramento and American rivers. As mentioned earlier, the City of San Francisco exports water from the Tuolumne River and EBMUD exports water from the Mokelumne River for use in the San Francisco Bay Region.

Much of the water supply from the San Joaquin River tributaries is diverted by several large irrigation districts for local use under senior water rights for direct diversion from those rivers. Oakdale ID and South San Joaquin ID divert water from the Stanislaus River. Turlock ID and Modesto ID take their water from the Tuolumne River below New Don Pedro Reservoir. Merced ID takes its water from the Merced River below Lake McClure. Chowchilla WD and Madera ID have rights to the Chowchilla and Fresno rivers, respectively. These districts provide most of the water for irrigation on the east side of the San Joaquin Valley.

The USBR and the DWR are the major diverters in the Delta. The USBR exports water from the Delta at Tracy Pumping Plant and CCWD diverts CVP water at Rock Slough and Old River under a water supply contract. The DWR exports from the Delta at Banks Delta Pumping Plant and Barker Slough to serve the SWP contractors. Table III-5 presents details of the USBR and DWR water right applications. Operation of the CVP and SWP Delta export facilities are coordinated to meet water quality and flow standards set by the Board, the USCOE, and more recently by federal fisheries agencies. However, there are approximately 1,800 local diversions within the Delta, many of which are made under claim of riparian right, which combine for potential instantaneous flow rates of more than 4,000 cfs.

Table III-6 lists the major water right holders that have diversion rights with a cumulative face value of 40,000 acre-feet per year or more from the Sacramento-San Joaquin river system. Table III-6 does not represent actual diversions by the water right holders. Actual diversions are frequently less than face value and there may be terms or conditions which limit actual diversions made under multiple permits held by the same water right holder. Table III-6 is not the basis for apportioning the responsibility for meeting the objectives of the 1995 Plan, but rather is included for illustrative purposes to demonstrate the relative magnitude of water rights held in the Central Valley.

Table III-5. Water Right Applications for the SWP and CVP in the Central Valley

DWR Water Right Applications *

Facility	Application	Priority	Max Dir Div (cfs)	Dir Div Season	Total Storage (AF)	Storage Season
Oroville	A005630	Jul 1927	1,400	1/1-12/31	380,000	9/1-7/31
Oroville	A014443	Aug 1951	1,360	1/1-12/31	3,500,000	9/1-7/31
			6,185	1/1-12/31	42,100	1/1-12/31
Banks Pumping Plant	A014445A	Aug 1951	2,115	1/1-12/31	44,000	
San Luis Facility	A017512	Mar 1957	0		1,100,000	1/1-12/31
North Bay Aqueduct	A017514A	Mar 1957	135	1/1-12/31	0	

USBR Water Right Applications

Facility	Application	Priority	Max Dir Div (cfs)	Dir Div Season	Total Storage (AF)	Storage Season
Contra Costa Canal	A009366	Aug 1938	200	1/1-12/31	0	
Contra Costa Canal	A009367	Aug 1938	250	1/1-12/31	0	
Contra Loma Reservoir	A022316	Oct 1965	0		5,400	10/1-6/30
Folsom Dam	A013370	Oct 1949	8,000	11/1-8/1	1,000,000	11/1-7/1
Folsom Dam	A013371	Oct 1949	700	11/1-8/1	300,000	11/1-7/1
Friant Dam **	A000023	Mar 1915	373	4/1-7/1	0	
Friant Dam **	A000234	Jan 1916	3,000	2/1-10/31	500,000	11/1-8/1
Friant Dam **	A001465	Sep 1919	3,000	2/1-10/31	500,000	11/1-8/1
Friant Dam **	A005638	Jul 1927	5,000	2/1-10/31	1,210,000	11/1-8/1
New Melones Dam	A014858A	Jun 1952	0		980,000	11/1-6/30
New Melones Dam	A014858B	Jun 1952	2,250	11/1-6/30	0	
New Melones Dam	A019304	Mar 1960	0		1,420,000	11/1-6/30
San Luis Facility	A015764	Mar 1954	0		1,000,000	11/1-4/30
Shasta Dam	A005626	Jul 1927	8,000	9/1-6/30	3,190,000	10/1-6/30
Shasta Dam	A009363	Aug 1938	1,000	1/1-12/31	310,000	10/1-7/1
Shasta & Keswick Dams	A009364	Aug 1938	9,000	1/1-12/31	1,303,000	10/1-6/30
Tracy Pumping Plant	A009368	Aug 1938	4,000	1/1-12/31	0	
Whiskeytown Dam	A017376	Nov 1956	3,600	11/1-4/1	250,000	11/1-4/1

* Any of the water permitted for diversion out of the Feather may also be taken directly at Banks without any initial diversions at Oroville. Any of the SWP's permitted storage quantities at Oroville or Banks may be stored in or re-stored San Luis. DWR stores water diverted under A17512 at any of its south of Delta facilities.

** Status as an export project vs. an inbasin project is an issue in the water right hearing.

Table III-6. Major Water Right Holders in the Central Valley

Includes applicants with a cumulative face value of or greater than 40,000 acre-feet
Water right holders in bold type include the Sacramento River Water Settlement Contractors, San Joaquin River Exchange Contractors, and others with contractual arrangements with either the CVP or SWP.

Water Right Holder	Cumulative Face Value	Cumulative Dir Div	Cumulative Storage	Points of Diversion
Turlock I D & Modesto I D	3,816,290	7,600	2,788,600	Tuolumne River
Pacific Gas & Electric Company	2,953,993	3,955	102,941	Sacramento-San Joaquin Delta Watershed
Nevada I D	2,586,397	3,816	441,607	Yuba and Bear River Watersheds
Yuba County Water Agency	2,350,000	1,593	1,250,000	Yuba River
Merced I D	2,339,523	5,757	879,025	Merced River
City of Sacramento	1,968,547	2,410	589,000	American and Sacramento Rivers
Oakdale I D & South San Joaquin ID	1,672,521	1,818	470,949	Stanislaus River
Placer County Water Agency	1,289,309	2,025	315,000	American River
Glenn-Colusa I D	1,282,972	3,072	0	Sacramento River
Central California I D	1,256,508	1,900	0	Mendota Pool on San Joaquin River
Oroville-Wyandotte I D	1,123,362	1,435	331,312	Feather and Yuba Rivers
Joint Water Districts Board	970,200	2,000	0	Feather River
East Bay Municipal Utilities District	931,874	510	562,950	Indian Slough and Mokelumne River
Calaveras County Water District	818,745	1,403	470,324	Stanislaus River and tributaries
Yolo County F C & W C District	751,774	1,128	614,000	Cache Creek, Trib to Yolo Bypass
City & County of San Francisco	679,453	940	115	Tuolumne River
Western Canal Water District	654,214	1,203	0	Feather River
Sutter Mutual Water Company	507,443	937	0	Sacramento River
Reclamation District #108	472,722	1,010	0	Sacramento River
Gallo Glass Company	447,765	823	0	Merced River
San Luis Canal Company	359,964	600	0	San Joaquin River
Anderson-Cottonwood I D	289,080	400	0	Sacramento River
Madera I D	261,449	463	0	Fresno River
Woodbridge I D	224,551	436	0	Central Delta Channels
Banta-Carbona I D	216,104	425	0	South Delta and San Joaquin River
South Sutter Water District	193,155	669	98,370	Sacramento River
West Stanislaus I D	189,456	262	0	San Joaquin River
Los Molinos Mutual Water Co.	187,902	260	41,000	Tributaries to Sacramento River
Parrott Investment Company	182,345	363	0	Butte Creek
Georgetown Divide Pub. Util. Dist.	182,343	255	44,000	South Fork American River
Provident I D	168,771	463	0	Sacramento River
Kelsey	160,182	350	0	Merced River
Stevinson Water District	154,531	317	0	Merced and San Joaquin Rivers
Natomas Central Mutual Water Co.	148,044	631	0	Sacramento River
Sutter Extension Water District	142,989	397	0	Feather River
Columbia Canal Company	138,877	210	0	San Joaquin River
U S Fish & Wildlife Service	134,191	235	16,521	Sacramento-San Joaquin Delta Watershed
Conaway Conservancy Group	132,567	409	0	Sacramento River
Hardesty	127,082	397	0	North Delta Channels

Table III-6 (cont.) Major Water Right Holders in the Central Valley

Water Right Holder	Cumulative Face Value	Cumulative Dir Div	Cumulative Storage	Points of Diversion
Schluter	126,271	504	5,000	Pit River Watershed
Browns Valley I D	117,440	136	60,000	Yuba River
Princeton-Codora-Glenn I D	116,741	290	0	Sacramento River
San Juan Suburban Water District	112,019	155	0	American River at Folsom Lake
Contra Costa Water District	105,490	115	105,490	Western Delta Channels
Premiere Farmland Partners III	103,649	100	0	Sacramento River
Reclamation District #1004	103,609	306	0	Butte Creek and Sacramento River
Reclamation District #999	97,778	290	0	North Delta Channels
M & T Incorporated	89,952	129	0	Butte Creek
Chowchilla Water District	83,449	101	50,000	Chowchilla River
Carman	81,087	112	0	Tribs to S. Fork American River
Wild Goose Club	75,735	250	0	Butte Creek
Jackson Valley I D	74,036	160	36,000	Tribs to Dry Creek / Mokelumne River
Maxwell I D	72,268	186	0	Sacramento River
Hot Springs Valley I D	68,400	0	68,400	Pit River Watershed
East Contra Costa I D	65,877	136	0	South Delta Channels
Edwards	65,043	90	0	Antelope Creek
Pescadero Recl. Dist. #2058	64,215	177	0	South Delta Channels
Patterson Water District	63,558	150	0	San Joaquin River
Pelger Mutual Water Company	62,527	147	0	Sacramento River
Reclamation District #2037	61,755	85	0	South Delta Channels
Stanford Vina Ranch Irrig. Co.	61,439	145	0	Deer Creek
Los Rios Farms Incorporated	60,622	169	0	Putah Creek
Collins Pine Company	60,201	83	0	N. Fork Feather River
Reclamation District #548	59,261	82	0	San Joaquin River Delta Channels
Tuolumne Utilities District	57,816	80	0	Tribs to Tuolumne River
Reclamation District #2039	56,804	79	0	San Joaquin River Delta Channels
McArthur	54,519	78	0	Pit and Fall Rivers
Belcher	53,893	223	25	Cosumnes River
Reclamation District #2038	51,846	72	0	San Joaquin River Delta Channels
California Dept. of Fish & Game	49,449	142	0	Sacramento-San Joaquin Delta Watershed
Willow Creek Mutual Water Co.	49,005	90	0	Central Drain, Colusa Basin Drain trib.
Olive Percy Davis Trust	48,527	128	0	Sacramento River
Zumwalt Mutual Water Co.	47,275	123	0	Colusa Basin Drain
Church of Jesus Christ of L D S	44,567	80	0	Sacramento River, South Delta Channels
Deer Creek I D	43,362	60	0	Deer Creek
The Prudential Insurance Co.	42,602	141	10	Putah Creek
Hallwood Irrigation Company	42,570	100	0	Yuba River
Elna Scohr Incorporated	41,669	115	0	Butte Creek
Lake County F C & W C D	41,000	0	41,000	Cache Creek
Maine Prairie Water District	40,298	108	0	Yolo Basin and North Delta Channels

2. Aquatic Resources

Historical fishery resources within the Central Valley were considerably different than the fisheries present today. Many native species have declined in abundance and distribution, and several introduced species have become well established. The decline of many species is due, in large part, to the alterations made to habitat as a result of human activities, the introduction of exotic species, and over-fishing. Early alterations to habitat included hydraulic mining, dredging, levee building, and dam construction. Operation of water storage and diversion facilities has had a significant impact on several species. Other factors that affect the fisheries of the Central Valley include agricultural, urban, and industrial development, grazing, mining, and logging, and the pollution generated by these activities.

A wide variety of fish are found throughout the waterways of the Central Valley. Many are common to several of the regions that will be described later in this chapter. Some, such as the anadromous fish, are found in particular parts of the San Francisco Bay/Sacramento-San Joaquin Delta and tributary rivers and streams only during certain stages of their life cycle.

Many of the fish species and communities found throughout the Central Valley could be affected by the implementation of the SWRCB water right decision. For the purposes of this EIR, the effects will be considered for anadromous species, other special-status species, and reservoir communities. Anadromous species include chinook salmon, steelhead trout, white and green sturgeon, striped bass, and American shad. Although striped bass and American shad are introduced species, both are abundant and contribute substantially to California's recreational fishery. These anadromous fish populate Central Valley waterways during the freshwater stages of their life cycles.

Delta smelt, Sacramento splittail, and longfin smelt are species of concern because of their declining numbers in the Delta and their federal status as threatened (delta smelt and Sacramento splittail) and species of concern (longfin smelt) under the ESA. All three species are native, and their abundance and distribution indicate the ecological health of the Sacramento-San Joaquin River system, the Delta, and the Bay.

Reservoirs have become one of the major fish habitats in the Central Valley since the development of the region's surface water projects. The nature of each reservoir and its fish fauna is determined by its elevation, size, location, and water quality. In general, reservoirs are less productive per surface acre than lakes because their typically deep, steep-sloped basins and fluctuating water levels greatly limit habitat diversity.

Warm-water reservoirs are typically suitable for black bass, sunfish, and catfish. Cold-water reservoirs have a zone of deep, well-oxygenated water cool enough in summer to be suitable for trout. Many of the Central Valley reservoirs lie at the mid-level elevations in the foothills and have characteristics of both warm-water and cold-water impoundments. These reservoirs provide greater fishing diversity, although extensive drawdowns limit species dependent on shallow-water habitat, such as black bass and sunfish. Reservoirs may enhance downstream fisheries by controlling the temperature and timing of releases.

The following life history summaries of selected fish in the Central Valley rivers are presented here to avoid repetition in the regional discussions that follow.

a. **Chinook Salmon**. Chinook salmon typically return to their natal stream to spawn. The timing of spawning of the four races of chinook salmon in Central Valley rivers is as follows:

1) Adult fall-run chinook salmon migrate through the Sacramento-San Joaquin Delta and into Central Valley rivers from July through December and spawn from October through December. Peak spawning activity usually occurs in October and November.

2) Adult late-fall run chinook salmon migrate through the Delta and into the Sacramento River from October through March or possibly April and spawn from January through April. Peak spawning activity occurs in February and March.

3) Adult winter-run chinook salmon migrate through the Delta from late November through June and into the Sacramento River from December through July. Winter-run chinook salmon do not spawn immediately but remain in the river up to several months before spawning. Spawning occurs from April through July, with peak spawning activity in May and June.

4) Adult spring-run chinook salmon migrate through the Delta from January through June, enter the Sacramento River and its tributaries from March through September, and remain in the rivers up to several months before spawning. Spawning occurs from August through October, with peak spawning activity in September. Table III-7 summarizes the timing of chinook salmon occurrence in the Sacramento-San Joaquin Delta by race and lifestage.

Chinook salmon lay their eggs in the gravel of the stream bottom where they incubate for generally 6 to 9 weeks depending on water temperature. The newly emerged fry remain in the gravel for another 2 to 4 weeks. The timing of rearing and outmigration is different for the various runs of chinook salmon. Rearing salmonids feed on a variety of aquatic and terrestrial insects and other small invertebrates, and newly emerged fry are sometimes prey of older steelhead. Juveniles begin the smolting process as they migrate seaward. Smolting consists of physiological, morphological and behavioral changes that stimulate emigration and prepare the salmonids for ocean life. Chinook salmon generally outmigrate within the first year and spend 2 to 4 years in the ocean before returning to spawn.

Winter-run chinook salmon are listed as endangered under both the state and federal endangered species acts. Spring-run chinook are listed as threatened under both the state and federal endangered species acts. Fall-run and late-fall run chinook, Central Valley Evolutionarily Significant Units, are considered candidate species under the federal Endangered Species Act.

Table III-7
Timing of Occurrence of Chinook Salmon by Race and Lifestage in the Sacramento-San Joaquin Delta

	Sacramento River				San Joaquin River
Lifestage	Fall-run	Late fall-run	Winter-run	Spring Run	Fall-run
Adult upstream migration	July - December[1]	October - April[1]	Late November - June[2]	January - June[2]	July - December[1]
Juvenile Rearing and Emigration	January - June[1] (fry/smolts) October - December[1] (yearlings)	April - December[1]	September - May[2]	October - June[2] (young-of-the-year) mid-October - March (yearlings)	January - June[1]

Sources: 1. USBR 1997c
2. DFG 1998

b. **Steelhead**. Steelhead typically return to their natal streams to spawn. There is considerable variation in steelhead run timing. Steelhead stocks in the Central Valley are all winter steelhead. Adults migrate upstream through the Delta and into the Sacramento River and tributaries during most months of the year. Steelhead begin moving through the mainstem in July, peak near the end of September, and continue migrating through February or March. A few adults have also been observed in April, May, and June. Steelhead in the Sacramento River basin spawn primarily from January through March, but spawning can begin as early as late December and can extend through April.

The timing of steelhead runs in the San Joaquin River basin is assumed to be similar to the Sacramento River basin. However, currently there is evidence of only a small anadromous run of steelhead in the basin and the origin of these fish is not known.

As for chinook salmon, steelhead lay their eggs in the gravel of the stream bottom where they incubate for approximately 6-9 weeks depending on water temperature. The newly emerged fry remain in the gravel for another 2-4 weeks. The timing of rearing and outmigration is different for the various runs of steelhead. Rearing salmonids feed on a variety of aquatic and terrestrial insects and other small invertebrates, and newly emerged fry are sometimes prey of older steelhead. Juveniles begin the smolting process as they migrate seaward. Smolting consists of physiological, morphological and behavioral changes that stimulate emigration and prepare the salmonids for ocean life.

The life history of steelhead differs from that of Pacific salmon in several ways. Unlike salmon, steelhead do not necessarily die after spawning, and a small portion of these survive to become repeat spawners. Post-spawning survival rates are generally low, and vary considerably between populations. Juvenile steelhead also have a longer freshwater rearing requirement (usually from one to three years) and both adults and juveniles are much more variable in the length of time they spend in fresh and salt water. Some individuals may remain in a stream, mature, and even spawn without ever going to sea, others may migrate to the ocean at less than a year old, and some may return to freshwater after spending less than a year in the ocean.

Due to significant declines in steelhead populations in the Central Valley, the NMFS listed the Central Valley, California, Evolutionarily Significant Unit as threatened under the ESA on March 19, 1998.

c. **Striped Bass**. Striped bass inhabit fresh and ocean water and require riverine habitat for spawning with currents sufficient to keep the eggs suspended off the bottom. Striped bass are considered adults at 3 years old and spawn in the lower reaches of the Sacramento and San Joaquin Rivers. Spawning begins first in the Delta, usually in mid-to-late April, and continues sporadically over 3-5 weeks. They are mass spawners, broadcasting eggs and sperm. The eggs are slightly denser than fresh water and in the absence of current, sink slowly to the bottom. Eggs hatch in approximately 2 days at 18-19EC. Larval stages last 4-5 weeks.

The striped bass rear in the Delta eating progressively larger prey as they grow. As the bass grow, the diet of juvenile bass shifts more to fish and becomes similar to the diet of adult striped bass, which includes small fish and invertebrates. Adult bass are found throughout the year in the Sacramento and San Joaquin rivers, the Delta, San Francisco Bay and the ocean but they show definite migration patterns. In the fall, adult striped bass migrate upstream to Suisun Bay and the Delta where they overwinter. During the spring, they disperse throughout the Delta and into the tributary rivers to spawn. Migration back to the Delta, Suisun Bay and San Francisco Bay occurs during summer. After the mid-1960's, most striped bass inhabit Suisun Bay and the Delta during summer and fall, and migration to San Francisco Bay and the Pacific Ocean is believed to have declined. However, data from Bennett and Howard (1997) suggest many older bass move to the ocean during warm El Niño events (i.e., 1976-77).

d. **American Shad**. Generally, American shad are anadromous, spending most of their life in the ocean and returning as adults to spawn in rivers. The adult spawning migration occurs primarily from April through June, with most spawning taking place in the American, Feather, Yuba, and upper Sacramento rivers. Some spawning occurs in moderate currents sufficient to keep eggs suspended off the bottom. The young can rear for several months in the Feather and Sacramento rivers or migrate downstream soon after hatching, lingering in the Delta for several weeks to several months. American shad become sexually mature while in the ocean at an average age of 3-5 years. Adult American shad initiate their spawning migration as early as February, however most adults do not migrate into the Delta until March or early April.

The peak spawning migration into upstream habitat takes place when water temperatures increase, usually in late May or early June. American shad spawn exclusively in freshwater, although spawning may be possible in brackish water. It is not clear whether flows or water temperatures are the primary factors responsible for attracting shad into the streams. Migration appears to decline after water temperature exceeds 68°F, usually in early July. Peak migration in the Sacramento river upstream of the Feather River occurs in May and angling surveys indicate that peak migration in the Feather and Yuba rivers occurs during June.

The newly hatched larvae are pelagic and most abundant at the water surface. They feed on zooplankton within 4-5 days of hatching. Newly hatched larvae are found downstream of spawning areas and can be rapidly transported downstream by river currents because of their small size. Some juvenile shad appear to rear in the Delta for up to a year or more before emigrating to the ocean. While in the Delta, juvenile shad are opportunistic feeders and prey on various invertebrates. Presumably, all juvenile shad eventually emigrate to the ocean, because immature shad greater than 8 inches long are rarely caught in the Delta. Seaward migration of juvenile shad in the Delta begins in late June and continues through November, with peak migration occurring between September and November.

Little is known about the oceanic ecology and behavior of juvenile and adult American shad. They are found in the Pacific Ocean from Baja California to Alaska; however, they are seldom found south of Monterey.

e. White Sturgeon. White sturgeon are the most abundant sturgeon in the Bay-Delta system and support a popular sportfishery. White sturgeon are long-lived and mature some time after 10 years of age. Their longevity allows them to reach large sizes; the California sport fishing record is a 468-pound fish that was probably 40 to 50 years old when caught in the mid-1980's.

In the Sacramento-San Joaquin system, a portion of the adult white sturgeon population moves upstream to freshwater environments to spawn between February and May. The species spawns in the Sacramento River between mid-February and late May, with peak spawning occurring between March and April. Most females spawn for the first time at approximately age 15 and could spawn as infrequently as every five years thereafter.

Spawning habitat requirements for white sturgeon in the system have not been definitively identified. Apparently sturgeon broadcast spawn in swift water. It is not known if eggs are fertilized in the water column or after they contact the bottom. The current initially disperses the adhesive eggs, which sink and adhere to gravel and rock on the bottom. The adhesive properties of the eggs are adaptive to spawning and retention of eggs in swift current environments. Hatching time depends primarily on water temperature. Egg incubation can last 4 to 14 days post-fertilization; yolk depletion can occur 15 to 30 days post-fertilization. Optimum temperatures for incubation and hatching range from 52 to 63 degrees F; higher temperatures result in greater mortality and premature hatching.

After hatching, yolk sac larvae swim up into the water column. Currents transport larvae downstream of the spawning area. The diet of white sturgeon changes as the fish become larger. Young-of-the-year sturgeon feed on a variety of prey, including small crustaceans and insect larvae, and potentially small fish fry. *Corophium* spp. and *Neomysids* are the most common prey of sturgeon captured in the Sacramento-San Joaquin River system. As the fish grow, the diet becomes more diverse and includes several benthic invertebrates and seasonally abundant food items, such as fish eggs or fry.

There is no defined age or size at which juvenile white sturgeon enter the estuarine environment. Adult and subadult sturgeon inhabit estuarine areas year-round. Adult sturgeon are found in Suisun, San Pablo, and San Francisco bays and in the Delta. Distribution in the Delta is thought to depend primarily on river flow and resulting salinity regimes. The center of the population is further upstream in low river flow years and downstream in high flow years.

In the Bay-Delta system, the major factors likely to be negatively affecting white sturgeon abundance are increased sport harvest, reduction in Delta outflow, entrainment, and toxic substances. A significant positive correlation has been found between white sturgeon year-class strength and Delta outflow in spring and early summer (April to July).

f. Green Sturgeon. San Francisco Bay, San Pablo Bay, Suisun Bay, and the Delta support the southernmost reproducing population of green sturgeon. White sturgeon are the most abundant sturgeon in the system and green sturgeon have always been comparatively uncommon. Habitat requirements of green sturgeon are poorly known, but spawning and larval ecology probably are similar to that of white sturgeon. Adult green sturgeon are more marine than white sturgeon, spending limited time in estuaries or freshwater.

Indirect evidence indicates that green sturgeon spawn mainly in the Sacramento River; spawning has been reported in the mainstem river as far north as Red Bluff. Spawning times in the Sacramento River are presumed to be March – July, with a peak from mid-April to mid-June. Adult sturgeon are in the river, presumably spawning, when temperatures range between 8 – 14 °C. Preferred spawning substrate likely is large cobble, but can range from clean sand to bedrock. Eggs are broadcast spawned and externally fertilized in relatively high water velocities and at depths >3 m. Female green sturgeon produce 60,000 – 140,000 eggs, about 3.8 mm. in diameter. Eggs probably hatch around 196 hours after spawning, and larvae are 8 – 19 mm. long. Juveniles likely range in size from 2.0 to 150 cm. Juveniles migrate to sea before two years of age, primarily during the summer and fall. They remain near estuaries at first, but can migrate considerable distances as they grow larger.

Green sturgeon grow approximately 7 cm per year until they reach maturity at 130-140 cm, around age 15-20. Thereafter growth slows down. The largest fish have been aged at 40 years, but this is probably an underestimate. Adults can reach sizes of 2.3 m FL and 159 kg, but in San Francisco Bay, most are probably less than 45 kg.

Juvenile and adult green sturgeon are benthic feeders and may also take small fish. Juveniles in the Delta feed on opossum shrimp (*Neomysis mercedis*) and amphipods (*Corophium* sp.)
The green sturgeon is apparently reduced in numbers throughout its range, although evidence is limited. Rough estimates of the abundance of green sturgeon longer than 102 cm. in the estuary between 1954 and 1991 range from 200 to 1,800 fish, based on intermittent studies by DFG. There is no direct evidence of a decline in the Sacramento River. However, the population is so small that a collapse could occur and hardly be noticed because of the limited sampling.

In the Bay-Delta system, the major factors likely to be negatively affecting green sturgeon abundance are sport fisheries, modification of spawning habitat, entrainment, and toxic substances. Green sturgeon are a federal Species of Concern and state Species of Special Concern.

g. Delta Smelt. The delta smelt generally spend their entire life cycle in the open, surface waters of the Sacramento-San Joaquin Delta and Suisun Bay. The delta smelt are small (typically 2.5 inches, maximum length about 5 inches), rarely live more than one year, have low fecundity, and are not taken in recreational or commercial fisheries. Delta smelt are euryhaline (a species that tolerates a wide range of salinity) fish that rarely occur in water of more than 10-12 parts per thousand salinity. Live fish are nearly translucent and have a steely-blue sheen to their sides.

Delta smelt are endemic to the upper Sacramento-San Joaquin Estuary. They occur in the Delta primarily below Isleton on the Sacramento River, below Mossdale on the San Joaquin River, and in Suisun Bay. They move into fresh water when spawning (ranging from January to July) and can occur in: (1) the Sacramento River as far upstream as Sacramento, (2) the Delta channels of the Mokelumne River, (3) the Cache Slough region, (4) the Delta, and (5) the Montezuma Slough area of the estuary. During the recent 6-year drought period, the center of delta smelt abundance was the western Delta. However, in water years 1993, 1995, 1997, and 1998, their distribution shifted into Suisun Bay and areas farther downstream. During high outflow periods, they also may be washed into San Pablo Bay, but they do not establish permanent populations there. Delta smelt are captured seasonally in the channels of Suisun Marsh.

Most spawning occurs in sloughs and shallow edge-waters of channels in the upper Delta. Specific areas that have been identified as important delta smelt spawning habitat include Barker, Lindsey, Cache, Prospect, Georgiana, Beaver, Hog, and Sycamore sloughs, and the Sacramento River in the Delta, and tributaries of northern Suisun Bay. Laboratory observations have indicated that delta smelt are broadcast spawners and that the eggs sink to the bottom and attach to the substrate. Newly hatched delta smelt have a large oil globule that makes them semi-buoyant, allowing them to maintain themselves just off the bottom, where they feed on rotifers and other microscopic prey. Once the swimbladder develops, larvae become more buoyant and rise up higher in the water column. At this stage (0.6-0.7 inch total length), most are presumably washed downstream until they reach the mixing zone or the area immediately upstream of it. Growth is rapid and juvenile fish are 1.6-2.0 inches long by August.

Delta smelt feed primarily on planktonic copopods, cladocerans, and amphipods (all small crustaceans commonly used by fish for food), and, to a lesser extent, insect larvae. Delta smelt are a minor prey item of juvenile and subadult striped bass, and have been reported in the stomach contents of white catfish and black crappie.

Delta smelt were once one of the most common pelagic fish in the upper Sacramento-San Joaquin estuary. While their annual abundance has fluctuated greatly in the past, between 1981 and 1990, delta smelt abundance was consistently low. Indices in 1991, 1993, and 1995 were more than double those of the 1981-1990 period; indices in 1993 and 1995 were the sixth and seventh highest on record. The causes of decline are multiple and synergistic, including: reduction in flows; entrainment losses to water diversions; high outflows; changes in food organisms; toxic substances; disease, competition, and predation; and, loss of genetic integrity. The decline was precipitous in 1982 and 1983 due to extremely high outflows and continued through the drought years 1987-1992. In 1993, numbers increased considerably, apparently in response to a wet winter and spring.

The USFWS listed the delta smelt as threatened on March 5, 1993 and issued a formal biological opinion for SWP and CVP operations on May 26, 1993. The DFG listed the delta smelt as threatened on December 9, 1993. USFWS issued an amended biological opinion for SWP and CVP operations on February 4, 1994 and again on March 3, 1995.

h. **Longfin Smelt**. The longfin smelt is a small, planktivorous fish that is found in several Pacific coast estuaries from San Francisco Bay to Prince William Sound, Alaska. Until 1963, the population in San Francisco Bay was thought to be a distinct species. Within California, longfin smelt have been reported from Humboldt Bay and the mouth of the Eel River. In California, the largest longfin smelt reproductive population inhabits the Bay/Delta Estuary.

Longfin smelt can tolerate salinities ranging from fresh water to seawater. Spawning occurs in fresh to brackish water over sandy-gravel substrates, rocks, or aquatic vegetation. In the Bay/Delta Estuary, the longfin smelt life cycle begins with spawning in the lower Sacramento and San Joaquin rivers, the Delta, and freshwater portions of Suisun Bay. Spawning may take place as early as November and extend into June, with the peak spawning period occurring from February to April. The eggs are adhesive and, after hatching, the larvae are carried downstream by freshwater outflow to nursery areas in the

lower Delta and Suisun and San Pablo bays. Adult longfin smelt are found mainly in Suisun, San Pablo, and San Francisco bays, although their distribution is shifted upstream in years of low outflow.

With the exceptions that both longfin smelt and delta smelt spawn adhesive eggs in river channels of the eastern Estuary and have larvae that are carried to nursery areas by freshwater outflow, the two species differ substantially. Consistently, a measurable portion of the longfin smelt population survives into a second year. During the second year of life, they inhabit San Francisco Bay and, occasionally, the Gulf of the Farallones; thus, longfin smelt are often considered anadromous.

Longfin smelt are also more broadly distributed throughout the Estuary and are found at higher salinities than delta smelt. Because longfin smelt seldom occur in fresh water except to spawn, but are widely dispersed in brackish waters of the Bay, it seems likely that their range formerly extended as far up into the Delta as salt water intruded. The easternmost catch of longfin smelt in fall mid-water trawl samples has been at Medford Island in the Central Delta. A pronounced difference between the two species in their region of overlap in Suisun Bay is by depth; longfin smelt are caught more abundantly at deep stations (>10 m), whereas delta smelt are more abundant at shallow stations (<3 m).

The main food of longfin smelt is the opossum shrimp, *Neomysis mercedis*, although copopods and other crustaceans are important at times, especially to small fish. Longfin smelt, in turn, are eaten by a variety of predatory fishes, birds, and marine mammals.

Longfin smelt were once one of the most common fish in the Sacramento-San Joaquin Estuary. Their abundance has fluctuated widely in the past but since 1982, abundance has declined significantly, reaching the lowest levels during drought years. Abundance improved substantially in 1995, but was again relatively low in 1996 and 1997. The number of longfin smelt also has declined in relative abundance to other fishes, dropping from first or second in abundance in most trawl surveys during the 1960s and 1970s, to being seventh or eighth in abundance. The causes of decline are multiple and synergistic, including: reduction in outflows; entrainment losses to water diversions; climatic variation; toxic substances; predation; and introduced species.

i. **Sacramento Splittail**. The Sacramento splittail is a large minnow endemic to the Bay/Delta Estuary. Once found throughout low elevation lakes and rivers of the Central Valley from Redding to Fresno, this native species now occurs in the lower reaches of the Sacramento and San Joaquin rivers and tributaries, the Delta, Suisun and Napa marshes, Sutter and Yolo bypasses, and tributaries of north San Pablo Bay. Although the Sacramento splittail is generally considered a freshwater species, the adults and sub-adults have an unusually high tolerance for saline waters (up to 10-18 ppt) for a member of the minnow family. The salt tolerance of splittail larvae is unknown, but they have been observed in water with salinities of 10-18 ppt. Therefore, the Sacramento splittail is often considered an estuarine species. When splittail were more abundant, they were commonly found in Suisun Bay and Suisun Marsh.

The Sacramento splittail, which has a high reproductive capacity, can live 5-7 years and generally begin spawning at 2 years of age. Spawning, which seems to be triggered by increasing water temperatures and day length, occurs over beds of submerged vegetation in slow-moving stretches of water, such as flooded terrestrial areas and dead-end sloughs. Adults spawn from February through May in the Delta, upstream tributaries, Napa Marsh, Napa and Petaluma rivers, Suisun Bay and Marsh, and the Sutter and Yolo bypasses. Hatched larvae remain in shallow, weedy areas until they move to deeper offshore habitat later in the summer. Young splittail may occur in shallow and open waters of the Delta and San Pablo Bay, but they are particularly abundant in the northern and western Delta.

Splittail are benthic foragers that feed extensively on opossum shrimp (*Neomysis mercedis*) and opportunistically on earthworms, clams, insect larvae, and other invertebrates. They are preyed upon by striped bass and other predatory fish in the Estuary. The splittail is commonly used by anglers as bait when fishing for striped bass.

Splittail have disappeared from much of their native range because dams, diversions, and agricultural development have eliminated or drastically altered much of the lowland habitat these fish once occupied. Access to spawning areas or upstream habitat is now blocked by dams on the large rivers.

Young-of-the-year splittail abundance appears to fluctuate widely from year to year. Young splittail abundance was dramatically reduced during the 1987-1992 drought. However, wet conditions in 1995 resulted in high indices for most measures of young-of-the-year abundance. Abundance was relatively low in 1996 and 1997, but higher than during the drought years. In 1998, young-of-the-year abundance, indexed by the summer townet survey, was again relatively high.

In contrast to young splittail, adult abundance showed no obvious decline during the 1987-1992 drought. Adult population variation is moderated by the species' long life span and multiple year classes. Factors affecting abundance of young splittail include: variation in flooding of terrestrial areas which provide spawning and rearing habitat; changed estuarine hydraulics, especially reduced outflow; modification of spawning habitat; climatic variation; toxic substances; introduced species; predation; and exploitation.

The Sacramento splittail was listed as threatened under the ESA by the USFWS on February 8, 1999.

j. White Catfish. The white catfish was introduced into the Bay/Delta Estuary in 1874 and rapidly increased in abundance. In recent years, the white catfish has supported an important sport fishery. In the Estuary, they are most abundant in areas of slow currents and dead-end sloughs. White catfish, which can live in salinities as high as 11 to 12 ppt, are the only catfish common in Suisun Bay.

k. Largemouth Bass. Largemouth bass, also know as black bass, were first introduced into California in 1874 and have spread to suitable habitat throughout the state. These bass are perhaps the most sought after warmwater gamefish in California. Many California reservoirs and farm ponds provide excellent bass fishing with sizable populations of large, fast-growing fish. One of the factors that influences bass populations in reservoirs, by influencing food availability and spawning success, is the manipulation of water levels for water supply or hydropower production.

The largemouth bass are found in warm, quiet water with low turbidities and aquatic plants such as farm ponds, lakes, reservoirs, sloughs and river backwaters. Adult bass remain close to shore and usually are abundant in water 1 to 3 meters deep near submerged rocks or branches. Young-of-the-year bass also stay close to shore in schools but swim about in the open.

Largemouth bass spawn for the first time during their second or third spring, when they are approximately 180-210 mm. The first notable spawning activity is nest building by males, which starts when water temperatures reach 14-16EC, usually in April. Spawning activity will often continue through June, at temperatures up to 24EC. Nests are generally shallow depressions fanned by the males in sand, gravel or debris-littered bottoms at depths of 1 to 2 m. Rising waters in reservoirs may cause active nests to be located as deep as 4 to 5 m. The eggs adhere to the nest substrate and hatch in two to five days. The sac fry then usually spend five to eight days in the nest or its vicinity.

For the first month or two after hatching, the fry feed mainly on rotifers and small crustaceans, but by the time they are 50 to 60 mm in length they feed largely on aquatic insects and fish fry, including those of their own species. Once largemouth bass exceed 100-125 mm in length, they feed principally on fish, however they also consume crayfish, tadpoles and frogs and prey preferences can vary from year to year.

3. Recreation

Lakes and rivers have always been a primary focus for outdoor recreation activities. Early development of recreational opportunities occurred incidentally at natural water bodies, streams, and rivers. After World War II, outdoor recreation gained in popularity with a rapidly growing population. Water-based recreation has become an integral part of meeting society's recreational needs.

The construction of large reservoirs and the alteration of major rivers have shaped recreation opportunities in the Central Valley. Public water supply projects, such as the CVP, SWP, and local developments, have helped to provide additional recreational opportunities throughout the State. The reservoirs have created extensive flatwater recreation opportunities. At the same time, recreation activities on the lower rivers have been affected as flows, water temperatures, and fisheries have been altered by the placement of dams, the operation of the reservoirs, and the diversion of water from the river system.

Many outdoor recreation activities are water-dependent or water-enhanced. Water-dependent activities include boating, fishing, and swimming; water-enhanced activities include camping, picnicking, hunting, and wildlife observation. Swimming, fishing, and boating are popular activities at California's reservoirs. Recreation facilities such as beaches, boat ramps, trails, restrooms, and access roads add to the quality and safety of the recreation experience. Picnic and camping facilities are often developed at reservoirs to meet public demand. The way that a reservoir is operated and water levels are managed directly affects the quality and economic value of recreational and other contingent activities.

Recreational activity and resources generally do not consume significant amounts of water. Although some water developments were designed and constructed primarily to provide recreation, most water-related recreational facilities are located on streams and reservoirs which are operated for other purposes. In some cases, minimum reservoir releases may be imposed to maintain recreation activities downstream, or the drawdown of a reservoir may be limited during the recreation season.

Reservoir operations for water supply are usually adequate to support established recreation activities, particularly when precipitation and surface runoff are near normal. Changes in operation, because of drought or excessive demands, can reduce recreational opportunities and the associated benefits. In general, reservoir recreation benefits decrease as receding water levels reduce water surface areas, make boat ramps less accessible, and leave recreation facilities farther from shorelines.

Riverine environments can offer recreation opportunities similar to those available at the large water surface impoundments, including boating, fishing, swimming, and related activities. In addition, rivers and streams offer white-water sports, such as rafting, kayaking, and canoeing, and certain fishing opportunities not found in reservoirs, particularly for anadromous fish.

Many streams are unimpaired by water development facilities, such as many of those listed under the State or federal Wild and Scenic Rivers Acts. These streams offer seasonal recreational opportunities in natural settings. Other streams, such as those controlled by reservoir releases, offer opportunities to enhance downstream flows that can benefit recreation values. Streams that would naturally run only intermittently, for example, can have year-round flows following reservoir construction and operation. This kind of conversion can develop new fisheries, add to recreational-area attractiveness, and enhance wildlife habitat. Regulation of larger streams and rivers can support white-water sports for a longer season or increase the diversity of available activities.

Hydroelectric generating facilities can have varying impacts on both reservoir and river recreation depending on whether the operation is constant or subject to peaking. As with water supply releases, increased stream flows from power generation provide recreation that to some degree offset the effects of diminished reservoir storage. In some cases a hydropower development can completely change river recreation benefits. For example, peak releases from the North Fork Stanislaus River project greatly increased white-water rafting but reduced opportunities for swimming in the summer.

Many wildlife refuges in California owe their existence to imported water which supports large populations of migratory waterfowl, upland game and other wildlife. Wetland habitat at refuges and at private hunting clubs is integral to the maintenance of seasonal waterfowl populations along the Pacific Flyway as well as resident game populations. Historically, recreation values associated with such wildlife have focused primarily on hunting. More recently, bird watching has been identified as one of the fastest growing recreational activities in the nation.

The regional descriptions of the environmental setting which follow include a section which describes the water related recreation areas and opportunities in those regions. The recreation areas that would most likely be affected, directly or indirectly, by the SWRCB action are located primarily in the Sacramento River Basin, San Joaquin River Basin, and the Sacramento-San Joaquin Delta, and include:

- reservoirs owned and operated by the CVP, SWP, or local water agencies;
- rivers and streams directly dependent on downstream flows controlled by these reservoirs or otherwise potentially affected by the water rights decision;
- national wildlife refuges (NWRs) or state wildlife management areas (WMAs) that receive surface water diversions; and,
- other facilities that provide limited recreation, such as aqueducts, canals, and private hunting clubs that receive surface water diversions.

B. TRINITY RIVER BASIN

The Trinity River drains a watershed of approximately 3,000 square miles; about one-quarter of which is above Lewiston Dam. The terrain is predominantly mountainous and forested, with little available farming area. Elevations in the basin range from more than 9,000 feet above sea level in the headwaters area to less than 300 feet at the confluence with the Klamath River. Figure III-9 shows the Trinity River Basin.

The Trinity River is the largest tributary to the Klamath River. It consists primarily of the mainstem, and the north and south forks. The mainstem Trinity River originates approximately 20 miles southwest of Mount Shasta in the canyons bordered by the Scott Mountains, the Eddy Mountains, and the Salmon-Trinity Alps. Trinity and Lewiston dams regulate Trinity River flows beyond approximately River Mile 112. The mainstem flows a total of 170 miles west from its origins to the Klamath River at Weitchpec, which is located 43.5 miles upstream from the Pacific Ocean. Major tributaries to the Trinity River include Coffee Creek, Canyon Creek, North Fork, Weaver Creek, New River and South Fork. Hayfork Creek is the major tributary of South Fork.

Urban development within the Trinity River Basin is primarily limited to the communities of Weaverville, Hayfork, Lewiston, Junction City, and Willow Creek. Access through the Basin is provided by State Highways 299, which follows the river from Junction City to Willow Creek, and by State Highway 96 from Willow Creek to Weitchpec. Several small communities have sprung up along State Highway 299 on shallow terrain adjacent to the river. The majority of lands directly adjacent to the river are managed by either the U.S. Forest Service (USFS) or the U.S. Bureau of Land Management (BLM).

The Hoopa Indian Reservation is located north of Willow Creek and encompasses approximately 140 square miles on either side of the Trinity River and State Highway 96 between Willow Creek and the confluence of the Trinity and Klamath rivers near Weitchpec. The Yurok Indian Reservation, which is located within the lower Klamath Valley, extends from the northern boundary of the Hoopa Reservation, along the Klamath River and State Highway 169, to the Pacific Ocean near Requa.

Figure III-9
Trinity River Basin

The climate of the Trinity River drainage is characterized by moderate temperatures and annual precipitation ranging from 35 inches along the Trinity River to over 70 inches at higher elevations. Most precipitation occurs during winter months, much of which occurs as snow at elevations 4,000 feet and above. Average temperatures at Weaverville range from 37°F in January to 71°F in July. Summer air temperatures occasionally exceed 100°F in some areas. The Trinity River Act of 1955 authorized the construction of the Trinity River Division of the CVP. The USBR constructed the Trinity River Division in the early 1960's to augment CVP water supplies. The facilities of the Trinity River Division store and divert water from the Trinity River for export to the Sacramento River Basin. The CVP uses the Trinity River water to meet agricultural and urban water demand in the Sacramento and San Joaquin valleys, and to generate hydroelectric power.

Trinity Lake (formerly Clair Engle Lake), impounded by Trinity Dam, stores over 2.4 million acre-feet of winter runoff from the Trinity River. Immediately downstream, Lewiston Dam and Reservoir regulate flows in the Trinity River and provide a forebay for the diversion of flows from the Trinity River Basin, through the Clear Creek Tunnel to Whiskeytown Reservoir in the Sacramento River Basin.

Water diverted through the 10.7-mile Clear Creek Tunnel enters Whiskeytown Reservoir through the Judge Francis Carr Powerhouse. Whiskeytown Reservoir, located on Clear Creek, has a storage capacity of about 240,000 acre-feet. Flows on Clear Creek vary depending on the year type, with mean annual flows of 265,000 acre-feet. Releases are made from Whiskeytown to Clear Creek (42,000 acre-feet per year) and Clear Creek South Unit (15,000 acre-feet per year) to satisfy fish flow requirements and water rights. The remaining water supply from Clear Creek, along with the Trinity exports, is diverted from Whiskeytown through the Spring Creek Tunnel to Keswick Reservoir on the Sacramento River. Power is generated at Trinity, Lewiston, Spring Creek, Judge Francis Carr, and Keswick powerplants.

The Trinity River Division of the CVP was completed in 1963, and exports from the Trinity River began in May of that year. The mean annual inflow to Trinity Reservoir is about 1.1 MAF, with annual flows ranging from approximately 0.27 to 2.7 MAF. Long-term average annual exports are about 881,000 acre-feet. From 1980 through 1992, these exports have averaged 864,000 acre-feet annually. There are no in-basin deliveries of water from the CVP's Trinity River Division. However, Humboldt County and other downstream users have a claim to 50,000 acre-feet under area-of-origin rights that may be requested in the future.

The export of water from the Trinity Basin resulted in reduced stream flows, sedimentation, and vegetation encroachment in the Trinity River, which has adversely impacted the fisheries. Originally, releases from the Trinity and Lewiston dams to the Trinity Rivers were approximately 120,000 AF per year. As much as 90 percent of the Trinity River annual flows have been diverted through the Clear Creek Tunnel. The 1955 Trinity River Act contains a clause that states that the Interior Secretary is "authorized and directed to adopt appropriate measures to insure the preservation and propagation of fish and wildlife." In the late 1970's, the USBR increased the releases to vary between 270,000 and 340,000 acre-feet per year in an effort to reverse salmon declines.

The Interior Department has a trust obligation to the Hoopa Valley and Yurok tribes to protect their federally reserved fishing rights, which includes providing adequate streamflow to protect and restore Trinity River fish populations for tribal harvest. The tribes rely on the harvest of salmonids for subsistence and ceremonial and commercial needs. In 1991, the Secretary of the Interior responded to a request for increased flows from the Hoopa Valley and Yurok tribes and increased the minimum flows to 340,000 acre-feet per year.

A major study is under way to establish the optimum flow schedule for fisheries on the Trinity River. A 1981 Interior Secretary's Decision directed the USFWS to conduct a 12-year Trinity River Flow Evaluation Study to evaluate the effects on fish habitat of adjusting the flows. Section 3406(b)(23) of the Central Valley Project Improvement Act (P.L. 102575) allocated a minimum of 340,000 acre-feet per year for the purposes of fishery restoration, propagation, and maintenance, and further required that the Trinity River Flow Evaluation Study be completed in a manner which ensures the development of recommendations for the restoration and maintenance of the Trinity River fishery.

The Draft Trinity River Flow Evaluation, released in January 1998, contains daily flow recommendations for the Trinity River, which range, depending on water year type, from 300 cfs to 10,564 cfs. If these daily flow recommendations are adopted, releases from Trinity Lake into the Trinity River will range from 368,621 acre feet in a critically dry year to 815,226 acre feet in an extremely wet year, excluding unscheduled releases associated with large storm events.

The USFWS, USBR, the Hoopa Valley Tribe, and Trinity County are preparing an EIR/EIS on Trinity River Mainstem Fishery Restoration (Trinity EIR/EIS), which will evaluate a range of alternatives for restoration of the Trinity River fisheries, including the recommended flows in the Flow Evaluation Study. The Trinity EIR/EIS will also evaluate economic and other impacts of the restoration alternatives on the Central Valley, Trinity, and lower Klamath Basin regions.

C. SACRAMENTO RIVER BASIN

1. Geography and Climate

The Sacramento River Basin contains the entire drainage area of the Sacramento River and its tributaries and extends almost 300 miles from Collinsville in the Sacramento-San Joaquin Delta to the Oregon border. The crests of the Sierra Nevada and Cascade ranges form the region's eastern and northern boundaries. The American River watershed and the northern Delta form the southern limits, and the crest of the Coast Ranges defines the western boundary of the region. Mount Shasta rises 14,162 feet above sea level in the north and the lower Sacramento Valley drops to near sea level. The Sacramento River meanders from north to south through the broad valley in the central part of the region. The region encompasses 17 percent of the State's total land area. Figure III-10 shows the Sacramento River Basin.

The climate varies considerably in the region. However, three distinct climate patterns can be defined: (1) The northernmost area, mainly high desert plateau, is characterized by cold, snowy winters with only moderate rainfall, and hot, dry summers. This area depends on melting snowpack to provide a summertime water supply. Average annual precipitation in the area ranges from 10 to 20 inches. (2) Other mountainous parts in the north and the east have cold, wet winters with major amounts of snow providing considerable runoff for the summer water supply. These higher mountainous areas may receive precipitation during any month of the year, with annual precipitation totals from about 20 to over 80 inches. Summers are usually mild in the mountains. (3) The Sacramento Valley, the south-central part of the region, has mild winters with less precipitation. Precipitation usually occurs from October through May. Summers in the valley are hot with virtually no precipitation from June to September. Sacramento's average annual precipitation is 18 inches.

2. Population

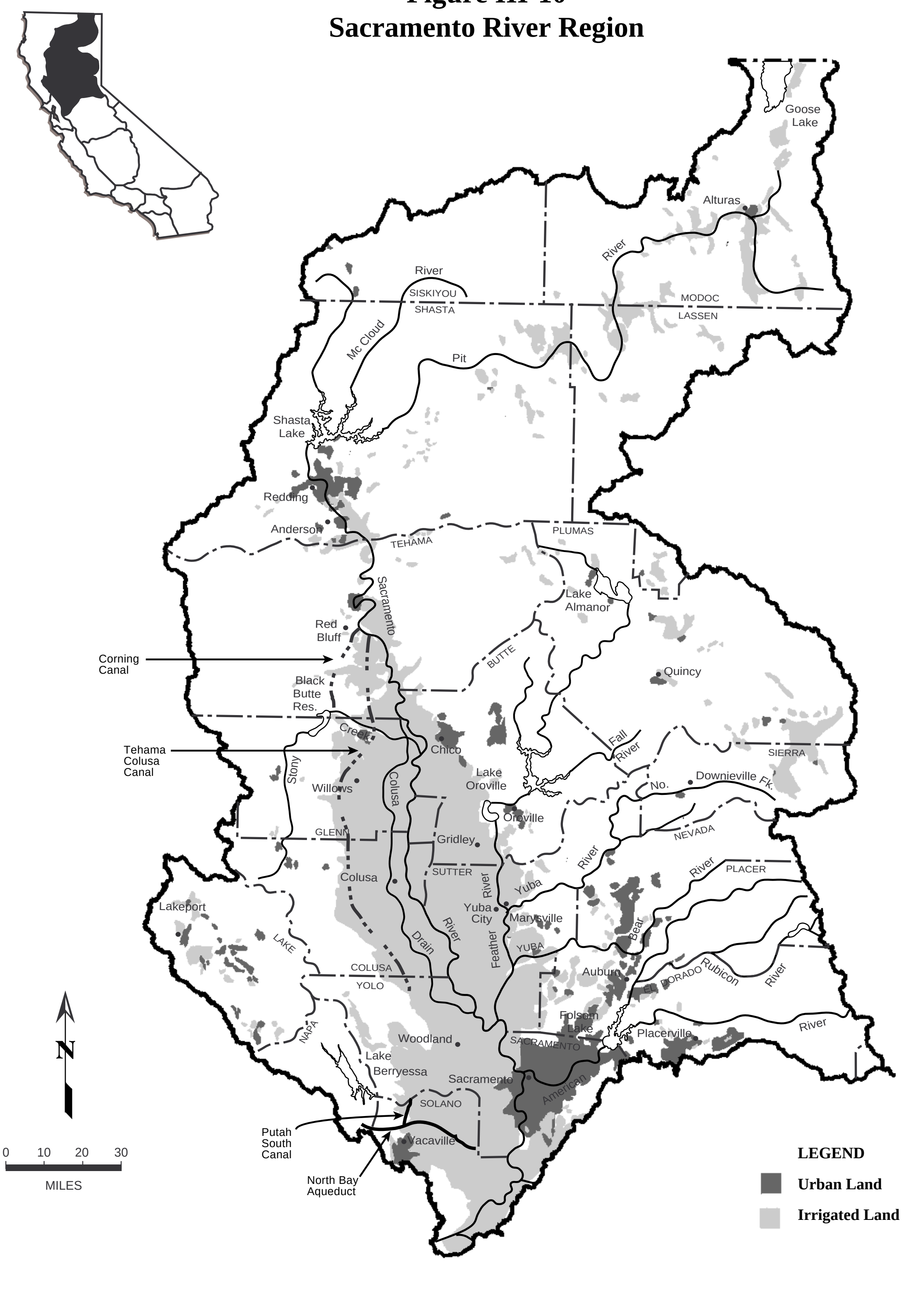
With a population of over 2.2 million, the 1990 census showed 535,000 more people in the Sacramento River Basin than in 1980, a 32-percent increase. Immigration from other parts of California played a big role in the increase. The fastest growing town was Loomis, a foothill community about 25 miles northeast of Sacramento, where there was a 344-percent increase between 1980 and 1990. The City of Sacramento had the greatest number of new residents: more than 93,600 additional people. More than half of the region's population lives in the greater metropolitan Sacramento area. Other fast-growing communities include Vacaville, Dixon, Redding, Chico, and various Sierra Nevada foothill towns.

3. Land Use and Economy

The economy of the Sacramento River Basin is based primarily on irrigated agriculture and livestock production. Related industries include food packing and processing, agricultural services and the farm equipment industry. Another important segment of the economy in the Sacramento River Basin consists of military and other federal government stablishments, the State government, and the aerospace industry. Emerging industries include electronics, computers and other high technology industries. Lumber industries are centered in the Sierra Nevada, Cascade Range, Modoc Plateau, and a portion of the Coast Ranges. Other natural resource industries are engaged in extraction or mining and production of natural gas, clay, limestone, sand, gravel, and other minerals. While agriculture is the largest land use it does not provide the most jobs. The largest proportions of wage and salary jobs are in the service, wholesale and retail trade, government and manufacturing sectors, respectively.

A wide variety of crops is grown in the Sacramento River Basin. The region produces a significant amount of the overall agricultural tonnage in California, especially rice, grain, tomatoes, field crops, fruit, and nuts. Because of comparatively mild weather and good soil, some double-cropping occurs in the region. The largest of any single crop is rice, which represents about 23 percent of the total.

Figure III-10
Sacramento River Region



Source: DWR, Bulletin 160-93 (1994)

The Sacramento River Basin supports about 2,145,000 acres of irrigated agriculture (22 percent of State total). About 1,847,000 acres are irrigated on the valley floor. The surrounding mountain valleys within the region add 298,000 irrigated acres (primarily pasture and alfalfa) to the region's total. Crop statistics show that irrigated agricultural acreage in the region peaked during the 1980s and has since declined. The main reason for this decline is the conversion of irrigated agricultural lands to urban development. The comparison of 1980 and 1990 crop patterns shows that grain, field, rice, and pasture crops decreased by 137,000 acres. On the other hand, orchard, alfalfa, and tomato crops gained a total of 106,000 acres. The net decrease of irrigated crops between 1980 and 1990 was 31,000 acres.

Major urban areas include Sacramento, West Sacramento, Davis, Vacaville, Woodland, Folsom, Roseville, Yuba City, Marysville, Chico, Redding, and Red Bluff. Larger foothill communities include Placerville, Auburn, Grass Valley, Nevada City, and Oroville. Towns and cities that primarily serve the agricultural interests in the upper valley include Williams, Willows, Corning and Colusa. Many small communities exist along the river in the upper valley, such as Tehama, Los Molinos, Hamilton City, Princeton, and Butte City. Along the lower river, major urban development from the City of Sacramento fronts the river, with minor residential and commercial development at Knights Landing, Rio Vista, Isleton, Walnut Grove, Locke, Hood, Clarksburg, and Freeport. Marinas are common along the river in this reach, especially between Clarksburg and just upstream of Discovery Park. Agriculture is the most important segment of the economy for the smaller communities, while manufacturing and services are more important for the economy of the larger towns.

4. Water Supply

The Sacramento River Basin produces about two-thirds of the surface water supply of the Central Valley. Average runoff from the basin is estimated at about 22 MAF per year, which is nearly one-third of the State's total runoff. Average annual water supply for the region is 11.7 MAF, of which surface water provides 50 percent and groundwater provides 22 percent. About 28 percent of the average annual water supply is considered dedicated natural flows which meet the instream flow requirements of the major streams in the basin. Water is both imported into the region and exported from the region.

Clear Creek Tunnel carries about 881,000 acre-feet per year from Lewiston Lake on the Trinity River to Whiskeytown Reservoir. Minor imports to the basin are made from Echo Lake, Sly Park Reservoir, and the Little Truckee River. About 6 MAF per year are exported from the Sacramento River Basin through State, federal and local conveyance facilities.

A number of reservoirs in the region provide water supply, recreation, power, environmental, and flood control benefits. A list of the major reservoirs in the Sacramento River Basin is presented in Table III-8. The area has a total of about 16 MAF of surface storage capacity.

a. **Surface Water Hydrology**. The major tributaries of the Sacramento River above Shasta Dam are the Pit and McCloud rivers. The Pit River, which is the most extensive tributary to Shasta Reservoir, contributes about 60 percent of the average annual surface inflow to the reservoir. The McCloud River, which originates in southeastern Siskiyou County, contributes about 10 percent of the average annual surface inflow to Shasta Lake. The Sacramento River, which originates as the north, middle, and south forks on the east slopes of the Trinity Divide in Siskiyou County, contributes about 14 percent of the total average annual surface inflow to Shasta Lake. Minor tributaries to the lake provide the remaining inflow.

The approximately 56 miles of the Sacramento River from Keswick Dam to Red Bluff is largely contained by steep hills and bluffs. River flows in the upper part of this reach are highly controlled by releases from Shasta Reservoir, but become more influenced by tributary inflow downstream. Major tributaries to the Sacramento River between Keswick Dam and Red Bluff include Cow, Stillwater, Bear, Battle, Paynes, Cottonwood, and Clear creeks.

The Sacramento River between Red Bluff and Colusa is a meandering stream, migrating through alluvial deposits between widely spaced levees. The Sacramento Canals Unit of the CVP serves over 200,000 acres in the Sacramento Valley in Tehama, Glenn, Colusa, and Yolo counties. This unit consists of the Red Bluff Diversion Dam, Corning Pumping Plant, and several canals including the 122-mile long Tehama-Colusa Canal which terminates in the northern part of Yolo County.

The Glenn Colusa Irrigation District supplies water from the Sacramento River near Hamilton City to about 175,000 acres of land, including 25,000 acres within three federal wildlife refuges. Numerous small diversions along the Sacramento River provide irrigation to riparian lands. The Colusa Basin drainage area is located west of the Sacramento River, extending from Orland to Knights Landing. The basin contains some 350,000 acres of rolling foothills located along the eastern slopes of the Coast Ranges, and about 650,000 acres in the flat agricultural lands of the Sacramento Valley. The area is served by the Colusa Basin Drain, a multi-purpose drain that is used both as an irrigation supply canal and as an agricultural return flow facility. The drain eventually discharges into the Sacramento River through the regulated outfall gates at Knights Landing or, during flood events, into the Yolo Bypass through the Knights Landing Ridge Cut.

In addition to the major reservoirs which provide flood control, the Sacramento basin has more than 2.2 MAF of potential flood control storage consisting of a highly developed system of flood control basins, levees, channels, and bypasses. The basins are composed of a series of natural and man-made bypass overflow areas that act as auxiliary channels to the Sacramento River during floodwater times. The bypass areas are used for agriculture during the summer and fall months, and are valuable wetlands during the flood season.

Table III-8
Major Reservoirs in the Sacramento River Basin

Reservoir Name	Stream	Capacity (TAF)	Owner
McCloud	McCloud River	35.2	PG&E
Iron Canyon	Pit River	24.2	PG&E
Lake Britton	Pit River	40.6	PG&E
Pit No. 6	Pit River	15.9	PG&E
Pit No. 7	Pit River	34.6	PG&E
Shasta	Sacramento River	4,552.0	USBR
Keswick	Sacramento River	23.8	USBR
Whiskeytown	Clear Creek	241.1	USBR
Lake Almanor	Feather River	1,143.8	PG&E
Mountain Meadows	Feather River	23.9	PG&E
Butt Valley	Butt Creek	49.9	PG&E
Bucks Lake	Bucks Creek	105.6	PG&E
Antelope	Indian Creek	22.6	DWR
Frenchman	Little Last Chance Creek	55.5	DWR
Lake Davis	Big Grizzly Creek	84.4	DWR
Little Grass Valley	Feather River	94.7	OWID
Sly Creek	Lost Creek	65.7	OWID
Thermalito	Feather River	81.3	DWR
Oroville	Feather River	3,537.6	DWR
New Bullards Bar	Yuba River	966.1	YCWA
Jackson Meadows	Yuba River	69.2	NID
Bowman Lake	Canyon Creek	68.5	NID
French Lake	Canyon Creek	3.8	NID
Spaulding	Yuba River	135.7	PG&E
Englebright	Yuba River	70.0	USCOE
Scotts Flat	Deer Creek	48.5	NID
Rollins	Bear River	66.0	NID
Camp Far West	Bear River	104.0	SSWD
French Meadows	American River	136.4	PCWA
Hell Hole	Rubicon River	207.6	PCWA
Loon Lake	Gerle River	76.5	SMUD
Slab Creek	American River	21.6	PG&E
Caples Lake	Caples Creek	16.6	PG&E
Union Valley	Silver Creek	277.3	SMUD
Ice House	Silver Creek	46.0	SMUD
Folsom Lake	American River	974.5	USBR
Lake Natoma	American River	9.0	USBR
East Park	Stony Creek	50.9	USBR
Stony Gorge	Stony Creek	50.0	USBR
Black Butte	Stony Creek	143.7	USCOE
Clear Lake	Cache Creek	313.0	YCFC&WCD
Indian Valley	Cache Creek	301.0	YCFC&WCD
Lake Berryessa	Putah Creek	1,600.0	USBR

Source: DWR 1993b

From about Colusa to the Delta, the Sacramento River is regulated by the Sacramento River Flood Control Project which diverts floodwater in the Sacramento River into the Sutter Bypass. The Sutter Bypass runs between the Sacramento and Feather Rivers and receives additional flow from the Feather River. The combined flow enters the Yolo Bypass at Fremont Weir near Verona. American River flood-flows enter the Yolo Bypass through the Sacramento Weir. The Yolo Bypass returns the entire excess flood flow to the Sacramento River, about 10 miles above Collinsville. The system provides flood protection to about 800,000 acres of agricultural lands and many communities, including the cities of Sacramento, Yuba City, and Marysville.

Major streams entering the Sacramento River between Red Bluff and the Delta include Thomes, Elder, Stony, and Putah creeks from the west, and Antelope, Mill, Deer, Big Chico, and Butte creeks and the Feather, Yuba, Bear, and American rivers from the east. Numerous small tributaries drain the low foothills on either side of the valley.

Butte Creek flows southwesterly from the Sierra Nevada into the Sacramento Valley near Chico, then parallels the Sacramento River until it flows into Butte Slough south of Colusa. The lower portion of the Butte Basin is known as the Butte Sink, an important wetland habitat for waterfowl. This area is one of five major flood basins in the Sacramento Valley and often floods in the winter. Flood flows are diverted to the Sutter Bypass and discharged through Sacramento Slough to the Sacramento River just above the confluence of the Feather River.

The Feather River is regulated by Oroville Dam and Reservoir. Electrical power is generated in the Hyatt-Thermalito complex at the base of the dam. Water released through the powerplant enters the Thermalito Diversion Pool created by the Thermalito Diversion Dam, about 4,000 feet downstream from Oroville Dam. From Oroville Dam, the Feather River flows south for 65 miles and empties into the Sacramento River near Verona, about 21 river miles above Sacramento.

Above Oroville Dam, the Feather River drains 3,634 square miles of watershed with an average annual runoff of 4.2 MAF. Three small reservoirs (Davis, Frenchman, and Antelope) on separate forks of the Feather River provide local irrigation, recreation, and incidental flood control. In addition, PG&E operates Lake Almanor and other storage and diversion facilities in the upper Feather basin to generate hydroelectric power. Below Oroville Dam two large tributaries, the Yuba and Bear rivers, contribute 1.5 MAF annually to the watershed.

The Yuba River, on the western slope of the Sierra Nevada mountains, has a watershed of about 1,300 square miles. Flows in the North Yuba River are impounded in New Bullards Bar Reservoir about 29 miles northeast of Marysville. Releases from New Bullards Bar Reservoir join the Middle Yuba River and flow into Englebright Reservoir along with flows from the South Yuba River. Releases from Englebright Dam flow westerly to join the Feather River at Marysville. About mid-way, Daguerra Point Dam serves both as a barrier to impair downstream movement of mining debris and as the point of diversion for the major water irrigation districts utilizing Yuba River flows. The facilities are operated for power production, fisheries maintenance, water supply, recreation, and flood control.

The Bear River drains the area south of the Yuba River and north of the American River Basins. Flows from the Bear River are conserved in Rollins and Camp Far West reservoirs. Average unimpaired runoff in the basin is about 300,000 acre-feet per year. The Bear River joins the Feather River just above Nicolaus.

The American River drains a 1,921 square mile area in the north-central portion of the Sierra Nevada, with mean annual unimpaired runoff estimated at 2.6 MAF. CVP facilities on the American River include Folsom Dam and Reservoir and Nimbus Dam which impounds Lake Natoma as an afterbay for Folsom Dam. These facilities regulate river flow for irrigation, power, flood control, municipal and industrial use, and other purposes. The American River joins the Sacramento River about 25 miles downstream from Nimbus Dam.

b. Surface Water Quality. Surface waters in the Sacramento River are of excellent mineral quality and suitable for most uses from the headwaters to Red Bluff. From Red Bluff to the Delta, the Sacramento River is of generally good quality although periodic degradation of water quality occurs. The principle surface water quality problems in the Sacramento River Basin include contaminated runoff from mines and mine tailings, warm water temperatures, discharges from industrial and municipal developments, agricultural drainage and saline water intrusion.

Drainage from abandoned mines and tailings has occasionally caused severe local fish kills in the upper watershed and/or adversely affected animals and plants on which fish feed. A particular problem is the Iron Mountain region a few miles northwest of Redding. This region produces acidic runoff containing high concentrations of copper, zinc, iron, aluminum and other toxic salts leached from tailings of both active and abandoned mines.

Warm water temperatures are a problem in both Shasta Lake and the Sacramento River. Shasta Lake thermally stratifies, producing significant differences between surface and bottom water temperatures. During summer thermal stratification, minimum dissolved oxygen levels have been found near the thermocline as low as 3 to 6 parts per million (ppm). Elevated temperatures in the upper river are a primary factor limiting winter-run chinook salmon survival.

Waste discharges originating from industrial and municipal developments enter the Sacramento River along the entire length from Keswick to Red Bluff. Lumber by-product industries, cities and towns, light industries, food product plants and a considerable volume of irrigation return flow all contribute a significant waste load to the Sacramento River. Concentrated effluent is discharged to the Sacramento River by the cities of Redding, Red Bluff, Chico, Sacramento, and West Sacramento. Additional discharges to the Sacramento River system are made from the wastewater treatment plants serving Roseville, Vacaville, Davis, Oroville and other communities.

Dioxins, a closely related group of highly toxic compounds, are discharged with mill waste into the Sacramento River near Anderson. Consequently, the Department of Health Services has issued an advisory not to eat resident fish from the Sacramento River between Keswick and Red Bluff. The

Central Valley RWQCB has ordered the paper company to reduce dioxins concentrations in the discharge.

Agricultural drainage contributes to lower water quality during low flow periods in the Sacramento River and the lower reaches of the major tributaries. Agricultural drainage contributes substantial mineral and nutrient loads to the Sacramento River and increases turbidity.

In the lower Sacramento River, water quality is affected by intrusion of saline water from the San Francisco Bay/Estuary. The lower the flows in the Sacramento River the farther inland tidally driven saline water from the estuary can intrude. Saline intrusion is of increasing concern as consumptive uses of freshwater continue to increase statewide.

The upper reaches of major tributaries, including the Feather, Yuba, and American rivers, all have excellent water quality characteristics. Downstream from storage reservoirs, however, some degradation occurs due to various discharges. Water quality concerns in tributaries include: low dissolved oxygen levels in Butte Slough, Sutter Bypass, and Colusa Basin Drain; high water temperatures below diversion structures on Butte Creek; concentrations of minor elements (chromium, copper, iron, lead, manganese, selenium, and zinc) that exceed beneficial use criteria in the Sutter Bypass; and pesticide residues in the Sutter and Yolo bypasses and Colusa Basin Drain. Additional concern exists for effects of tributary discharges to the Sacramento River, including elevated temperature, dissolved solids, minor elements, pesticides, and turbidity, especially from the Sutter and Yolo bypasses and Colusa Basin Drain. Downstream water temperature also is a concern on the Yuba and American rivers.

c. Groundwater Hydrology. Groundwater provides about 2.5 MAF of the average annual water supply for the Sacramento River Basin. Groundwater is found in both the alluvial basins and in the hard rock areas. Although groundwater is a lesser source of water in the foothills, it plays an important role in meeting the needs of many individuals. Groundwater within the mountain counties exists mostly in fractured rock. Yields in most of the upland hard rock areas are fairly low but can support most domestic activities or livestock. Some wells in the volcanic hard rock areas of the upper Sacramento River and Pit River watersheds yield large amounts of water.

The northern third of the Central Valley regional aquifer system is located in the Sacramento River Basin. This part of the aquifer system extends from north of Redding to the Delta. The DWR has subdivided this region into the Sacramento Valley basin and the Redding Basin, together covering over 5,500 square-miles. The Red Bluff Arch separates the groundwater basins. Other smaller subbasins exist in the Sacramento River Basin above the valley floor.

Depth to the base of fresh water ranges from 1,000 feet in the Orland area to 3,000 feet in the Sacramento area. Throughout the region, the aquifer system is unconfined to semiconfined with no extensive confining clay layers identified in the subsurface. Well yields in the alluvial basins vary from less than 100 to over 4,000 gpm. The aquifer system is recharged primarily through seepage from rivers, streams, and conveyance facilities, subsurface inflow along basin boundaries, and through deep percolation of rainfall and applied irrigation water. Discharge occurs through pumping and seepage to surface streams which provides much of the summer baseflow in the tributary streams to the Sacramento River.

Usable storage capacity has been estimated at 40 million acre-feet based on aquifer properties, water quality and economic considerations such as drilling and pumping costs. In the California Water Plan Update (DWR Bulletin 160-93) the perennial yield of the aquifer system is estimated to be 2.4 million acre-feet per year. Overdraft conditions occur locally as in the Sacramento County area where the water table has fallen to more than 40 feet below sea level. Local overdraft conditions also are responsible for land subsidence in the basin. The main area where land subsidence has been documented is between the towns of Davis and Zamora in the southwestern part of the basin.

High water tables contribute to subsurface drainage problems in several areas of the Sacramento River Basin including portions of Colusa County, particularly along the Sacramento River. The subsurface drainage functions of the Colusa Basin Drain and other local drainage facilities are periodically impaired in this area. Seepage from the Sacramento River helps to maintain high groundwater levels in many reaches. During extended periods of high streamflow, seepage can damage crop roots and prevent farm equipment from entering fields.

d. Groundwater Quality. Groundwater quality in the Sacramento River Basin is generally excellent; however, there are areas with localized groundwater contamination or pollution. Although total dissolved solids (TDS) in groundwater have increased since the 1950s, TDS concentrations generally do not exceed 500 mg/l in the region. Boron is an element toxic to most crops at concentrations above 4 mg/l and is toxic to some crops at concentrations as low as 0.75 mg/l. A large area of high boron concentration occurs in the southwestern part of the Sacramento River Basin extending south from Arbuckle to Rio Vista. The USEPA primary drinking water standard for nitrate concentration is 10-mg/l nitrate as N. Maximum nitrate concentrations greater than 10 mg/l have been reported throughout the region, however, concentrations exceeding 30 mg/l are rare and localized. Municipal use of groundwater as drinking water is impaired due to nitrate concentrations in the Chico area.

5. Water Use

The 1990 level annual net water use in the Sacramento River Basin is 11.7 MAF. Agricultural uses make up 58 percent of the net water demand (6.8 MAF), and environmental uses (which include instream flow requirements and wetlands) make up 32 percent (3.7 MAF). Urban water use for 1990 was 744,000 acre-feet (6 percent of total net water use) and conveyance facility losses, recreation uses, and energy production accounted for about 4 percent of the total net use for the region.

Some of the larger cities in the region take a substantial portion of their water supplies from the major rivers, but throughout most of the region, groundwater is the principal source for urban use. About 56 percent of all urban water use is residential and an average of 75 percent of all residential water use is for landscaping. The high water-using industries of the region are closely tied to agriculture and forestry. Tomato and stone fruit processing, sugar mills, paper pulp, and lumber mills consume large amounts of water.

The average annual applied water demand for agricultural uses in the region in 1990 was over 7.8 MAF. On-farm irrigation efficiencies vary widely, depending on individual crops, soils, irrigation methods, system reuse, water scarcity, and irrigation costs. Areas depending on groundwater or limited surface water tend to be very efficient. Others with higher priority to dependable supplies are often less conservative in their water usage, but excess water applied generally returns to the supply system through drainage canals, or recharges groundwater. Basin efficiency is usually very good because downstream users recycle the return flows which, in many places, constitute the only water source.

6. Vegetation

The Sacramento River Basin contains a variety of vegetative communities occupying nearly 6.8 million acres out of a total land area of 9.2 million acres. The natural communities include mixed conifer forest, montane hardwood forest, montane riparian, foothill woodland, valley oak woodland, mixed chaparral, valley and foothill riparian, valley grassland, and freshwater emergent wetland. Each community can be subdivided into more highly defined groups, but this level of distinction was not considered necessary for this document except for the mention of sensitive communities (as defined by the DFG's Natural Diversity Database). These communities consist of both native and nonnative species. Some have been heavily disturbed by activities such as agriculture and urban development. Within these communities there are approximately 30 endangered, threatened, or otherwise sensitive plant species. The largest number of special-status plant species in the region occurs in grassland which includes vernal pools. The second largest number of special-status plant species is found in mixed conifer forest. The majority of special-status wildlife species are found in the grasslands, fresh emergent wetlands and various riparian communities.

One type of sensitive community found in association with grasslands in the Sacramento and San Joaquin valleys and Southern California is the vernal pool -- low herbaceous communities dominated by annual herbs and grasses. They form over hardpan, claypan, basalt, and volcanic mudflow soils. Winter precipitation fills the pools, stimulating vegetative growth in the pool and around the margins. Some of this vegetation is endemic to the vernal pool habitat, having evolved to survive in the extreme and rapidly changing hydrologic conditions. By late spring, most pools have evaporated. In the Sacramento Valley, four types of vernal pools can occur: northern hardpan, northern claypan, northern basalt flow, and northern volcanic mudflow. Other sensitive communities of the Sacramento River Basin that can be generally categorized as valley grassland include valley needlegrass grassland, serpentine bunchgrass, wildflower fields, freshwater seeps, and alkali playas.

Sensitive habitats in the Sacramento River Basin that can be grouped into the valley and foothill riparian community type include: great valley-valley oak riparian forest, great valley cottonwood riparian forest, great valley mixed riparian forest, white alder riparian forest, great valley willow scrub, buttonbush scrub, and elderberry savanna. Three sensitive freshwater emergent wetland communities occur in the Sacramento River Basin, including cismontane alkali marsh, coastal and valley freshwater marsh, and vernal marsh. Sensitive mixed chaparral communities include Gabroic northern mixed chaparral, serpentine chaparral, and Ione chaparral.

The foothill woodland vegetation community type occurs in the foothills and valley borders, usually between 500 and 3,000 feet in elevation. It is typically dominated by one or more species of oaks in association with pines, California buckeye, *Ceanothus* species, manzanita, and annual grasses. Two subsets of this community type are blue oak woodland, found on the lower slopes of the foothills surrounding the Central Valley, and blue oak-foothill pine woodland, found at slightly higher elevation. Throughout California over the past 25 years, oak woodlands (both foothill and valley) have been lost at a rate of almost 14,000 acres annually to residential and commercial development.

Twelve plant species found in the Sacramento River Basin are listed by either the State or Federal Government as threatened, endangered, or rare. One other has been proposed for listing. Table III-9 lists the sensitive plant species found in the Sacramento River Basin.

7. Fish

The Sacramento River and tributaries between Keswick Dam and the Delta provide important habitats for a diverse assemblage of fish, both anadromous and resident species. The region contains a variety of native and introduced fish species, including both coldwater and warmwater fishes. Although the basin has been greatly modified by water development projects, many rivers and lakes still support excellent sport fisheries and runs of anadromous fish. Hatcheries on several rivers supplement the natural fish populations. Table III-10 lists the more commonly recognized fish species found in the Sacramento River and tributaries. Table III-11 lists the sensitive fish species found in the Sacramento River Basin.

Keswick Dam on the main stem and other dams on the tributaries form complete barriers to upstream migration of fish, primarily chinook salmon and steelhead. Migratory fish trapping facilities at Keswick Dam are operated in conjunction with the Coleman National Fish Hatchery on Battle Creek, 25 miles downstream. The Sacramento River upstream from Colusa produces about half of the Central Valley chinook salmon population. About one third of the river's naturally spawning salmon (mainly the fall run) spawn directly in the reach from Colusa to Red Bluff (mainly above Chico Landing), and all salmon use the river for rearing and migration.

Oroville Dam on the Feather River has made spawning areas upstream of the dam inaccessible for salmon and steelhead. To compensate for this loss, the DWR built the Feather River Fish Hatchery downstream from Oroville Dam. Anadromous fish cannot pass Nimbus Dam on the American River. Thus, the Nimbus Salmon and Steelhead Hatchery was constructed on the downstream side of Nimbus Dam. The following discussion provides a more detailed regional description of the fisheries found in the Sacramento River Basin.

Table III-9
Sensitive Plant Species in the Sacramento River Basin

Scientific Name	Common Name	Status State	Status CNPS	Status Federal
Brodiaea coronaria ssp. rosea	Indian Valley brodiaea	SE	1B	FSC
Calystegia stebbinsii	Stebbin's morning-glory			FE
Ceanothus roderickii	Pine Hill ceanothus			FE
Chamaesyce hooveri	Hoover's spurge		1B	FT
Cordylanthus palmatus	Plamate-bracted bird's-beak	SE	1B	FE
Eryngium constancei	Loch Lomond coyote-thistle			FE
Fremontodendron californicum ssp. decumbens	Pine Hill flannelbush	FE		
Galium californicum ssp. sierrae	El Dorado bedstraw			FE
Gratiola heterosepala	Boggs Lake hedge hyssop	SE	1B	
Limnanthes floccosa ssp. californica	Butte County meadowfoam	SE	1B	FE
Lupinus milo-bakeri	Milo Baker's lupine	ST	1B	FSC
Navarretia leucocephala ssp. Pauciflora	Few-flowered navarretia			FE
Navarretia leucocephala ssp. Plieantha	Many-flowered navarretia			FE
Neostapfia colusana	Colusa grass	SE	1B	FT
Orcuttia pilosa	Hairy Orcutt grass	SE	1B	FE
Orcuttia tenuis	Slender Orcutt grass	SE	1B	FT
Orcuttia viscida	Sacramento Orcutt grass	SE	1B	FE
Parvisedum leiocarpum	Lake County stonecrop			FE
Pseudobahia bahiifolia	Hartweg's golden sunburst	SE	1B	FE
Senecio layneae	Layne's butterweed			FT
Tuctoria greenei	Greene's tuctoria	SR	1B	FE
Tuctoria mucronata	Crampton's tuctoria	SE	1B	FE

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
CNPS: (California Native Plant Society) 1A=presumed extinct in California; 1B=rare,threatened, or endangered in California and elsewhere; 2=rare,threatened,or endangered in California but more common elsewhere; 3=need more information; 4=distribution limited (a watchlist).
FEDERAL: FE=endangered; FT=threatened; FPE=proposed endangered; FPT=proposed threatened; C=candidate for listing; FSC=species of concern.

Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

TABLE III-10
Common Fish Species in the Sacramento River and Tributaries.

ANADROMOUS	RESIDENT		
	Warmwater Game	Coldwater Game	Non-game
Chinook salmon (four races)	largemouth bass	rainbow trout	Sacramento squawfish
Steelhead trout	smallmouth bass	brown trout	Sacramento sucker
Striped bass	spotted bass		golden shriner
American Shad	white crappie		tule perch
green sturgeon	black crappie		carp
white sturgeon	channel catfish		threadfin shad
Pacific lamprey	white catfish		hardhead
	brown bullhead		
	yellow bullhead		
	bluegill		
	green sunfish		

Table III-11
Sensitive Fish Species in the Sacramento River Basin

Scientific Name	Common Name	Status State	Status Federal
Acipenser medirostris	Green Sturgeon	CSC	FSC
Catastomus microps	Modoc sucker	SE	FE
Cottus asperrimus	Rough sculpin	ST	FSC
Gila bicolor thalassina	Goose Lake tui chub	CSC	
Hypomesus transpacificus	Delta smelt	ST	FT
Lampetra tridentata ssp.	Goose Lake Lamprey	CSC	
Lavinia symmetricus mitrulus	Pit roach	CSC	
Oncorhynchus tshawytscha	Fall-run chinook salmon, Central Valley, CA ESU		C
Oncorhynchus tshawytscha	Late fall-run chinook salmon, Central Valley, CA ESU	CSC	C
Oncorhynchus tshawytscha	Spring-run chinook salmon	ST	FT
Oncorhynchus tshawytscha	Winter-run chinook salmon	SE	FE
Oncorhynchus mykiss ssp.	Goose Lake redband trout	CSC	FSC
Oncorhynchus mykiss ssp.	McCloud River redband trout	CSC	C
Oncorhynchus mykiss	Steelhead, Central Valley, CA ESU		FT
Pogonichthys macrolepidotus	Sacramento splittail	CSC	FT
Spirinichus thaleichthys	Longfin smelt	CSC	FSC

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
FEDERAL: FE=endangered; FT=threatened; C=candidate for listing; FSC=species of concern.

Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

a. **Upper Sacramento River Basin**. Before July 1991, 26 of the 40 miles of the Sacramento River below Box Canyon Dam was planted with catchable trout, and the lower 14 miles was managed as a wild trout stream. Rainbow trout was the dominant salmonid in the river, with some brown trout. Other species included hardhead, Sacramento squawfish, California roach, speckled dace, Sacramento sucker, and riffle sculpin. Smallmouth bass, Alabama spotted bass, and channel catfish live in the lower reaches. In July 1991, a train derailed while crossing the Sacramento River just north of Dunsmuir at the Cantarra Loop, spilling the chemical metam sodium from a ruptured tanker into the river and destroying downstream aquatic life. Fish and other aquatic life are gradually reappearing from upstream and tributary sources, as well as from Shasta Lake. The Department of Fish and Game has begun planting catchable trout in a 6-mile stretch near Dunsmuir; the lower 22 miles is a catch-and-release fishery.

Except in the South Fork Pit River above Likely, streams of the system above Fall River generally do not support significant fish populations because of the high mineral levels and intermittent flows. Principal sport fishing streams are Fall River, Hat Creek, Pit River below Fall River, and headwater streams of the South Fork.

The McCloud River supports an excellent sport fishery; rainbow trout is the dominant species. Access is limited and difficult along much of the lower portion of the river.

Shasta Lake supports a wide variety of coldwater and warmwater fish. Resident species include rainbow and brown trout, kokanee and landlocked chinook salmon, largemouth bass, smallmouth bass, spotted bass, black crappie, green sunfish, bluegill, brown bullhead, channel and white catfish, threadfin shad, Sacramento sucker, squawfish, and carp.

Warm water temperatures in the Sacramento River downstream from Shasta Dam have affected upstream salmon migration and caused egg mortality. The problem is most severe in early fall during dry years, when low flows of relatively warm water are further influenced by high air temperatures. Although high river temperatures are natural, operation of Shasta Dam has aggravated the problem. Temperatures are controlled somewhat by modifying operations and importing colder water from Trinity Lake, a part of the Trinity River facilities. Operation modifications include releasing colder water through lower dam outlets, which results in loss of power generation through hydroelectric facilities at the dam.

b. **Lower Sacramento River Basin**. The Sacramento River and tributaries between Keswick Dam and the Delta provide important habitat for a diverse assemblage of fish species, both anadromous and resident. Anadromous fish include chinook salmon (four races), steelhead trout, striped bass, American shad, green and white sturgeon, and Pacific lamprey. Approximately two-thirds of the striped bass population in the Delta spawn in the Sacramento River system, while the remainder spawn in the lower San Joaquin River. Resident fish can be separated into warmwater game fish (such as largemouth bass, white crappie, black crappie, channel catfish, white catfish, brown bullhead, yellow bullhead, bluegill, and green sunfish); coldwater game fish (such as rainbow and brown trout); and nongame fish (such as Sacramento squawfish, Sacramento splittail, delta smelt, Sacramento sucker, and golden shiner). Native nongame fish such as Sacramento perch (California's only native sunfish) are thought to be extirpated from the Delta and exist only in ponds and reservoirs. The native tule perch persists in the Sacramento River.

Keswick Reservoir supports both rainbow and brown trout, as well as some warmwater fish from Shasta Lake, including large and smallmouth bass. Keswick Dam forms a barrier to upstream migration of fish, primarily chinook salmon and steelhead. Fish trapping facilities at the dam are operated in conjunction with Coleman National Fish Hatchery on Battle Creek, 25 miles downstream.

Catfish, bluegill, sunfish, and bass are fished extensively in drains, channels, and ponds throughout the Colusa Basin. Most of the Yolo Bypass is dry and cultivated during much of the year, but irrigation and drainage canals and borrow ditches support warmwater fish. Resident species of the Sacramento River, Cache Creek, Willow Slough, Willow Slough Bypass, and South Fork Putah Creek may occupy the bypass during flooding. Game fish commonly caught include largemouth bass, black and white crappie, bluegill, redear and green sunfish, white and channel catfish, splittail, and black bullhead. Several nongame fish are also found, such as carp, goldfish, inland silverside, mosquitofish, bigscale logperch, and minnows. Sacramento sucker and Sacramento squawfish may also be found in the bypass. Anadromous fish such as striped bass, steelhead trout, American shad, Pacific lamprey and the four races of chinook salmon may be found in the Yolo Bypass when it is flooded. Anadromous fish runs in the lower Sacramento River and its tributaries have faced many problems including unscreened diversions, passage problems at some diversion structures, low stream flows, periodic high water temperatures and high sediment loads. There are a number of fishery restoration actions or projects taking place in the Sacramento Valley to correct these problems.

The State Water Resources Control Board has established a temperature objective of 56°F to be attained to the extent controllable throughout the Sacramento River spawning area between Keswick Dam and Red Bluff Diversion Dam. The operation of a temperature control device at Shasta Dam is expected to meet the objective most of the time. Temperatures below the upper lethal temperature of 62°F are maintained between Keswick Dam and Red Bluff except occasionally during August, September, and October. In September, temperatures remain below 62°F at Red Bluff in 75 percent of all years. Effects of Shasta Dam releases on water temperatures decrease with downstream distance. River temperatures are greatly affected by ambient air temperatures between the point of release and the Red Bluff Diversion Dam, particularly during summer. Ambient air temperature and tributary accretions combine to produce high summer river temperatures detrimental to some fish between Keswick Dam and Red Bluff Diversion Dam. Effects of high summer water temperatures are compounded in dry years.

In 1995, state legislation gave Mill and Deer creeks protection from future water development (similar to protection provided by the California Wild and Scenic Rivers Act), by restricting construction of new dams, reservoirs, diversions or other water impoundments. These two streams are among the last remaining vestiges of quality spring-run habitat in the Sacramento System. The

Mill and Deer Creek Watershed Conservancies were also formed in 1995 and have initiated a watershed planning and management process.

Butte Creek supports an anadromous fishery that includes a large spring-run and small fall-run population of chinook salmon as well as steelhead trout. Butte Creek has been the focus of several ambitious anadromous fish habitat recovery efforts. In 1995, M&T Chico Ranch and DFG agreed to install a new fish ladder at the Parrott Phelen Dam and new-screened diversions. M&T Ranch also dedicated 40 cfs of instream flow for fishery needs on Butte Creek. Western Canal Water District and private landowners agreed to remove the Point Four Diversion Dam near Nelson. During 1997, WCWD constructed a large inverted siphon at its former Butte Creek crossing and removed the Western Canal Dam. The siphon will separate the canal system from Butte Creek and eliminate fish losses caused by the diversion. Other dams on Butte Creek are scheduled to be removed or upgraded with fish ladders and diversion screens. An inventory and assessment of other potential fish passage improvements on lower Butte Creek and in the Butte Slough and Sutter Bypass areas is currently underway.

Big Chico Creek supports a remnant population of spring-run salmon, as well as some fall-run salmon. In 1996, M&T Ranch and Llano Seco Ranch pumps were relocated from the creek to the Sacramento River to eliminate a fish hazard at the mouth of the creek. The pumps created a substantial streamflow reversal which had impeded the passage of young out-migrating fish.

A number of Sacramento River water users have initiated fish screening projects for their diversions. The Pelger Mutual Water Company and Maxwell Irrigation District completed screens in 1995. Princeton-Codora-Glenn Irrigation District and Provident Irrigation District started construction on a new-screened pumping plant. Reclamation District 108 started building its new fish screen at its Wilkins Slough Diversion. Other fish screening facilities on the Sacramento River are being planned by Reclamation District 1008, Natomas Central Mutual Water Company, and Glenn-Colusa Irrigation District, and Browns Valley Irrigation District plans to install a fish screen on its diversion from the Yuba River.

c. **Feather River**. Construction of Oroville Dam on the Feather River eliminated spawning areas for salmon and steelhead upstream of the dam. To compensate for this loss, the DWR built the Feather River Fish Hatchery. About 23 miles of the Feather River below the Fish Barrier Dam is used for natural spawning. Juvenile salmon rear between the Fish Barrier Dam and the confluence with the Sacramento River. There appears to be limited natural steelhead spawning in the Feather River. Other species in the Feather River include American shad, striped bass, steelhead trout, and many resident warmwater and coldwater species.

d. **Yuba River**. Yuba River instream flows are governed by a 1965 agreement between YCWA and the DFG. Provisions include minimum flows for fish maintenance and controls to minimize streamflow fluctuations. The DFG has developed the Lower Yuba River Fisheries Management Plan which includes recommendations on instream flow, water temperature, and flow fluctuations. In 1993, flow requirements were modified in the system as part of the Federal Energy

Regulatory Commission (FERC) requirements for the relicensing of the Pacific Gas and Electric Company (PG&E) Narrows Project. The SWRCB held hearings to address flow and fishery needs of the Yuba River. A draft decision was issued by the SWRCB in 1999. However, no decision has been made to date.

Surveys in 1976 identified 28 species of resident and anadromous fish in the Yuba River system. Anadromous fish of special concern include chinook salmon, steelhead trout, and American shad. New Bullards Bar Reservoir supports both warmwater and coldwater fisheries. Common and abundant coldwater species include rainbow and brown trout; warmwater species include smallmouth and largemouth bass, crappie, bluegill, catfish, carp, Sacramento squawfish, Sacramento sucker, and threadfin shad. No rare or endangered species are known to inhabit the reservoir.

The fall-run chinook salmon is the most abundant anadromous fish in the lower Yuba River system. Historically, the Yuba River supported up to 15 percent of the Sacramento River fall run. In surveys from 1953 to 1989, the total number of adult fish ranged from 1,000 in 1957 to 39,000 in 1982. Fall-run chinook salmon typically begin migration into the Yuba

River in late September. Low flows and high temperatures may delay migration and spawning. Peak spawning occurs in October and November but has been known to continue into January. Fry emerge from the gravel between December and March. Some emigrate within a few weeks of emergence, while others rear in the river until June.

The original spring-run population had virtually disappeared from the Yuba River by 1959. Today's remnant spring run is probably the result of strays from the Feather River or the infrequent stocking of hatchery-reared fish by the DFG. Spring-run chinook salmon migrate into the Yuba River as early as March and as late as August. Generally, most of the run migrates in May and June. The adults spend the summer in deep pools in the Narrows reach of river, where water temperature seldom exceeds 60°F. Spawning can begin in August, but the peak is between September and October. Fry emergence begins in November and extends through January. Emigration can occur within a few weeks of emergence, or the juveniles can rear in the area until June.

The Yuba River supports one of the only self-sustaining populations of steelhead in the Central Valley. Up to 200,000 yearling steelhead were stocked annually from Coleman National Fish Hatchery from 1970 to 1979. It is unknown whether the present stock is of native origin or derived from Coleman NFH. It is currently managed as a self-sustaining population.

e. **American River**. Largemouth and smallmouth bass, white catfish, brown bullhead, channel catfish, and several sunfishes are among species found in Folsom Lake. During normal water years, the DFG plants hatchery-spawned rainbow trout and manages the reservoir to maintain kokanee salmon planted previously. At the Lake Natoma-Nimbus Dam afterbay complex, daily 4 to 7 foot water level fluctuations, cold water temperatures, and limited food production support few fish. Anadromous fish cannot pass Nimbus Dam. However, the DFG operates the Nimbus Salmon and Steelhead Hatchery just downstream of the dam to compensate for the loss of fish passage.

The lower American River flows within a restricted channel isolated from surrounding urban areas by 30-foot levees. Native riparian vegetation, backwater, dredge ponds, and urban recreational areas such as parks and golf courses border the waters' edge. The river and backwater areas support at least 40 species of fish, including chinook salmon, steelhead trout, striped bass, splittail, and American shad. Common resident fish include Sacramento sucker, black bass, carp, squawfish, and hardhead.

From 1969 to 1981, salmon spawning escapement to the American River and Nimbus Hatchery averaged 47,500. The proportion of hatchery vs. naturally produced fish in the annual escapement has not been estimated with any accuracy, due to insufficient data. During prolonged drought, low water levels at Folsom Dam have resulted in releases of warmer water, which ranges from marginal to lethal thresholds for salmon eggs spawned in the river and the hatchery.

8. Wildlife

A wide variety of wildlife species are found in the Sacramento River Basin. DFG's Wildlife Habitat Relationship Program identifies a total of 249 species of wildlife using the valley and foothill habitat of the Sacramento Valley. Included in this total are 151 species of birds, 65 species of mammals, and 33 reptile and amphibian species. Riparian zones also provide food and cover to other wildlife species more typical of adjacent upland areas and provide migratory corridors for many others. Riparian areas are also valuable habitats for numerous species of mammals, including furbearers. Between Red Bluff and the Delta, populations of most species that are dependent on riparian, oak woodland, marsh and grassland habitats have declined with the conversion of these habitats to agriculture and urban areas.

Many birds are common year-round or are seasonal residents of the Sacramento Valley; others are migrants or occasional visitors. Since the Sacramento Valley lies on the Pacific Flyway, its wetlands provide prime waterfowl habitat; the wintering population often exceeds 3 million. The Rice Straw Burning Reduction Act of 1991, which resulted in additional ricefield flooding, has helped create new winter habitat for migratory waterfowl. Waterfowl in the valley include mallards, northern pintails, widgeons, tundra swans, Canada geese, snow geese, and 20 other species. Shorebirds such as great blue herons, great egrets, and spotted sandpipers use riverbanks, sandbars, riparian vegetation, and emergent or submerged aquatic vegetation and forage on small mollusks, fish, and crustaceans.

Songbirds are found in large numbers in the riparian vegetative cover along the Sacramento River and its tributaries. Goldfinches, song sparrows, rufous-sided towhees, and American robins are some of the passerine species that use the trees, shrubs, and herbaceous plant species of the riparian habitat. Western meadowlarks, loggerhead shrikes, and American crows are found in the grassland and agricultural areas. Raptors such as Swainson’s or red-tailed hawks and great-horned owls nest in the larger trees of the riparian and grassland habitat and feed on voles, gophers, and other prey. Commonly observed birds of prey include red-tailed hawks, northern harriers, American kestrels, and burrowing owls. Game birds include ring-necked pheasants, mourning doves, California quail, and wild turkeys.

Mammals typical of the Sacramento River Basin include mule deer, mountain lions, bobcats, cottontail rabbits, and deer mice in the foothill habitats. Opossums, American badgers, raccoons, red foxes, gray foxes, river otters, beavers, muskrats, black-tailed hares, and small rodents are found throughout the grassland/riparian/wetland habitats. A DFG field study concluded that much of the Sacramento River riparian vegetation provides high quality habitat for furbearers; 14 species were recorded. Other species such as coyotes, California ground squirrels, and striped skunks occur throughout the basin.

Reptile and amphibian species are associated with upland, grassland, and riparian vegetation. The western fence lizard, northern Pacific rattlesnake, common king snake, and gopher snake are common reptiles in the Sacramento Valley. Amphibians such as bullfrogs, Pacific treefrogs, and western toads are usually restricted to riparian or lacustrine habitat, but some, such as California tiger salamanders, use the temporary wetlands habitat of vernal pools.

With conversion of riparian, oak woodland, wetland, and grassland habitats to agriculture and urban uses, populations of most species dependent on these habitats have declined. Populations of some Sacramento Valley species have declined so greatly that they have been listed as threatened or endangered or are under study for future listing. Table III-12 lists sensitive wildlife species in the Sacramento River Basin.

There are 188 designated Significant Natural Areas (SNAs), as defined by the DFG, in the Sacramento River Basin. These areas contain important habitats that support special-status wildlife species. Many of these habitats occur in riparian areas along the Sacramento River. Other areas include vernal pool and grassland habitats found throughout the region and marsh habitats in the southern portion of the region. Wetland areas of the basin are important as prime waterfowl wintering areas in the Pacific Flyway.

9. Recreation

Major recreation sites in the Sacramento River Basin include the key lakes and reservoirs (Shasta Lake, Whiskeytown Lake, Lake Oroville Complex, Folsom Lake, New Bullards Reservoir Bar, and Englebright Lake), key rivers and streams (the Sacramento, Feather, American, and Yuba Rivers and Clear Creek), and key federal wildlife refuges and state wildlife management areas (the Sacramento National Wildlife Refuge (NWR) Complex and Gray Lodge Wildlife Management Area (WMA)). Waterfowl and upland game hunting on private lands is also a leading form of recreation in the region. Other areas potentially affected by the water rights decision are Keswick Reservoir, Lake Red Bluff, Camp Far West Reservoir, and the Bear River below Camp Far West Reservoir.

Table III-12
Sensitive Wildlife Species in the Sacramento River Basin

Scientific Name	Common Name	Status State	Status Federal
Agelaius tricolor	Tricolored blackbird	CSC	FSC
Branta canadensis leucopareia	Aleutian Canada goose		FT
Buteo swainsonialassina	Swainson' hawk	ST	
Coccyzus americanus occidentallis	Western yellow-billed cuckoo	SE	
Empidonax traillii	Willow flycatcher	SE	
Grus canadensis tabida	Greater sandhill crane	ST	
Haliaeetus leucocepohalus	Bald eagle	SE	FT
Plegadis chihi	White-faced ibis	CSC	FSC
Riparia riparia	Bank swallow	ST	
Vireo bellii pusillus	Least Bell's vireo	SE	FE
Antrozous pallidus	Pallid bat	CSC	
Plecotus townsendii townsendii	Townsend's western big-eared bat	CSC	FSC
Ambystoma californiense	California tiger salamander	CSC	C
Hydromantes shastae	Shasta salamander	ST	FSC
Rana aurora draytonii	California red-legged frog	CSC	FT
Clemmys marmorata	Western pond turtle	CSC	
Thamnophis gigas	Giant garter snake	ST	FT
Branchinecta conservatio	Conservancy fairy shrimp		FE
Branchinecta lynchi	Vernal pool fairy shrimp		FT
Desmocerus californicus dimorphu	Valley elderberry longhorned beetle		FT
Lepidurus packardi	Vernal pool tadpole shrimp		FE
Pacifastacus fortis	Shasta crayfish	SE	FE

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
FEDERAL: FE=endangered; FT=threatened; FPE=proposed endangered; FPT=proposed threatened; C=candidate for listing; FSC=species of concern.

Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

a. Reservoirs. Between 1945 and 1970, flatwater recreation opportunities became more extensive in the Sacramento River Basin as lakes, reservoirs, and recreation facilities were constructed. During that period, Shasta and Folsom lakes provided most of the flatwater recreation opportunities in the region. In 1970, the combined annual recreation use at Shasta Lake, Folsom Lake, Whiskeytown Lake, and Lake Oroville totaled approximately 5.6 million visitor days. By 1990, this combined total had risen to approximately 6.4 million visitor days.

Shasta Lake. Shasta Lake, approximately 10 miles north of Redding, is a unit of the Whiskeytown-Shasta-Trinity NRA. Recreation facilities and activities are administered by USFS. When full, the lake has a surface area of approximately 30,000 acres, 370 miles of shoreline, and a surface elevation of 1,067 feet above mean sea level (msl). The lake has four main arms: Sacramento River, McCloud River, Pit River, and Squaw Creek.

Shasta Lake accommodates a wide variety of water-dependent and water-enhanced recreation activities. Water-dependent activities are power boating, house boating, water-skiing, and fishing. Water-enhanced activities include camping and sightseeing.

Six public boat ramps and 13 private marinas support boating activities at the lake. Some private marinas also provide boat launch facilities. The main body of the lake and all the major arms except Squaw Creek arm have at least one boat ramp. The marinas are clustered at the northern end of the Sacramento River arm, along the western shore of the McCloud River arm and at the Jones Valley area on the Pit River arm. In 1991, these marinas provided an estimated 2,890 mooring spaces. Most marinas provide boat storage, houseboat rental, boat repair, and boating and camping supply sales.

The lake has no designated swimming areas. Because of limited shore access and steep slopes, most of the swimming activity occurs from boats or near campgrounds. The lake's one designated fishing area/picnic area is adjacent to Shasta Dam, and two picnic areas are located on the McCloud River arm.

Camping facilities are provided at 22 public campgrounds, most of which are located on the upper reaches of the Sacramento River arm, with the remaining campgrounds located near Jones Valley on the Pit River arm and along the western shore of the McCloud River arm. Four of the campgrounds are accessible by boat only.

Almost the entire surface area of the lake is accessible by boat. High-speed boating activities such as water-skiing and cruising are allowed on most of the lake except for the ends of the arms and some coves where speeds are restricted for safety reasons.

Fishing at Shasta Lake occurs from boats and along the lakeshore. The most frequently caught species are rainbow trout, smallmouth bass, and crappie. Although the entire lake offers fishing opportunities from boats, the most popular fishing area is near Jones Valley, which also provides easy access to the Pit River and Squaw Creek arms. Because much of the shoreline is accessible by boat only, fishing from shore is concentrated at access points near Shasta Dam and along the arms of the lake. Shore fishing access points are found along the northern end of the McCloud River arm, at Jones Valley on the Pit River arm, at the northern end of the Sacramento River arm, and adjacent to Shasta Lake. Because of the lack of cover, the best fishing sites for warm-water fish at the lake are under or near structures such as docks or bridges. Shore fishing is also popular at the ends of the major arms where rivers enter the lake.

During 1992, use at Shasta Lake totaled approximately 7.3 million visitor days. Of this total, approximately 4.1 million visitor days involved water-dependent activities.

Public boat ramps on the lake begin to cease operation as the lake level falls 75 feet from full to a surface elevation of 992 feet above msl. The last public boat ramp on the main area of the lake ceases operation when the lake level falls 223 feet to a surface elevation of 844 feet above msl; on the Sacramento River arm, when the lake falls 117 feet to a surface elevation of 950 feet above msl; on the Pit River arm, when the lake falls 125 feet to a surface elevation of 942 feet above msl; and on the McCloud River arm, when the lake falls 115 feet to a surface elevation of 952 feet above msl. When the last ramp ceases operation, launching boats from trailers becomes difficult because of steep slopes and muddy shore conditions.

Most marinas remain in operation as the lake level falls. Marinas on the main portion of the lake, the Pit River arm, McCloud River arm, and the lower portion of the Sacramento River arm move in response to lower lake levels. Marinas at the end of the Sacramento River arm are not as flexible as other marinas because of the long, narrow channel and relatively shallow water in this area. Most marinas are first forced to move when the lake recedes 80 feet to a surface elevation of 987 feet above msl. Marinas at the end of the Sacramento River arm are first forced to move as the lake drops 60 feet to a surface elevation of 1,007 above msl. These marinas are typically forced out of operation as the lake falls 130 feet to a surface elevation of 937 feet above msl.

Camping becomes less popular as the lake level drops because of the increased distance between the campgrounds and the lakeshore, which affects boaters attempting to reach the campground and campers attempting to reach the lake. As the lake level falls, campgrounds located along the relatively shallow upper reaches of the arms of the lake become less popular than those near deeper waters do.

Because Shasta Lake is so large, most water-dependent activities remain available as the lake level falls, as long as access is maintained. However, boating activities become more constrained as hazards such as submerged islands, rocks, and snags appear. Generally, these hazards appear within the shoreline zone as the lake level drops 240 feet to a surface elevation of 827 feet above msl.

Whiskeytown Lake. Whiskeytown Lake is approximately eight miles west of Redding on the eastern slope of the Coast Range. A unit of the Whiskeytown-Shasta-Trinity NRA, the lake is administered by the NPS. When full, the lake has a surface area of 3,250 acres, 36 miles of shoreline, and a surface elevation of 1,210 feet above msl.

Whiskeytown Lake accommodates a variety of recreation activities, such as boating, fishing, swimming and beach use, and camping. Power boating, water-skiing, and sailing are popular boating activities. Fishing occurs from boats and along the shoreline. Swimming and beach use occur at designated areas and in dispersed areas along the lakeshore.

One marina and three boat ramps support boating activities at Whiskeytown Lake. The marina is along the northwestern shore of the lake and is easily accessible from State Route (SR) 299. Two of the boat ramps are on the northwestern side of the lake at Oak Bottom and on the Whiskey Creek arm; the third is at Brandy Creek on the south shore of the lake. The boat ramps at Oak Bottom and Whiskey Creek are easily accessible from SR 299. High speed boating activities are allowed on most of the lake except for the Clear Creek arm between the Judge Francis Carr Powerhouse and Oak Bottom.

Fishing occurs both from boats and along the lakeshore. The most frequently caught species are rainbow trout and kokanee salmon. The most popular shore fishing area is near the Judge Francis Carr Powerhouse because the water released from the powerhouse attracts planted fish.

Swimming and beach use are concentrated at the designated areas at the mouth of Brandy Creek on the south side of the lake and at Oak Bottom on the northwestern shore. Most of the lakeshore is open to the public, with the most popular informal swimming and beach areas along the eastern shore of the lake near the park headquarters and along SR 299. Swimming and beach use at informal sites along the lakeshore are constrained when the lake is full because of limited access.

Camping areas located at Brandy Creek, Oak Bottom, and Dry Creek provide a total of 187 camping spaces. Brandy Creek is a dispersed camping area, Oak Bottom provides tent and recreation vehicle (RV) spaces, and Dry Creek is a group camping area.

In 1992, recreational use at Whiskeytown Lake totaled approximately 833,000 visitor days. The most popular water-dependent activities at the lake are swimming and beach use, boating, and fishing.

Whiskeytown Lake is normally maintained at a relatively stable water level by the USBR. Historically, the lake is kept full during spring and summer when visitation is highest. The lake typically has an off-season drawdown of approximately 11 feet because water is not diverted into Whiskeytown Lake from Lewiston Lake. Recreation activities can become constrained as the lake level declines because facilities have been designed for use at higher levels. Lake levels of 1,209 feet above msl during summer and 1,198 feet above msl during winter are ideal for typical recreation activities during these seasons.

Boat access becomes constrained at Whiskey Creek and Oak Bottom ramps when the lake level drops 13 feet from full to a surface elevation of 1,197 feet above msl. Both ramps cease operation when the lake drops 15 feet to a surface elevation of 1,195 feet above msl. The Brandy Creek ramp ceases operation at a surface elevation of 1,190 feet above msl, or 20 feet below full. Boats with fixed keels, such as sailboats, cannot be launched when the lake level drops below 1,190 feet above msl.

Operation of the marina at Oak Bottom becomes constrained as the lake level drops to 1,204 feet above msl, or 6 feet from full. At this lake elevation, the marina operator must begin to reposition slips. At a lake level of 1,198 feet above msl, or 12 feet from full, the marina cannot be used.

Shoreline activities outside the designated swimming areas are enhanced as the lake level falls to an elevation of approximately 1,206 feet above msl, or 6 feet from full. Because of steep slopes and dense vegetation, exposing shoreline around the lake enhances access. Below 1,206 feet above msl, a wide band of shoreline devoid of vegetation affects the visual character of the lake.

Swimming and beach use at the Brandy Creek and Oak Bottom swimming areas become constrained as the lake level falls to approximately 1,206 feet above msl, or 4 feet from full, because the lake level drops below the sandy beach area.

Because the lake has historically been full during peak visitation periods, it is not clear how water-dependent activities are affected by lowered lake levels. Shore fishing can be enhanced by improved shore access as the lake level falls. The most popular fishing area on the lake, immediately below the Judge Francis Carr Powerhouse, is not affected by lowered lake levels because it depends more on flows from the powerhouse. Fishing at this site becomes less popular during winter because water is not diverted from Lewiston Lake.

Lake Oroville Complex. The Lake Oroville Complex, managed by the California Department of Parks and Recreation (DPR) as part of the Lake Oroville State Recreation Area (SRA), is on the Feather River in Butte County. The complex includes Lake Oroville and Thermalito Forebay and Afterbay. When full, Lake Oroville has a surface area of 15,800 acres, 167 miles of shoreline, and a surface elevation of 900 feet above msl.

Most of Lake Oroville SRA's formal recreation facilities are at the lake. The facilities accommodate boating, water-skiing, sailing, fishing, swimming, boat-in camping, and overnight camping. Unrestricted boat access to the shoreline is allowed for camping uses. Boating access is provided at three paved ramps in the southern reservoir area near Lake Oroville and on the West Fork Feather River. Car-top boat launching is allowed on all but the Middle Fork Feather River.

Day and overnight use areas at Lake Oroville are located along the main reservoir and tributary shorelines. Bidwell Canyon and Loafer Creek on the southern shoreline and Lime Saddle on the West Fork Feather River are the major use areas. A visitor center on Kelly Ridge overlooks the dam and lake. Camping is allowed along the shoreline and at boat-in camping areas at Craig Saddle, Foreman Creek, Bloomer Primitive Camp, and Potter Ravine. The Bidwell Canyon marina provides covered berthing slips, a store and snack bar, fuel dock, boat rental, and open mooring. Swimming is allowed along the shoreline. Designated swimming facilities are provided at the Loafer Creek unit only, at the southern end of the lake.

Fishing occurs throughout the lake from boats and the shoreline. Game fish are planted in the lake annually; rainbow trout and largemouth and smallmouth bass are the most frequently caught species.

Recreation activities in the 600-acre Thermalito Forebay are accommodated by day-use facilities that feature a turf picnic area, 200-yard-long swimming beach, and two-lane boat ramp. The forebay is reserved for sailboats, canoes, and other non-motorized boating. Facilities at Thermalito Afterbay consist of a parking lot, four-lane boat ramp, and chemical toilets. Fishing and motorized boating are the main recreation activities at the afterbay. Shore and boat fishing at the forebay and afterbay are primarily for rainbow trout, catfish, and largemouth and smallmouth bass.

Visitation at the Lake Oroville Complex totaled approximately 600,000 visitor days in 1992. Day use and overnight camping account for most of the recreation use. When the lake is full, recreation facilities are available and boating and water sports are optimized. In general, most water-oriented use is substantially reduced at or below an elevation of 750 feet above msl (150 feet below full), and obstacles are buoyed for safety reasons.

When the lake level falls to an elevation of 775 feet above msl, boat ramps at Loafer Creek cease operation, followed by Lime Saddle at 750 feet above msl, Spillway at 730 feet above msl, and Bidwell Canyon at 710 feet above msl. Car-top boat launching areas at the Enterprise and Stringtown access points cannot be used below lake elevations of 835 feet and 866 feet above msl, respectively. The designated swimming beach at Loafer Creek begins to be affected at a surface elevation of 860 feet above msl because the lake level falls below the designated beach areas. Recreation activities at the Thermalito Forebay and Afterbay are not directly affected by water level fluctuations because surface water elevations at these control reservoirs are generally maintained at constant levels.

Folsom Lake. Folsom Lake SRA, managed by DPR, is located on the American River east of Sacramento. The SRA includes both Folsom Lake and Lake Natoma. When full, Folsom Lake has a surface area of 11,450 acres, 75 miles of shoreline, and a surface elevation of 466 feet above msl. Lake Natoma, a potentially affected recreation area, is included in this description because DPR does not report use of the two lakes separately.

Folsom Lake SRA facilities accommodate a variety of water-oriented recreational activities including boating, fishing, swimming, jet skiing, windsurfing, and sailing. Camping, picnicking, and trail facilities are also provided in the lake watershed. Boat launches along the 75-mile shoreline provide boat access. Major use areas are Beals Point, Granite Bay, and Rattlesnake Bar on the western shoreline; Dike 8, Mormon Island, and Brown's Ravine Marina on the southern and eastern shorelines; and the Peninsula Campground between the north and south forks of the American River. Brown's Ravine Marina provides 670 berthing slips for year-round mooring and small craft rentals.

Fishing occurs from boats throughout the lake and especially in the upper arms that are designated as slow-boating zones. Fishing is mainly for rainbow trout and warm-water species. Swimming and sunbathing areas are provided at the designated Beals Point and Granite Bay beaches and at numerous non-designated areas along the reservoir shoreline. Boating, sailing, water-skiing, and other watercraft uses are popular activities throughout the main reservoir area.

Lake Natoma covers 500 acres, approximately 6 miles downstream of Folsom Lake. Lake Natoma has approximately 10 miles of shoreline, a maximum pool of 126 feet, and a maximum daily drawdown of approximately 7 feet. Picnic and camping areas and a boat ramp are located at

Negro Bar, environmental camping at Mississippi Bar, and boat launch facilities near Nimbus Dam and Willow Creek. The western shoreline also features an 8.4-mile portion of the popular American River bicycle trail. Recreation activities include fishing, non-motorized boating, and windsurfing. Lake Natoma is less heavily used for swimming and wading than Folsom Lake because of its cooler water temperature.

In 1992, visitation to the entire Folsom Lake SRA was estimated at 2.1 million visitor days. The SRA is one of the most heavily used units in the California state park system, primarily because of its proximity to the Sacramento metropolitan area, the arid summer climate, and high regional interest in recreation.

Water-dependent activities dominate Folsom Lake recreation use, accounting for more than 80 percent of the annual recreation use. Boating, the most popular activity at the lake includes launch and non-launch boating, windsurfing, and jet skiing.

The optimal lake elevation for recreation use is 436 feet above msl, or a surface area of 9,600 acres, because all facilities can be used at this elevation. Beaches can accommodate high use at this level, and boat ramp and parking facility use is maximized. Lake elevations higher than 436 feet above msl reduce the capacity of the lake because some boat ramps and parking spaces are inundated. When the lake level falls to an elevation of 426 feet above msl, Brown's Ravine Marina ceases operation. At elevation 420 feet above msl (8,500 surface acres), most of the boat ramps cannot be used and at elevation 405 feet above msl (7,300 surface acres), only one boat ramp can be used. At 401 feet above msl, all boat ramps are out of service.

Lake surface elevations have the greatest effect on recreation between April and August because visitation is greatest during these months. Although fluctuating elevations in winter can substantially affect recreation activities, only small proportions of the total annual users are affected. Boat ramps and recreation use areas at Lake Natoma are not substantially affected by lake drawdown because water levels are kept stable during the primary recreation season.

New Bullards Bar Reservoir. New Bullards Bar Reservoir is located on the Yuba River in Yuba County. The YCWA owns the lake, and the USFS provides recreation facilities and management. The lake has a surface area of approximately 4,800 acres.

The reservoir accommodates water-oriented recreation uses, including boating, water-skiing, fishing, and swimming. Picnicking, camping, and trail uses are also accommodated. Boat access is provided at the Cottage Creek boat ramp on the southwestern shore of the reservoir and at the Dark Day boat ramp 4 miles north of the dam on the eastern shoreline. The Emerald Cove Marina located at the Cottage Creek boat ramp provides a store, snack bar, 31 berthing slips for small crafts, mooring areas, and houseboat and fishing boat rentals. Currently, 42 houseboats are moored year-round at the reservoir.

The major use areas near the reservoir are the Burnt Bridge Campground and the Dark Day Campground and picnic area, both on the west side of the lake. Boat access camping is provided at the Garden Point, Frenchy Point, and Madrone Cove campgrounds.

Water-skiing is allowed throughout the reservoir at 200 feet from the shoreline. Boat and shore fishing opportunities are available for cold- and warm-water species. DFG manages the reservoir primarily for kokanee salmon and releases 220,000 to 250,000 fingerlings annually. The reservoir shoreline has no designated swimming areas.

Visitation to New Bullards Bar Reservoir was estimated at approximately 222,000 visitor days in 1992. Water-oriented activities dominate annual recreation use at the reservoir. Reservoir use patterns indicate high use of overnight camping and boat ramp facilities and low use of picnic areas. Occupancy rates at the two boat ramps are consistently more than 100 percent on weekends, with the heaviest use recorded at the Cottage Creek boat ramp. The reservoir shoreline areas most heavily used for day and overnight uses are the Little Oregon Creek area, the Garden Valley Road area, and the Bridger Creek and Brandy Creek shoreline areas in the extreme northeastern reservoir arm.

The maximum water surface elevation is 1,956 feet above msl. The Cottage Creek boat ramp ceases operation at 1,832 feet above msl, and the Dark Day boat ramp cannot be used at 1,798 feet above msl. The Emerald Cove Marina is operational at all lake levels.

Englebright Lake. Englebright Lake, owned and operated by the USCOE, is on the Yuba River downstream of New Bullards Bar Reservoir. The USCOE also provides recreation facilities and management. When full, the lake has a surface area of approximately 760 acres and an elevation of 534 feet above msl.

Englebright Lake facilities accommodate water-dependent recreation activities, such as boating, water-skiing, fishing, and boat-in camping. Boat access is available at the Narrows and Joe Miller Ravine boat ramps (four lanes total). The Narrows and Joe Miller Ravine recreation areas provide nearly all the day-use facilities; overnight camping and houseboat mooring areas spread out over approximately 9 miles of the lake. Skippers Cove Marina at the Joe Miller Ravine recreation area provides 223 berthing slips and mooring areas.

Water-skiing is allowed on approximately half the lake, with a no-ski zone enforced on the upper reach. Fishing occurs primarily in the northern half of the lake during the summer recreation season. Englebright Lake fisheries consist primarily of planted rainbow trout, kokanee salmon, and warm-water species. DFG stocks the lake with approximately 22,000 catchable-sized trout per year.

Visitation to Englebright Lake was estimated to total 137,000 visitor days in 1992. Visitation has increased substantially in recent drought years because of the relatively stable and full water levels. Boating, water-skiing, fishing, and swimming are popular activities. More than 80 percent of the lake's visitation is day use.

Surface water levels at Englebright Lake are stable as a result of operations of New Bullards Bar Reservoir upstream. When levels fall below 500 feet above msl (25 feet below full), the Narrows recreation area boat ramp cannot be used. At elevation 510 feet above msl (15 feet below full), the Joe Miller Ravine boat ramp cannot be used. During recent drought years, Englebright Lake was at full pool through the peak summer months. Fall drawdown is approximately 15 feet to provide flood storage.

b. **Rivers**. Construction and operation of the lakes and reservoirs that provide flatwater recreation opportunities have substantially affected instream uses below them. A sport fishery boom occurred in the Sacramento River in the years following construction of Shasta Lake as changes in water temperature and flow regimes benefited anadromous fish and adversely affected warm-water species. By the 1980s, the salmon and steelhead sport fishery had declined as diversions increased and instream flows decreased.

The Sacramento River environment provides the most important recreational resource for local residents. Over 2 million visitors participate in recreational activities along the Sacramento River annually. Fishing and relaxation are the most popular recreational activities. Other types of recreation include boating, water-skiing, swimming, camping, picnicking, hiking, sightseeing, bird watching and outdoor sports. Winter-run chinook salmon fishing was very popular prior to the severe decline in the population and current harvest restrictions. Striped bass, American shad, steelhead trout and spring, fall, and late-fall salmon runs remain popular among recreational anglers along the river.

Numerous public and private facilities provide recreational access along the Sacramento River between Keswick Dam and Red Bluff. Fishing is excellent along this stretch of the river. Rafting, kayaking, and canoeing are also popular because the river is fast flowing and there are a number of riffle areas. Fishing and hiking occur throughout the year, while picnicking and camping are limited to the spring through fall months. Water contact sports, such as swimming, kayaking, and canoeing, are generally restricted to the summer months where the daytime temperatures are often over 100EF.

Between Red Bluff and the Delta, little recreation land is available in the Sacramento Valley outside of riparian corridors. Public access to the river for recreational use is limited by the amount of public lands along the river. About 65 percent of the total recreational use on the river at and above Sacramento is by people living in counties adjacent to the river. Ninety percent of the summer day use activity is by local residents.

Sacramento River - Upper Reach - Shasta to Bend Bridge. The upper reach of the Sacramento River is approximately 60 miles long and flows through the foothill area of the northern Sacramento Valley. Relatively rapid flows and scenic views characterize this reach. The river flows through developed areas in Redding and Anderson and then passes through unpopulated foothills before reaching Red Bluff.

Although most of the upper reach flows through private lands, public access is more readily available than along the middle and lower reaches. Public access points are provided by the cities of Redding and Anderson, Tehama County, the State of California, and the BLM. Access points along this reach of the river include a 1-mile segment between Keswick Reservoir and Lake Redding (owned by the BLM and managed by the City of Redding) and Lake Redding Park and Turtle Bay Recreation Area (also managed by the City of Redding). Other popular access areas are Anderson River Park, managed by the City of Anderson, and a 7-mile segment below Jelly's Ferry, managed by the BLM.

Fishing is the most popular water-dependent activity on this reach. Water-contact activities, such as swimming and tubing, are not popular because the water is cold and flows swiftly. Popular water-enhanced activities include picnicking and sightseeing.

Sacramento River - Middle Reach - Bend Bridge to Knights Landing. This reach of the river is approximately 160 miles in length and is characterized by slower moving water and a meandering river channel lined with riparian thickets and orchards. Although most land along this reach is privately owned, some public access is provided by counties through which the river passes and by the DPR.

The DPR and Tehama, Glenn, Colusa, and Sutter counties provide access points along the middle reach. Private facilities, primarily fishing access points, marinas, and resorts are located along the entire reach. This reach of the river also includes the Woodson Bridge SRA.

Water-dependent activities in this reach include boat and shore fishing and swimming and beach use. Water-contact activities, such as swimming and tubing, are popular in this reach because the water is relatively warm compared to that in the upper reach. Water-enhanced activities include camping and relaxing.

Sacramento River - Lower Reach - Knights Landing to Courtland. The lower reach, between its confluence with the Feather River and Courtland, is an 80-mile segment of the river. Slow-moving water and a meandering river channel characterize the upper 20 miles. Near Sacramento, the character of the river changes because of urban influences such as levees and commercial development along the river. Between Sacramento and Courtland, the river passes through agricultural areas.

The City and County of Sacramento and DPR provide public access points along the lower reach. Private facilities, primarily marinas, are located along the entire reach. This reach of the river also includes Discovery Park at the confluence with the American River.

Fishing and boating are popular water-dependent activities on this reach. Water-contact activities such as swimming and beach use, are also popular. Water-enhanced activities include picnicking and relaxing.

Feather River. The lower Feather river flows approximately 40 miles from Oroville Dam to its confluence with the Sacramento River, largely through private lands. Major recreation areas along the river are the Oroville Wildlife areas south of Lake Oroville, Riverfront Park in Marysville, and Lake of the Woods Wildlife Area near its confluence with the Bear River. Boat access between Oroville and Marysville is provided at Marysville Riverfront Park and near the communities of Live Oak, Gridley, and Biggs. Undeveloped access points downstream of Marysville are located along Garden Highway, which generally borders the river to Verona.

Water-dependent recreation on the river consists of boat and shore fishing, pleasure boating, and swimming. Water-enhanced recreation activities include sightseeing, picnicking, and camping.

American River. The American River Parkway, a 23-mile-long river corridor, crosses the Sacramento metropolitan area between Nimbus Dam and the confluence with the Sacramento River at Discovery Park. The parkway, managed by the Sacramento County Parks and Recreation Department, is recognized as one of the nation's premier urban parkways.

The river corridor, an approximately 6,000-acre open space area, consists of a broad river channel with dense riparian vegetation. It features 28 automobile access points and 68 access points for pedestrians, equestrians, and bicyclists. The Jedediah Smith National Recreation Trail provides bicycle, pedestrian, and equestrian trails from Discovery Park to the Folsom Lake SRA. The parkway includes a series of 14 parks distributed on publicly owned lands.

Water-dependent activities on the lower American River include rafting, boating, fishing, swimming, and wading. Water-enhanced activities include picnicking, hiking, bicycling, and equestrian recreation.

Yuba River. The lower Yuba River flows from Englebright Lake and meets the Feather River at Marysville, a distance of approximately 20 miles. Most of this section of the river flows through private lands, restricting public access. No public recreation facilities exist along the river. Limited public access is available at the SR 20 crossing 5 miles downstream from Englebright Lake, at the end of Hallwood Boulevard about 8 miles upstream of the confluence with the Feather River, and through Riverfront Park in Marysville. Powerboat access to the river is possible from launches on the Feather River near its confluence with the Yuba River. Boats traveling up the river are constrained by flows and cannot pass Daguerre Point Dam approximately 10 miles upstream from the confluence with the Feather River.

Fishing is the primary recreation activity on the river. Important game fish include chinook salmon, steelhead, and American shad. Striped bass are also caught, although incidentally compared to other fish. Fishing occurs from the shore at access points available to the public and on the river from boats that travel upstream from the Feather River and from drift boats launched near the SR 20 crossing.

Clear Creek. Clear Creek flows from Whiskeytown Lake and discharges to the Sacramento River just south of Redding. The upper four miles of the creek flow through the Whiskeytown Unit of the Whiskeytown-Shasta-Trinity NRA. Most of the remaining 13 miles flow through private land. The upper half of the creek passes through steep terrain with many falls and cascades, whereas the lower portion has a flatter gradient with few cascades or falls.

No formal recreation facilities are found along the creek. The National Environmental Education Camp, administered by the NPS, is approximately 1.5 miles below Whiskeytown Dam and is used primarily by surrounding school districts. Public access is allowed along the portion of the creek that flows through the Whiskeytown-Shasta-Trinity NRA and at the mouth of the creek over a City of Redding easement. However, access is difficult because of the steep terrain. Popular recreation sites include the Redding Bar and Saeltzer Dam areas; both located on private lands on the lower portion of the creek. Recreation activities along the creek include swimming, beach use, relaxing, fishing, camping, picnicking, hiking, and tubing.

Bear River. The Bear River below Camp Far West Reservoir is a 20-mile-long reach that crosses private agricultural land in Placer, Yuba, and Sutter counties on a westerly route to its confluence with the Feather River north of the town of Nicolaus.

No public recreation facilities or public access sites are provided along this portion of the river. Informal access is available at the Forty-Mile Road crossing and McCourtney Road crossing near Camp Far West Reservoir. Recreation activities include warm-water fishing, sightseeing, and informal picnicking during winter and spring. Fishing activity is mainly for bass, catfish, and other warm-water species that move upstream from the Feather River or escape from Camp Far West Reservoir when flows are released to the river.

c. Wildlife Refuges. Recreation activities at the federal wildlife refuges and State WMAs which receive surface water diversions could be affected by the proposed actions. The NWRs in the Sacramento River Basin include Sacramento, Delevan, Sutter, and Colusa refuges managed as the Sacramento NWR Complex. Gray Lodge WMA is a State owned facility managed by the DFG.

Most recreation activities on the refuges are associated with the presence of waterfowl and upland game birds. These activities include hunting, hiking, and wildlife observation. Hunting of ducks, geese, and pheasants is permitted between October and January on portions of each refuge. Fishing is permitted at Delevan NWR from February to October and at Gray Lodge WMA. Facilities include parking areas, blinds, a visitor center at the Sacramento NWR, interpretive trails, viewing platforms, and self-guided driving tours.

d. Private Hunting Clubs. There are over 500 private hunting clubs in the Sacramento River Basin encompassing approximately 227,000 acres. Approximately 123,000 acres are flooded annually and much of the water comes from surface water diversions. These private clubs provide opportunities for hunting ducks, geese, and pheasants, and are an important component of the economy.

The Butte Basin is one of the least developed floodplains in the Sacramento Valley and lies in the heart of the Pacific Flyway. Over 50 percent of the ducks and geese that overwinter in California use the basin. The lower portion of the basin, known as the Butte Sink, still has extensive marshland and riparian habitat. Much of the land in the basin is owned by private clubs and devoted to waterfowl habitat. Wetlands maintenance requires artificial flooding, with most of the water use occurring between August and December and the greatest use occurring in October and November.

D. SAN JOAQUIN RIVER BASIN

1. Geography and Climate

The San Joaquin River Region is located in the heart of California and includes the northern portion of the San Joaquin Valley. It is bordered on the east by the Sierra Nevada and on the west by the coastal mountains of the Diablo Range. It extends from the southern boundaries of the Delta south to include all of the San Joaquin River drainage area. The San Joaquin River Basin is hydrologically separated from the Tulare Lake Basin by a low, broad ridge across the trough of the San Joaquin Valley between the San Joaquin and Kings rivers. Figure III-11 shows the San Joaquin River Basin.

The region is diverse but can be divided into two main topographies and associated climates: (1) the mountain and foothill areas, and (2) the valley area. The climate of much of the upland area west of the valley resembles that of the Sierra foothills. Precipitation in the mountainous areas varies greatly. The annual precipitation of several Sierra Nevada stations averages about 35 inches. Snowmelt runoff from the mountainous areas is the major contributor to local water supplies for the eastern San Joaquin Valley floor. The climate of the valley floor is characterized by long, hot summers and mild winters, and average annual precipitation ranges from 17 inches in the northeast to 9 inches in the south.

2. Population

The population of the San Joaquin River Region in 1990 was about 1.4 million. About 5 percent of the State's population live in this region. From 1980 to 1990, the region's population grew by 41 percent, primarily in Merced, Stanislaus, and San Joaquin counties. Communities such as Stockton, Modesto, Merced, and Tracy, once valley farm centers, are now major regional urban centers. These communities and their smaller neighboring cities, such as Lodi, Galt, Madera, and Manteca, are expected to continue expanding into the mostly agricultural northern San Joaquin Valley. Several counties expect their populations to nearly double by 2010.

Some of the growth in the region is due to the expansion from the San Francisco Bay Area and Sacramento. The relatively inexpensive housing available in the area offsets the long commute to Bay Area jobs for some San Joaquin County residents. Larger cities such as Stockton and Modesto are industrial and commercial centers in their own right.

In contrast to the large valley urban centers, separated by flat agricultural fields and linked by freeways, the foothills are sprinkled with small communities connected by small two-lane roads. Much of the foothill population lives along the old Mother Load route of the 1849 Gold Rush, Highway 49. Towns such as Jackson, Angels Camp, San Andreas,

Sonora, and Oakhurst have grown significantly in the last decade. Off from the north-south trending Highway 49 is a series of roads that lead to Sierra Nevada mountain passes. These mountain roads (Highways 88, 4, 108, and 120) generally follow east-west trending ridges, which are separated by one or more of the nine major river systems draining the Sierra. The economies of mountain communities along these routes depend on tourists and travel industries. These communities are also retirement areas for many former Bay Area and Southern California residents.

The western side of the region, south of Tracy, is sparsely populated. Small farming communities provide services for farms and ranches in the area, all relatively close to Interstate 5, the chief north-south transportation route in California.

3. Land Use

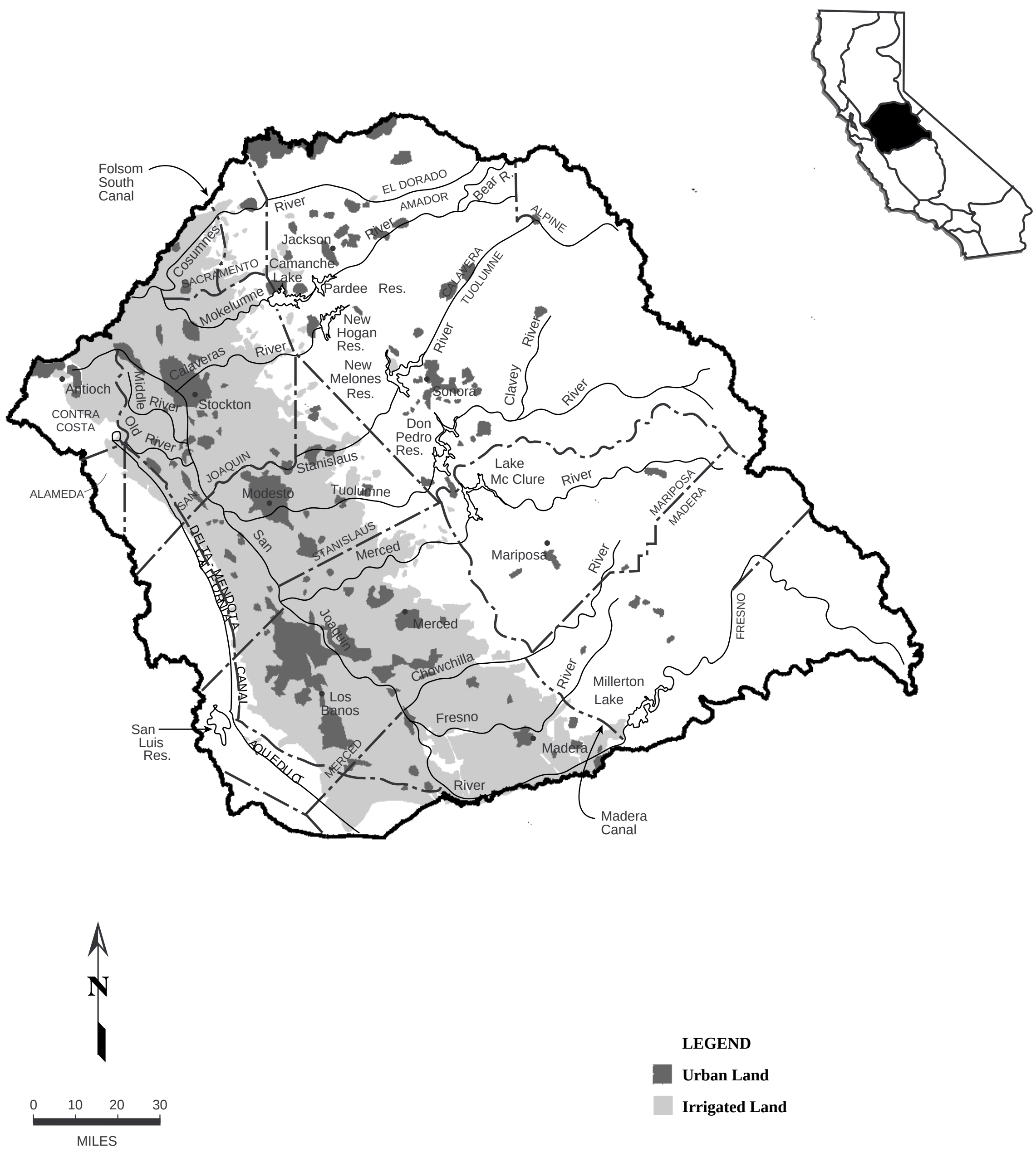
Agriculture is the major economic and land use activity in the San Joaquin River Basin. Other industries in the region include food processing, chemical production, lumber and wood products, glass, textiles, paper, machinery, fabricated metal products and various other commodities.

While the San Joaquin Valley is predominantly privately owned agricultural land, much of the Sierra Nevada is national forest land. The region includes the El Dorado, Stanislaus, and Sierra national forests and the Yosemite National Park. Public lands amount to about one-third of the region. The national forest and park lands encompass over 2,900,000 acres; state parks and recreational areas and other State-owned property account for about 80,000 acres; and BLM and military properties occupy some 221,000 and 37,000 acres, respectively.

The valley portion of the region constitutes about 3,500,000 acres, the eastern foothills and mountains total about 5,800,000 acres, and the western coastal mountains comprise about 900,000 acres. About 1,995,000 (19 percent) of the region's 10,200,000 acres were devoted to irrigated agriculture in 1990.

Irrigated acreage is very diversified with about 30 percent of the acres planted in grains, hay and pasture. Orchards (almonds, pistachios, and other deciduous) and vineyards also make up about 30 percent of the irrigated acres. Some of the other major crops include cotton, corn, tomatoes, and other field and truck crops.

Figure III-11
San Joaquin River Region



Source: DWR, Bulletin 160-93 (1994)

4. Water Supply

About 47 percent of the region's 1990 level average annual water supply comes from local surface sources, while 29 percent is from imported surface supplies. Groundwater provides about 19 percent of the water supply and about 5 percent of the total supply is considered dedicated natural flows for meeting instream flow requirements.

Surface water supply systems in the Sierra streams and rivers form a general pattern. A series of small reservoirs in the mountain valleys gathers and stores snowmelt. This water is used to generate electricity as it is released downstream. Some diversions occur for consumptive use in local communities, but most flows are recaptured in larger reservoirs located in the foothills and along the eastern edge of the valley floor. Most of these reservoirs were built primarily for flood control; however, many of them also have additional storage capacity for water supply and other uses included in their design. Irrigation canals and municipal pipelines divert much of the water from or below these reservoirs.

Most of the small communities in the Sierra foothills receive much of their water from local surface supplies. The extensive network of canals and ditches constructed in the 1850s for hydraulic mining forms the basis of many of the conveyance systems. In addition to surface water, many of these mountain communities pump groundwater from hard rock wells and old mines to augment their supplies, especially during droughts. Groundwater is the only source for many mountain residents who are not connected to a conveyance system.

The major river systems from the Sierra Nevada provide over half of the region's total water supply. Several large irrigation districts deliver most of the local surface water to agricultural users in the valley. Modesto ID and Turlock ID supply both agricultural and municipal users through the Modesto and Turlock Canals. Other irrigation districts, such as Merced, Oakdale and South San Joaquin, operate similar facilities.

Most of the region's imported supplies, about 2 million acre-feet per year, are delivered by the CVP. Oak Flat Water District receives about 5,000 acre-feet per year from the SWP.

a. Surface Water Hydrology. The primary sources of surface water in the San Joaquin River Basin are the rivers that drain the western slope of the Sierra Nevada Mountains. These include the San Joaquin River and its major tributaries, the Merced, Tuolumne, Stanislaus, Calaveras, Mokelumne, and Cosumnes rivers. Most of these rivers drain large areas of high elevation watershed that supply snowmelt runoff during the late spring and early summer months. Other tributaries to the San Joaquin River, including the Chowchilla and Fresno rivers, originate in the Sierra Nevada foothills, where most of the runoff results from rainfall. The three northernmost streams, the Calaveras, Mokelumne, and Cosumnes rivers, flow into the San Joaquin River within the boundaries of the Delta, and are commonly referred to as "eastside tributaries to the Delta."

The mainstem of the San Joaquin River originates on the western slope of the Sierra Nevada at elevations in excess of 10,000 feet. From its source, the river flows southwesterly until it enters the valley floor at Friant. The river then flows westerly to the center of the valley near Mendota, where it turns northwesterly to join the Sacramento River in the Delta. The mainstem of the San Joaquin River has a length of about 300 miles, one-third of which lies above Friant Dam.

Most of the water in the upper San Joaquin River is diverted at Friant Dam, and is conveyed north through the Madera Canal and south through the Friant Kern Canal. Releases from Friant Dam to the San Joaquin River are generally limited to those required to satisfy downstream water rights (above Gravelly Ford) and for flood control. In the vicinity of Gravelly Ford, high channel losses occur because the river bed is primarily sand and gravel. Average annual diversion from the San Joaquin River through the Friant-Kern Canal is 1,149,000 acre-feet.

Due to the operation of Friant Dam, there are seldom any flows in the lower San Joaquin River beyond those flows originating in the major tributaries plus agricultural and municipal return flows. However, prior to construction of Friant Dam, there was at times little or no flow in the San Joaquin River below Sack Dam, due to agricultural diversions and channel losses at Gravelly Ford.

During flood control operations, water that passes Gravelly Ford and exceeds demands at Mendota Pool is diverted from the San Joaquin River to the Chowchilla Bypass, which has a capacity of 6,500 cfs. The Chowchilla Bypass runs northwest, intercepts flows in the Fresno River, and discharges to the Chowchilla River. The Eastside Bypass begins at the Chowchilla River and runs northwesterly to rejoin the San Joaquin River above Fremont Ford. Together, the Chowchilla and Eastside bypasses intercept flows of the San Joaquin, Fresno, and Chowchilla rivers, and other lesser east side San Joaquin River tributaries, to provide flood protection for downstream agricultural lands. The bypasses are located in highly permeable soils, and much of the water goes to recharge of the groundwater basin.

The San Joaquin River tributaries provide the San Joaquin River Basin with high-quality water and most of its surface water supplies. Most of this water is regulated by reservoirs and used on the east side of the valley, but some is diverted across the valley to the Bay Area via the Mokelumne Aqueduct and the Hetch Hetchy Aqueduct. Average annual diversion from the Mokelumne and Tuolumne rivers that are directly exported from the basin include 245,000 acre-feet through the Mokelumne Aqueduct and 267,000 acre-feet through the Hetch-Hetchy Aqueduct.

Dams on the tributary streams include Pardee and Camanche dams on the Mokelumne River, New Melones, Donnells, and Beardsley dams on the Stanislaus River, O'Shaunessy and New Don Pedro dams on the Tuolumne River, and Exchequer Dam on the Merced River. In addition, there are a number of power and irrigation developments on these streams that serve to regulate and modify the natural runoff. A list of the major reservoirs in the San Joaquin River Basin is presented in Table III-13.

Runoff from the watersheds of both the major and minor streams in the San Joaquin River Basin shows wide seasonal, monthly, and daily variations modified by the effects of storage, releases from storage, diversions, and return flows. Stream flows are depleted by diversions and increased by drainage and return irrigation flows along the stream courses.

During the long dry season, the smaller streams often have no flows. Lowest flow conditions usually occur just prior to the advent of the rainy season, usually in late-November.

The San Joaquin River Basin is subjected to two types of floods: those due to prolonged rainstorms during the late-fall and winter, and those due to snowpack melting in the Sierra during the spring and early-summer, particularly during years of heavy snowfall. Major problem areas lie along valleys, foothill streams, and the lower San Joaquin River, where floodflows often exceed channel capacities and damage urban and highly developed agricultural areas.

Streams on the west side of the San Joaquin River Basin include Hospital, Del Puerto, Orestimba, San Luis, and Los Banos creeks. These streams are intermittent and contribute little to water supplies; however, they are an important source of groundwater recharge in local areas.

Table III-13
Major Reservoirs in the San Joaquin River Basin

Reservoir Name	Stream	Capacity (TAF)	Owner
New Melones	Stanislaus River	2,420	USBR
New Don Pedro	Tuolumne River	2,030	Turlock and Modesto IDs
Hetch Hetchy	Tuolumne River	360	City of San Francisco
Lake McClure	Merced River	1,024	Merced ID
San Luis	N/A	2,040	USBR and DWR
Shaver	San Joaquin River	135	Southern California Edison
Pardee	Mokelumne River	210	EBMUD
Salt Springs	Mokelumne River	139	PG&E
Millerton	San Joaquin River	520	USBR
Edison	San Joaquin River	125	Southern California Edison
Lloyd (Cherry)	Tuolumne River	268	City of San Francisco
Mammoth Pool	San Joaquin River	123	Southern California Edison
Camanche	Mokelumne River	431	EBMUD
New Hogan	Calaveras River	325	USCOE
Eastman	Chowchilla River	150	USCOE

Source: DWR 1993b

b. Surface Water Quality. The major water quality problems of streams on the San Joaquin Valley floor are a result of large salt loads from agricultural drainage and nutrients from municipal, industrial, and agricultural sources. The agricultural return water is estimated to carry a total annual salt load of 740,000 tons to the Sacramento-San Joaquin Delta. Salt loads are a problem principally under low flow conditions when adequate dilution water is not available. Although the water in the lower San Joaquin River is still usable for agriculture, severe crop damage has been occasionally experienced when salt concentrations exceed certain threshold limits. Major portions of basin streams are reaching an undesirable state of nutrient enrichment. Prolific aquatic plant and algal growth is causing detriments to beneficial water uses. Aquatic plants have, on occasion, nearly blocked reaches of the lower Stanislaus River and have interfered with recreational uses.

Diurnal fluctuation of dissolved oxygen has contributed to fish kills in the Tuolumne and San Joaquin rivers. The fluctuations are due to the presence of large algal concentrations and partially treated municipal and industrial wastes in the rivers. Other water quality problems include excessive coliform levels, pesticide concentrations, and turbidity.

Generally, water quality in the lower reaches of the San Joaquin River is degraded during summer and fall months of all water years. The poor water quality is due to upstream diversion of the natural flow and from the large volumes of drainage, waste waters, and return flows which, directly or indirectly, find their way into surface streams. The diversion of the natural flow at Friant Dam lessens the ability of the lower San Joaquin River to assimilate the poor quality discharges below Friant Dam. At times, the entire flow in the lower river is comprised of return flows.

Electrical conductivity (EC), boron, and other mineral concentrations are higher in dry and critical years due to a lack of dilution flows. This situation has imposed a slight to moderate degree of restriction on use of river water for irrigation. Among the trace elements analyzed during 1991, a critically dry year, median selenium values frequently exceeded USEPA ambient water quality criteria of 5 micrograms per liter (µg/l) for the protection of aquatic life in the middle portions of the river, and routinely exceeded the primary drinking water standard of 10 µg/l.

Generally, water quality in the Stanislaus, Tuolumne, and Merced rivers is good. Typically, water quality decreases during the late summer as natural flows in the river decrease and poorer quality water such as agricultural return flow increases. The tributary rivers, though contributing freshwater flows year round, do not have sufficient flows during summer and fall months to dilute the poor water quality in the mainstem San Joaquin River.

c. Groundwater Hydrology. The structural basin of the San Joaquin Valley, which contains the San Joaquin River Basin, is deep, asymmetric, and sedimentary. The deepest layers of rock in the structural basin, the crystalline igneous and metamorphic rock and the consolidated marine sedimentary rock, play no significant role in development of the groundwater basin. However, the continental sediments that overlie the marine sediments form the developed part of the groundwater basin. They range in thickness from more than 4,000 feet near the center of the trough to only a few feet along the valley perimeter.

The Mehrten Formation is also of great importance to the fresh groundwater basin of the northern San Joaquin Valley and yields large quantities of water to wells. It is found along the eastern edge of the valley to just south of the Chowchilla River. On the west side of the valley, the upper portion of the Tulare Formation and overlying alluvium constitutes a large portion of the developed groundwater basin.

In general, the top 2000 feet of sediment in the San Joaquin River Region contains fresh water. Beneath the east-side of the region the groundwater system consists of a single semi-confined aquifer. Beneath the western and central part of the region, the Corcoran Clay Member of the Tulare Formation divides the groundwater system into two aquifers: a confined aquifer below the Corcoran Clay and a semi-confined aquifer above the clay. The Corcoran Clay generally is found at depths of 100 to 400 feet, is a maximum of 160 feet thick and extends from the southeastern corner of Contra Costa County to the southern end of the Tulare Lake Basin.

The principal structure controlling the occurrence and movement of groundwater in the San Joaquin River Basin is the structural trough of the San Joaquin Valley. Overall groundwater movement in the basin is from the flanks toward the axis and from there toward the Sacramento-San Joaquin Delta. Secondary structures, such as arches and faults, also influence the occurrence and movement of groundwater. In several areas, groundwater flows toward localized pumping depressions.

The semi-confined aquifer is recharged from stream seepage, deep percolation of rainfall, subsurface inflow along basin boundaries, and with the expansion of irrigated agriculture, deep percolation of applied irrigation water and seepage from distribution and drainage canals. The confined aquifer below the Corcoran Clay is recharged from infiltration of water in areas of the valley where the clay is absent. The confined aquifer also receives water from the overlying semi-confined aquifer transmitted through unsealed well borings drilled through the Corcoran Clay.

DWR has divided this basin into several subbasins including the San Joaquin County, Modesto, Turlock, Merced, Chowchilla, Madera and Delta-Mendota subbasins. Other smaller subbasins exist in the San Joaquin River Region above the valley floor. DWR's most recent estimate of the usable storage capacity of the San Joaquin River Region is approximately 24 million-acre feet. The perennial yield of the region was estimated to be 3.3 million-acre feet. Groundwater pumping was estimated to exceed the perennial yield by approximately 200 thousand-acre feet under normal conditions. Three subbasins in the San Joaquin River Region have been designated by DWR as subject to critical conditions of overdraft: the Eastern San Joaquin County Basin, the Chowchilla Basin and the Madera Basin. Groundwater pumping in the region continues to increase in response to growing urban demand and reduced surface water deliveries from north of the Delta.

Declining groundwater levels have caused land subsidence throughout the part of the region underlain by the Corcoran Clay. The most significant problems have occurred in western Fresno County where land has subsided as much as 30 feet. An area of subsurface drainage problems exists along the western side of the San Joaquin River Basin. Deep percolation of imported water and a decrease in groundwater pumping in this area has resulted in a near- surface water table causing the drainage problem. Toxic trace elements, including selenium, in the drainage water complicates the disposal process. In the lower reaches of the San Joaquin River and near its confluence with major tributaries, high periodic streamflows combined with high groundwater tables have resulted in seepage damage to nearby farmland.

d. Groundwater Quality. Groundwater in the San Joaquin River Basin varies widely in type and concentration of chemical constituents. The differences are related to the quality of water that replenishes the groundwater reservoirs and chemical changes that occur as the water percolates through the soil including cation exchange, sulfate reduction, mineral matter solution, and precipitation of less soluble compounds.

Groundwater quality in the San Joaquin River Basin varies both laterally and vertically. TDS concentrations generally do not exceed 500 mg/l beneath the center and east side of the region due to good quality runoff from the Sierra Nevada. On the west side of the region, TDS concentrations are generally greater than 500 mg/l. At several locations in the region municipal use of groundwater for drinking is impaired due to high TDS, boron, arsenic and nitrate concentrations. High concentrations of dibromochloropropane (DBCP), a nematocide, impairs municipal use of groundwater for drinking near several cities in the region including Chowchilla, Madera, Merced and the Modesto-Turlock area. High boron concentrations also impair agricultural use of groundwater in eastern Stanislaus and Merced Counties. Selenium occurs in concentrations toxic to humans, wildlife and aquatic species in shallow groundwater on the west side of the San Joaquin River Basin. Use of groundwater to support aquatic species is impaired due to high selenium concentration between Los Banos and Mendota in the western part of the region.

5. Water Use

The average annual net water demand in the San Joaquin River Region is about 6.8 million acre-feet. The 1990 level total applied water for the San Joaquin River Region was 7,416,00 acre-feet.

Agricultural water demand represents 85 percent of the total for the region. Total applied water on about 2 million acres of irrigated agricultural land was 6,298,000 acre-feet in 1990. The total evapotranspiration of applied water for those crops was 4,297,000 acre-feet.

Urban demand, which includes residential, industrial, and commercial uses, accounts for 5 percent of the total demand for the region. The 1990 level urban applied water demand for the region was nearly 0.5 million acre-feet and average per capita water use is about 309 gallons per day.

Environmental water use for the region's wetlands and instream fishery requirements makes up 8 percent of the net demand. Wildlife refuges and other wetlands have a net use of 223,000 acre-feet. Four rivers in the region, the Mokelumne, Merced, Stanislaus, and Tuolumne, have significant instream flow requirements. The region's annual water requirement for instream flows is 1,169,000 acre-feet.

Portions of the Tuolumne and Merced rivers are designated wild and scenic under the California Wild and Scenic Rivers Act of 1972 which provides for the preservation of the natural watercourse and character of certain rivers in the State. The upper stretch of the Tuolumne River, below Hetch Hetchy Reservoir and above New Don Pedro Reservoir, was designated wild and scenic in 1984. Much of the Merced River above Lake McClure was given this status in 1987 and the eight-mile stretch from Briceburg to Bagby was added in 1992.

6. Vegetation

Eight common natural community types occur in the San Joaquin River Region occupying approximately 4.9 million acres out of a total land area of 8.3 million acres. The natural communities include mixed conifer forest, montane hardwood, montane riparian, valley foothill hardwood, valley foothill riparian, chaparral, grassland, chenopod scrub, and fresh and saline emergent wetlands. Grassland is the most abundant natural community in this region, with 1.9 million acres mostly on the edges of the valley floor. The largest numbers of special-status plant species are found in this community. Valley foothill woodland is the next most common natural community, occupying 1.3 million acres of the foothill areas of the region.

Historically, the basin contained a large floodplain that supported vast expanses of permanent and seasonal marshes, lakes and riparian areas. Almost 70 percent of the basin has been converted to irrigated agriculture with wetland acreage reduced to 120,300 acres. Even so, the basin contains the largest contiguous block of wetland habitat in the Central Valley. Much of the native vegetation in the San Joaquin River Basin has been replaced by introduced species or disturbed by cultivation or grazing. On the undisturbed portions of the basin, non-native species such as annual grasses and Russian thistle are common, with patches of native vegetation consisting of sagebrush and saltbush.

Sensitive habitats in the San Joaquin River Basin that can be grouped into the valley and foothill riparian community type include: great valley-valley oak riparian forest, great valley cottonwood riparian forest, great valley mixed riparian forest, white alder riparian forest, great valley willow scrub, buttonbush scrub, elderberry savanna, central coast cottonwood-sycamore riparian forest, central coast live oak riparian forest, and central coast arroyo willow riparian forest.

Sensitive grassland communities of the San Joaquin River Basin include vernal pools, valley needlegrass grassland, serpentine bunchgrass, wildflower fields, freshwater seeps, alkali playas, valley sacaton grassland, and pine bluegrass grassland. Three sensitive emergent wetland communities occur in the San Joaquin River Basin: cismontane alkali marsh, coastal and valley freshwater marsh, and vernal marsh. Two types of sensitive chaparral habitats, serpentine chaparral and upper Sonoran subshrub scrub, also occur in the region.

Sycamore alluvial woodland is a sensitive community that occurs on the west side of the San Joaquin Valley. This community type is found along the channels of intermittent streams in which flow is usually produced by rainfall rather than snowmelt. Sycamore alluvial woodland consists of a winter-deciduous broadleafed riparian woodland with widely spaced sycamores, California buckeyes, and elderberry bushes.

Chenopod scrub is a broad community type that includes valley, foothill, and desert habitats. The San Joaquin Valley once contained many examples of the various types of foothill and valley chenopod scrubs, but as a result of flood control, agriculture, and groundwater pumping, distribution of most of these communities is now limited. Chenopod scrub communities consist of shrubby, often succulent species, typically dominated by the Chenopodiaceae family. They occur on poorly drained soils, dry lakebeds, and alluvial fans, often in alkaline or saline soils. Valley sink scrub, valley saltbush scrub, and interior coast range saltbush scrub are particularly sensitive community types. Table III-14 lists the sensitive plant species found in the San Joaquin River Basin.

7. Fish

The San Joaquin River and tributaries provide habitat for a diverse assemblage of fish, both anadromous and resident species. About 45 species of fish are found upstream of the Delta. Of these, 20 are native species. A variety of both coldwater and warmwater fish, including salmonids, striped bass, sunfish, catfish, shad, lampreys, perch, cyprinids, sculpin, and suckers occur in the basin. Table III-15 lists the sensitive fish species occurring in the basin.

Historically, the upper San Joaquin River supported spawning and rearing habitat for the southern-most stocks of spring- and fall-run chinook salmon, and steelhead. Streamflow releases following the construction of Friant Dam are insufficient to support anadromous fish passage, spawning, or rearing. Major reaches of the mainstem river between Gravelly Ford and the confluence with the Merced River are essentially dry for much of the year. During summer and fall, water downstream of Mendota Pool often consists entirely of low-quality agricultural return water. Despite water quality problems, the mainstem river supports a variety of warmwater species, including striped bass, sunfish, catfish, shad, lampreys, perch, cyprinids, sculpin, and suckers. The mainstem river downstream from the confluence with the Merced River also provides a migration corridor for anadromous fish to the Delta and ocean.

Although there are no minimum flow requirements for the mainstem San Joaquin River upstream of Vernalis, there are various requirements for the basin, depending on season, water year type, and water quality standards. These flow requirements can be influenced by the need for maintaining the position of the 2-ppt isohaline (referred to as X2) in the estuary, fishery studies, and temperature needs of anadromous fish.

Table III-14
Sensitive Plant Species in the San Joaquin River Basin

Scientific Name	Common Name	Status: State	Status: CNPS	Status: Federal
Amsinckia grandiflora	Large-flowered fiddleneck	SE	1B	FE
Castilleja campestris ssp. succulenta	Succulent owl's-clover	SE	1B	FT
Caulanthus californicus	California jewelflower	SE	1B	FE
Chamaesyce hooveri	Hoover's spurge		1B	FT
Cordylanthus palmatus	Palmate-bracted bird's-beak	SE	1B	FE
Eriastrum hooveri	Hoover's eriastrum		4	FT
Eryngium racemosum	Delta button-clery	SE	1B	FSC
Gratiola heterosepala	Boggs Lake hedge-hyssop	SE	1B	
Lembertia congdonii	San Joaquin woollythreads		1B	FE
Neostapfia colusana	Colusa grass	SE	1B	FT
Orcuttia inaequalis	San Joaquin Valley Orcutt grass	SE	1B	FT
Orcuttia pilosa	Hairy Orcutt grass	SE	1B	FE
Pseudobahia bahiifolia	Hartweg's golden sunburst	SE	1B	FE
Pseudobahia peirsonii	San Joaquin adobe sunburst	SE	1B	FT
Tuctoria greenei	Greene's tuctoria	SR	1B	FE
Eschscholzia rhombipetala	Diamond petaled poppy		1B	FSC

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
CNPS: (California Native Plant Society) 1A=presumed extinct in California; 1B=rare,threatened, or endangered in California and elsewhere; 2=rare,threatened,or endangered in California but more common elsewhere; 3=need more information; 4=distribution limited (a watchlist).
FEDERAL: FE=endangered; FT=threatened; FPE=proposed endangered; FPT=proposed threatened; C=candidate for listing; FSC=species of concern.

Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

Table III-15
Sensitive Fish Species in the San Joaquin River Basin

Scientific Name	Common Name	Status: State	Status: Federal
Hypomesus transpacificus	Delta smelt	ST	FT
Lampetra hubbsi	Kern Brook lamprey	CSC	FSC
Mylopharodon conocephalus	Hardhead	CSC	
Oncorhynchus tshawytscha	Fall-run chinook salmon, Central Valley, CA ESU		C
Oncorhynchus tshawytscha	Late fall-run chinook salmon, Central Valley, CA ESU	CSC	C
Oncorhynchus mykiss	Steelhead, Central Valley, CA ESU		FT
Pogonichthys macrolepidotus	Sacramento splittail	CSC	FT

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
FEDERAL: FT=threatened; C=candidate for listing; FSC=species of concern.
Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

To meet the requirements of the Central Valley Project Improvement Act, the U.S. Fish and Wildlife Service is developing and implementing the Anadromous Fish Restoration Program (AFRP). The Draft Restoration Plan (May 1997) proposes minimum flows for CVP streams and recommends actions and evaluations for the mainstem San Joaquin River and its tributaries in order to meet the AFRP goal of doubling the natural production of anadromous fish populations in Central Valley streams. For some streams in the basin, Federal Energy Regulatory Commission (FERC) relicensing and water right processes are also underway or planned which may establish instream flow improvements for fisheries.

In March 1995, the U.S. Fish and Wildlife Service issued a Biological Opinion concerning the impacts of the CVP and SWP on delta smelt. This opinion requires interim flows for the San Joaquin River between February and June to be the same as those required in the 1995 Bay/Delta Plan. The USBR and DWR provide these interim flows. The interim flows vary, depending on water year type and the need for positioning X2, and include pulse flows for the transport of juvenile delta smelt from the San Joaquin River to Suisun Bay.

The major eastside tributaries to the San Joaquin River, the Stanislaus, Tuolumne, and Merced rivers, support spawning and rearing habitat for fall-run chinook salmon, late fall-run chinook, and rainbow trout/steelhead. These tributaries also support warmwater game fish populations, such as small and largemouth bass, sunfish, and catfish, and a variety of native fishes, such as hardhead, Sacramento squawfish, Sacramento sucker, sculpin, and lamprey. The Calaveras, Cosumnes, and Mokelumne rivers, tributary to the San Joaquin River in the Delta, support a variety of anadromous and resident species. Fishery resources in the major San Joaquin River tributaries are described in further detail below.

a. Mokelumne River. The lower Mokelumne River supports four species of anadromous fish: fall-run chinook salmon, steelhead, American shad, and striped bass, and a variety of resident species. Fall-run chinook salmon are the most abundant anadromous fish in the river.

Conditions of the aquatic habitat and variation in environmental conditions in the river have resulted in widely varying abundance of these species. Returns of fall-run chinook salmon reached a peak of slightly more than 11,000 in 1983, but declined to fewer than 410 spawners in 1991.

Before the completion of Camanche Dam in 1964, chinook salmon spawned primarily between the town of Clements and the canyon about 3 miles below Pardee Dam. Currently, the majority of salmon spawning occurs in the 5 miles between Camanche Dam and Mackville Road, with 95% of the suitable spawning habitat within 3.5 miles of the dam. As mitigation for the loss of spawning habitat with the construction of the dam, the Mokelumne River Fish Hatchery (MRFH) was constructed, with a capacity to produce 100,000 yearling steelhead and to process 15 million chinook salmon eggs per year. From 1964 to 1988, the MRFH received extremely low numbers of returning adult chinook and steelhead; eggs were imported from other hatcheries to meet production goals.

Prior to completion of Camanche Reservoir, steelhead were the most important sportfish in the lower Mokelumne River based on creel census data. The present natural production of steelhead in the river is thought to be very low.

In 1992, EBMUD prepared a comprehensive management plan for the lower Mokelumne River that included additional instream flows and non-flow enhancement components. In water year 1992, EBMUD voluntarily implemented the basic provisions of the FERC Principles of Agreement (EBMUD, CDFG, USFWS 1996), which included increased flow releases year-round. In recent years, adult chinook salmon returns to the river and hatchery have significantly improved.

b. Stanislaus River. Flow releases for fishery purposes in the lower Stanislaus River are designated in a 1987 agreement between USBR and CDFG. This agreement specifies interim annual flow allocations for fisheries between 98,300 AF and 302,100 AF, depending on carryover storage at New Melones Reservoir and inflow.

Historically, the river supported steelhead and spring- and fall-run chinook salmon. The river now supports fall-run chinook salmon, small numbers of late fall-run chinook and rainbow trout/steelhead, and a variety of resident species. Similar to other tributaries in the basin, fall-run spawning escapements have varied significantly since surveys were initiated in 1939. In the recent drought years (1987 – 1992), returns to the river reached extremely low levels. Since the end of the drought, returns have recovered somewhat.

Fall-run chinook typically begin migration into the river in late September to early October. Elevated water temperatures may delay upstream migration and spawning. Spawning occurs from October through December, typically peaking in November. Fry rearing occurs from January through March. Juveniles emigrate from the river either as fry from January through March, or as smolts from March through June.

c. Tuolumne River. Flow requirements for the lower Tuolumne River are specified in the New Don Pedro Proceeding Settlement Agreement (February 1996) and the FERC License Amendment for the New Don Pedro Project (July 1996). Minimum flows ranging from 94,000 AF to 300,923 AF are provided in the lower Tuolumne River, based on water year type.

Historically, the river supported spring and fall-run chinook salmon and steelhead trout. The river now supports fall-run chinook salmon, small numbers of late fall-run chinook and rainbow trout/steelhead, and a variety of resident species. As in the other San Joaquin River basin tributaries used for spawning, fall-run escapements in the lower Tuolumne River have varied significantly since surveys were initiated in 1939. These population fluctuations are the result of extreme variations in environmental conditions. Since surveys were initiated, the Tuolumne River, on average has supported the highest spawning escapements among the San Joaquin River tributaries.

As in other San Joaquin basin tributaries, spawning returns to the river reached extremely low levels in the recent drought years (1987 – 1992). Since the end of the drought, returns have recovered somewhat.

Fall-run chinook typically begin migration into the river in late September to early October. Elevated water temperatures may delay upstream migration and spawning. Spawning occurs from October through December, typically with a peak in November. Fry rearing occurs from January through March. Juveniles emigrate from the river either as fry from January through March, or as smolts from March through June.

d. Merced River. Streamflows for fishery purposes in the lower Merced River are mandated in FERC License No. 2179 for the New Exchequer Project (April 1964) and the Davis-Grunsky Contract No. D-GG417 between DWR and MID (October 1967). In recent years, water purchases/transfers have been used to supplement streamflows in the lower river.

Historically, the river supported spring and fall-run chinook salmon and perhaps steelhead. The river now supports fall-run chinook salmon, rainbow trout/steelhead, perhaps late fall-run chinook salmon, and a variety of resident fish species. As with the Stanislaus and Tuolumne rivers, the number of late fall-run chinook and rainbow trout/steelhead in the river is unknown. Each year, a few large rainbow trout/steelhead enter the Merced River Hatchery (MRH), but the origin of these fish is unknown.

As with other tributaries in the basin, fall-run chinook salmon escapements in the lower Merced River have varied significantly since surveys were initiated. During the 1987 to 1992 drought, spawning escapement declined to seriously low levels. Since the end of the drought, returns have recovered somewhat.

Merced River Hatchery, located below Crocker-Huffman Dam, is presently the only salmon hatchery in the San Joaquin River drainage south of the Delta. Operated by DFG, the hatchery was constructed in 1970 and operated for 10 years with funding provided in the Davis-Grunsky Agreement. The facility was recently modernized; production capacity was increased to 360,000 yearling salmon and 600,000 salmon smolts and egg production capacity was increased to 4 million.

Fall-run chinook typically begin migration into the river in October, although migration may be delayed due to low instream flows and elevated water temperatures. Spawning occurs from October through December, typically peaking in November. Fry rearing occurs from January through March. Juveniles emigrate from the river either as fry from January through March, or as smolts from March through June.

8. Wildlife

Historically, the San Joaquin Valley was composed of a combination of large seasonal wetlands, extensive grasslands, broad riparian corridors, and vast parcels of desert scrub. The valley supported an exceptionally diverse group of wildlife species, which included bison, elk, and grizzly bears. Agricultural, urban, and commercial development have reduced, fragmented, and heavily modified natural habitat on the valley floor; only about 5 to 10 percent of its historical habitats remain.

Although few large mammals remain in the San Joaquin Valley, the remnant habitat continues to support a diverse group of species. Coyotes, gray foxes, kit foxes, badgers, skunks, and opossums feed on the many species of rodents, rabbits, reptiles, and insects on the valley floor. California and antelope ground squirrels make up the majority of large terrestrial rodents, while beaver and muskrat represent semi-aquatic species.

Millions of waterfowl associated with the Pacific Flyway overwinter in the valley wetlands. Raptor species, including bald eagles, prairie falcons, and great-horned owls, hunt in the wetlands, grasslands, and riparian habitats of the San Joaquin Valley. Many passerines, including species of flycatchers, swallows, warblers, blackbirds, and sparrows, nest and/or overwinter in the variety of habitats associated with the San Joaquin River Basin. Upland game birds include dove, pheasant, chukar, and quail; shorebirds include multiple species of gulls, terns, plovers, sandpipers, and egrets.

Herptiles of the area include garter, gopher, night, and king snakes; western pond turtles; leopard, fence, alligator, and side-blotched lizards; skinks and whiptails; red-legged, yellow-legged, tree, and bull frogs; and tiger and slender salamanders. As with other diverse habitats, the San Joaquin River Basin is home to thousands of insect and other invertebrate species.

The loss of the majority of natural habitat in the valley, and its subsequent replacement by urban and agricultural monocultures, resulted in the decline of many of the valley's species, some to near extinction. Although conservation agencies have succeeded in slowing the habitat loss trends, many species continue to struggle for survival. Table III-16 lists the sensitive wildlife species found in the San Joaquin River Basin.

A total of 77 significant natural areas are scattered throughout the San Joaquin River Basin. These SNAs are important to waterfowl and shore birds that winter and nest in the San Joaquin River Basin, as well as for many special-status species.

Food and cover for native wildlife are limited throughout much of the valley. The hot, dry climate of the west side of the San Joaquin Valley limits vegetation on the valley floor mostly to sagebrush, tumbleweed, and some grasses, except in a few draws and creek channels. The foothills of the Coast Ranges are also dry and mostly treeless except in a few creek bottoms. Some wildlife cover plantings along the San Luis Canal have provided additional wildlife habitat.

In the trough of the San Joaquin Valley between Mendota and Gustine are tens of thousands of acres of excellent waterfowl land which constitute an important station along the Pacific Flyway. Drainage flows were previously an appreciable percentage of the water supply for this area and were used to grow feed and cover crops, and to provide resting ponds for the waterfowl using this area. While drainage seemed to be an attractive source of water for wetland use, selenium levels in the drainage water became toxic to waterfowl. The Grasslands Water District no longer accepts tile drainage flows in the Grasslands area for wetland use. Since passage of the CVPIA, water for these wetlands has been made available from the Delta-Mendota Canal or tailwater supplies. Selenium remains a concern because the Grasslands area has a significant accumulation of these salts from local tributary streams and the residues from past use of tile drain water.

9. Recreation

Key recreation areas in the San Joaquin River Region are Millerton Lake, San Luis Reservoir, New Melones Reservoir, Lake McClure, New Don Pedro Reservoir, and the San Joaquin, Merced, Tuolumne, and Stanislaus rivers. Key federal and State wildlife refuges that provide opportunities for hunting waterfowl and upland game are the San Luis, Merced, and Kern NWRs and the Volta and Los Banos WMAs. Waterfowl and upland game hunting on private lands is also described in this section. Other potentially affected recreation areas include Bethany Reservoir, O'Neill Forebay, New Hogan Lake, and Camanche Reservoir; the Mokelumne and Calaveras Rivers; and the California Aqueduct and Delta-Mendota Canal.

a. Reservoirs. Recreation opportunities in the San Joaquin River Basin have been shaped substantially by the construction of dams and creation of large lakes on the San Joaquin River and all of its major tributaries. Between 1945 and 1970, flatwater recreation opportunities in the San Joaquin River Region became more extensive as lakes, reservoirs, and recreation facilities were constructed. Between 1945 and the mid-1960s, Millerton Lake provided most of the flatwater recreation opportunities in the region. In 1970, the combined annual recreation use at San Luis Reservoir and Millerton Lake totaled approximately 678,000 visitor-days, increasing to approximately 1.6 million visitor days in 1980 with the addition of New Melones Reservoir.

San Luis Reservoir. The San Luis Reservoir SRA, operated by DPR, covers approximately 12,700 surface acres when full. Major components of the San Luis Reservoir SRA are the recreation facilities that accommodate boating, water-skiing, fishing, picnicking, camping, hunting, and trail use activities. Boat access is provided in the southeastern portion of the reservoir at the Basalt area, a two-lane concrete boat ramp and boarding dock, and at the northwestern Dinosaur Point use area, which features a four-lane concrete boat ramp and boarding dock.

Boat and shore fishing occurs throughout San Luis Reservoir. Striped bass is the primary game fish in the reservoir. Fishing is usually of high quality from late February through summer, with striped bass fishing best during winter and spring.

Table III-16
Sensitive Wildlife Species in the San Joaquin River Basin

Scientific Name	Common Name	Status State	Status Federal
Agelaius tricolor	Tricolored blackbird	CSC	FSC
Branta canadensis leucopareia	Aleutian Canada goose		FT
Buteo swainsoni	Swainson's hawk	ST	
Empidonax traillii	Willow flycatcher	SE	
Grus canadensis tabida	Greater sandhill crane	ST	
Haliaeetus leucocephalus	Bald eagle	SE	FT
Plegadis chihi	White-faced ibis	CSC	FSC
Vireo bellii pusillus	Least Bell's vireo	SE	
Ammospermophilus nelsoni	San Joaquin antelope squirrel	ST	FSC
Antrozous pallidus	Pallid bat	CSC	
Corynorhinus townsendii townsendii	Townsend's western big-eared bat	CSC	
Dipodomys ingens	Giant kangaroo rat	SE	FE
Dipodomys nitratoides exilis	Fresno kangaroo rat	SE	FE
Euderma maculatum	Spotted bat	CSC	FSC
Eumops perotis californicus	California mastiff bat	CSC	FSC
Myotis ciliolabrum	Western small-footed myotis		FSC
Myotis evotis	Long-eared myotis		FSC
Myotis volans	Long-legged myotis		FSC
Myotis yumanensis	Yuma myotis		FSC
Neotoma fuscipes riparia	Riparian woodrat	CSC	FPE
Sylvilagus bachmani riparius	Riparian brush rabbit	SE	FPE
Vulpes macrotis mutica	San Joaquin kit fox	ST	FE
Rana aurora draytonii	California red-legged frog		FT
Clemmys marmorata	Western pond turtle		
Gambelia sila	Blunt-nosed leopard lizard	SE	FE
Thamnophis gigas	Giant garter snake	ST	FT
Branchinecta conservatio	Conservancy fairy shrimp		FE
Branchinecta longiantenna	Longhorn fairy shrimp		FE
Branchinecta lynchi	Vernal pool fairy shrimp		FT
Desmocerus californicus dimorphus	Valley elderberry longhorn beetle		FT

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
FEDERAL: FE=endangered; FT=threatened; FPE=proposed endangered; FPT=proposed threatened; C=candidate for listing; FSC=species of concern.

Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

Wind conditions on the reservoir can create hazardous boating conditions. Warning lights at the DWR-operated Romero Overlook visitor center and DPR Quien Sabe Point facility indicate when wind conditions on the reservoir are hazardous. San Luis Reservoir has no designated swimming or lakeside beach areas. Water-skiing is allowed in designated areas around the 65-mile reservoir shoreline.

Migratory waterfowl hunting is permitted on most of the reservoir at approximately 300 feet from established reservoir and recreation facilities. Hunting for deer and wild pig is also allowed in the San Luis Reservoir SRA on the northwestern reservoir shoreline. Recreation use at San Luis Reservoir is optimized at a maximum reservoir pool elevation of 544 feet above msl. Use of the Basalt area boat ramp becomes inconvenient at approximately 340 feet above msl, but it can be used on a limited basis. The four-lane boat ramp at Dinosaur Point can be used at the minimum reservoir pool but is difficult to access below 360 feet above msl. Swimming activities are not affected by reservoir surface water fluctuations because the reservoir has no designated swimming facilities.

Millerton Lake. Recreation facilities at Millerton Lake are operated by DPR as part of the Millerton Lake SRA. When full, the lake has a surface area of 4,920 acres, 51 miles of shoreline, and a surface elevation of 537 feet above msl.

Recreation opportunities at Millerton Lake include fishing, swimming, boating, water-skiing, picnicking, camping, and trail use. Boat access is provided on the south and north shores of the lake. Major use areas are the La Playa, Grange Grove, Blue Oak, and South Bay picnic areas; McKenzie Point boat ramp and swimming area; and Winchell Bay Marina and South Finegold picnic area on the south shore. Five boat ramps located along the south shore provide 33 launching lanes. The north shore features camping facilities at Dumna Cove and a two-lane boat ramp at the Meadow Campground. The Winchell Bay Marina provides up to 450 berthing slips.

Fishing occurs from boats and the shore throughout the reservoir. The Millerton Lake fishery consists of trout and warmwater species. The warmwater fishery includes a popular inland striped bass program along with spotted and largemouth bass. It is a popular lake for bass tournaments. Swimming and sunbathing are popular at the La Playa and South Bay picnic areas from May through September. Boating and water-skiing are popular throughout the main southern reservoir areas. Northwest of Finegold Bay, the 16-mile San Joaquin River Canyon portion of the reservoir is designated as a no-skiing area with a 35-mile-per-hour (mph) boat speed limit. A 5-mph boat speed limit is enforced at the Temperance Flat boat and environmental camps.

Millerton Lake is a popular recreation destination for Fresno, Madera, and Merced county residents and regularly sustains heavy use during the peak summer season. In 1992, use at the Millerton Lake SRA totaled approximately 948,000 visitor days.

Despite the availability of usable boat ramps year-round, Millerton Lake recreation use decreases substantially when the reservoir drops to an elevation of 468 feet above msl. Boat Ramps No. 1

(La Playa) and 6 (Meadow Camp) can be used at all surface water elevations. Ramp No. 2 can be used between elevations 520 and 537 feet above msl; Ramp No. 3 at elevations above the normal maximum pool from 537 to 578 feet above msl; Ramp No. 4 at surface water elevations of 500 to 520 feet above msl; and Ramp No. 5 at elevations 468 to 500 feet above msl.

Winchell Bay Marina operations are affected by changes of approximately 3 feet in surface water elevation. Although the marina must be moved frequently when the lake fluctuates, it is operable at all surface water elevations.

The south shore swimming areas are also affected by changes in reservoir water elevations. The La Playa swimming area is generally used at high water elevations, and the McKenzie Point swimming area is generally used at low water elevations. Camping at most of the lake units is not affected by water elevations, except for the Temperance Flat camping unit, which cannot be used below 520 feet above msl.

New Melones Reservoir. Recreation facilities at New Melones Reservoir have operated since 1979 when initial recreation development was completed. When full, the reservoir has a surface area of approximately 3,600 acres, 105 miles of shoreline, and a surface elevation of 1,088 feet above msl.

Recreation facilities at the reservoir accommodate swimming, boating, water-skiing, fishing, picnicking, and camping. Boat access is provided on the north and east shores of the reservoir. Developed use areas are the Glory Hole recreation area in the northwestern portion of the reservoir and the Tuttletown recreation area on the eastern shore. The Mark Twain, Parrot's Ferry, Camp Nine, and Old Town recreation areas are undeveloped and offer minimal facilities.

The Glory Hole recreation area is the most intensively used facility on the reservoir and features three boat ramps (seven-lane) used for high, medium, and low reservoir levels; a concession-operated marina with berthing slips; three courtesy docks; picnic sites; and camping facilities. A developed beach area provides swimming opportunities.

The Tuttletown recreation area features three seven-lane boat ramps used for variable reservoir levels, three courtesy docks, a fish-cleaning station, picnic sites, and camping facilities. The designated swimming area and beach at Angels Arm recreation area is closed. Boating and water-skiing are popular throughout the main reservoir area, and fishing is popular from boats and the shoreline.

Approximately 1,495,000 visitor days at New Melones Reservoir were recorded in 1992. Water-dependent recreation activities, which account for the largest portion of annual visitation, include water-skiing, pleasure boating, and fishing. Camping is the most popular water-enhanced activity. The optimal reservoir level for recreation use is at an elevation of approximately 950 to 980 feet above msl. All boat ramps except one at Glory Hole cease operation as the lake reaches a surface elevation of 950 feet above msl. The Glory Hole boat ramp is a 2-lane facility constructed by volunteers to provide boat access at a reservoir elevation as low as 860 feet above msl. The Glory Hole Marina must be moved with changing water levels. At an approximate elevation of 900 to 950 feet above msl, use is substantially reduced by loss of all but the Glory Hole boat ramp. At an elevation of 880 feet above msl, which was reached during the recent drought, the marina closes. Other ramps in the Mark Twain, Parrot's Ferry, and Old Town undeveloped recreation areas are old roads that can be used on a limited basis to an elevation of approximately 850 feet above msl.

Lake McClure. Lake McClure is owned and operated by the Merced ID. When full, the lake has a surface area of 7,100 acres, 80 miles of shoreline, and an elevation of 867 feet above msl. Recreation facilities at Lake McClure accommodate a wide variety of water-dependent and water-enhanced activities. Boat access is provided at ramps located around the shoreline. The four major use areas are McClure Point and Barrett Cove recreation areas on the western shoreline, Horseshoe Bend recreation area on the northern shoreline, and Bagby recreation area at the SR 49 crossing on the eastern reservoir arm.

McClure Point facilities include 3 boat launch lanes, a swimming lagoon, a marina with a store and houseboat mooring, picnic areas, comfort stations, and 100 camping units. Barrett Cove features 2 boat ramps with a total of 5 lanes, a swimming lagoon, a marina, comfort stations, picnic areas, and 275 camping units. The Horseshoe Bend recreation area features a 2-lane boat ramp, a swimming lagoon, picnic areas, and 110 camping units. The Bagby recreation area provides a 1-lane boat ramp, marina, picnic area, and 25 camping units. Each use area has a concession store.

Approximately 606,000 visitor days were recorded at Lake McClure in 1992. Day-use activities accounted for most of the visitor days. Recreation activities include boating, water-skiing, fishing, swimming, sailing, jet skiing, hang gliding, picnicking, and camping. Boating and water-skiing occur throughout the reservoir. Year-round planting enhances rainbow trout fishing opportunities from boat and the shoreline. Bass fishing has improved since the Florida largemouth bass was introduced. Swimming areas are provided at three developed lagoons that feature beach and picnic areas.

The Lake McClure boat ramps cease operation between 590 and 793 feet above msl. The Bagby ramp is the first to cease operation at 793 feet above msl, followed by Horseshoe Bend at 758 feet above msl; McClure Point at 650 feet above msl; southern Barrett Cove ramp at 630 feet above msl; and northern Barrett Cove and Piney Creek, both at 590 feet above msl. The Horseshoe Bend and Bagby ramps were the only facilities affected during the peak summer recreation season under drought conditions in 1992.

New Don Pedro Reservoir. New Don Pedro Reservoir is owned and operated by the Modesto ID and the Turlock ID. The Don Pedro Recreation Agency operates recreation facilities. When full, the reservoir has a surface area of 13,000 acres, 160 miles of shoreline, and a maximum water surface elevation of 830 feet above msl.

Recreation facilities at the reservoir accommodate water-dependent and water-enhanced activities. The developed use areas are Fleming Meadows recreation area on the southern shoreline, Blue Oaks recreation area on the southwestern shoreline, and Moccasin Point recreation area on the northeastern arm of Moccasin Bay, all with boat launch facilities. Two full-service marinas featuring docks, boat slips, mooring areas, and provisions are provided at Fleming Meadows and Moccasin Point recreation areas. A 2-acre swimming lagoon at Fleming Meadows is separated from the main reservoir body and includes a swimming area with a maximum depth of 6 feet, picnic facilities, and a sandy beach area. Camping facilities consist of 550 sites for the 3 recreation areas. Primitive boat-in camping is allowed throughout the 160-mile shoreline.

Recreation activities include boating, swimming, water-skiing, jet skiing, windsurfing, sailing, houseboating, fishing, camping, boat-in camping, picnicking, and sightseeing. Boating and water-skiing occur throughout the reservoir. Swimming occurs mainly at the Fleming Meadows swimming lagoon. Shore and boat fishing is mainly for bass, trout, salmon, crappie, bluegill, and catfish.

Use at New Don Pedro Reservoir totaled approximately 419,000 visitor days in 1992. Water-dependent recreation, such as boating, water-skiing, fishing, and camping account for most of the annual visitation.

The full pool elevation for New Don Pedro Reservoir is 830 feet above msl. Generally, use of the reservoir declines moderately when the elevation reaches 790 feet above msl and considerably at 750 feet above msl. The Fleming Meadows boat ramp is out of operation at elevation 600 feet above msl (minimum pool). Between 710 feet and minimum pool, five ramps are lost. The Moccasin Point boat ramp cannot be used at an elevation of 722 feet above msl, and the Blue Oaks boat ramp cannot be used at 726 feet above msl. The Fleming Meadows and Moccasin Point marina operations are limited at 600 and 630 feet above msl, respectively. The swimming lagoon is used at all reservoir surface water elevations because it is separated from the main reservoir and water levels are maintained by pumping water from the reservoir to the lagoon.

Bethany Reservoir. The 160-acre Bethany Reservoir is located on the California Aqueduct just south of the Delta pumping plants in Alameda County. DPR operates the recreation facilities at the reservoir. The reservoir functions as a forebay for the South Bay Pumping Plant and a balancing pool for discharge from the Harvey O. Banks Pumping Plant.

Recreation facilities provide opportunities for fishing, boating, windsurfing, picnicking, hiking, and bicycling. Boat access is provided at a two-lane boat ramp on the northern shoreline near the main reservoir access point. Picnic areas are provided on the northern and southern shorelines; a bicycle path along the northern shoreline connects the picnic areas.

Fishing is the most popular activity at Bethany Reservoir, and striped bass and catfish are the species most often caught. Boating is allowed on Bethany Reservoir, however, although boat sizes are not limited, maximum speeds are limited to 15 mph in open water and 5 mph within 200 feet of the shore. Strong winds at the reservoir provide windsurfing opportunities.

Approximately 30,000 visitor days were recorded at Bethany Reservoir in 1991. Because Bethany Reservoir functions as a forebay and regulating reservoir on the California Aqueduct, its water surface elevation does not fluctuate substantially.

O'Neill Forebay. Recreation facilities at the 2,700-acre O'Neill Forebay supplement recreation opportunities provided on San Luis Reservoir. Recreation facilities include the Medeiros recreation area, which provides picnicking, camping, and boat ramp access, and the San Luis Creek day-use area, which provides picnicking, swimming, and boat ramp access.

Approximately 1,250,000 visitor days at O'Neill Forebay were estimated in 1992. Recreation facilities provide more diverse recreation opportunities at the forebay than at San Luis Reservoir. Windsurfing, swimming, wading, and relaxing are the most popular activities at the forebay.

Recreation use at O'Neill Forebay generally is not affected by water level fluctuations because, as with Bethany Reservoir, surface water elevations at these control reservoirs are usually maintained at constant levels. DWR tries to maintain high water surface elevations as operational needs allow at O'Neill Forebay to provide a safe windsurfing area. If water levels were to fluctuate greatly, beach use would probably be adversely affected because a minor drop in surface elevation would expose a relatively large amount of the forebay shoreline.

New Hogan Lake. New Hogan Lake is located on the Calaveras River and is operated by the USCOE. When full, the lake has a surface area of approximately 4,400 acres, 50 miles of shoreline, and a surface elevation of 713 feet above msl. Recreation facilities at New Hogan Lake provide opportunities for a wide variety of water-dependent activities, such as boating, water-skiing, fishing, swimming, and boat-in camping.

Boat access is available at Fiddleneck day-use area and Acorn East Campground. Major day- and overnight-use areas along the shoreline are primarily concentrated on the western and northern shoreline and include the Monte Vista picnic and trail use area, Wrinkle Cove picnic and swimming area, Acorn West and East campgrounds, Coyote Point Campground, and Fiddleneck day-use area. The Deer Flat boat-in camp is located on the southeastern shore. Shoreline fishing access is provided at the Bear Creek and Whiskey Creek access points on the southern shoreline and at major use areas on the western and northern shore. The New Hogan Marina at the south end of the Fiddleneck day-use area offers boating and fishing supplies, 80 to 90 berthing slips, and boat storage facilities.

Boating and water-skiing are popular lake activities during summer. Jet skiing is becoming increasingly popular at the lake, particularly during optimal water level periods. Boating speeds are restricted to 5 mph in most of the southern and western shoreline coves. Wrinkle Cove is a popular swimming area where boats are prohibited.

Fishing occurs from boats and the shore throughout the lake. According to a DFG creel census, naturally reproducing striped bass are plentiful in New Hogan Lake, although recent creel census data show a decline in fishing conditions during the 1988-1992 drought. Black bass, crappie, sunfish/bluegill, and catfish are caught regularly.

In 1992, use at the lake totaled approximately 555,000 visitor days. Water-dependent recreation activities (e.g., boating, water-skiing, swimming, and fishing) accounted for a large proportion of this use. Average reservoir pool elevation at the beginning of the recreation season is 680 feet above msl. The reservoir pool elevation for the average recreation season (April-September) is 665 feet above msl.

Lake levels that fall below normal or average levels adversely affect recreation at New Hogan Lake. Although extreme high water inundates some day-use and camping facilities, the quality of recreation is not substantially affected by high water. When lake levels are at or above normal levels, hazards and visually unappealing shorelines are not exposed. Recreation use is high during this period because a large amount of water surface is available and the shoreline is safely accessible.

Boat Ramps Nos. 1, 2, and 3 at the Fiddleneck day-use area cannot be used at elevations 575, 650, and 673 feet above msl, respectively. The Acorn East Campground ramp cannot be used at an elevation of 662 feet above msl. The New Hogan Marina must move facilities frequently during the summer recreation season. Low water levels greatly affect marina operation and business. Use of picnic facilities is usually not substantially affected by water levels, but campground use is greatly affected by low water levels in all of the New Hogan Lake facilities because access to lakeside camping facilities is reduced.

Camanche Reservoir. Camanche Reservoir, a 7,700-acre reservoir with 53 miles of shoreline, is owned and operated by EBMUD. Recreation facilities include 15,000 acres of recreation lands, 2 main recreation areas with tent and RV camp sites, 2 marinas, 3 paved boat ramps with a total of 17 lanes, cottages, tennis courts, riding stables, conference rooms, a general store, a coffee shop, and an amphitheater. The north and south shore marinas are full-service facilities featuring boat slips, boat rentals, and bait and tackle.

Water-dependent recreation activities are swimming, water-skiing, jet skiing, windsurfing and fishing year-round. Water-skiing is restricted in the upper reservoir arms. Fishing occurs for cold- and warm-water species such as rainbow and brown trout, channel and white catfish, sunfish, crappie, largemouth and smallmouth bass, spotted black bass, and white sturgeon.

Approximately 387,000 total visitor days were recorded at Camanche Reservoir's north and south shore recreation areas in 1992. Water-dependent recreation activities dominate reservoir use. In 1992, overnight use was greater than day use.

At full pool, the Camanche Reservoir surface water elevation is 235 feet above msl. One of the south shore boat ramps is operational at elevation 180 feet above msl to full pool. The second south shore boat ramp is operational at 170 to 180 feet above msl. The north shore boat ramp is operational at elevation 205 to 235 feet above msl and at elevation 160 to 190 feet above msl.

b. Rivers. Construction and operation of the lakes and reservoirs that provide flatwater recreation opportunities have substantially affected instream uses below them. Sport fisheries in rivers below major lakes and reservoirs have substantially declined. As upstream spawning areas have been lost and water has been diverted, salmon and steelhead populations have declined.

San Joaquin River. The lower San Joaquin River is more than 100 miles long from Millerton Lake to the Sacramento-San Joaquin Delta. Recreational development on the San Joaquin River below Friant Dam has been expanding in recent years with the creation of the San Joaquin River Conservancy, a state-established regional land conservancy. Recent parkway developments in the Fresno area include Lost Lake Park and the Lewis Moran Bicycle Trail. The river borders the Madera/Fresno county line from Millerton Lake to the Merced County line near the SR 152 crossing. Public access is available along this reach at several road and state highway crossings. The river borders the San Luis NWR and crosses the Fremont Ford SRA in Merced County. Stanislaus County recreation facilities include the Las Palmas fishing access site, Laird County Park, and numerous public access points. Recreation facilities on the river in San Joaquin County are Durham Ferry SRA, Mossdale Landing County Park, Dos Reis County Park, and numerous public road crossings. The City of Stockton has three recreation facilities on the Stockton Deep Water Channel. The Buckley Cove Marina is located on the San Joaquin River east of Stockton.

Merced River. The Merced River below McSwain Dam is a 50-mile-long reach that crosses private agricultural and grazing land in Merced County enroute to its confluence with the San Joaquin River at the Merced/Stanislaus county line. Major public recreation facilities on the river are Henderson County Park on Merced Falls Road east of Snelling, McConnell SRA northeast of Livingston on SR 99, Hagaman County Park at the SR 165 river crossing, and George J. Hatfield SRA on Kelley Road near the San Joaquin River confluence. County parks provide primarily day-use facilities, and State recreation areas provide day-use facilities and camping units.

The two county parks offer group picnic areas and softball fields. No swimming or other water contact activities are allowed at either park because lifeguards are not provided. No boat ramps are provided at the county parks, and boating use is generally low because the river is shallow as most of the flow is diverted upstream. Some canoeing and rafting occurs on the lower river.

Tuolumne River. The Tuolumne River below New Don Pedro Reservoir extends approximately 50 miles to its confluence with the San Joaquin River, traversing mainly private open space and grazing lands, property within the City of Modesto, and several public parks. Major recreation facilities are the La Grange County Regional Park on Yosemite Boulevard near La Grange, Turlock Lake SRA located on Lake Road between Turlock Lake and the river, Fox Grove Regional County Park near the Greer Road/Albers Road crossing, two golf courses adjacent to the river near the SR 99 crossing, and the Shiloh fishing access site at the Shiloh Road crossing upstream of the San Joaquin River/Tuolumne River confluence.

Recreation use on the lower Tuolumne River consists of primarily water-dependent activities, such as fishing, swimming, canoeing, rafting, and water-enhanced activities at picnic areas and campgrounds.

Stanislaus River. The reach of Stanislaus River between New Melones Reservoir and its confluence with the San Joaquin River is 60 miles long. The river traverses primarily private agricultural and grazing lands in Tuolumne, Stanislaus, and San Joaquin counties. It borders the Stanislaus/San Joaquin county line approximately 4 miles downstream from Oakdale. A number of developed and undeveloped public parks are located along the lower Stanislaus River. Caswell Memorial State Park is approximately 3 miles upstream of the Sacramento/San Joaquin river confluence; this public facility features day-use facilities and a campground. Public access to the river is dispersed at numerous road crossings. Access for a whitewater rafting run is provided just below Goodwin Dam. The 4-mile-long whitewater run between Goodwin Dam and Knights Ferry is rated Class II-VI (advanced) with several difficult portages. Other river activities include fishing, swimming, picnicking, and camping.

Mokelumne River. The lower Mokelumne River is a 29.6-mile-long segment of the river between Camanche Reservoir and the Sacramento/San Joaquin Delta. Most of the lower Mokelumne River traverses private rural lands. Major public recreation facilities on the river are EBMUD's Mokelumne River Day Use Area located on McIntire Road near Camanche Reservoir, Stillman McGee County Park on Mackville Road near Clementes, and Lake Lodi near the community of Woodbridge. Public access to the Mokelumne River is available at numerous road crossings in and around Lodi.

Recreation facilities at the Mokelumne River Day Use Area consist of parking, picnic areas, portable toilets, and river access. No boat launch facilities are provided in this recreation area. Popular recreation activities include fishing, wading, swimming, canoeing, kayaking, tubing, and picnicking.

Calaveras River. The Calaveras River below New Hogan Lake is 45 miles long and crosses primarily private land in Calaveras and San Joaquin counties enroute to its confluence with the San Joaquin River at the Stockton Deep Water Channel. In Stockton, the river crosses several roads that provide public access. The only public recreation facilities immediately adjacent to river are the Stockton Golf and Country Club and the Brookside Community Golf Course; both are located near the confluence with the San Joaquin River. The Buckley Cove Marina is located immediately downstream of the confluence. The marina consists of approximately 47 acres devoted to boat launching, parking, and marina uses and 5 acres for picnicking, a tot-lot play area, and shore fishing access. Activities include some small-craft boating, fishing, swimming, and wading.

c. **Conveyance Facilities**. Fishing is popular along many of the canals in the area. Public access is provided on the California Aqueduct and the Delta-Mendota Canal.

California Aqueduct. Fishing access is provided along much of the California Aqueduct, stretching from Bethany Reservoir west of Tracy to Silverwood Lake in Southern California. Most of the portion of the aqueduct that passes through the San Joaquin River Region has walk-in access for fishing. There are 11 fishing access sites which provide parking and toilet facilities. In addition, there are also 97 miles of bikeways along the Aqueduct.

A stock of many kinds of fish has developed from fish and eggs surviving the CVP and SWP pumps. Fish species caught in the aqueduct include striped bass, largemouth bass, catfish, crappie, green sunfish, bluegill and starry flounder.

Delta-Mendota Canal. Fishing access to the Delta-Mendota Canal is provided at Delta-Mendota Canal Site 2A in Stanislaus County and Delta-Mendota Canal Site 5 in Fresno County. Canal Site 2A, covering 87 acres, includes a parking area and restrooms. Canal Site 5, covering 570 acres, also includes parking areas and restrooms. Neither site provides picnicking or camping facilities. Fishing access to the Delta-Mendota Canal is limited to the developed access points.

Fishing is the primary activity at both access sites. Fish species most frequently caught at the access sites are striped bass and catfish.

d. **Wildlife Refuges**. Recreation activities at the federal wildlife refuges and State Wildlife Management Areas which receive surface water diversions could be affected by the proposed actions. Wildlife refuges in the San Joaquin River Region include the San Luis and Merced NWRs and Volta and Los Banos WMAs.

Most recreation activities on the refuges are associated with the presence of waterfowl and upland game birds. These activities include hunting, hiking, and wildlife observation. Hunting of ducks, geese, and pheasants is permitted between October and January on portions of each refuge. Fishing is permitted at San Luis NWR only. Recreation facilities are limited at San Luis and Merced NWRs; however, both refuges provide self-guided tours. Camping is permitted at staging areas on the NWRs during hunting season only. Camping is not permitted at the Volta or Los Banos WMA.

e. **Private Hunting Clubs**. There are some 176 private hunting clubs in the San Joaquin River Basin encompassing approximately 96,800 acres. Approximately 33,900 acres are flooded annually and much of the water comes from surface water diversions. These private clubs provide opportunities for hunting ducks, geese, and pheasants.

E. SACRAMENTO-SAN JOAQUIN DELTA

1. Geography and Climate

The Sacramento-San Joaquin Delta area forms the lowest part of the Central Valley, bordering and lying between the Sacramento and San Joaquin rivers and extending from the confluence of these rivers inland as far as Sacramento and Stockton.

The Delta, which has legal boundaries established in California Water Code Section 12220 (Figure III-12), comprises a 738,000-acre area generally bordered by the cities of Sacramento, Stockton, Tracy, and Pittsburg. This former wetland area has been reclaimed into more than 60 islands and tracts which are devoted primarily to farming. The Delta is interlaced with about 700 miles of waterways. A network of levees protects the islands and tracts, most of which lie near or below sea level, from flooding. Prior to development, which began in the mid-19th century, the Delta was mainly tule marsh and grassland, with some high spots rising to a maximum of about 10 to 15 feet above mean sea level. The low dikes of early Delta farmers became a system of levees that now protect about 520,000 acres of farmland. There are now about 1,100 miles of levees, some standing 25 feet high and reaching 200 feet across at the base.

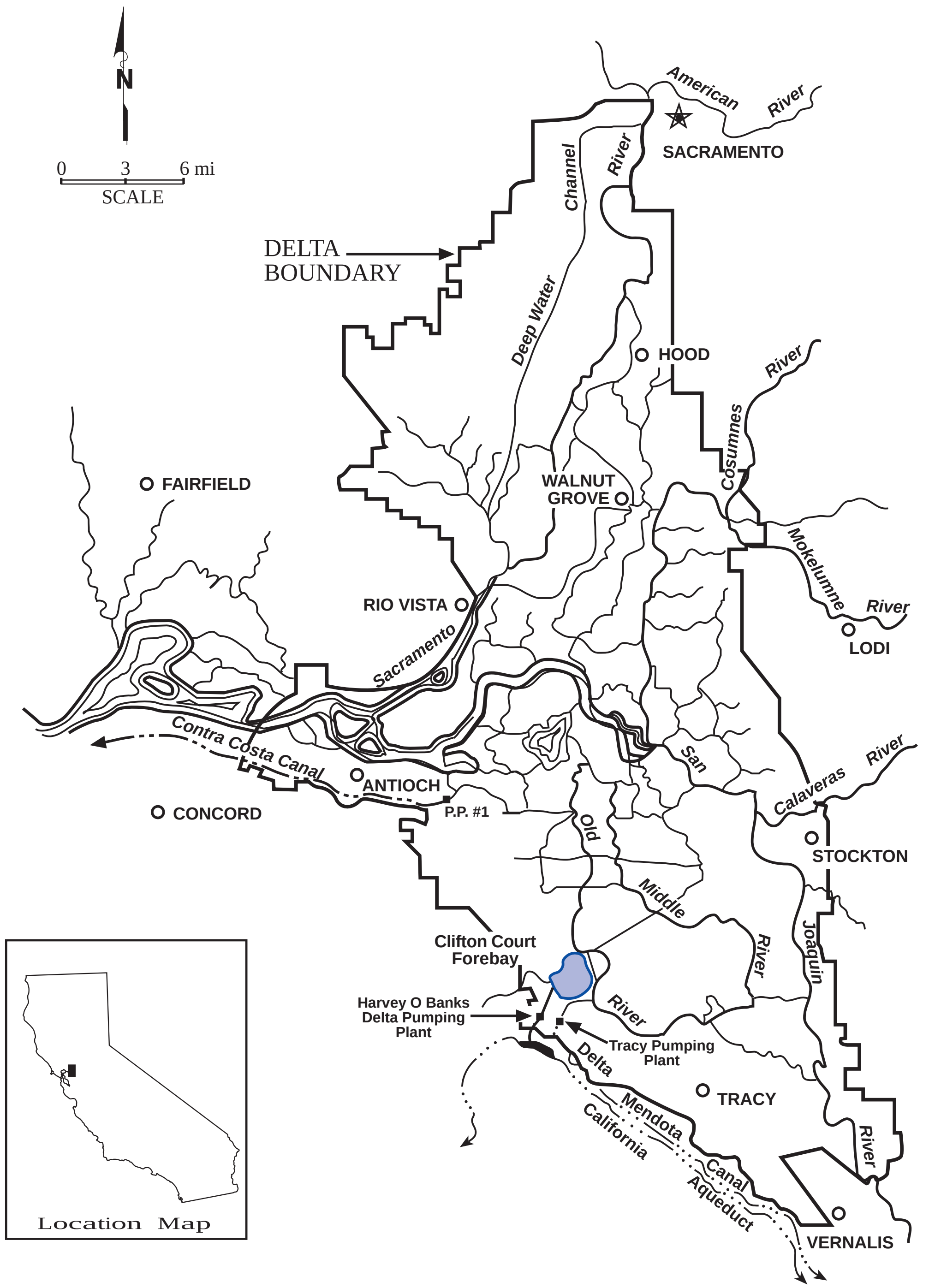
Behind the levees, surface elevations of many of the islands (particularly those in the central Delta) have subsided over the years due to oxidation and shrinkage of the peat soils and soil loss by wind erosion. As a result, some of the island surfaces now lie more than 20 feet below mean sea level and as much as 30 feet below high tide water levels in surrounding channels. All the major tracts and islands have been flooded at least once since their original reclamation, and a few have been allowed to remain flooded. Delta lands in the areas of deep peat soil, where subsidence has been greatest, are expensive both to protect from inundation and to reclaim from inundation once flooded.

The Delta area has a Mediterranean climate with warm, rainless summers and cool, moist winters. The annual rainfall varies from about 18 inches in the eastern and central parts to about 12 inches in the southern part. Ocean winds, which enter the Delta through the Carquinez Strait, are very strong at times in the western Delta.

2. Population

The population of the Sacramento-San Joaquin Delta is about 200,000 people, most of which is in upland areas on the eastern and western fringes. Although no major cities are entirely within the Delta, it does include a portion of Stockton, Sacramento, and West Sacramento. In addition, the cities of Antioch, Brentwood, Isleton, Pittsburg, and Tracy, plus about 14 unincorporated towns and villages, are located within the Delta. The Stockton area on the east and the Antioch-Pittsburg area on the west have undergone steady industrialization and urbanization. Most Delta islands are sparsely populated; however, some, including Byron Tract and Bethel Island, have large urban communities.

Figure III-12
Sacramento-San Joaquin Delta



3. Land Use and Economy

The Sacramento-San Joaquin Delta is an important agricultural area. Historically, the area was noted for its truck crops, such as asparagus, potatoes, and celery, but since the 1920's, there has been a shift toward lower valued field crops. Corn, grain, hay, and pasture currently account for more than 75 percent of the region's total production. The shift has been attributed mainly to market conditions, although changes in technology and growing conditions have also played a role. Delta farming produces an average gross income of about $375 million.

The western Delta includes some important industrial areas in eastern Contra Costa County. The extensive industrial complex adjacent to the San Joaquin River in the Antioch-Pittsburg area depends on the availability of large quantities of water for processing and cooling. The region also offers heavy industries the advantages of large land areas with waterfront access to a deep-water ship channel linking ocean and overland transportation. These industries include petroleum and coal products, paper and allied products, chemicals and allied products, primary metal industries, and food and related products.

Although much of the Delta is used for agriculture, the land also provides habitat for wildlife. Many agricultural fields are flooded in the winter, providing foraging and roosting sites for migratory waterfowl. In addition to these lands that are used seasonally, thousands of acres are managed specifically for wildlife. The DFG manages four such areas, including Lower Sherman Island and White Slough Wildlife Areas, Woodbridge Ecological Reserve, and Palm Tract Conservation Easement.

4. Water Supply

On the average, about 21 MAF of water reaches the Sacramento-San Joaquin Delta annually, but actual inflow varies widely from year to year and within the year. In 1977, a year of extraordinary drought, Delta inflow totaled only 5.9 MAF, while inflow for 1983, an exceptionally wet year, was about 70 MAF. On a seasonal basis, average natural flow to the Delta varies by a factor of more than 10 between the highest month in winter or spring and the lowest month in fall.
Surface water supplies are used to meet most of the water demand in the Delta region, especially for agricultural and industrial uses. Groundwater is used to meet some urban water demand and for domestic use in the upland areas around the periphery of the Delta.

a. Surface Water Hydrology. The Sacramento and San Joaquin rivers unite at the western end of the Sacramento-San Joaquin Delta at Suisun Bay. The Sacramento River contributes roughly 75 to 80 percent of the Delta inflow in most years, while the San Joaquin River contributes about 10 to 15 percent. The minor flows of the Mokelumne, Cosumnes, and Calaveras rivers, which enter into the eastern side of the Delta, contribute the remainder. The rivers flow through the Delta and into Suisun Bay. From Suisun Bay, water flows through the Carquinez Strait into San Pablo Bay, then south into San Francisco Bay, and then out to sea through the Golden Gate.

Hydraulics of the Estuary system are complex. The influence of tide is combined with freshwater outflow resulting in flow patterns that vary daily. Delta hydraulics are further complicated by a multitude of agricultural, industrial, and municipal diversions for use within the Delta itself, and by exports by the SWP and CVP.

Tidal influence is important throughout the Delta. The average tidal flow at Chipps Island, ebb or flood, is approximately 170,000 cfs. Historically, during summers when mountain runoff diminished, ocean water intruded into the Delta as far as Sacramento. During the winter and spring, fresh water from heavy rains pushed the salt water back, sometimes past the mouth of San Francisco Bay.

With the addition of Shasta, Folsom, and Oroville dams, saltwater intrusion into the Delta during summer months has been controlled by reservoir releases during what were traditionally the dry months. Typically, peaks in winter and spring flows have been dampened, and summer and fall flows have been increased. Average winter outflow is about 32,000 cfs while average summer outflow is about 6,000 cfs. In very wet years, such as 1969, 1982, 1983, and 1986, reservoirs are unable to control runoff so that during the winter and spring the upper bays become fresh; even at the Golden Gate, the upper several feet of water column sometimes consisted of fresh water.

In the Delta near Walnut Grove, the federal Delta Cross Channel diverts water, by gravity, from the Sacramento River into the North and South forks of the Mokelumne River. Sacramento River water moves down these channels through the central Delta and into the San Joaquin River. Flows in the Delta Cross Channel reverse as the tide changes and, at certain stages, there is considerable flow from the channel into the Sacramento River. Flows in the Delta Cross Channel can be controlled by two radial gates. The channel is closed for flood control purposes when Sacramento River flows exceed about 25,000 cfs. Other channels that convey water across the Delta include Georgiana Slough, and the San Joaquin, Old, and Middle rivers.

b. Surface Water Quality. The existing water quality problems of the Sacramento-San Joaquin Delta system may be categorized by toxic materials, eutrophication and associated dissolved oxygen fluctuations, suspended sediments and turbidity, salinity, and bacteria.

Many Delta waterways have impaired water quality due to toxic chemicals. High concentrations of some metals from point and nonpoint sources appear to be ubiquitous in the Delta. Tissues from fish taken throughout the Delta exceed the National Academy of Sciences/Food and Drug Administration guidelines for mercury. There is currently a health advisory in effect for mercury in striped bass. High levels of other metals (i.e., copper, cadmium, and lead) in Delta waters are also of concern. Also, in localized areas of the Delta (e.g., near Antioch and in Mormon Slough), fish tissues contain elevated levels of dioxin as a result of industrial discharges.

Pesticides are found throughout the waters and bottom sediments of the Delta. High levels of chlordane, toxaphene, and DDT from agricultural discharges impair aquatic life beneficial uses throughout the Delta, while diazinon can be found in elevated concentrations at various locations. The more persistent chlorinated hydrocarbon pesticides are consistently found throughout the system at higher levels than the less persistent organophosphate compounds. The sediments having the highest pesticide content are found in the western Delta. Pesticides have concentrated in aquatic life in the Delta. The long-term effects of pesticide concentrations found in aquatic life of the Delta are not known. The effects of intermittent exposure of toxic pesticide levels in water and of long-term exposure to these compounds and combinations of them are likewise unknown.

Much of the water in the Delta system is turbid as a result of an abundance of suspended silts, clays, and organic matter. Most of these sediments enter the tidal system with the flow of the major tributary rivers. Some enriched areas are turbid as a result of planktonic algal populations, but inorganic turbidity tends to suppress nuisance algal populations in much of the Delta. Continuous dredging operations to maintain deep channels for shipping has contributed to turbidity of Delta waters and is a factor in the temporary destruction of bottom organisms through displacement and suffocation.

The most serious enrichment problems in the Delta are found along the lower San Joaquin River and in certain localized areas receiving waste discharges, but having little or no net freshwater flow. These problems result in low dissolved oxygen levels which occur mainly in the late summer and coincide with low river flows and high temperatures. Dissolved oxygen problems are further aggravated by channel deepening for navigational purposes. The resulting depressed dissolved oxygen levels have not been sufficient to support fish life and, therefore, prevent fish from moving through the area. In the autumn these conditions, together with reversal of natural flow patterns by export pumping, have created environmental conditions unsuitable for the passage of anadromous fish (salmon) from the Delta to spawning areas in the San Joaquin Valley.

Warm, shallow, dead-end sloughs of the eastern Delta support objectionable populations of planktonic blue-green algae during summer months. Floating and semi-attached aquatic plants, such as water primrose and water hyacinths, frequently clog waterways in the lower San Joaquin River system during the summer. Extensive growths of these plants have also been observed in the waterways of the Delta. These plants interfere with the passage of small boat traffic and contribute to the total organic load in the Bay/Delta system as they break loose and move downstream in the fall and winter months.

Local diversions in shallow, low capacity channels may at times exceed flows through the channel. When this happens, water stops flowing out of the channel, or begins to flow into the channel from both ends. At the same time, drainage return flows continue to be discharged to the channels. These discharges do not move downstream and out of the area, but instead become trapped in “null zones” of zero net flow. The lack of circulation prevents better quality water otherwise available from the main channels from freshening the increasingly saline water in the shallow channel, even in wet years. Null zones exist predominantly in three areas of the Delta: in Old River between Sugar Cut and the CVP intake; in Middle River between Victoria canal and Old River; and in the San Joaquin River between the head of Old River and the City of Stockton.

Reduced tidal influence contributes to the surface water quality problems of the Delta. Previous reclamation of tidal wetlands and construction of levees in areas such as the eastern Delta have inhibited tidal exchange. Historically, larger volumes of water were exchanged twice daily with adjacent tidal wetlands and the resulting flows helped keep channels open and reduced the risk of water quality problems.

Salinity control is necessary because the Delta is contiguous with the ocean, and its channels are at or below sea level. Unless repelled by continuous seaward flow of fresh water, seawater will advance up the Estuary into the Delta and degrade water quality. During winter and early spring, flows through the Delta are usually above the minimum required to control salinity. At least for a few months in the summer and fall of most years, however, salinity must be carefully monitored and controlled. The monitoring and control is provided by the CVP and SWP, and regulated by the SWRCB under its water rights authority.

At present, salinity problems occur mainly during years of below normal runoff. In the eastern Delta, these problems are largely associated with the high concentrations of salts carried by the San Joaquin River into the Delta. Operation of the State and federal export pumping plants near Tracy draws high quality Sacramento River water across the Delta and restricts the low quality area to the southeast corner. Localized problems resulting from irrigation returns occur elsewhere, such as in dead-end sloughs. Salinity problems in the western Delta result primarily from the incursion of saline water from the San Francisco Bay system. The extent of incursion is determined by the freshwater flow from the Delta to the Bay. Salinity in the western Delta can impact municipal and industrial uses.

Bacteriological quality of Delta waters, as measured by the presence of coliform bacteria, varies depending upon proximity of waste discharges and significant land runoff. The highest concentration of coliform organisms is generally found in the western Delta. Local exceptions to this can be found in the vicinity of major municipal waste discharges.
Another human health concern is that of disinfecting by-products. Delta water contains precursors of trihalomethanes (THMs), which are suspected carcinogens produced when chlorine used for disinfecting reacts with natural substances during the water treatment process. Dissolved organic compounds that originate from decayed vegetation act as precursors by providing a source of carbon in THM formation reactions. During periods of low Delta outflow, tidal mixing of bromides from the ocean extend further into the Delta, thereby increasing the bromide concentrations in the vicinity of municipal drinking water intakes. When bromides are present in water along with organic THM precursors, THMs are formed during the treatment process that contain bromine as well as chlorine. When ozonation is used for disinfection of water with high concentrations of bromide, it results in the formation of bromate, which is also a suspected human carcinogen. Drinking water supplies taken from the Delta are treated to meet current THM standards. However, more restrictive standards are being considered which, if adopted, will increase the cost and difficulty of treating present Delta water sources.

c. Groundwater Hydrology. The groundwater hydrology of the Sacramento-San Joaquin Delta is contiguous with the lower portions of the Sacramento and the San Joaquin River Basins in the Central Valley regional aquifer system. Large amounts of water are stored in thick sedimentary deposits. Groundwater is replenished through deep percolation of streamflow, precipitation, and applied irrigation water. Recharge by subsurface inflow is negligible compared to other sources.

Groundwater is used to meet urban water demand and for domestic use in the upland areas around the periphery of the Delta. Groundwater use is not significant in the Delta lowlands where agricultural water demand is met with abundant surface water supplies.

d. Groundwater Quality. Groundwater quality in the Sacramento-San Joaquin Delta is generally very good throughout the area and is suitable for most uses, although at shallow depths within the Delta the water is often saline.

5. Water Use

The Sacramento-San Joaquin Delta is the hub of the major State and federal water development facilities, and numerous local water supply projects. Water projects divert water from Delta channels to meet the needs of about two-thirds of the State's population and to irrigate 4.5 million acres. During normal water years, about 10 percent of the water reaching the Delta would be withdrawn for local use, 30 percent would be withdrawn for export by the CVP and SWP, 20 percent would be needed for salinity control, and the remaining 40 percent would become Delta outflow in excess of minimum requirements. The excess outflow would occur almost entirely during the season of high inflow.

Delta agricultural water users divert directly from the channels, using more than 1,800 unscreened pumps and siphons, which vary from 4 to 30 inches in diameter, and with flow rates of 40 to about 200 cfs. These local diversions vary between 2,500 and 5,000 cfs during April through August, with maximum rates in July.

6. Vegetation

Sacramento-San Joaquin Delta vegetation community types include valley and foothill riparian, valley grassland, and freshwater emergent wetland. The complex interface between land and water in the Estuary provides rich and varied habitat for wildlife, especially birds. Dense stands of tules are found throughout the Delta. Many of the levees are covered in blackberry vines. Floating and semi-attached aquatic plants, such as water primrose and water hyacinths, frequently clog waterways of the Delta during the summer.

Sensitive riparian habitat types in the Delta that can be grouped into the valley and foothill riparian community type include: great valley-valley oak riparian forest, great valley cottonwood riparian forest, great valley mixed riparian forest, great valley willow scrub, buttonbush scrub, elderberry savanna, and central coast riparian scrub. Sensitive valley grassland communities include vernal pools, valley needlegrass grassland, serpentine bunchgrass, wildflower fields, freshwater seeps, alkali playas, coastal terrace prairie, and pine bluegrass grassland. There are three sensitive freshwater emergent wetland communities in the Delta: cismontane alkali marsh, coastal and valley freshwater marsh, and vernal marsh. Twelve rare or endangered plant species, most of which are associated with freshwater marshes, can also be found in the Delta. Table III-17 lists the sensitive plant species found in the Sacramento-San Joaquin Delta.

7. Fish

The Sacramento-San Joaquin Delta supports about 90 species of fish. The Delta, which is basically a freshwater environment, serves as a migratory route and nursery area for chinook salmon, striped bass, white and green sturgeon, American shad, and steelhead trout. These anadromous fishes spend most of their adult lives either in the lower bays of the Estuary or in the ocean. The Delta is a major nursery area for most of these species. Other fishes in the Estuary include delta smelt, Sacramento splittail, catfish, largemouth bass, black bass, crappie, and bluegill. The Sacramento perch is believed to have been extirpated from the Delta; however, it still exists in scattered ponds throughout the Central Valley. Table III-18 lists the sensitive fish species found in the Sacramento-San Joaquin Delta.

The Delta provides habitat for a wide variety of freshwater, estuarine, and marine fish species. Channels in the Delta range from dead-end sloughs to deep, open water areas and include a scattering of flooded islands that provide submerged vegetative shelter. The banks of the channels

Table III-17
Sensitive Plant Species in the Sacramento-San Joaquin Delta

Scientific Name	Common Name	Status		
		State	CNPS	Federal
Acanthomintha duttonii	San Mateo thornmint	SE	1B	FE
Amsinckia grandiflora	Large-flowered fiddleneck	SE	1B	FE
Cordylanthus palmatus	Palmate-bracted bird's-beak	SE	1B	FE
Eryngium racemosum	Delta button-celery	SE	1B	FSC
Erysimum capitatum spp. angustatum	Contra Costa wallflower	SE	1B	FE
Gratiola heterosepala	Boggs Lake hedge-hyssop	SE	1B	
Lasthenia conjugens	Contra Costa goldfields		1B	FPE
Lilaeopsis masonii	Manson's lilaeopsis	SR	1B	FSC
Neostapfia colusana	Colusa grass	SE	1B	FT
Oenothera deltoides spp. howellii	Antioch Dunes evening-primrose	SE	1B	FE
Tuctoria mucronata	Crampton's tuctoria	SE	1B	FE

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.

CNPS: (California Native Plant Society) 1A=presumed extinct in California; 1B=rare,threatened, or endangered in California and elsewhere; 2=rare,threatened,or endangered in California but more common elsewhere; 3=need more information; 4=distribution limited (a watchlist).

FEDERAL: FE=endangered; FT=threatened; FPE=proposed endangered; FPT=proposed threatened; C=candidate for listing; FSC=species of concern.

Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

Table III-18
Sensitive Fish Species in the Sacramento-San Joaquin Delta

Scientific Name	Common Name	Status: State	Status: Federal
Acipenser medirostris	Green Sturgeon	CSC	FSC
Hypomesus transpacificus	Delta smelt	ST	FT
Mylopharodon conocephalus	Hardhead	CSC	
Oncorhynchus tshawytscha	Fall-run chinook salmon, Central Valley, CA ESU		C
Oncorhynchus tshawytscha	Late fall-run chinook salmon, Central Valley, CA ESU	CSC	C
Oncorhynchus tshawytscha	Spring-run chinook salmon	ST	FT
Oncorhynchus tshawytscha	Winter-run chinook salmon	SE	FE
Oncorhynchus mykiss	Steelhead, Central Valley, CA ESU		FT
Pogonichthys marcrolepidotus	Sacramento splittail	CSC	FT
Spirinichus thaleichthys	Longfin smelt	CSC	FSC

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
FEDERAL: FE=endangered; FT=threatened; C=candidate for listing; FSC=species of concern.
Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

are varied and include riprap, tules, emergent marshes, and native riparian habitats. Water temperatures generally reflect ambient air temperatures; however, riverine shading may moderate summer temperatures in localized areas.

Food supplies for Delta fish communities consist of phytoplankton, zooplankton, benthic invertebrates, insects, and forage fish. The entrapment zone, where freshwater outflow meets and mixes with the more saline water of the bay, concentrates sediments, nutrients, phytoplankton, some fish larvae, and other fish food organisms. Biological standing crop (biomass) of phytoplankton and zooplankton in the estuary has generally been highest in this zone. General productivity in the Delta is in constant flux and an evaluation of the interrelationships of the food web is now underway by the Interagency Ecological Program. There are indications that overall productivity at the lower food chain levels has decreased during the past 15 or so years.

Flows which are provided or controlled by the CVP and SWP affect fish in numerous ways. Flows toward the project pumps draw both fish and fish food organisms into the export facilities. Most larger fish are screened out; however, many do not survive screening and subsequent handling. Most of the fish less than about an inch long and the fish food organisms pass through the screens and are removed from the Delta (additional discussion of entrainment related impacts is provided in Chapter VI). In addition, the draw of the pumps may cause water in some channels to flow too fast for optimal fish food production, and reverse flows in some channels may disorient migrating fish. Delta flows may act as cues for anadromous fish outmigrating to the ocean.

Factors other than CVP and SWP operations that affect fish include: water diversions within the Delta; upstream spawning conditions and diversions; municipal, industrial, and agricultural water pollution; habitat reduction by landfills; legal and illegal harvest; competition from introduced species; natural predator/prey interactions; and drought. Cumulative effects of these and other factors have contributed to declining populations of many Delta fish.

8. Wildlife

The complex interface between land and water in the Delta provides rich and varied habitat for wildlife, especially birds. Wildlife habitats include agricultural land, riparian forest, riparian scrub-shrub, emergent freshwater marsh, heavily shaded riverine aquatic, and grassland/rangeland.

The Delta is particularly important to waterfowl migrating via the Pacific Flyway. The principal attraction for waterfowl is winter-flooded fields, mainly cereal crops, which provide food and extensive seasonal wetlands. The Delta and other Central Valley wetlands provide winter habitat for 60 percent of waterfowl on the Pacific Flyway and 91 percent of all waterfowl that winter in California. More than a million waterfowl are frequently in the Delta at one time.

Small mammals find suitable habitat in the Delta and upland areas. Vegetated levees, remnants of riparian forest, and undeveloped islands provide some of the best mammalian habitat in the region. Species include muskrat, mink, river otter, beaver, raccoon, gray fox, and skunks. Other wildlife found in the area include many species of songbirds, as well as raptors, reptiles, and amphibians.

Numerous listed or candidate rare, threatened, and endangered species inhabit the Delta, but none is confined exclusively to that area. Currently, 19 wildlife species in the Delta are listed by either the State or the Federal government as threatened or endangered. Other wildlife species occurring in the Delta have been proposed for listing or are candidates for proposal. Table III-19 lists the sensitive wildlife species found in the Sacramento-San Joaquin Delta.

9. Recreation

Although the Delta environment has been extensively altered over the past 125 years by reclamation and development, natural and aesthetic values remain that make it a valuable and unique recreational asset. Waterfowl and wildlife are still abundant, sport fishing is still popular, and vegetation lining the channels and islands are still attractive. As a result, the miles of channels and sloughs that interlace the area attract a diverse and growing number of people seeking recreation. DWR estimated annual use at 12 million visitor days in 1993.

With its unique and numerous recreational opportunities, the Delta will continue to support large numbers of recreationists. Motor boating and fishing are the leading activities, with estimates of 17 and 15 percent of total recreation visits. Overnight camping, hunting, picnicking, swimming, and water-skiing are enjoyed by many people. The extensive riparian vegetation of the Delta area is

Table III-19
Sensitive Wildlife Species in the Sacramento-San Joaquin Delta

Scientific Name	Common Name	Status State	Status Federal
Agelaius tricolor	Tricolored blackbird	CSC	FSC
Charadrius alexandrinus nivosus	Western snowy plover	CSC	FT
Grus canadensis tabida	Greater sandhill crane	ST	
Haliaeetus leucocephalus	Bald Eagle	SE	FT
Laterallus jamaicensis coturniculus	California black rail	ST	FSC
Riparia riparia	Bank swallow	ST	
Antrozous pallidus	Pallid bat	FSC	
Eumops perotis californicus	California mastiff bat	CSC	FSC
Plecotus townsedii townsedii	Townsend's western big-eared bat	CSC	FSC
Reithrodontomys raviventris	Salt marsh harvest mouse	SE	FE
Sylvilagus bachmani riparius	Riparian brush rabbit	SE	C
Vulpes macrotis mutica	San Joaquin kit fox	ST	FE
Ambystoma californiense	California tiger salamander	CSC	C
Rana aurora draytonii	California red-legged frog	CSC	FT
Clemmy's marmorata	Western pond turtle	CSC	
Thamnophis gigas	Giant garter snake	ST	FT
Apodemia mormo langei	Lange's metalmark butterfly		FE
Branchinecta conservatio	Conservancy fairy shrimp		FE
Branchinecta longiantenna	Longhorn fairy shrimp		FE
Branchinecta lynchi	Vernal pool fairy shrimp		FT
Desmocerus californicus dimorphus	Valley elderberry longhorn beetle		FT
Elaphrus viridis	Delta green ground beetle		FT
Lipidurus packardi	Vernal pool tadpole shrimp		FE

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
FEDERAL: FE=endangered; FT=threatened; FPE=proposed endangered; FPT=proposed threatened; C=candidate for listing; FSC=species of concern.

Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

conducive to sightseeing, bird watching, and relaxing. Photography, bicycling, and sailing also occur in the Delta, although less frequently. During the 1976-77 and 1987-92 droughts, when most reservoirs throughout the State were extremely low, the Delta provided the same water-based recreational opportunities as in other years. There are about 20 public and more than 100 commercial recreational facilities in the Delta. These facilities provide rentals, services, camping guest docks, fuel, supplies and food.

Sport fishing in the Delta occurs year-round and takes place from private vessels, charter boats, and from shore. Species popular for sport fishing include striped bass, white sturgeon, salmon, American shad, catfish and largemouth bass. There are numerous private waterfowl and pheasant hunting clubs in the Delta region. Approximately 39,100 acres are flooded annually.

F. SUISUN MARSH

Suisun Marsh, shown in Figure III-13, is one of the few major marshes remaining in California and the largest remaining brackish wetland in Western North America. Located at the northern edge of Suisun Bay, just west of the confluence of the Sacramento and San Joaquin rivers and south of the City of Fairfield, the marsh consists of a unique diversity of habitats, including tidal wetlands, sloughs, managed diked wetlands, unmanaged seasonal wetlands, and upland grasslands. Numerous studies have established that tidal marshlands can have significant geomorphic and ecological values, including flood control, shoreline stabilization, sediment entrapment, water quality improvement, and food chain support for aquatic, semi-aquatic, and terrestrial plants and animals.

Under the 1984 Plan of Protection for the Suisun Marsh and the 1985 Suisun Marsh Preservation Agreement, the staged construction of extensive marsh water control facilities was planned in order to mitigate the effects of upstream water projects on the managed wetlands in Suisun Marsh. To date, the Initial Facilities (Roaring River Distribution System, Morrow Island Distribution System, and Goodyear Slough Outfall) and the Montezuma Slough Salinity Control Gates have been constructed. These facilities help to ensure that a dependable supply of suitable salinity water is available to preserve managed wetland habitat, including food plants for waterfowl.

1. Land Use

The portion of Suisun Marsh within the Suisun Resource Conservation District boundaries includes 52,000 acres of diked, managed wetlands; 6,300 acres of relict tidal marsh; 29,300 acres of bays and sloughs; and 27,000 acres of grasslands including vernal pools and other natural seasonal wetlands. These acreage figures do not include the diked and tidal wetlands adjacent to the Contra Costa shoreline, which are part of the Suisun Ecosystem and under the influence of regulatory standards reviewed in the draft EIR. The diked managed wetlands within Suisun include 153 privately owned managed wetlands. The Department of Fish and Game manages 15,000 acres of land, which includes diked wetlands, tidal marsh, and uplands. Concord Naval Weapons Station owns channel islands (Seal Island, Roe Island, Ryer Island, Snag Island, and Freeman Island) which are undiked tidal marsh set aside as wildlife sanctuary which support a variety of listed species.

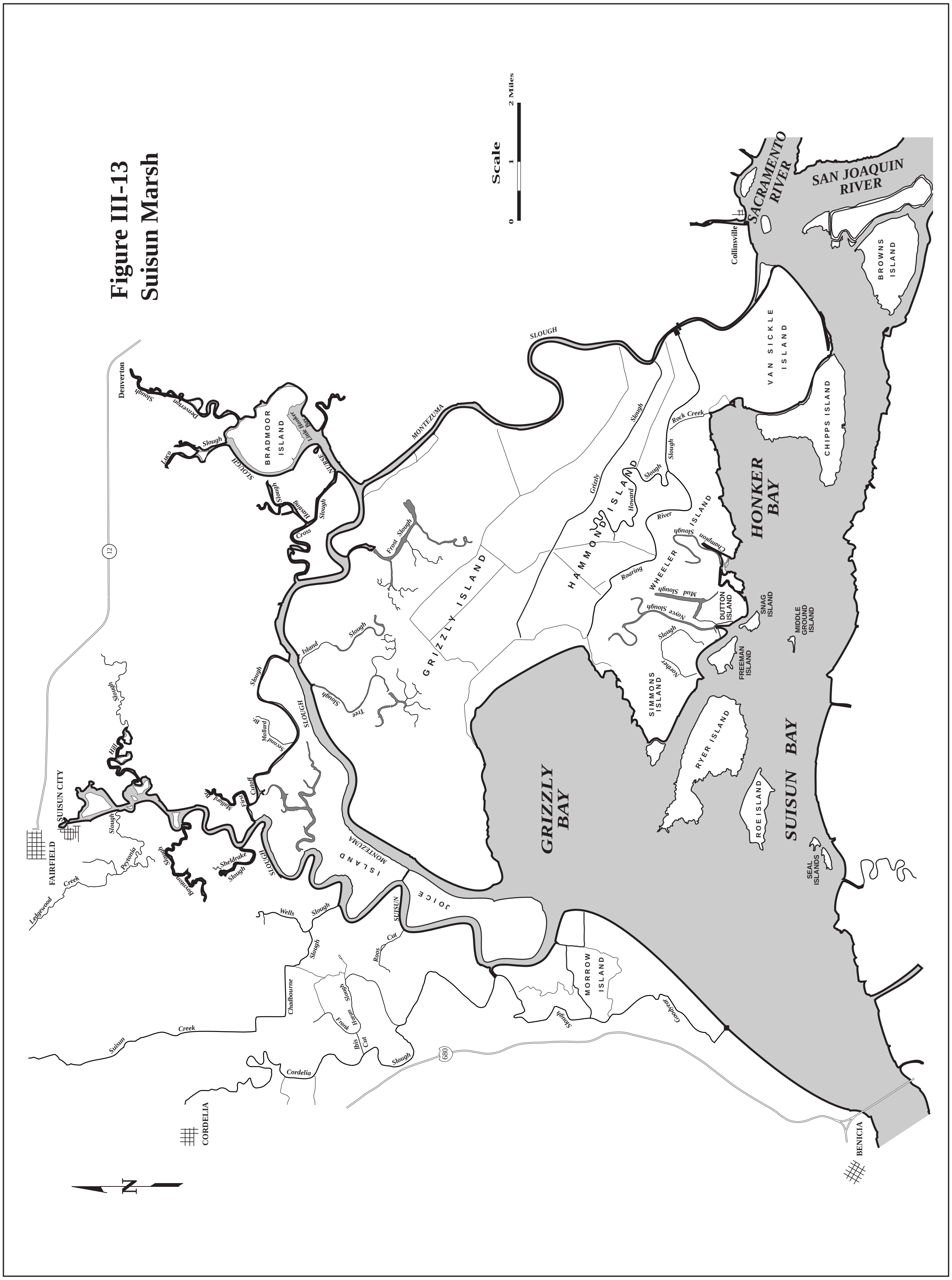


Figure III-13
Suisun Marsh

2. Vegetation

Elevation and salinity are the principal factors controlling the distribution of tidal marsh plants in San Francisco Bay and Suisun Marsh. The mix of plants influences the quality and quantity of habitat available for many species of wildlife. The structure of the plant communities in tidal marshland is strongly correlated to salinity regime. Within the diked wetlands, hydroperiod and management strategies are manipulated to maximize the production of alkali bulrush, fat hen, and brass buttons, plants which have traditionally been considered important for wintering waterfowl. Suisun Marsh supports two endangered plant species (soft haired bird's beak and Suisun thistle) which are both endemic to Suisun Marsh, the rare Mason's lilaeopsis, and several species of concern considered to be in decline due to habitat fragmentation and fill (Delta tule pea, Suisun aster, and Contra Costa goldfields). A more complete listing of sensitive species found in the Suisun Marsh is included in Table VII-11, later in this document.

3. Wildlife and Fish

Suisun Marsh supports 45 species of mammals, 230 species of birds, 51 species of fish, and 15 species of reptiles and amphibians. The marsh is a major wintering ground for waterfowl of the Pacific Flyway. Ducks, geese, swans, and other migrant waterfowl use the marsh as a feeding and resting area. As many as 25 percent of California's wintering waterfowl inhabit the marsh in dry winters. Waterfowl are attracted to the marsh by the water and the abundance of food plants. The growth of such plants depends on soil salinity, which is affected by the salinity of applied water and by land management practices. Freshwater flows from the Delta and tributary creeks into Suisun Bay and marsh channels affect the marsh salinities and waterfowl food production.

Striped bass, for which the marsh is an important nursery area, are the most common fish found in the marsh channels. Other anadromous species sometimes found in the marsh include chinook salmon, sturgeon, American shad, and steelhead trout. Delta smelt, Sacramento splittail, and longfin smelt are important native fish found in the marsh. Catfish are a common resident species in Suisun Marsh and provide a popular sport fishery.

Two endangered species (the salt marsh harvest mouse and the California clapper rail), one threatened species (the California black rail), and one candidate species for federal listing (the Suisun song sparrow) are found in the marsh.

G. SAN FRANCISCO BAY REGION

1. Geography and Climate

The San Francisco Bay Region, shown in Figure III-14, includes portions of nine counties surrounding the San Francisco Bay system and extends from Tomales Bay in the north to Pescadero Creek in the south and inland to the confluence of the Sacramento and San Joaquin rivers. The total land area of the region encompasses about 4,400 square miles, or 3 percent of the

State's total area. The mountains of the Coast Range rise to over 3,000 feet above sea level to the north and south of San Francisco Bay. The North Bay area includes the Napa and Sonoma valleys and the South Bay area includes the Santa Clara Valley. The Golden Gate connects San Francisco Bay to the Pacific Ocean and separates the San Francisco and Marin peninsulas.

San Francisco Bay, which includes Suisun, San Pablo, Central, and South bays, extends about 85 miles from the east end of Chipps Island (in Suisun Bay near the City of Antioch) westward and southward to the mouth of Coyote Creek (tributary to South Bay near the City of San Jose). The surface area of San Francisco Bay is about 400 square miles at mean tide. This is about a 40 percent reduction, due to fill, from its original size. Most of the bay's shoreline has a flat slope, which causes the intertidal zone to be relatively large. San Francisco Bay is surrounded by about 130 square miles of tidal flats and marshes.

The climate is generally cool and often foggy along the coast, with warmer Mediterranean-like weather in the inland valleys. The average high temperature in the inland valleys is nearly 10 degrees higher than at San Francisco. The gap in the hills at Carquinez Strait allows cool air to flow at times from the Pacific Ocean into the Central Valley. Most of the interior North Bay and the northern portions of the South Bay, by contrast, experience very little marine air movement. Average precipitation ranges from 14 inches at Livermore in the South Bay to almost 48 inches at Kentfield in Marin County in the North Bay.

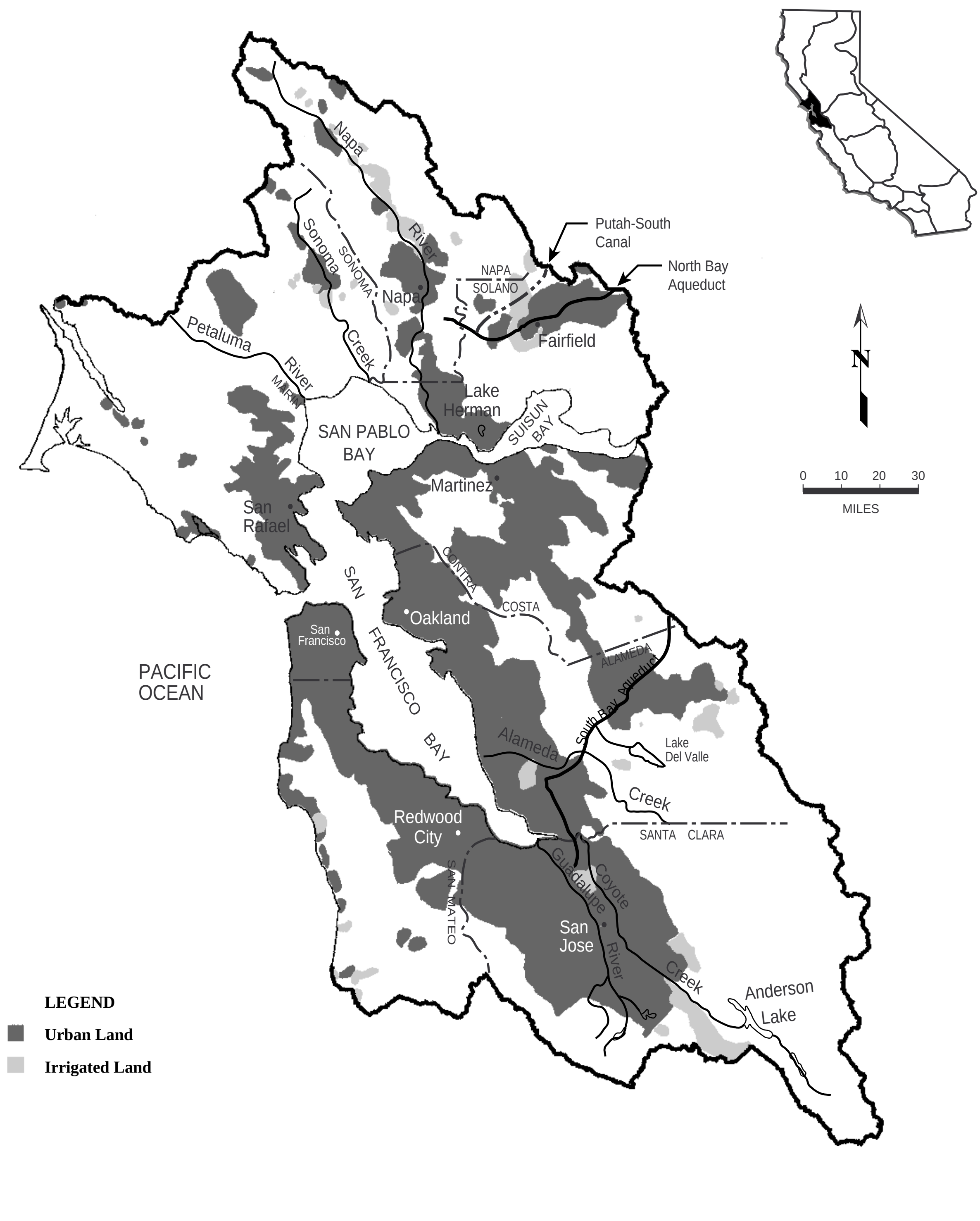
2. Population

The region is highly urbanized and includes the San Francisco, Oakland, and San Jose metropolitan areas. There are large undeveloped areas in the north, west, and southeast portions of the region. In 1990 the population for this region was nearly 5.5 million, which was about 18 percent of the State's total population and an increase of nearly 700,000 from the 1980 level. Most of the region's population lives in the South Bay area and much of the growth took place in the eastern part of that area. The population of the San Francisco Bay Region is expected to increase to over 6.9 million by 2020.

3. Land Use and Economy

The land use in the San Francisco Bay Region is very diverse. Much of the economy is based on commerce and industry. The City of San Francisco is a center of international business and tourism, the ports on the bay support shipping and trade, and the "Silicon Valley" is known for its technological development and production. The region also is home to the Napa Valley and Sonoma Valley wine industry.

Figure III-14
San Francisco Bay Region



Source: DWR, Bulletin 160-93 (1994)

Urban land accounts for 23 percent (655,600 acres) of the land area in the region. This proportion is expected to increase to 37 percent by 2020. Irrigated agricultural land in 1990 was 61,400 acres, which includes 36,000 acres of vineyards. Other irrigated crops include truck, orchard, alfalfa, and pasture. High-value crops include flowers and specialty vegetables, such as artichokes. Public lands make up a small portion of the total region.

4. Water Supply

Water supply sources for the San Francisco Bay Region include local surface water, imported surface water (both locally developed and purchased from other local agencies), groundwater, CVP water, other federal project water (Solano Project), SWP water, and a small amount of recycled waste water. About two-thirds of the urban supplies are imported to the region. More than 60 percent of the total water supply comes from the Delta. The conveyance systems that bring the majority of the water to the area are: the Hetch Hetchy, South Bay, North Bay, Mokelumne, Petaluma, and Santa Rosa-Sonoma aqueducts; Contra Costa and Putah South canals; Cache Slough Conduit; and the San Felipe Project.

Local Surface Supplies - Local surface supplies provide 365,000 acre-feet to the region in average years. Marin Municipal Water District (MMWD) serves the most populated southeastern portion of Marin County with local supplies stored in its reservoirs within Marin County. North Marin Water District (NMWD) supplements its imported supply from Sonoma County Water Agency (SCWA) with just over 1,000 acre-feet from Stafford Lake. The cities of Napa, Vallejo, and St. Helena receive surface water from reservoirs in Napa and Sonoma counties. Vineyards along the Napa River annually divert approximately 6,000 acre-feet from the river for irrigation and frost protection. The City of San Francisco, East Bay Municipal Water District (EBMUD), and Santa Clara Valley Water District (SCVWD) have developed most of the surface supplies in the South Bay area. The major reservoirs in the region are listed in Table III-20.

Imports by Local Agencies - In the North Bay, water is imported from the Russian and Eel rivers (North Coast Region) by SCWA and from the Delta by the City of Vallejo through the SWP. SCWA delivers water from the Russian River Project (which includes Lake Mendocino and Lake Sonoma, and the Potter Valley Project) to eight principal contractors, including four in the San Francisco Bay Region (Petaluma, Sonoma, Valley of the Moon, and North Marin water districts). NMWD supplements its local supply with water from SCWA.

San Francisco Water District (SFWD) imports Tuolumne River water via the 150-mile long Hetch Hetchy System. In addition to supplying water to the City and County of San Francisco, SFWD sells water wholesale to 30 water districts, cities, and local agencies in Alameda, Santa Clara, and San Mateo counties. The three pipelines in the Hetch Hetchy Aqueduct are capable of delivering 336,000 acre-feet annually to the Bay Area.

Table III-20
Major Reservoirs in the San Francisco Bay Region

Reservoir	River	Capacity (TAF)	Owner
Los Vaqueros	Kellogg Creek	100.0	CCWD
Lake Hennessey	Conn Creek	31.0	City of Napa
Nicasio	Nicasio Creek	22.4	Marin MWD
Kent Lake	Lagunitas Creek	32.9	Marin MWD
Alpine	Lagunitas Creek	8.9	Marin MWD
Soulajule	Walker Creek	10.6	Marin MWD
San Pablo	San Pablo Creek	38.6	East Bay MUD
New Upper San Leandro	San Leandro Creek	41.4	East Bay MUD
Chabot	San Leandro Creek	10.4	East Bay MUD
Briones	Bear Creek	60.5	East Bay MUD
Del Valle	Arroyo del Valle	77.1	DWR
San Antonio Reservoir	San Antonio Creek	50.5	City of San Francisco
Coyote	Coyote Creek	22.9	Santa Clara Valley WD
Leroy Anderson	Coyote Creek	89.7	Santa Clara Valley WD
Lexington	Los Gatos Creek	19.8	Santa Clara Valley WD
Lake Elsman	Los Gatos Creek	6.2	San Jose Water Works
Calaveras	Calaveras Creek	96.9	City of San Francisco
San Andreas	San Andreas Creek	19.0	City of San Francisco
Crystal Springs	San Mateo Creek	58.4	City of San Francisco

Source: DWR 1993b

EBMUD imports water from the Mokelumne River through its aqueducts and delivers this water to much of Alameda and Contra Costa counties. The district supplies water to approximately 1.2 million people in 20 cities and 15 unincorporated communities. EBMUD has water rights and facilities to divert up to 364,000 acre-feet annually from the Mokelumne River, depending on streamflow and water use by other water rights holders.

Contra Costa Water District (CCWD) delivers water throughout eastern Contra Costa County, including a portion of the district in the San Joaquin River Region. The district has a right to divert almost 27,000 acre-feet from Mallard Slough on Suisun Bay. With SWRCB Decision 1629, CCWD received a new water right associated with the Los Vaqueros Project, which allows it to divert up to 95,850 acre-feet of surplus water from the Delta to Los Vaqueros Reservoir. The 100,000 acre-foot reservoir, which was authorized in 1988 and recently constructed, will improve supply reliability and water quality by allowing the district to pump and store water from the Delta during high flows. The reservoir provides an emergency water supply to the District and provides blending water to reduce chlorides during periods of higher salinity in the Delta.

Groundwater - The annual supply from groundwater in the region is about 100,000 acre-feet in average years. This figure does not include the use of groundwater which is artificially recharged from surface sources into the groundwater basins. The larger alluvial basins in the North Bay area include Suisun-Fairfield, Napa-Sonoma, Petaluma, and Novato valleys. The estimated storage in these basins is 1.7 million acre-feet. The major groundwater basins of the South Bay area include the Santa Clara and Livermore valleys and the Pittsburg Plain. The total storage in the South Bay basins is estimated to be 6.5 million acre-feet.

Artificial recharge programs are in place in several South Bay localities. Programs operated by Alameda County Flood Control & Water Conservation District (Zone 7), Alameda County Water District, and SCVWD have resulted in a general rise to near-historic groundwater levels in many of the basins. These efforts have corrected overdraft problems such as salt-water intrusion in the Pittsburg Plain and land subsidence in the northern Santa Clara Valley.

Central Valley Project - CVP water is delivered through the Contra Costa Canal to the CCWD and through the San Felipe Project to SCVWD. CVP water was first delivered by CCWD in 1940. The current contract with USBR is for 195,000 acre-feet per year. Most of CCWD's demands are met through direct diversions from the Delta through the Contra Costa Canal. SCVWD's maximum entitlement from the CVP's San Felipe Division, which became operational in 1987, is 152,500 acre-feet per year. Average year deliveries to the region are about 93,200 acre-feet. Normally, about half of this water is used for recharge and the rest is used for direct supply.

Other Federal Projects - Solano County Water Agency contracts for water from Lake Berryessa via the Solano Project and delivers it to farmers and cities within the county. The project was built by the USBR and began operation in 1959. The project develops a dependable supply of over 200,000 acre-feet per year and most of the entitlement goes to agricultural users in the Sacramento River Basin. The 1990 level average year supply from the Solano Project to the North Bay area is 54,000 acre-feet.

State Water Project - The SWP delivers water through the North Bay Aqueduct to the Solano County Water Agency and Napa County Flood Control and Water Conservation District. The Aqueduct extends over 27 miles from Barker Slough to the Napa Turnout Reservoir in southern Napa County. Maximum SWP entitlements are for 67,000 acre-feet per year. The aqueduct also conveys water for the City of Vallejo, which purchased capacity in the NBA.

The South Bay Aqueduct conveys SWP water to SCVWD, Zone 7, and ACWD. The aqueduct is over 42 miles long beginning at the SWP's South Bay pumping plant on Bethany Reservoir and ending at the Santa Clara Terminal Facilities. SWP water is used in the South Bay area for municipal and industrial supply, agricultural deliveries, and groundwater recharge.

a. **Surface Water Hydrology**. The principal source of fresh water in San Francisco Bay is outflow from the Delta. Delta outflows vary greatly according to month and hydrologic year type. Historical Delta outflows have dropped to zero during critically dry periods such as 1928 and 1934. Present summer outflows are maintained by upstream reservoir releases. Although annual Delta outflow has averaged 27.8 MAF from 1980 to 1991, it has varied from less than 2.5 MAF in 1977 to more than 64 MAF in 1983.

Other significant sources of freshwater inflow to San Francisco Bay are the Napa, Petaluma, and Guadalupe rivers, and Alameda, Coyote, Walnut, and Sonoma creeks. These tributaries make up a total average inflow of about 350 TAF. Stream flow is highly seasonal, with more than 90 percent of the annual runoff occurring during November through April. Many streams often have very little flow during mid- or late-summer.

The surface hydrology of the bay can be divided into two distinct patterns. The northern part of the bay, including San Pablo and Suisun bays, receives freshwater outflow from the Delta and functions as part of the Estuary. The South Bay receives little runoff and behaves like a lagoon. Circulation in and flushing of the bay depend on tides and Delta outflow. Circulation is primarily a tidal process, while flushing is believed to depend on tidal action, supplemented by periodic Delta outflow surges following winter storms. The volume of water in the bay changes by about 21 percent from mean higher-high tide to mean lower-low tide. The depth of the bay averages 20 feet overall, with the Central Bay averaging 43 feet and the South Bay averaging 15 feet.

Freshwater outflow from the Delta to San Francisco Bay is believed to be important in maintaining desired environmental conditions in the bay, but no standards govern such outflow. High-volume, uncontrolled outflow surges during the winter cause freshwater to penetrate well into the central bay, from which it can enter the southern bay by tidal exchange. Such events cause salinity stratification in much of the South Bay that can persist for several weeks or months following the initial appearance of freshwater.

b. **Surface Water Quality**. Water quality in the San Francisco Bay system is impacted by several factors. For example, the presence of elevated concentrations of toxic pollutants in the bays, from both point and nonpoint sources, has caused them to be listed as impaired water bodies. The State Department of Health Services has issued health advisories on the consumption of the bays' fish and certain waterfowl due to their elevated levels of selenium and other metals.

Pesticides in the San Francisco Bay system, which pose a threat of unknown magnitude to the fisheries and wildlife resources, originate from municipal storm sewers and sanitary sewerage systems, urban runoff, and agricultural drainage from the Central Valley. Fish kills have occurred in the San Francisco Bay system as a result of accidental spills of toxic materials, and discharges of inadequately treated sewage and industrial wastes. Localized fish kills involving large numbers of striped bass have occurred in Suisun Bay from unknown causes.

The San Francisco Bay area has experienced oil pollution problems mainly localized at refinery docks, ports, marinas, and near storm sewer outlets. These problems are attributable to accidental spills, deliberate discharges, pipeline leaks, and pumping of bilge or ballast water.

Depressed levels of dissolved oxygen in the extreme portion of South San Francisco Bay occur during the late-summer and early-fall months due to municipal waste discharges. Dissolved oxygen deficiencies also occur in the Petaluma and Napa rivers. Algal growths have caused complete lack of dissolved oxygen in the extreme reaches of some tidal sloughs, creeks, and rivers. Recent years have brought red water discoloration caused by marine ciliates, a phenomenon probably aggravated by high nutrient concentrations.

Water in much of San Francisco Bay contains coliform bacteria levels greater than those recommended for water contact sports. Substantial improvement has been reported since the initiation of chlorination of the discharge from a large municipal sewerage system.

c. Groundwater Hydrology. Groundwater is found in both the alluvial basins and upland hard rock areas. Well yields in the alluvial basins range from less than 100 to over 3,000 gallons per minute. The yield from wells in the hard rock areas is generally much lower, but is usually sufficient for most domestic or livestock purposes. Recharge to the alluvial basins occurs primarily from rainfall and seepage from adjacent streams. However, a significant percentage, especially in the South Bay, is through artificial recharge facilities and incidental recharge from irrigation.

The larger alluvial basins in the North Bay area include Suisun-Fairfield, Napa-Sonoma, Petaluma, and Novato valleys. The estimated storage in these basins is 1.7 million acre-feet. The major groundwater basins of the South Bay area include the Santa Clara and Livermore valleys and the Pittsburg Plain. Total storage in the South Bay is approximately 6.5 MAF.

d. Groundwater Quality. The groundwater quality in the North Bay is generally good. Salt-water intrusion has been a problem at the lower end of the Napa and Sonoma valleys, but this has been substantially mitigated by using imported surface water instead of groundwater. Some isolated areas experience elevated levels of dissolved solids, iron, boron, hardness, and chloride. High levels of nitrates occur in the Napa and Petaluma valleys as a result of past agricultural practices. Groundwater salinity levels in the Suisun-Fairfield area typically range from 300 to 6,000 mg/l TDS, with average values generally exceeding 900 mg/l TDS. Putah Plain groundwater is of somewhat better quality, with average TDS levels generally under 600 mg/l. However, the deeper Tehama formations generally provide a higher quality of water than the overlying Putah Plains aquifer.

Groundwater quality is a problem to various degrees in some South Bay locations. The Livermore Valley has elevated of dissolved solids, chloride, boron, and hardness. The highly urbanized areas of the Santa Clara Valley have experienced groundwater pollution over large areas from organic solvents used in electronics manufacturing

5. Water Use

Total net water use for the San Francisco Bay Region in 1990 was 6,071,000 acre-feet. Seventy-nine percent (4,775,000 acre-feet) of the total use is considered environmental use. Almost all environmental water use in the region is associated with the Suisun Marsh demands and required Delta outflow. Urban water demand was 1,186,000 acre-feet (20 percent of total) and agricultural net water demand was 88,000 acre-feet.

Per capita urban water use for the region varies significantly, depending on factors such as local climate, population density, residential yard size, and volume of commercial and industrial use. The cooler coastal portions of the region have the lowest per capita water use. The low values of 100 gallons per capita per day (gpcd) in San Mateo County and 139 gpcd in San Francisco are generally related to cooler climate, small yards, and higher population densities. Santa Clara County's per capita use averages about 200 gpcd. The warmer, drier climate and greater range of lot sizes results in increased outdoor use. The county also has a mix of water-using industries, such as food processing and computer and electronics manufacturing, which tend to raise per capita use. The highest per capita urban use in the region is in Contra Costa County, where use averages 230 gpcd because many of the residential areas consist of large lots which have high landscape water requirements; there also is considerable industrial water use concentrated along the Bay. Average daily per capita water use for the San Francisco Bay region was 193 gallons in 1990. Total net urban water use is expected to increase by nearly 19 percent by 2020.

Agricultural water use is a small (1 percent) portion of the total net water demand for the region. Irrigated acreage has been reduced by 62 percent over the past 40 years. Urbanization has reduced agricultural acreage in the Santa Clara Valley from over 100,000 acres to less than 17,000 acres and Marin County has only about 700 irrigated acres remaining. Napa and Sonoma counties have actually increased agricultural acreage, due to an increase in vineyards and adoption of drip irrigation on lands too steep for furrow or sprinkler irrigation practices. Most of the agricultural lands are served by groundwater or direct diversions from the Napa River and other local streams. Irrigated acreage and net agricultural water demand are expected to increase slightly for the region, due primarily to further increases in vineyard acreage.

Suisun Marsh and Hayward Marsh are managed wetlands in the San Francisco Bay Region that have a combined water supply requirement of about 160,000 acre-feet per year. The Suisun Marsh consists of about 10,000 acres of State-owned wetlands and about 44,000 acres under private ownership and managed as duck clubs. The estimated annual water demand for Suisun Marsh is about 150,000 acre-feet. Hayward Marsh is part of the Hayward Shoreline Marsh Expansion Project, a wetland restoration project undertaken by several local agencies. As part of the project, 10,000 acre-feet of recycled water from Union Sanitary District is blended with brackish water from the Bay and applied to the 145-acre marsh to help restore habitat for fish, waterfowl, and wildlife. The largest environmental water use in the region is for Delta outflow to meet D-1485 salinity standards. The outflow requirements are for about 4.6 million acre-feet in average years and 2.9 million acre-feet in drought years.

6. Vegetation

The San Francisco Bay estuary is composed of six natural vegetation communities, including riparian, grassland, freshwater emergent wetland, saline emergent wetland, foothill woodland, and mixed chaparral. Sensitive plant species found in the San Francisco Bay region are listed in Table III-21.

Riparian habitat is typically composed of cottonwoods, sycamores, oaks, willows, blackberries, sedges, and rushes. It is generally found along perennial and intermittent waterways, flood plains, and estuarine channels. Sensitive riparian habitat in the San Francisco Bay estuary includes: great valley-valley oak riparian forest, great valley cottonwood riparian forest, great valley mixed riparian forest, white alder riparian forest, great valley willow scrub, buttonbush scrub, elderberry savanna, and central coast riparian scrub.

Grasslands are found throughout the region on the valley floor and on the well-drained slopes of the surrounding hills. Grazing and the introduction of non-native species have changed the composition to mostly annual grass species. The non-native grasslands include soft chess, red brome, wild oats, ripgut brome, and fescue. Sensitive grassland communities include coastal terrace prairie, pine bluegrass grassland, valley needlegrass grassland, serpentine bunchgrass, wildflower fields, freshwater seeps, and alkali playas.

Saline emergent wetlands are usually described as either brackish or salt marshes. Saline emergent wetlands occur in the upper intertidal zone of San Francisco and San Pablo bays, typically where wave action is reduced. The vegetation is dominated by perennial monocots along with algal mats on the soil. Two sensitive habitats in the Bay area could be grouped into the saline emergent wetland community: northern coastal salt marsh and coastal brackish marsh.

Freshwater emergent wetlands occur in a variety of topographies, so long as a basin is saturated or periodically flooded. The marshes are usually found around lakes and ponds and along river channels. Freshwater emergent wetlands are usually dominated by perennial hydrophytic monocots. Sensitive freshwater emergent wetland communities include cismontane alkali marsh, coastal and valley freshwater marsh, and vernal marsh.

Foothill woodlands are dominated by oaks and intermixed with other broad-leaved and evergreen vegetation. The woodlands are denser on the cool east and north facing slopes. Coast live oaks, the predominant species, are found higher up on the foothill slopes, above the canyon bottoms. Other trees include California buckeye, California bay, big leaf maple, and madrone. Mixed chaparral is composed of many species, including oaks, manzanita, chamise, sage, coyote brush, California buckeye, and poison oak. Chaparral and scrub communities occur on arid south-facing slopes and above woodlands. Northern maritime chaparral and serpentine chaparral are considered sensitive habitats.

Table III-21
Sensitive Plant Species in the San Francisco Bay Region

Scientific Name	Common Name	Status State	Status CNPS	Status Federal
Acanthomintha duttonii	San Mateo thornmint	SE	1B	FE
Arctostaphylos hookeri ssp. *ravenii*	Presidio manzanita	SE	1B	FE
Arctostaphylos imbricata	San Bruno Mountain manzanita	SE	1B	FPT
Arctostaphylos pallida	Pallid manzanita	SE	1B	FPT
Blennosperma bakeri	Sonoma sunshine	SE	1B	FE
Calochortus tiburonensis	Tiburon mariposa lily	ST	1B	FT
Castilleja affinis ssp. *neglecta*	Tiburon Indian Paintbrush	ST	1B	FE
Ceanothus ferrisae	Coyote ceanothus		1B	FE
Ceanothus masonii	Mason's ceanothus	SR	1B	FSC
Chorizanthe robusta var. *robusta*	Robust spineflower		1B	FE
Cirsium fontinale var. *fontinale*	Fountain thistle	SE	1B	FE
Cirsium hydrophilum ssp. *hydrophilum*	Suisun thistle		1B	FPE
Clarkia franciscana	Presidio clarkia	SE	1B	FE
Cordylanthus mollis ssp. *mollis*	Soft bird's-beak	SR	1B	FPE
Cupressus abramsiana	Santa Cruz cypress	SE	1B	FE
Delphinium bakeri	Baker's larkspur	SR	1B	C
Dichanthelium lanuginosum var. *thermale*	Geyser's dichanthelium	SE	1B	FSC
Dudleya setchellii	Santa Clara Valley dudleya		1B	FE
Eriophyllum latilobum	San Mateo woolly-sunflower	SE	1B	FE
Fritillaria liliacea	Fragrant fritillary		1B	FSC
Hesperolinon congestum	Marin western flax	ST	1B	FT
Holocarpha macradenia	Santa Cruz tarplant	SE	1B	C
Lessingia germanorum	San Francisco lessingia	SE	1B	FPE
Lilaeopsis masonii	Manson's lilaeopsis	SR	1B	FSC
Pentachaeta bellidiflora	White-rayed pentachaeta	SE	1B	FE
Plagiobothrys strictus	Calistoga popcornflower	ST	1B	FPE
Poa napensis	Napa Blue grass	SE	1B	FPE
Sanicula maritima	Adobe sanicle	SR	1B	FSC
Sanicula saxitilis	Rock sanicle	SR	1B	FSC
Streptanthus albidus ssp. *albidus*	Metcalf Canyon jewelflower		1B	FE
Streptanthus niger	Tiburon jewelflower	SE	1B	FE
Suaeda californica	California seablite		1B	FE

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
CNPS: (California Native Plant Society) 1A=presumed extinct in California; 1B=rare,threatened, or endangered in California and elsewhere; 2=rare,threatened,or endangered in California but more common elsewhere; 3=need more information; 4=distribution limited (a watchlist).
FEDERAL: FE=endangered; FT=threatened; FPE=proposed endangered; FPT=proposed threatened; C=candidate for listing; FSC=species of concern.

Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

7. Fish

The San Francisco Bay complex supports a wide variety of fish -- more than 100 fish species. Habitat types in the bay include open water, tidal mudflats, and marshland. The anadromous species of fish which occur in San Francisco Bay system include chinook salmon, striped bass, sturgeon, American shad, and steelhead trout. Marine fish, found mainly in the lower bays, include flatfish, sharks, Pacific herring, jacksmelt, topsmelt, and surf perch. Other fish in the estuary include catfish, black bass, crappie, and bluegill. Shellfish include mussels, oysters, clams, crabs, and shrimp. Threatened, endangered, or candidate fish species found in the San Francisco Bay system are listed in Table III-22.

Food supplies for San Francisco Bay estuary fish communities consist of phytoplankton, zooplankton, benthic invertebrates, insects, and fish. Seasonal variations in salinity in the bays, due to varying Delta outflows, affect the seasonal distribution of fish and invertebrates. Benthic invertebrates, such as clams, are limited to areas where conditions are favorable year-round. Once a thriving business, there is at present no commercial oyster industry in San Francisco Bay. There is sport clamming, although coliform bacteria concentrations are higher than the U.S. Public Health Service and State allowable limits.

8. Wildlife

The complex interface between land and water in the San Francisco Bay estuary provides a variety of habitats for wildlife. Large numbers of migratory waterfowl dominate the landscape, especially in Suisun Marsh. Habitats at low elevations include open water, tidal mudflats, diked and undiked marshland, and riparian vegetation; grassland, agricultural land, woodland, and chaparral can be found in upland areas.

Open water, tidal mudflats, shorelines, and marshland provide habitat for many species of waterfowl and shorebirds, including cormorants, grebes, sandpipers, plovers, rails, mallards, and pintails. Mammals commonly found in these areas include seals, sea lions, harvest mice, and shrews. These areas also support several types of amphibians and reptiles.

Species typical of uplands can be seen in the grassland, woodland, and chaparral areas. These include many types of raptors, songbirds, owls, and upland game birds, mammals such as hares, gophers, squirrels, and deer, and also reptiles.

The intense urban development in the estuary has caused destruction of much of the areas that historically provided wildlife habitat. There are currently 15 species in the estuary that are either State or Federally listed, and others are candidates for listing. Among these are the Alameda striped racer, salt marsh harvest mouse, San Francisco garter snake, California clapper rail, and California yellow-billed cuckoo. Sensitive wildlife species found in the San Francisco Bay region are listed in Table III-23.

Table III-22
Sensitive Fish Species in the San Francisco Bay Estuary

Scientific Name	Common Name	Status: State	Status: Federal
Acipenser medirostris	Green Sturgeon	CSC	FSC
*Eucyclogobius newberryi**	Tidewater goby	CSC	FE
Hypomesus transpacificus	Delta smelt	ST	FT
Oncorhynchus tshawytscha	Fall-run chinook salmon, Central Valley, CA ESU		C
Oncorhynchus tshawytscha	Late fall-run chinook salmon, Central Valley, CA ESU	CSC	C
Oncorhynchus tshawytscha	Spring-run chinook salmon	ST	FT
Oncorhynchus tshawytscha	Winter-run chinook salmon	SE	FE
Oncorhynchus mykiss	Steelhead, Central Valley, CA ESU		FT
Pogonichthys macrolepidotus	Sacramento splittail	CSC	FT
Spirinichus thaleichthys	Longfin smelt	CSC	FSC

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
FEDERAL: FE=endangered; FT=threatened; C=candidate for listing; FSC=species of concern.

Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

*Believed to have been extirpated from most of its historical range in the San Francisco Bay Estuary

9. Recreation

Mild temperatures and brisk winds make San Francisco Bay a very popular recreational boating area. Other water-oriented recreation includes fishing, sightseeing, picnicking, nature walking, and camping.

The San Francisco Bay Region includes lakes and reservoirs operated by the SFWD, EBMUD, and MMWD. Those operated by SFWD are San Andreas Lake, Crystal Springs Reservoir, San Antonio Reservoir, and Calaveras Reservoir. San Pablo Reservoir, Briones Reservoir, San Leandro Reservoir, and Lake Chabot are operated by EBMUD. Nicaso Reservoir is operated by MMWD.

Because these reservoirs are used as storage facilities for municipal water supplies, access and activities are restricted. However, EBMUD allows limited non-contact water recreation usage at its lakes and reservoirs, throughout the year. Recreational facilities include fishing docks, picnic sites,

Table III-23
Sensitive Wildlife Species in the San Francisco Bay Region

Scientific Name	Common Name	Status State	Status Federal
Agelaius tricolor	Tricolored blackbird	CSC	FSC
Branta canadensis leucopareia	Aleutian Canada goose		FT
Charadrius alexandrinus nivosus	Western snowy plover	CSC	FT
Geothlypis trichos sinuosa	Saltmarsh common yellowthroat	CSC	FSC
Haliaeetus leucocephalus	Bald eagle	SE	FT
Laterallus jamaicensis coturniculus	California black rail	ST	FSC
Melospiza melodia maxillaris	Suisun song sparrow	CSC	FSC
Pelecanus occidentalis californicus	California brown pelican	SE	FE
Rallus longirostris obsoletus	California clapper rail	SE	FE
Riparia riparia	Bank swallow	ST	
Sterna antillarum browni	California least tern	SE	FE
Antozous pallidus	Pallid bat	CSC	
Eumops perotis californicus	California mastiff bat	CSC	FSC
Microtus californicus sanpabloensis	San Pablo vole	CSC	FSC
Plecotus townsendii townsendii	Townsend's western big eared bat	CSC	FSC
Reithrodontomys raviventris	Salt Marsh harvest mouse	SE	FE
Sorex ornatus sinuosus	Suisun shrew	CSC	FSC
Sorex vagrans halicoetes	Salt marsh wandering shrew	CSC	FSC
Ambystoma californiense	California tiger salamander	CSC	C
Rana aurora draytonii	California red-legged frog	CSC	FT
Clemmys marmorata	Western pond turtle	CSC	
Masticophis lateralis euryxanthus	Alameda whipsnake	ST	FPE
Thamnophis sirtalis tetrataenia	San Francisco garter snake	SE	FE
Euphydryas editha bayensis	Bay checkerspot butterfly		FT
Icaricia icarioides missionensis	Mission blue butterfly		FE
Incisalia mossii bayensis	San Bruno elfin butterfly		FE
Syncaris pacifica	California freshwater shrimp	SE	FE

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
FEDERAL: FE=endangered; FT=threatened; FPE=proposed endangered; FPT=proposed threatened; C=candidate for listing; FSC=species of concern.

Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

and hiking and equestrian trails. Anderson Reservoir is owned by the SCVWD which receives CVP water. The Santa Clara County Parks and Recreation Department manage the recreation activities at the reservoir. Typical activities at the reservoir include boating, water skiing, jet skiing, and picnicking during the peak season. Off-season activities include fishing. Swimming and camping are not allowed at Anderson Reservoir. Reservoir facilities include a single boat ramp, which requires reservations for weekend use.

H. TULARE LAKE BASIN

1. Geography and Climate

The Tulare Lake Basin includes the southern San Joaquin Valley from the southern limit of the San Joaquin River watershed to the crest of the Tehachapi Mountains. It stretches from the Sierra Nevada on the east to the Coast Range on the west. Four main geographical areas make up this mostly agricultural region: the western side of the San Joaquin Valley floor and western uplands, the Sierra Nevada foothills on the region's eastern side, the central San Joaquin Valley floor, and the Kern Valley floor. The Tulare Lake region, which is shown in Figure III-15, encompasses almost 10 percent of the State's land area.

The major rivers in the region, the Kings, Kaweah, Tule, and Kern, begin in the Sierras and generally flow east to west into the San Joaquin Valley. They are sustained by snowmelt from the upper mountain elevations. All of the rivers terminate on the valley floor in lakes or sinks; water does not find its way to the ocean from the basin, as it once did under natural conditions, except during extremely wet years. The west side of the valley, the Coast Ranges, and the Tehachapis provide a large drainage area, but the streams are intermittent as there is generally scant rainfall in these areas and little runoff.

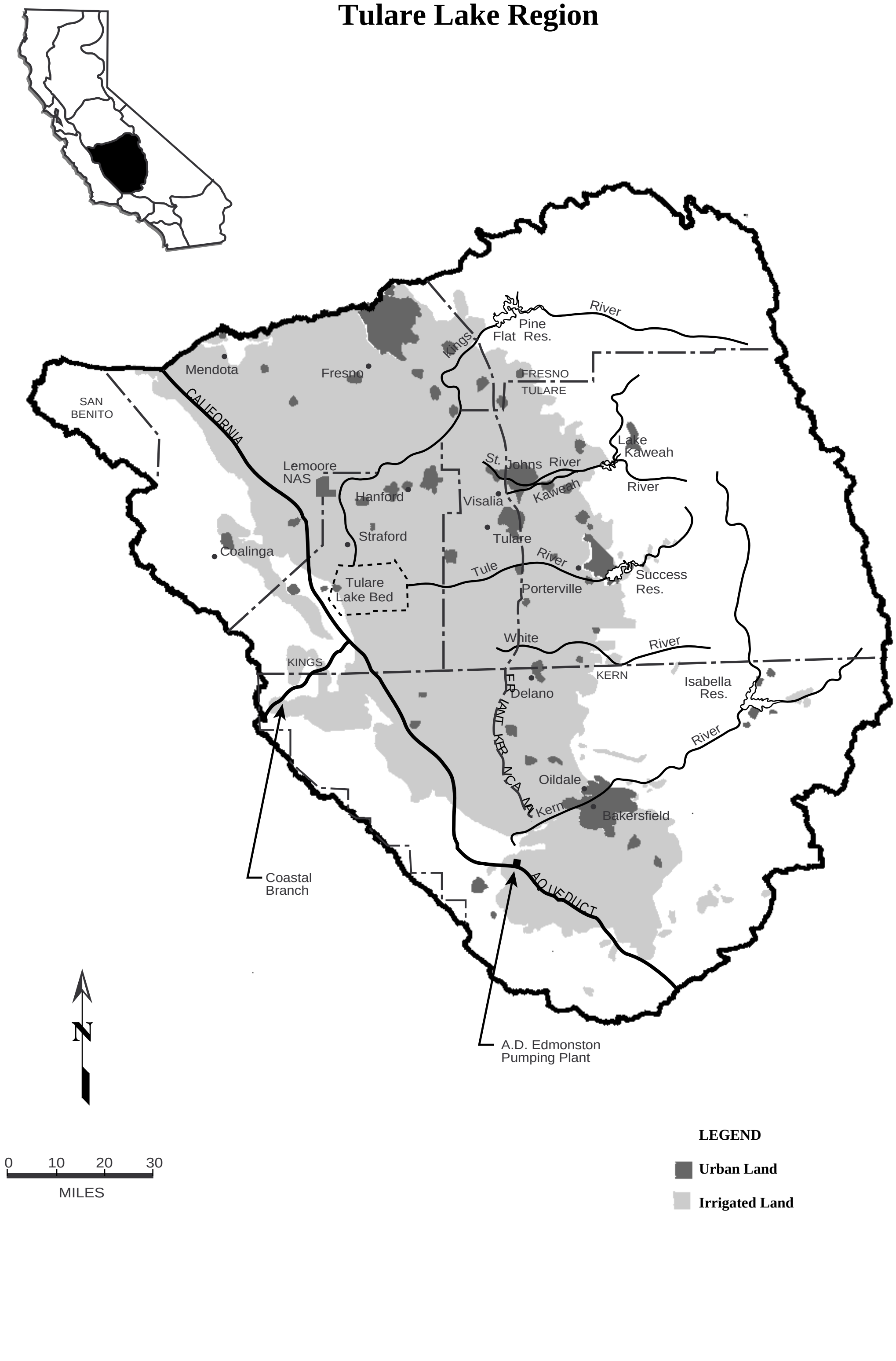
The region's climate varies between valley and foothill areas. The valley areas experience mild springs and hot, dry summers. Summer high temperatures often exceed 100EF. Winters are typically cold with some temperatures below freezing, but snowfall is rare. In some parts of the valley, thick tule fog is common at times during the winter. Climate in the foothills is typical of mountainous foothill areas where winters and springs are cold and where snowfall occurs at higher elevations.

Most of the region's winter and spring runoff from the Sierras is stored for later use in the summer to supply the drier valley floor areas. In most years, imported water from northern California supplements local supplies to meet the region's large agricultural water demand.

2. Population

The population of the Tulare Lake Region in 1990 was over 1.5 million. Many small agricultural communities dot the eastern side of the valley, but the rapidly growing cities of Fresno and Bakersfield and the Visalia-Tulare urban area anchor the region. These urban areas grew by 50 to 60 percent between 1980 and 1990. The population of the region is projected to more than double in the next 30 years, with most of the growth occurring in these same urban areas.

Figure III-15
Tulare Lake Region



Source: DWR, Bulletin 160-93 (1994)

3. Land Use and Economy

About 30 percent of the land area in the Tulare Lake Region is publicly owned, with 1.7 million acres of national forest, 0.8 million acres of national parks and recreation areas, and 0.5 million acres managed by the BLM. The publicly owned lands are primarily in the upland areas on the east side of the region and include Kings Canyon and Sequoia National Parks and Sierra National Forest.

Privately owned land totals about 7.4 million acres, of which urban areas take up 176,300 acres. Irrigated agriculture accounts for over 3.2 million acres of the private land, while other agricultural land cover an additional 1.4 million acres. The principal crops grown in the region are cotton, grapes, and deciduous fruits. Substantial acreage of almonds and pistachios are also grown, as well as increasing acreage of truck crops, such as tomatoes and corn.

In the eastern upland areas, agriculture and timber production account for most of the land use. Deciduous and citrus fruits are the main agricultural crops in the lower foothills. Timber harvesting occurs throughout many of the higher elevation areas.

4. Water Supply

The Tulare Lake Basin is one of the richest agricultural regions in the United States. The highly developed agricultural economy of the basin is dependent upon local surface runoff, import from basins to the north, and groundwater to supply its water needs.

The main local surface water supplies in the Tulare Lake Region come from the runoff from the southern Sierra Nevada rivers. Other water comes by way of the federal CVP's Delta-Mendota Canal and Friant-Kern Canal, and the SWP's California Aqueduct, which enters the region as part of the Joint-Use Facilities with the CVP's San Luis Unit. Groundwater pumping meets the remaining water demands.

Many valley cities, including Fresno and Bakersfield, rely primarily on groundwater for urban use, occasionally obtaining supplemental supplies from local surface water and some imported water. Fresno, for example, uses groundwater for its main urban supply, but also purchases local Kings River water and water from the Friant-Kern Canal and replenishes groundwater through recharge basins. In Bakersfield, the Kern County Water Agency treats CVP Cross Valley Canal water to supplement its urban groundwater supply. In isolated parts of the valley's western side, smaller cities like Avenal, Huron, and Coalinga rely on imported surface water from the San Luis Canal.

Cities in the Sierra Nevada foothills often have less dependable drought supplies than the valley communities. In many foothill areas, local surface water connections are not available and groundwater is limited to small pockets in the rock strata. A few cities, such as Lindsay and Orange Cove, receive surface water through the CVP's Friant-Kern Canal.

The SWP, through San Luis Reservoir and the California Aqueduct, provides an average of about 1.2 million acre-feet of surface water annually to the region. The USBR supplies an average of 2.7 million acre-feet during normal years from the CVP via Mendota Pool, the Friant-Kern Canal, and the San Luis Canal of the CVP/SWP San Luis Joint-Use Facilities. The Friant-Kern Canal receives water from Millerton Lake on the San Joaquin River; Mendota Pool and the California Aqueduct receive water from the Sacramento-San Joaquin Delta.

The 1990 level average water supply for the Tulare Lake Region was over 8.1 million acre-feet. Of this, about 33 percent comes from local surface supplies, 48 percent comes from the CVP and SWP (33 and 15 percent, respectively), and 19 percent comes from groundwater. The Kings-Kaweah-Tule River Planning Subarea (KKT PSA), which takes in most of the valley floor north of Kern County, accounts for just over half of the net water demand for the Tulare Lake Region. Supplies for the KKT PSA come mainly from local sources with local surface supplies providing 46 percent, groundwater providing 29 percent, and other sources providing 25 percent. The San Luis West Side and Kern Valley Floor PSAs rely more on other sources (90 and 60 percent, respectively).

a. <u>Surface Water Hydrology</u>. The Tulare Lake Basin is hydrologically separate from the San Joaquin River Basin and is not normally tributary to the Delta. The Kings River, which carries eroded material from the Sierra Nevada, and the Los Gatos Creek alluvial fan have built up a low, broad ridge across the trough of the valley so that the Tulare Lake Basin has essentially no natural surface water outlet.

The four major rivers in the basin, the Kings, Kaweah, Tule and Kern rivers historically drained to the Tulare Lake bed which covers about 200,000 acres. Tulare Lake tributaries are now heavily used for irrigation, with little water reaching the lake. Diversions and management of river flows have significantly reduced flow to the lake bed which remains dry except during periods of high flows in wet years. Floods are not an uncommon occurrence, but are variable in intensity and frequency. Levees have been built in the lakebed to contain the floodwater in cells and still maximize farming possibilities. During very wet periods, portions of the flow in the Kings River can enter the San Joaquin River via Fresno Slough.

Dams on the Kings, Kaweah, Tule, and Kern rivers provide flood control and water supply for groundwater recharge and for urban and agricultural uses. The Kings River, which drains the Sierra Nevada mountains in eastern Fresno County, is impounded by Pine Flat Dam and Reservoir, which stores about 1 MAF. The Kaweah River is impounded by Terminus Dam to form the 143 TAF Lake Kaweah. Success Dam impounds the Tule River to form the 82 TAF Lake Success. Lake Isabella, in Kern County, impounds water from the Kern and South Fork Kern rivers. The reservoir has a storage capacity of 570 TAF. These and other lakes and reservoirs in the Tulare Lake Region also support recreational opportunities. Table III-24 lists the major reservoirs in the Tulare Lake Basin.

Table III-24
Major Reservoirs in Tulare Lake Basin

Reservoir	River	Capacity (TAF)	Owner
Courtright	Helms Creek	123	PG&E
Wishon	Kings	128	PG&E
Pine Flat	Kings	1,000	USCOE
Lake Kaweah	Kaweah	143	USCOE
Success Lake	Tule	82	USCOE
Isabella Lake	Kern	568	USCOE

Source: DWR 1993b

b. Surface Water Quality. The water quality of the perennial streams which originate in the Sierra Nevada is generally very good. However, irrigation return-water forms a major portion of the summer base flow in the lower reaches of the larger streams. Saline water from oil wells is a contributor to the basin salt load. The salt content of Tulare Lake (about 570 mg/l TDS) is due mainly to soil salts historically in the basin and introduced fertilizers. Poso Creek also contributes salt to the southern portion of the basin, but the proportional quantity of water from this drainage is small.

c. Groundwater Hydrology. The valley floor overlies mostly one large groundwater basin that consists of alluvial sediments. In the western half to three quarters of the valley floor, the Corcoran clay layer, which is found at depths of 300 to 900 feet, divides the groundwater basin into essentially two separate aquifers. According to the SJREC, the Corcoran Clay layer is absent in much of the Kern Fan area. South of the Kern River, the Corcoran horizon drops below well depths but other clay layers provide some confinement. On the eastern side of the valley, both north and south of the Kern County line, older formations are tapped by wells that usually exceed 2,000 feet in depth. A small groundwater subbasin, with little hydraulic connection to the main aquifers, exists on the western side of Fresno, Kings, and Kern counties from Coalinga to Lost Hills. Two other subbasins in Kern County are separated from the main basin by the White Wolf and Edison faults. Productive aquifers with good quality water are the rule, except in the Tulare Lake area where lakebed clays yield little water, along the extreme eastern edge of the region where shallow depth to granite limits aquifer yields, and along the western side where water quality is poor.

The groundwater overdraft in the Tulare Lake Basin is a significant unresolved water resource problem in California. The average annual rate of groundwater overdraft was calculated to be about 650 TAF in 1990. The annual overdraft has decreased from about 1.3 MAF in 1972 due to the importation of SWP water and the availability of surplus supplies.

Numerous public and private water agencies are engaged in the acquisition, distribution, and sale of surface water to growers in the Tulare Lake Basin. Since most of the agencies overlie usable groundwater and use groundwater conjunctively with surface water, some of their operational practices, such as artificial recharge and use of surplus surface supplies in lieu of groundwater, can be viewed as elements of a groundwater management program.

d. Groundwater Quality. Groundwater in the Tulare Lake Basin ranges widely in type and concentration of chemical constituents. The differences are related to the quality of waters that replenish the groundwater reservoirs and the chemical changes that occur as the water percolates through the soil. In general, groundwater is divided into three main groups. Groundwater on the east side of the basin is generally of bicarbonate type and has low to moderate total dissolved solids. Groundwater throughout the axial trough ranges in chemical character and usually has higher total dissolved solids than the east side waters. The groundwater on the west side of the basin is of sulfate or bicarbonate type and nearly always has higher total dissolved solids than eastside groundwater.

Most groundwater in the basin is of usable quality and generally meets the needs of agricultural applications. There are areas of inferior quality groundwater, mostly occurring along the west side of the valley. Naturally occurring constituents that limit the usefulness of groundwater in these areas include total dissolved solids, sulfate, boron, arsenic, chloride, selenium, and uranium.

Groundwater near Tulare Lake has experienced an increase in dissolved solids concentrations over the years. Groundwater quality has suffered due to the agricultural practice of leaching salts from the root zone into shallow groundwater. In some locations, beneficial use of groundwater has been impaired as a result of quality degradation from salt loading.

Most of the region's urban population relies on groundwater to meet its water demands. Drinking water standards are much stricter than agricultural requirements and many of the urban areas are faced with water quality problems from their groundwater supplies. The groundwater in some areas of the basin exceeds the recommended TDS concentration limit in the U.S. Public Health Service Drinking Water Standard (500 mg/l). Nitrogen concentrations in some groundwater in the Tulare Lake Basin approach or exceed the levels recommended by the drinking water standards (10 mg/l). High nitrogen concentrations are usually attributed to sewage effluent, fertilizers, feedlots and dairies. Herbicides and pesticides from agricultural applications, as well as petroleum products and industrial solvents, are being discovered in excess of the maximum contamination limits in various areas throughout the basin.

5. Water Use

Water supplies in the Tulare Lake Region are mostly used for irrigated agriculture. With 1990 level average conditions, irrigated agriculture uses over 7.7 million acre-feet, which is about 95 percent of the region's total water use. Cotton accounts for 35 percent of the total evapotranspiration of applied water for irrigated crops. Municipal and industrial needs are about 214,000 acre-feet per year (3 percent of total). Average per capita daily water use within the region is about 301 gallons. Municipal and industrial net water use is expected to increase 112 percent by 2020 due to large population increases throughout the region, while agricultural water use may decline by over

0.5 million acre-feet (7 percent) as farm irrigation efficiencies continue to increase and some agricultural land is converted to urban use.

6. Vegetation

Ten common natural vegetation community types occur in the Tulare Lake Basin. They include valley and foothill riparian, valley grassland, freshwater emergent wetland, foothill woodland, valley oak woodland, sycamore alluvial woodland, mixed chaparral, and chenopod scrub. Mixed conifer forest, montane hardwood, and montane riparian vegetation communities typical of the Sierra Nevada are found in the eastern portion of the region. Chaparral is the most abundant natural community in the basin occurring on the foothill and mountain slopes surrounding the valley floor.

Plant species along the major tributaries to the basin are typical of those found in the riparian habitats throughout the west slope of the Sierra Nevada foothills. Around streams and lakes, riparian habitats include willows, western sycamore, cottonwood, alder, and California buckeye, as well as shrubs and herbaceous species. Sensitive riparian habitats in the Tulare Lake Basin include great valley-valley oak riparian forest, great valley cottonwood riparian forest, great valley mixed riparian forest, white alder riparian forest, great valley willow scrub, buttonbush scrub, elderberry savanna, central coast cottonwood-sycamore riparian forest, central coast live oak riparian forest, central coast arroyo willow riparian forest, and great valley mesquite scrub.

A large part of the riparian vegetation, including areas below the reservoirs, has been lost due to extensive agricultural encroachment and other development. However, there is a mature riparian forest on both sides of the Kaweah River immediately below Terminus Dam. Most natural vegetation below the reservoirs remains only in small disjunct patches. Further downstream, plant life becomes similar to that of the Tulare Lake Basin. Plant life of the lower Kern River is characterized as valley mesquite habitat, which is uniquely found in southwestern Kern County.

Grassland is a broadly defined community, occupying the perimeter of the valley portion of the region. Although valley grassland historically consisted of perennial bunch grasses, grazing and the introduction of non-native species have changed the composition to mostly annual grass species. Vernal pools are found among many of the grassland areas. Sensitive grassland habitat types in the Tulare Lake Basin, in addition to the vernal pools, include valley needlegrass grassland, serpentine bunchgrass, wildflower fields, freshwater seeps, alkali playas, pine bluegrass grassland, and valley sacaton grassland.

Historically, the Tulare Lake Basin contained the largest single block of wetland habitat present in California. Cattail-sedge species such as tule cattail and spike rush occur throughout the region in fresh and brackish marshes, farm ponds, and ditches. Diversion of water for agricultural and urban uses resulted in the reclamation of Tulare Lake and associated wetlands. Less than 1 percent of the freshwater lake habitat and 4 percent of the wetland habitat remains. Three sensitive freshwater emergent wetland communities occur in the Tulare Lake Basin: cismontane alkali marsh, coastal and valley freshwater marsh, and vernal marsh.

The foothill woodland community type occurs in the foothills and valley borders, usually between 500 and 3,000 feet in elevation. It is typically dominated by one or more species of oaks in association with pines, California buckeye, Ceanothus species, manzanita, and annual grasses. Two subsets of this community type are blue oak woodland, found on the lower slopes of the foothills surrounding the Central Valley, and blue oak-foothill pine woodland, found at slightly higher elevation. Throughout California over the past 25 years, oak woodlands (both foothill and valley) have been lost at a rate of almost 14,000 acres annually to residential and commercial development.

Patches of valley oak woodland occur in the Sacramento and San Joaquin valleys, in the Tehachapi Mountains, and in the valleys of the Coast Ranges. This community type is dominated by valley oak, with species such as sycamore, walnut, interior live oak, poison oak, and blackberry also commonly present. Although valley oak woodland can occur up to elevations of 2,000 feet, it is usually found in the well-drained alluvial soils of valley bottoms.

Sycamore alluvial woodland is a sensitive community that occurs in the southern Coast Ranges and in the Sierra Nevada foothills, from Alameda to Santa Barbara counties. This community type is found along intermittent streams. Rainfall rather than snowmelt usually produce flow in these streams. Sycamore alluvial woodland consists of a winter-deciduous broadleafed riparian woodland with widely spaced sycamores, California buckeyes, and elderberry bushes.

Mixed chaparral can be found in the Coast Ranges and along the lower slopes of the western Sierra Nevada. It usually does not occur above 5,000 feet elevation. This vegetation community is composed of many species, including oaks, manzanita, chamise, California buckeye, and poison oak. Structurally, mixed chaparral is a brushland with the canopy height varying from 3 to 13 feet. Sensitive chaparral habitats in the Tulare Lake Basin are serpentine chaparral and upper Sonoran subshrub scrub.

Chenopod scrub is a broad community type that includes valley, foothill, and desert habitats. The Sacramento and San Joaquin valleys once contained many examples of the various types of foothill and valley chenopod scrubs, but as a result of flood control, agriculture, and groundwater pumping, most of these communities are now limited in their distribution. Chenopod scrub communities consist of shrubby, often succulent species, typically dominated by the Chenopodiaceae family. They occur on poorly drained soils, dry lakebeds, and alluvial fans, often in alkaline or saline soils. Valley sink scrub, valley saltbush scrub, interior coast range saltbush scrub, and Sierra-Tehachapi saltbush scrub are particularly sensitive community types.

The majority of special-status wildlife species are associated with the grasslands, freshwater emergent wetlands and open water habitats that occur on the valley floor. The Tulare Lake Basin contains 106 significant natural areas which contain habitat for many special-status plant and animal species. Sensitive plant species found in the Tulare Lake Basin are listed in Table III-25.

7. Fish

Water diversions, channelization, and construction of irrigation canals and levees have dramatically altered aquatic and riparian habitats in the Tulare Lake area. The vast lakebottom and marsh areas of Tulare Lake and much of its native flora and fauna have been replaced by agriculture. Normal irrigation and farming practices dictate that these irrigation canals often dry up seasonally. In spite of this, several species of fish occur seasonally or perennially when there is water in Tulare Lake, usually only in above-normal water years.

Native fish species include rainbow trout, tule perch, Sacramento sucker, riffle sculpin, and endemic minnows. Recently, neither Sacramento perch nor tule perch has been reported from the drainage, and the extent and diversity of native minnow populations have diminished. Non-native species of both game and nongame fish have been introduced throughout the basin.
Principal game fish in tributaries upstream of the dams are rainbow and brown trout, smallmouth bass, bluegill, and green sunfish. In the reservoirs, the coldwater fishery consists mainly of planted rainbow trout. Largemouth bass, bluegill, redear sunfish, black crappie, and white catfish dominate the warmwater fishery.

Fish habitat downstream from tributary reservoirs is primarily warm water. Trout move out of the lakes and support a trout fishery immediately below some of the dams during fall and winter. Summer water temperatures in these reaches are too warm to sustain coldwater species year round. The rivers are commonly dewatered when there are no irrigation or flood control needs, so fish are seasonal and are usually from upstream areas. When intermittent pools exist, the more hearty and well-adapted species such as carp, Sacramento blackfish, bullhead, green sunfish, bluegill, mosquitofish, hitch, golden shiner, log perch, and Mississippi silverside can usually be found.

The Tulare Lake Basin is not inhabited by any threatened or endangered fish species, but the Kern Brook lamprey is a State listed species of special concern. There also are no species of commercial importance in the basin, although recreational fishing is quite popular, and a variety of coldwater and warmwater game fish are available.

8. Wildlife

A majority of the native wildlife has been extirpated from the Tulare Lake Basin. Many species that occurred historically in the lake basin have been greatly reduced in number due to habitat deterioration and destruction from farming and urban development in the area. A number of wildlife species have been able to adapt to the conversion of grassland community to cultivated lands. These converted lands support large populations of rodents that provide prey for raptors and other wildlife that include rodents in their diet. Other species that have adapted successfully to an agricultural environment include brush rabbits, beechy ground squirrels, white-crowned sparrows, mourning doves, American goldfinches, and house finches. Migratory waterfowl utilize open pastures, harvested fields, and the Goose and Buena Vista Lakes for fall and winter feeding.

Table III-25
Sensitive Plant Species in the Tulare Lake Basin

Scientific Name	Common Name	Status State	Status CNPS	Status Federal
Atriplex tularensis	Bakersfield smallscale	SE	1B	FSC
Brodiaea insignis	Kaweah brodiaea	SE	1B	FSC
Castilleja campestris ssp.*succulenta*	Succulant owl's-clover	SE	1B	FT
Caulanthus californicus	California jewelflower	SE	1B	FE
Chamaesyce hooveri	Hoover's spurge		1B	FT
Cordylanthus palmatus	Palmate-bracted bird's-beak	SE	1B	FE
Eremalche kernensis	Kern mallow		1B	FE
Eriastrum hooveri	Hoover's eriastrum		4	FT
Fritillaria striata	Striped adobe-lily	ST	1	FPT
Gratiola heterosepala	Boggs Lake hedge-hyssop	SE	1B	
Lembertia congdonii	San Joaquin woollythreads		1B	FE
Opuntia basilaris var. treleasei	Bakersfield cactus	SE	1B	FE
Orcuttia inaequalis	San Joaquin Valley Orcutt grass	SE	1B	FT
Pseudobahia bahiifolia	Hartweg's golden sunburst	SE	1B	FE
Pseudobahia peirsonii	San Joaquin adobe sunburst	SE	1B	FT
Tuctoria greenei	Greene's tuctoria	SR	1B	FE

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
CNPS: (California Native Plant Society) 1A=presumed extinct in California; 1B=rare,threatened, or endangered in California and elsewhere; 2=rare,threatened,or endangered in California but more common elsewhere; 3=need more information; 4=distribution limited (a watchlist).
FEDERAL: FE=endangered; FT=threatened; FPE=proposed endangered; FPT=proposed threatened; C=candidate for listing; FSC=species of concern.

Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

A wide variety of wildlife species inhabit the tributary drainages; among them are California mule deer, mountain lion, golden eagle, coyote, and bobcat. Farther downstream, wildlife typical of the low Sierra Nevada foothills becomes less prevalent and species more typical of the valley floor become more numerous. Species common in the lower elevations include valley quail, band-tailed pigeon, dove, osprey, and red-tailed hawk. Wild turkeys have recently been established near the boundary of Sequoia National Park.

A number of threatened or endangered species may occur within the area, including the Sierra red fox, California wolverine, San Joaquin kit fox, San Joaquin antelope squirrel, blunt-nosed leopard lizard, Tipton kangaroo rat, giant kangaroo rat, giant garter snake, peregrine falcon, Swainson's hawk, black-shouldered kite, great blue heron, western snowy plover and spotted owl. Bald eagles frequently winter along the lower reaches, and at one time, the endangered California condor occasionally ranged over the drainage during late summer. The yellow-billed cuckoo has not been reported in this area for a number of years though it was formerly widespread in San Joaquin Valley riparian areas. Its disappearance from the area is probably due to the lack of adequate habitat since it requires relatively large areas of undisturbed riparian areas. Sensitive wildlife species in the Tulare Lake Basin are listed in Table III-26.

9. Recreation

Some water use in recreation areas can be described as indirect usage. Along the California Aqueduct, there are many areas designated for fishing that include easy access from area roads and vehicle parking areas. In the Tulare Lake Region, there are five fishing access areas: Three Rocks, Huron, Kettleman City, Lost Hills, and Buttonwillow. In the foothills, the major reservoirs have recreation areas that are used for fishing, boating, camping, and other recreational uses. Both fishing access and recreation areas show reduced use during drought periods and low-flow months.

During years of normal runoff, white water rafting is a popular activity on the upper Kings and Kern rivers. Stretches of these rivers have been declared wild and scenic by federal legislation. The Kings River is designated as such on both the middle and south fork of the upper portion above Mill Flat Creek. The Kern River is designated wild and scenic on both the north and south fork of the upper portion above Isabella Lake.

The remaining wetlands in the region are mainly freshwater wetlands that provide habitat for migratory waterfowl. These wetlands include the Kern and Pixley NWRs, the Mendota Wildlife Area, and the Tulare lakebed. The Mendota Wildlife Area, which is a regulating basin for the Delta-Mendota Canal, receives about 23,000 acre-feet per year. The Kern NWR has no firm supplies and relies on surplus water from the SWP and groundwater. Pixley NWR has no firm supplies and relies on flood flows from Deer Creek and groundwater.

The Tulare Lake Region has approximately 40 private hunting clubs that encompass over 15,000 acres. In 1990, there were nearly 3,000 acres of privately managed wetlands, including duck clubs, nature preserves owned by nonprofit organizations, and rice lands. In average years, about 7,000 acre-feet of water is supplied to duck club properties.

I. CENTRAL COAST REGION

1. Geography and Climate

The Central Coast Region accounts for about 7 percent of California's total land area. It encompasses the area adjacent to the Pacific Ocean from Santa Cruz County in the north through Santa Barbara County in the south and includes a number of mountain ranges that make up the central portion of the Coast Ranges. The region includes the Pajaro, Carmel, Santa Maria, Cuyama, and Salinas valleys, and the rugged coastline features Monterey Bay and Morro Bay. The Central Coast region, shown in Figure III-16, consists of three broad physiographic regions, including coastal plains, coastal mountains and valleys, and interior mountains and valleys.

Table III-26

Sensitive Wildlife Species in the Tulare Lake Basin

Scientific Name	Common Name	Status: State	Status: Federal
Accipiter cooperi	Cooper's hawk	CSC	
Accipiter striatus	Sharp-shinned hawk	CSC	
Agelaius tricolor	Tricolored blackbird	CSC	FSC
Aquila chrysaetos	Golden eagle	CSC	
Asio flammeus	Short-eared owl	CSC	
Athene cunicularia	Burrowing owl	CSC	
Buteo swainsoni	Swainson's hawk	ST	
Charadrius alexandrinus nivosus	Western snowy plover	CSC	FT
Circus cyaneus	Northern harrier	CSC	
Coccyzus americanus occidentalis	Western yellow-billed cuckoo	SE	
Empidonax traillii	Willow flycatcher	SE	
Falco mexicanus	Prairie falcon	CSC	
Grus canadensis tabida	Greater sandhill crane	ST	
Gymnogyps californianus	California condor	SE	FE
Haliaeetus leucocephalus	Bald eagle	SE	FT
Icteria virens	Yellow-breasted chat	CSC	
Pandion haliaetus	Osprey	CSC	
Plegadis chihi	White-faced ibis	CSC	FSC
Riparia riparia	Bank swallow	ST	
Vireo bellii pusillus	Least Bell's vireo	SE	
Ammospermophilus nelsoni	San Joaquin antelope squirrel	ST	FSC
Antrozous pallidus	Pallid bat	CSC	
Dipodomys ingens	Giant kangaroo rat	SE	FE
Dipodomys ingens brevinasus	Short-nosed kangaroo rat	CSC	
Dipodomys nitratoides nitratoides	Tipton kangaroo rat	SE	FE
Euderma maculatum	Spotted bat	CSC	FSC
Eumops perotis californicus	California mastiff bat	CSC	FSC
Neotoma fuscipes riparia	Riparian woodrat	CSC	C
Onychomys torridus tularensis	Tulare grasshopper mouse	CSC	
Plecotus townsendii townsendii	Townsend's western big-eared bat	CSC	
Sorex ornatus relictus	Buena Vista Lake shrew	CSC	C
Vulpes macrotis mutica	San Joaquin kit fox	ST	FE
Clemmys marmorata	Western pond turtle	CSC	
Gambelia sila	Blunt-nosed leopard lizard	SE	FE
Thamnophis gigas	Giant garter snake	ST	FT
Ambystoma californiense	California tiger salamander	CSC	C
Rana aurora draytonii	California red-legged frog	CSC	FT
Rana boylii	Foothill yellow-legged frog	CSC	FSC
Scaphiopus hammondii	Western spadefoot toad	CSC	FSC
Branchinecta longiantenna	Longhorn fairy shrimp		FE
Branchinecta lynchi	Vernal pool fairy shrimp		FT
Desmocerus californicus dimorphus	Valley elderberry longhorn beetle		FT

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
FEDERAL: FE=endangered; FT=threatened; FPE=proposed endangered; FPT=proposed threatened; C=candidate for listing; FSC=species of concern.
Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

The varied geography of the region creates diverse climates. During the summer months, temperatures are generally cool along the coastline and warm inland. In the winter, temperatures remain cool along the coast and become even cooler inland.

Annual precipitation in the northern region ranges from 14 to 45 inches, usually in the form of rain, with most it occurring from November through April. The average annual precipitation near the City of Salinas is about 14 inches while in the higher elevations of the Big Sur area south of Monterey, precipitation averages about 40 inches per year. Average annual precipitation in the southern coastal basins ranges from 12 to 20 inches. The southern interior basins usually receive from 5 to 10 inches per year, with the mountain areas receiving more than the valley floors.

2. Population

With a 1990 population slightly under 1.3 million, the Central Coast Region contains roughly 4 percent of California's total population. Growth in this region from 1980 to 1990 exceeded the State's average. The collective population of incorporated cities in the Salinas Valley increased 37 percent, and population centers such as San Luis Obispo and Santa Maria had increases of 23 and 54 percent, respectively.

Despite population increases, much of the region is sparsely populated. The principal population centers are Santa Cruz, Salinas, Watsonville, Monterey, San Luis Obispo, Santa Maria, Santa Barbara, and Lompoc.

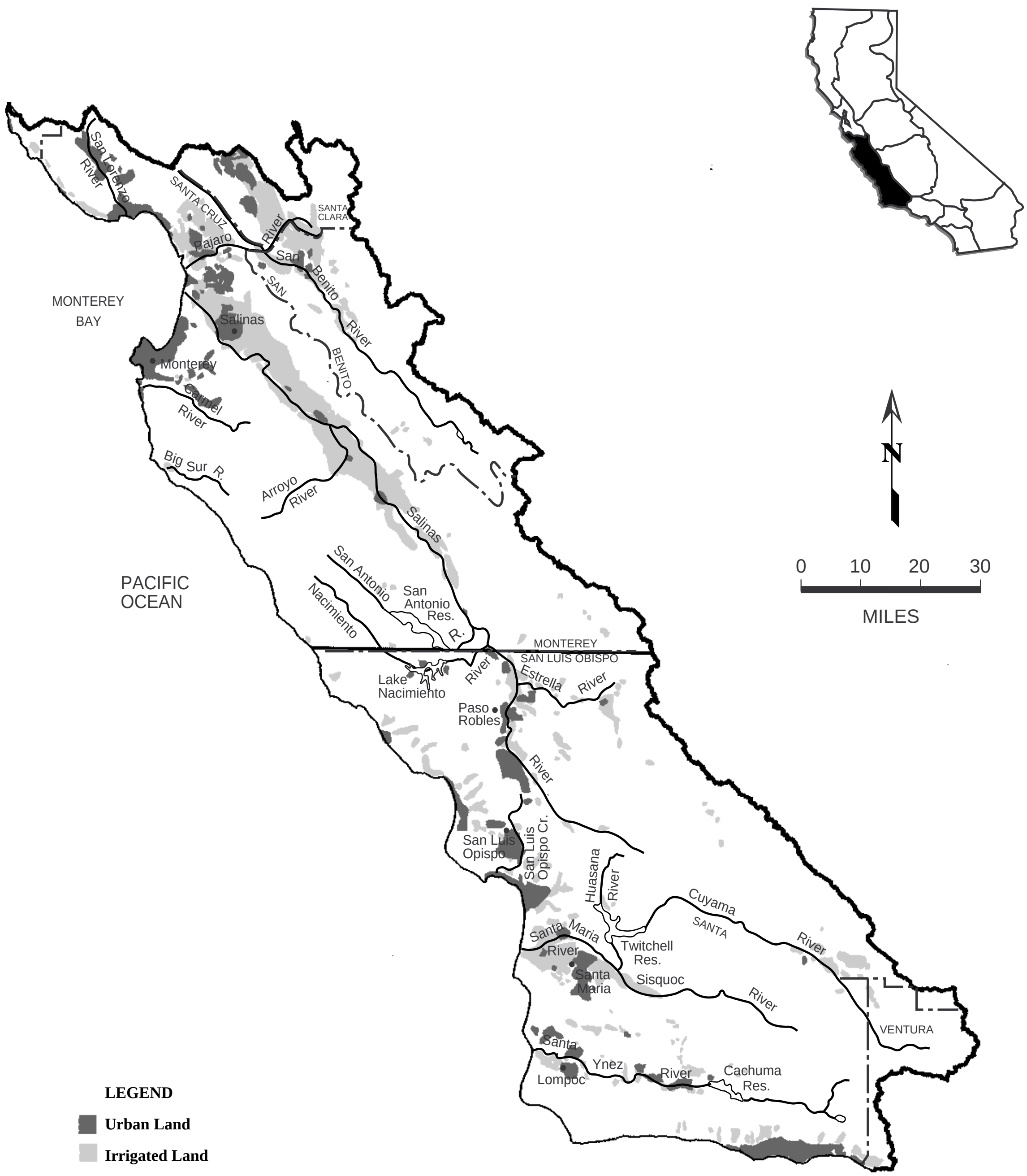
3. Land Use and Economy

The economy of several areas of the region is tied to military installations. Fort Ord, Hunter-Liggett Military Reservation, Camp Roberts, and Vandenberg AFB are the major military facilities in the region, although Fort Ord was recently closed.

Publicly owned lands constitute approximately 28 percent of the region's area. The four major military installations within the region occupy 340,000 acres. State parks and national forests provide about 1.3 million acres for public recreation. Elkhorn Slough National Estuarine Research Reserve is one of the few remaining coastal wetlands. The slough is on a migratory flyway and is an important feeding and resting ground for waterfowl.

Irrigated and nonirrigated agriculture remain the dominant land use for most of the Central Coast region. Intensive agriculture exists in the Salinas and Pajaro valleys in the north and the Santa Maria and lower Santa Ynez valleys in the south. Moderate levels of agricultural activity also occur near the upper Salinas, South Coast, and Cuyama areas. Most of the region's irrigated agriculture is in the northern and southwestern valleys, and irrigated acreage has decreased slightly in recent years as a result of urban encroachment.

Figure III-16
Central Coast Region



Source: DWR, Bulletin 160-93 (1994)

Vegetables and other truck crops are the primary crops grown in the region, with many acres planted in vineyards and orchards. Cut flowers, strawberries, and specialty crops, such as asparagus, mushrooms, artichokes, and holly, are distinctive to the northern region. The flower seed industry is important in Lompoc Valley and also attracts many tourists. Portions of the upper Salinas Valley and Carrizo Plain are dry-farmed to produce winter grain. These areas also support sheep and cattle ranching. Manufacturing is limited, but heavy water-using industries, such as petroleum production and refining, food processing, and stone, clay, and glass products manufacturing are present.

4. Water Supply

Groundwater is the primary source of water for the region. The average water supply for the 1990 level of development is about 1.1 million acre-feet. In 1990, groundwater pumping amounted to 82 percent of total supplies, 21 percent of which was in excess of the estimated prime supply and is considered overdraft.

Currently, imported supplies account for only 5 percent of the total water supply. This water is delivered to the northern part of the region from the CVP through the San Felipe Project. Completion of the Coastal Branch of the SWP in 1997 has lessened the reliance on groundwater supplies in San Luis Obispo and Santa Barbara counties. The Coastal Branch facilities are expected to transport 52.7 TAF of water to the area, though full SWP entitlement is 70.5 TAF per year for these areas. Santa Barbara County has the option to buy back an additional 12.2 TAF per year of SWP water.

a. Surface Water Hydrology. The Santa Ynez, Santa Maria, and Salinas rivers constitute the major drainages of the Central Coast region, although numerous lesser streams exist. There are in excess of 60 reservoirs, most of which are privately owned. The reservoirs in the region are used for residential and municipal water needs, flood control, recreation, irrigation, and riparian habitat. Table III-27 lists the major reservoirs in the Central Coast Region.

The Salinas River, the largest single watershed in the Central Coast area, flows northward through Monterey County to Monterey Bay. San Antonio and Nacimiento Reservoirs store and regulate the flows on the major tributaries to the Salinas River which, together with the Carmel and Pajaro rivers, provide most of the groundwater recharge for the northern part of the region. Smaller watersheds in the northern part of the region include San Luis, Chorro, San Juan, and Arroyo Grande creeks.

Basins in the southern part of the region are smaller, but locally important. The Santa Maria River and its Cuyama River tributary form the boundary between San Luis Obispo and Santa Barbara counties. Twitchell Reservoir is located on the Cuyama River. The Sisquouc River, tributary to the Santa Maria River, is listed as a federal Wild and Scenic River. The Santa Ynez River drains the southern portion of Santa Barbara County with Lake Cachuma as the primary storage facility. Salsipuedes Creek is a major stream in the Santa Ynez Valley. Lesser streams include San

Antonio, Alisal, Alamo Pintado, and Santa Aqueda creeks, Atascadero Creek in Goleta, Mission and Sycamore creeks in the city of Santa Barbara, and Santa Monica, Steer, and Rincon creeks in the Carpinteria area.

Table III-27
Major Reservoirs in the Central Coast Region

Reservoir	River	Capacity (TAF)	Owner
Santa Margarita Lake	Salinas	24	USACE
San Antonio	San Antonio	335	MCWRA
Nacimiento	Nacimiento	340	MCWRA
Gibralter	Santa Ynez	9	City of Santa Barbara
Cachuma (Bradbury)	Santa Ynez	190	USBR
Whale Rock	Old Creek	41	DWR
Lopez	Arroyo Grande Creek	52	SLOCFCWCD
Vaquero (Twitchell)	Cuyama River	240	USBR

Source: DWR 1993b

b. Surface Water Quality. The population of the Central Coast has grown substantially in the past few decades, and surface water of adequate quality is now in short supply. Water quality problems are not often evident, although bacterial contamination of coastal waters has been noted in Morro Bay and southern Santa Barbara County. Other streams in the Central Coast area, such as the Cuyama River, are highly mineralized (above 1000 milligrams/liter total dissolved solids), which contributes to high groundwater salinity.

Water quality of streams in San Luis Obispo County typically varies from good (water that supports and enhances the designated beneficial uses) to intermediate (water that supports designated beneficial uses but is degraded occasionally). However, some streams contain water of impaired quality (water that cannot reasonably be expected to attain or maintain applicable water quality standards). The Salinas River has about 120 miles of good water quality, 30 miles of intermediate, and 30 miles of impaired. Water quality problems are caused by agricultural return flows that carry toxic organics. San Luis Obispo Creek contains 8 miles of good water quality and 10 miles of impaired. Water quality problems are caused by sedimentation, which has led to impaired spawning habitat and a decline in the fishery. Lower San Luis Obispo Creek experiences eutrophication problems. Santa Rosa Creek consists of 12 miles of intermediate quality water. This may be a result of natural nickel, chromium, and mercury in the water and in streambed sediments. The Cuyama River, which runs through both San Luis Obispo and Santa Barbara counties, has 91 miles of intermediate water quality. Below Twitchell Reservoir, the river contains elevated levels of NO_3, SO_4 and total dissolved solids. Chorro Creek has 3 miles of intermediate quality water and 8 miles of impaired water. Inactive mines and sedimentation contribute to the water quality problems.

Major streams in Santa Barbara County typically have water of intermediate or impaired quality. Rincon Creek consists of 9 miles of intermediate water quality, principally caused by sedimentation problems. Santa Monica Creek, with pesticides present in stream sediments, has 4 miles of intermediate water quality. The Sisquouc River has 45 miles of river with intermediate quality and has only seasonal flow, with sedimentation problems. The Santa Ynez River has 59 river miles of intermediate water quality and 11 miles of impaired quality. Coliform, conductivity, and excessive total dissolved solids have contributed to the water quality problems. Mission Creek contains 9 miles of stream with impaired water quality. Coliform levels cause some of the water quality problems, and runoff is also suspected to contain metals and organics.

Half of the major reservoirs in the Central Coast area contain water of unknown quality (Vaquero/Twitchell, Santa Margarita, Lopez, and Whale Rock). Jameson Reservoir is characterized as having good water quality, as are Lake Cachuma and Gibraltar Reservoir, which also have limited sedimentation problems. Additionally, Gibraltar Reservoir contains mercury mine tailings. Lake Nacimiento contains water of impaired quality, as evidenced by elevated levels of toxic substances in fish tissue levels.

c. Groundwater Hydrology. There are approximately 53 groundwater basins, subbasins, and storage areas in the Central Coast Region. Most of the groundwater basins are small but important to their local communities. These shallow basins underlie seasonal coastal streams. During years with normal or above-normal rainfall, aquifers in the basins are continuously replenished by creek flows. In years of below-normal precipitation, the creek flows are intermittent, flow is insufficient for both agriculture and municipal uses, wells become dry, and seawater intrudes into some coastal groundwater basins.

There are nine groundwater basins in San Luis Obispo County, some of which are shared with Monterey and Santa Barbara counties. The nine basins are Paso Robles Basin, Cholame Valley, Los Osos Valley, San Luis Obispo Valley, Pismo Creek Valley, Arroyo Grande Valley-Nipomo Mesa area, Santa Maria River Valley, Cuyama Valley, and Carrizo Plain. Pismo Creek Valley (10 square miles) is the smallest, and Paso Robles Basin (860 square miles) is the largest. Storage capacity of the nine basins ranges from 30,000 acre-feet to 6,800,000 acre-feet, and usable capacity ranges from 10,000 acre-feet to 1,700,000 acre-feet.

Santa Barbara County has seven identified groundwater basins, including those that are shared with San Luis Obispo and Ventura counties. The seven basins are Santa Maria River Valley, Cuyama Valley, San Antonio Creek Valley, Santa Ynez River Valley, Goleta Basin, Santa Barbara Basin, and Carpinteria Basin. Carpinteria Basin (12 square miles) is the smallest, and Santa Ynez River Valley (260 square miles) is the largest. The storage capacity of these basins ranges from 140,000 acre-feet to 2,700,000 acre-feet and the usable capacity ranges from 19,000 acre-feet to 362,000 acre-feet.

The Cuyama Valley basin is subject to critical conditions of overdraft because extraction, evapotranspiration, and outflow outpace natural groundwater recharge. Irrigation water use in the basin increased 53,000 acre-feet between 1939 and 1980. Groundwater levels in the western and central parts of the valley declined from 50 to 200 feet between 1950 and 1980, and the loss of groundwater storage capacity between 1947 and 1978 was 700,000 acre-feet.

d. Groundwater Quality. Water quality in the Central Coast Region is generally quite good. Groundwater temperature ranges from about 55EF to about 75EF. TDS content of the water is generally less than 800 milligrams per liter, but locally it can be more than 11,000 milligrams per liter. The predominant water type is calcium bicarbonate; however, sodium, magnesium, sulfate, and chloride are present locally in significant quantities.

In San Luis Obispo County, most groundwater basins have only minor water quality problems. The Paso Robles Basin has locally high levels of boron for irrigation use, and the Los Osos Valley has some areas of sea water intrusion, as well as locally high levels of chlorides for domestic or irrigation uses and for prevention of seawater intrusion. Along the coastal margin of Pismo Creek Valley, TDS, chloride, and sulfate are high for domestic use, and locally, in the Pismo basin, TDS and nitrates are high for domestic use. The lower Arroyo Grande Valley commonly has high nitrates for domestic use, and along the coastal margin TDS, chlorides, and sulfates are high for domestic uses. The Santa Maria River Valley is locally high in TDS for domestic use. The Cuyama Valley has local areas of groundwater that are unsuitable for domestic or irrigation use, and near Soda Lake in the Carrizo Plain, the groundwater is generally unsuitable for domestic and irrigation uses.

In Santa Barbara County, the San Antonio Creek and Santa Ynez River valleys are locally high in TDS for domestic and irrigation use. In the Goleta Basin, there are locally high levels of TDS, manganese, and iron for domestic use. In the Santa Barbara Basin, TDS is high for domestic use and boron and chlorides are also high, and seawater is possibly intruding into the basin. The Carpinteria Basin also has possible seawater intrusion.

5. Water Use

In 1990, the total net water use was 1,143,000 acre-feet. Agricultural water use accounted for 78 percent of the total water use in the region, while urban water use was 20 percent of the total. Energy production, environmental needs, conveyance losses, and recreation make up the remainder of total water use. Forecasts indicate that average annual water demand will increase by about 13 percent by 2020.

Urban net water demand for the region in 1990 was 229,000 acre-feet. The average per capita water use in the Santa Barbara and San Luis Obispo areas was 187 and 190 gallons, respectively. These values reflect the average use for the region, which includes highs of about 250 gallons per day in the warmer inland communities of Hollister and King City and lows of about 150 gallons per day in the chronically water-short, but cooler Monterey-Carmel area. While population in the Central Coast is expected to increase by about 56 percent by 2020 to over 2 million people, the urban water use in the region is not projected to increase proportionally.

Irrigated agriculture has remained relatively stable in the Central Coast Region during the past decade and is forecasted to increase just slightly by 2020. Irrigated crop acreage in 1990 was

528,000 acres and the total applied water demand was 1,140,000 acre-feet. Total agricultural net water demand was 893,000 acre-feet.

6. Vegetation

Much of the natural vegetation in the Central Coast Region remains relatively undisturbed. Those areas that have been developed have mainly been the valleys, alluvial fans and plains, and terraces. Vegetation found in the Central Coast service area can be divided into a number of broad categories, or vegetation communities. These communities contain both native and non-native species.

Plant communities found in the area include valley and foothill riparian, grassland, freshwater emergent wetland, saline emergent wetland, foothill woodland, sycamore alluvial woodland, mixed chaparral, chenopod scrub, coastal scrub, coastal dunes, coast live oak forest, montane hardwood forest, and mixed conifer forest. Numerous sensitive plant species occur in these communities. Sensitive plant species found in the Central Coast region are listed in Table III-28.

Sensitive riparian habitats in the Central Coast region include central coast live oak riparian forest, central coast cottonwood-sycamore riparian forest, central coast arroyo willow riparian forest, and central coast riparian scrub. Sensitive grassland habitats include vernal pools, serpentine bunchgrass, pine bluegrass grassland, wildflower fields, and freshwater seeps. Sensitive wetland habitats include coastal and valley freshwater marsh, vernal marsh, northern coastal salt marsh and coastal brackish marsh. Other sensitive habitats that are found in the Central Coast region include central maritime chaparral, interior coast range saltbush scrub, and central dune scrub.

7. Fish

A wide variety of fish, including both warmwater and coldwater species, can be found in the streams and reservoirs of the Central Coast area. Threespine stickleback, sculpin, speckled dace, and Sacramento squawfish can be found in many of the streams. Some streams have runs of steelhead or populations of tidewater gobies. Most reservoirs contain populations of brown bullhead, bluegill, white catfish, channel catfish, smallmouth bass, largemouth bass, threadfin shad, and black crappie. Golden shiner, red-eared sunfish, trout (planted), Alabama bass, striped bass, and spotted bass are also found in some reservoirs. San Antonio Reservoir has a commercial fishery for carp and goldfish. Whale Rock Reservoir contains a population of landlocked steelhead, while California's only legal population of white bass is found in Nacimiento Reservoir.

No species of salmon are found in the streams south of Monterey Bay. However, three other significant fish species are found along the central coast streams, including winter run steelhead, tidewater goby, and the unarmored threespine stickleback. Sensitive fish species found in the Central Coast region are listed in Table III-29.

Table III-28

Sensitive Plant Species in the Central Coast Region

Scientific Name	Common Name	Status State	Status CNPS	Status Federal
Arctostaphylos hookeri ssp. *hearstorium*	Hearst's manzanita	SE	1B	FSC
Arctostaphylos morroensis	Morro manzanita		1B	FT
Arenaria paludicola	Marsh sandwort	SE	1B	FE
Bloomeria humilis	Dwarf goldenstar	SR	1B	FSC
Castilleja mollis	Soft-leaved Indian paintbrush		1B	FPE
Caulanthus californicus	California jewelflower	SE	1B	FE
Ceanothus hearstorium	Hearst's ceanothus	SR	1B	FSC
Ceanothus maritimus	Maritime ceanothus	SR	1B	FSC
Chlorogalum purpureum var.reductum	Camatta Canyon amole	SR	1B	C
Cirsium fontinale var. *obispoensis*	Chorro Creek bog thistle	SE	1B	FE
Cirsium loncholepis	La Graciosa thistle	ST	1B	C
Cirsium rhothophilum	Surf thistle	ST	1B	C
Clarkia speciosa ssp. *immaculata*	Pismo clarkia	SR	1B	FE
Crodylanthus maritimus ssp. *maritimus*	Salt marsh bird's-beak	SE	1B	FE
Cordylanthus rigidus ssp.*littoralis*	Seaside bird's-beak	SE	1B	FSC
Dithyrea maritima	Beach spectaclepod	ST	1B	FSC
Eremalche kernensis	Kern mallow		1B	FE
Eriastrum hooveri	Hoover's eriastrum		4	FT
Eriodictyon altissimum	Indian Knob mountainbalm	SE	1B	FE
Eriodictyon capitatum	Lompoc yerba santa	SR	1B	C
Hemizonia increscens ssp. *villosa*	Gaviota tarplant	SE	1B	C
Lasthenia conjugens	Contra Costa goldfields		1B	FPE
Layia carnosa	Beach layia	SE	1B	FE
Lembertia congdonii	San Joaquin woollythreads		1B	FE
Lupinus nipomensis	Nipomo Mesa lupine	SE	1B	C
Pedicularis dudleyi	Dudley's lousewort	SR	1B	FSC
Rorippa gambellii	Gambel's watercress	ST	1B	FE
Sanicula maritima	Adobe sanicle	SR	1B	FSC
Sidalcea hickmanii ssp. *anomala*	Cuesta Pass checkerbloom	SR	1B	FSC
Sidalcea hickmanii ssp. *parishii*	Parish's checkerbloom	SR	1B	C
Suaeda californica	Califomia sea blite		1B	FE
Thermopsis macrophylla	Santa Ynez false-lupine	SR	1B	FSC

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
CNPS: (California Native Plant Society) 1A=presumed extinct in California; 1B=rare,threatened, or endangered in California and elsewhere; 2=rare,threatened,or endangered in California but more common elsewhere; 3=need more information; 4=distribution limited (a watchlist).
FEDERAL: FE=endangered; FT=threatened; FPE=proposed endangered; FPT=proposed threatened; C=candidate for listing; FSC=species of concern.
Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

Table III-29
Sensitive Fish Species in the Central Coast Region

Scientific Name	Common Name	Status State	Status Federal
Eucyclogobius newberryi	Tidewater goby	CSC	FE
Gasterosteus aculeatus williamsoni	Unarmored threespine stickleback	SE	FE
Oncorhynchus mykiss	Steelhead, Southern California ESU	CSC	FE
Oncorhynchus mykiss	Steelhead, South Central California Coast ESU	CSC	FT
Oncorhynchus mykiss	Steelhead, Central California Coast ESU		FT

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
FEDERAL: FE=endangered; FT=threatened; FPE=proposed endangered; FPT=proposed threatened; C=candidate for listing; FSC=species of concern.

Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

Steelhead runs still exist within San Luis Obispo and Santa Barbara counties, although they have declined from historical levels. In San Luis Obispo County, both San Simeon and Santa Rosa creeks have reduced population levels due to loss of instream habitat. In Chorro Creek, the only spawning habitat is below an impassable dam and is often dewatered during the summer. Arroyo de la Cruz, however, remains fairly pristine and is one of the healthiest steelhead streams in the area.

The Santa Ynez River in Santa Barbara County historically had the largest steelhead runs in southern California. Now the population is almost extirpated due to dams blocking access to most spawning and rearing habitat. This population might possibly be restored if adequate flows are provided. The Santa Ynez River drains the north slope of the Santa Ynez Mountains. Streams draining the south slope also had steelhead runs historically. Resident rainbow trout are still present in most of these streams.

Steelhead, including the Southern California, South Central California Coast, and Central California Coast Evolutionary Significant Units (ESU), were listed under the Endangered Species Act by the National Marine Fisheries Service in August 1997.

8. Wildlife

The Central Coast region contains a wide variety of habitats, from desert scrub to riparian forest, which in turn support diverse animal communities. Because of the overlap between the northern and southern floristic elements, many rare and endangered species inhabit the Central Coastal region. Among the common animal species are mule deer, mountain lion, bobcat, coyote, turkey, hawks, passerines, rodents, snakes, lizards, amphibians, and insects.

Within the riparian areas of the Central Coast, common wildlife species include striped skunks, raccoons, gray fox, pond turtles, various passerines and neotropical migrants, waterfowl, and wading birds. Grasslands contain vernal pool species, as well as species adapted to more arid habitats, like the San Joaquin kit fox, kangaroo rats, and various raptors. The foothill and sycamore woodlands provide habitat for large mammals such as the mountain lion, bobcat, and black-tailed deer, as well as smaller creatures like squirrels, snakes, and quail.

In addition to the common species of the coastal mountains and valleys, the diverse plant communities support 51 sensitive animal species. These include State- or federal-listed species, candidate species, and species of special concern. Of these 51, about half are officially listed as threatened or endangered. Table III-30 lists the sensitive wildlife species found in the Central Coast region.

9. Recreation

The Central Coast Region contains a broad spectrum of recreational opportunities due to its wide variety of habitats. The topography ranges from the interior mountains and valleys to coastal mountains and valleys to the coastal plain. The coastline provides areas for tide-pooling, wildlife watching, hiking, picnicking, swimming, surfing, diving, and fishing, as well as recreational boating and sport fishing on the ocean. The Henry Cowell Redwoods and Pfeiffer Big Sur State Parks are popular recreation areas. Inland, the Los Padres National Forest also provides many recreational opportunities such as hiking, camping, wildlife watching, fishing, and picnicking. Water related recreational opportunities are provided at many of the rivers and reservoirs in the area, including Lake San Antonio, Lake Nacimiento, Lake Cachuma, and Lopez Lake.

J. SOUTHERN CALIFORNIA

The discussion of the environmental setting for Southern California will focus on the areas included in the SWP Contractors' Service Area. This will include the South Coast Region, as described in Bulletin 160-93 (DWR 1994), and will also include the Antelope Valley and Mojave areas of the South Lahontan Region and the Coachella Valley area of the Colorado River Region. Figure III-17 shows the Southern California region.

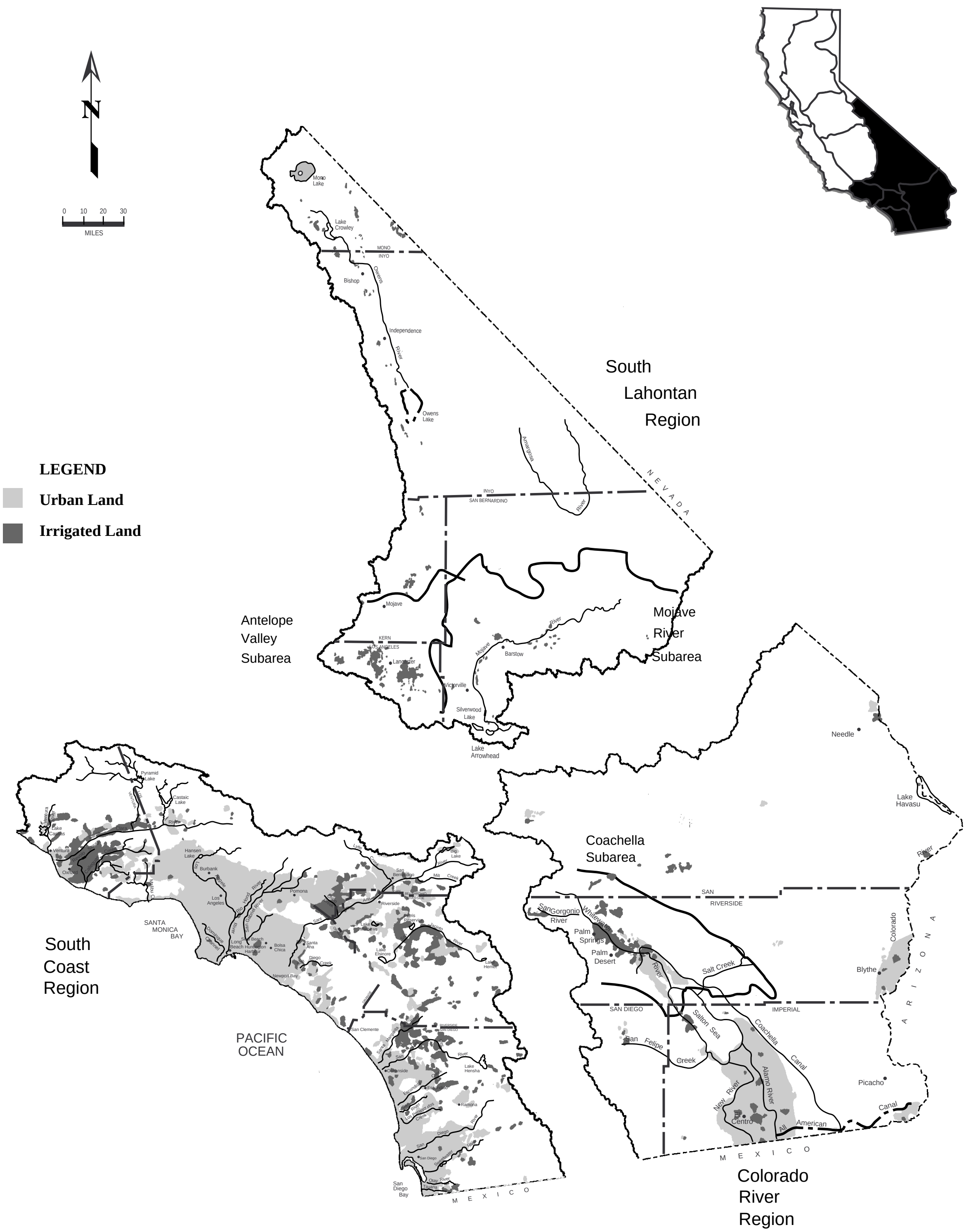
The principal SWP contracting agencies in the Southern California service area include: the Metropolitan Water District of Southern California; Antelope Valley-East Kern, Castaic Lake, Crestline-Lake Arrowhead, Desert, Mojave, and San Gorgonio Pass Water Agencies; Coachella Valley and San Gabriel Valley Municipal Water Districts; and Ventura County Flood Control District. The SWP Southern California service area comprises approximately 10.6 million acres.

Table III-30
Sensitive Wildlife Species in the Central Coast Region

Scientific Name	Common Name	Status: State	Status: Federal
Accipiter cooperi	Cooper's hawk	CSC	
Accipiter striatus	Sharp-shinned hawk	CSC	
Agelaius tricolor	Tricolor blackbird	CSC	FSC
Aquila chrysaetos	Golden eagle	CSC	
Asio flammeus	Short-eared owl	CSC	
Asio otus	Long-eared owl	CSC	
Athene cunicularia	Burrowing owl	CSC	
Brachyramphus marmoratus	Marbled murrelet	SE	FT
Buteo regalis	Ferruginous hawk	CSC	
Buteo swainsoni	Swainson's hawk	ST	
Charadrius alexandrinus nivosus	Western snowy plover	SC FT	
Circus cyaneus	Northern harrier	CSC	
Coccyzus americanus occidentalis	Western yellow-billed cuckoo	SE	
Dendroica petechia brewsteri	Yellow warbler	CSC	
Empidonax traillii	Willow flycatcher	SE	
Falco mexicanus	Prairie falcon	CSC	
Gymnogyps californianus	California condor	SE	FE
Haliaeetus leucocephalus	Bald eagle	SE	FT
Icteria virens	Yellow-breasted chat	CSC	
Ixobrychus exilis hesperis	Western least bittern	CSC	FSC
Laterallus jamaicensis conturniculus	California black rail	ST	FSC
Numenius americanus	Long-billed curlew	CSC	
Pelecanus occidentalis californicus	California brown pelican	SE	FE
Phalacrocorax auritus	Double-crested cormorant	CSC	
Progne subis	Purple martin	CSC	
Rallus longirostris obsoletus	California clapper rail	SE	FE
Riparia riparia	Bank swallow	ST	
Sterna antillarum browni	California least tern	SE	FE
Toxostoma lecontei	Le Conte's thrasher	CSC	
Vireo bellii pusillus	Least Bell's vireo	SE	
Ammospermophilus nelsoni	San Joaquin antelope squirrel	ST	FSC
Dipodomys heermanni morroensis	Morro Bay kangaroo rat	SE	FE
Dipodomys ingens	Giant kangaroo rat	SE	FE
Dipodomys nitratoides brevinasus	Short-nosed kangaroo rat	CSC	
Euderma maculatum	Spotted bat	CSC	FSC
Onychomys torridus tularensis	Tulare grasshopper mouse	CSC	
Plecotus townsendii townsendii	Townsend's western big-eared bat	CSC	
Vulpes macrotis mutica	San Joaquin kit fox	ST	FE
Clemmys marmorata	Western pond turtle	CSC	
Gambelia sila	Blunt-nosed leopard lizard	SE	FE
Phrynosoma coronatum frontale	California horned lizard	CSC	
Ambystoma californiense	California tiger salamander	CSC	C
Bufo microscaphus calfiornicus	Arroyo toad	CSC	FE
Rana aurora draytonii	Calfiornia red-legged frog	CSC	FT
Rana boylii	Foothill yellow-legged frog	CSC	FSC
Branchinecta longiantenna	Longhorn fairy shrimp		FE
Branchinecta lynchi	Vernal pool fairy shrimp		FT
Euphilotes enoptes smithi	Smith's blue butterfly		FE

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
FEDERAL: FE=endangered; FT=threatened; FPE=proposed endangered; FPT=proposed threatened; C=candidate for listing; FSC=species of concern.
Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

Figure III-17
Southern California Regions



Source: DWR, Bulletin 160-93 (1994)

1. Geography and Climate

The South Coast Region is the most urbanized region of California. Although it covers only about 7 percent of the State's total land area, it contains over half of the State's population. The region extends east from the Pacific coast and is bounded on the north by the Santa Barbara/Ventura county line and the San Gabriel and San Bernardino mountains, on the south by the Mexican border, and on the east by the San Jacinto Mountains and low-elevation mountain ranges in central San Diego County. The SWP Southern California service area includes Ventura, Los Angeles, and Orange counties, and portions of San Bernardino, Riverside, San Diego, Kern and Imperial counties.

Topographically, the South Coast Region is comprised of a series of broad coastal plains, gently sloping inland valleys, and mountain ranges of moderate elevation. The largest mountain ranges of the region are the San Gabriel, San Bernardino, San Jacinto, Santa Rosa, and Laguna mountains. Peak elevations are generally between 5,000 and 8,000 feet above sea level; however, some peaks are nearly 11,000 feet high. The SWP service area also includes interior deserts in the Antelope, Mojave, and Coachella valleys which are generally east of the South Coast Region. The Coachella Valley is located at the northwest end of the Salton Trough, which extends from San Gorgonio Pass to the Gulf of California. The Salton Sea is situated at the lowest point of the trough and lies below sea level.

The climate of the region is Mediterranean-like, with warm dry summers and mild wet winters. Summer temperatures along the coast are relatively cool as a result of the moderating influence of the ocean. In the warmer interior, summer temperatures are often over 90EF. In the inland deserts, average summer maximum temperatures are 105-110EF. During winter, temperatures seldom drop below freezing except in the mountains and some interior valleys.

Average annual rainfall can range from 10 to 15 inches on the coastal plains and 20 to 45 inches in the mountains. The interior deserts average as little as 4 inches per year. Most of the precipitation falls between December and March. Precipitation in the higher mountains frequently occurs as snow, and in most years, snowfall is sufficient to support winter recreation in the San Gabriel and San Bernardino mountains.

The primary River Basins of the South Coast Region include the Santa Clara, Los Angeles, San Gabriel, Santa Ana, Santa Margarita, and San Luis Rey. Some portions of these rivers have been intensively modified for flood control. The natural runoff of the region's streams and rivers averages about 1.2 million acre-feet per year.

2. Population

The population in the South Coast Region in 1990 was over 16 million, an increase of 26 percent from the 1980 level. Most of the increase is due to immigration, both from within the United States and from around the world. Most of the region's coastal plains are densely populated. The largest cities include Los Angeles, San Diego, Long Beach, Santa Ana, and Anaheim; each is among California's ten most populated cities and Los Angeles and San Diego rank second and sixth largest in the United States, respectively. The region includes six of the ten fastest growing cities with populations between 50,000 and 200,000. They include Corona, Fontana, Tustin, Laguna Niguel, National City, and Rancho Cucamonga. Areas undergoing increased urbanization include the coastal plains of Orange and Ventura counties, the Santa Clarita Valley in northwestern Los Angeles County, the Pomona/San Bernardino/Moreno valleys, and the valleys north and east of the City of San Diego. The population of this region is expected to increase by 55 percent by 2020.

The desert regions contain some of the fastest growing urban areas in California, including the cities of Lancaster and Palmdale in the Antelope Valley of Los Angeles County and the Victor and Apple valleys of San Bernardino County. Many new resident in these valleys commute to the greater Los Angeles area to work. Major local employment includes the aerospace industry of Palmdale Airport and Edwards Air Force Base. The combined population in the Mojave and Antelope valleys in 1990 was about 525,000. Major cities in the Coachella Valley include Palm Springs, Indio, Cathedral City, and Palm Desert. The 1990 population for the Coachella Valley was 263,000.

3. Land Use

Since the 1940's, Southern California has changed from a largely rural community with an agricultural economy to a highly urban-industrial society. Despite being so urbanized, about one-third of the South Coast Region's land is publicly owned. Of the approximately 2.3 million acres of public land, about 75 percent is national forest. Urban land use accounts for about 1.7 million acres and irrigated cropland accounts for less than 300,000 acres.

The major industries in the region are national defense, aerospace, recreation and tourism, and agriculture. Other large industries include electronics, motion picture and television production, oil refining, housing construction, government, food and beverage distribution, and manufacturing (clothing and furniture). While defense, aerospace, and oil refining are in decline, the South Coast Region has a strong and growing commercial services sector. International trading, financing, and basic services are major economic contributors to the region.

In the coastal areas of Southern California, agriculture remains important economically, despite urbanization. Farms generally produce high value crops on small irrigated parcels. The largest amount of irrigated agriculture is in Ventura County, where 116,600 acres of cropland is devoted primarily to fresh market vegetables, strawberries, and citrus and avocados. The San Diego area has more than 110,000 acres in irrigated agriculture, most of which is planted in citrus and avocados. Fresh market vegetables are grown throughout the regions coastal and inland valleys which are also ideally suited for growing other high-value crops such as nursery products and cut flowers. Other irrigated agriculture includes forage and field crops related to the dairy industry and vineyards.

Agriculture is also important in the Colorado Desert, especially in the Coachella and Imperial valleys, where livestock, field crops, truck crops, grain, sugar beets, and cotton are produced. There were 74,000 irrigated acres in the Coachella Valley in 1990. Poultry, livestock, and field crops are produced in the Mojave Desert. Alfalfa and pasture are the principal crops grown on approximately 26,000 acres of irrigated agricultural lands in the Antelope and Mojave basins. Almond, apple, apricot, pear, grain, and some truck crops are also grown.

Recreation and tourism together have become the second most important industry in the Coachella Valley. Developers have constructed world-class hotels, country clubs, golf courses, and residential communities. Over 90 golf courses have been established in the valley, contributing to the influx of retirees and vacationers from around the world.

4. Water Supply

Because local water supplies are limited, imported water has played a significant role in meeting the area's growing water demands. Since the turn of the century, water development has been carried out on a massive scale throughout Southern California. Steady expansion of the population and economy lead to sufficient demand and financial backing to build large water supply projects for importing water into the region. Due to the highly seasonal precipitation, the major rivers in the service area do not provide a substantial or reliable surface water supply. The runoff in the intermittent streams that flow from the mountains primarily percolates into groundwater basins. Most of the local water sources have been developed to provide flood control, groundwater recharge, and water supply. About two thirds of the South Coast Region's 1990 water supply comes from surface water imports. The remaining portion is supplied by groundwater (25 percent), local surface water (6 percent), and reclaimed water (2 percent).

Water is imported into Southern California from three sources: (1) the Owens Valley and Mono Lake Basin; (2) the Colorado River; and (3) the SWP. The City of Los Angeles first brought imported water into the area from Owens Valley via the Los Angeles Aqueduct in 1913. With the addition of a second conduit in 1970, the Mono-Owens supply is about 10 percent of the region's 1990 level water supply. As development on the coastal plain increased, the Colorado River was tapped as a second imported supply by the Metropolitan Water District of Southern California (MWD), which constructed the Colorado River Aqueduct in 1941. The Colorado River provides about 29 percent of the 1990 level water supply. Both of these import facilities have been operating at or near capacity. A third major source of imported water, the SWP, first made deliveries from the Sacramento-San Joaquin Delta to the Southern California area through the California Aqueduct in 1972, and today furnishes about 28 percent of the region's supply. SWP service contractors in Southern California have entitlement to 2.5 million acre-feet, which is 59 percent of the ultimate minimum yield of the project; however, not all of the SWP contractors receive their full entitlement at this time.

Three significant events have occurred subsequent to 1990 which will likely reduce imports to the region via the Los Angeles Aqueduct by a significant amount. These events include: (1) adoption by the SWRCB of Water Right Decision 1631, which substantially reduced the water available for export from the Mono Basin; (2) approval by the City of Los Angeles and the County of Inyo of the Inyo-Los Angeles Agreement, which will substantially reduce the quantity of groundwater that can be exported from the Owens Valley; and (3) adoption by the Great Basin Unified Air Pollution Control District of a state implementation plan, which provides for the release of water by the City of Los Angeles onto the historically dry Owens Lake bed to control the emission of PM10. Together, it is anticipated that these events will reduce the quantity of water imported into the region via the Los Angeles Aqueduct by up to 120,000 acre-feet per year, which is in excess of 25% of historical diversions of the Los Angeles Department of Water and Power.

Groundwater supplies a significant portion of the water in the Southern California service area. Although further development is possible in a few local areas, some of the basins have been over-used, and as a result, have been adjudicated or managed by public agencies.

In 1990, the Coachella Valley used 85,000 acre-feet of groundwater, 52,000 of which was considered overdraft. MWD has an exchange agreement with Desert Water Agency and Coachella Valley Water District that allows MWD to take the two agencies' SWP entitlement water. In return, MWD releases water from its Colorado River Aqueduct for groundwater recharge in the Coachella Valley.

Groundwater is the major, if not only, local source of water in the Mojave and Antelope valleys. Problems associated with overdraft have resulted in adjudication of the Mojave groundwater basin and sporadic efforts to either adjudicate or develop groundwater management plans for the Antelope Valley basin. These efforts could restrict the use of groundwater and give impetus to developing more active conjunctive use programs. Such programs would have to rely on imported water supplies to a considerable extent.

In the heavily urbanized Coastal Plain area extending into Ventura County and eastward into San Bernardino and Riverside counties, reliance on groundwater is less because more surface water is available. However, annual groundwater extractions exceed 1.5 million acre-feet, which is a much larger absolute use but a smaller proportion of the overall water supply. Annual overdraft has been estimated to be as high as 200,000 acre-feet. A long history of largely uncontrolled groundwater use in this area resulted in serious over-exploitation of many basins, with resultant seawater intrusion and declining water levels. As a result of litigation springing from these problems, most of the major groundwater basins have been adjudicated or have had active groundwater management programs developed. In the adjudicated basins, the rights to pump groundwater have been quantified and assigned. In these basins, the annual amount of water that can be pumped is controlled, and pumping in excess of an adjudicated rate generally requires procurement of an offsetting replenishment supply. The nature of the adjudication process makes it somewhat difficult to modify basin operation significantly to alleviate short-term water shortages, particularly under drought conditions. Managed basins often have similar restrictions but tend to be more flexible in their ability to respond to changing conditions.

Urban areas overlying much of the groundwater basins continue to expand, resulting in loss of recharge capability. This loss has been partially offset by development of extensive artificial recharge programs. Nevertheless, the limited opportunities for recharge will necessitate prudent use of groundwater as a source of supply during extended dry periods.

In San Diego County, groundwater basins tend to be much smaller. Although they constitute an important part of the water supply system, these basins have little potential for more use in the short term.

a. Surface Water Hydrology. Many streams flow down the southwestern slope of the Transverse Ranges and the western slope of the Peninsular Ranges to drain into the Pacific Ocean. These include the Santa Clara, Ventura, Los Angeles, San Gabriel, Santa Ana, San Jacinto, San Diego, San Luis Rey, Santa Margarita, Otay, and Tijuana rivers. Dams and reservoirs regulate many of these rivers. Large reservoirs in the area, most of which are storage facilities for imported supplies, include Pyramid Lake, Castaic Lake, Silverwood Lake, Lake Perris, Lake Casitas, Lake Mathews, El Capitan Reservoir, San Vicente and Lake Havasu. Table III-31 lists the major reservoirs in the Southern California Region.

On the eastern side of the Peninsular Ranges lie the Mojave and Colorado deserts. Streams there typically have intermittent flow and, with the exception of the Colorado River, primarily drain into groundwater basins or interior lakes. Rainfall in the desert is scarce and highly seasonal but at times is so intense that watercourses overflow and cover large areas with sheet flow. These conditions result in changing patterns of erosion and deposition. Desert rivers include the Mojave, Colorado, San Gorgonio, Alamo, and New rivers. Lakes and reservoirs are scarce in this area, with the exception of dry lakebeds and the Salton Sea.

b. Surface Water Quality. Southern California has many water quality problems. Along the coast, thermal discharges from electrical generation plants and nutrient overloading of streams cause local problems. In the desert, the problems are more general and relate to increasing salinity of groundwater and lakes such as the Salton Sea.

Along the coast, water quality in streams, lakes, and reservoirs varies from good (water that supports and enhances the designated beneficial uses) to intermediate (water that supports designated beneficial uses but with occasional degradation of water quality) to impaired (water that cannot reasonably be expected to attain or maintain applicable water quality standards).

The Santa Clara River contains 79 river miles of intermediate quality water due to pollutants in urban and agricultural runoff. The upper Ventura River consists of 9 miles of good quality water; the lower river has 6 miles of impaired quality from high ammonia levels and low dissolved oxygen. The Los Angeles River varies from intermediate to impaired water quality due to urban runoff, high ammonia levels, and high volatile organic compounds. The Santa Ana River varies from good to impaired, with impaired reaches exhibiting toxic bioassay results and threats to recreational and

Table III-31
Major Reservoirs in the Southern California Region

Reservoir	River	Capacity (TAF)	Owner
Casitas	Coyote Creek	254	USBR
Lake Piru	Piru Creek	88	United WCD
Pyramid	Piru Creek	171	DWR
Castaic	Castaic Creek	324	DWR
San Gabriel	San Gabriel	42	LACFCD/DWP
Big Bear Lake	Bear Creek	73	Big Bear MWD
Perris	Bernasconi Pass	132	DWR
Mathews	Trib Cajalco Creek	179	MWDSC
Irvine Lake	Santiago Creek	25	Serrano ID/Irvine Ranch
Skinner	Tucalota Creek	44	MWDSC
Vail	Temecula Creek	50	Rancho Calif. WD
Henshaw	San Luis Rey River	53	Vista ID
Lake Hodges	San Dieguito River	38	City of San Diego
Sutherland	Santa Ysabel Creek	29	City of San Diego
San Vincente	San Vincente Creek	90	City of San Diego
El Capitan	San Diego River	113	City of San Diego
Lower Otay	Otay River	50	City of San Diego
Morena	Cottonwood Creek	50	City of San Diego
Barrett	Cottonwood Creek	38	City of San Diego
Seven Oaks	Santa Ana River	146	USCOE (under const.)
Prado	Santa Ana River	183	USCOE
Silverwood	West Fork Mojave	75	DWR

Source: DWR 1993b

groundwater uses. The San Jacinto River has good water quality, the San Diego River has intermediate, and San Diego Creek suffers from impaired water quality. Elevated levels of toxins have been found in the tissues of fish and shellfish in San Diego Creek, as well as eutrophication problems. As with many rivers that cross the international border, the Tijuana River has impaired water quality due to untreated wastewater.

Many of the reservoirs along the west slope of the Peninsular Ranges contain water of good quality. However, Big Bear Lake is facing both eutrophication and sedimentation problems, as well as increasing levels of toxins in fish tissues; and Perris Reservoir contains potential precursors of trihalomethanes. Intermediate quality water can be found in Lake Hodges and in Casitas Lake, which suffers from turbidity problems.

Rivers within the Colorado and Mojave deserts, for the most part, have poor water quality. The Alamo River has impaired quality water, which is evident in the increasing levels of toxins in fish tissue and the threat of toxic bioassay results. The New River also contains water of impaired quality and has been declared a public health hazard. San Gorgonio River water quality is unknown. The Mojave River varies from good to impaired, with problems caused by sedimentation and toxic pollutants. The portion of the Colorado River that runs along the eastern boundary of California contains water considered to be of good quality.

Lakes and reservoirs in the desert seem to contain either good or impaired quality water, although even areas with good quality are threatened. Lake Silverwood is considered good quality water, although there is the potential for mercury problems. Lake Havasu is also considered good, but there is a threat of increasing levels of selenium in fish tissue. The Salton Sea contains water of impaired quality demonstrated by high salinity levels and high levels of selenium in fish tissues.

The water delivered to the City of Los Angeles via the LA Aqueduct generally has less than 230 mg/L total dissolved solids. Other water imported into Southern California ranges from less than 220 mg/L for SWP supplies to 750 mg/L for Colorado River water. In some areas, SWP water is blended with Colorado River water to provide a larger supply of water with acceptable TDS levels.

c. Groundwater Hydrology. The South Coastal Region has at least 44 major groundwater basins. Groundwater commonly occurs in alluvial basins that vary greatly in size and storage capacity. Typically, the basins contain a complex interfingering of coarse-grained aquifer and fine-grained material that limits water movement between aquifers. Many basins contain fine-grained material at or near the surface, which limits the area through which groundwater recharge can be accomplished. The relatively low recharge rates in comparison to storage capacity in many basins have resulted in a tendency toward over-exploitation.

The most significant groundwater basins in the interior desert portions of the service area include the Antelope, Mojave, and Coachella valleys. Urban areas are expanding in all three valleys, and supplemental water from the SWP is available to them. Nevertheless, annual groundwater extraction from these areas is about 433,000 acre-feet, with a resultant overdraft of as much as 221,000 acre-feet.

Potential adverse impacts of continued overdraft include land subsidence, increased pumping costs, and water quality degradation. In the 1970s, the Antelope Valley-East Kern Water Agency began receiving deliveries of SWP water and recharging the groundwater basin. Groundwater levels in some portions of the basin have risen 40 feet or more since the introduction of SWP water.

Seawater intrusion can be a significant water quality problem in coastal groundwater basins. Historically, seawater has intruded into most coastal basins in this area. Injection wells are used to create intrusion barriers along the coast in Orange and Los Angeles counties. The barriers use imported surface water and reclaimed waste water for injection and increase the extent to which inland groundwater levels can be drawn down. However, the barriers are not entirely effective (or even present in some basins), thus limiting the availability of groundwater for use during extended dry periods.

d. Groundwater Quality. Although much of the groundwater in Southern California is suitable for municipal and agricultural supplies, substantial degradation in some areas, such as San Diego County, limits groundwater use. Loss of production capability, while of concern, has been relatively small. Given the heavily urban character of the area and the former widespread citrus orchards, elevated levels of nitrate and total dissolved solids, as well as contamination by synthetic organics, are a fairly common problem in some basins. In particular, the San Fernando and San Gabriel basins have widespread synthetic organics contamination, which constrains basin operations in order to limit the spread of contamination. Similar but less severe limitations on operations exist in many other basins.

The groundwater within most basins of the south coastal area is suitable for all beneficial uses. Groundwater temperature and total dissolved solids content tends to vary considerably between basins. In basins where Colorado River water is being used for recharge, the groundwater has begun to take on qualities of the recharge water and is inferior to the natural groundwater. Hardness is a common water quality problem in many basins. Almost all of the basins are highly developed except in San Diego County, where the basins are not as extensive and, in some cases, contain water of inferior quality not suitable for domestic use. Sea water intrusion is known to be occurring or has the potential to occur in several south coastal basins, including the Coastal Plain of Los Angeles, the Coastal Plain of Orange County, Santa Margarita Valley, San Luis Rey Valley, San Dieguito Valley, and Mission Valley.

Groundwater quality in the Mojave River area is fair. Total dissolved solids concentrations range from about 300 to 1000 mg/L and are predominantly calcium or sodium bicarbonate in character, with calcium predominating in the recharge area of the foothills and sodium in the middle and lower discharge areas of the playas. Groundwater quality in the immediate vicinity of the California Aqueduct in Antelope Valley is excellent. Total dissolved solids concentrations of about 150 to 300 mg/L dominate, with a few smaller areas around the communities of Littlerock and Pearblossom having concentrations of about 300 to 500 mg/L. The predominant character of the water in the Coachella Valley is sodium sulfate or sodium chloride, but significant quantities of calcium and bicarbonate are also present in some locations. Groundwater temperature ranges from about 60° to about 90°F; however, a temperature in excess of 200°F has been recorded. Total dissolved solids content of the water varies considerably, but is generally less than 600 mg/L.

5. Water Use

The total net water demand for the South Coast Region in 1990 was nearly 4.4 million acre-feet. Urban use accounted for 80 percent of the net water demand, while agricultural use was 15 percent of the total. Urban water demand for the South Coast Region has rapidly increased due to tremendous growth rates and expanding urbanized areas. In many areas, urban expansion has led to reductions in agricultural acreage and water use.

The total net water demand for the Antelope Valley and Mojave River areas in 1990 was about 225,000 acre-feet, and was nearly equally split between urban and agricultural use. Net urban demand in the Coachella Valley was 165,000 acre-feet, and net agricultural demand was 313,000 acre-feet. Net water demand in the Coachella Valley is expected to increase slightly by 2020, but the ratio of urban-to-agricultural use is expected to reverse with urban use more than doubling and agricultural use falling by nearly half.

6. Vegetation

While some of the naturally occurring vegetation in the Southern California service area has been altered significantly by urban and agricultural development, a large part of the region, mostly uplands, retains it native cover. The dominant natural vegetation type in the non-urbanized portion of the South Coast Region is a mixture of coastal sage scrub and chaparral communities, covering nearly half of the land area. The other vegetation communities include grassland, freshwater emergent wetland, saline emergent wetland, coastal scrub, coastal dunes, desert scrub, desert dunes, woodland, forest, and agricultural/urban. Numerous sensitive plant species occur in those communities. Table III-32 lists the sensitive plant species found in the Southern California region.

Chaparral, the most abundant plant community in the Southern California area, represents the typical vegetation. Chaparral is composed of various species of manzanita, wild lilac, ceanothus, oak, sage, mountain mahogany, and chamise. This community is often found on hot, dry slopes, ridges, and mesas and on poor soils that are shallow, sandy, and have low water-holding capacity. While chaparral has little commercial value, it provides valuable wildlife habitat and forms a protective cover to prevent erosion in steep watersheds. Two types of sensitive chaparral habitat, southern maritime chaparral and southern mixed chaparral, occur in Southern California.

Coastal sage scrub, once abundant, is now disappearing because of urban development. Inland sage is usually found on dry slopes below 3,000 feet on the coastal side of mountains. Other scrub communities include the creosote brush scrub (found on the floor of the Mojave Desert and along its lower slopes) and succulent scrub (found in scattered locations throughout the southern desert) communities. Sensitive coastal scrub habitats in Southern California include southern coastal bluff scrub, maritime succulent scrub, Diegan coastal sage scrub, and Riversidean sage scrub.

Agriculture and urban uses have largely displaced the native grasslands of the Southern California service area. With few exceptions, the remaining grasslands consist of introduced annual grasses and forbs. Sensitive grassland habitats in Southern California include valley needlegrass grassland, serpentine bunchgrass, wildflower fields, southern interior basalt flow vernal pool, San Diego mesa hardpan vernal pool, San Diego mesa claypan vernal pool, alkali seep, freshwater seep, alkali playa, and pavement plain.

Coastal strand plants and coastal salt- and fresh-water marshes, once common along the coastline in Southern California, have almost disappeared due to filling and dredging to create seaside developments, marinas, and ports. Remnants of these communities have been set aside in public and private preserves. Sensitive freshwater wetland habitats in Southern California include coastal and valley freshwater marsh, cismontane alkali marsh, and transmontane alkali marsh. Sensitive saline wetland habitats in Southern California are the southern coastal salt marsh and coastal brackish marsh. Two types of sensitive coastal dune habitat in Southern California are southern foredunes and southern dune scrub.

Table III-32
Sensitive Plant Species in the Southern California Region

Scientific Name	Common Name	Status State	Status CNPS	Status Federal
Acanthomintha ilicifolia	San Diego thorn mint	SE	1B	FPE
Allium munzii	Munz's onion	ST	1B	FPE
Arabis johnstonii	Johnston's rock cress		1B	FTP
Arctostaphylos glandulosa ssp. *crassifolia*	Del Mar manzanita		1B	FE
Arenaria paludicola	Marsh sandwort	SE	1B	FE
Arenaria ursina	Bear Valley sandwort		1B	FPT
Astragalus albens	Cushenbury milk-vetch		1B	FE
Astragalus brautonii	Braunton's milk-vetch		1B	FE
Astragalus jaegerianus	Lane Mountain milk-vetch		1B	FPE
Astragalus lentiginosus var. *coachellae*	Coachella Valley milk-vetch		1B	FPE
Astragalus magdalenae var. *perisonii*	Peirson's milk-vetch	SE	1B	FPE
Astragalus tener var. *titi*	Coastal dunes milk-vetch	SE	1B	FPE
Astragalus tricarinatus	Triple-ribbed milk-vetch		1B	FPE
Atriplex coronata var. *notatior*	San Jacinto Valley crownscale		1B	FPE
Baccharis vanessae	Encinitas baccharis	SE	1B	FT
Berberis nevinii	Nevin's barberry	SE	1B	FPE
Brodiaea filifolia	Thread-leaved brodiaea	SE	1B	FPT
Calochortus dunnii	Dunn's mariposa lily	SR	1B	FSC
Castilleja cinerea	Ash-gray Indian paintbrush		1B	FPT
Castilleja gleasonii	Mt. Gleason Indian paintbrush	SR	1B	FSC
Ceanothus ophiochilus	Vail Lake ceanothus	SE	1B	FPT
Chorizanthe orcuttiana	Orcutt's spineflower	SE	1B	FE
Cordylanthus maritimus ssp. *maritimus*	Salt marsh bird's-beak	SE	1B	FE
Corethrogyne filaginifolia var. *linofolia*	Del Mar Mesa sand aster		1B	FSC
Croton wigginsii	Wiggin's croton	SR	2	
Delphinium hesperium ssp. *cuyamacae*	Cuyamaca larkspur	SR	1B	FSC
Dithyrea maritima	Beach spectaclepod	ST	1B	FSC
Dodecahema leptoceras	Slender-horned spineflower	SE	1B	FE
Downingia concolor var. *brevior*	Cuyamaca Lake downingia	SE	1B	FSC
Dudleya abramsii ssp. *parva*	Conejo dudleya		1B	FT
Dudleya blochmaniae ssp. *brevifolia*	Short-leaved dudleya	SE	1B	C1
Dudleya cymosa ssp. *marcescens*	Marcescent dudleya	SR	1B	FT
Dudleya cymosa ssp. *ovatifolia*	Santa Monica Mountains dudleya		1B	FT
Dudleya densiflora	San Gabriel Mountains dudleya		1B	C
Dudleya stolonifera	Laguna Beach dudleya	ST	1B	FPE
Dudleya verityi	Verityi's dudleya		1B	FT
Eriastrum densifolium ssp. *sanctorum*	Santa Ana River woollystar	SE	1B	FE
Erigeron parishii	Parish's daisy		1B	FT
Eriogonum crocatum	Conejo buckwheat	SR	1B	FSC
Eriogonum ericifolium var. *thornei*	Thorne's buckwheat	SE	1B	FSC
Eriogonum kennedyi var. *austromontanum*	Southern mountain buckwheat		1B	FPT
Eriogonum ovalifolium var. *vineum*	Cushenbury buckwheat		1B	FE
Eryngium aristulatum var. *parishii*	San Diego button-celery	SE	1B	FE
Fremontodendron mexicanum	Mexican flannelbush	SR	1B	FPE
Galium angustifolium ssp. *borregoense*	Borrego bedstraw	SR	1B	FSC
Helianthus niveus ssp. *tephrodes*	Algodones Dunes sunflower	SE	1B	FSC

Table III-32 (cont.)
Sensitive Plant Species in the Southern California Region

Scientific Name	Common Name	Status: State	Status: CNPS	Status: Federal
Helianthus nuttallii ssp. *parishii*	Los Angeles sunflower		1A	FSC
Hemizonia conjugens	Otay tarplant	SE	1B	FPE
Hemizonia minthornii	Santa Susana tarplant	SR	1B	FSC
Hemizonia mohavensis	Mohave tarplant	SE	1A	FSC
Ivesia callida	Tahquitz ivesia	SR	1B	FSC
Lesquerella kingii ssp. *bernardina*	San Bernardino Mtn. bladderpod		1B	FE
Limnanthes gracilis ssp. *parishii*	Parish's meadowfoam	SE	1B	FSC
Machaeranthera asteroides var. *lagunensis*	Laguna Mountains aster	SR	2	FSC
Monardella linoides ssp. *viminea*	Willowy monardella	SE	1B	FPE
Navarretia fossalis	Prostrate navarretia		1B	FPT
Nolina interrata	Dehesa nolina	SE	1B	FPT
Orcuttia californica	California Orcutt grass	SE	1B	FE
Oxytheca parishii var. *goodmaniana*	Cushenbury oxytheca		1B	FE
Pentachaeta lyonii	Lyon's pentachaeta	SE	1B	FE
Poa atropupurea	San Bernardino bluegrass		1B	FPE
Pogogyne abramsii	San Diego Mesa mint	SE	1B	FE
Pogogyne nudiuscula	Otay Mesa mint	SE	1B	FE
Puccinellia parishii	Parish's alkali grass		1B	FPE
Rorippa gambellii	Gambel's watercress	ST	1B	FE
Rosa minutifolia	Small-leaved rose	SE	2	FSC
Senecio ganderi	Gander's ragwort	SR	1B	FSC
Sidalcea hickmanii ssp. *parishii*	Parish's checkerbloom	SR	1B	C
Sidalcea pedata	Bird-footed checkerbloom	SE	1B	FE
Taraxacum californicum	California dandelion		1B	FPE
Trichostema austromontanum compactum	Hidden Lake bluecurls		1B	FPT
Verbesina dissita	Crown beard	ST	1B	FT

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
CNPS: (California Native Plant Society) 1A=presumed extinct in California; 1B=rare,threatened, or endangered in California and elsewhere; 2=rare,threatened,or endangered in California but more common elsewhere; 3=need more information; 4=distribution limited (a watchlist).
FEDERAL: FE=endangered; FT=threatened; FPE=proposed endangered; FPT=proposed threatened; C=candidate for listing; FSC=species of concern.

Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

Desert dune habitat, found throughout the Mojave and Sonoran deserts, varies from barren sand expanses to partial cover by shrubs and herbaceous plants to nearly complete shrub canopy closure. Desert dunes are usually found between sea level and 5,000 feet in elevation. Sensitive dune habitats in Southern California include active desert dunes, stabilized and partially stabilized desert dunes, and stabilized and partially stabilized desert sand fields.

Desert scrub is found throughout the Mojave and Sonoran deserts and is the most widespread desert vegetation community type. Many species are found in this habitat, including creosote bush, agave, barrel cactus, teddybear cholla, rabbitbrush, and yucca. In addition to the creosote brush scrub and the pinyon-juniper and Joshua tree woodlands, alkali communities are found in the desert areas where drainage is poor.

The woodland communities include the foothill, pinyon-juniper, and Joshua tree woodlands. The foothill woodlands (primarily southern oaks) serve as a transition zone between the grasslands and forest communities. The oak woodland communities continue to be threatened by urbanization and are impacted by firewood harvesting. Pinyon-juniper woodlands are found in the higher elevations of the Mojave Desert and Joshua tree woodlands are found in the lower elevations of the high desert. Sensitive foothill woodland communities in Southern California include valley oak woodland, open Englemann oak woodland, dense Englemann oak woodland, and California walnut woodland. Sensitive desert woodland communities include Joshua tree woodland, crucifixion thorn woodland, all-thorn woodland, and Arizona woodland.

The forest community occurring in Southern California is montane coniferous forest. This community is usually found in the higher elevations (above 5,000 feet) of the Transverse Range (Santa Ynez, Santa Monica, Santa Suzana, San Gabriel, and San Bernardino mountains) and the Peninsular Ranges (Santa Ana, San Jacinto, Santa Rosa, Palomar, Cuyamaca, and Laguna mountains). The majority of the forests in this area occur on U.S. Forest Service lands.

Stream channels pass through all of the above communities, but most are seasonal and carry water only during rainfall events or during spring. Many of these channels support riparian communities and contain vegetation that provides habitat for wildlife and migration or travel corridors to and from surrounding habitats. In many areas, large trees and shrubs are found only in and along stream courses and dry washes.

7. Fish

Many of Southern California's waterways have been heavily altered by human activities. The fish fauna of the area also has been significantly altered.

Southern California has a variety of different aquatic habitats which support a variety of fish species. Coldwater rivers along the coast support steelhead, trout, speckled dace, and suckers. Trout are available in many of the higher elevation lakes and streams and warm-water gamefish are found in most of the lakes throughout the area. The Colorado River, a warmwater river, has populations of catfish, suckers, squawfish, rainbow trout (in the colder tributaries), and red shiner. Aqueducts and reservoirs contain resident and stocked fish, including largemouth bass, smallmouth bass, striped bass, crappie, threadfin shad, tule perch, channel catfish, green sunfish, bluegill, and trout. The desert springs and streams support tui chub and pupfish.

There are two races of steelhead: winter steelhead and summer steelhead. Only winter steelhead occur naturally along the Southern California coast. Their historical range included streams as far south as the Tijuana River; however, the most extensive population declines and extinctions have occurred at this southern extent of their range. Other sensitive fish species are listed in Table III-33.

Table III-33
Sensitive Fish Species in the Southern California Region

Scientific Name	Common Name	Status: State	Status: Federal
Catostomus santaanae	Santa Ana sucker	CSC	FSC
Cyprinodon macularius	Desert pupfish	SE	FE
Cyprinodon nevadensis amargosae	Amargosa pupfish	CSC	
Cyprinodon nevadensis nevadensis	Saratoga Springs pupfish	CSC	
Eucyclogobius newberryi	Tidewater goby	CSC	FE
Gasterosteua aculeatus williamsoni	Unarmored threespine stickleback.	SE	FE
Gila bicolor mohavensis	Mojave tui chub	SE	FE
Ptychocheilus lucius	Colorado squawfish	SE	FE
Rhinichthys osculus ssp.1	Amargosa Canyon speckled dace	CSC	FSC
Rhinichthys osculus ssp.3	Santa Ana speckled dace	CSC	FSC
Xyrauchen texanus	Razorback sucker	SE	FE

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
FEDERAL: FE=endangered; FT=threatened; FPE=proposed endangered; FPT=proposed threatened; C=candidate for listing; FSC=species of concern.

Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

8. Wildlife

The Southern California area supports a great diversity of wildlife. The coastal strand community functions as an important breeding and rearing ground for numerous shorebirds including plovers, turnstones, sandpipers, and gulls. Marshes provide important habitat for migratory waterfowl, clapper rails, loons, and pelicans, amphibians, and western pond turtles (in fresh water). Lakes and reservoirs in Southern California provide habitat for numerous geese, ducks, and shorebirds.

The dominant animal in the chaparral community is the mule deer. Other common mammals in this habitat include coyotes, bobcats, foxes, woodrats, and skunks. Resident birds include thrashers, wrentits, bushtits, and jays. Migratory birds such as sparrows, warblers, and robins also use this habitat. Reptiles are abundant throughout this community, and amphibians occur in locations where moisture is continuously present.

While the scrub community may appear sparse, it supports many resident species including towhees, sparrows, wrens, and quail. Mammals supported by this habitat include coyotes, foxes, skunks, and mice. Creosote brush scrub is especially good habitat for numerous species of lizards and snakes.

The grassland community provides habitat for several species of mice, ground squirrels, and rabbits. Coyotes are the most abundant carnivores and this community supports several species of birds, including predators such as owls, hawks, and eagles, and seed-eating birds such as sparrows, doves, and quail.

The foothill woodland community provides roosting and nesting sites for raptors such as hawks and eagles. Several kinds of woodpeckers are commonly found in this habitat. The pinyon-juniper woodland community supports species that are found in both the desert and coniferous forest communities, including jays, warblers, and orioles.

The coniferous forest community supports several species of birds, including woodpeckers, nuthatches, and creepers. Dominant mammals include deer, coyotes, and mountain lions. California kingsnakes, lodgepole chipmunks, and porcupines are found only in this type of habitat.

The diversity of habitats available in the area, combined with the impacts of a rapidly developing human population, has resulted in a large number of rare and endangered species. Steps have been taken to preserve habitats that have unique biological significance. One endangered fish, the unarmored three-spine stickleback, exists in the service area but is no longer found in the Los Angeles, San Gabriel, and Santa Ana rivers. Increased recreational use and development threaten the population in the Santa Clara River. Other sensitive wildlife species are listed in Table III-34.

9. Recreation

Southern California contains a broad spectrum of recreational opportunities due to its wide variety of habitats. The topography ranges from the coastal plain to the interior mountains and valleys to the desert. Along the coastlines, beaches provide areas for tide-pooling, wildlife watching, hiking, picnicking, swimming, surfing, diving, and fishing.

Recreational boating and sportfishing on the ocean are also popular. Inland, national forests provide areas for hiking, camping, wildlife watching, fishing, picnicking, and other activities. Rivers and reservoirs in the area also provide for water-oriented recreation. The desert areas are used for hiking, wildlife watching, camping, and off-road vehicles.

The four SWP reservoirs and other lakes and reservoirs in Southern California receive heavy year-round recreational use. Castaic Lake provides as many as a million visitor-days per year, and Lake Perris receives more than 800,000. Boating, swimming, fishing, water-skiing, picnicking, camping, hiking, hunting, scuba diving, and rock climbing are available in and around the lakes and reservoirs.

Recreation facilities along the California Aqueduct include a bicycle trail that extends 105 miles from Quail Lake near Interstate Highway 5 to a point near Silverwood Lake in San Bernardino National Forest. The U.S. Forest Service plans to route a portion of the Pacific Crest National Scenic Trail along the California Aqueduct, establishing a hiking and equestrian route. Five fishing access sites are also available along the East Branch of the aqueduct.

Table III-34
Sensitive Wildlife Species in the Southern California Region

Scientific Name	Common Name	Status State	Status Federal
Accipiter cooperi	Cooper's hawk	CSC	
Accipiter striatus	Sharp-shinned hawk	CSC	
Agelaius tricolor	Tricolored blackbird	CSC	FSC
Aquila chrysaetos	Golden eagle	CSC	
Asio Flammeus	Short-eared owl	CSC	
Asio otus	Long-eared owl	CSC	
Athene cunicularia	Burrowing owl	CSC	
Brachyramphus marmoratus marmoratus	Marbled murrelet	SE	FT
Charadrius alexandrinus nivosus (Pacific Coast)	Western snowy plover	CSC	FT
Circus cyaneus	Northern harrier	CSC	
Coccyzus americanus occidentalis	Western yellow-billed cuckoo	SE	
Colaptes auratus chrysoides	Gilded northern flicker	SE	
Cypseloides niger	Black swift	CSC	
Dendroica petechia brewsteri	Yellow warbler	CSC	
Dendroica petechia sonorana	Sonoran yellow warbler	CSC	
Empidonax traillii	Willow flycatcher	SE	
Empidonax traillii extimus	Southwestern willow flycatcher		
Falco mexicanus	Prairie falcon	CSC	
Falco peregrinus anatum	American peregrine falcon	SE	FE
Gymnogyps californianus	California condor	SE	SE
Haliaeetus leucocephalus	Bald eagle	SE	FT
Icteria virens	Yellow-breasted chat	CSC	
Laterallus jamaicensis coturniculus	California black rail	ST	FSC
Melanerpes uropygiallis	Gila woodpecker	SE	
Micrathene whitneyi	Elf owl	SE	
Myiarchus tyrannulus	Brown-crested flycatcher	CSC	
Passerculus sandwichensis beldingi	Belding's savannah sparrow	SE	FSC
Pelecanus occidentialis californicus	California brown pelican	SE	FE
Phalacrocorax auritus	Double-crested cormorant	CSC	
Piranga flava	Hepatic tanager	CSC	
Piranga rubra	Summer tanager	CSC	
Polioptila californica californica	Coastal california gnatcatcher	CSC	FT
Progne subis	Purple martin	CSC	
Pyrocephalus rubinus	Vermilion flycatcher	CSC	
Rallus longirostris levipes	Light-footed clapper rail	SE	FE
Rallus longirostris yumamensis	Yuma clapper rail	ST	FE
Riparia riparia	Bank swallow	ST	
Rynchops niger	Black skimmer	CSC	
Sterna antillarum browni	California least tern	SE	FE
Toxostoma bendirei	Bendire's thrasher	CSC	
Toxostoma dorsale	Crissal thrasher	CSC	
Toxostoma lecontei	Le Conte's thrasher	CSC	
Vermivora virginiae	Virginia's warbler	CSC	
Vireo bellii arizonae	Arizona Bell's vireo	SE	

Table III-34 (cont.)
Sensitive Wildlife Species in the Southern California Region

Scientific Name	Common Name	Status State	Status Federal
Vireo bellii pusillus	Least Bell's vireo	SE	FE
Vireo vicinior	Gray vireo	CSC	
Antrozous pallidus	Pallid bat	CSC	
Dipodomys stephensi	Stephen's kangaroo rat	ST	FE
Euderma maculatum	Spotted bat	CSC	FSC
Eumops perotis californicus	California mastiff bat	CSC	FSC
Macrotus californicus	California leaf-nosed bat	CSC	FSC
Microtus californicus mohavensis	Mojave River vole	CSC	
Myotis velifer brevis	Cave myotis	CSC	FSC
Nyctinomops [=Tadarida] femorosaccus	Pocketed free-tailed bat	SC	
vis canadensis cremnobates	Peninsular bighorn sheep	ST	FPE
Perognathus alticola alticola	White-eared pocket mouse	CSC	FSC
Perognathus alticola inexpectatus	Tehachapi pocket mouse	CSC	FSC
Perognathus longimembris brevinasus	Los Angeles pocket mouse	CSC	FE
Perognathus longimembris pacificus	Pacific pocket mouse	CSC	FSC
Plecotus townsendii	Townsend's big-eared bat	CSC	
Sigmondon hispidus eremicus	Yuma cotton rat	CSC	FSC
Spermophilus mohavensis	Mojave ground squirrel	ST	FSC
Spermophilus tereticaudus chlorus	Palm Springs ground squirrel	CSC	FSC
Charina bottae umbratica	Southern rubber boa	ST	FSC
Clemmys marmorata pallida	Southwest pond turtle	CSC	FSC
Cnemidophorus hyperythrus	Orange-throated whiptail	CSC	FSC
Coleonyx switaki	Barefoot banded gecko	ST	FSC
Crotalus ruber ruber	Northern red-diamond rattlesnake	CSC	FSC
Eumeces skiltonianus interparietalis	Coronado skink	CSC	FSC
Xerobates agassizii	Desert tortoise	ST	FT
Heloderma suspectum	Gila monster	CSC	
Lampropeltis zonata pulchra	San Diego mountain kingsnake	CSC	FSC
Phrynosoma coronatum blainvillei	San Diego horned lizard	CSC	FSC
Phrynosoma coronatum frontale	California horned lizard	CSC	
Phrynosoma mcalli	Flat-tailed horned lizard	CSC	FPT
Salvadora hexalepis virgultea	Coast patch-nosed snake	CSC	
Uma inornata	Coachella Valley fringe-toed lizard	SE	FT
Batrachoseps aridus	Desert slender salamander	SE	FE
Bufo microscaphus californicus	Arroyo southwestern toad	CSC	FE
Ensatina eschscholtzi klauberi	Large-blotched slender salamander	CSC	FSC
Rana aurora draytonii	California red-legged frog	CSC	FT
Rana boylii	Foothill yellow-legged frog	CSC	FSC
Rana muscosa	Mountain yellow-legged frog	CSC	FSC
Scaphiopus hammondii	Western spadefoot	CSC	FSC

Table III-34 (cont.)
Sensitive Wildlife Species in the Southern California Region

Scientific Name	Common Name	Status: State	Status: Federal
Branchinecta lynchi	Vernal pool fairy shrimp		FT
Euphilotes battoides allyni	El Segundo blue butterfly		FE
Glaucopsyche lygdamus	Palos Verdes blue butterfly		FE
Rhaphiomidas terminatus	Delhi Sands flower-loving fly		FE
Streptocephalus woottoni	Riverside fairy shrimp		FE
Branchinecta sandiegonensis	San Diego fairy shrimp		FE

STATE: SE=endangered; ST=threatened; SR=rare; SC=candidate for listing; CSC=special concern.
FEDERAL: FE=endangered; FT=threatened; FPE=proposed endangered; FPT=proposed threatened; C=candidate for listing; FSC=species of concern.

Source: State Water Project Supplemental Water Purchase Program, Draft Program Environmental Impact Report (DWR, 1996)

Literature Cited in Chapter III

Bennett, B. and L. Howard. 1997. El Ninos and the Decline of Striped Bass. Interagency Ecological Program Newsletter. Volume 10, No. 4. Fall, 1997.

DFG. 1998. California Endangered Species Act Biological Opinion for the Interim South Delta Program. California Department of Fish and Game. March, 1998.

DWR. 1994. California Water Plan Update. Bulletin 160-93. California Department of Water Resouces. Sacramento, California. Volumes I and II.

DWR. 1996. State Water Project Supplemental Water Purchase Program. - Draft Program Environmental Impact Report. State Clearinghouse 94082033. California Department of Water Resouces. Sacramento, California. 150 pp. and appendix.

DWR. 1998. California Water Plan Update. Bulletin 160-98. California Department of Water Resouces. Sacramento, California. Volumes I and II.

SWRCB. 1995. Environmental Report. Appendix 1 to Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. May 1995. State Water Resources Control Board.

USBR. 1997a. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. Technical Appendix, Volume 2, Surface Water Supplies and Facilities Operations. U.S. Bureau of Reclamation.

USBR. 1997b. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. Technical Appendix, Volume 4, Recreation. U.S. Bureau of Reclamation.

USBR. 1997c. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. Technical Appendix, Volume 3, Fisheries. U.S. Bureau of Reclamation.

USFWS. 1996. Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes. U.S. Fish and Wildlife Service. Portland, Oregon. 195 pp.

CHAPTER IV. ANALYTICAL METHODS

This chapter describes the principal analytical methods and models used by the SWRCB to evaluate the environmental effects of alternative methods of implementing the objectives. The chapter contains a description of (a) DWR's planning simulation model (DWRSIM) which was used to determine the water supply and hydrologic effects of the alternatives; (b) DWR's Delta hydrodynamics and water quality model (DWRDSM) which simulates the hydrodynamics and salinity in the Bay/Delta Estuary; (c) the City of Stockton's dissolved oxygen model which was used to calculate dissolved oxygen concentrations in the San Joaquin River near Stockton; (d) the San Joaquin River Input/Output (SJRIO) model which was used to determine the effects of water quality control actions on salinity and flow in the San Joaquin Basin; (e) the USBR water temperature model which was used to assess the effects of the alternatives on water temperature in the major streams tributary to the Delta; (f) aquatic resource relationships which were used to provide a qualitative comparison of relative abundance of aquatic resources under the alternatives; and (g) the methodology used to calculate the responsibility of parties under the water right priority alternatives (Alternatives 3 and 4 under the flow objectives alternatives).

A. DWRSIM

DWRSIM is a generalized planning model for California's Central Valley and the SWP/CVP project systems. The model is designed to simulate the river and reservoir system upstream of the Delta, Delta export operations, and the SWP and the CVP conveyance systems in the export areas. The model accounts for system operational objectives, physical constraints, legal requirements, and institutional agreements. These parameters include requirements for flood control storage, instream flows for fish and navigation, allocation of storage among system reservoirs, hydropower production, pumping plant capacities and limitations, the Coordinated Operations Agreement (COA) between the SWP and the CVP, and required minimum Delta operations to meet Delta water quality and outflow objectives. DWRSIM models most of the river systems and major tributary reservoirs in the Central Valley. In the Sacramento Basin, the model includes: (1) the Sacramento River upstream to Shasta Lake, (2) the Feather River upstream to Lake Oroville, and (3) the American River upstream to Folsom Lake. In the San Joaquin Basin, the model includes: (1) the San Joaquin River upstream to Millerton Lake, (2) the Chowchilla and Fresno rivers upstream to Eastman and Hensley lakes, respectively, (3) the Merced River upstream to Lake McClure, (4) the Tuolumne River upstream to New Don Pedro Reservoir, and (5) the Stanislaus River upstream to New Melones Reservoir. The model also includes Trinity River diversions into the Sacramento Basin from Clair Engle and Lewiston lakes. The remaining river and reservoir systems in the Central Valley are incorporated into a depletion analysis, which is an input to DWRSIM. The following export-related facilities are also modeled: the Delta-Mendota Canal, the South Bay Aqueduct, the Coastal Aqueduct, and the California Aqueduct including the SWP-CVP Joint Reach, San Luis Reservoir, and Pyramid, Castaic, Silverwood, and Perris lakes. Descriptions of the DWRSIM model and the hydrology development process for the model have been prepared by the DWR (Barnes and Chung 1986; DWR 1986, 1992a, 1994a).

DWRSIM has several limitations that require the exercise of caution when interpreting model results. Many of these limitations are due to lack of information or objective criteria, and would be limitations of any similar model. Some of the more important limitations are discussed below.

1. DWRSIM operates on a monthly time step. Therefore, assumptions are made to model any standard that is not formulated on a monthly basis. Peak storm flows, which are usually considerably higher than monthly average flows, cannot be modeled. In addition, a monthly time step can not assess short-term aspects of project operation, such as fluctuations in daily pumping rates, and their associated environmental effects.

2. The federal ESA limitations on Delta export pumping based on actual take levels for delta smelt and winter-run chinook salmon are not modeled due to lack of information on when conditions requiring export constraints might be imposed.

3. The CVPIA mandates that 600 to 800 TAF of CVP yield be allocated annually for environmental purposes. The USBR has not yet fully established criteria on how this obligation will change CVP operations, or how much additional Delta inflow or outflow this mandate will provide (some instream flow prescriptions have been defined for the DWRSIM simulations). Until such criteria are established, interpretation of modeling results is subject to the uncertainty of the CVPIA allocation.

4. The effect of the water quality objectives or the federal ESA requirements on the sharing formula in the COA is unknown. This sharing will affect relative reservoir levels and available water for delivery between the SWP and the CVP.

5. The Depletion Analysis model, which provides hydrologic input to DWRSIM, accounts for use of ground water, but ground water itself is not physically modeled.

6. DWRSIM is not capable of analyzing the water supply impacts of water quality objectives for the interior stations in the southern Delta because of a lack of adequate understanding of relationships between the San Joaquin River flow and southern Delta water quality.

For any DWRSIM modeling study, the modeled conditions in a particular year will not conform with the observed conditions for the same year. This is because the purpose of the model is not to recreate historic conditions but to predict potential conditions for planning purposes. Even though the model uses unimpaired streamflows based on historic hydrology from 1922 to 1994, the consumptive use of water specified in the model is based on current or future demand level. Thus, superimposing current or future water demand on historic hydrology produces modeled exports and reservoir operations that are different from historic conditions. This is true even for recent years because the model optimizes reservoir and export operations for the entire period of record.

The following operations criteria and major assumptions are incorporated into all of the DWRSIM studies for the alternatives under consideration, unless specified otherwise as part of an alternative. A description of these and additional DWRSIM assumptions has been prepared by the DWR (DWR 1996a, 1996b).

Hydrology. DWRSIM operates on a monthly time basis and uses the historical 73-year hydrologic sequence of flows from water years 1922 through 1994 as input. The water year begins on October 1 and ends on September 30. The hydrologic sequence is adjusted to reflect the effect of estimated 1995-level land use patterns, which are based on land use projections from DWR Bulletin 160-93 (DWR 1994b). This adjustment is developed using two other models: the Consumptive Use model and the Depletion Analysis model. The hydrology is also modified to account for current operations of local upstream reservoirs. San Joaquin Basin hydrology was adapted from the USBR's SANJASM model.

Instream Flow Requirements. Instream flow requirements are described below, excluding flow requirements imposed through the CVPIA that are described in the next section.

1. Trinity River minimum fish flows below Lewiston Dam are maintained at 340 TAF/year for all years, based on a May 1991 letter of agreement between the USBR and the USFWS.

2. Sacramento River minimum fishery flows below Keswick Dam are maintained per an agreement between the USBR and the DFG (as revised October 1981). These flows range from 2,300 to 3,900 cfs, depending on the time of year according to the USBR's Shasta criteria.

3. Sacramento River navigation control point flows are maintained at 4,000 cfs in critical years and 5,000 cfs in all other years. These criteria are relaxed to 3,500 cfs when Shasta carry-over storage drops below 1.9 MAF.

4. Feather River fishery flows are maintained according to an August 26, 1983 agreement between the DWR and the DFG. In normal years these minimum flows are 1,700 cfs from October through March and 1,000 cfs from April through September. Lower minimum flows are allowed in dry and critical water years. If flows between October 15 and November 30 exceed 2,500 cfs, then flows through the end of March can decrease only 500 cfs from the high point.

5. Lower American River minimum fish and recreation flows are maintained per USBR operation criteria outlined in an April 26, 1996 letter from USBR to the SWRCB (USBR 1996). October through February flow requirements are based on available storage in Folsom

Reservoir. March through September flow requirements are based on storage and inflow to Folsom Reservoir.

6. Mokelumne River minimum fishery flows below Camanche Dam are maintained per an agreement between EBMUD, USFWS, and DFG (FERC Agreement 2916). These flows range from 100 cfs to 325 cfs from October 1 through June 30, depending on time of the year and water year type. Flows are maintained at 100 cfs from July 1 through September 30 for all water year types. Additional pulse flows of up to 200 cfs are also provided in April through June in some years depending on storage levels and water year type.

7. Stanislaus River minimum fish flows below New Melones Reservoir range from 98 TAF/year to 302 TAF/year, according to the interim agreement dated June 1987 between the USBR and the DFG. The actual minimum fish flow for each year is based on the water supply available for that year. Additional minimum flow requirements are imposed in June through September (15.2-17.4 TAF per month) to maintain dissolved oxygen levels in the river. Channel capacity below Goodwin Dam is assumed to be 8,000 cfs. CVP contract demands above Goodwin Dam are met as a function of New Melones Reservoir storage and inflow per an April 26, 1996 letter from USBR to SWRCB (USBR 1996).

8. Tuolumne River minimum fishery flows below New Don Pedro Dam are maintained per an agreement between Turlock and Modesto Irrigation Districts, City of San Francisco, DFG and others (FERC Agreement 2299). Base flows range from 50 cfs to 300 cfs. Base and pulse flow volumes depend on time of the year and water year type.

9. Merced River minimum fishery flows below New Exchequer are maintained per FERC agreement 2179. Minimum flow ranges from 16 cfs to 101 cfs. Minimum flow volumes depend on the time of the year and the water year type.

<u>CVPIA Flow Criteria</u>.

1. Flow requirements between 3,250 cfs and 5,500 cfs are maintained below Keswick Dam on the Sacramento River. Flow requirements during October through April are based on Shasta carry-over storage. Flow requirements during May through September are based on the previous month's storage.

2. Flow requirements between 52 cfs and 200 cfs are maintained below Whiskeytown Dam on Clear Creek, depending on time of year and year type.

3. Flow requirements below Nimbus Dam on the American River during October through February are triggered by Folsom carry-over storage. Flow requirements during March through September are triggered by the previous month's storage plus remaining water year

inflows. Minimum flows are maintained per USBR operation criteria outlined in an April 26, 1996 letter from USBR to the SWRCB (USBR 1996).

Target Reservoir Storage.

1. Shasta Reservoir carry-over storage is maintained at or above 1.9 MAF in all normal water years for winter-run chinook salmon protection per the NMFS biological opinion. However, in critical years following critical years, storage is allowed to fall to 1.2 MAF (and lower in extremely dry years).

2. Folsom Reservoir storage capacity is reduced from 1010 TAF to 975 TAF due to sediment accumulation as calculated from a 1992 reservoir capacity survey. Folsom Reservoir flood control criteria are in accordance with the December 1993 USCOE report "Folsom Dam and Lake Operation Evaluation." The maximum flood control reservation varies from 400 TAF to 670 TAF based on available storage in upstream reservoirs.

Trinity River Imports. Imports from Clair Engle Reservoir to Whiskeytown Reservoir (up to a 3,300 cfs maximum) are provided according to USBR criteria. Imports vary according to month and previous month Clair Engle storage.

SWP and CVP Pumping. The SWP Banks Pumping Plant's capacity is 10,350 cfs. However, unless specified otherwise, average monthly pumping is limited to 6,680 cfs (or 8,500 cfs in some winter months). The CVP Tracy Pumping Plant's permitted capacity is 4,600 cfs, but constraints along the Delta-Mendota Canal and at the relift pumps to O'Neill Forebay restrict export capacity to 4,200 cfs during some months.

SWP and CVP Sharing Formula. The SWP and the CVP share responsibility for the coordinated operation of the two projects based on the COA. Storage withdrawals for in-basin use are split 75 percent CVP and 25 percent SWP, and surplus flows are split 55 percent CVP and 45 percent SWP. The present COA does not specify how Delta pumping capacity is to be shared when export restrictions under the Bay/Delta Plan objectives control project operations. A sharing ratio of 50 percent CVP and 50 percent SWP is used.

SWP Demands, Deliveries and Deficiencies.

1. Maximum SWP contractor deliveries are designed to vary in response to local wetness indices. As such, maximum deliveries are reduced in the wetter years, assuming greater availability of local water supplies. Deliveries to all San Joaquin Valley agricultural contractors are reduced in wetter years, using a wetness index developed from annual Kern River inflows to Lake Isabella, as follows:

	Dry/Avg	Above	Wet
Kern River flow (TAF)	<1,000	1,000-1,400	>1,400
Max. ag delivery (TAF)	1,175	1,100	915

Deliveries to Metropolitan Water District (MWD) are reduced in wetter years as follows, using a 10-station, two-year average precipitation index:

	Dry	Avg.	Above	Wet
So. Cal. precip. (in/year)	<15	15-17.9	18-20.9	>20.9
Max. MWD delivery (TAF)	1,433	1,183	883	783

Maximum deliveries to all other SWP municipal and industrial (M&I) contractors are not adjusted for a wetness index, and are set at 857 TAF/year in all years. As a result of the use of these wetness indices, the total maximum delivery to all SWP contractors varies by year, ranging between 3,529 TAF in the dry-average years down to 2,619 TAF in the wetter years, as follows:

	Dry/Avg.	Avg.	Above	Wet
Max. ag delivery	1,175	1,175	1,100	915
Max. MWD delivery	1,433	1,183	883	783
Max. other M&I delivery	857	857	857	857
Fixed losses & recreation	64	64	64	64
Total maximum SWP delivery	3,529	(total varies)		2,619

A range of maximum SWP deliveries are possible, as the two wetness indices are independent of each other. Thus, a given year may be classified as "average" for agricultural deliveries by the Kern River flow index, and also be classified as "above average" or "wet" for MWD deliveries by the Southern California precipitation index.

2. Coastal Aqueduct deliveries to Santa Barbara and San Luis Obispo counties are assumed to be zero at the present level of development, but full deliveries are assumed at future levels of development.

3. Deficiencies are imposed according to the draft Monterey Agreement criteria (Monterey 1994) and are calculated from the following entitlements:

Agricultural entitlements	1,175 TAF/year
M & I entitlements	2,869
Recreation & losses	64

Total entitlements	4,108 TAF/year

4. When available, interruptible water is delivered to SWP south-of-Delta contractors in accordance with the following assumptions (interruptible water deliveries are deliveries to SWP contractors in excess of their entitlements):

   a. Interruptible water cannot be stored in San Luis Reservoir for later delivery to contractors.

   b. A contractor may accept interruptible water in addition to its monthly scheduled entitlement water. Interruptible water deliveries do not impact entitlement water allocations.

   c. If demand for interruptible water is greater than supply in any month, the supply is allocated in proportion to the entitlements of the contractors requesting interruptible water. The maximum demand assumed for interruptible water is 84 TAF per month.

<u>CVP Demands, Deliveries & Deficiencies</u>.

1. 1995 level CVP export demands, including canal losses, are assumed as follows:

Contra Costa Canal	=	140 TAF/year
DMC and Exchange Contractors	=	1,561
CVP San Luis Unit	=	1,260
San Felipe Unit	=	196
Cross Valley Canal	=	128
Wildlife Refuges	=	288
Total CVP Delta Exports	=	3,573 TAF/year

   CVP Delta export demands are reduced in certain wet years in the San Joaquin River Basin when flood flows and flows from the James Bypass are available in the Mendota Pool to satisfy Exchange Contractor demand.

   The Cross Valley Canal demands are imposed in some of the alternatives for the combined use of points of diversion (JPOD Alternatives 3-8).

2. Sacramento Valley refuge demands are modeled implicitly in the hydrology through rice field and duck club operations. Sacramento Valley refuges include Gray Lodge, Modoc, Sacramento, Delevan, Colusa and Sutter. Level II refuge demands in the San Joaquin Valley are explicitly modeled at an assumed level of 288 TAF/year. San Joaquin refuges include Grasslands, Volta, Los Banos, Kesterson, San Luis, Merced, Mendota, Pixley and Kern.

3. CVP South-of-Delta deficiencies are imposed when needed by contract priority. Contracts are classified into four groups: agricultural, M&I, exchange, and refuge. Deficiencies are imposed in accordance with the Shasta Index and sequentially according to the following rules:

    a. Agricultural requests are reduced up to a maximum of 50 percent.

    b. Agricultural, M&I, and exchange requests are reduced by equal percentages up to a maximum of 25 percent. At this point, cumulative agricultural deficiencies are 75 percent.

    c. Agricultural, M&I, and refuge requests are reduced by equal percentages up to a maximum of 25 percent. At this point, cumulative agricultural and M&I deficiencies are 100 percent and 50 percent, respectively.

    d. M&I requests are reduced until cumulative deficiencies are 100 percent.

    e. Further reductions are imposed equally upon exchange and refuge.

4. Deficiencies in the form of "dedicated" water and "acquired" water to meet the 800 TAF/year CVPIA demands are not imposed.

<u>Delta Standards</u>. The Delta objectives are maintained as required in the Bay/Delta Plan or D-1485, as applicable, except as specified below.

1. A buffer is added to insure that the M&I chloride objective at Contra Costa Canal is maintained on a daily basis. DWRSIM uses a value of 130 mg/L chloride concentration for the 150 mg/L objective and a value of 225 mg/L chloride concentration for the 250 mg/L objective.

2. Salinity and chloride water quality objectives are not modeled at the following locations: Cache Slough, Clifton Court Forebay, Tracy Pumping Plant, Mokelumne River at Terminous, Old River, western Suisun Marsh, and the San Joaquin River at San Andreas Landing, Prisoners Point, and Brandt Bridge site.

3. The San Joaquin River salinity objectives at Vernalis are maintained by releasing water from New Melones Reservoir. There is no cap on reservoir releases to meet these objectives. If

New Melones Reservoir storage drops to 80 TAF, additional water is not provided for salinity control and the objectives are violated.

4. The dissolved oxygen objective in the San Joaquin River is not modeled.

5. The Kimmerer-Monismith monthly equation, provided below, is used to calculate the outflow required to maintain the outflow/X2 objectives.

   EC position = 122.2 + [0.3278 x (previous month EC position in km)] - [17.65 x $\log_{10}$(current month Delta outflow in cfs)]

   In months when the X2 objective is specified in more than one location (e.g., 19 days at the confluence and 12 days at Chipps Island), required outflow for the month is computed as a flow weighted average of the partial month objectives.

6. The relaxation of the outflow/X2 objectives that allows the transfer of excess outflow/X2 days in a single month to be credited to the next month is not modeled (see Bay/Delta Plan, Footnote "a", page 26).

7. The X2 trigger to activate the Roe Island objective is set at 66.3 km from the previous month, as an average monthly value.

B. DWRDSM

DWRDSM is a mathematical computer model that simulates the hydrodynamics and water quality in the Bay/Delta Estuary. Two versions of the model were used. The Flow Alternatives were analyzed using DWRDSM-1, which uses the Martinez tide as the downstream tidal boundary condition. The Suisun Marsh Alternatives were analyzed using DWRDSM (Suisun Marsh Version), which uses the 19-year Golden Gate mean tide as the downstream condition. Both versions use the I Street Bridge and Vernalis as the upstream boundary on the Sacramento and San Joaquin rivers respectively. The model is a variant of the Fischer Delta Model, which was developed by Hugo Fischer and is currently under the proprietorship of Flow Science Inc. DWR modified the Fischer Delta Model and created DWRDSM. DWRDSM is specifically designed to simulate salinity changes in the Delta as affected by changes in geometry and hydrology (DWR 1995).

The hydrodynamics of the Delta are described in the model by governing equations for long wave, non-uniform, unsteady flow in prismatic channels. The equations are solved numerically using the Method of Characteristics for flows, stages, and velocities at discrete locations.

The transport of dissolved water quality constituents, (total dissolved solids), is explained in the model by two distinct processes: advection and dispersion. The advection process is largely dependent on flow velocities, which are obtained by solving the hydrodynamics equations.

The dispersion process is dependent on the concentration gradient and the dispersion coefficient. The dispersion coefficients vary from one location to another and are commonly used as calibration parameters.

For the purposes of the analysis in this draft EIR, some of the boundary conditions for DWRDSM are obtained from the monthly average results from DWRSIM. In addition, the mean of the measured tidal variation over 19 years is used as a boundary condition to simulate the effects of ocean tides. DWRDSM calculates changes on a 60-second time step for flow, and a one to five minute time step for salinity. Although these time steps are relatively short, the use of monthly average flow and mean tidal variation as boundary conditions prevents the model from simulating the extremes that may result from, for example, a short-duration, high intensity storm event or a week-long period of high pumping rates.

C. DISSOLVED OXYGEN MODEL

The City of Stockton developed a model for simulating water quality, including dissolved oxygen conditions, under a variety of flow and water quality conditions (Stockton 1993). The model simulates the transport of water quality constituents, including constituents from the Stockton wastewater treatment plant outfall, in a limited segment of the San Joaquin River based on upstream inflows, Delta water withdrawals, tides, and constituent loading rates. The model includes a near-field component that simulates mixing and dilution in the immediate vicinity of the outfall and a far-field component that simulates mass transport of constituents through the river and Stockton shipping channel.

The near-field component of the model is comprised of one of the USEPA's existing plume models, UDKHDEN, which analyzes the development of the plume through the zone of flow establishment. The output parameters are plume trajectory, travel time, plume width, average dilution, and minimum dilution. UDKHDEN, like other plume models, assumes steady-state conditions. In the Stockton case, however, the currents change dynamically with the tides. Therefore, the model is applied for multiple segments of time and the results are reconstructed to provide a dynamic representation of the conditions.

The far-field component of the model is a link-node model that tracks the transport, dispersion, and decay of constituents in the river. The model encompasses the section of the San Joaquin River between Rindge Tract and McDonald Tract to the north and the confluence of the San Joaquin and Old rivers to the south. The model also includes Fourteen Mile Slough, the lower Calaveras River, the Mormon Slough, the Stockton Diverting Canal, and the French Camp Slough. The water quality parameters simulated by the model are dissolved oxygen, ammonia, biochemical oxygen demand, nitrate, total dissolved solids and coliform bacteria. The model has a hydrodynamic module and a water quality module. The hydrodynamic module generates output of tidal elevations for each node and flows for each link. The water quality module uses the output from the hydrodynamic module and performs mass balance calculations for constituents by accounting for advection, diffusion, and chemical and biological reactions. The final output is the concentrations of water quality parameters for each node on an hourly time step.

The dissolved oxygen model has been calibrated with 1991 data and verified with 1993 and 1996 data. The year 1991 was critically dry, 1993 was an above normal year, and 1996 was a wet year. Thus, the model has been shown to simulate conditions under various hydrologic year types.

A sensitivity analysis has also been performed to provide information about the effectiveness of various factors in raising dissolved oxygen concentrations. Results of the sensitivity analysis can be found in Chapter X.

D. SJRIO MODEL

SJRIO is a mass balance water quality model developed to study the effects of agricultural drainage on water quality in the San Joaquin River (SWRCB 1992, CVRWQCB 1996). Flows and concentrations of total dissolved solids (TDS), boron, and selenium are calculated for a 60 mile reach of the San Joaquin River. The upstream boundary of the model is the San Joaquin River at Lander Avenue, and the downstream boundary is near Vernalis. The following tributary river segments are also within the model boundaries:

1. Five miles of the Merced River below the United States Geological Survey (USGS) gaging station near Stevinson;

2. Fifteen miles of the Tuolumne River below the USGS gaging station at Modesto;

3. Nine miles of the Stanislaus River below the DWR gaging station at Koetitz Ranch;

4. Six miles of Salt Slough below the DWR gaging station near Stevinson;

5. Nine miles of Mud Slough below the USGS gaging station near Gustine; and

6. Several miles of three west side tributaries: Del Puerto, Orestimba and Hospital/Ingram creeks.

The San Joaquin River at Lander Avenue was chosen as the upstream boundary of the model because (1) it is downstream of Friant Dam where most of the river is diverted; (2) it is upstream of significant agricultural drainage inputs from Mud and Salt sloughs; and (3) there are substantial monitoring data available at the location. Vernalis was chosen as the downstream boundary because of data availability at this location and because it is upstream of tidal effects.

The following sources and sinks are accounted for in the model's mass balance calculations for flows and salt loads:

1. The San Joaquin River at Lander Avenue, the upstream boundary to the model;

2. The eight tributaries identified above;

3. Appropriative and riparian diversions from the San Joaquin River and the east side tributaries at 41 points;

4. Subsurface agricultural discharges at nine discharge points;

5. Surface agricultural discharges, including tail water and operational spill water at 35 sites;

6. Municipal and industrial discharges at three sites;

7. Groundwater accretions or depletions calculated for every river mile along the San Joaquin River and along the three east-side tributaries within the model study area;

8. Riparian vegetation water use for every five-mile reach of the San Joaquin River and for each of the east-side tributaries;

9. Evaporation and precipitation for every five mile reach of the San Joaquin River and for each of the east-side tributaries;

E. WATER TEMPERATURE MODEL

The water temperature model developed by the USBR (USBR 1990, 1993, 1997) was used to assess the effects of the Flow and Joint POD Alternatives on water temperature in four major streams in the Sacramento-San Joaquin River system, the Sacramento, Feather, American, and Stanislaus rivers. DWRSIM, described in Section A, was used to predict monthly project operations that were input to the temperature model for the 72-year hydrologic period of record (1922-93).

The reservoir temperature models simulate monthly mean vertical temperature profiles and release temperatures for Whiskeytown, Shasta, Oroville, Folsom, New Melones and Tulloch reservoirs based on hydrologic and climatic input data. The temperature control devices (TCD) at Shasta, Oroville, and Folsom Dams can selectively withdraw water from different reservoir levels to provide downstream temperature control. The TCDs are generally operated to conserve cold water for the summer and fall months when stream temperatures become critical for fisheries. The models simulate the TCD operations by making upper level releases in the winter and spring, mid-level releases in the late-spring and summer, and low level releases in the late-summer and fall.

Temperature changes in the downstream regulating reservoirs, Keswick, Thermalito, Natomas, and Goodwin, are computed from equilibrium temperature decay equations in the reservoir models, which are similar to the river model equations.

The river temperature models predict mean monthly water temperatures at twelve locations on the Sacramento River from Keswick Dam to Freeport, twelve locations on the Feather River from Oroville Dam to the mouth, nine locations on the American River from Nimbus Dam to the mouth, and eight locations on the Stanislaus River from Goodwin Dam to the mouth. The river temperature calculations are based on regulating reservoir release temperatures, river flows, and climatic data. Monthly mean historical air temperatures for the 72-year period and other long-term average climatic data for Shasta, Whiskeytown, Redding, Red Bluff, Colusa, Oroville, Marysville, Folsom, Sacramento, New Melones, and Stockton were obtained from Weather Bureau records and used to represent climatic conditions for the five river systems.

Assessment of impacts on aquatic resources is limited by the monthly time-step used in the DWRSIM and temperature models. Mean monthly flows and temperatures do not define daily variations that occur in the rivers due to dynamic flow and climatic conditions. These variations may have significant effects on habitat for aquatic resources. However, monthly results are useful for general comparison of the alternatives.

F. AQUATIC RESOURCE RELATIONSHIPS IN THE DELTA

The following three types of aquatic resource relationships are used in the analysis of the effects of the alternatives on aquatic resources in the Delta: (1) salmon smolt survival models, (2) estuarine outflow/abundance relationships, and (3) young-of-the-year striped bass model.

1. Salmon Smolt Survival Models

The USFWS has developed models to predict survival of juvenile chinook salmon migrating through the Delta (USFWS 1995). For the Sacramento River, models have been developed for fall-run, late fall-run, and winter-run smolts, and spring-run young-of-the-year and yearlings. For the San Joaquin River, a model has been developed for fall-run smolts.

The models are based on survival indices generated from coded-wire-tagged (CWT) fall-run hatchery smolts released at various locations in the Delta and recovered within a few weeks after release by midwater trawl at Chipps Island. Survival indices were calculated based on the number recovered at Chipps Island corrected for effort in both time and space.

Both the Sacramento and San Joaquin models split the Delta into various reaches and use backward-stepping multiple-regression analyses to identify environmental variables (exports, flows, and temperature) important to survival within each reach. Professional judgment by the model authors was used to some extent in selecting variables for consideration. Both models assume that smolts enter the various reaches of the model in proportion to flow.

The Delta smolt survival model, developed for fall-run smolts emigrating from the Sacramento River Basin, was slightly modified to better index the survival of Sacramento River juvenile winter-run, late fall-run, and spring-run chinook salmon through the Delta. The period of occurrence of each race in the Delta and associated temperature conditions were incorporated into the model.

For the Sacramento River, the models indicate that the factors with the greatest effect on smolt survival are: (1) water temperature at Freeport; (2) percent flow diverted through the Delta Cross Channel gates and Georgiana Slough; and (3) CVP and SWP exports during the migratory period. On the San Joaquin River, the corresponding primary factors are: (1) percent flow diverted into upper Old River; (2) percent flow remaining in the river at Stockton; (3) temperature at Jersey Point; and (4) CVP and SWP exports in April and May.

The model for smolt survival on the Sacramento River illustrates the importance of keeping the migrating salmon smolts on the mainstem of the Sacramento River and minimizing their diversion into the central Delta. Survival, as predicted by the model, significantly improves when the Delta Cross Channel gates are closed. The model also indicates that smolt survival is significantly affected by water temperature. Survival is very poor above a temperature of approximately 68°F regardless of other conditions.

Similarly, the model for smolt survival on the San Joaquin River illustrates the importance of keeping the migrating salmon smolts on the mainstem of the San Joaquin River and minimizing their diversion into Old River. Survival, as predicted by the model, is enhanced by operation of a barrier at the head of Old River. For those smolts that migrate down the mainstem of the San Joaquin River, factors affecting survival include flow, temperature at Jersey Point, and exports. The smolts that migrate down upper Old River and survive are assumed to have gone through the export salvage facilities and then been transported and released into the western Delta.

The models can be used to estimate the relative benefits of controllable parameters in the Delta, specifically flows, exports, Delta Cross Channel gate operation, and construction of the Old River barrier. A number of other implementation measures may also improve smolt survival, but the effects of those other measures have not been modeled.

The statistical validity of the USFWS' smolt survival model has been disputed (Kimmerer 1994). A peer review analysis facilitated by Kimmerer concluded that the models are too complex, contain too many parameters, and inappropriately convert smolt survival index values to probabilities to calculate survival through successive reaches of the Delta.

However, the USFWS salmon smolt models are not used in the analysis as quantitative management tools or to establish the outflow or export objectives. The models are used only for qualitative comparisons among the alternatives and to illustrate the factors that are believed to affect smolt survival. The models have been modified to increase their ability to predict outside the range of the original data set.

2. Estuarine Abundance/Outflow Relationships

The DFG has sampled the abundance of estuarine and bay fish species for many years. Since 1980, as part of the Interagency Ecological Program, the DFG has undertaken a specific study to investigate the relationship between Delta freshwater outflow and the abundance and distribution of fish and invertebrates. Factors other than flow can affect fish and invertebrates, but the major objective of this study was to consider outflow as it influences estuarine and bay fish resources (DFG 1987).

The abundance of 70 species of fish, shrimp, and crabs were analyzed for years since 1980. A majority of the species (55.6 percent) showed no difference in their abundance between wet and dry years. Most of the species that showed no significant difference in abundance between wet and dry years were marine. In contrast, over two-thirds of the species in the study considered to be estuarine, anadromous, or freshwater were significantly more abundant in wet years. Significant positive relationships between Delta outflow and abundance were found for four of these estuarine species: a bay shrimp, *Crangon franciscorum*; longfin smelt; starry flounder; and Sacramento splittail (DFG 1987, 1992a).

In addition to these outflow/abundance relationships, Jassby developed relationships between X2 and several aquatic resources in the Estuary, including: particulate organic carbon (POC), a small mysid shrimp, *Neomysis mercedis, C. franciscorum*, starry flounder, longfin smelt, striped bass, and mollusks (SFEP 1992). These aquatic resources were selected because they were found by the DFG to be affected by outflow, and because they are representative of various trophic levels in the Estuary. The regression equations for six of these estuarine resources/species (POC, *Neomysis mercedis, C. franciscorum*, longfin smelt, starry flounder, and Sacramento splittail), and the data used to develop the equations are plotted in the ER to the Bay/Delta Plan (Chapter VI, pages VI-8, VI-9, and VI-11).

In recent years, there is evidence that a number of these relationships have weakened since the introduction of the Asian clam, Potamocorbula (Kimmerer 1997a). In addition, recent work by Sommer et al (1997) suggests that Sacramento splittail abundance is more closely associated with floodplain inundation from February through May than Delta outflow.

In spite of these drawbacks, the outflow/abundance relationships for some species remain significant and were considered adequate tools to evaluate the relative effects of the alternatives on abundance of these species. Current outflow/abundance relationships (revised in 1998) are used in Chapters VI and XIII to evaluate effects of the Flow and Joint POD alternatives on *C. franciscorum*, longfin smelt, starry flounder, and Sacramento splittail.

3. Young-of-the-Year Striped Bass Model

The DFG has sampled the abundance of young-of-the-year striped bass in the Bay/Delta system using standardized methods since 1959. Analysis developed by DFG in the 1970's showed significant positive relationships between young-of-the-year abundance at 38 mm. and Delta outflow and exports (Turner and Chadwick 1972; Chadwick et al. 1977). Although these relationships have weakened in recent years, a significant positive relationship still exists between young-of-the-year striped bass abundance from 1959 through 1998 and Delta outflow and export variables.

A multiple regression recently developed by DFG relating total young-of-the-year striped bass abundance at 38 mm. to the mean April – July San Joaquin River flow past Jersey Point, $\log_{10}$ net Delta outflow, and total Delta exports (including CVP, SWP, Contra Costa Canal, and miscellaneous Delta diversions) (Lee Miller, DFG, personal communication) was used to evaluate effects of the alternatives on striped bass. Young-of-the-year indices for 1959 – 1998 were correlated with April - July flow data from DWR DAYFLOW. This relationship was used to predict the effects of the Flow, Joint POD, and Cumulative Impacts Alternatives on young-of-the-year striped bass abundance. The DWRSIM model was used to simulate flows for the project alternatives over the 1922-1994 period of hydrologic record.

The abundance of adult striped bass was not modeled for the following reasons: 1) recent literature indicates that many factors other than those included in existing adult striped bass models affect the size of the adult striped bass population (Bennett and Howard 1997; Kimmerer 1997b), and 2) the alternatives under consideration will primarily affect the young-of-the-year life stage through changes in Delta outflow and exports.

G. WATER RIGHT PRIORITY ANALYSIS

This section describes the calculations used to allocate responsibility to meet the flow objectives based on the water right priority system (Flow Alternatives 3 and 4). The discussion is in two parts: (1) calculation of water subject to allocation and (2) calculation of stream depletions due to diversions.

1. Calculation of Water Subject to Allocation

The beginning point of the water right priority calculation is the recognition that the watershed protection statutes (Water Code §§ 11460 et seq. and §§ 15505 et seq.) assign the SWP and the CVP export projects the most junior priority in the Central Valley. The export projects are assumed to include both the export pumps and the reservoirs that release water for diversion at the export pumps. Therefore, both direct diversions to the export pumps and storage in a reservoir that provides water to the export pumps are treated in the calculations as having a priority junior to all other diversions in the basin. This junior priority extends only to the natural and abandoned flow in the system. This junior priority does not apply to SWP and CVP storage releases or their imports into the basin. Consequently, the SWP and the CVP export projects must bypass all of the inflow to their reservoirs plus either release from storage or import into the basin sufficient water to meet their export demands before any other party is required to curtail diversion.

For purposes of a water right priority analysis, the flow objectives for the San Joaquin River at Vernalis are treated separately from the Delta outflow objectives. This segregation is necessary because only San Joaquin Basin water right holders are responsible for the Vernalis objectives, but all water right holders in the Sacramento and San Joaquin basins are responsible for the Delta outflow objectives. In addition, because there are two water right priority flow alternatives, one in which the Friant Project is treated as an in-basin project and entitled to watershed of origin protections (Flow Alternative 3) and one in which it is treated as an export project (Flow Alternative 4), there are a total of four sets of calculations: (a) Vernalis calculation for Flow Alternative 3; (b) Delta calculation for Flow Alternative 3; (c) Vernalis calculation for Flow Alternative 4; and (d) Delta calculation for Flow Alternative 4.

a. **Vernalis Calculation for Flow Alternative 3**. The watershed protection statutes do not apply to this calculation because the Friant Project is treated as an inbasin project, and there is, therefore, no SWP or CVP export project in the San Joaquin Basin. The quantity of water in excess of natural and abandoned flow needed to meet the Vernalis flow objectives can be obtained from the DWRSIM output files. The model calculates the quantity of releases from New Melones Reservoir, New Don Pedro Reservoir, and Lake McClure required for this purpose, and specific model output files identify this quantity of water. This quantity of water is provided by curtailing diversions of water right holders in the San Joaquin Basin water right holder database in order of water right priority. Water is available from a water right holder to meet the Vernalis objectives if the water right holder is directly diverting water or diverting water to storage in the months in which flows are required. Monthly average diversions to storage are available from the DWRSIM output files. The calculation of monthly average direct diversion quantities is described in the next section of this report.

In real-time operation of this alternative, an estimate would be made of the near-term flow deficiency in the San Joaquin River, and the appropriate number of water right holders would be directed to curtail diversions.

b. **Delta Calculation for Flow Alternative 3**. The watershed protection statutes apply to this calculation. The SWRCB includes Standard Term 91 in all permits issued since 1965 to ensure that inbasin users are not diverting water that is released from storage by the DWR and the USBR to meet Delta objectives. The method for calculating the responsibility of other users to provide water for Delta objectives is based on a modified Term 91 approach. Term 91 states:

> No diversion is authorized by this permit when satisfaction of inbasin entitlements require release of supplemental project water by the SWP and the CVP.

a. Inbasin entitlements are defined as rights to divert water from streams tributary to the Delta for use within the respective basins of origin or the legal Delta, natural requirements for riparian habitat and conveyance losses, and flows required by the SWRCB for maintenance of water quality and fish and wildlife. Export diversions and project carriage water are specifically excluded from the definition of inbasin entitlement.

b. Supplemental project water is defined as water imported to the basin by the projects and water released from project storage which is in excess of export diversions, project carriage water, and project inbasin deliveries.

As shown in Figure IV-1, the Term 91 method treats the Delta watershed as if it is a fully interconnected basin below the foothill reservoirs. Water availability is assumed to be the same throughout the basin. When natural and abandoned flow in the basin is greater than the inbasin demand plus Delta outflow requirements, water is available for appropriation. When natural and abandoned flows are insufficient to supply inbasin needs and Delta outflow requirements, the SWP and the CVP must release stored water, under the present regulatory requirements, to ensure that inbasin entitlements are met.

Term 91, as presently applied, can be expressed in the following mathematical notation, and an example of a Term 91 calculation is provided in Figure IV-1.

$$SW = SR - (EX + CW)$$

Where:	SW	=>	Supplemental water, as defined above.
	SR	=>	Project storage releases from Shasta, Oroville and Folsom reservoirs, plus imports from the Trinity River.
	EX	=>	Export diversions into the California Aqueduct, the Delta-Mendota Canal, the Contra Costa Canal, and the North Bay Aqueduct.
	CW	=>	Carriage water required to repel seawater due to operation of the export pumps.

This method of calculating supplemental water was approved by the SWRCB in Order 81-15. The order states that carriage water does not apply when a flow objective is the controlling objective in the Delta. Under D-1485, salinity objectives controlled the majority of the time, and carriage water was an important consideration. However, under the 1995 Bay/Delta Plan, outflow objectives control the majority of the time. Therefore, the carriage water term is almost always zero, and it can be ignored in the Term 91 calculation at this time. In addition, the version of DWRSIM used in the modeling study for this draft EIR does not include a carriage water calculation and so the information is not available for purposes of calculation in the draft EIR.

Figure IV-1 Term 91

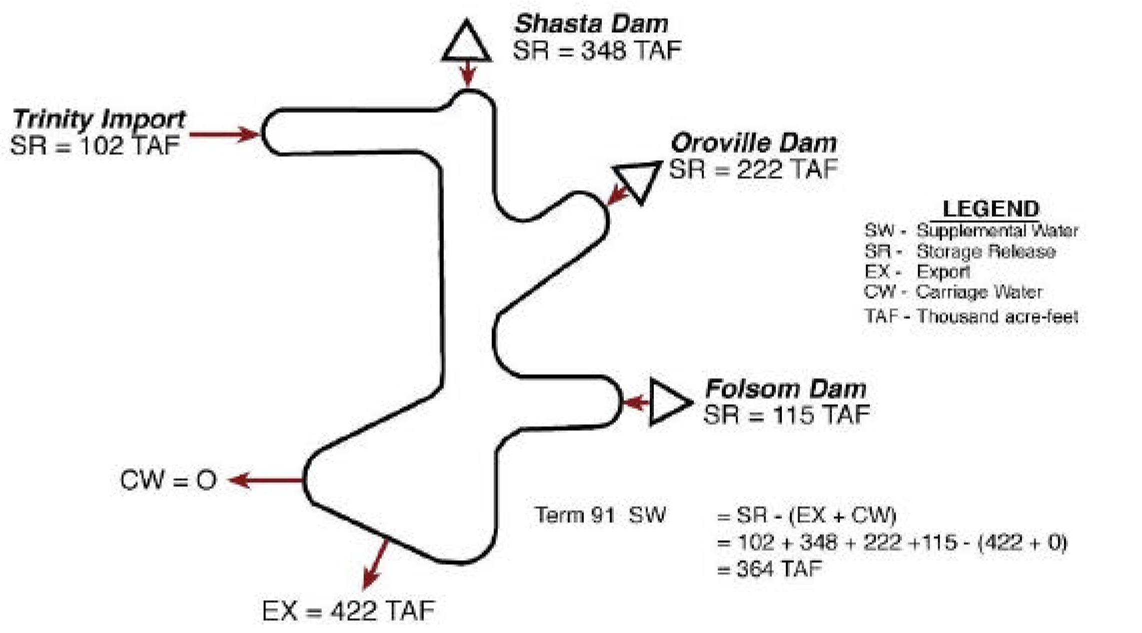
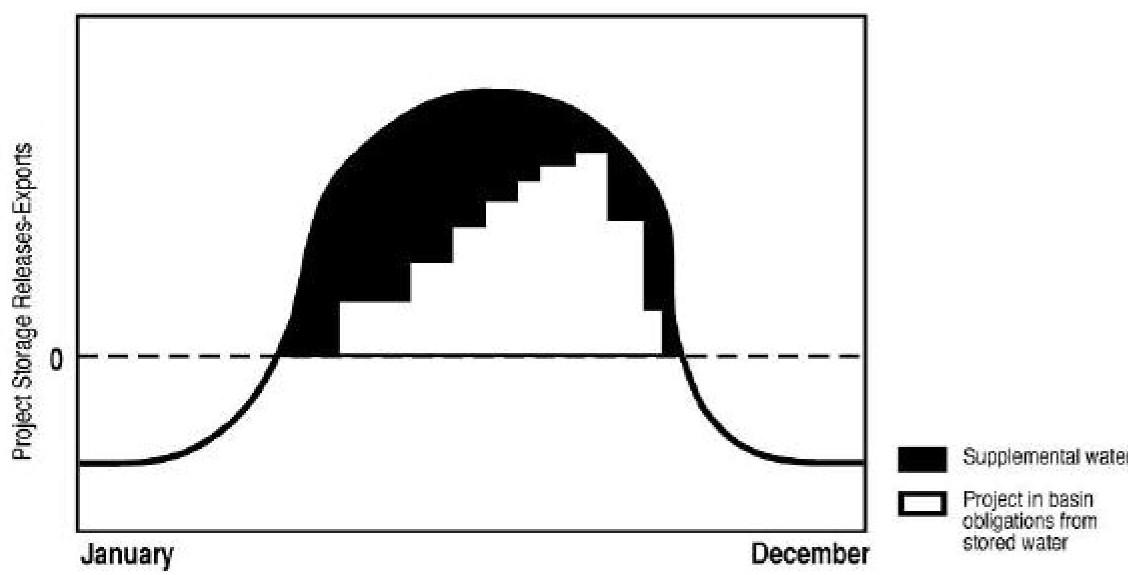


Figure IV-2. Graphical Representation of Supplemental Water Calculations



Although Term 91 recognizes the projects' obligation for inbasin deliveries, the equation above does not include a term for this obligation. This is because Term 91 presently is included only in appropriative water rights issued after 1965, and those rights are junior to the inbasin rights of the SWP and the CVP. Before the equation used to calculate supplemental water can be applied to all post-1914 appropriators on the data base, the equation must be modified to account for the projects' obligation to serve their inbasin contractors with stored water. For contractors with no independent water rights and contractors with water rights junior to the projects, the obligation exists when the contractors are being served with water under the projects' rights, and the projects' inbasin direct diversions have been curtailed. For contractors with water rights senior in priority to the projects, the obligation exists when the contractors' rights to divert water have been curtailed. The new term that must be added to the Term 91 equation tracks this inbasin obligation (IO) that requires the release of stored water. As direct diversions under the projects' inbasin rights are curtailed and as direct diversions of contractors with rights senior to the projects are curtailed, the storage release obligations of the projects increase in an amount adequate to serve these contractors. These increased storage release obligations are project obligations and not the responsibility of inbasin users and must be subtracted from the projects' storage release when supplemental project water is calculated. This situation is illustrated in Figure IV-2.

The new equation that can be used to implement a Term 91 approach for all post-1914 appropriators is defined below.

$$SW_3 = SR - (EX + IO_n)$$

In real-time operation, water right holders would be required to curtail diversions to ensure that supplemental water does not exceed zero. In the context of the model results, DWRSIM output files can be used to calculate the number of water right holders that would be required to curtail diversion by using the following equation:

$$SR - (EX + IO_n) = DD_n + Sto_n$$

Where:

- SW_3 => Supplemental water for Flow Alternative 3.
- IO_n => Project inbasin obligations at water right priority (n) that require the release of stored water.
- DD_n => Reduction in stream depletions from cessation of direct diversions at water right priority (n).
- Sto_n => Reduction in stream depletion from cessation of storage at water right priority (n).

For purposes of calculation, it is convenient to express the equation in the following form:

$$SR - EX = DD_n + Sto_n + IO_n$$

The quantity on the left side of the equation identifies the amount of water that is needed to satisfy inbasin entitlements after the obligations of the SWP and the CVP due to their export operations have been met. Another way to think of this term is that it is the quantity of water being used by inbasin water users beyond their inbasin rights. The terms on the right side of the equation identify the inbasin sources available to satisfy the inbasin entitlements.

The DWRSIM output provides the quantities SR, EX, and Sto_n on a monthly average basis, and monthly average estimates of IO_n and DD_n can be calculated, as described in the next section of this report. The number of direct diversions and diversions to storage that need to be curtailed can also be calculated on a real-time basis using this equation. The quantities SR, EX, and Sto_n can be obtained on a daily basis from the SWP and the CVP and from non-project reservoirs subject to curtailment of diversions to storage, and daily estimates of IO_n and DD_n can be calculated.

For ease of analysis of an alternative of this nature, water right holders in the database subject to this alternative have been placed into one of eight groups based on their water right priority. All of the water right holders in a group would be directed to curtail diversions at the same time. A group is not directed to curtail diversions unless there is no water available to the entire group. However, the SWRCB could direct that water right holders be treated individually and not placed into water right priority groups.

c. **Vernalis Calculation for Flow Alternative 4**. The watershed protection statutes apply to this calculation because the Friant Project is treated as an export project. The alternative further assumes that the Friant Project's obligations will be met by releases from New Melones Reservoir.

A principal issue in the analysis of this alternative is the treatment of the Exchange Contractors. These contractors have retained their riparian and pre-1914 appropriative water rights on the upper San Joaquin River, but they executed a contract with the CVP to receive water from any source, including the Delta, in exchange for their San Joaquin River water. This exchange allows the diversion of the majority of the San Joaquin River at Friant Dam for use in the Tulare Lake Basin. This routing of water is more efficient than the alternative of supplying the Friant-Kern service area with water diverted from the Delta. From a water right perspective, deliveries to the Exchange Contractors can be treated as inbasin deliveries because the contractors have inbasin rights. The conceptual model for the calculation is a water routing system in which (1) San Joaquin River water is provided to the Exchange Contractors; (2) unmet demands of the Exchange Contractors are met with diversions from the Delta; (3) any remaining water from Millerton Lake after the inbasin demands are met is exported to the Friant-Kern service area; and (4) remaining export demands in the Friant-Kern service area are met with diversions from the Delta.

The following additional assumptions are made to calculate responsibility to achieve the Vernalis flow objectives under this alternative.

1. Friant-Kern exports are defined, for the purposes of application of the watershed protection statutes, as total diversions into the Friant-Kern Canal minus deliveries to the Kings River Basin. This definition is based on the statutes, which provide protection both to the watershed of origin and to immediately adjacent areas that can be conveniently served from the watershed of origin. The Kings River Basin is assumed to be an immediately adjacent area that can be conveniently served from the San Joaquin River.

2. Exchange contractor deliveries are obtained from the DWRSIM output files. In order to determine the inbasin deliveries, the output files are capped based on two other considerations. First, the deliveries cannot exceed the contractual amount of 840 TAF. Second, the deliveries cannot exceed the amount of water that would be available under the contractors' water rights if they were diverting from the San Joaquin River. This quantity is obtained by subtracting riparian diversions between Millerton Lake and Gravelly Ford from the inflow to Millerton Lake.

3. Exchange contractor monthly deliveries, as defined in (2) above, are subtracted from Friant-Kern monthly exports, as defined in (1) above, to obtain the final Friant-Kern export term used for subsequent calculations. If the exchange contractors' deliveries are greater than exports, the Friant-Kern export term is set to zero.

Using the assumptions and conceptual model described above and DWRSIM output files, the responsibility of water right holders other than the CVP to release water to meet the Vernalis objectives can be calculated using the following equation:

$$SW_{SJ} = Add + SR_F - (EX_F + IO_{Fn})$$

Where:

- SW_{SJ} => Supplemental water for the Vernalis objective - the quantity of water that water users, other than the Friant Project, are required to bypass to meet the Vernalis flow objectives (negative numbers are set to zero and SW_{SJ} # Add).
- Add => The quantity of water above natural and abandoned flows in the San Joaquin River needed to achieve the Vernalis flow objectives.
- SR_F => Millerton Lake storage releases.
- EX_F => Friant-Kern exports, as defined above
- IO_{Fn} => Friant Project inbasin obligations that would require the release of stored water at water right priority (n) because of the Vernalis objective.

The number of direct diversions and diversions to storage in the San Joaquin River that need to be curtailed to achieve the quantity SW_{SJ} is determined using the method described in the previous section. Specifically, the following equation is used.

$$Add + SR_F - (EX_F + IO_{Fn}) = DD_n + Sto_n$$

In this equation, the terms DD_n and Sto_n represent the reductions in stream depletions in the San Joaquin Basin from cessation of direct diversions and storage, respectively, of water users in the basin at water right priority (n).

For purposes of calculation, it is convenient to express the equation in the following form.

$$Add + SR_F - EX_F = DD_n + Sto_n + IO_{Fn}$$

The quantity on the left side of the equation identifies the amount of water that is needed to satisfy inbasin entitlements in the San Joaquin Basin after the obligations of the Friant Project due to its export operations have been met. (When SR > or = to EX, the left side of the equation is set equal to Add.) Alternatively, the term can be thought of as the amount of water being used by inbasin water users beyond their inbasin water rights. The terms on the right side of the equation identify the inbasin sources in the San Joaquin Basin available to satisfy the inbasin entitlements.

The Friant Project's share of the Vernalis flow objectives (FO) can be calculated using the following equation. New Melones Reservoir is responsible for releasing this quantity of water.

$$FO = Add - SW_{SJ}$$

All of the terms described above can be either calculated or extracted from the DWRSIM output. In real-time operation, the terms of the equations can be determined on a daily basis from monitoring data or they can be calculated, as described in the sections above.

d. Delta Calculation for Flow Alternative 4. The only difference between the calculation for this alternative and the calculation for the responsibility to achieve the Delta objectives under Flow Alternative 3 is that the Friant Project has been added as an export project. Consequently, the following equation applies:

$$SW_4 = SW_3 + SR_F - (EX_F + IO_{Fn}) + FO$$

Where: SW_4 => Supplemental water for Flow Alternative 4

For purposes of calculation, it is convenient, for the reasons described in the previous two sections, to express the equation in the following form.

$$SR - EX + FO = DD_n + Sto_n + IO_n$$

In this equation, the terms SR, EX, and IO_n apply to all of the export-related operations of the projects in the Sacramento and San Joaquin basins, including the operations of the Friant Project.

The quantity on the left side of the equation identifies the amount of water that is needed to satisfy inbasin entitlements after the obligations of the SWP and the CVP due to their export operations have been met. The terms on the right side of the equation identify the inbasin sources throughout the Sacramento and San Joaquin basins available to satisfy the inbasin entitlements.

2. Calculation of Stream Depletions Due to Diversions

Most of the terms in the equations described in the previous section are obtained from DWRSIM output files. However, two of the terms, DD and IO, are calculated. A description of how these terms are calculated is provided below.

a. DD Calculation. The DD term provides the depletions due to direct diversions of water right holders without a contract with the SWP and the CVP. The term is calculated by multiplying the irrigated acreage of the water right holder both by the monthly consumptive use of applied water (CUAW) factor for the depletion study area (DSA) in which the depletion occurs and by a nonrecoverable losses factor. The irrigated acreage data is obtained from Reports of Permittee and Licensee in the SWRCB files. The monthly CUAW factor for each DSA is available from DWR and is based on land use studies conducted by the DWR. The nonrecoverable losses factors were obtained from the DWR. The factor is ten percent for diversions on the valley floor and fifteen percent for diversions in the rim areas. For applicants with multiple rights, diversions are assumed to occur first under the senior right until the full face value of the right is exhausted. When multiple rights have overlapping places of use, the acreage applied to each right is determined on a case-by-case basis by reviewing detailed place of use maps. Volume 2, Appendix 3 contains tables that identify the magnitude of the DD term at the different water right priorities.

b. IO Calculation. The projects' inbasin contractors fall into one of two categories: water supply contractors and water settlement contractors. Water supply contractors divert under the projects' rights and make full payment for water received. Water settlement contractors have their own water rights, and they divert under those rights until water is no longer available under their priority, at which time they divert under the projects' rights. The CVP settlement contracts specify monthly quantities of water available under the contractors' water rights (base supply). Amounts of water used in excess of the base supply are considered the CVP's supply for which payment is required.

The projects have inbasin direct diversion water rights that they use to provide service to their contractors. When water is no longer available under these direct diversion water rights, depletions due to the contractors diverting under these rights must be met by releases from the projects' storage. Some settlement contractors have rights to divert water at priorities senior to the projects' inbasin rights. When these contractors rights are curtailed, their depletions also become a storage release obligation of the projects. The IO term provides the depletions due to diversions of the projects' contractors when the contractors are no longer able to divert under their own rights, if any.

The IO term is calculated by multiplying monthly average deliveries to each contractor by the basin efficiency and a non-recoverable loss factor. The monthly average deliveries are derived by distributing the average annual deliveries for the period 1982 through 1989 (excluding 1983 which was an exceptionally wet year), which were provided by the projects, among the months of the irrigation season based on the delivery pattern to the Tehama-Colusa Canal. The basin efficiency and the non-recoverable loss factor were obtained from the DWR.

The IO term for a specific contractor may be reduced in years when deficiencies are imposed on inbasin project deliveries. Deficiencies are calculated as a percentage of base and project entitlement. Deficiencies are applied first to project water contractors up to a maximum of 50 percent of entitlement, then to settlement contractors up to 25 percent of combined project and base supply. A preliminary IO term under deficiency conditions is calculated for each contractor based on the assumptions described above. This quantity is then compared to the IO term under normal conditions, which is based on depletions caused by average deliveries. The smaller of the terms is used as the final IO term under deficiency conditions. Volume 2, Appendix 3 contains tables of the possible combinations of IO terms used in the calculations.

H. WATERSHED ANALYSIS

Flow Alternative 5 establishes flow requirements to meet Vernalis and Delta outflow objectives for individual watersheds tributary to the Delta based upon their relative contribution to unimpaired Delta inflow. Data for unimpaired flow were obtained from DWR and is published in a document titled California Central Valley Unimpaired Flow Data – 1920-1992 (DWR 1994c). For each basin, a minimum monthly flow obligation is calculated for each of the five water year types defined in the 1995 Bay/Delta Plan. The individual tributary flow requirements are listed in Table II-7. The responsibility to meet requirements is assigned to the rim reservoirs that control downstream flow. In addition, upstream reservoir owners with cumulative capacity of greater than 100 TAF would also share responsibility. The affected reservoirs are listed in Table II-8. If more than one party has an obligation on a given tributary, the responsibility is divided among parties based on each party's depletion of the tributary. The responsibility on rivers controlled by the SWP or the CVP is assigned entirely to the projects, as is overall responsibility for meeting the Delta outflow objectives.

1. Calculation of Watershed Allocation

Average required monthly flows are calculated for each watershed and each water-year type. In the calculation, the Sacramento and San Joaquin basins are treated differently, depending on the month. Tributaries to the San Joaquin River upstream of Vernalis contribute to both the Vernalis and the Delta outflow objectives during the months of February through June and in October. In the Sacramento basin and for the East Side Streams, tributaries contribute only to Delta outflow. Consumptive use within the Delta, which is assumed to be entirely riparian, is assigned to the Sacramento basin tributaries. Also, for the purposes of this analysis, Putah and Cache creeks are assigned no obligation to Delta outflow.

Tributary obligations are calculated using the following equations:

For months with Vernalis objectives:

SR Tribs = (SR %) x (Adjusted Average Minimum Delta outflow) +
(SR %) x (Average Delta CU)

SJR Tribs = (SJR %) x (Avg. SJR flow objective)

Where:
CU => Consumptive Use
SR => Sacramento River
SJR => San Joaquin River
SR % => the average unimpaired contributions of the Sacramento River expressed as a percent of the total contribution of tributaries participating in the basin

SJR % => the average unimpaired contributions of the San Joaquin River expressed as a percent of the total contribution of tributaries participating in the basin

The Average Minimum Delta Outflow, San Joaquin River Objective, and Delta Consumptive Use data are taken directly from a DWRSIM study in which all 1995 Bay/Delta Plan objectives are met by the projects and other sources as needed. The adjusted minimum Delta outflow for each water year type is equal to the minimum required Delta outflow minus the required San Joaquin River flow. Tables showing the details of the calculation are in Volume 2, Appendix 4.

In months without Vernalis objectives:

SR Tribs = (Overall %) x (Adj. Avg. Min. Delta outflow) + (SR %) x (Avg. Delta CU)
SJR Tribs = (Overall %) x (Adj. Avg. Min. Delta outflow)

In watersheds with multiple major parties, a cost sharing formula was devised based on each party's depletion of water from the tributary. Exported water creates no return flow. Therefore, for the districts that export water, depletions are equal to total diversion. Table IV-1 specifies the diversion, depletion, and percent of the total depletion for the Yuba, Bear, and Tuolumne Rivers. The responsibility of each party to meet the flow obligation for its tributary is equal to the percent total depletion for the tributary.

Table IV-1
Flow Alternative 5 Obligations for the Yuba, Bear, and Tuolumne Rivers

Agency	Average Diversion (afa)	Average Depletion (afa)	Total Depletion (%)
Yuba River Obligations[1]			
Yuba Co Water Agency	232,470	166,472	24.83
PG&E	381,808	381,808	56.95
Nevada I.D.	58,600	58,600	8.74
Oroville Wyandotte I.D.	63,538	63,538	9.48
Bear River Obligations[2]			
Nevada I.D.	52,201	37,381	34.90
South Sutter W.D.	82,350	61,651	57.55
Camp Far West I.D.	10,803	8,088	7.55
Tuolumne River Obligations[3]			
City of San Francisco	240,258	240,258	21.1
Modesto I.D.	264,812	235,074	20.6
Turlock I.D.	749,138	665,010	58.3

1. Data Source: April 30, 1997 letter from Bookman Edmonston
2. Data Source: SWRCB files for A2652A and A14804
3. Data Source: SWRCB files

Literature Cited in Chapter IV

Barnes, G. and F. Chung. 1986. Operational Planning for California Water System. Journal of Water Resources Planning and Management 112:71-86.

Bennett, B. and L. Howard. 1997. El Ninos and the Decline of Striped Bass. Interagency Ecological Study Program Newsletter. Vol. 10, No. 4. Autumn, 1997.

Bookman-Edmonston. 1997. Letter from Stuart Robertson to Victoria Whitney, Comments on Materials Distributed at March 18, 1997 Bay-Delta Staff Workshop, SWRCB File A005625, April 30, 1997. 4 pp plus attachments.

Chadwick, H.K., D.E. Stevens, L.W. Miller, and W. Van Winkle. 1977. Some Factors Regulating the Striped Bass Population in the Sacramento-San Joaquin Estuary, California. In *Proceedings of the Conference on Assessing the Effects of Power-Plant-Induced Mortality on Fish Populations, Gatlinburg, Tennessee, May 3-6, 1977.* Pergamon, New York.

CVPIA. 1994. A Model for Projection of Striped Bass Abundance in Terms of Flows and Diversions. Striped Bass Technical Team for the CVPIA. November 1994. 18 pp.

CVRWQCB. 1996. SJRIO2 Documentation and Users Manual (Draft). Central Valley Regional Water Quality Control Board. February 21, 1996. 26 pp. plus attachments.

DFG. 1987. Delta Outflow Effects on the Abundance and Distribution of San Francisco Bay Fish and Invertebrates, 1980-1985. California Department of Fish and Game.

DFG. 1992a. Estuary Dependent Species. 97 pp.

DFG. 1992b. A Model for Evaluating the Impacts of Freshwater Outflow and Export on Striped Bass in the Sacramento-San Joaquin Estuary. 44 pp. plus appendices.

DWR. 1986. Operations Criteria Applied in DWR Planning Simulation Model. California Department of Water Resources. 62 pp.

DWR. 1992a. Comparison of DWRSIM Versus the Historical Measured Inflow to the Delta. 13 pp.

DWR. 1992b. Predictive Ability of the Striped Bass Model. July 27, 1992. 18 pp.

DWR. 1994a. Summary of Hydrologies at the 1990, 1995, 2000, 2010, and 2020 Levels of Development for Use in DWRSIM Planning Studies. California Department of Water Resources. July 1994. 34 pp.

DWR. 1994b. California Water Plan Update. Bulletin 160-93. California Department of Water Resources. Sacramento, California. 150pp.

DWR. 1994c. Central Valley Unimpaired Flow Data, Third Edition. DWR Division of Planning. August 1994. 54 pp.

DWR. 1995. Delta Hydrodynamics and Water Quality Model (DWRDSM). Description of Model by Francis Chung. April 21, 1995. 2 pp.

DWR. 1996a. DWR Planning Simulation Model (DWRSIM) Assumptions for SWRCB Base Study with D-1485 Delta Standards. 1995C6F-SWRCB-467. November 12, 1996 Preliminary Draft. 7 pp.

DWR. 1996b. DWR Planning Simulation Model (DWRSIM) Assumptions for SWRCB Study with May 1995 WQCP Delta Standards. 1995C6F-SWRCB-468. November 12, 1996 Preliminary Draft. 5pp.

Kimmerer, W. 1994. Setting Goals for Salmon Smolt Survival in the Delta. August 10, 1994. 15 pp.

Kimmerer, W. 1997a. X2 Update. Interagency Ecological Study Program Newsletter. Vol. 10, No. 3. Summer, 1997.

Kimmerer, W. 1997b. Flow Effects and Density Dependence in Striped Bass. Interagency Ecological Study Program Newsletter. Vol. 10, No. 4. Autumn, 1997.

Monterey. 1994. 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. December 1, 1994. 9 pp. plus exhibits.

Newman, K. and J. Rice. 1997. A Statistical Model for the Survival of Chinook Salmon Smolts Outmigrating Through the Lower Sacramento-San Joaquin System. November 19, 1997. 67 pp.

Sommer, T.; Baxter, R; and Herbold, B. 1997. Splittail Revisited. Interagency Ecological Study Program Newsletter. Vol., No. 3. Summer, 1997.

Stockton. 1993. City of Stockton Water Quality Model, Volume 1: Model Development and Calibration. September 1993. 38 pp. plus attachments.

SFEP. 1992. The 2 ppt Bottom Isohaline as an Index of Conditions for Biological Resources. Alan D. Jassby, Division of Environmental Studies, University of California, Davis. June 17, 1992. Entered by the San Francisco Estuary Project, U. S. Environmental Protection Agency, San Francisco, California. 12 pp.

SFEP. 1993. Managing Freshwater Discharge to the San Francisco Bay-Delta Estuary: the Scientific Basis for an Estuarine Standard. San Francisco Estuary Project, U.S. Environmental Protection Agency, San Francisco, California. 17 pp. plus appendices.

SWRCB. 1992. Stochastic Water Quality Modeling and Numerical Groundwater Simulation for the Lower San Joaquin River Basin. State Water Resources Control Board. April 1992. 128 pp.

Turner, J.L. and H.K. Chadwick. 1972. Distribution and Abundance of Young-of-the-Year Striped Bass, *Morone saxatilis,* in Relation to River Flow in the Sacramento-San Joaquin Estuary. Trans. Am. Fish. Soc. 101:442-452.

USBR. 1990. Monthly Temperature Model - Sacramento River Basin. Mid-Pacific Region, Sacramento, CA. June 1990.

USBR. 1993. Stanislaus River Basin Temperature Model. Sacramento, CA, Draft Report, June 1993, Revised 1997.

USBR. 1996. Letter from Lowell Ploss, Operations Manager, USBR, to Tom Howard, SWRCB. April 26, 1996. 3 pp. plus attachments.

USBR. 1997. CVPIA Draft PEIS, Draft Methodology/Modeling Technical Appendix, Volume 9, Fish Habitat Water Quality M/M. Sacramento, CA. September 1997.USFWS. 1995. Working Paper on Restoration Needs (Habitat Restoration Actions to Double Natural Production of Anadromous Fish in the Central Valley of California). Volume 3. May 9, 1995. Page 3-Xe-1.

CHAPTER V. WATER SUPPLY IMPACTS OF THE FLOW ALTERNATIVES

The purpose of this chapter is to evaluate the water supply impacts of the seven alternatives for implementing the flow objectives in the 1995 Bay/Delta Plan. The seven alternatives are described in detail in Chapter II, section E.1. A number of parameters have water supply implications among the alternatives being evaluated. The principal parameters are delivery changes, export reductions, carry-over storage changes, and water transfer export capacity in the Delta.

In addition to evaluating impacts to the quantities of water available under the seven alternatives, this chapter contains an analysis of the time of year and frequency that diversions are curtailed for individual water rights holders in the Central Valley under Alternatives 3 and 4. These two alternatives require surface water diversion curtailments, based on the water rights priority system, when the SWP and CVP are releasing supplemental water to meet inbasin entitlements. Implementation of Alternatives 3 and 4 will affect the exercise of water rights and the water supply available to individual water right holders in the Central Valley.

Where applicable, impacts are determined by subtracting the value of a water supply parameter for the base case from that of the alternatives. Because hydrologic conditions vary considerably from year to year in the project area, the water supply impacts are calculated for two different hydrology scenarios: (1) the average annual impacts based on the historic 73-year period hydrology of 1922 through 1994, and (2) the average annual impacts based on the critically dry period hydrology of May 1928 through October 1934 (called the critical period).

This chapter is divided into the following sections: (A) water deliveries, (B) carryover storage in Central Valley reservoirs, (C) Delta exports, (D) capacity for water transfers, (E) diversion curtailments under Alternatives 3 and 4, and (F) summary and conclusions.

A. WATER DELIVERIES

The amount of water delivered for beneficial consumptive use under each alternative was determined using results from DWRSIM, EBMUDSIM and HEC 3. Chapter IV of this EIR discusses the assumptions and operating criteria used in the DWRSIM modeling studies for each of the flow alternatives. EBMUD provided results from its planning model, EBMUDSIM, for the base case and Alternatives 3, 4 and 5. EBMUD reservoir operations under Alternatives 2, 6, 7, and 8 are identical to the base case; thus, these alternatives were not modeled. For Alternative 5, the HEC 3 model of the Yuba and Bear river systems, which provides input to DWRSIM, was run. The HEC 3 model results provide information on delivery impacts on the Yuba and Bear rivers for Alternative 5. The HEC 3 analysis shows substantial reductions in diversions through the Bear River Canal. However, these diversion reductions are not included in the delivery reduction analysis. DWRSIM output shows full deliveries to the Bear River Canal vicinity because the model attempts to make full deliveries from other available sources, including groundwater, when one of the available sources has deficient supplies. This feature of the model causes upstream delivery reductions to be translated into export reductions. The HEC 3 model was not rerun for Alternatives 3 and 4, because, although those alternatives could affect deliveries on the Bear and Yuba rivers, the impact would be small. Additional information regarding the modeling of the Bear and Yuba River systems is located in Chapter IV, section H.

The delivery reduction calculations for Alternatives 3 and 4 are affected by assumptions included in the modeling. When a direct diversion is curtailed under these alternatives, the water right holder can either contract for a substitute water supply, as other prior right water users have in the past, or pump groundwater. For modeling purposes, the assumption is made that a water right holder in the Sacramento Basin will contract for a substitute water supply while a water right holder in the San Joaquin Basin will pump groundwater. Consequently, the model results show no impact on Sacramento Basin direct diverters under these alternatives, but do show an impact on the San Joaquin Basin direct diverters. The Sacramento Basin impact is translated into an export area delivery impact because the SWP and the CVP are supplying stored water to the water right holders required to curtail direct diversions. Because of these assumptions, the results of this section and section E of this chapter should be considered together to understand the delivery impacts of Alternatives 3 and 4. Section E evaluates the time of year and frequency that individual water right holders in the Central Valley must curtail diversions to meet the flow objectives.

As formulated, Alternative 5 significantly exceeds the Delta flow objectives and results in the largest average water delivery reductions for the 73-year period. Further refinement of this alternative would result in modeled water supply impacts closer to those of the other alternatives. The model results for Alternative 5 are still useful indicators of trends in water supply impacts.

A large part of the demand in the study area is met through delivery of water stored in reservoirs. The amount of water delivered versus the amount retained in a reservoir as carryover storage is an operations decision that can change from year to year. For modeling purposes, reservoir operation assumptions regarding deliveries versus carryover storage are programmed into the models. Thus, actual reservoir operations may vary from modeled operations resulting in different deliveries and carryover storage amounts than those calculated here. Nonetheless, the model results are a good tool for comparing the alternatives for relative impacts.

Table V-1 shows the annual average reductions, or in one case, increase, in deliveries for the different alternatives compared to the base case for the 73-year period. Table V-2 presents the information for the critical period. Delivery impacts are broken out by service area or supplier where possible. The total delivery reductions are shown at the bottom of both tables.

Table V-1

Base Case Water Deliveries and Delivery Changes, 73-Year Period Annual Average (TAF)

	Delivery Base Case	Delivery Change from the Base Case Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
Non-CVP/SWP Supplies								
Yuba River System	403	0	0	0	-45	0	0	0
Bear River System	290	0	0	0	-57	0	0	0
East Bay MUD	238	0	-3	-4	-22	0	0	0
San Joaquin River System Direct Diversions	857	0	-73	-65	0	0	0	0
City of San Francisco	243	0	0	0	0	0	0	0
Modesto ID/Turlock ID	1,138	0	0	0	-6	0	0	0
Merced Irrigation District	1,343	0	0	0	0	0	0	0
Eastman Lake (Chowchilla WD)	292	0	-14	-13	-10	0	0	0
Hensley Lake (Madera ID)	384	0	0	0	-7	0	0	0
Subtotal	**5,188**	**0**	**-90**	**-82**	**-147**	**0**	**0**	**0**
Selected SWP Supplies								
North Bay	42	-2	-2	-2	-1	-2	-2	-2
South Bay	167	-7	-5	-5	-2	-6	-8	-7
Tulare Basin	1,117	-45	-36	-36	-5	-44	-53	-45
Southern California	1,532	-61	-54	-54	-22	-59	-67	-60
Subtotal	**2,858**	**-115**	**-97**	**-97**	**-30**	**-111**	**-130**	**-114**
Selected CVP Supplies								
Contra Costa Canal	143	0	0	0	0	0	0	0
Stockton-East WD/Central San Joaquin WCD	107	-37	-22	-24	-9	-4	-84	-47
San Felipe Service Area	175	-9	-7	-7	-6	-8	-10	-10
Exchange Contractors	894	-20	-15	-16	-7	-21	-24	-18
Other CVP and DMC Ag Diversions	406	-44	-39	-39	-32	-25	-49	-55
Cross Valley Canal Ag Diversions	96	-10	-9	-9	-7	-6	-11	-12
Total Refuge Diversions	288	-3	-2	-2	-1	-4	-3	-3
San Luis Unit	913	-98	-86	-86	-71	-55	-107	-125
Friant Project	1,343	0	0	0	-423	0	0	0
Subtotal	**4,365**	**-221**	**-180**	**-183**	**-556**	**-123**	**-288**	**-270**
Total	**12,411**	**-336**	**-367**	**-362**	**-733**	**-234**	**-418**	**-384**

Table V-2

Base Case Water Deliveries and Delivery Changes, Critical Period Annual Average (TAF)

	Delivery Base Case	Delivery Change from the Base Case Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
Non-CVP/SWP Supplies								
Yuba River System	412	0	0	0	-90	0	0	0
Bear River System	224	0	0	0	-108	0	0	0
East Bay MUD	233	0	-15	-15	-37	0	0	0
San Joaquin River System Direct Diversions	853	0	-99	-82	0	0	0	0
City of San Francisco	260	0	0	0	0	0	0	0
Modesto ID/Turlock ID	1,171	0	0	0	-61	0	0	0
Merced Irrigation District	1,408	0	0	0	1	0	0	0
Eastman Lake (Chowchilla WD)	304	0	-19	-17	-8	0	0	0
Hensley Lake (Madera ID)	401	0	0	0	-6	0	0	0
Subtotal	**5,266**	**0**	**-133**	**-114**	**-309**	**0**	**0**	**0**
Selected SWP Supplies								
North Bay	31	-9	-8	-9	-4	-8	-9	-9
South Bay	125	-22	-21	-21	-6	-20	-22	-20
Tulare Basin	876	-152	-149	-149	-47	-145	-160	-146
Southern California	1,475	-307	-295	-294	-112	-292	-298	-293
Subtotal	**2,507**	**-490**	**-473**	**-473**	**-169**	**-465**	**-489**	**-468**
Selected CVP Supplies								
Contra Costa Canal	154	0	0	0	0	0	0	0
Stockton-East WD/Central San Joaquin WCD	38	-38	-38	-38	-17	-17	-30	-23
San Felipe Service Area	153	-17	-10	-10	-3	-20	-18	-16
Exchange Contractors	875	-64	-46	-45	-18	-76	-69	-63
Other CVP and DMC Ag Diversions	262	-56	-33	-33	-4	-60	-56	-52
Cross Valley Canal Ag Diversions	61	-13	-8	-8	-1	-13	-12	-11
Total Refuge Diversions	298	-5	-2	-2	-1	-7	-4	-5
San Luis Unit	578	-120	-72	-71	-9	-131	-121	-110
Friant Project	959	0	0	0	-327	0	0	0
Subtotal	**3,378**	**-313**	**-209**	**-207**	**-380**	**-324**	**-310**	**-280**
Total	**11,151**	**-803**	**-815**	**-794**	**-858**	**-789**	**-799**	**-748**

Alternative 6 results in the lowest total reduction in average deliveries for the 73-year period, but this result should be viewed with caution. Alternative 6 is the only flow alternative that includes unlimited combined use of SWP and CVP points of diversion in the Delta. The other alternatives would have smaller 73-year period average delivery reductions, when compared to Alternative 6, if they also included unlimited combined use of points of diversion. Combined use of points of diversion could be authorized as part of the implementation of the 1995 Bay/Delta Plan for any of the alternatives, as described in Chapter XIII of this report.

For the critical period, Alternative 8 reduces total deliveries the least. Alternative 5 has the largest delivery reductions for both the 73-year and critical period principally due to reductions in non-project deliveries and Friant Project deliveries.

B. CARRYOVER STORAGE IN CENTRAL VALLEY RESERVOIRS

Carryover storage is the amount of water retained in a reservoir at the end of September of each year. Carryover storage helps meet future demand in the event that the next year is dry. The amount of water dedicated to carryover storage is balanced against the amount needed to meet immediate delivery needs, hydropower generation needs, and instream flow requirements of a project, according to operation rules that differ for each reservoir. For the SWP and CVP reservoirs, the operation rules have been determined through optimization studies. Reservoir functions are modeled in DWRSIM according to these rules.

To determine the impacts of implementing the 1995 Bay/Delta Plan flow objectives on carryover storage, average September end-of-month storage amounts for each flow alternative are compared to those of the base case. Reservoirs in this analysis include, from north to south, Trinity Lake, Lake Shasta, Lake Oroville, Folsom Lake, Camanche Reservoir, Pardee Reservoir, New Melones Reservoir, New Don Pedro Reservoir, Lake McClure, Eastman Lake, Hensley Lake, and Millerton Lake. Tables V-3 and V-4 show carryover storage volumes in these reservoirs for the 73-year period and the critical period for the alternatives and the base case. Bar charts for each reservoir (Figures V-1 through V-11) show the increase or decrease in carryover storage for each alternative compared to the base case for the two scenarios. Trinity Lake carryover storage was not charted because there is no difference among the alternatives.

The charts show that Alternative 5 generally has more favorable carryover storage in the SWP and CVP reservoirs in the Sacramento Valley than the other alternatives. With the exception of New Melones Reservoir, Alternative 5 is the least favorable alternative for the Delta east-side and San Joaquin Valley reservoirs. This relationship is true for both the long-term average and the critical period average. For the San Joaquin Valley reservoirs (except New Melones), Alternatives 2, 6 and 7, which have little effect relative to the base case, are the most favorable alternatives. An anomalous result is apparent for Alternative 7 in New Don Pedro Reservoir where carryover storage is shown to increase although demands on the reservoir are higher in this alternative. This anomaly is caused because the FERC instream flow requirements for New Don Pedro Reservoir were modeled slightly differently under

Table V-3
Carryover Storage in Central Valley Reservoirs (TAF)
73-Year Period Annual Average

Alternative	Trinity	Sacramento Valley			Delta Eastside Area		San Joaquin Valley					
		Shasta	Oroville	Folsom	Pardee	Camanche	New Melones	N. Don Pedro	McClure	Eastman	Hensley	Millerton
Alt. 1	1329	2,910	2,310	481	163	238	1,543	1,365	657	27	23	186
Alt. 2	1330	2,886	2,195	444	163	238	1,238	1,365	657	27	23	186
Alt. 3	1330	2,929	2,204	458	168	210	1,457	1,275	602	40	21	186
Alt. 4	1330	2,929	2,203	457	168	208	1,358	1,292	631	39	22	186
Alt. 5	1330	3,015	2,328	482	134	162	1,554	1,124	522	18	12	175
Alt. 6	1329	2,805	2,181	408	163	238	1,560	1,365	657	27	23	186
Alt. 7	1329	2,819	2,141	426	163	238	1,788	1,377	654	27	23	186
Alt. 8	1330	2,896	2,165	448	163	238	1,392	1,346	612	27	23	186

Table V-4
Carryover Storage in Central Valley Reservoirs (TAF)
Critical Period Annual Average

Alternative	Trinity	Sacramento Valley			Delta Eastside Area		San Joaquin Valley					
		Shasta	Oroville	Folsom	Pardee	Camanche	New Melones	N. Don Pedro	McClure	Eastman	Hensley	Millerton
Alt. 1	775	1,944	1,608	261	155	205	1,104	1,101	644	12	14	156
Alt. 2	775	1,827	1,454	174	155	205	511	1,101	644	12	14	156
Alt. 3	775	1,956	1,418	206	159	161	996	776	598	21	10	156
Alt. 4	775	1,955	1,420	207	159	161	706	854	625	23	11	156
Alt. 5	775	2,079	1,646	266	95	57	1,228	410	433	9	6	149
Alt. 6	775	1,762	1,430	160	155	205	1,180	1,101	644	12	14	156
Alt. 7	775	1,857	1,453	187	155	205	1,531	1,133	642	12	14	156
Alt. 8	775	1,904	1,439	204	155	205	748	1,064	574	12	14	156

this alternative than under the other alternatives. In any event, the effect of Alternative 7 on New Don Pedro Reservoir is small. For New Melones Reservoir, Alternative 7 is the most favorable alternative for carry-over storage, due to modeling assumptions made for this alternative. Alternative 2 results in the lowest carry-over storage in New Melones Reservoir.

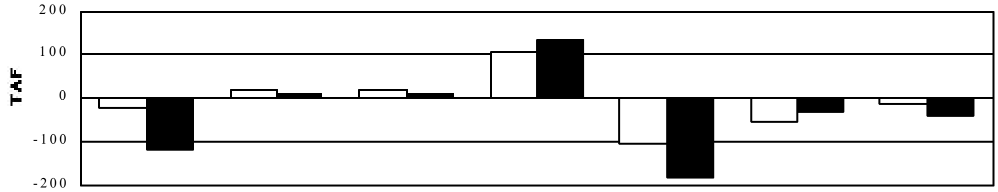
For Alternatives 3 and 4, the modeling assumption that water right holders in the Sacramento Valley will seek contracts from the DWR and USBR when their diversions are curtailed affects the carryover storage calculations for SWP and CVP reservoirs. If water right holders do not seek substitute water supply contracts when their diversions are curtailed, carryover storage in Sacramento Valley SWP and CVP reservoirs could increase over the amounts calculated in this analysis.

C. DELTA EXPORTS

The 1995 Bay/Delta Plan limits the rate of Delta export pumping to a percent of Delta inflow.[1] Total exports evaluated in this section include SWP Banks Pumping Plant exports,

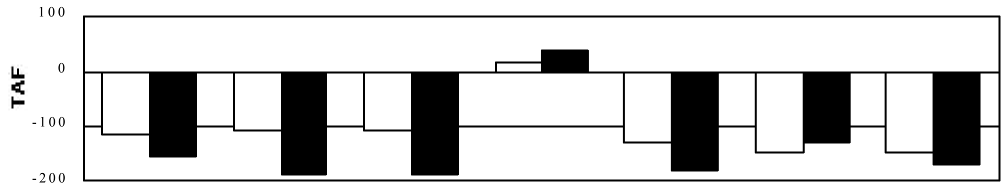
[1] The method for calculating the percent of Delta inflow diverted is described on page 25 of the 1995 Bay/Delta Plan.

Figure V-1
Shasta Lake Carryover Storage Impacts



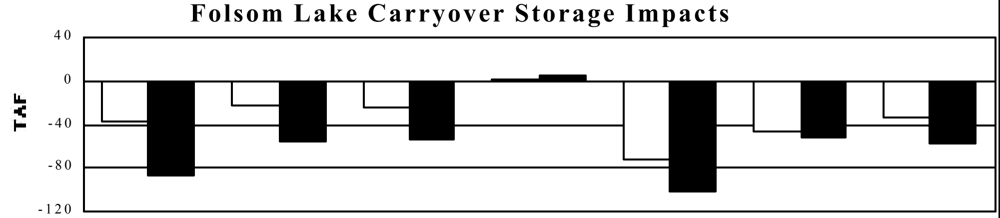
	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
□ 73-Year Period Avg.	-24	19	19	105	-105	-54	-14
■ Critical Period Avg	-117	11	11	135	-182	-30	-40

Figure V-2
Lake Oroville Carryover Storage Impacts



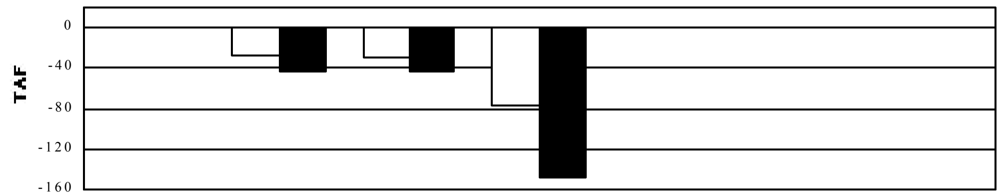
	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
□ 73-Year Period Avg.	-115	-106	-107	18	-129	-147	-145
■ Critical Period Avg	-154	-190	-188	38	-178	-129	-169

Figure V-3
Folsom Lake Carryover Storage Impacts



	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
□ 73-Year Period Avg.	-37	-23	-24	1	-73	-46	-33
■ Critical Period Avg	-87	-55	-54	5	-101	-52	-57

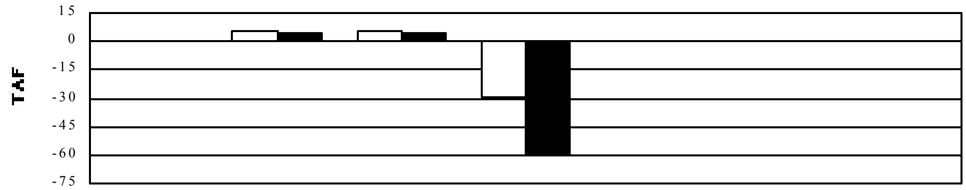
Figure V-4
Camanche Reservoir Carryover Storage Impacts



	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
□ 73-Year Period Avg.	0	-28	-30	-76	0	0	0
■ Critical Period Avg	0	-44	-44	-148	0	0	0

Figure V-5

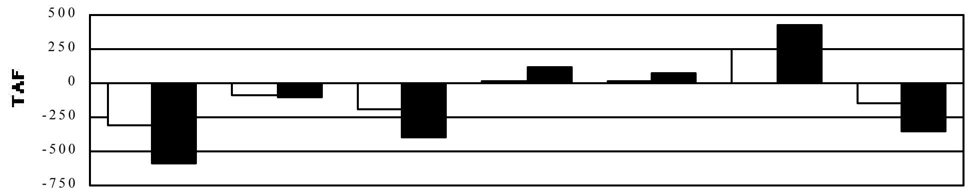
Pardee Reservoir Carryover Storage Impacts



	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
□ 73-Year Period Avg.	0	5	5	-29	0	0	0
■ Critical Period Avg	0	4	4	-60	0	0	0

Figure V-6

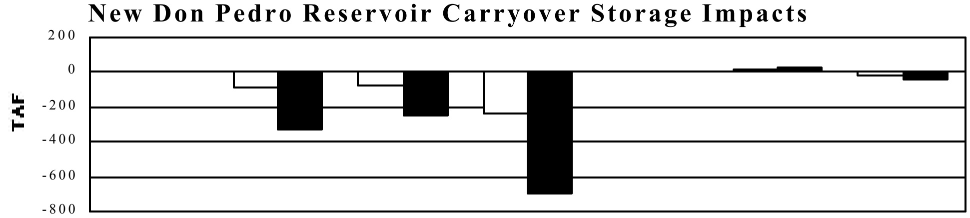
New Melones Reservoir Carryover Storage Impacts



	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
□ 73-Year Period Avg.	-305	-86	-185	11	17	245	-151
■ Critical Period Avg	-593	-107	-397	124	77	427	-356

Figure V-7

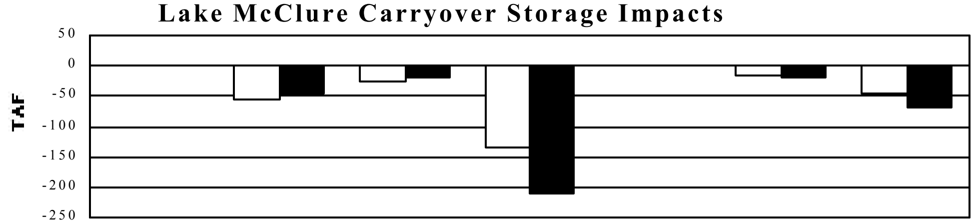
New Don Pedro Reservoir Carryover Storage Impacts



	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
□ 73-Year Period Avg.	0	-90	-73	-241	0	12	-19
■ Critical Period Avg	0	-325	-247	-691	0	31	-37

Figure V-8

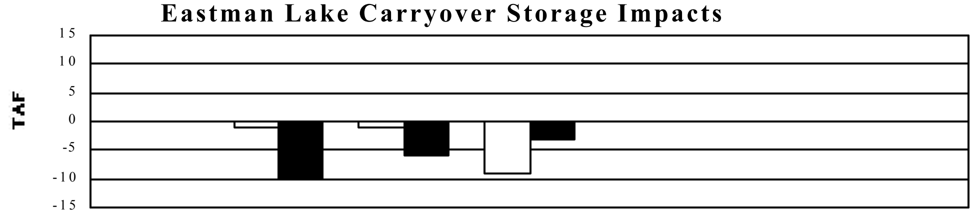
Lake McClure Carryover Storage Impacts



	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
□ 73-Year Period Avg.	0	-55	-26	-135	0	-17	-45
■ Critical Period Avg	0	-47	-20	-211	0	-18	-70

Figure V-9

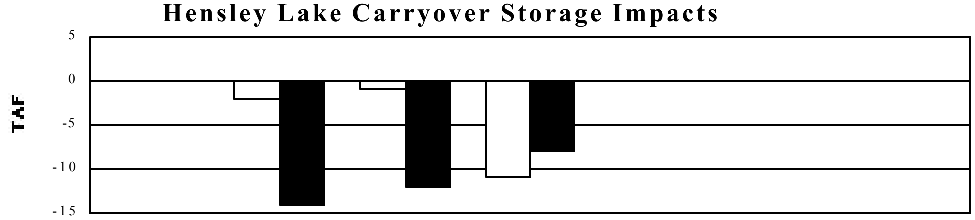
Eastman Lake Carryover Storage Impacts



	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
□ 73-Year Period Avg.	0	-1	-1	-9	0	0	0
■ Critical Period Avg	0	-10	-6	-3	0	0	0

Figure V-10

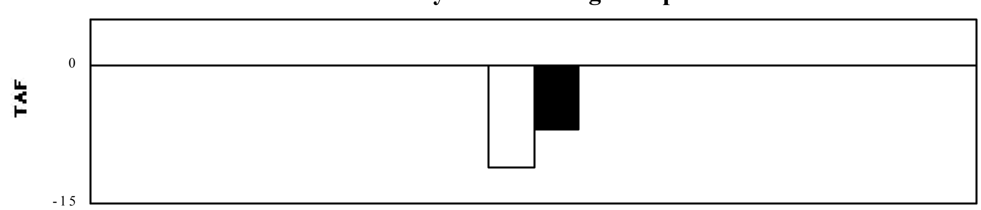
Hensley Lake Carryover Storage Impacts



	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
□ 73-Year Period Avg.	0	-2	-1	-11	0	0	0
■ Critical Period Avg	0	-14	-12	-8	0	0	0

Figure V-11

Millerton Lake Carryover Storage Impacts

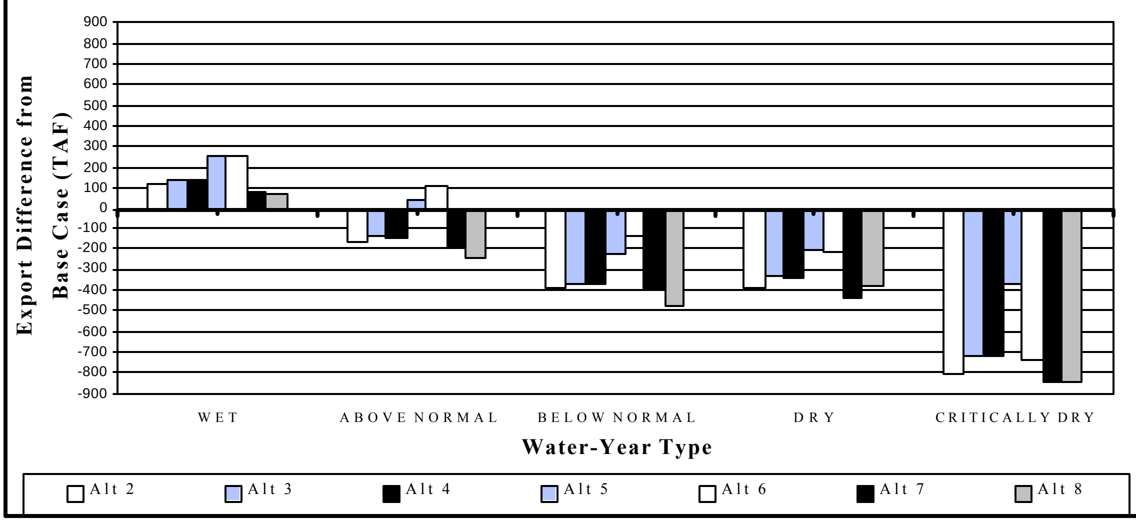


	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
□ 73-Year Period Avg.	0	0	0	-11	0	0	0
■ Critical Period Avg	0	0	0	-7	0	0	0

CVP Tracy Pumping Plant exports, Contra Costa Canal exports and North Bay Aqueduct exports. Figure V-12 shows the yearly average Delta exports by water year type. The 1995 Bay/Delta Plan allows an increase in export during wet years when compared to D-1485. Exports are reduced progressively as conditions become drier. Figure V-13 shows the average annual exports under the base case and alternatives for the 73-year hydrology and critical period hydrology. Figure V-14 shows the average annual export impact. The impacts to exports were calculated by subtracting the base case exports from the exports under each alternative. Figure V-14 shows that exports are reduced under all alternatives, but the reduction is least under Alternative 5, making it the favorable alternative with respect to exports. The largest export reductions occur under Alternative 8 for the 73-year period and Alternative 7 for the critical period.

Figure V-12

Average Annual Delta Export by Water-Year Type



Like carryover storage, exports under Alternatives 3 and 4 are affected by the assumption that water right holders in the Sacramento Valley will seek substitute water supply contracts from the DWR and USBR when their diversions are curtailed. More water may be available for export from the SWP and CVP than indicated by this analysis if water right holders do not seek contracts to replace curtailed diversions. Chapter VI discusses the potential effects if water right holders use groundwater instead of seeking substitute water supply contracts.

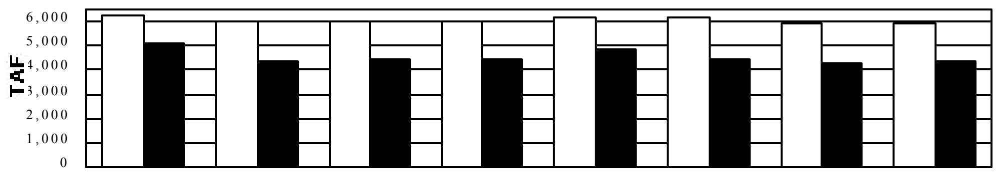
D. CAPACITY FOR WATER TRANSFERS

Water transfers using the SWP and the CVP export facilities are an important tool for meeting the water supply needs of the state. The capacity of export facilities to accommodate transfers has water supply implications for the different alternatives. The purpose of this analysis is to identify the maximum amounts of water that could be transferred under the flow alternatives, under optimal conditions. The actual transfer capacity may be less in many years. Nonetheless, the analysis provides valuable information about the relative impacts of the alternatives on transfer capacity. The analysis also provides a basis for determining the maximum environmental impacts that could occur.

For this evaluation, July through October is assumed to be the most likely period for water transfers to occur. This assumption is based on historical operations, the objectives in the 1995 Bay/Delta Plan, which are more restrictive in February through June, and the increased

Figure V-13

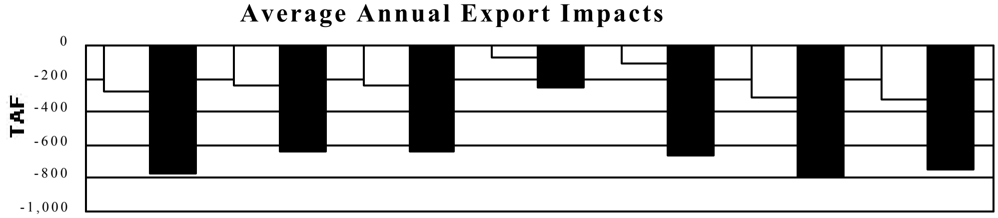
Average Annual Exports



	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
□ 73-Year Period Avg.	6,256	5,974	6,016	6,015	6,187	6,153	5,941	5,927
■ Critical Period Avg	5,102	4,329	4,462	4,466	4,843	4,438	4,310	4,357

Figure V-14

Average Annual Export Impacts



	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
□ 73-Year Period Avg.	-282	-240	-241	-69	-103	-315	-329
■ Critical Period Avg	-773	-640	-636	-259	-664	-792	-745

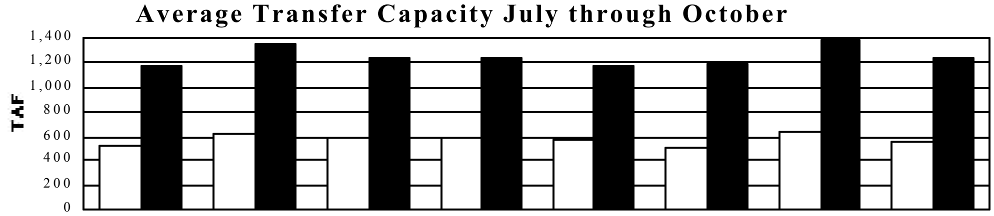
possibility of fishery impacts in other periods. The ability of the projects to accommodate water transfers during the July through October period depends on two factors: (1) unused pumping capacity at the Banks and Tracy pumping plants and (2) limits on exports in the 1995 Bay/Delta Plan.

The following method was used to analyze the capacity for water transfers during July through October for each of the seven alternatives. Using DWRSIM study results, the unused Delta pumping capacity was determined for each flow alternative by subtracting the monthly exports at the Banks and Tracy pumping plants from their respective physical and authorized maximum pumping capacities. The portion of the unused capacity that could be transferred through the Delta without exceeding the export ratio limit of 65 percent of Delta inflow was then determined. An iterative process was used because as the volume of transferred water increases, the Delta inflow increases allowing increased exports within the 65 percent limit. Transfer capacity could be increased beyond the quantities calculated in this analysis if the parties to the transfer provide supplemental Delta inflow to keep exports within the 65 percent limit. This analysis does not consider other possible operational restrictions such as storage or conveyance capacity south of the Delta. In this analysis, a 72-year hydrologic period was used instead of a 73-year period because data were not available for October of the 1995 water year.

The transfer capacity of the base case and alternatives and the impacts of the alternatives are shown in Figures V-15 and V-16. The only scenario in which transfer capacity is less than the base case is the Alternative 6 critical period. Alternative 7 has the greatest transfer capacity and is the favorable alternative with respect to this parameter.

Figure V-15

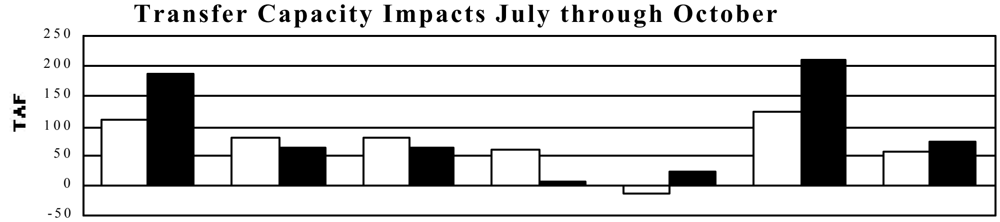
Average Transfer Capacity July through October



	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
□ 73-Year Period Avg.	513	623	595	594	573	499	637	568
■ Critical Period Avg	1,171	1,359	1,232	1,232	1,178	1,194	1,380	1,246

Figure V-16

Transfer Capacity Impacts July through October



	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
□ 73-Year Period Avg.	110	82	81	60	-14	124	55
■ Critical Period Avg	188	61	61	7	23	209	75

E. DIVERSION CURTAILMENTS UNDER FLOW ALTERNATIVES 3 AND 4

In Alternatives 3 and 4, the availability of water for appropriation by water right holders in the Bay/Delta watershed is determined by using the orders of priority described for these alternatives in Chapter II. This section evaluates the frequency and time of year that individual water right holders must curtail diversions under Alternatives 3 and 4. The method for calculating the frequency and time of year of curtailments is described in Chapter IV of this report. The method uses a modified Term 91 approach, which can be applied to all post-1914 appropriative water right permits and licenses; but for the purposes of this report is only applied to larger water right holders, as described in Chapter II.

Alternatives 3 and 4 are the only alternatives that curtail diversions under individual water rights using an order of priority and a modification of the Term 91 process. The other flow alternatives will continue to apply the existing Term 91 process. Term 91 currently is included in the relatively small group of appropriative water rights issued by the SWRCB (and its predecessor) after 1965 for diversion of more than one cfs or 100 acre-feet annually in the Central Valley. Implementation of any of the alternatives could affect the date on which the existing Term 91 water right holders are required to curtail diversions. The effect on these diverters will not be substantial because they already have arranged for fill-in supplies.

The analysis in this section identifies when different groups of post-1914 appropriative water right holders (post-1914 rights) would be required to curtail diversions. The analysis does not identify pre-1914 rights for curtailment because many pre-1914 appropriative right claims are neither documented nor quantified. Thus, the relative priorities of most pre-1914 rights are unknown.

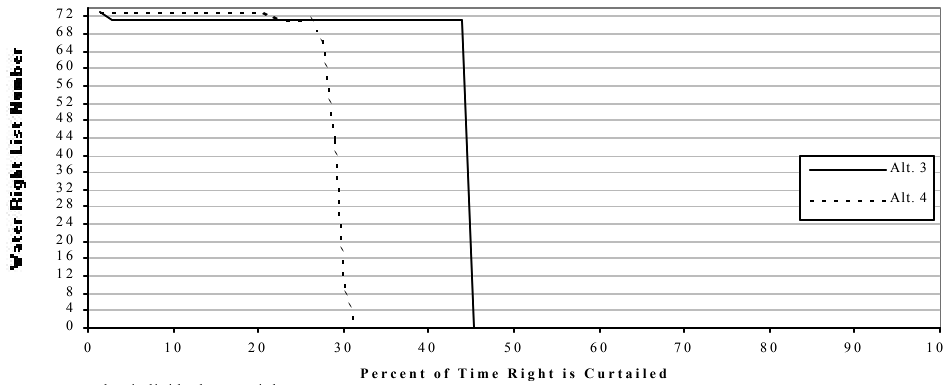
In this analysis, there are 72 post-1914 appropriative diverters in the San Joaquin Basin whose water rights are affected by implementing the Vernalis objectives. These diverters were assigned water right priority numbers from 1 to 72 as shown in Chapter II, Table II-6. Figures V-17 through V-22 show the frequency that diversions under these water rights must be curtailed in October, and February through June to meet the Vernalis objectives. The results of both Alternatives 3 and 4 are shown on each figure.

The graph for October shows frequent diversion curtailments for almost all water rights. Alternative 3 will result in curtailment of all post-1914 diversions in 45 percent of the years. Alternative 4 is less drastic with curtailment of most rights in about 30 percent of the years. February and March are not nearly as severe. In February, diversions under the eight lowest priority rights are curtailed in less than ten percent of the years while in March diversions are curtailed in about twelve percent of the years. However, occasionally under both alternatives, the curtailments include the 36 most junior rights for Alternative 3 and the 48 most junior rights for Alternative 4.

Availability of water in the remaining spring months is a problem for the 16 lowest priority rights under Alternative 3. Curtailment of diversion under the eight lowest priority rights occurs in April in almost 60 percent of the years, in May in almost 80 percent of the years, and in June in almost 45 percent of the years. Diversions pursuant to water rights 9 through 16 in the priority ranking are curtailed in April in about 50 percent of the years, in May in about 55 percent of the years, and in June in over 35 percent of the years. This situation is significantly better in Alternative 4 where none of the 16 lowest priority rights are curtailed in more than 40 percent of the years for any of the spring months. For rights with a priority above 16, the most severe curtailments occur in April and June at a frequency of 30 percent of the years.

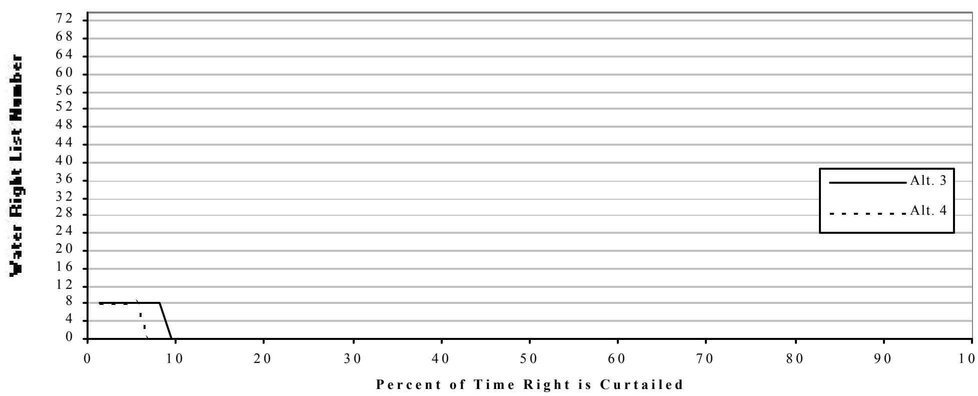
Under Alternatives 3 and 4, the satisfaction of in-basin entitlements is the responsibility of all water right holders in both the Sacramento and San Joaquin Basin. For ease of administration of these alternatives, the post-1914 water right holders are placed into eight groups depending on priority. Table II-5 lists Central Valley water rights in groups 1 through 8.

Figure V-17
Frequency of Curtailing Diversions To Meet Vernalis Objective in October



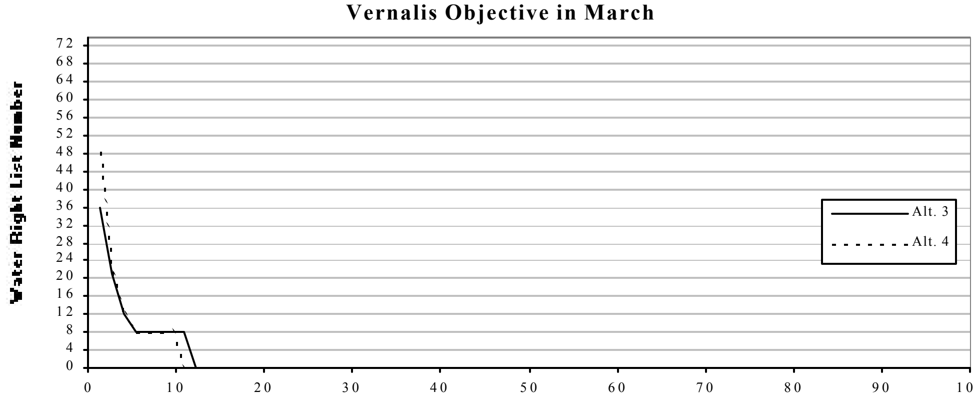
List numbers correspond to individual water rights.

Figure V-18
Frequency of Curtailing Diversions To Meet Vernalis Objective in February



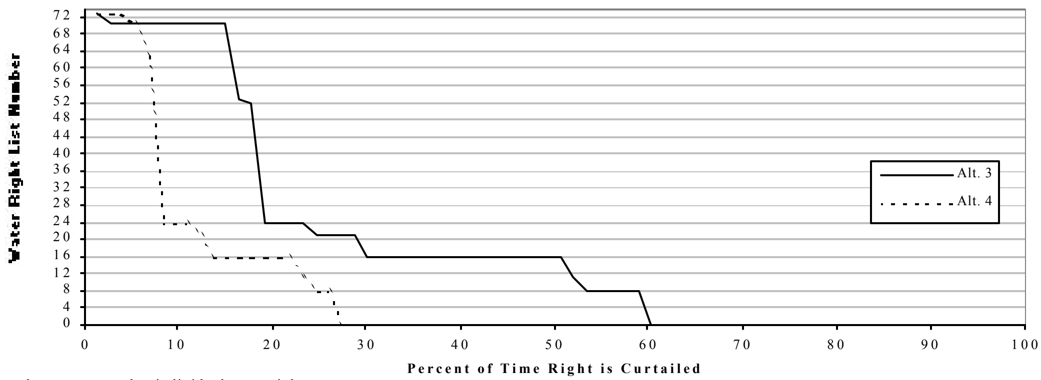
List numbers correspond to individual water rights.

Figure V-19
Frequency of Curtailing Diversions To Meet Vernalis Objective in March



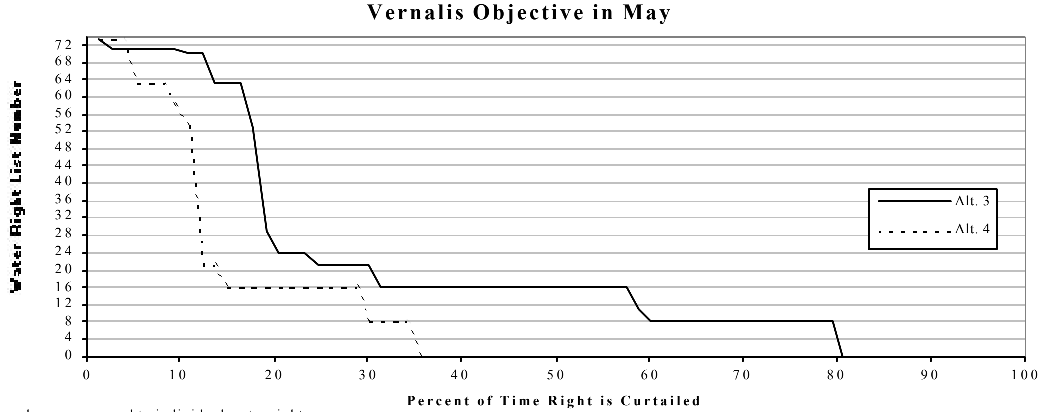
List numbers correspond to individual water rights.

Figure V-20
Frequency of Curtailing Diversions To Meet Vernalis Objective in April



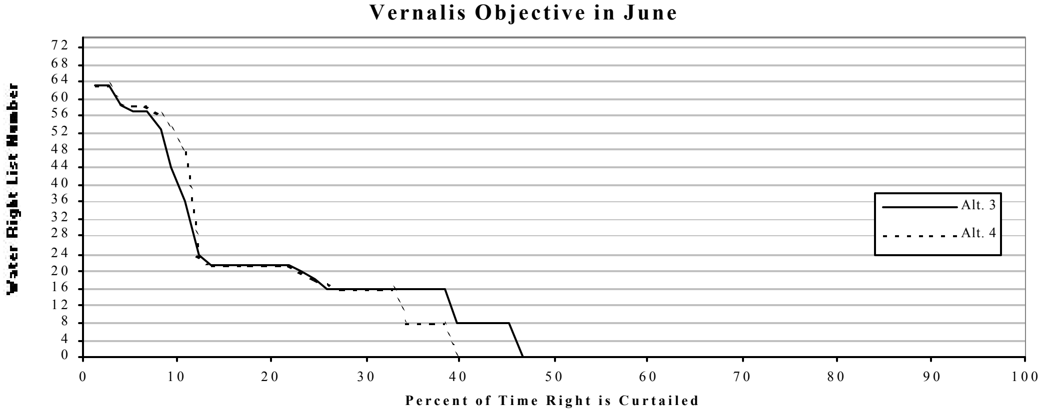
List numbers correspond to individual water rights.

Figure V-21
Frequency of Curtailing Diversions To Meet Vernalis Objective in May



List numbers correspond to individual water rights.

Figure V-22
Frequency of Curtailing Diversions To Meet Vernalis Objective in June



List numbers correspond to individual water rights.

Figures V-23 through V-31 show the frequency that diversions in the water rights groups are curtailed for each month. Post-1914 appropriators can use these graphs to determine how frequently their diversions would be curtailed under Alternatives 3 and 4.

These figures show that June, July and August require the most frequent curtailments for all groups under both Alternatives 3 and 4. With few exceptions, Alternative 4 requires greater frequency of curtailment for all groups than Alternative 3. Curtailments also occur in October, February, March, April, and May for some or all of the different groups, but never at a frequency greater than about 10 percent.

Alternatives 3 and 4 have similar curtailment frequencies for June and July. However, August curtailments are more severe for all groups under Alternative 4 than Alternative 3. The figures also show that for Alternative 3, all of the post-1914 diversions (groups 1 through 8) would be curtailed for the month of June in about 25 percent of the years, for July in 50 percent of the years and for August in less than 5 percent of the years. For Alternative 4, all of the post-1914 diversions would be curtailed for the month of June in about 35 percent of the years, for July in about 70 percent of the years, and for August in about 25 percent of the years. For groups 1 through 5, representing the majority of post-1914 rights, water is unavailable for appropriation in June in over half of the years and in July in 80 percent of the years.

Although infrequent in occurrence, there are years in which curtailment of all post-1914 diversions provides insufficient flow to meet the supplemental water requirement needed to meet Delta flow objectives. This occurs in February, April, June, and July at a frequency of less than 5 percent of the years. Using a strict priority approach, this additional increment of flow would become the obligation of the junior-most pre-1914 appropriative diverters. However, the relative priorities of the pre-1914 diverters are not established. In addition, many pre-1914 diverters hold settlement contracts with the USBR. If these contractors' diversions were curtailed, they would become an in-basin obligation of the USBR. Thus, any additional increment of flow needed to meet the supplemental water requirement after all of the post-1914 appropriative diversions have been curtailed becomes the obligation of the USBR and the DWR under Flow Alternatives 3 and 4.

F. SUMMARY AND CONCLUSIONS

Following is a summary description of the seven flow alternatives and the water supply impacts associated with each alternative. Conclusions explaining why the impacts occur also are provided.

Alternative 2: The SWP and the CVP are responsible for meeting the flow objectives under this alternative. Therefore, carryover storage at SWP and CVP reservoirs declines in relation to the other alternatives and exports also decline because stored water is not available for export. The more restrictive export requirements from the base case also limit export opportunities. Transfer capacity increases in comparison with other alternatives because export capacity is not used by the projects. Carryover storage in New Melones Reservoir is depleted because it is the only reservoir in the San Joaquin Basin required to release water to meet the Vernalis objectives.

Figure V-23

Group 1 Frequency of Diversion Curtailment

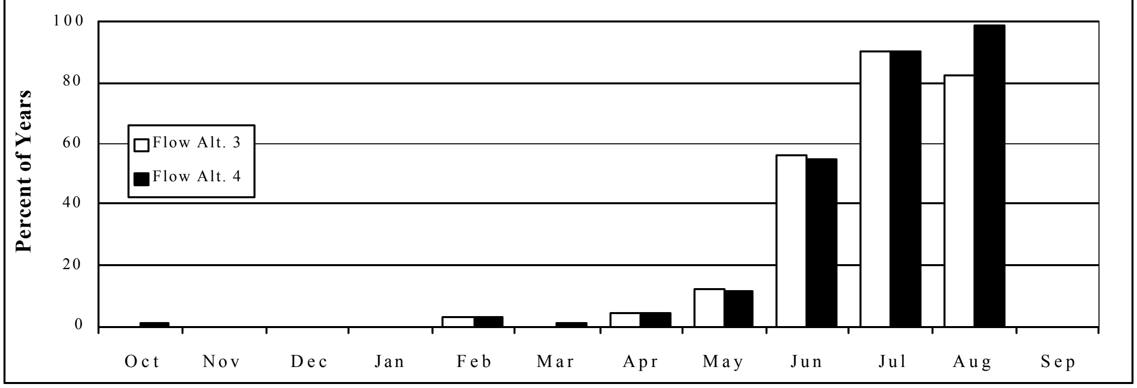


Figure V-24

Group 2 Frequency of Diversion Curtailment

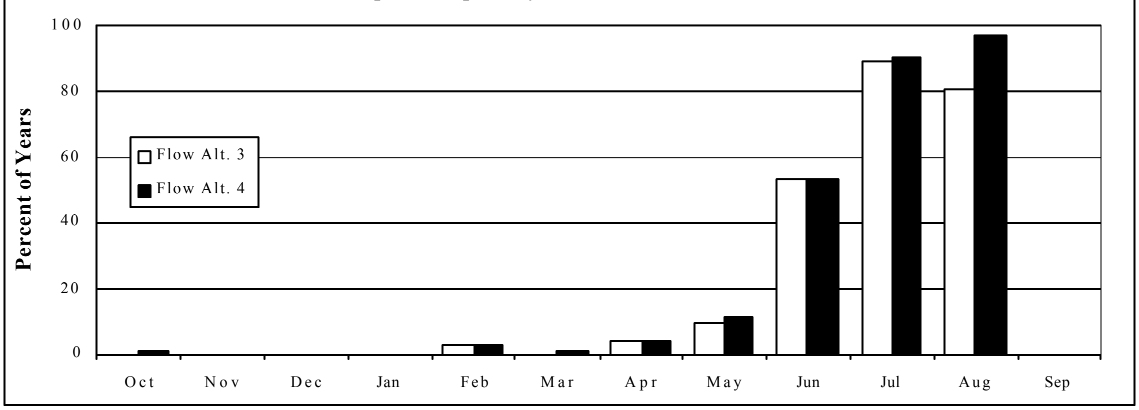


Figure V-25

Group 3 Frequency of Diversion Curtailment

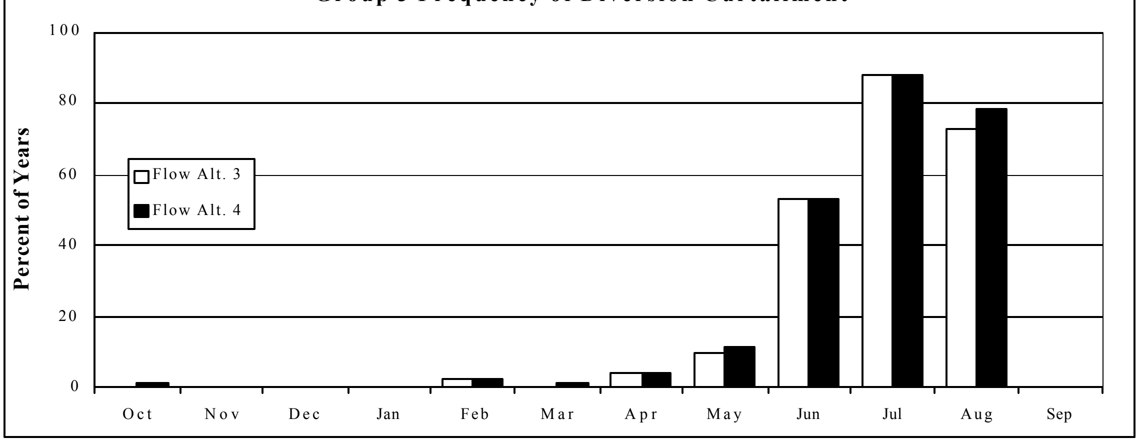


Figure V-26

Group 4 Frequency of Diversion Curtailment

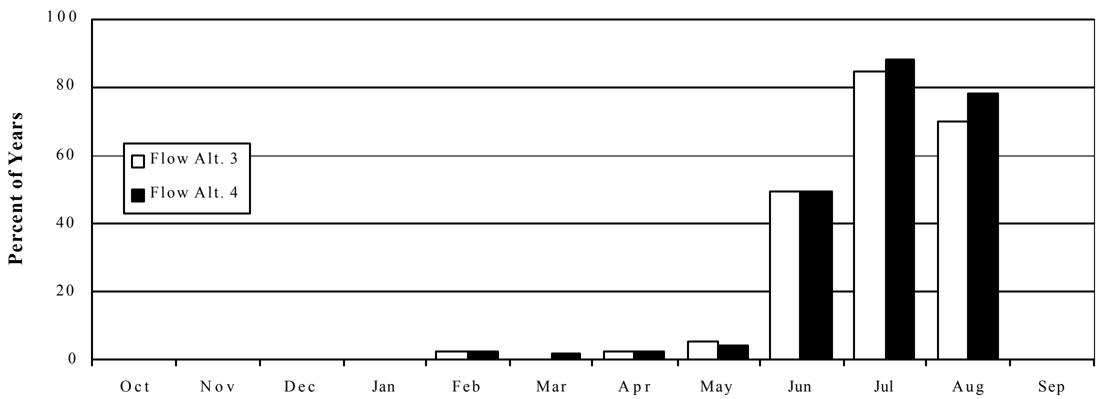


Figure V-27

Group 5 Frequency of Diversion Curtailment

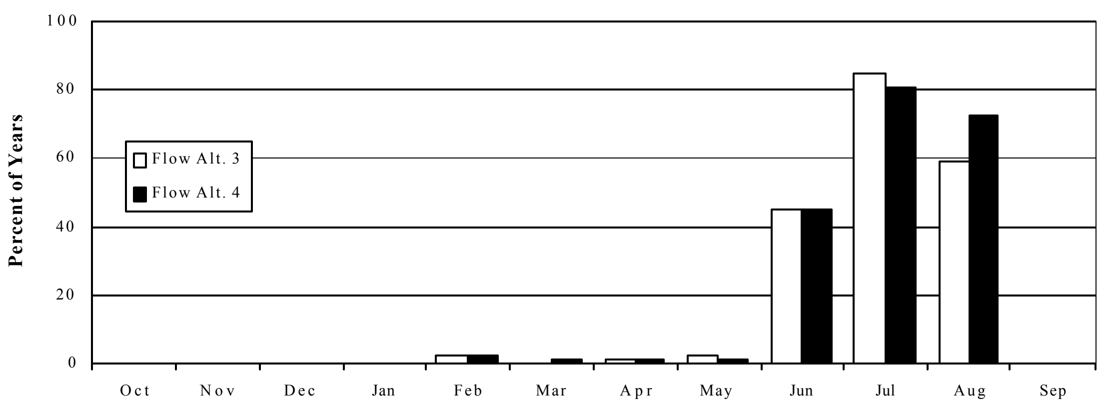


Figure V-28

Group 6 Frequency of Diversion Curtailment

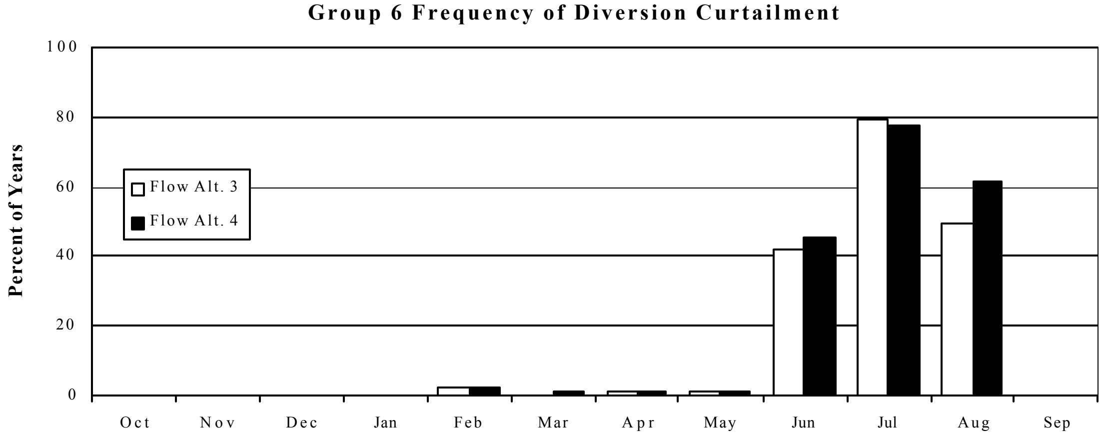


Figure V-29

Group 7 Frequency of Diversion Curtailment

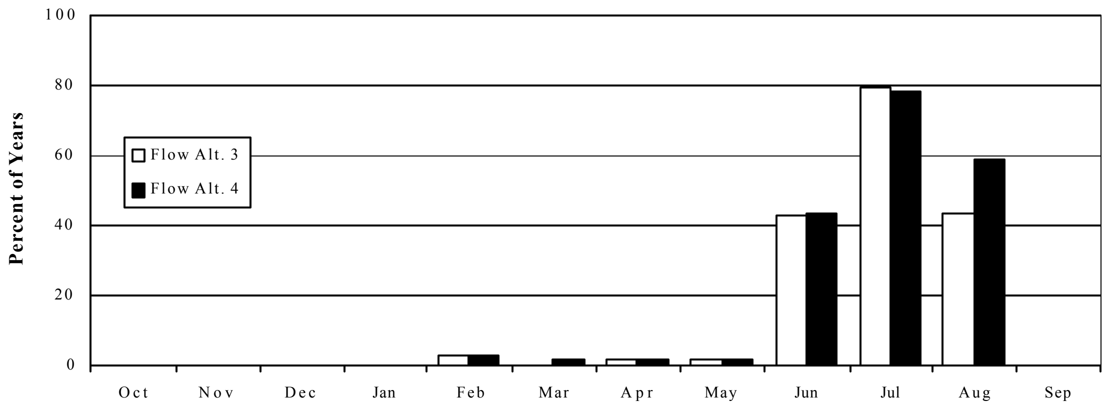


Figure V-30

Group 8 Frequency of Diversion Curtailment

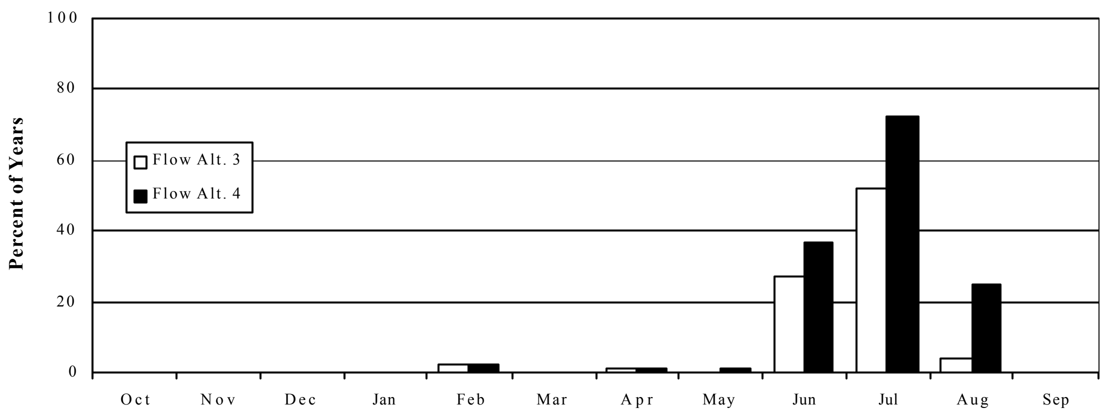
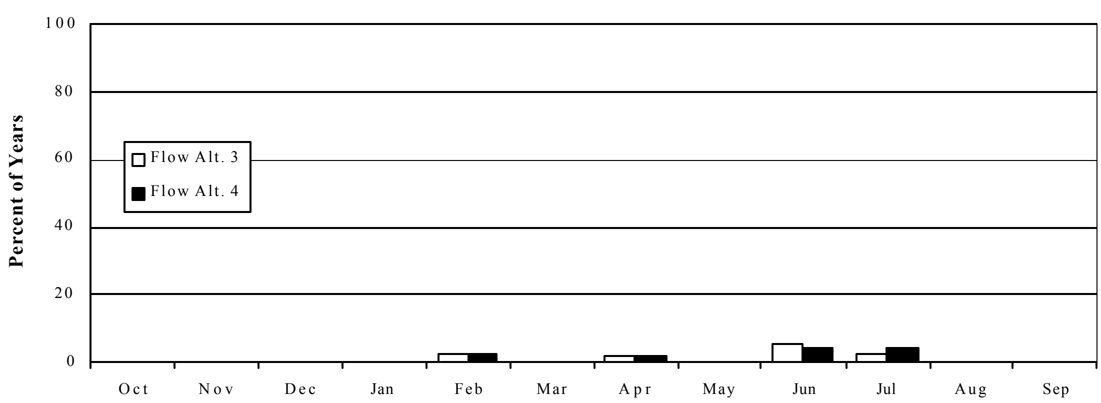


Figure V-31

Frequency When Additional Supplemental Water is required of the SWP and the CVP



Alternative 3: Post-1914 appropriators are responsible for meeting the objectives under this alternative based on an order of priority. The SWP and the CVP in connection with their exports meet the bulk of the responsibility to achieve the objectives because the exports are junior in water right priority. The Friant Project and the New Melones Project are assumed to be in-basin projects, not exports, and the New Melones Project meets all flow responsibility incurred by the Friant Project.

Overall carryover storage in SWP and CVP reservoirs in the Sacramento Basin increases in comparison to Alternative 2 because other parties are sharing responsibility to meet inbasin entitlements. Additional increases in carryover storage could be realized if, contrary to the modeling assumption, water rights holders do not seek contracts when their diversions are curtailed under this alternative. Carryover storage in New Melones Reservoir improves substantially because other parties in the San Joaquin Basin are bypassing flows that would otherwise be diverted. Carryover storage in other reservoirs declines because of bypass requirements.

Deliveries to SWP and CVP export areas increase because of the shared responsibility. However, San Joaquin River direct diverters are required to cease diversion at some times which reduces their deliveries. San Joaquin water right holders with storage rights in New Don Pedro and Lake McClure do not have any delivery reductions because, through reservoir reoperations, they have adequate storage to meet the flow obligations plus full deliveries. Export transfer capacity declines in comparison to Alternative 2 because the SWP and the CVP are making more use of their export facilities.

Alternative 4: The difference between Alternative 3 and Alternative 4 is that the Friant Project is considered to be an export project in Alternative 4. Therefore, the part of the water delivered by the Friant Project to the export area shifts from being treated as a comparatively senior water right to a junior water right compared to inbasin users. The principal effect of this change is that carryover storage in New Melones Reservoir declines because this reservoir makes releases to meet the Friant Project obligations.

Alternative 5: Under this alternative, flow requirements are established for the principal tributaries to the Bay/Delta watershed to meet the 1995 Bay/Delta Plan Vernalis and outflow objectives based on the unimpaired flow contribution of the tributaries to the watershed. The Friant Project is required to make releases to meet the flow requirements assigned to the upper San Joaquin River. Compared with the other alternatives, this alternative shifts more responsibility to meet the flow objectives onto water right holders other than the SWP and CVP export facilities. Alternative 5 also has a very substantial effect on Friant Project deliveries.

Carryover storage in Sacramento Basin SWP and CVP reservoirs and in New Melones Reservoir increases slightly. Carryover storage in Millerton Lake declines slightly while in the other modeled reservoirs declines are substantial.

Total 73-year period average deliveries under this alternative decline more than any other alternative, but the Friant Project accounts for 58 percent of the total delivery reductions.

Deliveries to the Yuba and Bear river system and the EBMUD service area decline substantially because of increased flow obligations from these watersheds. Modest reductions occur in the Madera ID and Chowchilla WD. Deliveries to Modesto, Turlock, and Merced irrigation districts do not decline substantially because these districts have adequate storage to meet the new flow requirements plus make deliveries. Deliveries to SWP and CVP export areas improve substantially because water from other sources is entering the Delta and can be exported. Also, the reduced responsibility to meet the flow objectives leaves more water in storage upstream, which can be exported as the need arises. The increase in transfer capacity under Alternative 5 is less than the increases in the other alternatives because the SWP and the CVP are making more use of their export facilities.

Alternative 6: This alternative is similar to Alternative 2, but the Vernalis flow objectives are met by the CVP by using the export facilities to meet the Vernalis flow objectives through recirculation rather than by making releases from New Melones Reservoir. Additional flow requirements at Vernalis are also established under this alternative to meet the consumptive use in the southern Delta, and these requirements are also met through recirculation. Combined use of SWP and CVP points of diversion are incorporated in this alternative.

This alternative places a substantial new demand on the CVP storage in the Sacramento Basin and on the SWP and the CVP export facilities. Other facilities have no responsibility to meet the objectives. Consequently, CVP carryover storage in Shasta and Folsom lakes declines. Carryover storage in New Melones Reservoir increases because this reservoir is not responsible for meeting the Vernalis flow objectives.

Exports increase under this alternative compared to most of the other alternatives. Even though much of this increase is used to meet the Vernalis requirements, CVP deliveries to export areas also increase because of the combined use of SWP and CVP points of diversion in the Delta. Transfer capacity at the export facilities substantially declines because of the other demands on the facilities. However, transfer requirements should also decline.

Alternative 7: Under this alternative, the minimum flows required at Vernalis are reduced from the Bay/Delta Plan objectives based on the Letter of Intent. The SWP and the CVP facilities in the Sacramento Basin are responsible for meeting the Delta outflow objectives. The San Joaquin tributaries group guarantees flow releases to meet the minimum flows on the San Joaquin River at Vernalis identified in the Letter of Intent. Carryover storage in Sacramento Basin SWP and CVP facilities is similar to Alternative 2, but New Melones carryover storage improves because of the new operating rules for New Melones Reservoir, including a 70 TAF cap on releases for salinity control at Vernalis. Minor carryover storage changes occur in New Don Pedro Reservoir and Lake McClure because of the new demands on these reservoirs.

Deliveries by the SWP and CVP to export areas decline compared to Alternative 2 because there is less water available to export in the April-May period due to the reduced Vernalis flow requirements and the export restrictions during this period. Deliveries to all other water right holders in the Central Valley are unaffected by this alternative. Transfer capacity is similar to the capacity under Alternative 2.

Alternative 8: Under Alternative 8, the Vernalis pulse flows and the export levels during the pulse flows are replaced with target values in the San Joaquin River Agreement. The SWP and the CVP facilities in the Sacramento Basin are responsible for meeting the Delta outflow objective. New Melones Reservoir is operated according to the New Melones Interim Plan of Operation (Interim Plan). If additional water is needed to meet the Vernalis target flows, the San Joaquin tributaries group provides up to 110 TAF.

Carryover storage in Sacramento Basin SWP and CVP reservoirs is similar to Alternative 2, but New Melones Reservoir carryover storage improves because of the Interim Plan. A decline in carryover storage occurs in New Don Pedro Reservoir and in Lake McClure compared to Alternative 2 due to releases from these reservoirs to meet the target flows.

Deliveries by the SWP and CVP to export areas decline slightly compared to Alternative 2 for the 73-year period because of the export restrictions during the Vernalis pulse flow. Transfer capacity is improved over the base case but declines in comparison to Alternative 2.

CHAPTER VI. ENVIRONMENTAL EFFECTS OF IMPLEMENTING FLOW AND WATER OPERATION ALTERNATIVES

The purpose of this chapter is to evaluate and disclose the environmental effects of implementing the flow and water operation alternatives (flow alternatives) described in Chapter II.D. The flow alternatives implement the water quality objectives found in Table 3, page 19 of the 1995 Bay/Delta Plan. For the purposes of this analysis, flow objectives include Delta outflow and river flow objectives (flow objectives), salinity objectives in the Delta that occasionally control outflows, Vernalis salinity objectives, limits on exports and restrictions on Delta Cross Channel gate operations.

This chapter is divided into the following five sections: (A) background information on flow objectives, (B) environmental effects in the Delta, (C) environmental effects in upstream areas, (D) export areas, and (E) Friant service area.

A. BACKGROUND INFORMATION ON FLOW OBJECTIVES

Prior to the 1978 Bay/Delta Plan, salinity standards were adopted in the water quality control plans for the Delta to ensure adequate flow through the estuary for fish and wildlife. Salinity standards were used instead of flow objectives because methods had not been developed to quantify Delta inflow and outflow and because both flow and salinity are closely related to the health of aquatic resources in the Delta. The 1978 Bay/Delta Plan, however, included Delta outflow objectives and river flow objectives for the Sacramento River at Rio Vista. Then, as now, the principal purpose of the flow objectives was for fish and wildlife protection.

The objectives in the 1978 and 1991 Bay/Delta Plans were reviewed and updated in the 1995 Bay/Delta Plan. Two major features of the new Delta outflow objectives are that (1) they apply on a year-round basis, and (2) from February through June, they can be met either through Delta outflow or through compliance with specified salinity conditions at three locations in the Delta and Suisun Bay. Delta outflow and its related salinity values are included in the objectives because these parameters have been found to correlate with the abundance of certain estuarine resources (see Chapter IV, sections E.2 and E.3).

The river flow objectives in the 1995 Bay/Delta Plan for the Sacramento and San Joaquin rivers provide attraction and transport flows and suitable habitat for various life stages of aquatic organisms. River flows are measured at gages on the Sacramento and San Joaquin rivers at Rio Vista and Vernalis, respectively.

The 1995 Bay/Delta Plan also contains export limits to protect the habitat of estuarine-dependent species by reducing the entrainment of the various life stages of aquatic species by the major export pumps in the southern Delta. The export limits are expressed as a maximum percent of Delta inflow diverted.[1] CVP operations are further constrained in the 1995 Bay/Delta Plan by objectives that restrict the operation of the Delta Cross Channel gates. The

[1] The method for calculating the percent of Delta inflow diverted is described on page II-11 of this report.

gates are required to be closed in the winter and spring to reduce the diversion of eggs, larvae, and smolts into the central Delta where survival is generally reduced.

Seven alternatives for achieving the flow objectives and the "no project alternative" are summarized in Chapter II, section E. The environmental effects of implementing the flow alternatives are evaluated in this chapter using a two step process. First, the base case and each of the seven alternatives were modeled to determine the river flows, Delta outflow, Delta salinity distribution and reservoir levels that will result from implementing each of the alternatives. For each of these factors, the alternatives were compared to the base case to evaluate changes in hydrology. The modeled hydrology was then compared to biological criteria for fish, other aquatic resources, vegetation and wildlife to evaluate the environmental effects of implementing each of the flow alternatives.

B. ENVIRONMENTAL EFFECTS IN THE DELTA

The evaluation of the environmental effects in the Delta is divided into the following subsections: (1) hydrology, (2) salinity, (3) fish and aquatic resources, (4) Delta vegetation and wildlife, (5) land use, and (6) recreation.

1. Hydrology

The principal factors affecting Delta hydrology are river inflow from the San Joaquin and Sacramento river systems, Delta outflow, exports and local diversions. Another comparatively small source of Delta inflow is from the streams draining the area immediately east of the Delta. Local diversions are assumed to be the same under all of the alternatives. Freeport is the measuring site for Delta inflow from the Sacramento River while Vernalis is the measuring site for Delta inflow from the San Joaquin River.

Because of tidal influence, outflow from the Delta cannot be measured directly. Thus, Delta outflow is estimated using the Net Delta Outflow Index. This index is described on page II-11 of this report.

Tables VI-1 through VI-12 list the base case monthly flows of the Sacramento River at Freeport, the San Joaquin River at Vernalis, total Delta inflow (which includes inflow from the San Joaquin and Sacramento rivers, and the eastside streams), Delta outflow, Delta export pumping and the export/inflow ratio for the 73-year period and critical period. Below the base case flows are the reductions and increases from the base case flows resulting from the seven flow alternatives. The bolded entries in the tables signify the highest flows among the seven alternatives for each month.

Table VI-1
Sacramento River Flow at Freeport, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	14,211	17,053	24,238	32,539	38,481	35,441	23,335	19,893	16,904	16,385	13,951	11,812

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-704	-43	-659	-690	85	220	267	-256	2,889	694	-1,616	167
3	-554	161	-481	-513	187	237	278	-269	2,367	365	-1,643	190
4	-556	158	-507	-515	175	241	276	-273	2,408	378	-1,647	185
5	***-315***	***706***	***10***	***-162***	***543***	***847***	345	***-171***	2,274	-861	-1,732	262
6	-572	-292	-1,090	-885	-379	12	198	-327	***3,461***	894	-1,255	***573***
7	-819	-366	-907	-888	-174	352	***1,092***	-831	3,394	923	-1,498	109
8	-736	-146	-793	-742	40	204	-31	-438	2,955	***1,007***	***-1,223***	222

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-2
Sacramento River Flow at Freeport, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	10,186	8,893	12,867	16,315	15,126	14,694	10,534	10,121	11,029	14,321	12,063	8,107

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-1,227	350	-729	-697	-1,123	534	952	1,445	3,500	-681	***-1,838***	293
3	-1,248	468	-702	-656	-1,084	905	994	1,559	2,955	-671	-2,251	161
4	-1,250	462	-702	-656	-1,084	911	994	***1,566***	2,941	-678	-2,254	161
5	-1,060	***717***	***-293***	***-296***	***-640***	***1,456***	126	1,017	3,885	-1,622	-2,166	221
6	***-983***	398	-816	-865	-1,330	-54	1,067	1,519	***4,384***	-486	-2,546	***317***
7	-1,106	193	-697	-653	-1,081	271	***2,804***	437	3,750	-1,380	-2,265	238
8	-1,271	375	-743	-697	-1,168	201	387	966	4,000	***-186***	-1,961	118

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-3
San Joaquin River Flow at Vernalis, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	3,169	2,076	2,927	4,413	6,808	6,177	5,448	4,653	3,722	1,798	1,361	1,874

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-47	-68	-150	-217	-390	-83	356	719	93	178	236	-27
3	26	-94	-193	-335	-512	-89	389	774	785	552	417	-31
4	-1	-75	-174	-354	-532	-57	385	760	761	545	442	-12
5	***433***	-14	-161	-469	***387***	***729***	***2,360***	***2,144***	***926***	***1,728***	***523***	***97***
6	85	-43	-73	-54	-64	34	401	726	307	294	339	-19
7	358	***23***	***145***	***127***	95	64	-54	255	256	221	-22	-201
8	-140	22	-80	-261	-532	-73	645	1,063	306	200	164	-40

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-4
San Joaquin River Flow at Vernalis, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1,870	1,442	1,675	1,778	2,983	2,231	2,409	1,770	1,277	1,099	1,138	1,464

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	105	-131	-160	-108	-87	-30	210	781	-65	-132	-106	-74
3	151	-126	-154	-157	-416	-27	235	802	973	695	***551***	-31
4	165	-126	-154	-146	-253	-27	235	781	***1,001***	695	***551***	-31
5	***530***	***-5***	***-21***	***-11***	***221***	***782***	***1,661***	***1,564***	592	***1,240***	292	***160***
6	172	-134	-146	-106	-90	-30	199	776	286	411	426	-45
7	-21	-95	-43	-13	-2	70	103	344	197	223	-253	-237
8	-58	-106	-68	-105	-305	-5	433	936	194	152	-64	-69

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-5
Total Delta Inflow, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	18,019	20,328	32,458	47,069	58,534	50,483	34,350	26,372	22,014	19,312	16,354	14,552

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-775	-116	-814	-912	-309	114	571	378	2,866	749	-1,484	81
3	-542	64	-678	-851	-328	136	638	455	3,081	844	-1,285	125
4	-573	79	-685	-872	-360	170	629	432	3,092	844	-1,271	136
5	***76***	***658***	***-214***	***-706***	***850***	***1,757***	***2,986***	***2,296***	***3,777***	1,092	-1,274	228
6	-493	-338	-1,167	-943	-444	40	588	377	3,741	***1,159***	***-941***	***541***
7	-519	-350	-767	-765	-82	364	913	-775	3,382	862	-1,754	-224
8	-944	-129	-876	-1,006	-543	67	568	471	3,067	1,038	-1,164	163

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-6
Total Delta Inflow, Critical Period

Base Case Period Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	12,388	10,736	15,499	19,367	19,587	17,849	13,568	12,446	12,871	15,936	13,661	9,963

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-1,152	216	-894	-816	-1,219	496	1,146	2,137	3,323	-941	-2,052	156
3	-1,125	345	-859	-819	-1,503	870	1,213	2,272	3,803	-105	-1,808	72
4	-1,113	336	-859	-808	-1,343	876	1,213	2,258	3,820	-112	-1,808	72
5	***-583***	***667***	***-317***	***-301***	***-414***	***2,385***	2,173	***3,137***	***5,315***	***-58***	***-1,807***	***399***
6	-825	272	-968	-976	-1,429	-95	1,249	2,263	4,619	-128	-2,163	245
7	-1,150	95	-743	-675	-1,086	336	***2,902***	709	3,860	-1,259	-2,602	-50
8	-1,359	269	-813	-810	-1,521	184	781	1,789	4,107	-119	-2,079	27

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-7
Delta Outflow, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	8,216	9,974	22,176	38,689	49,942	42,012	24,417	18,415	12,891	6,627	3,870	4,145

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-919	591	-252	-507	971	864	3,083	155	334	59	176	528
3	-753	734	-162	-493	945	854	3,122	185	474	60	181	563
4	-791	756	-151	-507	910	892	3,118	172	471	60	184	571
5	***-322***	***1,213***	***224***	***-412***	***1,928***	***2,321***	***4,576***	***1,267***	***948***	***140***	168	***691***
6	-1,105	172	-1,041	-1,516	1,382	1,220	3,090	126	916	69	***190***	468
7	-650	347	-293	-448	1,208	1,118	2,013	847	749	69	124	435
8	-1,132	569	-291	-645	772	896	4,020	913	469	57	160	536

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-8
Delta Outflow, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	5,708	3,050	5,998	10,604	8,443	8,118	8,190	4,800	4,228	3,973	4,842	2,650

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-1,536	***1,767***	-377	-2,139	3,269	4,627	1,101	3,559	3,236	883	-957	379
3	-1,545	1,762	-379	-2,160	3,069	4,646	1,095	3,564	3,287	883	-957	384
4	-1,540	1,756	-379	-2,152	3,170	4,646	1,095	3,564	3,287	883	-957	384
5	-1,582	1,650	***-295***	***-1,927***	***3,614***	***4,760***	***1,308***	***3,868***	3,860	***883***	-1,067	***387***
6	-1,880	1,759	-401	-2,201	3,083	4,397	1,112	3,571	***3,930***	883	***-776***	384
7	***-1,373***	1,518	-342	-2,033	3,083	4,031	1,006	3,799	3,714	883	-1,129	379
8	-1,779	1,754	-349	-2,136	3,060	4,345	1,285	3,608	3,397	883	-830	385

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-9
Delta Exports, 73-Year Period

Base Case Average Monthly Exports (TAF)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	534	578	624	611	544	526	527	358	323	526	592	514

Change in Exports from the Base Case (TAF)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	9	-42	-34	-25	-72	-46	-149	14	150	42	-102	-27
3	13	-40	-31	-22	-72	-44	-147	17	155	48	-90	-26
4	13	-41	-33	-23	-71	-44	-148	16	155	48	-89	-26
5	24	-33	-27	-18	***-61***	***-34***	-94	***63***	***168***	58	-89	-28
6	***38***	***-31***	***-7***	***35***	-102	-72	-149	16	***168***	***67***	***-69***	***4***
7	8	-42	-29	-20	-73	-46	***-65***	-100	156	48	-115	-39
8	11	-42	-36	-22	-74	-51	-203	-24	154	60	-81	-22

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-10
Delta Exports, Critical Period

Base Case Average Monthly Exports (TAF)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	335	410	573	591	657	573	231	334	295	480	366	326

Change in Exports from the Base Case (TAF)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	24	-92	-32	82	-250	-254	2	-88	5	-112	-68	-13
3	26	-85	-30	83	-255	-232	7	-80	31	-61	-53	-18
4	26	-85	-30	83	-252	-232	7	-80	32	-61	-53	-18
5	***61***	***-59***	***-1***	***100***	***-224***	***-147***	51	***-45***	***87***	***-57***	***-47***	***1***
6	65	-89	-35	76	-252	-276	8	-80	41	-62	-86	-8
7	14	-85	-25	84	-233	-227	***113***	-190	8	-132	-91	-25
8	26	-89	-28	81	-256	-256	-28	-108	43	-61	-77	-21

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

The tables show that, of all the alternatives, Alternative 5 generally results in the highest river flows at Freeport and Vernalis. Notable exceptions to this trend include the Sacramento River at Freeport where the Alternative 5 flows are the lowest of the alternatives for June, July, and August over the 73-year period and the San Joaquin River at Vernalis where the Alternative 7 flows are the highest of the alternatives for November, December and January over the 73-year period.

In most months, Alternative 5 results in the highest total Delta inflow and Delta outflow of all the alternatives. However, Alternative 6 results in the highest total Delta inflow in July, August, and September over the 73-year period. The Delta outflow reported in Tables VI-7 and VI-8 meets the minimum required outflow objective in the 1995 Bay/Delta Plan for all seven alternatives.

Average monthly Delta export/inflow ratios for the alternatives are shown in Tables VI-11 and VI-12. For both the 73-year period average and critical period average, the alternatives are not significantly different from each other with respect to the average monthly export/inflow ratio achieved. The tables show that the average monthly export/inflow ratio achieved under the different alternatives is significantly lower than the objective for every month except June. This result is expected because the objective represents a maximum value and the monthly data are averages. Reviewing the entire data set, the export/inflow ratio limit is never violated in April, July or August for the entire 73-year period for Alternatives 2, 3, 4, 6, and 8, or in July and August for Alternatives 5 and 7. The environmental significance of the changes in Delta outflow and exports is described in the following section of this chapter.

Table V1-11
Delta Export/Inflow Ratio, 73-Year Period

Base Case Average Monthly E/I Ratio*

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.48	0.55	0.45	0.33	0.28	0.27	0.36	0.28	0.28	0.43	0.55	0.58

1995 WQCP Monthly E/I Objective

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0.65	0.65	0.65	0.65	0.35**	0.35	0.35	0.35	0.35	0.65	0.65	0.65

Flow Alternatives Average Monthly E/I Ratio

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	0.52	0.50	0.44	0.35	0.21	0.22	0.22	0.24	0.32	0.43	0.48	0.55
3	0.52	0.50	0.44	0.35	0.21	0.22	0.22	0.25	0.32	0.43	0.49	0.55
4	0.52	0.50	0.44	0.35	0.21	0.22	0.23	0.25	0.32	0.43	0.49	0.55
5	0.52	0.49	0.44	0.34	0.21	0.22	0.24	0.26	0.32	0.44	0.50	0.55
6	0.54	0.51	0.46	0.38	0.20	0.21	0.23	0.25	0.32	0.44	0.50	0.57
7	0.51	0.50	0.44	0.35	0.22	0.22	0.28	0.16	0.32	0.43	0.47	0.54
8	0.52	0.49	0.44	0.35	0.21	0.22	0.19	0.22	0.32	0.44	0.49	0.55

*There is no E/I objective under D-1485
**Is increased to 0.45 if the Eight River Index for January is less than or equal to 1.0 MAF

Table V1-12
Delta Export/Inflow Ratio, Critical Period

Base Case Average Monthly E/I Ratio*

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.41	0.60	0.58	0.49	0.62	0.58	0.27	0.42	0.37	0.47	0.39	0.51

1995 WQCP Monthly E/I Objective

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0.65	0.65	0.65	0.65	0.35**	0.35	0.35	0.35	0.35	0.65	0.65	0.65

Flow Alternatives Average Monthly E/I Ratio

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	0.49	0.45	0.58	0.59	0.39	0.29	0.25	0.25	0.28	0.33	0.32	0.49
3	0.50	0.46	0.58	0.59	0.39	0.30	0.26	0.26	0.30	0.36	0.34	0.48
4	0.50	0.46	0.58	0.59	0.39	0.30	0.26	0.26	0.30	0.36	0.34	0.48
5	0.52	0.48	0.59	0.59	0.40	0.34	0.28	0.28	0.33	0.38	0.35	0.50
6	0.53	0.45	0.58	0.59	0.39	0.28	0.26	0.26	0.29	0.36	0.30	0.49
7	0.48	0.47	0.58	0.59	0.40	0.31	0.34	0.16	0.27	0.30	0.30	0.48
8	0.51	0.45	0.58	0.59	0.39	0.29	0.22	0.24	0.31	0.36	0.29	0.48

* There is no E/I objective under D-1485
** Is increased to 0.45 if the Eight River Index for January is less than or equal to 1.0 MAF

2. Salinity

This section analyzes salinity conditions under the seven flow alternatives and the base case as modeled by DWRSIM and the DWR Delta Simulation Model, DWRDSM1. Two analyses are discussed below to illustrate the flow alternatives' effects on salinity in the Estuary. In the first analysis, the position of X2, the 2 parts per thousand (ppt) isohaline, for each of the flow alternatives is compared with the X2 position of the base case. In the second analysis, the electrical conductivity (EC) of each of the flow alternatives at stations throughout the Delta is compared to that of the base case.

a. X2. The significance of the changes in the X2 position is related to their effects on aquatic resources in the Delta. X2 is defined as the distance from the Golden Gate Bridge in kilometers (km) of the 2 part per thousand (ppt) isohaline at a depth of one meter from the bottom of the channel. Figure VI-1 shows the distance in kilometers from the Golden Gate Bridge along a path through the Bay/Delta. This figure can be used to locate the X2 position. The 1995 Bay/Delta Plan provides that the Delta outflow objectives are met from February through June if the location of the X2 isohaline is downstream of specified locations for a certain number of days per month. During the development of the X2 objectives, it was agreed that the 2-ppt salinity isohaline at the bottom of the water column could be represented by a specific conductance of 2.64 mmhos/cm at the surface. This conversion was made because the majority of the field salinity EC data are measured at the surface. These data are adjusted to 25°C to provide comparable data.

DWRSIM was used to determine the location of the X2 isohaline position for each of the seven flow alternatives and the base case. The model predicts the location of X2 as a function of the current and previous months' flows (see Chapter IV section A). Table VI-13 shows monthly average X2 positions for Alternative 1 for the 73-year period and the critical period as predicted by the model. The table also compares these monthly average X2 positions for the base case to the X2 positions for each of the other alternatives. Positive changes indicate westward movement of the X2 line, which is generally desirable for aquatic species in the Estuary; negative changes indicate a shift toward the Delta.

Some general observations regarding the position of X2 can be noted. Over the 73-year period, the X2 position for the flow alternatives moves slightly downstream as compared to the base case in November and December and from February through September. The greatest downstream movement occurs in April. X2 moves upstream in October and January. This upstream movement corresponds with a reduction in Delta outflow as compared to the base case (see Table VI-7). The same general trends are observed during the critical period, except that upstream movement of X2 also occurs in August. This corresponds to reduced critical period Delta outflow during August (see Table VI-8). Delta outflow in December for the critical period is also reduced from the base case; however, the X2 position is downstream of the base case. This is likely the result of antecedent conditions.

The effects of Alternatives 2, 3, 4, 7, and 8 on X2 are virtually indistinguishable from each other for both the 73-year period and the critical period. This is to be expected since monthly average Delta outflow varies little among these alternatives. The X2 position is farther downstream for all months under Alternative 5 than for any other alternative because of the higher outflow under this alternative. The X2 position is farther upstream in October through January under Alternative 6 than the other alternatives because higher exports associated with combined use of SWP and CVP points of diversion in the Delta result in lower Delta outflows during this period.

Figure VI - 1
X2 Location Map
Sacramento - San Joaquin Delta and San Francisco Bay

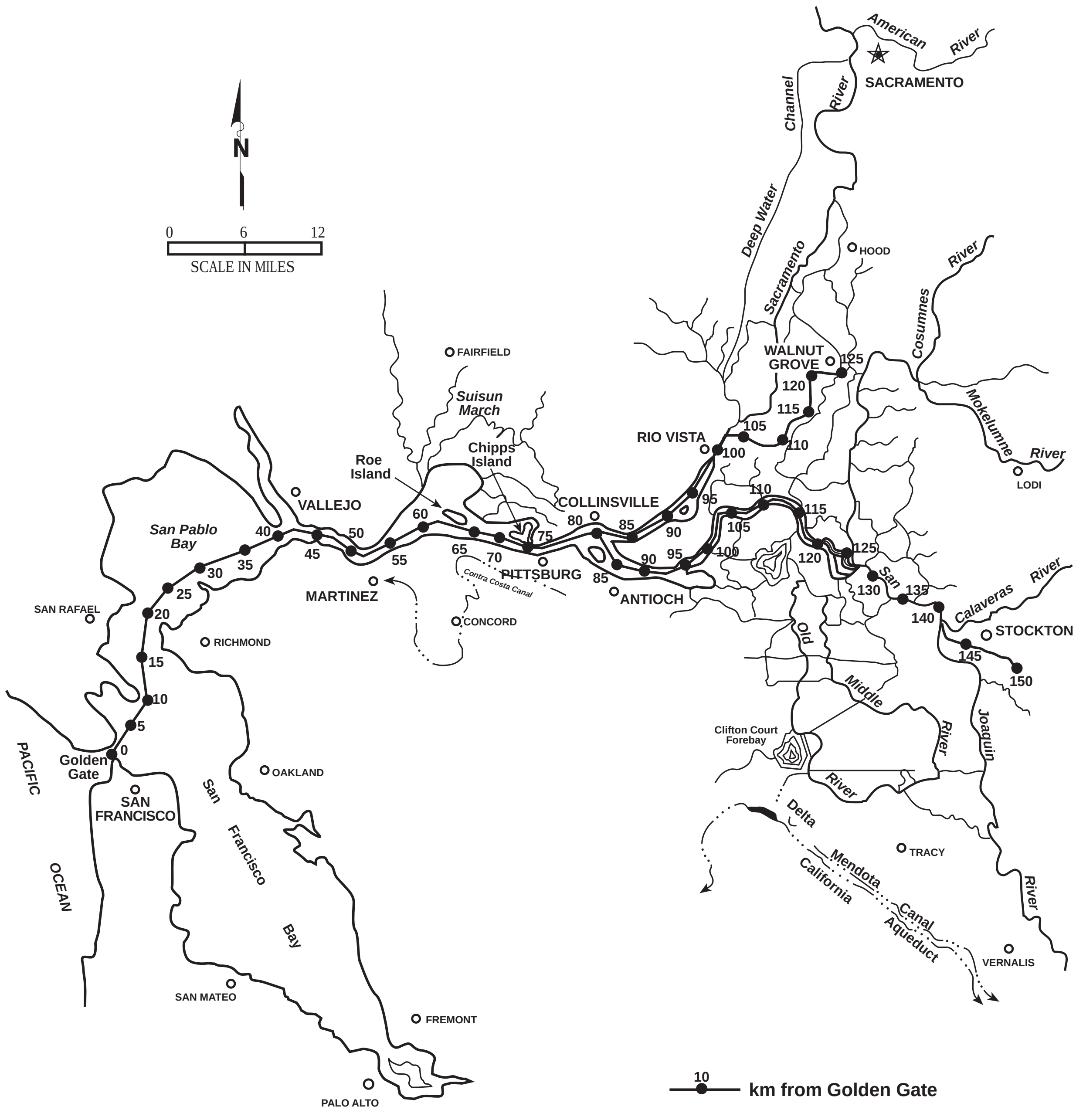


Table VI-13
Modeled Isohaline (X2) Position

73-Year Period Average Monthly X2 Position (km)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	83.0	82.4	77.4	70.4	66.4	66.1	70.8	73.3	76.6	80.9	85.7	88.1

Change in X2 Position from the Base Case (km)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-0.9	1.1	0.2	-0.5	1.1	1.4	3.0	1.9	2.5	1.5	1.0	1.5
Alt 3	-0.7	1.2	0.2	-0.5	1.2	1.5	3.1	1.9	2.5	1.5	1.0	1.5
Alt 4	-0.7	1.2	0.2	-0.5	1.2	1.5	3.1	1.9	2.5	1.5	1.0	1.6
Alt 5	-0.4	1.6	1.6	-0.2	1.5	2.0	3.7	2.7	3.0	1.6	1.1	1.4
Alt 6	-1.1	0.7	-0.3	-1.1	1.0	1.4	3.0	1.9	2.9	1.6	1.1	1.4
Alt 7	-0.7	0.9	0.1	-0.6	1.1	1.5	2.6	2.1	2.8	1.6	1.0	1.4
Alt 8	-1.0	1.1	0.2	-0.5	1.1	1.4	3.4	2.3	2.7	1.5	1.0	1.5

Critical Period Average Monthly X2 Position (km)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	85.4	88.8	84.9	79.1	79.8	82.6	81.1	83.5	85.9	87.3	85.9	90.0

Change in X2 Position from the Base Case (km)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-2.3	2.6	0.3	-2.0	2.6	6.7	3.9	5.4	6.4	3.8	-0.5	0.9
Alt 3	-2.4	2.6	0.3	-2.0	2.5	6.7	3.9	5.4	6.4	3.8	-0.5	0.9
Alt 4	-2.4	2.6	0.3	-2.0	2.5	6.7	3.9	5.4	6.4	3.8	-0.5	0.9
Alt 5	-2.3	2.3	-0.1	-0.8	-3.2	8.0	6.1	6.3	7.5	3.9	-0.8	0.7
Alt 6	-3.0	2.6	0.2	-2.1	2.5	6.5	3.9	5.4	7.0	4.0	0.0	1.0
Alt 7	-2.0	2.4	0.2	-1.9	2.5	6.4	3.8	5.5	6.9	4.0	-0.7	0.8
Alt 8	-2.7	2.6	-0.2	-1.0	2.8	7.3	5.9	6.0	7.2	3.8	-0.4	0.9

Overall, the shift in X2 locations for all the flow alternatives in comparison to the base case is downstream and should have positive effects on aquatic resources. In October and January, the X2 position under the alternatives would be slightly eastward, but this limited shift in the X2 location is not significant and will not require mitigation.

b. Electrical Conductivity Within the Delta. DWRDSM was used to determine the effect of each of the eight flow alternatives on EC in the Delta. To estimate monthly average salinity in the Delta, DWRDSM (described in Chapter IV) uses the hydrology generated by DWRSIM studies of the base case and alternatives as input. Thus, the modeling assumptions for DWRSIM, discussed in Chapter IV, also apply to the salinity analysis. DWRDSM is not intended to provide absolute predictions of future Delta hydrodynamic and EC conditions; rather, the model is meant as a tool to compare Delta conditions under various alternative actions.

This analysis examines results of simulations at the following 13 locations shown on Figure VI-2 and listed in Table VI-14: Contra Costa Canal at Pumping Plant No. 1/Rock Slough; Contra Costa Los Vaqueros Intake; Banks Pumping Plant; Tracy Pumping Plant; Sacramento River at Emmaton; San Joaquin River at Jersey Point; South Fork of the Mokelumne River at Terminous; San Joaquin River at San Andreas Landing; San Joaquin River at Prisoners Point; San Joaquin River at Vernalis; San Joaquin River at Brandt Bridge

Figure VI-2
Delta Salinity Recording Stations

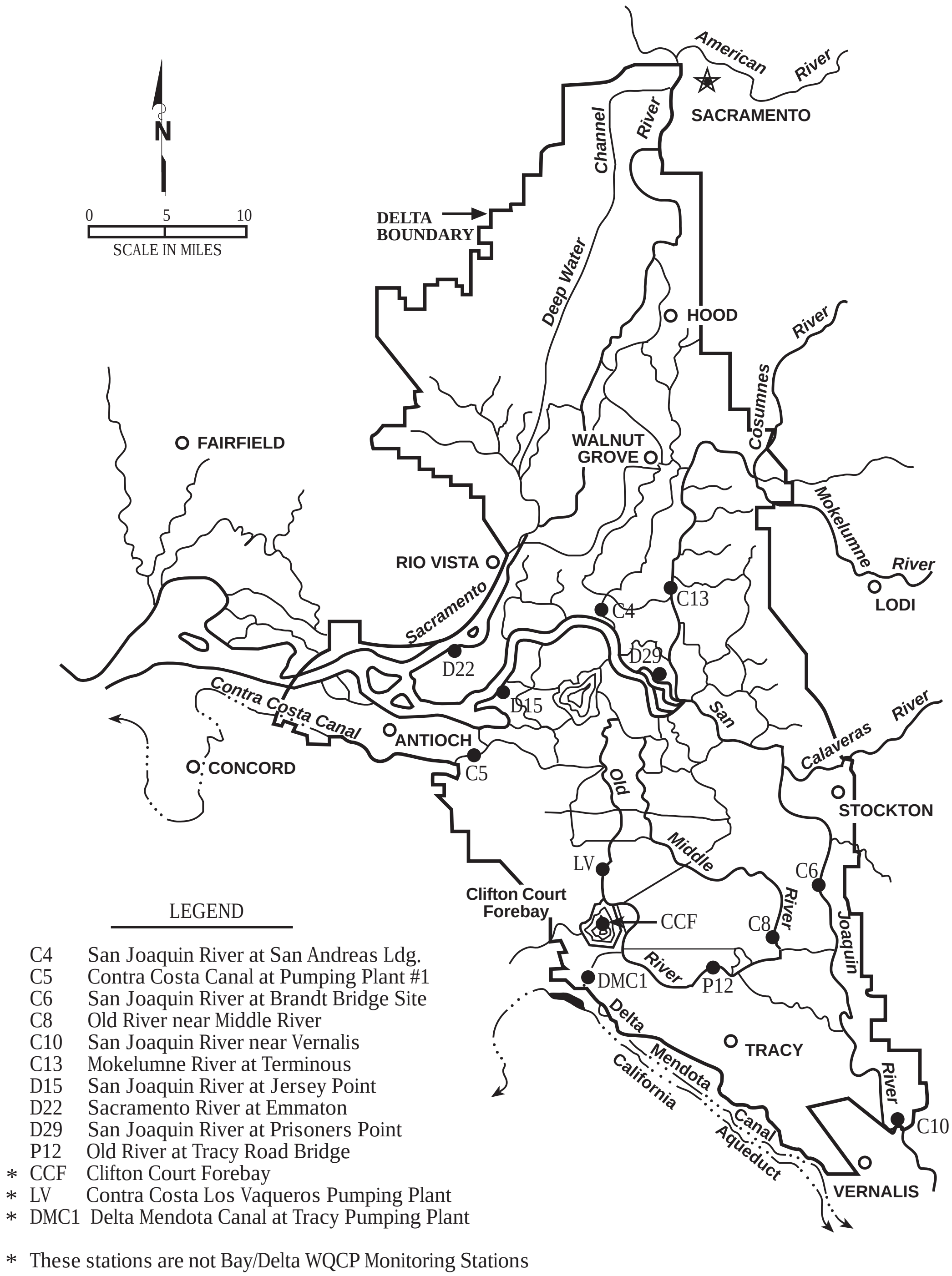


Table VI-14
Salinity Recording Stations

Sacramento Valley 40-30-30 Index	San Joaquin Valley 60-20-20 Index
Contra Costa Canal Pumping Plant # 1	San Joaquin River at Vernalis
Contra Costa Los Vaqueros Intake	San Joaquin River at Brandt Bridge site
Banks Pumping Plant	Old River at Tracy Road Bridge
Tracy Pumping Plant	Old River near Middle River
Sacramento River at Emmaton	
San Joaquin River at Jersey Point	
South Fork Mokelumne River at Terminous	
San Joaquin River at San Andreas Landing	
San Joaquin River at Prisoners Point	

site; Old River at Tracy Road Bridge; and Old River near Middle River. Figures VI-3 through VI-22 show expected chloride concentrations for Contra Costa's Intakes and the Banks and Tracy pumping plants, under the seven flow alternatives and the base case for water years 1976 through 1991. Figures VI-23 through VI-63 show expected electrical conductivity (EC) at the remaining stations. Where possible, objectives are noted on the figures. EC objectives for stations in the south Delta are the same for all year types, while EC objectives at other stations change based on the year type. The first figure for each station shows the average EC (or chloride concentration) for wet years during the 16-year period, followed by above normal, below normal, dry, and critically dry years. Year types are based on the Sacramento Valley "40-30-30" classification system with the exception of the four Southern Delta Salinity stations, which are based on the San Joaquin Valley "60-20-20" hydrologic classification system. Below normal years under the San Joaquin 60-20-20 hydrologic classification system do not occur during the model study period (1976 – 1991). Consequently below normal year types are omitted for stations under the San Joaquin Valley 60-20-20 Index convention.

Modeled chloride concentrations at Contra Costa Canal Pumping Plant No. 1 are shown in Figures VI-3 through VI-7. A feature of these plots is that the maximum mean daily chloride objective is exceeded slightly in December of critically dry years under Alternatives 2 through 8. This is caused by differences between the methods used by DWRSIM and DWRDSM to calculate salinity or chloride concentrations. DWRSIM, the operations model, uses a relationship between outflow and salinity to determine concentrations of these parameters at selected western Delta stations, including the Contra Costa Pumping Plant. DWRSIM makes reservoir releases as necessary to meet the objectives at these locations and DWRSIM output indicates that these objectives are always met. The hydrology output from DWRSIM is used as input to DWRDSM, which uses a more complicated method for calculating salinity and chloride concentrations. The method used by DWRDSM considers other factors such as exports and tidal influence. Output from DWRDSM may show significant violations of salinity objectives. In summary, the DWRDSM output indicates a need for carriage water, but the DWRSIM model does not presently include a method for calculating carriage water. Although DWRDSM output predicts that salinity objectives at some locations will be violated, in actual operations, the projects would be operated to meet salinity and chloride objectives in the western Delta under all of the alternatives, and violations would not be expected to occur. Because of the conditions described above, salinity information depicted in Figures VI-3 through VI-67 is generally discussed relative to base case salinity, rather than to the objectives.

Figures VI-3 through VI-7 show predicted chloride concentrations for Contra Costa Canal at Pumping Plant No.1. The graphs show that chloride levels among Alternatives 2 through 8 increase relative to the base case in December of above normal years and in December, January, and February of both dry and critically dry years. Chloride levels among Alternatives 2 through 8 decrease in August and September of wet and above normal year types, in June through September of below normal and dry years, and in March through August of critically dry years. Chloride levels of Alternatives 2 through 8 are similar throughout the year, with the limited exception of Alternative 6 in some winter months in below normal years. At these times the chloride levels rise because of increased exports and decreased outflow associated with use of the combined points of diversion.

Figures VI-8 through VI-12 show predicted chlorides for Contra Costa Water District's Los Vaqueros Intake on Old River. The graphs show that chloride levels among Alternatives 2 through 8 are greater than the base case in December of above normal years and December, January and February of dry and critical years. Alternatives 2 through 8 are lower than the base case chlorides in September of above normal years; July, August and September of below normal and dry years, and June, July and August of critically dry years. Otherwise chloride levels are similar throughout the year.

Figures VI-13 through VI-17 and Figures VI-18 through VI-22 show predicted chlorides for the SWP Banks Pumping Plant and CVP Tracy Pumping Plant, respectively. The graphs show that chloride levels among Alternatives 2 through 8 are greater than base case chlorides in December of above normal years and December, January, and February of dry and critical years. Alternatives 2 through 8 are lower than the base case in July, August and September of below normal and dry years, and June, July, and August of critically dry years. Other differences are not significant.

Figures VI-23 through VI-27 show predicted salinity for the Sacramento River at Emmaton. Salinity for Alternatives 2 through 8 increases over the base case in October of wet years; decreases from June to December of below normal years and from April to September of dry years. In critically dry years salinity for Alternatives 2 through 8 is higher than the base case in August, October, December, and January but is lower from February to July.

Figures VI-28 through VI-32 show predicted salinities in the San Joaquin River at Jersey Point in the western Delta. Salinity levels under Alternatives 2 through 8 are higher than base case salinity in October of wet and above normal years and in January of dry and critically dry years. Salinity levels under Alternatives 2 through 8 are similar to or lower than the base case throughout the summer months in all year types.

Figures VI-33 through VI-47 show predicted central Delta salinities at Terminous, and the San Joaquin River at San Andreas Landing and Prisoners Point. The alternatives and the base case have very similar salinity conditions at Terminous on the South Fork of the

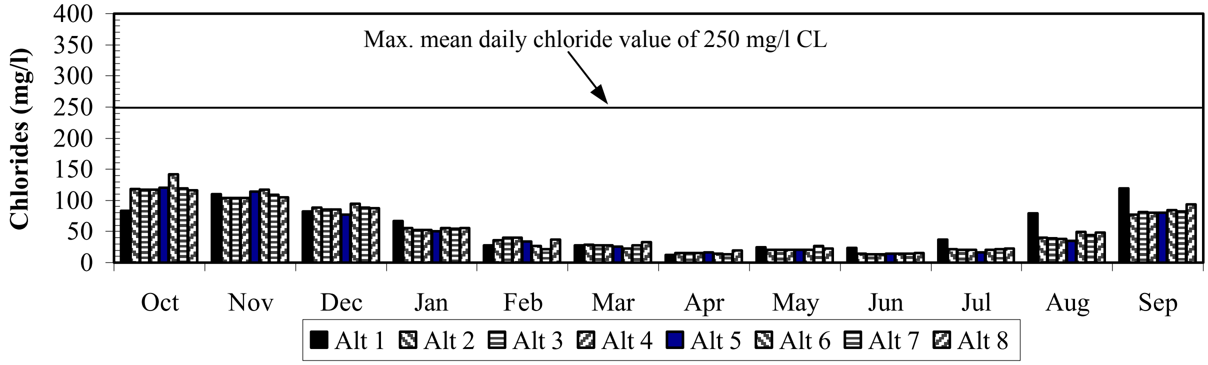
Mokelumne River. The salinity patterns at San Andreas and Prisoners Point are similar to the salinity patterns in the western Delta stations. Salinity at these stations increases relative to the base case in December of dry and critically dry years when the Delta Cross Channel is closed and exports are high. In the spring and summer, salinity decreases as outflow increases. The spring salinity decreases at these stations are not as pronounced as in the western Delta because the Delta Cross Channel gates are closed more often than under the base case.

Figures VI-48 through VI-63 show predicted salinity levels at the four southern Delta stations: San Joaquin River at Vernalis, and at Brandt Bridge, Old River at Tracy Road Bridge, and Old River near Middle River. The salinity objectives at Vernalis in the Bay/Delta Plan are 0.7 mmhos/cm from April through August and 1.0 mmhos/cm from September through March. The salinity requirement at Vernalis in D-1422 (base case) is 500 ppm (approximately 0.86 mmhos/cm). The exceedances of the objectives predicted by DWRDSM are not caused by the differences between DWRSIM and DWRDSM, as described above. Salinity conditions at Vernalis predicted by DWRSIM are boundary conditions in DWRDSM and are, therefore, the same in both models. DWRSIM makes releases from New Melones Reservoir to meet salinity objectives at Vernalis. When there is insufficient water in New Melones Reservoir to meet all of the demands, salinity objectives are violated. During the 16-year, 192-month period, Alternatives 2 and 5 exceed the monthly Vernalis salinity objective three times. Alternative 7 exceeds salinity objectives 23 times and Alternative 8 exceeds objectives 15 times. Flow Alternatives 3, 4 and 6 do not have any exceedances of the Vernalis salinity objective. Because of the difference in objectives at Vernalis between the base case and the seven alternatives, Vernalis salinity is generally higher in the summer for the base case than for the other alternatives. Alternative 7 exceeds Plan objectives at the four stations in August of dry and critically dry years. This is because, under the Letter of Intent, there is a 70 TAF cap on releases from New Melones Reservoir for salinity control. Alternative 8 exceeds Plan objectives in August of critically dry years because of New Melones Reservoir release limits for salinity control specified in the Stanislaus River Interim Operations Plan.

The model is not operated to require the release of higher dilution flows to meet salinity objectives at the other three southern Delta stations (Brandt Bridge, Old River at Tracy Bridge, and Old River near Middle River). Consequently, salinity at these stations exhibit a pattern similar to Vernalis salinity, but the objectives at these locations are exceeded more often than the Vernalis objectives, especially under dry conditions, because of the local water use and drainage patterns.

All four of the south Delta stations show Alternative 5 having the lowest salinity in July, except for Brandt Bridge in dry and critical years. Alternative 5 also tends to exhibit slightly lower salinity in the spring, although the decrease is small.

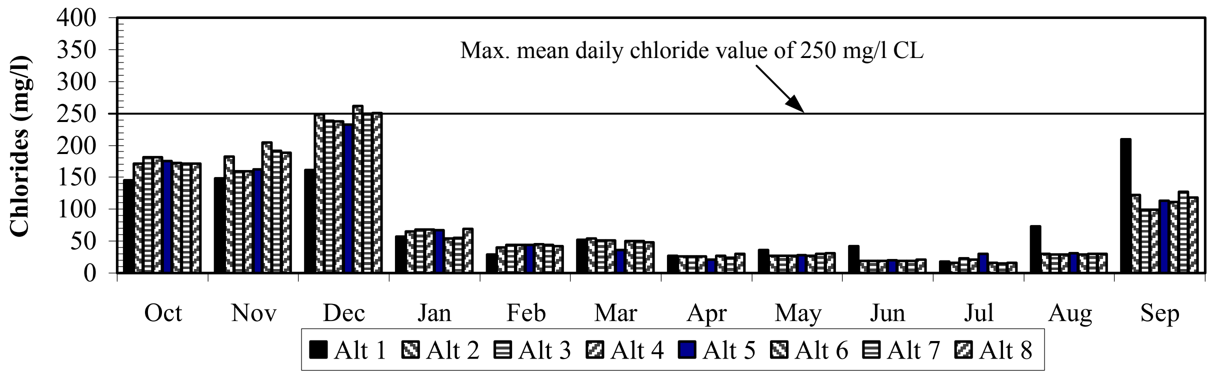
Figure VI-3
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Wet Years



For a Wet water year; 240 (66%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

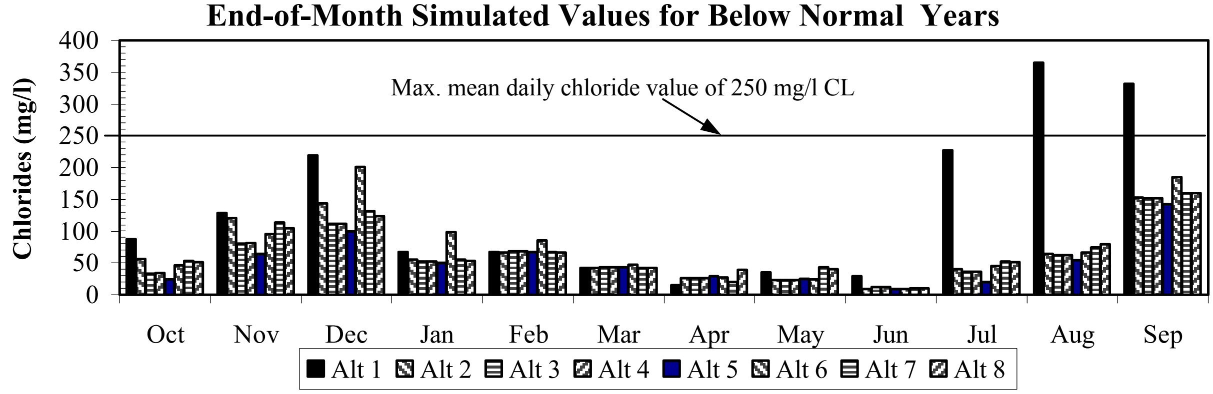
Figure VI-4
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Above Normal Years



For a Above Normal water year; 190 (52%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

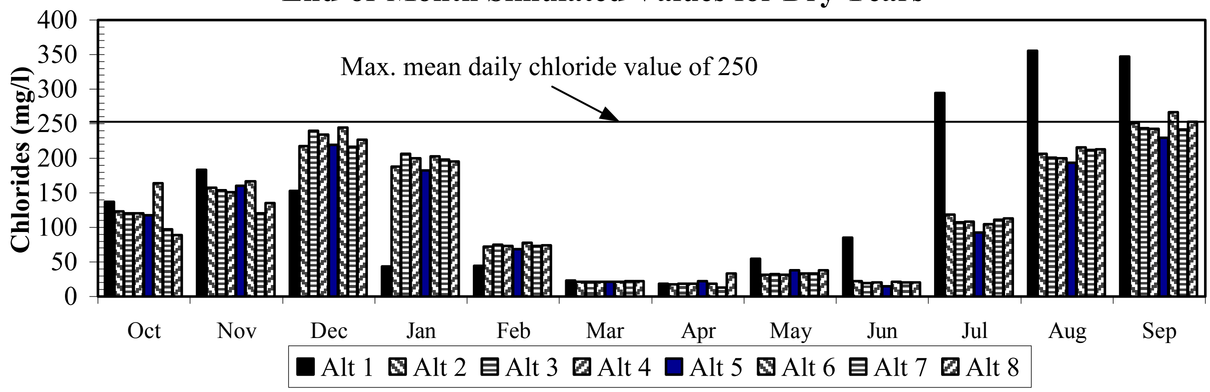
Figure VI-5
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Below Normal Years



For a Below Normal water year; 175 (48%) days <= 150 mg/l
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **below normal** year (1979)

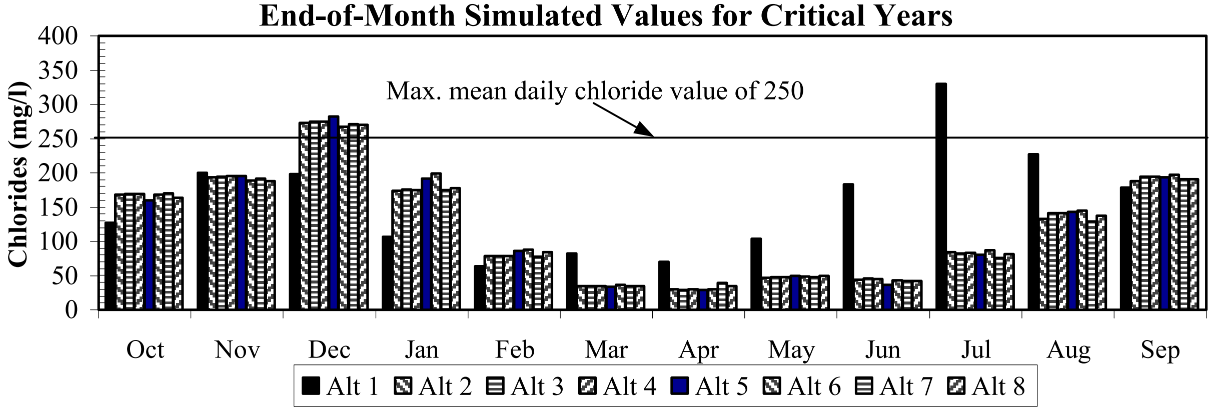
Figure VI-6
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Dry Years



For a Dry water year; 165 (45%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

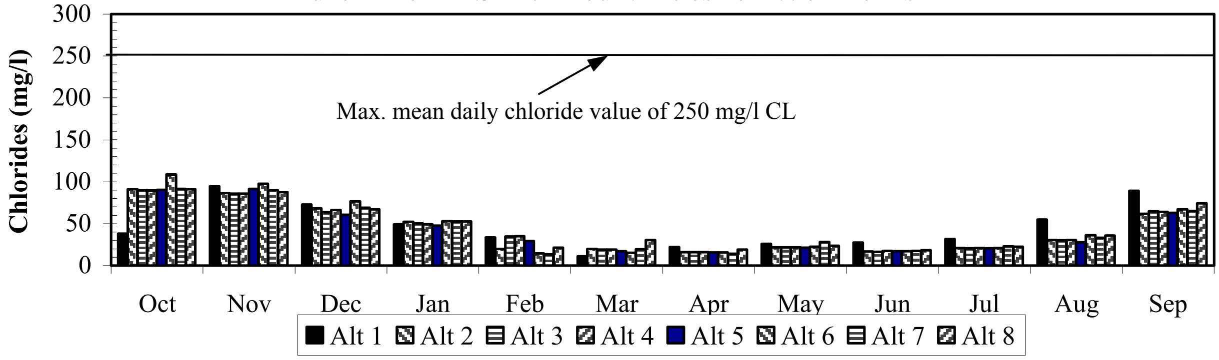
Figure VI-7
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Critical Years



For a Critical water year; 155 (42%) days <= 150 mg/l
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

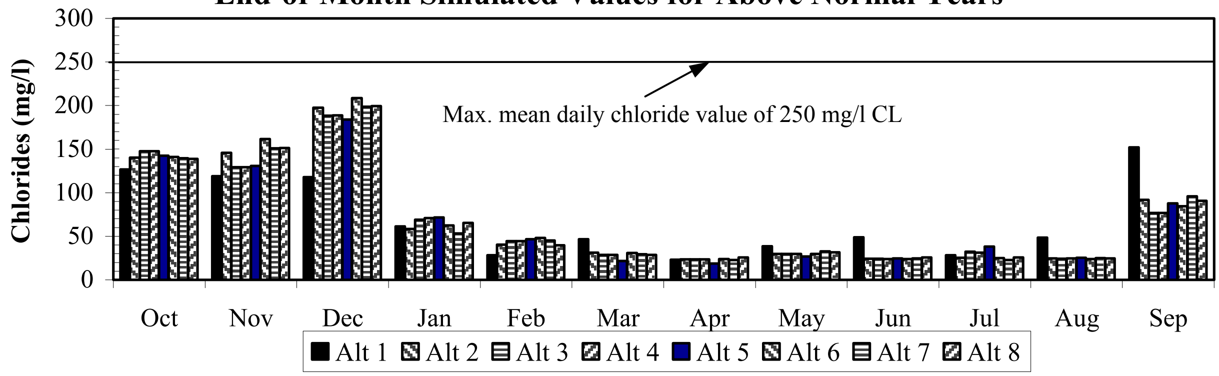
Figure VI-8
Salinity for Los Vaqueros Intake on Old River
End-of-Month Simulated Values for Wet Years



For a Wet water year; 240 (66%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

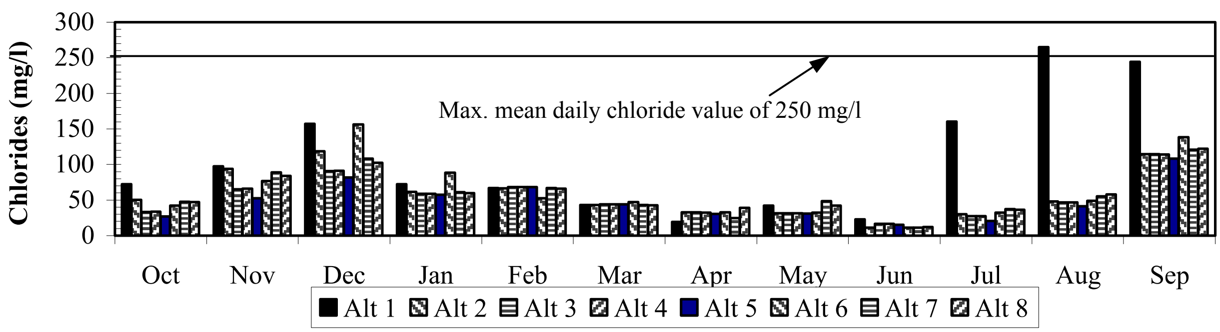
Figure VI-9
Salinity for Los Vaqueros Intake on Old River
End-of-Month Simulated Values for Above Normal Years



For a Above Normal water year; 190 (52%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

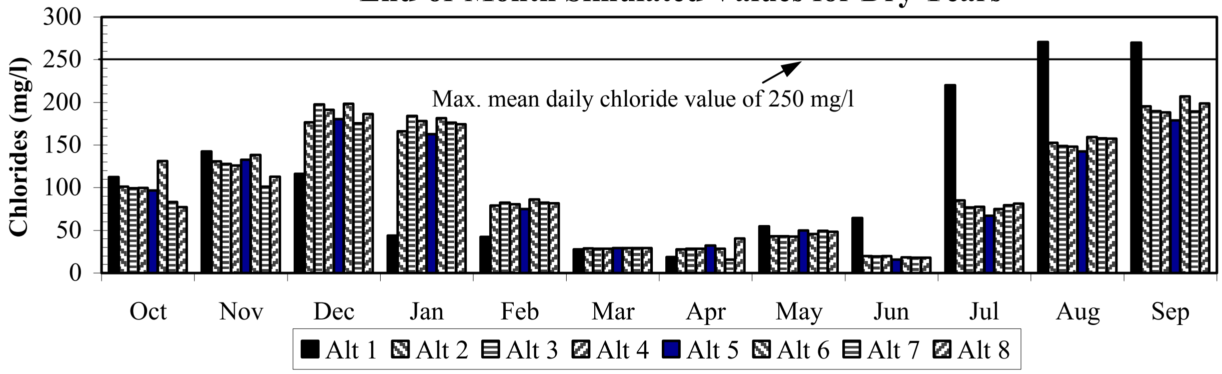
Figure VI-10
Salinity for Los Vaqueros Intake on Old River
End-of-Month Simulated Values for Below Normal Years



For a Below Normal water year; 175 (48%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **below normal** year (1979)

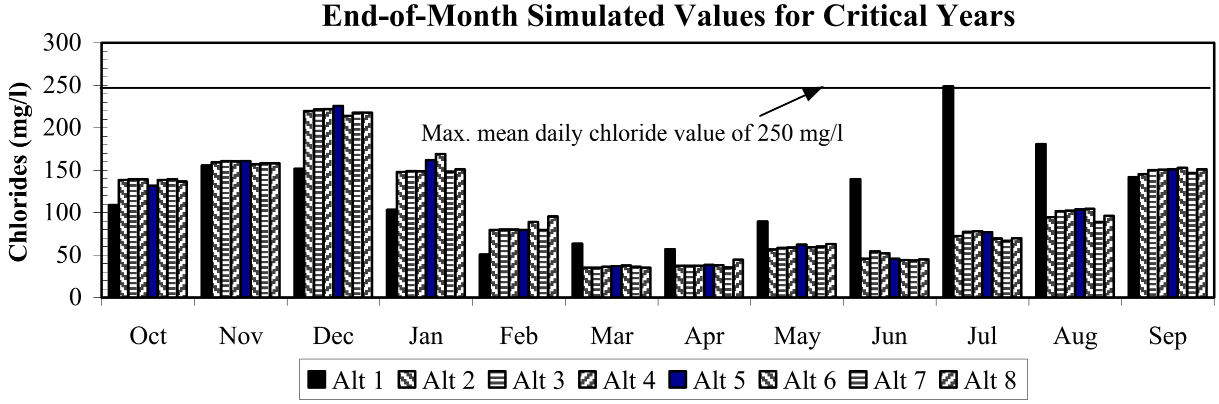
Figure VI-11
Salinity for Los Vaqueros Intake on Old River
End-of-Month Simulated Values for Dry Years



For a Dry water year; 165 (45%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

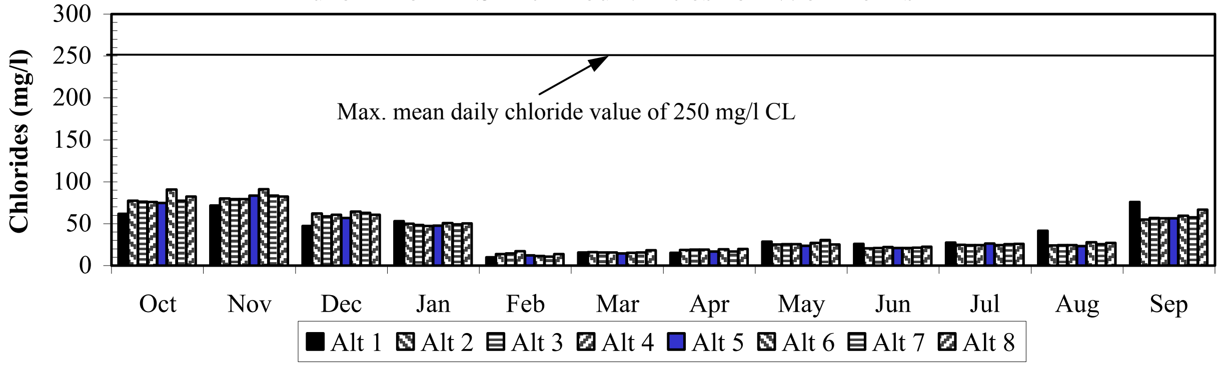
Figure VI-12
Salinity for Los Vaqueros Intake on Old River
End-of-Month Simulated Values for Critical Years



For a Critical water year; 155 (42%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

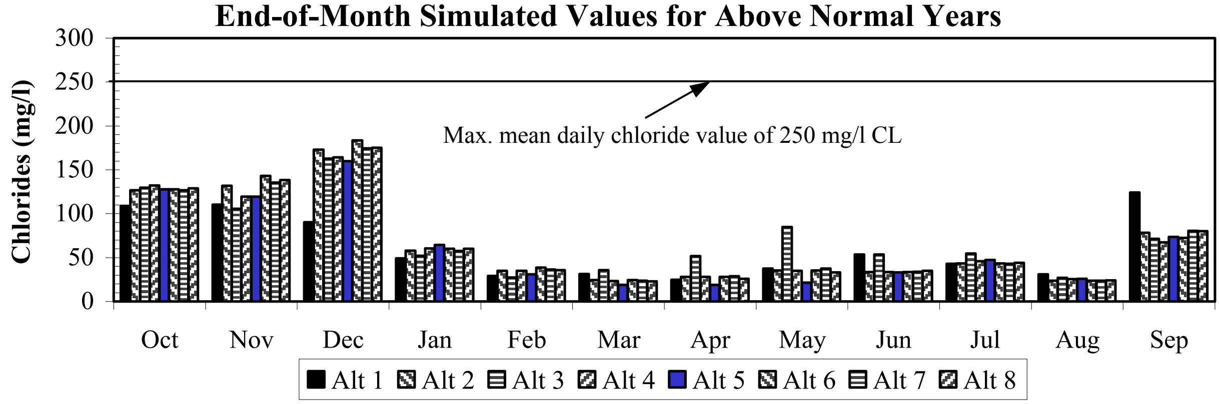
Figure VI-13
Salinity for Banks Pumping Plant
End-of-Month Simulated Values for Wet Years



For a Wet water year; 240 (66%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

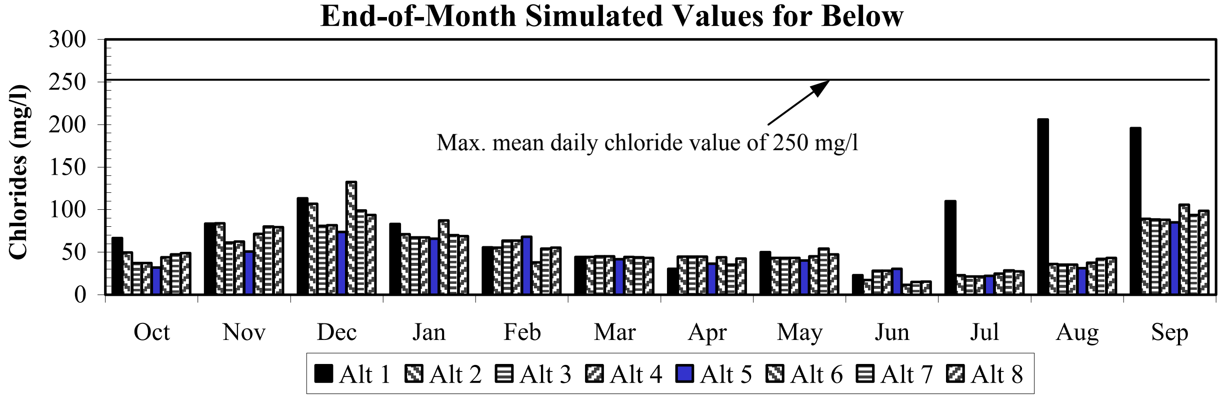
Figure VI-14
Salinity for Banks Pumping Plant
End-of-Month Simulated Values for Above Normal Years



For a Above Normal water year; 190 (52%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

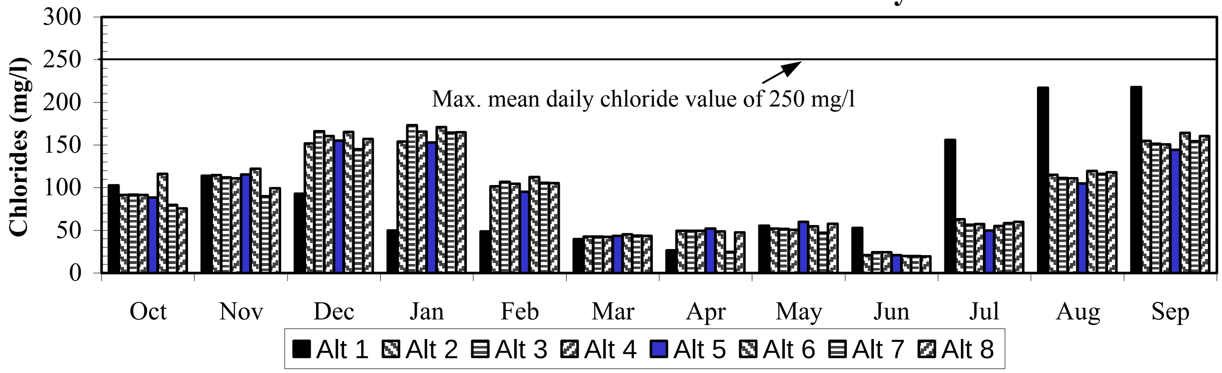
Figure V-15
Salinity for Banks Pumping Plant
End-of-Month Simulated Values for Below



For a Below Normal water year; 175 (48%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **below normal** year (1979)

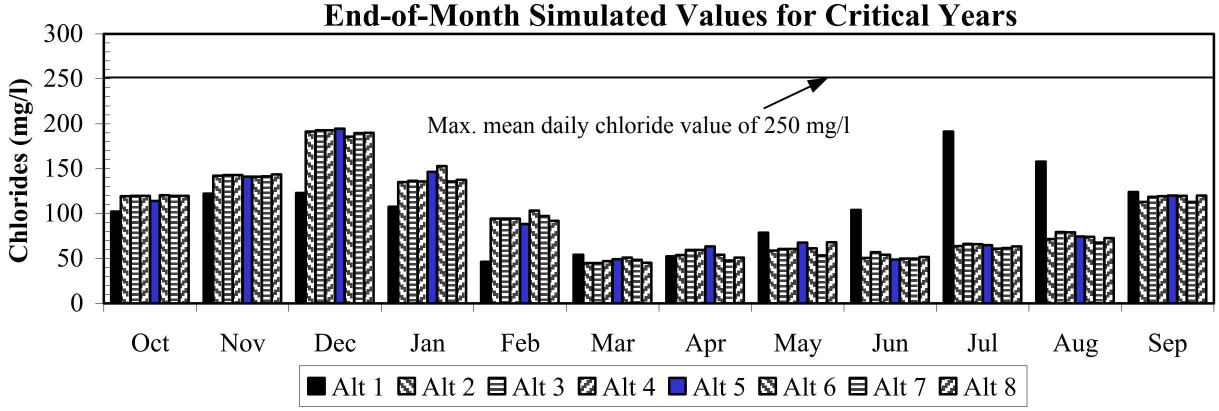
Figure VI-16
Salinity for Banks Pumping Plant
End-of-Month Simulated Values for Dry Years



For a Dry water year; 165 (45%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

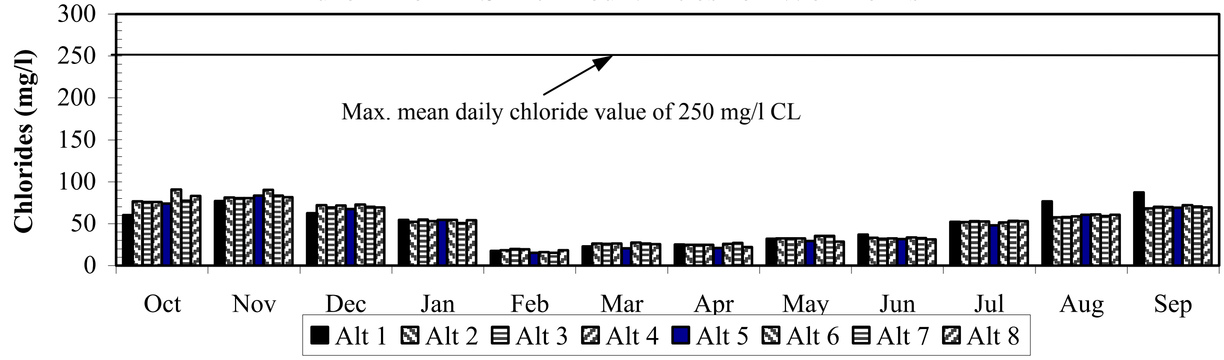
Figure VI-17
Salinity for Banks Pumping Plant
End-of-Month Simulated Values for Critical Years



For a Critical water year; 155 (42%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

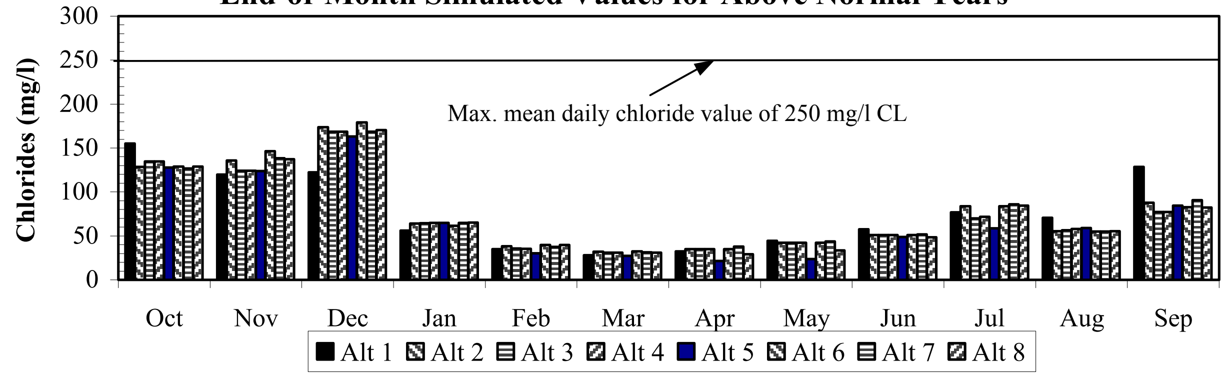
Figure VI-18
Salinity for Tracy Pumping Plant
End-of-Month Simulated Values for Wet Years



For a Wet water year; 240 (66%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30 "**wet** years averaged (1982, 83, 84 & 86)

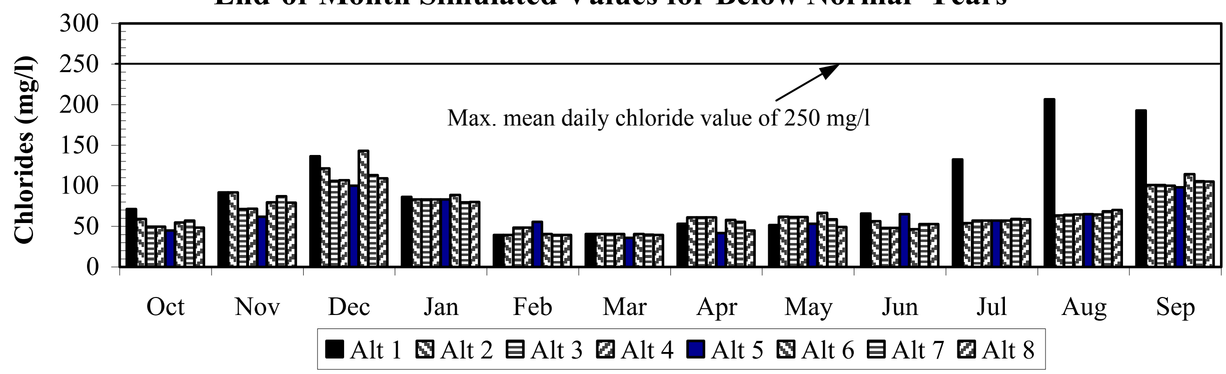
Figure VI-19
Salinity for Tracy Pumping Plant
End-of-Month Simulated Values for Above Normal Years



For a Above Normal water year; 190 (52%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30 "**above normal** years averaged (1978 & 80)

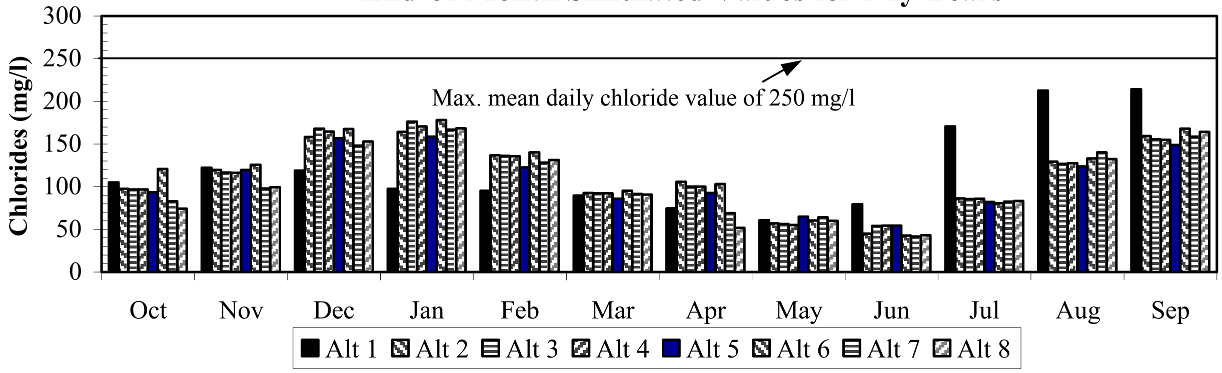
Figure VI-20
Salinity for Tracy Pumping Plant
End-of-Month Simulated Values for Below Normal Years



For a Below Normal water year; 175 (48%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **below normal** year (1979)

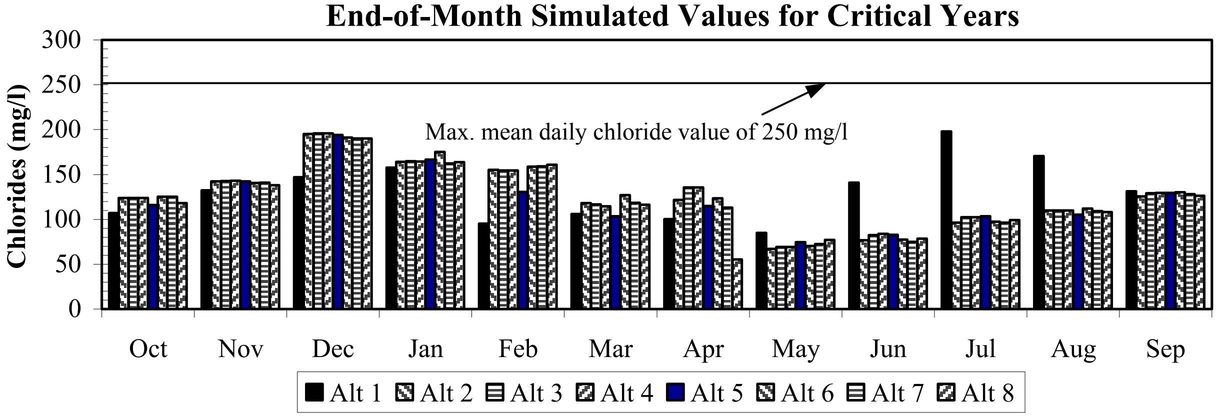
Figure VI-21
Salinity for Tracy Pumping Plant
End-of-Month Simulated Values for Dry Years



For a Dry water year; 165 (45%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30 "**dry** years averaged (1981, 85, 87 & 89)

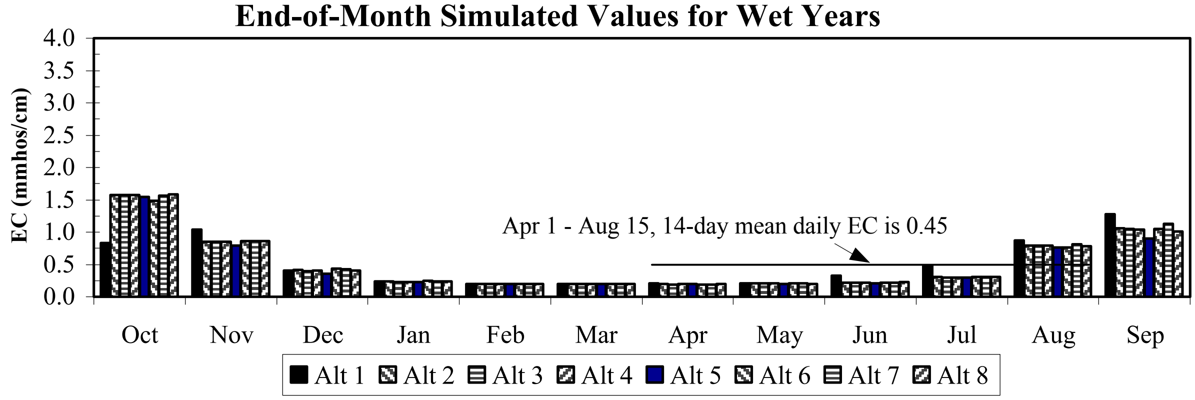
Figure VI-22
Salinity for Tracy Pumping Plant
End-of-Month Simulated Values for Critical Years



For a Critical water year; 155 (42%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30 "**critical** years averaged (1976, 77, 88, 90 & 91)

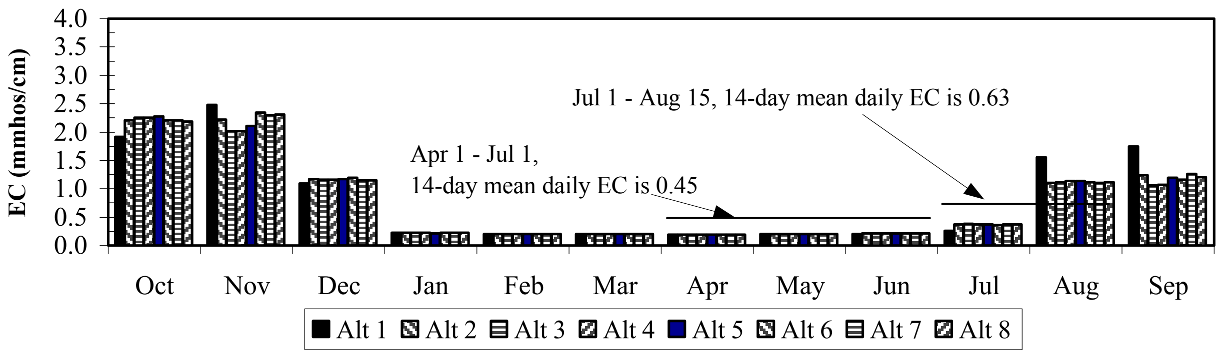
Figure VI-23
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Wet Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

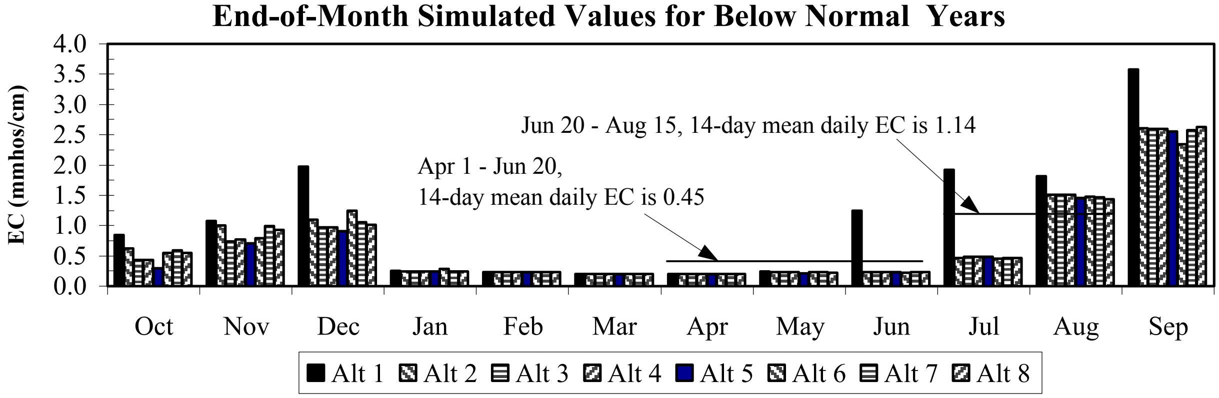
Figure VI-24
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Above Normal Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

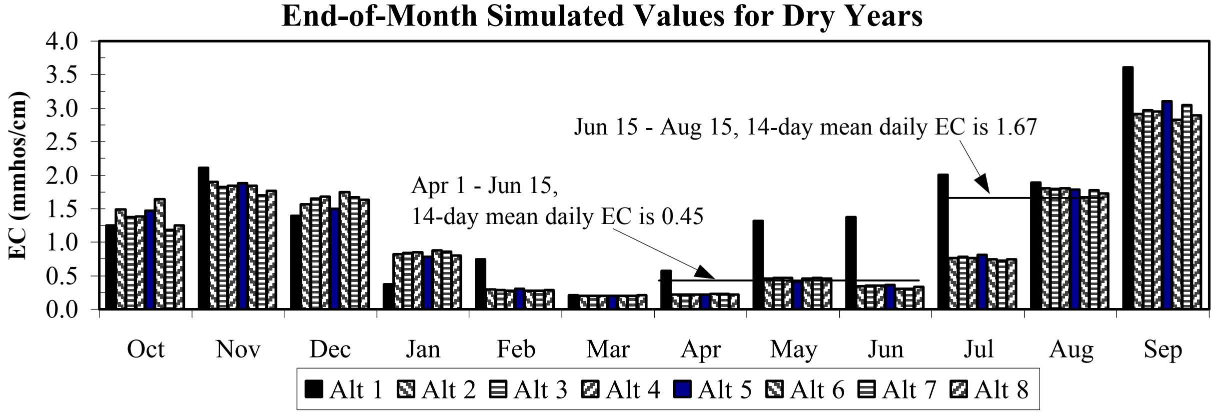
Figure VI-25
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Below Normal Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **below normal** year (1979)

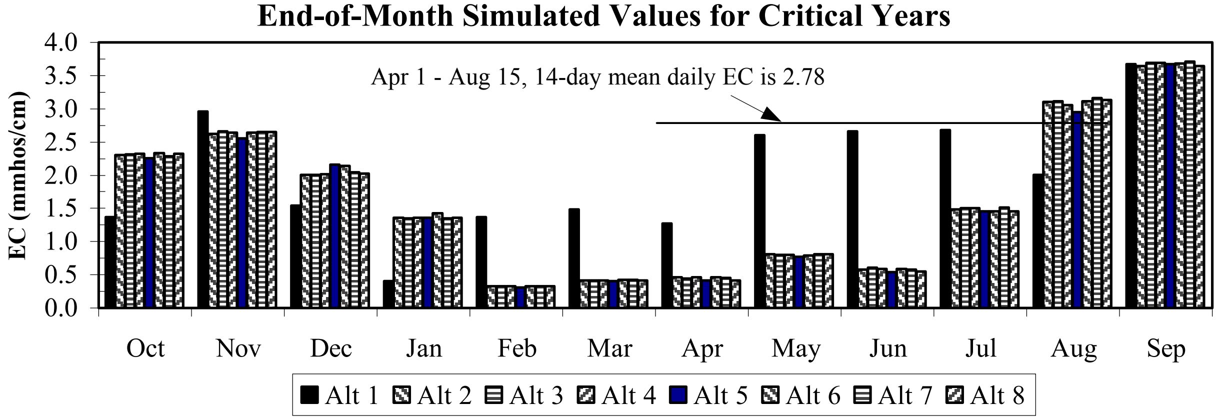
Figure VI-26
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Dry Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30 "**dry** years averaged (1981, 85, 87 & 89)

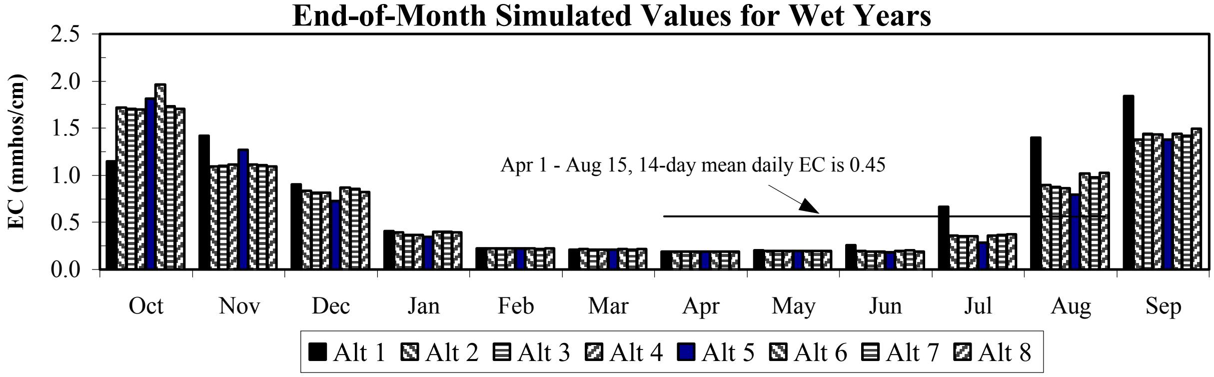
Figure VI-27
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Critical Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30 "**critical** years averaged (1976, 77, 88, 90 & 91)

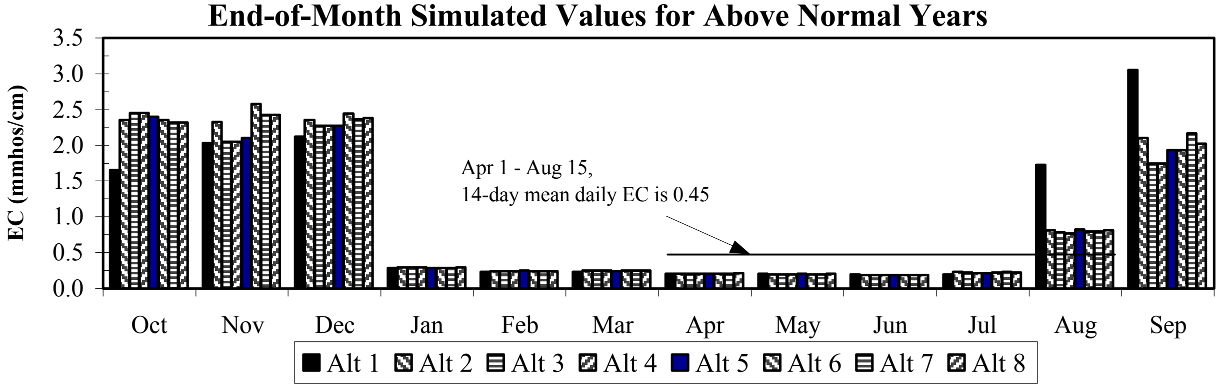
Figure VI-28
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Wet Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30 "**wet** years averaged (1982, 83, 84 & 86)

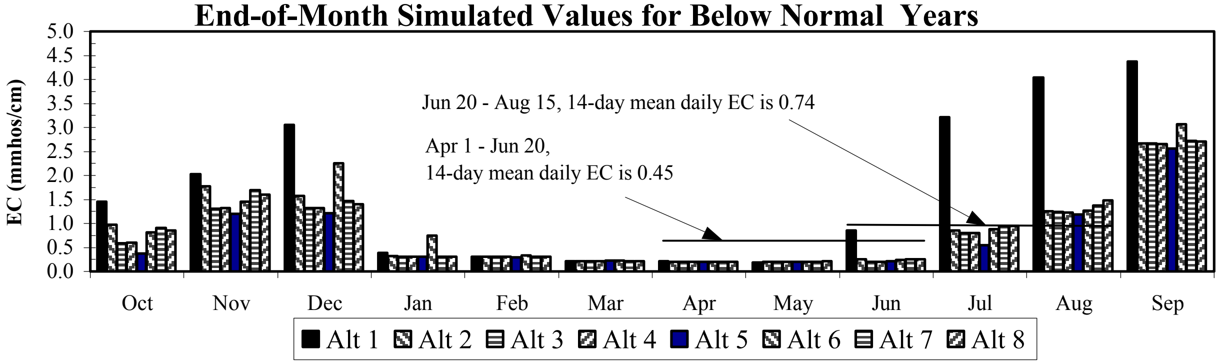
Figure VI-29
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Above Normal Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30 "**above normal** years averaged (1978 & 80)

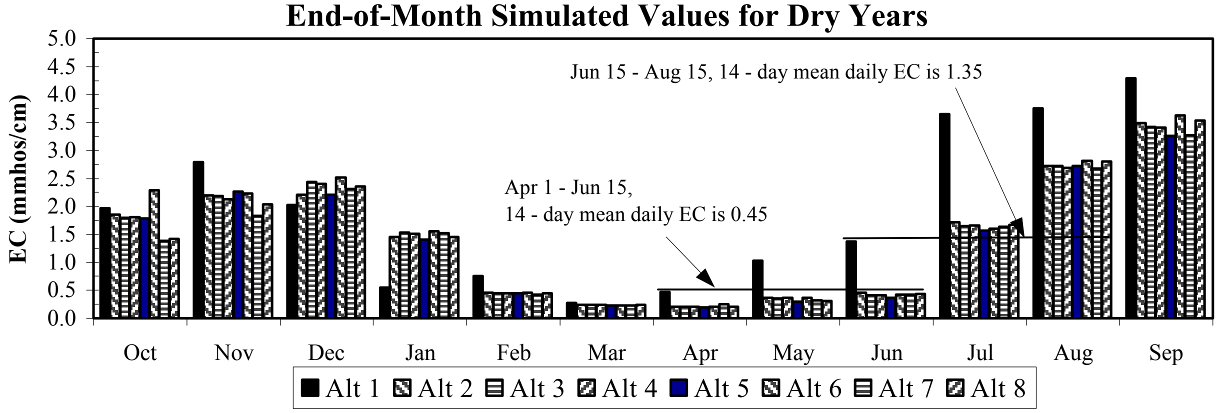
Figure VI-30
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Below Normal Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **below normal** year (1979)

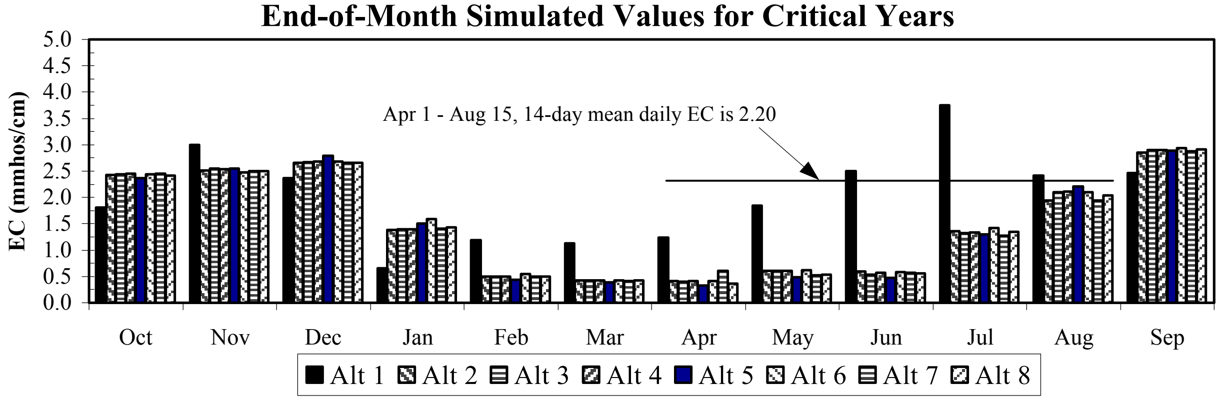
Figure VI-31
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Dry Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

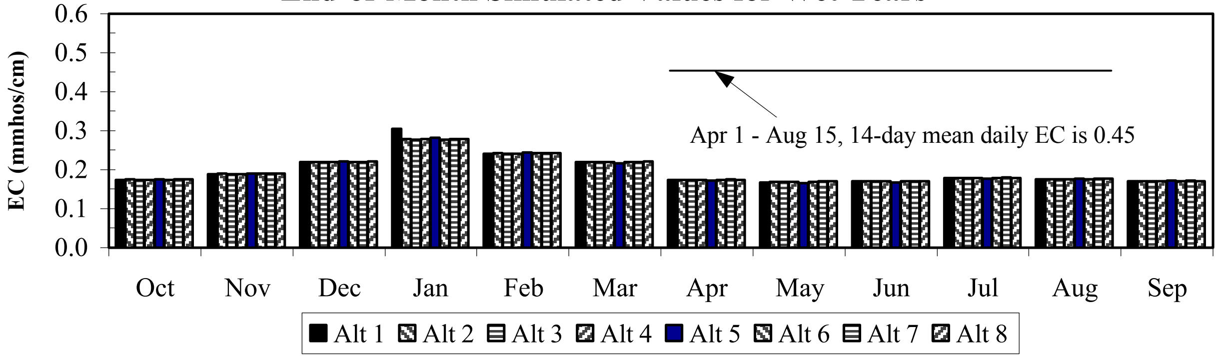
Figure VI-32
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Critical Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **critica**l years averaged (1976, 77, 88, 90 & 91)

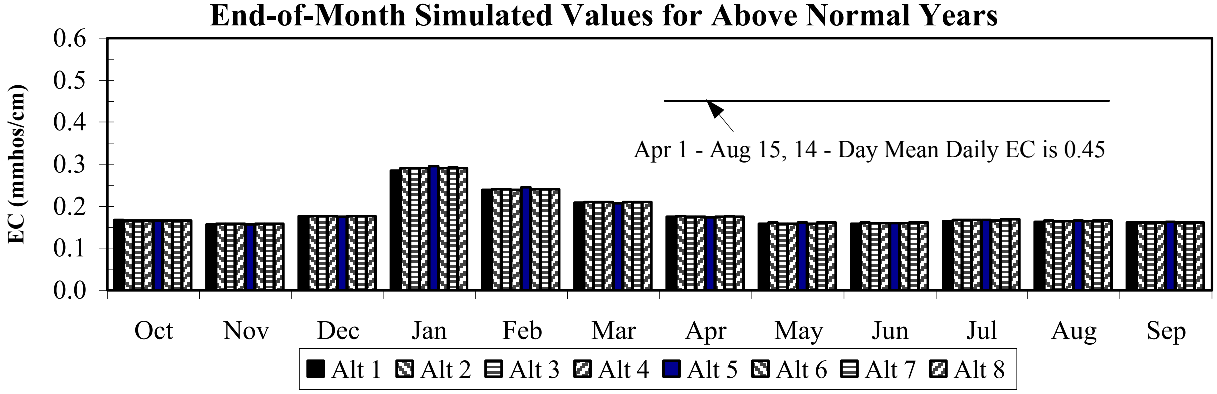
Figure VI-33
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Wet Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

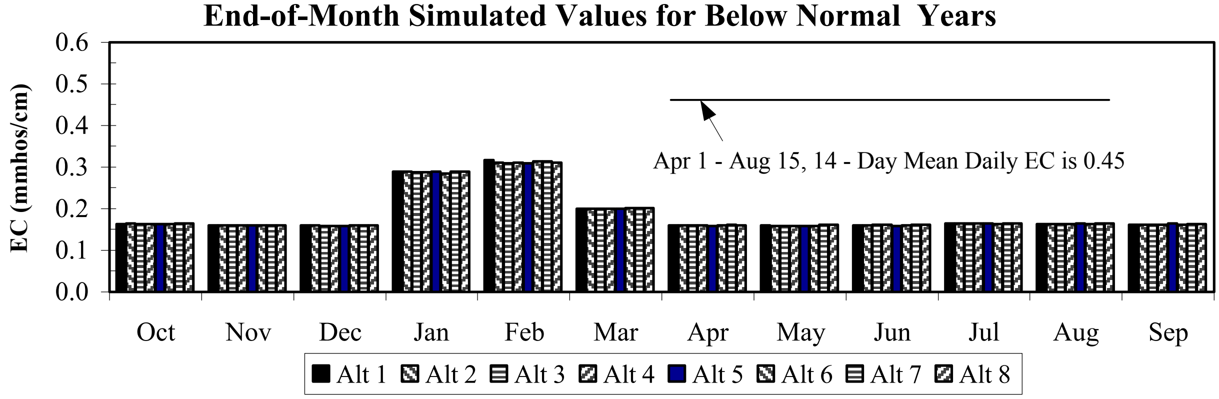
Figure VI-34
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Above Normal Years



Salinity objectives are the same for D-1485 & Bay/Delta

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

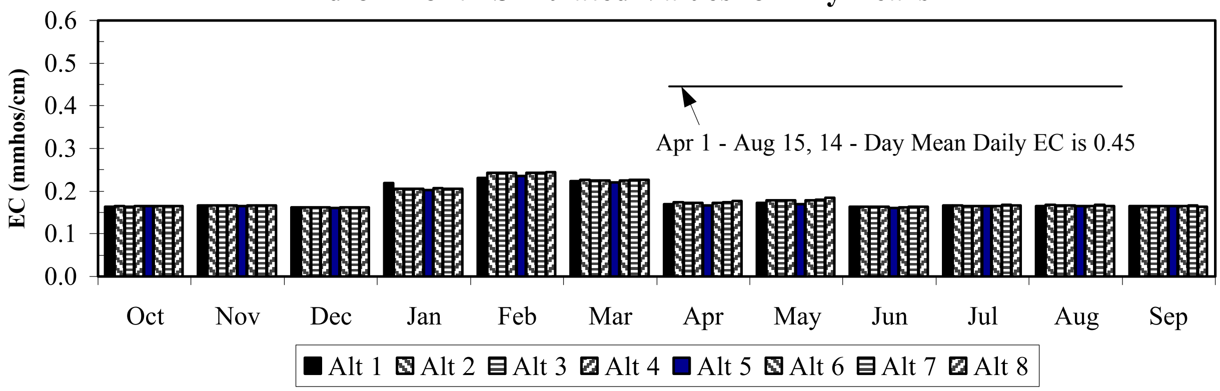
Figure VI-35
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Below Normal Years



Salinity objectives are the same for D-1485 & Bay/Delta

Sacramento "40-30-30" **below normal** year (1979)

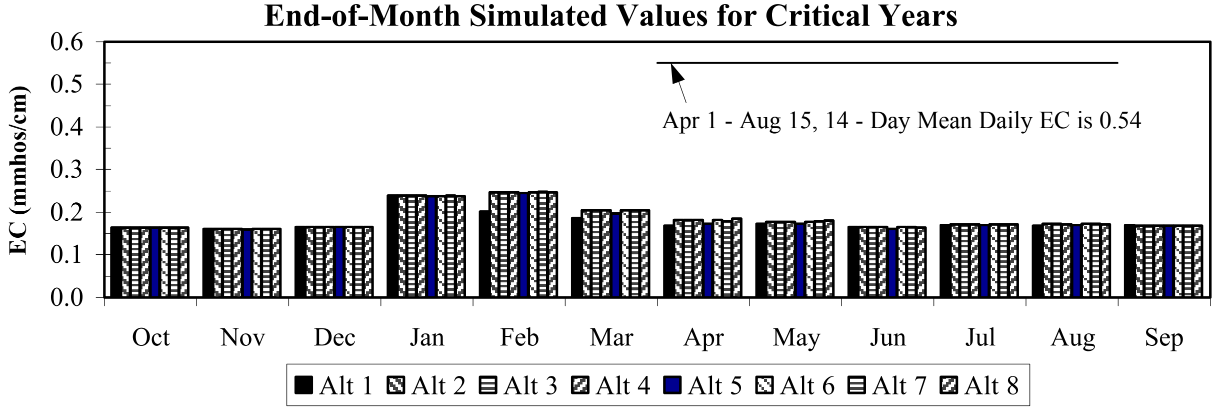
Figure VI-36
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Dry Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30 " **dry** years averaged (1981, 85, 87 & 89)

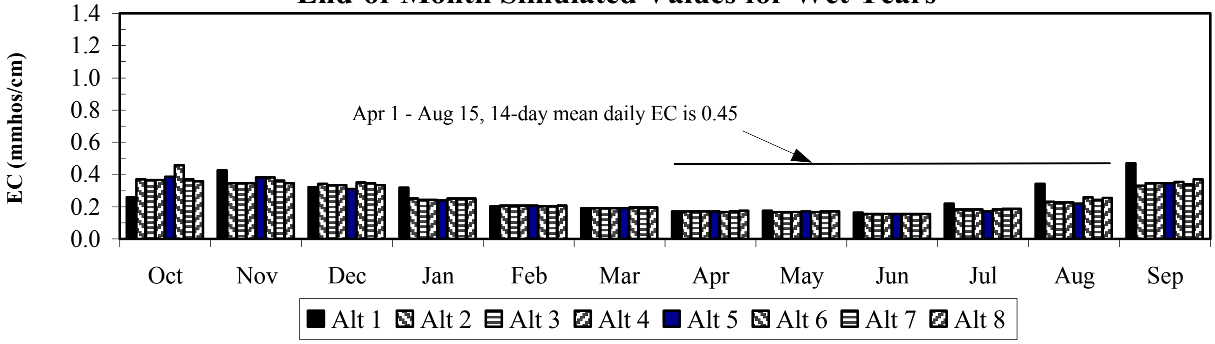
Figure VI-37
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Critical Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30 " **critical** years averaged (1976, 77, 88, 90 &

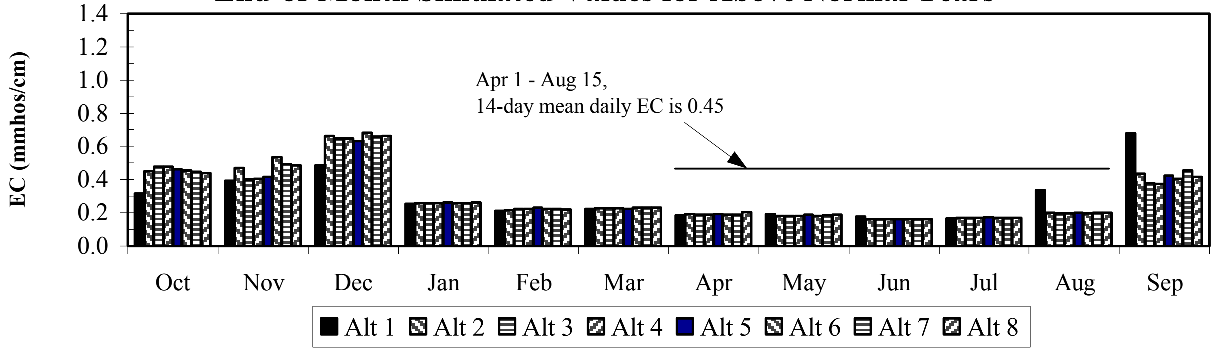
Figure VI-38
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Wet Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

Figure VI-39
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Above Normal Years

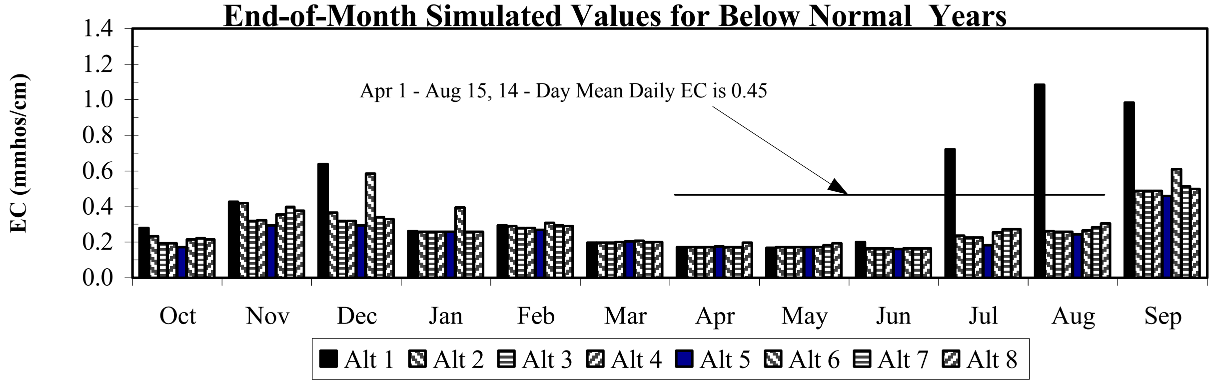


The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

Figure VI-40

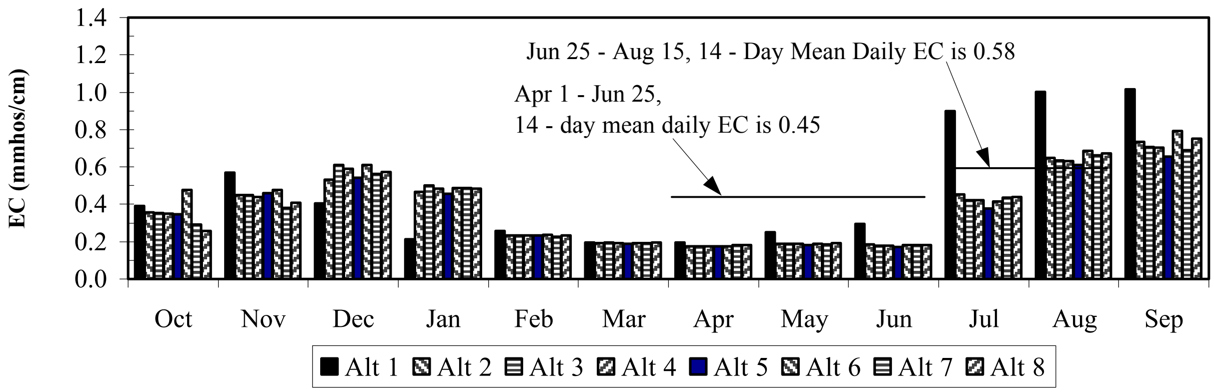
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Below Normal Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **below normal** year (1979)

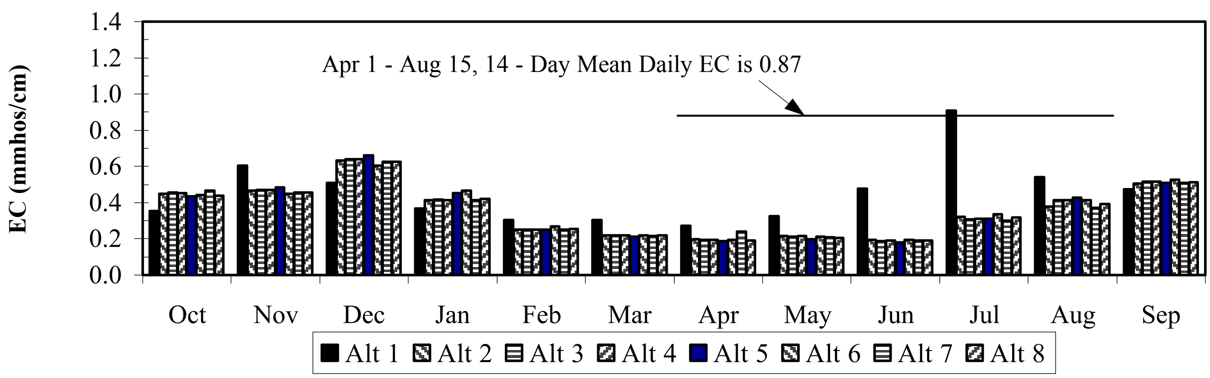
Figure VI-41
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Dry Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan.
The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

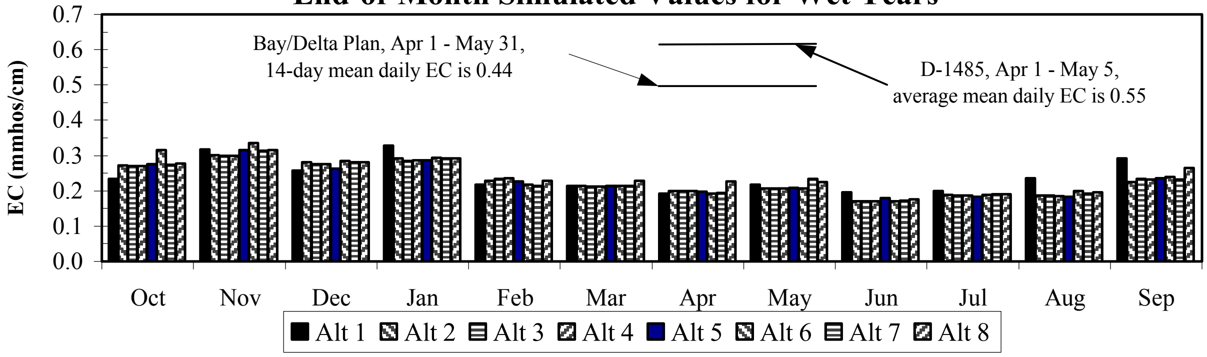
Figure VI-42
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Critical Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan.
The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

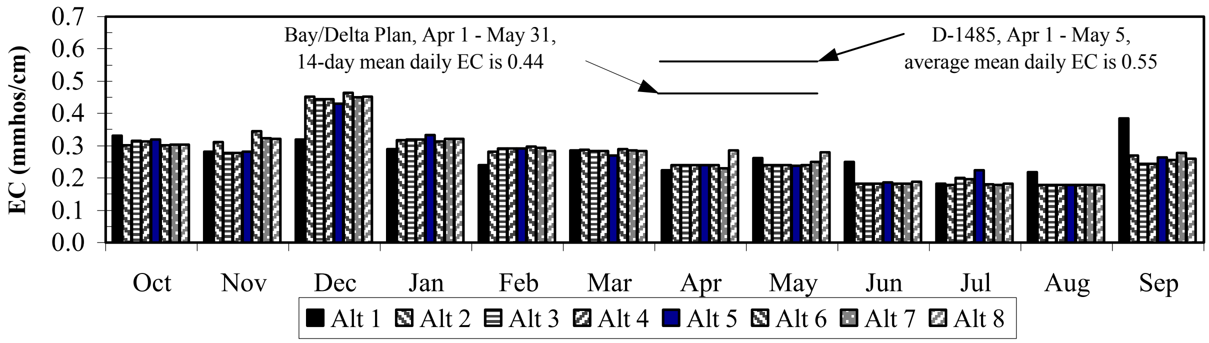
Figure VI-43
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Wet Years



The 14 - day mean daily salinity objectives for Bay/Delta Plan are 0.44 EC from Apr 1 - May 31, and for D-1485 is 0.55 EC from Apr 1 - May 5

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

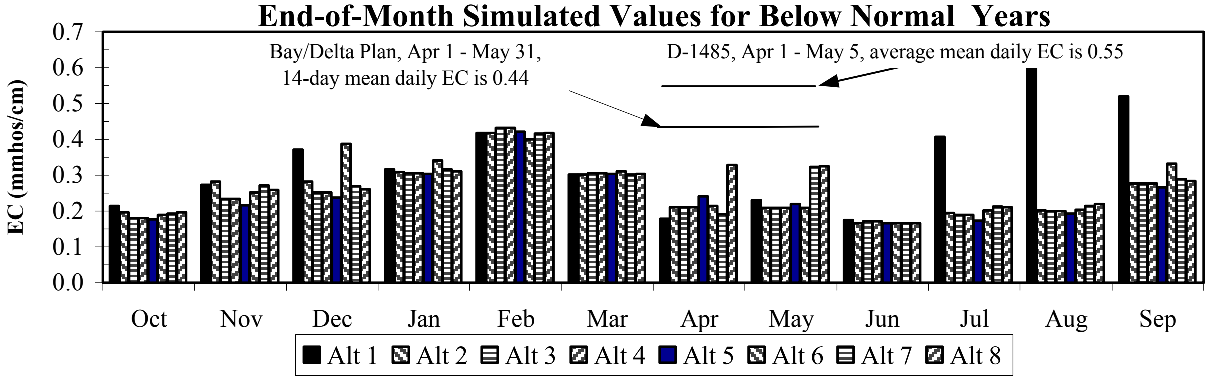
Figure VI-44
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Above Normal Years



The 14 - day mean daily salinity objectives for Bay/Delta Plan are 0.44 EC from Apr 1 - May 31, and for D-1485 is 0.55 EC from Apr 1 - May 5

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

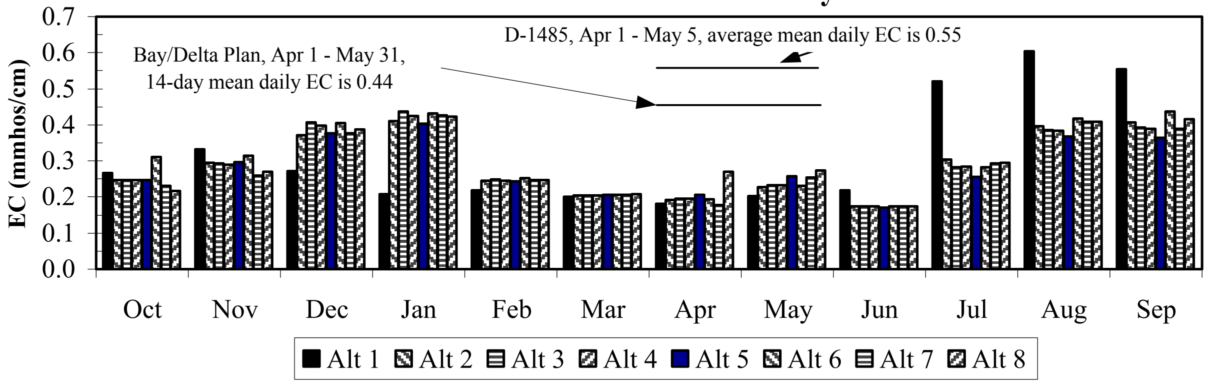
Figure VI-45
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Below Normal Years



The 14 - day mean daily salinity objectives for Bay/Delta Plan are 0.44 EC from Apr 1 - May 31, and for D-1485 is 0.55 EC from Apr 1 - May 5

Sacramento "40-30-30" **below normal** year (1979)

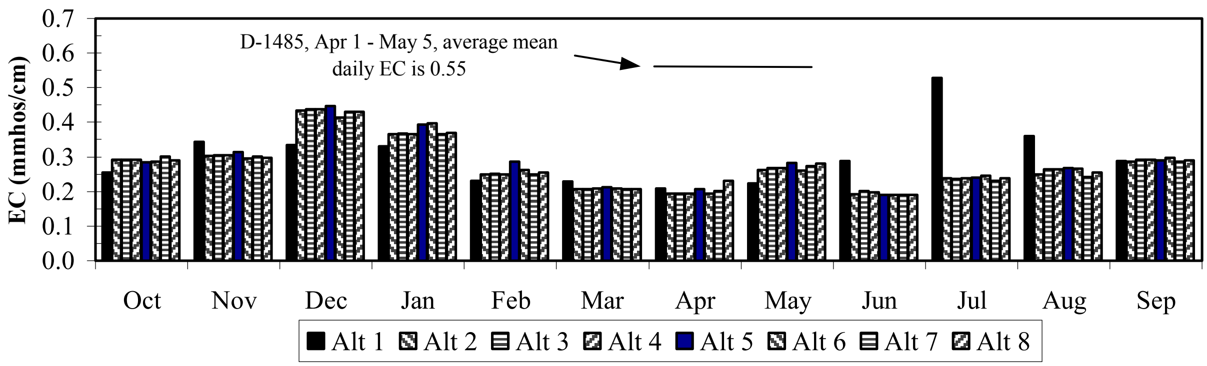
Figure VI-46
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Dry Years



The 14 - day mean daily salinity objectives for Bay/Delta Plan are 0.44 EC from Apr 1 - May 31, and for D-1485 is 0.55 EC from Apr 1 - May 5

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

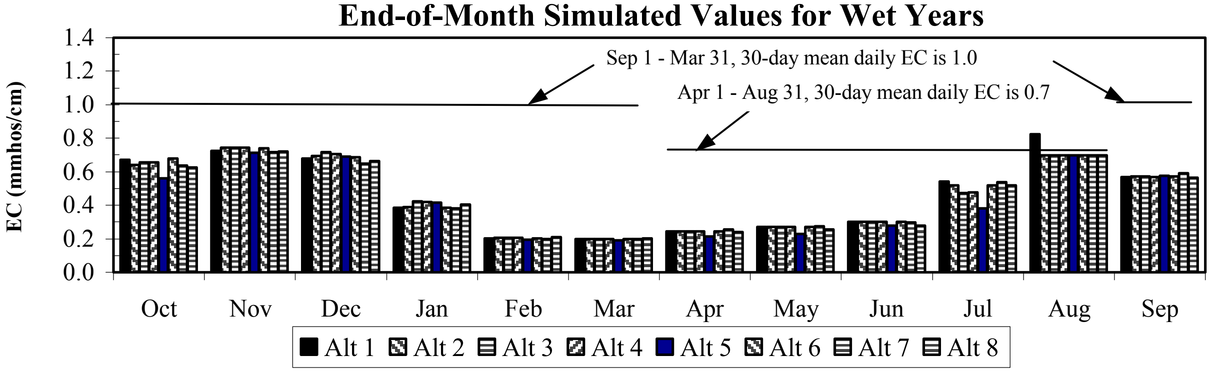
Figure VI-47
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Critical Years



The Bay/Delta Plan has no salinity objectives for critical years

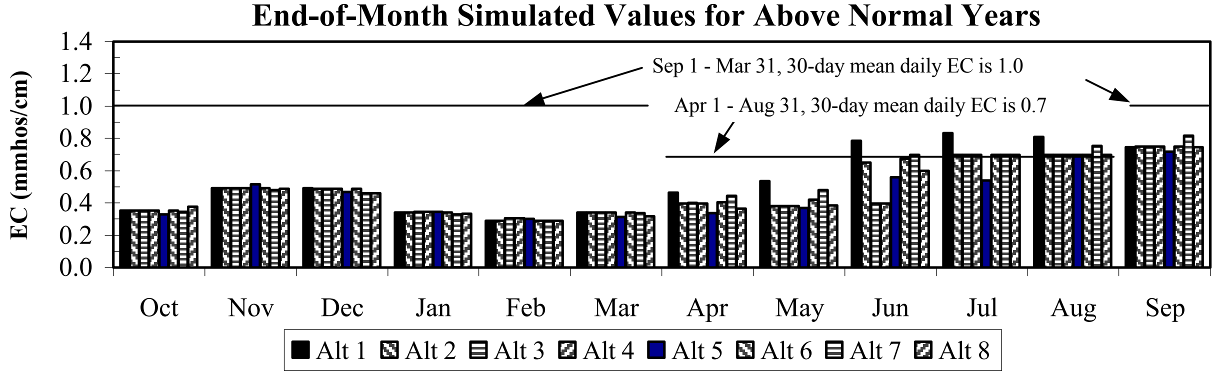
Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

Figure VI-48
Salinity for San Joaquin River at Airport Bridge (Vernalis)
End-of-Month Simulated Values for Wet Years



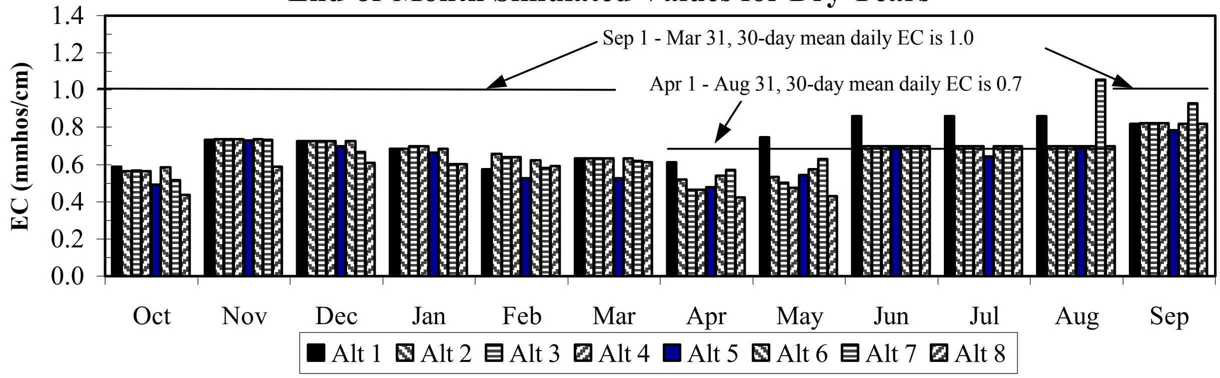
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1978, 80, 82, 83 & 86).

Figure VI-49
Salinity for San Joaquin River at Airport Bridge (Vernalis)
End-of-Month Simulated Values for Above Normal Years



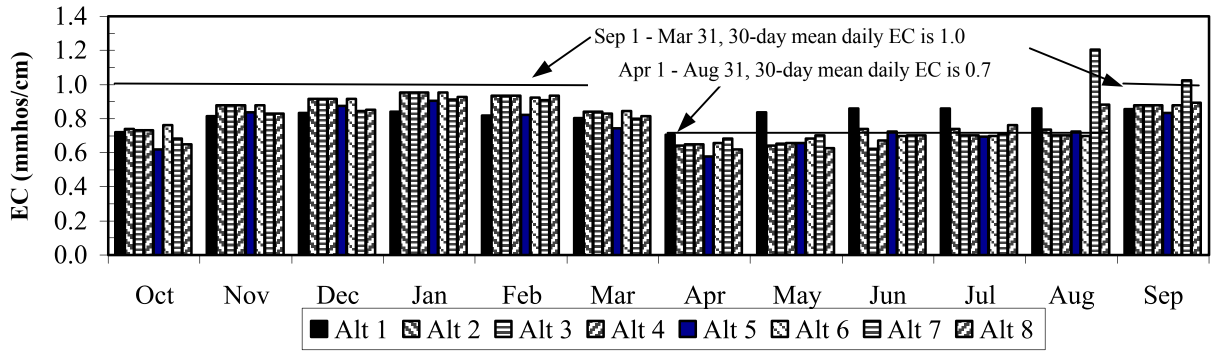
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" above normal years averaged (1979 & 84).

Figure VI-50
Salinity for San Joaquin River at Airport Bridge (Vernalis)
End-of-Month Simulated Values for Dry Years



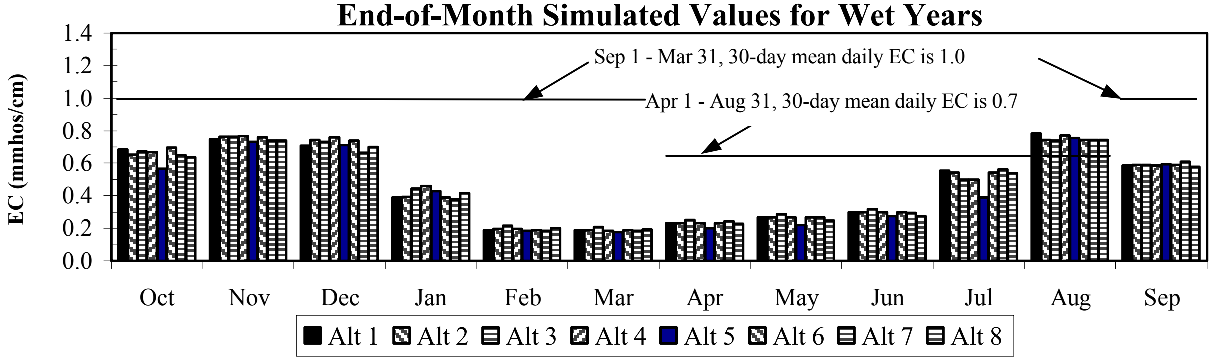
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" dry years averaged (1981 & 85).

Figure VI-51
Salinity for San Joaquin River at Airport Bridge (Vernalis)
End-of-Month Simulated Values for Critical Years



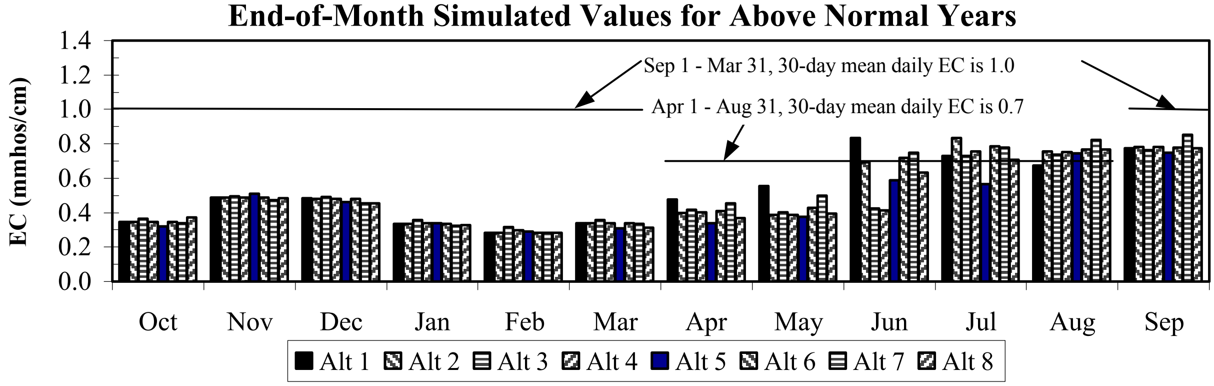
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" critical years averaged (1976, 77, 87, 88, 89, 90 & 91).

Figure VI-52
Salinity for San Joaquin River at Brandt Bridge
End-of-Month Simulated Values for Wet Years



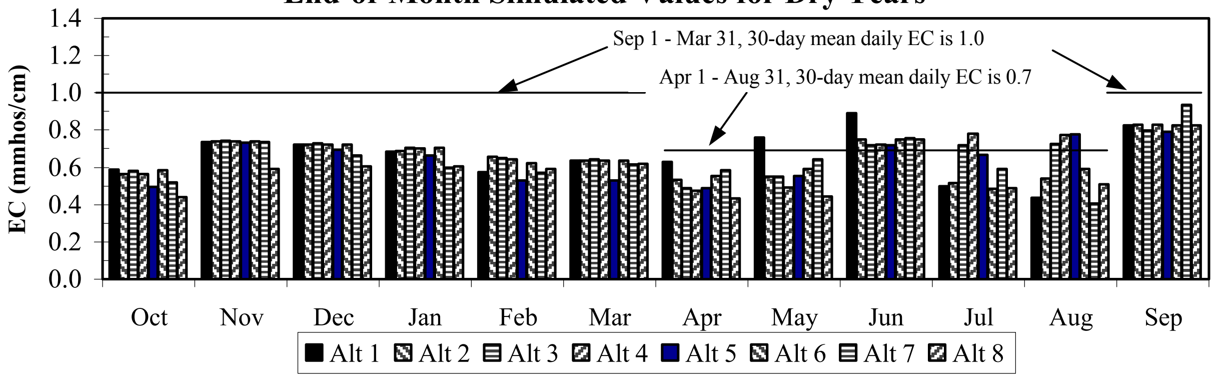
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1978, 80, 82, 83 & 86).

Figure VI-53
Salinity for San Joaquin River at Brandt Bridge
End-of-Month Simulated Values for Above Normal Years



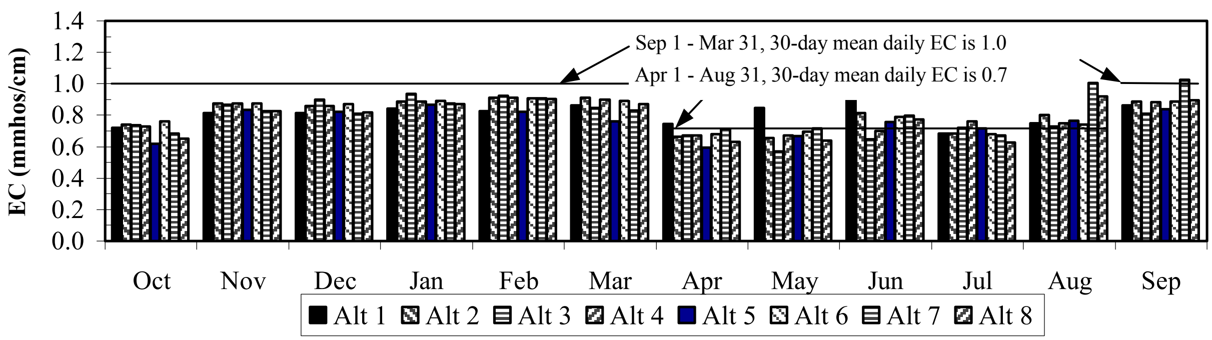
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" above normal years averaged (1979 & 84).

Figure VI-54
Salinity for San Joaquin River at Brandt Bridge
End-of-Month Simulated Values for Dry Years



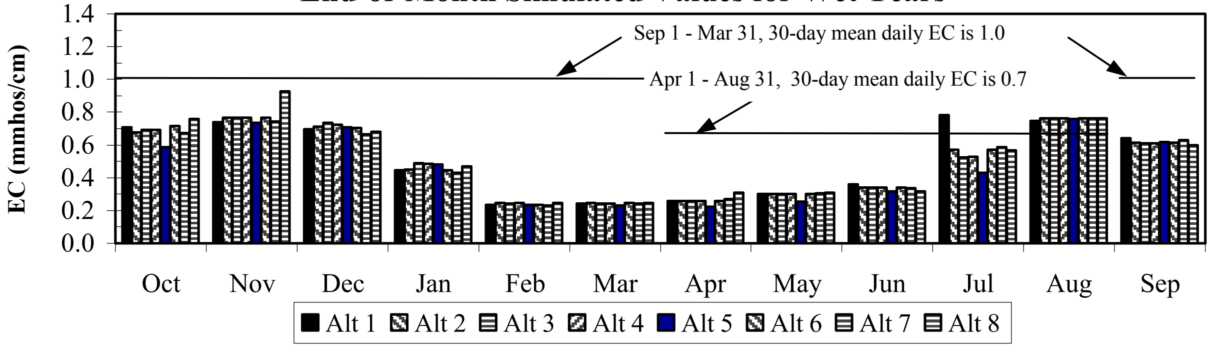
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" dry years averaged (1981 & 85).

Figure VI-55
Salinity for San Joaquin River at Brandt Bridge
End-of-Month Simulated Values for Critical Years



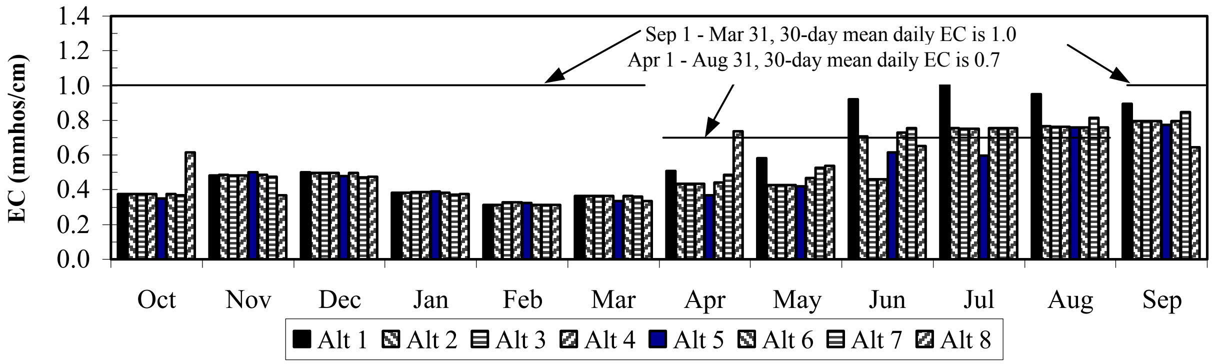
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" critical years averaged (1976, 77, 87, 88, 89, 90 & 91).

Figure VI-56
Salinity for Old River at Tracy Road Bridge
End-of-Month Simulated Values for Wet Years



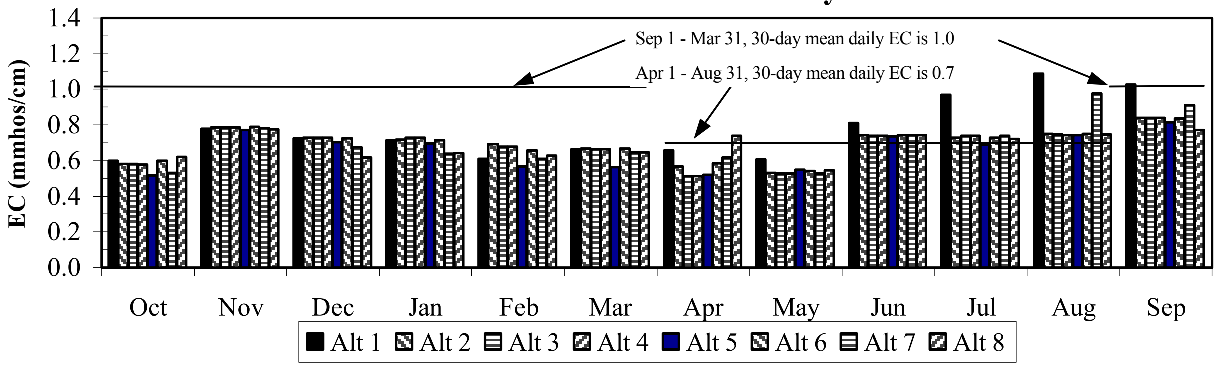
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1978, 80, 82, 83 & 86).

Figure VI-57
Salinity for Old River at Tracy Road Bridge
End-of-Month Simulated Values for Above Normal Years



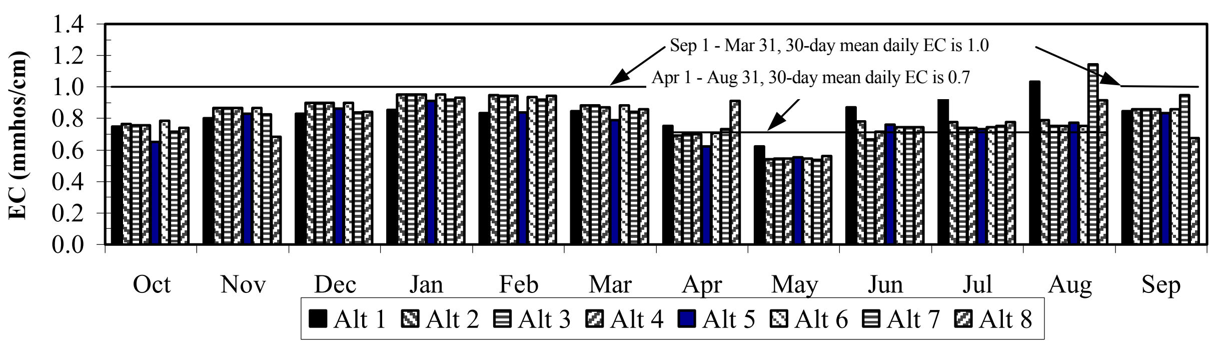
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" above normal years averaged (1979 & 84).

Figure VI-58
Salinity for Old River at Tracy Road Bridge
End-of-Month Simulated Values for Dry Years



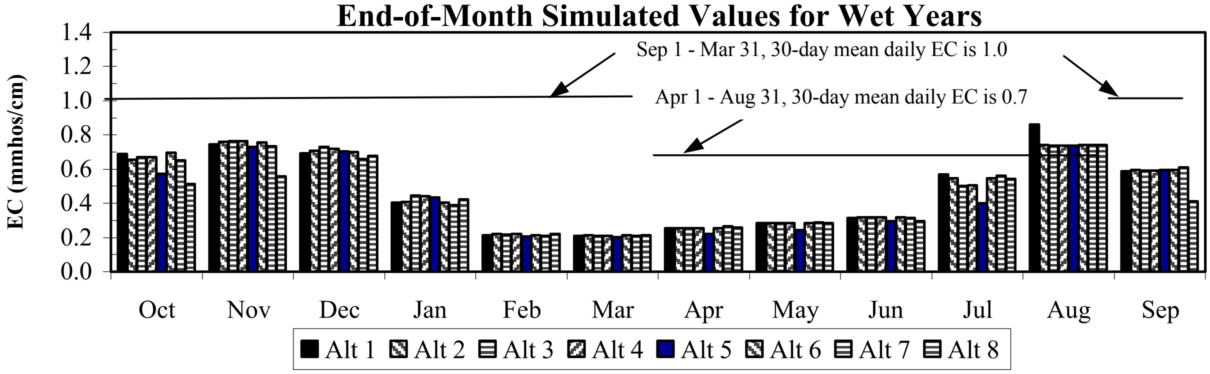
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" dry years averaged (1981 & 85).

Figure VI-59
Salinity for Old River at Tracy Road Bridge
End-of-Month Simulated Values for Critical Years



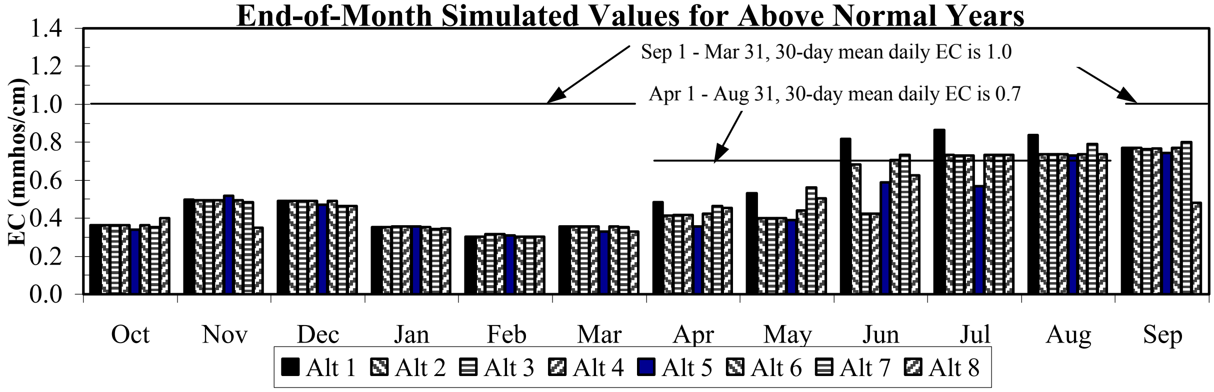
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" critical years averaged (1976, 77, 87, 88, 89, 90 & 91).

Figure VI-60
Salinity for Old River Near Middle River
End-of-Month Simulated Values for Wet Years



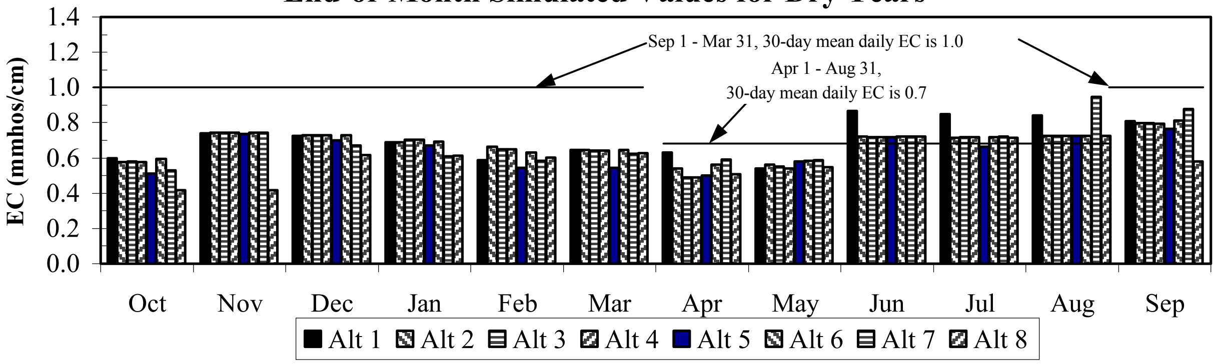
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1978, 80, 82, 83 & 86).

Figure VI-61
Salinity for Old River Near Middle River
End-of-Month Simulated Values for Above Normal Years



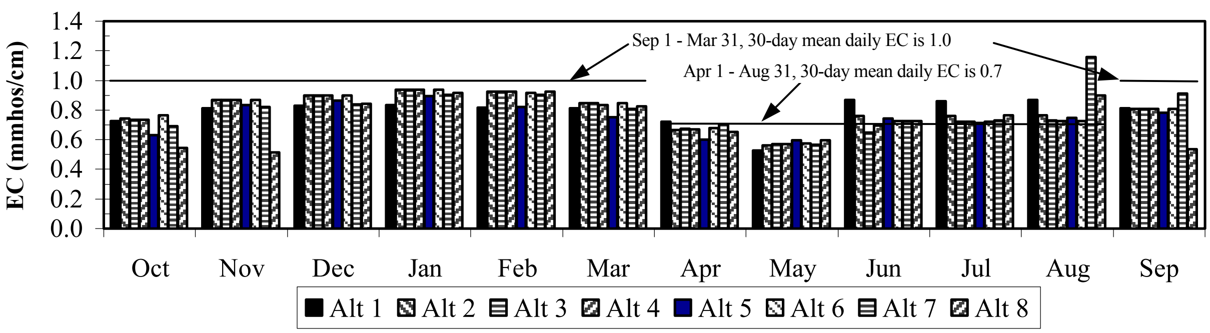
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" above normal years averaged (1979 & 84).

Figure VI-62
Salinity for Old River Near Middle River
End-of-Month Simulated Values for Dry Years



Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" dry years averaged (1981 & 85).

Figure VI-63
Salinity for Old River Near Middle River
End-of-Month Simulated Values for Critical Years



Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" critical years averaged (1976, 77, 87, 88, 89, 90 & 91).

In summary, the salinity conditions in the central and western Delta reflect the changes in outflow caused by implementation of the Bay/Delta Plan. The Bay/Delta Plan provides for higher outflows in spring and summer than the base case. These higher outflows deplete upstream reservoirs, which results in decreased outflows in some fall and winter months. Consequently, salinity conditions in the central and western Delta under the Bay/Delta Plan are generally better than or equivalent to the salinity conditions under the base case in the spring and summer but in some winter months salinity conditions decline in these locations in comparison to the base case. Nonetheless, water quality objectives will be met under all of the alternatives and the higher salinity conditions in some winter months will be offset by lower concentrations in the spring and summer. Therefore, there are no significant adverse salinity-related effects in the central and southern delta associated with implementation of the Bay/Delta Plan, and mitigation is not required. In addition, there is no clearly superior alternative among Alternatives 2 through 8 with respect to salinity conditions at these locations.

Salinity conditions in the southern Delta, while significantly affected by outflow conditions, are also significantly affected by salinity conditions in the San Joaquin River. The implementation of the Bay/Delta Plan will generally improve salinity conditions in the principal irrigation season (April to August) because the salinity objective is more restrictive than the salinity objective in the base case. Among Flow Alternatives 2 through 8, salinity conditions in the southern Delta are similar except with the exception of Flow Alternatives 7 and 8. For these alternatives, dilution water releases from New Melones Reservoir are capped and salinity will occasionally be higher than the other alternatives, especially in the late summer. For Alternative 7, salinity conditions will on occasion both exceed objectives and base case salinity conditions. This is a significant environmental effect. In the short term if this alternative is adopted, this significant effect cannot be mitigated. In the long-term, the water quality control actions described in Chapter VIII can be used as mitigation.

3. Fish and Aquatic Resources

The Bay/Delta Estuary is the largest estuarine system on the west coast of the United States and drains over 40 percent of California's land (SFEP 1992a). Estuaries are among the most productive ecosystems, supporting a wide range of fish and aquatic resources with their rich nutrients and diverse habitats. The estuary is a transition zone between the freshwater riverine and marine environments. Many of the organisms inhabiting this area have evolved special adaptations to cope with the variability in environmental conditions. The diverse assemblage of aquatic resources in the estuary is of great economic, aesthetic, and scientific value. A significant proportion of California's commercial fisheries depends on species that inhabit or migrate through the Estuary (USBR 1997a).

More than 130 species of fish inhabit the Bay/Delta Estuary for at least part of their life cycle (SFEP 1992a). Approximately ¼ of these species have been introduced. Some of the most abundant species (threadfin shad, white catfish, inland silverside, and striped bass) in the Delta were introduced from other areas (Herbold and Moyle 1989). Most historical introductions were intentional, for sportfishing, increased production, or control of other organisms. Recent introductions occurred primarily from ship ballast discharges.

a. General Factors. Significant population declines have occurred for many aquatic species in the Delta over the past few decades. Simultaneous declines of several species suggest overall impacts to the Estuary. The primary factors thought to significantly impact the Estuary and its inhabitants are: (a) reduced Delta outflow, (b) entrainment of organisms by export water pumps, (c) reverse flows in the Delta, (d) temperature fluctuations; (e) food limitations, (f) habitat loss; (g) introduced species, (h) harvest, and (i) contamination by pollutants. The relative magnitude of these factors and their complex interactions (synergistic or antagonistic) are not fully understood. The main factors are only briefly discussed here. A detailed discussion of these factors is available in the ER (SWRCB 1995).

Outflow. The seasonal pattern and annual volume of Delta outflow affects the abundance of many aquatic species dependent on the Delta. Outflow affects physical variables such as water temperature, salinity, pollutant concentrations, habitat availability for aquatic organisms, floodplain inundation, and the migration and transport of organisms through various life stages. Delta outflow affects both estuarine and anadromous species by altering the time required to move upstream or downstream and the availability of habitat. Transport time affects species that spawn upstream and depend on currents to carry their eggs and larvae to downstream nursery areas (SWRCB 1995). Generally, the higher the outflow, the farther downstream fish and invertebrates are dispersed (DFG 1993). Although fluctuations exist, outflow is generally highest from January to March and lowest from July through September. Flow during April, May, and June is particularly important to the reproductive success and survival of many estuarine species (SFEP 1992b). The reduction of spring outflows is considered to have adverse impacts on the aquatic resources. Monthly Delta outflow under the flow alternatives is shown in Tables VI-7 and VI-8. In general, Delta outflow is lower under Flow Alternatives 2 through 8 than in the base case in October through January. However, in the spring months, predicted outflow under Alternatives 2 through 8 is greater than outflow for the base case which may improve conditions for spawning and survival of aquatic resources in the estuary in this critical period.

Entrainment. Entrainment is broadly defined to include diversions of water that take, damage, or kill aquatic organisms (IEP 1996). Diversion of water and in- Delta pumping results in the entrainment and mortality of numerous aquatic organisms. In addition to the direct mortality that occurs with physical entrainment, losses are incurred through predation at intakes and fish salvage facilities, by the Delta fish salvage process itself (SWRCB 1995), and by removal from preferred habitat. Other factors that may influence entrainment are the type of diversion, the velocity caused by the diversion, type of screens or other protective devices, the time of year, and the species composition in the area. Smaller, less mobile organisms and critical life stages (eggs, larvae, and juveniles) of larger organisms are more susceptible to entrainment.

Sources of entrainment in the Delta include the SWP and the CVP export facilities and the approximately 1,800 other municipal, industrial, and agricultural diversions. Currently, SWP and CVP exports can reach approximately 10,000 cfs most of the year with higher levels possible in the winter. Agricultural diversions, which peak between April and August (with an estimated combined capacity of 4,000 cfs), may account for significant fish losses in localized areas of the Delta. Large numbers of fish including chinook salmon, striped bass, American shad, and delta smelt, are present during the diversion season. The majority of these diversions are not effectively screened.

Potential effects of entrainment vary among the flow alternatives. In general, flow alternatives with lower Delta outflow and higher exports have the highest entrainment potential. Over the 73-year period of record, exports are predicted to increase in May, June, July, and October under Alternatives 2 through 6; exports are predicted to increase in June, July, and October under Alternatives 7 and 8 compared to the base case. In critical years, exports are predicted to increase in April, June, and October under Alternatives 2 through 8 compared to the base case, except for Flow Alternative 8 in April. However, increased Delta outflows exceed these increased exports, except in October when Delta outflow decreases and exports increase. Alternatives 2 through 8 also have higher total outflow and lower total exports than the base case on an annual basis. Therefore, in general, these alternatives are not likely to result in significantly higher entrainment rates.

Reverse Flows. When SWP and CVP exports are high and Delta inflow is low, the net flow in the lower San Joaquin River and Delta channels south of the San Joaquin River are usually toward the southern Delta, rather than downstream towards Suisun Bay. Reverse flows may result in increased straying. Reverse flows may also carry eggs, larvae and young fish into the central and southern Delta, reducing survival because of poor rearing conditions, increased predation, and increasing vulnerability to entrainment at the export facilities and in local agricultural, municipal, and industrial diversions (SWRCB 1995).

Table VI-15 lists QWEST flows from the DWRSIM studies (QWEST is the net flow at Jersey Point on the San Joaquin River). To a certain extent, QWEST can be used as a measure of reverse flow conditions in Delta channels. As QWEST decreases, reverse flows in some Delta channels will increase. Model output indicates that predicted QWEST values for Alternatives 2 through 8 are generally higher than for the base case in February, March, and April, which may benefit aquatic resources in this important period. However, in the fall and winter months, November through January, QWEST is generally decreased under Alternatives 2 through 8 compared to the base case.

Table VI-15

QWest Flow

73-Year Period Annual Average (cfs)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	242	-1,134	785	4,357	7,402	6,367	3,334	3,539	3,245	-1,665	-3,111	-1,711
2	-185	-1,459	-126	3,704	7,587	6,355	4,595	2,820	1,057	-2,098	-1,792	-1,309
3	-126	-1,478	-220	3,567	7,473	6,330	4,625	2,861	1,579	-1,864	-1,769	-1,289
4	-164	-1,502	-188	3,555	7,448	6,365	4,621	2,851	1,547	-1,873	-1,764	-1,279
5	136	-1,580	-242	3,387	8,148	7,268	6,022	3,859	1,998	-916	-1,717	-1,215
6	-392	-1,678	-474	2,861	8,400	6,890	4,663	2,852	1,222	-2,229	-2,035	-1,656
7	239	-1,454	76	3,954	8,049	6,494	2,809	4,009	1,103	-2,252	-1,932	-1,362
8	-380	-1,399	-53	3,635	7,427	6,399	5,788	3,737	1,143	-2,321	-2,088	-1,340

Critical Period Annual Average (cfs)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	997	-927	-1,258	-361	-1,261	-1,244	2,717	425	-339	-2,769	-702	-399
2	309	-328	-2,670	-3,667	-73	331	532	-156	-65	-1,417	-360	-262
3	311	-423	-2,694	-3,722	-315	33	490	-251	387	-1,422	-74	-168
4	311	-426	-2,694	-3,716	-211	27	490	-256	399	-1,417	-74	-168
5	156	-717	-2,930	-3,776	-147	-325	1,465	525	286	-743	-235	-204
6	-214	-373	-2,627	-3,594	-82	610	448	-211	-17	-1,550	316	-276
7	381	-457	-2,664	-3,594	-301	-30	-1,168	957	230	-920	-237	-223
8	93	-359	-2,635	-3,667	-246	344	1,204	311	-266	-1,763	-153	-137

Temperature. Water temperature regimes affect migration, spawning, incubation success, growth, inter- and intra-specific competitive ability, and resistance to disease and parasites. Most successful fish spawning occurs within a narrow temperature range. Temperature variations outside this range may inhibit the development of eggs and sperm or reduce survival of eggs, larvae, and juvenile fish. Warmer water may result in emigration to areas of more suitable water temperature (Baxter 1960). The return to temperature regimes that existed under unimpaired conditions is, in general, beneficial to native organisms. Anadromous species depending on temperature to cue reproduction cycles are significantly affected by temperature changes. Of these, steelhead and chinook salmon have the lowest temperature requirements.

The effects of the flow alternatives on water temperature in the Delta are difficult to assess. In general, water temperatures in the Delta are affected primarily by ambient air temperatures. Minor temperature fluctuations in the Delta may be caused by the discharge of cooling water from power plants, release of warm water from reservoirs, changes in flow regimes, loss of stream side (riparian) vegetation, and climate changes (SWRCB 1995). The relative change in Delta outflow among the alternatives is low and is unlikely to result in detectable water temperature changes in the Delta. Flow Alternative 6, which recycles water, may increase San Joaquin River temperatures which may significantly affect migrating San Joaquin River salmon smolts. If this alternative were adopted, this significant effect could not be mitigated.

Food Limitation. Food supply affects the abundance of organisms at all trophic levels. Food may be limited in various ways, including decreased availability of nutrients, and decreased abundance and availability of preferred food items (SWRCB 1995). Studies have shown that small fish larvae are more susceptible to predation than large larvae. Thus, reduction in growth through food limitation may result in lower survival and recruitment even if larvae are not starving (IEP 1996). Introduction of species, such as the Asiatic clam, has increased competition for food and altered the food web. Increased flow increases habitat for food organisms in the Bay/Delta (USBR 1997a). Reduced diversions, in general, reduce the entrainment of food from the Delta.

The effects of the flow alternatives on available food supply are complex. However, the higher outflows and lower exports under Alternatives 2 through 8 compared to the base case in the spring months may increase available food supply in the Delta, because habitat for food organisms may be increased and entrainment of food organisms may be decreased.

Habitat Loss. Land reclamation and waterway modification have caused major ecological changes in the Estuary and throughout the Central Valley. These changes include the destruction of most tidal marshes in the Estuary and the seasonally flooded wetlands upstream of the Estuary (DFG 1993). Marsh and habitat losses are important factors that shape and control existing populations of organisms (SWRCB 1995). Losses of habitat have probably reduced the resilience of certain populations, resulting in decline of certain species. Reduced wetland habitat also reduces the buffering capacity of the area leading to more pollutants reaching the waterways. Urbanization increases the volume and decreases the runoff time of storm events, increasing the suspended solids load to the Estuary. The removal of riparian vegetation contributes to habitat loss. By maintaining bank stability, providing shade and instream cover for aquatic organisms, moderating water temperatures, contributing nutrients, and providing habitat diversity, riparian vegetation performs a variety of critical functions in stream ecosystems (USBR 1997a). The transformation of vast areas of freshwater marsh into cropland eliminated the contribution of marsh productivity to downstream food web organisms. Channelization has removed the shallow margins of most river channels, preventing the growth of submerged aquatic vegetation. Additionally, dredging and disposal of estuarine sediments temporarily increase turbidity and may disperse toxic pollutants and increase their availability to aquatic organisms (SWRCB 1995).

Flow changes due to implementation of the flow alternatives may result in slight changes in water elevations and wetted channel periphery in the Delta. Changes in wetted periphery may affect the availability of habitat for certain species of fish, such as Sacramento splittail, that depend on newly flooded areas for spawning and early rearing.

However, the project alternatives are not expected to have significant effects on available habitat. The alternatives will not result in direct loss of physical habitat. Changes in wetted channel periphery due to the flow changes are expected to be slight under the project alternatives compared to the base case. In the spring months, there may be a slight increase in wetted periphery and available habitat under Alternatives 2 through 8, since Delta outflow in February through June will be increased compared to the base case.

Introduced Species. The Bay/Delta Estuary is dominated by more than 150 introduced species of aquatic plants and animals (SWRCB 1995). Introduced species have caused major shifts in the food web dynamics that may drive some native species to extinction or inhibit recovery of depleted species (USFWS 1996). Many species were intentionally introduced to diversify the Estuary and control pests. Recent introductions have primarily occurred from ship ballast water. Competition for food and space, predation, habitat alteration, hybridization and pathogen transport are only a few of the adverse effects on the native species. More details are provided in the Environmental Report, Chapter V, page 22 (SWRCB 1995).

The flow alternatives are not expected to affect the introduction or propagation of introduced species. One of the primary introductions resulting in the food web shift, the Asiatic clam (*Potamocorbula amurensis*), may inhabit a smaller area with increased Delta outflow because of its preference for brackish waters, but there is no evidence that increased outflow will significantly affect abundance of the species.

Harvest. Over-exploitation of many Bay/Delta species, including mollusks, crustaceans, and fish, has contributed to their population declines. The number of spawning adults and the average age (potential fecundity) of the species are affected by harvest. Illegal harvest is of concern because of the difficulty in estimating the catch and the potential decrease in reproducing stocks. The flow alternatives will have no direct effects on harvest of Bay/Delta species.

Contaminants. Aquatic resources in the Bay/Delta may be affected by numerous sources of contaminants. Up to 40,000 tons of toxic pollutants enter the Estuary each year, mainly from non-point sources such as agricultural and urban runoff (SWRCB 1995). Other sources include municipal and industrial discharges, mine drainage, dredging, atmospheric deposition, accidental spills, leaks from waste disposal sites and marine vessel discharges (SFEP 1992a). Control of these sources requires full implementation and enforcement of existing regulatory controls and development of new initiatives to remediate existing conditions.

Pollutants are distributed in the Bay/Delta by a combination of physical, chemical, and biological processes (SFEP 1992a). Many contaminants naturally accumulate in the entrapment zone of the Estuary, which is preferred by many Delta organisms, increasing exposure. Some pollutants bioaccumulate in organisms by direct absorption or by ingestion of contaminated food. Bioconcentration can result in levels of pollutants accumulating in higher trophic levels.

Many pollutant-related effects in the Delta have been identified, although conclusive evidence quantifying these effects to individual populations and the whole aquatic community is hard to establish (SFEP 1992a). Toxic pollutants of particular concern are trace elements such as selenium, copper, cadmium, and chromium, organochlorine and other pesticides (DDT and Dioxin), and petroleum hydrocarbons like benzene and chrysene (USBR 1997a). Pesticides from urban and agricultural runoff are also of concern. Pollutant effects on organisms range from subtle physiological and reproductive changes to deformity and mortality (SWRCB 1995).

The flow alternatives do not directly affect contaminant input, concentrations, or effects. Flow alternatives may affect pollutant concentrations by altering dilution rates; however, changes in concentration are expected to be minor. Therefore, the alternatives are unlikely to have a significant effect on contaminant problems. No mitigation measures are required.

b. Impacts of Alternatives on Selected Species. The species discussed below are intended to be representative of the range of species present in the Bay/Delta system. They were selected because of their relative importance and the availability of data. Not all species have been as thoroughly studied as chinook salmon; these species are only qualitatively discussed. This section describes impacts to selected species in the Delta; section C describes impacts in upstream areas. Detailed descriptions of the selected species can be found in the Environmental Report (SWRCB 1995).

Salmon. Chinook salmon (*Onchorhynchus tshawytscha*), also called king salmon, has the broadest geographic range of the five Pacific salmon species and is the largest of the salmon species. Chinook salmon migrate to the ocean early in their life, mature in the ocean, and return inland as adults to spawn in freshwater streams (SWRCB 1995).

There are four distinct runs of chinook salmon in the Bay/Delta Estuary: spring, fall, late-fall, and winter. These runs are distinguished primarily by the time of entry into freshwater. Each run's migration pattern is different (identified in Chapter III, Table III-7). The winter-run chinook salmon are listed as endangered under both the state and federal endangered species acts. Spring-run chinook are listed as threatened under both the state and federal endangered species acts. Fall-run and late-fall run chinook are candidate species under the federal Endangered Species Act.

The CVP and SWP export facilities in the southern Delta adversely affect anadromous fish survival in the Delta through direct entrainment losses and indirect effects related to changes in the cycle, direction, and magnitude of flow in the Delta channels (USBR 1997a). Reduced inflow to the Delta in combination with increased diversions from the Delta have caused adverse impacts on anadromous and resident species by reducing net flow through the Delta and Delta outflow (USBR 1997a). Water diversions reduce survival of emigrating juvenile salmonids through direct losses at inadequately screened diversions and indirect losses associated with reduced stream flows. Fish losses at diversions result from injury, impingement, entrainment and predation. Higher flow rates through the Delta generally increase juvenile salmon survival by decreasing migration time, reducing exposure to diversions, and maintaining favorable water quality and habitat conditions during migration.

Fall-run and late fall-run chinook salmon juveniles are particularly vulnerable to entrainment related mortality at local diversions because the emigration period (April-June) coincides with the onset of the irrigation season (April-October). Losses are minimal during the summer from entrainment in irrigation diversions because most juveniles are not actively migrating during that period. Generally, most juvenile salmon salvaged in the spring at the Delta pumps are from the San Joaquin Basin. Salvage records from the SWP indicate salmon fry and smolts are entrained year-round but peak in the late winter and spring when the fall-run pass through the Delta. Losses of chinook salmon at the SWP and CVP Delta export facilities typically range from 400,000 to 800,000 fry and smolts per year. (USBR 1997d).

The USFWS salmon smolt survival model, described in Chapter IV, was used to evaluate the effects of the flow alternatives on survival of chinook salmon through the Delta. Survival indices for the following chinook salmon runs/lifestages were modeled:

- Sacramento River fall-run, late fall-run, and winter-run (smolts), and spring-run (young-of-the-year and yearlings)
- San Joaquin fall-run smolts (with and without the Head of Old River barrier)

The model formulas incorporate multiple-regression survival indices generated from coded-wire-tagged smolt survival studies. The models split the Sacramento and San Joaquin rivers into various reaches and use backward-stepping smolt mortality equations using selected environmental variables (flows, exports, and temperature) shown to affect smolt mortality in each reach. Both the Sacramento and San Joaquin models assume that smolts enter the various reaches of the model in the same proportion as flow. Water temperatures on the Sacramento River for November through March are assumed to be monthly constants of 53, 47, 47, 50 and 55 degrees, respectively. Historical temperature estimates from the USBR for both the San Joaquin and Sacramento rivers were used as input for April, May, and June. Survival indices were predicted over the hydrologic period of record (1922-1992). Model calculations are shown in Volume 2, Appendix 5.

Although none of the models predict absolute survival, they are a useful tool for obtaining a baseline index and comparing the effects of the alternatives. Given the fixed temperatures used in the models, the higher survival can be expected with higher flows, lower exports, and increased DCC closure.

Figures VI-64 through VI-70 show the predicted indices for through-Delta migration of each chinook salmon run by flow alternative and water year type. For all runs, predicted survival indices were generally higher in wetter water years. Indices predicted under Flow Alternatives 2 through 8, in general, were higher than in the base case.

For Sacramento River fall-run smolts (Figure VI-64), survival indices in a wet water year were similar in all of the flow alternatives and the base case. In all other water year types, survival indices for Flow Alternatives 2 through 8 were generally similar, and higher than in the base case.

For late fall-run smolts (Figure VI-65), predicted survival indices were higher under Flow Alternatives 2 through 8 than in the base case in all water year types. The difference between the flow alternatives and the base case increased in drier water years. Among the flow alternatives, survival indices were similar.

For winter-run smolts (Figure VI-66), survival indices were higher under Flow Alternatives 2 through 8 than in the base case in all water year types. The difference between the flow alternatives and the base case increased in drier water years. Among the flow alternatives, survival indices were similar.

For young-of-the-year spring-run (Figure VI-67), survival indices in wet, above normal, and below normal water years were similar in all of the flow alternatives and the base case. In dry and critical years, predicted survival indices under Flow Alternatives 2 through 8 were similar, and higher than in the base case.

For yearling spring-run (Figure VI-68), survival indices were higher under Flow Alternatives 2-8 than in the base case in all water year types. The difference between the flow alternatives and the base case increased in drier water years. Among the flow alternatives, survival indices were generally similar.

For San Joaquin fall-run (Figures VI-69 and VI-70), predicted survival indices were higher with the operation of the Head of Old River barrier than without the barrier, but the relationships between the flow alternatives and the base case were similar with and without the barrier. Predicted survival indices were higher under Flow Alternatives 2-8 than in the base case, except for Alternative 7 in a wet year. The difference between the flow alternatives and the base case generally increased in drier water years. Among the flow alternatives, Alternatives 5 and 8 were generally higher, and Alternative 7 lower, than the other alternatives.

While the smolt survival models indicate that factors such as flow, exports, barrier operations, and temperature affect smolt survival, other factors are likely to affect survival as well. These factors include contaminants, availability of suitable rearing habitat in the Delta, and introduced species impacts. Ocean harvest also has a significant effect on adult survival. The alternatives will not significantly affect these other factors. The general effects of the flow alternatives on contaminants and introduced species impacts are described previously in section B.3.a. The effects of the flow alternatives on the availability of rearing habitat for chinook salmon in the Delta could not be assessed directly, because the relationship between flow and rearing habitat availability has not been described.

Figure VI-64

Sacramento River Fall-Run Salmon Smolt Survival

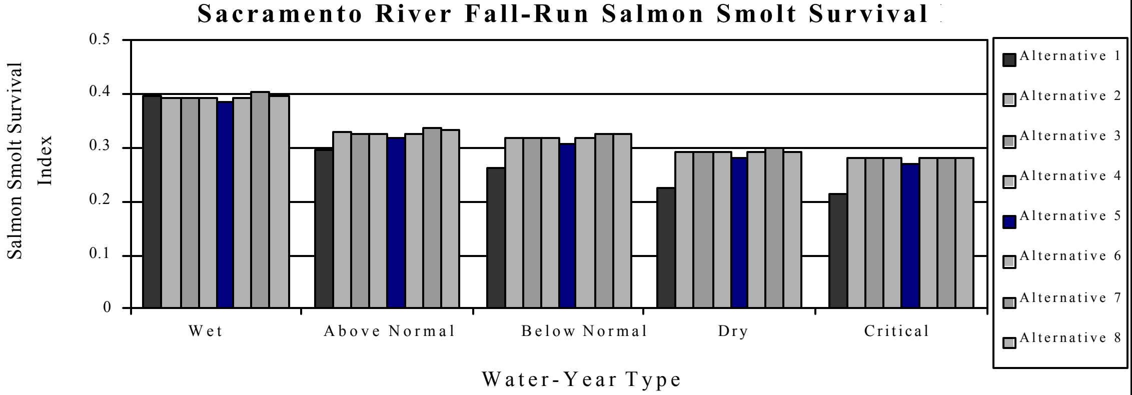


Figure VI-65
Sacramento River Late Fall-Run Salmon Smolt Survival Index

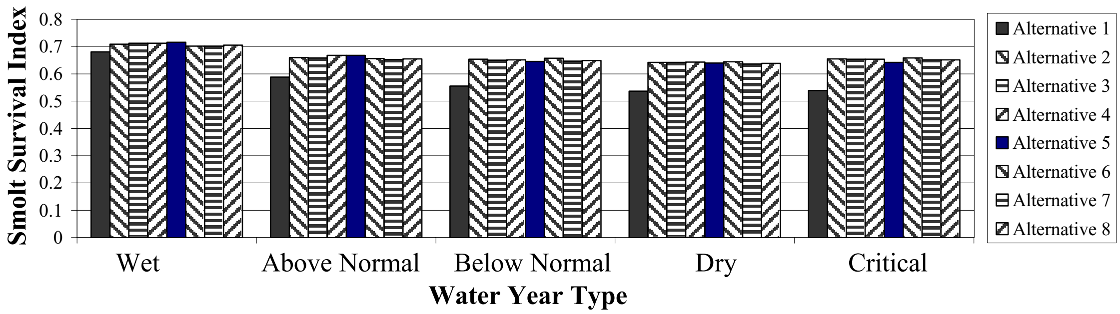


Figure VI-66
Sacramento River Winter Run Salmon Smolt Survival Index

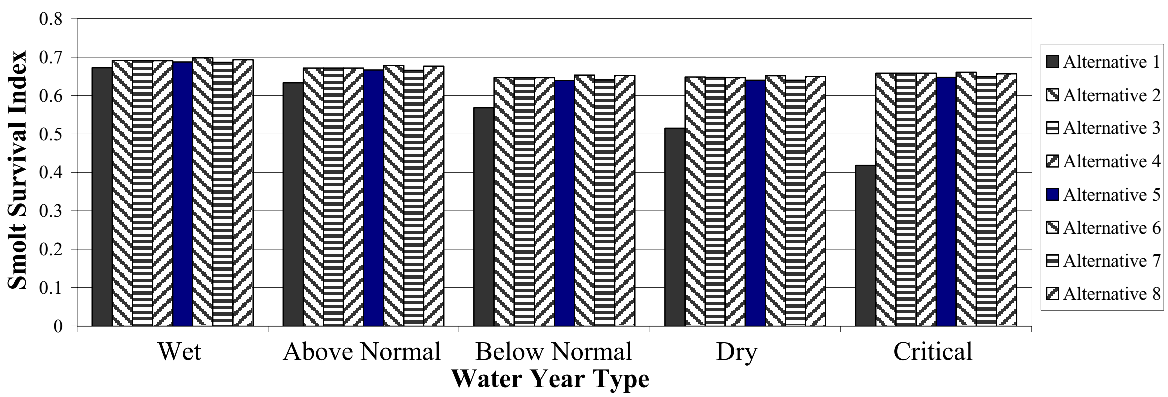


Figure VI-67
Sacramento River Young-of-the-Year Spring-Run Salmon Smolt Survival Index

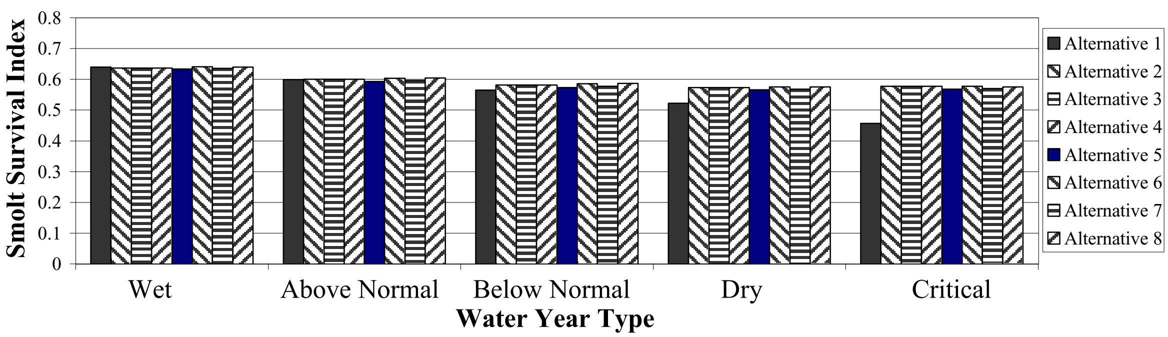


Figure VI-68
Sacramento River Yearling Spring-Run Salmon Survival Index

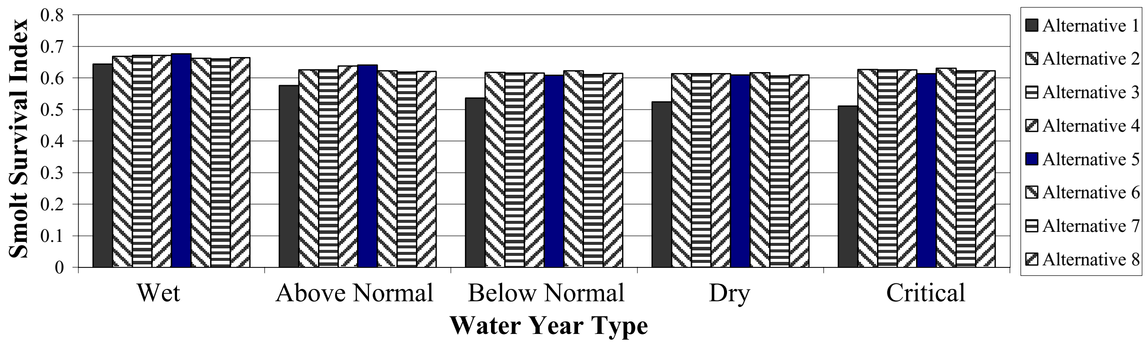


Figure VI-69
San Joaquin River Fall-Run Salmon Smolt Survival Index with Barrier

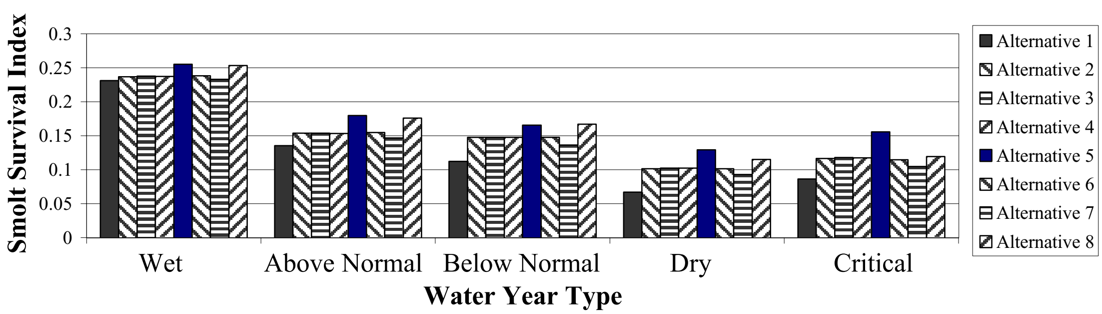
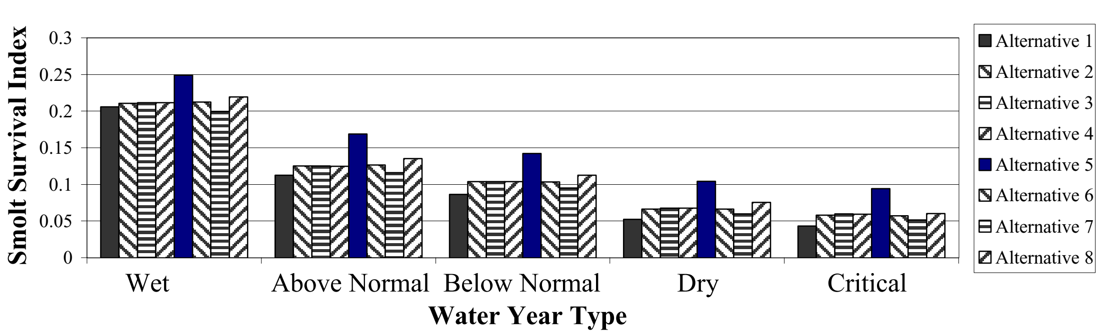


Figure VI-70
San Joaquin River Fall-Run Salmon Smolt Survival Index without Barrier



Recirculation under Flow Alternative 6 will increase the percentage of Sacramento River water that returns to the San Joaquin River. This may impact the imprinting of juvenile fall-run chinook salmon emigrating from the San Joaquin Basin in April and May. However, under current conditions, substantial quantities of Sacramento River water are imported into the San Joaquin basin. The significance of the potential impact of additional water imports is not known.

Steelhead. The flow alternatives have the potential to affect juvenile steelhead (*Onchorhynchus mykiss*) during the period of emigration through the Delta. Emigration through the Delta occurs from December through May, with peak migration occurring from February through April (DWR and USBR 1999). The primary factors affected by the flow alternatives that may affect survival of juvenile steelhead in the Delta are Delta inflows, exports, and closure of the Delta Cross Channel gates.

Operations of the CVP and SWP export facilities in the southern Delta may adversely affect steelhead survival in the Delta through direct entrainment losses and indirect effects related to changes in the cycle, direction, and magnitude of flow in the Delta channels (USBR 1997a). Reduced inflow to the Delta in combination with increased diversions may cause adverse impacts on anadromous species by reducing net flow through the Delta and Delta outflow (USBR 1997a). Higher flow rates through the Delta may generally increase steelhead survival by decreasing migration time, reducing exposure to diversions, and maintaining favorable water quality and habitat conditions during migration. Closure of the Delta Cross Channel gates may reduce entrainment of juvenile steelhead from the Sacramento River into the central Delta where survival may be lower.

In general, survival of juvenile steelhead emigrating through the Delta in the February through April period may improve under Flow Alternatives 2 through 8 compared to base case conditions. Delta inflow will generally be higher under Flow Alternatives 2 through 8 in March and April, but lower in February. Delta exports will be lower in the February through April period, except in April of critical water years. The DCC gates will be closed in the February through April period under Flow Alternatives 2 through 8 but the gates would be open most of this period under the base case condition.

Delta Smelt. Delta smelt (*Hypomesus transpacificus*) are small, annual, euryhaline fish that are endemic to the Sacramento-San Joaquin Delta Estuary (USBR 1997a). Delta smelt were once one of the most abundant fish species in the Delta, but their recent decline has led to the species being listed in 1993 as threatened under the state and federal Endangered Species Acts (USBR 1997a). Adults and older juveniles principally live in shallow water or near the surface in deeper water where they feed on zooplankton, particularly copepods. After release during spawning, delta smelt eggs sink toward the bottom and adhere to any available hard substrate (USBR 1997a). Little is known about the annual movement of smelt in the Bay/Delta. In some years, more fish are found in the north tributaries of the Estuary than in others.

Entrainment is another key factor in the decline of delta smelt. The primary mechanism for increased entrainment is low outflow and high exports, which shift the population closer to the diversions (IEP 1996). Entrainment is generally highest during drier years, suggesting that a greater proportion of smelt is entrained when the population is most sensitive. The entrainment of delta smelt by SWP and CVP pumps predominately affects spawning adults, larvae, and young juveniles. Prespawning adults and older juveniles inhabiting the western Delta and Suisun Bay are probably beyond the influence of the SWP and CVP pumps (USBR 1997a). Entrainment losses at agricultural diversions are unknown but are assumed to be significant because of the large number of diversions (1,800) and total diversion capacity (4,000 cfs). Diversions in the northern and central Delta where they are most abundant are likely the greatest source of entrainment (USFWS 1996).

Reduced Delta outflow also has a significant effect on delta smelt abundance (USBR 1997a). Outflow affects survival because smelt spawn in the Delta and young are transported to downstream nursery areas. High flows increase survival by dispersing smelt over a greater area of the Estuary, by increasing the available food supply, and by reducing vulnerability to predation, entrainment, and contaminant effects in upstream channels (DFG, 1993). However, extremely high Delta outflow, as in 1982-1983, may also affect delta smelt by flushing them out of the system. High February-June flows are thought to be necessary for transport of larval and juvenile smelt away from export areas in to productive rearing habitat (USFWS 1996). Increased exports and the associated adverse changes in the position of X2 and reductions in net westerly flows measured by QWEST in the spring months are important factors affecting delta smelt abundance. There is a weak positive correlation between abundance and the number of spring days that the entrapment zone remains in Suisun Bay (IEP 1996).

Contaminants have also been found to have potential population-level effects on delta smelt abundance. An inverse relationship between copper applications to rice fields and delta smelt midwater trawl abundance has been identified in a preliminary study (IEP 1996).

The USFWS issued a biological opinion to the SWP and the CVP that operation to the objectives in the Bay/Delta Plan would not cause jeopardy to delta smelt using the current facility configuration and operations (USFWS 1995). The requirements of this opinion are generally met with Alternatives 2 through 8, and improve conditions for delta smelt. The export and outflow differences among Flow Alternatives 2 through 8 are probably not large enough to cause a substantial effect on delta smelt populations. Flow Alternative 5 may be beneficial to delta smelt because of the higher Delta outflows.

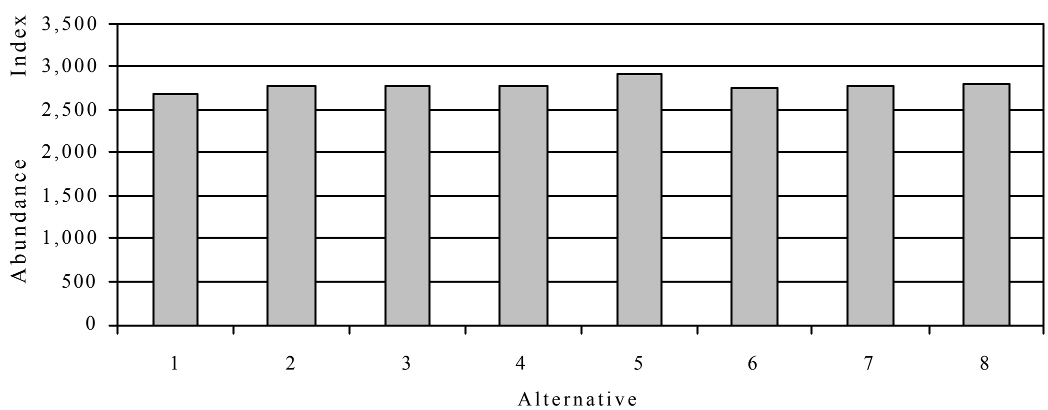
Longfin Smelt. Longfin smelt (*Spirinchus thaleichthys*) are a small planktivorous fish that can tolerate salinities ranging from fresh water to sea water and are an important component of the estuarine food chain in that they are eaten by predatory fish, birds, and marine mammals (BDOC 1993). Longfin smelt migrate from salt and brackish water to the Delta during the winter and spawning occurs in the Delta from December to April (Stevens 1983). They deposit adhesive eggs in fresh to brackish water over sandy-gravel substrates, rocks, or aquatic vegetation in channels of the eastern Estuary. Longfin smelt larvae are then transported to nursery areas by freshwater outflow (SWRCB 1995).

The factor most closely associated with the recent decline in the abundance of longfin smelt is the decrease in outflow during the winter and spring months when the smelt are spawning (SWRCB 1995). In low outflow conditions, adults must migrate further upstream to find suitable freshwater spawning habitat. Reverse flows, which draw freshwater from the Sacramento River, may entrain adults into the southern Delta where adults and their larvae are more vulnerable to entrainment in diversions and other causes of mortality (USBR 1997a). Adequate flow is crucial for the survival of longfin smelt because it provides an increased area of suitable brackish water rearing habitat.

A significant positive relationship exists for longfin smelt abundance and December to May Delta outflow (SWRCB 1995). Figure VI-71 shows the predicted abundance index for each of the flow alternatives, based on the outflow/abundance relationship. The indices predicted for Alternatives 2 through 8 are slightly higher than for Alternative 1, the base case. The indices for Flow Alternatives 2 through 8 are similar. Slightly higher outflow in Flow Alternative 5 resulted in a slightly higher index. The significance of these slight differences in predicted abundance indices is unknown.

Figure VI-71

Predicted Abundance Indices for Longfin Smelt



Sacramento Splittail. The Sacramento splittail (*Pogonichthys macrolepidotus*) are a highly fecund large minnow endemic to the Bay/Delta Estuary with a moderate tolerance for salt water (SWRCB 1995). Sacramento splittail can live 5-7 years and typically begin spawning at 2 years of age in areas of submerged vegetation in slow moving stretches of water. Hatched larvae remain in shallow, weedy areas until they move to deeper habitat in the late summer. Neomysis is the primary food for splittail, but they will opportunistically feed upon earthworms, clams, insect larvae, and other invertebrates. Splittail, in turn, are preyed upon by striped bass and other predatory fish in the Estuary (SWRCB 1995).

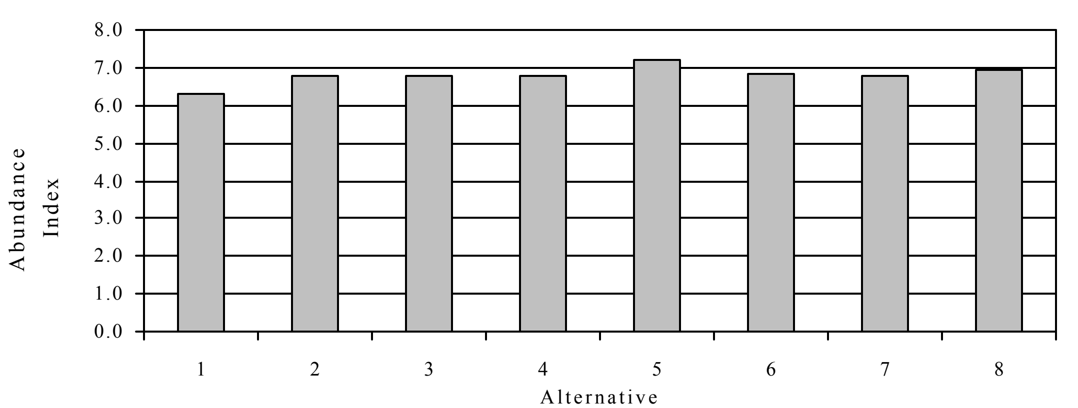
The flooding of spawning habitat and heavy feeding on terrestrial organisms prior to spawning are two mechanisms by which habitat conditions influence successful splittail reproduction (IEP 1996). The operation of upstream storage reservoirs and diversions, including SWP and CVP facilities, may adversely affect spawning by reducing freshwater flow and the availability of temporarily flooded habitat (USBR 1997a). Consequently, spawning adults are forced to use less favorable habitat, thereby decreasing reproductive success (USBR 1997a). Freshwater flow duration may be an important factor in determining egg and larval survival because larval splittail are commonly found in the shallow, weedy areas where spawning occurs. Additionally, reduced duration of flooding during spawning and early rearing may degrade conditions necessary for optimal egg and larval development, or may desiccate these habitats before larvae are able to move to other rearing areas.

Sacramento splittail are entrained in Delta water diversions. However, Sommer et al (1997) suggests that entrainment at the south Delta pumps does not have important effects on the population, although individual year classes may be impacted. Although adult splittail are entrained year-round, most adults are entrained between January and April, which coincides with the migration and spawning period. Juveniles account for the majority of splittail entrained and most of the juvenile entrainment occurs from April to August (USBR 1997a). Late winter and spring Delta diversions coincide with the splittail spawning period. Splittail are most abundant in the north and western Delta (USFWS 1996). Entrainment appears to be proportional to abundance (USFWS 1996).

A relationship exists between juvenile Sacramento splittail abundance and March to May Delta outflow (SWRCB 1995). Figure VI-72 shows the predicted abundance indices for each of the alternatives. The indices predicted for Alternatives 2 through 8 are slightly higher than Alternative 1, the base case. The indices for all of the flow alternatives are similar, particularly Alternatives 2, 3, 4, 6, and 7. Indices for Alternative 5 are slightly higher than for the other alternatives. Alternative 8 has the next highest index. The significance of these slight differences in predicted abundance indices is unknown.

Figure VI-72

Predicted Abundance Indices for Sacramento Splittail



Striped Bass. Striped bass (*Morone saxatilis*) flourished in the Bay/Delta Estuary after their introduction from their native Atlantic Coast estuaries in 1887. Within a decade, striped bass became established in the Bay/Delta Estuary and supported a large commercial fishery until 1935. At that time, the commercial fishery was outlawed and became exclusively a sport fishery (USBR 1997a). The annual catch reported for the sport fishery was larger than that for the commercial fishery. In 1955, catch in the annual sport fishery exceeded four million pounds (Skinner 1962). Sport fishery and mark-recapture data indicated the population plummeted from around three million fish in the early 1960's to approximately 1.7 million in the late 1960's (USBR 1997a). The population, estimated at 1,948,000 adults in 1967, eroded to approximately 574,000 in 1990 (DFG 1993). Slight recovery is evident in population estimates for 1994 (1,192,000 adults) and 1996 (775,000 adults).

Bay/Delta striped bass spend the majority of their lives in the Estuary and along the Pacific coast, within a few miles north and south of the Golden Gate. Once this anadromous fish reaches maturity it migrates upstream into fresh water to spawn in the spring. Approximately one-half to two-thirds of the striped bass spawn in the Sacramento River system with the remainder spawning in the lower San Joaquin River (SWRCB 1995). Most spawning occurs in moderately swift currents when the water is between 61 and 69 degrees. Striped bass spawn in small groups by releasing eggs and sperm simultaneously at the surface of main currents. Semi-buoyant eggs are carried downstream with the currents towards the Delta. Eggs hatch in two or three days and larvae begin feeding on small zooplankton after absorbing their yolk sacs. Upon reaching the western Delta, their primary rearing area, they are large enough to begin feeding on opossum shrimp (*Neomysis mercedis*). This remains a major food source until their second year when they become more opportunistic and feed on bay shrimp and small forage fish. In three or four years, bass reach maturity and migrate upstream to spawn. Striped bass may live for twenty or more years. Older and larger, which are more fecund, are no longer present in the Bay in great numbers. The majority of the adult population in the Bay/Delta is in the 4 to 7 year age classes.

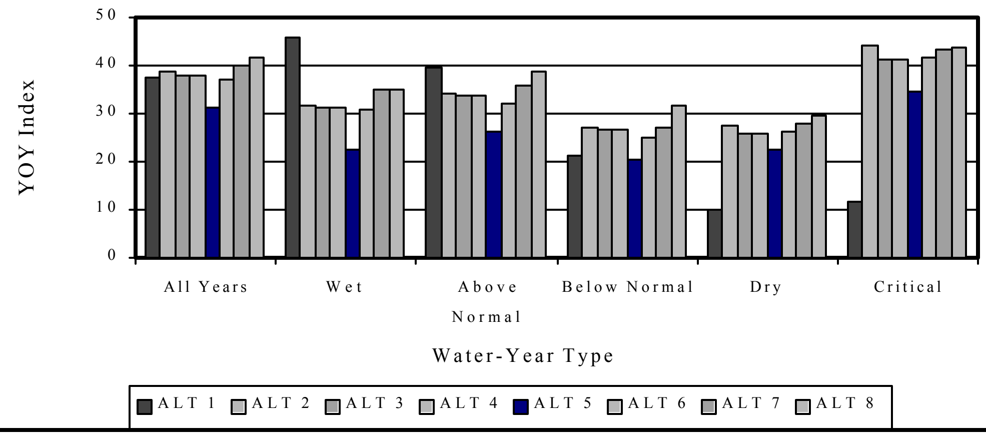
There are many possible factors contributing to the declining abundance of adult striped bass in the Bay/Delta Estuary including survival of critical life stages, entrainment in water diversions, food limitations, exposure to contaminants, and reduced habitat. Recent literature indicates that the population may also be affected by loss of older fish and declining carrying capacity (Kimmerer 1997).

Changes in flow and Delta exports due to the flow alternatives will primarily affect the young-of-the-year striped bass lifestage. The effects of the flow alternatives on young-of-the-year striped bass abundance were modeled using a multiple regression relating total young-of-the-year striped bass abundance at 38 mm. to the mean April to July San Joaquin River flow past Jersey Point, $\log_{10}$ net Delta outflow, and total Delta exports (including CVP, SWP, Contra Costa Canal, and miscellaneous Delta diversions) (Lee Miller, DFG, personal communication). The regression is described in Chapter IV; regression calculations are shown in Volume 2, Appendix 5.

Figure VI-73 shows the predicted young-of-the-year indices for the flow alternatives, by water year type and all years combined. The pattern of predicted indices among Flow Alternatives 2 through 8 was similar in each water year type. Indices for Alternatives 3, 4, and 6 were similar, and higher than for Alternative 5, but lower than for Alternatives 2, 7, and 8. Indices predicted for the base case varied significantly among water year types, being higher than Alternatives 2 through 8 in wet and above normal water years, but generally lower than Alternatives 2 through 8 in below normal, dry, and critical years.

Figure VI-73

Predicted Striped Bass Young-Of-Year Index



In all years combined, the predicted young-of-the-year index for the base case was similar to Alternatives 2, 3, 4, and 6, higher than Alternative 5, and lower than Alternatives 7 and 8. In general, Flow Alternative 5 may have a slight adverse impact on young-of-the-year abundance compared to the base case; Flow Alternatives 7 and 8 may result in slightly higher abundance than in the base case.

The observed differences in abundance indices are primarily due to changes in total Delta exports. Of the flow/export variables included in the regression, mean April – July total Delta exports had a dominant effect on the predicted abundance indices. In general, total exports were higher in this period under Alternative 5, and lower under Alternatives 7 and 8, than under Alternatives 2, 3, 4, and 6.

The predicted changes in young-of-the-year abundance under Alternative 5 may have a slight adverse impact on the adult striped bass population. Striped bass losses under Alternative 5 could be mitigated through funding of additional stocking.

American Shad. American shad (*Alosa sapidissima*) are members of the herring family. American shad are oceanic as adults except for a brief spawning run in fresh water (SWRCB 1995). River flow is the only factor known to correlate with American shad abundance. Higher flow probably improves attraction of upstream migrating adults (the number of adults spawning in a tributary is proportional to the amount of flow from that tributary), increases upstream spawning area, and improves rearing habitat (IEP 1996). Hypotheses explaining reduced abundance at lower Delta outflows include the following: (1) water velocities needed to suspend eggs and larvae off the bottom are reduced, increasing the likelihood that eggs and larvae will settle to the river bottom and die, (2) warmer water temperatures associated with lower river flows reduce survival of eggs and larvae, (3) eggs and larvae are more susceptible to exposure to toxic substances in the rivers and Delta, (4) a lower proportion of larvae are carried to the Delta, and (5) a higher proportion of larvae are drawn into the central and south Delta where vulnerability to entrainment is greater (USBR 1997a).

The survival of shad eggs is also closely associated with water temperature. Less than optimal water temperatures may cause poor development, reduced growth rates, and increased mortality of developing larvae (USBR 1997a). The optimum temperature range for spawning is 62-68°F, with mortality increasing with an increase in temperature, especially above 68°F (USBR 1997a).

High Delta outflow and reduced exports would be expected to minimize impacts. Flow Alternative 5 has the highest outflow but also has increased exports. Therefore, Delta conditions for survival of American shad may be similar under all of the alternatives.

Starry Flounder. The starry flounder (*Platichthys stellatus*) is a flatfish that feeds on benthic organisms. It is common downstream of the Delta in Suisun and San Pablo bays and lives on all types of substrates except rocky areas (Baxter 1960). The starry flounder is a euryhaline fish, which enables it to tolerate salinities ranging from nearly seawater to freshwater (Turner 1966), and may be found in the Bay during all stages of life (USBR 1997a).

Eggs, larvae, and small juveniles of the starry flounder are pelagic (open water) and primarily inhabit the upper water column (Hergessell 1993). Larval starry flounder consume phytoplankton and zooplankton. Juveniles smaller than four inches in length feed upon copepods and other small crustaceans. Larger juveniles and adults are benthic, and consume crustaceans such as *Crangon*, Dungeness crabs, worms, clams, and occasionally fish (USBR 1997a). Starry flounder are preyed upon by marine mammals and piscivorous birds. They are also prey of striped bass in both the fresh and marine waters of the Bay/Delta Estuary (DFG 1992b).

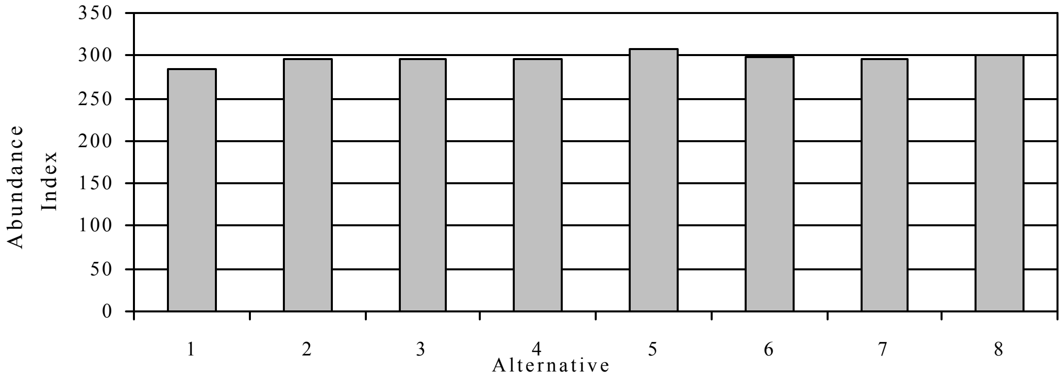
Outflow is an important factor in the survival of starry flounder. Starry flounder spawn in winter and early spring and abundance is correlated to outflow during the same period (DFG, 1993). Moderate to high outflow increases the amount of rearing habitat in San Pablo, Suisun, and Honker bays (IEP 1996). The amount and location of shallow, brackish water nursery habitat for recently settled and small juveniles is most important from March through June, which is also when most of the larvae and juvenile immigration occurs (SWRCB 1995). The quantity of this habitat is correlated with starry flounder abundance in the Estuary later in the year. In addition, gravitational circulation in the lower Estuary is strongly affected by freshwater flows and may aid in the immigration of young flounder into the estuarine nursery areas (IEP 1996).

The decline of starry flounder abundance in Suisun Bay principally reflects reduced production of young (SWRCB 1995). Other factors may include pollution and competition.

Abundance of starry flounder is strongly dependent on outflow. Exports do not have as strong an influence on abundance. Since most immigration occurs from March to June, outflow during this period is considered critical. Figure VI-74 shows abundance indices predicted for each flow alternative during that period. Indices for Alternatives 2, 3, 4, 6, and 7 are very similar and are slightly higher than for Alternative 1, the base case. The index for Alternative 5 is slightly higher due to higher flow. Alternative 8 has the second highest index. The significance of these slight differences in predicted abundance indices is not known.

Figure VI-74

Predicted Abundance Indices for One-Year-Old Starry Flounder



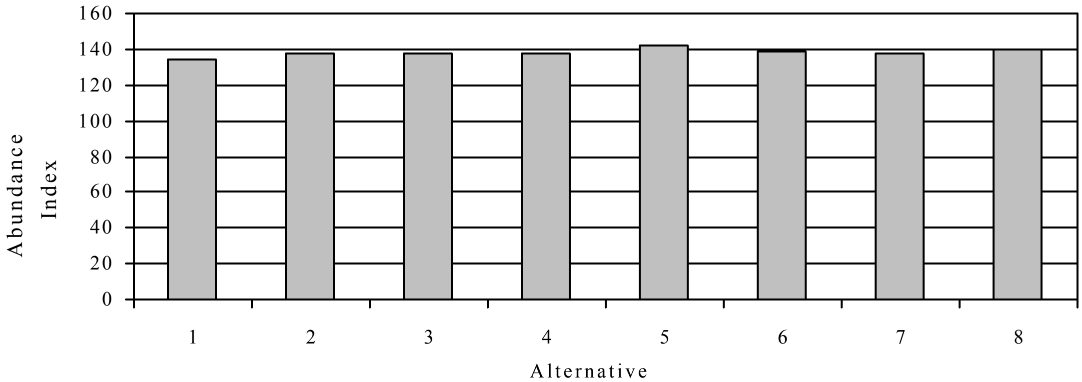
Crangon. *Crangon franciscorum*, commonly known as bay shrimp, is a type of caridean shrimp that seldom exceeds 70 mm in total length and dominates the smaller benthic fauna in the Bay/Delta Estuary (SWRCB 1995). *C. franciscorum* exhibits a response to outflow that may be attributed to two flow-related mechanisms. First, higher river inflows transport the small post-larval shrimp into the bay and disperse them into estuarine nursing areas. Second, higher river inflows reduce bay salinity and increase the amount of suitable nursery habitat for juvenile shrimp (SWRCB 1995).

C. franciscorum spawn in the winter and early spring. Densities are correlated to outflow during this period (DFG 1993). In low flow years, the distribution of *C. franciscorum* is further upstream and exposes them to entrainment at the PG&E Delta power plants. Large numbers of *C. franciscorum* were entrained during a wet year and numbers may be substantially higher during dry years (IEP 1996). The species is also entrained at other diversions, including the SWP and CVP facilities. *C. franciscorum* populations may be adversely affected by lower phytoplankton food availability. The 1986 invasion of the Asiatic clam, *Potamocorbula amurensis*, has reduced chlorophyll *a* levels by a factor of 10 in Suisun Bay.

The amount of shallow, brackish water habitat seems to be a key population factor for this species. Shallow water habitat provides physical refuge for juvenile *C. franciscorum* from predators and adult shrimp, as *Crangon* are cannibalistic (IEP 1996).

A significant positive relationship exists between juvenile *C. franciscorum* abundance and March to May Delta outflow (SWRCB 1995). Figure VI-75 shows that the abundance indices predicted for all of the flow alternatives slightly exceed that of the base case. Among the flow alternatives, the indices are quite similar. Alternative 5 has a slightly higher index than the other alternatives that may be due to higher outflow. Alternative 8 has the next highest index. The significance of these slight differences in predicted abundance indices is not known.

Figure VI-75
Predicted Abundance Indices for Immature *Crangon Franciscorum*



Neomysis. *Neomysis mercedis*, a native mysid shrimp, is an important food source for many estuarine fish and feeds upon phytoplankton, rotifers, and copepods (SWRCB 1995). The life span, survival, size, and abundance of *Neomysis* are regulated by outflow, water temperature and food supply. The SWP and CVP pumps may export large numbers of *N. mercedis* in low outflow years when they are further upstream (SWRCB 1995). Food supply is probably the most important limiting factor for *N. mercedis*., Abundance has decreased with the decline of phytoplankton (chlorophyll *a*) concentrations since the 1970s (Orsi and Mecum 1996). In recent years, the introduced *Acanthomysis* shrimp appears to be replacing *Neomysis* in certain areas/time periods.

Until 1986, a positive relationship existed between *N. mercedis* abundance and average March through November Delta outflow (SWRCB 1995). In recent years, *Neomysis* abundance has been significantly lower than predicted by that relationship. In general, increased flow and reduced diversions are believed to increase phytoplankton biomass, increase potential habitat, and push *Potamocorbula amurensis* populations farther downstream, reducing the competition for food. The flow alternatives, therefore, may have a slight beneficial effect on *Neomysis* abundance compared to the base case.

Copepods. Copepods are small crustaceans, many of which are planktonic. They feed upon a variety of diatoms, green and blue-green algae, and flagellated protozoans. Copepods, in turn, are the main food source for many small fish and other organisms in the Estuary and are an important link in many food webs. The abundance of copepods is closely linked with phytoplankton abundance and spring temperatures (USBR 1997a). A significant correlation between chlorophyll and copepod biomass has been found and may suggest food limitation, although this effect is specific to species, location, and time (IEP 1996).

A variety of copepod species inhabit the Delta. Complex interactions among native and recently introduced copepod species affect the overall abundance and biomass of copepods in the system. Entrainment in diversions and residence time are probably important factors affecting copepod abundance in the Delta. (IEP 1996).

Phytoplankton. Phytoplankton are very small, usually microscopic, algae that are suspended in the water column and drift with the currents. The major phytoplankton groups in the Bay/Delta Estuary are diatoms, dinoflagellates, and cryptomonads. As primary producers that convert solar energy into food through photosynthesis, phytoplankton comprise an essential part of the food web in the Estuary. Phytoplankton productivity, biomass, density, and species composition are influenced by several factors, including light, temperature, nutrients, residence time, inflow, and grazing by aquatic animals (SWRCB 1995).

Light limitation due to turbidity and depth affects phytoplankton growth rates in the Estuary (USBR 1997a). In general, phytoplankton are light limited due to the high turbidity in the Estuary. Net production is consistently negative in the channels of the Delta, where most phytoplankton occur in light-limited conditions below the surface. Only in the shoal areas, like those in Suisun Bay, where the phytoplankton cells are frequently mixed into the surface waters, can net production be positive; phytoplankton growth rate is about ten times higher in the shoals than the channels of Suisun Bay (SWRCB 1995). The introduction of the Asiatic clam, *Potamocorbula amurensis*, in 1986, however, has decreased chlorophyll *a* concentrations by a factor of 10 in Suisun Bay (SFED 1997).

Entrainment and Delta outflow are important to phytoplankton variability in the Delta (IEP 1996). Export pumping was negatively correlated with phytoplankton community composition and chlorophyll *a* concentration. Subsequently, it has been shown that diversions and Delta outflow together account for 86 percent of chlorophyll *a* concentrations in the entrapment zone (SWRCB 1995). Extremely high flows, however, may decrease phytoplankton biomass by flushing phytoplankton out of the estuary. Since freshwater flow influences the location of the entrapment zone, flow also becomes a crucial factor in the maintenance of an abundant population of phytoplankton. Consequently, habitat for phytoplankton in the Delta is greatly affected by exports and also by residence time, which varies with flow conditions (SWRCB 1995).

In general, flow alternatives with higher Delta outflow and lower exports are expected to be beneficial to phytoplankton.

c. Summary of Effects on Fish and Aquatic Resources. The major factors affecting aquatic resources in the Bay/Delta are reasonably well understood, although the interactions of these factors and the relative magnitude of the effects are still controversial. In general, the condition of aquatic resources in the Bay/Delta improves as the hydrologic regime moves towards unimpaired conditions. In general, habitat conditions under Flow Alternatives 2 through 8 are expected to improve for aquatic species compared to the base case. The primary factors affecting aquatic organisms that may be affected by the SWRCB in this proceeding include Delta outflow and exports.

In general, Flow Alternatives 2-8 result in lower exports in the spring months than in the base case, which may reduce entrainment and the adverse effects of reverse flows in the critical period for spawning, rearing, and outmigration of many aquatic species in the Delta. However, in some months, Alternatives 2 through 8 result in higher Delta exports and greater reverse flows than in the base case, which may result in increased entrainment of aquatic organisms at the Delta export facilities.

In the critical spring months, Delta outflow under Flow Alternatives 2 through 8 is greater than in the base case, which may improve conditions for spawning and survival of aquatic resources. However, in general, Delta outflow is lower under Alternatives 2 through 8 than in the base case in October through January.

In general, implementation of Flow Alternatives 2 through 8 is predicted to have slight beneficial effects on through-Delta survival of juvenile chinook salmon and steelhead, and on abundance of longfin smelt, Sacramento splittail, starry flounder, *Crangon franciscorum*, and *Neomysis*, compared to the base case.

Due to higher exports predicted in some of the spring months, young-of-the-year striped bass abundance is predicted to be lower under Alternative 5 than in the base case. Potential impacts on striped bass under Alternative 5 could be mitigated through additional stocking.

Recirculation under Flow Alternative 6 will increase the percentage of Sacramento River water that returns to the San Joaquin River. This may impact the imprinting of juvenile fall-run chinook salmon emigrating from the San Joaquin Basin in April and May. However, under current conditions, substantial quantities of Sacramento River water are imported into the San Joaquin basin. The significance of the potential impact of additional water imports is not known.

4. Vegetation and Wildlife

This section considers the potential impact that the flow alternatives might have on vegetation and wildlife within the Delta. The Delta consists of a mosaic of levied islands and open waterways. Of the total area, 72 percent is farmland on which a wide variety of crops are grown. Natural habitats comprise 12.6 percent of the total area and consist of freshwater and saline emergent marsh, riparian, and open water habitat (USBR 1997b). Wetlands within the interior Delta are dominated by freshwater plant species. A gradual transition from freshwater to brackish and then saline conditions occurs between Emmaton and Jersey Point on the Sacramento and San Joaquin rivers and Benicia further downstream. This salinity gradient results in a gradual shift in plant community species composition. Base assumptions in the analysis of impact are that (1) there will be no change in the amount of agricultural land in production, and (2) there will be no change in the extent, frequency, or intensity of levee maintenance.

Potential impacts to Delta vegetation and wildlife resulting from implementation of the flow alternatives are related to changes in river stage in the lower Sacramento and San Joaquin rivers, and changes in salinity caused by a new flow regime. Drought represented by low summer stages, and inundation mortality (high stages year-round) are the major impact mechanisms of river stage on riparian and wildlife habitat. Long-term changes in salinity could cause a gradual shift in the relative proportion of freshwater, brackish, and saltwater marsh within the estuary. Populations of wildlife species dependent on a particular habitat type might shift accordingly.

The effect of river stage changes is greatest at the upstream margins of the Delta and decreases with distance into the Delta. This is due to the tidal effects and the high volume of water in the Delta compared to the inflow. River stages have been calculated for the Sacramento River at Verona and the San Joaquin River at Vernalis in section C.3 of this chapter (see Tables VI-39 and VI-43). These sites are indicative of conditions at the upstream boundaries of the Delta. Reductions in river stage of less than 20 percent are considered to be less than significant in terms of impact on riparian and wetland habitat. At Vernalis, higher flows during the May to July period of dry years in Alternatives 3 and 4, and during the April to October period in all water year types in Alternative 5 produce a beneficial effect on riparian and wildlife habitat in the lower portion of the river and may also be beneficial in the Delta. On the Sacramento River at Verona there is a significant reduction in wet year flows from February to May for Alternative 5. This reduction should not adversely impact riparian vegetation under wet weather conditions.

The impact of the flow alternatives on salinity (expressed as electrical conductivity) and "X2" position (the 2 ppt isohaline) is discussed in section A.2 above. Salinity information for water years 1976 to 1992 was determined for the alternatives at representative points within the southern, central, and western Delta using the DWRDSM model. This information is presented in Figures VI-3 through VI-63. In general, salinity under the base case (Alternative 1) is greater than or equal to the other alternatives during the April to July period in the western and central Delta. Other months are variable. In the southern Delta, modeled salinity under the alternatives varies from just below the salinity objectives to greater than the objectives during the June to August period. In some instances, the alternatives exceed the base case.

Soil salinity tolerance ranges have been established for certain dominant wetland plant species (Jones & Stokes and EDAW 1975). Common freshwater plant species, such as cattail and tule, display a wide range in soil water salinity tolerance. The salinity changes predicted by the DWRDSM modeling are well within the tolerance ranges and therefore would not cause long term changes in plant species composition.

5. Land Use

This section considers the potential impact that the flow alternatives might have on patterns of land use within the Delta. The Delta is used primarily for agricultural purposes. The area, much of which is now below sea level, is interlaced with hundreds of miles of waterways and relies on more than 1,000 miles of levees for protection against flooding. A wide variety of crops are grown on more than 500,000 acres of rich farmland. Delta farmland is irrigated by water diverted from Delta channels under a combination of riparian and appropriative water rights.

Ambient water quality is the parameter that most directly affects irrigated agriculture in the Delta. Water availability is not a problem because most of the Delta has an elevation at or near sea level. The results of the DWRDSM salinity modeling are discussed in sections B.2. and B.4. above. Under all of the alternatives, water quality is adequate for agricultural uses in the western and central Delta. However, the modeling results indicate that salinity objectives in the southern Delta are not always met in the summer. Even with the long-standing water quality problem in the southern Delta, the basic agricultural use of the land has not changed. Implementation of the flow objectives will not worsen the problem. Thus, none of the alternatives are expected to change the current land uses in the Delta.

A number of appropriative water right holders identified in Table II-5 are located within the Delta. If diversions under their appropriative water rights were curtailed, they probably would continue to divert under riparian right if natural flow is available at the time, or seek contracts for project water. In either case, there likely would be no effect on water availability and land use practices resulting from implementation of the outflow alternatives.

6. Delta Recreational Impacts

Many water-dependent and water-enhanced activities occur in the Sacramento-San Joaquin Delta. Annual use is estimated at over 12 million visitor days. Boating and fishing, as separate activities, are the most important recreational activities, accounting for 17 percent and 15 percent of the recreational use in the region, respectively.

Closure of the Delta Cross Channel in some months, as required by the 1995 Bay/Delta Plan, will have adverse effects on boating in the Delta as it impedes navigation between the Sacramento and Mokelumne rivers. Under D-1485, the DCC gates are closed between January 1 and April 15, whenever Delta outflow exceeds 12,000 cfs. Additionally, between April 16 and May 31, gates may be closed up to 20 days (but no more than two out of four consecutive days) at the discretion of the DFG.

Under the plan, DCC gates are closed between February 1 and May 20. Additionally, between November 1 and January 31, gates are closed for up to a total of 45 days, as needed for protection of fish. Between May 21 and June 15, gates are closed for a total of 14 days, as needed for fish protection.

Sport fishing could be enhanced by improved water quality in the Delta. Fish populations in the Delta have been declining for a number of reasons. The flow objectives in each of the alternatives may stabilize or improve the fish populations in the Delta. An increase in game fish populations should result in increased sport fishing opportunities.

C. ENVIRONMENTAL EFFECTS IN UPSTREAM AREAS

The upstream areas considered in this evaluation include the Sacramento and San Joaquin river basins north and south of the Delta described in Chapter III of this report. The evaluation of the environmental effects in upstream areas is divided into the following subsections: (1) hydrology, (2) water temperature, (3) aquatic habitat, (4) vegetation and wildlife, (5) erosion, (6) land use, (7) urban development, (8) energy, (9) recreation, (10) aesthetics, (11) cultural resources, and (12) groundwater pumping.

1. Hydrology

Changes in river flows are evaluated in this section to provide a basis for evaluating the impacts of the flow alternatives on fish and aquatic resources and other flow dependent resources in the upstream areas. The points at which river flows are evaluated correspond to control points in the DWRSIM model. These points were selected to coincide with actual gauging stations or with points on the tributaries upstream of their confluence with the Sacramento or San Joaquin rivers.

Tables VI-16 through VI-31 list the modeled base case monthly flows for eight locations in the Sacramento/San Joaquin River system for the 73-year period and critical period. Below the base case flows are the changes in these flows from the base case that result from implementing the seven flow alternatives.

Table VI-16

Sacramento River Flow at Red Bluff, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	7,277	8,978	12,377	15,272	18,163	15,350	11,477	10,672	10,936	12,776	10,506	6,236

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	73	216	30	-126	60	127	16	**-190**	1,173	-565	-681	36
3	128	335	115	-75	120	154	31	-199	972	-787	-713	74
4	128	331	109	-75	124	128	36	-199	984	-764	-716	69
5	**344**	**615**	**272**	**145**	**312**	**279**	-1	-350	707	-1,458	-701	110
6	86	-40	-187	-255	-252	6	37	-269	**1,656**	**-486**	**-457**	**317**
7	-52	-18	-61	-208	-88	187	**358**	-417	1,584	-550	-569	23
8	99	174	37	-130	223	121	-68	-231	1,224	-523	-696	82

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-17

Sacramento River Flow at Red Bluff, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	4,793	4,790	6,785	6,904	6,948	6,470	6,907	7,604	8,252	9,739	9,772	5,191

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-79	50	-82	-84	-84	306	20	281	765	**993**	**-1,294**	117
3	-249	**246**	-41	-44	-42	385	207	**379**	480	454	-1,338	112
4	-249	212	-41	-44	-42	388	216	**379**	492	447	-1,341	112
5	-132	-21	**40**	**40**	**93**	**645**	294	103	957	-788	-1,356	**204**
6	**14**	72	-206	-209	-210	-149	196	277	**1,656**	867	-1,696	153
7	-272	-222	-166	-168	-168	52	**574**	195	1,289	570	-1,361	182
8	-158	8	-82	-84	-49	3	-2	257	988	981	-1,696	163

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-18

Sacramento River Flow at Verona, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	11,776	13,579	19,218	26,962	31,867	30,444	19,148	15,623	12,712	12,853	10,543	9,488

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-506	-12	-433	-547	92	152	233	-361	2,042	1,044	-1,260	-151
3	-373	174	-305	-437	172	162	274	-386	1,628	759	-1,245	-145
4	-373	170	-321	-438	161	145	275	-378	1,654	776	-1,250	-146
5	***11***	***835***	***248***	***-23***	***816***	***785***	553	***-65***	1,935	36	-1,015	***197***
6	-461	-165	-733	-650	-215	40	177	-474	***2,454***	1,164	-1,003	142
7	-623	-269	-651	-723	-168	238	***949***	-823	2,422	1,220	-1,121	-147
8	-568	-107	-583	-609	283	144	1	-527	2,087	***1,331***	***-872***	-69

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-19

Sacramento River Flow at Verona, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	8,494	7,232	9,837	13,840	12,231	12,084	8,111	7,686	8,336	10,246	9,066	7,032

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-1,252	120	-252	-236	-213	520	746	980	1,411	604	-1,297	-240
3	-1,452	350	-220	-195	-174	536	978	1,096	1,005	430	-1,394	-379
4	-1,450	308	-220	-195	-174	542	984	1,096	1,022	414	-1,394	-379
5	***-1,145***	***439***	***9***	***36***	***79***	***1,197***	1,236	***1,362***	***2,978***	-318	***-812***	***-6***
6	-1,359	174	-380	-358	-339	62	743	1,003	2,227	941	-1,657	-339
7	-1,382	-244	-364	-317	-315	198	***2,409***	404	1,690	-58	-1,255	-267
8	-1,412	107	-260	-240	-172	169	271	496	1,659	***1,236***	-1,287	-344

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-20

Feather River Flow at Gridley, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	2,941	2,623	4,525	5,627	6,472	6,280	3,160	3,948	3,351	4,398	3,727	1,818

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-580	-226	-462	-421	32	25	220	***-171***	***868***	1,608	-576	-189
3	-501	-161	-419	-362	49	8	244	-188	654	1,545	-528	-221
4	-501	-160	-429	-362	34	17	241	-180	669	1,540	-531	-216
5	***-307***	***30***	***-113***	***-108***	***280***	***221***	71	-374	262	824	-615	***-28***
6	-544	-123	-544	-395	35	33	143	-205	798	1,649	-544	-175
7	-572	-249	-587	-516	-82	52	***592***	-406	838	1,771	-530	-171
8	-665	-277	-616	-477	10	21	72	-298	861	***1,853***	***-176***	-151

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-21

Feather River Flow at Gridley, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	2,841	1,868	2,496	1,185	1,522	1,645	1,661	1,789	3,018	4,382	2,486	1,556

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-1,171	76	***-170***	-155	***-135***	212	731	706	648	-388	9	***-365***
3	-1,201	101	-178	-155	***-135***	149	773	720	526	-26	-51	-497
4	-1,196	98	-178	-155	***-135***	152	773	720	526	-35	-51	-497
5	***-921***	***284***	-378	-155	-379	***412***	555	223	564	-334	119	-375
6	-1,361	98	***-170***	-155	***-135***	212	552	***730***	574	70	46	-497
7	-1,103	-22	-197	-155	-153	149	***1,832***	214	398	-630	107	-452
8	-1,248	99	-177	-155	-145	170	278	243	***669***	***253***	***414***	-512

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-22

American River Flow at Nimbus Dam, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	2,159	2,696	3,651	4,374	5,145	4,001	3,695	3,359	3,895	3,513	2,763	1,898

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-196	-32	-227	-143	-7	68	34	104	846	-348	-360	316
3	-180	-12	-176	-76	18	76	5	118	738	-394	-402	333
4	-181	***-11***	-186	-78	18	97	2	104	754	-398	-400	329
5	***-110***	84	***-68***	***0***	***103***	***115***	-120	-5	533	-654	***-252***	***452***
6	-114	-129	-359	-235	-163	-27	20	***145***	***1,006***	***-269***	-254	429
7	-194	-98	-257	-163	-3	114	***141***	-8	973	-296	-398	252
8	-172	-41	-211	-136	49	63	-30	87	869	-323	-351	287

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-23

American River Flow at Nimbus Dam, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1,571	1,314	1,277	1,212	2,039	1,868	2,622	1,791	2,715	4,210	2,412	576

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	25	224	-483	-458	-907	21	210	460	2,087	-1,285	***-546***	526
3	199	123	-486	-458	-907	376	22	458	1,945	-1,106	-862	536
4	195	154	-486	-458	-907	***379***	14	465	1,916	-1,099	-862	533
5	***371***	***526***	***-85***	***-87***	***-463***	370	-918	-49	1,239	***-958***	-737	***707***
6	367	227	-442	-499	-991	-112	325	***514***	2,154	-1,429	-895	651
7	267	434	-336	-316	-760	75	***392***	33	2,063	-1,322	-1,009	497
8	136	268	-480	-462	-916	33	116	466	***2,339***	-1,426	-675	458

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-24
San Joaquin River Flow at Newman, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1,638	866	1,290	1,816	2,979	2,233	1,521	2,140	1,610	650	528	830

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-7	-4	-5	-3	-9	-4	-8	-6	-9	-8	-8	-11
3	-64	-46	-69	-66	-181	-30	204	283	181	159	44	-17
4	-35	-20	-38	-53	-114	20	69	143	179	161	53	2
5	***334***	***39***	-63	-41	***473***	***815***	***2,121***	***1,783***	***772***	***1,392***	***425***	***116***
6	152	-4	***-4***	***-2***	12	52	408	732	242	174	100	-8
7	-26	-22	-23	-33	-83	-5	85	81	-16	-9	-10	-14
8	45	-47	-68	-68	-189	-28	242	254	-53	-10	-9	-26

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-25
San Joaquin River Flow at Newman, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1,004	479	545	575	1,306	748	415	421	471	418	434	631

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-14	-11	-3	-3	-15	-11	-17	-14	-17	-16	-18	-24
3	-116	-3	-8	-55	-356	-5	193	295	204	244	114	-19
4	-110	-3	-8	-46	-193	-5	78	116	237	244	114	-19
5	***355***	***138***	***134***	***93***	***95***	***566***	***1,352***	***1,279***	***511***	***978***	***388***	***169***
6	227	-14	-8	-3	-15	-11	204	789	170	409	277	-28
7	-119	-11	-3	-38	-93	-11	114	120	-77	-16	-20	-24
8	-86	-10	-5	-44	-307	-8	245	406	-93	-15	-19	-24

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-26
Stanislaus River Flow Upstream of the San Joaquin River Confluence, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	853	523	588	739	1,048	736	1,124	789	877	634	601	597

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-36	-62	-146	-214	-381	-78	***365***	731	107	193	246	-12
3	79	-46	-113	-132	-191	14	152	396	92	150	***251***	***-8***
4	28	-54	-124	-174	-287	-19	316	577	80	146	239	***-8***
5	-19	-42	-61	-110	35	***103***	42	89	-1	-47	97	-9
6	-65	-38	-71	-51	-75	-17	-7	-6	67	123	243	***-8***
7	***394***	47	***165***	***158***	***165***	73	-132	225	272	***237***	-8	-179
8	-177	***68***	2	-176	-330	-6	358	***734***	***382***	218	180	-9

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-27

Stanislaus River Flow Upstream of the San Joaquin River Confluence, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	374	451	407	333	307	344	840	609	653	646	646	588

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	121	-118	-155	-111	-66	-19	**227**	**801**	-36	-100	-84	-48
3	249	-118	-144	-103	-54	-19	28	413	106	176	**197**	**-9**
4	**258**	-118	-144	-103	-54	-19	160	653	101	176	**197**	**-9**
5	-37	-119	-154	-111	29	69	49	55	-103	-102	-82	-14
6	-56	-118	-144	-103	-66	-19	0	-14	118	16	158	**-9**
7	114	**-76**	**-33**	**28**	**98**	**87**	48	285	293	**255**	-230	-206
8	29	-96	-63	-68	-20	7	121	417	**295**	180	-41	-44

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-28

Tuolumne River Flow Upstream of the San Joaquin River Confluence, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	558	523	672	1,277	1,753	1,983	1,486	1,148	1,090	575	321	423

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	0	0	0	0	0	**0**	0	0	0	0	0	**0**
3	1	0	-12	-137	-141	-75	-3	52	**387**	19	0	**0**
4	0	0	-12	-128	-133	-60	-16	21	371	19	0	**0**
5	**126**	-11	-36	-314	-157	-203	**189**	**267**	156	**388**	**5**	-5
6	0	0	0	0	0	**0**	0	0	0	0	0	**0**
7	-2	-1	**4**	**5**	**13**	**0**	-5	-44	8	1	1	**0**
8	-1	**2**	-13	-15	-23	-34	48	80	-15	-1	-1	-1

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-29

Tuolumne River Flow Upstream of the San Joaquin River Confluence, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	323	325	350	344	424	342	613	609	202	197	202	209

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	0	**0**	0	0	0	0	0	0	0	0	0	0
3	0	**0**	0	0	0	0	0	14	**492**	0	0	0
4	0	**0**	0	0	0	0	0	0	**492**	0	0	0
5	**217**	-27	**2**	**3**	**80**	**152**	**261**	**231**	191	**381**	**1**	**17**
6	0	**0**	0	0	0	0	0	0	0	0	0	0
7	-16	-6	-6	-5	0	-3	-56	-56	0	0	0	0
8	-2	-2	**2**	**3**	7	0	69	118	4	-2	-3	-1

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-30
Merced River Flow Upstream of the San Joaquin River Confluence, 73-Year Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1,026	305	563	784	1,306	601	226	586	696	157	110	197

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	0	**0**	**0**	**0**	**0**	0	0	0	0	0	0	0
3	-59	-35	-64	-66	-194	-50	201	**282**	**148**	101	48	-9
4	-29	-12	-33	-50	-128	-1	71	144	146	101	**54**	**10**
5	-317	-62	-186	-193	-214	**84**	**541**	266	-25	**239**	28	-46
6	0	**0**	**0**	**0**	**0**	0	0	0	0	0	0	0
7	-18	-18	-17	-30	-72	0	92	87	-5	0	0	-2
8	**54**	-40	-60	-64	-193	-24	210	219	-43	0	1	-12

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

Table VI-31
Merced River Flow Upstream of the San Joaquin River Confluence, Critical Period

Base Case Average Monthly Flow (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	511	137	165	214	593	171	70	70	101	79	93	79

Change in Flow from the Base Case (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	**0**	0	**0**	**0**	**0**	0	0	0	0	0	0	0
3	-114	0	-2	-38	-341	0	193	283	141	158	**121**	0
4	-107	0	-2	-38	-187	0	73	100	**175**	158	**121**	0
5	-275	**3**	1	-59	-322	**97**	**400**	**388**	91	**179**	35	**7**
6	**0**	0	**0**	**0**	**0**	0	0	0	0	0	0	0
7	-104	0	**0**	-35	-79	0	132	134	-60	0	0	0
8	-72	**3**	1	-41	-304	-4	223	358	-75	0	0	1

Note: Bolded entries signify the highest flow among the seven alternatives for each month.

In the Sacramento Valley, Alternative 5 generally provides the highest river flows of the alternatives for the fall and winter months, and the lowest flows for the summer months. Alternative 7 provides the highest river flows in April. For the Sacramento River at Red Bluff and the American River at Nimbus Dam, Alternative 6 generally produces the highest flows during the summer months for the 73-year period analysis (Tables VI-16 and VI-22). For the Sacramento River at Verona and the Feather River at Gridley (Tables VI-18 and VI-20), summer flows are highest in July and August under Alternative 8. June flows are highest at Verona under Alternative 6 and at Gridley under Alternative 2.

For the critical period analysis, Alternatives 2, 5, 6 and 8 produce the highest flows in the summer months depending on the month and the location (Table VI-17, VI-19, VI-21 and VI-23) and Alternative 5 generally produces the highest flows in the winter months. Alternative 6 produces the lowest flows on the Sacramento River at Red Bluff and Verona in the period December through March. Alternative 7 produces the lowest flows on the Feather River at Gridley in November, January, March, and May through July. On the American

River, Alternative 6 produces the lowest flows from January through March and Alternative 5 produces the lowest flows from April through June.

Trends are different in the San Joaquin River Basin than in the Sacramento River Basin. For the San Joaquin River at Newman in the 73-year period analysis (Table VI-24), Alternative 5 provides the highest flows in every month except December and January, and Alternative 8 generally provides the lowest flows. For the critical period analysis, Alternative 5 provides the highest flows year round. Flows are the lowest in April and May under Alternative 2, July and August under Alternative 7, and January and February under Alternative 3; however, flows under Alternative 8 are among the lowest in each month during the critical period.

The tributaries show different trends. On the Stanislaus River, Alternative 7 generally results in the highest winter flows and Alternative 2 results in the lowest winter flows in each period of analysis (Table VI-26 and VI-27). Alternative 5 results in the lowest flows in June and July and Alternative 7 results in the lowest flows in August and September for both periods. In the 73-year period analysis, Alternatives 2 and 8 result in the highest flows during the pulse flow period of April and May, and Alternatives 7 and 8 result in the highest flows in June and July. For the critical period analysis, Alternative 2 results in the highest flows during the pulse flow period of April and May while Alternative 6 provides the lowest.

For the Tuolumne River (Tables VI-28 and VI-29), Alternative 5 results in the highest flows in April, May, July, August and October, and the lowest flows from November through March in the 73-year period analysis. Alternatives 3 and 4 provide the greatest increase in flow in June for both periods of analysis. For the critical period analysis, most of the monthly river flows for the alternatives are equal to or better than the base case flows. Alternative 5 provides the highest flows in eight months including most of the summer months. Table VI-29 shows that during the pulse flow period of April through May, Alternative 7 flows are less than the base case even though releases are made from New Don Pedro Reservoir in accordance with the Letter of Intent. This is an artifact of the way FERC flows on the Tuolumne River were modeled in Alternative 7 rather than a result of the Letter of Intent.

For the Merced River in the 73-year period analysis, Alternatives 2 and 6 have the highest flows from November through February with flows equal to the base case (Table VI-30). This trend is also apparent in the critical period (Table VI-31) although some other alternatives also have flows equal to the base case during this period. From March to September in the 73-year period analysis, Alternatives 3, 4, and 5 provide the highest flows depending on the month. Alternative 5 provides the lowest flows from through the fall and winter months. In the critical period, Alternative 5 provides the highest flows from March through May, and in July and September. Alternatives 3 and 4 provide the highest flows in June and August.

2. Water Temperature

The effects of changes in flow on water temperature in upstream areas were analyzed to evaluate potential effects on habitat for fish and aquatic resources. The water temperature model developed by the USBR (USBR 1990, 1993, 1997d; described in Chapter IV) was used to assess the effects of the flow alternatives on water temperature in four major streams in the Sacramento-San Joaquin River system, the Sacramento, Feather, American, and Stanislaus rivers. Monthly project operations, modeled with DWRSIM, were input to the temperature model for the 72-year hydrologic period of record (1922-93). The model was used to predict mean monthly water temperatures at eight to twelve locations on each stream.

The following sites were selected for detailed analysis of temperature effects:

- Sacramento River – Below Keswick Dam, Ball's Ferry, Jelly's Ferry, and Vina
- Feather River – Downstream of the Afterbay, Honcut Creek, and Mouth
- American River – Below Nimbus Dam, Watt Avenue, and Mouth
- Stanislaus River – Below Goodwin Dam, Orange Blossom Bridge, and Mouth

Representative water years were selected for analysis from the period of record for wet, above normal, below normal, dry, and critical water year types. Representative years selected were years closest to the median monthly temperature values for each water year type over the period of record. For the Sacramento River system, water years 1942, 1928, 1979, 1964, and 1992, respectively, were selected to represent the five water year types. For the Stanislaus River, water years 1980, 1963, 1950, and 1976 were selected to represent wet, above normal, below normal, and critical water year types, respectively. Dry water years were not analyzed for the Stanislaus River because no impacts were identified in other water year types.

Predicted mean monthly water temperatures for the above-described stations and water years are shown in Volume 2, Appendix 5.

The precision of the model was estimated at approximately ± 1.0°F between the alternatives (J. Rowell, personal communication). In this analysis, water temperatures predicted for Flow Alternatives 2 through 8 were compared with values predicted for Alternative 1 (base case) for each location and representative water year. Predicted temperatures for Flow Alternatives 2 through 8 within 1.0°F of those predicted for the base case were considered within the error of model predictions.

a. Sacramento River. Water temperatures predicted under the flow alternatives were not different from those predicted for the base case at any location in wet, above normal, or below normal water years. In dry years, predicted temperatures in September were approximate 1-3°F higher under Alternatives 2, 5, and 6 than in the base case at most locations. In critical years, predicted temperatures in the late summer to early fall (August, September, or October) were approximately 1-3 °F higher under Alternatives 2, 3, 4, 6, and 8 than in the base case at most locations.

These differences are related directly to changes in carryover storage at Shasta Reservoir. In dry and critical years, carryover storage is reduced under Alternatives 2 through 8 compared to the base case, resulting in slightly elevated water temperatures in the late summer/early fall period.

These modeled temperature differences due to implementation of the flow alternatives are unlikely to result in significant impacts to fishery resources. SWRCB Order WR 90-5 specifies temperature objectives for the mainstem Sacramento River. Temperature criteria also have been established for the protection of winter-run chinook salmon spawning, egg incubation, and rearing in the mainstem Sacramento River in the biological opinion for the operation of the CVP and SWP (NMFS 1993). The Sacramento River Temperature Task Group, consisting of representatives from the SWRCB, USBR, USFWS, WAPA, USACOE and NMFS, meets on a regular basis during the temperature control season (May through October). Typical discussions include an assessment of the temperature control operations and forecast of operations for the remainder of the season. Operational adjustments are made on a real-time basis to reduce temperature impacts on winter-run chinook salmon and other species. Operation of the temperature control device at Shasta Dam is increasing the ability to control water temperatures for anadromous fish protection in the mainstem Sacramento River.

b. **Feather River**. Predicted water temperatures in a wet water year were similar to or lower under the flow alternatives than in the base case, except for the Honcut Creek site, where temperatures in July under Alternative 5 were predicted to be approximately 3°F higher than in the base case. In an above normal water year, no adverse effects on water temperature were predicted under any flow alternative.

In a below normal year, water temperatures in August were predicted to be approximately 2.5°F higher under all of the flow alternatives, than in the base case. In a dry year, temperatures in April and May under the alternatives were predicted to be up to 2 °F higher than in the base case. In a critical water year, no adverse effects on water temperature were predicted under any of the flow alternatives.

These modeled water temperature increases in the lower river are not likely to result in significant impacts to fishery resources compared to the base case condition.

Fall and spring-run chinook salmon and steelhead spawn and rear in the lower Feather River. Fall-run chinook salmon typically emigrate from the lower river from January through March and therefore are not affected by elevated water temperatures. Spring-run chinook salmon spawn in the low flow channel from late August through October; steelhead rear in the low flow channel year-round.

Temperatures in the lower river are controlled through operation of a temperature control device. The DFG/DWR Hatchery Water Supply Temperature Agreement (August 26, 1983) established minimum and maximum criteria for temperatures at the intake to Feather River Hatchery at the Thermalito Diversion Dam. These requirements, in addition to providing suitable rearing temperatures at the hatchery, provide suitable temperature releases for coldwater species in the lower river.

The NMFS is currently completing evaluation of the short-term effects of operation of the CVP and SWP on steelhead trout and spring-run chinook salmon. A biological opinion will be issued in the near future which is likely to include water temperature conditions to protect spring-run chinook salmon spawning and steelhead rearing in the low flow channel of the Feather River.

c. American River. No adverse effects on water temperature were predicted under the flow alternatives in wet, above normal, and below normal water year types. Temperatures were similar to or lower under each of the flow alternatives compared to the base case condition.

In a dry water year, water temperatures were similar to or lower under the flow alternatives than in the base case, except in August, when predicted temperatures under Alternative 6 were approximately 3 °F higher than under the other flow alternatives and the base case. In a critical water year, predicted temperatures were approximately 3 °F higher in July under Alternatives 2, 3, 4, 6, and 8, and approximately 3 - 4 °F higher in August under all flow alternatives, than in the base case. These differences are due to changes in storage at Folsom Reservoir. In critical water years, reservoir storage would be lower under the flow alternatives than the base case, resulting in higher summer water temperatures.

These modeled water temperature increases in the lower river are not likely to result in significant impacts to fishery resources compared to the base case condition. This is true for the following reasons: 1) even under the base case condition, suitable habitat is not available year-round for all salmonid lifestages, 2) the model did not include real-time operational adjustments that are made to reduce water temperature impacts, 3) the model did not include the planned construction and operation of a multi-level release structure at Folsom Dam, which is expected to allow the release of cooler water in the late summer months.

Under the base case condition, warm summer and fall water temperatures on the lower American River have been identified as a limiting factor to juvenile steelhead rearing in the river (USFWS 1995). Water temperatures in the lower American River from July to October are commonly higher than optimum levels for survival of juvenile steelhead. In general, steelhead do not survive extended periods of warm water, and in many years move prematurely out of the American River to seek cooler water. High water temperatures have significantly limited natural steelhead production in the lower river (McEwan and Nelson 1991). Elevated temperatures in the late summer are also suspected to delay fall-run chinook spawning in the lower river and may impede reproductive success (USFWS 1995).

The temperature modeling assumed that no operational changes would be made to control temperatures in the lower river. However, the USBR, DFG, USFWS, and NMFS meet routinely to discuss operational changes to benefit fishery resources in the lower American River. Flow and water temperature needs for fisheries are taken into consideration for operations on a real-time basis. A temperature target of 65°F at Watt Avenue is used to protect juvenile steelhead rearing in the lower river. Operational adjustments are often made to reduce impacts on water temperatures in the late summer months of dry and critical water years.

In addition, the predicted effects on water temperature in the lower American River in July and August assume that no new facilities would be constructed. The planned construction and operation of a multi-level release structure at Folsom Dam is expected to permit the release of cooler water in the late summer and fall than was indicated by the model simulations.

The NMFS is currently completing evaluation of the short-term effects of operation of the CVP and SWP on steelhead trout. A biological opinion will be issued in the near future which is likely to include conditions to reduce adverse effects of water temperature on steelhead in the lower American River.

d. **Stanislaus River**. No adverse effects on water temperature were predicted under the flow alternatives in any water year type. In a wet water year, Alternative 8 is predicted to result in improved temperature conditions throughout the lower river for coldwater species. Water temperatures are higher in the winter (January/February) and lower in the spring (April, May and June) than under base case conditions. In other water years (above normal, below normal, and critical years), water temperatures under the alternatives are similar to or lower than temperatures under the base case.

3. Aquatic Habitat

The purpose of this section is to analyze the impact of the flow alternatives on aquatic habitat in the upstream areas of the Central Valley. Implementation of the Bay/Delta Plan will affect the operation of water supply projects by changing the timing and magnitude of reservoir releases. These operational changes can affect upstream aquatic habitat in rivers and reservoirs. The factors that affect species in these habitats are discussed in detail in Chapter V of the ER (SWRCB 1995; Appendix 1). The following sections describe the method of analysis and assess the effect of each of the flow alternatives on controllable factors compared to the base case.

a. **Rivers**.

Assessment Method. The Range of Variability Approach (RVA) developed by Richter et al (1997) was used to assess the impact of the flow alternatives on aquatic habitat in rivers in the Sacramento-San Joaquin system. This approach, described below, is based on aquatic ecology theory concerning the critical role of hydrologic variability, and associated characteristics of duration and timing, in sustaining aquatic ecosystems.

Native riverine species possess life history traits that enable individuals to survive and reproduce within a certain range of environmental variation. Many ecological attributes are known to shape the habitat templates that control aquatic species distribution and abundance. Natural hydrologic variation plays a major part in structuring the biotic diversity in river ecosystems as it controls key habitat conditions in the river channel; hydrologic variation is now recognized as a primary driving force in river ecosystems.

The RVA methodology provides an approach to translate this ecological theory to the establishment of streamflow targets based on the natural streamflow regime. Numerous flow characteristics are assumed to be important for the maintenance of riverine habitat and biological diversity, including: the seasonal pattern of flow, timing of extreme conditions, the frequency, predictability, and duration of floods, droughts, and intermittent flow, daily, seasonal, and annual flow variability, and rates of change.

The RVA method identifies annual management targets for regulated streams based on a characterization of ecologically relevant flow regime characteristics. The natural range of streamflow variation is characterized using a suite of 32 ecologically relevant hydrologic parameters calculated from the natural hydrology. Based on measures of central tendency (e.g. mean, median) and dispersion (e.g. range, standard deviation, coefficient of variation) calculated from the natural hydrology, management target ranges for each hydrologic parameter are identified. In the absence of detailed ecological information, the method recommends a target range of ± 1 standard deviation from the mean for each of the thirty-two hydrologic parameters. For those parameters where a skewed distribution results in a standard deviation that exceeds the minimum or maximum value, the actual minimum or maximum value is used as the lower or upper target range boundary.

The method then can be used to assess the relative suitability of alternate flow management scenarios by calculating the frequency that flows fall within the calculated target range.

Analysis of the Flow Alternatives. The Range of Variability Analysis method was used to assess the relative effects of the flow alternatives on stream ecosystems in the Sacramento-San Joaquin River system, at locations where estimates of unimpaired flow were available:

- Sacramento River near Red Bluff
- Feather River near Oroville
- American River at Fair Oaks
- San Joaquin River above Vernalis
- Stanislaus River at Melones Reservoir
- Tuolumne River at Don Pedro Reservoir
- Merced River at Exchequer Reservoir

Since estimated unimpaired flows were available only on a monthly time step, a subset of the 32 hydrologic parameters recommended in the RVA analysis was calculated for the available period of record (1922-1993). Hydrologic parameters used in the analysis are summarized in Table VI-32, and include the magnitude of monthly flows, the magnitude of annual extreme flow conditions, and the timing of annual extreme flow conditions.

From the estimated unimpaired flows, management targets were established for each of the flow parameters (± 1 standard deviation from the mean). For those parameters where a skewed distribution resulted in a standard deviation that exceeded the minimum or maximum value, the actual unimpaired minimum or maximum value was used as the lower or upper target range boundary.

Table VI-32

Summary of Hydrologic Parameters Used in the Stream Ecosystem Impacts Analysis

Flow Statistics Group	Regime Characteristics	Hydrologic Parameters
Magnitude of monthly flow conditions	Magnitude	Mean monthly flow
Magnitude of annual extreme flow conditions	Annual Extremes	Mean annual minimum and maximum monthly flow
Timing of annual extreme flow conditions	Timing	Month of annual minimum and maximum flow

Simulated flows for the period of record (1922-1993) for each of the flow alternatives (DWRSIM analysis) were then compared with flow target ranges to evaluate the relative suitability of the alternatives in meeting ecological objectives. For the flow simulations, locations from the DWRSIM analysis were selected that were closest to sites on each river where estimated unimpaired flow data were available. The rate of non-attainment of the flow management targets was calculated for each site and flow parameter.

Table VI-33 shows an example of the Range of Variability Analysis for the Stanislaus River at Melones Reservoir. Analyses for all sites are presented in Volume 2, Appendix 5.

Cases where flow parameters showed a greater than 10% deviation in the non-attainment rate between the flow alternatives and the base case are described below. In some cases, the difference in the rate of non-attainment showed a slight positive effect, moving closer to unimpaired conditions; in other cases, the difference showed a slight adverse effect, moving away from unimpaired conditions.

Sacramento River. No differences in the rate of non-attainment greater than 10% were observed between the flow alternatives and the base case in any of the flow parameters.

Feather River. In October, mean monthly flows simulated for Alternatives 2 through 8 were lower than in the base case, resulting in flows that are more similar to the unimpaired condition (more often falling within the target range for monthly flow magnitude). In January, mean monthly flows simulated for Alternatives 2 through 8 were lower than in the base case, resulting in a slight shift away from unimpaired conditions.

The magnitude of the annual 30-day maximum flow was increased in Alternatives 2 through 8 compared to the base case, resulting in maximum flows more similar to the unimpaired condition. The timing of the annual minimum flow was shifted later in the year in Alternatives 2 and 3 compared to the base case, resulting in timing more similar to unimpaired conditions.

American River. No differences in the rate of non-attainment greater than 10 percent were observed in monthly flow magnitude between the flow alternatives and the base case.

The timing of the annual minimum was more variable for Alternative 3, resulting in timing that was less similar to unimpaired conditions than the other alternatives and the base case. The timing of the annual maximum for Alternatives 2 through 8 was closer than the base case to unimpaired conditions.

San Joaquin River. In October, simulated mean monthly flows for Alternatives 2 through 8 are higher than for the base case, resulting in a shift away from unimpaired conditions. In March and April, simulated mean monthly flows for Alternative 6 are higher than in the base case, resulting in a shift toward unimpaired conditions.

Minor differences were observed in the magnitude and timing of the annual extremes at this site. For Alternative 8, the magnitude of the annual 30-day minimum was closer than the base case to unimpaired conditions. For Alternative 2, the timing of the annual 30-day minimum flow was closer than the base case to unimpaired conditions. For Alternatives 6 and 8, the timing of the annual 30-day maximum flow was closer than the base case to unimpaired conditions.

Although flow effects were not analyzed for the upper mainstem San Joaquin River below Friant Dam, it is evident that flow conditions there would not change under Flow Alternatives 2 through 4 and 6 through 8. Flow Alternative 5 would result in a substantial improvement in flow conditions below Friant Dam and a shift toward unimpaired conditions from the base case.

Stanislaus River. In October, simulated mean monthly flows for Alternatives 2, 4, 5, and 8 are higher than for the base case, resulting in a shift away from unimpaired conditions. In February, simulated mean monthly flows for Alternative 8 are higher than for the base case, resulting in a shift toward unimpaired conditions. In August, simulated mean monthly flows for Alternatives 2 through 8 are higher than for the base case, resulting in a shift away from unimpaired conditions.

The magnitude of the simulated annual 30-day minimum for Alternative 8 was higher than for the base case, and the annual 30-day maximum was lower, both resulting in a shift away from unimpaired conditions. The timing of the annual 30-day minimum was shifted later in the year in Alternatives 2, 4, and 5 compared to the base case, resulting in a shift away from unimpaired conditions. For Alternatives 3, 6, and 8, the timing of the annual 30-day minimum flow was closer than the base case to the unimpaired condition. The timing of the annual 30-day maximum flow was shifted later in the year or was more variable in Alternatives 3 and 6 compared to the base case, resulting in a shift away from unimpaired conditions. For Alternatives 2 and 5, the timing of the annual 30-day maximum flow was closer than the base case to unimpaired conditions.

Tuolumne River. In July, simulated mean monthly flows for Alternative 5 were higher than in the base case, resulting in a shift toward unimpaired conditions. The timing of the annual 30-day minimum and maximum was shifted later in the year in Alternative 5 compared to the base case and other flow alternatives, also resulting in a slight shift toward unimpaired conditions.

Table VI-33
Range of Variability Analysis Stanislaus River at New Melones Reservoir

	Unimpaired Conditions (1922 - 93)						Alternative 1					Alternative 2					Alternative 3				
			Range limits		RVA Target Range				Range limits		Rate of Non-			Range limits		Rate of Non-			Range limits		Rate of Non-
IHA Group 1	Mean	SD	Low	High	Low	High	Mean	SD	Low	High	Attainment	Mean	SD	Low	High	Attainment	Mean	SD	Low	High	Attainment
Monthly Flow Magnitude (cfs)																					
October	160	179	0	1,434	0	339	601	1,292	63	5,362	15%	565	1,060	0	5,362	44%	535	1,234	63	5,362	14%
November	475	878	34	6,162	34	1,353	381	466	198	3,360	3%	317	471	198	3,360	3%	341	475	198	3,360	3%
December	858	1,309	49	6,712	49	2,166	463	754	130	4,744	4%	317	653	130	4,744	3%	392	710	130	4,744	4%
January	1,178	1,354	49	6,240	49	2,533	651	949	130	4,918	7%	435	859	130	4,918	6%	599	976	130	4,918	7%
February	1,651	1,507	18	9,596	144	3,158	965	1,204	124	4,986	22%	576	923	124	4,969	29%	888	1,175	124	4,969	31%
March	2,003	1,229	212	6,696	775	3,232	544	988	130	5,292	85%	466	921	130	5,292	90%	527	989	130	5,292	86%
April	3,222	1,263	589	7,290	1,958	4,485	750	433	471	1,467	100%	1,120	630	471	3,243	92%	744	424	471	1,467	100%
May	4,558	2,247	717	9,694	2,311	6,805	449	328	255	2,067	100%	1,186	575	255	2,707	94%	443	325	255	2,067	100%
June	2,914	2,033	185	10,640	881	4,947	585	909	255	4,595	90%	687	651	255	4,595	85%	648	882	255	4,595	90%
July	836	807	0	4,659	30	1,643	352	244	265	2,231	1%	542	258	265	2,231	1%	475	243	265	2,231	1%
August	200	193	0	1,254	6	393	317	44	283	407	10%	563	122	283	702	88%	558	52	412	675	100%
September	108	113	0	640	0	221	264	102	249	1,110	100%	253	67	0	758	99%	256	62	249	774	100%
IHA Group 2																					
Mean Annual Extremes																					
Annual 30-day minimum	69	67	0	488	2	135	115	60	63	289	19%	120	81	0	631	14%	101	82	63	616	14%
Annual 30-day maximum	4,922	2,280	717	10,640	2,642	7,202	1,547	1,543	471	5,362	78%	1,759	1,179	478	5,362	83%	1,520	1,464	488	5,362	79%
IHA Group 3																					
Timing of Annual Extremes																					
Month of annual minimum	9	1	7	2	8	10.33	11	2	8	3	31%	11	2	5	3	53%	9	3	3	10	17%
Month of annual maximum	4	1	12	6	3	5.00	3	2	10	6	44%	5	2	1	10	28%	6	3	1	12	90%

	Alternative 4					Alternative 5					Alternative 6					Alternative 8				
			Range limits		Rate of Non-			Range limits		Rate of Non-			Range limits		Rate of Non-			Range limits		Rate of Non-
IHA Group 1	Mean	SD	Low	High	Attainment	Mean	SD	Low	High	Attainment	Mean	SD	Low	High	Attainment	Mean	SD	Low	High	Attainment
Monthly Flow Magnitude (cfs)																				
October	677	1,177	63	5,362	46%	627	1,109	63	5,362	43%	582	1,289	63	5,362	15%	418	456	125	1,501	29%
November	333	474	198	3,360	3%	326	472	198	3,360	3%	342	475	198	3,360	3%	451	416	208	1,501	13%
December	350	661	130	4,744	3%	339	660	130	4,744	3%	403	775	130	4,744	4%	463	484	208	3,187	1%
January	518	902	130	4,918	6%	476	880	130	4,918	6%	543	915	130	4,918	6%	473	571	146	3,487	3%
February	769	1,044	124	4,969	26%	672	953	124	4,969	26%	995	1,129	124	4,969	21%	621	724	146	4,825	1%
March	558	968	130	5,292	82%	525	947	130	5,292	85%	648	941	130	5,292	86%	533	851	146	6,502	85%
April	898	448	471	1,701	100%	1,068	505	471	2,572	97%	797	403	471	1,467	100%	1,124	396	475	1,591	100%
May	835	606	255	2,425	97%	1,022	528	255	2,484	99%	540	315	255	2,067	100%	1,196	572	455	3,837	96%
June	621	860	255	4,595	89%	607	770	255	4,595	88%	579	897	255	4,595	90%	971	1,073	241	8,460	78%
July	392	241	265	2,231	1%	390	240	265	2,231	1%	308	246	265	2,231	1%	575	271	255	2,545	1%
August	505	102	283	699	83%	482	102	283	699	76%	413	126	283	655	46%	506	150	268	684	72%
September	256	60	249	758	100%	256	60	249	758	100%	260	90	249	1,016	100%	270	100	224	1,067	100%
IHA Group 2																				
Mean Annual Extremes																				
Annual 30-day minimum	131	79	63	631	22%	129	79	63	631	22%	123	72	63	380	22%	218	83	125	635	82%
Annual 30-day maximum	1,743	1,348	471	5,362	81%	1,757	1,218	471	5,362	83%	1,590	1,487	471	5,362	78%	1,367	1,050	588	8,460	94%
IHA Group 3																				
Timing of Annual Extremes																				
Month of annual minimum	12	2	8	3	58%	12	2	8	3	58%	10	1	8	3	7%	9	2	3	10	17%
Month of annual maximum	6	3	1	10	47%	5	2	1	10	31%	5	3	1	12	64%	5	2	1	12	40%

Merced River. In October, simulated mean monthly flows for Alternative 5 were lower than in the base case, resulting in a shift toward unimpaired conditions. In February, simulated mean monthly flows for Alternatives 3 and 8 are lower than in the base case, resulting in a shift away from unimpaired conditions. Also in February, simulated mean monthly flows for Alternative 5 are higher than the base case, resulting in a shift toward unimpaired conditions. In July, mean monthly flows simulated for Alternatives 3 and 4 were lower than in the base case, resulting in a shift away from unimpaired conditions. Also in July, mean monthly flows simulated for Alternative 5 were higher than in the base case, resulting in a shift toward unimpaired conditions.

For Alternative 5, the magnitude of the annual 30-day maximum flow was shifted away from unimpaired conditions. However, the timing of the annual 30-day maximum flow for Alternative 5 was shifted toward unimpaired conditions.

In conclusion, the differences among the flow alternatives in the rate of non-attainment of the target ranges are minor. Rates of non-attainment are high in some months for all of the flow alternatives, since the pattern of regulated flow releases in the system differs significantly from the unimpaired condition. However, the pattern of non-attainment of the target ranges is generally similar among the flow alternatives. No significant impacts on riverine aquatic habitat in upstream areas are therefore expected. No mitigation is required.

b. Reservoirs. Central Valley reservoirs are generally either warm water reservoirs or two-level reservoirs that contain a lower zone of well-oxygenated cool water in summer with an upper zone of warm water. Warm water reservoirs are suitable for black bass, sunfish, and catfish. Because of drawdowns, inshore zones inhabited by warmwater species are often unproductive. Likewise, the deep, open-water portion of large reservoirs does not provide satisfactory habitat for most game fish.

Large, low elevation, two-level reservoirs such as Shasta, Oroville, Pine Flat and Berryessa support warmwater fish such as bass, sunfish, and catfish in the upper zone and coldwater species such as trout in the lower zone. These reservoirs provide greater fishing diversity than warm water reservoirs, although drawdowns limit species dependent on shallow water habitat, such as black bass and sunfish (USBR 1997a).

In general, reservoirs with shallow average water depths are more productive than reservoirs with greater average water depths. Optimal conditions for juvenile fish growth and survival are found in shallow water habitats. Maximum reservoir productivity is therefore assumed to occur with stable reservoir water surface elevations that maximize the surface area of shallow water habitat.

Factors Affecting Reservoir Fish. Reservoir surface area, reservoir morphology and water level fluctuations play an important role in productivity of reservoir fish populations. At high reservoir surface elevations, the physical habitat available for fish increases and the diversity and quality of the habitat is generally improved. Higher reservoir elevations typically provide greater surface area, shoreline, spawning opportunities, cover, and habitat diversity resulting in larger populations and more diverse fish communities. Reductions in reservoir storage and associated reductions in water elevation during critical time periods can adversely affect reservoir fisheries by affecting the quality and quantity of important shallow water habitat available for sensitive life stages. Water level fluctuation was the most frequently cited factor affecting fish production in the Central Valley Fish and Wildlife Management Study (Leidy and Meyers 1984). Extreme fluctuations are arguably the most significant controllable environmental factor affecting populations of warmwater fish in reservoirs, and are a direct result of reservoir management priorities (USBR 1997a).

Another important variable affecting reservoir fish productivity is fluctuating water surface elevation (i.e. reservoir drawdown and filling). When lake levels drop, juvenile fish are often forced into areas with less cover. Cover is important because it is typically correlated with food abundance and provides shelter from predation. Reservoir drawdowns limit fish production in multi-purpose reservoirs, especially if drawdown during the spring months is significant. Benefits of controlled reservoir drawdown include: increased availability of prey species, improved predator growth rates and revegetation of exposed shorelines (USBR 1997a; Lee and Paulsen 1989a).

Flooded terrestrial vegetation has been shown to be a factor in the development of strong year classes in fluctuating reservoirs (USBR 1997a). The upper area of the fluctuation zone is the most heavily invaded by terrestrial vegetation and is the least severely eroded by wave action. Flooded cover protects juvenile fish from predation and provides food sources during the summer and fall growing periods. Receding water levels can affect survival by exposing shoreline areas and leaving limited cover available for shelter of juvenile fish. Adverse impacts also include dewatering of nests and desiccation of eggs, disruption of spawning and nest-guarding areas, gradual loss of shoreline shelter due to erosion, reduction in food supplies, increased predation on nests and juvenile fish, and reduced habitat diversity. The degree of impact will depend upon the magnitude and timing of the drawdown, shoreline gradient, and amount and quality of habitat remaining inundated. Because vegetation density and encroachment along the shoreline of reservoirs is different for every reservoir and changes from year to year, an assumption for this analysis is that the juvenile habitat is best when the reservoir is at or near maximum pool elevation.

Central Valley reservoirs include a number of warmwater fish species. A major goal of reservoir fishery management is to provide quality black bass (*Micropterus spp*.) fishing for anglers. Black bass are found in numerous reservoirs and the Sacramento-San Joaquin Delta (DFG 1995). The black bass species most sensitive to reservoir water level fluctuations is the largemouth bass, *Micropterus salmoides*. Largemouth bass are one of the most popular warmwater game fish in California (USBR 1997a). Since largemouth are the most sensitive of the bass to water level fluctuations, this assessment of the impacts of changes in reservoir operations on warmwater fish in Central Valley reservoirs is based on the sensitive life history requirements of this species. Largemouth bass are therefore an indicator species in this analysis for other warmwater species, such as smallmouth bass, bluegill, crappie and sunfish. Analysis of effects on largemouth bass will provide a conservative (worst case) estimate of potential impacts of the proposed alternatives on all reservoir fishery resources. Largemouth bass was also used as an indicator species for the reservoir impact assessment in the CVPIA PEIS (1997). Because dams in the Central Valley preclude access to anadromous fish, the AFRP does not make recommendations regarding reservoir aquatic habitat.

The most critical periods for largemouth bass are the adult spawning period in the spring and early rearing period of juveniles in the spring and summer months. Largemouth bass spawning begins when water temperatures reach and exceed approximately 60°F. Although the initiation of spawning will vary between reservoirs depending on the latitude, elevation and size of the reservoir, the majority of the largemouth bass spawning probably occurs from March through May in California waters. The maximum depth of largemouth bass spawning reported or observed in California reservoirs was 7.2 feet and, based on the literature, could range from 3.2 to 13.1 feet. Stable or rising water levels during the spring spawning season have been associated with strong year classes of largemouth bass (Lee and Paulsen 1989a).

Methods of Analysis. The purpose of the analysis is to determine the effect of implementing the flow alternatives on upstream fisheries using largemouth black bass as an indicator species. Modeled end-of-month elevations for eight major reservoirs are used to determine the potential quality of reservoir fishery habitat for each flow alternative. Scoring criteria were developed to evaluate the suitability of the reservoir elevation for spawning and rearing of largemouth bass. The months considered in this analysis are March through September, the most sensitive time period for black bass (Lee and Paulsen 1989a and 1989b; Lee, D. pers. comm. March 1997). Scoring criteria in this analysis are based on the findings of the DFG (Lee and Paulsen 1989a and 1989b).

The following eight major reservoirs were selected for this analysis: Shasta, Oroville, Folsom, New Melones, New Don Pedro, Lake McClure, Millerton Lake and San Luis. Striped bass is the dominant species in San Luis Reservoir, however, San Luis also has largemouth bass. Millerton Lake has Alabama spotted bass, *Micropterus punctulatus punctulatus*, which nest in deep water, with no shallow water spawning bass (i.e., largemouth or smallmouth bass). The remaining reservoirs contain varying percentages of large- and smallmouth bass species (Lee, D. pers. comm. March 1997) as shown in Table VI-34. Although water elevation fluctuations may not affect the spotted and striped bass, the analysis characterizes reservoir operations in the spring and summer months and indicates relative potential impacts to warmwater aquatic species.

There are two critical factors that influence spawning habitat conditions: (1) starting elevation and (2) change in reservoir elevation during the spawning season. Stable and maximum pool levels are preferable for fry and juveniles that rear primarily in nearshore, shallow areas. Year class sizes may be large if rearing conditions are favorable even if spawning conditions were poor (Lee, D. pers. comm. March 1997). Therefore, in this analysis, each month is scored by: (1) the water surface elevation relative to maximum pool at the beginning of the month[2] and (2) the change in elevation during that month. These two scores are summed for the months of concern, March through September. The summed scores are then multiplied together to arrive at a reservoir habitat index value.

[2] The water surface elevation is actually the end-of-period elevation for the previous month. In other words, the elevation in the beginning of June is actually the elevation at the end of May.

Stable or rising water levels are considered to be preferred conditions for bass spawning. The maximum pool elevation for a given reservoir was given the highest score of six, and every decreasing increment of five feet was given a decreasing score down to one at greater than 20 feet below maximum pool. If a reservoir water level in the current month rose or remained stable, it was also given the highest rank of six. The scoring for lower reservoir levels during the spawning season was based on five-foot increments. A decrease in water surface elevation of five feet would be ranked five, a decrease of ten feet would be ranked four, and so on. A decrease greater than 20 feet in one month is given a score of one. Because reservoirs draw down in the summer, maximum potential habitat scores do not occur.

Table VI-34
Species Composition of Black Bass in Selected Reservoirs

Reservoir	Largemouth Bass %	Smallmouth Bass %	Spotted Bass %
Shasta	10	10	80
Oroville	5	15	80
Folsom	33	33	33
New Melones	100	0	0
New Don Pedro	100	0	0
McClure	15	5	80
Millerton	0	0	100
San Luis	0[1]	0	0

[1] Striped Bass Dominate (Lee, D. pers comm March 1997)

The results of the habitat analysis are shown in Tables VI-35 and VI-36. The higher the index, the better the quantity and quality of habitat. The best habitat conditions are predicted for Flow Alternative 5 for the major Sacramento River reservoirs, Shasta, Oroville, and Folsom, as indicated by both the 73-year average indices and the dry-year average indices. However, the poorest habitat conditions are predicted for Flow Alternative 5 for the major non-project reservoirs on the San Joaquin River system, New Don Pedro, Lake McClure, and Millerton, for both the 73-year average and dry-year averages. The best habitat conditions are predicted for Alternative 7 for New Melones Reservoir over the 73-year average; conditions predicted for Alternative 2 are the poorest. Alternative 5 is the preferred alternative during the critical period. Overall, given the small (<4%) difference between the lowest (Alternative 5) and highest (Alternative 7) of the summed index scores, and limitations of the model as discussed above, there is no significant difference among the alternatives in the summed scores across all eight reservoirs. Therefore, using this scoring system for comparative analysis, an overall preferred alternative with respect to reservoir aquatic habitat quality cannot be identified.

Table VI-35

73-Year Period Average Reservoir Habitat Index

Reservoir	Alt 1 (Base)	73-Year Period Average Index - Difference from the Base Case						
		Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
Shasta	459	0	4	4	15	-18	-16	-2
Oroville	388	-4	1	1	44	-5	-14	-11
Folsom	438	-11	-7	-8	8	-31	-21	-10
New Melones	298	-45	-13	-26	-1	-4	40	15
New Don Pedro	358	0	-19	-18	-44	0	2	-8
McClure	387	0	-21	-7	-93	0	-4	-20
Millerton	329	0	0	0	-45	0	0	0
San Luis	265	21	24	24	28	55	37	10
Sum Total	2,922	-39	-32	-31	-44	-4	24	-24

Table VI-36

Critical Period Average Reservoir Habitat Index

Reservoir	Alt 1 (Base)	Critical Period Average Index - Difference from the Base Case						
		Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
Shasta	202	0	1	0	5	-5	1	-1
Oroville	184	4	9	7	41	5	6	6
Folsom	250	-27	-41	-42	-7	-22	-35	-23
New Melones	219	-40	-4	-24	10	4	-2	-21
New Don Pedro	229	0	-14	-34	-34	-6	1	-4
McClure	288	0	-5	-3	-69	0	0	-29
Millerton	194	0	0	0	4	0	0	0
San Luis	191	-14	-7	-8	0	4	22	16
Sum Total	1,757	-77	-61	-104	78	-20	-7	-87

Modeled reservoir elevations can be expected to have a margin of error of approximately 10 to 20 percent. Therefore, differences between the base case and the various alternatives for individual reservoirs are considered significant only if the indices are more than 10 percent different than the index for the base case.

Over the 73-year period, significant adverse impacts to habitat in New Melones Reservoir occur under Alternative 2 compared to the base case (15 percent difference). Predicted habitat indices are significantly lower for New Don Pedro Reservoir, Lake McClure and Millerton Lakes under Alternative 5 (12 percent, 24 percent and 14 percent, respectively).

Over the critical period, predicted habitat indices for Folsom Reservoir are significantly lower under Alternatives 2 (11 percent), 3 (16 percent), 4 (17 percent) and 7 (12 percent). Indices for New Melones Reservoir are significantly lower under Alternatives 2 (18 percent) and 4 (11 percent). Significant adverse impacts occur at New Don Pedro under Alternatives 4 and 5 (15 percent each), and at Lake McClure under Alternative 5 (24 percent).

Mitigation. The implementation of the flow alternatives may result in significant impacts to reservoir fisheries at one or more reservoirs, depending on the alternative selected. These impacts are generally temporary and mitigable. If significant effects on reservoir fish populations are observed, mitigation could include additional fish planting, habitat improvement through planting of shoreline vegetation, addition of habitat structures, or improved management of shoreline grazing practices.

4. Vegetation and Wildlife

Implementation of the flow alternatives may result in impacts to vegetation and wildlife resources upstream of the Delta. Changes in reservoir operations may affect reservoir water levels and resulting downstream flows. Changes in reservoir water levels could affect the amount of riparian vegetation in the drawdown zone and the amount of reservoir habitat available to wildlife species. Changes in downstream flows may affect the maintenance and regeneration of riparian and wetland vegetation and its associated wildlife. Reductions in water supply could affect wetland habitat at wildlife refuges and privately owned duck clubs.

This analysis of impacts on vegetation and wildlife focuses on potential changes in habitat rather than populations of individual species. Wildlife populations may be affected by factors beyond the control of the SWRCB and appropriate analytical tools are not available for many potentially impacted species (USBR 1997c). Four general categories of habitat are considered: (a) wetland and riparian habitats which would be affected by changes in river hydrology, (b) riparian vegetation within reservoir drawdown zones, (c) aquatic habitats used by waterfowl species at reservoirs, and (d) wetland habitat at wildlife refuges and duck clubs. Impacts to the first three categories of habitats are assessed by considering: (1) the changes in modeled river stage and (2) the changes in modeled reservoir operations. This analysis is based on the methodology developed by the CVPIA for analyzing the effects on vegetation and wildlife. Modeling studies assume that no agricultural farmland is fallowed to obtain water to meet the flow objectives and that cropping patterns in the Central Valley remain unchanged. Hence, impacts to agricultural and terrestrial habitats are not assessed by means of hydrologic modeling. However, the potential for changes to occur in wetland habitat at wildlife refuges and private duck clubs was considered based on the likelihood of water supplies being reduced through the implementation of the 1995 Bay/Delta Plan.

a. Impacts on Riparian Vegetation and Riparian Wetland Habitats. The condition of riparian vegetation and wetland habitat in the riparian zone of major rivers was assessed using simulated river water surface elevation (stage) at representative locations. Average monthly stage was calculated for the base case and each alternative for average, wet and dry year conditions[3]. Differences among alternatives are expressed as a percent change from the base case. Drought represented by low summer stages, and inundation mortality (high stages year-round) are considered to be the major impact mechanisms. Adequate spring and summer stages are considered critical for habitat maintenance; fall and winter water levels are relatively less important. Due to the nature of the hydrologic input data and the use of average monthly operations, modeled surface water elevations may be expected to have a margin of error of plus or minus 10 to 20 percent. Therefore, differences between alternatives are considered to be significant only if greater than 20 percent in a detrimental direction (USBR 1997b).

Simulated river flows obtained from DWRSIM, expressed in cubic feet per second, are converted to stage using the general relationship:

$$\text{Gage Depth} = (\text{Coefficient}) \times (\text{Flow}^{\text{Exponent}})$$

Coefficients and exponents were developed by the CVPIA for each gage location using historic data and non-linear regression techniques. The location of river stage gages and other relevant information are listed in Table VI-37 (USBR 1997d).

Results of the analysis are contained in Tables VI-38 through VI-43. Values that exceed the 20 percent significance threshold are indicated in bold type and in bold italics if the impact is negative.

On the lower Sacramento River at Verona (Table VI-39), beneficially higher stages are predicted in June of dry years under Alternatives 2, 6, 7 and 8. Likewise, beneficially higher flows are expected at Verona under Alternative 5 during the December to June period of dry years. Reduced river stages are expected in wet years at Verona under Alternative 5 between December and May, exceeding the significance threshold in February, April and May. Significantly reduced river stages are expected on the Feather River under Alternatives 5, 7 and 8 in May of dry years, and under Alternative 5 in August of wet years (Table VI-40). Significantly higher river stages are expected at Gridley during dry conditions in June under all alternatives except Alternative 5. On the American River (Table VI-41), dry year stages are significantly higher for Alternatives 2, 6 and 8 in June and for Alternatives 2 through 6 in September.

[3] "Wet" years are the average of wet and above normal years as defined in the 1995 Bay/Delta Plan for the Sacramento and San Joaquin river basins. "Dry" years are the average of below normal, dry, and critically dry year types.

Table VI-37
Information Used for Estimation of River Stage

Stream Reach	Gage Location	DWRSIM Nodes	Coefficient	Exponent
American River	Fair Oaks	CP09 dsf	0.110	0.460
Feather River	Gridley	CP106 dsf	0.027	0.587
Upper Sacramento R.	Bend Bridge	CP74 dsf	0.020	0.630
Lower Sacramento R.	Verona	CP43 dsf minus CP64 dsf minus CP43 local inflow	0.016	0.678
Upper San Joaquin R.	Newman	CP695 dsf plus CP704 div plus CP762 div	0.400	0.400
Lower San Joaquin R.	Vernalis	CP682 dsf	0.130	0.500

Note: dsf = downstream flow, div = actual diversion

On the upper San Joaquin River, Alternative 5 produces dramatically improved river stage conditions at Newman (Table VI-42) between April and August of all year types and in March of dry years. In dry years, Alternatives 3, 6 and 8 enhance the upper San Joaquin River during the April-June time period. In the lower San Joaquin River basin, significantly higher river stages are expected at Vernalis (Table VI-43) in dry years from May to July for Alternatives 3 and 4, and from April to July for Alternative 5 under all water year conditions. The additional river flow expected in Alternative 5 would enhance San Joaquin River riparian habitat from Friant Dam to the Delta. Alternatives 3, 6 and 8 would enhance the river from the confluence with the Merced River to the Delta.

Reduced river stages predicted at Verona occur during wet years and therefore would not have a significant adverse impact to riparian habitat. Periodic high flows are needed by riparian vegetation to promote regeneration. Peak river stages are unaffected by any of the flow alternatives (see Table VI-46). Lower river stages are predicted on the Feather River in dry years and therefore are presumed to be detrimental. Exceedances range from 0.1 to 3.6 percent higher than the 20 percent criteria for significance and occur in only one month for each of the affected alternatives. The differences are small enough that riparian vegetation would adjust to the new flow regime without specific mitigation.

Table VI-38
Sacramento River at Red Bluff Vegetation Impact Analysis

73-Year Average Monthly River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	5.3	6.0	7.2	8.1	9.0	8.2	7.0	6.8	7.0	7.7	6.8	4.9

Percent Change in Average Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	0.5	1.7	0.0	-0.6	0.6	0.9	0.1	-1.1	6.5	-2.7	-4.2	0.1
Alt 3	1.0	2.5	0.4	-0.4	0.8	1.0	0.2	-1.2	5.4	-3.8	-4.4	0.5
Alt 4	1.0	2.5	0.4	-0.4	0.8	0.9	0.2	-1.2	5.5	-3.7	-4.4	0.4
Alt 5	2.9	4.4	1.3	0.7	1.5	1.7	0.0	-2.1	4.0	-7.3	-4.3	0.9
Alt 6	0.8	0.0	-1.1	-1.1	-0.5	0.2	0.2	-1.6	9.2	-2.3	-2.9	3.1
Alt 7	-0.5	0.0	-0.5	-1.0	0.1	1.1	2.2	-2.5	8.7	-2.7	-3.5	0.0
Alt 8	0.7	1.3	0.0	-0.6	1.2	0.8	-0.5	-1.4	6.8	-2.5	-4.3	0.6

Average Monthly Dry Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	5.1	5.4	5.5	5.8	6.6	6.1	5.8	6.1	6.7	7.5	6.7	4.4

Percent Change in Dry Year Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	0.0	2.5	-0.4	-0.9	2.1	2.3	-0.8	-2.0	9.9	-0.9	-6.6	-1.8
Alt 3	0.4	3.1	0.1	-0.7	2.3	2.5	-0.6	-2.1	8.0	-2.1	-6.8	-1.5
Alt 4	0.4	3.0	0.1	-0.7	2.3	2.5	-0.6	-2.1	8.1	-1.9	-6.9	-1.6
Alt 5	2.7	3.7	1.3	0.6	3.0	3.5	-0.5	-3.6	4.8	-6.5	-6.6	-1.8
Alt 6	0.6	1.9	-1.1	-1.5	0.3	0.8	-0.6	-3.2	14.0	-0.6	-5.9	3.0
Alt 7	-1.2	1.0	-0.9	-1.4	1.5	2.7	2.2	-3.5	12.8	-1.3	-5.5	-1.8
Alt 8	0.0	2.1	-0.3	-0.9	2.9	2.1	-1.3	-2.8	11.0	-0.7	-6.7	-1.1

Average Monthly Wet Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	5.7	6.8	9.5	11.2	12.3	10.9	8.6	7.8	7.3	8.0	6.9	5.6

Percent Change in Wet Year Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	1.2	0.8	0.3	-0.4	-0.4	-0.2	0.9	-0.2	2.3	-5.0	-1.0	2.1
Alt 3	1.7	1.9	0.7	-0.1	-0.2	-0.1	0.9	-0.2	2.2	-6.1	-1.1	2.6
Alt 4	1.7	1.9	0.6	-0.1	-0.2	-0.2	0.9	-0.2	2.2	-6.0	-1.1	2.6
Alt 5	3.1	5.2	1.3	0.7	0.4	0.3	0.4	-0.6	3.0	-8.3	-1.1	3.6
Alt 6	1.1	-1.9	-1.1	-0.9	-1.0	-0.2	0.8	0.2	3.2	-4.5	1.2	3.3
Alt 7	0.3	-1.0	-0.2	-0.7	-0.9	0.0	2.2	-1.4	3.7	-4.5	-0.8	1.9
Alt 8	1.6	0.5	0.3	-0.4	0.0	-0.1	0.3	0.1	1.5	-4.8	-1.0	2.4

Table VI-39

Sacramento River at Verona Vegetation Impact Analysis

73-Year Average Monthly River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	9.1	9.8	12.2	15.5	17.4	16.9	12.2	10.7	9.5	9.7	8.5	7.9

Percent Change in Average Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-3.2	0.3	-1.7	-1.5	0.5	0.6	1.0	-2.2	11.6	5.1	-8.6	-1.2
Alt 3	-2.4	1.2	-1.2	-1.2	0.7	0.7	1.2	-2.3	9.3	3.7	-8.5	-1.2
Alt 4	-2.5	1.1	-1.3	-1.2	0.7	0.6	1.2	-2.3	9.4	3.8	-8.5	-1.2
Alt 5	-0.4	4.4	0.9	0.1	2.1	2.2	2.2	-0.6	11.1	0.0	-6.8	1.1
Alt 6	-2.9	-0.3	-2.8	-1.7	-0.1	0.3	0.8	-2.7	13.8	5.8	-6.9	1.0
Alt 7	-3.8	-1.0	-2.6	-2.0	-0.1	0.8	4.1	-4.5	13.6	5.9	-7.6	-1.2
Alt 8	-3.6	-0.2	-2.3	-1.7	0.9	0.6	0.0	-3.1	11.8	6.6	-6.0	-0.6

Average Monthly Dry Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	8.7	8.6	9.5	11.5	13.2	12.5	8.6	5.0	7.9	9.2	8.5	7.0

Percent Change in Dry Year Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-4.6	1.1	-2.2	-1.8	1.7	1.7	1.3	-7.6	**21.3**	7.6	-9.6	-3.3
Alt 3	-3.9	1.7	-1.8	-1.6	2.0	1.7	1.7	-7.9	17.4	6.0	-9.5	-3.7
Alt 4	-3.9	1.6	-1.8	-1.6	2.0	1.7	1.7	-7.8	17.7	6.1	-9.5	-3.7
Alt 5	0.7	9.4	**23.6**	**26.8**	**33.2**	**29.7**	**39.4**	**37.0**	**32.4**	5.4	-8.0	7.8
Alt 6	-4.0	1.4	-2.4	-1.9	0.9	1.0	0.7	-8.8	**25.3**	8.4	-8.7	0.2
Alt 7	-5.3	-0.2	-3.1	-2.3	1.2	2.1	6.9	-10.8	**23.7**	6.6	-9.4	-3.1
Alt 8	-4.8	0.7	-2.9	-1.9	2.3	1.4	-0.4	-9.4	**22.4**	8.8	-7.3	-2.6

Average Monthly Wet Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	9.6	11.5	15.9	20.9	13.3	22.7	16.8	14.4	11.6	10.5	8.5	9.0

Percent Change in Wet Year Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-1.6	-0.6	-1.3	-1.3	-0.4	-0.2	0.8	1.9	2.6	2.2	-7.1	1.0
Alt 3	-0.7	0.7	-0.8	-0.9	-0.3	-0.2	0.8	1.9	1.8	0.9	-7.1	1.4
Alt 4	-0.7	0.6	-0.9	-0.9	-0.3	-0.2	0.9	1.9	1.8	0.9	-7.2	1.4
Alt 5	-1.6	-0.6	-17.5	-19.8	***-21.7***	-18.3	***-24.2***	***-28.9***	-8.4	-6.5	-5.1	-5.9
Alt 6	-1.5	-2.1	-3.1	-1.6	-0.9	-0.2	0.8	1.9	3.3	2.8	-4.6	1.8
Alt 7	-2.0	-1.9	-2.2	-1.7	-1.0	-0.1	2.1	0.3	4.3	5.0	-5.1	0.9
Alt 8	-2.1	-1.1	-1.7	-1.5	-0.1	-0.1	0.3	1.7	2.1	4.1	-4.3	1.4

Table VI-40

Feather River at Gridley Vegetation Impact Analysis

73-Year Average Monthly River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	2.9	2.6	3.4	3.8	4.1	4.1	2.7	3.1	3.1	3.7	3.2	2.1

Percent Change in Average Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-12.8	-4.4	-7.2	-5.7	1.1	0.7	5.6	-3.3	15.5	17.3	-12.1	-6.6
Alt 3	-10.9	-3.1	-6.6	-5.2	1.4	0.4	6.1	-3.7	11.9	16.5	-11.6	-7.5
Alt 4	-11.0	-3.1	-6.7	-5.2	1.3	0.4	6.0	-3.6	12.1	16.5	-11.6	-7.4
Alt 5	-7.5	1.2	-2.6	-1.9	3.1	3.1	2.4	-7.7	4.3	7.1	-12.8	-1.4
Alt 6	-11.9	-1.9	-8.1	-5.3	1.3	0.7	3.7	-3.8	14.4	17.8	-11.6	-6.1
Alt 7	-12.4	-4.9	-9.0	-7.0	-0.1	1.2	14.3	-7.5	15.1	19.0	-11.2	-6.1
Alt 8	-14.5	-5.4	-9.4	-6.6	0.7	0.5	2.2	-5.8	15.5	**20.3**	-5.4	-5.3

Average Monthly Dry Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	2.8	2.4	2.8	2.6	2.7	2.6	1.9	2.6	2.7	3.8	3.4	2.1

Percent Change in Dry Year Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-16.2	-3.4	-7.4	-7.4	3.4	1.7	11.3	-16.7	**28.0**	16.4	-8.2	-8.6
Alt 3	-14.4	-2.7	-7.1	-7.3	4.4	1.4	12.7	-17.7	**23.3**	15.6	-7.4	-10.4
Alt 4	-14.5	-2.8	-7.1	-7.3	4.4	1.4	12.5	-17.3	**23.8**	15.5	-7.3	-10.2
Alt 5	-9.6	1.9	-5.4	-5.7	7.4	6.3	4.8	***-23.6***	16.1	12.7	-6.0	-7.6
Alt 6	-15.0	-0.4	-6.5	-6.3	5.1	2.2	6.7	-16.7	**26.3**	17.2	-7.5	-7.8
Alt 7	-15.9	-3.9	-9.3	-8.5	1.9	3.7	**29.1**	***-22.3***	**25.5**	15.1	-9.9	-7.7
Alt 8	-17.1	-3.9	-10.4	-8.2	2.9	0.7	4.8	***-20.1***	**27.7**	18.4	-2.3	-7.3

Average Monthly Wet Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	2.9	2.9	4.3	5.4	6.1	6.1	3.8	3.9	3.5	3.4	3.0	2.2

Percent Change in Wet Year Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-8.4	-5.5	-7.0	-4.6	-0.2	0.1	1.8	8.7	2.4	18.7	-18.2	-4.1
Alt 3	-6.4	-3.6	-6.2	-3.8	-0.3	-0.2	1.7	8.6	-0.2	17.9	-18.1	-3.9
Alt 4	-6.3	-3.5	-6.4	-3.8	-0.6	-0.1	1.8	8.7	-0.3	17.9	-18.3	-3.8
Alt 5	-4.7	0.5	-0.1	0.5	0.6	1.3	0.8	6.5	-8.3	-1.3	***-23.4***	6.4
Alt 6	-7.8	-3.7	-9.5	-4.7	-0.9	-0.1	1.7	7.6	1.8	18.8	-18.0	-4.0
Alt 7	-7.9	-6.1	-8.8	-6.1	-1.3	-0.3	4.4	5.6	4.1	**24.8**	-13.2	-4.1
Alt 8	-11.2	-7.1	-8.6	-5.5	-0.5	0.4	0.5	6.9	2.6	**23.0**	-10.3	-2.8

Table VI-41
American River at Natoma Vegetation Impact Analysis
73-Year Average Monthly River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	3.7	3.9	4.4	4.7	5.1	4.7	4.6	4.3	4.8	4.6	4.1	3.3

Percent Change in Average Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-4.5	-1.1	-4.6	-2.9	-0.5	1.0	0.3	2.0	11.3	-5.3	-7.9	7.3
Alt 3	-4.2	-0.7	-3.8	-1.8	0.0	1.3	0.0	2.3	10.0	-5.4	-8.7	10.6
Alt 4	-4.2	-0.7	-4.0	-1.9	0.0	1.6	-0.1	2.1	10.2	-5.4	-8.7	10.4
Alt 5	2.3	1.6	-1.5	-0.3	1.0	1.9	-2.4	-0.2	7.4	-8.6	-5.4	13.4
Alt 6	2.7	-3.4	-7.0	-4.4	-2.6	-0.5	0.3	3.0	13.0	-4.3	-6.4	13.9
Alt 7	4.3	-2.6	-4.9	-3.3	-0.4	1.5	2.6	-0.1	12.7	-4.2	-8.6	8.5
Alt 8	3.9	-1.3	-4.3	-2.7	0.1	1.0	-0.7	1.6	11.5	-4.8	-7.6	9.6

Average Monthly Dry Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	3.6	3.6	3.7	3.6	4	3.8	3.8	3.5	4.1	4.5	3.9	2.5

Percent Change in Dry Year Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-2.4	-0.5	-6.6	-5.5	-1.0	2.2	0.0	3.6	**20.8**	-4.7	-14.7	**21.0**
Alt 3	-2.0	0.0	-5.0	-4.2	-0.1	2.8	-0.7	4.2	18.1	-3.9	-16.1	**20.8**
Alt 4	-2.0	-0.3	-5.4	-4.6	-0.1	3.4	-1.0	3.7	18.6	-4.1	-16.0	**20.5**
Alt 5	-0.6	2.5	-2.6	-0.9	1.9	3.9	-5.2	-0.6	12.5	-7.2	-11.0	**25.5**
Alt 6	0.5	-1.2	-8.5	-8.1	-5.8	-1.0	-0.2	5.3	**23.2**	-3.9	-14.1	**28.4**
Alt 7	0.2	6.7	4.3	7.4	5.5	3.6	-3.9	-0.7	4.2	-16.1	-18.9	17.8
Alt 8	-1.9	-0.1	-6.1	-4.9	-0.2	2.1	-1.7	2.6	**21.7**	-4.1	-14.3	19.5

Average Monthly Wet Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	3.8	4.3	5.3	6.2	6.7	5.9	5.6	5.4	5.6	4.8	4.4	4.4

Percent Change in Wet Year Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-7.2	-1.8	-2.7	-0.9	0.0	-0.1	0.7	0.7	1.9	-5.9	0.3	2.1
Alt 3	-7.1	-1.4	-2.6	0.1	0.0	0.0	0.7	0.7	1.9	-7.2	0.2	2.8
Alt 4	-7.1	-1.3	-2.7	0.2	0.0	-0.1	0.7	0.7	1.9	-7.2	0.2	2.8
Alt 5	-4.5	0.5	-0.6	0.2	0.3	0.0	0.2	0.2	2.4	-10.5	1.4	4.3
Alt 6	-7.0	-5.9	-5.6	-1.5	-0.1	-0.1	0.7	1.0	2.9	-4.9	2.9	2.8
Alt 7	-8.2	-4.2	-3.2	-0.8	0.1	-0.1	1.7	0.1	2.8	-5.1	-0.2	1.9
Alt 8	-6.5	-2.7	-2.5	-1.0	0.3	0.0	0.2	0.8	1.3	-5.6	0.4	2.0

Table VI-42
San Joaquin River at Newman Vegetation Impact Analysis

73-Year Average Monthly River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	7.3	5.7	6.2	7.0	8.6	7.6	6.4	7.0	6.4	5.1	4.9	5.8

Percent Change in Average Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-0.3	-0.3	-0.3	-0.1	-0.3	-0.2	-0.4	-0.3	-0.5	-0.6	-0.7	-0.6
Alt 3	-1.9	-1.6	-1.5	-1.9	-3.2	-1.0	9.0	11.8	9.9	10.8	3.3	-0.8
Alt 4	-1.1	-0.7	-0.9	-1.6	-2.0	0.3	3.3	5.9	9.0	10.9	3.9	-0.1
Alt 5	11.9	3.6	2.0	2.2	10.5	19.6	**57.5**	**45.6**	**27.1**	**62.0**	**26.8**	5.9
Alt 6	5.7	-0.3	-0.2	-0.1	0.4	1.5	16.0	**25.8**	11.2	11.0	6.8	-0.5
Alt 7	-1.0	-0.7	-0.6	-1.2	-1.8	-0.2	4.6	4.2	-0.9	-0.7	-0.8	-0.7
Alt 8	2.5	-1.6	-1.7	-1.9	-3.7	-0.7	11.1	11.3	-2.0	-0.8	-0.7	-1.2

Average Monthly Dry Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	7.2	5.4	5	5.1	6.1	5.8	4.8	4.7	4.6	4.8	4.9	5.5

Percent Change in Dry Year Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-0.3	-0.4	-0.4	-0.1	-0.7	-0.4	-0.8	-0.7	-1.1	-1.0	-1.0	-1.0
Alt 3	-2.5	-0.8	-0.4	-1.1	-3.2	0.0	15.9	**29.0**	**21.4**	14.4	3.7	-0.7
Alt 4	-1.2	-0.5	-0.4	-1.1	-2.2	0.3	5.1	12.2	19.2	14.4	3.8	**-0.7**
Alt 5	10.8	5.5	7.7	8.9	18.0	**25.2**	**64.3**	**65.6**	**37.9**	**55.8**	**23.7**	8.5
Alt 6	5.7	-0.2	-0.3	-0.1	1.0	1.9	**27.1**	**47.5**	17.7	**21.6**	12.7	-0.9
Alt 7	-1.5	-0.3	-0.5	-1.0	-2.1	-0.4	9.6	-1.3	-1.1	-1.2	-1.1	
Alt 8	1.5	0.1	2.3	5.1	9.9	4.1	**22.3**	**28.9**	1.8	-1.2	-1.5	-0.9

Average Monthly Wet Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	7.3	6.1	7.5	9.3	11.4	9.7	8.2	9.5	8.5	5.4	4.9	6.2

Percent Change in Wet Year Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-0.3	-0.2	-0.2	-0.1	-0.1	-0.1	-0.2	-0.1	-0.2	-0.3	-0.3	-0.3
Alt 3	-1.2	-2.3	-2.4	-2.5	-3.2	-1.6	4.4	2.1	2.6	7.1	2.9	-0.9
Alt 4	-1.0	-0.9	-1.3	-2.0	-1.8	0.2	2.0	2.4	2.6	7.4	4.1	0.6
Alt 5	13.1	1.7	-2.4	-2.0	5.8	15.7	**52.9**	**34.3**	**20.4**	**68.3**	**30.4**	3.3
Alt 6	5.6	-0.3	-0.2	-0.1	0.0	1.3	8.4	13.5	7.1	0.2	0.0	-0.1
Alt 7	-0.5	-1.1	-0.8	-1.2	-1.6	-0.1	1.1	1.0	-0.6	-0.3	-0.4	-0.4
Alt 8	3.9	-2.4	-2.3	-2.7	-9.3	-0.8	6.4	5.0	-0.4	0.8	0.2	-0.6

Table VI-43

San Joaquin River at Vernalis Vegetation Impact Analysis

73-Year Average Monthly River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	6.9	5.7	6.4	7.7	9.7	9.2	8.9	8.0	6.9	5.2	4.8	5.6

Percent Change in Average Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	0.7	-2.0	-2.9	-3.0	-2.9	-0.2	4.7	10.9	4.0	5.8	8.1	-0.8
Alt 3	1.4	-2.3	-3.2	-4.1	-3.9	-0.6	5.0	11.7	16.6	17.1	14.5	-0.8
Alt 4	1.2	-2.0	-3.1	-4.4	-3.8	-0.2	5.0	11.5	16.4	17.0	15.3	-0.4
Alt 5	9.1	0.1	-1.7	-3.9	5.0	8.3	**22.8**	**25.9**	17.2	**43.8**	17.7	2.8
Alt 6	2.3	-1.3	-1.7	-1.4	-0.7	0.5	5.1	10.9	7.1	9.6	12.0	-0.5
Alt 7	4.8	0.6	2.4	1.3	0.7	0.9	0.1	4.1	4.9	7.2	-2.0	-6.0
Alt 8	0.3	1.0	0.0	-2.4	-4.0	-0.3	7.8	14.5	6.1	6.6	5.4	-1.2

Average Monthly Dry Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	6.8	5.4	5.4	5.5	6.4	6.2	6.5	5.5	4.6	4.4	4.5	5.1

Percent Change in Dry Year Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-0.6	-2.8	-4.1	-4.6	-3.2	0.5	9.2	**20.5**	**9.2**	7.9	8.2	-1.2
Alt 3	1.0	-2.2	-3.2	-4.1	-3.2	-0.6	9.6	**22.2**	**34.2**	**25.5**	18.3	-0.8
Alt 4	0.6	-2.5	-3.6	-4.7	-3.1	-0.4	9.5	**21.8**	**32.9**	**25.5**	19.2	-0.8
Alt 5	8.4	0.4	-0.1	0.1	10.6	14.1	**27.1**	**34.8**	**27.5**	**48.1**	19.6	4.8
Alt 6	2.1	-1.9	-2.9	-3.3	-1.7	0.5	9.1	**20.0**	14.2	15.6	15.3	-0.9
Alt 7	4.4	-0.3	1.1	0.4	1.1	1.7	2.9	9.0	10.9	10.8	-11.1	-8.0
Alt 8	-1.6	1.7	3.7	3.7	10.8	9.2	**20.9**	**32.3**	15.1	11.0	4.4	-0.3

Average Monthly Wet Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	7.0	6.1	7.7	10.3	13.3	12.6	11.7	10.9	9.5	6.2	5.1	6.1

Percent Change in Wet Year Monthly River Stage Compared to the Base Case (%)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	2.0	-1.1	-2.0	-2.0	-2.8	-0.7	1.8	5.4	1.2	4.1	8.1	-0.4
Alt 3	1.9	-2.4	-3.3	-4.1	-4.3	-0.6	2.1	5.6	6.8	10.1	10.6	-0.8
Alt 4	2.0	-1.5	-2.6	-4.2	-4.2	-0.1	2.1	5.5	7.2	9.9	11.3	0.1
Alt 5	9.9	-0.3	-3.1	-6.3	1.9	5.0	**20.1**	**20.7**	11.4	**40.2**	15.8	1.0
Alt 6	2.6	-0.7	-0.8	-0.2	-0.2	0.5	2.5	5.6	3.1	4.7	8.5	-0.2
Alt 7	5.3	1.5	3.4	1.8	0.5	0.5	-1.6	1.2	1.5	4.2	7.3	-4.1
Alt 8	3.0	1.4	-0.7	-2.3	-8.8	-1.7	2.6	7.7	5.5	5.1	7.7	-0.6

b. **Impact on Vegetation in Reservoir Drawdown Zones**. Changes in the operations of reservoirs controlled by the SWP, the CVP, and others to meet the flow objectives could result in long term changes in reservoir water levels. Lower average water elevations would allow reemergence and long term survival of former riparian habitat along tributary streams. Due to extensive loss of topsoil in the drawdown zone, establishment of new upland terrestrial vegetation on the reservoir sidewall would not be expected.

Quantitative data on the abundance and distribution of riparian habitat is available only for Folsom Lake, which supports about 65 acres of willow scrub between elevations 400 and 470. The response of riparian vegetation in other reservoirs to changing operations is assumed to follow a pattern similar to that observed at Folsom. Willow is subject to drowning if inundated for more than three consecutive months during the March-August growing season (USBR 1997b). Therefore, operating reservoirs at lower average elevations, though it might adversely impact other resources or beneficial uses, could have a positive impact on riparian vegetation within a reservoir.

An analysis of Folsom Lake elevations is presented in Table VI-44. The data represents the percent of years in which the reservoir water level exceeds the elevation specified in column one of Table VI-44 for three consecutive months during the growing season.

Table VI-44
Folsom Lake Vegetation Inundation Assessment
(Percent of Years Reservoir Level Exceeds Column 1 Elevation)

Elevation (ft)	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
440	41.1	39.7	41.1	41.1	50.7	37.0	38.4	39.7
430	68.5	60.3	58.9	58.9	64.4	53.4	54.8	60.3
420	74.0	65.8	68.5	69.9	72.6	64.4	65.8	65.8
410	82.2	79.5	80.8	78.1	80.8	75.3	74.0	80.8
400	87.7	80.8	82.2	82.2	80.8	80.8	82.2	80.8

In general, reservoir levels are higher for Alternative 1 than for the other alternatives, with the exception of Alternative 5. The percentage of years during which vegetation is exposed to prolonged inundation at the 440-foot level, for example, varies between -4.1 percent and +9.6 percent. The differences among alternatives are not significant.

c. **Waterfowl at Reservoirs**. Changes in reservoir operations can affect availability of prey species, such as fish, as well as the amount of shallow and open water habitat utilized by waterfowl. The impact of altered reservoir operations on fishery resources is presented in section C.2. An analysis was performed on selected reservoirs to determine the acreage of shallow water (0 to 1 foot deep), mid-water (1 to 15 feet deep), and open water habitat (>15 feet deep) among alternatives for selected reservoirs. The results of the analysis are presented in Tables VI-45a through VI-45c. Mallards, cinnamon teal and other dabbling ducks use shallow water habitat. Mid-water habitat is utilized by lesser scaup and ring necked ducks; open water is favored by species such as gulls and grebes. The results for Alternative 1 represent the absolute numbers of acres for a particular habitat; results for the other alternatives represent the change in acreage compared to the base case.

Results of the shallow water analysis are highly variable. There is considerable uncertainty in the reservoir elevation/surface area relationship derived from the DWRSIM output. Therefore, firm conclusions can not be drawn, though the differences are most likely insignificant.

Mid-water habitat decreases by more than 20 percent when compared to the base case during dry years at New Melones Reservoir under Alternatives 2. Open water habitat is decreased by more that 20 percent in dry years at Folsom Lake under Alternatives 2, 6, 7 and 8 when compared to the base case. In average years and dry years for Alternative 2, New Melones Reservoir open water habitat is reduced by 23.3 percent and 27.7 percent respectively. Alternative 5 produces 26.7 and 24.7 percent declines in open water habitat at New Don Pedro Reservoir and Lake McClure respectively. Reductions is gross habitat area could be significant if gross habitat area was the factor limiting population size or growth. As this is unlikely to be the case, the gross habitat reductions would have an insignificant impact.

d. <u>Wetland Habitat at Wildlife Refuges and Duck Clubs</u>. Wildlife refuges and management areas and privately owned and managed duck clubs provide important wetland habitat. Surface water supplies are used at most of these locations to provide seasonal flooding, maintain wetland habitat and to grow feed crops that attract waterfowl. Implementation of the flow objective alternatives is not expected to have a significant impact to the wetland habitat at wildlife refuges and management areas or privately owned and managed duck clubs.

Most of the water needs for wetlands management occur from September through April. This includes water used for winter rice field flooding that is generally diverted in the fall months. Under the 1995 Plan flow alternatives, water right holders would be required to reduce diversions most frequently in June, July, and August and rarely in other months. Therefore, most of the diversion for wetlands management occurs outside the period of impact.

The majority of the privately owned and managed wetlands in the Sacramento Valley are located in the Butte, Sutter, and Colusa basins. Much of the surface water that is in these basins is tailwater from irrigation districts with pre-1914 water rights. The pre-1914 water rights will not be curtailed under the flow alternatives; therefore, this water supply would not be affected. The private landowners that support wetlands and divert surface water under appropriative rights generally have relatively small cumulative face value in their water rights and, thus, most fall below the threshold included in this document.

Table VI-45a

Average Area of Shallow Reservoir Habitat, 0-1 Foot Depth

Average of All Years (acres)

Alternative	Shasta	Oroville	Folsom	New Molones	McClure	N. Don Pedro
Alt 1	147	23	72	36	24	37
Difference Between Alternative and Base Case						
Alt 2	-40	4	11	11	0	0
Alt 3	-16	15	6	-7	15	-5
Alt 4	-16	4	6	10	8	3
Alt 5	-5	8	0	72	3	23
Alt 6	-11	17	32	11	0	0
Alt 7	-33	11	-9	2	4	15
Alt 8	-40	11	5	-10	3	8

Average of Dry Years (acres)

Alternative	Shasta	Oroville	Folsom	New Molones	McClure	N. Don Pedro
Alt 1	84	42	85	51	26	50
Difference Between Alternative and Base Case						
Alt 2	8	-22	-26	12	0	0
Alt 3	0	7	-36	-4	-3	-25
Alt 4	0	-22	-36	-12	0	-15
Alt 5	-39	-9	-13	-27	-7	9
Alt 6	25	-35	-25	-11	0	0
Alt 7	12	7	27	-6	0	-88
Alt 8	19	7	-56	-27	-2	-6

Average of Wet Years (acres)

Alternative	Shasta	Oroville	Folsom	New Molones	McClure	N. Don Pedro
Alt 1	140	60	79	33	26	55
Difference Between Alternative and Base Case						
Alt 2	-22	-8	0	-8	0	0
Alt 3	-22	-16	-15	0	-2	-10
Alt 4	-22	-16	-15	15	15	-8
Alt 5	-13	-13	-10	-1	0	-18
Alt 6	20	-16	3	9	0	0
Alt 7	0	-16	-9	8	7	-14
Alt 8	-22	-19	-15	2	15	-31

Table VI-45b

Average Area of Mid-Water Reservoir Habitat, 1-15 Foot Depth

Average of All Years (acres)

Alternative	Shasta	Oroville	Folsom	New Melones	McClure	N. Don Pedro
Alt 1	1,667	516	1,039	576	383	659

Difference Between Alternative and Base Case

Alt 2	15	0	-6	91	0	0
Alt 3	102	-16	215	108	-28	-29
Alt 4	102	0	-14	89	-17	-18
Alt 5	33	-1	0	-55	-44	-77
Alt 6	-16	-9	-38	-55	0	0
Alt 7	-33	81	-18	-77	-8	4
Alt 8	15	-9	18	99	-19	-19

Average of Dry Years (acres)

Alternative	Shasta	Oroville	Folsom	New Melones	McClure	N. Don Pedro
Alt 1	1,396	487	1,007	669	361	646

Difference Between Alternative and Base Case

Alt 2	69	-12	130	-427	0	0
Alt 3	0	-20	91	12	-63	-79
Alt 4	0	-12	91	-1	-25	-71
Alt 5	88	34	33	23	-53	-131
Alt 6	52	13	-34	6	0	0
Alt 7	89	-14	76	1	6	71
Alt 8	24	-14	81	23	-49	-25

Average of Wet Years (acres)

Alternative	Shasta	Oroville	Folsom	New Melones	McClure	N. Don Pedro
Alt 1	1,710	682	1,048	503	433	688

Difference Between Alternative and Base Case

Alt 2	9	8	0	53	0	0
Alt 3	9	9	6	-7	-11	8
Alt 4	9	9	6	-6	-19	-1
Alt 5	23	2	-8	5	-27	-3
Alt 6	-33	9	0	-11	0	0
Alt 7	0	21	15	38	-5	12
Alt 8	9	8	6	6	-19	16

Table VI-45c

Average Area of Open Water Reservoir Habitat, Greater than 15 Foot Depth

Average of All Years (acres x 1000)

Alternative	Shasta	Oroville	Folsom	New Melones	McClure	N. Don Pedro
Alt 1	19.9	10.7	6.1	8.6	4.5	8.8
Difference Between Alternative and Base Case						
Alt 2	-0.1	-0.4	-0.6	-2.0	0.0	0.0
Alt 3	0.0	-0.4	-0.6	-0.5	-0.3	-0.5
Alt 4	0.0	-0.4	-0.4	-1.2	-0.2	-0.4
Alt 5	0.7	0.1	0.0	0.2	-0.9	-1.5
Alt 6	-0.6	-0.5	-0.9	0.2	0.0	0.0
Alt 7	-0.3	-0.6	-0.6	0.3	-0.1	0.1
Alt 8	-0.1	-0.5	-0.5	-0.9	-0.3	-0.1

Average of Dry Years (acres x 1000)

Alternative	Shasta	Oroville	Folsom	New Melones	McClure	N. Don Pedro
Alt 1	17.8	9.2	4.9	7.2	3.9	7.7
Difference Between Alternative and Base Case						
Alt 2	-0.5	-0.4	-1.1	-2.0	0.0	0.0
Alt 3	0.0	-0.4	-0.7	-0.5	-0.5	-0.6
Alt 4	0.0	-0.4	-0.7	-1.4	-0.2	-0.5
Alt 5	0.6	0.0	-0.2	-1.2	-1.0	-1.9
Alt 6	-1.0	-0.6	-1.5	0.3	0.0	0.0
Alt 7	-0.6	-0.5	-1.2	0.6	-0.1	0.2
Alt 8	-0.3	-0.5	-1.1	-1.2	-0.4	-0.1

Average of Wet Years (acres x 1000)

Alternative	Shasta	Oroville	Folsom	New Melones	McClure	N. Don Pedro
Alt 1	23.5	13.1	7.8	9.9	5.3	10.1
Difference Between Alternative and Base Case						
Alt 2	0.2	-0.4	0.0	-1.2	0.0	0.0
Alt 3	0.2	-0.3	0.1	-0.4	-0.1	-0.4
Alt 4	0.2	-0.3	0.1	-0.7	-0.1	-0.4
Alt 5	0.3	0.1	0.2	-0.1	-0.5	-0.9
Alt 6	-0.1	-0.3	-0.2	0.0	0.0	0.0
Alt 7	0.0	-0.6	-0.1	0.1	0.0	0.1
Alt 8	0.2	-0.5	0.1	-0.5	-0.1	-0.1

Among the assumptions for analyzing the impacts of the flow alternatives was that the USBR would continue to deliver water to most of the wildlife refuges and management areas under contracts guaranteed by the CVPIA. For the wildlife refuges and management areas that are not included in the CVPIA and the privately owned and managed wetlands that may have surface water diversions curtailed under some alternatives, it is likely that an alternate source of water would be sought, either through contract or from groundwater.

5. Channel Erosion

Erosion is the wearing away of soil and rock by weathering, mass wasting, and the action of streams, glaciers, waves, wind, and underground water. Of these erosive agents, the only one affected by implementation of the flow objectives is stream flow. Stream or channel erosion increases as the energy exerted by the stream increases. Simply stated, the higher the stream flow, the higher the potential for channel erosion. Thus, the greatest potential for channel erosion occurs during flood flows.

River flow stage data for the project area are shown in Table VI-46. The table shows that the maximum annual river stages associated with the seven flow alternatives generally do not exceed those of the base case. Thus, implementation of the flow objectives is not expected to increase channel erosion in the project area. The highest river stages are the result floods caused by natural climatic extremes, rather than implementation of the flow objectives.

Table VI-46
Maximum Annual River Stage in Feet

	Sacramento River		Feather R.	American R.	San Joaquin River	
Alternative	Red Bluff	Verona	Gridley	Nimbus Dam	Newman	Vernalis
Alt. 1	24.2	36.6	12.7	13.2	21.8	26.4
Alt. 2	24.2	36.6	12.7	13.2	21.8	26.4
Alt. 3	24.2	36.6	12.7	13.2	21.8	26.4
Alt. 4	24.2	36.6	12.7	13.2	21.8	26.4
Alt. 5	24.2	36.6	12.7	13.2	22.3	26.6
Alt. 6	24.2	36.6	12.7	13.2	21.8	26.4
Alt. 7	24.2	36.6	12.7	13.2	21.8	26.4
Alt. 8	24.2	36.6	12.7	13.2	21.8	26.7

6. Land Use

Implementation of the 1995 Bay/Delta Plan outflow objectives will result in either no change in upstream water deliveries or reduced water deliveries to upstream areas in Alternatives 3, 4, 5, 7 and 8 when compared to the base case (see Tables V-1 and V-2). Reduced water supplies can lead to regional changes in land use by shifting the types of crops grown, short-term fallowing, or long-term retirement of agricultural land. Land use changes that may occur as a result of the 1995 Bay/Delta Plan cannot be accurately predicted, because such changes are the result of numerous decisions made by individuals, water districts, and governmental agencies.

A study of the response of the agricultural community to reduced water supplies concluded that agricultural producers will respond to decreased surface water supplies in one of three ways: (1) obtaining alternative sources of supply to supplement reduced surface water allocations, (2) increasing water use efficiency, and (3) matching land use and cropping patterns to available water supplies through a combination of fallowing and shifts in crop type (Archibald et al. 1992). These responses can be further broken down into short-term and long-term options.

In order to prepare the input files for the DWRSIM modeling of Alternatives 3 and 4, simplifying assumptions were made regarding water user response to diversion curtailments. These assumptions were: (1) water right holders in the Sacramento basin would seek a contract for an alternate surface water supply and (2) water right holders in the San Joaquin basin would pump groundwater if their diversions were curtailed. The fallowing of farmland was assumed to be a less likely response under these alternatives, and therefore was not considered in the modeling. Water supply reductions under Alternative 5 are the most severe and could result in widespread fallowing. Under Alternatives 2 and 6, deliveries are reduced only to areas that receive exports from the Delta. In Alternatives 7 and 8, water is made available by a group of agencies in the San Joaquin basin to meet minimum flows on the San Joaquin River at Vernalis. This water is assumed to result from release of excess storage capacity, or improvements in irrigation efficiency.

In general, agricultural producers expect that, if shortages continue, marginal land will be taken out of production. The extent of reductions will depend on the costs and feasibility of alternative water supplies. The option of land retirement can be high for producers in districts with high fixed costs as these costs must be spread over the remaining acres if land cannot be sold or leased to other producers.

The case study approach used by Archibald et al. (1992) also indicated that cropping patterns can change as a result of water shortages. For example, 1989 and 1991 were drought years in which water shortages occurred. During this period, cotton, rice, alfalfa, and vegetable (excluding tomatoes) acreage declined while tomato acreage increased and acreage in permanent crops remained stable. These shifts exceeded normal trends, but factors other than water reductions could be responsible for these shifts.

While crop shifts are possible, there are a wide range of constraints that limit producers' abilities to shift cropping patterns in response to water shortages. These constraints include:

(1) federal commodity program regulations that can encourage or discourage shifts away from program commodities such as cotton and rice, (2) multi-year supply obligations to processors of such crops as garlic, onions, processing tomatoes, and rice, (3) concern about maintaining market share in a particular commodity; (4) producer ownership of processing operations, (5) agroclimatic constraints, including soil type, temperature ranges, and pest conditions, and (6) farm management expertise, and machinery and equipment complements, required to grow a particular crop.

If the SWRCB were to require upstream water users to provide water toward the 1995 Bay/Delta Plan flow objectives, crop shifts and land retirement could occur. Overall, shortages are greatest under Alternative 5 in the Yuba, Bear, Tuolumne, and Mokelumne river watersheds. Due to the wide range of factors governing a water user's response to reduced supply, it is difficult to predict how such reductions would translate into changed land use patterns.

7. Urban Development

Between 1930 and 1990, the area of land devoted to urban uses approximately quadrupled in the upstream areas. During the last decade, urban development in California shifted from coastal regions to the interior as the availability of land decreased along the coast and the price of remaining available land increased (USBR 1997e). Urban development in the Sacramento River and San Joaquin River regions occurred in conjunction with population increases of 32 percent and 41 percent respectively during this time period.

In the upstream areas, groundwater is the principal source of supply for urban uses (DWR 1994). Therefore, surface water supply reductions generally will not have a significant impact on urban users. The most notable exception is the Stockton East Water District, a major supplier to the City of Stockton. Thus, the analysis below is applicable mainly to the City of Stockton; however, the analysis is also applicable to any urban areas that might experience delivery reductions as a result of implementing the flow objectives.

a. Growth-Inducing Effects. Implementation of any of the seven flow alternatives could reduce water deliveries throughout the Delta watershed depending on the future decisions of water managers (see Chapter V). To the extent that historic patterns indicate future trends, reduced water availability is unlikely to affect growth in urban areas. Water is one of many factors influencing growth in a region but does not, by itself, cause the growth of a region. Water shortages have rarely done more than slow the progress of adequately financed development proposals. Reductions in municipal and industrial water supplies have typically been replaced through groundwater, reclamation, more intensive management, and price-induced conservation. In addition, reductions in existing surface water supplies may be replaced in many areas through long-term transfers of surface water supplies from other sources. Thus, implementation of any of the seven flow alternatives is not expected to have growth-inducing or growth-restricting effects.

b. Urban Landscape. The State Water Contractors have identified beneficial effects and uses of urban landscapes (SWC 1992). The effects and uses are described on page VIII-78 of the ER (SWRCB 1995; Appendix 1). Because urban landscapes depend on an adequate water supply for continuance, a reduction in supply could adversely affect some of the beneficial effects and uses of an urban environment. For example, during the 1987-1992 drought in Southern California, there was a well-documented loss of ornamental trees and landscaping in Santa Barbara County.

The reduced supplies to upstream urban areas that could result from the flow alternatives are likely to result in locally mandated, more efficient management of water resources. Most of the elements of such management are contained within the Memorandum of Understanding Regarding Urban Water Conservation in California. Most of the urban water exported from the Delta is delivered by agencies that have signed the MOU. Urban areas in the upstream portions of the Bay/Delta watershed could implement similar elements.

c. Public Health and Safety. Average reservoir levels could decline if stored water is used to meet delivery reductions. Water quality typically declines as reservoir levels drop significantly. The quality of drinking water supplied to urban areas could be compromised if water is drawn from reservoirs with lower levels. Sanitation and fire protection are not expected to be affected as supply reductions are likely to be replaced through alternative supplies, more intensive management of supplies and conservation as noted above.

d. Socioeconomic Effects. If alternative water supplies are not secured to replace delivery reductions, more intensive management and conservation of existing supplies is likely to occur. Depending on the measures implemented some local businesses could suffer, especially water intensive businesses. Although decreased water supplies may increase costs to some businesses in some areas of the state, these increases will be small relative to other factors affecting businesses. Also, offsetting the negative impacts of the flow alternatives on businesses is a quality of life improvement that will result from improved water quality in the Bay-Delta Estuary (Sanders et al. 1990).

e. Need for Developing Housing. Because the flow alternatives will have no growth inducing effects, they will have no direct effects on housing demand. The alternatives could alter demand indirectly by affecting economic conditions. One economic effect of the flow objectives that could affect housing demand is job losses in agricultural areas where irrigation water supplies are reduced. Housing demand would decrease in the affected areas and increase in the regions to which displaced workers migrate. However, these effects would be much smaller than other factors affecting migration between various parts of the state.

8. Energy

The flow objectives in the 1995 Bay/Delta Plan will affect both energy production and energy consumption. This section discusses the impact of implementing the flow alternatives on: (a) hydroelectric power availability, (b) groundwater pumping, and (c) fossil fuel consumption.

a. Hydroelectric Power Availability. Hydroelectric power generation plants provide approximately 24 percent of California's electrical generation capacity and produce in excess of $1.3 billion of power, as measured by replacement costs, in a typical year (McCann 1994). Electric utilities seek to maximize the value of their hydroelectric power production. Power produced during peak energy demand periods is more valuable than that produced during lower demand periods. Because hydropower is a low cost energy source that can be turned on and off quickly, utilities generally employ it to meet peak loads. In California, these peak loads typically occur in the summer when maximum groundwater pumping, industrial, and air conditioning demands occur. When water is released in the spring to maintain river flows, less water is available in the summer to provide peak hydropower generation. Reductions in a hydroelectric plant's ability to meet peak load requirements accelerate the need for additional peaking resources and increases utility costs (McCann 1994).

The 1995 Bay/Delta Plan requires higher flows in the spring than were historically required. Model results show that achieving these flows often requires a shift in reservoir releases from the summer to the spring. This shifting of releases affects the hydropower generation and consumption of the SWP and CVP, particularly in regard to the alternatives in which they have primary responsibility for meeting the Bay/Delta Plan objectives. The SWP and CVP are exclusively responsible for meeting the Bay/Delta Plan objectives under Alternatives 2 and 6. Recirculation water is provided by the USBR from the Delta-Mendota Canal, if necessary, to meet the Vernalis objectives under Alternative 6. Bay/Delta Plan Alternatives 3, 4, 5, 7, and 8 partially shift the obligation of meeting the flow objectives to other parties, and have varying effects on hydroelectric power generation and consumption.

Net CVP Hydropower Generation. The CVP is both a producer and consumer of hydroelectric power through its storage and conveyance of water for agricultural and municipal water users. This section discusses the impacts of the alternatives on CVP net hydroelectric generation. The information regarding energy generation and consumption are standard output of DWRSIM.

Table VI-47 shows the average monthly difference in net energy generation for Flow Alternatives 2 through 8 compared to Alternative 1 (the base case) for the 73-year period of historic hydrology. This information is graphically represented in Figure VI-76. The net CVP energy generation was calculated by subtracting CVP energy consumption from CVP energy generation.

Table VI-47 shows a long-term average annual increase in net CVP generation for Alternatives 2, 3, 4, 7, and 8 compared to the base case. These results are consistent with the conclusions of a 1994 report which found that slightly increased amounts of energy are available to the CVP from implementation of the Bay/Delta Plan due to reduced export pumping (Beck 1994). Energy consumption increases under Alternative 6 due to the increased pumping required to provide recirculation water on the San Joaquin River to meet Vernalis requirements. Alternatives 7 and 8 result in the highest net energy production. This is largely due to substantially reduced export pumping in April and May combined with increased reservoir releases from CVP reservoirs during those months.

Table VI-47
Net CVP Energy Generation

Base Case Average Monthly Net Generation (GWHrs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	213.5	186.8	231.4	243.5	271.8	286.1	316.6	489.3	559.7	516.9	361.1	202.4

Change in Net Generation from the Base Case (GWHrs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2	-17.8	3.1	-9.9	-18.7	3.3	12.7	66.8	3.9	-22.1	9.3	17.0	-11.7	35.9
3	-11.1	7.4	-6.9	-13.8	8.8	13.5	65.4	-2.0	-27.3	3.7	19.5	-5.7	51.5
4	-13.5	6.8	-7.6	-15.0	6.1	12.8	68.6	1.3	-29.4	1.9	16.5	-7.8	40.7
5	-11.0	14.0	-2.4	-8.6	10.3	17.2	34.2	-29.2	-31.5	-15.3	22.3	-0.4	-0.4
6	-36.1	-16.0	-37.8	-63.7	12.9	25.7	69.9	1.8	-5.8	10.8	12.1	-12.4	-38.6
7	-0.1	0.4	-4.8	-6.4	18.3	21.1	30.5	30.5	-13.3	8.6	13.9	-9.3	89.4
8	-20.6	6.4	-6.2	-18.3	5.8	15.9	90.2	19.8	-18.9	7.6	16.7	-8.7	89.7

Note: Negative numbers indicate less energy is produced (net) under the alternatives than the base case.

Figure VI-76
Net CVP Energy Generation

73-year monthly average compared to Alternative 1 (Base Case)

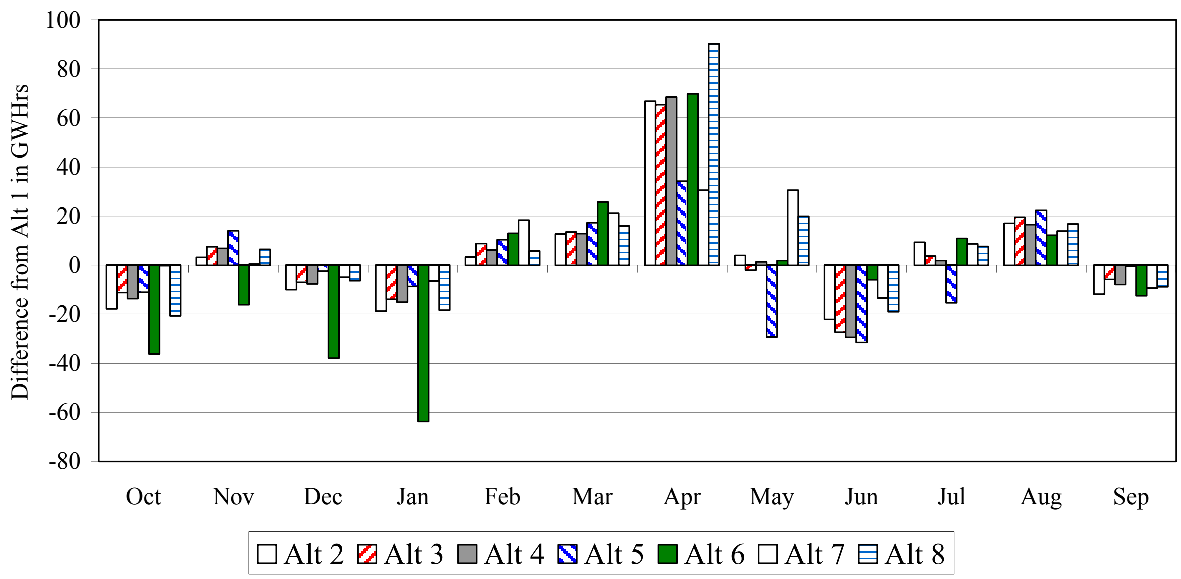


Figure VI-76 illustrates the seasonal shift in net CVP energy generation. The data points represent the difference between the alternatives and the base case. There is a significant reduction in winter net generation under Alternative 6 (due to high CVP energy consumption from pumping). The increased spring net generation is a result of increased spring stream flow and outflow requirements and restrictions in export pumping under the Bay/Delta Plan, particularly illustrated in April under Alternative 8. CVP power consumption rises in June as spring export limits are relaxed and the CVP increases pumping rates. CVP net generation fluctuates above and below the base case in late-summer and fall months. In general, net CVP hydroelectric power production is higher under the alternatives than the base case due to the reduction in energy consumption from implementation of the Bay/Delta Plan.

Net SWP Hydropower Generation. The SWP includes 22 dams and reservoirs, eight hydroelectric plants, and 17 pumping plants. While the CVP is a net producer of electricity, the SWP is a net electricity user due to the number of pumping lifts required along the length of the California Aqueduct.

Table VI-48 shows the average monthly difference in net energy generation for Alternatives 2 through 8 compared to Alternative 1 (the base case) for a 73-year period (1922-1994). This information is graphically represented in Figure VI-77. The average annual difference in SWP net energy generation is higher under all alternatives than the base case. Reductions in export pumping decrease SWP energy consumption thereby increasing available SWP energy over the base case. Alternative 5 results in the lowest net hydroelectric generation due to increases in export pumping and decreases in hydroelectric generation as the responsibility to meet the Bay/Delta objectives shifts to non-project upstream reservoirs. Alternative 7 results in the greatest increase in net energy generation by the SWP.

Net combined SWP and CVP Hydropower Generation. The difference in combined net SWP and CVP energy generation between each alternative and the base case is provided in Table VI-49. This information is graphically represented in Figure VI-78. Combined SWP and CVP net energy generation is higher under all alternatives than under the base case. Alternative 7 yields the highest net combined SWP and CVP power generation. Figure VI-78 shows trends similar to Figure VI-76.

Impacts on other Facilities. Effects are not limited to just SWP and CVP-related facilities; the implementation of the 1995 Bay/Delta Plan will have effects on most hydropower operations, but particularly those that depend upon use of hydropower's inexpensive peak energy production. The most significant impacts will likely be on hydropower facilities associated with large reservoirs located on the tributaries to the Sacramento and San Joaquin rivers (McCann 1994). Water rights for reservoirs with power as the main purpose of use will not be affected by the alternatives, while multi-use reservoirs that generate hydropower, such as Lake McClure, Don Pedro, Pardee/Camanche, and New Bullards Bar will have changes in their operations that will affect hydroelectric power operations. In general, requiring flow releases from these reservoirs will reduce their flexibility to meet peak hydropower demands which will likely decrease their reserves for hydropower generation.

Table VI-48
Net SWP Energy Generation

Base Case Average Monthly Net Generation (GWHrs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-366.6	-442.7	-380.6	-280.2	-234.5	-234.2	-282.0	-213.6	-242.6	-269.4	-330.7	-436.0

Change in Net Generation from the Base Case (GWHrs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2	-25.8	-3.1	-1.2	24.2	47.3	25.5	54.3	-8.1	14.3	50.5	8.1	18.7	204.7
3	-26.6	-3.6	-2.5	25.7	45.3	24.7	52.4	-11.5	2.7	44.9	4.9	15.0	171.4
4	-26.9	-3.7	-1.3	23.9	45.2	24.9	52.2	-11.3	3.7	44.8	4.3	14.9	170.7
5	-26.4	3.1	15.2	20.2	39.9	23.5	29.2	-39.0	-20.2	6.9	-2.9	15.5	65.0
6	-23.7	1.1	-10.3	14.1	49.3	24.5	54.0	-8.6	11.6	48.9	3.6	16.0	180.5
7	-23.7	-0.3	-16.9	16.6	45.6	24.6	47.2	9.2	16.9	59.3	17.6	21.9	218.0
8	-27.9	-7.3	-8.9	22.0	44.3	23.8	60.3	-7.0	12.0	53.8	13.4	16.8	195.3

Note: Negative numbers indicate less energy is produced (net) under the alternatives than the base case.

Figure VI-77
Net SWP Energy Generation
73-year monthly average compared to Alternative 1 (Base Case)

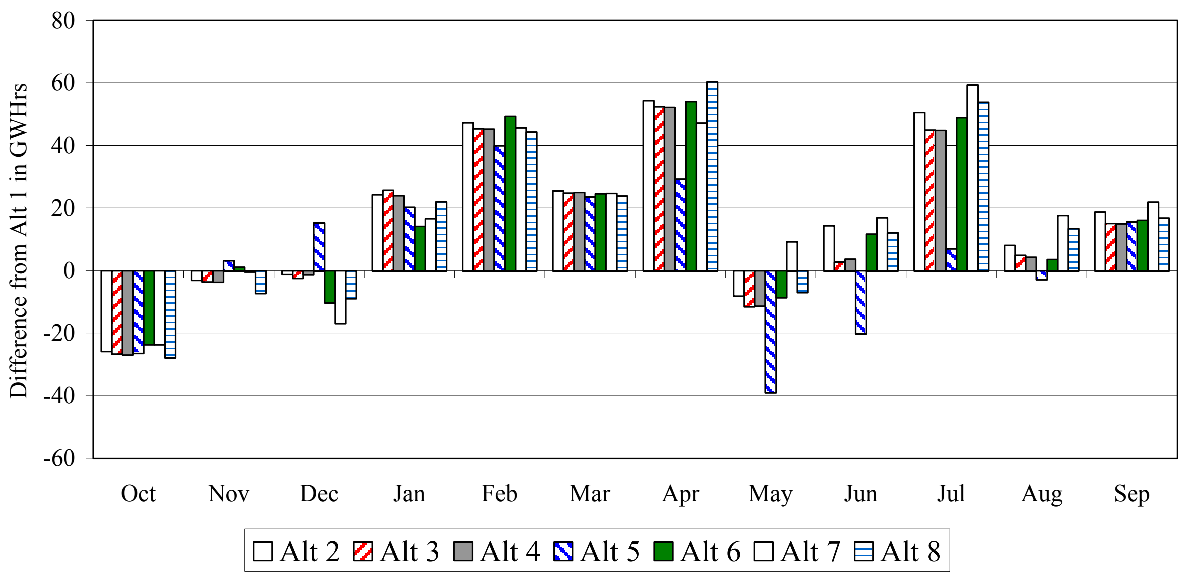


Table VI-49
Net SWP and CVP Energy Generation

Base Case Average Monthly Net Generation (GWHrs)

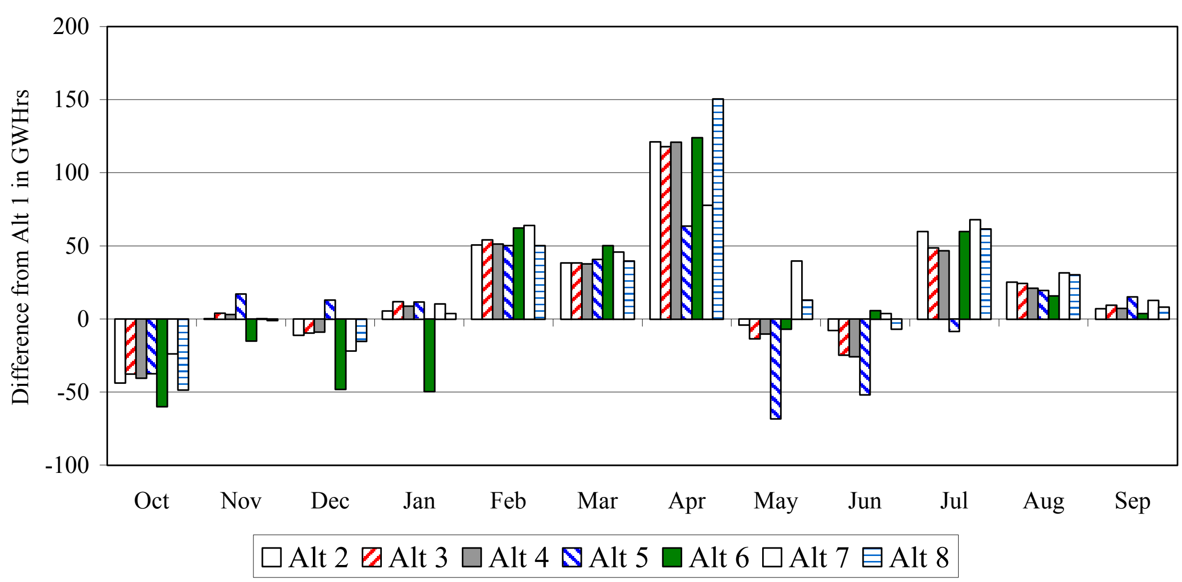
Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-153.1	-256.0	-149.2	-36.6	37.3	51.9	34.6	275.8	317.1	247.5	30.4	-233.7

Change in Net Generation from the Base Case (GWHrs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2	-43.6	0.1	-11.1	5.5	50.6	38.2	121.1	-4.1	-7.7	59.8	25.1	7.0	240.9
3	-37.6	3.9	-9.4	11.8	54.1	38.3	117.8	-13.5	-24.6	48.6	24.3	9.3	223.0
4	-40.4	3.1	-8.9	8.8	51.2	37.7	120.8	-10.1	-25.7	46.7	20.9	7.1	211.2
5	-37.4	17.1	12.8	11.6	50.2	40.7	63.4	-68.2	-51.7	-8.4	19.4	15.1	64.6
6	-59.8	-14.9	-48.1	-49.6	62.2	50.2	123.9	-6.8	5.7	59.7	15.7	3.6	141.8
7	-23.8	0.1	-21.7	10.3	63.9	45.7	77.8	39.7	3.7	67.9	31.5	12.6	307.7
8	-48.5	-0.9	-15.1	3.7	50.1	39.7	150.5	12.8	-6.9	61.4	30.1	8.1	285.0

Note: Negative numbers indicate less energy is produced (net) under the alternatives than the base case.

Figure VI-78
Net SWP & CVP Energy Generation
73-year monthly average compared to Alternative 1 (Base Case)



Mitigation. Reductions in summer hydroelectric power production reduce the amount of energy available for meeting summer-time peak loads. Increasing generation from fossil fuel power plants or from other sources including nuclear, geothermal, biomass, solar thermal, solar photovoltaic and wind generation may make up such reductions. However non-mitigable impacts would occur with increases in energy generation from fossil fuel sources.

b. Groundwater Pumping. The implementation of the 1995 Bay/Delta Plan may cause reductions in surface water deliveries as shown on Tables V-1 and V-2. Substitution of groundwater for surface water generally increases energy consumption. Increased groundwater pumping may lower groundwater levels resulting in higher pumping lifts and, thus, further increase energy consumption.

Surface delivery reductions may result in the affected water user purchasing water from another source, fallowing land, or pumping additional groundwater. Under worst case conditions, all of the reductions shown on Tables V-1 and V-2 would be made up by increased groundwater pumping. In a recent study performed by PG&E, the average cost to pump groundwater in the California Central Valley ranges between $25 and $30 per acre-foot for flood irrigation and between $35 and $40 per acre-foot for pressure and drip irrigation, based on a large sample of pump tests conducted in the California Central Valley (Jeff Savage, personal communication).

Mitigation. The increase in energy consumption due to groundwater pumping can be partially mitigated through off-peak pumping operations.

c. Fossil Fuels. The implementation of the 1995 Bay/Delta Plan will alter hydroelectric power generation and consumption patterns and increase groundwater pumping in substitution for surface water supplies. These changes may result in increased use of fossil-fuel generation, thereby increasing air pollution. Common air pollutant emissions associated with the generation of electricity by fossil fuels include oxides of nitrogen (NOx), particulate matter of less than 10 microns in diameter (PM10), reactive organic gases (ROG), carbon emissions (Cx), and oxides of sulfur (SOx).

Table VI-50 provides an estimate of the possible air emissions from implementation of the Bay/Delta Plan. The quantities in the table were developed for a slightly different set of objectives than are contained in the Bay/Delta Plan. The objectives used in this analysis had a higher water supply impact than the objectives in the Bay/Delta Plan; therefore, the analysis should be considered a worst-case scenario. The quantities in the table account for both the effect of hydropower availability problems in some seasons and the effects of increased groundwater pumping. The average increases of 131.6 tons of NOx, 52.9 tons of SOx, 8.8 tons of PM10, and 5.5 tons of ROG are not large relative to emissions inventories in the impacted air basins, however these emissions are large enough to trigger new source review requirements or the purchase of emission reduction credits (McCann 1994). The effects may, therefore, be significant.

Table VI-50

Net Increase in Air Emissions under Bay/Delta Plan[1]

(tons per year, probability weighted[2])

Year	NOx	SOx	PM10	ROG	Cx
1995	232	81	7.8	5.6	42,427
1996	208	59	8.0	6.0	46,984
1997	119	65	9.3	6.8	50,543
1998	86	60	8.5	5.5	57,037
1999	104	40	8.8	6.7	52,048
2000	120	57	9.0	5.8	55,491
2001	74	35	8.7	6.4	59,981
2002	117	50	8.6	5.5	60,619
2003	90	47	9.5	6.3	65,080
2004	74	10	8.9	7.0	70,245
2005	121	49	7.8	4.5	64,361
2006	135	44	8.7	5.3	64,640
2007	235	63	11.1	4.4	57,399
2008	113	59	8.7	4.9	65,113
2009	126	58	9.2	5.0	66,984
2010	156	70	9.3	5.0	67,790
2011	130	53	8.1	4.0	66,504
Average:	132	52.9	8.8	5.6	59,603

[1] From Table F-1 of "Impact of Bay/Delta Water Quality Standards on California's Electric Utility Costs," prepared by Richard McCann, et al., for the Association of California Water Agencies, October 7, 1994.

[2] 20 percent dry, 55 percent normal, and 25 percent wet years.

Mitigation. The effect of increasing fossil fuel generation is not entirely mitigable, however other sources of energy generation are available including nuclear, geothermal, biomass, solar thermal, solar photovoltaic and wind generation.

9. Recreation

This section presents the results of the assessment of impacts to recreation that would occur with implementation of the flow objective alternatives. Recreation impacts can be expected in the Sacramento River and San Joaquin River regions at selected reservoirs and in the rivers that provide flows to the Delta. The assessment of recreation impacts analyzes how changes in reservoir storage and river flows would affect opportunities for water-related activities at key recreation facilities.

a. Reservoirs. Implementation of the 1995 Plan could result in adverse impacts to recreation at some reservoirs. Each alternative can have the effect of lowering water levels earlier in the season, for longer periods, or below the levels than would otherwise occur in a given year at certain reservoirs. Lowered reservoir elevations can substantially decrease opportunities for public recreational use by reducing water surface area and shoreline and by making access to the water more difficult. Extreme drawdowns can force the closure of marinas and boat launch ramps, resulting in a loss of access for boating and fishing. These conditions can in turn reduce visitor use levels and attendant revenues. The potential impacts to recreation are similar to and generally within the range of those impacts typically experienced at most reservoirs during drought periods.

Recreation impacts are assessed for the major rim reservoirs that are operated by the SWP, the CVP, and by other agencies, and that could be affected by implementation of the 1995 Bay/Delta Plan. The reservoirs include Shasta Lake, Lake Oroville, Folsom Lake, Camanche Reservoir, Pardee Reservoir, New Melones Reservoir, New Don Pedro Reservoir, Lake McClure, and Millerton Lake.

Projected reservoir operations under each alternative were obtained from DWRSIM and EBMUDSIM output (EBMUDSIM was used for Camanche Reservoir and Pardee Reservoir). Critical thresholds for recreation opportunity were then compared to the reservoir operations to determine when recreation activities begin to significantly decline or cease. Most of the thresholds were developed for the CVPIA PEIS and were based on information provided by operators of each of the major reservoirs (USBR 1997f). EBMUD provided thresholds for Camanche Reservoir and Pardee Reservoir (EBMUD 1997a).

Recreation opportunity thresholds were developed for important recreation activities during both peak and off-seasons. Peak seasons vary by reservoir, beginning in April or May and running through September. Typical peak-season activities include boating, beach use, camping, and picnicking. Assessment of off-season activities was limited to boating. Changes in recreation opportunities were assessed for the full 73-year period as well as for the 1928-1934 critical period. Due to the size and configuration of Shasta Lake and the number of recreation facilities located throughout the lake, separate analyses were performed for the main body and for each of the tributary arms.

The recreation impact analysis considers the frequency of occurrence with which end-of-month storage (converted to surface elevation) falls below or, in some cases, exceeds the various threshold levels established for each reservoir. Tables VI-51 through VI-59 summarize the frequency of occurrence in absolute numbers and as a percentage of the total number of months in the study period. A frequency of occurrence that is lower than the base case would indicate an increase in recreational opportunities (a beneficial impact). A frequency of occurrence that is higher than the base case would indicate a decrease in recreational opportunities (a negative impact).

Due to the nature of the hydrologic input data and the use of average monthly operations, modeled surface water results may be expected to have a margin of error of 10 to 20 percent. Therefore, differences between the base case and the various alternatives are considered to be significant only if greater than 10 percentage points, higher or lower, from the base case. Significant differences were observed for each reservoir analyzed, with the exception of Lake McClure. The critical thresholds for Lake McClure are at extremely low surface elevations that are never reached under any of the operation alternatives.

Tables VI-60 and VI-61 summarize which alternatives have significant recreation impacts (beneficial or negative) at the major reservoirs. Table VI-60 indicates that, for the 73-year period average, significant negative impacts occur during the peak season at Camanche, Pardee, New Don Pedro, and Millerton under Alternative 5 and at Folsom under Alternative 6; significant negative impacts also occur during the off season at Camanche, Pardee, New Don Pedro, and Millerton under Alternative 5. Table VI-61 indicates that, for the critical period average, significant negative impacts occur during the peak season and off season at various reservoirs under each Alternative, and that significant beneficial impacts occur at Shasta, Oroville, and Folsom under Alternative 5.

Mitigation. Recreational use at some reservoirs may be reduced as a result of implementing the flow objective alternatives. Some reservoirs could be lowered earlier in the season, for longer periods, or below the levels than would otherwise occur. This would result in less water-related recreational opportunities and could be significant to those who participate in activities such as boating and fishing and to recreation concessionaires that rely on a certain amount of recreation use annually for their livelihood. Generally, these impacts are not mitigable. Modification or relocation of facilities (such as boat ramps and marinas) to accommodate lower water levels would help to reduce the impact to recreation at reservoirs that are adversely affected.

b. Rivers. Impacts to recreation were considered for the rivers below major reservoirs that are operated by the SWP, the CVP, or by other agencies, and that could be affected by implementation of the flow objective alternatives. The analysis of recreation impacts on these rivers is based on the changes in recreation opportunities that might result from implementing the flow alternatives.

Impact thresholds that were used for the analysis were developed for the CVPIA PEIS. The thresholds were developed based on information provided by operators of recreation facilities along the rivers, rafting guides, and fishing guides. The thresholds indicate when recreation activities begin to significantly decline or cease in response to changes in river flows. The frequency with which river flows drop below, rise above, or fall within these thresholds is used to determine changes in recreation opportunities under each of the alternatives.

Table VI-51
Results of Recreation Impact Assessment for Shasta Lake

Main Area
Peak Season (May - Sept.)

Water Year Type/Alternative	# of Months	844 ft. total	844 ft. %	947 ft. total	947 ft. %	987 ft. total	987 ft. %
		Frequency with which Reservoirs are below Critical Elevation Thresholds					
73-YEAR PERIOD	365	total	%	total	%	total	%
Alternative 1 (Base Case)		0	0%	17	5%	64	18%
Alternative 2		0	0%	24	7%	73	20%
Alternative 3		0	0%	19	5%	69	19%
Alternative 4		0	0%	17	5%	69	19%
Alternative 5		0	0%	9	2%	61	17%
Alternative 6		0	0%	27	7%	79	22%
Alternative 7		0	0%	20	5%	75	21%
Alternative 8		0	0%	22	6%	72	20%
CRITICAL PERIOD	35						
Alternative 1 (Base Case)		0	0%	9	26%	22	63%
Alternative 2		0	0%	10	29%	24	69%
Alternative 3		0	0%	7	20%	21	60%
Alternative 4		0	0%	7	20%	21	60%
Alternative 5		0	0%	3	9%	18	51%
Alternative 6		0	0%	11	31%	25	71%
Alternative 7		0	0%	6	17%	23	66%
Alternative 8		0	0%	9	26%	23	66%

Main Area
Off-Season (Oct.- April)

Water Year Type/Alternative	# of Months	844 ft. total	844 ft. %	947 ft. total	947 ft. %
		Frequency with which Reservoirs are below Critical Elevation Thresholds			
73-YEAR PERIOD	511	total	%	total	%
Alternative 1 (Base Case)		0	0%	26	5%
Alternative 2		0	0%	37	7%
Alternative 3		0	0%	28	5%
Alternative 4		0	0%	30	6%
Alternative 5		0	0%	15	3%
Alternative 6		0	0%	42	8%
Alternative 7		0	0%	31	6%
Alternative 8		0	0%	35	7%
CRITICAL PERIOD	43				
Alternative 1 (Base Case)		0	0%	14	33%
Alternative 2		0	0%	16	37%
Alternative 3		0	0%	12	28%
Alternative 4		0	0%	12	28%
Alternative 5		0	0%	4	9%
Alternative 6		0	0%	16	37%
Alternative 7		0	0%	11	26%
Alternative 8		0	0%	14	33%

NOTES:
< 844 ft. msl - last boat ramp out of operation
< 947 ft. msl - limited lake surface area (boating constrained)
< 987 ft. msl - marina relocated

Table VI-51 Continued

McCloud River Arm
Peak Season (May - Sept.)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Water Year Type/Alternative	# of Months	952 ft. total	952 ft. %	960 ft. total	960 ft. %	967 ft. total	967 ft. %	987 ft. total	987 ft. %
73-YEAR PERIOD	365								
Alternative 1 (Base Case)		18	5%	22	6%	29	8%	64	18%
Alternative 2		27	7%	38	10%	42	12%	73	20%
Alternative 3		24	7%	33	9%	40	11%	69	19%
Alternative 4		26	7%	33	9%	40	11%	69	19%
Alternative 5		13	4%	21	6%	32	9%	61	17%
Alternative 6		32	9%	45	12%	49	13%	79	22%
Alternative 7		26	7%	33	9%	47	13%	75	21%
Alternative 8		25	7%	36	10%	45	12%	72	20%
CRITICAL PERIOD	35								
Alternative 1 (Base Case)		9	26%	11	31%	12	34%	22	63%
Alternative 2		11	31%	14	40%	15	43%	24	69%
Alternative 3		9	26%	12	34%	14	40%	21	60%
Alternative 4		9	26%	12	34%	14	40%	21	60%
Alternative 5		5	14%	9	26%	12	34%	18	51%
Alternative 6		13	37%	15	43%	16	46%	25	71%
Alternative 7		8	23%	11	31%	14	40%	23	66%
Alternative 8		10	29%	13	37%	15	43%	23	66%

McCloud River Arm
Off-Season (Oct.- April)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Water Year Type/Alternative	# of Months	952 ft. total	952 ft. %	967 ft. total	967 ft. %
73-YEAR PERIOD	511				
Alternative 1 (Base Case)		27	5%	45	9%
Alternative 2		44	9%	52	10%
Alternative 3		43	8%	47	9%
Alternative 4		39	8%	47	9%
Alternative 5		24	5%	43	8%
Alternative 6		46	9%	60	12%
Alternative 7		37	7%	51	10%
Alternative 8		39	8%	51	10%
CRITICAL PERIOD	43				
Alternative 1 (Base Case)		14	33%	18	42%
Alternative 2		16	37%	18	42%
Alternative 3		16	37%	16	37%
Alternative 4		15	35%	16	37%
Alternative 5		9	21%	16	37%
Alternative 6		16	37%	20	47%
Alternative 7		15	35%	16	37%
Alternative 8		14	33%	18	42%

NOTES:
< 952 ft. msl - last boat ramp out of operation
< 960 ft. msl - decline in campground use
< 967 ft. msl - limited lake surface area (boating constrained)
< 987 ft. msl - marina movement

Table VI-51 Continued

Pit River Arm
Peak Season (May - Sept.)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Water Year Type/Alternative	# of Months	907 ft. total	907 ft. %	942 ft. total	942 ft. %	987 ft. total	987 ft. %	1007 ft. total	1007 ft. %
73-YEAR PERIOD	365								
Alternative 1 (Base Case)		5	1%	13	4%	64	18%	105	29%
Alternative 2		6	2%	16	4%	73	20%	110	30%
Alternative 3		4	1%	12	3%	69	19%	107	29%
Alternative 4		4	1%	12	3%	69	19%	108	30%
Alternative 5		1	0%	9	2%	61	17%	97	27%
Alternative 6		6	2%	22	6%	79	22%	125	34%
Alternative 7		5	1%	14	4%	75	21%	126	35%
Alternative 8		4	1%	17	5%	72	20%	111	30%
CRITICAL PERIOD	35								
Alternative 1 (Base Case)		1	3%	6	17%	22	63%	29	83%
Alternative 2		1	3%	8	23%	24	69%	30	86%
Alternative 3		0	0%	4	11%	21	60%	30	86%
Alternative 4		0	0%	4	11%	21	60%	30	86%
Alternative 5		0	0%	3	9%	18	51%	29	83%
Alternative 6		1	3%	10	29%	25	71%	30	86%
Alternative 7		0	0%	5	14%	23	66%	30	86%
Alternative 8		0	0%	7	20%	23	66%	30	86%

Pit River Arm
Off-Season (Oct.- April)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Water Year Type/Alternative	# of Months	942 ft. total	942 ft. %	1007 ft. total	1007 ft. %
73-YEAR PERIOD	511				
Alternative 1 (Base Case)		21	4%	148	29%
Alternative 2		29	6%	152	30%
Alternative 3		21	4%	143	28%
Alternative 4		21	4%	142	28%
Alternative 5		10	2%	137	27%
Alternative 6		34	7%	172	34%
Alternative 7		23	5%	155	30%
Alternative 8		29	6%	148	29%
CRITICAL PERIOD	43				
Alternative 1 (Base Case)		12	28%	39	91%
Alternative 2		14	33%	41	95%
Alternative 3		8	19%	41	95%
Alternative 4		8	19%	41	95%
Alternative 5		3	7%	39	91%
Alternative 6		16	37%	41	95%
Alternative 7		8	19%	40	93%
Alternative 8		13	30%	39	91%

NOTES:
< 907 ft. msl - decline in campground use
< 942 ft. msl - last boat ramp out of operation
< 987 ft. msl - marina movement
< 1007 ft. msl - limited lake surface area (boating constrained)

Table VI-51 Continued

Sacramento River Arm
Peak Season (May - Sept.)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Water Year Type/Alternative	# of Months	937 ft. total	937 ft. %	950 ft. total	950 ft. %	967 ft. total	967 ft. %	1007 ft. total	1007 ft. %	1017 ft. total	1017 ft. %
73-YEAR PERIOD	365										
Alternative 1 (Base Case)		11	3%	18	5%	29	8%	105	29%	138	38%
Alternative 2		13	4%	27	7%	42	12%	110	30%	144	39%
Alternative 3		11	3%	21	6%	40	11%	107	29%	136	37%
Alternative 4		11	3%	22	6%	40	11%	108	30%	137	38%
Alternative 5		7	2%	13	4%	32	9%	97	27%	122	33%
Alternative 6		17	5%	29	8%	49	13%	125	34%	153	42%
Alternative 7		12	3%	25	7%	47	13%	126	35%	153	42%
Alternative 8		12	3%	24	7%	45	12%	111	30%	145	40%
CRITICAL PERIOD	35										
Alternative 1 (Base Case)		4	11%	9	26%	12	34%	29	83%	30	86%
Alternative 2		5	14%	11	31%	15	43%	30	86%	31	89%
Alternative 3		4	11%	7	20%	14	40%	30	86%	30	86%
Alternative 4		4	11%	8	23%	14	40%	30	86%	30	86%
Alternative 5		2	6%	5	14%	12	34%	29	83%	30	86%
Alternative 6		8	23%	11	31%	16	46%	30	86%	32	91%
Alternative 7		4	11%	8	23%	14	40%	30	86%	31	89%
Alternative 8		4	11%	10	29%	15	43%	30	86%	30	86%

Sacramento River Arm
Off-Season (Oct.- April)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Water Year Type/Alternative	# of Months	950 ft. total	950 ft. %	1017 ft. total	1017 ft. %
73-YEAR PERIOD	511				
Alternative 1 (Base Case)		27	5%	182	36%
Alternative 2		44	9%	193	38%
Alternative 3		37	7%	185	36%
Alternative 4		38	7%	185	36%
Alternative 5		20	4%	175	34%
Alternative 6		46	9%	206	40%
Alternative 7		34	7%	197	39%
Alternative 8		37	7%	194	38%
CRITICAL PERIOD	43				
Alternative 1 (Base Case)		14	33%	41	95%
Alternative 2		16	37%	41	95%
Alternative 3		14	33%	41	95%
Alternative 4		15	35%	41	95%
Alternative 5		6	14%	41	95%
Alternative 6		16	37%	41	95%
Alternative 7		13	30%	41	95%
Alternative 8		14	33%	41	95%

NOTES:
< 937 ft. msl - marina closes
< 950 ft. msl - last boat ramp out of operation
< 967 ft. msl - decline in campground use
< 1007 ft. msl - marina movement
< 1017 ft. msl - limited lake surface area (boating constrained)

Table VI-52
Results of Recreation Impact Assessment for Lake Oroville

Peak Season (April - Sept.)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Water Year Type Alternative	# of Months	700 ft. total	700 ft. %	710 ft. total	710 ft. %	750 ft. total	750 ft. %	819 ft. total	819 ft. %	840 ft. total	840 ft. %
73-YEAR PERIOD	438										
Alternative 1 (Base Case)		13	3%	24	5%	46	11%	133	30%	176	40%
Alternative 2		16	4%	27	6%	64	15%	157	36%	191	44%
Alternative 3		18	4%	26	6%	67	15%	152	35%	192	44%
Alternative 4		19	4%	27	6%	67	15%	153	35%	192	44%
Alternative 5		11	3%	12	3%	45	10%	140	32%	177	40%
Alternative 6		20	5%	29	7%	67	15%	158	36%	196	45%
Alternative 7		17	4%	29	7%	65	15%	164	37%	204	47%
Alternative 8		16	4%	27	6%	66	15%	162	37%	194	44%
CRITICAL PERIOD	41										
Alternative 1 (Base Case)		2	5%	4	10%	12	29%	34	83%	36	88%
Alternative 2		1	2%	5	12%	21	51%	36	88%	36	88%
Alternative 3		5	12%	7	17%	24	59%	35	85%	36	88%
Alternative 4		5	12%	7	17%	24	59%	35	85%	36	88%
Alternative 5		0	0%	1	2%	11	27%	34	83%	35	85%
Alternative 6		4	10%	6	15%	23	56%	35	85%	36	88%
Alternative 7		2	5%	4	10%	19	46%	36	88%	36	88%
Alternative 8		3	7%	6	15%	23	56%	34	83%	36	88%

Off-Season (Oct.- March)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Water Year Type Alternative	# of Months	710 ft. total	710 ft. %	750 ft. total	750 ft. %
73-YEAR PERIOD	438				
Alternative 1 (Base Case)		39	9%	77	18%
Alternative 2		42	10%	87	20%
Alternative 3		54	12%	88	20%
Alternative 4		54	12%	88	20%
Alternative 5		26	6%	69	16%
Alternative 6		49	11%	89	20%
Alternative 7		42	10%	88	20%
Alternative 8		47	11%	85	19%
CRITICAL PERIOD	37				
Alternative 1 (Base Case)		9	24%	18	49%
Alternative 2		8	22%	25	68%
Alternative 3		16	43%	25	68%
Alternative 4		16	43%	25	68%
Alternative 5		4	11%	17	46%
Alternative 6		12	32%	24	65%
Alternative 7		7	19%	23	62%
Alternative 8		12	32%	24	65%

NOTES:
<700 ft. msl - decline in campground/picnicking use
<710 ft. msl - limited boat ramp availability/marina relocation
<750 ft. msl - limited lake surface area (boating constrained)
<819 ft. msl - beach area closed
<840 ft. msl - decline in beach use

Table VI-53

Results of Recreation Impact Assessment for Folsom Lake

Peak Season (April - Sept.)

Frequency with which Reservoirs are below Critical Elevation Thresholds (or above 450 ft.)

Water Year Type Alternative	# of Months	360 ft. total	360 ft. %	400 ft. total	400 ft. %	405 ft. total	405 ft. %	430 ft. total	430 ft. %	> 450 ft. total	> 450 ft. %
73-YEAR PERIOD	438										
Alternative 1 (Base Case)		39	9%	76	17%	85	19%	167	38%	101	23%
Alternative 2		56	13%	105	24%	112	26%	180	41%	100	23%
Alternative 3		50	11%	102	23%	106	24%	176	40%	101	23%
Alternative 4		50	11%	102	23%	107	24%	176	40%	100	23%
Alternative 5		33	8%	85	19%	97	22%	158	36%	104	24%
Alternative 6		62	14%	114	26%	126	29%	201	46%	92	21%
Alternative 7		57	13%	109	25%	118	27%	191	44%	95	22%
Alternative 8		52	12%	102	23%	112	26%	178	41%	99	23%
CRITICAL PERIOD	41										
Alternative 1 (Base Case)		13	32%	20	49%	22	54%	30	73%	3	7%
Alternative 2		18	44%	27	66%	28	68%	34	83%	2	5%
Alternative 3		16	39%	26	63%	26	63%	34	83%	1	2%
Alternative 4		16	39%	26	63%	26	63%	34	83%	1	2%
Alternative 5		9	22%	21	51%	24	59%	31	76%	3	7%
Alternative 6		19	46%	29	71%	30	73%	35	85%	2	5%
Alternative 7		14	34%	30	73%	30	73%	36	88%	1	2%
Alternative 8		13	32%	25	61%	28	68%	34	83%	2	5%

Off-Season (Oct.- March)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Water Year Type Alternative	# of Months	360 ft. total	360 ft. %	400 ft. total	400 ft. %
73-YEAR PERIOD	438				
Alternative 1 (Base Case)		29	7%	128	29%
Alternative 2		39	9%	129	29%
Alternative 3		34	8%	121	28%
Alternative 4		36	8%	122	28%
Alternative 5		31	7%	114	26%
Alternative 6		61	14%	150	34%
Alternative 7		41	9%	135	31%
Alternative 8		37	8%	130	30%
CRITICAL PERIOD	37				
Alternative 1 (Base Case)		4	11%	26	70%
Alternative 2		12	32%	27	73%
Alternative 3		10	27%	24	65%
Alternative 4		10	27%	24	65%
Alternative 5		9	24%	25	68%
Alternative 6		19	51%	28	76%
Alternative 7		10	27%	27	73%
Alternative 8		10	27%	26	70%

NOTES:
<360 ft. msl - last boat ramp out of operation
<400 ft. msl - limited lake surface area (boating constrained)
<405 ft. msl - marina closes
<430 ft. msl - decline in campground/picnicking use
>450 ft. msl - beach area inundated

Table VI-54
Results of Recreation Impact Assessment for Camanche Reservoir

Peak Season (April - Sept.)

Water Year Type / Alternative	# of Months	160 ft. total	160 ft. %	178 ft. total	178 ft. %	193 ft. total	193 ft. %
		Frequency with which Reservoirs are below Critical Elevation Thresholds					
73-YEAR PERIOD	438	total	%	total	%	total	%
Alternative 1 (Base Case)		14	3%	39	9%	68	16%
Alternative 2		14	3%	39	9%	68	16%
Alternative 3		34	8%	56	13%	104	24%
Alternative 4		45	10%	56	13%	104	24%
Alternative 5		109	25%	145	33%	196	45%
Alternative 6		14	3%	39	9%	68	16%
Alternative 7		14	3%	39	9%	68	16%
Alternative 8		14	3%	39	9%	68	16%
CRITICAL PERIOD	41						
Alternative 1 (Base Case)		0	0%	3	7%	8	20%
Alternative 2		0	0%	3	7%	8	20%
Alternative 3		0	0%	4	10%	23	56%
Alternative 4		0	0%	4	10%	23	56%
Alternative 5		30	73%	34	83%	36	88%
Alternative 6		0	0%	3	7%	8	20%
Alternative 7		0	0%	3	7%	8	20%
Alternative 8		0	0%	3	7%	8	20%

Off-Season (Oct.- March)

Water Year Type/Alt.	# of Months	160 ft. total	160 ft. %	178 ft. total	178 ft. %	193 ft. total	193 ft. %
		Frequency with which Reservoirs are below Critical Elevation Thresholds					
73-YEAR PERIOD	438	total	%	total	%	total	%
Alternative 1 (Base Case)		13	3%	32	7%	85	19%
Alternative 2		13	3%	32	7%	85	19%
Alternative 3		34	8%	63	14%	116	26%
Alternative 4		40	9%	64	15%	116	26%
Alternative 5		111	25%	134	31%	185	42%
Alternative 6		13	3%	32	7%	85	19%
Alternative 7		13	3%	32	7%	85	19%
Alternative 8		13	3%	32	7%	85	19%
CRITICAL PERIOD	37						
Alternative 1 (Base Case)		0	0%	3	8%	10	27%
Alternative 2		0	0%	3	8%	10	27%
Alternative 3		2	5%	5	14%	20	54%
Alternative 4		2	5%	5	14%	20	54%
Alternative 5		26	70%	30	81%	31	84%
Alternative 6		0	0%	3	8%	10	27%
Alternative 7		0	0%	3	8%	10	27%
Alternative 8		0	0%	3	8%	10	27%

NOTES:
<160 ft. msl - marinas close/last boat ramp out of operation
<178 ft. msl - relocation of main marina, limited lake surface area
<193 ft. msl - limited boat ramp availability

Table VI-55
Results of Recreation Impact Assessment for Pardee Reservoir

Peak Season (Apr - Sept.)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Water Year Type Alternative	# of Months	500 ft. total	500 ft. %	532 ft. total	532 ft. %	537 ft. total	537 ft. %	542 ft. total	542 ft. %
73-YEAR PERIOD	438								
Alternative 1 (Base Case)		12	3%	35	8%	41	9%	51	12%
Alternative 2		12	3%	35	8%	41	9%	51	12%
Alternative 3		14	3%	43	10%	47	11%	56	13%
Alternative 4		17	4%	46	11%	49	11%	56	13%
Alternative 5		77	18%	114	26%	124	28%	135	31%
Alternative 6		12	3%	35	8%	41	9%	51	12%
Alternative 7		12	3%	35	8%	41	9%	51	12%
Alternative 8		12	3%	35	8%	41	9%	51	12%
CRITICAL PERIOD	41								
Alternative 1 (Base Case)		0	0%	3	7%	3	7%	5	12%
Alternative 2		0	0%	3	7%	3	7%	5	12%
Alternative 3		0	0%	8	20%	8	20%	9	22%
Alternative 4		0	0%	8	20%	8	20%	9	22%
Alternative 5		16	39%	25	61%	26	63%	29	71%
Alternative 6		0	0%	3	7%	3	7%	5	12%
Alternative 7		0	0%	3	7%	3	7%	5	12%
Alternative 8		0	0%	3	7%	3	7%	5	12%

Off-Season (Oct.- March)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Water Year Type/Alt.	# of Months	500 ft. total	500 ft. %	532 ft. total	532 ft. %	537 ft. total	537 ft. %	542 ft. total	542 ft. %
73-YEAR PERIOD	438								
Alternative 1 (Base Case)		17	4%	58	13%	67	15%	70	16%
Alternative 2		17	4%	58	13%	67	15%	70	16%
Alternative 3		18	4%	61	14%	71	16%	76	17%
Alternative 4		20	5%	67	15%	73	17%	78	18%
Alternative 5		75	17%	139	32%	146	33%	153	35%
Alternative 6		17	4%	58	13%	67	15%	70	16%
Alternative 7		17	4%	58	13%	67	15%	70	16%
Alternative 8		17	4%	58	13%	67	15%	70	16%
CRITICAL PERIOD	37								
Alternative 1 (Base Case)		0	0%	7	19%	7	19%	7	19%
Alternative 2		0	0%	7	19%	7	19%	7	19%
Alternative 3		0	0%	12	32%	13	35%	13	35%
Alternative 4		0	0%	12	32%	13	35%	13	35%
Alternative 5		10	27%	28	76%	29	78%	30	81%
Alternative 6		0	0%	7	19%	7	19%	7	19%
Alternative 7		0	0%	7	19%	7	19%	7	19%
Alternative 8		0	0%	7	19%	7	19%	7	19%

NOTES:
<500 ft. msl - low water, ramp closes
<532 ft. msl - closure and removal of marina
<537 ft. msl - main boat ramp closes
<542 ft. msl - relocation of marina, limited boat ramp availability

Table VI-56

Results of Recreation Impact Assessment for New Melones Reservoir

Peak Season (April - Sept.)

Water Year Type / Alternative	# of Months	850 ft. total	850 ft. %	860 ft. total	860 ft. %	880 ft. total	880 ft. %	900 ft. total	900 ft. %
		Frequency with which Reservoirs are below Critical Elevation Thresholds							
73-YEAR PERIOD	438								
Alternative 1 (Base Case)		8	2%	9	2%	11	3%	15	3%
Alternative 2		26	6%	31	7%	49	11%	59	13%
Alternative 3		3	1%	5	1%	9	2%	13	3%
Alternative 4		16	4%	21	5%	27	6%	39	9%
Alternative 5		0	0%	1	0%	3	1%	8	2%
Alternative 6		3	1%	3	1%	5	1%	9	2%
Alternative 7		4	1%	4	1%	10	2%	13	3%
Alternative 8		12	3%	14	3%	22	5%	32	7%
CRITICAL PERIOD	41								
Alternative 1 (Base Case)		0	0%	0	0%	0	0%	1	2%
Alternative 2		13	32%	14	34%	21	51%	26	63%
Alternative 3		0	0%	1	2%	2	5%	3	7%
Alternative 4		7	17%	9	22%	12	29%	16	39%
Alternative 5		0	0%	0	0%	0	0%	0	0%
Alternative 6		0	0%	0	0%	0	0%	0	0%
Alternative 7		0	0%	0	0%	1	2%	3	7%
Alternative 8		4	10%	5	12%	8	20%	14	34%

Off-Season (Oct.- March)

Water Year Type/Alt.	# of Months	850 ft. total	850 ft. %	860 ft. total	860 ft. %
		Frequency with which Reservoirs are below Critical Elevation Thresholds			
73-YEAR PERIOD	438				
Alternative 1 (Base Case)		9	2%	10	2%
Alternative 2		31	7%	39	9%
Alternative 3		5	1%	7	2%
Alternative 4		20	5%	25	6%
Alternative 5		1	0%	3	1%
Alternative 6		3	1%	4	1%
Alternative 7		4	1%	4	1%
Alternative 8		16	4%	18	4%
CRITICAL PERIOD	37				
Alternative 1 (Base Case)		0	0%	0	0%
Alternative 2		12	32%	13	35%
Alternative 3		1	3%	1	3%
Alternative 4		5	14%	8	22%
Alternative 5		0	0%	0	0%
Alternative 6		0	0%	0	0%
Alternative 7		0	0%	0	0%
Alternative 8		3	8%	3	8%

NOTES:

<850 ft. msl - last boat ramp out of operation

<860 ft. msl - limited lake surface area and decline in campground/picnicking use

<880 ft. msl - marina closes

<900 ft. msl - decline in beach use

Table VI-57
Results of Recreation Impact Assessment for New Don Pedro Reservoir

Peak Season (May - Sept.)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Water Year Type Alternative	# of Months	600 ft. total	600 ft. %	720 ft. total	720 ft. %	780 ft. total	780 ft. %
73-YEAR PERIOD	365						
Alternative 1 (Base Case)		0	0%	34	9%	155	42%
Alternative 2		0	0%	34	9%	155	42%
Alternative 3		0	0%	54	15%	179	49%
Alternative 4		0	0%	51	14%	177	48%
Alternative 5		12	3%	105	29%	214	59%
Alternative 6		0	0%	34	9%	155	42%
Alternative 7		0	0%	29	8%	149	41%
Alternative 8		0	0%	38	10%	163	45%
CRITICAL PERIOD	35						
Alternative 1 (Base Case)		0	0%	6	17%	27	77%
Alternative 2		0	0%	6	17%	27	77%
Alternative 3		0	0%	18	51%	32	91%
Alternative 4		0	0%	15	43%	32	91%
Alternative 5		11	31%	32	91%	35	100%
Alternative 6		0	0%	6	17%	27	77%
Alternative 7		0	0%	6	17%	27	77%
Alternative 8		0	0%	9	26%	30	86%

Off-Season (Oct.- April)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Water Year Type Alternative	# of Months	600 ft. total	600 ft. %	720 ft. total	720 ft. %
73-YEAR PERIOD	511				
Alternative 1 (Base Case)		3	1%	65	13%
Alternative 2		3	1%	65	13%
Alternative 3		3	1%	114	22%
Alternative 4		3	1%	109	21%
Alternative 5		25	5%	175	34%
Alternative 6		3	1%	65	13%
Alternative 7		3	1%	62	12%
Alternative 8		3	1%	70	14%
CRITICAL PERIOD	43				
Alternative 1 (Base Case)		0	0%	9	21%
Alternative 2		0	0%	9	21%
Alternative 3		0	0%	32	74%
Alternative 4		0	0%	27	63%
Alternative 5		12	28%	43	100%
Alternative 6		0	0%	9	21%
Alternative 7		0	0%	7	16%
Alternative 8		0	0%	10	23%

NOTES:
<600 ft. msl - marinas close/last boat ramp out of operation
<720 ft. msl - limited lake surface area and decline in campground/picnicking use
<780 ft. msl - decline in beach use

Table VI-58
Results of Recreation Impact Assessment for Lake McClure

Peak Season (April - Sept.)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Water Year Type / Alternative	# of Months	590 ft. total	590 ft. %	600 ft. total	600 ft. %
73-YEAR PERIOD	438				
Alternative 1 (Base Case)		0	0%	0	0%
Alternative 2		0	0%	0	0%
Alternative 3		0	0%	0	0%
Alternative 4		0	0%	0	0%
Alternative 5		0	0%	0	0%
Alternative 6		0	0%	0	0%
Alternative 7		0	0%	0	0%
Alternative 8		0	0%	0	0%
CRITICAL PERIOD	41				
Alternative 1 (Base Case)		0	0%	0	0%
Alternative 2		0	0%	0	0%
Alternative 3		0	0%	0	0%
Alternative 4		0	0%	0	0%
Alternative 5		0	0%	0	0%
Alternative 6		0	0%	0	0%
Alternative 7		0	0%	0	0%
Alternative 8		0	0%	0	0%

Off-Season (Oct.- March)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Water Year Type/Alt.	# of Months	590 ft. total	590 ft. %	600 ft. total	600 ft. %
73-YEAR PERIOD	438				
Alternative 1 (Base Case)		0	0%	0	0%
Alternative 2		0	0%	0	0%
Alternative 3		0	0%	0	0%
Alternative 4		0	0%	0	0%
Alternative 5		0	0%	0	0%
Alternative 6		0	0%	0	0%
Alternative 7		0	0%	0	0%
Alternative 8		0	0%	0	0%
CRITICAL PERIOD	37				
Alternative 1 (Base Case)		0	0%	0	0%
Alternative 2		0	0%	0	0%
Alternative 3		0	0%	0	0%
Alternative 4		0	0%	0	0%
Alternative 5		0	0%	0	0%
Alternative 6		0	0%	0	0%
Alternative 7		0	0%	0	0%
Alternative 8		0	0%	0	0%

NOTES:
<590 ft. msl - last boat ramp out of operation
<600 ft. msl - limited lake surface area and marina closes

Table VI-59

Results of Recreation Impact Assessment for Millerton Lake

Peak Season (May - Sept.)

Water Year Type/Alt.	# of Months	468 ft. total	468 ft. %	470 ft. total	470 ft. %
		Frequency with which Reservoirs are below Critical Elevation Thresholds			
73-YEAR PERIOD	365				
Alternative 1 (Base Case)		24	7%	28	8%
Alternative 2		24	7%	28	8%
Alternative 3		24	7%	28	8%
Alternative 4		24	7%	28	8%
Alternative 5		56	15%	65	18%
Alternative 6		24	7%	28	8%
Alternative 7		24	7%	28	8%
Alternative 8		24	7%	28	8%
CRITICAL PERIOD	35				
Alternative 1 (Base Case)		7	20%	7	20%
Alternative 2		7	20%	7	20%
Alternative 3		7	20%	7	20%
Alternative 4		7	20%	7	20%
Alternative 5		8	23%	9	26%
Alternative 6		7	20%	7	20%
Alternative 7		7	20%	7	20%
Alternative 8		7	20%	7	20%

Off-Season (Oct.- April)

Water Year Type/Alternative	# of Months	468 ft. total	468 ft. %	470 ft. total	470 ft. %
		Frequency with which Reservoirs are below Critical Elevation Thresholds			
73-YEAR PERIOD	511				
Alternative 1 (Base Case)		10	2%	11	2%
Alternative 2		10	2%	11	2%
Alternative 3		10	2%	11	2%
Alternative 4		10	2%	11	2%
Alternative 5		17	3%	26	5%
Alternative 6		10	2%	11	2%
Alternative 7		10	2%	11	2%
Alternative 8		10	2%	11	2%
CRITICAL PERIOD	43				
Alternative 1 (Base Case)		1	2%	1	2%
Alternative 2		1	2%	1	2%
Alternative 3		1	2%	1	2%
Alternative 4		1	2%	1	2%
Alternative 5		2	5%	3	7%
Alternative 6		1	2%	1	2%
Alternative 7		1	2%	1	2%
Alternative 8		1	2%	1	2%

NOTES:
<468 ft. msl - last boat ramp out of operation
<470 ft. msl - limited lake surface area/decline in beach use

Table VI-60

Summary of Recreation Impacts at Major Reservoirs, 73-Year Period

73-year Period Average -- Peak Season

Reservoir	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
Shasta	0	0	0	0	0	0	0
Oroville	0	0	0	0	0	0	0
Folsom	0	0	0	0	-	0	0
Camanche	0	0	0	-	0	0	0
Pardee	0	0	0	-	0	0	0
New Melones	-	0	0	0	0	0	0
New Don Pedro	0	0	0	-	0	0	0
McClure	0	0	0	0	0	0	0
Millerton	0	0	0	-	0	0	0

73-year Period Average -- Off Season

Reservoir	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
Shasta	0	0	0	0	0	0	0
Oroville	0	0	0	0	0	0	0
Folsom	0	0	0	0	0	0	0
Camanche	0	0	0	-	0	0	0
Pardee	0	0	0	-	0	0	0
New Melones	0	0	0	0	0	0	0
New Don Pedro	0	0	0	-	0	0	0
McClure	0	0	0	0	0	0	0
Millerton	0	0	0	-	0	0	0

\+ indicates a significant change that increases recreational opportunities

\- indicates a significant change that decreases recreational opportunities

0 indicates no significant change in recreational opportunities

Table VI-61
Summary of Recreation Impacts at Major Reservoirs, Critical Period

Critical Period Average -- Peak and Off Season

Reservoir	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
Shasta	0	0	0	+	-	0	0
Oroville	-	-	-	+	-	-	-
Folsom	-	-	-	+ /-	-	-	-
Camanche	0	-	-	-	0	0	0
Pardee	0	-	-	-	0	0	0
New Melones	-	0	-	0	0	0	-
New Don Pedro	0	-	-	-	0	0	0
McClure	0	0	0	0	0	0	0
Millerton	0	0	0	-	0	0	0

\+ indicates a significant change that increases recreational opportunities

\- indicates a significant change that decreases recreational opportunities

0 indicates no significant change in recreational opportunities

\+ /- (increased opportunities in the peak season and decreased opportunities in the off season)

As with the reservoir impacts, the analysis is based on output from DWRSIM and EBMUDSIM (EBMUDSIM was used for the Mokelumne River). The projected changes in average monthly flows reflect the estimated modifications in reservoir operations and can be used to compare the effects of Alternatives 2 through 8 to the base case (Alternative 1). An impact analysis was conducted for each of the major rivers that could be affected by implementation of the water right decision and for which hydrologic modeling results were available.

Impact thresholds were developed for important peak-season (May-September) recreation activities, including boating and swimming. Impacts were not assessed for the off-season because most water contact activities do not occur during this period. Changes in recreation opportunities were assessed for the upper Sacramento (Keswick to Red Bluff), American, San Joaquin (above the confluence with the Merced), upper and lower Stanislaus (New Melones to Oakdale and Oakdale to the San Joaquin), Tuolumne, Merced, and Mokelumne rivers. Changes in recreation opportunities were not assessed for the Feather, Yuba, lower Sacramento, and lower San Joaquin rivers because recreation activities can be accommodated within a wide range of flows on these rivers. Changes in recreation opportunities were assessed for the full 73-year period as well as for the 1928-1934 critical period.

The recreation impact analysis considers the frequency of occurrence with which average monthly flows are above or below the various threshold levels or fall within an optimal range as defined for each river. Table VI-62 summarizes the frequency of occurrence in absolute numbers and as a percentage of the total number of months in the study period for the impact assessment on the selected rivers.

When the critical threshold is a given flow, above or below which recreational activities are impaired, a frequency of occurrence which is higher than the base case would indicate a decrease in recreational opportunities (a negative impact) and a frequency of occurrence which is lower than the base case would indicate an increase in recreational opportunities (a beneficial impact). When the critical threshold is an optimal range of flow, the reverse is true. A frequency of occurrence which is higher than the base case would indicate an increase in recreational opportunities (a beneficial impact), and a frequency of occurrence which is lower than the base case would indicate a decrease in recreational opportunities (a negative impact).

The critical thresholds for some of the river recreation opportunities identified in this analysis tend to overlap, yet a change in river flow may affect one activity and not another. In addition, it is possible for a change in river flow to have a negative impact to one activity and a beneficial impact to another (e.g. flows may drop below the optimal range for boating and into the optimal range for swimming). Some of the flow alternatives result in sustained flows that are higher than the optimal flow range identified for certain activities, such as some kinds of boating. While this results in a negative impact to those activities, there may be other recreational opportunities associated with the higher flows.

Due to the nature of the hydrologic input data and the use of average monthly operations, the modeled river flows may be expected to have a margin of error of 10 to 20 percent. Therefore, differences between the base case and the various alternatives are considered to be significant only if greater than 10 percentage points, higher or lower, from the base case. Table VI-63 summarizes which alternatives have significant recreation impacts (beneficial or negative) on the selected rivers. Significant differences in recreational opportunities occur on at least one river under each alternative but the majority of the significant impacts are beneficial, resulting in increased recreational opportunities.

Mitigation. Recreation in the rivers that could be affected would likely benefit by implementing the flow objective alternatives. In most cases, streamflow will be increased over normal conditions and swimmers, boaters, and others may actually benefit. For those cases where changes in streamflow result in decreased recreational opportunities, it is unlikely that the effects can be mitigated.

c. Wildlife Refuges and Wetlands. Wildlife refuges, wildlife management areas, and privately owned and managed wetlands (such as duck clubs) provide recreational opportunities, primarily in the form of hunting and bird watching. Surface water supplies are used at most of these locations to provide seasonal flooding, maintain wetland habitat and to grow feed crops that attract waterfowl. However, as discussed earlier in the section on impacts to vegetation and wildlife, implementation of the flow objective alternatives is not expected to have a significant impact to wetland habitat at wildlife refuges, wildlife management areas or privately owned and managed wetlands. Therefore, no significant impact to the recreational use of these areas is expected to occur.

Table VI-62
Results of Recreation Impact Assessment for Rivers in the Sacramento River Region

Sacramento River
Upper Reach
Peak Season (May - Sept.)

Water Year Type/Alt.	**Total Months**	Frequency with which Rivers are between Flow Thresholds: Between 2,500 and 12,000 cfs	
		total	%
73-YEAR PERIOD	365		
Alternative 1 (Base Case)		264	72%
Alternative 2		251	69%
Alternative 3		264	72%
Alternative 4		262	72%
Alternative 5		277	76%
Alternative 6		243	67%
Alternative 7		245	67%
Alternative 8		250	68%
CRITICAL PERIOD	35		
Alternative 1 (Base Case)		33	94%
Alternative 2		30	86%
Alternative 3		32	91%
Alternative 4		32	91%
Alternative 5		33	94%
Alternative 6		31	89%
Alternative 7		30	86%
Alternative 8		31	89%

NOTES:
2,500 to 12,000 cfs - optimal flow range for all boating activities

American River

Peak Season (May - Sept.)

Water Year Type/Alt.	**Total Months**	Frequency with which Rivers are between or below Flow Thresholds: Between 1,750 and 3,000 cfs		Below 1,750 cfs		Below 1,500 cfs	
		total	%	total	%	total	%
73-YEAR PERIOD	365						
Alternative 1 (Base Case)		110	30%	85	23%	74	20%
Alternative 2		236	65%	85	23%	73	20%
Alternative 3		234	64%	81	22%	68	19%
Alternative 4		233	64%	81	22%	70	19%
Alternative 5		115	32%	79	22%	59	16%
Alternative 6		244	67%	80	22%	64	18%
Alternative 7		89	24%	89	24%	77	21%
Alternative 8		93	25%	84	23%	66	18%
CRITICAL PERIOD	35						
Alternative 1 (Base Case)		8	23%	17	49%	14	40%
Alternative 2		16	46%	16	46%	13	37%
Alternative 3		16	46%	17	49%	12	34%
Alternative 4		16	46%	16	46%	12	34%
Alternative 5		8	23%	15	43%	12	34%
Alternative 6		15	43%	14	40%	12	34%
Alternative 7		5	14%	19	54%	16	46%
Alternative 8		8	23%	15	43%	14	40%

NOTES:
1,750 to 3,000 cfs - optimal flow range for all boating activities
< 1,750 cfs - minimum flow range for all boating activities
< 1,500 cfs - optimal flow for swimming

Table VI-62 (cont.)
Results of Recreation Impact Assessment for Rivers in the San Joaquin Valley Region

San Joaquin River
Upstream of Merced River
Peak Season (May - Sept.)

Water Year Type/Alt.	Total Months	Above 500 cfs		Between 300 and 500 cfs		Between 200 and 300 cfs		Below 300 cfs	
		Frequency with which Rivers are above, between, or below Flow Thresholds							
73-YEAR PERIOD	365	total	%	total	%	total	%	total	%
Alternative 1 (Base Case)		150	41%	209	57%	6	2%	6	2%
Alternative 2		144	39%	202	55%	19	5%	19	5%
Alternative 3		187	51%	170	47%	8	2%	8	2%
Alternative 4		188	52%	169	46%	8	2%	8	2%
Alternative 5		364	100%	1	0%	0	0%	0	0%
Alternative 6		146	40%	196	54%	23	6%	23	6%
Alternative 7		143	39%	202	55%	20	5%	20	5%
Alternative 8		145	40%	202	55%	17	5%	17	5%
CRITICAL PERIOD	35								
Alternative 1 (Base Case)		7	20%	25	71%	3	9%	3	9%
Alternative 2		5	14%	23	66%	7	20%	7	20%
Alternative 3		6	17%	27	77%	2	6%	2	6%
Alternative 4		6	17%	27	77%	2	6%	2	6%
Alternative 5		35	100%	0	0%	0	0%	0	0%
Alternative 6		5	14%	19	54%	11	31%	11	31%
Alternative 7		5	14%	22	63%	8	23%	8	23%
Alternative 8		5	14%	23	66%	6	17%	6	17%

NOTES:
>500 cfs - unknown recreational opportunities
300 to 500 cfs - optimal flow range for all boating activities
200 to 300 cfs - optimal range of canoeing flows
<300 cfs - below optimal flows for swimming

Mokelumne River

Peak Season (May - Sept.)

Water Year Type/Alt.	Total Months	Between 400 and 700 cfs		Below 200 cfs		Below 100 cfs	
		Frequency with which Rivers are between or below Flow Thresholds					
73-YEAR PERIOD	365	total	%	total	%	total	%
Alternative 1 (Base Case)		44	12%	54	15%	0	0%
Alternative 2		44	12%	54	15%	0	0%
Alternative 3		106	29%	44	12%	0	0%
Alternative 4		109	30%	43	12%	0	0%
Alternative 5		67	18%	18	5%	0	0%
Alternative 6		44	12%	54	15%	0	0%
Alternative 7		44	12%	54	15%	0	0%
Alternative 8		44	12%	54	15%	0	0%
CRITICAL PERIOD	35						
Alternative 1 (Base Case)		3	9%	8	23%	0	0%
Alternative 2		3	9%	8	23%	0	0%
Alternative 3		14	40%	6	17%	0	0%
Alternative 4		14	40%	6	17%	0	0%
Alternative 5		10	29%	3	9%	0	0%
Alternative 6		3	9%	8	23%	0	0%
Alternative 7		3	9%	8	23%	0	0%
Alternative 8		3	9%	8	23%	0	0%

NOTES:
400 to 700 cfs - optimal flow range for all boating activities
<200 cfs - below minimum flows for all boating activities
<100 cfs - below minimum flows for swimming

Table VI-62 (cont.)
Results of Recreation Impact Assessment for Rivers in the San Joaquin Valley Region

Stanislaus River
Lower Reach
Peak Season (May - Sept.)

Water Year Type/Alt.	Total Months	Between 700 and 800 cfs total	Between 700 and 800 cfs %	Below 300 cfs total	Below 300 cfs %
73-YEAR PERIOD	365				
Alternative 1 (Base Case)		2	1%	0	0%
Alternative 2		17	5%	0	0%
Alternative 3		39	11%	0	0%
Alternative 4		40	11%	0	0%
Alternative 5		23	6%	0	0%
Alternative 6		47	13%	0	0%
Alternative 7		27	7%	1	0%
Alternative 8		18	5%	0	0%
CRITICAL PERIOD	35				
Alternative 1 (Base Case)		0	0%	0	0%
Alternative 2		0	0%	0	0%
Alternative 3		6	17%	0	0%
Alternative 4		7	20%	0	0%
Alternative 5		1	3%	0	0%
Alternative 6		7	20%	0	0%
Alternative 7		2	6%	0	0%
Alternative 8		0	0%	0	0%

Frequency with which Rivers are between or below Flow Thresholds

NOTES:
700 to 800 cfs - optimal flow range for all boating activities
<300 cfs - below minimum flows for all boating activities

Stanislaus River
Upper Reach
Peak Season (May - Sept.)

Water Year Type/Alt.	Total Months	Between 700 and 2000 cfs total	Between 700 and 2000 cfs %	Below 700 cfs total	Below 700 cfs %
73-YEAR PERIOD	365				
Alternative 1 (Base Case)		256	70%	0	0%
Alternative 2		121	33%	0	0%
Alternative 3		178	49%	0	0%
Alternative 4		164	45%	0	0%
Alternative 5		232	64%	0	0%
Alternative 6		164	45%	0	0%
Alternative 7		156	43%	0	0%
Alternative 8		135	37%	0	0%
CRITICAL PERIOD	35				
Alternative 1 (Base Case)		27	77%	0	0%
Alternative 2		24	69%	0	0%
Alternative 3		21	60%	0	0%
Alternative 4		18	51%	0	0%
Alternative 5		30	86%	0	0%
Alternative 6		22	63%	0	0%
Alternative 7		17	49%	0	0%
Alternative 8		19	54%	0	0%

Frequency with which Rivers are between or below Flow Thresholds

NOTES:
700 to 2,000 cfs - optimal flow range for all boating activities
<700 cfs - below minimum flows for all boating activities

Table VI-62 (cont.)
Results of Recreation Impact Assessment for Rivers in the San Joaquin Valley Region

Tuolumne River

Peak Season (May - Sept.)

Water Year Type/Alt.	Total Months	Between 400 and 700 cfs total	Between 400 and 700 cfs %	Between 200 and 600 cfs total	Between 200 and 600 cfs %	Below 500 cfs total	Below 500 cfs %	Below 150 cfs total	Below 150 cfs %
73-YEAR PERIOD	365								
Alternative 1 (Base Case)		128	35%	174	48%	222	61%	47	13%
Alternative 2		128	35%	174	48%	222	61%	47	13%
Alternative 3		118	32%	156	43%	204	56%	43	12%
Alternative 4		120	33%	158	43%	205	56%	43	12%
Alternative 5		128	35%	170	47%	145	40%	12	3%
Alternative 6		128	35%	174	48%	222	61%	47	13%
Alternative 7		114	31%	177	48%	226	62%	45	12%
Alternative 8		119	33%	160	44%	228	62%	66	18%
CRITICAL PERIOD	35								
Alternative 1 (Base Case)		8	23%	12	34%	30	86%	12	34%
Alternative 2		8	23%	12	34%	30	86%	12	34%
Alternative 3		8	23%	11	31%	28	80%	10	29%
Alternative 4		8	23%	12	34%	28	80%	10	29%
Alternative 5		14	40%	22	63%	23	66%	3	9%
Alternative 6		8	23%	12	34%	30	86%	12	34%
Alternative 7		5	14%	13	37%	32	91%	12	34%
Alternative 8		11	31%	10	29%	30	86%	16	46%

Frequency with which Rivers are between or below Flow Thresholds

NOTES:
400 to 700 cfs - optimal flow range for all boating activities
200 to 600 cfs - optimal flow range for swimming
<500 cfs - below minimum flows for power boating
<150 cfs - below minimum flows for canoeing and kayaking

Merced River

Peak Season (May - Sept.)

Water Year Type/Alt.	Total Months	Below 500 cfs total	Below 500 cfs %	Between 50 and 200 cfs total	Between 50 and 200 cfs %
73-YEAR PERIOD	365				
Alternative 1 (Base Case)		316	87%	167	46%
Alternative 2		316	87%	167	46%
Alternative 3		290	79%	195	53%
Alternative 4		300	82%	214	59%
Alternative 5		132	36%	294	81%
Alternative 6		316	87%	167	46%
Alternative 7		317	87%	140	38%
Alternative 8		308	84%	115	32%
CRITICAL PERIOD	35				
Alternative 1 (Base Case)		34	97%	15	43%
Alternative 2		34	97%	15	43%
Alternative 3		33	94%	18	51%
Alternative 4		33	94%	21	60%
Alternative 5		14	40%	33	94%
Alternative 6		34	97%	15	43%
Alternative 7		35	100%	12	34%
Alternative 8		32	91%	11	31%

Frequency with which Rivers are between or below Flow Thresholds

NOTES:
<500 cfs - below minimum flows for all boating activities
50 to 200 cfs - optimal flow range for swimming

Table VI-63
Summary of Recreation Impacts on Selected Rivers

73-year Period Average -- Peak Season

River	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
Sacramento	0	0	0	0	0	0	0
American	+	+	+	0	+	0	0
Mokelumne	0	+	+	+	0	0	0
Stanislaus - upper	-	-	-	0	-	-	-
Stanislaus - lower	0	+	+	0	+	0	0
Tuolumne	0	0	0	+	0	0	0
Merced	0	0	+	+ /-	0	0	-
San Joaquin	0	-	-	-	0	0	0

Critical Period Average -- Peak Season

River	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
Sacramento	0	0	0	0	0	0	0
American	+	+	+	+	+	0	0
Mokelumne	0	+	+	+	0	0	0
Stanislaus - upper	0	-	-	0	-	-	-
Stanislaus - lower	0	+	+	0	+	0	0
Tuolumne	0	0	0	+	0	0	-
Merced	0	0	+	+ /-	0	0	-
San Joaquin	+ /-	0	0	-	+ /-	+ /-	0

\+ indicates a significant change that increases recreational opportunities
\- indicates a significant change that decreases recreational opportunities
\+ /- indicates significant changes that increase and decrease recreational opportunities
0 indicates no significant change in recreational opportunities

10. Scenic Quality

The implementation of the 1995 Bay/Delta Plan flow alternatives will not result in the obstruction of any scenic vista or view open to the public. However, potentially significant aesthetic effects, often referred to as "the bathtub ring," may occur at multiple-use reservoirs. The bathtub ring, which is the exposed shoreline below the maximum water surface elevation, is a normal occurrence at multiple-use reservoirs as water levels decline. The ring is usually devoid of vegetation. The flow alternatives will result in changes in the operation of upstream reservoirs which may cause water levels to be lower for longer periods, reducing the aesthetic values of the reservoirs.

To analyze the effects of implementing the flow alternatives on reservoir aesthetics, end-of-month surface area at selected reservoirs, as modeled using DWRSIM, was compared to the base case (Alternative 1). Table VI-64 summarizes the average monthly difference (May - September) in reservoir surface area for the 73-year period and dry-year average (average of below normal, dry, and critically dry years). The selected reservoirs include Lake Shasta, Lake Oroville, Folsom Lake, New Melones Reservoir, New Don Pedro Reservoir, Lake McClure, and Millerton Lake. The significant changes in reservoir surface area under each alternative are discussed below.

Under Alternative 2, reservoir surface area for the 73-year period is somewhat less than the base case at Shasta, Oroville, and Folsom, and significantly less than the base case at New Melones. For the dry-year average, reservoir surface area is significantly less than the base case at Folsom and New Melones. There are no changes in operations at New Don Pedro, McClure, or Millerton under this alternative.

Under Alternative 3, the dry-year average reservoir surface area is significantly less than the base case at McClure because of its relatively recent water right priority, but all of the reservoirs (except Millerton) have reduced surface area, particularly at Folsom and New Don Pedro.

Under Alternative 4, reservoir surface area is significantly less than the base case at New Melones for the 73-year period and the dry-year average and at Folsom during dry years.

Under Alternative 5, reservoir surface area for the 73-year period and the dry-year average is significantly less than the base case at New Don Pedro, McClure, and Millerton. This is the only alternative that affects Millerton because it is the only alternative that requires releases from Friant Dam.

Table VI-64
Average Monthly Difference in Reservoir Surface Area
May - September

Average of 73-Year Period Compared to the Base Case (percent)

	Shasta	Oroville	Folsom	N. Melones	N. Don Pedro	McClure	Millerton
Alt 2	-1.1	-2.8	-5.2	-14.0	0.0	0.0	0.0
Alt 3	-0.2	-2.7	-3.5	-4.0	-4.3	-5.5	0.0
Alt 4	-0.2	-2.7	-3.6	-9.1	-3.4	-2.5	0.0
Alt 5	1.4	0.5	0.4	-0.5	-14.3	-16.2	-10.4
Alt 6	-2.2	-3.2	-8.1	1.6	0.0	0.0	0.0
Alt 7	-2.0	-3.8	-7.3	5.6	-1.4	-3.1	0.0
Alt 8	-0.8	-2.6	-3.9	-8.5	-3.0	-7.4	0.0

Average of Dry Years Compared to the Base Case (percent)

	Shasta	Oroville	Folsom	N. Melones	N.Don Pedro	McClure	Millerton
Alt 2	-2.3	-3.6	-10.8	-18.5	0.0	0.0	0.0
Alt 3	-0.8	-3.6	-7.4	-4.6	-6.0	-10.0	0.0
Alt 4	-0.8	-3.7	-7.6	-11.5	-4.7	-4.1	0.0
Alt 5	2.0	0.7	-0.1	0.9	-20.2	-22.8	-9.2
Alt 6	-4.1	-4.5	-15.7	2.5	0.0	0.0	0.0
Alt 7	-3.7	-4.9	-14.2	8.3	-1.0	-4.1	0.0
Alt 8	-1.8	-3.8	-10.0	-11.9	-3.4	-11.5	0.0

Under Alternative 6, reservoir surface area for the 73-year period and the dry-year average is significantly less than the base case at Folsom. There are no changes in operations at New Don Pedro, McClure, or Millerton under this alternative.

Under Alternative 7, reservoir surface area for the 73-year period and the dry-year average is significantly less than the base case at Folsom and is significantly greater at New Melones.

Under Alternative 8, reservoir surface area for the 73-year period is somewhat less than the base case at Oroville, Folsom, and New Don Pedro, and significantly less than the base case at New Melones and McClure. For the dry-year average, reservoir surface area is somewhat less than the base case at Oroville and New Don Pedro, and significantly less than the base case at Folsom, New Melones and McClure.

In summary, Alternative 2 has the greatest negative impact to scenic quality at New Melones and, to a lesser extent, Folsom because the USBR would use these reservoirs to meet the flow objectives. Alternative 3 has the greatest negative impact at McClure because of its relatively low water right priority. Alternative 4 has a significant negative impact at New Melones because it would be used to meet Friant obligations that are significant during the pulse flow period. Alternative 5 has significant negative impacts at New Don Pedro, McClure, and Millerton because some of the Delta flow objectives are met by the San Joaquin River users. Alternatives 6 and 7 have the greatest negative impact at Folsom, but also affect Shasta and Oroville. Under Alternative 6, the SWP and CVP reservoirs in the Sacramento Valley would be used to meet the Vernalis flow objectives through releases from the Delta-Mendota Canal. Under Alternative 7, salinity control releases from New Melones are capped at 70 TAF and additional releases to meet the minimum flows on the San Joaquin River at Vernalis identified in the Letter of Intent would be made from New Don Pedro and McClure. SWP and CVP would meet the rest of the objectives through releases from Shasta, Oroville, and Folsom. Alternative 8 has the greatest impact at New Melones and McClure in most years, although Folsom is significantly affected in dry years.

Mitigation. The implementation of the flow alternatives will likely result in some degradation of the scenic quality at one or more reservoirs as water levels may be lower for longer periods. This is a temporary, although recurring, impact that is similar to what normally occurs under dry-year conditions. The temporary effect is alleviated when water levels rise during the wet season. It is unlikely that the impacts to scenic quality can be mitigated.

11. Cultural Resources

For the purposes of this EIR, cultural resources are defined as prehistoric and historic archeological sites, architectural properties (e.g., buildings, bridges, and structures), and traditional properties with significance to Native Americans. This definition is consistent with the CEQA, the California Register of Historical Resources, California Historical Landmarks and California Points of Interest. Under federal law, historic properties are defined by Section 106 of the National Historic Preservation Act (NHPA) of 1966, as amended and its implementing regulations, 36 CFR Part 800.

a. Regulatory Framework. CEQA provides the principal state policy for the protection of prehistoric and historic archeological resources. (See Pub. Resources Code § 21083.2) Additionally, the CEQA Guidelines in Appendix K outline procedures for the protection, preservation or mitigation of such resources. If a project may cause a substantial adverse change in the significance of an historical resource, the project may have a significant effect on the environment. (Pub. Resources Code § 21084.1; CEQA Guidelines, Appendix K).

An impact is considered significant under CEQA, if there is a substantial adverse change in the significance of an historical resource. The primary guiding policy in assessing potential impacts on cultural resources at both the state and federal levels is that impacts on sites should be avoided whenever feasible, whether or not the resource is eligible for the NRHP or is considered important. If after identification and evaluation an archeological deposit is determined not to be significant, the resource should be noted but should not be considered further under CEQA.

b. Data Limitations. Some parts of California have been inventoried more extensively than others. As a result, the number of known resources usually depends on the amount of research that has been conducted in the region, rather than on actual site density. The database is also biased in terms of site types because historic sites were not commonly recorded until the 1970's, resulting in an inaccurate ratio of historic to prehistoric sites. Native American groups were often not consulted until even more recent times as to the existence of traditional cultural properties (TCPs). Additionally they are often reluctant to reveal or publish the locations of TCPs. The available data on TCPs for various portions of California ranges from incomplete to non-existent.

Many Information Centers of the Historical Resources Information System have incomplete data bases due to backlogs in processing and the failure of individuals or agencies to submit site records and reports. Several of the reservoirs that could be impacted were completed prior to the implementation of laws protecting cultural resources, and only their basin areas were partially inventoried. Those that were subject to inventories were largely assessed for prehistoric resources and not for historic and TCPs. Some basin areas of the reservoirs that may be affected by the implementation of the 1995 Bay/Delta Plan have been partially inventoried during dry-year surveys while others have not. There are historic maps of reservoir basin areas indicating that many historic sites existed prior to inundation, but these resources have not been verified during field surveys.

Of all the reservoirs, New Melones has had the most extensive survey and mitigation measures undertaken, as it was constructed later than the other reservoirs. Currently, 627 sites have been recorded at New Melones. These sites are distributed throughout the project area. In the permanent pool zone lower than 808 feet above mean sea level (msl), there are 122 sites that have been recorded. The permanent pool zone/fluctuation pool at elevations from 808 feet to 1088 feet msl has 33 previously recorded sites. There are 232 sites located in the fluctuating pool zone only, while 24 other sites were located in the fluctuating pool zone/above pool area. The remainder of the sites are situated outside of the reservoir basin area.

Preliminary reoperation studies for Folsom Reservoir have documented some of the cultural resources that are subject to continuing impacts from reservoir operations. At least 123 prehistoric sites (including ethnographic sites) and 52 historic properties have been recorded as a result of surveys at Folsom Reservoir. Many of these sites have both prehistoric and historic components. Judging by field observations made since the 1970's, inundation has had a serious detrimental effect on many, if not most, of the sites within the reservoir basin. Studies at Folsom, and other reservoirs in northern California have suggested, however, that important scientific and/or cultural data may still survive within some of these sites. Previous surveys at Folsom, and surveys and excavations at other reservoirs in northern and central California have suggested that viable and important research data may survive in many of the reservoir sites. There is reason to believe that future archeological study within reservoirs can contribute significant knowledge of the prehistory, history, and ethnohistory of these areas. (Waechter et al 1994).

c. Impact Mechanisms. The following impact mechanisms have been identified as potentially affecting cultural resources.

Hydrology. Changes in reservoir operations could affect cultural resources at reservoir margins by changing historic patterns of reservoir filling and emptying and by changing flows (and therefore stages) in rivers and streams downstream of the reservoir. Sites in reservoirs are affected by pool fluctuation. They suffer effects of wavewash erosion, siltation, redeposition of materials, mixing of artifacts, and chemical alteration of site deposits from changing water levels, resultant water movement, and periodic inundation. The resources then dry out when exposed and get wet again when the water level comes up. This disrupts stratigraphy and increases the rate of decomposition of perishable materials. Sites located lower in the reservoir, within the deep pool (including those adjacent to old river flood plains), were more likely to be covered with silt, which sometimes formed a protective cap. Sites at or near the high water line, and sites exposed during drawdown, suffer both erosion and vandalism. (Waechter et al 1994). Decreasing the amount of storage at a reservoir may expose existing known and unknown cultural resources within the drawdown zone to more sustained and frequent impacts and cover a more extensive area than under existing operating criteria. When resources are physically exposed they are also open to vandalism, theft, and vehicular destruction.

Stream Channels. Changes in stream flows can cause impacts on cultural resources by exposing sites when river stages are below historic levels. High flood stages may cause bank erosion and relocation of river channels, both of which may expose cultural resource sites. Changes in stream flows can also cause impacts by changing recreational use. The types of impacts by recreational use are discussed in the following section under "Recreational Activities".

Reservoir Margins. Cultural resources located in the drawdown zone of reservoirs are most prone to damage from hydrologic changes. The most damaging impacts would probably be caused by erosion when lower reservoir levels expose a cultural resource site. Erosion can be caused by waves created by either wind or boat traffic. Boat-caused waves can be very destructive to cultural resources, especially on smaller reservoirs (Lenihan, et al., 1981). This is especially true if natural vegetation, which could help hold soil, is no longer present. Some erosion occurs from rising and falling waters across the resources during times of reservoir drawdown (Lenihan, et al., 1981).

Drawdowns can expose sites, many of which become visible to treasure seekers because inundation has removed vegetative cover. Drawdowns often leave a fine silt bench where the water has receded. The type of landform created when reservoirs are drawn down is a favorite of off highway vehicle users, who may unknowingly destroy cultural resources by using these areas (Lenihan, et al., 1981). Lowering water levels could also require new construction to extend boat ramps, create new beaches, or relocate marinas.

Less obvious, but also potentially destructive to resources, is wet/dry cycling. The repeated inundation and exposure of resources cause Wet/dry cycling, which causes perishable items (e.g., bone, wood, shell, ceramics, pollen, and leather) to disintegrate rapidly.

Another impact tied to the exposure of resources during drawdowns is caused by animals. For example, at Folsom Lake, site CA-Eld-204 had soils containing cultural remains (referred to as middens); exposure of the site during a drought revealed that the burrowing actions of the introduced clam *Corbicula fluminea* caused a major impact on this site. Raccoons that dug into the exposed midden while hunting for the clams (Lenihan, et. al., 1981), caused further damage. Lenihan et al. (1981) also noted the destruction of site features caused by cattle walking on sites still soft from having been recently exposed.

Water levels beyond historic conditions also pose a threat to cultural resources. For example, an historic site that was formerly reached by an arduous six-mile hike was exposed to greater vandalism when it became a ten-minute hike from the new lake margin (Lenihan, et. al., 1981).

Recreational Activities. Vandalism, whether caused by organized treasure seekers or by inadvertent disturbance, is a constant threat to the public's cultural resources. As the number of recreationists at facilities increases (because of better boating, swimming, or fishing opportunities), cultural resources are at greater risk. These risks occur not only at sites that are exposed at water margins, but also in the zone above inundation. Improved fishing could bring more anglers who would walk through this area to reach the river, which could lead to the discovery and possible looting of cultural resources.

Increased numbers of recreationists at river and reservoir facilities could require construction of new recreational facilities that in turn, may affect cultural resources. Impacts could occur from construction of new roads, restrooms, parking lots, marinas, and boat ramps.

Off-highway vehicle traffic and other forms of vandalism occur when reservoir levels are low. Lower water levels at reservoirs can be expected to increase enforcement problems and costs as vehicles can access areas previously inundated, causing damage to natural and cultural resources. The California Department of Parks and Recreation has documented the human destruction of sites by vandals both above and below reservoir gross pool.

Changes in Agricultural Practices and Land Use. Agricultural practices associated with various types of crops can lead to lesser or greater impacts on cultural resources. For instance, planting rice (where it is necessary to recontour the landscape) or planting orchards and/or vineyards (where it is necessary to plow the land to a depth approximately 2 meters) can be very destructive to cultural resources. None of the alternatives are expected to increase water diversions or deliveries to levels which would cause changes in agricultural practices. Therefore, there will be no impacts from changes in crops due to the alternatives.

d. Potential Impacts to the Cultural Resources Types. This section describes how different types of cultural resources may be affected by the impact mechanisms discussed above.

Prehistoric Site Types. Of the various types of prehistoric sites that may be affected by the alternatives, habitation sites, especially those sites containing midden soils, are most susceptible to damage. Generally the scientific value of habitation sites lies in the information on prehistoric life ways that can be extracted. Any activity that moves, removes, or destroys aspects of a site will compromise that information. Soils containing middens tend to be loose and easily eroded by wave action or the movement of water across a site. Midden soils often retain identifiable remnants of faunal material (e.g., bone or shell), possibly human burials, and occasionally perishable artifacts (e.g., basketry remains) that, if exposed, would deteriorate due to wet/dry cycling. Habitation sites are highly susceptible to intentional vandalism by artifact collectors and unintentional damage by off highway vehicle users.

Another site type commonly found are lithic scatters (strictly defined as those sites that contain only material manufactured from stone). The greatest danger to these sites is from artifact collection. If artifacts are moved from their original location by rising or falling waters, information about the site will be lost. Also erosional forces could remove artifacts from a site. Further, the submersion of obsidian artifacts could prevent the accurate dating using hydration-dating techniques.

Rock art sites containing petroglyphs, pictographs, and intaglios (artistic alignments of rocks) can be extremely vulnerable to changes in water level. Sites that may have been previously submerged under reservoirs and are exposed during drawdowns may suffer from wet/dry cycling, erosion due to wave action, and vandalism.

Bedrock mortars (used for grinding vegetal materials) are the prehistoric resource type least susceptible to damage through hydrologic mechanisms. However, midden, which is often associated with bedrock mortars, would be vulnerable to hydrologic impacts.

Historic Site Types. Historic resources (including archeological resources, structures, and buildings) include sites associated with early historic settlement, mining (hardrock and placer), agriculture (farming and ranching), transportation (railroads and roads), oil exploration, and logging.

Historic structures (including buildings, windmills, mining winches, and bridges) or their remains are highly susceptible to water level changes. The exposure of structures in reservoirs previously covered by inundation could subject them to erosion (especially if they are in a wave zone), wet/dry cycling, and vandalism.

Wooden portions of ditches and flumes (often associated with agriculture, mining, and logging) are highly susceptible to wet/dry cycling and erosion. Earthen ditches are affected principally by water level changes, especially wave action.

Debris scatters, which can be found within any type of historic site, are extremely vulnerable to water level changes. Erosion can completely remove a debris scatter, and wet/dry cycling can accelerate the decomposition of metal, wood, and leather artifacts. Debris scatter exposed by receding waters is very susceptible to vandalism.

Historic stone resources such as tailings piles (remnants from mining) and rock walls (often associated with ranching) are less prone to water damage unless these resources are left in a wave zone by changing water levels.

Traditional Cultural Properties. TCPs are properties that are identified as significant to an identifiable social group. The properties can be important because of cultural practices or beliefs, and are difficult to identify because often only members of the group are allowed to know their locations.

Common TCPs include geographic features such as prominent boulders or springs (locations where people traditionally gathered), harvesting locations (where plant food and medicinal and basketry materials were traditionally gathered), and large geographic features. Changes in hydrology and recreational use associated with the alternatives could disrupt the use of TCPs. Hydrologic damage could occur through inundation or erosion.

e. Impacts Analysis. This section describes the potential for impacts on cultural resources due to implementation of the flow alternatives. The description includes those impacts that may be caused by changes in hydrology and recreational activities.

Changes in Hydrology. Implementing the alternatives will result in changes to river flows. Table VI-65 shows the minimum and maximum river stage over the 73-year hydrology in feet above zero gage reading for the base case. It also shows the difference between this value and the corresponding stages for Alternatives 2 through 8. As shown on the table, none of the alternatives cause river stage to drop significantly below the minimum annual river stage for the base case. Therefore, there will be no impacts to cultural resources from fluctuating river levels due to the alternatives.

Implementing the alternatives will also result in changes to reservoir levels. Table VI-66 lists the minimum and maximum reservoir levels over the 73-year period for the base case. The table also lists the difference between reservoir levels for the base case and each of the other flow alternatives. Tables VI-51 through VI-59 describe the frequency of lower reservoir elevations in comparison to the base case.

The anticipated differences between the base case and the other seven alternatives in minimum pool elevations for the eight modeled reservoirs vary significantly. These range from a projected lower minimum pool of 55 feet to a higher minimum pool of 90 feet, which would occur at New Don Pedro Reservoir and New Melones Reservoir, respectively. Most of the changes would occur at the CVP and SWP reservoirs, except under Alternative 5, which would result in a significantly lower minimum pool at New Don Pedro Reservoir. Differences of only several feet will probably produce no measurable

Table VI-65
Minimum and Maximum Annual River Stage

73-Year Minimum Annual River Stage, (ft)

Alternative	Red Bluff	Feather	Verona	Natoma	Newman	Vernalis
Alt 1	3.5	1.3	4.9	1.5	4.0	4.0

Difference Between Minimum Annual River Stage and Base Case (ft)

Alternative	Red Bluff	Feather	Verona	Natoma	Newman	Vernalis
Alt 2	0.0	0.0	0.3	-0.1	0.0	-0.4
Alt 3	0.0	0.0	0.3	-0.1	0.0	0.3
Alt 4	0.0	0.0	0.3	-0.1	0.0	0.3
Alt 5	0.1	0.0	0.4	-0.1	0.6	0.4
Alt 6	0.0	0.0	0.3	-0.1	0.0	0.3
Alt 7	0.0	0.0	0.2	-0.1	-0.1	-0.7
Alt 8	0.0	0.0	0.2	-0.1	-0.1	-0.3

73-Year Maximum Annual River Stage, (ft)

Alternative	Red Bluff	Feather	Verona	Natoma	Newman	Vernalis
Alt 1	24.2	12.7	36.6	13.2	21.8	26.4

Difference Between Maximum Annual River Stage and Base Case (ft)

Alternative	Red Bluff	Feather	Verona	Natoma	Newman	Vernalis
Alt 2	0.0	0.0	0.0	0.0	0.0	0.0
Alt 3	0.0	0.0	-0.2	0.0	0.0	0.0
Alt 4	0.0	0.0	0.0	0.0	0.0	0.0
Alt 5	0.0	0.0	0.0	0.0	0.5	0.2
Alt 6	0.0	0.0	0.0	0.0	0.0	0.0
Alt 7	0.0	0.0	0.0	0.0	0.0	0.0
Alt 8	0.0	0.0	0.0	0.0	0.0	0.3

impacts as they are likely to be within the present operating margins. Sites within the reservoir pool will continue to be subjected to the same types of impacts as they have been historically (i.e., inundation and exposure during drawdowns under any of the alternatives), but the frequency of such drawdowns may increase significantly for some reservoirs under the various alternatives as compared to the base case. The consensus among researchers is that the nature and extent of the effects of reservoir inundation are dependent on several factors, most notably the location of a cultural property within the reservoir basin. Sites within the zone of seasonal fluctuation or drawdown suffer the greatest impacts, primarily in the form of erosion/scouring, deflation, hydrologic sorting, and artifact displacement, caused by waves and currents (Waechter et al 1994).

Table VI-66

Minimum and Maximum Annual Reservoir Elevation

73-Year Minimum Annual Reservior Elevation, (ft)

Alternative	Shasta	Oroville	Folsom	N. Melones	N. Don Pedro	McClure	Millerton
Alt 1	879	589	286	759	579	626	461

Difference Between Minimum Annual Reservoir Elevation and Base Case, (ft)

Alternative	Shasta	Oroville	Folsom	N. Melones	N. Don Pedro	McClure	Millerton
Alt 2	-12	3	0	-44	0	0	0
Alt 3	-7	-10	1	57	0	0	0
Alt 4	-6	-8	1	-21	0	0	0
Alt 5	32	11	4	90	-55	-1	-2
Alt 6	-20	-7	-10	62	0	0	0
Alt 7	-12	-8	0	46	1	0	0
Alt 8	-6	15	1	13	0	0	0

73-Year Maximum Annual Reservior Elevation, (ft)

Alternative	Shasta	Oroville	Folsom	N. Melones	N. Don Pedro	McClure	Millerton
Alt 1	1,067	900	466	1,088	832	867	576

Difference Between Maximum Annual Reservoir Elevation and Base Case, (ft)

Alternative	Shasta	Oroville	Folsom	N. Melones	N. Don Pedro	McClure	Millerton
Alt 2	0	0	0	0	0	0	0
Alt 3	0	0	0	0	0	0	0
Alt 4	0	0	0	0	0	0	0
Alt 5	0	0	0	0	0	0	0
Alt 6	0	0	0	0	0	0	0
Alt 7	0	0	0	0	0	0	0
Alt 8	0	0	0	0	0	0	0

Changes in Recreational Activities. Recreational activities at reservoir facilities are influenced by changes in reservoir surface elevation. None of the alternatives will involve increasing the height of the reservoirs, therefore water elevation will not reach beyond historic levels. Recreational activities are not expected to increase as a result of any of the alternatives. Accordingly, there will be no impacts on cultural resources due to increased recreational activities. If reservoir elevation falls below minimum levels described in Table VI-66 for a significant period of time, then there could be a possibility of impacts to cultural resources due to increased opportunities for OHV traffic and other forms of vandalism to occur when reservoir levels are low.

f. Potential Mitigation Measures. CEQA provides the principal state policy for the protection of prehistoric and historic archeological resources. Public Resources Code section 21083.2(b), in CEQA, states that "If it can be demonstrated that a project will cause damage to a unique archeological resource, the lead agency may require reasonable efforts to be made to permit any or all of these resources to be preserved in place or left in an undisturbed state." The CEQA Guidelines, Appendix K, outline procedures for the protection, preservation or mitigation or such resources. They direct public agencies to avoid damaging effects on an archeological resource whenever feasible. In order to accomplish this, it will be necessary to inventory areas to be impacted and evaluate any resources that are located. If avoidance of an important archeological site is not feasible, the agency operating the reservoir should prepare an excavation plan for mitigating the effect of the project on the qualities that make the resource important as outlined in Appendix K.

A public agency following the Federal clearance process under the National Historic Preservation Act (NHPA) or NEPA may use the documentation prepared under the federal guidelines in place of documentation necessary for CEQA. For the CVP reservoirs, any cultural resource research will need to meet federal standards, which will in turn satisfy the CEQA Guidelines. Separate cultural resource studies could become necessary for Lake Oroville, New Don Pedro Reservoir, and Lake McClure if an alternative affecting those reservoirs is selected.

Alternatives 2 through 8 could result in a federal undertaking. If the project constitutes a federal undertaking, then the federal agency must give full consideration to preservation values. Section 106 requires that federal agencies inventory and evaluate cultural resources and mitigate impacts on significant cultural resources prior to initiating their undertakings. At present it is not known which federal, state, and local agencies will be responsible for the different undertakings required to implement each of the proposed flow alternatives, however any impacts caused by an undertaking must be evaluated under Section 106 criteria.

The federal agency responsible for operation of the reservoir should ensure that resources eligible for the National Register of Historic Places resources that may affected by implementation of the project, will be treated. Treatments of historic properties include a variety of techniques to preserve or protect properties, or to document their historic values and information. In the case of unavoidable adverse effects on historic or prehistoric archeological sites, data recovery programs are usually implemented. Preservation, rehabilitation, restoration, and stabilization are common treatments for architectural properties.

Mitigation measures will vary depending on ownership and the way in which the selected alternative is operated. Previous surveys at Folsom Lake, and surveys and excavations at other reservoirs in northern and central California, have suggested that viable and important research data may survive in many of the reservoir sites. While distributional data and artifact assemblages will probably be incomplete, there is reason to believe that future archeological study within the project areas and the reservoir basins as a whole can add to knowledge of the prehistory and ethnohistory. (Waechter et al 1994).

Any required mitigation measures, as outlined above, should be undertaken after the SWRCB makes a water right decision. If the alternative chosen affects reservoirs operated by the federal government, then the federal agencies should complete the Section 106 process. If the reservoirs affected by the chosen alternative are owned or operated by the state or a public entity then the SWRCB will require the reservoir operators to implement mitigation measures that will ensure compliance with the CEQA Guidelines, Appendix K. Compliance with CEQA requires that any significant project-generated impacts to important cultural resources will be avoided or mitigated. Required measures could include surveys of areas newly exposed during minimum pool conditions, evaluation of any resources identified in those areas and implementation of any CEQA mandated mitigation measures.

12. Groundwater Resources

In the upstream areas of the Delta watershed, groundwater is a readily available water supply that can be used to replace surface water deliveries reduced as a result of implementing the flow objectives. In California, there is no permit procedure to regulate groundwater appropriations unless the appropriation is from a subterranean stream flowing through a known and defined channel. Groundwater that is not part of a subterranean stream flowing through a known and defined channel is called "percolating groundwater." Most of the groundwater in California is presumed to be percolating groundwater. Percolating groundwater withdrawals in general are regulated only where;

1) basins have been adjudicated establishing the water rights of various parties;
2) the State Legislature has granted a local water district the power to levy a groundwater extraction charge, or "pump tax";
3) groundwater management districts have been established with authority to regulate pumping by ordinance;
4) a local agency adopts a groundwater management plan pursuant to Water Code sections 10753 et seq.;
5) counties have exercised their police power to limit groundwater extractions; or
6) water agencies in an area have agreed to self-regulation.

Existing problems caused by groundwater pumping could be magnified if pumping increases as a result of surface water delivery reductions. These problems include surface land subsidence and the associated loss of aquifer capacity, groundwater overdraft, groundwater quality deterioration, increases in energy consumption, and decreases in agricultural productivity. Increases in energy consumption are discussed in section C.7 of this chapter.

In this analysis, surface water delivery reductions resulting from the flow alternatives are assumed to be replaced by groundwater pumping in the Delta watershed. For Alternatives 3 and 4, this assumption is different than the assumptions used in the development of the hydrology, as described in Chapter V. In that case, the Sacramento Basin water right holders were assumed to seek contracts for an alternative water supply and the San Joaquin Basin water right holders would pump groundwater. The actual response of water right holders to curtailed diversions is uncertain, but the groundwater pumping assumption is made in this section to ensure that a worst case scenario is used for evaluating impacts to groundwater resources.

The description of impacts to groundwater resources is discussed in this section for the entire Central Valley. Additional groundwater impacts in the Friant Service Area are described in section E of this chapter.

a. Land Subsidence. Subsidence occurs in the Delta, western San Joaquin Valley, and a portion of the central Sacramento Valley. Subsidence in the Delta is due to the compaction and erosion of the organic peat soils due to agricultural practices. As the flow objectives will not change land use practices in the Delta, subsidence there will not be affected by implementation of the flow objectives. Subsidence in the San Joaquin and Sacramento valleys results from lowered groundwater elevations and the subsequent compaction of the dewatered soil interstitial spaces. Land subsidence can change canal gradients, damage buildings, and require repair of other structures. Another negative effect of subsidence is the permanent loss of aquifer capacity. This loss occurs when beds of clay and silt compress as groundwater is extracted. Once these fine-grained beds compress, they can never hold as much water again and aquifer capacity is permanently lost.

In Chapter V, section A, the reductions in surface water deliveries resulting from implementation of the flow objectives are quantified. Assuming that these reductions are made up through groundwater pumping, subsidence could occur from implementing the flow objectives if groundwater elevations fall to critical thresholds.

The area of concern for subsidence in the Sacramento Valley is in Yolo County between the towns of Davis and Zamora in the south central part of the valley. Some localized subsidence was documented in this area during the 1987-1992 drought (USBR 1997g). Under Alternatives 2, 5, 6, 7 and 8, surface water delivery reductions are not anticipated for this area and should not contribute to renewed subsidence. Under Alternatives 3 and 4, the direct diversions of some water rights holders will be curtailed in the vicinity of the subsidence area, which would contribute to subsidence problems in the Davis/Zamora area during extended droughts. However, contracts for surface supplies to replace the lost supplies would mitigate the impacts.

Land subsidence is a significant problem in the western San Joaquin Valley in both the San Joaquin River basin and the Tulare Basin. The largest of the three land subsidence areas in the San Joaquin Valley is the 2,600 square mile Los Banos-Kettleman City area which extends from Merced County to Kings County and lies within both the San Joaquin River basin and the Tulare Basin. Prior to completion of the California Aqueduct in 1967, groundwater was the only source of irrigation water for most of the western San Joaquin Valley. Several decades of groundwater pumping lowered water levels and caused land subsidence of 1 foot regionally and up to 29 feet locally (Poland et al. 1975). With the completion of the aqueduct, surface water replaced groundwater as the principal source of irrigation water and total irrigation increased in the area. From 1967 to the present, the water table has risen across the area, as much as 100 feet locally. The increase in the altitude of the water table increased the area underlain by shallow groundwater creating the need for subsurface drainage of agricultural fields (Belitz et al. 1992).

Land subsidence and agricultural drainage problems are at the opposite ends of the "too little/too much groundwater" problem in the western San Joaquin Valley. Since 1967, subsidence has occurred only during the two extreme droughts of 1976-77 and 1987-92 when groundwater was used extensively to replace surface water supplies. In 1990, subsidence of up to 2 feet was measured by the DWR along the California Aqueduct in western Fresno County (USBR 1997g). DWR (1994) reports that the highest amount of subsidence occurred in 1992. Thus, subsidence has been a significant drought-related problem. There is also a subsurface drainage problem in this area (discussed in Chapter VIII). The San Joaquin Valley Drainage Program (SJVDP 1990) proposed a groundwater management solution that called for replacing surface water supplies with groundwater supplies to bring the system into hydrologic balance and stabilize the water table at a lower depth. The SJVDP's recommended plan included pumping 56 TAF of groundwater annually from beneath problem drainage areas in the Grasslands, Westlands and Tulare subareas to help manage drainage problems. Therefore, increased groundwater pumping on the west side of the San Joaquin Valley caused by implementation of the flow objectives may help meet the San Joaquin Valley Drainage Program recommendations, but it could increase subsidence problems in drought years. Additional groundwater pumping to replace surface water can also have the undesired effect of decreasing agricultural productivity due to the higher salinity of groundwater. This impact is discussed in section d.

Other areas of land subsidence in the Tulare Basin are the Tulare-Wasco area located between Fresno and Bakersfield, and the Arvin-Maricopa area located 20 miles south of Bakersfield in Kern County. Land subsidence has exceeded 12 feet locally in the Tulare-Wasco area and 9 feet locally in the Arvin-Maricopa area. Oil and gas withdrawal is partly responsible for subsidence in the Arvin-Maricopa area (USBR 1997g).

Table VI-67 shows the critical period changes in surface water deliveries for the alternatives compared to the base case associated with the subsidence areas in the San Joaquin Valley. Delivery reductions vary from 265 TAF under Alternative 4 to 401 under Alternative 5. Since subsidence occurred during the last two droughts, subsidence problems are likely in future droughts under existing conditions. The reductions in surface deliveries associated with flow objective implementation in subsidence areas likely will exacerbate the subsidence problem. Assuming that these delivery reductions are replaced with groundwater pumping, then implementation of all of the alternatives could significantly exacerbate the subsidence problems during drought periods. Under Alternative 5, the impacts would be felt mostly in the Friant Project area. Increased subsidence over current levels during droughts is a significant impact because the subsidence is likely to occur along important water conveyance facilities including the Delta-Mendota Canal, Mendota Pool and California Aqueduct as it did in the 1987-92 drought. Water conveyance facilities are especially susceptible to damage because subsidence can change the gradients of these facilities. Additionally, subsidence permanently reduces the capacity of the aquifer.

Table VI-67
Water Delivery Changes in Land Subsidence Areas of the San Joaquin Valley Critical Period Annual Average (TAF)

	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
SWP Tulare Basin Service Area	-152	-149	-149	-47	-145	-160	-146
Exchange Contractors	-64	-46	-45	-18	-76	-69	-63
CVP San Luis Unit	-120	-72	-71	-9	-131	-121	-110
CVP Friant Project	0	0	0	-327	0	0	0
Total Delivery Changes	-336	-267	-265	-401	-352	-350	-319

Possible mitigation for the subsidence problems in both the Sacramento and San Joaquin valleys includes:

1. Limits on groundwater pumping. The SWRCB has authority to prohibit water diversion if the method of diversion is unreasonable pursuant to Article X, section 2 of the California Constitution. This authority could be used to limit groundwater pumping to keep water levels above the threshold levels where subsidence begins. Counties could use their police power to limit groundwater pumping.

2. Land retirement to reduce demand. This measure may improve the agricultural drainage problems on the west side of the San Joaquin Valley. Retirement of 43,000 acres in the Grasslands, Westlands and Tulare subareas already has been recommended by the San Joaquin Valley Drainage Program as a management option for agricultural drainage.

3. Conservation through a change in cropping patterns to reduce consumptive use.

4. Water Transfers. Alternate surface water supplies could be secured through water transfers.

b. Groundwater Overdraft. Groundwater overdraft is defined by the DWR as the condition of a groundwater basin where the amount of water extracted exceeds the amount of groundwater recharging the basin “over a period of time” (DWR 1980). To quantify overdraft, the period of time must be long enough to produce a record that can be used to approximate the long-term average hydrologic conditions in the basin. In the California Water Plan Update (DWR 1994), the DWR estimated the amount of groundwater overdraft in the Central Valley. In the Sacramento River Basin, groundwater overdraft is reported in Sacramento County at a level of 33 TAF. Groundwater overdraft in the San Joaquin River Basin is estimated to be 224 TAF and in the Tulare Basin is estimated to be 630 TAF. All quantities were calculated at the 1990 development level. Table VI-68 shows the overdraft quantities in the Central Valley by basins or counties.

Because groundwater is used to replace much of the shortfall in surface water supplies, water delivery reductions resulting from the flow alternatives would increase groundwater overdraft in the Central Valley by increasing groundwater pumping and eliminating surface water imports as a source of recharge. Water delivery reductions for the major suppliers resulting from the seven flow alternatives are reported in Table VI-69. For this evaluation of groundwater overdraft, the quantities shown in Table VI-69 are assumed to be the increases in groundwater pumping that will result from the different alternatives.

Table VI-68
Average Annual Groundwater Overdraft in the Central Valley at the1990 Level of Development

Basin	Overdraft (TAF)
Sacramento River Basin	
Sacramento County	33
San Joaquin River Basin	
Sacramento County	19
San Joaquin County	70
Modesto Basin	15
Turlock Basin	18
Merced Basin	28
Chowchilla Basin	13
Madera Basin	45
Delta-Mendota Basin	16
Tulare Basin	
Westside Basin	30
Pleasant Valley Basin	30
Kings Basin	245
Tulare Lake Basin	85
Kaweah Basin	45
Tule Basin	65
Kern County Basin	130

Data from DWR 1994a.

Sacramento River Basin. The Sacramento County area is the only area in the Sacramento River Basin with a groundwater overdraft problem. The DWR expects the amount of overdraft to more than double in Sacramento County and neighboring Placer and El Dorado Counties by 2020 (Bulletin 160-98, v. 1, p. 3-51). The Sacramento County area meets most of its need for agricultural and urban water with groundwater. Significant surface water delivery reductions are not expected in this area as a result of implementing the flow objectives, thus, the overdraft problem should not be affected by implementation of the objectives.

San Joaquin River Basin. Average annual overdraft in the San Joaquin River Basin is estimated at 224 TAF (DWR 1994a). Average annual reductions in surface water delivery in the basin vary from 50 TAF to 163 TAF under the alternatives. Thus, depending on the alternative implemented, groundwater overdraft in the San Joaquin River Basin could increase between 22 and 73 percent causing a significant impact to the overdraft problem. On a local level, different areas in the San Joaquin Valley are impacted by different alternatives. The following discussion deals with the local basins of the valley listed in Table VI-68 and shown in Figure VI-79.

Table VI-69
Average Annual Surface Water Delivery Changes in Overdrafted Areas of the Central Valley for the 73-Year Period (TAF)

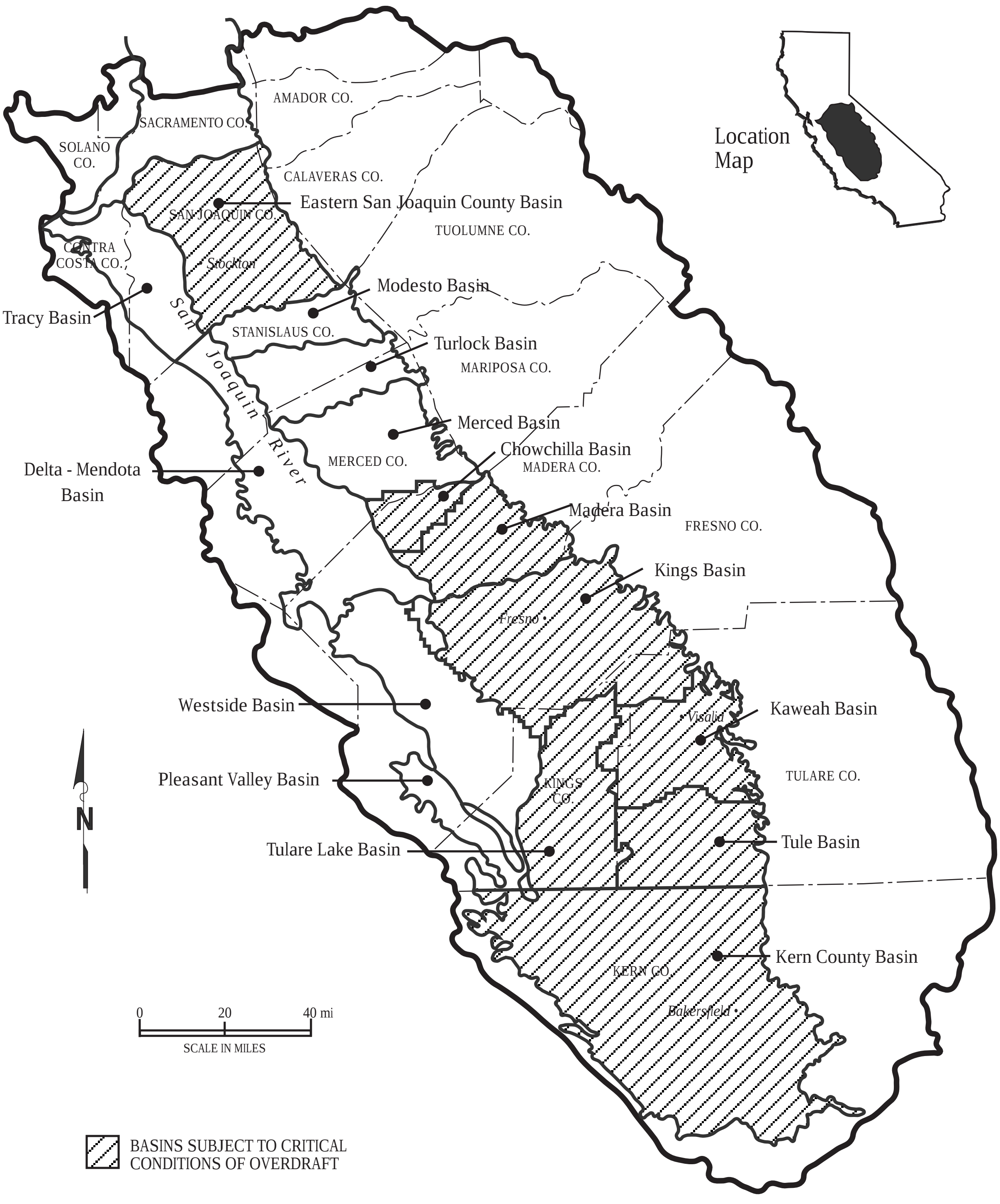
	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
San Joaquin River Basin							
Stockton East WD/							
Central San Joaquin WCD (CVP)	-37	-22	-24	-9	-4	-84	-47
Modesto ID/Turlock ID	0	0	0	-6	0	0	0
Merced ID	0	0	0	0	0	0	0
Eastman Lake (Chowchilla WD)	0	-14	-13	-10	0	0	0
Hensley Lake (Madera ID)	0	0	0	-7	0	0	0
Exchange Contractors (CVP)	-20	-15	-16	-7	-21	-24	-18
Other CVP and DMC Ag Diversions	-44	-39	-39	-32	-25	-49	-55
San Joaquin River System Direct Diversions	0	-73	-65	0	0	0	0
Total	-101	-163	-157	-71	-50	-157	-120
Tulare Basin							
Tulare Basin (SWP)	-45	-36	-36	-5	-44	-53	-45
San Luis Unit (CVP)	-98	-86	-86	-71	-55	-107	-125
Friant Project (CVP)	0	0	0	-423	0	0	0
Total	-143	-122	-122	-499	-99	-160	-170

In the San Joaquin County area, delivery reductions occur under each of the seven alternatives for both the 73-year and critical periods. Assuming that groundwater pumping will replace this source of supply, the flow alternatives will increase overdraft in San Joaquin County by amounts varying from six percent under Alternative 6 to 120 percent under Alternative 7. The most serious problem associated with the overdraft in San Joaquin County is the deterioration of groundwater quality from saline water drawn into the basin. This problem is discussed in section c. below.

With the exception of San Joaquin County, the other overdrafted basins in the San Joaquin River Valley are in areas that use very little surface water. The areas that incur the surface delivery reductions are generally adjacent to the overdrafted areas and function as recharge areas to the overdrafted basins. Lowering groundwater levels in these recharge areas will have the negative effect of decreasing the rate at which groundwater migrates into and recharges the overdrafted basins. Assuming that all surface water delivery reductions are made up through groundwater pumping, each of the seven alternatives will increase groundwater overdraft in the San Joaquin River Valley.

The Modesto Basin lies between the Stanislaus and Tuolumne Rivers, from the San Joaquin River on the west to the Sierra Nevada foothills on the east. The Turlock Basin lies between the Tuolumne and Merced Rivers and is bounded on the west by the San Joaquin River and on the east by the Sierra Nevada foothills (DWR 1980). The Modesto ID and Turlock ID together incur average annual surface water delivery reductions in the amount of 6 TAF under Alternative 5 for the 73-year period, about 13 percent of the annual average overdraft. Reductions under the other alternatives are zero. If this amount is made up through groundwater pumping, declining water levels could impact recharge and worsen overdraft in the Modesto and Turlock groundwater basins.

Figure VI-79
Groundwater Basins in the San Joaquin Valley



The Merced Basin includes lands south of the Merced River between the San Joaquin River on the west and the Sierra Nevada foothills on the east (DWR 1980). No surface water delivery reductions were identified for the Merced Irrigation District, thus, the alternatives are not expected to impact groundwater overdraft in this basin.

The Chowchilla Basin includes lands in Madera and Merced Counties and is bounded on the west by the San Joaquin River (DWR 1980). The Chowchilla Basin is impacted under Alternatives 3, 4, and 5 due to delivery reductions from Eastman Lake and the Friant project. Implementation of Alternatives 3 and 4 potentially could double the existing overdraft of 13 TAF. Under Alternative 5, overdraft could increase by over 75 percent. Additional surface water reductions to the Chowchilla Irrigation District from the Friant Project will add to the overdraft impact of Alternative 5. The Chowchilla Irrigation District is a CVP contractor and has the option of purchasing replacement water, if available, from the CVP rather than pumping groundwater. If replacement water is not available from the CVP, Alternatives 3, 4, and 5 will have a significant effect on groundwater overdraft in the Chowchilla Basin.

The Madera Basin consists of lands overlying the alluvium in Madera County (DWR 1980). Delivery reductions under Alternative 5 from Lake Hensley and the Friant project will impact groundwater overdraft in the Madera Basin. Average annual reductions for Lake Hensley average 7 TAF, approximately 16 percent of the annual overdraft of 45 TAF. With the additional reductions to the Madera Irrigation District from the Friant Project, Alternative 5 most likely will have a significant impact on groundwater overdraft in the Madera Basin.

The Delta-Mendota basin lies for the most part west of the San Joaquin River and south of the Stanislaus County line. Its southern boundary is generally the northern boundary of Westlands Water District in Fresno County (DWR 1980). Annual overdraft in this basin is 16 TAF. Surface water delivery reductions for this area include those to the Exchange Contractors and Delta Mendota agricultural diversions. These reductions are incurred under all six flow alternatives and range from a low of 39 TAF under Alternative 5 to a high of 73 TAF under Alternatives 7 and 8. These reductions are equal to 244 percent to 456 percent of the annual overdraft and would probably have a severe impact on groundwater overdraft in this basin.

Under Alternatives 3 and 4, surface water delivery reductions are incurred throughout the San Joaquin River system by water rights holders with direct diversion rights. These reductions could result in additional groundwater pumping in the amount of 87 TAF under Alternative 3, or 78 TAF under Alternative 4. The party incurring most of the delivery reductions, the West Stanislaus Irrigation District, is a CVP contractor. The district has the option of contracting with the CVP for replacement water rather than pumping groundwater if water is available from that source. If CVP water is not available, then Alternative 3 and 4 would have a significant impact on overdraft in the San Joaquin River Valley.

The existing groundwater overdraft problem in the San Joaquin River Basin will be significantly impacted by implementation of any of the six flow alternatives. Alternative 6 has the least impact because this alternative allows for use of combined SWP and CVP points of diversion which reduces the water supply impact to the area.

Tulare Basin. Average annual overdraft in the Tulare Basin is estimated at 630 TAF (DWR 1994a). Average annual surface water delivery reductions in the basin vary from 99 TAF to 499 TAF under the alternatives. Thus, depending on the alternative implemented, groundwater overdraft in the Tulare Basin could increase between 16 and 79 percent causing a significant impact to the overdraft problem. On a local level, different areas in the Tulure Basin are impacted by different alternatives. The following discussion deals with the local basins listed in Table VI-68 and shown in Figure VI-79.

The Westside Basin and Pleasant Valley Basin are located within the CVP San Luis Unit in western Fresno and northwestern Kings Counties. The combined average annual overdraft in these two basins is 60 TAF. Surface water delivery reductions occur under all seven flow alternatives and range from an annual average of 55 TAF to 125 TAF. These reductions are equal to 92 to 208 percent of the annual overdraft. Implementation of any of the flow alternatives is likely to have a significant impact on overdraft in the Westside and Pleasant Valley basins.

The Kings, Tulare Lake, Kaweah, Tule and Kern County basins comprise the rest of the Tulare Basin and are served by the CVP Friant Project and SWP Tulare Basin Unit. The CVP Friant Project generally serves the east side of the Tulare Basin although some water is delivered from this project to the San Joaquin River Basin. The SWP Tulare Basin Unit generally serves the central and southern parts of the Tulare Basin. In 1980, the DWR designated each of these five groundwater basins as subject to critical conditions of overdraft because of declining water levels and land subsidence (DWR 1980). Average annual overdraft in these basins is estimated to be 570 TAF although 43 percent of this overdraft is in the Kings Basin. Surface water delivery reductions occur under all seven flow alternatives, however, reductions are significantly higher under Alternative 5 because this is the only alternative that results in delivery reductions from the Friant Project. Annual average delivery reductions range from 36 to 428 TAF for these basins. These reductions equal 6 to 75 percent of the annual overdraft and would have significant impacts on groundwater overdraft in these basins. Groundwater overdraft impacts would be highest under Alternative 5.

Groundwater Overdraft Mitigation. Mitigation measures for groundwater overdraft impacts include:

1. Local agencies could adopt and implement local groundwater management plans in accordance with Water Code section 10750 et seq. or other authority. Section 10750 et seq. provides authority and procedures for certain local agencies to produce and implement groundwater management plans. Coordination between agencies in the same basin is encouraged.

2. Establish a groundwater management agency by statute. The Legislature has enacted several specific statutes establishing local groundwater management agencies that can

enact ordinances to regulate the amount of groundwater that is extracted and limit its place of use within the district's boundaries.

3. Develop conjunctive use programs. A conjunctive use program involves constructing facilities to enable the use of surface water supplies during wet years and groundwater supplies during drought years. Additionally, surplus surface water can be stored underground for extraction and use during droughts.

4. Conservation of water supplies by planting crops with lower consumptive use requirement and by providing financial incentives for crop rotation programs to the farming community.

5. Water transfers. Alternate surface water supplies could be secured through water transfers.

c. Groundwater Quality Deterioration. Groundwater quality deterioration reduces the usable groundwater storage in basins and thus, the available supply. Groundwater overdraft can lead to water quality deterioration because it produces a gradient that induces movement of water from adjacent areas. If the adjacent areas contain poor quality water, degradation of groundwater in the basin can occur. Usable storage lost to groundwater quality deterioration was included in DWR's estimate of overdraft in the San Joaquin Valley (DWR 1994).

Overdraft in San Joaquin County area has caused the migration of saline water from the Delta sediments eastward near the City of Stockton. The DWR estimated annual overdraft to be 70 TAF at the 1990 demand level (1994). Wells have been abandoned and replacement supplies have come from new wells drilled farther east, and from the Calaveras River through the Stockton-East Water District Aqueduct. Alternate water supplies are needed to stop the degradation of water quality in the aquifer (DWR 1980). A reduction in CVP deliveries in San Joaquin County could cause a significant increase in the groundwater overdraft and an increase in the deterioration of groundwater quality in the underlying aquifer. This problem is especially serious because it threatens a municipal water supply.

Another groundwater quality problem area in the San Joaquin Valley occurs in the valley trough between Merced County and Kern County where a pumping induced west-to-east gradient is causing the migration of poor quality water into the valley trough. This problem affects both agricultural and municipal beneficial uses of groundwater. Water with total dissolved solids of 2,000 to 7,000 milligrams per liter is displacing water with total dissolved solids of 300 to 700 milligrams per liter (DWR 1994). Groundwater overdraft in the Merced, Chowchilla, and Madera Basins is causing the west-to-east gradient. According to the San Joaquin River Exchange Contractors' comment on page 292 of Volume 3 of the FEIR, a well-developed cone of depression and overdrafting in the Raisin City area also contributes to this problem. This problem could worsen significantly under Alternatives 3, 4, and 5 because of the magnitude of the surface water delivery reductions incurred in the Chowchilla and Madera Basins. The other alternatives would have no impact because they do not cause surface water delivery reductions in these two basins.

Mitigation for this impact includes those mitigations for groundwater overdraft listed in section b. In addition to these actions, the SWRCB has authority under Article X, section 2 of the California Constitution to limit groundwater pumping if the method of diversion is unreasonable. Further, the SWRCB has authority under Water Code sections 2100 and 2101 to file an action in Superior Court to restrict pumping, impose physical solutions, or both, to prevent the destruction of or irreparable injury to the quality of groundwater.

d. Decreased Agricultural Productivity. Scientists generally believe that plant growth is inhibited as plants expend more energy under high salt conditions to acquire water from the soil and to make biochemical adjustments necessary to survive (SWC 1992). Reduced surface water supplies may contribute to problems of salt buildup in agricultural soils because substitute groundwater supplies have higher salinity levels than imported surface water. This problem is most likely to occur in the San Joaquin River Valley west of the San Joaquin River where groundwater quality generally ranges from 500 to more than 1500 milligrams per liter in totals dissolved solids concentrations (USBR 1997f).

Vegetables, fruits, and nuts are sensitive to salt damage; grains, cotton, and sugar beets are more tolerant. Water with less than 2,000 parts per million total dissolved solids can be used to irrigate most salt-tolerant cops with limited reduction in yields.

Mitigation measures for this impact include:

1. Blending groundwater supplies with surface water supplies to reduce the salinity of applied irrigation water.

2. Crop shifting to grow more salt tolerant crops.

3. Water transfers to secure alternate surface water supplies.

4. Conservation of water supplies through planting higher value crops requiring less consumptive use and through higher irrigation efficiencies.

D. EXPORT AREAS

The export areas include all areas receiving water through the Delta-Mendota Canal, the California Aqueduct, the Contra Costa Canal, the North Bay Aqueduct, the South Bay Aqueduct, the Mokelumne Aqueduct, and the Hetch Hetchy Aqueduct. The following discussion of export area impacts is divided into two sections: (1) SWP and CVP export service area and (2) the EBMUD service area. The area served by the Hetch Hetchy Aqueduct is not discussed in this section because implementation of the alternatives should not affect deliveries to this area.

1. SWP and CVP Export Service Area

A summary of the delivery reductions expected to occur in the export areas served by the SWP and the CVP due to implementation of one of the alternatives is provided in Table VI-70. The allocation of these impacts between the SWP and the CVP is uncertain because the alternatives as formulated do not address this issue, and the SWP and the CVP have not developed an up-to-date operating agreement.

Table VI-70
Summary of Average Annual Export Service Area Delivery Reductions for the SWP and CVP (TAF)

	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
73-year period	-296	-256	-257	-155	-229	-333	-337
Critical period	-768	-643	-643	-213	-778	-770	-727

The relative magnitude of the environmental impacts of the alternatives in the export areas is a function of the delivery reductions - the larger the delivery reduction caused by an alternative the greater the environmental effects in the export areas. Based on this characterization, over the 73-year period, Alternative 5 has the least effects in the export areas followed by Alternative 6. Alternatives 3 and 4 are indistinguishable, and Alternatives 2, 7, and 8 entail the greatest delivery reductions among the alternatives in the export areas.

The ER, Appendix 1 to the 1995 Bay/Delta Plan, describes the environmental effects of implementing the plan in the export areas served by the SWP and the CVP. That analysis assumes that the SWP and the CVP are solely responsible for meeting the plan objectives. The delivery reductions in the SWP and the CVP export areas caused by implementation of the alternatives identified in this report are less than or similar to the delivery reductions in the SWP and the CVP export areas identified in the ER. Therefore, the description of the environmental effects of implementation of the alternatives in the export areas served by the SWP and the CVP are not repeated here. However, the significant environmental effects that may occur due to delivery reductions in these areas, as described in the ER, are summarized below.

a. Groundwater. The previous section of this report provides a detailed description of impacts to groundwater in the Sacramento and San Joaquin valleys, excluding the Friant Service Area. This summary is applicable to the entire export area. These two areas overlap.

The reduction in surface water deliveries caused by implementation of the plan could cause increased pumping of groundwater because many water users will replace their reduced surface water supplies with groundwater. Groundwater pumping does not require prior authorization in much of California. Consequently, water users in most export areas can drill new wells or increase the capacity of existing wells without needing government authorization. They could, however, be subject to challenges either in court or before the SWRCB if their diversion and use of groundwater adversely affected other water uses or environmental values. The significant environmental effects that could occur due to substitution of groundwater for surface water are: depletion of groundwater resources, permanent loss of aquifer capacity, surface land subsidence, sea water intrusion, water quality degradation, decreased agricultural productivity, and increased energy consumption.

This draft EIR assumes that reductions in surface water supplies will be replaced by groundwater.

b. **Land Use Changes**. Land use changes that will occur as a result of the implementation of the Bay/Delta Plan are uncertain because such changes are the result of numerous decisions by individuals, water districts, and governmental agencies. However, the most likely land use changes are crop shifts and land fallowing.

c. **Wildlife Habitat**. Exports from the Delta support wildlife habitat both through planned deliveries to wildlife refuges and through incidental benefits associated with the transport, use, and discharge of the water. Table V-1, which provides a detailed description of the delivery reductions, indicates that wildlife refuge deliveries are largely unaffected by the alternatives; however, incidental benefits will be significantly affected.

d. **Urban Landscape**. The State Water Contractors identified the following uses and beneficial effects of urban landscapes (SWC 1992): aesthetics and scenic design; embellishment of private dwellings and surroundings; creation of private domestic space; community involvement activities, as in community gardens; public amenities such as public parks, greenways, and scenic reservations; wildlife habitat; reduction in use of fossil fuels for air conditioning with a concomitant reduction in production of associated air pollutants; reduction of water pollution in wetlands; and resistance to erosion, especially in areas with steep slopes, unstable soils, and variable rainfall.

In the long-term, reduced water deliveries are likely to result in locally mandated, more efficient management of water resources. Most of the elements of such management are contained within the Memorandum of Understanding Regarding Urban Water Conservation in California. Most of the urban water exported from the Delta is delivered by agencies that have signed the MOU.

e. **Recreation**. Recreational facilities that receive water from Delta exports could be affected by the delivery reductions. The San Luis Reservoir is the export facility most vulnerable to recreational impacts caused by export reductions.

f. **Water Reclamation**. Most uses of reclaimed water can be served when the TDS is no greater than 800 mg/l. Normal urban water use generally adds about 300 mg/l TDS to the potable water supply. Therefore, to achieve an acceptable TDS level of 800 mg/l in reclaimed water, which will allow for a full range of beneficial uses that could be served with reclaimed water, a source low in TDS (no more that 500 mg/l) is needed. For the urban areas of Southern California, where most water reclamation efforts in the State are taking place, this means that a reliable source of imported water that is low in TDS is required. Loss of high quality exports from the Delta could be replaced in some years with imported Colorado River water, which typically has TDS levels of 600-750 mg/l. Replacement of imported Delta water with imported Colorado River water could retard water reclamation efforts.

Export area delivery reductions could also have positive effects. Reduced deliveries to the San Joaquin Basin will reduce the salt loading to the river. Additional groundwater pumping can be a beneficial effect in some problem drainage areas by lowering or stabilizing the water table.

g. Growth Inducing Effects. Implementation of any of the flow alternatives will reduce water deliveries throughout the SWP and CVP export service areas (see Chapter V). To the extent that historic patterns indicate future trends, reduced surface water availability is unlikely to affect growth in urban areas. Water is one of many factors influencing growth in a region but does not, by itself, cause the growth of a region (DWR 1996). Water shortages have rarely done more than slow the progress of adequately financed development proposals. Reductions in municipal and industrial supplies have typically been replaced through groundwater, reclamation, more intensive management, and price-induced conservation. Thus, implementation of any of the flow alternatives is not expected to affect growth.

h. Mitigation. There are several methods available to water districts in export areas to minimize the effects of reduced water supplies. These methods are described in section B. of chapter XII.

2. EBMUD Service Area

EBMUD supplies water originating principally from the Mokelumne River watershed to customers in 20 cities and 15 unincorporated communities in parts of Alameda and Contra Costa counties. Approximately 1.2 million people are served in a 325 square mile area extending from Crockett in the north southward to San Lorenzo encompassing the major cities of Oakland, Berkeley and Richmond, and eastward from San Francisco Bay to Walnut Creek, Danville and San Ramon. A map of the Mokelumne River watershed, the Mokelumne Aqueduct, and the EBMUD service area is provided in Figure VI-80.

The following discussion is divided into three sections: (a) summary of customer deficiencies, (b) EBMUD's response to increased flow requirements, and (c) effects in the EBMUD service area.

a. Summary of Customer Deficiencies. EBMUD used an operations model, EBMUDSIM, to assess impacts to its customers as the result of implementing the flow alternatives. The model was used to project customer deficiencies caused by implementation of the base case (Alternative 1) and Alternatives 3, 4, and 5 at current (1995) levels of development (EBMUD 1997b). For the purpose of this study, customer deficiencies occur when EBMUD deliveries are less than 248,640 acre-feet per year. The customer deficiencies for Alternatives 2, 6, 7, and 8 are assumed to be the same as those for Alternative 1 because these alternatives do not require additional releases from EBMUD reservoirs. A summary of the results of the model studies is provided in Table VI-71. The table identifies the number of years that deficiencies would occur during the 75-year hydrologic simulation.

Figure VI - 80
EBMUD Water Supply and Service Area

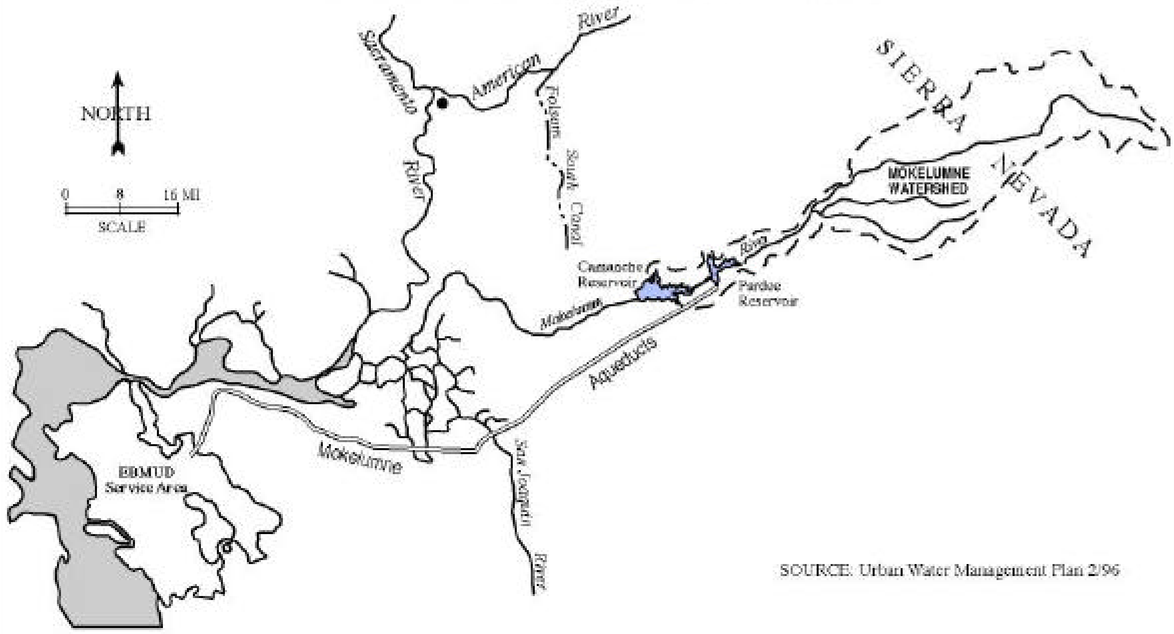


Table VI-71
EBMUD Customer Deficiencies*

	Total Number of Deficiencies	15 Percent or Greater Deficiencies	25 Percent or Greater Deficiencies
1961 Agreement	15	7	2
Alternative 1 (Base)	25	12	2
Alternative 3	30	14	7
Alternative 4	30	14	8
Alternative 5	42	25	18

* Number of years that deficiencies occur during the 75-year hydrologic simulation.

For reference purposes, the table also lists the deficiencies under the 1961 agreement between EBMUD and DFG. EBMUD's current requirements to release water from Camanche Reservoir for fishery purposes are set forth in the 1961 agreement. EBMUD entered into the 1961 agreement to comply with permit terms contained in EBMUD's water right (Permit No. 10478) granted to EBMUD by the SWRCB's predecessor agency in 1956. The 1961 agreement provides that 13 TAF of water above releases for all other purposes must be released from Camanche Reservoir annually for fishery purposes. The 1961 agreement is not used as the base case flow requirements on the Mokelumne River in this report because

EBMUD is currently operating to meet the flows in the 1997 Joint Settlement Agreement. Thus, the 1997 agreement is used as the base case.

The 1997 Joint Settlement Agreement initiated by EBMUD, USFWS, and DFG sets forth flow and non-flow measures to protect the fishery resources of the lower Mokelumne River. The agreement was developed as a settlement of the proceedings before the Federal Energy Regulatory Commission to review EBMUD's fish flow release requirements from Camanche Reservoir. The flow requirements under the 1997 agreement constitute an increase from the 1961 agreement requirements. In 1996, an SWP and CVP export group signed a Memorandum of Understanding stipulating that the export group agreed that the flow requirements in the 1997 agreement are sufficient to meet EBMUD's responsibility for the objectives in the SWRCB's 1995 Bay/Delta Plan. This agreement was initiated as is being implemented through the FERC licensing process; therefore, the effects of the agreement are not discussed in this document.

The table shows that the deficiencies are lowest in the base case, excluding the 1961 agreement deficiencies which are provided only for information. Alternatives 3 and 4 have very similar deficiencies and the deficiencies under Alternative 5 are significantly higher. EBMUD considers deficiencies between 15 and 25 percent to be severe. Deficiencies in this range may warrant a declaration of a water short emergency and institution of mandatory water use reductions. EBMUD considers deficiencies of 25 percent or more to be critical (EBMUD 1996).

The model studies also show that carryover storage levels in EBMUD's reservoirs would be more severely depleted during droughts under the Alternatives 3, 4, and 5 than they would be under Alternative 1. Decreased carryover storage during drought periods indicates increased risk of severe water shortages. Combined storage levels in Pardee and Camanche reservoirs during the modeled 1985 through 1993 hydrologic period under Alternatives 3 and 4 showed depletions of as much as 160 TAF. Under Alternative 5, storage levels would be almost completely depleted during drought events. Under this alternative, storage levels during the modeled 1985 through 1993 hydrologic period decline to near dead storage amounts in mid-1988, the second year of the 1987-92 drought, and stay near that level throughout the remainder of the drought period. In addition, the model shows that in 1991, EBMUD's customers would have received only approximately 10 percent of their normal year water supply. This model result indicates that water supply may not be reliably maintained under Alternative 5.

b. EBMUD's Response to Increased Flow Requirements (Mitigation). EBMUD will respond to water supply reductions by seeking new sources of water. Reasonable options available to EBMUD are contained in the 1993 programmatic EIR for its updated Water Supply Management Program (EBMUD 1993). The EIR describes the following five measures, which are summarized below: (1) conservation, (2) reclamation, (3) groundwater storage/conjunctive use, (4) additional reservoir storage, and (5) supplemental supply. The programmatic level analysis of the impacts of these measures is contained in the 1993 EIR.

Conservation. EBMUD currently manages a conservation program that includes education, incentives, regulation, and ongoing studies. Conservation savings are achieved primarily by introducing water-saving hardware and by persuading customers to use water more efficiently. Long-term changes that could achieve additional water savings for EBMUD customers include the installation of ultra-low-flush toilets, low-flow showerheads and faucets, water-efficient appliances, efficient outdoor irrigation systems, and enhanced commercial and industrial water audits. Alternative conservation programs studied include inspections to assure that water-saving hardware will remain in use by customers, rebates, mandatory landscaping measures, and programs that foster public awareness of water use. Depending on the level of effort expended on conservation measures, annual water savings in the year 2020 are estimated to range from 7.8 to 39.2 TAF above the savings from existing and adopted conservation programs.

Reclamation. The use of recycled water for selected exterior irrigation and industrial processes is an ongoing EBMUD practice. A number of reclamation programs have already been implemented by EBMUD, and additional reclamation opportunities have been identified. The alternatives analysis for the updated Water Supply Management Program examined a broad range of techniques including expanding the existing use of non-potable water by major irrigators (golf courses and parks), exporting treated wastewater to the Bay/Delta Estuary for salinity control, and pursuing advanced treatment technology for potable use of recycled water. The most feasible alternatives identified through this process include additional reclamation projects that provide non-potable water for irrigation and industrial uses. In the year 2020, these projects could save EBMUD between 9 and 32.5 TAF above the savings already realized from existing and adopted reclamation programs.

Groundwater Storage/Conjunctive Use Component. The concept of groundwater storage/conjunctive use is to store surface water in the ground in years when water is available and to use this stored groundwater in conjunction with or in lieu of surface water supplies in dry years. Potential basins with the ability to provide storage were examined and the best opportunities were found to exist in San Joaquin County near Lodi. A broad range of recharge methods and alternative withdrawal scenarios were evaluated.

Reservoir Storage. Alternative surface storage opportunities were examined at a number of locations throughout the Bay Area and the Sierra foothills. The alternatives included the development of new reservoirs, the expansion of existing reservoirs, and cooperative efforts with other agencies for the development of reservoirs. Three reservoir alternatives, Buckhorn Reservoir, Los Vaqueros Reservoir, and the raising of Pardee Dam to expand Pardee Reservoir, were studied in detail and the latter alternative was perceived to be feasible. The project would raise Pardee Dam by 57 feet, thereby increasing the capacity of the reservoir by 150 TAF.

Supplemental Supply. Several sources of additional water for use by EBMUD customers were evaluated in the 1993 programmatic EIR. Two alternatives appeared feasible and were studied in detail: (1) diversions from the Delta and (2) construction of a pipeline to allow EBMUD to utilize its existing American River contract with the USBR.

The EBMUD and the USBR issued a DEIR/EIS on the Supplemental Water Supply Project in November 1997, which addresses two primary project alternatives, both involving American River diversions. The first alternative is an EBMUD-only project that involves deliveries from the American River near Nimbus Dam, via the Folsom South Canal to a new pipeline connection between the FSC in southern Sacramento County and EBMUD's Mokelumne Aqueducts in San Joaquin County. The second alternative is a joint project between EBMUD, the City of Sacramento, and the County of Sacramento. Under this alternative, water would be diverted from the lower American River near the confluence with the Sacramento River and conveyed to the City's water treatment plant. Water for EBMUD would then be conveyed through new pipelines from the treatment plant to the FSC and from the FSC to the Mokelumne Aqueducts.

c. **Effects of Reduced Water Supply**. The effects of reduced water supply in the EBMUD service area are described in the 1993 EIR. The effects include shortages for EBMUD customers, significant public health and safety risks, and adverse socioeconomic consequences.

EBMUD claims that its customer demand at the 1995 level of development is approximately 249 TAF per year. This demand is estimated by EBMUD to increase to 362 TAF by the year 2020. Shortages under the alternatives at the 1995 level of development are described above, and these shortages will increase at the 2020 level of development. EBMUD is required to serve customers within its service area with a water supply that is reliable and of sufficient quantity and quality. EBMUD intends to augment its water supply under the base case. More aggressive augmentation measures will be required if Alternatives 3, 4, or 5 are adopted.

Public Health and Safety. Average reservoir levels under Alternatives 3, 4, or 5 would probably decline in comparison to the base case. Water quality typically declines as reservoir levels drop significantly. Therefore, the quality of drinking water supplied to customers could be compromised as the water would be drawn from reservoirs with lower water levels.

At the very low delivery levels modeled under Alternative 5, public health could be severely compromised as water deliveries are curtailed to the EBMUD service area. Sanitation and firefighting capabilities could be affected.

Socioeconomic Effects. EBMUD would likely have to impose a new service connection moratorium or significant amounts of rationing in response to projected shortages under all the alternatives unless new water supplies can be secured. These actions would have a significant, negative effect on the economy and the quality of life in and around the EBMUD service area. Depending on the measures implemented and the ability of individual firms to respond, some local businesses would suffer, especially water intensive businesses such as food processing, car washes, laundromats, and electronics firms. Employment opportunities in the service area could decrease, and total personal income might also decline. Property values could be adversely affected, which could adversely affect the services local government could afford to provide.

E. FRIANT SERVICE AREA

The Friant Unit of the CVP delivers water to over one million acres of irrigatable farmland on the east side of the southern San Joaquin Valley from approximately Chowchilla on the north to the Tehachapi Mountains on the south. The principal features of the Friant Unit begin with the San Joaquin River at Millerton Reservoir (Friant Dam), located northeast of Fresno. Water is distributed from Millerton Lake to contracting irrigation and water districts and local cities through the Friant-Kern Canal to the south and through the Madera Canal to the north. A map with the principal features of the Friant Unit is provided in Figure VI-81.

Downstream riparian and pre-1914 water right holders originally held the majority of the water rights to the San Joaquin River. The USBR signed purchase and exchange agreements with these water right holders at the time the Friant Project was developed. The largest of these agreements requires annual delivery of 800 TAF of water, excluding deficiency periods, to the central San Joaquin Valley near Mendota. These deliveries are usually made with water exported from the Delta. Therefore, the Friant Unit is dependent upon other features of the CVP, including Shasta Dam, the Tracy Pumping Plant, and the Delta-Mendota Canal, to facilitate the required exchange. The following discussion is divided into two sections: (a) summary of delivery reductions, (b) effects in the Friant service area.

1. <u>Summary of Delivery Reductions</u>. Alternative 5 is the only alternative that results in direct reductions in deliveries to the Friant service area. Alternatives 3 and 4 assign a responsibility to the Friant Project to provide flows, but the water is released from New Melones Reservoir under these alternatives. A summary of the Friant service area deliveries under the alternatives and the reductions under Alternative 5 in comparison to all of the other alternatives is provided in Table VI-72.

Table VI-72
Summary of Average Friant Project Deliveries and Reductions

Alternative	73-year Period (TAF)	Critical Period (TAF)
Base Case	1,343	959
Alternative 5	920	632
Reduction	423	327

The Friant service area employs a two-class system of water allocation. Class 1 water is the firm supply amounting to the first 800 TAF of yield from the San Joaquin River and Millerton Reservoir. Class 2 water is available only after the Class 1 allotment has been fully met. Class 1 water is typically under contract to districts that serve areas with limited or no access to good quality groundwater. Class 2 water is typically under contract to those districts that have access to good quality groundwater supplies and can accept reoccurring deficiencies by using their wells as their principal source of supply. Many of the Class 2 areas also have substantial recharge capability - both natural and artificial.

Figure VI -81
Principal Features of the Friant Unit and Crop Producing Regions of the Central Valley Production Model

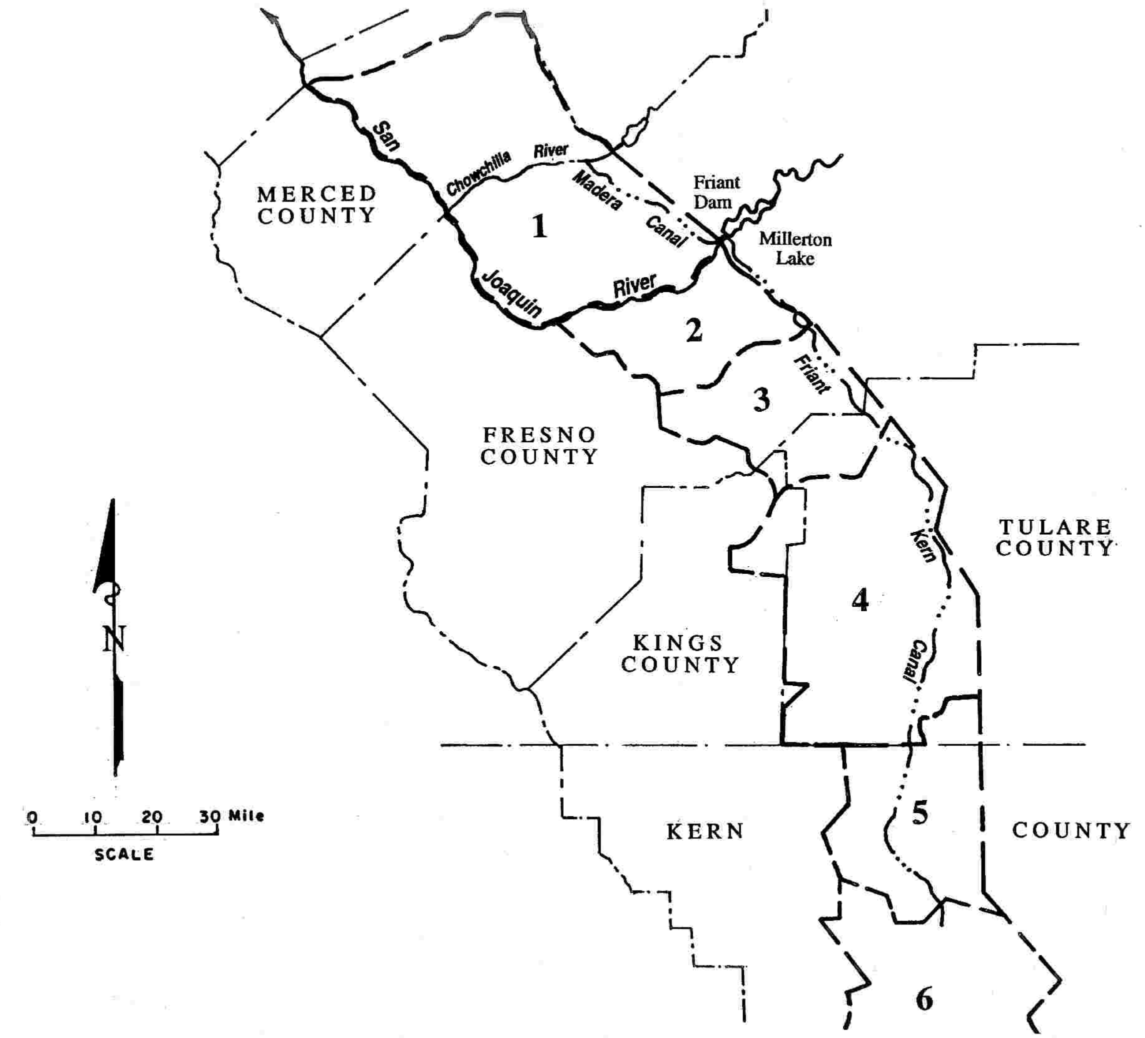


Table VI-73 lists the Friant Unit contractors and their Class 1 and Class 2 contract amounts. The reductions imposed under Alternative 5 will severely curtail the availability of Class 2 water in most years and will reduce the availability of Class 1 water in some years.

2. Effects in the Friant Service Area. Reductions in Friant Unit water deliveries, such as those possible under Alternative 5, would have serious effects in the service area. Reduced water deliveries would initially cause shifts in cropping patterns, increased costs associated with the adoption of more efficient irrigation systems, and idling of croplands. Groundwater would be used to replace a significant portion of the reduced water supplies, and over time the increased pumping would draw down an already over-drafted groundwater basin and cause subsidence. The increased costs associated with pumping from increasingly greater depths would cause more land to be removed from production. Ultimately, water quality problems associated with lower water tables and generally depleted aquifers would result in the idling of even more acreage.

Table VI-73
Friant Unit Long-Term Contractors and Contract Amounts

Contractor	Class 1 (TAF)	Class 2 (TAF)
Arvin-Edison WSD	40	312
Chowchilla WD	55	160
City of Fresno	60	0
City of Orange Cove	1.4	0
City of Lindsay	2.5	0
Delano-Earlimart ID	109	75
Exeter ID	11.5	19
Fresno Co. Water Works District No	0.2	0
Fresno ID	0	75
Garfield WD	3.5	0
Gravelly Ford WD	0	14
International WD	1.2	0
Ivanhoe ID	7.7	739
Lewis Creek WD	1.5	0
Lindmore ID	33	22
Lindsay-Strathmore ID	27.5	0
Lower Tule River ID	61.2	238
Madera County	0.2	0
Madera ID	85	186
Orange Cove ID	39.2	0
Porterville ID	16	30
Saucelito ID	21.2	32.8
Shafter-Wasco ID	50	39.6
Southern San Joaquin MUD	97	50
Stone Corral ID	10	0
Tea Pot Dome WD	7.5	0
Terra Bella ID	29	0
Tulare ID	30	141
Total	**800.3**	**1,402.30**

Groundwater traditionally has been used to buffer the effects of reduced surface water supplies during droughts. In a similar manner, groundwater pumping would temporarily buffer irrigators from the effects of the reductions caused by implementation of Alternative 5. Because of the continual pressure that would be put on groundwater supplies, in addition to that experienced during natural droughts, the groundwater basin would likely not be sufficiently recharged during wet years. Consequently, in the long-run, acreage would be removed from production not only because of reduced CVP supplies and increased pumping costs but also because of the reduced ability of the groundwater aquifer to provide a buffer against natural droughts.

The effects of a 500 TAF annual reduction in deliveries to the Friant service area were recently studied by two different groups (Brown et al 1996, FWUA 1997). This level of reduction is similar to the 73-year average annual delivery reduction that would result from adoption of Alternative 5 (423 TAF); therefore, these studies are used in this report to characterize the effects of implementation of the alternative in the Friant service area.

The results cited in this report are obtained principally from the study conducted by Northwest Economic Associates (NEA) for the Friant Water Users Authority (FWUA) (FWUA 1997). The FWUA retained NEA to review and validate a similar study completed by the University of California (UC) (Brown et al 1996) and to extend the modeled forecasts in the UC study, which were limited to a ten year period, for an additional ten years into the future. The core model used in both studies is the Central Valley Production Model (CVPM). The model is used to simulate and predict aggregate decision making by Central Valley farmers. Both the UC and the NEA groups modified the CVPM by adding a groundwater hydrology component to the model, but the assumptions for the modifications were different between the two groups.

The CVPM aggregates agricultural production in the Central Valley into 22 crop producing regions. Each region is intended to represent a group of water districts with similar growing conditions. These regions are assumed to operate as single, large farms with one decision maker. In the UC and NEA studies, the 22 regions were aggregated to ten regions, six of which are located in the Friant service area. These regions are shown in Figure VI-81. All of the regions are bounded on the east by the lower Sierra foothills. The total land area covered by the six regions is very large and includes substantial amounts of land that is not within the Friant Unit. The CVPM also simplifies the mix of crops found in the Central Valley into 26 representative crop categories. In the UC and NEA studies, these categories were further aggregated into 12 crop categories, including irrigated pasture, alfalfa, sugar beets, field crops, rice, truck crops, tomatoes, orchards, grain, grapes, cotton, and citrus.

As with all models, the CVPM is only a representation of reality, and its usefulness is limited by the assumptions around which it is built. The model results are best used to understand the general direction and implications of an action. Specific acreage and groundwater elevation effects should be interpreted cautiously.

The impacts on groundwater levels and crop acreage of a 500 TAF annual reduction in water deliveries to the Friant service area in the final year of a 20 year period are provided on Tables VI-74 and VI-75, respectively.

Table VI-74 shows that adoption of Alternative 5 could have a significant effect on groundwater levels throughout the Friant service area. The smallest effect on groundwater is seen in Region 2, which receives a comparatively small percentage of its water supply from the Friant Project. Very significant effects are seen in Regions 3 through 6. The model indicates that groundwater levels fall until they are constrained. The NEA study included assumptions regarding the levels at which the groundwater is depleted. In regions 3 through 6, groundwater levels reached the depletion point. There are sparse data regarding depth limits; however, on the east side of the San Joaquin Valley, the aquifer is thin and underlain with granite from the Sierra foothills, limiting access to groundwater to replace surface water. Even if groundwater were accessible, many farmers would need to drill deeper wells and purchase more powerful pumps. As the UC researchers report, wells drilled to depths of 800 to 1,000 feet cost roughly $85,000. The financial feasibility of individual farmers to construct and operate such wells is questionable.

Table VI-74
Impacts of a 500 TAF Reduction on
Groundwater Levels and Groundwater Costs

Region	Starting GW Level (ft)	Final GW Level (ft)	Change in GW Level (ft)	Starting GW Cost ($/AF)	Final GW Cost ($/AF)	Change in GW Cost ($/AF)
1	160.1	244.7	-84.6	$48.76	$65.23	$16.47
2	138.7	148.8	-10.1	$41.74	$46.43	$4.69
3	138.7	451.3	-312.6	$43.42	$103.03	$59.61
4	192.1	499.4	-307.3	$54.48	$114.72	$60.24
5	352.2	713.9	-361.7	$86.08	$158.29	$72.21
6	350.0	650.7	-300.7	$88.98	$148.53	$59.55

Table VI-75 shows that adoption of Alternative 5 could have a significant effect on crop acreages and land use. Region 4 is the hardest hit with over 180,000 acres being taken out of production with cotton and alfalfa accounting for the majority of this acreage. There is very little impact on Region 2 because Friant Unit water comprises a relatively small portion of its water supply and it can take advantage of slightly higher crop prices caused by reduced supplies from the other regions. In general, lower value, water intensive crops dominate the acreage being removed from production throughout the Friant service area. For the six Friant regions, slightly less than 232,000 acres of alfalfa and cotton are removed from production while approximately 28,000 acres of high value citrus and orchards are taken out of production.

While the impacts on regional economic activity and employment would be substantial for the entire region if Alternative 5 is adopted, they would be especially severe for many of the small communities. Of the roughly 373,000 acres of cropland estimated to be removed from production, 261,000 acres, or 70 percent, are in Regions 4 and 5. Consequently, the small farm communities in these regions would be most affected. Most of these towns are heavily dependent upon agriculture, and the businesses in these towns are linked to agriculture for most or all of their business - from firms supplying farm machinery, chemicals, and credit to those processing cotton, fruits, and vegetables for consumer use.

Table VI-75
Change in Crop Acreages and Percentages by Region for a 500 TAF Reduction

Crop	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Total
Irrigated Pasture	-4,514 -8%	-68 0.4%	-5,597 -53.2%	-6,157 -64.3%	-678 -100%	-1,235 -54.5%	-18,249 -19.2%
Alfalfa	-2,385 -3.8%	140 1.60%	-4,190 -46%	-49,814 -58.8%	-16,711 -91.5%	-19,085 -46.7%	-92,045 -41%
Sugar Beets	-79 -1%	NA	-38 -27.5	-1,183 -30.9	-528 -61.1	-608 -10.4	-2,436 -13.2%
Field Crops	-1,507 -3.1%	-36 -0.4%	-1,990 -32.8%	-23,614 -43.1%	-2,545 --71.9%	-3,541 -10.3%	-33,233 -24.4%
Rice	-350 -6%	NA	NA	NA	NA	-211 -41.9%	-561 -8.8%
Truck Crops	-4 0.1%	3 0.03%	-1,505 -24.56%	-1,530 -23.8%	-6,510 -52.1%	-420 -0.7%	-9,966 -10%
Tomato	-60 -0.8%	NA	-200 -27%	-15 -28.9%	-167 -60.3%	-221 -7.7%	-663 -5.8%
Orchard	-104 -0.1%	6 0.03%	-3,314 -5.4%	-3,713 -5.9%	-9,482 -18%	-230 -1.1%	-16,837 -5%
Grain	-520 -1.33%	-9 -0.1%	-1,733 -28.1%	-19,277 -32.9%	-4,280 -65.2%	-3,912 -19%	-29,681 -21.6%
Grapes	-12 -3.1%	160 0.2%	-6,375 -5.4%	-3,291 -6%	-7,173 -18.1%	-334 -0.9%	-17,025 -4%
Cotton	-2,159 -3.1%	7 0.1%	-3,554 -31,7%	-67,726 -40.3%	-27,231 -73.5%	-39,272 -29%	-139,935 -32.2%
Citrus	9 0.1%	11 0.1%	-1,552 -5.1%	-4,380 -5.2%	5,316 -18.4%	-41 -0.2%	-11,269 -6.1%
Total Acreage	-11,685 -2.2%	214 0.1%	-30,048 -11.5%	-180,650 -30.8%	-80,621 -40.1%	-69,110 -19.4%	-371,900 -17.6%

The impacts of a scaled-down, less viable agricultural production sector would flow quickly throughout the local and regional economy.

Mitigation. The water supply reductions under Alternative 5 can only be partially mitigated through increased conservation, conjunctive use, and groundwater management.

Literature Cited in Chapter VI

Archibald, S., T. Kuhnle, R. Marsh, M. Renwick, and B. Thompson. 1992. An Economic Analysis of Water Availability in California Central Valley Agriculture. Phase II Draft Report Prepared by Center for Economic Policy Research. Stanford University, California. District Responses and Adjustments to Water Availability.

Bagsall, M.E. and D.L. True. 1985. Archaeological Investigation in Crowder Canyon, 1973-1984: Excavations at Sites SBR-421B, SBR-421C, SBR-421-D, and SBR-713. Report on File, Caltrans, Sacramento, California.

Baxter, John L. 1960. Inshore Fishes of California. Department of Fish and Game. Sacramento, California. 80 pp.

BDOC. 1993. Draft Briefing Paper on Biological Resources of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Bay-Delta Oversight Council. May 1994. 33 pp. plus appendices.

Bean, L.J. and H.W. Lawton. 1973. Some Explanations for the Rise of Cultural Complexity in Native California with Comments on Proto-Agriculture and Agriculture. Ramona: Ballena Press Anthropological Papers. 1:i-xlvii.

Beck, R.W. 1994. Impacts of Bay-Delta Water Quality Standards on CVP Power Production. Prepared for the Western Area Power Administration.

Belitz, K., S.P. Phillips, and J.M. Gronberg. 1992. Numerical Simulation of Groundwater Flow in the Central Part of the Western San Joaquin Valley, California. U.S. Geological Survey Open-File Report 91-535. 71 pp.

Botsford, L.W., and J. Britnacher. 1994. A Model for Projection of Striped Bass Abundance in Terms of Flows and Diversions. Prepared for the Striped Bass Technical Team for the Central Valley Project Improvement Act. November 1994. 18 pp.

Brown, C., G. Goldman, R. Howitt, J. Seibert, and J. Sullins. 1996. Impacts of Water Reallocations on the Eastern San Joaquin Valley. December 31, 1996. 9 pp. plus attachments.

DFG. 1992a. A Model Explaining the Decline of Striped Bass in California's Sacramento-San Joaquin Estuary. 27 pp. plus appendices.

DFG. 1992b. Exhibit WRINT-DFG-Exhibit #6 Entered by the California Department of Fish and Game for the State Water Resources Control Board 1992 Water Quality/Water Rights Proceedings on the San Francisco Bay/Sacramento-San Joaquin Delta. 97 pp.

DFG. 1993a. Factors Controlling the Abundance of Aquatic Resources in the Sacramento-San Joaquin Estuary. Department of Fish and Game. 46 pp.

DFG. 1993b. Past Trends and Present Status of Selected Fish and Invertebrate Species of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. January. Prepared for the Bay Delta Oversight Council by the California Department of Fish and Game, Bay-Delta and Special Water Projects Division. 59 pp.

DFG. 1993c. Restoring Central Valley Streams: A Plan for Action. California Department of Fish and Game, Inland Fisheries Division. November 1993.

DFG. 1995. Assessment of California Black Bass Angling Regulations by Inland Fisheries Staff, California Department of Fish and Game, Inland Fisheries Division. August, 1995. 130 pp.

DWR. 1980. Ground Water Basins in California; A Report to the Legislature in Response to Water Code section 12924. Department of Water Resources Bulletin 118-80. 73 pp.

DWR. 1994. California Water Plan Update. Department of Water Resources Bulletin 160-93, Volumes I and II.

DWR and USBR. 1999. Biological Assessment – Effects of the Central Valley Project and State Water Project Operations from October 1998 through March 2000 on Steelhead and Spring-Run Chinook Salmon. January 1999.

EBMUD. 1993. Final Environmental Impact Report for the Updated Water Supply Management Program, Volumes I and II. September 1993.

EBMUD. 1996. Urban Water Management Plan. February 1996. p VIII-61.

EBMUD. 1997a. Letter Plus Attachments from Jon Meyer, Manager Water Resources Planning Division, to Thomas Howard. September, 17, 1997.

EBMUD. 1997b. Letter Plus Attachments from John Skinner, Senior Civil Engineer, to David LaBrie. October 7, 1997.

FWUA. 1997. Analysis of the Impacts of Surface Water Reductions on the Eastern San Joaquin Valley of California. Prepared for the Friant Water Users Authority by Northwest Economics Associates. August 26, 1997. 40 pp.

Herrgessell, Perry L. 1993. 1991 Annual Report, Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary. 37 pp.

IEP. 1996. Assessing Evidence on the Importance of Various Limiting Factors on Selected Ecological Features of the San Francisco Estuary. September 12, 1996. Report to CALFED by Members of the IEP Estuarine Ecology Project Work Team. 18 pp.

Jones and Stokes Associates and EDAW Inc. 1975. Fish and Wildlife Element Suisun Marsh Protection Plan. 412 pp.

Kimmerer, W. 1997b. Flow Effects and Density Dependence in Striped Bass. Interagency Ecological Study Program Newsletter. Vol. 10, No. 4. Autumn, 1997.

Lee, D. P. and I. Paulsen. 1989a. Water Level Fluctuation Criteria for Black Bass in California Reservoirs. Unpublished Inland Fisheries Information Leaflet. Inland Fisheries Division, California Department of Fish and Game, Rancho Cordova, CA. 8 pp.

Lee, D. P. and I. Paulsen. 1989b. Water Level Fluctuation Criteria for Selected Warmwater Gamefish in California Reservoirs. Inland Fisheries Administrative Report No. 89. Inland Fisheries Division. 38 pp.

Leidy, G. and M. Myers. 1984. Central Valley Fish and Wildlife Management Study: Fishery Management Problems at Major Central Valley Reservoirs, California. Special Report. U.S. Bureau of Reclamation, Mid-Pacific Region. Sacramento, CA.

Lenihan, D.J., T.L. Carrell, S. Fosberg, L. Murphy, S.L. Rayl, and J.A. Ware. 1981. The Final Report of the National Reservoir Inundation Study, Volume I. Santa Fe, New Mexico, National Park Service.

McCann, R., D. Mitchell, and L. House. 1994. Impact of Bay-Delta Water Quality Standards on California's Electric Utility Costs. Prepared for ACWA by M. Cubed, Sacramento.

McEwan, D., and J. Nelson. 1991. Steelhead restoration plan for the American River. California Department of Fish and Game, Inland Fisheries Division. Sacramento, CA.

Moratto, M.J. 1984. California Archaeology: New York, Academic Press.

NMFS. 1993. Biological Opinion for the Operation of the Federal Central Valley Project and the California State Water Project. National Marine Fisheries Service. February 12, 1993. 81 pp.

NMFS. 1996. West Coast Steelhead Briefing Package. National Marine Fisheries Service. 26 pp.

Poland, J.F., F.E. Lofgren, R.L. Ireland, and R.G. Pugh. 1975. Land Subsidence in the San Joaquin Valley, California as of 1972. U.S. Geological Survey Professional Paper 437-H. 78 pp.

Richter, B.D., Baumgartner, J.V., Wigington, R., and D.P. Braun. 1997. How Much Water Does a River Need? Freshwater Biology **37**: 231-249.

Sanders, L., R. Walsh, and J. Loomis. 1990. Toward Empirical Estimation of the Total Value of Protecting Rivers. Water Resources Research. 23(7):1345-1357.

SFEP. 1992a. Comprehensive Conservation and Management Plan. August 1992. 137 pp. plus appendices.

SFEP. 1992b. State of the Estuary: A Report on Conditions and Problems in the San Francisco Bay/ Sacramento-San Joaquin Delta Estuary. June 1992. 270 pp.

Shipley, W.F. 1978. Native Languages of California. In R.F. Heizer, ed., Handbook of North American Indians, Volume VIII: California. Washington, D.C., Smithsonian Institution.

SJVDP. 1989. Preliminary Planning Alternatives for Solving Agricultural Drainage and Drainage Related Problems in the San Joaquin Valley. San Joaquin Valley Drainage Program. August 1989.

SJVDP. 1990. A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley. September 1990. Final Report of the San Joaquin Valley Drainage Program. 183 pp.

Stevens, D. E. and L. W. Miller. 1983. Effects of River Flow on Abundance of Young Chinook Salmon, American Shad, Longfin Smelt, and Delta Smelt in the Sacramento-San Joaquin River System. North American Journal of Fisheries Management. 3:425-437.

SWC. 1992. The Ecological Importance of Urban Vegetation. State Water Contractors. June 1992. 4 pp.

SWRCB. 1995. Environmental Report. Appendix 1 to Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. May. State Water Resources Control Board.

USBR. 1990. Monthly Temperature Model - Sacramento River Basin. Mid-Pacific Region, Sacramento, CA. June 1990.

USBR. 1993. Stanislaus River Basin Temperature Model. Sacramento, CA, Draft Report, June 1993, Revised 1997.

USBR. 1997. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. U.S. Bureau of Reclamation.

USBR. 1997a. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. Technical Appendix, Volume 2, Fisheries. U.S. Bureau of Reclamation. November 1997.

USBR. 1997b. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. Technical Appendix, Volume 4, Vegetation and Wildlife. U.S. Bureau of Reclamation. November 1997.

USBR. 1997c. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. Technical Appendix, Volume 9, Vegetation and Wildlife Methodology/Modeling. U.S. Bureau of Reclamation. November 1997.USBR. 1997d. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. Technical Appendix, Volume 9, Fish Habitat Water Quality Methodology/Modeling. U.S. Bureau of Reclamation. November 1997.

USBR. 1997e. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. Technical Appendix, Volume 5, Municipal and Industrial Land Use and Demographics. U.S. Bureau of Reclamation. November 1997.

USBR. 1997f. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. Technical Appendix, Volume 4, Recreation. U.S. Bureau of Reclamation. November 1997.

USBR. 1997g. Central Valley Project Improvement Act. Draft Programmatic Environmental Impact Statement. Technical Appendix, Volume 2, Groundwater. U.S. Bureau of Reclamation. November 1997.

USFWS. 1993. Abundance and Survival of Juvenile Chinook Salmon in the Sacramento-San Joaquin Estuary. 1992 Annual Progress Report. Fishery Resource Office. Stockton, CA.USFWS. 1995. Biological Opinion on the Long-Term Operation of the CVP and SWP on the Delta Smelt. Memorandum from Joel Medlin, Field Supervisor, Sacramento, CA to Regional Director, U.S. Bureau of Reclamation, Sacramento, CA, Dated March 6, 1995. 52 pp. plus attachments.

USFWS. 1995. Working Paper on Restoration Needs; Habitat Restoration Actions to Double Natural Production of Anadromous Fish in the Central Valley of California. May 1995. Prepared for the USFWS Under the Direction of the Anadromous Fish Restoration Program Core Group. Volume 3, 387 pp. plus appendices.

USFWS. 1996. Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes. Prepared by the Native Fishes Recovery Team for the U.S. Fish and Wildlife Service. 195 pp.

USFWS. 1997. Revised Draft Restoration Plan for the Anadromous Fish Restoration Program: A Plan to Increase Natural Production of Anadromous Fish in the Central Valley of California. May 1997. Prepared for the Secretary of the Interior by the United States Fish and Wildlife Service with Assistance from the Anadromous Fish Restoration Plan Core Group Under the Authority of the Central Valley Project Improvement Act. 112 pp. plus appendices.

Waechter, S.A., S.D. Mikesell, H. McCarthy, and D.S. Byrd. 1994. Research Design for Prehistoric, Ethnographic, and Historic Cultural Resources at Folsom Reservoir, California. Report on file, U.S. Bureau of Reclamation. Sacramento, California.

Personal Communications

Lee, D. Department of Fish and Game. Sacramento, California. March 19, 1997. Personal Communication.

Savage, Jeff. Pacific Gas and Electric Company. Yosemite Division. August 27, 1997. Personal Communication.

Miller, L. Department of Fish and Game. Stockton, California. April 19, 1999. Personal Communication.

CHAPTER VII. ALTERNATIVES FOR IMPLEMENTING SUISUN MARSH SALINITY OBJECTIVES

The 1995 Bay/Delta Plan contains salinity objectives for the channels of Suisun Marsh (Figure VII-1) to protect the beneficial uses of the marsh. This chapter describes the environmental effects of the alternatives for implementing the Suisun Marsh objectives. The chapter is divided into the following sections: (A) background, (B) physical description of existing facilities, (C) alternatives for implementing the objectives, (D) environmental effects of the alternatives and (E) summary.

A. BACKGROUND

The background discussion is divided into two sections: (1) regulatory history and (2) historical salinity conditions in Suisun Marsh.

1. Regulatory History

In 1963 the Suisun Resource Conservation District (SRCD) was formed by public and private landowners in Suisun Marsh. The conservation district undertakes administrative, regulatory, and technical functions that include: representing landowner interests, both individually and collectively; obtaining environmental permits for routine maintenance activities; preparing wetland management plans for all private land within the district; enforcing implementation of the management plans; and providing technical expertise on issues related to marsh management. The district includes 52,000 acres of managed wetlands, 6,300 acres of unmanaged tidal wetlands, 30,000 acres of bays and sloughs, and 27,700 acres of upland grasslands. There are 153 privately owned duck clubs in the marsh, and the DFG manages 15,000 acres of the managed and tidal wetlands (DWR 1993).

A review of the issues related to Suisun Marsh resulted in a memorandum of agreement signed by the USBR, USFWS, DWR, and DFG on July 13, 1970. A goal of this agreement was to select a water supply and marsh management plan that would protect and enhance waterfowl habitat.

The California Legislature, recognizing the threat of urbanization to Suisun Marsh, enacted the Nejedly-Bagley-Z'berg Suisun Marsh Preservation Act of 1974. The act required the DFG and the San Francisco Bay Conservation and Development Commission (BCDC) to develop a plan to protect the marsh. In December 1975, the DFG released the Fish and Wildlife Element of the Suisun Marsh Protection Plan, which contains an inventory of fish and wildlife species found in and around the marsh, an interpretation of how the marsh functions, and recommendations for protection of the marsh.

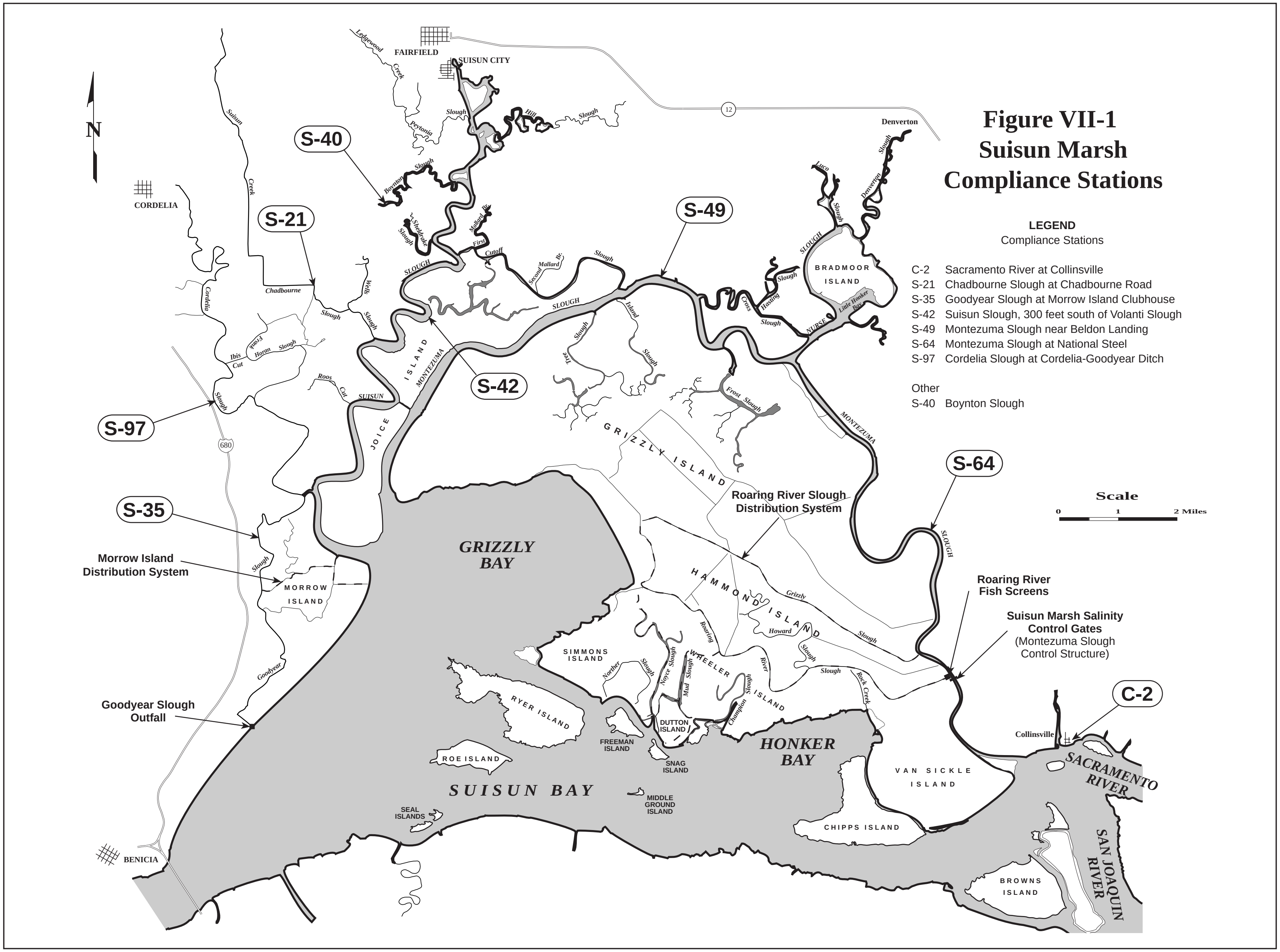


Figure VII-1
Suisun Marsh Compliance Stations

LEGEND
Compliance Stations

C-2 Sacramento River at Collinsville
S-21 Chadbourne Slough at Chadbourne Road
S-35 Goodyear Slough at Morrow Island Clubhouse
S-42 Suisun Slough, 300 feet south of Volanti Slough
S-49 Montezuma Slough near Beldon Landing
S-64 Montezuma Slough at National Steel
S-97 Cordelia Slough at Cordelia-Goodyear Ditch

Other
S-40 Boynton Slough

In 1976, the BCDC submitted the Suisun Marsh Protection Plan to the California Governor and Legislature. The Protection Plan divided the marsh into primary and secondary management zones based on land use. Tidal wetlands and diked lands managed as wetlands were placed in the primary management zone; annual and perennial grasslands and vernal pools adjacent to the marsh were classified as the secondary management zone. The purpose of the secondary management zone is to provide a buffer between urban development and wetland areas of the marsh. Under the Suisun Marsh Protection Plan, the BCDC serves as the permitting agency for all major projects within the primary management zone and as an appellate body with limited functions in the secondary management area. The Suisun Marsh Protection Plan recommended that local agencies develop a plan of compliance. It recommended and prioritized the acquisition of properties, proposed a tax assessment plan based on land use, and identified both state and federal sources of funding to achieve its objectives.

In 1977, the California Legislature added the Suisun Marsh Preservation Act of 1977 to the Public Resources Code and implemented the recommended protection measures outlined in the Suisun Marsh Protection Plan. This act emphasized the importance of the marsh as a unique and irreplaceable resource, particularly because of the habitat available for wintering waterfowl.

Salinity objectives for the marsh were first adopted by the SWRCB in 1978. The regulatory history of these salinity objectives is discussed below, including: (1) the 1978 Delta Plan, D-1485, (2) 1985 amendments to D-1485, the Suisun Marsh Preservation Agreement (SMPA), the 1995 Bay/Delta Plan, and (3) Water Right Order 98-09 (WR 98-09).

a. 1978 Delta Plan, D-1485, and the 1985 Amendments. The origin of the 1978 Delta Plan Suisun Marsh salinity objectives can be traced to the DFG's early studies on waterfowl food habits, plant salinity tolerances, and soil salinities. In 1969, the DFG conducted a study to determine waterfowl plant food preferences and the soil and water conditions necessary to support the preferred foods. The study determined that the preferred waterfowl plant food was alkali bulrush seed (*Scirpus robustus*)[1] followed by brass buttons (*Cotula coronopifolia*). The most important factors influencing plant distribution were soil submergence time and soil salinity. Soil salinities during May were found to be critical to September alkali bulrush seed yield. Optimal soil salinity levels were between 7 and 14 parts per thousand (ppt). No seed production resulted when May soil salinity exceeded 24 ppt (Mall 1969).

In 1973, the DFG investigated the relationship between soil salinity and the salinity of applied water. A significant correlation was found to exist between the salinity of applied water and the salinity in the first two feet of the soil. The leaching of marsh soils by alternate flooding and draining with low salinity water was found to be an effective means of reducing soil salinity. Methods of water management were recommended for maintaining suitable soil salinity (Rollins 1973).

1. The species is now determined to be *Scirpus maritimus*.

The DFG and others submitted exhibits during Bay/Delta hearings in 1976 and 1977 which recommended monthly channel water salinity objectives in Suisun Marsh. The salinity objectives adopted in the 1978 Delta Plan were similar to the recommendations of the California Waterfowl Association, which were designed to achieve an average of 90 percent of maximum alkali bulrush seed production and 60 percent seed germination (CWA 1976).

A report by the San Francisco Estuary Project summarizes the studies that have been conducted on food habits of waterfowl in Suisun Marsh (SFEP 1992). Although Mall concluded that alkali bulrush seeds were the most important food item in the diets of dabbling ducks in the marsh (Mall 1969), Swanson and Bartonek demonstrated that analyses of gizzard content inflate the importance of seeds in the diet of ducks (Swanson et al. 1970). Analyses of esophageal contents soon after birds have fed more accurately reflect the diet of waterfowl. More recent studies of waterfowl food habits in the San Joaquin and Sacramento valleys found animal matter constituted a much higher percentage of the diet of wintering waterfowl than previously reported. The percentage of animal matter in the diet was highest in winter, whereas vegetative food items predominated in the fall (SFEP 1992). This finding was confirmed in the Suisun Marsh (Batzer 1993). The 1978 Delta Plan set channel water salinity objectives for the Suisun Marsh from October through May. D-1485 required the SWP and the CVP to develop and implement a plan, in cooperation with other agencies, that would meet all of the salinity objectives by October 1, 1984. Immediate compliance with the objectives was not considered reasonable because such compliance could be achieved only through large increases in outflow, then estimated at as much as two million acre feet annually. The DWR, in cooperation with the SRCD, USBR, DFG, and USFWS, developed the "Plan of Protection for the Suisun Marsh including Environmental Impact Report" (Plan of Protection) in 1984 to meet the D-1485 requirements. The Plan of Protection proposed staged implementation of a combination of activities, including physical facilities, a wetlands management program for marsh landowners, and supplemental releases from SWP and CVP reservoirs. Staged implementation allowed the effect of each action to be evaluated before deciding whether to implement a subsequent action.

At the request of the DWR and the USBR, the SWRCB amended D-1485 in 1985 by changing some of the Suisun Marsh compliance locations and compliance dates. The amended compliance monitoring locations and the effective dates of compliance are listed below in Table VII-1; the compliance monitoring stations are illustrated in Figure VII-1.

b. The Suisun Marsh Preservation Agreement. In 1987, the DWR, USBR, DFG, and SRCD signed the SMPA which is the contractual framework for implementing the Plan of Protection, including controlling channel water salinity. The agreement included proposed normal period and deficiency period[2] salinity requirements that are different from the objectives in the 1978

2. A deficiency period is: (a) the second consecutive dry water year following a critical year; (b) a dry water year following a year in which the Sacramento River Index was less than 11.35: or (c) a critical water year following a dry or critical water year (1995 Bay/Delta Plan).

Table VII-1
Suisun Marsh Compliance Stations and Effective Dates

Station ID	Location	Effective Date
C-2	Sacramento River at Collinsville	October 1, 1988
S-49	Montezuma Slough near Beldons Landing	October 1, 1988
S-64	Montezuma Slough at National Steel	October 1, 1988
S-21	Chadbourne Slough at Chadbourne Road	October 1, 1995
S-97	Cordelia Slough at Ibis Club	October 1, 1997
S-35	Goodyear Slough at Morrow Island Club	October 1, 1997
S-42	Suisun Slough at Volanti Club	October 1, 1997

Delta Plan and D-1485, as amended. A comparison between the SMPA-proposed requirements and the 1978 Delta Plan objectives is provided in Table VII-2.

In 1987, the DWR requested that the SWRCB adopt the SMPA requirements as water quality objectives. The principal concern expressed by the DWR regarding the 1978 Delta Plan objectives was that they are not adjusted during deficiency periods. In response, the SWRCB requested, at the recommendation of the DFG, that the DWR and the USBR prepare a Biological Assessment to determine whether any flow and salinity changes that occur as a result of the actions taken pursuant to the SMPA would jeopardize any rare, threatened, or endangered species. The DWR and the USBR planned to complete a Biological Assessment in 1996. This task was never completed because the 1995 Bay/Delta Plan adopted the SMPA concept of deficiency year objectives, but the deficiency objectives were only applied to stations in the western marsh.

The SMPA called for staged construction of facilities in Suisun Marsh to provide the required channel salinities at a capital cost of $120 million (1985 dollars). The initial facilities (phase 1) were constructed in 1980 including the Roaring River Distribution System, Morrow Island Distribution System, and Goodyear Slough Outfall. The second phase, and most important facility, the Suisun Marsh Salinity Control Gates (SMSCG), were constructed and went into operation in 1988. The gates are used to tidally pump lower salinity water through Montezuma Slough into the central marsh to reduce channel salinities during periods of low to moderate Delta outflow. Operation of the gates restricts the upstream flow of more saline water from Suisun Bay during flood tides while allowing the normal flow of freshwater from the Sacramento River during ebb tides. During full operation, the gates open and close twice each tidal day. Flows past the gates vary from no flow when the gates are closed to several thousand cfs with all three gates open; the net flow through the gates is about 1,800 cfs when averaged over one tidal day. Extended testing established that gate

Table VII-2
1978 Delta Plan Objectives (with 1985 Amendments) and SMPA Salinity Requirements

Month	Mean Monthly High Tide Electrical Conductivity (mmhos/cm)		
	1978 Delta Plan	SMPA Normal Year	SMPA Deficiency Year
October	19.0	19.0	19.0
November	15.5	16.5	16.5
December	15.5	15.5	15.6
January	12.5	12.5	15.6
February	8.0	8.0	15.6
March	8.0	8.0	15.6
April	11.0	11.0	14.0
May	11.0	11.0	12.5

operation, in conjunction with reasonable outflow levels, results in compliance with the eastern marsh objectives at stations C-2, S-49, and S-64 under most circumstances; however, gate operation can not consistently achieve compliance at the remaining stations in the western marsh. After gate operation began, salinities at the eastern marsh stations were generally below the 1978 Delta Plan objectives and always below the SMPA deficiency standards. Salinities at the western marsh stations were generally below 1978 Delta Plan objectives and SMPA deficiency standards in wetter years or water years following wet periods, such as 1985, 1986, 1987, and 1994. However, during prolonged dry or critically dry periods, salinities in the western marsh were often above both 1978 Delta Plan objectives and SMPA deficiency standards.

In order to comply with the western marsh objectives, the DWR and the USBR began the planning and environmental review process for the Western Suisun Marsh Salinity Control Project in June 1990 (DWR 1991a). This review resulted in the identification of nine individual alternative actions and eighteen combinations of actions that warranted further investigations (DWR 1993). Field tests for one of the more promising actions, flow augmentation in Green Valley Creek, were conducted in 1994 with North Bay Aqueduct water. The DWR and the USBR suspended their planned activities under the Western Suisun Marsh Salinity Control Project after the adoption of the 1995 Bay/Delta Plan in order to reevaluate the needs of the western marsh under the new conditions imposed by the plan.

In August 1995, the parties to the SMPA began discussions to update the agreement (SMPA Amendment III; SMPA 1998) to reflect anticipated future hydrologic and salinity conditions in the Suisun Marsh under the conditions of the 1995 Bay/Delta Plan and Suisun Marsh Salinity Control Gate operation. Execution of Amendment III is pending completion of CEQA/NEPA environmental documentation and the CESA/ESA consultation process. The parties have recommended that the SWRCB consider a series of management actions as the next step in implementing the Bay/Delta Plan rather than focus on the channel water salinities in the western marsh (DWR 1996). The basis for the recommendation is that management actions may provide more appropriate soil salinity conditions in all years on managed wetlands than would strict adherence to the salinity objectives. The Bay/Delta Plan states that the salinity objectives in the channels do not have to be achieved if a demonstration of equivalent or better protection is provided at the location. The recommendation of the parties to the SMPA is considered in this EIR (Chapter VII, section B, Alternative 5).

c. 1995 Bay/Delta Plan. The 1978 Delta Plan Suisun Marsh objectives, as amended, included salinity objectives at the seven compliance points listed above, and flow and salinity objectives at Chipps Island from October through May. During the proceeding leading to adoption of the 1995 Bay/Delta Plan, the signatories to the SMPA (DWR, USBR, DFG, and SRCD) recommended that the SWRCB adopt the SMPA requirements as water quality objectives for the marsh (DWR 1994b, DFG 1994). The following discussion describes the changes made to Suisun Marsh objectives by the adoption of the Bay/Delta Plan and the rationale for the changes.

First, the Chipps Island standards for protection of Suisun Marsh were replaced with the year-round outflow standards for general habitat protection. The new outflow should provide equivalent or better protection for the marsh. Second, the eastern Suisun Marsh salinity objectives (stations C-2, S-64, and S-49) were not changed. These objectives have been met since 1989, with minor exceptions, and operation of the Suisun Marsh Salinity Control Gates, in combination with outflow conditions required by the 1995 Bay/Delta Plan, should be adequate to ensure continued compliance under most circumstances. Recent modeling over the 1987-1992 hydrologic sequence indicates that the objectives at these stations will be met except for the month of February 1991, assuming full-bore[3] operation of the SMSCG and compliance with the Bay/Delta Plan outflow objectives (DWR 1995). Third, the western Suisun Marsh salinity objectives (stations S-21, S-42, S-97, and S-35) were amended to include the SMPA deficiency standards, and the compliance dates for S-97 and S-35 were extended to 1997[4]. The 1978 Delta Plan objectives had not been implemented in the western marsh; therefore, the implementation of the combination of 1978 Delta Plan objectives in average hydrologic conditions and SMPA deficiency standards in dry conditions

3. Full-bore operations consist of tidally pumping water for as long as tidal conditions permit (over the falling tide and into the beginning of the next rising tide) (DWR 1995a).

4 The effective date for compliance at stations S-35 and S-97 was extended by the SWRCB, pursuant to Water Code §1435, on October 30, 1997, August 14, 1998 and April 30, 1999. The Water Code allows for additional 180 day extensions.

should provide lower salinity habitat than existing conditions. Also, there should be a natural gradient of increasing salinity from east to west which is not reflected in the 1978 Delta Plan objectives, but is included in the Bay/Delta Plan objectives when deficiency period objectives are in effect. Fourth, a narrative objective for protection of tidal marshlands was included. This objective is expected to be achieved through compliance with the year-round outflow objectives, but it is added to ensure that the tidal marshlands receive adequate protection. Lastly, the plan recommended that the DWR form a multiagency Suisun Marsh Ecological Work Group (SEW). The principal charge of SEW is to evaluate the scientific basis for the objectives and to identify specific measures to implement the narrative objective, if necessary. The results of this review will be used in the next triennial review of the Suisun Marsh water quality objectives.

d. SWRCB Order WR 98-09. In 1995, the DWR and the USBR petitioned the SWRCB to change some of the permit terms and conditions imposed by D-1485 so that they conform with the objectives in the 1995 Bay/Delta Plan and the Principles for Agreement. In D-1485, the SWRCB found that the SWP and the CVP have a mitigation responsibility to protect Suisun Marsh because their operations affect salinity conditions in the marsh. The SWRCB received no new information in the 1995 water quality proceeding relevant to this finding. The SMPA deficiency objectives, as applied in water short years, makes it even more likely that these objectives could have been met absent the CVP and SWP. Therefore, these new Suisun Marsh objectives were incorporated into the water right permits of the SWP and the CVP with the adoption of SWRCB Order WR 95-6. WR 95-6 was a temporary order, expiring on December 31, 1998. On December 3, 1998, the effective term of WR 95-6 was extended until December 31, 1999, when the SWRCB adopted Order WR 98-09. If at that time a new water right decision has not been adopted, D-1485 will once again become effective.

2. Historical Salinity Conditions in Suisun Marsh

The controllable, and most easily measured, water quality parameter in Suisun Marsh is salinity. Salinity influences the types of vegetation that can grow on both managed and unmanaged portions of the marsh, and the types of vegetation in turn influences the occurrence of animal life in the marsh. The following factors affect salinity in the Suisun Marsh:

1. D-1485: the regulatory framework
2. SMPA: the contractual framework
3. Plan of Protection for the Suisun Marsh: facilities planning
4. Suisun Marsh Salinity Control Gate operation (beginning October 31, 1988)
5. Delta outflow
6. Creek inflows
7. Managed wetland operations
8. Fairfield-Suisun Wastewater Treatment Plant effluent inflows into Boynton Slough
9. Precipitation/evaporation conditions
10. Tidal variations, wind, and barometric pressure

Of these factors, facilities planning, the operation of facilities in the marsh, and to an extent, Delta outflows are controlled by the DWR and the USBR. Operations of the private managed wetlands in the marsh are controlled by 153 individual landowners, and the public areas are managed by the DFG. The ultimate destination and discharge of Fairfield-Suisun Sewer District (FSSD) wastewater treatment plant effluent is controlled by the Fairfield-Suisun Sewer District and the Solano Irrigation District (SID), under permits issued by the San Francisco Bay RWQCB. Precipitation, runoff, tidal variations, winds, barometric pressure, and evaporation are natural, uncontrollable factors.

The ER for the 1995 Bay/Delta Plan described the historical salinity conditions in Suisun Marsh for water years 1984-1994 and compared them to D-1485 and SMPA objectives. This description is summarized below. A more detailed description can be found in Chapter VIII of the ER and in a report prepared by the DWR (DWR 1994c).

Mean monthly high tide salinity for water years 1984-1994 for eastern marsh compliance stations C-2, S-64, and S-49 and western marsh compliance stations S-21, S-97, and S-35 are presented in Figures VII-2 and VII-3, respectively (two pages each). Station S-42 is not included in this analysis, but the salinities at this station are very similar to the salinities at station S-21. In some cases, data are not shown for a station in a particular year because either the station was not established or the data did not meet quality assurance/quality control criteria. Mean monthly high tide salinities are presented on each bar chart, one bar per station as indicated on the legend in the upper left-hand corner of the figures. The monthly 1978 Delta Plan (solid line, indicated as D-1485) and SMPA deficiency (dashed line) objectives are also shown on each of the six bar charts (per page) to facilitate comparison of the actual salinities with the 1978 Delta Plan and SMPA deficiency objectives. As described above, the 1995 Bay/Delta Plan objectives are the same as the D-1485 objectives for the eastern marsh stations, and the plan objectives are the same as the SMPA objectives for the western marsh stations in deficiency periods and the same as the D-1485 objectives in other periods. Deficiency periods occurred in 1988, 1989, 1990, 1991, and 1992.

The SMSCG began operating on October 31, 1988. After gate operation began, salinity at the eastern marsh stations was generally below the 1978 Delta Plan standards and always below SMPA deficiency standards. Salinity at the western marsh stations was generally below 1978 Delta Plan standards and SMPA deficiency standards in wetter years or water years following wet periods, such as 1985, 1986, 1987, and 1994. However, during prolonged dry or critically dry periods, salinity in the western marsh is often above both 1978 Delta Plan standards and SMPA deficiency standards. Salinity in northwestern marsh sloughs (e.g., station S-97) is primarily affected by surface water inflows from local creeks and drainage water from the managed wetlands, and is relatively unaffected by SMSCG operations.

Figure VII-2
Suisun Marsh Mean Monthly High Tide Salinity
Specific Conductance in mSiemens
Water Year = 1984-94
Eastern Marsh Sites

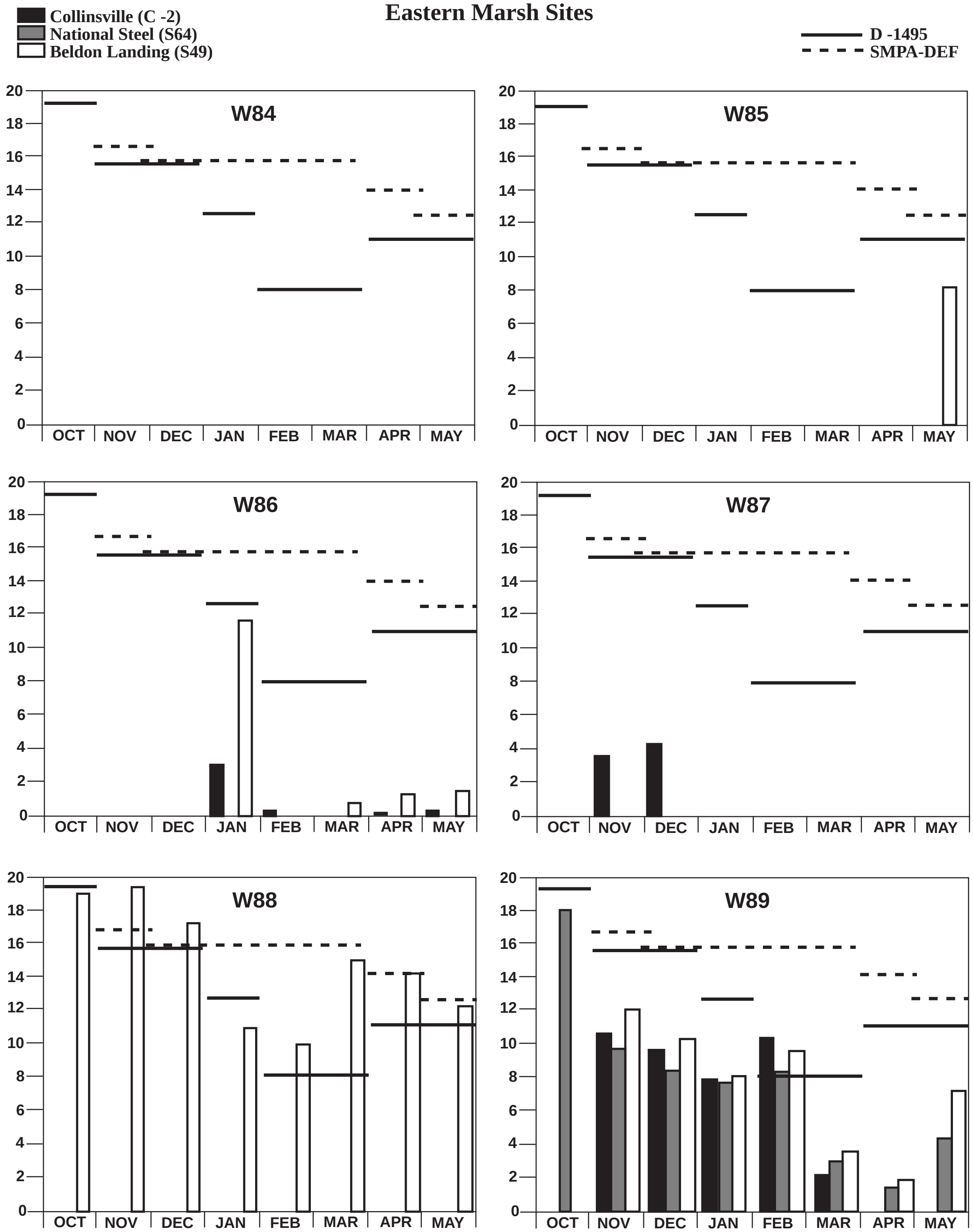


Figure VII-2 (continued)
Suisun Marsh Mean Monthly High Tide Salinity
Specific Conductance in mSiemens
Water Year = 1984-94
Eastern Marsh Sites

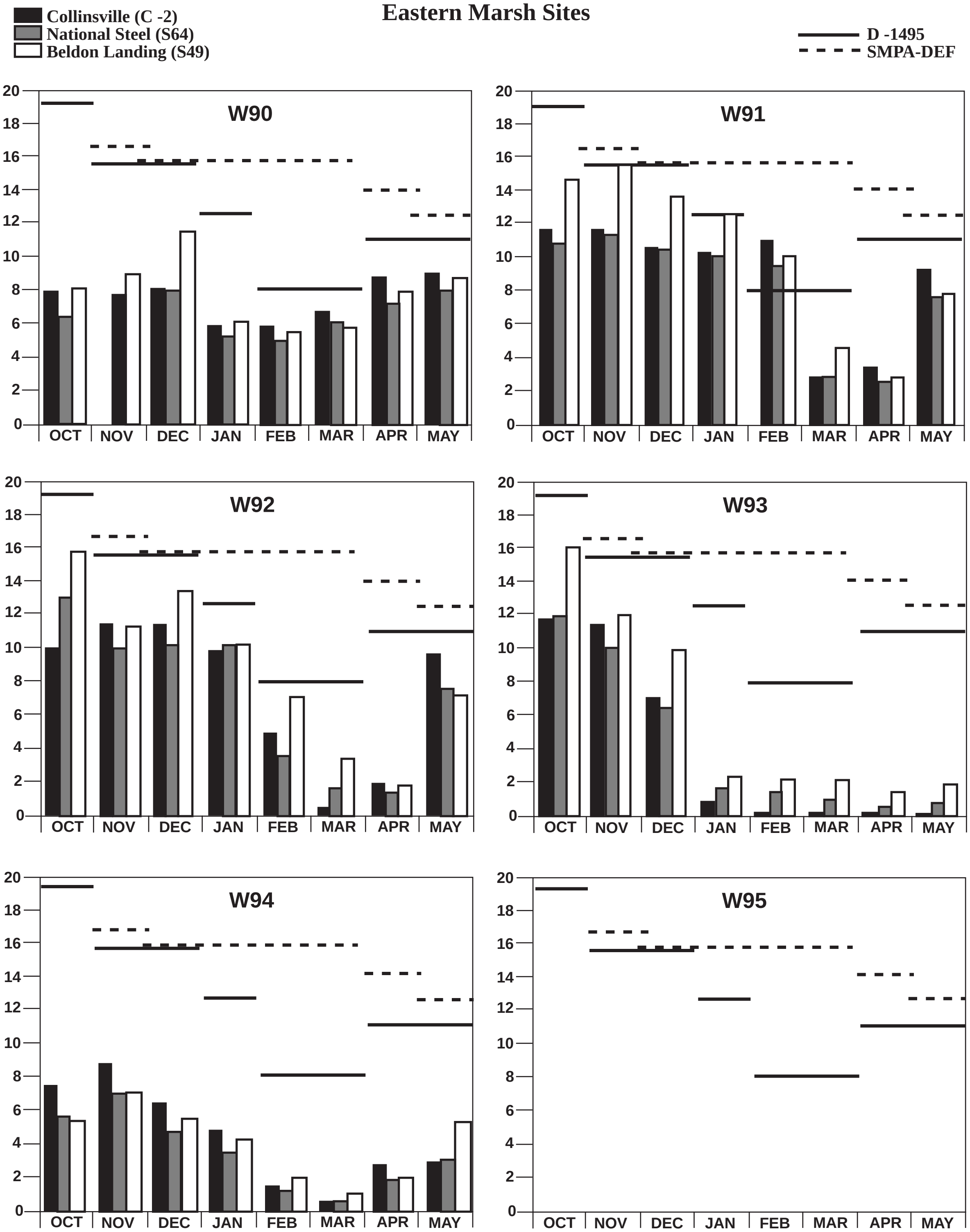


Figure VII-3
Suisun Marsh Mean Monthly High Tide Salinity
Specific Conductance in mSiemens
Water Year = 1984-94
Western Marsh Sites

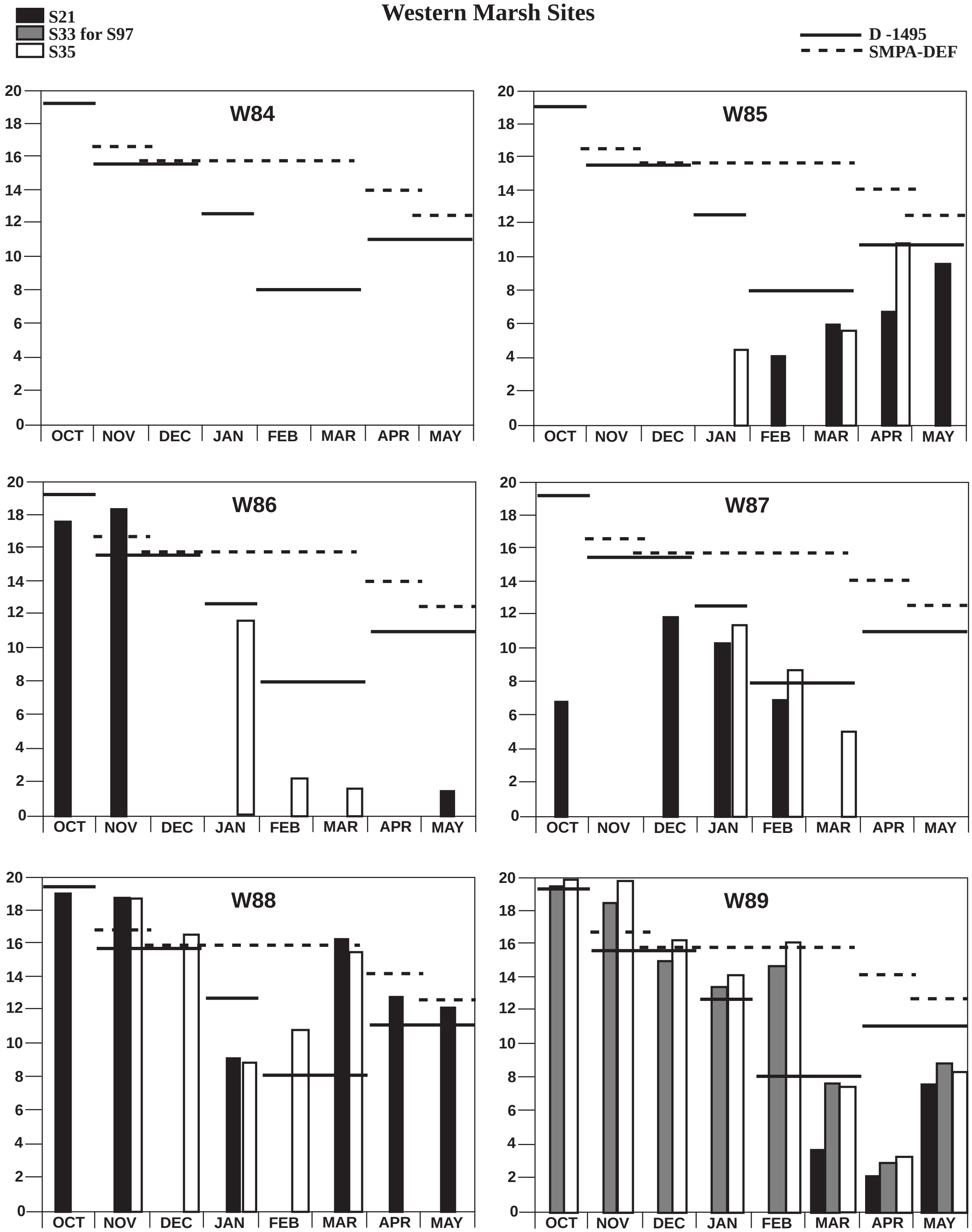
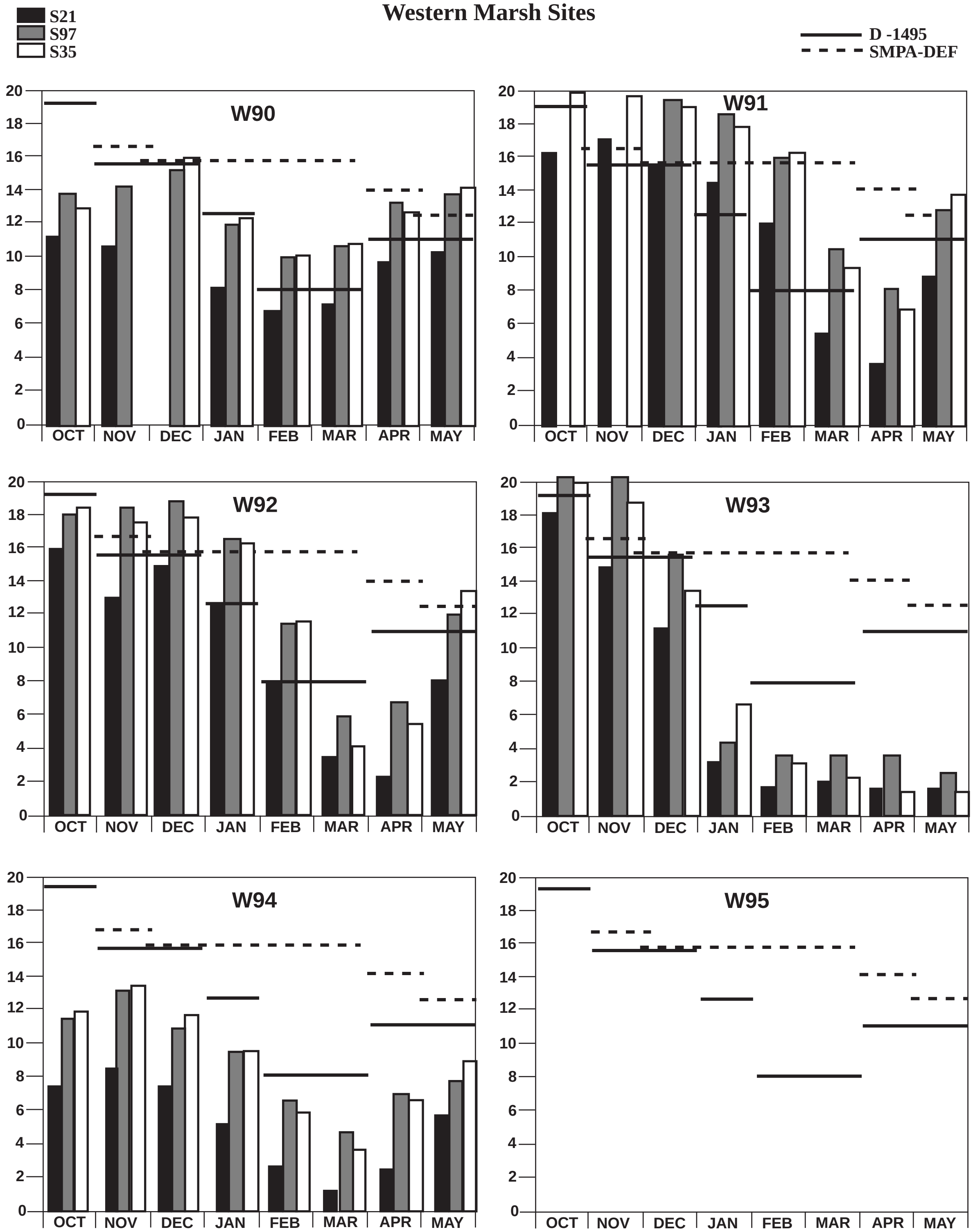


Figure VII-3 (continued)
Suisun Marsh Mean Monthly High Tide Salinity
Specific Conductance in mSiemens
Water Year = 1984-94
Western Marsh Sites



B. PHYSICAL DESCRIPTION OF EXISTING FACILITIES

This section describes the physical features of the existing facilities that could be used in the implementation of the alternatives. The focus of the descriptions is on the potential role of these facilities to control salinity in the western marsh, so aspects of certain facilities that may not pertain to that specific role are not described. Facilities in other parts of the marsh which are operated for salinity control include the Roaring River Distribution System, Morrow Island Distribution System, Goodyear Slough outfall, and the SMSCG. Operation of these facilities could be modified depending on future actions.

The information on existing facilities was gathered from the DWR and local agencies. Much of the DWR information is contained in a report entitled "Screening Alternative Actions and Describing Remaining Actions for the Proposed Western Suisun Marsh Salinity Control Project" (DWR 1993).

The facilities discussed in this section include: (1) Green Valley Creek and City of Vallejo Reservoirs, (2) the North Bay Aqueduct, (3) the Fairfield-Suisun Sewer District Wastewater Treatment Plant and (4) Lake Berryessa and the Putah South Canal.

1. Green Valley Creek and City of Vallejo Reservoirs

The City of Vallejo owns and operates three reservoirs, two in the Green Valley Creek watershed, Lake Madigan and Lake Frey, and one in the Suisun Creek watershed, Lake Curry (on Gordon Valley Creek tributary to Suisun Creek). The reservoir storage capacities of the three City of Vallejo reservoirs are listed below in Table VII-3.

Table VII-3
Reservoirs that Drain to Suisun Marsh

Reservoir	Capacity (AF)	Watershed Area (mi^2)
Lake Madigan	1,744*	1.5
Lake Frey	1,075	3.1
Lake Curry	10,700	17

* Subject to change due to dam safety concerns

Suisun Creek flows into Chadbourne Slough and can therefore influence salinities at the salinity station S-21 in Chadbourne Slough in the northwestern marsh. At present, no flow augmentation is proposed for Suisun Creek. Green Valley Creek becomes Cordelia Slough less than 0.5 mile downstream (south) of the confluence with an unnamed ditch (the most downstream location affected by tidal action). Green Valley Creek can influence flows into Cordelia Slough, and to a lesser extent Goodyear Slough, and can therefore influence the salinities at stations S-97 and S-35. Releases from the two reservoirs in the Green Valley Creek watershed are considered as a possible way, at least in part, to meet the objectives at these two stations (see Figures VII-4 and VII-5b).

Lake Madigan and Lake Frey are located on Wild Horse Creek, tributary to Green Valley Creek, and were built in 1894 and 1911, respectively. The City of Vallejo claims a pre-1914 water right to divert at Lake Madigan and Lake Frey and has filed a Statement of Diversion and Use with the Division of Water Rights to document its claim. Lake Frey has a capacity of 1,075 AF and Lake Madigan, upstream of Lake Frey, has a capacity of 1,744 AF (see Table VII-3). The operating capacity of Lake Madigan may be reduced in the near future because of concerns regarding the seismic safety of the dam (Exequiel Ganding, City of Vallejo, pers. comm., 11/96). The two reservoirs are operated in conjunction with one another because they are located in close proximity to one another on the same creek. Water from Lake Madigan is released into the stream channel to flow down to Lake Frey, and water is released from Lake Frey to flow into the creek channel. The Green Valley Diversion Dam, downstream of both reservoirs, diverts water into a 14-inch diameter pipeline that goes through the Green Valley Water Treatment Plant and is then distributed by the City of Vallejo. The annual safe yield of the reservoirs is approximately 600 AF per year. Water use information from the City of Vallejo Lakes Water System Master Plan (City of Vallejo 1989, 1994) indicates that the average annual water production from this watershed from 1978 to 1987 was 358 AF. Currently, there are no minimum required instream flow requirements downstream of Lake Frey. The system operates on demand; therefore, only flows in excess of demands and the storage capacity of the reservoirs reach Suisun Marsh.

In 1924, Lake Curry was constructed on Suisun Creek in Napa County. The City has a water right to directly divert 7 cfs year round and to divert to storage 5,400 AF from November 1 to May 1. The total annual water use is not to exceed 5,058.9 AF, and the total amount of water in storage at any one time in Lake Curry may not exceed 10,700 AF. The firm yield of Lake Curry is approximately 3,500 AF. The average annual water production from this watershed from 1978 to 1987 was 705 AF. The water right license does not require releases of water to maintain fish below the dam. The DFG believes that the habitat would be suitable below the dam to support a fishery if water was provided, and releases from the dam for this purpose may be required under Fish and Game Code section 5937 (DFG 1993).

In addition to the three reservoirs, the City also has four additional sources of water: Lake Berryessa, groundwater, treated water from the City's Fleming Hill water treatment plant (sources of water are from Putah-South Canal and the North Bay Aqueduct (NBA)), and treated water from the City of Fairfield (from Putah-South Canal) (City of Vallejo 1994).

2. North Bay Aqueduct

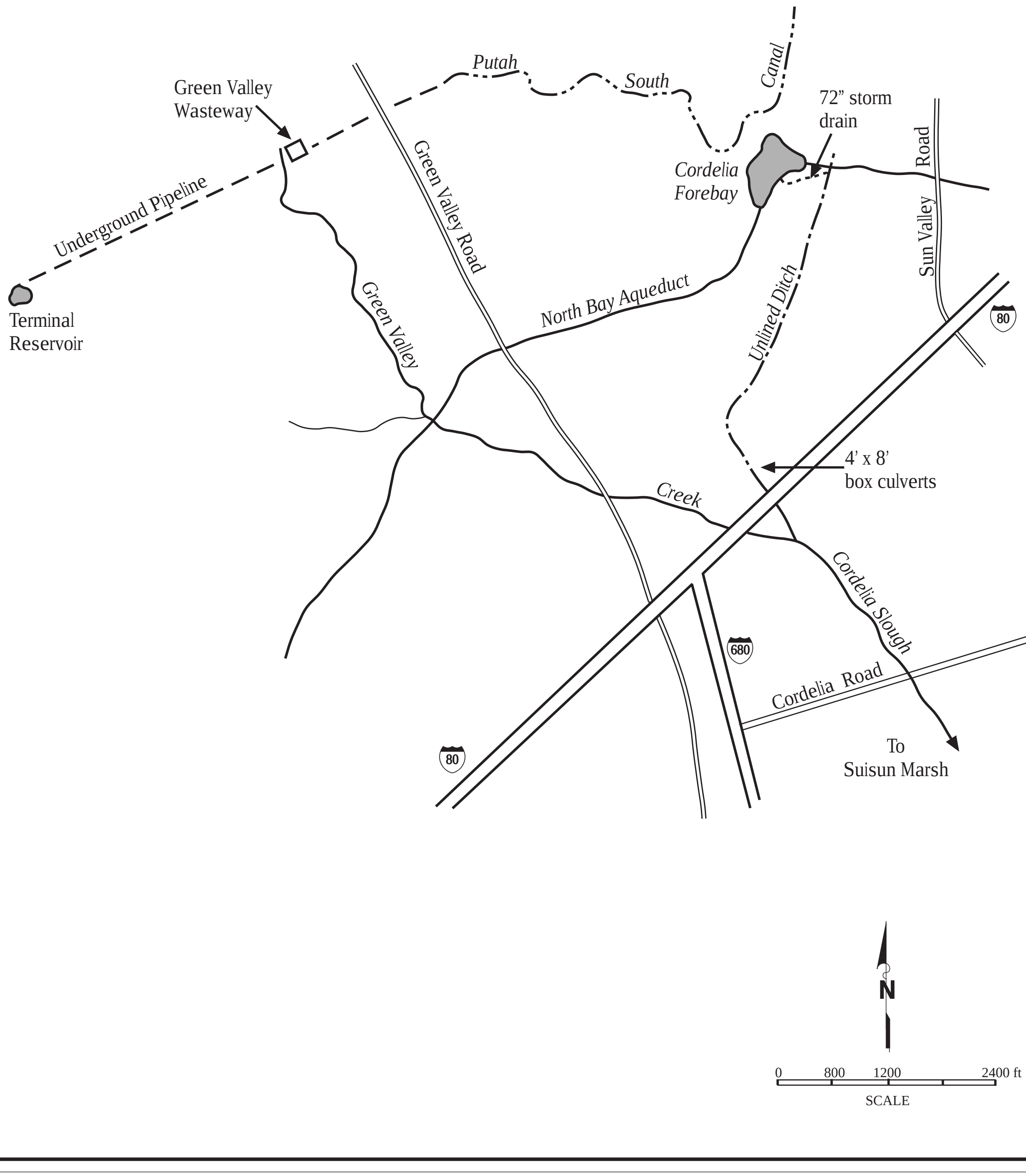
The NBA extends over 27 miles from Barker Slough to the Napa Turnout Reservoir in southern Napa County (see Figure VII-5b). The capacity of the NBA is 174 cfs between Barker Slough Pumping Plant and the Cordelia Forebay. The SWP uses the NBA to meet project entitlements in Napa and Solano counties, including the City of Vallejo (DWR 1994a). Ultimate scheduled allocations are expected to be about 67 TAF annually, with 42 TAF to Solano County Water Agency (SCWA) and 25 TAF to the Napa County Flood Control and Water Conservation District. Pumping from Barker Slough through the NBA averaged 36 TAF in 1990 and 1991 (DWR 1993). At present, deliveries through the NBA are not using the entire capacity of the canal during the Suisun Marsh salinity control season (DWR 1993). Although capacity is currently available in the NBA that could be used for Green Valley Creek augmentation flows, long term availability is not certain.

Supplementing flow in Green Valley Creek from the NBA for salinity control in western Suisun Marsh would require the use of natural channels and the City of Fairfield storm drains. Water would be transported from the intake of the NBA at Barker Slough to the Cordelia Forebay. The water would then flow into an existing 72-inch diameter pipe that connects to a 72-inch City of Fairfield storm drain along Mangles Road. At the outlet of the storm drain, the additional water would flow into an unlined ditch. This ditch, FSSD Treatment Plant and North-Bay Aqueduct constructed by the City of Fairfield, extends southwesterly for about 0.6 mile. It passes under Interstate 80 and adjacent frontage roads through a series of box culverts with cross-sectional diameter of 8 feet wide by 4 feet high and discharges into Green Valley Creek about 50 yards south of Interstate 80 (see Figure VII-4). The ditch is designed to handle maximum flows of 300 cfs (DWR 1993). The City plans to construct a storm drainage retention pond where the ditch is located.

3. Fairfield-Suisun Sewer District Wastewater Treatment Plant

The Fairfield-Suisun Sewer District (FSSD) wastewater treatment plant presently discharges to Suisun Marsh. The DWR investigated the use of effluent from the treatment plants serving the cities of Vacaville, Vallejo, Benicia, and Sacramento to reduce salinity in Suisun Marsh (DWR 1991b). The DWR concluded that the treatment plants in these cities were not able to provide the level of treatment necessary to allow discharge to the marsh. The San Francisco Bay RWQCB requires that any National Pollutant Discharge Elimination System (NPDES) permits issued for Suisun Marsh must meet water quality requirements similar to those specified in the NPDES permit for the FSSD treatment plant, which provides tertiary-level treatment. The concentrations of critical water quality parameters in the effluent from the treatment plants serving the cities of Vacaville, Vallejo, Benicia, and Sacramento exceed the requirements for these parameters in the FSSD's NPDES permit. The discharge from the FSSD treatment plant is, therefore, the only treatment plant discharge considered as a source for water to control salinity in the marsh.

Figure VII-4
Green Valley Creek Detail



The FSSD is located in central Solano County near the southeast corner of the intersection of Cordelia and Chadbourne Roads (see Figure VII-5a). The service area, which includes the City of Fairfield, Suisun City, and Travis Air Force Base, is adjacent to Suisun Marsh. The San Francisco Bay RWQCB Basin Plan prohibits discharge to Suisun Marsh from May 1 to September 21 unless it can be shown that the discharge will provide a net environmental benefit. The FSSD received an NPDES permit to discharge to the marsh through the Basin Plan exemption process. The effluent from the plant has been certified for use on food crops and for nonrestrictive recreational purposes. During the summer months, the treated effluent is reclaimed to the greatest degree possible and used by SID for agricultural irrigation. The remainder of the treated effluent not used for irrigation purposes is discharged to Boynton Slough east of I-680 which is tributary to Suisun Slough and Suisun Bay. During the winter months, the permit allows discharge from the treatment plant to Boynton Slough for management of duck club ponds (FSSD Publication). The locations of the discharge points are Boynton Slough Outfall and Duck Club Turnouts No. 1 and No. 2 (SWRCB WQ Order No. 90-101).

The treatment plant has a dry weather design capacity of 17.5 million gallons per day (mgd). The plant presently has an average dry weather discharge of 11.6 mgd and an annual average discharge of 12.8 mgd. Approximately 40 percent of the annual average discharge is reclaimed and 60 percent is released to Boynton Slough. The reclaimed water is used by SID mainly to irrigate a grass-sod farm because other uses are limited by the high boron content in the water (DWR 1991b). The SID currently has a contract for the use of the first 12 mgd of effluent, except as specified below.

1. From September 22 to December 1, up to one-half of the discharge is available for marsh maintenance and enhancement.

2. From December 2 to March 1, the entire discharge is available for marsh maintenance and enhancement.

3. From March 2 to April 1, two-thirds of the discharge is available for marsh maintenance and enhancement; and

4. From April 2 to May 1, one tenth of the discharge is available for marsh maintenance and enhancement.

In a letter dated January 24, 1997, the DWR and the USBR proposed a collaborative effort with the FSSD to construct a pipeline from the FSSD treatment plant to Green Valley Creek (DWR 1997a). The pipeline would provide the infrastructure needed to discharge surplus treated effluent into the northwestern Suisun Marsh. The letter defines surplus treated effluent as effluent from the FSSD treatment plant that is not now, or in the future, beneficially used by the SID or any other entity in Solano County and is not needed to maintain Boynton Slough salinity within water quality objectives set by the SWRCB. In a letter to the DWR dated April 23, 1997, the FSSD responded that there are too many obstacles to proceed with the proposal at this time (DWR 1997c).

Figure VII - 5a
FSSD Treatment Plant

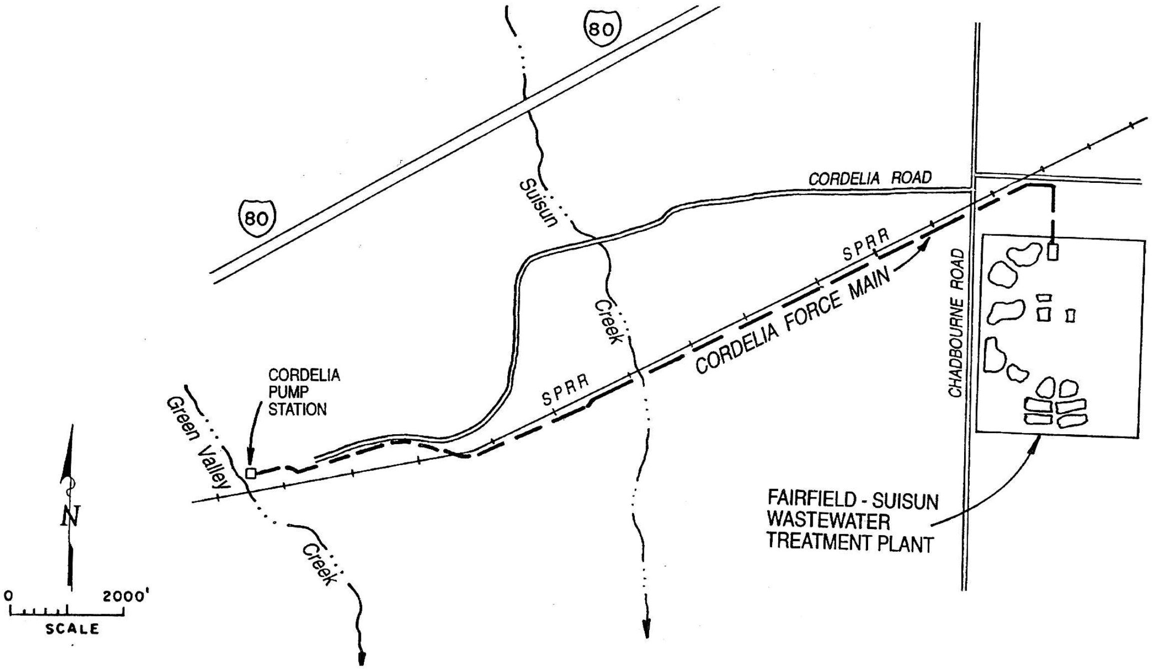
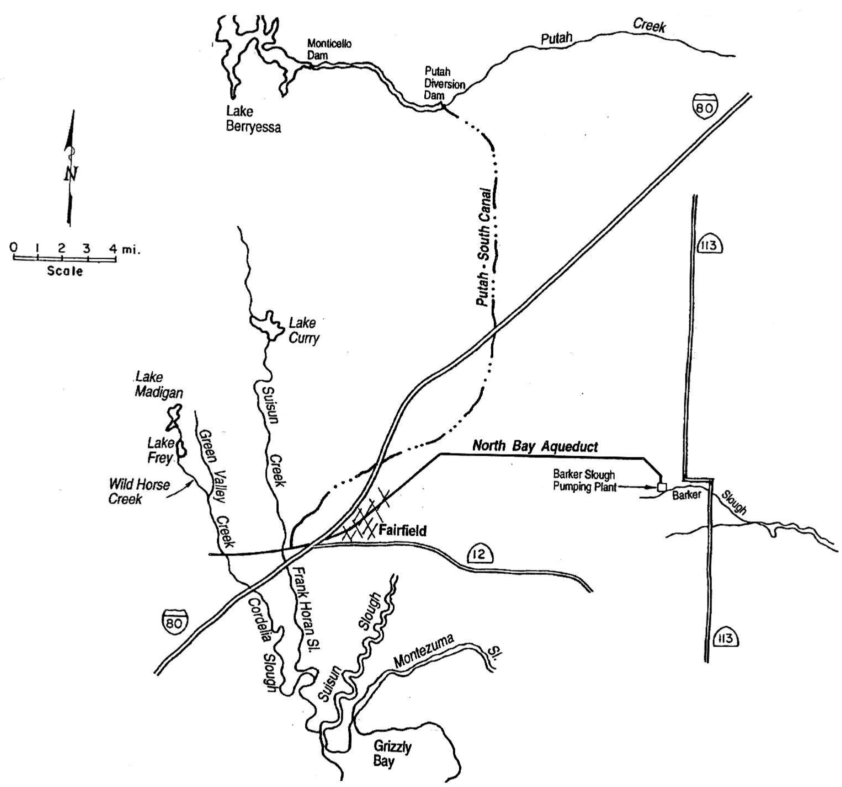


Figure VII - 5b
North Bay Aqueduct and Putah-South Canal



4. Lake Berryessa and Putah-South Canal

Lake Berryessa, formed by Monticello Dam on Putah Creek, and Putah-South Canal are part of the USBR's Solano Project. The storage capacity of Lake Berryessa is 1.6 MAF and the average annual runoff of Putah Creek at Monticello Dam was about 372 TAF between 1958 and 1977. The present long-term contract demand from the project is about 200 TAF (DWR 1993). Water is marketed through the SCWA, of which 73 percent of the supply is allocated to the SID for agricultural purposes. Other purposes of use are recreation, municipal, industrial, and military facilities supply.

Flow augmentation into Green Valley Creek could be accomplished using water from Lake Berryessa (Figure VII-5b). Water dedicated for this purpose would be released from Lake Berryessa into Putah Creek and would flow into Solano Lake about 6 miles below Monticello Dam. Solano Lake, with a capacity of 750 AF, was created by construction of the Putah Diversion Dam on Putah Creek to divert water into Putah-South Canal. The canal is concrete-lined and it has a diversion capacity of 956 cfs, and a terminal capacity of 116 cfs. Water can be released into Green Valley Creek from the Putah-South Canal through the Green Valley Creek Wasteway. The wasteway consists of a concrete conduit, approximately 1.5 miles in length, with a capacity of 14 cfs. The capacity of the wasteway would have to be increased in order to handle the quantity of water required to meet northwestern Suisun Marsh salinity objectives. Another option for increasing the flow capacity into Green Valley Creek would be to divert water from the terminal reservoir on Putah-South Canal to Green Valley Creek through a new pipeline (DWR 1993).

C. ALTERNATIVES FOR IMPLEMENTING THE SUISUN MARSH OBJECTIVES

The alternatives for meeting the Suisun Marsh numerical salinity objectives are based on two principal assumptions: (1) a flow alternative will be adopted that implements the outflow objectives in the 1995 Bay/Delta Plan; and (2) the DWR and the USBR will operate the initial facilities and the SMSCG when Delta outflow alone is not sufficient to achieve the eastern and two of the western marsh objectives (Stations C-2, S-64, S-49, S-21, and S-42). Modeling indicates that, under these conditions, the objectives at these stations and the objectives at the water supply intakes at Chipps and Van Sickle Islands will be met, with limited exceptions. (The modeling results are described in section D.) Consequently, the DWR and the USBR will be held responsible for meeting the numerical objectives at the above stations in all of the alternatives because they operate the salinity control gates. An exception to this responsibility could be made when hydrologic conditions are such that even with gate operation, as described above, the objectives cannot be achieved.

The 1995 Bay/Delta Plan also includes a narrative Suisun Marsh objective that requires conditions sufficient to support a brackish marsh throughout all elevations of the tidal marshes bordering Suisun Bay. The conditions necessary to achieve this narrative objective are not adequately defined at this time. Compliance with the other flow and water quality objectives in the 1995 Bay/Delta Plan may be sufficient to achieve this objective. The SEW is evaluating whether this objective is being achieved, and if not, what actions are necessary for its implementation. This issue will be considered in the next triennial review of the Bay/Delta Plan. This EIR will not, therefore, include specific alternatives to achieve this objective.

Based on the rationale provided above, the alternatives considered in this draft EIR focus on methods to meet the two remaining western marsh objectives (Stations S-35 and S-97). The alternatives include options such as increased flow in Green Valley Creek from various sources, construction of facilities in the western marsh, and management actions to improve soil salinity and habitat conditions without achieving the numerical salinity objectives.

One possible alternative, increased Delta outflow, is not included because available evidence indicates that this alternative would require very substantial increases in Delta outflow. For example, DWR modeling indicates that, with D-1485 standards under 1990 conditions, salinity objectives at S-97 would not have been met with an increase in the Delta Outflow Index from January through May of 2.4 MAF.

The following six alternatives are considered in this EIR.

1. Suisun Marsh Alternative 1

This alternative is the base case and the first No Project alternative. The SWP and the CVP are responsible for meeting D-1485 Suisun Marsh objectives as modified. D-1485 outflow objectives are in effect and the initial facilities and SMSCG are in place and operated to meet objectives at all of the stations, to the extent possible. The DWR and the USBR take no further action to meet the D-1485 western marsh objectives, and the objectives are sometimes not met.

At present, the DWR and the USBR have no firm plans to meet the western marsh objectives under these base case hydrology conditions, and if the SWRCB does not take any action to implement the new Suisun Marsh objectives, this alternative would be in effect as plans are developed and implemented.

2. Suisun Marsh Alternative 2

This alternative is the second No Project alternative and is described in the Western Suisun Marsh Salinity Control Project Screening Report (DWR 1993). The SWP and the CVP are responsible for meeting D-1485 Suisun Marsh objectives as modified. As in Alternative 1, D-1485 objectives are in effect and the initial facilities and the SMSCG are in place and operated to meet objectives to the extent possible. The objectives at the two stations in the western marsh are met, to the extent feasible, through construction and operation of the Cordelia-Goodyear Ditch and an associated tide gate structure, and through flow augmentation in Green Valley Creek with NBA water (DWR 1993).

The modeling of this alternative assumes that the Cordelia-Goodyear Ditch and the Goodyear Slough Tide Gate are operated to meet the objectives at S-35. The flows in Green Valley Creek are supplemented by up to 80 cfs, as necessary, to meet the objectives at S-97.

A preliminary analysis of this action, along with seventeen other actions to meet D-1485 standards, was undertaken by the DWR and the USBR and described in the Western Suisun Marsh Salinity Control Project (DWR 1993). In this EIR, Suisun Marsh Alternatives 2 and 4 assume construction of the Cordelia-Goodyear Ditch, associated tidal gates, and Goodyear Slough Tide Gate (see Figure VII-6). Other methods of complying with the objectives are possible, but construction of these, or similar facilities, are a reasonable assumption. Additional environmental and engineering analyses would be required before these facilities could be constructed; therefore, the analysis of these structures is programmatic.

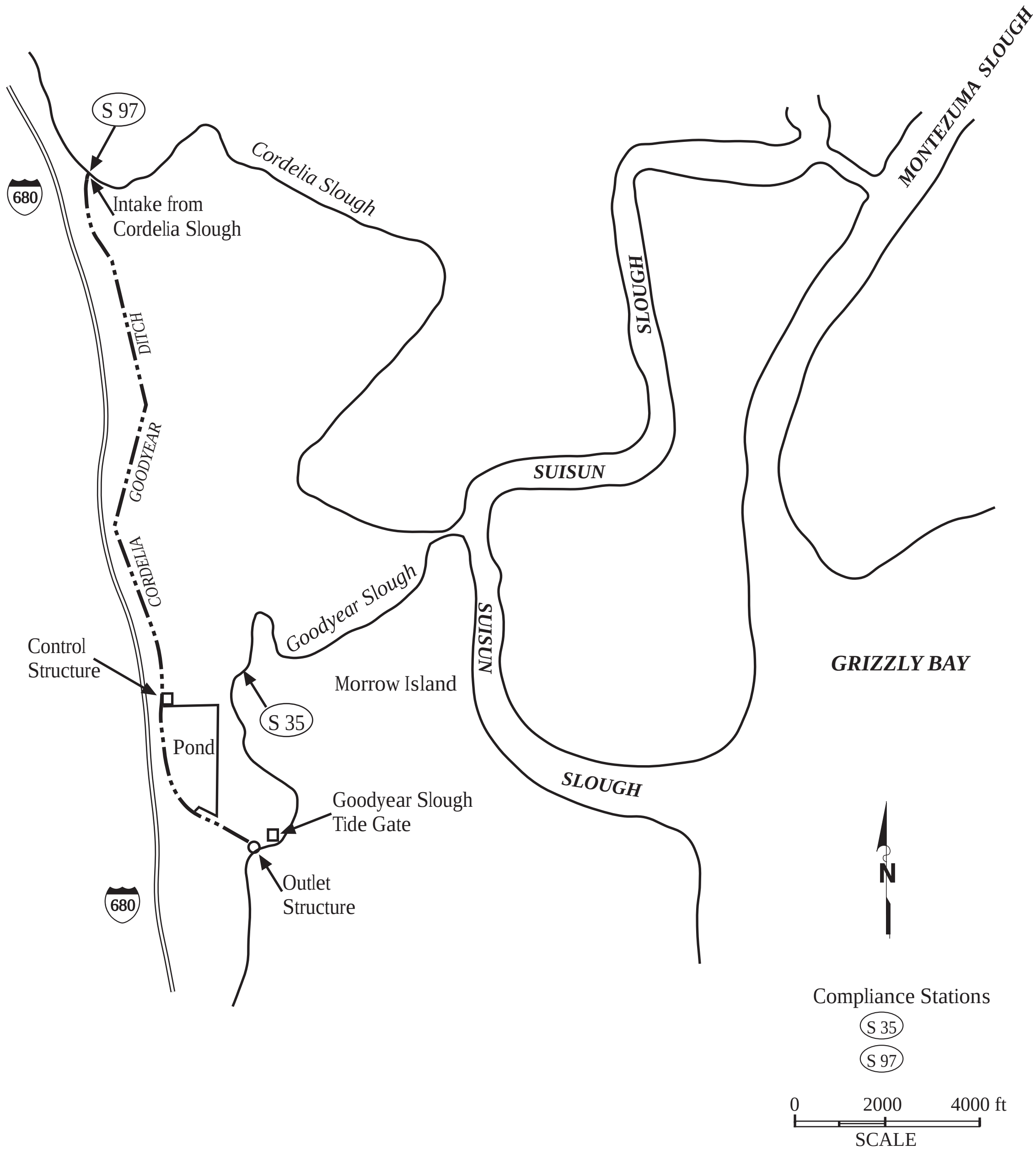
The Cordelia-Goodyear Ditch and associated tidal gates would move lower salinity water from upper Cordelia Slough near the Ibis Club to Goodyear Slough about 0.5 miles north of the intake to the Morrow Island Distribution System. The ditch would be parallel to the eastern side of Interstate Highway 680 (I-680). A pond would be constructed on the Goodyear Slough end of the ditch to increase its holding capacity and to provide public recreation facilities (DWR 1993). The 40-acre pond would be connected to the ditch south of Pierce Lane, between Interstate-680 and the railroad. The pond would be connected to Goodyear Slough about 0.2 miles upstream (south) of Pierce Harbor, with buried pipes and open channel about 0.1 mile long. The pipes would pass beneath the railroad.

The inlet tide gate on Cordelia Slough would use tidal action to move lower salinity water from Cordelia Slough southward through the Cordelia-Goodyear Ditch. The outlet tide gate on Goodyear Slough, just south of Pierce Harbor, would use tidal action to move lower salinity water from the Cordelia-Goodyear Ditch's peaking pond into Goodyear Slough. The inlet and outlet gates would be operated in conjunction. The gates would be designed to move up to 225 cfs net flow over a tidal cycle, with a maximum flow of 625 cfs.

The Goodyear Slough Tide Gate would prevent higher salinity water from entering the upstream (southern) end of Goodyear Slough during flood tide from Suisun Slough near Grizzly Bay. The tide gate would be on Goodyear Slough just downstream (north) of the proposed outlet of the Cordelia-Goodyear Ditch. This tide gate would only be considered in conjunction with the Cordelia-Goodyear Ditch (DWR 1993).

The proposed site for the Goodyear Slough Tide Gate is shown on Figure VII-6. The tide gate would be designed to move up to 250 cfs net flow over a 25-hour tidal cycle, with a maximum flow of 675 cfs. The downstream (northern) end of Goodyear Slough is connected to Suisun Slough and its upstream end is connected to Suisun Bay via the Goodyear Slough Outfall culvert pipes. The intake of the existing Morrow Island Distribution System is connected to Goodyear Slough and the outlet for the proposed Cordelia-Goodyear Ditch would be on Goodyear Slough about 0.2 mile

Figure VII-6
Cordelia-Goodyear Ditch and Goodyear Slough Tide Gate



upstream (south) of Pierce Harbor. Boat passage facilities would be required, should this facility be constructed (DWR 1993).

The tide gate would be in place all year, but would probably only be operated from October through May when necessary to meet the objectives.

3. Suisun Marsh Alternative 3

This alternative is the same as Alternative 1 except that the 1995 Bay/Delta Plan outflow objectives are in effect.

4. Suisun Marsh Alternative 4

This alternative is the same as Alternative 2 except that the 1995 Bay/Delta Plan outflow objectives are in effect.

5. Suisun Marsh Alternative 5

The 1995 Bay/Delta Plan outflow objectives are in effect and the SMSCG is operated to meet objectives to the extent feasible. Compliance stations S-35 and S-97 in the northwest corner of the marsh will become monitoring stations. The following management actions, as recommended by the parties to the SMPA Amendment III, are implemented as described in the "Demonstration Document" (DWR 1997c).

1. *Water Manager Program* - SRCD will institute a Water Manager Program and employ support staff to coordinate and improve water management practices throughout the marsh.

2. *Joint-Use Facilities Program* - A joint-use facility is a structure used by two or more properties, and can include levees, ditches, and water control structures. In coordination with the Water Management Program, this program is to provide more efficient and cooperative use of water delivery and leaching systems to managed wetlands in order to produce better waterfowl habitat.

3. *Portable Pumps for Diversions and Drainage Program* - This program will be coordinated with the Water Management Program. The Water Manager, under the SRCD's direction, will use twenty diesel-powered portable pumps to improve salinity conditions in managed marshes. The pumps are for the benefit of managed wetlands to provide lower salinity water during low tide diversions and better removal of soil salts during drainage. The pumps will be moved throughout the marsh as appropriate to maximize their effectiveness. The Water Manager will be responsible for assuring that any pumps for diverting water from the exterior sloughs have appropriate fish screens attached.

4. *Updating of Existing Management Plans* - The SRCD will prepare updated Individual Ownership Management Plans to provide landowners with information needed to improve salinity conditions on their property.

5. *Operate the SMSCG in September to Meet October Salinity Objectives* - The DWR and the USBR will operate the SMSCG in September when the 7-day running average mean daily high tide salinity in September at any compliance station, or at the S-35 Monitoring Station is 17.0 mmhos/cm or greater. The running averages for September 1-6 will be determined using salinity data from the last six days of August. The purpose of September gate operation is to improve wetland habitat management in the fall and improve leaching efficiency the following spring.

6. *Managed Wetland Improvement Fund* - This action provides for $2,000,000 (plus any remaining funds from the original agreement) to be utilized between two cost share programs for improvements on private managed wetlands.

7. *Drought Response Fund* - This fund would compensate landowners within the marsh, including the Department of Fish and Game, that apply higher salinity channel water to their managed wetlands because of prolonged drought conditions. Funds would be used for activities to offset the effects of the higher salinity water.

Other provisions of the SMPA Amendment III address responsibilities of parties, funding, coordination, criteria, and contingencies. (SMPA 1998)

Not all of the actions in this alternative can be modeled, such as the water manager activities and operation of the portable pumps. Under this alternative, the numerical salinity objectives in the western marsh will not always be met, but the intent is to provide equivalent protection to the managed wetlands through management actions that achieve soil salinities necessary to produce suitable vegetation for waterfowl. The 1995 Bay/Delta Plan states that the salinity objectives in the channels do not have to be achieved if "a demonstration of equivalent or better protection is provided at the location."

6. Suisun Marsh Alternative 6

Multiple parties are responsible for full implementation of the 1995 Bay/Delta Plan western marsh objectives through flow augmentation in Green Valley Creek. The additional sources of water will come from: (1) the FSSD; (2) upstream reservoirs (Lake Madigan and Lake Frey); and (3) if needed, water will be released from Lake Berryessa (see Figure VII-5b).

Lake Berryessa is part of the USBR's Solano Project, and it stores water from Putah Creek, a tributary of the Sacramento River. Lake Berryessa water can be released into the western marsh by diversion into the Putah-South Canal and then to Green Valley Creek. Under this alternative, Lake Berryessa water will be repaid to the Solano Project by the DWR and the USBR through the NBA, unless the Solano Project has an obligation to the Delta under the outflow alternatives, in which case that obligation will be met by releasing water into the western Suisun Marsh. In the past, the SCWA has agreed to provide water to agencies, including the DWR (SCWA Agreements 1992 and 1995); however, no water was actually transferred under these agreements. In the future, the NBA is expected to be operating closer to its full capacity for delivery of SWP supplies, so repayment of water used for the Suisun Marsh will have to be made during times when excess capacity exists.

Arrangements could probably be agreed upon among the involved parties, for sale or exchange of Lake Berryessa water between November and March, including arrangements for the annual cleaning of the canal. A requirement for water from the Putah Creek basin would need to be consistent with SWRCB Order WR 96-002[5]. In addition, it would need to be consistent with the Sacramento County Superior Court Judgment in the case of *Putah Creek Council* v. *SID and SCWA,* filed August 23, 1996. The court ruled, in part, that the SID and SCWA shall release, monitor and record specific instream flows in Putah Creek downstream of the Putah Diversion Dam (lower Putah Creek). The Court's decision is currently under appeal and has been stayed.

D. ENVIRONMENTAL IMPACTS OF THE ALTERNATIVES

This section describes the effects of implementation of the alternatives on: (1) salinity, (2) hydrology, (3) landscape (construction-related impacts), (4) aquatic resources, (5) terrestrial resources, and (6) recreation.

1. Salinity

This section describes the results of the salinity modeling, and the conclusions reached as a result of the modeling studies. In general, the results indicate that Suisun Marsh salinity objectives are met in most months under all alternatives in the eastern and the central marsh. Discussion is therefore focused on the western compliance stations, S-35 and S-97, where a significant number of objective exceedences occur. The hydrodynamic and water quality model DWRDSM (Suisun Marsh Version) was used to analyze the six methods for implementing Suisun Marsh objectives described in section C above. The model simulates the average monthly high tide salinities, expressed in mmhos/cm, for the 1922-1994 time period. Results are reported for all alternatives at compliance monitoring stations C2, S-64, S-49, S-42, S-21, S-35, and S-97 (DWR 1997b, DWR 1999).

5 SWRCB Order WR 96-0025 amended appropriative water rights in the upper Putah Creek watershed filed subsequent to October 29, 1945 which were subject to condition 12 of the USBR's permitted water right Applications 11199, 12578, and 12716.

The SMSCG is operated within the model as needed to meet objectives during the October-May control season. In order to determine when gate operations would be required, two preliminary model runs, without gate operation, were made using D-1485 and 1995 Bay/Delta Plan hydrology. The preliminary model runs are designated as Alternatives 1A and 3A. Though these are not alternatives being analyzed in this EIR, the data is included in the table of results to document the effect that SMSCG operation has on marsh salinity. SMSCG operation is triggered whenever salinity at S-21, S-35, S-49, or S-64 is within 2 mmhos/cm of the applicable monthly objective during the control season (October through May). Based on field test data, SMSCG operation has little or no effect on salinity at S-97, hence S-97 is not used as a trigger for gate operation.

The alternatives were modeled as follows:

Alternative 1 - D-1485 objectives are in effect with SMSCG operation as described above.

Alternative 2 - Same as Alternative 1 plus operation of the Goodyear Slough tide gate, the Cordelia-Goodyear Ditch, and augmentation of Green Valley Creek with up to 80 cfs from the NBA.

Alternative 3 - 1995 Bay/Delta Plan objectives are in effect with full SMSCG operation.

Alternative 4 - 1995 Bay/Delta Plan objectives are in effect with same facilities and SMSCG operation as Alternative 2.

Alternative 5 - Implementation of the SMPA Amendment III (SMPA 1998) is most like modeling of Alternative 3 with the addition of September SMSCG operation, which mostly affects October salinities during dry years. Modeling of Amendment III could not include many management actions, and would understate the net benefit that may be expected from implementation of the alternative.

Alternative 6 - Same as Alternative 3 plus incremental flow augmentation in Green Valley Creek from the FSSD and other unidentified sources until marsh standards are met at both S-35 and S-97.

a. <u>Modeling Results</u>. Results of the salinity modeling are summarized in Table VII-4 and in Figures VII-7 through VII-15. Results of the preliminary runs, Alternatives 1A and 3A, are presented in Table VII-5. The tables list the percentage of time that Suisun Marsh salinity objectives are exceeded at each compliance station for each month of the salinity control season over the 73-year period. As D-1485 does not provide for relaxation of objectives during deficiency periods, (as defined in footnote 2) a straight comparison of exceedence frequencies under the two hydrologies can be misleading. Table VII-6 compares Alternatives 1 and 3 with deficiency years excluded, thus providing a true comparison of the effect that base hydrology has upon marsh salinity.

The figures convey similar information in a graphical "area-frequency" format. The plots are designed to answer two questions: (1) how frequently objectives are exceeded; and (2) by how much objectives are exceeded. Area-frequency plots are prepared by subtracting the monthly salinity standard from the progressive daily mean high tide salinity for the month at each compliance station. The resulting differences are sorted for the entire 73-year period from the largest positive difference (above the objective) to the largest negative difference (below the objective). The sorted differences are normalized from 0 to 100 percent and then plotted. The amount by which an objective is exceeded over the entire 73-year period is estimated by calculating an "exceedence index." The exceedence index is defined as the ratio of the area above the zero difference line to the total area both above and below the same line, expressed as a percent (see Figure VII-7).

Comparison of the exceedence frequencies for Alternative 1 to 1A and Alternative 3 to 3A (Tables VII-4 and VII-5) demonstrates the crucial role that the SMSCG plays in maintaining Suisun Marsh water quality objectives. Without SMSCG operation, only C-2 consistently meets objectives under D-1485 hydrology. The higher outflows in the 1995 Bay/Delta Plan produce compliance in April and May at S-42, S-21, and S-35; otherwise, all stations exceed standards in some months without SMSCG operation. With SMSCG operation, all eastern stations (C-2, S-64, and S-49) and stations S-42 and S-21 in the western marsh either meet, or very nearly meet, objectives under both hydrologies. All stations that meet objectives under D-1485 when the salinity control gates are operating, are marginally freshened with 1995 Bay/Delta Plan hydrology.

Due to the effectiveness in meeting objectives in the eastern marsh and at S-42 and S-21 in the western marsh with SMSCG operation, and the fact that the DWR and the USBR alone have operational control of the gates, there will be no further consideration given to implementation of 1995 Bay/Delta Plan objectives at these stations. The remaining discussion will focus on alternative methods for meeting objectives at S-35 and S-97. The impact of removing treated wastewater from Boynton Slough (Station S-40) under Alternative 6 will also be discussed.

b. <u>Salinity Impacts at S-97</u>. Compliance station S-97 is located on Cordelia Slough at the Ibis Club in the northwestern corner of the marsh. It is located furthest from the SMSCG and therefore is least affected, if at all, by SMSCG operation. Salinities in the northwest marsh are influenced strongly by freshwater inflow from tributary creeks. Green Valley Creek flows have a direct effect on salinity at S-97.

c. <u>Salinity Impacts at S-35</u>. Station S-35 is located in the southwestern corner of the marsh on Goodyear Slough at the Morrow Island Club. Like S-97, S-35 benefits from the increased outflow required by the 1995 Bay/Delta Plan. The flow augmentation proposed in Alternatives 2 and 4 benefits S-35 considerably less than S-97. Salinity control at S-35 is achieved primarily through operation of the Cordelia-Goodyear Ditch and the associated tide gates. Exceedence frequencies are reduced by 5.8 percentage points when Alternatives 2 and 4 are compared, but remain significant at 12.7 percentage points under Alternative 4. The exceedence index is reduced

Table VII-4
Percentage of Time Suisun Marsh Salinity Objectives Would be Exceeded by Station and by Month

Alternative 1

	Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Exceedence Index
East	C-2	0.0	0.0	0.0	0.0	0.0	5.5	0.0	0.0	0.1
	S64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
West	S42	0.0	0.0	0.0	0.0	9.6	2.7	0.0	0.0	0.2
	S21	0.0	0.0	0.0	0.0	11.0	4.1	0.0	0.0	0.3
	S35	53.4	38.4	23.3	12.3	15.1	8.2	6.8	9.6	6.1
	S97	64.4	71.2	30.1	34.2	56.2	63.0	9.6	16.4	35.5

Alternative 2

	Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Exceedence Index
East	C-2	0.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0	0.0
	S64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
West	S42	0.0	0.0	0.0	0.0	6.8	1.4	0.0	0.0	0.1
	S21	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0
	S35	57.5	41.1	5.5	4.1	26.0	8.2	5.5	0.0	4.4
	S97	24.7	4.1	0.0	0.0	15.1	8.2	0.0	0.0	0.6

Alternative 3

	Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Exceedence Index
East	C-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
West	S42	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0
	S21	0.0	0.0	0.0	0.0	5.5	0.0	0.0	0.0	0.0
	S35	49.3	39.7	12.3	6.8	5.5	0.0	0.0	0.0	3.5
	S97	56.2	57.5	28.8	20.5	38.4	42.5	0.0	5.5	18.6

Alternative 4

	Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Exceedence Index
East	C-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
West	S42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S35	49.3	30.1	4.1	1.4	16.4	0.0	0.0	0.0	2.2
	S97	20.5	2.7	0.0	0.0	12.3	0.0	0.0	0.0	0.2

Alternative 5

	Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Exceedence Index
East	C-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
West	S42	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0
	S21	0.0	0.0	0.0	0.0	5.5	0.0	0.0	0.0	0.0
	S35	47.9	39.7	11.0	6.8	5.5	0.0	0.0	0.0	3.0
	S97	50.7	47.9	15.1	15.1	37.0	38.4	0.0	5.5	12.4
Other	S40	0.0	0.0	0.0	0.0	6.8	6.8	0.0	0.0	0.2

Alternative 6

	Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Exceedence Index
East	C-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
West	S42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S35	8.2	2.7	4.1	0.0	1.4	0.0	0.0	0.0	0.1
	S97	6.8	4.1	0.0	0.0	13.7	13.7	0.0	0.0	0.1

Table VII-5
Percentage of Time Suisun Marsh Salinity Objectives
Would be Exceeded by Station and by Month
Without Suisun Marsh Salinity Control Gate Operation

Alternative 1A

	Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Exceedence Index
East	C-2	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0
	S64	21.9	57.5	45.2	37.0	24.7	19.2	13.7	13.7	22.8
	S49	65.8	69.9	47.9	43.8	42.5	31.5	9.6	13.7	32.8
West	S42	65.8	71.2	47.9	41.1	47.9	32.9	8.2	13.7	32.3
	S21	65.8	71.2	45.2	41.1	46.6	34.2	8.2	13.7	31.4
	S35	65.8	54.8	39.7	26.0	26.0	12.3	8.2	15.1	16.3
	S97	68.5	76.7	49.3	46.6	58.9	65.8	19.2	35.6	50.9

Alternative 3A

	Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Exceedence Index
East	C-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S64	13.7	56.2	43.8	37.0	27.4	15.1	11.0	12.3	18.8
	S49	56.2	64.4	47.9	42.5	41.1	30.1	8.2	2.7	28.3
West	S42	56.2	63.0	45.2	39.7	32.9	12.3	0.0	0.0	20.0
	S21	56.2	63.0	42.5	38.4	31.5	17.8	0.0	0.0	19.3
	S35	56.2	50.7	37.0	20.5	12.3	0.0	0.0	0.0	10.0
	S97	58.9	63.0	45.2	38.4	42.5	50.7	8.2	16.4	32.0

Table VII-6
Percentage of Time Suisun Marsh Salinity Objectives
Would be Exceeded by Station and by Month
With SMPA Deficiency Years Excluded

Alternative 1

	Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Exceedence Index
East	C-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S49	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
West	S42	5.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.1
	S21	5.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.1
	S35	43.3	25.0	13.3	1.7	5.0	1.7	1.7	3.3	3.4
	S97	51.7	61.7	18.3	21.7	46.7	58.3	1.7	8.3	24.3

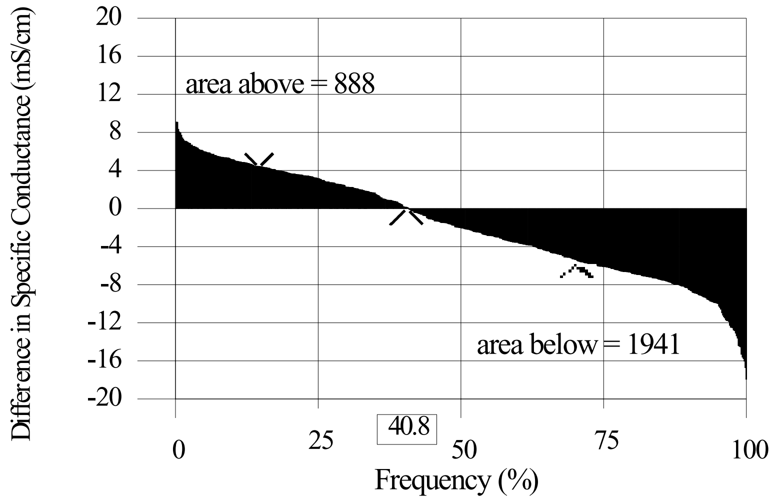
Alternative 3

	Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Exceedence Index
East	C-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
West	S42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S35	40.0	25.0	8.3	5.0	3.3	0.0	0.0	0.0	2.3
	S97	46.7	46.7	16.7	18.3	36.7	43.3	0.0	3.3	13.6

SMPA deficiency years excluded are: 1925, 1926, 1930, 1931, 1932, 1933, 1934, 1977, 1988, 1989, 1990, 1991, and 1992.

Figure VII-7

Example of Area-Frequency Analysis
Plot and Table for Site X



Site	Frq. Above Std. %	Exceedence Index %
X	40.8	31.4

Objective of Area-Frequency Plots:

Area-frequency plots are prepared to indicate how often and to what extent salinity at a particular location was either above or below standards or target salinity.

Definition of Frequency and Exceedence:

Frequency above standards: Defined to be where the area frequency plot crosses the zero line.

Exceedence Index: Defined to be the area above the zero line divided by the sum of the areas above and below the the zero line, and multiplied by 100 to convert to a percentage. The equation and an example calculation are shown below:

$$\text{Exceedence Index} = [\text{AreaAbove} / (\text{AreaAbove} + \text{AreaBelow})]\ X100$$
$$31.4\% = [\,888 / (\,888 + 1941)\,]\ x100$$

Area-Frequency Preparation:

To prepare the area-frequency plots, the standards (normal or deficiency) were subtracted from the respective mean monthly high tide salinities for the control season. The differences were then assigned to each month and sorted from the largest positive difference (above the target standard) to the greatest negative difference (below the target standard). The sorted differences were then normalized from 1 to 100 percent and plotted.

DWR, Suisun Marsh Planning
08/25/97

Figure VII-8

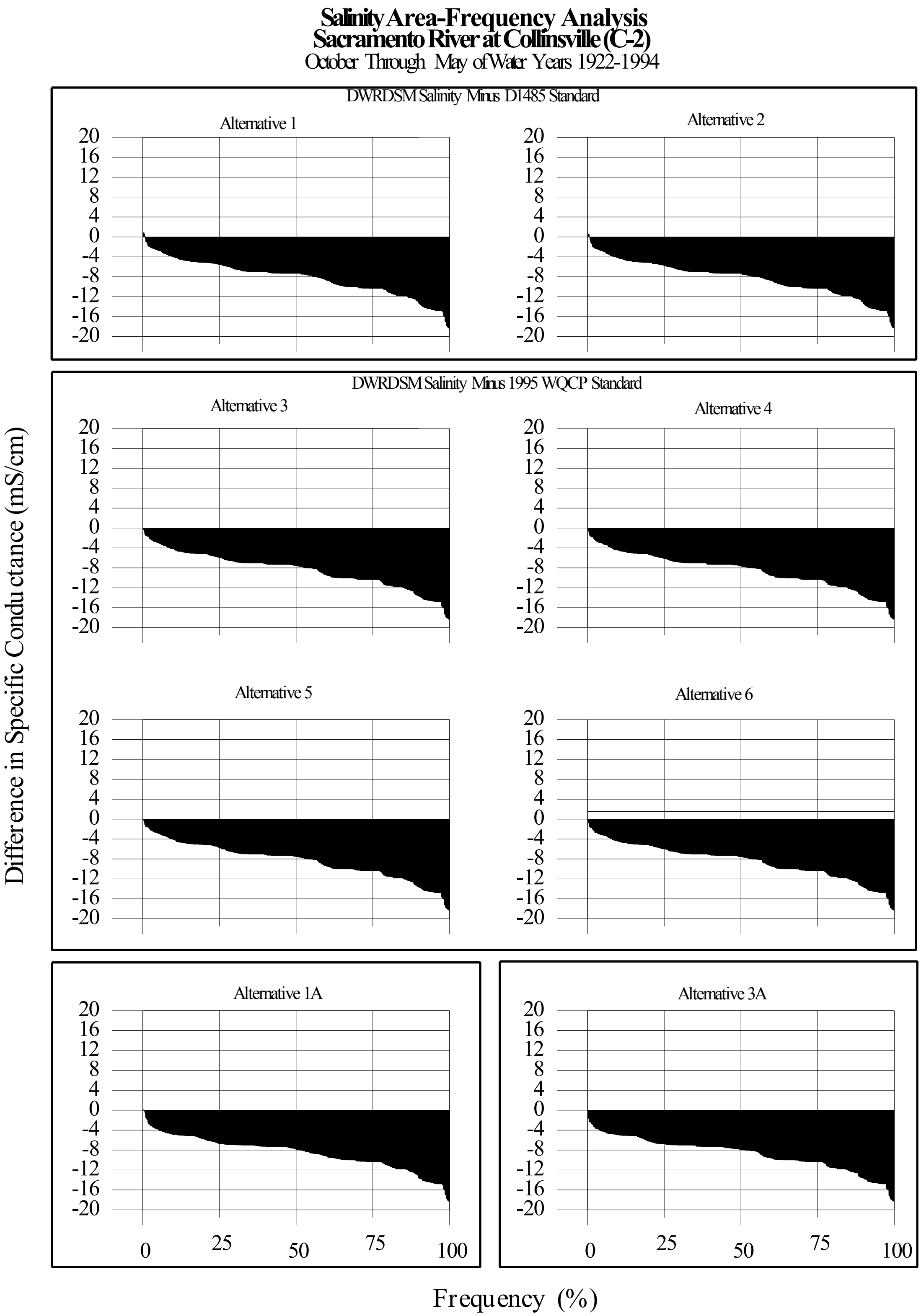

Salinity Area-Frequency Analysis
Sacramento River at Collinsville (C-2)
October Through May of Water Years 1922-1994
DWRDSM Salinity Minus D1485 Standard
Alternative 1
Alternative 2
DWRDSM Salinity Minus 1995 WQCP Standard
Alternative 3
Alternative 4
Alternative 5
Alternative 6
Alternative 1A
Alternative 3A
20
16
12
8
4
0
-4
-8
-12
-16
-20
0
25
50
75
100
Difference in Specific Conductance (mS/cm)
Frequency (%)

Figure VII-9

Salinity Area Frequency Analysis
Montezuma Slough at National Steel (S64)
October Through May of Water Years 1922-1994

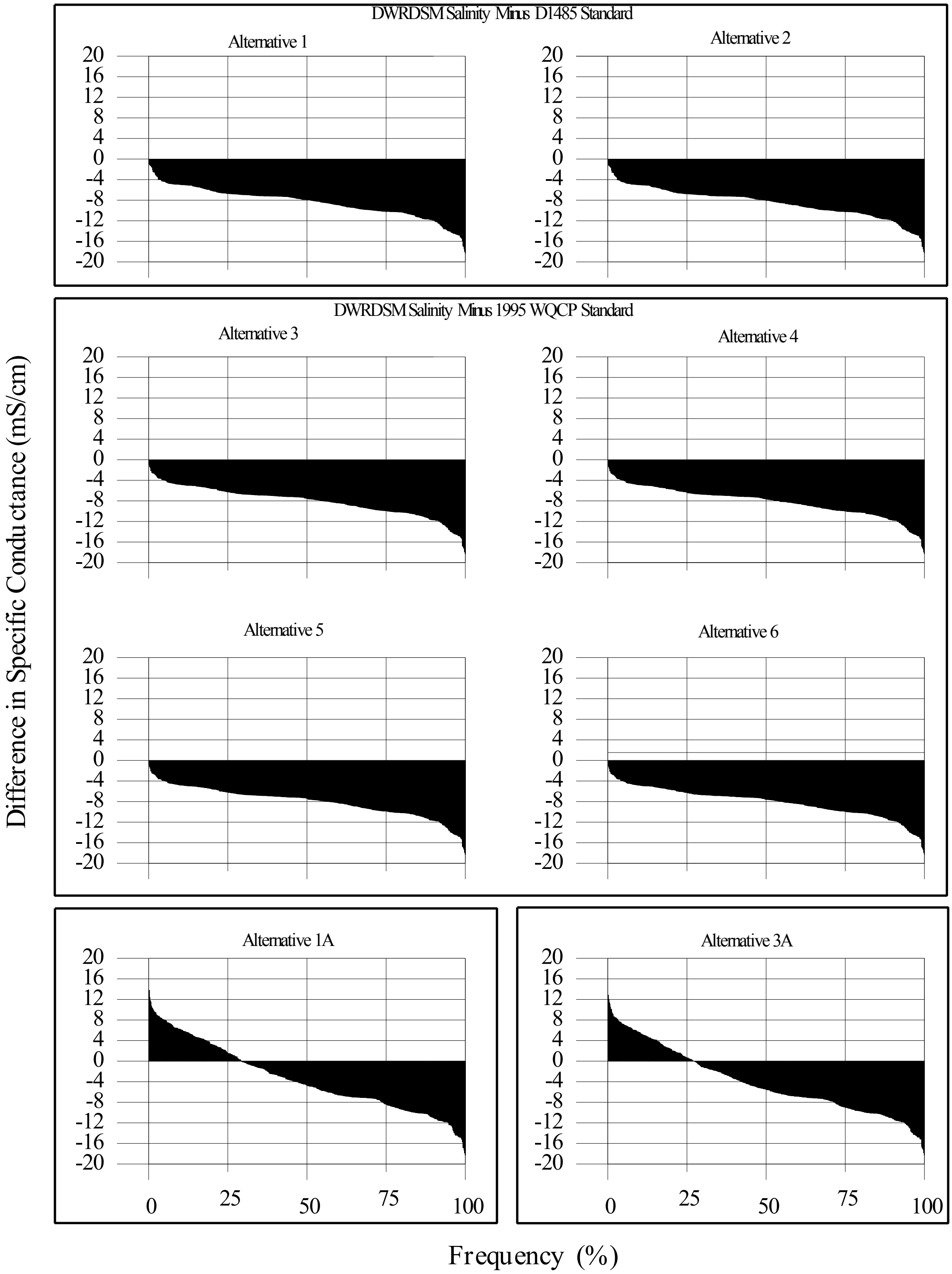


Figure VII-10

Salinity Area-Frequency Analysis
Montezuma Slough near Boldon Landing (S-49)
October Through May of Water Years 1922-1994

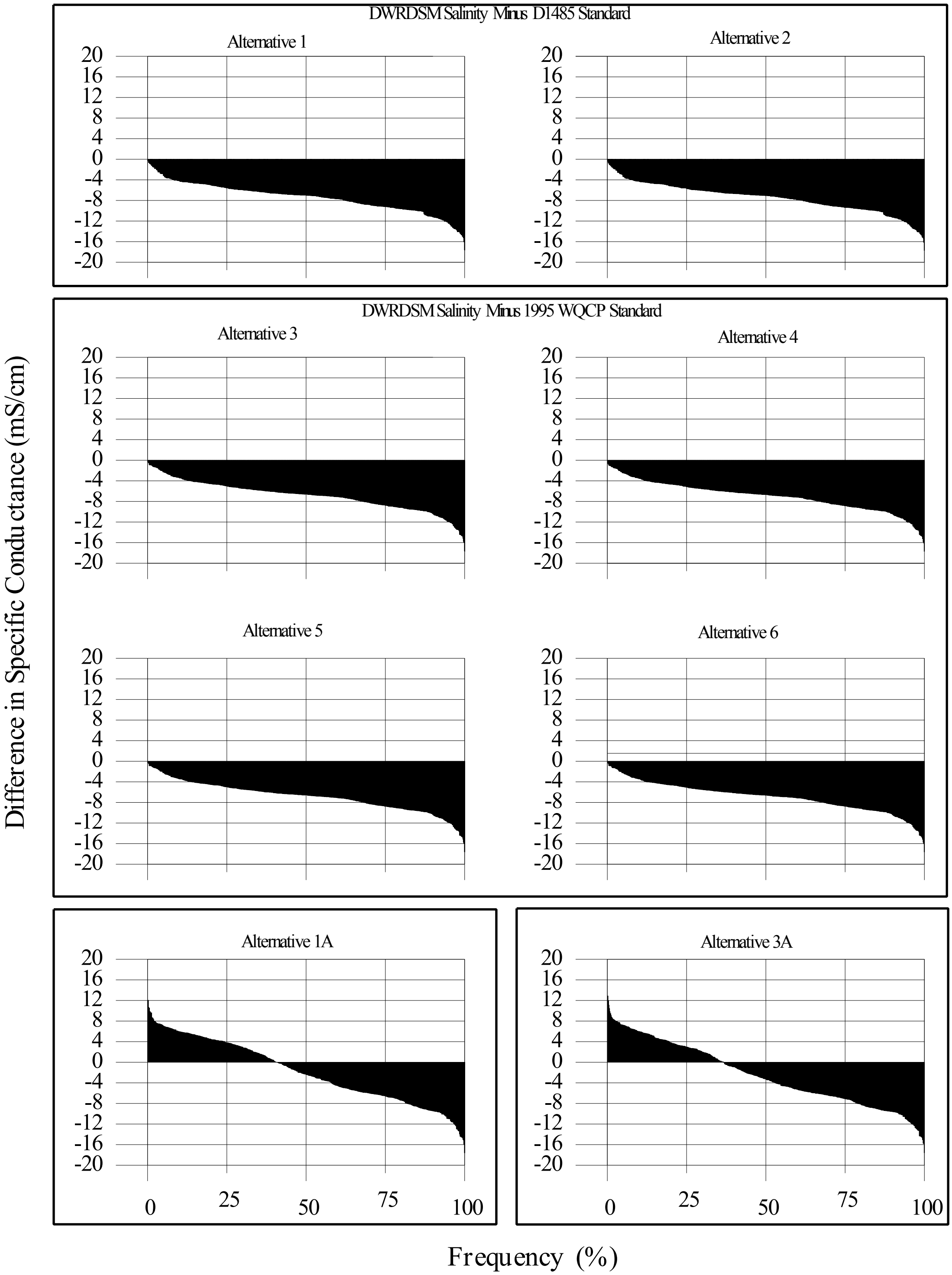


Figure VII-11

Salinity Area Frequency Analysis
Suisun Slough South of Volanti Slough (S-42)
October Through May of Water Years 1922-1994

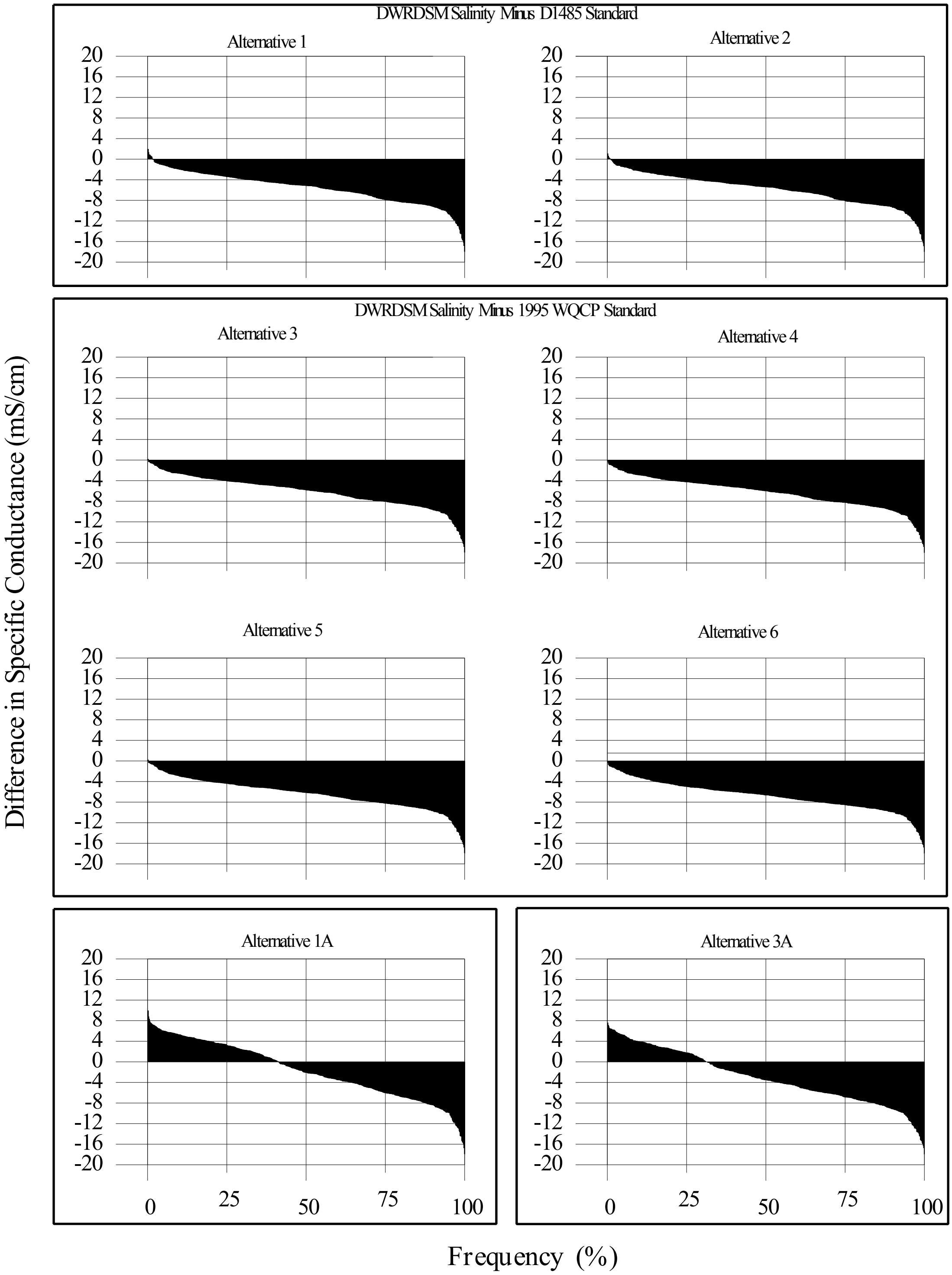


Figure VII-12

Salinity Area-Frequency Analysis
Chadbourne Slough at Chadbourne Road (S-21)
October Through May of Water Years 1922-1994

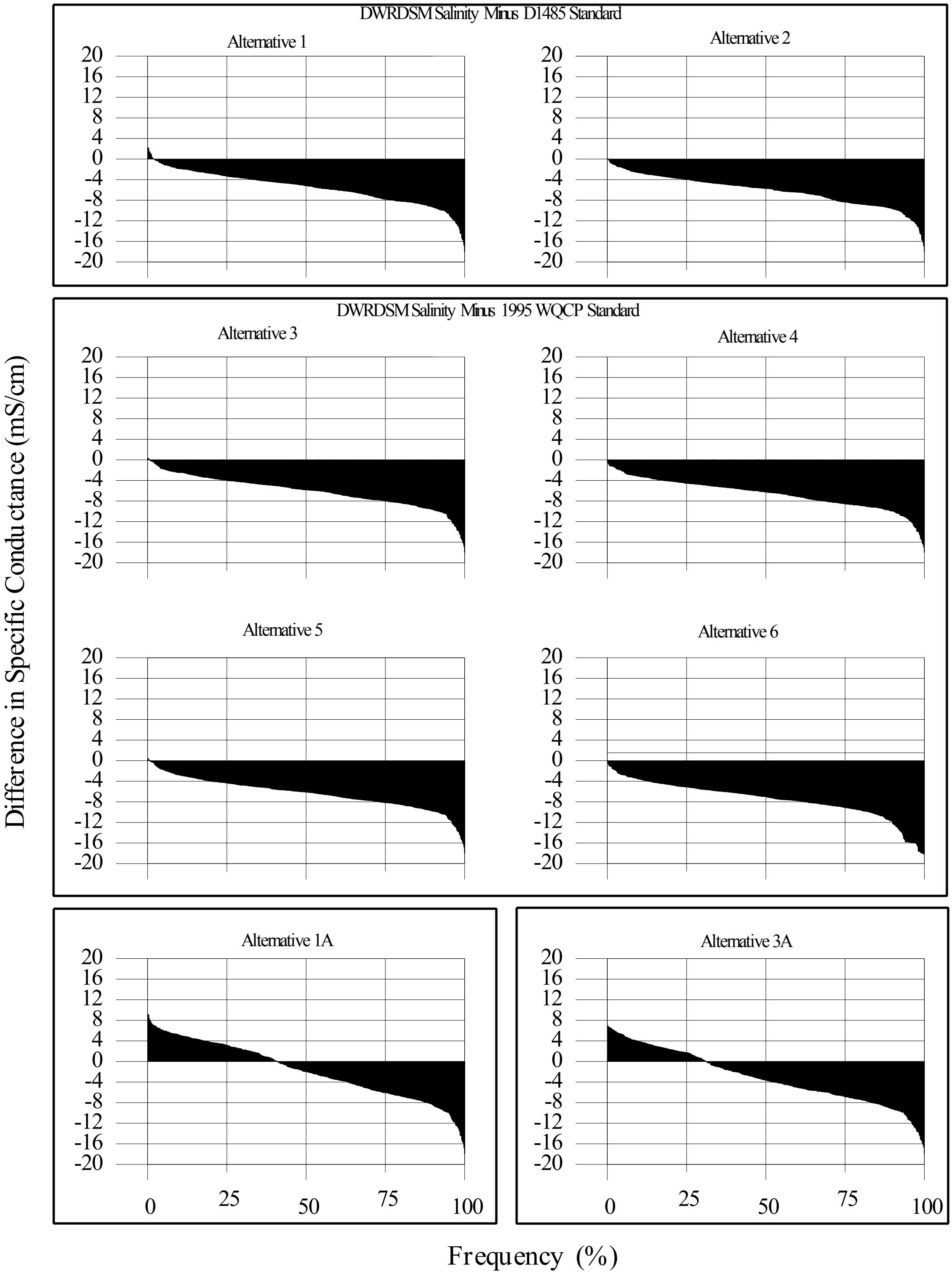


Figure VII-13

Salinity Area-Frequency Analysis
Goodyear Slough at Morrow Island Clubhouse (S-35)
October Through May of Water Years 1922 - 1994

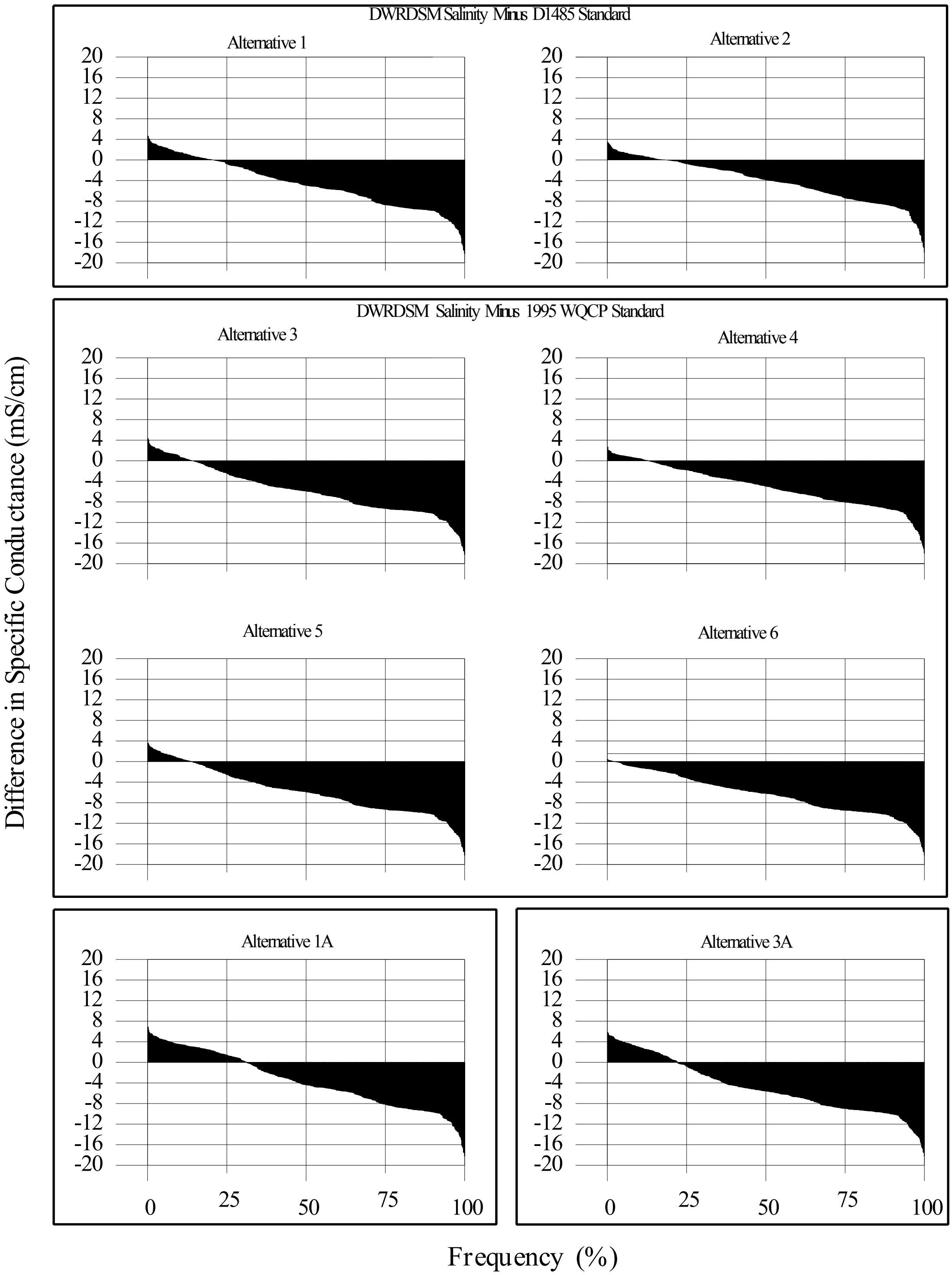


Figure VII-14
Salinity Area-Frequency Analysis
Cordelia Slough at Cordelia Goodyear Ditch (S-97)
October Through May of Water Years 1922-1994

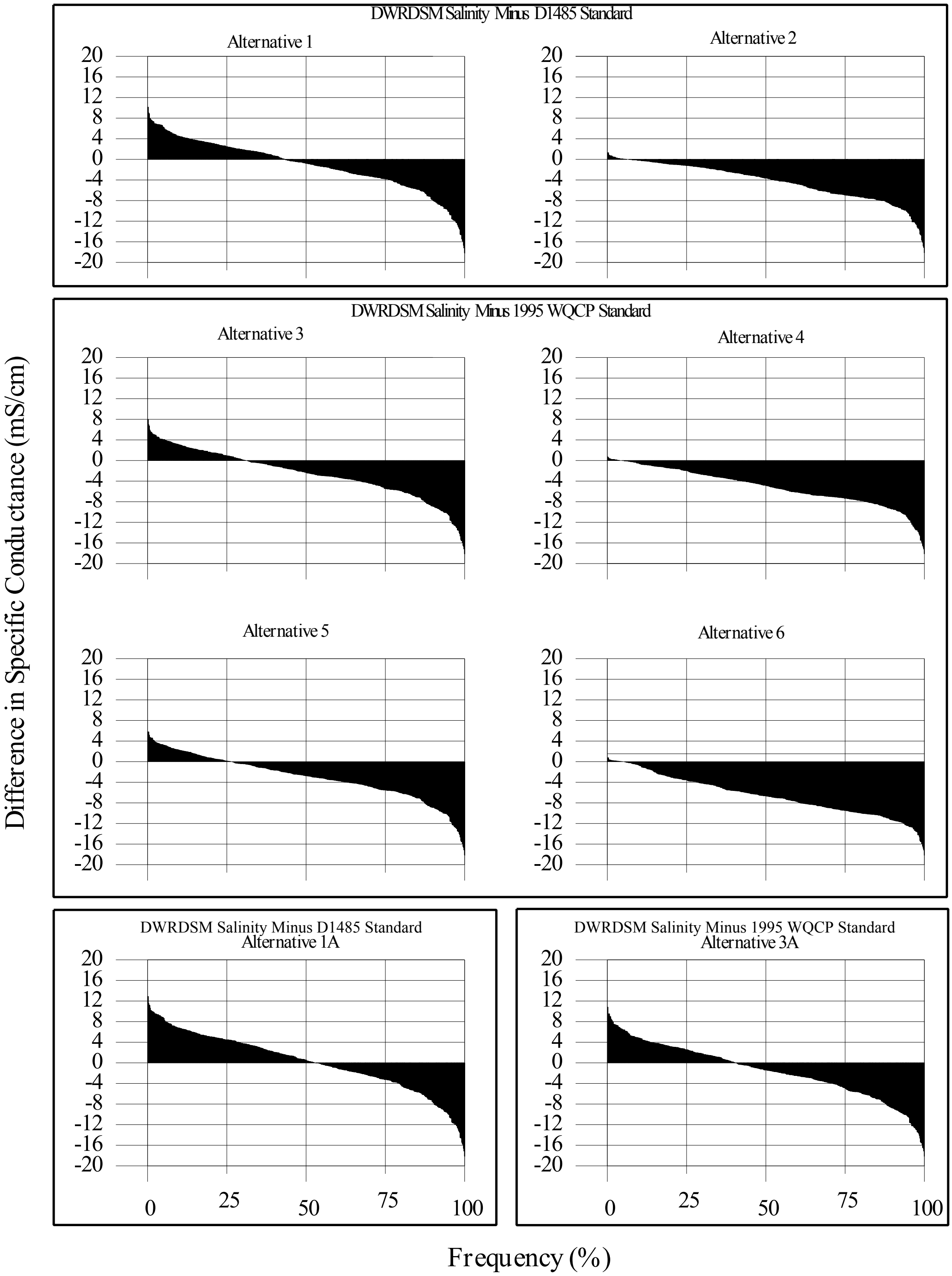


Figure VII-15

**Salinity Area-Frequency Analysis
Boynton Slough (S-40)**
October Through May of Water Years 1922 - 1994

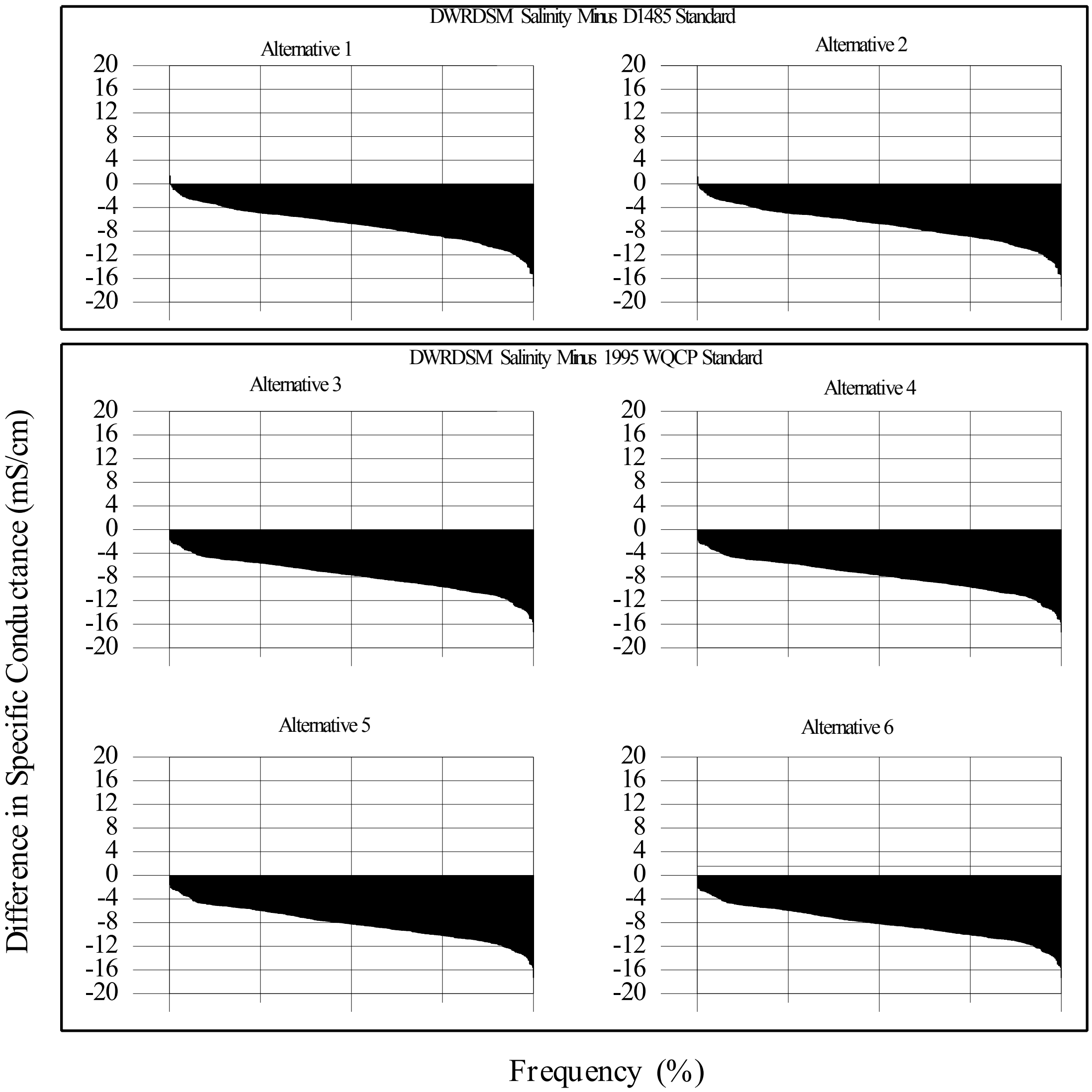


Table VII-7
Estimated Monthly Flow Augmentation
Required for Suisun Marsh Alternatives
Water Years 1922-1994 (TAF)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
Wet Years									
Alt 2	1.7	0.1	0	0	0	0	0	0	1.8
Alt 4	0.9	0	0	0	0	0	0	0	0.9
Alt 6	11.2	0.6	0	0	0.6	0.4	0	0	12.8
Above Normal Years									
Alt 2	2.2	0.5	0	0	0	0	0	0	2.7
Alt 4	0.8	0.2	0	0	0	0	0	0	1.0
Alt 6	7.1	1.3	0	0	0.3	0.2	0	0	8.8
Below Normal Years									
Alt 2	0.7	0.1	0	0	0.1	0	0	0	1.0
Alt 4	0.3	0.0	0	0	0.2	0	0	0	0.5
Alt 6	4.8	0.5	0	0.3	1.4	0.6	0	0	7.7
Dry Years									
Alt 2	1.4	0.5	0	0.1	1.1	0.1	0	0	3.2
Alt 4	1.4	0.4	0	0.0	0.6	0	0	0	2.5
Alt 6	13.4	2.7	0	0.7	2.8	1.1	0	0	20.7
Critically Dry Years									
Alt 2	3.6	1.4	0	0.7	2.9	0.9	0	0	9.5
Alt 4	2.9	0.9	0	0.1	0.5	0	0	0	4.4
Alt 6	27.9	5.7	0.1	1.2	1.4	0.6	0	0	37.0
73-Year Average									
Alt 2	1.8	0.5	0	0.1	0.7	0.2	0	0	3.4
Alt 4	1.2	0.3	0	0	0.3	0	0	0	1.8
Alt 6	12.8	2.0	0	0.4	1.3	0.6	0	0	17.2
1928-1934 Critical Period Average									
Alt 2	3.7	1.5	0	0.3	3.4	0.9	0	0	10.0
Alt 4	2.6	0.9	0	0	0.4	0	0	0	3.9
Alt 6	23.6	5.7	0	0.3	1.1	0.5	0	0	31.2
Absolute Maximum									
Alt 2	4.9	3.0	0	3.2	4.4	2.0	0	0	15.5
Alt 4	4.9	2.1	0	0.6	2.6	0.4	0	0	7.5
Alt 6	55.3	11.1	0.6	5.0	9.2	3.2	0	0	66.5

Table VII-8
Estimated Monthly Flow Augmentation
Required for Suisun Marsh Alternatives
Water Years 1922-1992 (cfs)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Wet Years								
Alt 2	27	2	0	0	0	0	0	0
Alt 4	14	1	0	0	0	0	0	0
Alt 6	181	11	0	0	10	6	0	0
Above Normal Years								
Alt 2	35	9	0	0	0	0	0	0
Alt 4	14	3	0	0	0	0	0	0
Alt 6	115	21	0	0	6	2	0	0
Below Normal Years								
Alt 2	12	2	0	0	2	0	0	0
Alt 4	5	0	0	0	3	0	0	0
Alt 6	78	9	0	5	25	10	0	0
Dry Years								
Alt 2	23	9	0	1	19	1	0	0
Alt 4	23	6	0	0	11	0	0	0
Alt 6	218	45	0	11	50	17	0	0
Critically Dry Years								
Alt 2	59	24	0	11	51	14	0	0
Alt 4	48	15	0	1	9	1	0	0
Alt 6	454	96	2	19	25	10	0	0
73-Year Average								
Alt 2	30	8	0	2	13	3	0	0
Alt 4	20	5	0	0	5	0	0	0
Alt 6	208	34	0	7	24	10	0	0
1928-1934 Critical Period Average								
Alt 2	61	26	0	5	61	15	0	0
Alt 4	42	15	0	0	8	0	0	0
Alt 6	385	95	0	5	19	9	0	0
Absolute Maximum								
Alt 2	80	50	0	52	79	33	0	0
Alt 4	80	35	0	10	47	7	0	0
Alt 6	899	187	10	81	160	52	0	0

by 2.2 percentage points for the same alternatives. The exceedence frequency for Alternative 5 is midway between Alternatives 3 and 4. Alternative 6 has the lowest exceedence frequency and the lowest exceedence index of the alternatives, but at a very high water cost. The modeling predicts that a peak October augmentation rate of 900 cfs would be needed to meet standards at S-35. The73-year average augmentation rate in October is 205 cfs. Data on augmentation water costs are presented in Tables VII-7 and VII-8. In general, the difference in water cost between Alternative 6 and Alternative 4, 15,200 AF on average, is the additional water required to meet objectives at S-35.

d. Salinity Impacts at Boynton Slough (S-40). Alternative 6 augments Green Valley Creek with effluent from the FSSD treatment plant and other sources. To the extent that this water comes from the treatment plant, there is a potential for impact to salinity in Boynton Slough. Though the maximum rate of FSSD augmentation is 20 cfs, the limited availability of wastewater, and the desirability of maintaining a net downstream flow of 3 cfs in Boynton Slough, results in augmentation rates which are frequently less than 10 cfs. The modeling showed that a slight increase in salinity would occur at the location under Alternative 6. The average exceedence of the objectives on an annual basis increased from no exceedence under Alternative 3 to 1.7 percentage exceedence. This is not considered a significant impact.

e. Suisun Marsh Salinity Control Gate Operation. The SMSCG is operated as needed under all alternatives to help meet salinity objectives. There are three different modes of operation: (1) operation using D-1485 hydrology (Alternatives 1 and 2); (2) operation using 1995 Bay/Delta Plan hydrology (Alternatives 3, 4, and 6); and (3) operation using 1995 Bay/Delta Plan hydrology plus September gate closure (Alternative 5). The frequency with which the SMSCG is operated in the DWRDSM model runs is presented in Table VII-9.

The SMSCG operates less frequently in all months of all water year classifications, especially in the February through May period, under 1995 Bay/Delta Plan hydrology. The western marsh stations S-35 and S-21 are most often responsible for triggering gate operations under both hydrologies. Allowance for SMSCG operation in September reduces the frequency of gate operation in October of Below Normal water years only, due to the fact that carryover of antecedent salinity is generally less than one month. The magnitude of exceedences are reduced with September gate operation. Stations meeting standards without September gate operation are marginally freshened.

2. Hydrology

This section describes changes in flows in natural and constructed channels and changes in reservoir levels as a result of implementing the different alternatives. A comparison of the hydrologic changes, from existing conditions to the various alternatives, is made for the following water bodies and facilities: (a) Green Valley Creek, (b) Lake Madigan and Lake Frey, (c) Sacramento River, (d) NBA, (e) FSSD, (f) Putah-South Canal, and (g) Lake Berryessa. A description of the physical facilities needed to implement the different alternatives precedes this discussion in section C.

Table VII-9
Suisun Marsh Salinity Control Gate Operation Frequency (%)

Alternatives 1 and 2 (without September operation)

Water Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Sept
C	85.7	85.7	85.7	85.7	85.7	85.7	85.7	92.9	0.0
D	71.4	85.7	85.7	78.6	92.9	92.9	64.3	64.3	0.0
BN	50.0	70.0	50.0	50.0	70.0	70.0	30.0	30.0	0.0
AN	54.5	81.8	72.7	63.6	54.5	54.5	27.3	27.3	0.0
W	68.0	68.0	36.0	21.0	28.0	10.0	16.0	16.0	0.0
Avg	68.5	78.1	63.0	56.2	61.6	65.8	42.5	43.8	0.0

Alternatives 3, 4 and 6 (without September operation)

Water Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Sept
C	83.3	91.7	83.3	91.7	91.7	75.0	16.7	50.0	0.0
D	56.3	75.0	68.8	62.5	75.0	56.3	0.0	6.3	0.0
BN	50.0	57.1	50.0	50.0	42.9	21.4	0.0	0.0	0.0
AN	45.5	45.5	27.3	9.1	0.0	0.0	0.0	0.0	0.0
W	47.6	52.4	9.5	9.5	4.8	0.0	0.0	0.0	0.0
Avg	56.2	64.4	45.2	42.5	41.1	28.8	2.7	9.6	0.0

Alternative 5 (with September operation)

Water Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Sept
C	83.3	91.7	83.3	91.7	91.7	75.0	16.7	50.0	100.0
D	56.3	75.0	68.8	62.5	75.0	56.3	0.0	6.3	100.0
BN	50.0	57.1	50.0	50.0	42.9	21.4	0.0	0.0	0.0
AN	45.5	45.5	27.3	9.1	0.0	0.0	0.0	0.0	0.0
W	47.6	52.4	9.5	9.5	4.8	0.0	0.0	0.0	0.0
Avg	53.4	64.4	45.2	42.5	41.1	28.8	2.7	9.6	38.4

Year Types are based on the Sacramento 40-30-30 Index, as defined in the 1995 Bay/Delta Plan

The modeling used to determine salinity impacts within the marsh also produced estimates of monthly flow augmentation required by various alternatives. Monthly estimates for different water year classifications are presented in Tables VII-8 and VII-9. The annual Green Valley Creek augmentation frequency is presented in Table VII-10.

a. Green Valley Creek. Flow augmentation in Green Valley Creek could be accomplished in four ways: (1) releasing water from the two City of Vallejo reservoirs in the upper watershed; (2) pumping tertiary-treated effluent from the FSSD treatment plant into lower Green Valley Creek; (3) transporting water from Barker Slough on the Sacramento River via the NBA; and (4) releasing Lake Berryessa water into Putah-South Canal then into lower Green Valley Creek.

The source and method of transportation of the water would dictate where it was released into Green Valley Creek and would influence the biota in the creek downstream of the release point. The release of water from the reservoirs would enhance the flows throughout the length of Green Valley Creek, whereas the flow augmentation with water from either the FSSD, the NBA, or Putah-South Canal would enhance the flows only in the lower portion of the creek. The effect on the marsh, downstream of Green Valley Creek, would be slightly different due to the differences in water quality from the different sources; however, the major influence on the marsh would be the amount of fresh water input rather than the source.

Table VII-10
Frequency of Green Valley Creek Flow Augmentation

Percentage of Months with Average Flow Greater than the Value (cfs)

Alternative	>0	>5	>15	>40	>75	>150
Alt 2	17.3	17.0	13.7	7.2	3.8	0.0
Alt 4	12.5	11.0	8.0	3.4	0.7	0.0
Alt 6	26.2	25.2	21.6	13.7	10.3	6.0

To conduct the modeling studies, the hydrology of Green Valley and Suisun creeks was synthesized from local rainfall data. The calculated flows were calibrated against available historic data for the creeks. Knowledge of creek base flow is needed in order to calculate the additional flow needed to meet objectives. The information suggests that Green Valley Creek experiences peak flows of about 200 cfs.

Alternatives 2, 4, and 6 require augmentation of Green Valley Creek flows (see Tables VII-8 and VII-9). The highest augmentation rates occur in October, followed by November, February and March. The modeling studies suggest that under Alternative 6, average monthly augmentations of greater than 150 cfs would be required 6 percent of the time, up to a maximum of 900 cfs. Maximum annual water cost of the alternative would be 66.5 TAF. Nearly full compliance with salinity standards at S-97 can be achieved with a maximum release into Green Valley Creek from the NBA of 80 cfs under Alternatives 2 and 4. The difference between the Alternative 6 and Alternative 4 augmentation rates represents the additional amount of freshwater inflow needed to meet objectives at S-35. The general effect of Alternative 6 in the vicinity of S-97 would be to produce salinities significantly lower than the historic condition. Green Valley Creek flow would not be augmented from June through September, nor during periods of high natural flow.

The resources potentially impacted by flow augmentation in Green Valley Creek are aquatic and terrestrial habitats discussed in sections 4 and 5 below. Unmanaged tidal wetlands downstream of Green Valley Creek might also be affected. The extent of the impact would be influenced by: (1) the source of water used for flow augmentation; (2) when it is released; and (3) where the flow is released into the creek.

b. Lake Madigan and Lake Frey. Lake Madigan, Lake Frey, and Lake Curry together constitute the City of Vallejo's Lakes Water System. Over time the system has evolved from the primary water source for the city to a source that provides less than 5 percent of the average City demand. As the city continues to grow, the Lakes System will supply even less. It is, however, the sole drinking water source for over 700 connections in unincorporated Solano County.

The production records for the Lakes Water System reveal that average annual raw water use during the 1977-1988 period was 358 AF and 1,757 AF for the Green Valley Creek reservoirs and Lake Curry, respectively (City of Vallejo 1989, 1994). The capacities of the reservoirs exceed the average annual use, as indicated in Table VII-3. Releases from Lake Curry flow into Suisun Creek and then Chadbourne Slough in the northwestern marsh, influencing salinity in the general vicinity of S-21. At present, no flow augmentation is proposed for Suisun Creek because the objectives are generally met at S-21. Therefore, Lake Curry will receive no further consideration.

Lake Madigan and Lake Frey have a combined capacity of 2,819 AF. If 700 AF were reserved for municipal use, and the reservoirs had no minimum pool, then a maximum of 2,119 AF of water might be available on an annual basis. In Alternative 6, the average annual augmentation quantity is 17.2 TAF. Hence, even under ideal circumstances, these lakes could supply no more than 8 percent of the average annual water requirement. If a bypass flow of 1 cfs from October through May was required pursuant to Fish and Game Code section 5937, about 480 AF per year would be needed, representing nearly 80 percent of the safe yield of the system. Such a bypass flow would clearly have a beneficial impact on riparian habitat in the upper Green Valley Creek watershed. By itself, it would have little impact on salinity at S-97, and none at S-35.

c. Sacramento River. Water is pumped from the Sacramento River at Barker Slough into the NBA to supplement flows in Green Valley Creek under Alternatives 2, 4 and 6. The DWR modeling assumes that the NBA has 80 cfs of available capacity. Thus, in any given month a maximum of 4.9 TAF could be pumped. This amount of water represents 0.6 percent of the average October flow at Freeport on the Sacramento River, an insignificant reduction in Sacramento River flow. Increased pumping could have a significant impact on aquatic resources in Barker Slough, particularly delta smelt. This issue is discussed further in section D.5 of this chapter.

d. North Bay Aqueduct. The NBA has a capacity of 174 cfs from Barker Slough pumping plant to Cordelia Forebay. The modeling assumes that there is 80 cfs of available capacity in the aqueduct during the October-May salinity control season. Under Alternatives 2 and 4, the full capacity would be utilized less than one percent of the time. However, about six percent and three percent of the time, respectively, additional pumping capacity would be needed to fill the pipeline. If the NBA were to be used to help augment Green Valley Creek flow under Alternative 6, there is sufficient capacity to meet the requirement in 90 percent of months. The maximum annual amount of water conveyed for augmentation purposes would be 22 TAF. The average annual amount would be 6 TAF.

Environmental impacts of increased NBA conveyance take place at the point of diversion and downstream of the point of discharge.

e. FSSD Wastewater Treatment Plant. Alternative 6 assumes that up to 20 cfs of treated wastewater from the FSSD could be available for dilution flow in Green Valley Creek during the December to March period and lesser amounts in other months. The modeling further assumes that a minimum discharge of three cfs would be maintained in Boynton Slough to prevent stagnation. The maximum annual amount of water transferred from the FSSD to Green Valley Creek is 4.3 TAF; the 73-year average amount is 1.2 TAF. A significant impact to the hydrology of Boynton Slough or Green Valley Creek is unlikely.

f. Putah-South Canal. The Putah-South Canal could be used in Alternative 6 to augment flow in Green Valley Creek. The canal is concrete lined and has a capacity of 116 cfs in the vicinity of Green Valley Creek. Water could be released through the Green Valley Wasteway, having at present a capacity of 14 cfs, or it could be released from the terminal reservoir through a new pipeline. Water diverted into the canal is derived mainly from release of water stored in Lake Berryessa.

Data supplied to the SWRCB by SCWA indicates that diversion into the Putah-South Canal in October averages about 210 cfs and that October agricultural demand is about 150 cfs, leaving about 50 cfs of available capacity in the terminal reach of the canal. If augmentation flows in Alternative 6 came from the Putah-South Canal alone, there would be sufficient capacity to meet the augmentation requirement in 88 percent of months. If augmentation flows in Alternative 6 came from both the NBA and the Putah-South Canal, there would be sufficient combined capacity to meet the augmentation requirement in 93 percent of months. The maximum annual water cost of using the Putah-South Canal alone to meet the Alternative 6 augmentation requirement would be 14.8 TAF. The average annual cost would be 4.4 TAF.

Environmental impacts of increased Putah-South Canal conveyance would occur mainly at the point of release into Green Valley Creek. Commitments to provide instream flow below Putah Creek diversion dam would remain unchanged.

g. <u>Lake Berryessa</u>. The water supply for Lake Berryessa is derived from the 568 square mile drainage basin above the dam. The elevation of the basin ranges from 182 feet at the dam to 4,772 feet at the upper end of Putah Creek, with most of the basin lying below 1,500 feet. There are four principal creeks that flow into Lake Berryessa: (1) Capell Creek; (2) Pope Creek; (3) Eticuera Creek; and (4) Putah Creek, the main drainage in the basin. Lake Berryessa has a storage capacity of 1.6 MAF at an elevation of 440 feet. The average annual inflow to the reservoir is 369 TAF; the annual firm yield is 201 TAF. A release of 22 TAF is required annually to meet prior downstream water rights along Putah Creek. An upstream reservation of 33 TAF was established by the SWRCB to provide water for future development of the area above Monticello Dam. The USBR has appropriated 7.5 TAF of the reservation to provide for future development around the lake. The reservoir water level may fluctuate from 455 feet to a minimum elevation of 253 feet. A water level of 309 feet is considered dead storage elevation. During the severe drought of 1977 the level was lowered to 388 feet (USBR 1992).

The average annual amount of water that might be required from Lake Berryessa would be 4.4 TAF, or 2.2 percent of the average project safe yield, if this were the sole source of augmentation flow. The maximum annual water cost would be 14.6 AF. Though the impact on water surface elevation might appear small when compared to the maximum reservoir capacity, it becomes potentially significant under dry conditions and could affect the yield of the Solano Project.

3. Landscape (Construction-Related) Impacts

Some of the alternatives for implementing the Suisun Marsh salinity objectives involve impacts due to construction. If an alternative is chosen that results in construction impacts, detailed site-specific environmental documentation will need to be completed by the agencies charged with carrying out the alternative. The following discussion is programmatic in nature. A detailed description of specific construction actions is contained in the DWR/USBR publication "Screening Alternative Actions and Describing Remaining Actions for the Proposed Western Suisun Marsh Salinity Control Project" (DWR 1993). The potential impacts to terrestrial resources (plants and animals) are described in section 4 below.

a. <u>Alternatives 1 and 3</u>. Alternatives 1 and 3 require no new facilities and therefore would not result in construction-related impacts. Any impacts to terrestrial resources would be a result of changes in channel water salinity that could affect the unmanaged tidal marshes. Any changes in terrestrial resources on the managed marshes would primarily be a result of water management practices on the private and state lands.

b. <u>Alternatives 2 and 4</u>. Alternatives 2 and 4 require identical facility modification and new construction. Green Valley Creek flow augmentation would require minor reconstruction of the NBA to accommodate sustained releases to the creek. The Cordelia-Goodyear Ditch and the Goodyear Slough Tide Gate would require major amounts of construction in the vicinity of S-35.

Therefore, implementing either of these alternatives would result in potentially significant construction-related impacts, depending on the projects ultimately approved.

North Bay Aqueduct. Water transported in the NBA could be released from the Cordelia Pumping Plant to an unlined ditch tributary to Green Valley Creek. The ditch is owned by the City of Fairfield and is not available on a long-term basis. A long-term solution would require minor modification of the emergency spillway at the Cordelia Forebay to accommodate sustained releases.

Cordelia-Goodyear Ditch. The approximately 6,300 foot-long ditch would be 100 feet wide and require excavation of 225,100 cubic yards of material. The sixteen foot wide levee roads on either side would require the placement of 61,800 cubic yards of fill. Construction would be required for access/haul roads, pile-supported bridges, the inlet and outlet tide gates, and placement of culverts. Construction related impacts would be significant. Operation and routine maintenance of this facility could result in continuing impacts to endangered species in the area. Detailed site investigations and further environmental documentation would have to be completed prior to construction.

Goodyear Slough Tide Gate. The Goodyear Slough Tide Gate would be similar in construction to the SMSCG, featuring two radial gates, a flashboard structure, and a boat lock. Modules would be constructed in a dry dock facility and floated to the site. On-site modifications include the construction of setback levees to accommodate the structure, channel dredging, access and haul roads, and a control building. Construction related impacts would be significant. Operation and routine maintenance of the tide gate could result in continuing impacts to endangered species. Detailed site investigations and further environmental documentation would have to be completed prior to construction.

c. Alternative 5. The actions in Alternative 5 are water management activities that would not result in construction related land disturbance. Environmental documentation for the SMPA Amendment III actions has been prepared jointly by the DWR, USBR, DFG, and the SRCD.

d. Alternative 6. Alternative 6, which emphasizes flow augmentation in Green Valley Creek, would require moderate construction to accommodate additional flow through existing waterways. If the NBA were used to convey the water, the construction impacts would be the same as described for Alternatives 2 and 4 above. If the Putah-South Canal were used to convey Lake Berryessa water into Green Valley Creek, then modification to the existing Green Valley Wasteway would be needed to transport the water on a long-term basis. Alternatively, a pipeline of about 0.3 mile in length could be constructed between the Putah-South Canal terminal reservoir and the creek. This work could be completed in about 15 working days and would have minor construction related impacts (DWR 1993). If Alternative 6 were chosen, detailed site investigations and further environmental documentation would have to be completed prior to construction.

This Alternative might also require modification of the FSSD facility to provide flow augmentation to Green Valley Creek. The FSSD could pump treated effluent, in reverse of the usual direction, through an existing 27-inch force main. This action would require a new pump, the replacement of an existing pump, 1,200 feet of new pipeline, and a concrete energy dissipater adjacent to Green Valley Creek. Construction impacts would occur mainly within the existing FSSD treatment plant boundary.

4. Potential Impacts to Terrestrial and Wetland Resources

The Suisun Marsh alternatives will result in channel water salinity slightly different from historic conditions. This may either indirectly affect terrestrial habitat or directly affect wetland habitat within the marsh. Some of the alternatives, if implemented, may significantly disturb limited areas of the marsh habitat. Others will cause minor disturbances to areas near the marsh. In this section, the general effects of changes in channel water salinity are discussed first, then the effects specific to an alternative are considered. The following discussion is programmatic with regard to construction related impacts; detailed site-specific environmental documentation will be developed by the agency responsible for the construction if an alternative is chosen that necessitates construction.

Hydrology is the most important factor for establishment and maintenance of specific types of wetland habitat. Hydrologic conditions affect many abiotic factors including, but not limited to, channel water salinity. These factors, in turn, determine the flora and fauna that develops in the wetlands. The three Suisun Marsh wetland types that may be influenced by salinity are: undiked tidal wetlands, diked seasonal wetlands, and diked permanent wetlands (DWR 1994d).

When Europeans first arrived, the Suisun region was an expanse of continuous tidal marsh. Diking of the historic marsh proceeded over time from the late 1870’s through the 1970’s, though by the 1930’s nearly 90 percent of the total area had been diked. Now, less than eight percent of the original area remains. Tidal brackish marsh occurs where salt water from San Francisco Bay is diluted by freshwater runoff from the interior rivers. A delicate and highly fluctuating interaction exists between saline and freshwater conditions on a diurnal, seasonal, and interannual cycle. These dynamic factors produce a mix of saline and freshwater species that varies locally due to soil salinity, moisture, organic content, inundation, evaporation, and plant competition. Biodiversity is high within the brackish marshes as a result of this convergence (SEW 1997). Many wetland experts believe that retaining, to the extent possible, the full range of hydrologic conditions is essential for long term maintenance of this diversity.

The primary wetland type in Suisun Marsh is diked seasonal wetland managed for wintering waterfowl habitat. Diked wetlands are areas of historic tidal marsh which have been isolated from tidal influence. Plant communities in the diked wetlands can vary widely from site to site. The diversity of species, and the overall quality of the habitat, is strongly influenced by land use and water management practices. Though the managed wetlands also support a wide variety of plants and animals, they usually have fewer native species than natural tidal plant communities, and often a larger component of exotic species.

A small percentage of the managed waterfowl habitat is permanently flooded; the amount of this habitat is limited due to mosquito abatement regulations. A number of special status animal and plant species occur in Suisun Marsh wetland habitats. A listing of the sensitive terrestrial species known from the area is included in Table VII-11. Of the species listed in the table, about fifty percent occur in habitat that may be influenced by changes in the channel water salinity resulting from implementation of the Suisun Marsh water quality objectives (DWR 1994d).

Under D-1485, the DWR and the USBR were responsible for meeting the salinity standards in the marsh. Compliance dates at various stations were met over time as the DWR and the USBR built facilities to achieve the standards. As part of the planning effort to determine how best to meet the salinity objectives in the western marsh, the two agencies proposed the Western Suisun Marsh Salinity Control Test (WSCT). The test provided for augmentation of Green Valley Creek with flow from the NBA and was to be conducted from September 1994 through May 1995.

The DWR, in compliance with the Endangered Species Act (ESA), requested informal consultation with, and approval from, the USFWS to conduct the WSCT. In October 1994, the USFWS approved the September 1 to November 14 portion of the test; however, they expressed a concern that continuation of the test for the remainder of the year would have an adverse affect on listed endangered species. The USFWS was also concerned that achieving the western marsh objectives through flow augmentation might have a long-term negative impact on fish and wildlife habitat (USFWS 1994).

The salinity objectives in D-1485 were designed to satisfy the water quality requirements of waterfowl food plant species. Alkali bulrush, fathen, and brass buttons were thought, when the D-1485 objectives were established, to be the preferred food for migratory waterfowl using the marsh. The salinity objectives did not attempt to enhance the physical environment for pickleweed and other more salt tolerant plant species used by the endangered California clapper rail, the salt marsh harvest mouse, and other species as refuge and nesting habitat. The objectives failed to provide a salinity gradient from the eastern marsh to the western marsh reflective of the natural gradient that would exist under natural conditions. The USFWS concluded that as the D-1485 objectives sought to maintain an artificial regime, they do not enhance habitat appropriate for fish and wildlife species currently residing in the area. Furthermore, the objectives may cause conditions that decrease or eliminate suitable tidal marsh habitat used by federally listed terrestrial species, thus perpetuating their decline.

a. <u>Alternatives 1 and 3</u>. The modeling of Alternative 1 assumes that the salinity objectives at all stations would be complied with, to the extent possible, with SMSCG operation and Delta outflow. There would be slight changes from historical salinity conditions, and the western marsh stations would be made as fresh as possible, given existing facilities.

Table VII-11
Special Status and Sensitive Plant and Wildlife Species Known from the Suisun Marsh Area

Species Which May Be Influenced by Changes in Salinity Gradients

Common Name	Scientific name	Federal Status	California Status	Occur in Freshwater Marshes	Occur in Brackish Marshes	Occur in Salt Marshes	Not Present in Affected Habitats
Birds							
California black rail	*Laterallus jamaicensis coturniculus*	SC	T	X	X	X	
California clapper rail	*Rallus longirostrus obsoletus*	E	E		X	X	
Suisun song sparrow	*Melospiza melodia maxillaris*	SC	SC		X		
Mammals							
Salt marsh harvest mouse	*Reithrodontomys raviventris*	E	E		X	X	
Suisun ornate shrew	*Sorex ornatus sinuosus*	SC	SC		X	X	
Plants							
Mason's lilaeopsis	*Lilaeopsis masonii*	SC	R	X	X		
Soft-haired bird's beak	*Cordylanthus mollis spp. mollis*	E	R		X	X	
Suisun Slough thistle	*Cirsium hydrophilum spp. hydrophilum*	E	-		X		
Delta tule pea	*Lathyrus jepsonii jepsonii*	SC	-	X	X		
Suisun aster	*Aster lentus*	SC	-	X	X		

Species Which Are Not Likely to be Influenced by Changes in Salinity Gradients

Common Name	Scientific name	Federal Status	California Status	Occur in Freshwater Marshes	Occur in Brackish Marshes	Occur in Salt Marshes	Not Present in Affected Habitats
Birds							
American peregrine falcon	*Falco peregrinus anatum*	E	-	X	X	X	
Bald eagle	*Haliaeetus leucocephalus*	T	E				X
Saltmarsh common	*Geothylpis trichos sinuosa*	SC	SC	X	X	X	
Reptiles and Mammals							
Northwestern pond turtle	*Clemmys marmorata marmorata*	SC	SC	X	X	X	
California tiger salamander	*Ambystoma californiense*	C	SC				X
Western spadefoot toad	*Scaphiopus hammondi*	SC	SC				X
Plants							
Antioch dunes evening primrose	*Oenothera deltoides ssp. howellii*	E	E				X
Contra Costa wallflower	*Erysimum capitatum ssp. angustatum*	E	E				X
Tiburon indian paintbrush	*Castilleja affinis ssp. neglecta*	E	T				X
Colusa grass	*Neostapfia colusana*	PT	E				X
Contra Costa goldfields	*Lasthenia conjugens*	PE	-				X
Hispid bird's beak	*Cordylanthus mollis spp. hispidis*	SC	-				X
Heartscale	*Atriplex cordulata*	SC	-				X
Legenere	*Legenere limosa*	SC	-				X

(DWR 1994d)

E = Federal or State Endangered; PE= Proposed Endangered; R = California Rare Plant Species; C =Federal Candidate Species
SC= Federal or State Species of Concern; PT= Proposed Threatened; T = Federal or State Threatened Species; - = No Status

As stated above, the USFWS has concerns that meeting the D-1485 salinity standards would result in too much freshwater in the northwestern marsh and therefore reduce brackish and salt-water habitat. Because implementation of this alternative would be achieved only with outflow and operation of the SMSCG, standards are not met in all years. No construction would be required to meet the objectives in Alternative 1.

Alternative 3 assumes 1995 Bay/Delta Plan hydrology and is otherwise identical to Alternative 1. The differences between D-1485 and the 1995 Bay/Delta Plan objectives in the western marsh are presented in Table VII-4. Salinity throughout the marsh is lower under Alternative 3. The DWR has prepared a report on Sensitive Plant and Wildlife Resources in Suisun Marsh (DWR 1994d). The report states that there are several species of birds, mammals and plants that could be influenced by changes in estuarine salinity gradients resulting from the Suisun Marsh salinity objectives or higher outflows under the 1995 Bay/Delta Plan. The degree to which the objectives would influence terrestrial resources has not been determined with certainty. It is important to note, however, that salinity is only one factor influencing brackish marsh vegetation patterns. Other factors, such as depth and duration of flooding and plant competition, may be of equal or greater importance. The SEW is addressing this and related issues at the present time, and will submit a report to the SWRCB prior to triennial review (SEW 1997).

b. Alternatives 2 and 4. Implementation of Alternative 2 could have a number of different significant impacts to terrestrial and wetland habitats within the marsh. The alternative includes flow augmentation in Green Valley Creek plus construction of the Goodyear-Cordelia Ditch and the Goodyear Slough Tide Gate to meet the D-1485 salinity objectives.

Water for augmentation of Green Valley Creek would come from the NBA. Modification of the Cordelia Forebay spillway would be needed for long-term implementation. The impact of this action to terrestrial resources would be minor and transitory. Flow augmentation would introduce substantial quantities of low salinity water to northwestern marsh. The impact to species requiring brackish or salt marsh habitat is potentially significant.

Construction of the Goodyear-Cordelia Ditch and the Goodyear Slough Tide Gate would result in a significant disturbance of marsh habitat. The ditch and its associated inlet/outlet tide gates would require construction on both private and state lands. The ditch inlet would be located on Cordelia Slough at the Tule Belle Duck Club and run south through the DFG West Family Property. A 40-acre pond on the south side of Pierce Lane would be connected to the system to increase the holding capacity of the ditch. There would be another ditch crossing private land from the pond to the outlet tide gates. Several years ago, the DFG trapped salt marsh harvest mice in the proposed site. At the point where the ditch would enter Cordelia Slough on the Tule Belle lands, there is habitat suitable for sensitive plant species, such as the Delta tule pea and Suisun aster. There is also a possibility that soft haired bird's beak (*Cordylanthus mollis* ssp. *mollis*) may be present in the area as well (Brenda Grewell, DWR, pers. comm. 12/96). Prior to construction of these facilities, it would be necessary to survey the affected habitats for plants and animals of concern, and to complete a site-specific CEQA document.

c. Alternative 5. Alternative 5 includes local water management actions on managed wetlands in the marsh. The water management actions are designed to use available channel water more effectively, while maintaining soil salinity within limits acceptable for production of waterfowl food plants. Under this alternative, the 1995 Bay/Delta Plan the numeric salinity objectives at S-35 and

S-97 need not be met. The DWR and the USBR may demonstrate that equivalent or better protection will be provided by actions in lieu of the numeric objectives.

The implementation of Alternative 5 will most likely improve the quality of the managed wetland habitat. The DFG recognizes that the lack of active water management by many landowners in the marsh has resulted in the degradation of managed wetland habitat. The parties negotiating SMPA Amendment III have endorsed the concept of a water manager to oversee individual property owner water management plans and to insure consistent and efficient water management practices critical for the long term maintenance of seasonally flooded wetland. Data generated from eight years of monitoring in the seasonal wetlands of Suisun Marsh indicate that current waterfowl habitat management objectives can be achieved with the implementation of the SMPA Amendment III actions (DWR 1997b). The DWR, USBR, DFG, and the SRCD are preparing the needed environmental documentation.

Channel water salinity conditions under this alternative will fluctuate more widely than Alternatives 2 and 4 and be nearly indistinguishable from Alternative 3. Species and habitats adapted to brackish or variable salinity conditions will benefit accordingly.

d. **Alternative 6**. In Alternative 6, multiple parties may be responsible for full implementation of the Suisun Marsh objectives using flow augmentation in Green Valley Creek. In this alternative, alterations to the NBA and the Putah-South Canal at the point of discharge into Green Valley Creek would be required.

If flow augmentation were derived, at least in part, by releases from the upstream reservoirs, riparian habitat along Green Valley Creek stream corridor could benefit. The largest quantity of augmentation flow is needed in October and November. A large pulse of water, followed by no additional release from the upstream reservoirs would be of less value to Green Valley Creek riparian habitat than a smaller release made over a longer period of time. A small continuous release, however, would have only a slight freshening effect at S-97, and no effect at S-35.

If FSSD effluent is used for flow augmentation, additional habitat surveys and environmental documentation will need to be prepared.

5. Aquatic Resources

The Suisun Marsh alternatives result in slightly different channel water salinities which may directly affect aquatic habitat in the marsh and possibly the distribution and abundance of resident and migratory aquatic species. The alternatives that involve construction would physically disrupt areas of aquatic habitat. Other potential sources of impact to aquatic resources include: (1) the importation of water from the Sacramento River to Green Valley Creek through the NBA; (2) the use of Lake Berryessa water and effluent from the FSSD; and (3) the operation of the SMSCG for salinity control. The following discussion is divided into three sections: (a) status and trends of aquatic resources in Suisun Marsh; (b) effects of SMSCG operation; (c) affects of Green Valley Creek flow augmentation; and (d) effects of the alternatives.

a. Status and Trends of Aquatic Resources in Suisun Marsh. Long term aquatic sampling programs have been conducted in the marsh since the late 1970's. Short term sampling programs to evaluate the effect of SMSCG operation on aquatic resources have either been completed, or are currently underway. The following section describes the sampling that occurs in the marsh and the trends in abundance and distribution of the various aquatic species.

Since 1979, the DWR has contracted with the University of California at Davis to monitor fish populations in Suisun Marsh. The study is designed to track trends in diversity, abundance and habitat requirements of marsh fishes before and after installation of the SMSCG. Monthly samples are taken year-round with an otter trawl. The study has 21 stations throughout Suisun Marsh, including two in Montezuma Slough (Matern 1995). Six of the stations are east of Cutoff Slough. Moyle et al (1986) analyzed data from 1979 to 1983 and concluded that declines in fish abundance and species diversity were related to temporary perturbations. The structure of the fish assemblage was considered fairly consistent. The decline in abundance was attributed to higher than average outflows and weak year classes of striped bass, splittail, threespine stickleback, tule perch, prickly sculpin, yellowfin goby, Sacramento sucker, and common carp (DWR 1995a).

An analysis from 1979 to January 1992 reached conclusions different from Moyle's five-year study (Meng et al 1993). With data from a 14-year period, Meng concluded that the declines in abundance and species diversity are long-term rather than temporary conditions. The declines were correlated with decreases in outflow and increases in salinity, with the exception of 1986, when downward trends in abundance and species diversity were attributed to high outflows.

The report states that since 1986, the decline in abundance has steadily continued. The abundance of native fish (prickly sculpin, Sacramento splittail, Sacramento sucker, three-spine stickleback, tule perch) was consistently lower than the abundance of introduced species (shimofuri goby, common carp, striped bass, and yellowfin goby) over the 14-year period in the marsh. Abundance indices for seasonal species (delta smelt, longfin smelt, staghorn sculpin, starry flounder, and threadfin shad) fluctuated from 3 to 21 from 1979 to 1985, but remained at or below 4 from 1985 to 1992. Fish abundance, number of species, and the seasonal species index were negatively correlated with salinity. Fish abundance, number of species, introduced species, and native species were positively correlated with Delta outflow, and outflow was negatively correlated with years.

The Meng report also states that the distribution of fish within the marsh has changed over time. In the 1986 study, introduced species were found throughout the marsh but were captured most often in the larger sloughs. In the 1993 analysis, introduced species had become less abundant in the larger sloughs and more abundant in the dead-end sloughs. As in the 1986 study, native species were still found more often in dead-end sloughs, but over time, they were less abundant in those sloughs (DWR 1995a).

The summary of sampling from January 1992 through December 1993 is reported by Matern et al (1994). The abundance of few species increased in response to the wet 1993 water year, but overall, long-term declines in fish abundance were observed between 1983 and 1993. The trend in species in Suisun Marsh continued toward a less diverse assemblage of fish dominated by introduced species. A summary of the U.C. Davis fish sampling follows:

- Total catch of delta smelt has declined since 1983. Of the 443 delta smelt captured since 1979, only 20 have been captured since 1983.

- Total catches of longfin smelt have declined since the late 1980's. An increase in total catch in 1990 consisted of high number of longfin smelt fry. Low numbers of adults and fry were captured in subsequent years, and therefore, the prolific spawn in 1990 did not alter the overall decline.

- Young-of-year striped bass was the most abundant species caught in all years except 1988, 1990 and 1993. Overall, the catch of young-of-year striped bass declined since the early 1980's. Catches of adult striped bass have declined and fluctuated at low levels since 1981. Otter trawling is not an efficient way to catch adult striped bass because the adults can avoid the net, consequently these catch results may not be a good indication of the population abundance in Suisun Marsh.

- Catches of adult and young splittail have declined since 1980. High numbers of young-of-year were caught between 1980 and 1982 and in 1986; young-of-year catches dropped off until 1991, when there was a slight increase in abundance. The catch reached an all time low in 1993.

- Catches of yellowfin gobies have had two major peaks since 1980. The first peak of an average of 6 fish/trawl was in 1984. After 1984, catch levels fluctuated from 1 to 4 fish/trawl. The average catch per trawl of yellowfin gobies reached its highest ever in 1993 with a peak of 16 fish per trawl.

- The population of shimofuri goby peaked in 1989 with 1,348 captured. In 1993, only 118 were captured. Sampling in the spring of 1994 revealed high numbers of juvenile gobies which may result in another increase in the population.

- Prickly sculpin populations respond strongly to changes in Delta outflow. High outflow years produced peak numbers of 1,137, 362 and 242 in 1983, 1986 and 1993, respectively. From 1980 to 1983, catch levels were at their highest. The lowest catch was in 1990 and rose slightly from 1991 to 1993, however, overall, the population has declined since 1983.

- Tule perch is usually one of the most abundant fish in Suisun Marsh. It is considered a year-round resident of the marsh. Tule perch are captured most often in smaller sloughs, possibly a result of the higher otter trawl efficiency in small sloughs. Tule perch abundance peaked between 1980 and 1982 and again in 1987 and 1988. Since 1988, the catches have been below the 1983 levels. Total catch for 1993 was the lowest on record.

- Introduced species have moved from large sloughs to dead-end sloughs, mixing with the native species. Fish assemblages in the Sacramento-San Joaquin Estuary are shifting from an assemblage dominated by striped bass and native fishes to one dominated by exotic species. These changes are likely tied to overall decreases in Delta outflow, increases in salinity and introductions of exotic species (Meng et al 1993 in DWR 1995a).

The DFG conducts *Neomysis mercedis* and zooplankton field sampling twice a month from April through October. Due to naturally low winter abundance of *N. mercedis*, sampling is normally not done from November to March. Phytoplankton are the base of the aquatic food web in Suisun Marsh. *Neomysis* feed on phytoplankton and are, in turn, an important dietary component for many marsh fishes. Phytoplankton respond quickly to major alterations in their environment, and alterations in phytoplankton abundance can affect the *Neomysis* population and consequently many fish species. (Field studies indicate *Neomysis* abundance decreases in salinity above 7.2 parts per thousand (ppt) and are least abundant when salinity exceeds 18 ppt.) Data from March 1974 to November 1993 indicate *Neomysis* abundance and phytoplankton production, as measured by chlorophyll a, are usually higher in Suisun Slough than in western Montezuma Slough. No phytoplankton bloom occurred in Montezuma Slough in 1992, a critical water year, which is consistent with the lack of a phytoplankton bloom recorded during the 1977 drought. By reducing marsh salinity during periods of low Delta outflow, operation of the salinity control gates could help create more favorable conditions for *Neomysis*. Operation of the control gates produces a saltwater/freshwater interface in the marsh, a preferred *Neomysis* habitat, probably similar to the entrapment zone in the larger channels and bays of the estuary (DWR 1995a).

The DFG striped bass egg and larval survey provides an abundance index of developing striped bass every fourth day through the spawning season. In years prior to 1991, the survey was initiated early enough to collect eggs and larvae from early spawning. Spawning is triggered by water temperatures, so survey dates varied from year to year within the months of April, May, June and July. The striped bass egg and larval survey was conducted in Montezuma Slough from 1984 to 1988 and then resumed in 1993. The Montezuma Slough index comprises a small proportion of the total 6-14 mm larval abundance estimated by the survey. However, any area suitable for rearing larval striped bass is important to the Estuary's low population. A 1987 DFG study concluded that the SMSCG would have a minimal effect on striped bass eggs and 3-6 mm larvae (Raquel 1988).

The DFG striped bass tow-net survey results are used to produce an abundance index of the year-class strength for striped bass when their average size is 38.1 mm. When the striped bass are this size, the sampling gear is most efficient. Due to variations in environmental conditions, survey dates vary from year to year within the months of June, July and August. Spring and summer conditions affect spawning time and larval growth and therefore the time when the young become vulnerable to the sampling gear. In 1993, three stations in Montezuma Slough downstream of the control structure were sampled during three surveys. Increased abundance during this wet year seems to indicate that Montezuma Slough remains a relatively small but important habitat for juvenile striped bass. It is difficult to determine whether changes in abundance are caused by the installation and operation of the SMSCG (DWR 1995a).

b. Effects of Suisun Marsh Salinity Control Gate Operation. The use of the SMSCG changes the net direction of flow in Montezuma Slough and could cause outmigrating juvenile chinook salmon to use the slough more than normal as a migratory route. This change in migratory route could delay their migration and cause an increase in losses due to predation. In low outflow years, the net flow of water between Montezuma Slough and the Suisun Bay area tends to be from west to east within the slough, from Grizzly Bay towards Collinsville. However, operation of the SMSCG in drier years changes the net circulation pattern, and flow moves from east to west, as in wet years.

In 1987 and 1992, the USFWS sampled in Montezuma Slough to estimate the use of the slough by outmigrating salmon, and losses of salmon as a result of predation upstream and downstream of the salinity control gates. The trawling surveys were conducted in April and May. Concurrent sampling in Montezuma Slough and Chipps Island in 1987 and 1992 showed that a small, yet equal percentage of the outmigrant salmon leaving the western Delta were diverted into Montezuma Slough both with (1992) and without (1987) the salinity control structure in place. In both years, between 0 and 2.72 percent of the fish leaving the western Delta passed through Montezuma Slough. These fish could have lower survival, since their migration would be delayed or the distance to the ocean increased. However, operation of the control structure did not change the percentage of fish diverted into Montezuma Slough during those critically dry water years (DWR 1995a). Little information is available on how conditions in the Suisun Bay area and the marsh may specifically affect winter-run salmon. The extent to which Montezuma Slough is used as a migration route as opposed to Suisun Bay, is unknown. There is no reason to assume that the use of Montezuma Slough by the winter-run salmon would be different from the other outmigrating races.

Since April 1987, the DFG has conducted sampling to determine the presence of predators near the salinity control gates. There is concern that the structure will increase the predation rate for migrating juvenile fishes such as Chinook salmon, striped bass and American shad. From 1987 to 1992, adult fish were collected at about two-week intervals during May and June. Stomach contents of potential predators (striped bass and Sacramento squawfish) were examined for remains of salmon, striped bass and other prey. Three sites were sampled, one upstream and one downstream of the SMSCG and another reference station (added in 1993) two miles upstream of the salinity control gates.

Before initial operation of the gates in October 1988, the primary prey species in stomach samples were threespine stickleback, shimofuri goby, and sculpins. Gobies, bigscale logperch, and striped bass were also found. With the structure in place, threespine stickleback was the primary fish species consumed by squawfish and striped bass from 1988-1990. In 1991, shimofuri goby was the primary prey species consumed by Sacramento squawfish. There was some evidence of predation on juvenile salmon in 1987, 1991, and 1992 but only one or two salmon were found each year. No salmon were found in 1993. No striped bass prey were found in 1990-1993. Predation on American shad was evident in 1989, 1990 and 1992, but not in 1988, 1991 or 1993.

During the U.S. Army Corps of Engineers (USCOE) permitting process, concerns were raised about the potential effect of the control structure on adult salmon migration. To determine impacts on migrating adult Chinook salmon, a sonic tracking study was conducted in the fall of 1993 and 1994. Fall-run adult salmon were captured, tagged and monitored during three SMSCG operational phases:

- While the gates were open and the flashboards were not in place;
- While the gates were open and the flashboards were in place; and
- While the gates were operating.

The preliminary results in 1993 indicated that salmon passage times were significantly increased when the flashboards were in place, regardless of control gate status. The study also indicated that 85 percent of the fall-run chinook migrated through the gates on a flood or high tide. When the gates are operating, there is only a 20-minute period at the beginning of the flood tide when the gates are open and salmon can migrate upstream. However, fish did migrate through the gates on low tide when the gates were operating (DWR 1995a).

Preliminary results from the study suggested that placement of the flashboards and operation of the salinity control structure delayed and prolonged the upstream migration of fall-run salmon. The study was repeated in 1994 and no significant differences were found in passage times. When data for the two years were combined, the overall trends of decreasing passage numbers and increasing passage time with installation of the flashboards were consistent between years. Results from these studies suggest that the SMSCG has the potential to delay the upstream migration of adult salmon. The biological significance of this delay, however, is uncertain and is the subject of ongoing study (DWR 1997d).

All studies except the DFG predation sampling and the water quality profiling continued in 1994 (DWR 1995a). The predation sampling was discontinued because of the remote possibility of finding salmon in the stomachs of predators and the difficulty in determining when the increase in striped bass numbers in Montezuma Slough was significantly different from other areas in the marsh, or the Delta. The 1994 USFWS delta smelt biological opinion requires development of a predation rate on delta smelt at the salinity control structure. Difficulties encountered in detecting predation on salmon will likely be repeated when trying to assess effects on delta smelt.

c. **Effects of Green Valley Creek Flow Augmentation**. The DWR and USBR, in an effort to implement the D-1485 salinity objectives in the western marsh conducted the WSCT (see section 4). The WSCT proposal was to augment flow in Green Valley Creek up to 50 cfs between September 1, 1995 and May 31, 1995. This water would be diverted from Barker Slough via the NBA in the fall and spring, and from Lake Berryessa via Putah-South Canal between November 15 and the first week in March.

When the DWR proposed the WSCT in 1994, the USFWS expressed concerns about the adverse effects on fish during the November 15 through May 30, 1994 portion of the test. They also were concerned about the long-term effect that Green Valley Creek flow augmentation would have on marsh habitat. They felt that implementation of the standards may lead to attraction flows and diversions in environmentally sensitive areas, thus perpetuating the decline of federally-listed aquatic species. The USFWS stated that an analysis should be done to develop new quantifiable standards that provide suitable habitat and appropriate flows to protect and sustain viable populations of federally listed species (USFWS 1994).

The USFWS was concerned that the delta smelt may be attracted by fresh water flow into Green Valley Creek seeking potential spawning habitat. Spawning in the creek may lead to spawning failure and increased entrainment of the young from diversions along Cordelia Slough. This effect could take place regardless of the source of the augmenting flow.

The USFWS was also concerned that the augmentation flow coming from the NBA might entrain delta smelt at the NBA Barker Slough intake. Delta smelt adults migrate upstream from Suisun Bay and spawn in Barker Slough on the Sacramento from February through May. Larval delta smelt have been sampled in Barker Slough from early March to early June. Entrainment of larval delta smelt at the Barker slough intake in 1993 and 1994 was estimated by DWR to be 8,289 and 22,489, respectively. The effectiveness of the screened intake at Barker Slough for juvenile and adult delta smelt is not known.

The USFWS concluded that diversion of water from Barker Sough for flow augmentation in Green Valley Creek might decrease water available for transport and habitat maintenance flows in the Sacramento River. These flows move delta smelt larvae and juveniles to suitable rearing habitat in Suisun Bay and maintain that habitat downstream of the "zone of influence" of the State and federal pumping plants. Any diversion that removes water from the Sacramento River drainage has an incremental effect in these flows (USFWS 1994).

The NMFS also commented on the WSCT, focusing their attention on the January through May period (NMFS 1994). The NMFS concluded that the 1994 proposal would provide only minimal attracting flows to upstream migrating adult winter-run chinook salmon. However, they were concerned that using Sacramento River water to augment flows on a long-term basis, particularly during critically dry years, could adversely impact upstream reservoir cold water storage and the ability to control upper Sacramento River water temperatures for winter-run chinook salmon spawning and egg incubation. Modeling studies for critical water year 1990 indicate up to 80 cfs of additional flow would be required in Green Valley Creek from January through May to effectively lower channel water salinity. Larger diversions and discharges of Sacramento River water in future years will increase the risk of attracting winter-run chinook adults into the western Marsh.

The NMFS also had concerns regarding the appropriateness of the D-1485 objectives. They suggested it would be prudent to evaluate the recent actions pertaining to the proposed 1995 Bay/Delta Plan and review management practices/objectives within Suisun Marsh prior to implementing long-term actions that may adversely affect listed species such as the winter-run chinook salmon.

As part of the WSCT, fishery monitoring was conducted. Following release of NBA water into Green Valley Creek, on November 14, 1994, DFG and DWR biologists conservatively estimated that 80 adult fall-run chinook salmon migrated up Green Valley Creek into the City of Fairfield unlined ditch toward the Cordelia Forebay (DWR-ESO 1996). As a result of observing the fall-run chinook salmon, and concern that NBA water released into the northwestern marsh would attract endangered winter-run salmon, the DWR and the USBR reinitiated informal consultation with the USFWS, NMFS and DFG for the remainder of 1994-1995 WSCT. To continue the WSCT, the regulatory agencies required the DWR and the USBR to develop and implement a fisheries monitoring program to address concerns for winter-run chinook salmon, steelhead trout, splittail, delta smelt, longfin smelt and tidewater goby.

The DWR monitored for winter-run chinook salmon, steelhead trout and splittail from February through May, 1995. A false weir, essentially a fence across the creek with a single opening leading to a box with a one-way entrance, was installed on Green Valley Creek. The DWR staff checked the holding box for fish four days per week, eight hours per day. Staff also checked for spawning salmon and redds twice per week at four locations.

The DWR sampled for delta smelt and longfin smelt by electrofishing twice per month at three sites within Green Valley Creek. Electrofishing was conducted from December 1994 through May 1995. Minnow traps were also tested as a method for capturing these species. The traps were set once a week for eight hour periods.

A survey was conducted to determine if suitable tidewater goby habitat was present in Green Valley Creek. Because of the configuration of the creek bed and the extreme fluctuations in the tidal elevation, no suitable habitat was found. Consequently, no sampling for tidewater gobies was required.

While no winter-run chinook salmon, splittail, Delta or longfin smelt were captured, the presence of fall-run chinook salmon and rainbow trout, possibly steelhead, was documented. An additional

14 fish species were also found during the sampling. Complete results and analysis from the fisheries monitoring will be presented in a report detailing water quality, hydrodynamic and biological effects of the 1994-1995 WSCT.

d. Effects of the Alternatives. This section examines the general effect that the alternatives may have on aquatic resources in Suisun marsh. The alternatives could affect aquatic resources by: (1) changing channel water salinity; (2) operation of the SMSCG; (3) augmentation of Green Valley Creek flow; and (4) by construction of new facilities. Impacts to aquatic resources that arise as results of construction activities are programmatic with respect to this EIR, and would require further analysis and CEQA documentation

Alternative 1. In Alternative 1, the DWR and the USBR are responsible for meeting the D-1485 salinity objectives. The alternative assumes compliance at all monitoring stations, regardless of effective compliance date. The SMSCG is operated as needed to meet objectives and no new facilities are constructed. Under this alternative, objectives are frequently not met at S-35 and S-97 in the western marsh. Impacts to aquatic resources would result from changing salinity and SMSCG operation.

Alternative 2. Alternative 2 seeks to meet D-1485 objectives by a combination of flow augmentation and construction of new facilities. SMSCG operation and salinity in the eastern and central marsh are the same as Alternative 1; salinity in the western marsh would be lower than Alternative 1. Species that may have declined due to the increasingly saline conditions observed in the marsh should benefit.

The introduction of Sacramento River water into Green Valley Creek via the NBA could significantly impact chinook salmon, delta smelt, and other aquatic resources in Barker Slough and in the western marsh. Construction of the Goodyear-Cordelia Ditch and the Goodyear Slough Tide Gate could impact aquatic resources through dredging and related activities. Operation of the Tide Gate could also impact the movement of delta smelt within the slough, increase the number of predatory fish in the area, and thus increase predation near the gate.

Alternative 3. The impact of Alternative 3 to aquatic resources would be similar to Alternative 1. Overall, channel water throughout the marsh is less saline under this alternative due to the higher Delta outflow requirement in the 1995 Bay/Delta Plan. When compared to Alternative 1, species that may have declined due to the increasingly saline historic conditions should benefit. The SMSCG is operated less frequently under 1995 Bay/Delta Plan hydrology. Therefore, impacts due to SMSCG closure should be reduced.

Alternative 4. This alternative is similar to Alternative 2. The hydrology associated with the 1995 Bay/Delta Plan creates less saline conditions throughout the marsh and less frequent SMSCG operation. Impacts due to construction and flow augmentation are identical to Alternative 2.

Alternative 5. Channel water salinity, and the corresponding impacts to aquatic resources under Alternative 5 are similar to Alternative 3.

Some of the management actions proposed in the SMPA Amendment III negotiations may impact aquatic resources. September operation of the SMSCG may increase the impact to aquatic resources over that in Alternatives 3, 4, and 6. Portable pumps are to be used to facilitate the movement of water onto and off of managed wetland areas. Fish screens will be an integral part of the pump design, thereby minimizing fish entrainment. All management actions that are part of the SMPA Amendment III are being analyzed in an environmental document prepared jointly by the SMPA parties.

Alternative 6. The highest Green Valley Creek augmentation rates and quantities are required under Alternative 6. If the NBA were used up to its full available capacity for flow augmentation, the average annual amount of pumping would increase from 1.8 TAF to 6.1 TAF when compared to Alternative 4. The maximum NBA pumping would increase from 7.5 TAF to 22 TAF. Impacts to delta smelt and chinook salmon associated with Alternatives 2 and 4 would be magnified under this alternative. If augmentation water were to come from local sources (Lake Frey, Lake Madigan, or Lake Berryessa), impacts at Barker Slough could be avoided.

In an effort to meet objectives in all months, the modeling predicts that very high augmentation rates would on occasion be needed. The difference in the amount of water needed for augmentation between Alternative 6 and Alternative 4 is the additional amount of water needed to meet objectives at S-35. This large input of freshwater would create conditions at S-97 far less saline than the historic condition, or under any of the other alternatives. Aquatic species in the western marsh preferring brackish conditions would tend to be displaced in favor of freshwater species.

SMSCG operation under this alternative is the same as Alternatives 3 and 4. Construction activities would not impact aquatic resources.

6. Recreation

Diked seasonal wetlands occupy 88 percent of Suisun Marsh. The DFG and a number of private landowners manage this area primarily as waterfowl habitat. Waterfowl hunting is presently the major economic and recreational use of the marsh. The Suisun Marsh channel water salinity objectives adopted by the SWRCB in D-1485 were established to protect waterfowl food plants growing in the managed wetlands. Assuming that the salinity objectives provide the desired level of protection to managed wetland areas, the alternatives that are most effective in achieving the objectives would also be most protective of the major recreational uses in the marsh.

Alternative 6 fully meets the Suisun Marsh objectives. Objectives are exceeded at stations S-35 and S-97 under Alternatives 2 and 4, and with increasing frequency under Alternatives 5, 3, and 1. Among these alternatives, Alternative 6 is presumed to be most protective for marsh waterfowl hunting interests.

Research by the DWR suggests that landowner water management practices are critical for maintaining soil salinity suitable for the growth of desired plant species (DWR 1997c). Carefully timed flooding, drawdown, and leaching cycles have allowed some properties in the western marsh, where channel water salinity has historically been highest, to achieve lower soil salinity than neighboring properties, or similar properties in the eastern marsh using higher quality irrigation water. Therefore, the management actions under Alternative 5 are thought to be equally protective of recreational beneficial use. Recreational pursuits such as bird watching, canoeing, hiking, and wildlife observation are becoming increasingly popular in the tidal marsh areas. Educational programs are conducted in the tidal marshes at Rush Ranch and DFG's Peytonia Slough Ecological Reserve. The Napa-Solano Audubon Society volunteers conduct Christmas bird counts and breeding season surveys in Suisun Marsh. Recreational boating has increased within the marsh with the improvements to the Suisun City waterfront and harbor facilities.

Although current land use in the marsh is predominantly diked seasonal wetland, three major Estuary-wide resource agency planning efforts are calling for extensive tidal marsh restoration to facilitate the recovery of endangered species and sensitive wetland habitat values[6] (Goals Project 1999). Therefore, the recreational use of the marsh may be expected to change over time.

a. Green Valley Creek. Alternatives 2, 4, and 6 require varying degrees of flow augmentation in Green Valley Creek. The largest flows would occur in October and to a lesser extent in November and February. As the Suisun Marsh salinity control season occurs during a period of generally lower recreational use, there would be little beneficial impact to recreation in the lower section of the creek.

b. Lake Frey, Lake Madigan and Lake Berryessa. The City of Vallejo prohibits public access to Lake Frey and Lake Madigan. Therefore, there would be no impact to public recreation at these facilities.

Water from Lake Berryessa could be used for Green Valley Creek flow augmentation under Alternative 6. As stated in section 2.g above, if there were 50 cfs of available capacity in the Putah-South Canal and water from the Putah Creek watershed was the sole source of augmentation flow, then the maximum annual demand placed on Lake Berryessa would be 14.8 TAF. The average annual demand would be 4.4 TAF. Considering the large size of Lake Berryessa, reducing the volume by the above amounts would have an insignificant impact on the lake's surface area, and its potential for water based recreational activities.

E. SUMMARY

The 1995 Bay/Delta Plan establishes numeric salinity objectives at seven stations within the Suisun Marsh from October through May and a narrative objective pertaining to brackish tidal marshes. These objectives replace those adopted in 1978 in Decision 1485 (D-1485), and later amended in 1985. The purpose of these objectives is to make irrigation water available for the managed

6 The San Francisco Bay Area Ecosystem Goals Project, the CALFED Ecosystem Restoration Program Plan, and the USFWS Tidal Marsh Recovery Plan call for extensive tidal marsh restoration.

wetlands that will bring soil salinity into a range capable of supporting plants characteristic of a brackish marsh.

In 1977, the California legislature adopted the Suisun Marsh Preservation Act. Recognizing the unique nature of the resource, the act implemented the Suisun Marsh Protection Plan, developed previously by the DFG and the San Francisco Bay Conservation and Development Commission. The SMPA was adopted in 1987, and continues to serve as a contractual framework between the DWR, the USBR, the DFG, and the SRCD to carry out the Protection Plan. The SMPA calls for the staged construction of facilities to provide required channel water salinity. The initial facilities (phase 1) included the Roaring River distribution system, the Morrow Island distribution system, and the Goodyear Slough outfall. The SMSCG was constructed in 1988 as the second phase of the SMPA. The SMSCG began regular operation in October 1988; since that time, salinity in the eastern marsh (see Figure VII-1) has been below current 1995 Bay/Delta Plan objectives, with minor exceptions in water year 1991. During prolonged dry or critically dry periods, however, salinity in the western marsh often exceeds objectives. Salinity in the northwestern and far western marsh are affected primarily by surface water inflows from local creeks and drainage water from managed wetlands, and are relatively unaffected by SMSCG operation.

In order to comply with the western marsh objectives, the DWR and the USBR began in 1990 the planning and review of the Western Suisun Marsh Salinity Control Project. Field testing for one of the more promising alternatives, flow augmentation of Green Valley Creek, was conducted in the fall of 1994. The test was not carried out for the entire salinity control season as planned due, in part, to concerns expressed by the USFWS and the NMFS regarding potential impacts to resident or migratory endangered species, and because hydrologic conditions were such that augmentation was not needed to meet standards.

In D-1485, the SWRCB found that the SWP and the CVP have a mitigation responsibility to protect Suisun Marsh because their operations affect salinity conditions in the marsh. In 1995, the DWR and the USBR petitioned the SWRCB to change some of the permit terms and conditions imposed by D-1485 so that they conform to the objectives in the 1995 Bay/Delta Plan. In response to the petition, the SWRCB incorporated the 1995 Bay/Delta Plan's Suisun Marsh objectives temporarily into the water right permits of the SWP and the CVP through SWRCB Order WR 95-6. The order expired December 31, 1998.

Upon adoption of Order WR 95-6, parties signatory to the SMPA began discussions to amend the agreement. The draft SMPA Amendment III reflects anticipated future hydrologic and salinity conditions in the marsh under 1995 Bay/Delta Plan hydrology and SMSCG operation. The parties have recommended that the SWRCB consider a series of management actions as the next step in implementing the 1995 Bay/Delta Plan rather than focus on the channel water salinity in the western marsh. Strict adherence to the numeric objectives is not required if it can be demonstrated that other actions will provide equivalent or better protection to the managed wetlands. The DWR and the USBR petitioned the SWRCB to extend the compliance date for S-35 and S-97 to enable the

SMPA parties to finalize Amendment III. The SWRCB granted a 180 day extension on October 30, 1997, and renewals of the extension on August 14, 1998 and April 30, 1999.

In the water right proceeding to implement the 1995 Bay/Delta Plan, the SWRCB focused on alternatives to meet water quality objectives at the two western stations, S-35 and S-97. Because the DWR and the USBR control operation of the gates, the SWRCB will not consider at this time assigning responsibility for meeting objectives at the eastern stations to other parties.

Six alternative methods for implementing the Suisun Marsh objectives are analyzed in this draft EIR. The alternatives assume SMSCG operation as needed to meet objectives and Delta outflow conditions based either on D-1485 hydrology or 1995 Bay/Delta Plan hydrology. To meet objectives at S-35 and S-97 different combinations of physical facilities and Green Valley Creek flow augmentation are employed. The alternatives are summarized in Table VII-12.

Table VII-12
Summary of Suisun Marsh Alternatives

Alternative	Regulatory Condition	New Facilities	Green Valley Creek Flow Augmentation	Other Actions
1	D-1485	None	None	None
2	D-1485	Cordelia-Goodyear Ditch and Goodyear Slough Tide Gate. Minor construction on NBA	Up to 80 cfs as needed from NBA to meet S-97	None
3	1995 Bay/Delta Plan	None	None	None
4	1995 Bay/Delta Plan	Cordelia-Goodyear Ditch and Goodyear Slough Tide Gate. Minor construction on NBA	Up to 80 cfs as needed from NBA to meet S-97	None
5	1995 Bay/Delta Plan	None	None	SMPA Amendment III management actions plus September SMSCG operation as needed
6	1995 Bay/Delta Plan	Minor construction on Putah-South Canal and NBA	As needed from all sources until objectives are met at S-97 and S-35	None

The alternatives were modeled using the water quality and hydrodynamic model DWRDSM (Suisun Marsh Version). Average monthly salinities at the seven compliance stations were simulated for the 1922 to 1994 period. Important observations and conclusions based on the modeling results are as follows:

1. Preliminary model runs demonstrate the importance of the SMSCG in achieving the Suisun marsh objectives. Without gate operation, objectives are violated in all months at all compliance stations under D-1485 hydrology. The increased Delta outflow under the 1995 Bay/Delta Plan reduces the exceedence frequency significantly. However, objectives are still exceeded in most months at most stations, though by lesser amounts.

2. The SMSCG operates significantly less frequently under alternatives with 1995 Bay/Delta Plan base hydrology. Therefore, impacts to anadromous fish passage related to gate operation should be reduced compared to Alternatives 1 and 2.

3. With SMSCG operation and 1995 Bay/Delta Plan outflow, objectives are very nearly met in all months at stations C-2, S-64 and S-49 in the eastern marsh and stations S-21 and S-42 in the western marsh. Objectives can not be met with 1995 Bay/Delta Plan outflow and SMSCG operation at stations S-35 and S-97.

4. Green Valley Creek flow augmentation is an effective means of controlling salinity in the northwestern marsh in the vicinity of S-97 under Alternatives 2 and 4. The Cordelia-Goodyear Ditch and the Goodyear Slough Tide Gates provide marginal benefits in the vicinity of S-35.

5. The frequency with which objectives are exceeded under Alternative 5 is midway between Alternatives 2 and 4. Many of the SMPA Amendment III management actions which are part of the alternative can not be modeled. Therefore, the modeling results understate the net benefit that may be expected from the alternative.

6. Alternative 6 meets objectives at all stations using Green Valley Creek flow augmentation as needed. The October augmentation rates range from a 73-year average of 205 cfs to maximum of 899 cfs. Flows greater than 150 cfs would be required in 6 percent of months during the simulated period. The difference in augmentation rates between Alternative 6 and Alternative 4 is the additional freshwater input required to dilute salinity at S-35. If the entire available capacity of the North Bay Aqueduct and the Putah-South Canal were used along with water stored in the City of Vallejo lakes (lakes Frey and Madigan), the maximum flow rates could not be achieved.

Significant environmental impacts may occur as a result of implementing certain of the above alternatives. Comments received from the USFWS and the NMFS on the DWR and USBR proposal to augment Green Valley Creek flow suggests that importing water from the Sacramento River may attract spawning salmon and delta smelt into areas of unsuitable habitat. Supplying augmentation flows by releases from the North Bay Aqueduct would result in additional pumping at Barker Slough and thereby potentially result in increased entrainment of delta smelt at the pump intakes. Introducing additional fresh water into the western marsh will reduce the salinity gradient now present in the area. The salt marsh harvest mouse and the California clapper rail, both terrestrial endangered species requiring saline marsh conditions for their continued survival, could be impacted by this additional freshwater input. Alternative 6 would be particularly detrimental in this regard. Alternatives 2 and 4 would also potentially impact these species, though to a lesser extent. There is no flow augmentation from sources outside the marsh in Alternatives 1, 3 and 5. Alternative 5, however, contains management actions proposed in SMPA Amendment III designed to provide equivalent protection to managed wetland areas. Therefore, Alternative 5 is the environmentally preferred alternative.

No significant impacts of implementing Alternative 5 are identified in this document. The final determination on this matter must await completion of the CEQA/NEPA process by the SMPA parties.

Literature Cited in Chapter VII

Batzer, D. P., et al. 1993. Characteristics of Invertebrates Consumed by Mallards and Prey Response to Wetland Flooding Schedules. Wetlands. Vol 13, No 1, pp. 41-49.

California Waterfowl Association. 1976. Salinity of Applied Water Required to Achieve an Average of 90 Percent of Maximum Alkali Bulrush Seed Production and 60 Percent Seed Germination, Table 2. Exhibit 4. 1976 SWRCB Delta hearings, Application No. 5625 et al. 1 p.

City of Vallejo. 1994. Lakes Water System Master Plan, Prepared by Brown and Caldwell Consultants, January 1994. 51 pp. plus appendices.

City of Vallejo. 1989. Lakes Water System Master Plan, City of Vallejo, California. Prepared by Raymond Vail and Associates. January 1989. Volume 1 of III. 80 pp. plus appendices.

DFG. 1993. Letter from Brian Hunter at Region 3 of DFG to Dwight Russell of DWR Regarding Lake Curry Water Release and Western Suisun Marsh Salinity Control Project Dated April 15, 1993. 1 pp.

DFG. 1994. Memorandum from Perry Herrgesell to Tom Howard. October 19, 1994. 2 pp.

DWR. 1991a. Scoping Report for the Proposed Western Suisun Marsh Salinity Control Project; Plan of Protection for Suisun Marsh Phases III and IV Environmental Impact Statement/Environmental Impact Report. State Clearinghouse Number 90030973. August 1991.

DWR. 1991b. Preliminary Investigation of Additional Water Resources for the Suisun Marsh Salinity Control Program by Jeff Sandburg, USBR for the DWR. August 1991. 5 pp. plus attachments.

DWR. 1993. Screening Alternative Actions and Describing Remaining Actions for the Proposed Western Suisun Marsh Salinity Control Project. DWR and USBR. State Clearinghouse Number 90030973. May 1993. 100 pp. plus appendices.

DWR. 1994a. California Water Plan Update. Volume 2. Bulletin 160-93. Department of Water Resources. October 1994

DWR. 1994b. Comments of the Department of Water Resources at the Fifth Workshop of the State Water Resources Control Board on Bay-Delta Standards. Presented by David B. Anderson, September 1, 1994. 9 pp.

DWR. 1994c. Summary of Salinity Conditions in Suisun Marsh During Water Years 1984-1992. Environmental Services Office, Department of Water Resources. November 23, 1994. 15 pp. plus tables and figures.

DWR. 1994d. Summary of Sensitive Plant and Wildlife Resources in Suisun Marsh During Water Years 1984-1994. Environmental Services Office, Department of Water Resources. December 1994. 107 pp.

DWR. 1995. Estimates of Salinity Changes in Suisun Marsh for Water Years 1987-1992 with CUWA/AG criteria. Dwight Russel and Kamyar Guivetchi of DWR Suisun Marsh Branch.

DWR. 1995a. Suisun Marsh Salinity Control Gates Fisheries Monitoring. 1993 Annual Report. DWR. April 1995. 36 pp.

DWR. 1996. Comments of the Department of Water Resources on the Revised Notice of Preparation of an EIR for a Water Rights Proceeding to Consider Implementation of Objectives in the 1995 Water Quality Control Plan for the Bay-Delta Estuary and to Reauthorize Consolidated Points of Diversion for the State Water Project and Central Valley Project.

DWR-ESO. 1996. 1995 Progress Report. Implementation of Suisun Marsh Mitigation Facilities. Suisun Marsh Branch. Environmental Services Office. Department of Water Resources. March 1996. 13 pp.

DWR. 1997a. Letter from DWR to Fairfield-Suisun Sewer District Dated January 24, 1997. 4 pp. plus attachments.

DWR. 1997b. Suisun Marsh 73-Year Modeling Studies in Support of the SWRCB EIR for Implementation of the Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta Estuary. Environmental Services Office, Department of Water Resources. November 1997.

DWR. 1997c. Demonstration Document: Suisun Marsh Preservation Agreement Amendment Three Actions as a Means to Provide Equivalent or Better Protection than Channel Water Salinity Standards at Suisun Marsh Stations S-35 and S-97, September 1997. 55 pp.

DWR. 1997d. Suisun Marsh Salinity Control Gates Fisheries Monitoring. 1995 Annual Report. DWR. July 1997. 59 pp.

DWR. 1999. Suisun Marsh 73-Year Modeling Studies in Support of the SWRCB EIR for Implementation of the Water Quality Control Plan for the San Francisco/Sacramento-San

Joaquin Delta Estuary - Addendum. Environmental Services Office, Department of Water Resources. May 1999.

FED. 1996. Statement of the Federal Ecosystem Directorate to the State Water Resources Control Board's Workshop on the Development of a Water Right Decision to Implement Requirement for San Francisco Bay/Sacramento-San Joaquin Delta Estuary. SWRCB Workshop February 20, 1996, Exhibit 1, 5 pp.

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A Report of Habitat Recommendations Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, Calif./ S.F. Bay regional Water Quality Control Board, Oakland, Calif.

Herbold, B. A. D. Jassby, and P.B. Moyle. 1992. Status and Trends Report on Aquatic Resources in the San Francisco Estuary. USEPA Report.

JCWU. 1996. Comments to the State Water Resources Control Board Regarding the Development of a Water Right Decision to Implement Requirements for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. February 20, 1996.

Mall, Rolf E. 1969. Soil-Water-Salt Relationships of Waterfowl Food Plants in the Suisun Marsh of California. Wildlife Management Branch, DFG. Wildlife Bulletin No.1. 59 pp.

Matern, S. and P.B. Moyle. 1994. Trends in Fish Populations of Suisun Marsh, January 1992-December 1993. Annual Report for Contract B-59287. Department of Water Resources. Sacramento. 32 pp.

Matern, S., L. Meng and P.B. Moyle. 1995. Trends in Fish Populations of Suisun Marsh, January 1994-December 1994. Annual Report for Contract B-59636. Department of Water Resources. Sacramento. 36 pp.

Meng, L., P. Moyle and B. Herbold. 1993. Abundance and Distribution of Native and Introduced Fishes of Suisun Marsh. Annual Report for Contract B-58854. Department of Water Resources. Sacramento. 32 pp.

Meng, L. P., Moyle and B. Herbold. 1994. Changes in Abundance and Distribution of Native and Introduced Fishes in Suisun Marsh. Transactions of the American Fisheries Society 123:498-507.

NMFS. 1994. Letter from Anneka W. Bane, Acting Regional Director for the NMFS, Southwest Region, Long Beach CA to Bellory Fong, DWR, Sacramento, CA Dated February 15, 1994. 2 pp.

NMFS. 1995. Letter from Rolland A. Schmitten, Assistant Administrator for Fisheries, NMFS to Roger Patterson, Regional Director, USBR Dated May 17, 1995. (Amends CVP-OCAP Biological Opinion dated February 12, 1993). 13 pp.

Raquel, P. 1988. Striped Bass Egg and Larval Monitoring near the Montezuma Slough Salinity Control Structure, 1987. Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary. Technical Report 16. 7 pp.

Rollins, Glenn L. 1973. Relationships Between Soil Salinity and the Salinity of Applied Water in the Suisun Marsh of California. California Fish and Game, 59 (1): 5-35. 31 pp.

SEW. 1997. Suisun Ecological Workgroup - Interim Report to the State Water Resources Control Board. September 1997. 200 pp.

SCWA. 1992. Solano County Water Agency-City of Fairfield Putah Creek Water Exchange Agreement. October 8, 1992. 5 pp.

SCWA. 1995. Agreement Among California Department of Water Resources, United States Bureau of Reclamation, and the Solano County Water Agency, for the Purchase of Water for Salinity Control in Suisun Marsh. 9 pp. plus exhibits.

SCWA. 1996. Comments on Revised Notice of Preparation from Solano County Water Agency to the SWRCB dated March 28, 1996. 3 pp.

SFEP. 1992. Status and Trends Report on Wildlife of the San Francisco Estuary. Prepared by the USFWS under EPA Cooperative Agreement CE-009519-01-0. 283 pp. Plus appendices.

SMPA. 1998. Draft Amendment Number Three to the Suisun Marsh Preservation Agreement among the USBR, DWR, DFG and Suisun Resource Conservation District. June 20, 1998. 37 pp. plus attachments.

SMPA Parties. 1996. Letter from the Parties to the Suisun Marsh Preservation Agreement: DFG, DWR, USBR and SRCD to Victoria Whitney, SWRCB, Regarding Scoping Information for SWRCB Draft Water Rights Decision EIR Dated April 23, 1996 with Attached SMPA Negotiated List of Alternative Actions. 5 pp.

Swanson, G.A. and J.C. Bartonek. 1970. Bias Associated with Food and Analysis in Gizzards of Blue-Winged Teal. Journal of Wildlife Management 34(4): 739-746. 7 pp.

SWRCB. 1995. Order Regarding Petition for Changes in Water Rights that Authorize Diversion and Use of Water Affecting the San Francisco Bay/Sacramento-San Joaquin Delta Estuary.

Order: WR 95-6 In the Matter of Petition for Changes in the Water Rights Authorizing Diversion and Use of Waters in the Watershed of the Sacramento-San Joaquin Delta, Held by the DWR and the USBR.

SWRCB. 1995a. Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, 95-1 WR. May 1995. State Water Resources Control Board. 45 pp.

USBR. 1992. Environmental Impact Statement, Lake Berryessa Reservoir Area Management Plan, Napa, CA. Final, May 1992. 134 pp. plus appendices.

USFWS. 1994. Memorandum from Joel Medlin, Field Supervisor, Sacramento, CA to Regional Director, Bureau of Reclamation, Sacramento, CA, dated October 31, 1994. 13 pp.

USFWS. 1995. Biological Opinion on the Long-term Operation of the CVP and SWP on the Delta Smelt. Memorandum from Joel Medlin, Field Supervisor, Sacramento, CA to Regional Director, Bureau of Reclamation, Sacramento, CA, Dated March 6, 1995. 52 pp. plus attachments.

USFWS. 1995a. Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes Plan. U.S. Fish and Wildlife Service, Portland, Oregon. 195 pp.

Personal Communication

Grewell, Brenda. Personal Communication. December, 1997.

CHAPTER VIII. ALTERNATIVES FOR IMPLEMENTING SALINITY CONTROL MEASURES IN THE SAN JOAQUIN RIVER BASIN

The 1995 Bay/Delta Plan contains salinity objectives for the San Joaquin River at Vernalis to protect agricultural beneficial uses of water in the southern Delta. The salinity objectives can be met either through provision of high-quality dilution water or through salinity control measures in agricultural lands and wetlands that drain to the San Joaquin River. The environmental effects of provision of dilution water are described in Chapter VI.

Salinity control measures can be used to achieve the Vernalis salinity objectives either alone or in combination with dilution water releases. The CVRWQCB is principally responsible for implementing salinity control measures in the San Joaquin Valley. The purpose of this chapter is to review the existing salinity control actions in the San Joaquin Valley and to analyze any new salinity control alternatives that are not presently being implemented or analyzed in some other forum. The information in this chapter will be used by the SWRCB to decide whether it should recommend further evaluation and implementation of salinity control measures to the CVRWQCB. A SWRCB decision to recommend evaluation of an action by the CVRWQCB does not require CEQA compliance. Nonetheless, the alternatives in this chapter are analyzed at the programmatic level to provide information to the SWRCB and to interested parties.

The chapter is divided into three sections: (A) background, (B) alternatives for implementing the objectives, and (C) environmental effects of the alternatives.

A. BACKGROUND

The background discussion is divided into three sections: (1) problem description, (2) regulatory history, and (3) existing salinity management programs.

1. Problem Description

The salinity problem in the San Joaquin River Basin is caused both by saline discharges, principally from irrigated agriculture, and by low flows due to water development. Detailed descriptions of the salinity problems in the San Joaquin River Basin were prepared by the SWRCB in a report entitled "Regulation of Agricultural Drainage to the San Joaquin River" (SWRCB 1987) and by the San Joaquin Valley Drainage Program in a report entitled "A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley" (SJVDP 1990). The following discussion summarizes parts of these reports.

The southern portion of California's Central Valley is comprised of two hydrologic basins, the San Joaquin River Basin and the Tulare Lake Basin, which are separate except during extremely high runoff events (Figure VIII-1). This report focuses on agricultural drainage in the San Joaquin River Basin.

The approximately seven-million acre San Joaquin River Basin extends from the Delta, south to the upper San Joaquin River, west to the Coast Range, and east to the Sierra Nevada. Three main tributaries to the San Joaquin River, the Merced, Tuolumne, and Stanislaus rivers, drain the east side of the basin. On the west-side, ephemeral streams drain the Coast Range, rarely contributing to the San Joaquin River flows. Approximately two million acres in the San Joaquin River Basin are devoted to irrigated agriculture.

Salinity and drainage problems are not new in the San Joaquin Basin. They developed rapidly as irrigated agriculture spread into arid lands, areas with naturally poor drainage and high water tables, and low-lying flood overflow lands. As early as 1886, elevated soil salinity and waterlogging related to agricultural operations were observed. By the turn of the century, these conditions reduced productivity and forced abandonment of some areas on the east-side of the basin. In an attempt to solve this problem, the U.S. Department of Agriculture demonstrated the use of subsurface tile drainage systems in 1909.

During the 1920s, the demand for reliable irrigation supplies resulted in the first comprehensive, statewide water analysis and plan. In 1929, the DWR published the California Water Plan in its Bulletin Number 3. The elements of the 1929 California Water Plan were known as the CVP (see Water Code §11100 et seq.). The primary objective of the plan was to store water from the northern Sacramento Valley where there was a water surplus and transport this water to irrigate lands in the San Joaquin Valley where there was a water shortage. The CVP included Shasta Dam, the Contra Costa Canal, the Delta Cross Channel, Tracy Pumping Plant, the Delta-Mendota Canal, Friant Dam, the Madera Canal, and the Friant-Kern Canal (see Figure VIII-2). The State approved the CVP in 1933 and issued bonds to finance its construction, but due to the Great Depression the bonds were not sold. Federal financing was eventually obtained, and the USBR was given responsibility for construction and operation of the above elements of the CVP. The federal CVP facilities serving the San Joaquin Valley were constructed between 1944 and 1951.

The CVP diverted high-quality San Joaquin River water into the Tulare Lake Basin and substituted the San Joaquin River supply with poorer quality water from the Delta. The CVP also facilitated expansion of irrigated agriculture into the arid uplands of the west-side of the San Joaquin Valley. Formerly, irrigated agriculture in these areas was limited due to poor quality or inaccessible ground water supplies. The availability of CVP water contributed to a new set of drainage and water quality problems.

With a reliable supply of surface water, groundwater pumping for irrigation was reduced and the groundwater basin began to refill. The semiconfined aquifer above the Corcoran Clay is now fully saturated in much of the west side of the San Joaquin Valley. Most of the soils in this area are derived from marine sediments of the Coast Ranges that contain salts and potentially toxic trace elements such as arsenic, boron, molybdenum and selenium. When these soils are irrigated, the substances are dissolved and leached into the shallow groundwater. Irrigation-induced leaching of the soil and accumulation of salts from imported water have concentrated dissolved salts in the upper portion of the semiconfined aquifer.

Figure VIII - 1
San Joaquin Valley showing San Joaquin River Basin, Tulare Lake Basin and Sacramento-SanJoaquin Delta

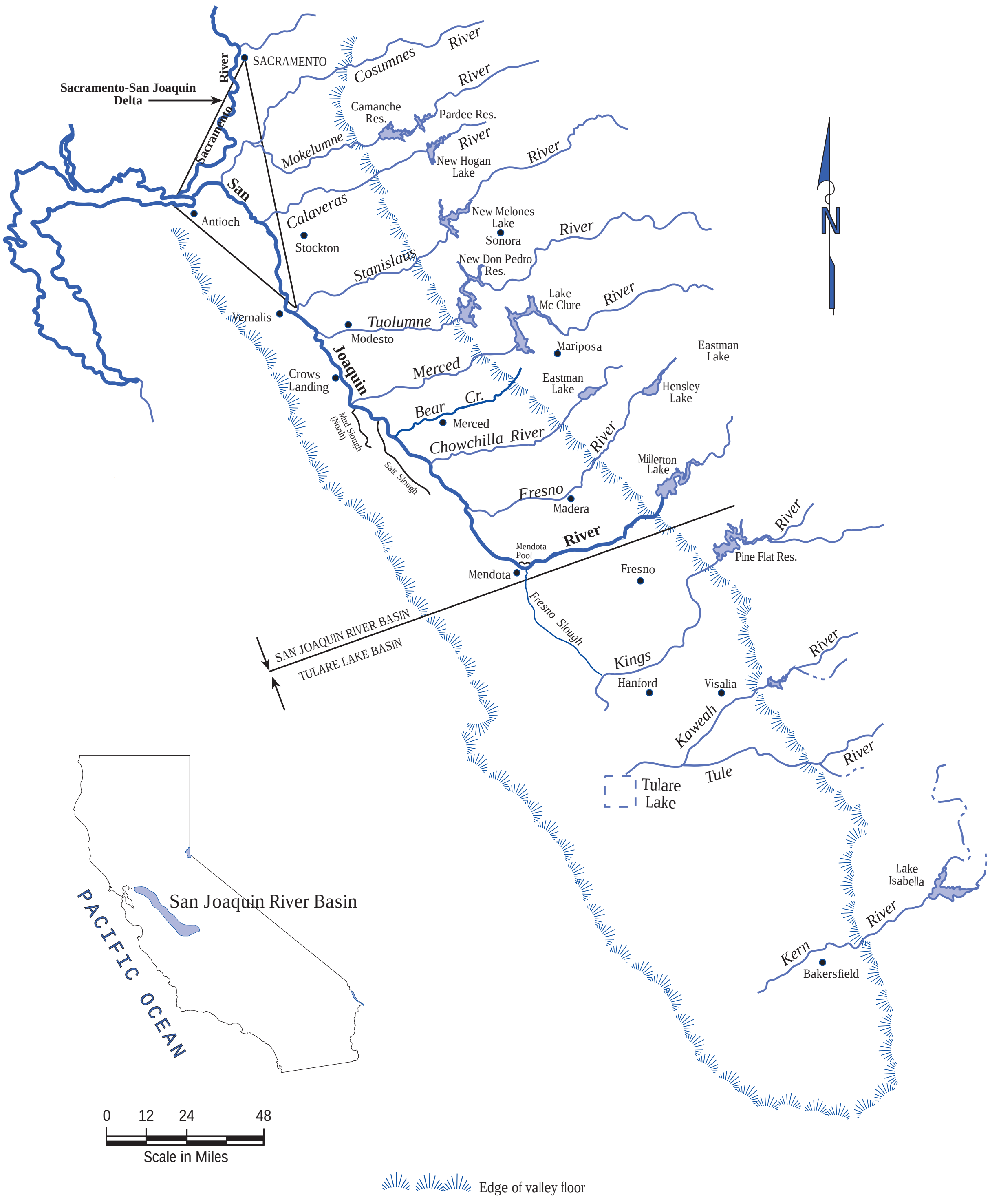
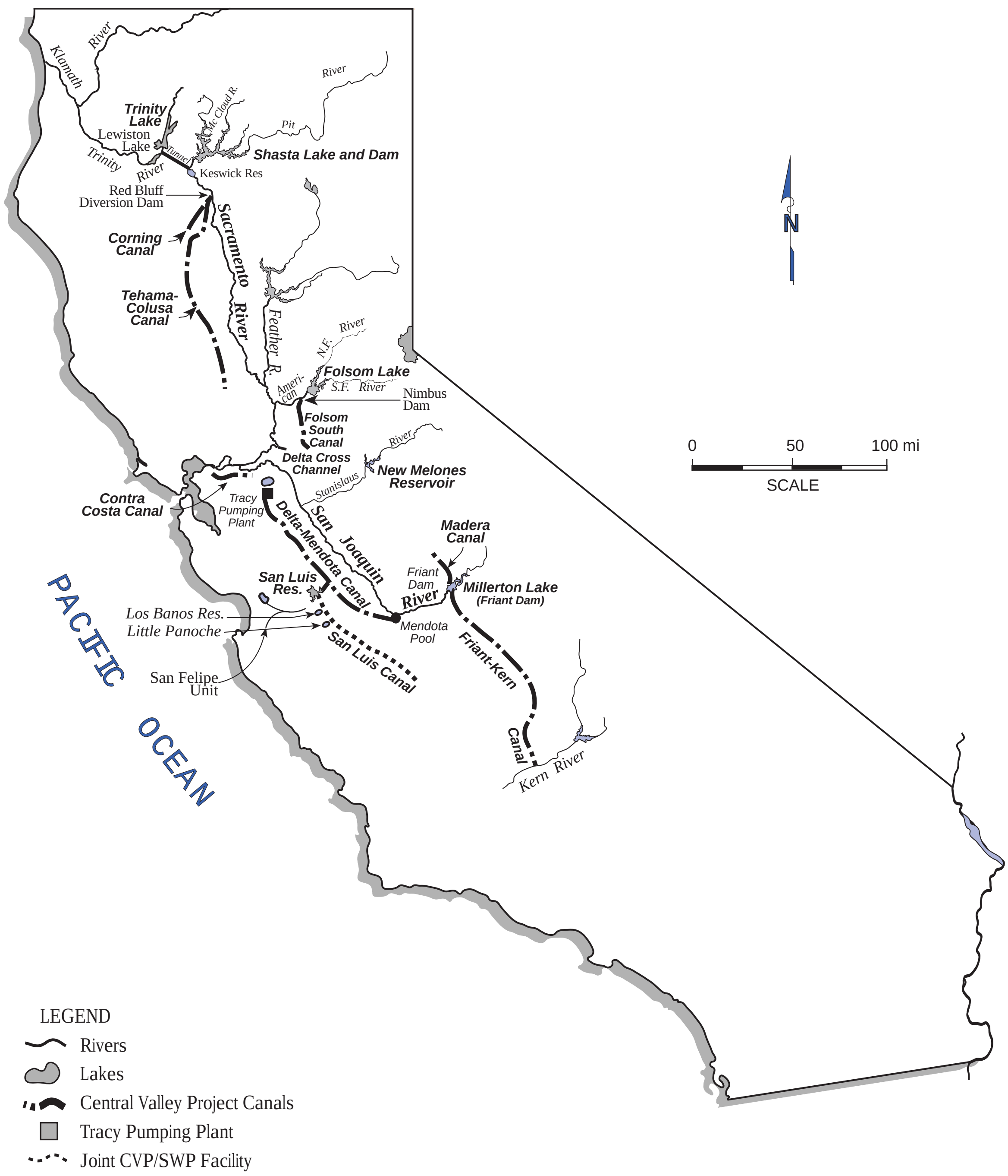


Figure VIII-2
Major Features of the Central Valley Project



In order to alleviate salt buildup in the soil and high water table conditions, growers in the west-side of the San Joaquin Basin began installing subsurface drainage systems in the 1950s to dispose of accumulated drain water to the San Joaquin River. The location of drainage problem areas and existing tile drained areas in the San Joaquin River Basin are shown in Figure VIII-3 (SWRCB 1987).

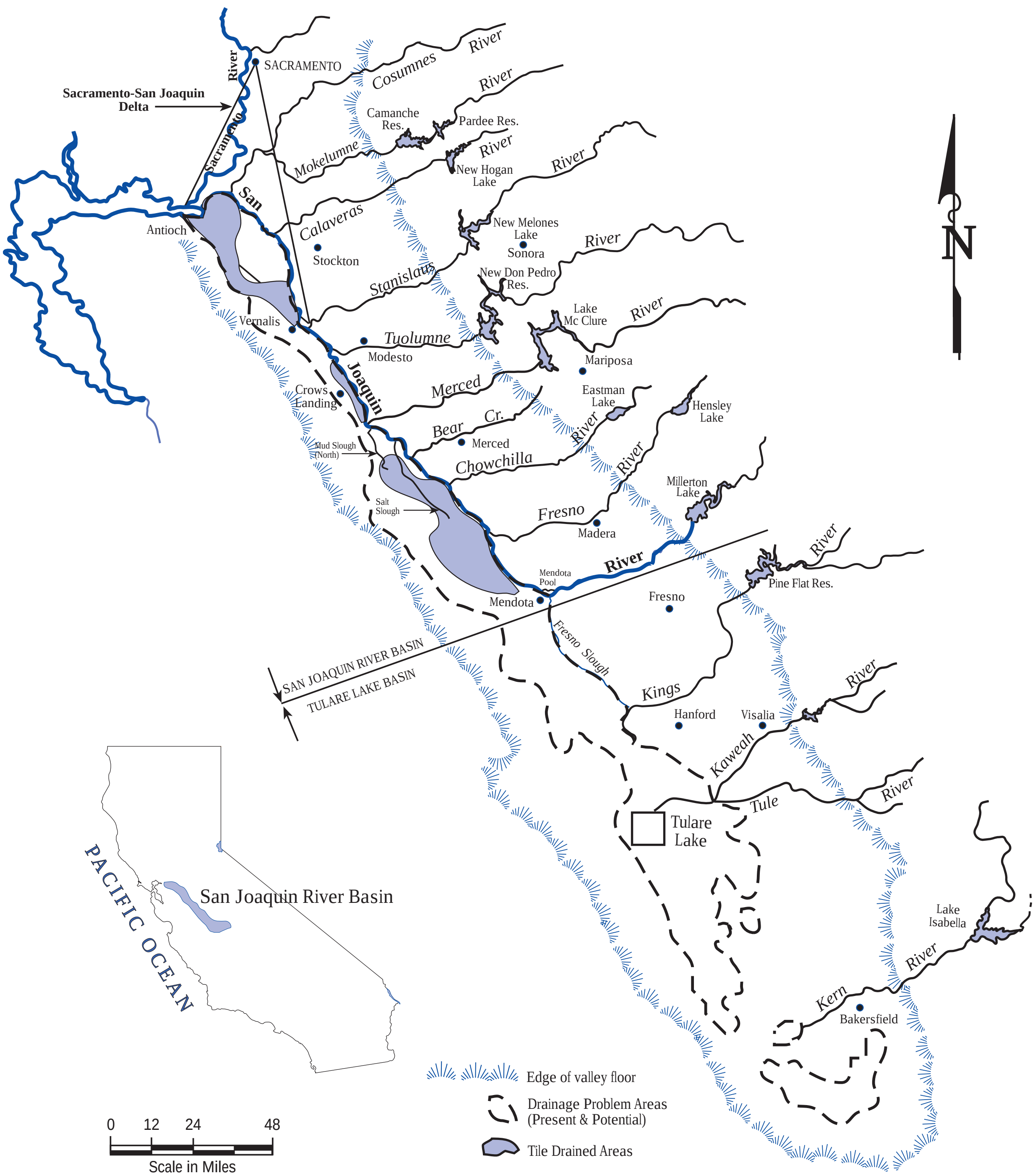
In the 1950s, state and federal agencies realized that planned water importation projects would worsen these problems. The authorization for the SWP and the San Luis Unit of the CVP included plans for a master drain to remove subsurface drainage from the San Joaquin Valley. During the 1960s, the USBR and the DWR collaborated on plans for staged construction of a San Joaquin Valley drain that would discharge in the Delta. The DWR eventually withdrew from the planning process because it was unable to develop a method for repayment of reimbursable costs that was acceptable to the future drain users. The USBR continued with plans to build a 188 mile San Luis Interceptor Drain. From 1968 to 1975, an 85 mile segment was built between the town of Five Points and Kesterson Reservoir. San Luis Drain construction was halted in 1975 because of federal funding problems, environmental impact concerns, and uncertainty about a final location for drain discharges. Consequently, the Interagency Drainage Program was formed to develop an economically, environmentally, and politically acceptable plan to handle these issues.

The Interagency Drainage Program's recommendations were published in 1979 (IDP 1979). The preferred plan was a 290 mile long drain extending from the Tulare Basin to the discharge point near Chipps Island in Suisun Bay. In 1981, the USBR requested the SWRCB to issue a permit for discharge of San Luis Drain effluent to Suisun Bay. The SWRCB then specified the information that the USBR would have to submit to support its application. Federal drainage studies began shortly thereafter.

By 1978, subsurface agricultural drainage blended with irrigation water began flowing in the San Luis Drain. This water was discharged into Kesterson Reservoir, which operated as a terminal evaporation facility. By 1981, the entire flow of the drain was subsurface drainage originating from approximately 8,000 acres in the Westlands Water District (5,000 acres with tile drains plus 3,000 acres influenced by the 42,000 acre collector system). Shortly thereafter, waterfowl deaths and embryonic deformities were observed at Kesterson Reservoir. These observations were traced to the presence of selenium at an average concentration of approximately 300 ppb in the drainage water. In response to a complaint from a landowner near Kesterson Reservoir, the SWRCB held a series of evidentiary hearings and, in 1985, adopted Order No. WQ 85-1. Among other provisions, this order established conditions for continued discharge to the reservoir. The USBR, however, announced that it would no longer accept subsurface drainage from Westlands Water District into the San Luis Drain, and Kesterson Reservoir was closed. Since then, the district has not discharged subsurface collector drain water beyond its boundaries.

There has not been substantial progress on construction of a drainage facility since this period. The existing status of the drainage facility is discussed in section A.3 of this chapter.

Figure VIII -3
Drainage Problem Area Including Existing Tile Drained Area in the San Joaquin River Basin



The drainage problem in the San Joaquin Basin is exacerbated by extensive water development, which has reduced the assimilative capacity of the San Joaquin River. The level of water development in the basin is illustrated in Table VIII-1, which lists the major reservoirs in the basin and their capacities. In 1980, the USBR and the South Delta Water Agency jointly prepared a report entitled "Report on the Effects of the CVP upon the Southern Delta Water Supply Sacramento-San Joaquin River Delta, California" (USBR 1980). The report states that construction of the CVP alone reduced the average annual flow in the San Joaquin River at Vernalis by somewhere in the range of 544 TAF to 943 TAF, which is as much as 29 percent of the average annual post-1947 flow at this location.

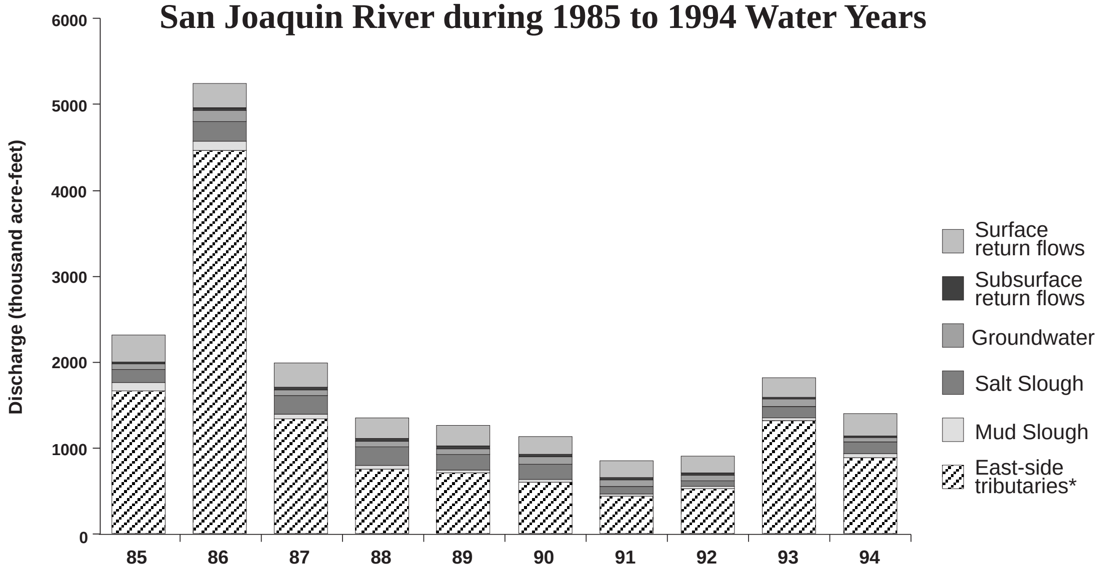
Table VIII-1
Major Reservoirs in the San Joaquin River Basin

Name	River	Date of Completion	Capacity (acre-feet)
Millerton	San Joaquin	1947	520,500
New Exchequer	Merced	1967	1,025,000
Hetch Hetchy	Tuolumne	1923	360,000
Cherry Valley	Tuolumne	1956	268,000
New Don Pedro	Tuolumne	1971	2,030,000
New Melones	Stanislaus	1979	2,400,000

a. **Salinity Sources**. The SJRIO model was used to estimate flow and TDS loading in the lower San Joaquin River (Lander Avenue to Vernalis). The magnitudes of flows and TDS loads from different sources in each year from 1985 through 1994 are shown in Figures VIII-4 and VIII-5. The average annual flow and TDS load contribution from these sources for the same period are shown in Figures VIII-6 and VIII-7. The east- side tributaries and the upstream segment of the San Joaquin River account for 69 percent of the flow but only 16 percent of the TDS load to the lower San Joaquin River. The Mud and Salt sloughs contribute only 11 percent of the flow but 44 percent of the TDS load to the San Joaquin River. Mud and Salt sloughs are composed of discharge from surface and subsurface return flows, wetland releases, ground water accretions, and flood flows. Additional sources of the TDS load are groundwater accretions (21%), surface return flows (16%), and subsurface return flows (3%) along the main stem of the San Joaquin River, downstream of Mud Slough. Recent studies show that March and April wetland releases from the southern half of Grassland Water District can account for ten percent of the TDS load in Salt Slough during these months (Grober et al, 1995). This represents approximately four percent of the total salt load in the San Joaquin River near Vernalis during these months just from a portion of the Grasslands Water District.

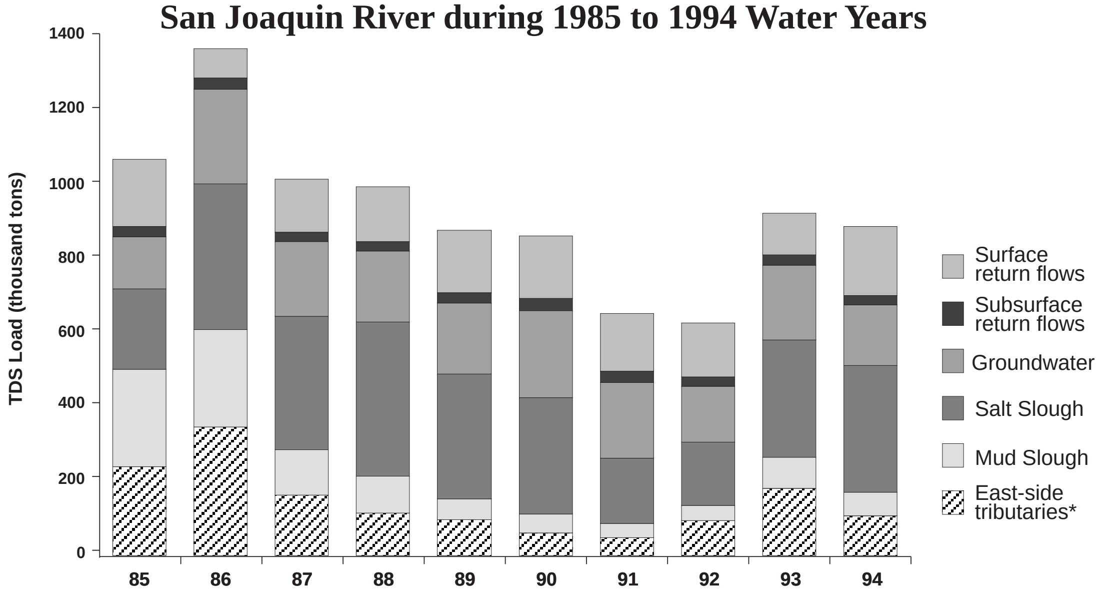
Salt Slough originates at Sand Dam near the confluence of Salt Slough Ditch and West Delta Drain and flows northwestward until it reaches the San Joaquin River approximately 3.5 miles

Figure VIII-4
Sources and Magnitude of Flow in the Lower San Joaquin River during 1985 to 1994 Water Years



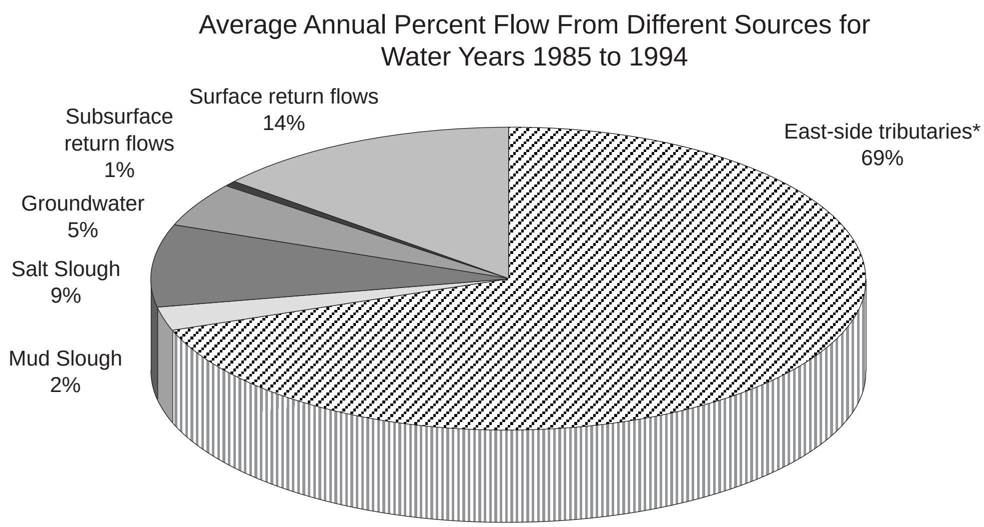
** includes upstream segment of the San Joaquin River*

Figure VIII-5
Sources and Magnitude of TDS Load in the Lower San Joaquin River during 1985 to 1994 Water Years



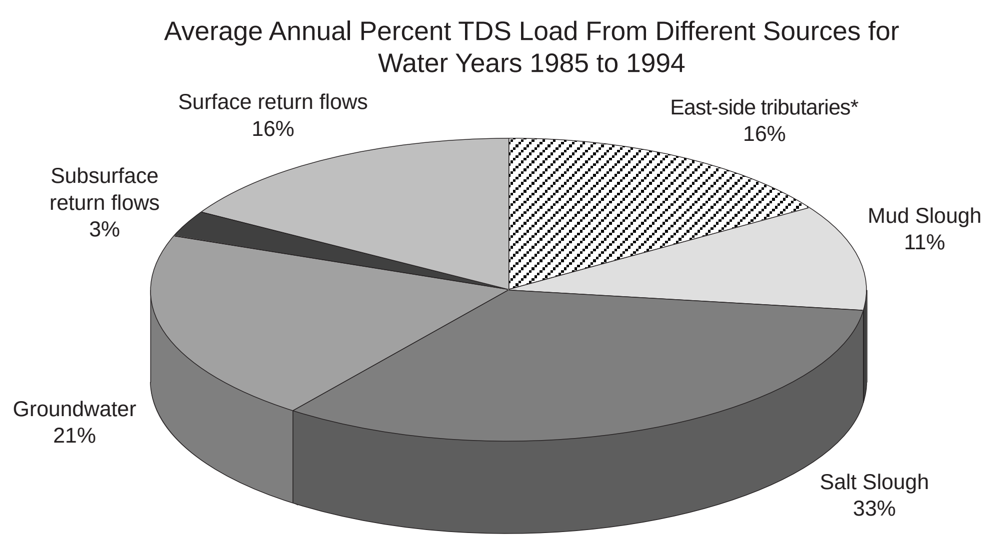
** includes upstream segment of the San Joaquin River*

Figure VIII-6
Lower San Joaquin River Flow



* includes upstream segment of the San Joaquin River

Figure VIII-7
Lower San Joaquin River TDS Loads



* includes upstream segment of the San Joaquin River

downstream of Fremont Ford State Park. Salt Slough is a typical valley floor slough. It has a very small slope; it meanders and is generally shallow and slow moving except during periods of exceptionally high flow. The majority of the flow in Salt Slough originates in the San Luis Canal Company Water District; however, major inputs are received from the Central California Irrigation District, the Poso Canal Company, and the Grassland Water District. During the winter and early spring, its flows are a mixture of subsurface agricultural drainage, precipitation runoff, and discharges from local duck clubs and wildlife refuges. During the summer and fall months, its flows are made up of agricultural tailwater, irrigation spill water, and subsurface agricultural drainage. An inventory of discharges to Salt Slough has been prepared by the CVRWQCB (CVRWQCB 1989a), and 71 discharges are identified in this inventory. The majority of discharges enter Salt Slough prior to the south entrance of the San Luis National Wildlife Refuge, in the first 9.9 miles of the 20.7 miles length of Salt Slough. Most of these discharges carry tailwater drainage from areas planted in field crops. The discharges to Salt Slough north of this point are either from pasture land or duck ponds.

Mud Slough (North) flows in a northerly direction from Kesterson Ditch to the San Joaquin River, which it intersects approximately two miles upstream of the Merced River confluence. Like Salt Slough, during the winter and early spring, its flows are a mixture of subsurface agricultural drainage, precipitation runoff, and drainage from local duck clubs and wildlife refuges. During the summer and fall, its flows are made up of agricultural tail water, irrigation spill water, and subsurface agricultural drainage. There are 42 discharges into Mud Slough (North) (CVRWQCB 1989b). Numerous discharges are from wetland areas, either private duck clubs or federal refuges, and are seasonal discharges of low volume. The major discharges are from the tributaries: Kesterson Ditch, Fremont Canal, Santa Fe Canal, and Los Banos Creek. All four tributaries carry agricultural subsurface drainage and irrigation spill water at one time or another. The majority of the subsurface agricultural drainage reaches Mud Slough (North) via the Santa Fe Canal; the majority of the flows in Los Banos Creek are irrigation spill water.

Starting in October, 1996, all subsurface drainage that previously discharged to Mud or Salt sloughs through a series of wetland channels was routed via the Grassland Bypass Project into the northernmost portion of the San Luis Drain. The San Luis Drain discharges into Mud Slough (North) approximately nine miles upstream of the confluence with the San Joaquin River.

Table VIII-2
Average TDS Load at Vernalis* (Tons)

Period	1960-69	1970-79	1980-89
April-August	288,000	316,000	466,000
Annual	846,000	897,000	1,166,000

* Calculated using monthly average of daily EC or TDS and monthly average of daily flow at Vernalis from 1960 to 1989 (Grober 1996).

b. <u>Historical Salinity Conditions and Future Trends</u>. The increase in the salt load and concentration at Vernalis from the 1930s through the 1960s are documented in a 1980 report prepared jointly by the USBR and South Delta Water Agency (USBR 1980). More recent increases in the salt load at Vernalis are illustrated in Table VIII-2. This table shows that the April through August salt load in the 1980s was 62 percent higher than the load in the 1960s, and the corresponding annual load increase was 38 percent. This load increase, coupled with reduced flows due to water development, has reduced the quality of water available to water users diverting water from the lower San Joaquin River and the southern Delta. Salinity conditions at Vernalis for water years 1986 through 1995 are illustrated in Figure VIII-8. During this period, the USBR made releases of dilution water from New Melones Reservoir to meet a year-round water quality objective of 500 ppm TDS (approximately 800 mmhos/cm), as required by D-1422. This objective was often exceeded because of insufficient water in New Melones Reservoir to provide adequate dilution flows. The objectives adopted in the 1995 Bay/Delta Plan are also plotted in Figure VIII-8, and the percent of days these objectives would have been exceeded if they had been in effect in water years 1986 through 1995 is illustrated in Figure VIII-9. These plots show that additional control measures will be needed to ensure compliance with Vernalis water quality objectives, especially during the irrigation season.

The problem of increasing salt loads and concentration at Vernalis will worsen in the future unless some action is taken because the rate of accretion of salt in the basin exceeds the rate of excretion. The difference in these rates between 1950 and 1989 averaged approximately 446,000 tons per year and totaled 18,621,000 tons (Orlob 1991).

2. Regulatory History

This section describes the history of the SWRCB's and the CVRWQCB's regulation of salinity at Vernalis. Relevant plans and decisions include: (a) D-1275, (b) D-1422, (c) 1978 Delta Plan and D-1485, (d) 1991 Bay/Delta Plan, (e) 1995 Bay/Delta Plan and Order WR 95-6, and (f) CVRWQCB Basin Plans.

a. <u>D-1275</u>. In 1967, the SWRCB adopted D-1275, which approved the DWR's water right applications for the development and operation of the SWP. The decision requires that the permits are subject to the water quality criteria included in an agreement, dated November 19, 1965, among the Sacramento River and Delta Water Association, the San Joaquin Water Rights Committee, the DWR, and the USBR (SRDWA 1965) in so far as the criteria do not conflict with other terms included in the permits. The agreement states that, in the event New Melones Reservoir is operated to provide water quality control, the average TDS at Vernalis will be maintained at 500 ppm or less, provided that not more than 70 TAF shall be released in any calendar year for this purpose.

Figure VIII-8
San Joaquin River Near Vernalis

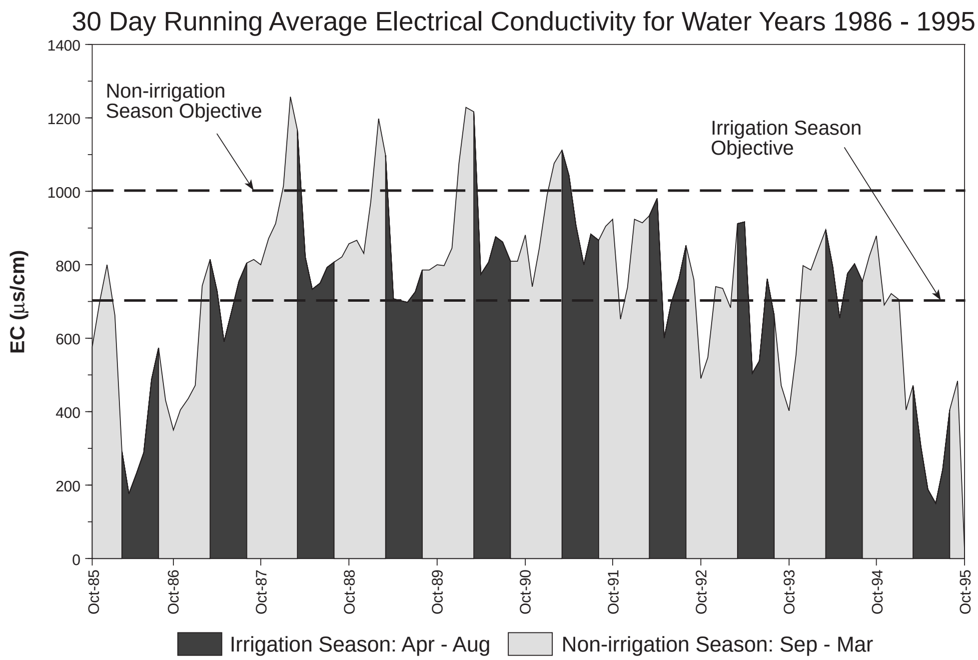
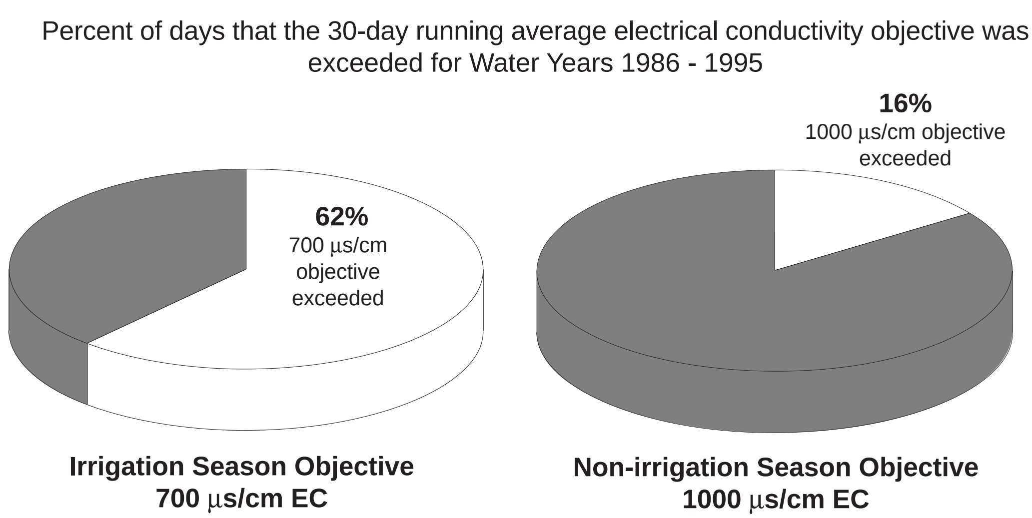


Figure VIII-9
San Joaquin River Near Vernalis



b. D-1422. In 1973, the SWRCB adopted D-1422, which approved the USBR's water right applications to appropriate water from the Stanislaus River at New Melones Reservoir for power generation, preservation and enhancement of fish and wildlife, recreation, and water quality control. D-1422 requires the USBR to release water to maintain a mean monthly TDS of 500 ppm or less in the San Joaquin River at Vernalis. The decision notes that the USBR plans to release up to 70 TAF per year for this purpose, but it does not limit releases to this quantity.

c. 1978 Delta Plan/D-1485. In 1978, the SWRCB adopted both the 1978 Delta plan, which revised the water quality objectives for the Delta, and D-1485, which implemented the objectives. The 1978 Delta Plan established a two-phase approach regarding Vernalis salinity objectives. In the first phase, the existing objective of 500 ppm maximum 30-day running average of mean daily TDS would become effective after New Melones Reservoir is operational. The phase two objectives are 0.7 mmhos/cm and 1.0 mmhos/cm maximum 30-day running average of mean daily EC from April 1 through August 31 and from September 1 through March 31, respectively. The phase two objectives would become effective only upon completion of suitable circulation and water supply facilities. The plan stated that if contracts to ensure such facilities were not executed by January 1, 1980, the SWRCB would take appropriate enforcement actions to prevent encroachment on riparian rights in the southern Delta. The phase two objectives were based on the water quality needs of crops grown in the southern Delta. During the irrigation season of April 1 through August 31, the representative crop used to develop the objective was beans, and alfalfa was used as the representative crop for the rest of the year.

D-1485 conditioned the DWR and the USBR water right permits to implement most of the water quality objectives of the 1978 Delta Plan, but the Vernalis salinity objectives were not included in the decision. Therefore, the requirements of D-1422 remained in effect.

d. 1991 Bay/Delta Plan. The 1991 Bay/Delta Plan revised the water quality objectives in the 1978 Delta Plan. The magnitude of the Vernalis salinity objectives was not changed in the 1991 Bay/Delta Plan, but the implementation schedule was changed. The plan called for the year-round Vernalis salinity objective of 500 ppm TDS to be replaced by the seasonal objectives of 0.7 mmhos/cm and 1.0 mmhos/cm EC from April 1 through August 31 and from September 1 through March 31, respectively, no later than 1994. The plan also stated that, if a three-party contract is implemented among the DWR, the USBR, and the South Delta Water Agency, that contract would be reviewed prior to implementation of the objective and, after also considering the needs of other beneficial uses, revisions would be made to the objectives, as appropriate.

The 1991 Bay/Delta Plan included a program of implementation for the Vernalis salinity objective. This program included direction to the CVRWQCB to develop and adopt a salt load reduction program. The 1991 Bay/Delta Plan states that the salt load reduction program should include a plan to reduce annual salt loads by at least ten percent and to adjust the timing of salt discharges from low flow to high flow periods.

In 1991, the SWRCB did not adopt a water right decision implementing the provisions of the 1991 Bay/Delta Plan; therefore, the USBR continued to be responsible to meet the water quality objective of 500 ppm contained in D-1422.

e. 1995 Bay/Delta Plan and Order WR 95-6. The 1995 Bay/Delta Plan revised the water quality objectives in the 1991 Bay/Delta Plan. The seasonal objectives at Vernalis of 0.7 mmhos/cm and 1.0 mmhos/cm EC from April 1 through August 31 and from September 1 through March 31, respectively, were however retained, and these objectives were effective immediately. The program of implementation of the 1995 Bay/Delta Plan includes several provisions related to the Vernalis salinity objectives. In the short-term, the plan recommends implementation of the recommendations from the San Joaquin Valley Drainage Program and coordination of drainage water releases with higher flows in the river to maximize the use of the assimilative capacity of the river. In the long-term, the plan states that the in-basin management of salts must be supplemented by the disposal of salts outside of the valley, and the USBR should reevaluate alternatives for completing a drain to discharge salts out of the basin.

On June 8, 1995, the SWRCB adopted Order WR 95-6, which makes the water rights of the SWP and the CVP consistent with their implementation of the 1995 Bay/Delta Plan. This action allows the SWP and the CVP to operate their facilities in accordance with the 1995 Bay/Delta Plan while the SWRCB prepares a long-term water right decision to implement the plan. Among other provisions, Order WR 95-6 requires the USBR to release conserved water from New Melones Reservoir to comply with 1995 Bay/Delta Plan salinity objectives at Vernalis. The order was to expire on December 31, 1998 or upon adoption by the SWRCB of a long-term water right decision implementing the 1995 Bay/Delta Plan, whichever occurred first. On December 3, 1998, the effective term of WR 95-6 was extended until December 31, 1999, when the SWRCB adopted Order WR 98-09.

f. CVRWQCB Basin Plans. The CVRWQCB adopted a number of basin plans in the period described above (CVRWQCB 1994). In general, the regional basin plans included the same salinity objectives at Vernalis that were in effect pursuant to SWRCB plans. In the event of any conflicts, the SWRCB-adopted salinity objectives superseded the Regional Board-adopted salinity objectives.

The existing CVRWQCB basin plan includes a program of implementation for objectives. Among other provisions related to salinity control, the plan states that there are two major options for the disposal of salts produced by irrigated agriculture: out-of-valley export and discharge to the San Joaquin River. The plan states that a valley-wide drain remains the best technical solution to the water quality problems of the San Joaquin River and the Tulare Lake Basins caused by agricultural drainage.

3. Existing Salinity Management Programs

Salinity objectives at Vernalis can be met either by release of fresh water to dilute the salinity loads, by reducing the salinity load entering the river, or by changing the timing of salt load releases to the river to maximize the use of the assimilative capacity of the river. In the past the principal method used to reduce salt levels has been dilution with fresh water from New Melones Reservoir. Recently, state, federal, and local public and private agencies began taking actions to reduce and control salt loads entering the San Joaquin River. This section summarizes the following principal programs and actions to reduce and control salt loads entering the river: (a) out-of-valley disposal, (b) water conservation, (c) drainage reuse, (d) evaporation ponds, (e) subsurface storage, (f) change in point of diversion in the Delta, (g) land retirement, and (h) regulated releases to the San Joaquin River.

a. Out-of-Valley Disposal. Implementation of in-basin measures, if the only means used to reduce salt loading to the San Joaquin River, will be effective only for the short-term. A long-term solution must include disposal of salts outside the valley, along with continuation of in-basin measures as an ongoing means of reducing drainage volumes and salt and trace element loads. At present, the San Joaquin River is being used to convey a substantial portion of the salt load out of the valley, but this disposal option is affecting the beneficial uses of the river.

The construction of an out-of-valley facility has a lengthy history, as described earlier in this chapter. The USBR recently began discussions with the SWRCB regarding actions needed to secure a permit from the SWRCB for the construction of an out-of-valley facility. These discussions led to the adoption of Resolution No. 96-029 by the SWRCB, which directed the USBR to use the CEQA and the NEPA process to evaluate alternatives for out-of-valley disposal.

b. Water Conservation. Water conservation can improve salinity conditions in the San Joaquin River both by leaving more water in the river for dilution flows and by decreasing the salt load imported into the basin through the CVP. Four principal legislative actions have been passed recently that encourage water conservation, three for agricultural water conservation and one for urban water conservation. These actions are discussed below:

1. The California Agricultural Water Management Planning Act (California Water Code Sections 10800 through 10855) requires all agricultural water suppliers delivering over 50 TAF of water per year to prepare an Information Report and identify whether the district has a significant opportunity either to conserve water or to reduce the quantity of drainage water through improved irrigation water management. The legislation affected the 80 largest agricultural water purveyors in California. The districts that have a significant opportunity to conserve water or to reduce drainage are required to prepare water management plans.

2. The Agricultural Water Suppliers Efficient Water Management Practices (EWMP) Act of 1990 (California Water Code Sections 10900 through 10904) requires the DWR to establish

an advisory committee consisting of members of the agricultural community, University of California, DFG, environmental and public interest groups, and other interested parties to develop a list of EWMPs for agricultural water users. On November 13, 1996, the committee completed a six year effort by releasing a "Memorandum of Understanding (MOU) regarding EWMP by Agricultural Water Suppliers in California" (AWSC 1996). The MOU, which is to be voluntarily signed by agricultural and environmental communities and by other interested parties, provides a mechanism for planning and implementing cost-effective EWMPs that benefit water suppliers. The MOU requires implementation of some EWMPs, and it sets out an evaluation process for other EWMPs that must have net benefits to the water supplier before they are implemented. The MOU also (a) requires preparation of water management plans by water suppliers, (b) establishes the Agricultural Water Management Council to oversee implementation of the MOU, and (c) provides a mechanism for evaluation and endorsement of the water management plans. The MOU was signed in May 1997 authorizing the Agricultural Water Management Council to implement the process.

3. The Reclamation Reform Act of 1982 (Section 210) and the CVPIA (PL 102-575, Section 3405e) require federal water contractors to prepare water conservation plans. In California, the USBR's Mid-Pacific Region developed a criteria and a set of guidelines to prepare water conservation/management plans and required all agencies (districts) that contract with the USBR for M&I water in excess of 2,000 acre-feet and/or for agricultural (irrigation) water to serve over 2,000 irrigable acres to submit water conservation plans. The CVPIA required the USBR's Mid-Pacific Region to revise its existing guidelines for reviewing conservation plans to include, but not be limited to, BMPs and EWMPs developed in California.

4. The Urban Water Management Planning Act (California Water Code sections 10610 through 10656) requires urban water suppliers that provide water to more than 3,000 customers or that supply more than 3,000 acre-feet of water annually (a) to prepare urban water management plans, (b) to submit the plans to the DWR for review, and (c) to implement the plans. These code sections also specify the minimum requirements for an acceptable plan. Many of these requirements are incorporated from the "Memorandum of Understanding Regarding Urban Water Conservation in California," dated September 1991. Most of the major urban water agencies in the state are signatories to this MOU. The primary purpose of the 1991 MOU is to expedite implementation of reasonable water conservation measures/best water management practices in urban areas and to establish assumptions for use in calculating estimates of reliable future water conservation savings resulting from proven and reasonable water conservation measures.

In addition to the legislative programs discussed above, agricultural water conservation is also encouraged through the SJVDP and through the actions of the CVRWQCB. The SJVDP Report (SJVDP 1990) recommends agricultural water conservation as one of the inbasin management methods for reducing the load of salt and other pollutants discharged to the water bodies in the San Joaquin Valley. In December 1991, eight State and Federal agencies, including the SWRCB, signed a Memorandum of Understanding to coordinate activities implementing the recommended plan.

On December 8, 1988, the CVRWQCB adopted Resolution 88-195 approving amendments to the water quality control plan for the San Joaquin River Basin. The amendments require that parties discharging or contributing to the generation of agricultural subsurface drainage submit drainage operation plans. The amendment further states that the principal best management practice for the control of subsurface drainage is water conservation. On September 21, 1989, the SWRCB approved the basin plan amendments by adoption of SWRCB Resolution No. 89-88. The SWRCB at that time directed the CVRWQCB to issue waste discharge requirements if the drainage operation plans are not implemented in a timely fashion. The CVRWQCB has continued to pursue the drainage operation plan approach, and the main element of the plans has been water conservation efforts.

c. Drainage Reuse. The SJVDP recognized that, if drainage water could be economically reused, it would be a resource. The reuse of drainage water for power plant cooling, energy producing solar ponds, salts and mineral recovery, fish and wildlife habitat, and aquaculture has limited potential in the San Joaquin Valley. Reuse of drainage water by irrigating salt-tolerant crops or by blending with normal irrigation supplies are the only reuse options that appear promising at this time. Consequently the SJVDP emphasized reuse of drainage water on progressively more salt-tolerant crops to reduce the drainage volume for easy containment and/or disposal. Volume reduction through reuse would also substantially reduce disposal costs and treatment costs, if treatment became necessary. Several studies are being done to explore the potential of drainage reuse. Studies have been done by Ayars and others (Ayars 1994, 1996) on the west-side of the San Joaquin Valley to demonstrate that, rather than discharge tile drainage, some of the tile drainage can be retained in the soil profile to meet crop water requirements by subirrigation. Application of this technique reduces drainage volume, salt loading of surface waters, and irrigation water requirements. When the ground water is saline, the potential of its reuse will be limited by the crop tolerance for salinity.

The Department of Food and Agriculture, in cooperation with University of California and several other agencies, has studied the feasibility of drainage reduction by using tile drain effluent to irrigate eucalyptus trees and halophytes (Tanji 1991). The strategy is currently being practiced by at least two farmers on the west-side of the San Joaquin Valley and additional farmers may adopt this practice in the future (Cal Poly 1994).

Researchers at Cal Poly (Cal Poly 1994) report that the districts in the west-side of the San Joaquin Valley can promote reuse of drainage water by not accepting any tailwater from its members and accepting tile water only when the electrical conductivity of the tile water is greater than five mmhos/cm. District recycling facilities should be in place to allow recycling of tail water, tile only if water quality allows. Recycling pipelines or ditches must terminate at irrigation water inlets to the districts so that drainage water will be reused in all areas.

d. Evaporation Ponds. Evaporation ponds are discussed as an agricultural drainage in-basin management option in the SJVDP report. These ponds can be used independently or in conjunction with eucalyptus trees/halophyte plants.

Evaporation ponds are not common in the San Joaquin River Basin. However, evaporation ponds are the only means available for storage and disposal of drainage water in the Tulare Lake Basin. Evaporation ponds can generate several possible problems depending on the quality of water discharged to the ponds and the management of the ponds (CVRWQCB 1996): (1) they can pose a threat to wildlife; (2) they can contribute to the impairment of ground water; and (3) they take lands out of production.

e. Subsurface Storage. Subsurface storage refers to holding of tile drainage water in the tile laterals, subsurface submains (if any), and soil profile above tile lines but below rootzone when assimilative capacity of the San Joaquin River is low and discharging it when the assimilative capacity of the San Joaquin River is high. Subsurface storage may promote compliance with water quality objectives at Vernalis and save water by reducing water quality releases from New Melones Reservoir. If salinity levels in tile drainage water are below crop salt tolerance levels, some of the stored water may be used through capillary rise (upflux) to meet a part of crop irrigation requirements thereby leading to a reduction of drainage volumes. A recent USBR report (USBR 1991) discusses methods of retrofitting existing systems with valves and/or weirs or designing new systems that include these valves/weirs to create temporary storage above tile lines and below the rootzone. Subsurface storage has no adverse effects on wildlife; its effect on salt build up in the rootzone and crops may have to be closely monitored.

There are several limitations that may be encountered for subsurface storage. First, the leaching process is slow and consequently salts cannot be moved quickly to take advantage of assimilative capacity in the San Joaquin River. Second, stored salts may impact crop production. Third, additional water supplies may be needed to leach salts, especially over a series of dry years. Last, lateral seepage from upslope areas may interfere with the project.

f. Change in Point of Diversion in the Delta. Water exported from the Delta has a higher salt concentration than water diverted from the Sacramento River. Therefore, changing the point of diversion for exports to the San Joaquin Valley from the Delta to the Sacramento River can substantially reduce the load of salt imported to the basin. This reduction will in turn reduce the salt load discharged to the San Joaquin River.

The CALFED Bay/Delta Program's strategy is to develop a through-Delta conveyance alternative based on the existing Delta configuration with some modifications, evaluate its effectiveness and add additional conveyance and/or other water management actions if necessary to achieve CALFED goals and objectives. For example, inability to meet CALFED program goals for drinking water quality or fishery recovery using this strategy could lead to a decision to move forward with modifications to this strategy including a change in point of diversion to the Sacramento River (CALFED 1998). The environmental review process for this program is scheduled for completion in late 1999.

g. Land Retirement. The recommended drainage management actions in the SJVDP Report (1990) included the selective retirement of irrigated lands that are characterized by low productivity, poor drainage, and high selenium concentrations in shallow groundwater. Based on these recommendations, Section 3408(h) of the CVPIA authorized a federal land retirement program. Land retirement, or taking lands out of irrigated agricultural production, may reduce irrigation drainage problems, depending on how the freed up irrigation water is reallocated. Other associated benefits would be lowering of the water table, and opportunities to use the CVP water, which was previously used on the retired lands, for other beneficial uses including protection of fish and wildlife resources in the San Joaquin River. The Water Quality Common Program of CALFED also describes land retirement as a possible method available to address drainage problems.

The federal program is expected to retire a total of 100,000 acres of irrigated farm land. The actual amount of land retired and the duration of the program will be dependent upon the number of willing sellers and budget constraints. All lands that receive CVP water are eligible to participate, but lands selected for retirement will probably be located south of the Delta. Also in 1992, California Water Code section 14900 was adopted authorizing the DWR to implement the State land retirement program. As currently envisioned, the land retirement will be accomplished cooperatively by the DOI and DWR through a process in which willing sellers volunteer to remove their lands from irrigation production in return for monetary compensation. The State land retirement program is not currently funded; however, the federal government is moving forward with implementing its land retirement program. The USBR, in consultation with DWR, developed and released ‘Interim Guidelines – Land Retirement Program’ in 1997 (USBR 1997). The Guidelines address procedures for soliciting lands eligible for retirement, criteria for selecting lands for retirement, the role of the local water districts in setting priorities for retirement, control of land and water resources that may be acquired, and post-retirement management of land and water resources. The USBR is currently implementing a demonstration project to evaluate the environmental benefits and constraints of land retirement.

h. Controlled Discharges to the San Joaquin River. SWRCB Order WQ 85-1 (SWRCB 1985), which was adopted principally for the purpose of directing cleanup of Kesterson Reservoir, required the CVRWQCB to adopt and implement basin plan amendments to evaluate wetland releases and drain discharges to the San Joaquin River. In addition, the SWRCB's 1991 Bay/Delta Plan and 1995 Bay/Delta Plan directed the CVRWQCB to implement a program to reduce the annual salt load discharged to the San Joaquin River by at least 10 percent and to adjust the timing of salt discharges from low flow to high flow periods.

In response to these directives, the CVRWQCB intensified monitoring of drainage discharges, completed hydrological investigations of discharges to the San Joaquin River, Mud Slough, and Salt Slough, and required the preparation of drainage operation plans. The CVRWQCB is also beginning a basin planning process to adopt and implement salinity objectives at upstream locations on the San Joaquin River.

The control and regulation of wetland releases and drain discharges to the San Joaquin River is also recommended in the San Joaquin River Management Program (SJRMP) plan (SJRMP 1995). This program was established by Assembly Bill 3603 (California Water Code sections 12260 through 12273) and its focus is to establish a consensus based plan to improve conditions in the San Joaquin River.

Controlled timing of agricultural drainage and wetland releases to the San Joaquin River can maximize the assimilative capacity of the river. From September 1 through March 30, the salinity objectives at Vernalis are higher (1.0 mmhos/cm instead of 0.7 mmhos/cm) and flows are often higher. In addition, a pulse flow objective from April 15 through May 15 often results in high flows during this period. Moving agricultural drainage and wetland releases to these periods should help meet the salinity objectives. Adequate coordination may require formation of regional drainage bodies, execution of agreements with dischargers, issuance of waste discharge requirements that restrict the discharge of drainage water to the river, or adoption of time specific waste discharge prohibitions. Many tile drain systems will require modification in order to control the timing of discharges from the systems.

The successful regulation and control of drain water discharge to the San Joaquin River would be aided by a real-time monitoring program being developed by the DWR, the USBR and the CVRWQCB.

B. SALINITY CONTROL ALTERNATIVES UNDER CONSIDERATION

There are several salinity control actions that the SWRCB could undertake in the San Joaquin River basin to improve salinity conditions in the San Joaquin River. The previous section described eight methods that are presently being used or analyzed to manage salt loads in the San Joaquin Basin: (1) out-of-valley disposal, (2) water conservation, (3) change in point of diversion in the Delta, (4) land retirement, (5) controlled releases to the San Joaquin River, (6) drainage reuse, (7) evaporation ponds, and (8) subsurface storage.

The first four methods (out-of-valley disposal, water conservation, change in point of diversion in the Delta, and land retirement) are either under consideration in another forum or are already being implemented. On April 18, 1996, the SWRCB adopted Resolution No. 96-029, which directed staff of the SWRCB and the USBR to complete a workplan for a CEQA/NEPA document that analyzes alternatives for out-of-valley disposal. Water conservation efforts are ongoing through implementation of the recent legislation discussed in the previous section of this report. Change in point of diversion may eventually be a part of the CALFED Bay/Delta Program, depending on the outcome of the initial phase of the program. The DWR and the USBR are working together to fund and manage the land retirement program. Further consideration in this process would be duplicative.

The fifth method, controlled releases to the San Joaquin River, is under the direct regulatory authority of the SWRCB and the CVRWQCB and is not being evaluated or implemented by other agencies. Therefore, alternatives to control the timing of releases from wetlands and tile drains are analyzed in this report. Water Code section 13243 authorizes the SWRCB or the CVRWQCB, in a water quality control plan or in waste discharge requirements, to specify certain conditions or areas where the discharge of waste, or certain types of waste, will not be permitted. The CVRWQCB also has authority, under Water Code section 13260, et seq., to require persons discharging waste that could affect the quality of the state's water to report on the discharges and to obtain waste discharge requirements before continuing the discharges.

The last three methods (drainage reuse, evaporation ponds, and subsurface storage) are implementation methods for controlled releases to the San Joaquin River or, in the case of drainage use, also a water conservation measure. In this programmatic analysis only one of these methods to implement the controlled releases to the San Joaquin River, subsurface storage, will be evaluated. If the SWRCB elects to direct the CVRWQCB to evaluate controlled releases in more detail, the CVRWQCB will prepare a CEQA document that considers all reasonable implementation methods.

The hydrology used in the analysis of all the alternatives, including the reference case, assumes full implementation of the 1995 Bay/Delta Plan. This reference case hydrology is different than the base case hydrology used in the rest of this report, which assumes D-1485 regulatory conditions. The reason for the difference is that the principal focus of this analysis is to determine whether, after implementation of the Bay/Delta Plan, dilution water requirements from New Melones Reservoir could be reduced through implementation of salinity control actions.
The four salinity control alternatives described below are: (1) Salinity Control Alternative 1 - reference case, (2) Salinity Control Alternative 2 - controlled timing of wetland releases, (3) Salinity Control Alternative 3 - controlled timing of tile drain releases; and (4) Salinity Control Alternative 4 - combination of Alternatives 2 and 3.

1. Salinity Control Alternative One - Reference Case

In the reference case, no water quality action is taken. The wetland releases and agricultural subsurface drain discharges continue to flow into the San Joaquin River in accordance with present practices. A summary of the present practices is provided below.

a. Grassland Area Wetlands. Grassland Resource Conservation District (GRCD) comprises more than 74,700 acres within the Grassland area. Located within the GRCD is the Grassland

Water District (GWD), a CVP contractor that delivers water to private lands and to the three public wildlife areas within its boundaries: San Luis National Wildlife Refuge, Los Banos Wildlife Management Area, and the North Grassland Wildlife Management Area. Land within the GWD is used primarily for duck hunting clubs and seasonal grazing of livestock. Although the properties within GWD are managed separately, the overall management objective is to enhance natural food plant production and to protect wetland habitat for migratory and resident waterfowl. Historically, about 70 to 80 percent of GRCD lands were flooded from mid-September to mid-January to provide waterfowl habitat. Water was released from the seasonally flooded areas from mid-January through April to the San Joaquin River via Mud and Salt sloughs. Prior to discharge, salt concentrations in the wetlands rise due to evaporation and to leaching from the naturally saline soils. Consequently, the spring releases from wetlands add to the overall San Joaquin River salt load.

The GWD's water supplies come from several sources. A 1953 settlement over disputed San Joaquin River water rights in the Grassland area makes 50 TAF annually of CVP water available to the GWD from the Delta-Mendota Canal. Delivery of this water is limited by contract to the September 15 to November 30 period. Until 1985, agricultural drainage and operational spills from upslope irrigators provided up to 148 TAF annually of additional water for the Grassland wetlands. Concerns regarding the quality of the drainage water caused the GWD to cease accepting drainage water in 1985. Interim supplies were then obtained through a series of temporary contracts with the CVP. The passage of the CVPIA in 1992 provided the GWD with firm water supplies. The CVPIA requires the Secretary of the Interior to immediately provide firm water supplies of suitable quality to specified wetland habitat areas. The GWD, the state's wildlife management areas, and the federal wildlife refuges presently receive approximately 168 TAF under the CVPIA, and deliveries are to be increased to 250 TAF by the year 2002.

With the advent of CVPIA water, Grassland wetland managers adopted new management practices. Fall flooding begins in mid-September, timed to coincide with early arriving waterfowl and is complete by late October. Typical application rates range from 1.5 to 3 acre-feet per acre per year. Water levels averaging 8 inches are maintained throughout the winter in the ponded areas. In the past, many duck clubs released their water in mid-January at the end of hunting season. Now, managers prefer to hold water longer and release it more gradually.

Actual timing of releases depends on weather conditions and which plant species are being encouraged. The average monthly release schedule, as modeled for the reference condition, is summarized in Table VIII-3. These reference conditions represent moderate to worst case wetland discharges and are not necessarily representative of all years.

The average TDS of the historic wetland releases (prior to implementation of the CVPIA) is assumed to be 1900 mg/l based on limited information for the southern subarea of GWD. The

Table VIII-3
Average Monthly Wetland Releases (acre-feet)

Month	Historic	CVPIA*	Total
October	1,000	1,000	2,000
November	1,000	2,000	3,000
December	2,000	5,000	7,000
January	3,000	5,000	8,000
February	3,000	7,000	10,000
March	7,000	10,000	17,000
April	6,000	10,000	16,000
May	2,000	7,000	9,000
June	1,000	4,000	5,000
July	1,000	2,000	3,000
August	1,000	1,000	2,000
September	1,000	1,000	2,000
Total	29,000	55,000	84,000

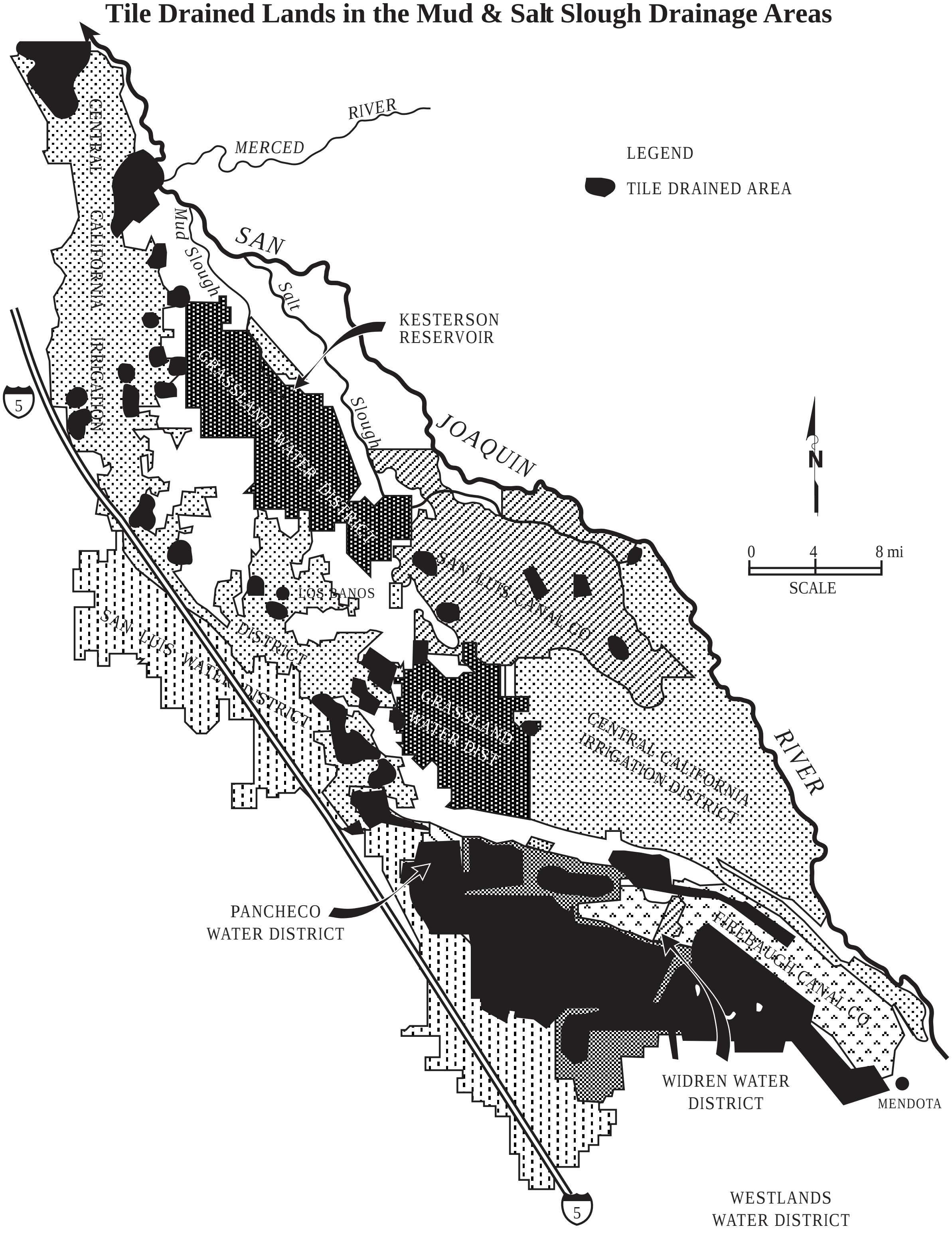
* This term represents the additional wetland releases caused by the recent introduction of CVPIA water.

average TDS attributed to the discharge of CVPIA wetland supplies is set at roughly half that of the historical wetland release (960 mg/l) to account for reduced evapoconcentration and salt mobilization that would be likely with these additional supplies.

b. Agricultural Drainage. Subsurface tile drainage systems have been installed in many areas on the west-side of the San Joaquin River basin to lower the water table and allow needed periodic leaching of the soils. Figure VIII-10 shows areas with tile drains on the west-side of the San Joaquin River Valley (SWRCB 1987). Many more acres will need tile drainage to remain productive in the future.

Approximately 50,000 acres of the tile drained area discharge to Salt and Mud sloughs. The quantity of the average discharge is estimated to be 19,145 AF per year. The districts discharging this water are Broadview Water District, Central California Irrigation District, Firebaugh Canal District, Wildern Water District, Charleston Drainage District, Pacheco Drainage District, and Panoche Water District. Prior to 1985, much of this water was applied to wetlands within the GWD. Provision of CVP water for the wetlands has eliminated this use of the drainage water. Since October 1996, all tile drainage from this area is conveyed via a portion of the San Luis Drain

Figure VIII-10
Tile Drained Lands in the Mud & Salt Slough Drainage Areas



to Mud Slough where it then flows into the San Joaquin River. This routing of drainage water is referred to as the Grassland Bypass Project. No tile drainage water is commingled with wetlands water supplies.

In addition to the sources of tile drainage water described above, 10,010 acres discharge directly to the San Joaquin River. The quantity of the average discharge is estimated to be 7,806 AF per year. The districts/areas discharging directly to the river are Newman Drainage District, Spanish Grant Drainage District, Reclamation Districts 1602, 2099, and 2100, Patterson Water District, West Stanislaus Irrigation District, El Soyo Water District, and the McCracken Road Drain (Grober 1997).

The average monthly tile discharge to the San Joaquin River from all of the sources named above, as modeled in this chapter, is shown in Table VIII-4.

Table VIII-4
Tile Drain Discharges (acre-feet)

Month	Reference Conditions			Reoperation Conditions if Implemented
	Via Mud & Salt Sloughs	Directly to San Joaquin River	Total	
January	1,687	241	1,928	0
February	2,262	484	2,746	0
March	2,471	699	3,170	0
April	2,269	933	3,202	7,013
May	2,047	933	2,980	7,013
June	1,935	933	2,868	0
July	1,717	933	2,650	0
August	1,490	853	2,343	0
September	879	699	1,578	5,342
October	699	545	1,244	5,342
November	644	312	956	956
December	1,045	241	1,286	1,286
Total	19,145	7,806	26,951	26,952

2. Salinity Control Alternative 2 - Controlled Timing of Wetland Releases

Under this alternative, the CVRWQCB implements a regulatory program or coordinates a cooperative program in which wetland operators within GWD shift all of their historical and recent CVPIA releases during the months of March and April to the month of February. This program is implemented whenever the salinity objectives at Vernalis during the month of March are likely to be exceeded. This reoperation requires one month of foresight because a February release is being made based on forecasted March water quality. Such foresight may be possible because the availability of reservoir dilution flows may be reasonably estimated based on forecasted watershed runoff.

The shift of all releases from the months of March and April to February can adversely affect the diversity of waterfowl food in the managed wetlands because different plants are favored depending on when the land is drained. In order to avoid this effect, 10 TAF of additional CVPIA water is provided in both March and April to maintain a flow through system in the wetlands. This additional 20 TAF of CVPIA water is the difference between CVPIA Level 2 and Level 4 supplies to the Grassland Area Refuges in the spring and consequently is available for the management of wetlands.

The wetlands reoperation affects releases during the months of February, March, and April only; the releases during other months are unchanged. Table VIII-5 shows modeled wetland releases for the three relevant months for the reference (Alternative 1) and the reoperated (Alternative 2) conditions.

The average TDS concentration of the discharge of each of these sources of water can differ. For modeling purposes, the assumption is made that the average concentration of historical wetland releases, CVPIA water and additional CVPIA water is 1,900 mg/l, 960 mg/l, and 600 mg/l, respectively (Grober 1997).

Table VIII-5
Wetland Releases for Reference and Reoperation Conditions (acre-feet)

	Reference Conditions				Reoperation Conditions			
Month	Historic	CVPIA	Add - CVPIA	Total	Historic	CVPIA	Add - CVPIA	Total
Feb	3,000	7,000	-	10,000	16,000	27,000	-	43,000
March	7,000	10,000	-	17,000	0	0	10,000	10,000
April	6,000	10,000	-	16,000	0	0	10,000	10,000

3. Salinity Control Alternative 3 - Controlled Timing of Tile Drain Discharges

Under this alternative, the CVRWQCB implements a regulatory program or coordinates a cooperative program in which parties with tile drainage systems hold the drainage for limited periods when assimilative capacity is not available in the San Joaquin River. The parties would have flexibility in deciding how to temporarily cease their discharge. For illustrative purposes, the assumption in this programmatic analysis is that the parties store their drainage in laterals, submains, sumps, and the soil column for up to three months. Under this alternative, tile drainage is stored in January, February, and March and released in April and May when the Vernalis salinity objective is exceeded in January. The pulse flows required by the Bay/Delta Plan in April and May will dilute the release in these months. Tile drainage may be unnecessarily stored in February and March at times when objectives are not actually exceeded in these months under these operations criteria. Similarly, tile drainage may not be stored in February and March when objectives are exceeded. Tile drainage is also held in June, July, and August and released in September and October when the Vernalis salinity objective is exceeded in June, July, or August. Tile drainage may be unnecessarily stored in June, July, or August under these operating rules because exceedance of the salinity objective in any month results in storage of tile drainage for all three months. These modeling criteria are used to simplify the analysis. Actual implementation of this alternative would probably be based on real-time data and somewhat greater benefits could be obtained.

Table VIII-4 shows the discharges that occur under the reference conditions and the discharges that would occur if the tile drainage was being released according to the reoperation criteria above. For purposes of the modeling analysis, the assumption is made that the average TDS concentration of drain discharges through Mud and Salt sloughs and directly to the river are 4,754 mg/l and 1,812 mg/l, respectively. These figures are based on a flow weighted average of tile drainage TDS concentrations from the areas (Grober 1997).

4. Salinity Control Alternative 4 - Combination of Alternatives 2 and 3

This alternative combines the operational measures in both Alternative 2 and Alternative 3. The CVRWQCB implements a regulatory program or coordinates a cooperative program in which (1) wetland operators within GWD shift all of their historical and recent CVPIA releases during the months of March and April to the month of February, and (2) parties discharging subsurface agricultural drainage hold the drainage when assimilative capacity is not available in the San Joaquin River.

C. ENVIRONMENTAL IMPACTS OF IMPLEMENTING SALINITY CONTROL ALTERNATIVES

As described above, the USBR is responsible, pursuant to D-1422, for meeting the Vernalis salinity objectives by releasing dilution water from New Melones Reservoir. The focus of this analysis is to determine whether the need for dilution water releases can be significantly reduced by implementing the salinity control alternatives. The description of the environmental impacts of implementing the salinity control alternatives is divided into the following five sections: (1) description of modeling process, (2) reduction in required releases from New Melones Reservoir, (3) San Joaquin River EC, (4) construction-related effects, and (5) crop production.

1. Description of Modeling Process

SJRIO is the principal model used in this analysis (Grober 1997). However, the derivation of the simulated hydrology for the major eastside tributaries to the San Joaquin River for the reference case begins with a DWRSIM study in which all Bay/Delta Plan flow objectives are met (see Chapter IV for a description of the SJRIO and DWRSIM models). In this DWRSIM study, New Melones Reservoir is operated to meet instream flow and contractual obligations, as described in Chapter IV, and additional releases are made to meet Vernalis flow and salinity objectives. When insufficient water is available from this reservoir to meet all of these obligations, releases are made from New Don Pedro Reservoir and Lake McClure in equal amounts.

The resulting DWRSIM hydrology (DWRSIM 1997) for eastside streams is used as input to SJRIO, and the Vernalis flow is calculated using SJRIO. Adjustments are made to eastside stream flows in SJRIO, excluding the Stanislaus River, until the DWRSIM and SJRIO calculated flows at Vernalis are identical over the entire 73 year hydrologic sequence. Stanislaus River flows are next adjusted in SJRIO by removing releases called for in DWRSIM for salinity control. The final SJRIO hydrology for the reference case is then obtained by increasing the Stanislaus River flows as necessary to meet the salinity objectives at Vernalis using the SJRIO algorithm to calculate dilution water requirements to meet the Vernalis salinity objectives. For a detailed description of other assumptions used to develop the hydrology, see Grober 1997.

It is not possible to calibrate SJRIO salinity results at Vernalis with DWRSIM salinity results at Vernalis. The algorithms used to calculate salinity in the two models are significantly different. Table VIII-6 provides a comparison of the dilution release requirements calculated under SJRIO and DWRSIM. The table shows that the 73 year average annual difference in dilution water release requirements is approximately 20 TAF. Other relevant observations from Table VIII-6 include: (1) the maximum release in many months is much greater in SJRIO than in DWRSIM; (2) the percentage of time that dilution releases are required in July and August is much less in SJRIO than in DWRSIM; (3) SJRIO indicates that dilution water for salinity control is needed from January through August, but DWRSIM indicates that with limited exceptions dilution water for salinity control is needed only from May through August with very little water required in May.

2. Reduction in Required Releases from New Melones Reservoir

The first step in the analysis is to determine whether discharges from wetlands and tile drains have a significant effect on the quantity of dilution water required to meet the Vernalis salinity objectives. This issue was examined by using SJRIO to model the effect on releases at New Melones Reservoir of completely eliminating: (1) the wetland discharges, (2) tile drain discharges, and (3) both wetland and tile drain discharges. These three studies are limiting cases used to analyze the maximum expected effect of the drainage. The results of this analysis are provided in Table VIII-7, which shows that New Melones Reservoir release are reduced by an average of 23 TAF when wetland discharges are eliminated, 35 TAF when tile drain discharges are eliminated, and 46 TAF when both sources of drainage are eliminated. These reductions in dilution releases are calculated on an annual average basis over the 73 years of modeled hydrology. These model results are sufficiently large to warrant modeling of the reoperation alternatives described in section B of this chapter.

Table VIII-6
Comparison of SJRIO and DWRSIM Dilution Release Requirements (TAF)

Description		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Tot
SJRIO Reference Case	avg	0	0	0	3	3	2	7	3	19	17	14	0	68
	max	0	1	13	34	35	34	78	67	102	84	60	0	-
	%	0%	1%	3%	22%	15%	11%	19%	14%	49%	56%	53%	0%	-
DWRSIM Releases	avg	0	0	0	0	0	0	0	1	9	18	20	0	48
	max	0	0	3	6	10	0	0	7	27	27	26	0	-
	%	0%	0%	9%	14%	8%	0%	0%	14%	50%	86%	97%	0%	-
Difference	avg	0	0	0	3	3	2	7	2	10	-1	-6	0	20

Notes: (1) % refers to the percent of months in which dilution water is required to meet the Vernalis objectives.
(2) The row labeled "difference" provides the average change between the two models.

The effect of the reoperation alternatives, Salinity Control Alternatives 2, 3, and 4, on dilution release requirements from New Melones Reservoir are also provided in Table VIII-7. This table shows that, with respect to dilution water release requirements, there is no demonstrable long-term benefit to Alternative 2, the wetlands reoperation alternative, as formulated. Small benefits may be possible with other reoperation alternatives, but the need to drain the wetlands in the spring in order to encourage appropriate plant growth (discussed in section B.1.a of this chapter) limits the range of possible alternatives.

Table VIII-7 shows that reoperation of tile drains pursuant to Alternative 3 could generate average annual savings of 21 TAF from New Melones Reservoir. Average water savings occur during the months of January, February, March, June, July, and August while additional releases would be required during the months of April and May. The modeled observation that additional average releases are required in April and May is questionable for two reasons. First, the model operates on a monthly average basis; therefore, the effect of the April 15 through May 15 pulse flow is attenuated. The need for dilution water releases during a pulse flow period is unlikely. Second, reoperation of tile drains moves the discharges into the pulse flow period, reducing the quantity of reservoir releases required to achieve the pulse flow. The model indicates that an average of 2 TAF and a maximum of 9 TAF of tile drain discharges are moved into the April/May period as a result of reoperation, but the resulting reduction in reservoir release requirements is not included in Table VIII-7.

Table VIII-7 also shows that Alternative 4, combined wetlands and tile drain reoperation, generates the same water savings from New Melones Reservoir as Alternative 3, reoperation of tile drains alone. Consequently, there is no water savings benefit for combined reoperation.

The results cited above indicate that Alternatives 2 and 4 do not achieve the objective of the project - reduction of releases from New Melones Reservoir for salinity control at Vernalis. Therefore, these alternatives are not analyzed further in this report. The remaining analysis is limited to Alternative 3.

3. San Joaquin River Water Quality

The SJRIO-modeled EC conditions at Vernalis and Crows Landing under Alternatives 1 and 3 are provided in Figures VIII-11 through VIII-14. (See Figure VIII-1 for the location of Crows Landing.) Figures VIII-11 and VIII-12 provide the 73 year average monthly EC, and Figures VIII-13 and VIII-14 provide the average EC of each month in water years 1984 through 1994. Figures VIII-11 and VIII-13 show the effect of implementation of Alternatives 1 and 3 on the EC conditions at Vernalis. As expected, relative to Alternative 1, Alternative 3 results in reduced EC in months when the drainage is retained and increased EC when the drainage is released. The EC is unchanged in November and December. Sufficient dilution water from the Stanislaus River is assumed to be available at all times in this analysis; therefore, the EC objectives are always achieved at Vernalis.

Figures VIII-12 and VIII-14 show the effect of implementation of Alternative 3 on the EC conditions at Crows Landing in comparison to Alternative 1. These figures show the same EC pattern as FiguresVIII-11 and VIII-13. However, the EC at Crows Landing is significantly higher than the EC at Vernalis. There are no EC objectives on the San Joaquin River upstream of Vernalis, and there are no requirements to provide dilution water on the San Joaquin River upstream of its confluence with the Stanislaus River. Comparison of the EC at Crows Landing with the EC objectives at Vernalis indicates that, if the Vernalis objectives were adopted at Crows Landing, they would seldom be achieved. The CVRWQCB staff is presently evaluating the issue of appropriate EC objectives in the San Joaquin River.

Table VIII-7
Comparison of Reference Case Dilution Release Requirements with Limiting Cases of Elimination of Wetland and Tile Discharges, and with the Alternatives (TAF)

Description		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Tot
Alternative 1 (Reference)	avg	0	0	0	3	3	2	7	3	19	17	14	0	68
	max	0	1	13	34	35	34	78	67	102	84	60	0	-
	%	0%	1%	3%	22%	15%	11%	19%	14%	49%	56%	53%	0%	-
Elimination of Wetland Releases	avg	0	0	0	1	1	0	1	1	15	14	12	0	45
	max	0	0	4	20	22	12	32	48	93	79	56	0	-
	%	0%	0%	1%	11%	11%	5%	10%	7%	41%	44%	52%	0%	-
Difference	avg	0	0	0	2	2	2	6	2	4	3	2	0	23
Elimination of Tile Discharges	avg	0	0	0	1	1	1	2	1	11	10	6	0	33
	max	0	0	3	17	15	15	47	39	85	69	40	0	-
	%	0%	0%	1%	10%	10%	7%	11%	5%	36%	38%	36%	0%	-
Difference	Avg	0	0	0	2	2	1	5	2	8	7	8	0	35
Elimination of Wetlands and Tiles	Avg	0	0	0	0	0	0	0	1	8	8	5	0	22
	max	0	0	0	4	5	0	7	29	77	65	36	0	-
	%	0%	0%	0%	4%	3%	0%	1%	4%	30%	34%	32%	0%	-
Difference	avg	0	0	0	3	3	2	7	2	11	9	9	0	46
Alternative 2 (Wetlands Reoperation)	avg	0	0	0	3	7	0	5	3	19	17	14	0	68
	max	0	1	13	34	66	13	60	67	102	84	60	0	-
	%	0%	1%	3%	22%	16%	5%	15%	14%	49%	56%	53%	0%	-
Difference	avg	0	0	0	0	-4	2	2	0	0	0	0	0	0
Alternative 3 (Tile Reoperation)	avg	0	0	0	1	1	1	10	7	11	10	6	0	47
	max	19	1	13	17	23	33	86	111	85	69	40	1	-
	%	5%	1%	3%	10%	11%	8%	23%	19%	36%	38%	36%	1%	-
Difference	avg	0	0	0	2	2	1	-3	-4	8	7	8	0	21
Alternative 4 (Wetlands and Tile)	avg	0	0	0	1	2	1	9	7	11	10	6	0	47
	max	19	1	13	17	61	15	86	111	85	69	40	1	-
	%	5%	1%	3%	10%	12%	7%	22%	19%	36%	38%	36%	1%	-
Difference	avg	0	0	0	2	1	1	-2	-4	8	7	8	0	21

Notes: (1) % refers to the percent of months in which dilution water is required to meet the Vernalis objectives.
(2) The row labeled "difference" provides the average change from Alternative 1 (reference case) in TAF. Positive values denote improved conditions and negative values denote degraded conditions.

The effect of the implementation of Alternative 3 on selenium levels was not modeled, but the monthly average concentration and the load of selenium and other trace elements in the San Joaquin River will decrease in months with restrictions on discharges and they will increase in months with allowed discharge. This effect is problematic because the CVRWQCB has adopted waste discharge requirements for the Grassland Bypass Project that set monthly load limits for selenium discharges. The CVRWQCB may have to reexamine this approach if it implements a program like Alternative 3.

4. Construction Related Effects

The specific tile drain reoperation proposed in Alternative 3 is not presently practiced in the San Joaquin Valley. Therefore, pilot studies would have to be completed before full implementation of the alternative. However, controlled drainage systems, constructed for the purpose of reducing the volume of tile drainage that leaves an irrigated area have been studied (USBR 1987, USBR 1989). The type of reoperation proposed in this report has many similarities to the controlled drainage systems evaluated by the USBR, and the analysis in this section is based on the USBR evaluations.

Controlled drainage can be accomplished by including control points in the tile line of a new system or retrofitting an existing system. Each control point in the tile laterals and submains contains a weir to control the level of water stored in the soil profile above the tile lines. A conceptual diagram of a controlled drainage system is shown in Figure VIII-15. Terminal sumps may also need to be expanded to provide short-term additional storage.

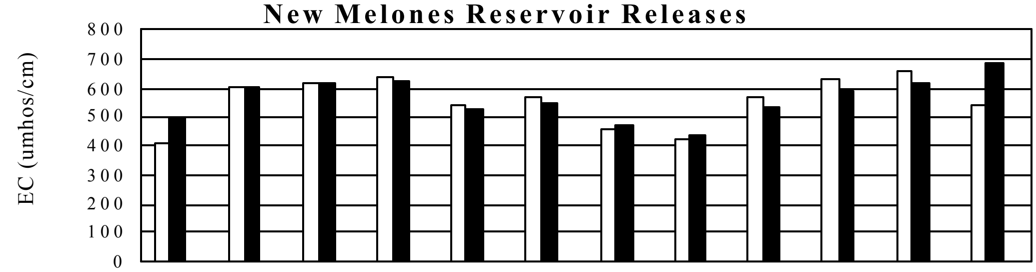
Retrofitting an existing drainage system will require construction activities. Installing a new controlled drainage system will also require construction activities; however, the type of construction activities required for a new controlled drainage system is the same as for a drainage system without any water level control features. Alternative 3 does not affect the decision of any particular individual to install a drainage system. Such a decision would be based on the water table conditions of the irrigated land. Therefore, with respect to construction-related effects, Alternative 3 could affect only existing tile drained areas.

Retrofitting tile drainage systems will take place in areas presently under cultivation. The retrofitting activities are compatible with and will have environmental effects similar to those caused by existing farming operations. Consequently, these activities will have no significant construction-related environmental effects.

The cost of retrofitting a tile drain system has also been evaluated by the USBR (USBR 1987, USBR 1989). The cost depends on site conditions and the layout of the existing system; areas with steep slopes and narrow tile spacings will have higher costs. In 1987, the estimated costs were $25 to $50 per acre for design, $12 to $90 per acre for installation of drainage control measures, and $24 to $40 per acre per year for management consulting during the first year of operation with cost reduction in succeeding years. Some indirect benefits, such as reduced water and fertilizer use due to the potential for subsurface irrigation, may offset some of the retrofitting costs.

Figure VIII-11

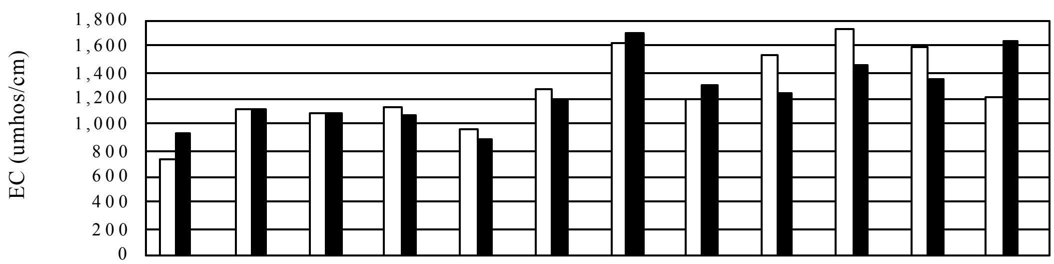
Comparison of Average EC at Vernalis After New Melones Reservoir Releases



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
□ 73-Year Period Avg.	405	601	617	640	539	568	459	424	569	630	657	539
■ Critical Period Avg	499	601	617	627	522	546	470	435	534	591	615	685
Difference	94	0	0	-13	-17	-22	11	11	-35	-39	-42	146

Figure VIII-12

Comparison of Average EC at Crows Landing



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
□ 73-Year Period Avg.	727	1,112	1,084	1,141	964	1,262	1,617	1,201	1539	1743	1592	1222
■ Critical Period Avg	947	1,112	1,084	1,070	892	1,198	1,702	1,301	1246	1457	1345	1638
Difference	220	0	0	-71	-72	-64	85	100	-293	-286	-247	416

Figure VIII-13
Comparison of Monthly Average EC at Vernalis
During Water Years 1984-1994

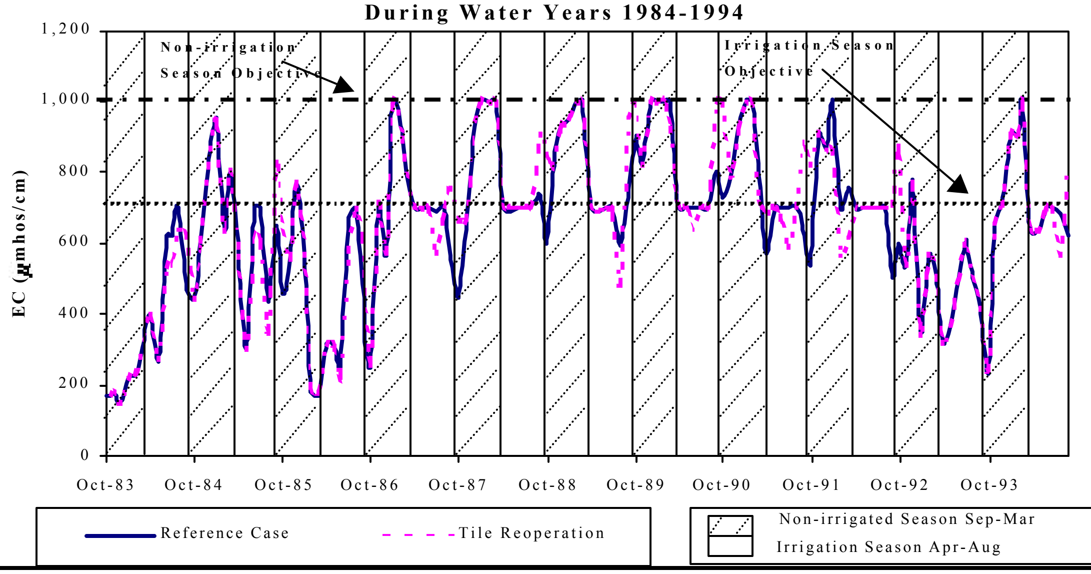


Figure VIII-14
Comparison of Monthly Average EC at Crows Landing
During Water Years 1984-1994

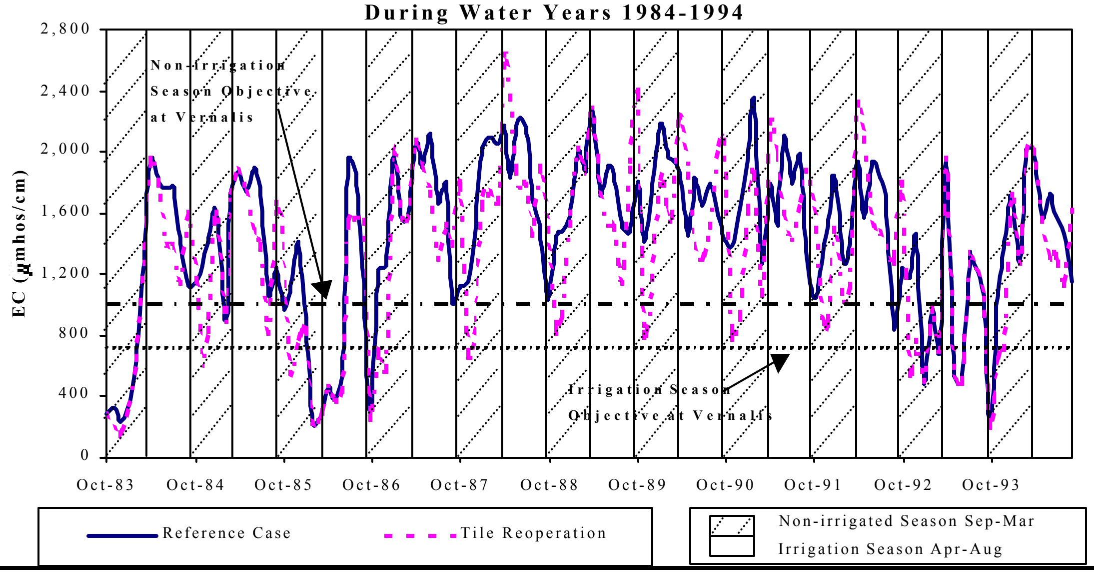
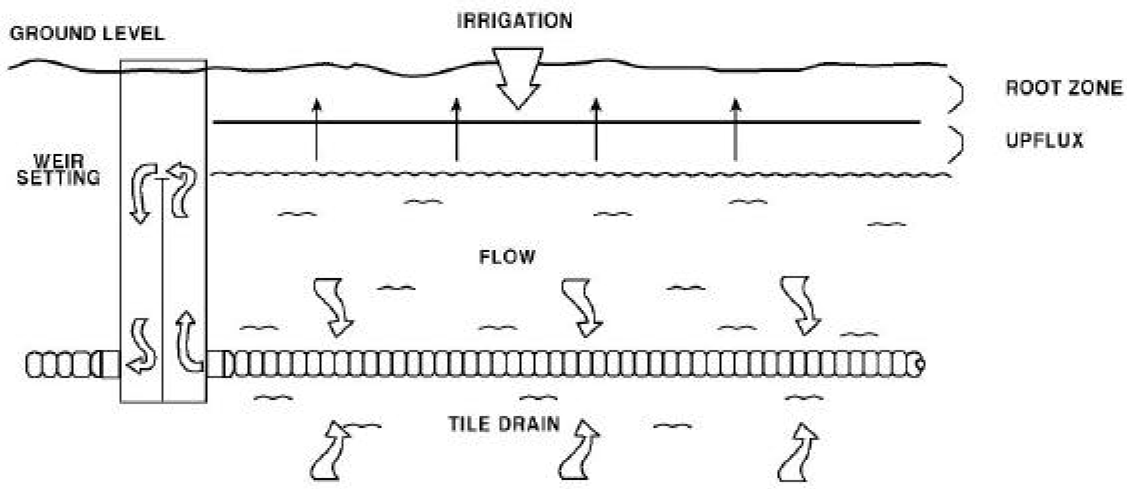


Figure VIII-15
Conceptual Operation of Controlled Drainage



The USBR reported in 1991 that the total construction cost for a new controlled drainage system over 320 acres ranged from $476 to $697 per acre, depending primarily on soil texture and tile drain spacing (USBR 1991). Generally fine-textured soils require closer drain spacing and consequently higher costs for drainage systems than do coarse textured soils. The annual operation and maintenance cost for the drainage systems was $24 per acre.

5. Crop Production

The storage of tile drainage for three months in the soil profile above tile lines and subsurface mains can affect crop production through two mechanisms: (1) the water table can rise into the root zone; and (2) salt can accumulate in the root zone.

Under most circumstances, the rising water table conditions can be controlled through monitoring and management-the costs of which are identified in the previous section. Control is more difficult on sloping lands. The rising water table can also be a resource under some conditions. The USBR studies showed controlled drainage provided 15 percent of tomato crop water requirements and 35 percent of cotton water requirements through upflux. Ground water quality, crop salt tolerance, and ground water depth limit crop water use from a shallow water table. However, for a substantial portion of this water savings to be realized, irrigation must be applied uniformly. Similar findings have been reported by Ayars (Ayars 1994, Ayars 1996). He found that irrigation depths could be reduced to make better use of the high water table created by controlled drainage. Most irrigation practices do not account for ground water contributions to crop water use. Neglecting such a contribution will result in waterlogging due to over-irrigation. Nonetheless, in order to mitigate for problems caused by a rising water table, Alternative 3 may have to allow some drainage to occur if water tables rise too high. The CVRWQCB will examine this issue if the SWRCB directs further evaluation of this alternative.

Under some circumstances, the potential salt accumulation problems can also be controlled through monitoring and management. Controlled drainage can limit the leaching process and may contribute to soil salinity build up and reduced crop productivity. However, Alternative 3, as formulated, allows drainage to be discharged for at least six months of the year, and this level of drainage can help maintain a salt balance. This issue will have to be evaluated further by the CVRWQCB if the SWRCB directs further evaluation of this alternative.

In summary, a controlled drainage system requires careful monitoring and management to be successful. The costs of this effort are identified in the previous section and will have to be considered as part of any decision to implement this alternative.

Literature Cited in Chapter VIII

AWSC. 1996. The Memorandum of Understanding Regarding Efficient Water Management by Agricultural Water Suppliers in California. November 13, 1996.

Ayars, J.E. and D.W. Meek. 1994. Drainage Load-Flow Relationships in Arid Irrigated Areas. Transactions of the ASAE. 37:431-437.

Ayars, J.E. 1994. Managing Drainage Systems in Arid Irrigated Areas. Proceedings of the Fifteenth International Exposition & Technical Conference. Atlanta, Georgia. November 5-8, 1994.

Ayars, J E. 1996. Alternatives for Managing Shallow Ground Water in Arid Irrigated Areas. North American Water and Environmental Congress. ASCE.

Ayars, J.E., et al. 1996. Shallow Ground Water Management Project by J.E. Ayars, USDA-ARS Water Management Research Laboratory, DWR and SWRCB, December 1996.

CALFED. 1998. CALFED Bay-Delta Program, Revised Phase II Report. December 1998.

Cal Poly 1994. Grassland Basin Irrigation and Drainage Study, Volume 1 - Final Report, Prepared by Cal Poly, San Luis Obispo, for the Central Valley RWQCB.

CVRWQCB. 1989a. Hydrology Study of Salt Slough, Merced County, Central Valley RWQCB, February 1989.

CVRWQCB. 1989b. Hydrology Study of Mud Slough (North), Merced County, Central Valley RWQCB, February 1989.

CVRWQCB. 1994. Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins, Third Edition 1994 and All Subsequent Amendments.

CVRWQCB. 1996. Staff Report: Amendments of the Water Quality Control Plan for The Sacramento River and San Joaquin River Basins, Policy for Obtaining Salt Balance in the San Joaquin Valley, October 22, 1996.

DWRSIM. 1997. Study SWRCB 469

Grober et al. 1995. Water Quality Impact of Wetlands on San Joaquin River, California, by L.F. Grober, J. Koroski, and T. Poole, AWRA Versatility of Wetland in the Agricultural Landscape, Proceedings of ASAE/AWRA, Tampa Florida, September 17-20, 1995.

Grober. 1996. A Memorandum Regarding Vernalis Salt Load/ USBR-SDWA Report Review, by Les Grober of CVRWQCB, December 23, 1996.

Grober. 1997. SJRIO Wetland Discharge and Tile Drainage Reoperation Studies, Staff Report of the CVRWQCB, October 1997.

IDP. 1979. Agricultural Drainage and Salt Management in the San Joaquin Valley, Final Report and Appendices.

Orlob G.T. 1991. San Joaquin Salt Balance Problem in The Economics and Management of Water and Drainage in Agriculture, Aerial Diner and David Zilberman, Editors. Boston: Kluwer Academic Publishers.

SJRMP 1995. San Joaquin River Management Plan, February 1995 by the AB 3603 Advisory Council for the California Resources Agency.

SJVDP. 1990. A Management Plan for Agricultural Subsurface Drainage and Related Problems on the West Side of the San Joaquin valley by Federal and State Agencies, September 1990.

SWRCB. 1985. Order WQ 85-1 Regarding Cleanup and Abatement of Kesterson Reservoir, 1985.

SWRCB. 1987. Regulation of Agricultural Drainage in the San Joaquin River (including appendices A-J). State Water Resources Control Board. August 1987.

SWRCB. 1995. Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, 95-1WR, May 1995.

SRDWA et al. 1965. Water Quality Criteria Agreement Among Sacramento River and Delta Water Users Association, San Joaquin Water Rights Committee, DWR, and USBR, November 19, 1965.

Tanji, K.K. 1991. Paper Entitled 'Saline Drain Water Reuse in Agroforestry Systems' by K.K. Tanji and F.F. Karajeh, University of California; and Presented at ASCE Irrigation and Drainage National Conference, Honolulu, HI, 1991.

USBR and SDWA. 1980. Effects of CVP Upon the Southern Delta Water Supply, Sacramento-San Joaquin River Delta, California, June 1980.

USBR 1987 & 1989. San Joaquin Valley Drainage Program, Study of Innovative Techniques to Reduce Subsurface Drainage Flows, Phase I, II, and III Reports, by J. M. Lord

USBR 1991. San Luis Unit Drainage Program - Detailed Options Descriptions by USBR, April 1991.

USBR. 1996. Land Retirement Program Interim Guidelines, Central Valley Project Improvement Act, December 1996.

CHAPTER IX. ENVIRONMENTAL EFFECTS OF IMPLEMENTING SOUTHERN DELTA SALINITY ALTERNATIVES (OTHER THAN VERNALIS)

The 1995 Bay/Delta Plan (SWRCB 1995a) contains salinity objectives for the protection of agricultural beneficial uses of water in the channels of the southern Delta. This chapter describes three alternatives for achieving the southern Delta salinity objectives and discusses the environmental effects of implementing the alternatives. The chapter is divided into the following sections: (A) background, (B) alternatives for implementing the objectives, and (C) environmental impacts of the alternatives.

A. BACKGROUND

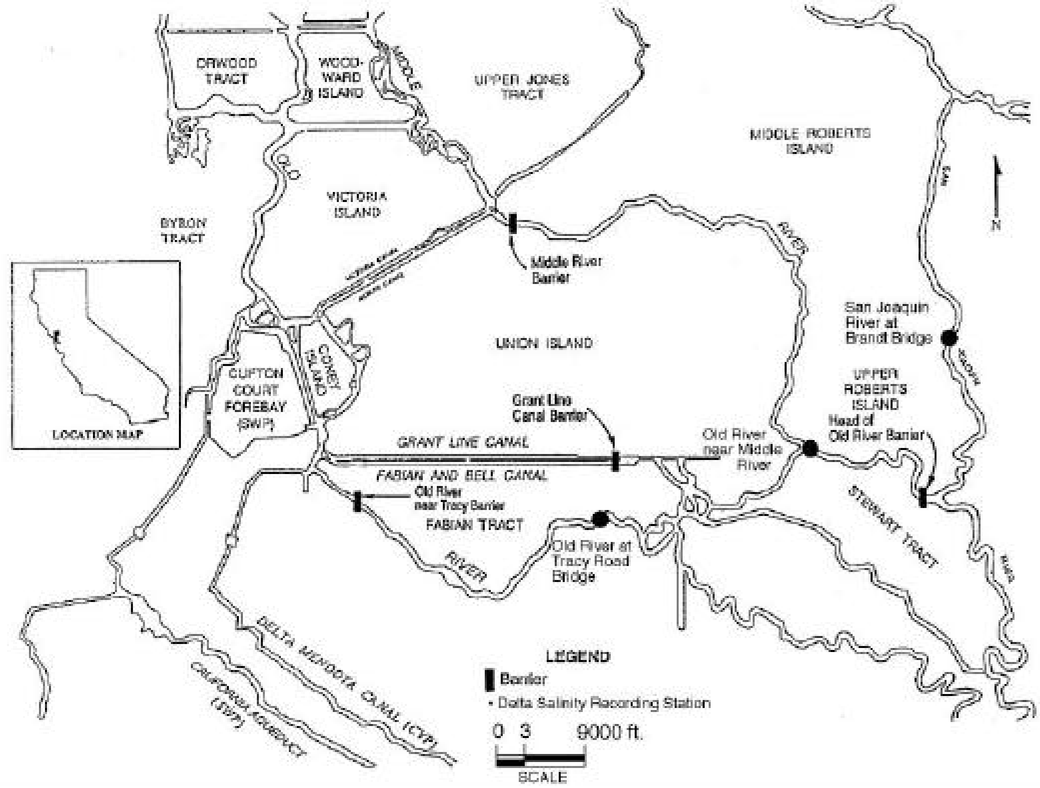
The southern Delta area generally encompasses the lands and channels of the Delta southwest of Stockton (Figure IX-1). Of its 150,000 acres, 120,000 acres are used for irrigated agriculture. The remainder consists of waterways, berms, channel islands, levees, and lands devoted to homes and industries. About 450,000 acre-feet of water are diverted from the 75 miles of southern Delta channels each year to irrigate the fully developed and highly productive agricultural land. In addition to the local agricultural diversions, the area includes the SWP and CVP pumping facilities and the intake to Contra Costa Water District's Los Vaqueros Project. For more detail, see the discussion in Chapter III - Environmental Setting.

Water conditions in the southern Delta are influenced by San Joaquin River inflow; tidal action; SWP, CVP, and local pump diversions; agricultural return flows; channel capacity; and upstream development. Tidal action and Delta outflow work to create a long and gradual salinity gradient from the Pacific Ocean into the Delta (DWR 1995A). Salinity control is necessary because the Delta is contiguous with the ocean, and its channels are at sea level. Unless repelled by continuous seaward flow of fresh water, seawater will advance up the Estuary into the Delta and degrade water quality (SWRCB 1995b).

The extent of salinity intrusion into the Delta is determined by the relative magnitude of the opposing forces of tidal action and Delta outflow (SWRCB 1978b). During the winter and early spring, flows through the Delta are usually above the minimum required to control salinity. When Delta inflow is low, however, salt water tends to move inland from the ocean, which can cause problems for agricultural diverters within the southern Delta. Agricultural crops are sensitive to salt, and increases in salinity of applied water can be detrimental to crop production.

The southern Delta has a long history of water quality problems. By 1905, streamflow, always low during the summer, was significantly depleted by the diversion of water for irrigation. Water was first applied to the land along the Merced River in 1852, and by 1870, so much water was being taken from the San Joaquin River and its tributaries that streamflow was noticeably reduced. Because it had less rainfall than the Sacramento Valley, agricultural development in the San Joaquin Valley depended heavily on irrigation. As a result, virtually the entire summer flow of the San Joaquin River was appropriated, and had it not been for the return of some water applied to but not used by crops, the river might have been entirely dry (Jackson and Paterson 1977).

Figure IX-1
Southern Delta Area



At present, salinity problems occur mainly during years of below normal runoff. In the southeastern Delta, these problems are largely associated with the high concentrations of salts carried by the San Joaquin River into the Delta. Operation of the SWP and CVP pumping plants near Tracy draws higher quality Sacramento River water across the Delta and restricts the low quality area in the southern Delta to the southeast corner (SWRCB 1995b).

Land-derived salts and local agricultural return flows further impact water quality. Irrigation practices concentrate the salts of the applied water, and the irrigation drainage in the channels degrades the channel water accordingly. In major channels that carry large flows, local diversions and discharges generally exert only moderate influences on flow and quality, but in the shallow, low capacity channels common in the southern Delta, diversions from the channel can begin to equal or exceed the flows entering the channel at the upstream end. At times, local saline discharges do not move downstream and out of the area but instead become trapped and concentrated in "null zones" of zero flow. This, in turn, can result in water quality degradation irrespective of how fresh the water flowing into the Delta may be.

During heavy irrigation periods, the agricultural drainage can be reapplied to the land several times, further concentrating the salts and degrading water quality.

1. Regulatory History

The SWRCB established water quality objectives for the protection of beneficial uses through a series of water quality control plans and water right decisions. The following is a brief summary of the plans and decisions as they pertain to southern Delta objectives.

a. **D-1275**. D-1275 approved permits for operation of the SWP. D-1275 conditioned the permits with water quality criteria contained in Exhibit A of Exhibit 17 submitted by the Sacramento River and Delta Water Association insofar as the criteria did not conflict with other terms in the permits. Exhibit 17 is an agreement dated November 19, 1965 between the State of California and Sacramento River and Delta Water Association, Delta Water Users Association, San Joaquin County Flood Control and Water Users Conservation District, and John A. Wilson. Among other provisions, the agreement established water quality criteria at several locations in the Delta, including Old River at Clifton Court in the southern Delta. The criteria called for a mean daily total dissolved solids (TDS) of 700 ppm or less for any 10 consecutive days, a mean monthly TDS of 500 ppm or less for any calendar month, and a mean annual TDS of 450 ppm or less for any calendar year. However, under dry water-year conditions, TDS criteria were increased to 800, 600, and 500 ppm, respectively. Upon construction and operation of the Peripheral Canal, the same criteria were to apply at the bifurcation of Old and Middle rivers.

b. **D-1422**. In 1973, the SWRCB adopted D-1422, which approved the USBR's water right applications to appropriate water from the Stanislaus River at New Melones Reservoir for power generation, preservation and enhancement of fish and wildlife, recreation, and water quality control. D-1422 requires the USBR to release water to maintain a mean monthly TDS of 500 ppm or less in the San Joaquin River at Vernalis.

c. **The 1978 Bay/Delta Plan and D-1485**. The 1978 Bay/Delta Plan included salinity objectives at four southern Delta stations (San Joaquin River at Vernalis; Old River near Middle River; Old River at Tracy Road Bridge; and San Joaquin River at Brandt Bridge) for the protection of agricultural beneficial uses. With the adoption of the 1978 Bay/Delta Plan, objectives were expressed in terms of electrical conductivity (EC). While total dissolved solids and chloride ion concentration had been employed traditionally as measures of Delta water quality, electrical conductivity is more closely related to osmotic pressure (to which the plant responds) than other measures of salinity.

The approach used in developing the agricultural standards involved a determination of the water quality needs of significant crops. The University of California Guidelines provide equations for determining the maximum salinity of the applied water that provides a 100 percent yield of specific crops. Beans and alfalfa, the two most widely grown salt-sensitive crops in the southern Delta, were chosen as target crops for the purpose of setting the southern Delta objectives. Meeting the objectives for bean and alfalfa crops would also protect the less salt-sensitive crops. An applied water quality of 0.7 mmhos EC at the monitoring stations in the southern Delta protected beans during the summer irrigation season (April through August), and the objective of 1.0 mmhos/cm EC protected alfalfa during the winter irrigation season (September through March) (SWRCB 1978a).

The SWRCB was of the opinion that the most practical solution for long-term protection of southern Delta agriculture was the construction of physical facilities to provide adequate circulation and substitute supplies, but negotiations concerning these facilities were underway at the time D-1485 was under consideration, and the facilities had not been constructed. Therefore, D-1485 did not allocate responsibility for the EC objectives contained in the 1978 Bay/Delta Plan. The Plan included the note: "If contracts to ensure such facilities and water supplies are not executed by January 1, 1980, the Board will take appropriate enforcement actions to prevent encroachment on riparian rights in the southern Delta." D-1485 contains a similar statement. Contracts were not executed, but the South Delta Water Agency (SDWA) asked the SWRCB to delay taking action.

d. 1991 Bay/Delta Plan. The SWRCB did not change the southern Delta objectives for the protection of agricultural beneficial uses when it adopted the 1991 Bay/Delta Plan. However, because of on-going negotiations among the DWR, USBR, and SDWA, the SWRCB established a staged implementation plan for the objectives, which included two interim stages and a final stage.

Interim Stage 1. (to be implemented upon adoption of the 1991 Bay/Delta Plan) The mean monthly TDS was limited to 500 ppm at Vernalis.

Interim Stage 2. (to be implemented no later than 1994) The 30-day average EC objectives of 0.7 mmhos/cm between April 1 and August 31 and 1.0 mmhos/cm EC between September 1 and March 31 were to apply at two locations (Vernalis and Brandt Bridge stations) for all year types.

Final Stage. (to be implemented no later than 1996) The 30-day average EC objectives of 0.7 mmhos/cm between April 1 and August 31 and 1.0 mmhos/cm EC between September 1 and March 31 were to apply at four locations (Vernalis, Brandt Bridge, Old River near Middle River, and Old River at Tracy Road Bridge) for all year-types.

The 1991 Bay/Delta Plan also stated that "if a three-party contract has been implemented among the DWR, USBR, and SDWA, that contract will be reviewed prior to implementation of the above and, after also considering the needs of other beneficial uses, revisions will be made to the objectives and compliance/monitoring locations noted, as appropriate."

e. 1995 Bay/Delta Plan. The 1995 Bay/Delta Plan objectives in the southern Delta for agricultural beneficial uses were unchanged from the 1991 Plan except that the effective date of the objectives on Old River was extended from January 1, 1996 to December 31, 1997. The 1995 Bay/Delta Plan includes the same condition as the 1991 Bay/Delta Plan regarding review of the objectives upon execution of a three-party agreement.

f. **Order WR 95-6**. On June 8, 1995, the SWRCB adopted Order WR 95-6, which temporarily makes the existing water rights of the SWP and the CVP consistent with their meeting the 1995 Bay/Delta Plan. This action allows the SWP and the CVP to operate their facilities in accordance with the 1995 Bay/Delta Plan while the SWRCB prepares a long-term water right decision to implement the plan. Among other provisions, Order WR 95-6 requires the USBR to release conserved water from New Melones Reservoir to comply with 1995 Bay/Delta Plan salinity objectives at Vernalis. The order was to expire on December 31, 1998 or upon adoption by the SWRCB of a long-term water right decision implementing the 1995 Bay/Delta Plan.

g. **Order WR 98-9**.On December 3, 1998, the SWRCB adopted Order WR 98-9 which continued the temporary terms and conditions set forth in Order WR 95-6. Order 98-9 added new temporary conditions to the water rights of the SWP and the CVP. The order expires on December 31, 1999 or upon adoption by the SWRCB of a long-term water right decision implementing the 1995 Bay/Delta Plan.

h. **Regional Water Quality Control Board (RWQCB) Basin Plans**. Each of the RWQCBs has adopted regional water quality control plans. The southern Delta is included in the basin plan for the Sacramento-San Joaquin Delta Basin (Basin 5B Plan), adopted by the Central Valley RWQCB. The 1995 revision of the Basin 5B Plan incorporates the southern Delta salinity objectives found in the 1991 Bay/Delta Plan. Further revisions of the Basin 5B Plan regarding San Joaquin River salinity are being evaluated and this process is expected to be completed in December 1999. In the event of any conflict, the objectives adopted by the SWRCB supersede objectives adopted by the RWQCBs.

2. Historical Salinity Conditions in the Southern Delta

Figures IX-2 through IX-4 depict recent salinity conditions for each of the three southern Delta stations listed in the 1995 Bay/Delta Plan (see Figure IX-1 for locations of EC monitoring stations). The EC limit, first introduced in the 1978 Plan and retained in the 1995 Bay/Delta Plan, is also shown on each plot--700 µmhos/cm during April through August and 1000 µmhos/cm during September through March. The plots show that the objectives are frequently exceeded at all three of the stations listed in the 1991 and 1995 plans.

Water quality patterns appear to follow the same trends from one location to another, but in general, EC data at Tracy Road Bridge are higher than data recorded at Old River near Middle River, which are in turn higher than Brandt Bridge data, for any given year. That is, the limits are exceeded more severely the further the station is from San Joaquin River inflows. Not surprisingly, years with more precipitation (1986 and 1993) correspond with lower EC levels at all three stations.

3. Existing Salinity Management Programs in the Southern Delta

Salinity management programs have been initiated to improve salinity conditions in the San Joaquin River and the southern Delta. A discussion of the programs that could affect salinity at Vernalis can be found in Chapter VIII; salinity management programs within the southern Delta are discussed below.

The SDWA represents the agricultural diverters within the southern Delta. In July 1982, the SDWA filed a lawsuit concerning the effects of SWP and CVP operations on the southern Delta. The suit sought a declaration of the rights of the parties, a preliminary injunction, and a permanent injunction requiring that the projects be operated to protect the southern Delta. Since 1985, there has been an on-going effort, via temporary measures, to resolve water level and circulation problems in the southern Delta.

In October 1986, a framework agreement among the DWR, USBR, and SDWA committed the parties to work together to develop a mutually acceptable, long-term solution to the water supply problems of SDWA water users. In 1990, the parties agreed to a draft settlement which contained short-term and long-term actions to resolve the water supply problems in the southern Delta. The settlement provided for interim releases by the USBR from New Melones Reservoir to resolve the portion of the litigation relating to San Joaquin River flows, and it set forth the framework for the USBR and SDWA to negotiate an amendment to the agreement. A more recent draft contract has been proposed to resolve the portion of the SDWA's lawsuit relating to the effects of CVP and SWP export pumps and operations on water levels within SDWA channels. The SDWA has approved the contract, the DWR expects to obtain authority to sign, and the USBR is currently seeking authorization from Congress to sign.

As a result of the litigation and framework agreement, the DWR took the following steps to partially relieve the problem in certain channels: (1) Tom Paine Slough was dredged and siphons were installed to improve the water level in the slough; (2) the Temporary Barriers Project was initiated to test and construct barrier facilities in southern Delta channels for the purpose of improving channel water levels and water quality within SDWA boundaries; and (3) the South Delta Water Management Program (SDWMP) was initiated to bring permanent improvements to the area. In June 1990, a draft EIR/EIS for the SDWMP was released for public review; however, the draft was not finalized due to the controversy surrounding a variety of unresolved Delta issues.

a. Temporary Barriers Project. The purpose of the draft contract among the DWR, USBR, and SDWA was, in part, to provide for the design, construction, operation, testing, and evaluation of barrier facilities to afford the SDWA an adequate agricultural water supply. The barriers testing program, referred to as the South Delta Temporary Barriers Project, was initiated in 1991. Its objectives are the short-term improvement of water conditions for the southern Delta and the development of data for the design of permanent barriers. The project involves the seasonal installation of four barriers: one in Middle River, two in Old River, and one in Grant Line Canal. Three of the barriers are designed to improve water levels and circulation for agricultural diversions, and they are to be in place during the growing season.

Figure IX-2
Actual average monthly water quality for San Joaquin River at Brandt Bridge Station for WY 1985-1993

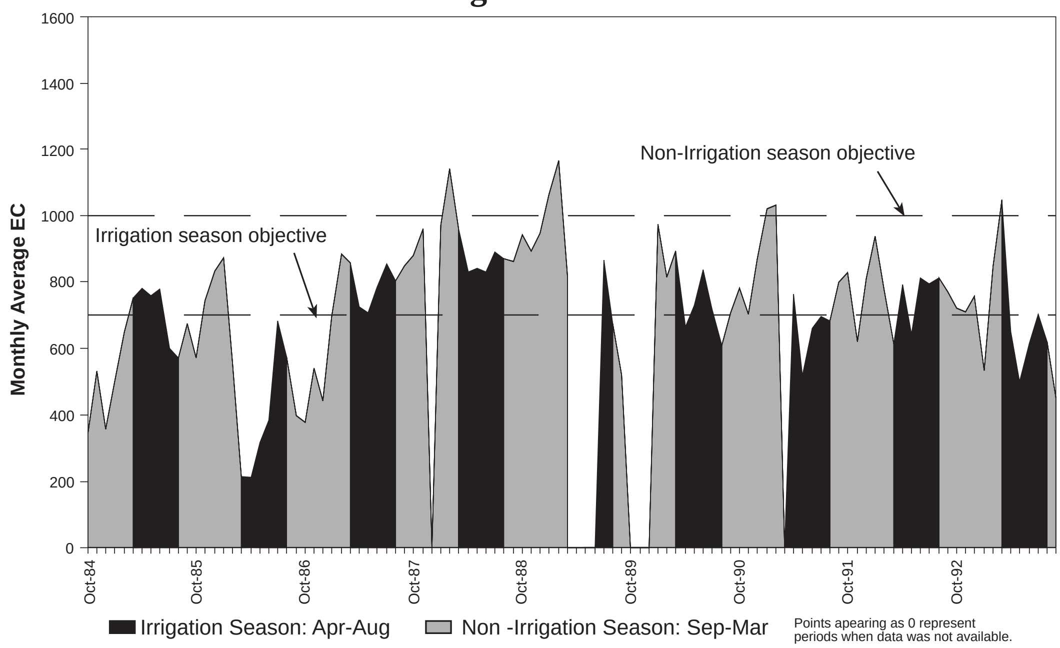


Figure IX-3
Actual average monthly water quality for Old River at Tracy Road Bridge Station for WY 1984-1992

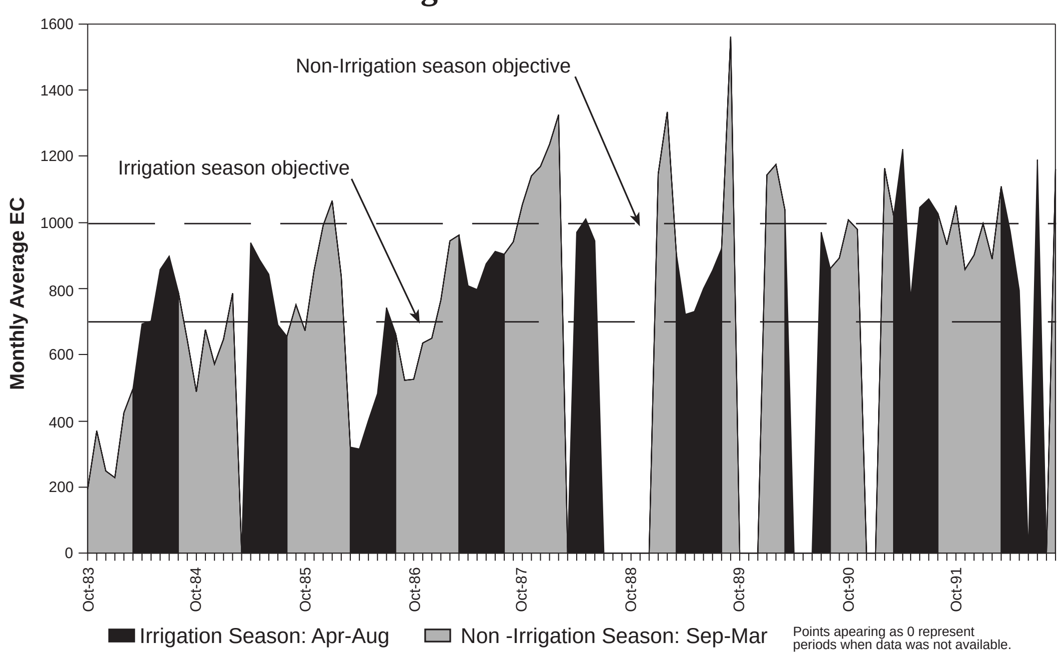
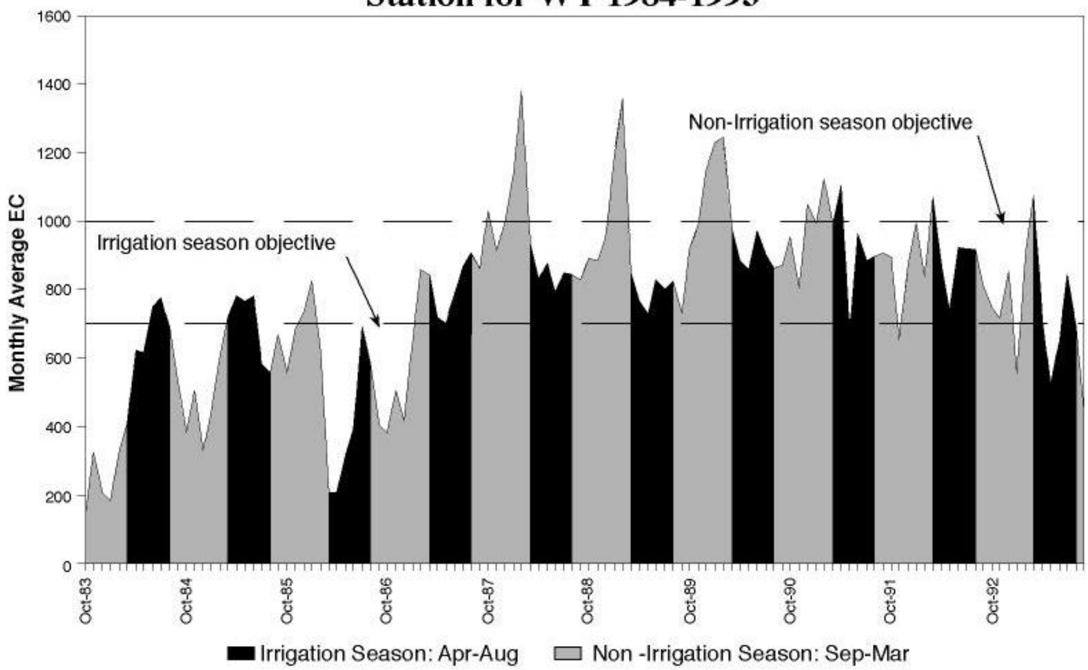


Figure IX-4
Actual average monthly water quality for Union Island Station for WY 1984-1993



Of those, the temporary barrier on Middle River was installed every year beginning in 1987; and the temporary barrier in Old River near Tracy, east of the Delta-Mendota Canal, was installed for various periods every year since 1991. The barrier in Grant Line Canal was installed for the first time in 1996. The fourth barrier, at the head of Old River at San Joaquin River, is designed to assist fish migration on the San Joaquin River. This barrier has been installed intermittently during the fall since 1963 to improve flow and dissolved oxygen conditions in the lower San Joaquin River, principally for the benefit of adult fall-run chinook salmon migrating to upstream spawning locations. As part of the Temporary Barriers Project, it was also installed during the spring in 1992, 1994, and 1997 to assist outmigrating salmon smolts, but it was not installed in 1993, 1995, or 1999 and only briefly in 1996, due to high San Joaquin River flows and/or concerns regarding Delta smelt.

The DWR and USBR proposed the installation of permanent barriers through the Interim South Delta Program (ISDP) to improve water levels and circulation in the southern Delta. The barriers were to be designed and operated based on information developed by the Temporary Barriers Project. In May 1999 the ISDP was rolled into the CALFED South Delta Improvements Program (SDIP). A revised CALFED Draft EIS/EIR was issued in June 1999, and a Final EIS/EIR is expected by summer, 2000. The CALFED document contains a programmatic discussion of the SDIP. A project-specific EIS/EIR for the SDIP will follow release of the CALFED's Final EIS/EIR and prior to implementation of the ISDP/SDIP. Consequently discussion in this chapter regarding southern delta salinity improvements is subject to change.

b. **ISDP**. The purpose of the ISDP was to: (1) improve water levels and circulation in the southern Delta for local agricultural diversions; and (2) improve southern Delta hydraulic conditions to increase diversions into Clifton Court Forebay to maximize the frequency of full pumping capability at DWR's Banks Pumping Plant. The program is consistent with a number of recent State and federal policies and laws. In l992, Governor Pete Wilson issued a water policy statement, declaring that "the Delta is broken" and that "we need to take immediate interim actions in the southern Delta that will help restore the environment and improve the water supply." Also in 1992, the CVPIA was approved. Section 3406(b)(15) of this law directs the Secretary of Interior to "construct...a barrier at the head of Old River...to increase the survival of young out-migrating salmon...in a manner that does not significantly impair the ability of local entities to divert water" (CVPIA 1992). More recently, on December 15, 1994, officials of several State and federal agencies, and some stakeholders, signed the Principles Agreement, a plan for the protection of the Bay Delta Estuary. One of the elements in the Principles Agreement is to install a barrier at the head of Old River to protect San Joaquin River salmon during April and May of all water year types. The DWR and the USBR released a draft EIR/EIS for the ISDP on August 19, 1996. The draft EIR/EIS analyzes the effects of eight alternatives. The ISDP preferred alternative is comprised of channel dredging, the construction of a new intake to Clifton Court Forebay, a fish barrier, and three agricultural flow control structures, as discussed below (see Figure IX-1 for locations of ISDP project components).

The ISDP preferred alternative would result in approximately 1.25 million cubic yards of material being dredged from a 4.9-mile reach of Old River to increase the channel capacity north of the new intake. The proposed intake would be operated either in conjunction with, or independent of, the existing intake, depending on water quality, specific tidal conditions, the amount of water to be diverted into the forebay, and other factors. Together, the channel dredging and the new intake would facilitate diversions from the Delta in amounts that would support the full pumping capacity of 10,300 cfs at Banks Pumping Plant. Channel modification would require a permit from the U.S. Army Corps of Engineers (USCOE).

A permanent barrier would be constructed at the head of Old River near its confluence with the San Joaquin River, and would be operated only during the spring and fall each year. During the rest of the year, the gates would remain fully raised. The barrier would improve dissolved oxygen levels in the fall along the portion of the San Joaquin River from its confluence with Old River downstream to the Port of Stockton, and it would enhance the survival of migrating San Joaquin River salmon smolts by lessening the chances of exposure to the influences of project and local diversions during the spring.

Agricultural flow control structures would improve water levels and circulation in the southern Delta by "tidal pumping." The radial gates would be raised to allow uni-directional flow into the channels upstream of the barriers during incoming tides (flood tide) and lowered to impede water movement out of these areas during outgoing tides (ebb tide). These operations would retain flood tide flows in southern Delta channels for a longer period of time to raise water levels.

Permanent flow control structures were originally proposed for three locations. The Middle River structure would be located on Middle River, near the confluence of Middle River, North Canal, Victoria Canal and Trapper Slough, approximately 13 miles east of Stockton. This barrier would consist of two radial gates housed in a reinforced concrete gate bay structure and a boat ramp. The boat ramp would be used to transfer boats and people across the structure. The Grant Line Canal and Old River flow control structures are very similar in design. However, the ISDP/SDIP is presently evaluating the option of not including a barrier on Grant Line canal. The Old River structure, east of the Delta Mendota Canal, is approximately 4,000 feet southeast of the intersection of the Alameda, Contra Costa, and San Joaquin county lines. The two barriers would consist of concrete control structures with radial gates. A 50-foot-wide by 105-foot-long boat lock would also be included in each structure. All of the flow control structures would be operated only during the agricultural irrigation season (April to September) to increase flows from the northwest direction to the southeast direction (DWR and USBR 1996).

B. ALTERNATIVES FOR IMPLEMENTING SOUTHERN DELTA SALINITY OBJECTIVES IN THE 1995 BAY/DELTA PLAN

There are two general categories of alternatives for implementing the southern Delta salinity objectives: (1) actions to improve the salinity of water entering the Delta at Vernalis and (2) water management actions within the Delta. The first category of alternatives is analyzed in Chapter VI (provision of dilution water) and Chapter VIII (salinity control actions) of this report. The second category of alternatives is analyzed in the draft EIR for the ISDP.

This chapter will analyze the effect on southern Delta salinity of both meeting the flow objectives and constructing and operating the barriers proposed in the ISDP. The analysis for construction of the barriers will be programmatic only. CALFED will need to complete an EIS/EIR on the project prior to its implementation.

As described above, shallow, low capacity channels are common in the southern Delta, and local diversions from the channels can exert a major influence on flow and quality. At times, local saline discharges do not move downstream and out of the area but instead become trapped and concentrated in "null zones" of zero flow. Facilities designed to improve southern Delta circulation can alleviate high-salinity problems associated with agricultural return flows. The flow control structures proposed in the ISDP are such facilities, and much study has gone into their development; therefore, it is reasonable to assume they represent a likely facility.

The three alternatives currently being considered to implement the southern Delta agricultural objectives in the 1995 Bay/Delta Plan are listed below.

1. Southern Delta Salinity Control Alternative 1 - Base Case

The SWP and the CVP are responsible for meeting D-1485 requirements. The CVP is responsible for meeting the D-1422 salinity objective at Vernalis. Existing temporary barriers in the southern Delta are installed and operated to improve salinity conditions in the southern Delta. No further action is taken to implement the southern Delta salinity objectives.

2. Southern Delta Salinity Control Alternative 2 - 1995 Bay/Delta Plan

The 1995 Bay/Delta Plan flow objectives are met by implementation of one of the flow objective alternatives. Existing temporary barriers in the southern Delta are installed and operated by the SWP and the CVP to improve salinity conditions in the southern Delta. No further action is taken to implement the southern Delta salinity objectives.

3. Southern Delta Salinity Control Alternative 3 - Permanent Barrier Construction

The 1995 Bay/Delta Plan flow objectives are met by implementation of one of the flow objective alternatives. The barriers proposed in the ISDP preferred alternative are constructed and operated by the SWP and CVP to achieve the southern Delta salinity objectives to the extent feasible. Other elements of the ISDP not necessary to support barrier operation are not constructed.

These three alternatives were modeled for the entire 73-year period of record. Alternatives 2 and 3 assume that the Bay/Delta Plan flow objectives are fully met. To model these two alternatives, the SWRCB used an operations study in which the objectives are being met to the extent possible by the DWR and the USBR. When necessary to meet Vernalis flow objectives, additional water is acquired from tributary sources on the San Joaquin River. This study is intended to be representative of the Delta hydrology that would result from full implementation of the objectives. In order to fully analyze the effect of different flow alternatives on Delta salinity, however, Flow Alternatives 3 through 7 are modeled for the period 1976-1992, and the results are discussed in Chapter VI of this EIR.

C. ENVIRONMENTAL IMPACTS OF THE ALTERNATIVES

This section describes the environmental impacts of the alternatives being considered to meet southern Delta salinity objectives. Implementation of the southern Delta salinity objectives is analyzed at the project level for Alternatives 1 and 2 and at the programmatic level for Alternative 3. The findings of the Draft EIR/EIS for the ISDP (DWR and USBR 1996) determined that there would be both substantial benefits and significant adverse impacts associated with implementing the ISDP, including constructing the barriers called for under Alternative 3. That document contains detailed analyses of all the ISDP's environmental impacts and lists mitigation measures to reduce the significant impacts to less than significant levels where possible. Fifteen areas of potential impact are listed and discussed in the Draft EIR/EIS for the ISDP, including:

- Aesthetics, Light, and Glare
- Air Quality
- Aquatic Resources
- Cultural Resources
- Energy
- Geological Conditions
- Hazards
- Land Use Planning
- Navigation and Transportation
- Noise
- Public Services and Utilities
- Recreation
- Socioeconomic Impacts
- Terrestrial Biological Resources
- Water Quality

For this report, the discussion is divided into the following topics: (1) impacts caused by construction; (2) impacts to water levels and water quality; (3) impacts to aquatic resources; (4) impacts to recreation; and (5) impacts to navigation. Chapter III of this draft EIR describes the existing conditions for each of these topics. Impacts under Alternative 3 are summarized from the ISDP Draft EIR/EIS, but only those impacts pertaining to the construction and operation of the fish and flow control structures are included. The impact of the barriers on dissolved oxygen levels is discussed in Chapter X of this draft EIR.

1. Impacts Caused By Construction

Under Alternatives 1 and 2, impacts will be limited to those associated with seasonal construction of temporary barriers. The DWR Division of Planning prepared an Initial Study for the Temporary Barriers Project in 1995 (DWR 1995b). As part of the ongoing environmental analysis for the Temporary Barriers Project, a USCOE jurisdictional wetland delineation survey was prepared for DWR by a consultant. DWR prepared a biological assessment required as part of the endangered species process, which discussed potential impacts of the project on listed species and species proposed for listing. At the same time, DFG staff prepared an assessment of non-endangered species including assessments of impacts of fish, wildlife, and plant community resources. The studies did not specifically identify any other significant adverse impacts due to the proposed Temporary Barrier installations. They did, however, identify some possible adverse impacts and concluded that it could not be determined that there were no significant impacts based on available data. (DWR 1995b)

Following is an evaluation of the potential consequences of barrier construction under Alternative 3. The discussion is divided into five parts: (a) water quality; (b) aquatic resources; (c) terrestrial biological resources; (d) recreation; (e) navigation; and (f) transportation.

a. Water Quality. This section summarizes the potential water quality consequences of constructing the permanent barriers under Alternative 3, as disclosed in the Draft EIR/EIS for the ISDP.

Two regulatory controls are intended to limit the consequences of the construction activities on water quality. The first is the USCOE, which implements the Rivers and Harbors Act, section 10 and the Clean Water Act, section 404. The second is the SWRCB General Construction Activity Storm Water Permit, which is required for construction activities and associated storm water discharges which occur outside USCOE jurisdiction on upland sites. Sites that are regulated by the USCOE are excluded from the Storm Water Permit process but are subject to the water quality certification requirements of the Clean Water Act, section 401. Construction of the fish and flow control structures in the southern Delta will temporarily affect water quality in southern Delta channels, increasing turbidity and flow velocities.

"Turbidity" refers to the amount of light that is scattered or absorbed by a fluid and is related to the concentration of suspended particulate matter and the amount of dissolved organic matter. Turbidity is a difficult parameter to evaluate because, in nature, it is often highly dynamic, changing rapidly in space and time. In the Delta, turbidity is highly variable, especially when produced by construction activities, and is usually due to the presence of suspended particles of silt and clay, although other materials such as finely divided organic matter, colored organic compounds, plankton, and microorganisms can contribute to turbidity.

Furthermore, turbidity measurements are often reported using a variety of noninterchangeable units. The concentration of suspended particulate matter is typically measured in milligrams per liter (mg/L), whereas light scattering or absorption is measured in Nephelometric Turbidity Units (NTU) or, to a lesser extent, in Jackson Turbidity Units (JTU). Unfortunately, different measures are used in different reports of turbidity levels injurious to fish or of turbidity levels caused by construction activities in the Delta. Turbidities expressed using one of these measures cannot be converted to turbidities using another of the measures. Because of the difficulties associated with evaluating turbidity effects, only a very approximate analysis could be made of the turbidity impacts of the project and alternatives.

The placement and removal of cofferdams to facilitate construction of the control structures, along with construction of the new levee at the Old River site, are expected to result in short-term elevated levels of turbidity. The duration and concentration of the turbidity would depend, in part, on the length of time required to place and remove the cellular cofferdams and the area of sediment disturbed. Minor sediment may also be suspended by barge activities. There would also be a brief introduction of sediment into the channels during breaching of the levees at the Old River control structure during existing levee removal; this is expected to be a short-term event. No substantial increase in suspended sediment is expected during removal of the cofferdams, particularly at the Middle River control structure where construction specifies that cofferdams be cut off at the selected invert depth. Also, the area affected would be minimized using silt curtains.

Based on turbidity increases observed during the Temporary Barriers Program, construction of the permanent structure should not produce significant turbidity. The method of installing the present temporary barriers causes a relatively small increase of 20 to 40 NTU which is considered to be a less-than-significant adverse impact.

Since construction would block half the channel with sheet-pile coffer dams, velocities would increase in the vicinity of the construction area. Since the channel restriction will lead to some flow being routed down the San Joaquin River, water velocities may increase by approximately 50 percent. Velocities are not anticipated to reach values of concern for scouring. These are considered to be less-than-significant adverse impacts.

No significant water quality impacts from the construction of the southern Delta barriers are identified. Therefore, no mitigation is required.

b. **Aquatic Resources**. Construction of the barriers would likely have short-term effects upon aquatic resources. This section summarizes the impacts to aquatic resources caused by constructing the barriers, as disclosed in the Draft EIR/EIS for the ISDP.

The assessment of construction impacts focuses mostly on qualitatively identifying impacts, because useful quantitative data for the affected area are limited. Ecological literature concerning the effects of turbidity, burial, direct removal of organisms and habitat, and alteration of aquatic habitat on aquatic organisms was reviewed and compared to expected background turbidity levels in the Delta, expected turbidity levels associated with construction activities, and estimated amount of aquatic habitat losses resulting from the proposed construction activities.

Potential construction impacts include effects of turbidity, burial, direct removal and alteration of aquatic habitat, and removal of organisms, and would potentially result in loss of aquatic organisms and their habitat. This section summarizes the effects of the proposed construction of the control structures by impact type as disclosed in the ISDP Draft EIR/EIS, and discusses their significance based on criteria from CEQA Guidelines, the Clean Water Act, and NEPA regulations.

Turbidity. Depending upon season, suspended sediment concentrations in Delta channels range up to 1,000 mg. Placement and removal of cellular cofferdams at the fish barrier located at the Head of Old River and at the flow control structures located at Middle

River, Grant Line Canal, and Old River would cause an increase in light attenuation and reduction of water clarity, and would affect plankton, benthic invertebrates, and fish.

Phytoplankton and zooplankton are important food sources for many organisms, including the early life stages of most fish species. Phytoplankton growth is dependent on light; where light has been limiting, growth and production by phytoplankton may be reduced locally. Low levels of turbidity, however, may improve phytoplankton production in areas where nutrients are limiting if suspended material contains and releases the limiting nutrients.

Prolonged periods of relatively high turbidity levels (primarily suspended particulate matter) can lead to a measurable reduction in the number of species of benthic invertebrates that settle and develop in affected communities. Eggs and larvae of some bivalve species develop abnormally when silt levels are high. Organisms that can protect themselves from turbid flows may survive temporarily. For example, bivalve mollusks can close organs that circulate water through their system, and polychaetes and some crustaceans can burrow into the sediment to avoid turbidity temporarily. Delta invertebrates that would be affected include amphipods and isopods, which provide food for fish.

High concentrations of suspended sediment may adversely affect fish and their eggs. The most important factors determining the lethal concentration of suspended solids to fish include the species and age of the fish, the type of particulate matter, the time of exposure, and the size distribution of the particles. A high concentration of smaller-sized particles is more likely to cause gill clogging and asphyxia than a similar concentration of larger particles.

The expected turbidity levels caused by dredging and construction activities would affect fish that are in areas near the proposed dredging operations. Potential effects of high concentrations of suspended particulate matter on fish include unsuccessful development of fish eggs and larvae; reduced availability of food; reduced feeding efficiency; reduced growth rate and resistance to disease; alteration of fish migrations; exposure to toxic sediments released into the water column; and direct mortality.

Turbidities as low as 1,000 mg/l may negatively affect fish eggs of some species. Although fish eggs and larvae may be adversely affected by turbidity increases, embryos of some fish species are tolerant of relatively high-suspended particle concentrations. No detectable effect on hatching success was found for embryos of yellow perch, white perch, striped bass, and alewife exposed to concentrations of suspended material up to 500 mg/l. Eggs and embryos of Delta fish species may be affected differently because actual turbidity levels resulting from construction activities in the Delta may be higher than 500 mg/l.

Turbidity can affect feeding efficiency. According to studies, several fish species appear to prefer turbid over clear water during early life, so increased turbidity resulting from increased suspended sediments may attract some fish species to construction areas where elevated turbidity levels are expected. Other fish species, however, avoid cloudy water. Striped bass larvae feeding on natural prey consumed similar quantities of zooplankton at turbidity levels between 0 and 75 mg/l, but 40 percent fewer prey were consumed in suspended solids concentrations of 200 and 500 mg/l. Juvenile chinook salmon foraging rates (for surface and benthic prey) were low in clear water and higher at intermediate turbidity levels (35 to 150 NTU). In contrast, turbidity levels influenced the reactive distance at which largemouth bass noticed prey and caused reduced activity (at turbidity of 14 to 16 JTU) of juvenile largemouth bass and green sunfish. The actual turbidity (suspended particulate matter and water cloudiness) observed during construction activities in the Delta may be higher than the turbidity measurements and values reported by these investigators.

Extremely high turbidity concentrations could cause direct mortality to adult fish species. Fish species found in the Delta, such as largemouth bass, sunfish, and catfish, experienced direct mortality when exposed to turbidities exceeding 69,000 mg/l. Other Delta fish species that would be affected by increased turbidity levels include Sacramento splittail and Delta smelt. Turbidity levels observed in the Delta during construction activities may be higher than the reported turbidity values affecting fish.

As noted earlier, the impacts of turbidity on aquatic resources in the affected area are difficult to evaluate, but turbidity would be caused mostly by dredging, and dredging would be conducted when sensitive species are unlikely to inhabit the affected area. The effects would be temporary because the suspended material would settle out. Therefore, the proposed construction activities are expected to have a less-than-significant impact with respect to turbidity effects on aquatic resources.

Burial. Placement and removal of the cofferdams and construction of the new levee at the proposed Old River Flow Control Structure will also increase sedimentation; however, expected sedimentation rates have not been estimated. Increased sedimentation results in the burial of aquatic vegetation, less mobile invertebrates, and benthic fish eggs and larvae in the vicinity of construction activities. Benthic fish eggs and larvae are those found near the bottom of the water column. The extent of the area affected would depend on a variety of factors such as the concentration of suspended sediment, water temperature, flow direction and strength, length of operations causing sedimentation, and tidal influences.

The rapid settling of suspended material on channel bottoms may result in smothering of benthic invertebrates and may influence invertebrate distribution. Burial may result in the complete loss of some benthic species within the affected area, followed by their recolonization of the new bottom materials. Benthic organisms, such as bacteria, protozoans, mollusks, and arthropods, represent a food source for many animals. This temporary reduction in benthic prey and degradation of habitat quality can be adverse to species that reside in or migrate through the southern Delta such as striped bass, San Joaquin River fall-run chinook salmon, and delta smelt.

Sedimentation may affect embryos of some fish species. Burial would not affect those species with no habitat in the affected area and is unlikely to affect planktonic fish embryos. Eggs and larvae of species in the southern Delta that spawn on bottom substrates such as largemouth bass, sunfish species, and catfish species, however, may be buried by rapid sedimentation and suffocated. Sacramento splittail, which attach eggs on submersed aquatic vegetation, would also be susceptible to sedimentation.

Burial effects would generally be temporary because plants and invertebrates would rapidly recolonize most of the disturbed sediments. However, the CEQA Guidelines indicate that an action is significant if "in regard to threatened or endangered species, smothering, impairment or destruction of the habitat to which the species is limited" occurs. This criterion applies directly to Delta smelt because burial would cause smothering of habitat within the federally designated limits of critical habitat for Delta smelt. Therefore, the proposed construction activities are considered to have a significant adverse impact with respect to burial of habitat and food web organisms.

Direct Removal and Habitat Alteration. Direct removal and alteration of habitat and removal of the organisms occupying the habitat would result from the removal of streambank and levees at the construction sites and the installation of riprap to protect new levees. The direct removal and alteration of habitat and removal of food web organisms in the area of the proposed construction activities would affect those fish species that reside in the southern Delta or pass through the area during migrations. These species include striped bass, splittail, and fall-run chinook salmon. Other resident fish that would be affected are largemouth bass and species of sunfish and catfish.

The construction of the fish and flow control structures would permanently alter near-shore shallow-water habitat. The near-shore vegetation and woody debris would be permanently lost, since existing levees would be removed and the new levee sections would be protected by riprap. Riprap produces lower-quality habitat for most Delta species, compared with shorelines supporting vegetation. The nearshore, shallow-water habitats are especially important because they are used by fish and invertebrates as foraging sites and as shelter and rearing habitats. This alteration of habitat could cause local reductions in the survival of those life stages of species that depend upon shoreline habitats.

The construction of the proposed Old River Fish Control Structure would result in permanent loss of about 450 feet of nearshore habitat on each side of the channel. The construction of the Middle River Flow Control Structure would result in the permanent loss of approximately 150 feet of shoreline habitat on one side of Middle River and little loss on the other side of the channel. If constructed, the Grant Line Canal Flow Control Structure would result in the loss of approximately 500 feet of shoreline habitat on each side of the canal. The construction of the Old River Flow Control Structure east of the Delta-Mendota Canal would result in the loss of about 400 feet of nearshore aquatic habitat on each side of the channel. Thus, the permanent loss of nearshore habitat resulting from construction of the fish and flow control structures would total about 2,850 feet.

Removal of aquatic organisms would occur in the same areas described for loss of aquatic habitat. Aquatic organisms, particularly benthic invertebrates and some lifestages of some fish species, will be lost when they are removed along with streambank habitat, or when they are stranded in dewatered areas behind the cofferdams. The impact of benthic invertebrate removal may be temporary, since rapid recolonization of the substrate by benthic invertebrates is expected. Some reported rates of recolonization range from about one month to 45 days in the freshwater environment, and 28 days for recolonization of dredged areas within a bay.

The quantities of habitat and organisms lost as a result of direct removal would be small relative to their total quantities in the Delta. However, despite the relatively small amount of habitat loss expected from direct removal and habitat alteration, the loss would be permanent. Furthermore, direct removal and habitat alteration would result in a permanent loss of designated critical habitat of Delta smelt. Therefore, the direct removal and alteration of habitat and the associated removal of organisms is considered to be a significant adverse impact.

Mitigation. Elimination of habitat for Delta smelt, splittail, and striped bass as a result of levee removal and installation of riprap would be reduced to less-than-significant levels by the adoption of the following mitigation measures. Agricultural and other lands in the western, central or northern portion of the Delta would be purchased by the DWR and restored to produce spawning and rearing habitat for Delta smelt, splittail, and striped bass. Acreages restored would equal or exceed the acreages of habitats adversely affected by the project. Habitats in the area affected by the proposed construction activities are now marginally suited, at best, for these species.

c. Terrestrial Biological Resources. This section summarizes the impacts to terrestrial biological resources caused by construction of the barriers under Alternative 3, as disclosed in the Draft EIR/EIS for the ISDP.

Construction of the barriers is expected to disturb the habitats adjacent to the construction sites. Expected disturbances include noise associated with grading and operation of other heavy equipment, increased truck and barge traffic, erosion and sedimentation associated with grading, and human intrusion. During the summer months, dust from grading and truck traffic on dirt roads would be expected to drift and coat adjacent vegetation and reduce the quality of these habitats for resident wildlife. Due to local farming activities, these sites currently experience noise associated with heavy equipment on a periodic basis. However, the construction activities at these sites would be expected to continue daily for prolonged periods of time. Impacts to plant and wildlife habitat could occur from the exposure of construction-related solvents, fuels, and other toxic materials including diesel, oil, gasoline, and raw concrete.

Potential adverse impacts to the following species or habitat types are considered significant:

Active Raptor Nests. Construction of the barriers could affect nesting raptors. Specific areas of concern include the following barrier sites: (1) Grant Line Canal: disturbance of two nesting Swainson's hawks and one great horned owl nest; (2) Old River: disturbance of a nesting Swainson's hawk; and (3) Middle River: disturbance of a nesting Swainson's hawk and a red-tailed hawk. Because of changes in raptor populations, nesting sites may change from year to year. The current nests could be unused in future years in favor of other locations. Exact nesting sites could change prior to proposed project construction.

Swainson's Hawk. Project implementation has the potential to reduce the number of Swainson's hawks within the area. The potential significant adverse impacts that may occur at the flow barrier sites include disturbance to active nest sites and the loss of 5.8 acres of cropland habitat that provide suitable foraging habitat for nesting pairs.

Mason's Lilaeopsis. The construction of the proposed Old River flow control structure is expected to remove most of a 1,000-foot colony of Mason's lilaeopsis.

Western Pond Turtle. The construction of the proposed barriers could result in the inadvertent destruction of turtles and nest sites.

San Joaquin Kit Fox. Potential kit fox occurrences are limited to the Old River flow barrier site. While surveys of this area have not confirmed the presence of kit fox at or near the barrier site, resource agencies have indicated that the kit fox may sporadically occur within this area. Construction efforts within kit fox territories may result in the loss of individuals due to den entrapment, vehicular conflict, and other construction site hazards.

Riparian (Willow) Scrub Habitat. The ISDP proposed construction of a Grant Line barrier. If constructed, the Grant Line barrier would result in the loss of 1.36 acres of riparian scrub habitat. Construction of the Old River flow control structure would result in the loss of 0.61 acres of blackberry scrub, for a total loss 1.97 acres of habitat.

Mitigation. Detailed mitigation for all of these impacts is proposed in the draft EIR/EIS for the ISDP. Much of the mitigation entails close coordination with DFG and USFWS, and the use of standard protocols developed by these agencies to avoid significant impacts.

d. Recreation. This section summarizes the impacts to recreation caused by constructing the barriers under Alternative 3, as disclosed in the Draft EIR/EIS for the ISDP.

Construction of the Head of Old River, Grant Line Canal, and Old River Tracy barriers will conflict with San Joaquin County's recreation-oriented goals and policies, which generally encourage the protection of the natural resources that support the area's recreational uses, including the Delta waterways. The goals and policies also encourage adequate public access to, and the navigability of, the waterways. The construction and operation of the control structures would not be consistent with these goals and policies of the San Joaquin County's General Plan. This is considered a significant adverse impact.

At the Middle River location, there are natural constraints to public access and navigability. Accordingly, the construction and operation of the proposed control structure would not conflict with the goals and policies of the General Plan. This is considered a less-than-significant adverse impact.

Mitigation. According to the Draft EIR/EIS for the ISDP, the DWR should take the following actions to mitigate for the impacts discussed above: (1) avoid construction work on the Old River fish control structure and the Grant Line flow control structure during major summer holiday periods; (2) post warning signs and buoys in the channels of the San Joaquin River and Old River (for the fish control structure) and within Grant Line Canal near all construction equipment and operations during construction of the barrier; (3) set up an information telephone hotline and a homepage on the internet to provide updates on the construction activities and operation of the barriers; and (4) provide adequate warning about activities and equipment to minimize disruption of boating movement during the barrier construction process.

e. Navigation. Review of the proposed facilities determined that the construction of the ISDP facilities would likely have short-term effects upon navigation in the immediate project area. Navigation conditions are typically related to the absence or presence of obstacles to travel on area waterways. Therefore, the proposed barriers will affect navigation. The following discussion provides an evaluation of the construction-related potential consequences of the ISDP upon navigation as disclosed in the ISDP Draft EIR/EIS.

Middle River Control Structure. Navigation along the 10-mile stretch of the Middle River (from about the Borden Highway Bridge at Victoria Canal and Trapper Slough to the confluence of Middle River with Old River) would be affected by the construction of the Middle River barrier. Construction would likely severely limit navigation, and once construction is complete, the barrier would prevent navigation. Boat ramps are to be constructed and used to transfer small craft from one side of the barrier to the other to allow access to Middle River. This portion of Middle River is little used by small craft due to the occurrence of shallows and abundant snags. The barrier is not considered to have a significant adverse impact upon navigation because of the infrequent use of the river in this location.

Old River Fish Control Structure. The construction of a barrier at the head of Old River would be expected to severely limit or prevent navigation for the 30-month construction period. The barrier would use radial gates, similar to other agricultural flow control structures. The barrier would prevent navigation during its operational period, from April 16 through May, and October through November, but would allow navigation the rest of the year. The creation of a seasonal barrier to navigation is considered to be an unavoidable significant adverse impact.

Old River Flow Control Structure East of the Delta-Mendota Canal. The construction period for the control structure and associated boat lock would last approximately 30 months. Navigation is expected to be severely limited or prevented during the 30-month construction period. This is considered to result in a significant adverse impact upon navigation. Once constructed, the barrier would allow passage through a boat lock. Notwithstanding the availability of a boat lock, the creation of a barrier to navigation is considered to be an unavoidable significant adverse impact.

Grant Line Canal Flow Control Structure. The Grant Line barrier would be located at the western end of an 8-mile stretch of Grant Line Canal. The proposed boat lock would be constructed first, followed by the construction of the radial gate structure and the other components of the barrier, in several phases over the 36-month construction period. The boat lock would be available early in the construction period, and then would be available during the operation of the structure to allow boat passage. Notwithstanding the availability of a boat lock, the creation of a barrier to navigation is considered an unavoidable significant adverse impact.

Mitigation. All the fish and flow control structures would severely limit navigation during the 30 to 36 month construction periods. Thereafter, the structures would have facilities available to transport most watercraft around the barriers. Notwithstanding the availability of these facilities, the creation of barriers to navigation is considered an unavoidable significant impact, with the exception of the Middle River Flow Control Structure, due to the low volume of use by small craft. These impacts cannot be mitigated to a level below significance.

f. Transportation. Construction of the barriers facilities would also likely have short-term effects upon transportation in the immediate project area. The following discussion provides an evaluation of the construction-related potential consequences of the ISDP upon transportation as disclosed in the ISDP Draft EIR/EIS (DWR and USBR 1996).

Implementation of the proposed project would add a maximum of 288 vehicles per day (256 commute trips plus 32 truck trips) to area roadways. Construction traffic would add a maximum of about 72 vehicles per day (vpd) to Highway 4, 25 vpd to Byron Highway, 82 vpd to I-205 and I-5, and 99 vpd to Tracy Boulevard. (Chapter 16 of the ISDP Draft EIR/EIS includes tables showing the duration of construction activity for each project element, and the amount of truck and employee traffic on a typical weekday.) The maximum level of construction traffic would occur over an 18-month period, when all of the facilities are simultaneously under construction.

All southern Delta roadways studied are currently operating at acceptable or better levels of service. The addition of construction traffic associated with the proposed barrier facilities would cause a less-than-significant adverse impact on the level of service on affected roads. The presence of numerous slow-moving trucks would, however, present a safety hazard. This hazard would be apparent on Tracy Boulevard and Clifton Court Road. This is considered a significant adverse impact.

The construction-related truck traffic on Byron Highway has the potential to inadvertently leave debris in the Class II bike lane. The debris, which could include spilled construction materials such as aggregate or sand, or dirt tracked up from private access roads, would create a potential hazard to cyclists. This is considered a significant adverse impact.

Mitigation. To minimize safety hazards to motorists in the ISDP construction traffic routes, the contractor should install “Truck Crossing” warning signs in advance of each access point to alert drivers to the presence of slow-moving trucks. These signs should be maintained for the duration of construction activity. Implementation of this mitigation measure would reduce this adverse impact to a less-than-significant level.

To minimize bicycle safety hazards within the Byron Highway bike lane, the contractor should regularly inspect the bike path and traveled way throughout the duration of construction activity. The contractor should maintain the bike path and traveled way in a clear condition with a scraper, street sweeper, or equivalent method, as necessary to assure safety. Implementation of this mitigation measure would reduce this adverse impact to a less-than-significant level.

2. Impacts to Water Levels and Salinity

This section discusses the effects of implementing the alternatives on water conditions in the southern Delta. Output from the DWRSIM and DWRDSM models, described in Chapter IV, together with results from the Temporary Barriers Project, are the basis for evaluating the environmental impacts of each alternative on water levels and water quality. DWRDSM is a mathematical simulation model used to evaluate flow, salinity, and water levels in the Delta. The model is not intended to provide absolute predictions of future Delta hydrodynamic and water quality conditions; rather the modeling is meant to be used as a tool to compare Delta conditions under various alternative actions.

For the purposes of analyzing the effects of barrier operations on water levels and salinity, barrier operations were modeled according to the schedule shown in Table IX-1. Operation of the barriers for the full duration of the spring and fall periods may not always occur due to Endangered Species Act and other requirements.

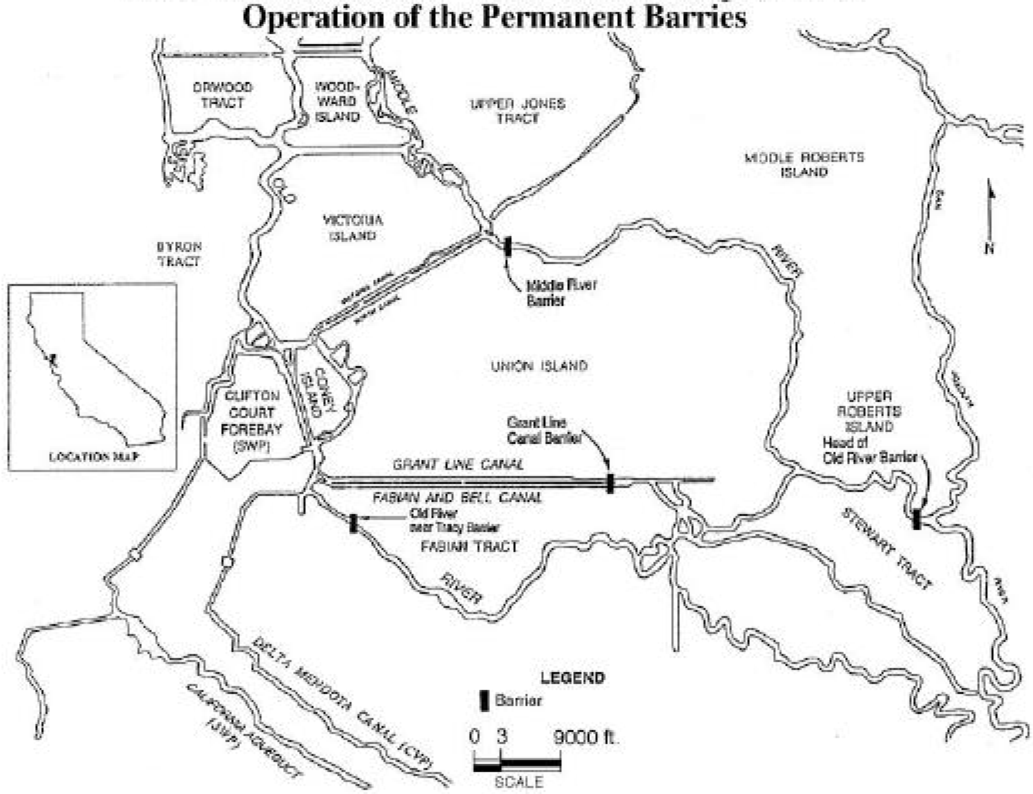
Table IX-1
Schedule of Temporary Barrier Installation and Permanent Barrier Operation

Time Period	Temporary Barriers	Permanent Barriers
October	Head of Old River	Old River, Middle River, Head of Old River
November	Head of Old River	Head of Old River
December	No Barriers	None Operating
January	No Barriers	None Operating
February	No Barriers	None Operating
March	No Barriers	None Operating
April 1 - 15	No Barriers	Old River, Middle River
April 16 - 30	No Barriers	Old River, Middle River, Head of Old River
May	Old River near Tracy, Middle River, Head Old River	Old River, Middle River, Head of Old River
June	Old River near Tracy, Middle River	Old River, Middle River, Grant Line Canal
July	Old River near Tracy, Middle River	Old River, Middle River, Grant Line Canal
August	Old River near Tracy, Middle River	Old River, Middle River, Grant Line Canal
September	Old River near Tracy, Middle River, Head of Old River	Old River, Middle River, Head of Old River

The following section is organized in three parts: (a) impacts to water levels; (b) impacts to salinity; and (c) mitigation for impacts.

a. <u>Minimum Water Levels</u>. Figures IX-6 through IX-16 depict water levels under the three alternatives at eleven locations in the southern Delta. Locations were selected upstream and downstream of temporary and permanent barrier sites (see Figure IX-5 for locations) in addition to other sites in the southern Delta. Each time period along the x-axis represents a constant condition during which the barrier combination does not change. The heights of the bars show minimum water levels averaged over the period. When a temporary barrier is installed or removed, or a permanent barrier is opened or closed, the change creates a new condition and a new time period begins.

Figure IX-5
Locations Examined for Water Level Changes Due to Operation of the Permanent Barries



<u>Middle River Barrier Site</u> Model output shown in Figure IX-6 shows predicted water levels downstream of the Middle River barrier site. Outputs indicate that installation of the temporary barrier and operation of the permanent barrier have very little effect on minimum water levels downstream of the barrier site.

Immediately upstream of the Middle River barrier site, minimum water levels change dramatically with the operation of the permanent barrier under Alternative 3 in October and again in April, as shown in Figure IX-7. Beginning May 1, minimum water levels at this location rise under all three alternatives, due to the barriers.

Figure IX-6
Average Minimum Water Levels by Period at
Middle River Downstream of Barrier

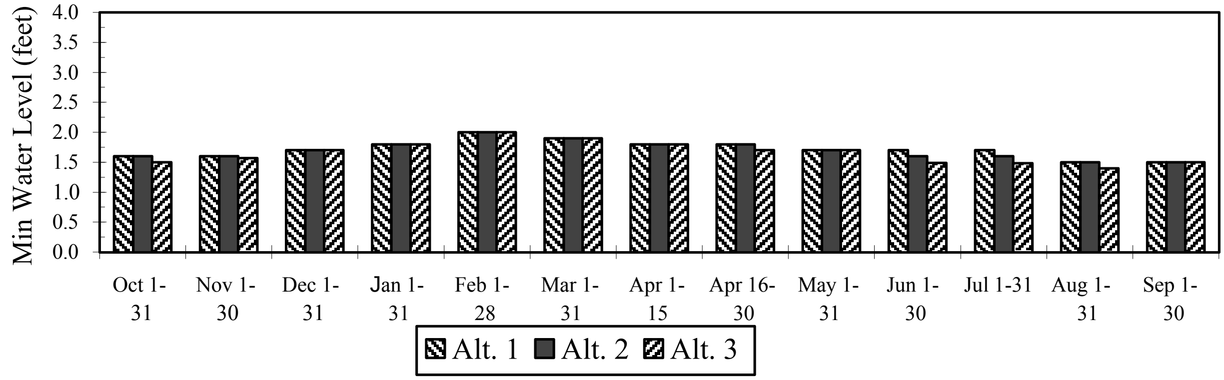


Figure IX-7
Average Minimum Water Levels by Period at
Middle River Upstream of Barrier

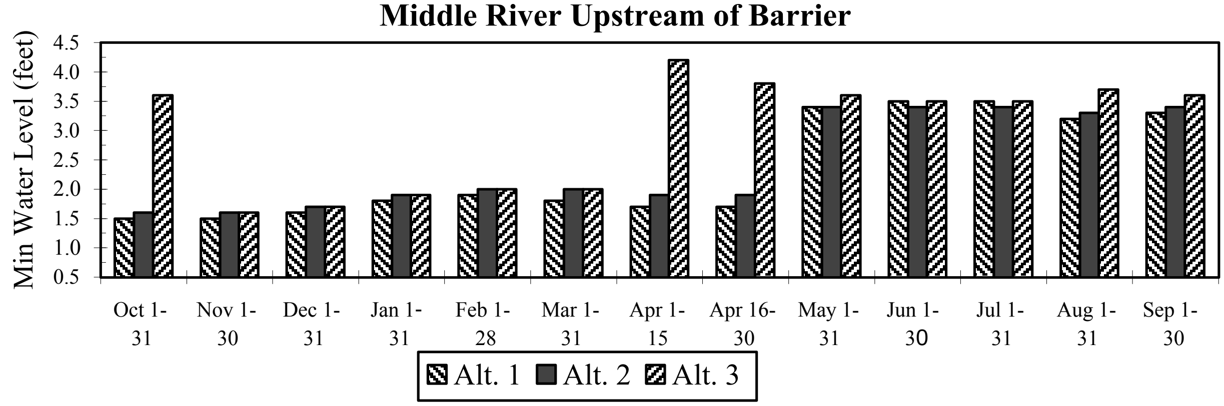


Figure IX-8
Average Minimum Water Levels by Period at
Old River Downstream of Barrier

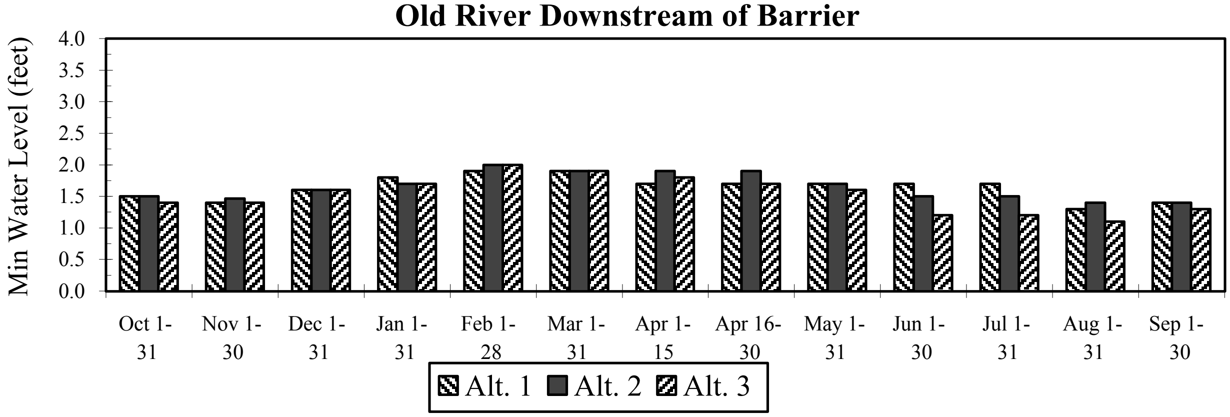


Figure IX-9
Average Minimum Water Levels by Period at
Old River Upstream of Barrier

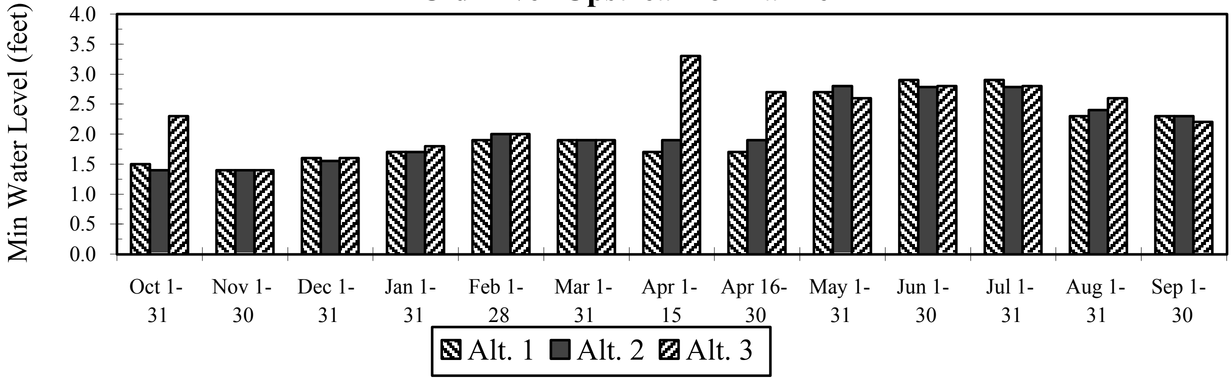


Figure IX-10
Average Minimum Water Levels by Period at
Grant Line West of Tracy Road Bridge

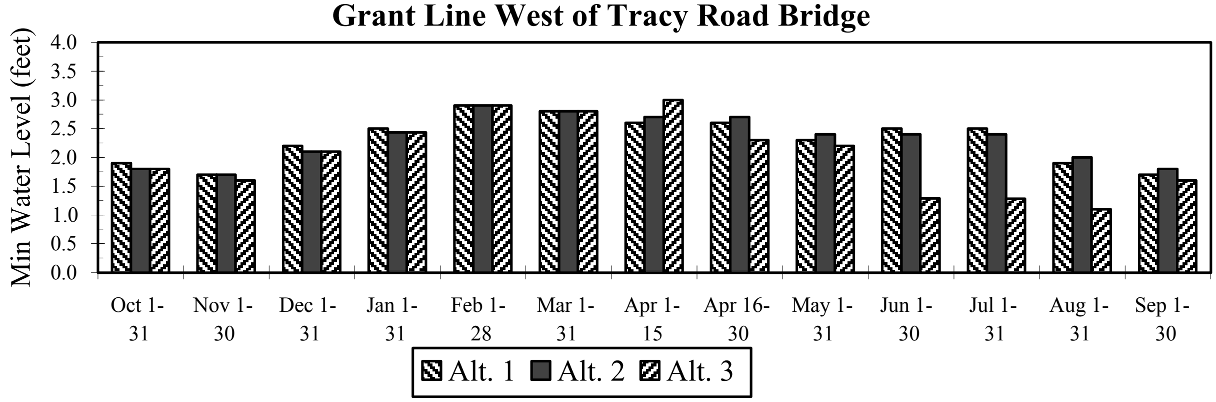


Figure IX-11
Average Minimum Water Levels by Period at
Grant Line East of Tracy Road Bridge

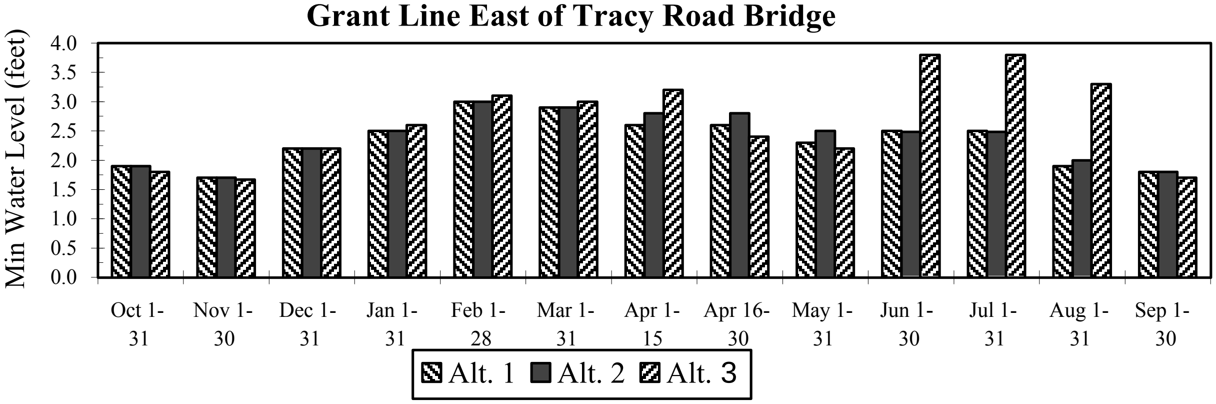


Figure IX-12
Average Minimum Water Levels by Period at Grant Line
Upstream of Grant Line & Old River Confluence

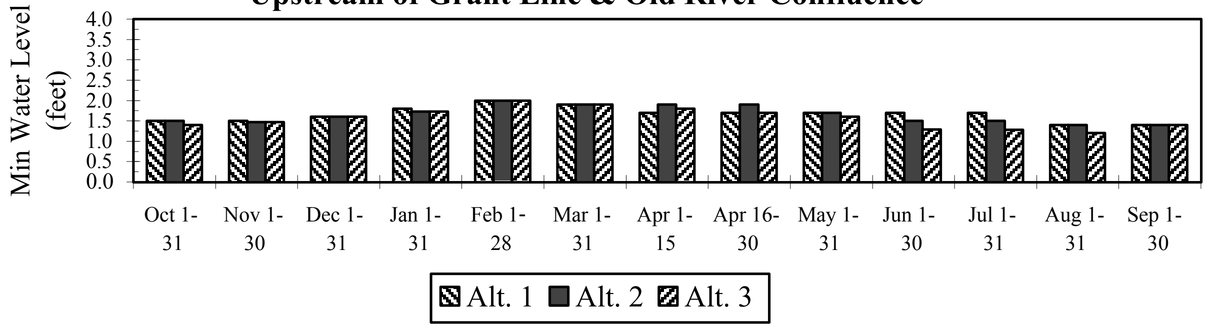


Figure IX-13
Average Minimum Water Levels by Period at
Old River East of Tracy Road Bridge

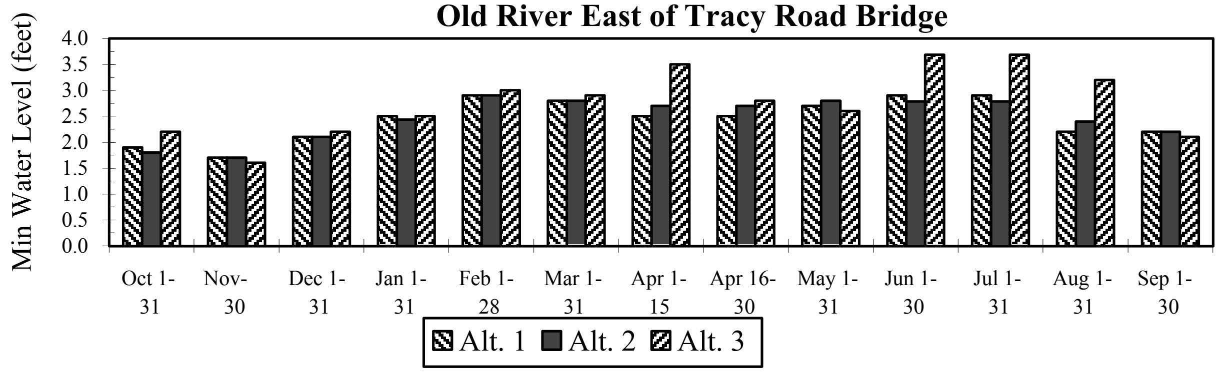


Figure IX-14
Average Minimum Water Levels by Period at
Middle River Near Undine Bridge

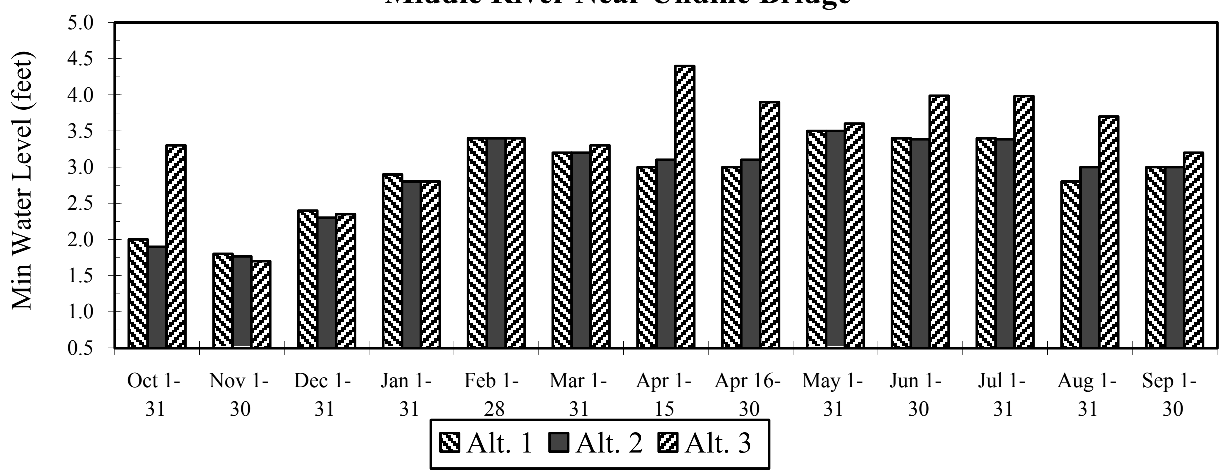


Figure IX-15
Average Minimum Water Levels by Period at Old River
Upstream of Old River & Middle River Confluence

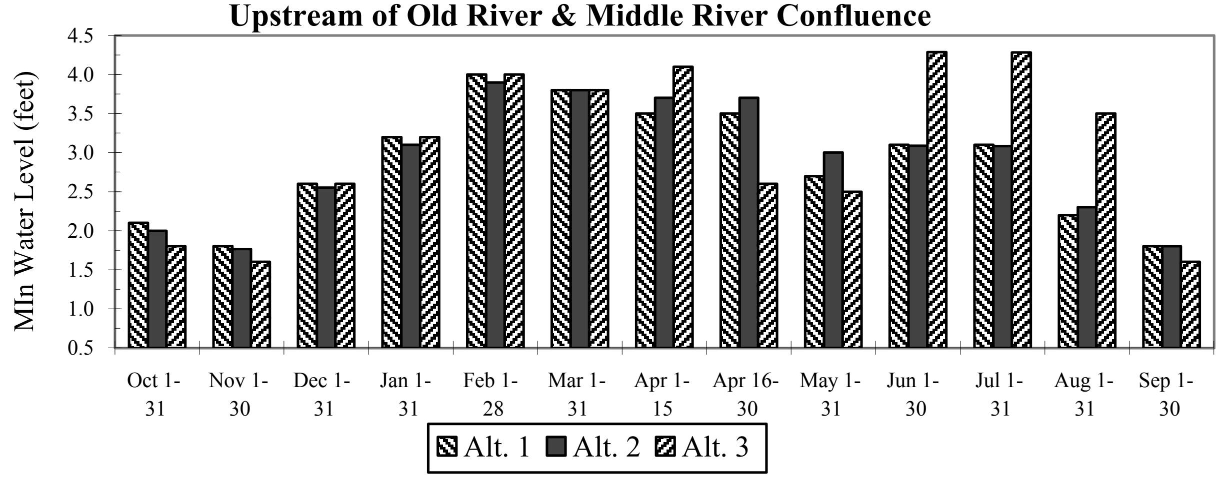
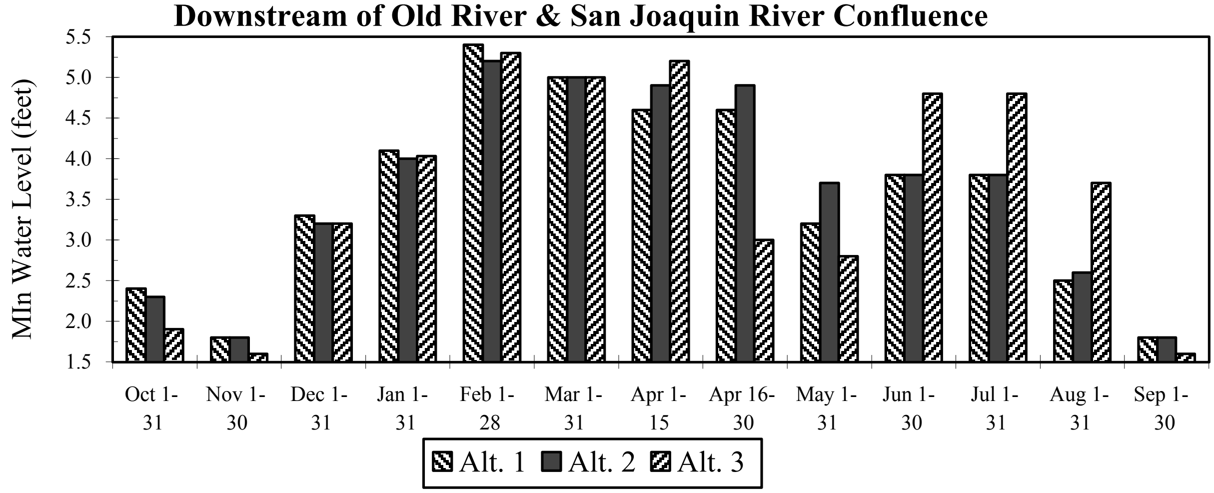


Figure IX-16
Average Minimum Water Levels by Period at Old River
Downstream of Old River & San Joaquin River Confluence



Old River Barrier Site. Figure IX-8 shows water levels downstream of the Old River barrier site. As at the Middle River site, the barrier has very little effect on downstream water levels. Immediately upstream of the Old River barrier site, the installation of a temporary barrier from May through September under Alternative 2 causes another significant increase in minimum water levels upstream of the barrier site, particularly during May and June, as shown in Figure IX-9. Minimum water levels change dramatically in April (and to a lesser degree through October) with the operation of the permanent barrier under Alternative 3.

Grant Line Canal Barrier Site. Figure IX-10 shows output for a site downstream of the Grant Line Canal barrier site. The DWRDSM model assumptions include a permanent barrier on the East end of Grant Line Canal. The operation of the permanent barrier under Alternative 3 would reduce minimum water levels by approximately one foot, which may have a potentially significant adverse impact on diverters downstream of the site from June through August. Moving the barrier further west on Grant Line Canal could eliminate this water level reduction.

Figure IX-11 (upstream of the Grant Line Canal barrier site) shows water levels very similar to those in Figure IX-10; however, there is a dramatic increase in Alternative 3 minimum water levels June through August, corresponding to the operation of the permanent Grant Line barrier.

Other Locations. Figure IX-12, shows predicted minimum water levels at a site further downstream of the Grant Line Canal barrier site. Model output indicates that the barrier has very little effect on minimum water levels at this location downstream of Grant Line Canal barrier.

Figure IX-13 shows minimum water levels for a location further upstream from the Tracy barrier site. Overall minimum water levels on Old River East of Tracy Road Bridge appear to be higher under Alternative 3 than under either Alternative 1 or 2, particularly in the first part of April and in June through August.

Minimum water levels for a location further upstream of the Middle River barrier site are shown in Figure IX-14. Alternative 3 provides the highest minimum water levels from April through October.

Figure IX-15 shows that minimum water levels at the confluence of Middle and Old rivers are very similar under all three alternatives from September through March. Relative to the other alternatives, Alternative 3 water levels are lowest in late April through May, then highest for June through August.

Figure IX-16 shows that minimum water levels drop on the Old River downstream of its confluence with the San Joaquin River when the head of Old River barrier is closed. In the summer months water levels rise under Alternative 3 in comparison to the other alternatives because of increased tidal pumping from the downstream permanent barriers.

In conclusion, according to the model output depicted in Figures IX-6 through IX-16, the installation of permanent barriers under Alternative 3 reduces minimum water levels in some cases, but in general minimum water levels rise during the irrigation season at most locations.

b. **Salinity**. Figures IX-17 through IX-26 show the probability of exceedance of the EC or chloride objectives of each of the three alternatives by comparing modeled values under the alternatives to the objectives. The figures use model output from 73-year DWRDSM runs (water years 1922 through 1994). Figures IX-17 and IX-18 show percent-of-time exceedence of year-round chloride objectives at Contra Costa Water District's Pumping Plant # 1/Rock Slough intake and Pumping Plant # 2/Los Vaqueros intake on Old River. Figures IX-19 through IX-26 show exceedance of the EC objectives for the April through August period (objective of 0.7 mmhos/cm) and the September through March period (objective of 1.0 mmhos/cm) for the following four locations identified in the 1995 Bay/Delta Plan: San Joaquin River at Airport Way Bridge (Vernalis); Old River near Middle River (Union Island); San Joaquin River at Brandt Bridge site; and Old River at Tracy Road Bridge.

Contra Costa Water District. Figures IX-17 and IX-18 show frequencies of exceedence for modeled chlorides at Contra Costa Water District's Rock Slough and Los Vaqueros Reservoir intakes (depicted as Pumping Plants # 1 and # 2, respectively). At pumping plant # 1, the modeling indicates that the municipal and industrial (M&I) water quality objective of 250 mg/l chlorides would be exceeded under the base case about 13 percent of the time over the 72 year hydrology. This contrasts with Alternatives 2 and 3, which are nearly identical and would exceed the M&I water quality objective about eight percent of the time. At Pumping Plant 2, the M&I objective would be exceeded about ten percent of the time under the base case while Alternatives 2 and 3 would exceed the M&I objective about seven percent of the time. In the worst two percent of months (i.e., those 18 discreet months over the 72-year hydrology when chlorides are highest), Alternatives 2 and 3 chlorides are somewhat higher than the base case. As described in Chapter VI, in actual operation the chloride objectives are not expected to be exceeded because the SWP and the CVP will operate to meet them. The operations model, DWRSIM, was operated to meet the chloride objective at Rock Slough at all times. The salinity transport model, DWRDSM, however, provides different salinity estimates at Rock Slough. Consequently, the value of the model output is in its comparison of salinity or chloride concentrations among the alternatives rather than comparison of the predicted salinity or chloride concentrations in comparison to the objectives.

Overall, Figures IX-17 and IX-18 indicate that implementation of southern Delta salinity alternatives would not adversely affect chloride levels at the Contra Costa Water District and may improve water quality up to half the time.

Vernalis. Figures IX-19 and IX-20 show frequencies of exceedance for modeled EC at Vernalis on the San Joaquin River during the irrigation and non-irrigation seasons, respectively. Under Alternative 1, the CVP makes releases from New Melones Reservoir to meet an objective of 500 ppm TDS on a year-round basis, which corresponds to an EC of approximately 0.86 mmhos/cm. Consequently, as depicted in Figure IX-19, the EC at Vernalis often exceeds the Bay/Delta Plan objectives of 0.7 mmhos/cm in April through August, as well as the modeled salinity for the other two alternatives during the period. For the September through March period, the salinity objective under Alternative 1 is less than the objective for the other alternatives (1.0 mmhos/cm), and this situation is reflected on Figure IX-20 when the salinity under Alternative 1 is lower at the upper range of salinity conditions.

Modeled EC levels for Alternatives 2 and 3 are identical during both seasons because the Vernalis hydrology for both alternatives comes from the same model study.

<u>Other Southern Delta Locations</u>. Figures IX-21 through IX-26 show the effect of the alternatives on compliance locations downstream of Vernalis. The following observations apply to the figures:

1. The higher upper range salinity at Vernalis under Alternative 1, which is caused by the difference in the objectives, results in higher upper range salinities at the downstream locations as well.
2. Salinity conditions in the three interior stations are worse than salinity conditions at Vernalis. Because the salinity objective at Vernalis is just met about half the time during the summer, substantial noncompliance with the objective at the interior southern Delta are expected even with barrier operation.
3. Overall, Alternative 3 provides the best salinity conditions in the southern Delta.

Salinity conditions in the southern Delta are also portrayed in Figures IX-27 through IX-33. The figures show, by month and year-type, how often EC levels under one of the alternatives will be greater than or less than the base case. For example, Figure IX-27 shows the frequency of change in salinity of Alternatives 2 and 3 compared with Alternative 1 at Vernalis (San Joaquin River at Airport Way Bridge). That is, EC predicted by the model under Alternative 1 (base condition) is used as the baseline salinity, represented by a horizontal 'zero' line, for each month of each year type. The vertical lines show the frequency of any increase or decrease in EC under Alternative 2 compared to EC for Alternative 1. A line above 'zero' represents an increase in EC as a result of implementing Alternative 2, and a line below represents a decrease in EC as a result of implementing Alternative 2. The bars above and below the 'zero' line represent the times when EC under Alternative 2 differs from that of Alternative 1 by more than ten percent.

Figure IX-17
Percent Probability of Exceedence of Water Quality Objectives at Contra Costa Canal Pumping Plant # 1
(72-year model hydrology)

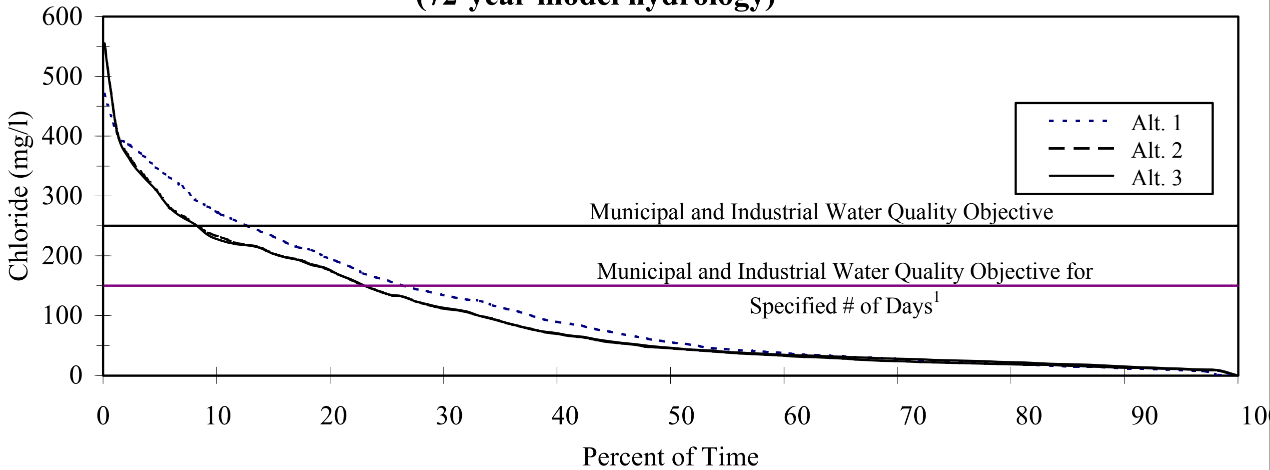
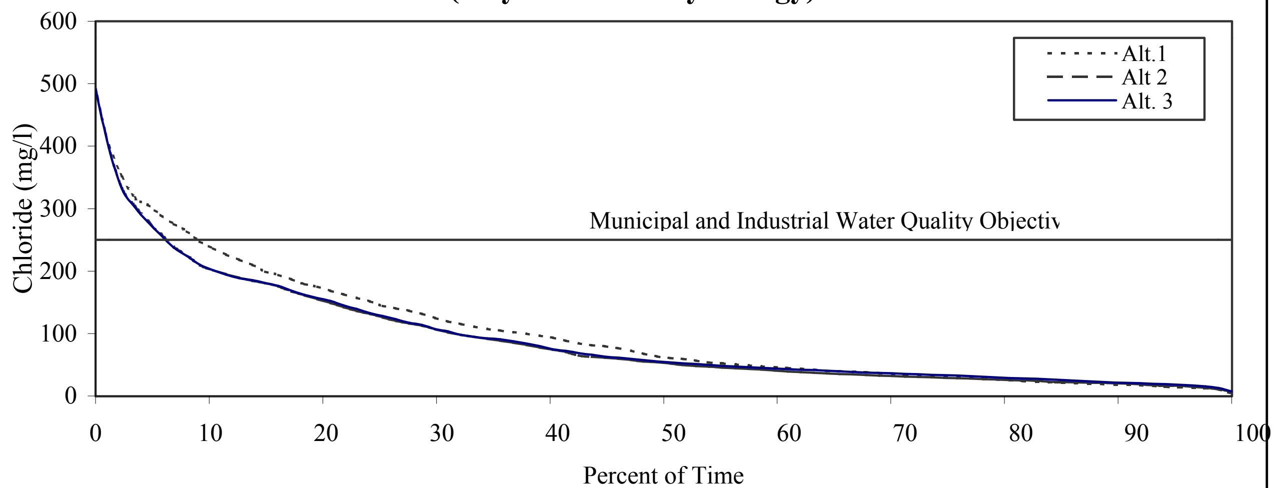


Figure IX-18
Percent Probability of Exceedence of Water Quality Objectiv
Contra Costa Water District Pumping Plant # 2
(72-year model hydrology)



[1] Minimum number of days that mean daily chlorides <= 150 mg/l must be provided in intervals of not less than two weeks duration. Standard applies at Contra Costa Canal Intake

Year Type	Wet	Above Normal	Below Normal	Dry	Critical
# Days	240	190	175	165	155

Figure IX-19
Percent Probability of Exceedance of Plan Salinity Objectives at SJR at Airport Way Bridge (Vernalis) For April - August

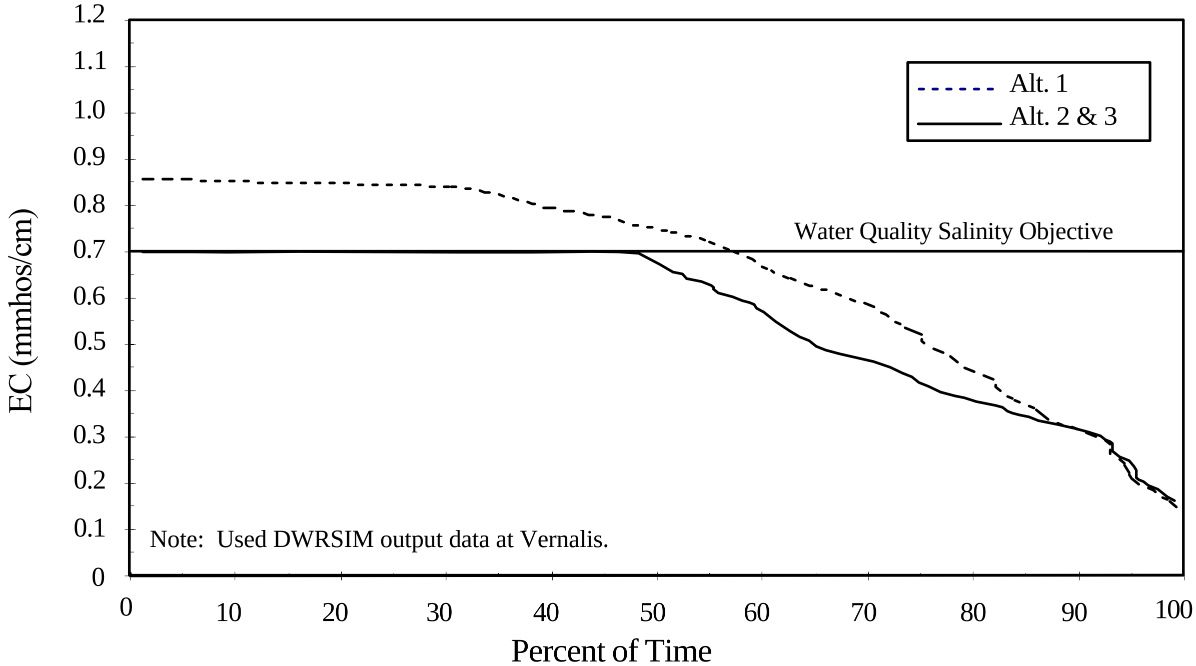


Figure IX-20
Percent Probability of Exceedance of Plan Salinity Objectives at SJR at Airport Way Bridge (Vernalis) For September - March

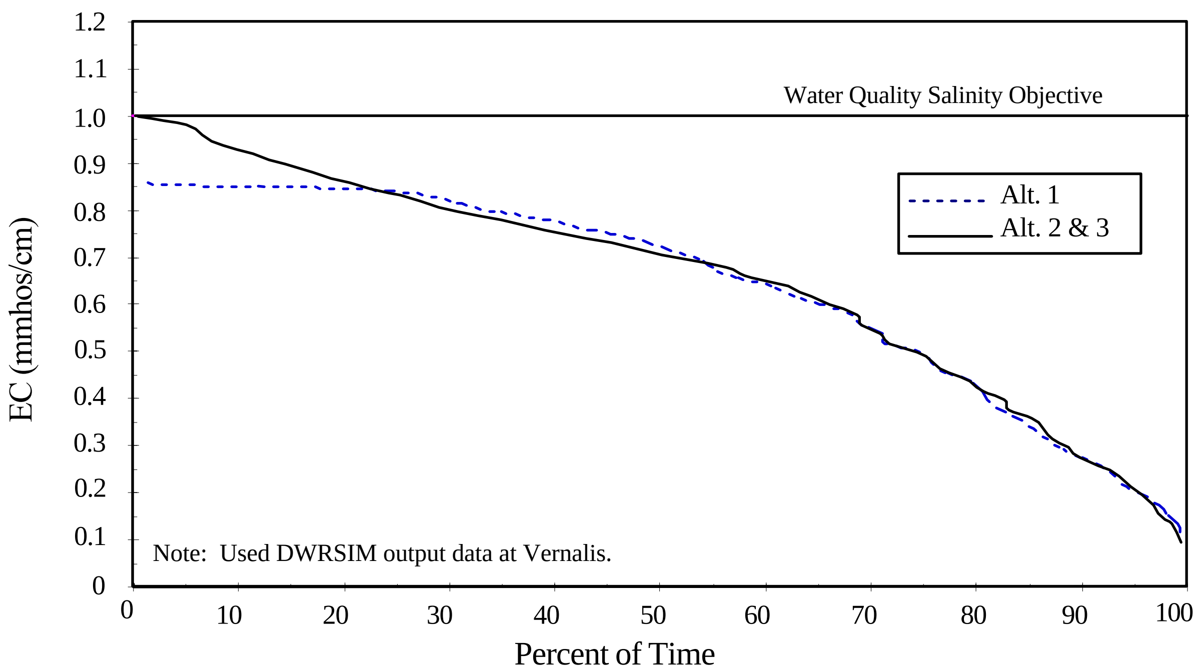


Figure IX-21
Percent Probability of Exceedance of Plan Salinity Objectives at Union Island For April - August

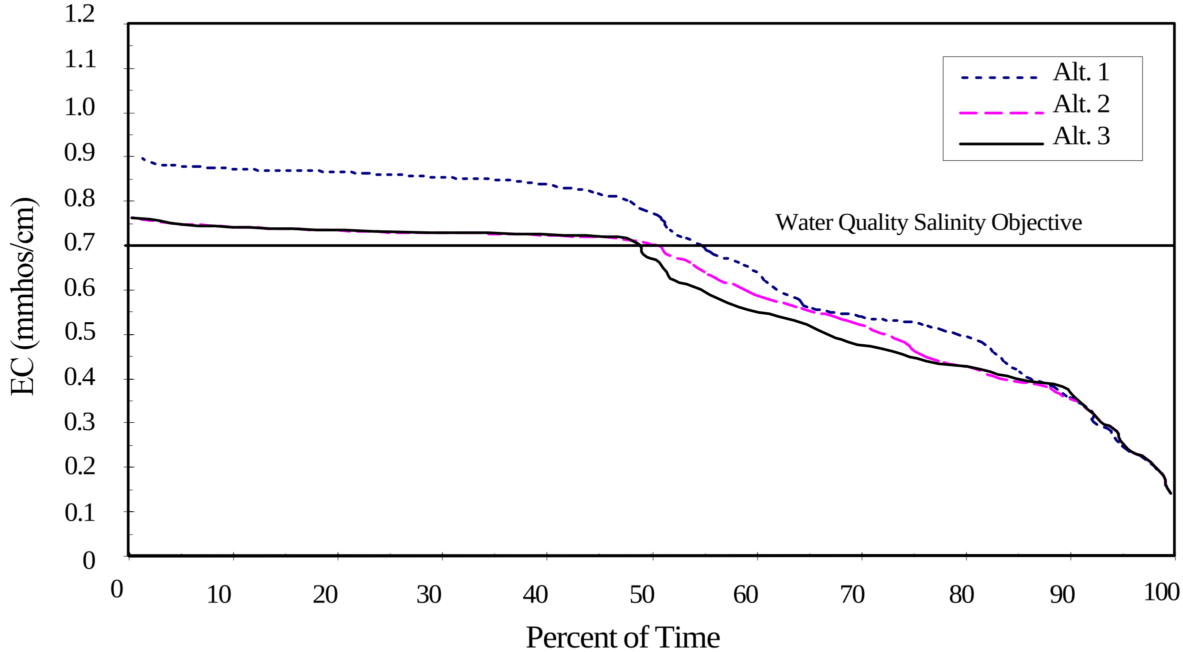


Figure IX-22
Percent Probability of Exceedance of Plan Salinity Objectives at Union Island For September - March

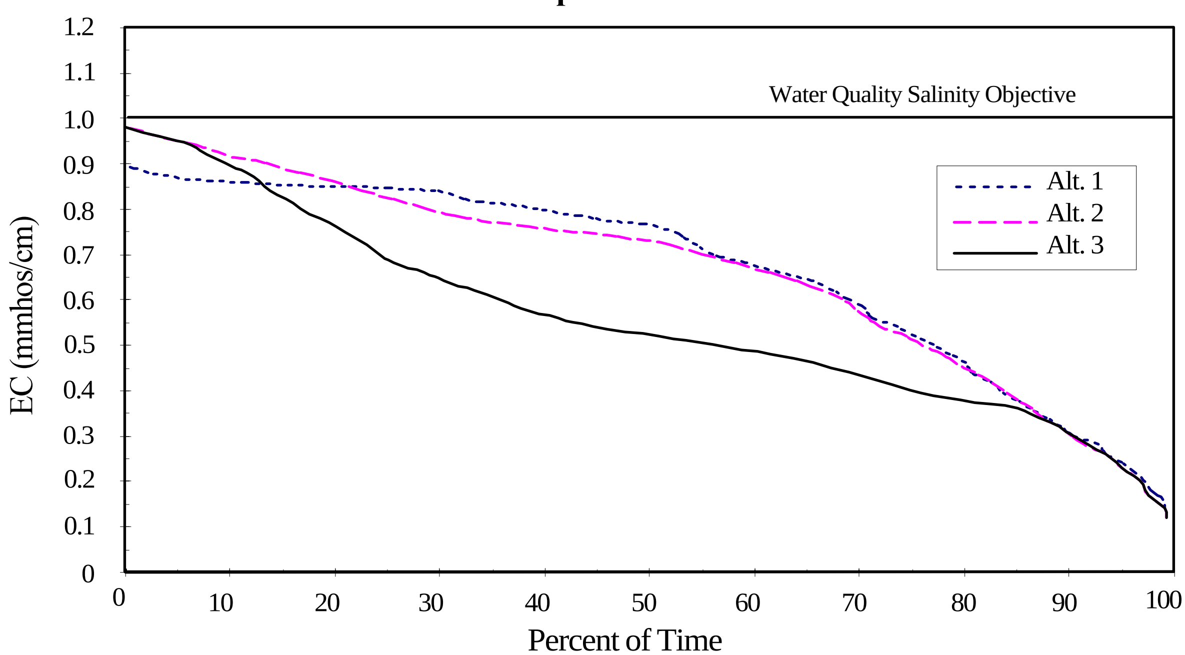


Figure IX-23
Percent Probability of Exceedance of Plan Salinity Objectives at Brandt Bridge on SJR For April - August

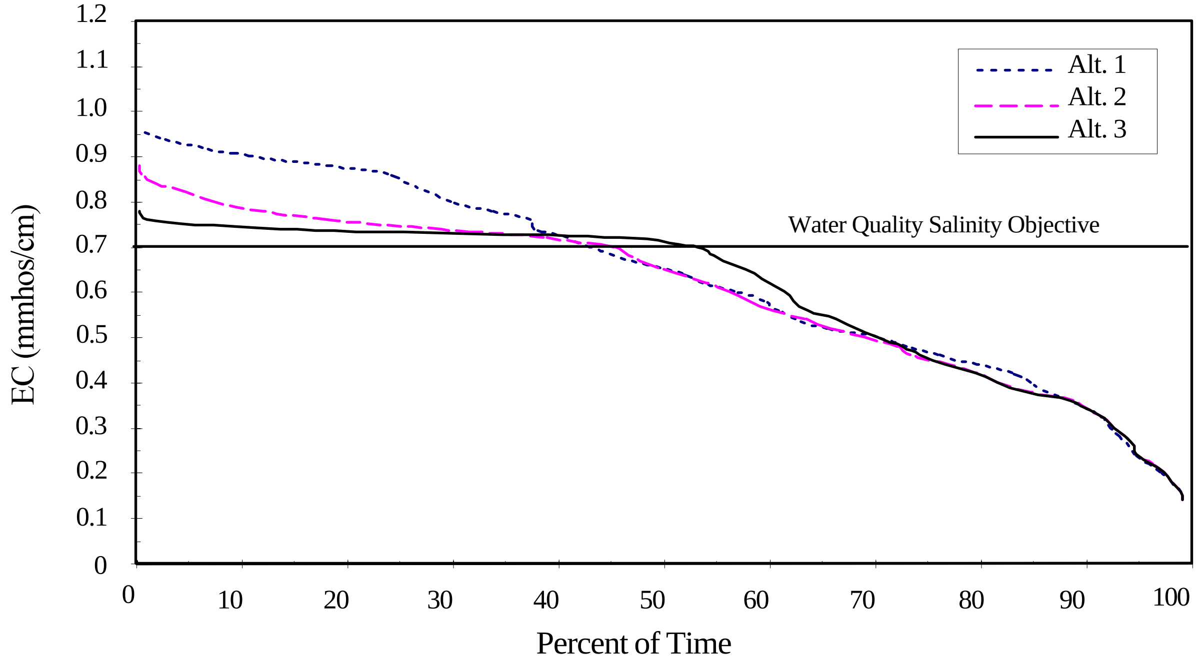


Figure IX-24
Percent Probability of Exceedance of Plan Salinity Objectives at Brandt Bridge on SJR For September - March

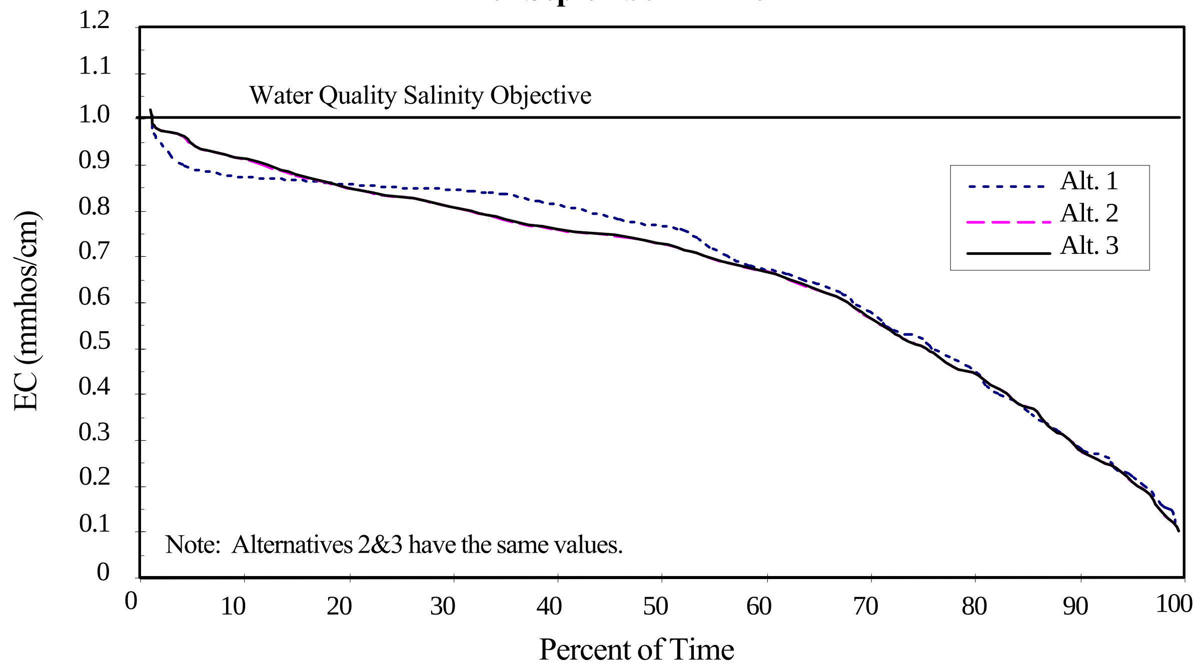


Figure IX-25

Percent Probability of Exceedance of Plan Salinity Objectives at Old River at Tracy Road Bridge For April - August

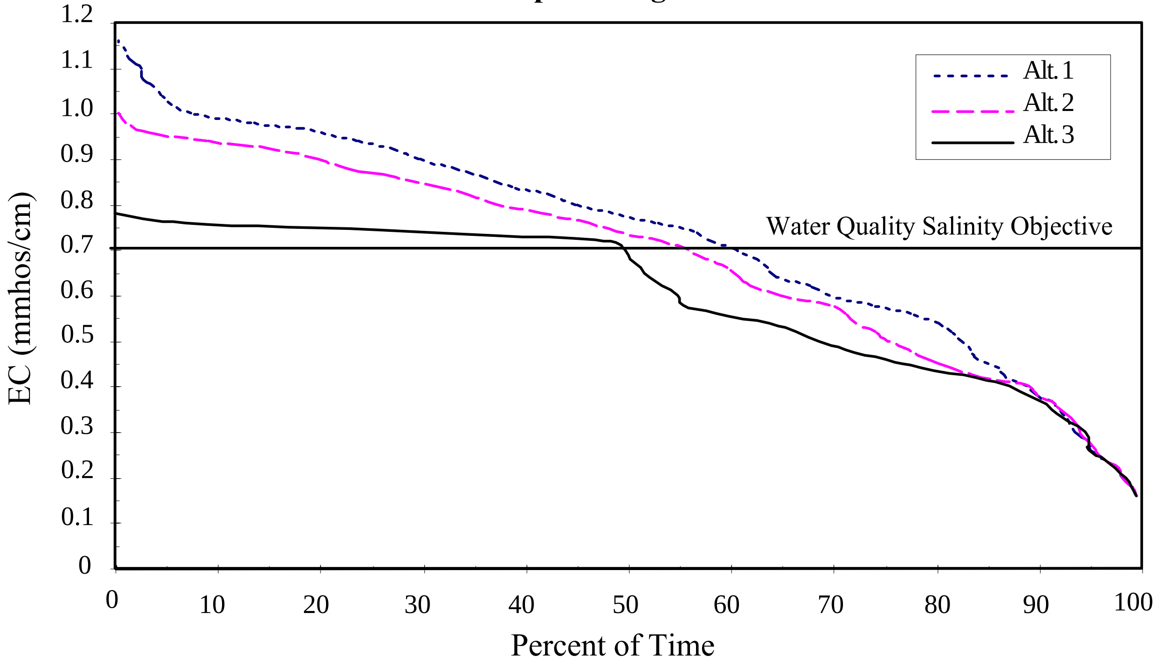
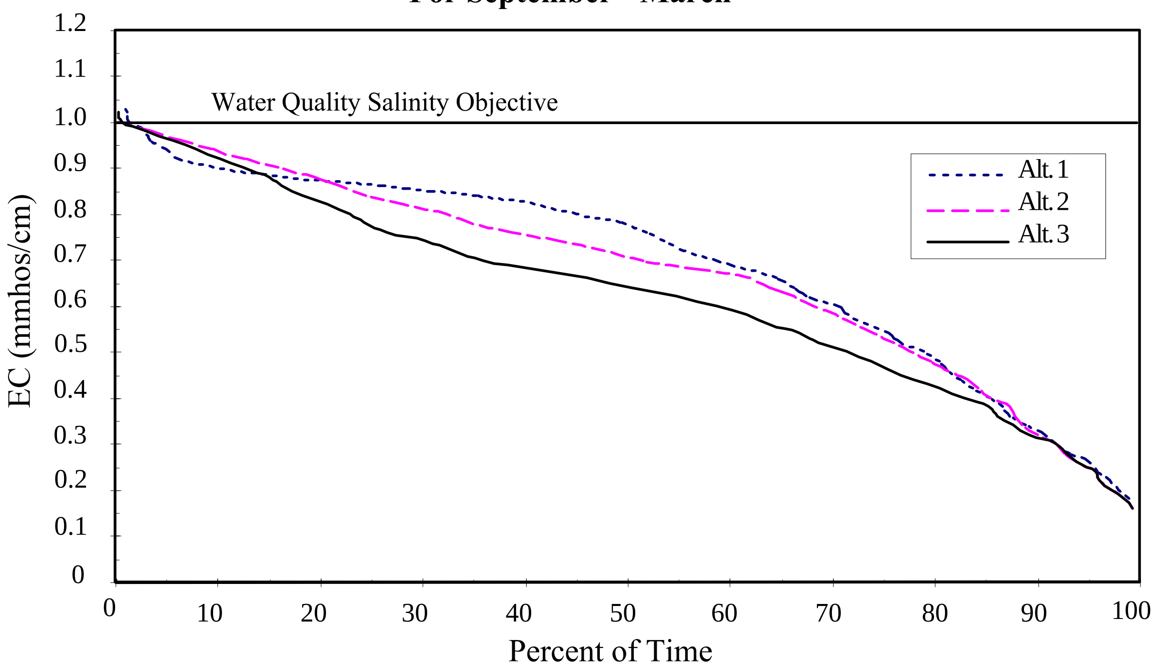


Figure IX-26

Percent Probability of Exceedance of Plan Salinity Objectives at Old River at Tracy Road Bridge For September - March



Vernalis. Figure IX-27 shows the relative EC at Vernalis for each year-type for Alternatives 2 and 3 compared with Alternative 1 by month for all the years on record. Alternatives 2 and 3 have exactly the same EC at Vernalis because they use the same DWRSIM input study. During October of wet years, the figure shows that EC for Alternatives 2 and 3 exceeds EC for Alternative 1 approximately 48 percent of the time--the vertical line above 'zero' for wet years ends at 48 percent along the y-axis. That is, the model predicted an increase in EC under Alternatives 2 and 3 in 48 percent of all the wet-year Octobers on record.
Figure IX-25 also shows that October EC levels in wet years under Alternatives 2 and 3 are at least ten percent greater than EC levels for Alternative 1 approximately six percent of all the wet-year Octobers on record (solid bar above 'zero'). On the other hand, the model predicts that October EC levels will be lower under Alternatives 2 and 3 than under Alternative 1 in about 52 percent of the wet-year Octobers on record, and will be at least ten percent lower than for Alternative 1 in about 38 percent of those Octobers. This suggests that overall, in wet years, October EC levels can be expected to decrease under Alternatives 2 and 3 (vs. Alternative 1). All of Figure IX-25 can be interpreted in this manner. In general, Alternative 1 provides lower salinity conditions than Alternatives 2 and 3 during the November through March period at Vernalis, since EC levels under Alternatives 2 and 3 fall almost completely above the line representing EC under Alternative 1. The difference in salinity between Alternative 1 compared to Alternatives 2 and 3 is caused by the difference in flow and EC objectives at Vernalis, not by implementation of temporary or permanent barriers. The most dramatic differences occur during critically dry years. However, beginning in April, Alternatives 2 and 3 provide better salinity conditions than Alternative 1, again because of the difference in objectives.

Union Island. Figure IX-28 shows the frequency of change in salinity for Union Island station between Alternatives 1 and 2. As at Vernalis, Alternative 1 EC is lower than that of Alternative 2 during the November through March period, and Alternative 2 is better overall than Alternative 1 between April and October. In fact, the frequencies of change shown in Figure IX-28 are almost identical to those for Vernalis (Figure IX-27), with the exception of May. According to model results, May salinity under Alternative 2 is likely to be higher than that of Alternative 1 salinity in dry and critically dry years. The difference in salinity between Alternative 1 compared to Alternative 2 is driven principally by the difference in flow and EC objectives at Vernalis.

Figure IX-29 shows a substantial improvement in EC conditions in October, November, April and September under Alternative 3 in comparison to Alternatives 1 and 2. This improvement is caused by the permanent barrier operation.

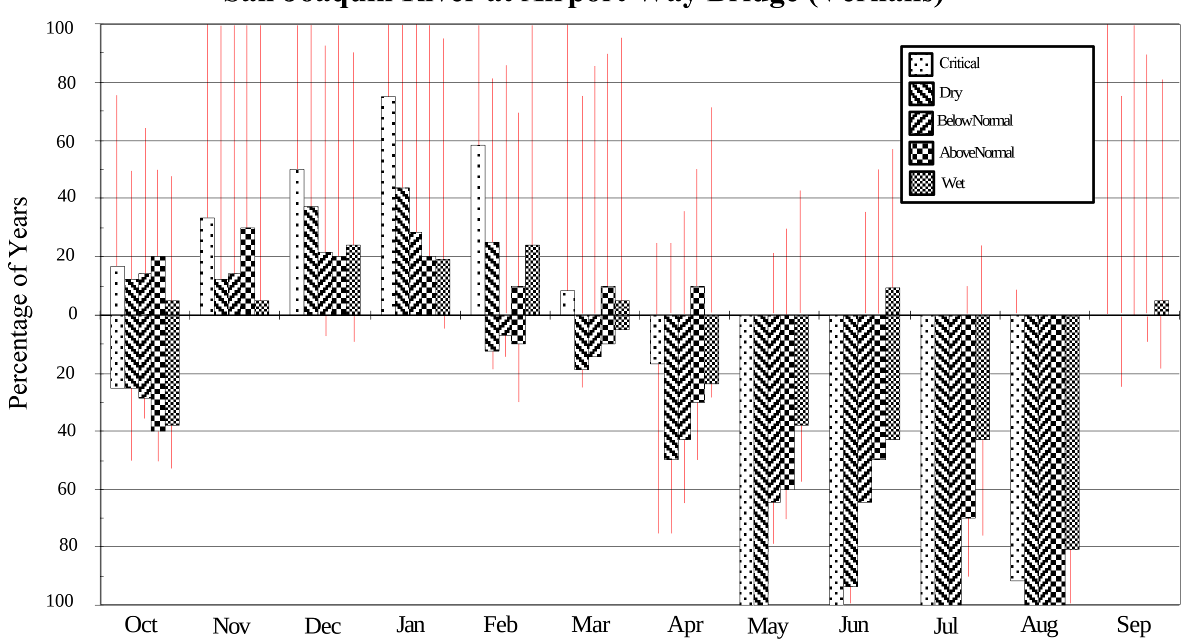
San Joaquin River at Brandt Bridge site. Figures IX-30 and IX-31 provide a comparison of EC conditions at Brandt Bridge under Alternatives 2 and 3 compared to Alternative 1. These two figures show very little difference between Alternatives 2 and 3 relative to Alternative 1. Alternatives 2 and 3 cause improved EC conditions in April through June, worse EC conditions from November through February, and mixed conditions in March and from July through October.

During July and August, both Alternatives 2 and 3 generate higher salinities at this location relative to the no-action alternative than at the other southern Delta locations. (Salinity is at least as likely to increase under Alternative 2 or 3 compared with Alternative 1, whereas at the other stations, Alternatives 2 and 3 appear to improve water quality rather consistently.) The increase in salinity is explained by a change in circulation patterns. Under Alternative 1, reverse flow occurs, taking higher quality (Sacramento River) water from the Delta and carrying it upstream past Brandt Bridge. Alternatives 2 and 3 change the direction of flow past Brandt Bridge, and poorer quality water from Vernalis flows downstream past the station (Ghorbanzadeh, pers. comm.).

Old River at Tracy Road Bridge. Figures IX-32 and IX-33 provide a comparison of EC conditions at Tracy Road Bridge under Alternatives 2 and 3 compared to Alternative 1. The pattern of EC conditions under Alternatives 2 and 3 relative to Alternative 1 is similar to the pattern at Union Station. Overall, Alternative 3 provides the most improvement in EC conditions during the irrigation season.

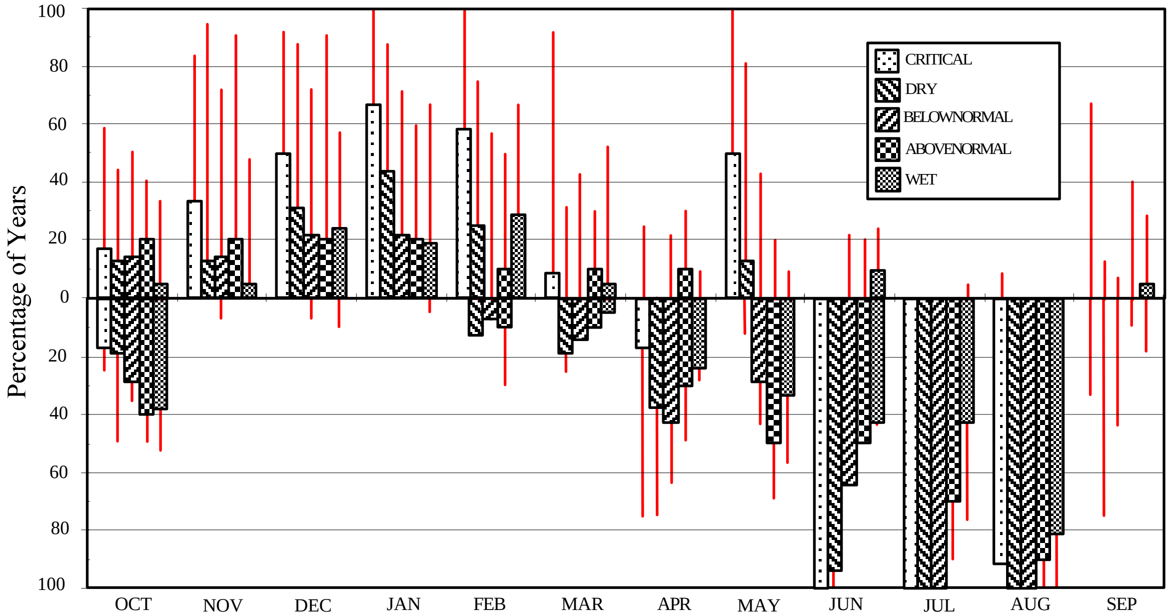
In summary, according to the model output depicted in Figures IX-17 through IX-31, none of the alternatives eliminates exceedances during the irrigation season; in general, however, Alternative 3 appears to be most effective in reducing EC levels at southern Delta stations during the irrigation season (April-August).

Figure IX-27
Frequency of Change
in Salinity of Alternatives 2 & 3 Compared with Alternative 1
San Joaquin River at Airport Way Bridge (Vernalis)



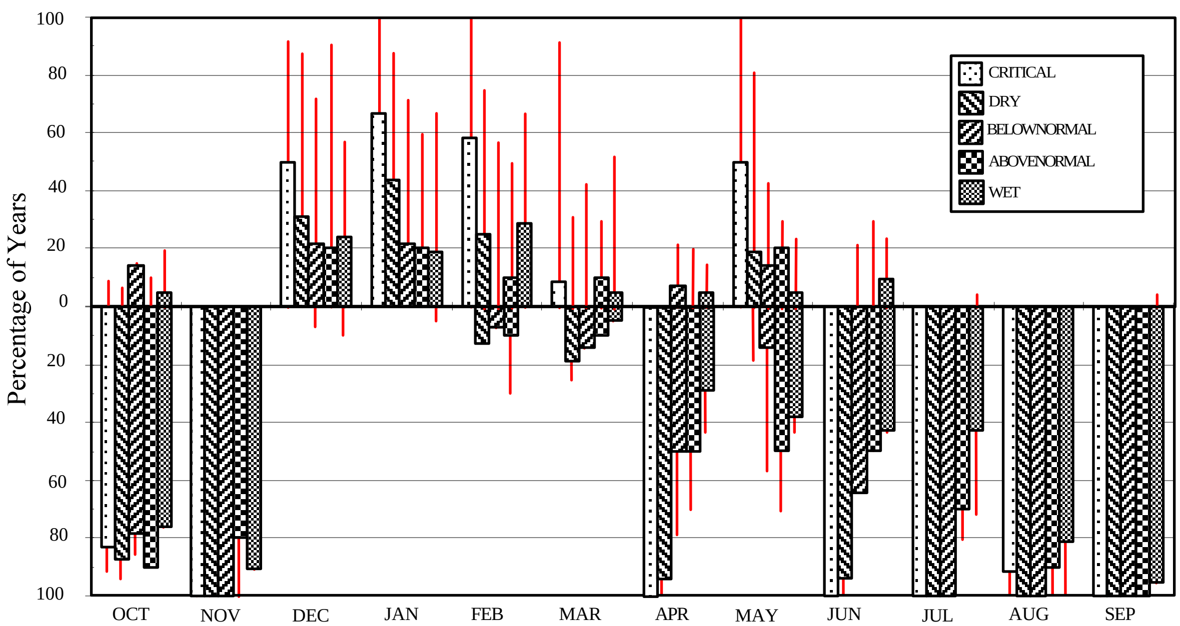
Note: Bars show results for >10% increases and decreases, vertical lines show results for all increases and decreases

Figure IX-28
Frequency of Change
in Salinity of Alternative 2 Compared with Alternative 1
Old River at Middle River (Union Island)



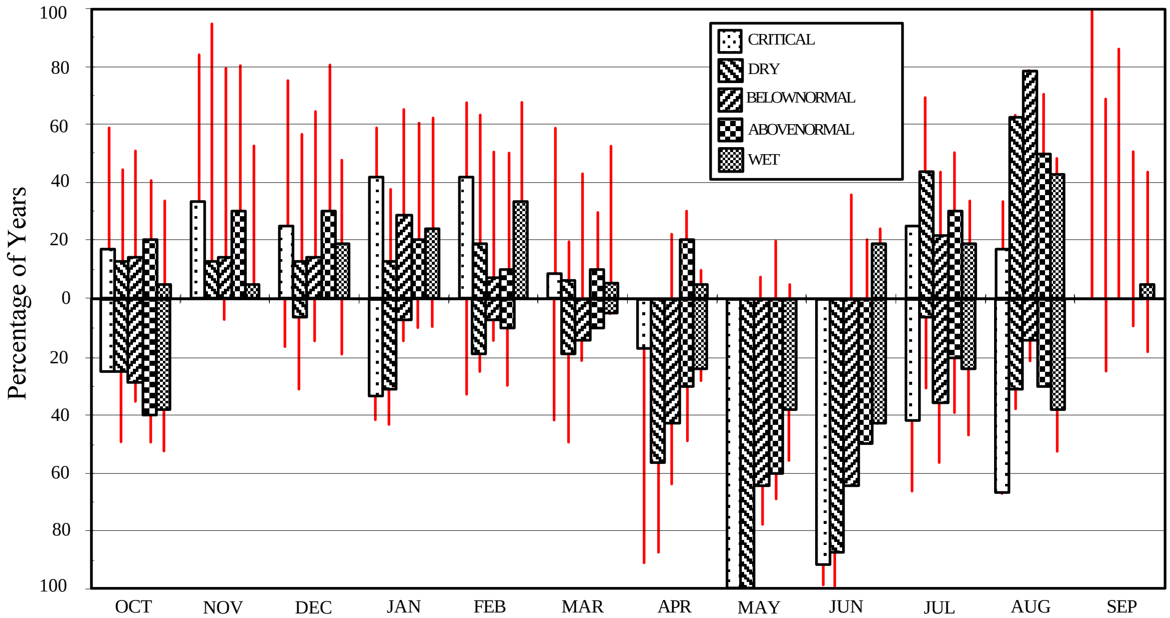
Note: Bars show results for >10% increases and decreases, vertical lines show results for all increases and decreases

Figure IX-29
Frequency of Change
in Salinity of Alternative 3 Compared with Alternative 1
Old River at Middle River (Union Island)



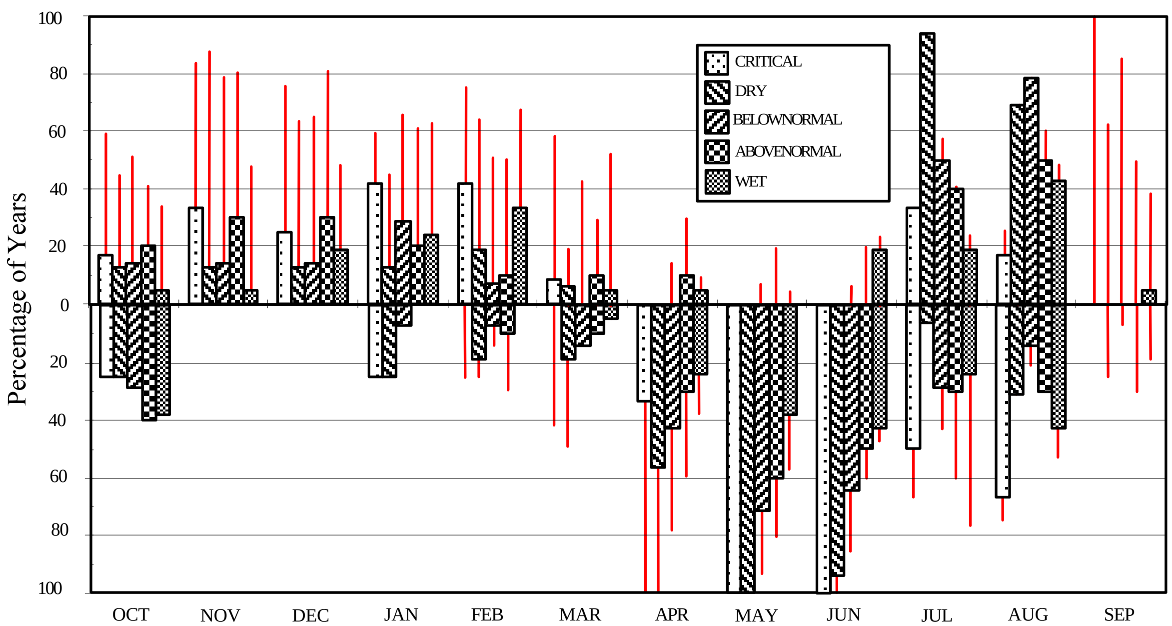
Note: Bars show results for >10% increases and decreases, vertical lines show results for all increases and decreases

Figure IX-30
Frequency of Change
in Salinity of Alternative 2 Compared with Alternative 1
San Joaquin River at Brandt Bridge



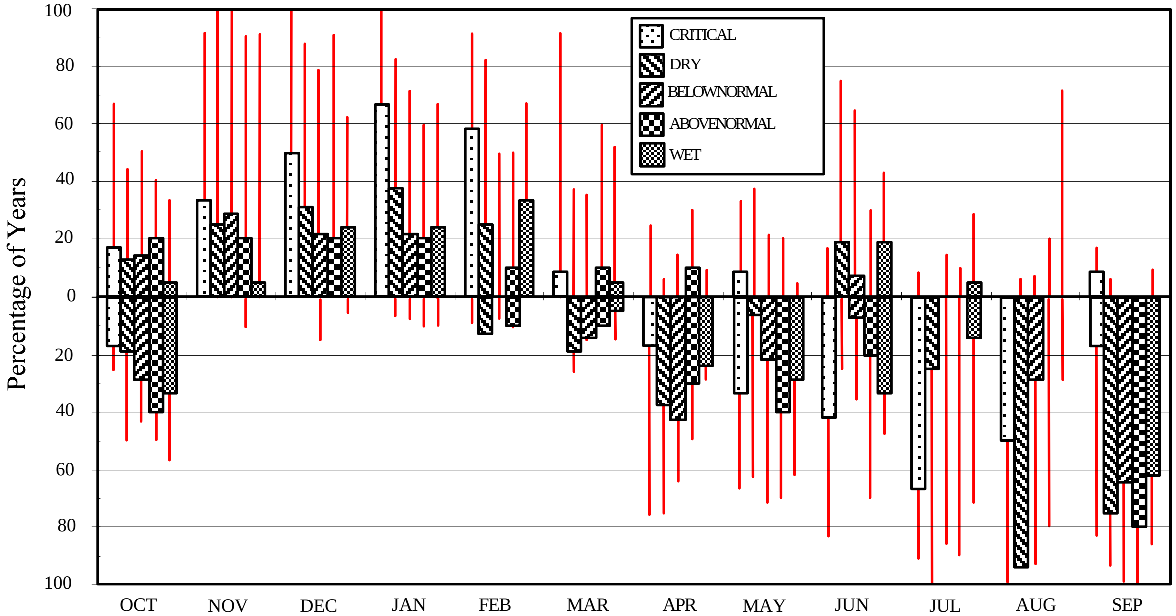
Note: Bars show results for >10% increases and decreases, vertical lines show results for all increases and decreases

Figure IX-31
Frequency of Change
in Salinity of Alternative 3 Compared with Alternative 1
San Joaquin River at Brandt Bridge



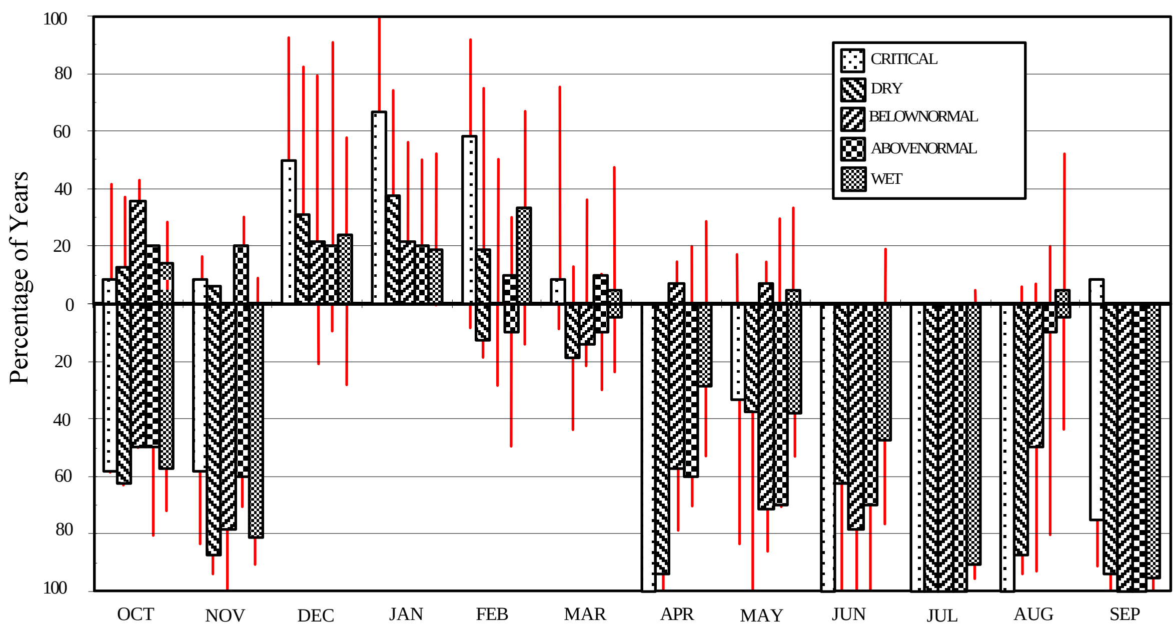
Note: Bars show results for >10% increases and decreases, vertical lines show results for all increases and decreases

Figure IX-32
Frequency of Change
in Salinity of Alternative 2 Compared with Alternative 1
Old River at Tracy Road Bridge



Note: Bars show results for >10% increases and decreases, vertical lines show results for all increases and decreases

Figure IX-33
Frequency of Change
in Salinity of Alternative 3 Compared with Alternative 1
Old River at Tracy Road Bridge



Note: Bars show results for >10% increases and decreases, vertical lines show results for all increases and decreases

c. Mitigation for Impacts. No significant water quality impacts from the operation of the barriers were identified. Therefore, no mitigation is required.

3. Impacts to Aquatic Resources

This section describes the effects of the alternatives on aquatic resources. The discussion of potential impacts under Alternative 3 only includes those impacts that result from the barrier operation. The impacts to aquatic resources from implementing the flow objectives are discussed in Chapter 6 of this draft EIR.

The section is organized in three parts: (a) method for analysis; (b) impacts; and (c) mitigation for impacts.

a. Method for Analysis. This analysis is qualitative and limited to reviewing when various fish species are present in the Delta and how those species could be affected by the operation of the barriers. Qualitative criteria were used to evaluate the significance of the impacts of the alternatives because the available information regarding southern Delta habitats and fish populations is inadequate for developing meaningful quantitative criteria. The effects of the barriers are evaluated based on how they are expected to affect hydrologic variables when a given species is present in the Delta. The time of year of greatest sensitivity for most species is assumed to be during spawning and development of the larvae and young juveniles.

Species selected for evaluation of impacts include: fall-run, winter-run, late fall-run, and spring-run chinook salmon; steelhead; striped bass; American shad; white and green sturgeon; delta smelt; longfin smelt; and Sacramento splittail. The evaluation of impacts for each species is based on general knowledge of the species. Effects of the barriers on fish passage were evaluated on the basis of known historical migration patterns of the fish species.

b. Impacts. This section summarizes the impacts associated with the operation of the fish and flow control structures proposed under Alternative 3. Principally, impacts are straying, transport and entrainment at diversions, and physical obstruction of migratory routes. The impacts as a result of permanent barrier operations under Alternative 3 are examined only in comparison to the operation of temporary barriers under Alternatives 1 and 2. Since barrier operation is the same for Alternatives 1 and 2, no impacts are expected from Alternative 2 relative to Alternative 1.

The impact of the barriers on each species is dependent on the life-stage of the fish during the barrier operation. The life stages for some of these fish are provided in Chapter 3 of this draft EIR. The distribution of these species in the Delta during operation of the barrier is only briefly noted in this chapter. A more detailed description is provided in the Draft ISDP EIR/EIS.

Table IX-2 shows the differences between the periods when the temporary barriers are installed under Alternatives 1 and 2 and the permanent barriers are closed under

Alternative 3. As shown in the table, differences between the barrier operation schedules occur in October, April, and June through August. However, operation of the barriers for the full duration of the spring and fall periods may not always occur due to ESA and other requirements.

Table IX-2
Difference In Periods When Barriers Are Closed Between Temporary and Permanent Barriers

Time Period	Temporary Barriers	Permanent Barriers
October	Head of Old R.	Old R. near Tracy, Middle R., Head of Old R.
April 1 - 15	No Barriers	Old R. near Tracy, Middle R.
April 16 - 30	No Barriers	Old R. near Tracy, Middle R., Head of Old R.
June	Old R.near Tracy, Middle R.	Old R. near Tracy, Middle R., Grant Line Canal
July	Old R. near Tracy, Middle R.	Old R. near Tracy, Middle R., Grant Line Canal
August	Old R. near Tracy, Middle R.	Old R. near Tracy, Middle R., Grant Line Canal

Operation of the barriers would not alter flow conditions in the rivers upstream of the Delta. Therefore, they should have no effect on upstream spawning and/or rearing habitats.

Operation of the fish and flow control structures will change the flow regime in some channels of the central and southern Delta. Closure of the Grant Line Canal and Head of Old River barriers will reduce the net downstream flow in Old River and increase the net downstream flow in the segment of the San Joaquin River immediately downstream of its confluence with Old River. Water that previously had been diverted to the pumps at Old River would instead be diverted from the central Delta through channels such as Turner Cut and Columbia Cut. The risk of egg and larval transport from the Central Delta, as well as straying by juveniles, smolts, and adults, would increase in connection with these changes. The increase in net upstream flow in Central Delta channels would be particularly great during April and May when the Head of Old River barrier would be closed.

During the late spring and summer, installation of the barriers would result in large increases in net upstream flows in channels leading from the central to the southern Delta. These flows are expected to transport eggs and larvae of the estuarine species into the southern Delta, where risks of diversion, predation, and other sources of mortality are higher than in other parts of the Delta. The flows are also expected to cause increased straying of adults and juveniles of all of the fish species evaluated.

Although the barriers are designed to allow upstream passage of fish, they could interfere with movements of fish in the southern Delta. Immigrating adults that stray into the channels leading from the lower San Joaquin River may be less likely to succeed in returning to their natal stream to spawn.

Juveniles straying into the southern Delta from the central Delta may suffer higher mortality rates than those juveniles in upper Old River. Fish from the central Delta are more likely to be entrained by the SWP pumps than by the CVP pumps, and salmon mortality is believed to be higher at the SWP facilities due to predation in Clifton Court Forebay. They may also be entrained through the inlet valves of the flow control structures and be exposed to increased predation and entrainment in agricultural diversions.

Operation of the Old River and Middle River permanent barriers in the first part of April and the Head of Old River barrier in late April coincides with migration of American shad, sturgeon, delta smelt, and longfin smelt, and with the peak downstream migration of fall-run Sacramento River and San Joaquin River chinook salmon, winter-run chinook salmon, and steelhead. Adult late fall-run and spring-run chinook salmon and striped bass may also be migrating through the Delta, and Sacramento splittail are spawning in the upper Delta and lower reaches of the San Joaquin River. Striped bass and Delta smelt spawn and rear in the central or western Delta during this period. Downstream migration of sturgeon larvae typically peaks during April, as does the presence of longfin-smelt larvae and juveniles. The operation of barriers during April have the potential to block the passage of migrating species and change the flow regimes which may impact egg and larval transport leading to increased entrainment at agricultural diversions or export pumps.

Virtually all the species considered can be present during June, July, and August in some years when the Grant Line Canal permanent barrier is operated. Operation of the barrier during this period may cause the same problems as in April.

In October, the operation of the permanent barriers at Middle River and Old River (in addition to the Head of Old River barrier) coincides with upstream migration of adult fall-run Sacramento River and San Joaquin River chinook salmon, steelhead, and the emigration of American shad. The additional operation of these two barriers also has the potential to cause blocked passage, straying, and increased entrainment problems for these species.

The permanent barrier project is considered to have potentially significant adverse impacts with no identifiable benefits for all of the species mentioned above, with the possible exception of San Joaquin fall-run chinook salmon. The barriers provide a potential benefit to San Joaquin fall-run chinook salmon by increasing downstream flows toward the central Delta, rather than through the southern Delta towards the export pumps. Straying of San Joaquin smolts into the southern Delta increases the emigration time out of the Delta which increases potential mortality from predation and entrainment.

The permanent barriers are designed to be operated at higher flows than the temporary barriers. Therefore, they can be operated over a longer period each year. As a result, the permanent barriers provide more protection to San Joaquin fall-run chinook salmon, but extend the period of potential impacts to the other species considered in this analysis.

c. Mitigation for Impacts. This section proposes measures to mitigate for impacts to aquatic resources associated with the operation of the permanent barriers in the southern Delta.

According to the ISDP Draft EIR/EIS, most of the expected changes in flow regimes are caused by the proposed Head of Old River barrier. Hydrologic simulations indicate that reverse flows in the channels leading from the central to the southern Delta would be lessened if the project was implemented without the fish barrier. The proposed flow control structures cause relatively minor increases in net upstream flows in simulations run without the fish barrier. Therefore, the DWR will link operation of the spring barrier at the head of Old River to daily monitoring reports of San Joaquin River chinook salmon smolt abundance at a site upstream of Old River.

Operation of the Head of Old River barrier in the spring is designed to reduce diversion of San Joaquin River fall-run chinook salmon smolts into Old River. Smolts diverted into Old River have a good chance of being entrained by the CVP or SWP export pumps. Under the mitigation plan, smolt abundance would be monitored daily by sampling with a Kodiak trawl and a hydro-acoustic fish detection system. The barrier gates would be left open during April and May except on days when unusually high abundance of salmon smolts are expected based on the Kodiak trawl and hydro-acoustic sampling results. Kodiak trawling has been used successfully to sample smolts in the San Joaquin and Sacramento rivers, and hydro-acoustics using side-facing or upward-facing transducers has been used for many years to sample salmon smolts in rivers in Canada, Alaska, and Washington.

Some smolts are found near the Head of Old River nearly every day during the period of smolt emigration. The barrier gates would be closed only when pulses of outmigrating smolts appear to be present. A behavioral barrier could be deployed in front of the structural barrier to keep smolts out of Old River at other times, if the barrier was shown to be effective at repelling fish. The behavioral barrier would allow San Joaquin River flow to enter Old River, but would be designed to discourage smolts from following this flow. Thus, use of the behavioral barrier would allow barrier gates to be left opened when smolt abundance is low. The effectiveness of acoustic, electrical, or light barriers is not assured, but strategic deployment of such barriers at the head of Old River, possibly accompanied by minor structural modifications of the channel, may reduce entrainment of the smolts.

4. Impacts to Terrestrial Biological Resources

This section summarizes the effects of barrier operations on terrestrial biological resources of the Bay/Delta Estuary as disclosed in Chapter 10 of the ISDP Draft EIR/EIS (DWR and USBR 1996). This discussion only includes those impacts that result from the barrier operation component of the ISDP.

a. **Impacts**. The operation of the barriers could result in significant adverse impacts to the following special status plant species and habitats: populations of Mason's lilaeopsis, along with freshwater marsh and riparian habitat; a population of Delta tule pea in Grant Line Canal; rosemallow populations on Grant Line Canal and Middle River; and Delta mudwort and its habitat in Grant Line Canal.

b. **Mitigation for Impacts**. Measures are proposed in the ISDP Draft EIR/EIS to mitigate for impacts to terrestrial biological resources named above to levels that are less-than-significant.

To identify and quantify adverse impacts to freshwater marsh and riparian habitats, the DWR will continue its vegetation monitoring plan, and the DWR and USBR should locate areas of intertidal habitat that can be enhanced or improved to support Mason's lilaeopsis. Project-related losses of habitat identified by the program will be replaced at other locations within the Delta.

5. Impacts to Recreation

This section considers whether the installation of barriers under the alternatives would increase the demand for recreational facilities or affect existing recreational opportunities. In general, the impacts identified below are relevant for all of the alternatives with the exception of the Grant Line Canal, which is not installed in Alternatives 1 and 2. In addition, the impacts will occur in different periods, as identified in Table XI-2. Impacts of Alternatives 1 and 2 on recreation are also discussed in Chapter VI of this draft EIR.

The analysis is extracted from Chapter 13 of the ISDP Draft EIR/EIS (DWR and USBR 1996). The section is organized in three parts: (a) methods for analysis; (b) impacts; and (c) mitigation for impacts.

a. **Methods for Analysis**. A variety of methods and information sources were used to determine recreation impacts, including recreation surveys, boater surveys, and maps. Quantitative recreation surveys were conducted by DWR from 1991 to 1993 in order to evaluate the types of recreation found in the southern Delta as well as boaters' impressions of the existing temporary barriers and portage facilities. The quantitative survey included the tabulation of all types of recreational activities, boat sizes, and recreationist responses to existing portage facilities on typical weekdays, weekends, and holidays. Qualitative recreation surveys were conducted in 1994, to determine the perceived effects of the proposed barriers. To account for opinions of recreationists throughout the southern Delta, eight major recreation facilities were surveyed: Del's Boat Harbor, the Lazy M Marina, Tracy Oasis Marina, Union Point Resort, Discovery Bay Yacht Club, Cruiser Haven, Dos Reis County Park and Mossdale Marina. The results of these surveys are incorporated in this analysis.

The Contra Costa and San Joaquin County general plans emphasize the preservation and protection of recreational resources, and the provision of adequate public access to those resources. In addition, both counties have policies addressing the protection of water-related recreational resources. Finally, Contra Costa and San Joaquin counties emphasize the protection of the Delta's recreational value for its statewide and international importance, respectively.

In accordance with the CEQA Guidelines and professional standards, impacts are considered "significant" if implementation of the alternatives would: (1) conflict with established recreational uses of the area; (2) result in a substantial need for new, altered or expanded recreational facilities; or (3) not support existing recreation goals and policies of local planning documents.

b. Impacts. Although existing facilities would still draw patrons to participate in camping, picnicking, biking, hiking, bank fishing, and bird watching, introduction of the Old River Fish Control Structure could interfere with boating activities; the presence of the Grant Line Canal Flow Control Structure could hinder travel on the waterway and boaters launching outside the immediate area would be less likely to fish along Grant Line Canal; and although the Old River Flow Control Structure would include a boat lock to facilitate river travel, the structure would still impede boat travel.

The County of San Joaquin's recreation-oriented goals and policies generally encourage the protection of the natural resources that support the area's recreational uses, including the Delta waterways. The goals and policies also encourage adequate public access to, and the navigability of, the waterways. The operation of the proposed control structure would not be consistent with these goals and policies of the County of San Joaquin's General Plan. This is considered a significant adverse impact.

The specific impacts at the four barrier locations are identified below.

Old River Fish Control Structure. The area around the proposed Old River fish control structure site currently supports several marinas and a substantial number of boaters; additional facilities are planned nearby within the proposed Gold Rush City project. The structure would use a radial gate design and include a boat lock. Placement of a barrier in this location could deter boat travel along Old River. Consequently, although existing facilities would still draw patrons to participate in camping, picnicking, biking, hiking, bank fishing and bird watching, introduction of this structure may interfere with boating activities. This is considered a significant adverse impact.

Middle River Flow Control Structure. Surveys conducted by the DWR show that the most frequent recreation activity at the Middle River site is fishing; however, this site receives less usage than many areas of the southern Delta. The nearby Union Point Marina functions as a midday rest stop for boaters during a day on the water. Boaters generally access the marina from the north and west on Middle River, Victoria Canal or North Canal; few venture eastward on Middle River due to the shallow water and snags in the channel. Neither construction nor operation of the proposed barrier is expected to affect recreational activity in the area. This is considered a less-than-significant adverse impact.

Grant Line Canal Flow Control Structure. Some of the best fishing on the Delta is located along Grant Line Canal, which is known for its catfish and striped bass. In addition, the area is heavily used for boating. The presence of the structure could hinder travel on the waterway, and boaters launching outside the immediate area would be less likely to fish along Grant Line Canal. This would be considered a significant adverse impact.

Old River Flow Control Structure. The Old River flow control structure site lies in a preferred fishing and boating area, near several existing marinas and directly adjacent to one proposed marina. The San Joaquin County General Plan designates the southern bank of Old River adjacent to the barrier site for a 70-acre regional park and a 40-acre marina. These planned uses are expected to draw additional recreationists to this popular area. Although the barrier would include a boat lock to facilitate river travel, the flow control structure would impede boat travel. This is considered a significant adverse impact.

c. Mitigation for Impacts. To mitigate for the impacts discussed above, the DWR should take the following actions: (1) educate boaters about procedures for the boat lock at the Head of Old River structure through a variety of methods (including, but not limited to: posting clearly readable instructional signs on the banks and waterway at all approaches to the barrier site; distributing educational flyers containing maps, operation schedules, portage procedures and alternate routes at marinas and public launching facilities; and classes at local marinas on the use of the devices); and (2) set up an information telephone hotline and a homepage on the internet to provide updates on the operation of the barriers.

Education in the use of the boat lock should make boaters less hesitant to use the facilities, thereby reducing travel restrictions during periods of barrier operation.

6. Impacts to Navigation

This section evaluates the potential effects of Alternative 3 on navigation and recommends mitigation to reduce or eliminate identified significant adverse impacts. Navigation conditions are typically related to the absence or presence of obstacles to travel on area waterways. For the purposes of this analysis, navigation impacts are considered significant if implementation of a proposed action would create a substantial hazard to navigation or substantially affect the ease of navigation.

a. Impacts. The operation of the proposed facilities would affect the movement of small craft in several adjacent waterways and constitute a significant barrier to navigation as described above in the section on recreation.

b. Mitigation for Impacts. All fish and flow control structures would have facilities available to transport watercraft around the barriers. Notwithstanding the availability of these facilities, the creation of obstacles to navigation is considered an unavoidable significant impact with the exception of the Middle River Flow Control Structure, due to the low volume of use by small craft. These impacts cannot be mitigated to a level below significance.

D. SUMMARY

This chapter describes the alternatives for implementing the southern Delta salinity objectives contained in the 1995 Bay/Delta Plan and discusses the environmental effects of implementing the alternatives. Potential significant impacts to aquatic resources, terrestrial biological resources, recreation, navigation and transportation as a result of both construction and operation of the barriers (under Alternative 3) are identified. Much of the discussion contained in this chapter regarding the impacts of barrier construction and operation under Alternative 3 was summarized from the ISDP Draft EIR/EIS. The findings of this chapter are summarized below.

Construction and operation of the permanent barriers under Alternative 3 will potentially have adverse impacts on the following: raptor nests; Swainson's hawks and foraging habitat; western pond turtles and nest sites; potential kit fox territory; Mason's lilaeopsis; Delta tule pea; rose-mallow; Delta mudwort; freshwater marsh habitat; riparian scrub habitat; fall-run (Sacramento River), winter-run, late fall-run, and spring-run chinook salmon; steelhead rainbow trout; striped bass; American shad; white and green sturgeon; Delta smelt; longfin smelt; and Sacramento splittail. San Joaquin fall-run chinook salmon are expected to benefit from the operation of the barriers. Barrier construction is also expected to: cause temporary smothering within critical habitat for Delta smelt; permanently alter near-shore shallow-water habitat; and cause direct removal of aquatic organisms. Measures are proposed to mitigate for or reduce impacts to these resources.

Impacts to recreation, navigation, and transportation include: conflict with the County of San Joaquin's recreation-oriented goals and policies; limited navigation during the 30- to 36-month construction periods; and safety hazards due to debris in the Class II bike lane and the presence of numerous slow-moving trucks. Measures are proposed to mitigate for some of these impacts.

Impacts to aquatic resources, recreation, and navigation expected to result from Alternatives 1 and 2 are discussed in Chapter 6.

Alternative 1 meets water quality objectives at southern Delta stations in the winter months, but frequently exceeds objectives during the summer months. Alternative 2 also meets water quality objectives at southern Delta stations for the September through March period, and reduces the frequency of exceedance of salinity objectives during the summer months. Objectives are still exceeded, however, according to model runs. Alternative 2 consistently improves salinity levels at Vernalis and Union Island stations between April and August. There are also improvements, though to a lesser degree, at Brandt Bridge on the San Joaquin River and Tracy Road Bridge on Old River during the irrigation season. There is no marked improvement in water levels under Alternative 2 compared to Alternative 1. Alternative 3 meets salinity objectives in the southern Delta during the non-irrigation season, and reduces the frequency of exceedance compared to both Alternatives 1 and 2 during the irrigation season. Consistent improvements in salinity compared to the base case can be seen during the April through August period at the Vernalis, Union Island, and Tracy Road Bridge stations.

Many southern Delta locations see significant improvements in minimum water levels at certain times of the year as a result of barrier operations under Alternative 3 as compared to the base case. The following locations have monthly minimum water levels of at least one (+1) foot higher than the base case: The Middle River upstream of Barrier in October and April; The Old River upstream of Barrier in April; The Middle River near Undine Bridge in October and the first half of April; The Old River upstream of its confluence with the Middle River in June, July, and August; The Old River east of Tracy Road Bridge in August and the first half of April; and Grand Line Canal east of Tracy Road Bridge in June, July, and August.

In certain months, at certain locations, Alternative 3 will cause elevations which are lower than the base case. A monthly minimum water level of negative (-) 0.5 feet or lower (with respect to base case water levels) is considered to have a significant adverse impact and occurs on the Old River upstream of its confluence with the Middle River in the second half of April, and on the Grant Line canal west of Tracy Road bridge in June, July, and August.

The relative magnitude of impacts to various species and habitat as a consequence of the barriers cannot be quantified. The barriers would provide a benefit to San Joaquin fall-run salmon, but are expected to be a detriment to other aquatic species. With regard to water quality, Alternative 3 is the preferred alternative, but with regard to water levels, the preferred alternative is dependent on location. As a result, there is no clearly preferred alternative for meeting the southern Delta salinity objectives.

Literature Cited In Chapter IX

CVPIA. 1992. Central Valley Project Improvement Act - Title 34 of Public Law 102-575. October 30, 1992.

DWR. 1995a. Sacramento-San Joaquin Delta Atlas. Department of Water Resources. Sacramento, California. 134 pp.

DWR. 1995b. Initial Study for the Proposed Test Program Temporary Barriers Project. Department of Water Resources, Sacramento, California. 76 pp.

DWR and USBR. 1990. Draft Environmental Impact Report/Environmental Impact Statement for the South Delta Water Management Program, Phase I of Water Banking Program. Department of Water Resources and U.S. Bureau of Reclamation Sacramento, California. June 1990. 494 pp.

DWR and USBR. 1995. Interim South Delta Program Update. Department of Water Resources and U.S. Bureau of Reclamation. Sacramento, California. July 1995. 4 pp.

DWR and USBR. 1996. Draft Environmental Impact Report/Environmental Impact Statement on the Interim South Delta Program (Volume I). Prepared by Entrix, Inc. and Resource Insights for the Department of Water Resources and U.S. Bureau of Reclamation. Sacramento, California. July 1996. 700 pp.

Jackson, W.T. and A.M. Paterson. 1977. The Sacramento-San Joaquin Delta: the Evolution and Implementation of Water Policy. California Water Resources Center, University of California, Davis. June 1977. 192 pp.

Johnston, W.R. and G.T. Orlob. 1993. A Preliminary Plan for the Management of Water and Salt Flowing into the San Joaquin River from the Draining Entities on the West Side of the San Joaquin Valley. Prepared for the South Delta Water Agency. May 1993. 13 pp. plus figures.

RWQCB. 1994. Water Quality Control Plan (Basin Plan). California Regional Water Quality Control Board, Central Valley Region. Sacramento, California. 68 pp. Plus appendices.

RWQCB. 1995. Water Quality Control Plan. San Francisco Bay Basin (Region 2). Oakland, California. June 21, 1995. 158 pp. plus appendix.

SWRCB. 1967. Water Right Decision 1275. State Water Rights Board. Sacramento, California. May 31, 1967.

SWRCB. 1978a. Water Quality Control Plan. Sacramento-San Joaquin Delta and Suisun Marsh. State Water Resources Control Board. Sacramento, California. August 1978. 155 pp. plus appendices.

SWRCB. 1978b. Water Right Decision 1485. Sacramento-San Joaquin Delta and Suisun Marsh. State Water Resources Control Board. Sacramento, California. August 1978. 46 pp.

SWRCB. 1990. Status of Settlement of South Delta Water Agency, et al. v. United States of America, et al. Memorandum from W. Pettit to J. Baetge. September 17, 1990. 3pp. plus attachments.

SWRCB. 1991. Water Quality Control Plan for Salinity. San Francisco Bay/Sacramento-San Joaquin Delta Estuary. State Water Resources Control Board. Sacramento, California. May 1991. 204 pp. plus appendices.

SWRCB. 1995a. Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. State Water Resources Control Board. Sacramento, California. May 1995. 45 pp.

SWRCB. 1995b. Environmental Report: Appendix 1 to Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. State Water Resources Control Board. Sacramento, California. May 1995. 520 pp.

Wilson, Pete. 1992. "Governor Pete Wilson's Water Policy Statement," April 6, 1992.

Personal Communication

Herrick, John. 1997. Attorney to the SDWA. Personal Communication, July 15, 1997.

CHAPTER X. ALTERNATIVES FOR IMPLEMENTING THE DISSOLVED OXYGEN OBJECTIVE IN THE SAN JOAQUIN RIVER

The 1995 Bay/Delta Plan contains a dissolved oxygen (DO) objective of 6.0 mg/l from September through November in the lower San Joaquin River to protect fall-run chinook salmon. In addition, the Central Valley Regional Water Quality Control Board (CVRWQCB) Basin Plan includes a DO objective of 5.0 mg/l throughout the year. DO is required for the respiration of fish as well as for the respiration of the microorganisms that form their food web.

This chapter describes the environmental effects of the implementation of the alternatives to meet the 6.0 mg/l DO objective. The chapter is divided into three sections: (A) background, (B) alternatives for implementing the DO control objective, and (C) environmental effects of the alternatives.

A. BACKGROUND

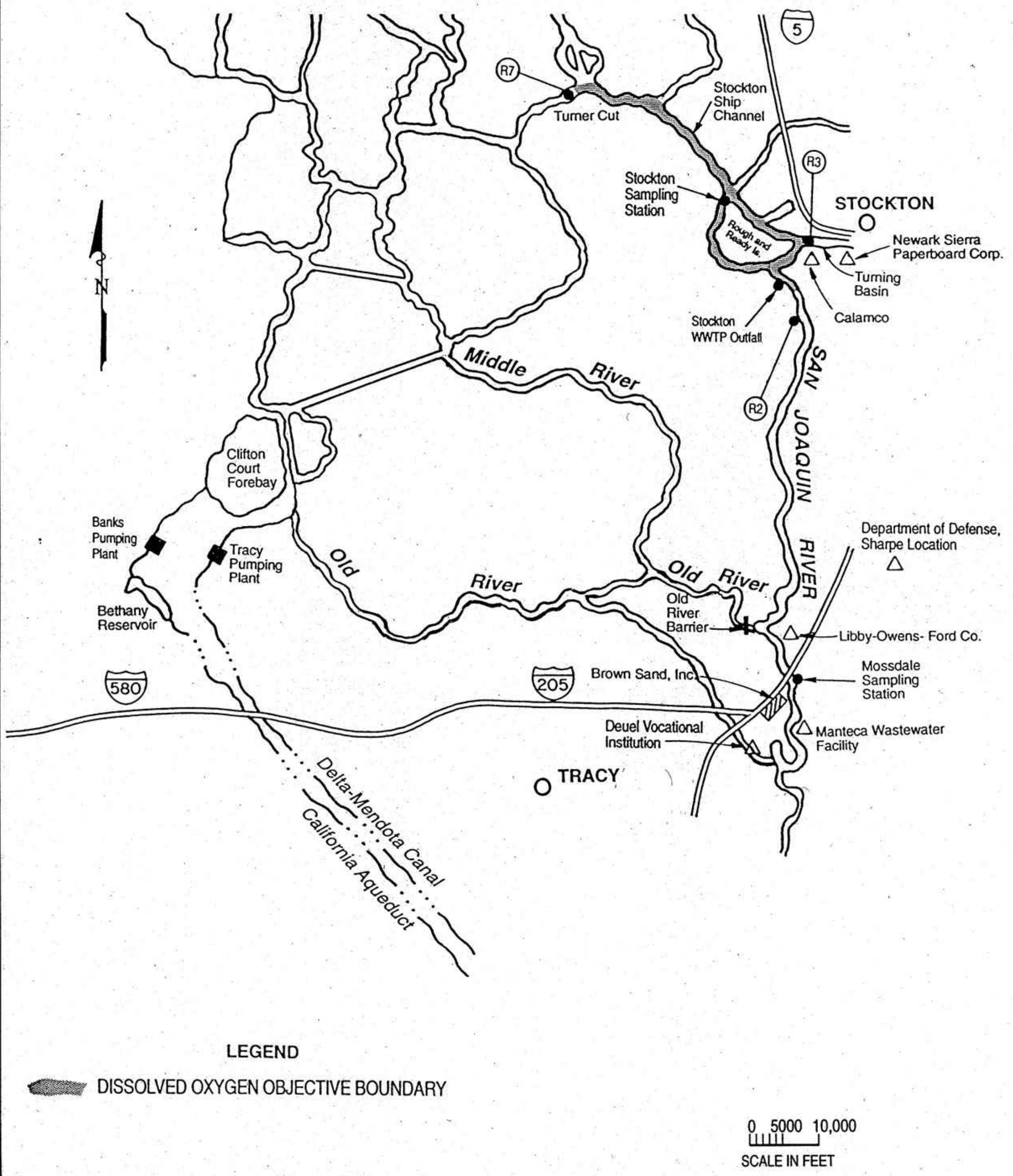
The background discussion is divided into four sections: (1) factors that affect DO levels in the San Joaquin River, (2) regulatory history, (3) historic DO conditions, and (4) current and proposed management actions to improve DO.

1. Factors that Affect DO Levels in the San Joaquin River

The fall-run chinook salmon pass through the Delta on their way to spawning areas in upstream tributaries. In order to migrate successfully to their natal streams, San Joaquin salmon must encounter favorable conditions in the Delta and the lower San Joaquin River. Water quality conditions in the reach of the San Joaquin River near the City of Stockton (Stockton), however, are often unfavorable, particularly in regard to temperature and DO levels. The reach of river (see Figure X-1) from Turner Cut to the head of Old River, which includes the Stockton ship channel, the Port of Stockton's turning basin, and the Stockton Wastewater Treatment Plant (Stockton WWTP) outfall has been identified as an area of concern because of low DO levels. DO levels below 5.0 mg/l create an "oxygen block" which impedes salmon migration upstream (Hallock 1970). DO levels as low as 1.5 mg/l have been recorded in the reach of the San Joaquin River from the turning basin to Turner Cut, and levels as low as 0 mg/l have been recorded in the turning basin. Reduced DO levels can cause physiological stress and increased mortality to fish in addition to delaying or blocking upstream migration (DFG 1995).

Water quality conditions in the San Joaquin River typically begin to deteriorate in the late spring, summer, and fall when flow in the river is low, water diversion rates are high, water temperature is high, and wastewater discharges into the river from upstream sources combine to increase the biochemical oxygen demand (BOD). The City of Stockton used a model to evaluate the sensitivity of DO to variations in river flow, temperature, sediment oxygen demand, algae, and waste loads. Each of the sensitivity analyses incorporated herein were prepared for the City of Stockton in a 1997 report entitled "Evaluation of Alternatives to Meet the Dissolved Oxygen Objectives of the Lower San Joaquin River." Descriptions of the San Joaquin River model, calibration and

Figure X - 1
Location of Dissolved Oxygen Objective Boundary and NPDES Dischargers



verification, Bay/Delta operations, and the sensitivity analyses can all be found in the aforementioned report.

Factors that contribute to low DO levels in the lower San Joaquin River include: (a) San Joaquin River flow, (b) San Joaquin River geometry, (c) water temperature, and (d) oxygen demand. Each of these factors is discussed below.

a. San Joaquin River Flow. Flow in the portion of the San Joaquin River that is subject to the 6.0 mg/l DO objective is influenced by upstream San Joaquin River flow, tidal fluctuations, pumping from the SWP and CVP facilities, and local diversions.

When evaluating the effects of flow in the lower San Joaquin River, both flow volume and flow direction are important to consider. Flow volume refers to the quantity of water moving through a river channel. Flow direction refers to whether the flow is moving upstream or downstream. Net positive flow means that the average flow is moving downstream, and net reverse flow means that the average flow is moving upstream. Sometimes a "slack water" condition occurs, where there is no significant net flow. A slack water condition significantly affects DO concentrations by reducing the assimilative capacity of the river (the ability of a waterway to dilute substances to a level where there are no deleterious effects on humans or the aquatic environment) and by promoting algae growth which results in increased oxygen demand as the algae die and decompose.

Positive flows do not always occur in the reach of the San Joaquin River near Stockton due, in part, to tidal effects. The Delta and its river systems are affected by four tides daily, two high tides and two low tides. These alternating tides can change the direction of the river several times a day during periods of low flow. The net effect at Stockton is poor circulation and a decreased assimilative capacity of the river.

The export operations of the SWP and the CVP also strongly influence flow in the San Joaquin River. The exports draw water from the San Joaquin River into the Old River, which decreases the flow of water past Stockton (Chen and Schanz 1993). Local diversions exacerbate this problem. Export pumping and local diversions also cause slack water conditions and net flow reversals in local channels.

Sensitivity of DO to Flow. San Joaquin River flow varies daily and seasonally. This analysis held flow constant at a given level throughout the year to eliminate the daily fluctuation of flow and its effects on DO. Waste loads from the WWTP are based on 1996 data. River flow was maintained at five constant levels of (1) -500 cfs, (2) 0 cfs, (3) 500 cfs, (4) 1,000 cfs, and (5) 2,000 cfs.

The modeling results contained in Table X-1 show seasonal trends of low DO in the summer even at high flow conditions, especially during July and August. This indicates that the historical low DO in the summer was not caused exclusively by the historical low flows, but low flow did accentuate the DO problem. The modeling shows that increasing river flow increases DO concentrations at

Stations R2 and R3 and decreases DO concentrations at station R7 as the oxygen demands are carried further downstream. Generally, zero net river flow (0 cfs) produced the lowest DO concentrations due to the lack of dilution.

Table X-1
DO Concentrations (in mg/l) at Stations R2, R3 and R7 under Five Different River Flow Conditions

	River Flow = -500 cfs			River Flow = 0 cfs			River Flow = 500 cfs			River Flow = 1000 cfs			River Flow = 2000 cfs		
Date	R2	R3	R7	R2	R3	R7	R2	R3	R7	R2	R3	R7	R2	R3	R7
Oct. 1995	6.8	6.9	8.0	5.9	5.8	7.8	7.5	6.2	7.3	8.0	6.9	7.0	8.3	7.7	7.0
Nov. 1995	7.0	7.1	8.3	5.2	4.2	7.6	8.2	6.3	7.0	8.6	7.6	7.2	8.7	8.3	7.8
Dec. 1995	7.9	7.8	8.8	6.4	5.1	8.1	9.1	7.6	7.9	9.2	8.6	8.2	9.2	9.0	8.7
Jan. 1996	8.4	8.3	9.1	6.9	5.7	8.5	9.4	8.1	8.4	9.5	8.9	8.7	9.6	9.3	9.0
Feb. 1996	8.0	8.2	9.2	5.6	4.4	8.3	9.2	7.5	8.1	9.3	8.6	8.5	9.4	9.1	8.9
Mar. 1996	7.9	8.1	9.0	5.5	4.3	8.2	9.0	7.3	8.0	9.2	8.5	8.4	9.3	9.0	8.7
Apr. 1996	7.7	7.8	8.5	6.0	5.2	8.1	8.2	7.0	7.8	8.5	7.8	7.9	8.6	8.3	8.1
May 1996	7.0	7.1	8.0	5.9	5.5	7.7	7.5	6.5	7.4	7.9	7.2	7.4	8.0	7.7	7.5
Jun. 1996	6.2	6.2	7.4	5.3	5.1	7.2	6.9	6.0	6.9	7.4	6.8	6.9	7.7	7.4	7.1
Jul. 1996	5.5	5.6	6.8	4.7	4.5	6.6	5.7	4.9	6.2	6.4	5.6	6.0	6.9	6.3	6.0
Aug. 1996	4.9	5.0	6.7	3.8	3.4	6.3	5.8	4.1	5.7	6.6	5.3	5.5	7.1	6.4	5.6
Sep. 1996	5.0	5.2	7.1	3.1	2.4	6.5	6.9	4.4	5.8	7.7	6.2	5.9	8.0	7.4	6.6
12 month Avg:	6.9	6.9	8.1	5.4	4.6	7.6	7.8	6.3	7.2	8.2	7.3	7.3	8.4	8.0	7.6

b. **San Joaquin River Geometry**. The geometry of the San Joaquin River is important because it controls many of the hydrodynamic conditions that affect water quality processes in the vicinity of Stockton. The San Joaquin River upstream of the Stockton ship channel is relatively shallow; between the head of Old River and the Stockton ship channel, the river has a mean depth of 7.5 feet. The San Joaquin River downstream of Stockton is much deeper because it is dredged to a depth of 35 feet to maintain the Stockton ship channel. The river has a mean depth of approximately 20 feet between Stockton and Turner Cut.

The mean depth of the San Joaquin River is a very important variable controlling the effects of surface reaeration and sediment oxygen demand on DO concentrations. The rate of reaeration per unit volume of water is reduced in deeper waters, which reduces the assimilative capacity of the waters.

The channel depth also affects algal photosynthesis and respiration. Because the turbidity of the San Joaquin River is relatively high, light penetration is limited and the fraction of the water column that supports photosynthesis and algae growth is less in the ship channel section of the river. Algal populations tend to grow in the upstream portion of the San Joaquin River and decline in the downstream portion of the river.

c. Water Temperature. Oxygen is only slightly soluble in water, and its solubility decreases as the temperature increases. For example, oxygen saturation is about 12.5 mg/l at 40°F and just over 8.0 mg/l at 80°F. When water is warm and complete saturation is in the range of 8.0 to 9.0 mg/l, a relatively low oxygen demand will bring the water below 6.0 mg/l or even 5.0 mg/l (Stockton 1996).

High temperatures also increase the rate of oxygen-consuming biological activity. Most biological processes speed up as the temperatures increase and slow down as the temperatures decrease. High temperatures stimulate the growth of aquatic organisms, such as algae, and increases the rate at which these organisms decompose and oxidize after they die.

Sensitivity of DO to Temperature. The effect of temperature on DO was evaluated by a constant addition or subtraction of temperature from the base case. The simulations were performed for constant flows of -500 cfs, 500 cfs, and 1,000 cfs.

The modeling results in Table X-2 show an uneven response of DO with respect to temperature. At a negative flow, a temperature decrease of 2°C led to an increase in DO by up to 1.0 mg/l. A temperature increase of 2°C led to a decrease of DO only by 0.1 mg/l. In other words, at the modeled conditions, more dissolved oxygen is gained by a reduction in temperature than is lost by an increase in temperature. The effects of reducing river temperature are more dramatic at lower flows.

Table X-2
Sensitivity of Dissolved Oxygen to Change in Temperature

	Change in Dissolved Oxygen, mg/l					
	Flow -500 cfs		Flow +500 cfs		Flow +1,000 cfs	
Station	+2°C	-2°C	+2°C	-2°C	+2°C	-2°C
R2	-0.1	+1.0	-0.2	+0.2	-0.2	+0.1
R3	-0.1	+1.0	-0.2	+0.5	-0.2	+0.2
R7	-0.1	+0.1	-0.1	+0.3	-0.2	+0.2

d. Oxygen Demand. Sources of BOD loading along the San Joaquin River include point and nonpoint discharge sources, algae, and dredging activities. BOD includes carbonaceous oxygen demand (CBOD) and nitrogenous oxygen demand.

Sensitivity of DO to Sediment Oxygen Demand. The sensitivity analysis for sediment oxygen demands was performed by cutting the sediment oxygen demand by 50% and 100%. Sediment oxygen demands used in the model include all diffused sources of nonpoint source pollutants.

Table X-3 presents a summary of the sensitivity of DO to sediment oxygen demands. The modeling shows that reductions in sediment oxygen demands would significantly increase DO concentrations in the lower San Joaquin River.

Table X-3
Sensitivity of Dissolved Oxygen to Sediment Oxygen Demand

	Change in Dissolved Oxygen, mg/l					
	Flow -500 cfs		Flow +500 cfs		Flow +1,000 cfs	
Station	50%	100%	50%	100%	50%	100%
R2	+1.3	+2.5	+0.8	+2.0	+0.6	+1.1
R3	+1.3	+2.5	+1.2	+2.5	+0.7	+1.5
R7	+0.2	+0.4	+0.6	+1.5	+0.9	+2.0

Point Sources. Point sources of oxygen demand include municipal and industrial discharges to the river. Point sources to navigable waterways are regulated by the federal Clean Water Act through the National Pollutant Discharge Elimination System (NPDES) permit program. NPDES permits specify discharge limits for various constituents and mandate monitoring water quality of effluent and receiving water. The purpose of the NPDES discharge limits is to protect identified beneficial uses of the river including recreation, water supply, fisheries, and wildlife. Important factors that determine discharge limits are the mixing characteristics of the receiving water, the chemical and biological reactions that transform constituents as they are transported in the river, and the sensitivity of the aquatic ecosystem. In California, the NPDES program is implemented by the RWQCBs.

The reach of the San Joaquin River near the Port of Stockton is the area of greatest concern in regard to DO. The turning basin at the port acts as an oxygen sink because there is relatively little water circulation or tidal activity in the basin. Dead or dying algae in the stagnant water produces an oxygen demand. The problem is exacerbated in the late summer and early fall months when water temperature is high. The point discharge from Stockton's WWTP has been identified as an important factor to water quality in the area (see Figure X-1).

A DO study prepared for Stockton identifies the most significant sources of oxygen demand in the San Joaquin River (Chen et al 1993). Near the WWTP's outfall, BOD and ammonia are the most significant sources of oxygen demand. Farther from the outfall, other BOD sources become the significant sources of oxygen demand. The study indicates that CBOD and ammonia discharged by the Stockton WWTP consume 16.8 percent and 25.8 percent, respectively, of the oxygen resources at the monitoring station located near the WWTP's outfall. Other BOD sources account for an estimated 57.4 percent of oxygen demand at this location; however, other BOD sources account for an estimated 78.1 percent of oxygen demand further away from the outfall (Chen et al 1993).

Other municipal and industrial discharges upstream of the Stockton WWTP include the Cities of Modesto, Turlock and Newman. There are other NPDES dischargers on the San Joaquin River that may also have impacts on dissolved oxygen. NPDES discharges located in the San Joaquin River and its tributaries between Mossdale and the Stockton WWTP are listed in Table X-4 and shown on Figure X-1.

Table X-4
NPDES Dischargers in the San Joaquin River Between Mossdale and Stockton

Discharger	Point of Discharge	Maximum Discharge Rate
Brown Sand, Inc.	San Joaquin River	3.6 MGD
Calamco	Stockton Deep Water Channel	1.7 MGD
Department of Defense-Sharpe Location	South San Joaquin Irrigation Canal	1.2 MGD
Deuel Vocational Institution	Deuel Drain	0.6 MGD
Libby-Owens-Ford Co.	San Joaquin River	2.1 MGD
Manteca Wastewater Facility	San Joaquin River	5.8 MGD
Newark Sierra Paperboard Corp.	McDougald Slough	3.5 MGD
City of Stockton WWTP	San Joaquin River	67.0 MGD

Sensitivity of DO to Waste Load. Sensitivity of DO to waste load from Stockton's WWTP was evaluated by comparing DO concentrations under 1996 levels of waste load to a zero discharge condition, as shown in Table X-5. The simulations were performed for five hydrologic year types and the sensitivity of DO to waste load was measured by the DO increase in the critical summer months (June to August).

Table X-5
Sensitivity of Dissolved Oxygen to Waste Loads from Stockton WWTP

	Maximum Change in Summer DO by Eliminating Stockton's WWTP Discharge, mg/l				
Station	1991 Critically Dry	1981 Dry	1966 Below Normal	1957 Above Normal	1982 Wet
R2	+0.2	+1.0	+1.0	+0.6	+0.6
R3	+1.0	+1.0	+1.0	+1.0	+1.0
R7	+0.2	+0.1	+0.1	+0.2	+0.2

Nonpoint Sources. Nonpoint source discharges include agricultural drainage and urban runoff. The San Joaquin River carries substantial amounts of agricultural return water or drainage. Agricultural drainage contributes salts, nutrients, pesticides, trace elements, sediments, and other by-products that affect the water quality of the river and the Delta. In particular, nutrients contributed by irrigation runoff and livestock operations constitute significant sources of BOD, or promote the processes that consume oxygen. Urban runoff may contain metals, oil and grease, sediment, nutrients and trace amounts of various organic toxins. Urban runoff also contains organic materials that are an additional source of BOD. Urban runoff is generated primarily during storm events, when constituents are washed off of impervious surfaces into the storm drainage system.

Algae. Algal production can have considerable effects on DO in the San Joaquin River. Episodes of DO supersaturation in the San Joaquin River coincide with high chlorophyll concentrations at Mossdale and Vernalis and are thus almost certainly the results of algal photosynthesis. During most years, these periods of supersaturated conditions (high algal productions) at Mossdale are associated with extremely low DO levels in the Stockton ship channel. The diurnal variation of pH also indicates algal photosynthesis (Van Nieuwenhuyse, E., pers. Comm. 1997).

High levels of algal biomass prevail in the San Joaquin River at Vernalis and Mossdale because the river offers an abundant supply of phosphorus, nitrogen, light, and time for algal production. High phosphorus and nitrogen levels are due in part to natural fertility of basin soils, fertilization of row crops and orchards, runoff of manure from feedlots, and erosion from poorly managed land throughout the watershed. Light supply is generally adequate because the river is shallow and the water column is fully mixed. Thus, even though the water is moderately turbid, algae are frequently exposed to high light intensities during a given day because turbulent currents transport the algae through well-lit water near the surface. In addition, there is enough flow in the mainstem of the river during the summer to provide sufficient time for high biomass levels to develop.

The algae that prevail at Vernalis and Mossdale are generally a mixture of diatoms and, to a lesser extent, chlorophytes. Most of the diatoms are adapted to stream conditions in that they depend on the turbulence of stream flow to stay in suspension and are capable of surviving or even actively photosynthesizing if they temporally settle out onto shallow sediments. When these algae are transported to the deeper water (7.5 feet deep) of the San Joaquin River channel between Old River and Stockton or the Stockton ship channel (20 feet deep), they encounter conditions for which they are poorly adapted. Consequently, most of the algal biomass transported to this reach of the system dies, settles to the dark riverbed, and decomposes. Compliance monitoring has shown that late summer and fall phytoplankton blooms periodically occur within the Stockton turning basin (at the extreme eastern end of the Stockton ship channel). Dissolved oxygen levels can exceed 14.0 mg/L (supersaturation) in the surface bloom area, and approach 0.0 mg/l (total anoxia) near the bottom as dead or dying algae settle out of the water column and accumulate at the bottom. The decomposition of this algal biomass exerts a large DO demand.

Sensitivity of DO to Algae. This sensitivity analysis models the effects of increasing algal density at Vernalis and Mossdale from the base condition (1X) to assumed values of five times (5X) and ten times (10X) the base condition. There was no chlorophyll-a data for September 1991, therefore chlorophyll concentrations were assumed to be the same as in August.

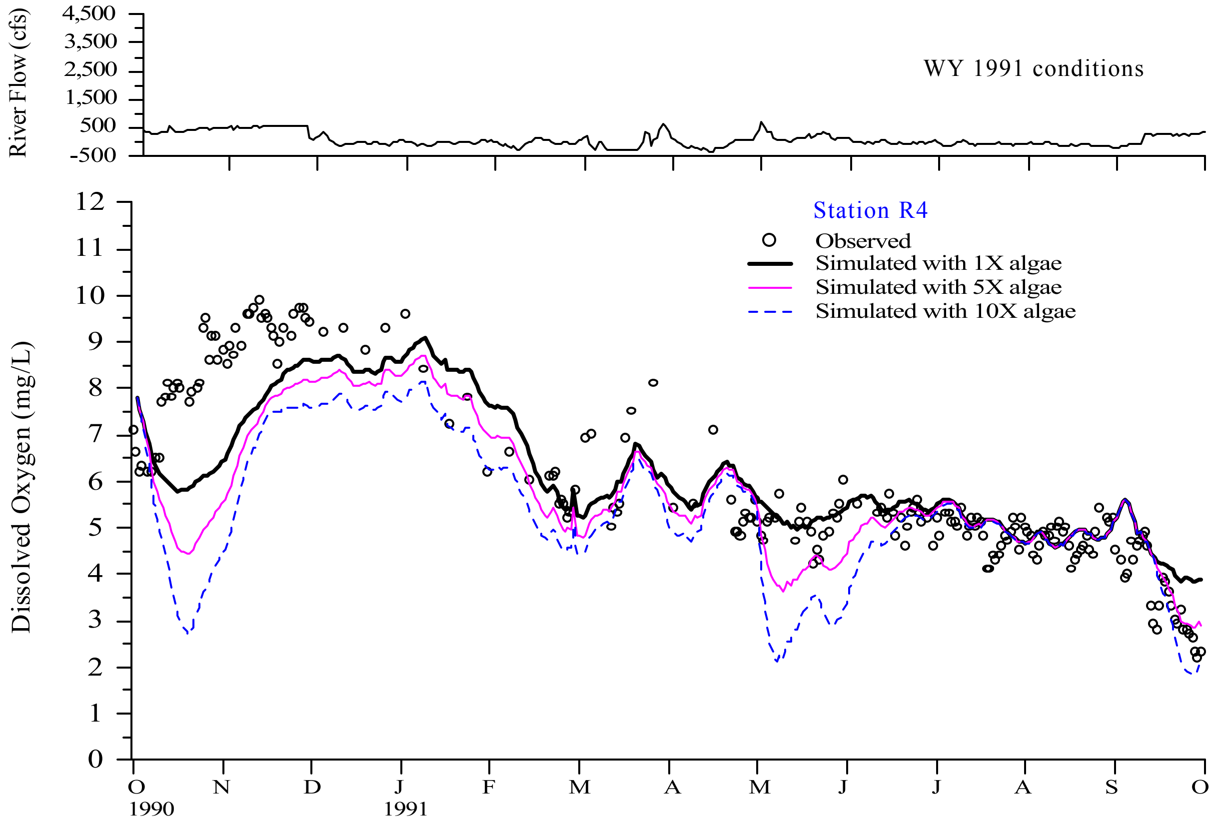
The sensitivity analysis results in Figure X-2 shows that algal blooms at Mossdale can depress DO in the San Joaquin River at Stockton. An increase of chlorophyll level by five times resulting from algal blooms at Mossdale coupled with a positive flow can cause a DO depression at Station R4 by as much as 3 mg/l.

Dredging Activities. Dredging activities in the ship channel have also been identified as a source of water quality problems. In the short term, dredging re-suspends solids and constituents containing BOD into the water column. In the long term, channel deepening decreases DO by reducing velocities and reaeration of the water column, and increasing oxygen demand by dying phytoplankton (Chen and Schanz 1993). A USCOE study found that dredging of the ship channel reduced DO levels in the area of the Port of Stockton up to approximately 0.2 mg/l (USCOE 1990). This reduction can be significant because DO concentrations are often already low during the important fall period when salmon migration is occurring.

2. Regulatory History

This section discusses the history of the SWRCB’s and the CVRWQCB's regulation of DO in the San Joaquin River and the Delta. Water quality objectives for the Delta are established by the SWRCB and the San Francisco Bay and the Central Valley RWQCBs through water quality control plans. These plans are implemented through water right decisions and through the RWQCB's NPDES and Waste Discharge Requirement permitting process. The SWRCB’s

Figure X-2
Simulated Dissolved Oxygen under Three Algae Concentrations



Delta water right decisions are summarized in Chapter I of this EIR and discussed here as they pertain to DO objectives. There are two DO water quality objectives that currently apply to the lower San Joaquin River: (1) the 1995 Bay/Delta Plan DO Objective, and (2) the CVRWQCB Basin Plan DO Objective.

A four-year study conducted from 1964 through 1967 indicated that salmon migration in the San Joaquin River is blocked when DO levels are below 4.5 mg/l and that "the run did not become steady until the dissolved oxygen levels were above 5.0 ppm" (Hallock 1970). To address the problem of low DO levels in the San Joaquin River, an agreement was reached in 1969 between the DWR, DFG, USBR, and USFWS to take specific actions "to maintain the dissolved oxygen content in the Stockton ship channel generally above 6.0 ppm when necessary." The study and resulting agreement formed the basis for the DO objectives that were subsequently adopted.

a. 1967 Interim Water Quality Control Policy for the Sacramento-San Joaquin Delta. The 1967 objectives were adopted to meet federal requirements for interstate waters for the Delta. Supplemental objectives were adopted in 1969. The 1967 objectives established a DO objective of 5.0 mg/l with two exceptions: (1) where the reduction occurs as a result of natural causes, and (2) in certain bodies of water which are constructed for special purposes and from which fish have been excluded.

b. 1975 Basin Plan. The 1975 CVRWQCB Basin Plan contains specific DO objectives for areas within and outside the legal boundaries of the Delta. The Basin Plan continues the 1967 DO objective of 5.0 mg/l with an exception for special purpose bodies of water which exclude fish. The objectives applied to all Delta waters except: (1) the Sacramento River below the I Street Bridge and in all Delta waters west of the Antioch bridge where the objective was 7.0 mg/l and (2) waters where the fishery is not important as a beneficial use.

c. 1991 Bay/Delta Plan. The Plan establishes a DO water quality objective of 6.0 mg/l for the segment of the San Joaquin River from Turner Cut to Stockton from September 1 through November 30.

d. 1995 Basin Plan. The 1995 CVRWQCB Basin Plan established a DO objective of 7.0 mg/l in the Sacramento River below the I Street Bridge and in all Delta waters west of the Antioch Bridge, a DO objective of 6.0 mg/l in the San Joaquin River between Turner Cut and Stockton from September 1 to November 30, and a DO objective of 5.0 mg/l in all other Delta waters.

e. 1995 Bay/Delta Plan. The 1991 Bay/Delta Plan was superseded by the 1995 Bay/Delta Plan. The DO objectives remained unchanged, with the exception of the addition of a provision that specifies that if it is infeasible for waste dischargers to meet the objective immediately, a time extension or schedule of compliance may be granted. The objectives, however, must be met by September 1, 2005.

3. Historic DO Conditions

Observations of low DO have been made in the lower San Joaquin River near Stockton since 1935. In 1963, however, the effect of low DO levels on fish was recognized as a result of a study conducted by the DFG, DWR, and the Central Valley Water Pollution Control Board. In 1961, salmon escapement declined from the previous year's run of 53,000 fish to 2,550 fish. During the following two years the escapement decreased even further to 320 fish by 1963. The 1963 study was designed to identify the causes of the decreased salmon runs and to determine possible solutions. As part of the study, DO observations were made throughout the lower San Joaquin River. The study area included the reach of river starting from a point near Turner Cut to a point approximately eight miles upstream from Stockton. These observations found DO levels less than 3.0 mg/l and as low as 0.4 mg/l throughout the study area. DO levels as low as 0.1 mg/l were observed in the Stockton ship channel (DFG 1964).

The 1963 study identified pollution originating at Stockton as a significant cause of the DO problem. Most of the pollution was the result of waste discharges from fruit and vegetable canneries. DO levels would decline as the weather warmed and cannery discharges increased. The oxygen block would eventually break in the fall when the cannery season ended, temperatures cooled, and flows increased.

In the fall of 1963, a barrier at the head of Old River was installed for the first time. At the same time, river flows were augmented by releases into the San Joaquin River through the Newman and Westly waterways. It was hoped that the barrier and flow augmentation would increase flows past Stockton thereby improving both flow conditions for fish and water quality conditions, including DO. The action had most of the desired effects (Hallock 1970).

In 1965, 1966 and 1967, DO concentration was identified as the factor that controlled the movement of salmon past Stockton. DO was typically lowest at the San Joaquin River at Turner Cut, but occasionally the lowest DO levels were found near the current Stockton WWTP outfall (Hallock 1970).

The critical area of concern regarding oxygen blocks affecting the migration of adult salmon continues to be the reach of river located from the head of Old River to Turner Cut. Recent monitoring data for DO in this area have been collected at several sampling stations. The data for two of the sampling stations are described in this report. The first sampling station (Mossdale sampling station) is located at the Mossdale crossing about 1.5 miles upstream of the head of Old River. The second station (Stockton sampling station) is located at the Stockton ship channel about 4.5 miles upstream of Turner Cut (see Figure X-1).

DO levels at the stations have been taken since 1984. Daily average DO readings are summarized in Figures X-3 and X-4 for the four-year period from 1990 through 1994. This time period includes three critically dry years and one wet year, based on the San Joaquin River Basin 60-20-20 hydrologic classification. DO levels at the Mossdale sampling station, shown in Figure X-3, appear to be adequate to support aquatic habitat. DO levels at the Stockton sampling station, shown in Figure X-4, are significantly lower than at Mossdale and the DO objectives were exceeded on numerous occasions.

4. Current and Proposed Management Actions to Improve DO

This section discusses the following current and proposed management actions to improve DO conditions: (a) U.S. Army Corps of Engineers (USCOE) aeration facility, (b) the barrier at the head of Old River, (c) Interim South Delta Program (ISDP), and (d) water quality regulatory actions by the CVRWQCB.

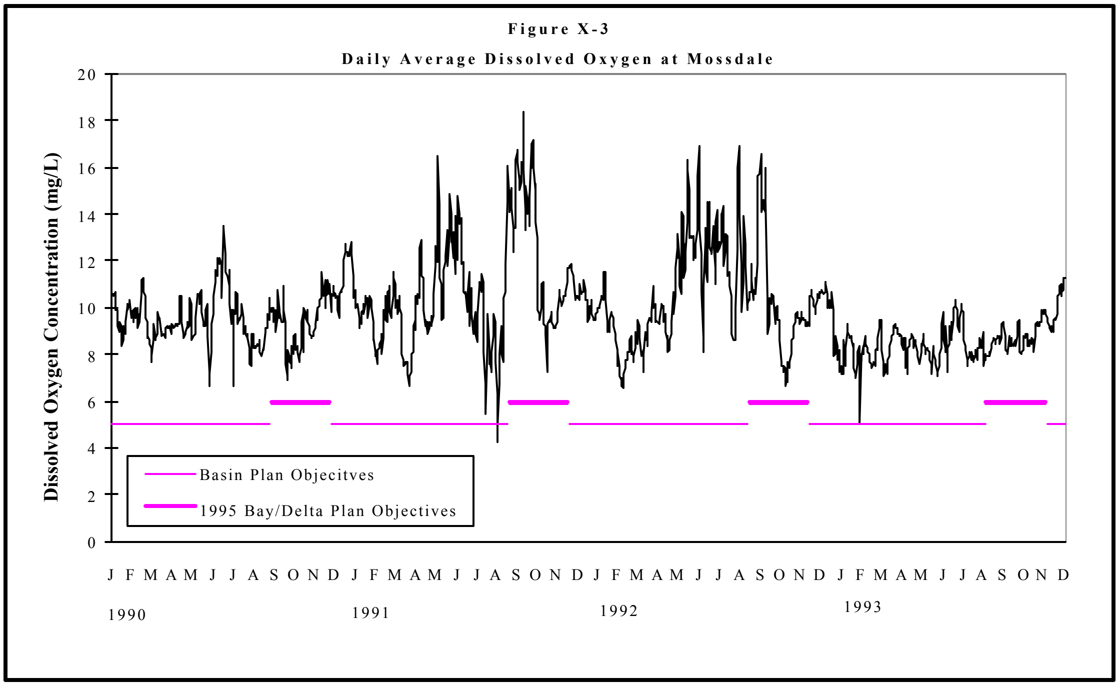


Figure X-3
Daily Average Dissolved Oxygen at Mossdale
Dissolved Oxygen Concentration (mg/L)
0
2
4
6
8
10
12
14
16
18
20
Basin Plan Objecitves
1995 Bay/Delta Plan Objectives
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1990
1991
1992
1993

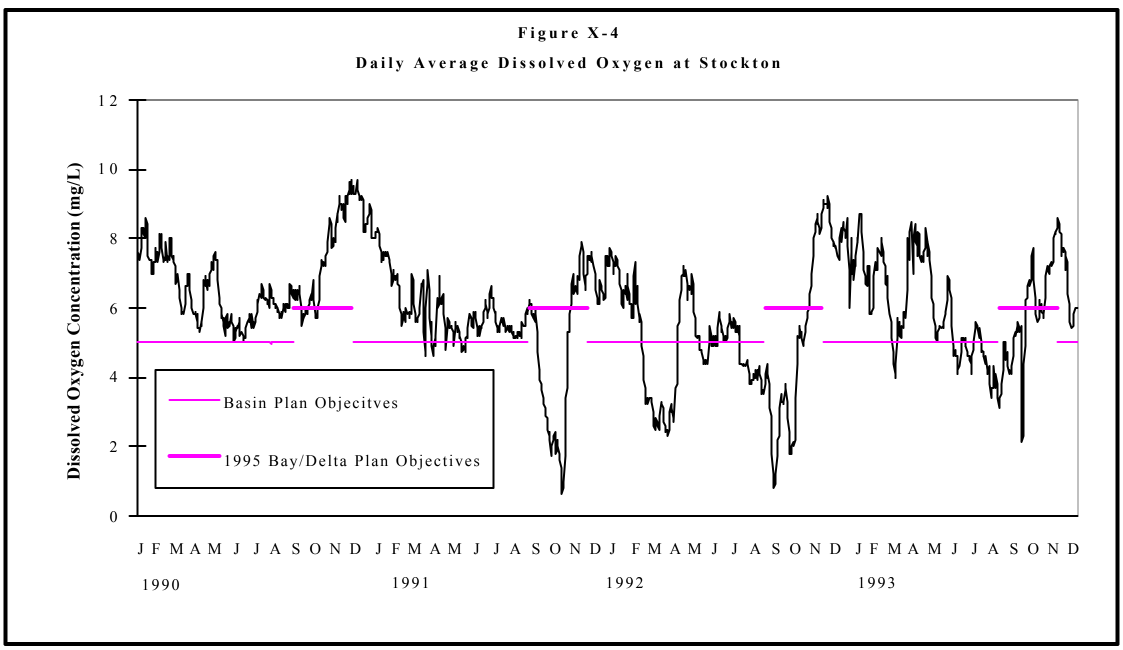


Figure X-4
Daily Average Dissolved Oxygen at Stockton
Dissolved Oxygen Concentration (mg/L)
0
2
4
6
8
10
12
Basin Plan Objecitves
1995 Bay/Delta Plan Objectives
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1990
1991
1992
1993

a. USCOE Aeration Facility. The USCOE installed a jet aeration facility in the Stockton ship channel at the Port of Stockton in the vicinity of Rough and Ready Island. The purpose of the facility is to mitigate for the reduction of about 0.2 mg/l (approximately 2,000 lbs/day of oxygen at a flow of 2,000 cfs) in DO concentrations which occurs when the ship channel is dredged. The aeration facility consists of two manifolds with eight mixing nozzles each that introduce a jet of water mixed with air bubbles into the river. The aeration system is lowered to a depth of about 20-feet and is designed to inject about 2,000 lbs/day of DO into the river. The pump intake includes fish screens and is designed to achieve low intake velocities in order to prevent entrainment of fish (USCOE 1990).

The facility is operated by the USCOE in cooperation with the Port of Stockton and the City of Stockton. The USCOE is currently negotiating an agreement to transfer operational responsibilities to the Port of Stockton. The facility is operated whenever the DO levels at any of Stockton's eight river monitoring stations drop below 5.2 mg/l during the fall chinook salmon run (September through November).

b. Barrier at Head of Old River. Under a 1969 agreement between the DWR, DFG, USBR and U.S. Bureau of Sport Fisheries and Wildlife (predecessor to U.S. Fish and Wildlife Service), a temporary barrier is installed at the head of Old River from September through November in order to increase flow in the San Joaquin River past Stockton. When the barrier is in place, water flowing in the San Joaquin River is restricted from flowing down Old River and continues to flow downstream in the mainstem of the river. When the barrier is not in place, more than half of the San Joaquin River flow measured at Vernalis flows down Old River.

Monitoring data show that installation of the fall Head of Old River barrier usually improves DO concentrations in the lower San Joaquin River, especially in years with low San Joaquin river flows, although the rate of improvement has varied. The most pronounced beneficial effects of the barrier occur when its installation eliminates net negative flows in the San Joaquin River. Under these circumstances, adverse effects of slack water are avoided, and the turning basin is not a significant DO sink for the river (Stockton 1996).

The flow necessary to achieve the DO objectives in the absence of a barrier is not known. Low DO levels have been recorded even when San Joaquin River flows were relatively high.

c. ISDP. The ISDP is described in detail in Chapter IX. The ISDP is a proposed action to: (1) improve water quality and raise water levels in the southern Delta; (2) settle pending litigation by the South Delta Water Agency against the USBR and the DWR; (3) implement an element of the Central Valley Project Improvement Act (CVPIA); and (4) enhance the existing water delivery capability of the SWP. The ISDP includes five project components, one of which is the construction and seasonal operation of a permanent barrier at the head of Old River in spring and fall to improve fishery conditions for salmon migrating along the San Joaquin River. The permanent barrier would be operated to improve flow conditions past Stockton similar to the current temporary barrier operation.

d. Water Quality Regulatory Actions by the CVRWQCB. Oxygen levels in the San Joaquin River have improved as a result of incremental treatment of wastewater discharges required by the CVRWQCB. The pretreatment of cannery waste and its subsequent treatment at treatment plants has significantly reduced the BOD loading from this source.

The largest point source discharge of BOD in the southern Delta is the City of Stockton. In 1990, Stockton applied to renew its NPDES permit which would expire in 1991. During the application review, Stockton and the CVRWQCB staff agreed to develop new information to address permit renewal issues including the effects of the discharge on downstream DO concentrations (SWRCB 1996). As a result, Stockton developed a computer model that, among other things, simulates the effect of the WWTP and DO concentrations in the river in the immediate vicinity of the WWTP's outfall and Stockton shipping channel (Chen and Schanz 1993). The City's model showed that the treatment plant discharge was a significant contributor to the DO problem, even though the City complied with existing effluent limits. Consequently, the CVRWQCB staff proposed more stringent effluent limitations in the draft NPDES permit. The proposed effluent limitations are summarized in Table X-6.

Table X-6
Proposed NPDES Limitations

Time Period	Carbonaceous BOD (mg/l)			NH_3 (mg/l)		
	Monthly Avg.	Weekly Avg.	Daily Max.	Monthly Avg.	Weekly Avg.	Daily Max.
Dec. 1-Mar. 31	20	--	--	no nitrification required	--	--
Apr. 1-Oct. 31	10	20	25	2	4	5
Nov. 1-Nov. 30	15	23	30	10	15	-

The City objected to the 2.0 mg/l monthly average ammonia limit during the April through October period. The City's objection was based on several grounds. First, it claimed that compliance with new effluent limitations would be unreasonably expensive. Stockton is in the process of designing and constructing improvements to its WWTP. The improvements are planned to achieve effluent quality of 10.0 mg/l CBOD and 7.0 mg/l ammonia. Stockton claimed that the cost of constructing the incremental improvement to achieve an effluent quality of 2.0 mg/l ammonia would be too expensive. Second, Stockton asserted that it could not complete improvements to comply with the effluent limitations during the five-year life of the NPDES permit, and it would be unfairly subject to enforcement actions. Finally, Stockton argued that even without its discharge, the DO levels in the area of its discharge would not consistently comply with current water quality objectives. Stockton claims that water quality impairments of the lower San Joaquin River are caused by man-made conditions, including Delta export pumping and other operations, which reduce and reverse flows in the San Joaquin River near Stockton (SWRCB 1996).

On October 28, 1994, the CVRWQCB adopted Waste Discharge Requirements for the Stockton WWTP, Order No. 94-324 (NPDES Permit No. CA0079138) which includes the effluent limitations recommended by staff. The order acknowledges that other causes contribute to the low DO levels, but finds that Stockton's discharge contributes to the violation of the DO water quality objectives and that more stringent effluent limitations for CBOD and ammonia would substantially reduce that contribution.

Stockton subsequently filed a petition with the SWRCB objecting to certain provisions of the NPDES permit. After review of the petition, the SWRCB adopted Order No. WQ 96-09 which remands the NPDES permit back to the CVRWQCB for review and revision. The SWRCB specified that the CVRWQCB should reconsider the CBOD and ammonia effluent limitations in the permit, taking into account new river flow conditions caused by implementation of the 1995 Bay/Delta Plan flow objectives. The CVRWQCB should also incorporate flexibility in the NPDES permit to revise the effluent limitations to accommodate both future improvements in receiving water DO levels and alternatives for reducing the discharger's impact to DO. The order requires the CVRWQCB to adopt a cease and desist order with a compliance schedule and to establish a compliance schedule in the NPDES permit to implement effluent limitations and receiving water limitations necessary to comply with DO objectives. The SWRCB continued a stay of the effluent limitations for ammonia and receiving water limitations for DO until the CVRWQCB completes the review and revision required in the order. In all other respects, the NPDES permit remains in full force and effect. The CVRWQCB and Stockton agreed to postpone action, including the adoption of a cease and desist order, until Stockton completes further modeling of the WWTP's effects on the river.

B. ALTERNATIVES FOR IMPLEMENTING THE DO OBJECTIVE

DO conditions near Stockton are controlled by net flows past Stockton, BOD loading, water temperature, sediment oxygen demand, and algal blooms. The alternatives in this report evaluate two of the controlling factors, increased flows and BOD loading. Increased flows past Stockton can be provided either by increasing flows in the San Joaquin River entering the Delta or by placing a barrier at the head of Old River. Water temperatures, sediment oxygen demand, and algal blooms were not evaluated because there are no controllable mechanisms by which the SWRCB can significantly affect these parameters. The following four alternatives are evaluated in this report.

1. DO Control Alternative 1 - Base Case

The SWP and the CVP are responsible for meeting D-1485 flow objectives. The quantity and quality of effluent from the Stockton WWTP are at present levels. The Head of Old River temporary barrier is installed in September, October, and November. No further water right action is taken to implement the dissolved oxygen objective. This is the existing condition.

2. DO Control Alternative 2 - Bay/Delta Plan Flows

The 1995 Bay/Delta Plan flow objectives are met by implementation of one of the flow alternatives. Effluent quantity and quality from the Stockton WWTP are at present levels. The Head of Old River temporary barrier is installed in September, October, and November. No further action is taken to implement the dissolved oxygen objective.

3. DO Control Alternative 3 - ISDP Barriers Operation

The 1995 Bay/Delta Plan flow objectives are met by implementation of one of the flow alternatives. Effluent quantity and quality from the Stockton WWTP are at present levels. The permanent barriers proposed in the ISDP are constructed and operated and the barrier at the head of Old River is closed in September, October, and November.

4. DO Control Alternative 4 - Reduced BOD Loading from the Stockton WWTP

The 1995 Bay/Delta Plan flow objectives are met by implementation of one of the flow alternatives. The permanent barriers proposed in the ISDP are constructed and operated and the barrier at the head of Old River is closed in September, October, and November. The discharge quantity from the Stockton treatment plant is at the present levels; however, the effluent meets CBOD and ammonia effluent limits as specified in the NPDES permit issued by the CVRWQCB and shown in Table X-6. Stockton complies with the permit limits by constructing enhanced treatment facilities.

C. ENVIRONMENTAL EFFECTS OF THE ALTERNATIVES

This section describes the environmental effects of implementing the DO control alternatives. The discussion is divided into eight sections: (1) Impacts to Water Quality in the San Joaquin River; (2) Impacts on Aquatic Resources; (3) Energy Effects; (4) Public Nuisance Considerations; (5) Use of Hazardous/Toxic Substances; (6) Socioeconomic, Fiscal and Secondary Effects; (7) Construction-Related Impacts; and (8) Summary. Section 1 discusses the water quality impacts in the San Joaquin River of the three DO alternatives and the base case. Sections 2 through 7 focus on impacts expected from implementation of Alternative 4. The information in these sections is summarized from an expanded initial study for the Stockton WWTP (Engineering-Science, Inc 1994) and an addendum to the expanded initial study (Stockton 1994). Other impacts expected to result from Alternative 2 are already described in Chapters V (water supply impacts), VI (environmental impacts) and XI (economic impacts) of this EIR. Other expected impacts of Alternative 3 are already discussed in Chapter IX of this EIR. Alternatives 3 and 4 include actions that would require subsequent project level evaluations pursuant to CEQA, and they will be evaluated as programmatic actions for the purpose of this EIR.

1. Impacts to Water Quality in the San Joaquin River

Stockton's San Joaquin River model was used to simulate DO levels in the San Joaquin River resulting from the DO control alternatives (Chen 1997). The DO model is described in Chapter IV of this EIR. The model was used to simulate five years; one year for each of the five year types as classified by the Sacramento Valley 40-30-30 Water Year Hydrologic Classification system described on page 23 of the 1995 Bay/Delta Plan. The selected years are: water year 1982 - wet; water year 1957 - above normal; water year 1966 - below normal; water year 1981 – dry, and; water year 1991- critically dry. These are the same years that were selected by the DWR in consultation with the DFG for the purposes of modeling the impacts to the Delta of implementing the ISDP (DWR 1996).

For each simulation, the river flows of the San Joaquin River at Stockton were obtained from the output of the DWR's Delta Simulation Model (DWRDSM). The river flows reflect the upstream reservoir operations and Head of Old River barrier operations. For Alternatives 1 and 2, temporary barrier operation is assumed. Alternatives 3 and 4 assume operation of a permanent barrier. Barrier operations are described on Table IX-1.

Simulations for Alternatives 1, 2, and 3 assume CBOD and ammonia loading at Stockton's WWTP at 1996 levels. Alternative 4 reduces CBOD and ammonia loading through enhanced treatment. Stockton is in the process of expanding and rehabilitating its WWTP and the master plan is currently being updated to reflect the planned upgrade to 48 million gallons per day (mgd) capacity with an ultimate build-out of 55 mgd. The six-stage expansion project as planned, will meet the CBOD limits, with monthly average effluent quality of 10.0 mg/l CBOD. The designed effluent quality of 7.0 mg/l ammonia will not meet the proposed 2.0 mg/l ammonia monthly average limit. Stockton testified during the Bay/Delta water rights hearing that the cost of constructing nitrification facilities to achieve an effluent quality of 2.0 mg/l ammonia would be $61 million plus additional financial costs of $17 million. This analysis focuses on three of Stockton's monitoring stations: R2, R3, and R7 (see Figure X-1). Monitoring Station R2 is located just upstream of the WWTP outfall, monitoring Station R3 is located at the turning basin, and monitoring Station R7 is located at Turner Cut. These locations were chosen to show the simulated DO at approximately the upstream and downstream boundaries of the DO objective and where the lowest DO levels are often measured (the turning basin). Figures X-5 through X-19 show the minimum monthly DO levels for each objective at the three monitoring stations for each of the five years modeled.

Figures X-5 through X-9 show minimum monthly DO levels at Station R2, south of the WWTP. This station is normally upstream of the WWTP and the turning basin; however, during periods of reverse flow, the station is downstream. The figures show that minimum monthly DO levels at this station are consistently above the objectives for all year types from October through June, except during the critically dry year of 1991 when Alternatives 3 and 4 are slightly below the objective in June. Additionally, minimum monthly DO levels for the three alternatives during the time period of October through June generally are equal to or better than minimum monthly DO levels under the base case. Where minimum monthly DO is less than under the base case, the difference is either slight, or else the difference occurs in the winter when DO levels are not a problem. As the conditions become dryer in July and August, DO conditions worsen. Minimum monthly DO during July and August is generally better than the base case for Alternatives 3 and 4; however, minimum monthly DO levels for Alternative 2 are often worse than the base case in this period. By September, minimum monthly DO levels begin to recover. September minimum monthly DO levels are generally better for Alternatives 3 and 4 than for the base case.

Figures X-10 through X-14 show minimum monthly DO levels at Station R3, the turning basin. These figures show the same yearly trends as Figures X-5 through X-9, with the minimum monthly DO levels above the objectives through the winter and spring and DO levels declining through the summer until September when they start to recover. Alternative 3 generally provides the highest DO concentrations during June and July, while Alternative 4 is generally more beneficial to DO levels during the August through October time period. The effects of the barriers are also noticeable, especially in September and October, when the Head of Old River Barrier is in place. During the summer months, the barriers sometimes cause DO to worsen as compared to the base case, most notably during the dryer year types. Implementation of Alternative 2, the Bay/Delta Plan, improves DO conditions in April and May, the pulse flow period, but there is a corresponding drop in DO in the late summer for all year types.

Figures X-15 through X-19 show minimum monthly DO levels at Station R7, Turner Cut. DO levels follow the same yearly trends as the other figures. Minimum monthly DO levels at Turner Cut are generally higher than the minimum monthly DO for the same period at the turning basin. This is due, in part, to the greater mixing that occurs at this location.

All of the alternatives achieve the 5.0 mg/l objective for all year types. Even though DO levels improve from upstream stations, the 6.0 mg/l objective is often not met in September for Alternatives 1, 2, and 3. The objective is also not met in October for every alternative for every year type, except during the critically dry year of 1991, when every alternative met the October DO objective.

The flow in the lower San Joaquin River is highly regulated by the upstream reservoirs. For that reason, a wet year does not necessarily result in a higher stream flow during the critical summer months. The minimum DO for a dry year may be higher than the minimum DO for a wet year.

Figure X-5
Simulated Minimum Monthly DO at Station R2 for Wet Year

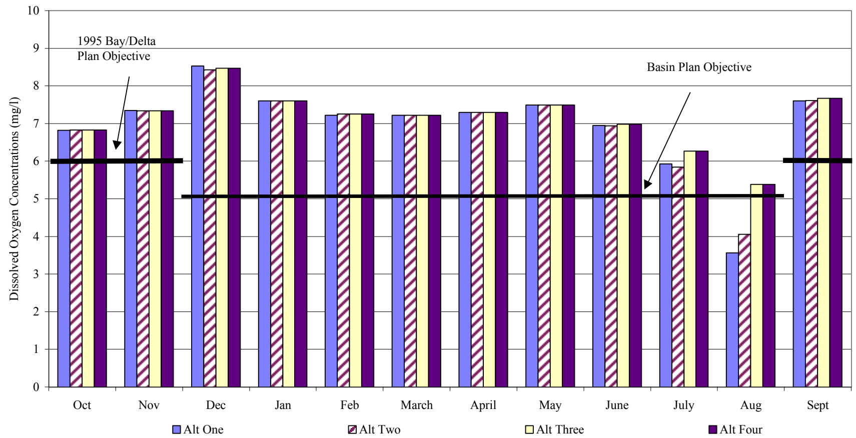


Figure X-6
Simulated Minimum Monthly DO at Station R2 for Above Normal Year

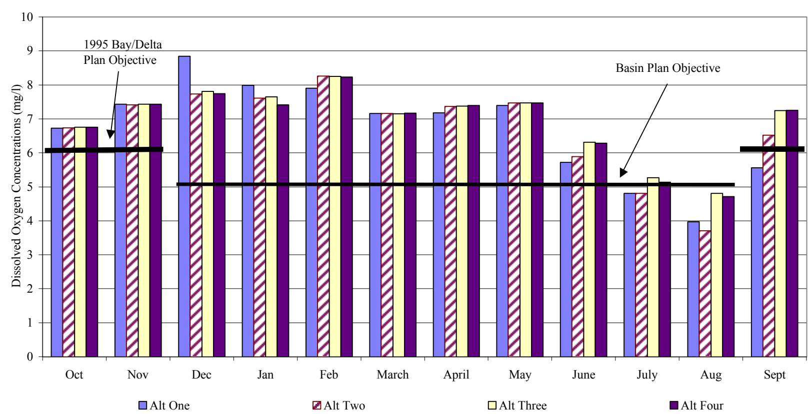


Figure X-7
Simulated Minimum Monthly DO at Station R2 for Below Normal Year

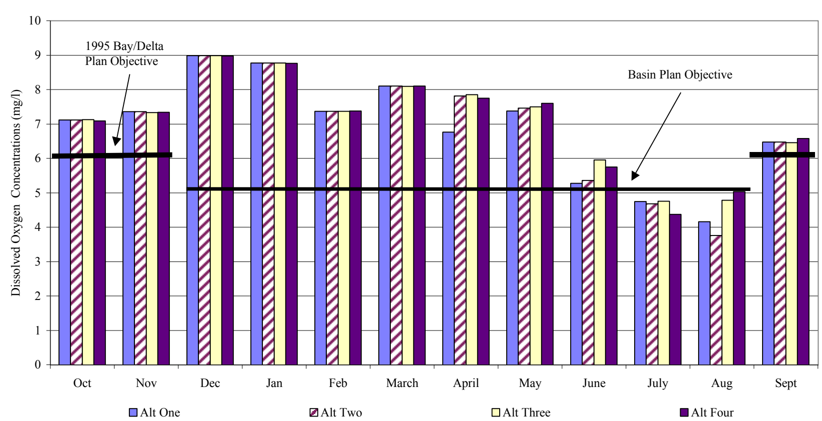


Figure X-8
Simulated Minimum Monthly DO at Station R2 for Dry Year

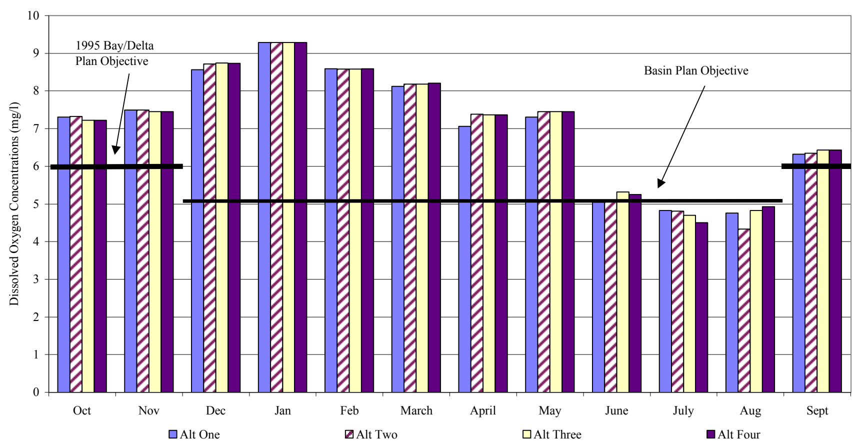


Figure X-9
Simulated Minimum Monthly DO at Station R2 for Critically Dry Year

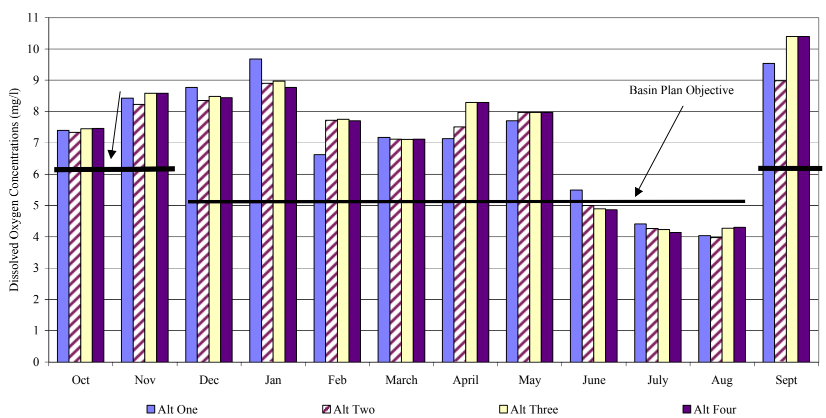


Figure X-10
Simulated Minimum Monthly DO at Station R3 for Wet Year

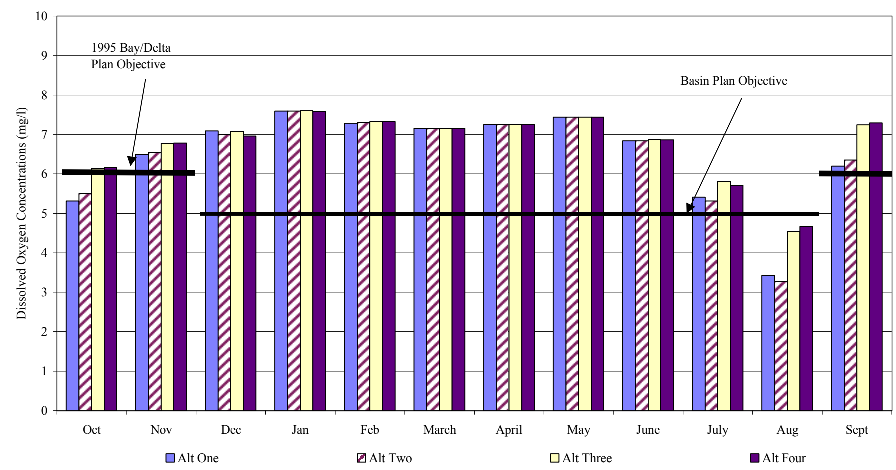


Figure X-11
Simulated Minimum Monthly DO at Station R3 for Above Normal Year

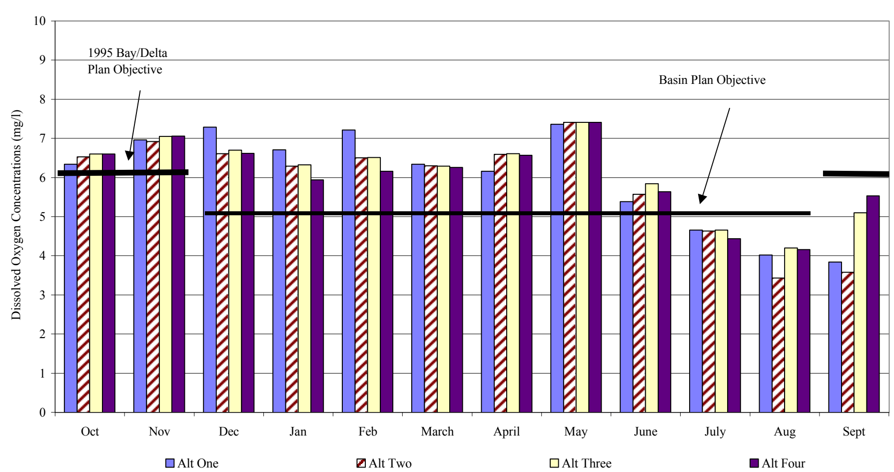


Figure X-12
Simulated Minimum Monthly DO at Station R3 for Below Normal Year

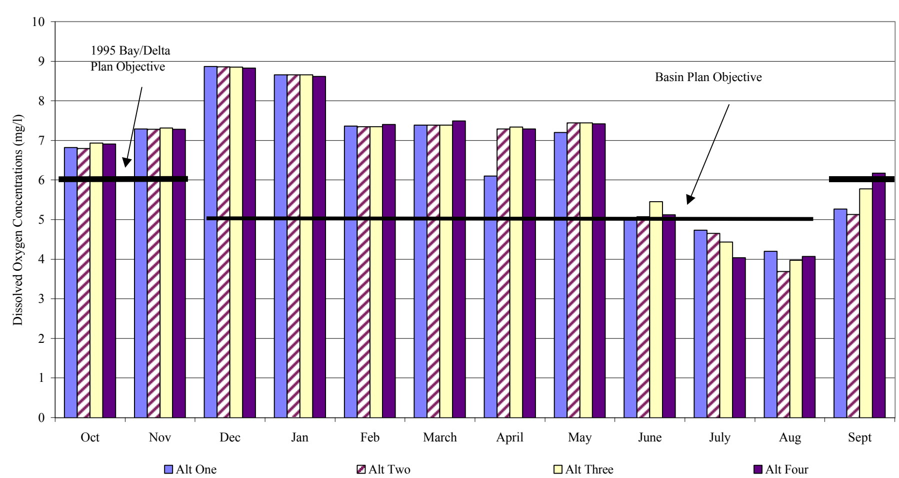


Figure X-13
Simulated Minimum Monthly DO at Station R3 for Dry Year

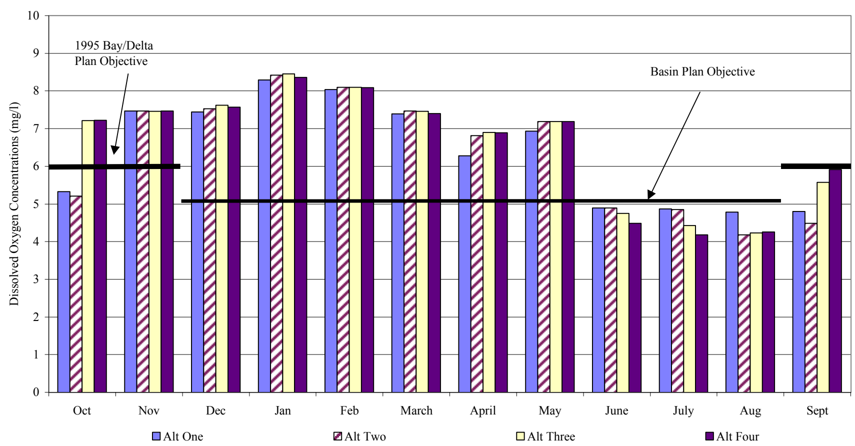


Figure X-14
Simulated Minimum Monthly DO at Station R3 for Critically Dry Year

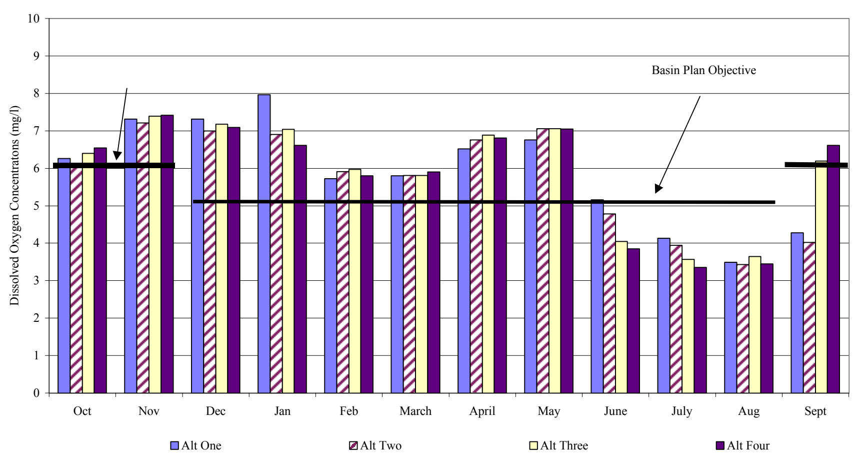


Figure X-15
Simulated Minimum Monthly DO at Station R7 for Wet Year

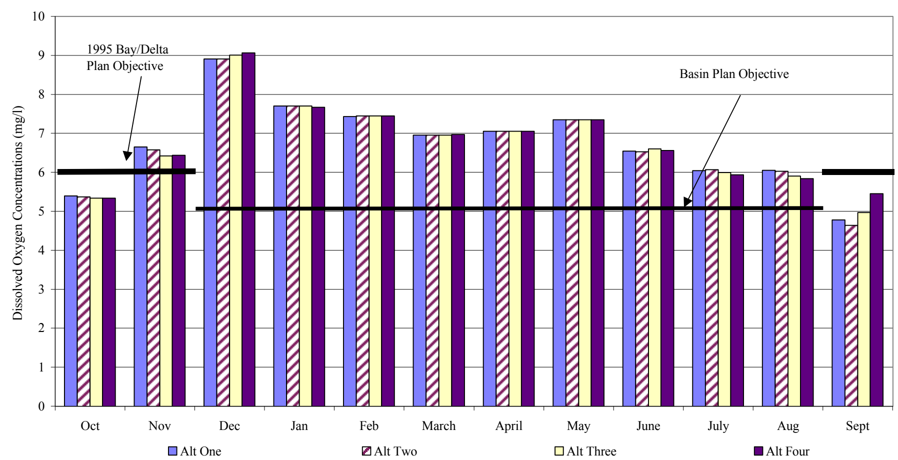


Figure X-16
Simulated Minimum Monthly DO at Station R7 for Above Normal Year

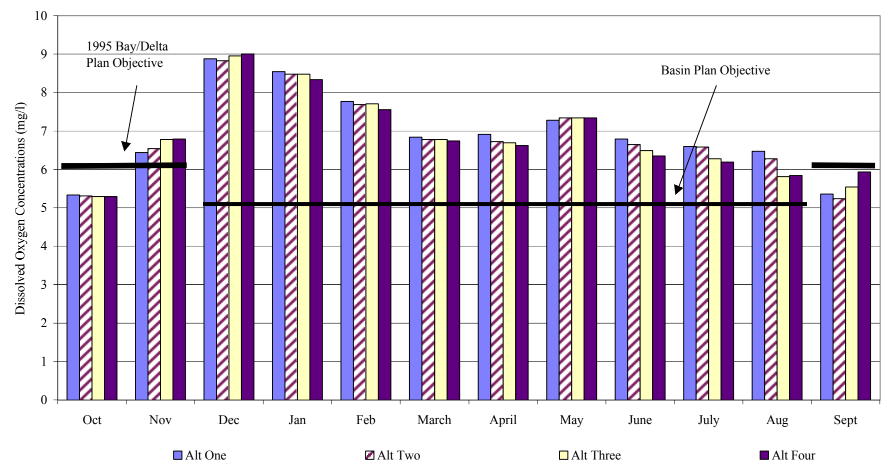


Figure X-17
Simulated Minimum Monthly DO at Station R7 for Below Normal Year

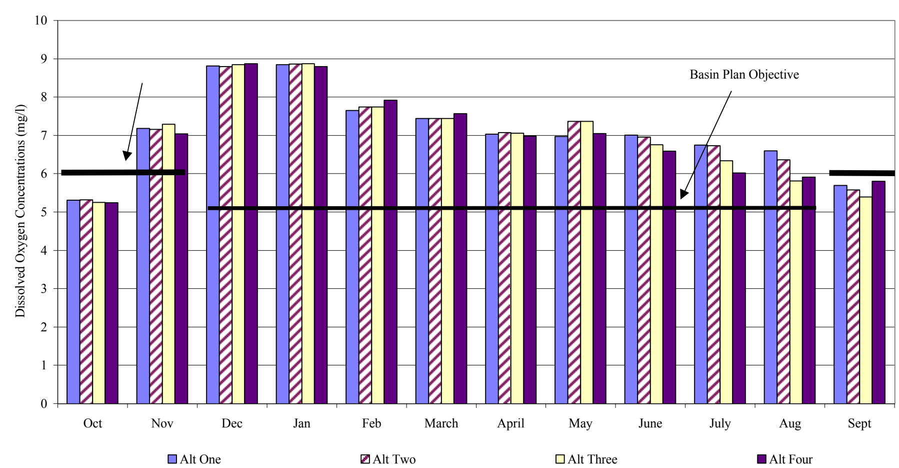


Figure X-18
Simulated Minimum Monthly DO at Station R7 for Dry Year

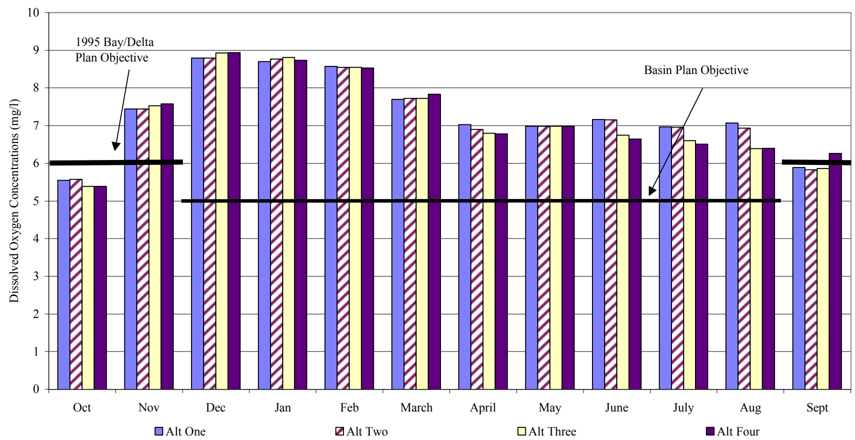
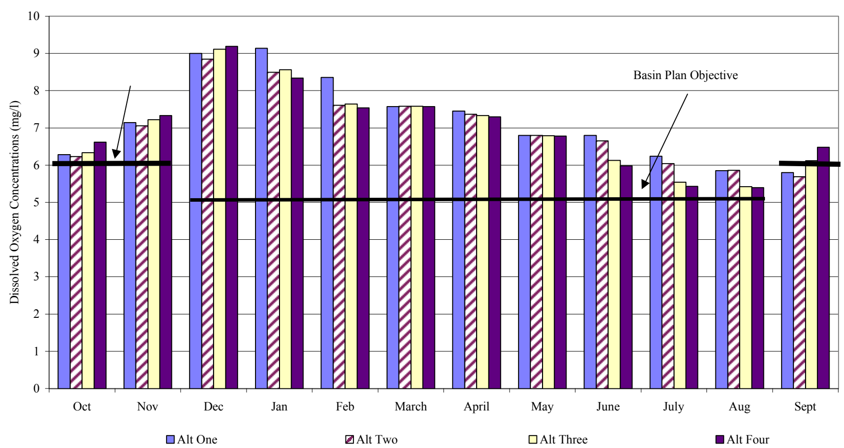


Figure X-19
Simulated Minimum Monthly DO at Station R7 for Critically Dry Year



Figures X-20 through X-29 show the frequency distribution of DO levels for each water-year type at monitoring Station R3. Historically, the lowest DO levels have been measured at Station R3. The first figure for each water year shows the period from September to November when the Bay/Delta Plan 6.0 mg/l DO objective is in effect, and the second figure for each water year shows the period from December to August when the CVRWQCB Basin Plan 5.0 mg/l objective is in effect. The objectives are also shown on the figures.

Figure X-20 shows that during the wet year of 1982, the DO levels vary little among the alternatives during the September through November period. Alternatives 3 and 4 provide slightly higher DO levels and meet the objective most of the time. The other alternatives fail to meet the objective only slightly less often. During the December to August period, shown on Figure X-21, Alternatives 3 and 4 meet the objective slightly more often than Alternatives 1 and 2. When the objective is not met, the DO under Alternatives 1 and 2 is up to 1.5 mg/l lower than the DO under Alternatives 3 and 4.

Figure X-22 shows that during the above normal year of 1957, all the alternatives result in similar DO levels in September through November. Alternatives 3 and 4 meet the objective slightly more often than Alternatives 1 and 2. Figure X-23 shows that during December through August, the alternatives provide similar DO levels, with Alternatives 3 and 4 providing slightly higher DO levels than Alternatives 1 and 2. When the objective is not being met, DO levels are up to 1.5 mg/l below the 5.0 mg/l objective.

Figure X-24 and X-25 show DO levels during the below normal year of 1966. During the September through November period Alternatives 1 and 2 do not meet the objective about 20 percent of the time. Alternative 3 meets the objective in all but about 10 percent of years and Alternative 4 always meets the DO objective during the months of September through November. During December through August, Alternatives 2, 3, and 4 meet the objective equally often and result in similar DO levels.

Figure X-26 shows that during the fall of the dry year 1981, Alternative 4 most often meets the DO objective. Figure X-27 shows that during December through August, DO levels are similar among the alternatives, with DO levels falling below the objective about 25 percent of the time. Alternatives 3 and 4 least often meet the objective and result in the lowest overall DO when the objective is not being met.

Figure X-28 shows that during the critically dry year of 1991, Alternatives 3 and 4 provide slightly higher DO levels and always meets the objective. Figure X-29 shows that during December through August, all alternatives result in similar DO levels. Alternative 1 meets the objectives most often, but the other alternatives meet the objectives only slightly less often than Alternative 1.

Figure X-20
Frequency Distribution of Dissolved Oxygen Levels at Stockton in a Wet Year (Water Year 1982) for September - November

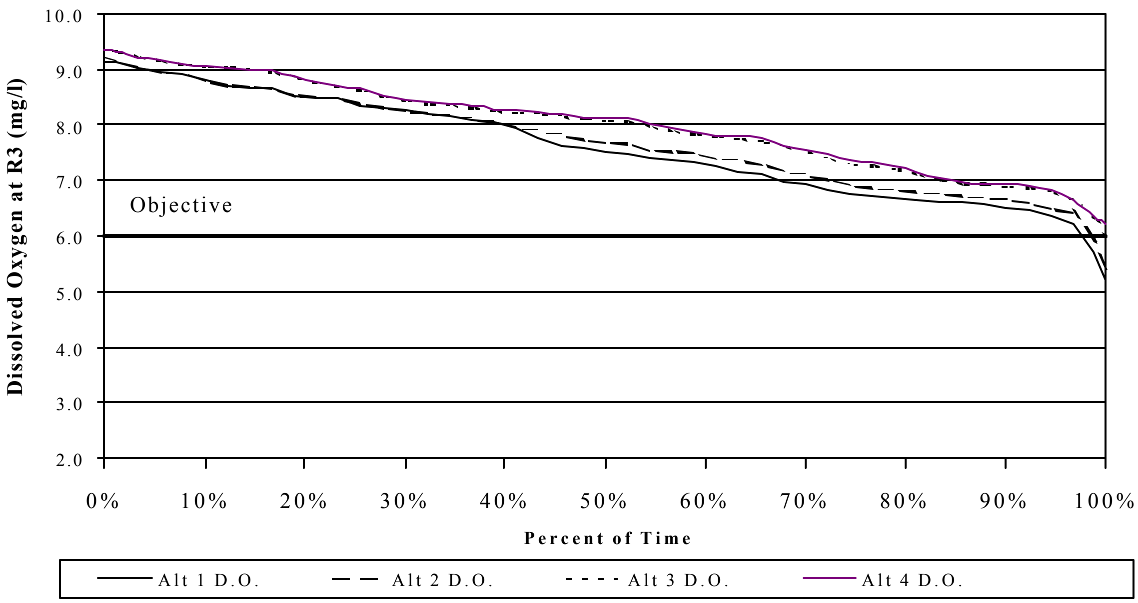


Figure X-21
Frequency Distribution of Dissolved Oxygen Levels at Stockton in a Wet Year (Water Year 1982) for December - August

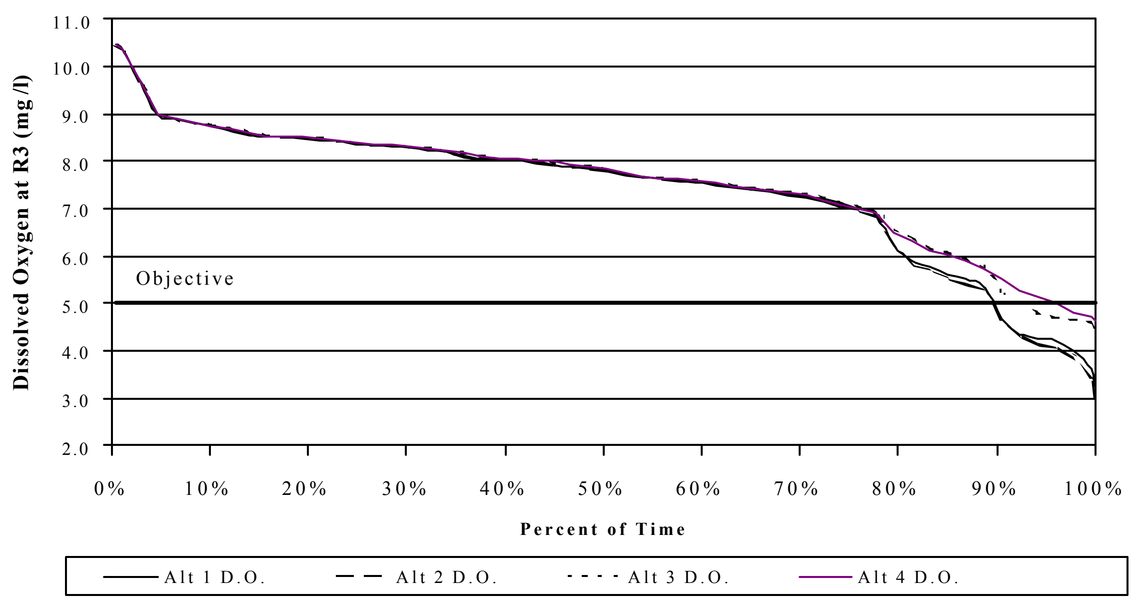


Figure X-22
Frequency Distribution of Dissolved Oxygen Levels at Stockton in an Above Normal Year (Water Year 1957) for September - November

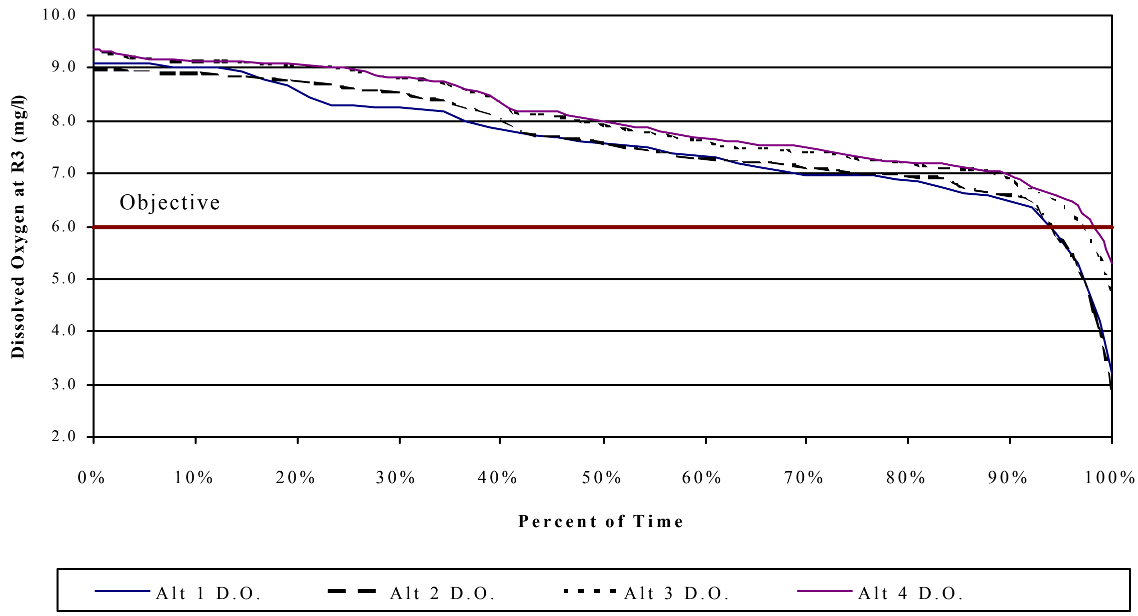


Figure X-23
Frequency Distribution of Dissolved Oxygen Levels at Stockton in an Above Normal Year (Water Year 1957) for December - August

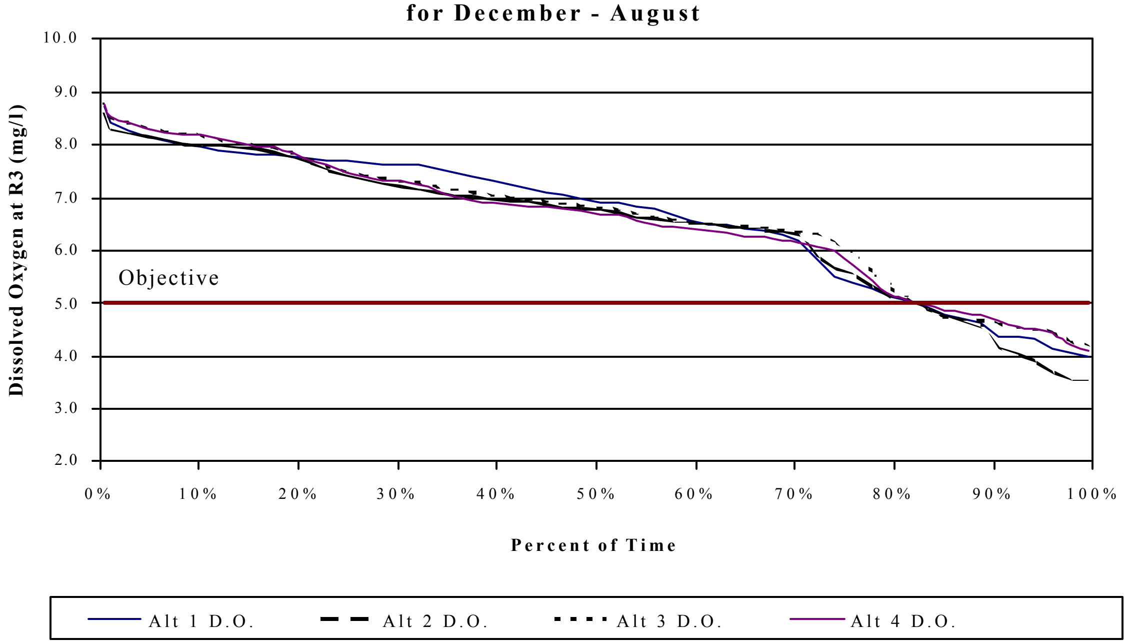


Figure X-24
Frequency Distribution of Dissolved Oxygen Levels at Stockton in a Below Normal Year (Water Year 1966) for September - November

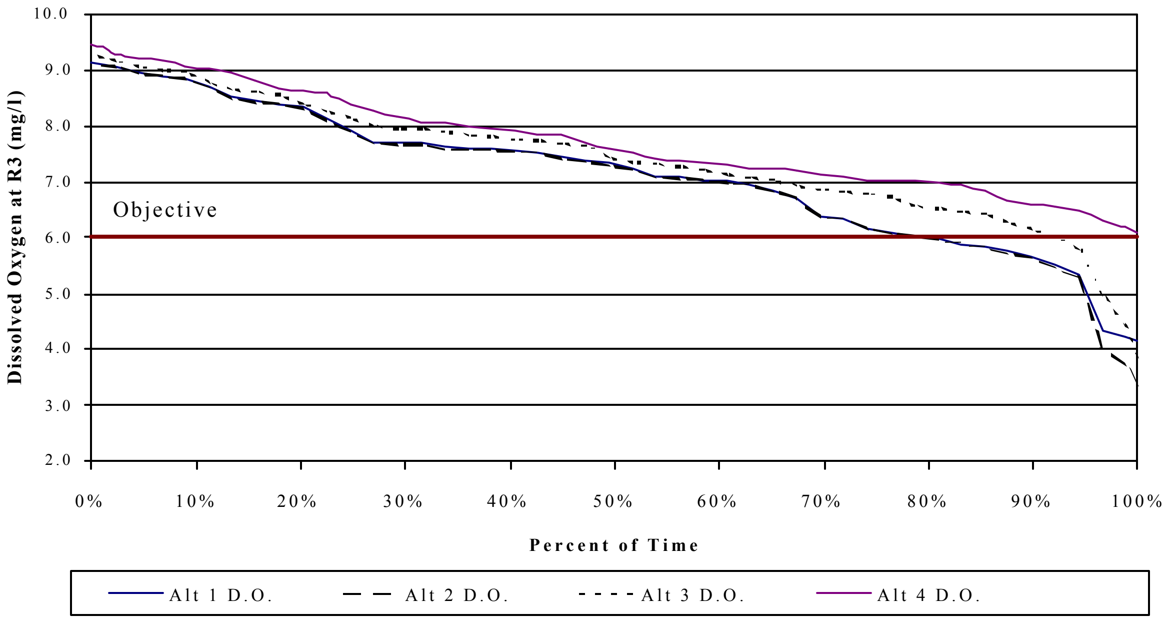


Figure X-25
Frequency Distribution of Dissolved Oxygen Levels at Stockton in a Below Normal Year (Water Year 1966) for December - August

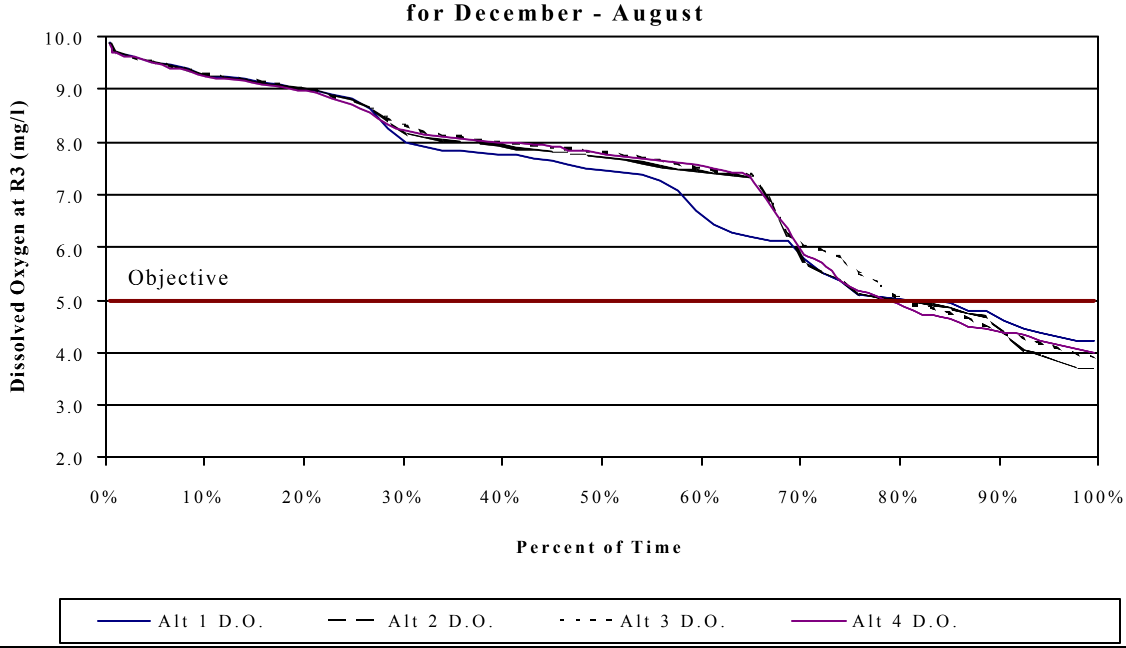


Figure X-26
Frequency Distribution of Dissolved Oxygen Levels at Stockton in a Dry Year (Water Year 1981) for September - November

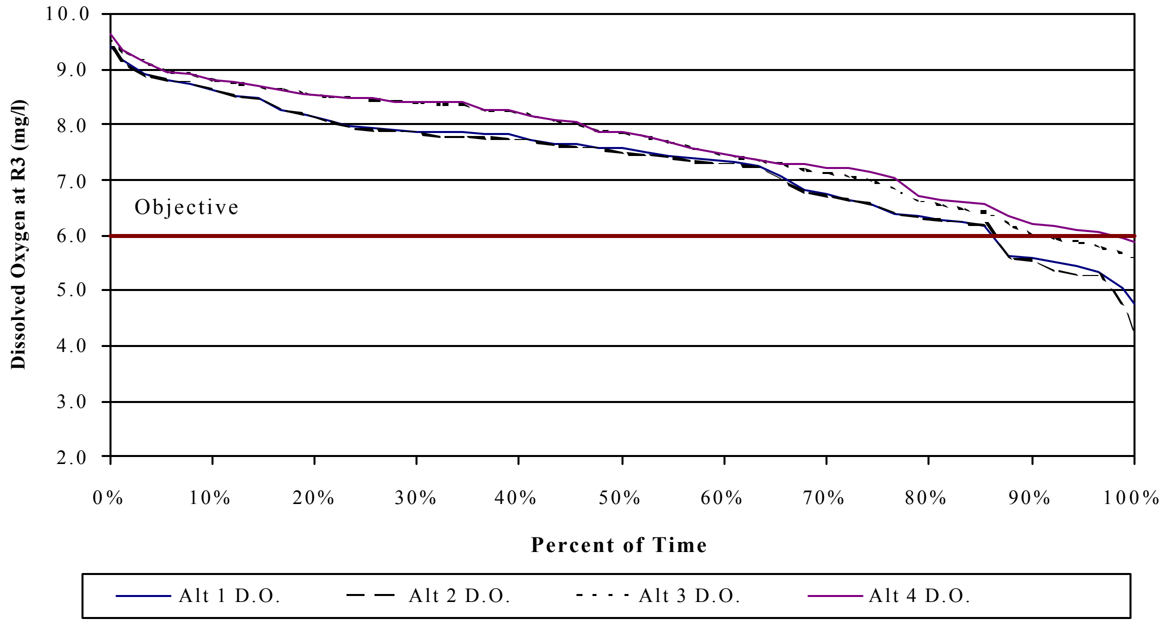


Figure X-27
Frequency Distribution of Dissolved Oxygen Levels at Stockton in a Dry Year (Water Year 1981) for December - August

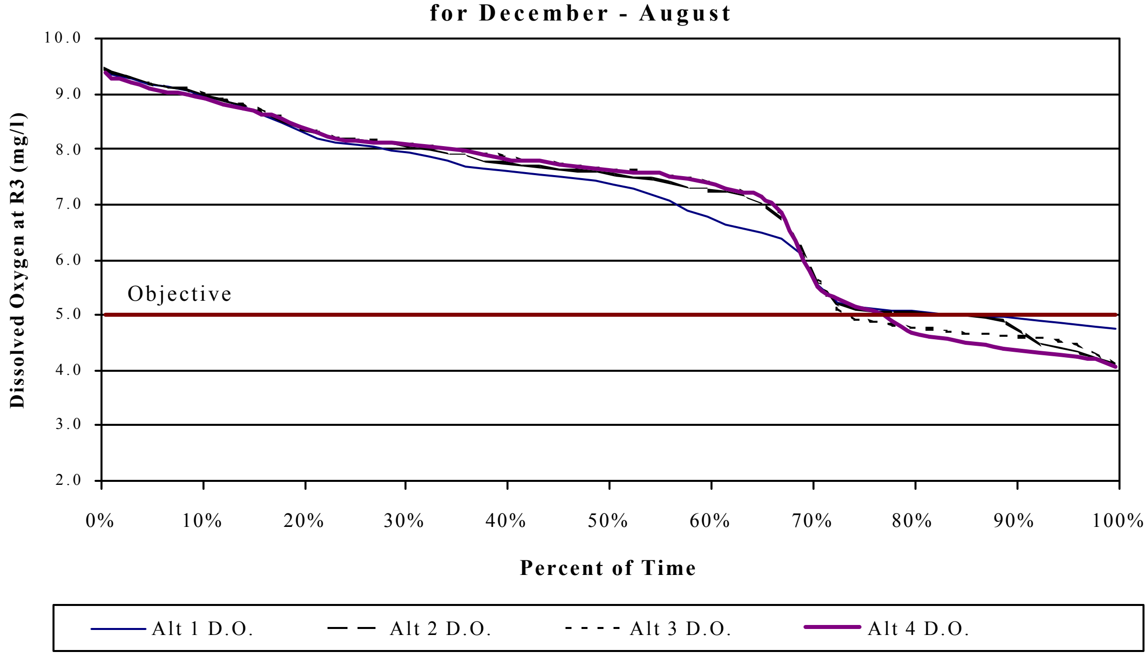


Figure X-28
Frequency Distribution of Dissolved Oxygen Levels at Stockton in a Critically Dry Year (Water Year 1991) for September - November

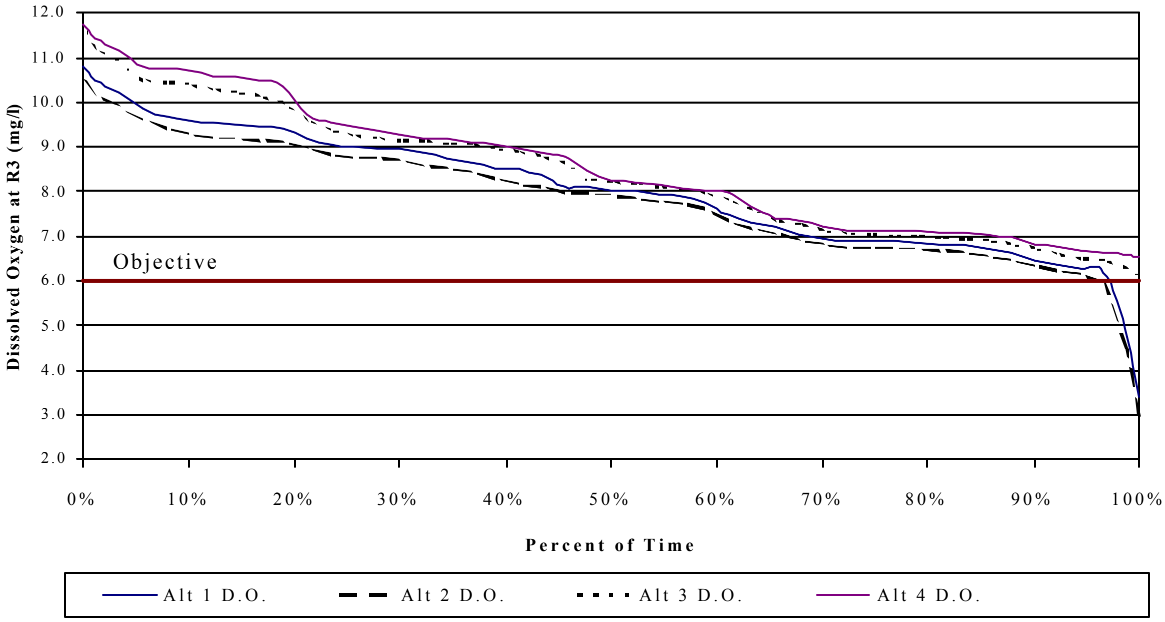
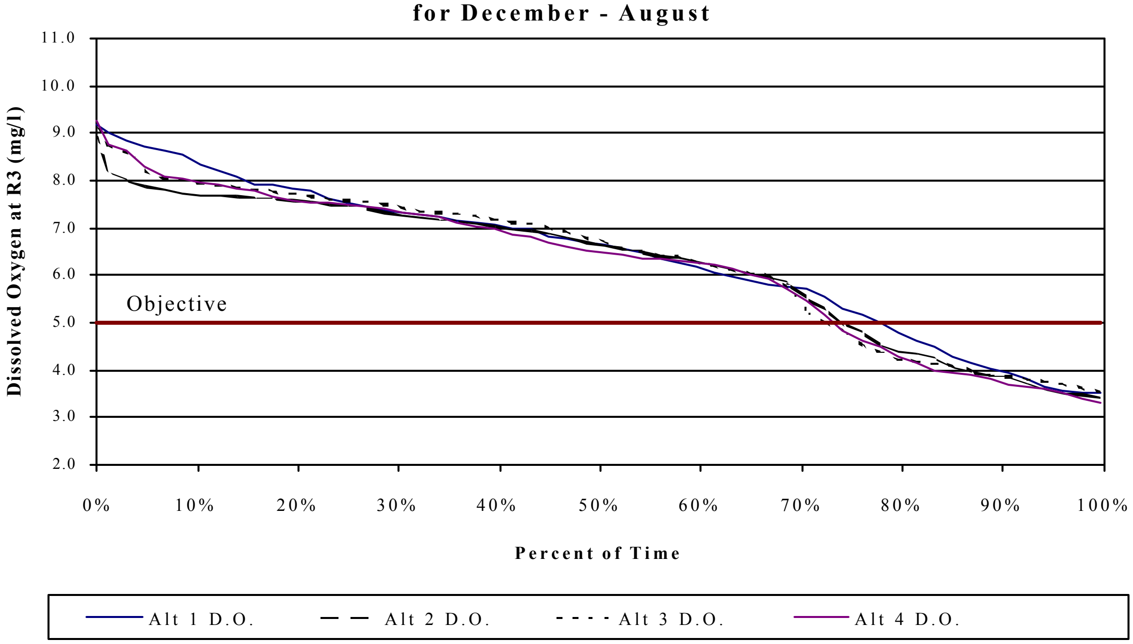


Figure X-29
Frequency Distribution of Dissolved Oxygen Levels at Stockton in a Critically Dry Year (Water Year 1991) for December - August



None of the alternatives will result in DO objectives being met in all water year types. During the period of November to May, the DO objective is met by all alternatives during each water year modeled. DO levels begin to subside at the downstream stations (R3 and R7) during June and July when Alternatives 1 and 2 often provide higher DO concentrations than Alternatives 3 and 4. During the month of August, DO levels are highest under Alternatives 3 and 4 at Stations R2 and R3, while Alternatives 1 and 2 produce higher DO levels at Station R7. During September and October, Alternatives 3 and 4 provide the highest DO levels and often meet the objective that is otherwise not met under Alternatives 1 and 2. Alternative 4 provides the greatest benefit to DO concentrations during September. Alternative 3, permanent barrier installation, meets the objectives almost as often as Alternative 4, as modeled, and sometimes provides higher DO levels, although not generally when DO levels are at their lowest. The modeling results also show that implementing the flow alternatives in the Bay/Delta Plan does not significantly affect DO.

2. Impacts on Aquatic Resources

Stockton's proposed expansion and rehabilitation project will consist of a six-stage construction project. Stages I and II will include rehabilitating existing wastewater treatment facilities and constructing new facilities. The purpose of Stages I and II is to correct existing process deficiencies, handle increased wastewater strengths and restore the rated capacity of the WWTP back to approximately its previously estimated capacity of 48 mgd. The entire expansion will take place on the existing plant site. Stages III through VI would expand the plant's rated capacity to 55 mgd. If required, nitrification facilities would be constructed during stages III through VI. Stockton has initiated the EIR process for this project.

Nitrogen in the form of ammonia exerts an oxygen demand in the receiving body of water and can be toxic to fish. When nitrification is needed to protect the receiving body of water, a nitrification facility is added to the end of the conventional treatment process to remove the nitrogen. Nitrification can be achieved by either biological or chemical processes. Both processes involve long detention times in plug-flow reactors or complete mix reactors followed by a clarifier to settle out solids.

3. Energy Effects

The expanded facility would not use a substantial amount of fuel or energy or substantially increase demand upon existing sources of energy, or require the development of new energy sources. The nitrification facility would impose a higher energy demand on the WWTP; however, it is not expected to alter the energy demand significantly.

4. Public Nuisance Considerations

Alternative 4 may have an impact on public nuisance, specifically aesthetics, lights and glare, and odor. The proposed project would increase the number of industrial structures at the WWTP site;

however, these would not be visible from any scenic road or major public viewing location. Boaters along the San Joaquin River may view some of the new structures, but these would be considered visually compatible with existing industrial buildings along this stretch of the river.

Lighting of the facility would be increased with the proposed project but would not result in significant impacts due to the location of the project site within an industrial area of Stockton. Outdoor lighting would be located on poles, with lighting directed downward onto paved areas and structures.

Normal treatment plant operations produce odors that may be considered objectionable by some people. The nitrification process produces carbon dioxide and nitrogen gas, neither of which are odiferous. The amount of emissions released by the nitrification process will depend on the type of nitrification process adopted by Stockton. Due to the additional process units, emissions from the WWTP would likely increase.

5. Use of Hazardous/Toxic Substances

After completion of the project facilities, the use of chemicals to facilitate the nitrification process would increase. The types of chemicals used would depend on the type of nitrification facility adopted by Stockton.

6. Socioeconomic, Fiscal, and Secondary Effects

If Stockton must meet the more stringent 2.0 mg/l ammonia standard, the cost of the six-staged expansion would increase to include the cost of the detention chambers and associated clarifiers. The cost to build the nitrification facility may cause an increase in sewage fees, and may affect Stockton's plans to build several reclamation facilities. The reclamation facilities are intended to provide needed water supply by reclamation and to preclude the need to add extensive additional treatment processes (Carollo 1992).

The cost of expanding the WWTP may also cause Stockton to change or reconsider the way it operates the WWTP. For example, it may preclude deliveries from industries whose discharges have high loads in terms of wastewater strength or volume. Increased costs may also result in a decision to discontinue discharge into the San Joaquin River. Lastly, costs may affect Stockton's plans to expand its service area.

7. Construction-Related Impacts

Although environmental documents prepared by Stockton do not specifically address construction of a nitrification facility, they do address construction of the other phases of the expansion. The impacts of those construction activities are assumed to be similar to the impacts of the nitrification facility. Impacts with respect to the following parameters are possible: (a) air, (b) noise, (c) population and housing, (d) traffic, (e) earth, (f) water, (g) terrestrial life, and (h) cultural resources.

a. **Air**. Construction-related emissions from Alternative 4 would be short-term and would not be significant. The project site is located in an industrial area of southwest Stockton where emissions would not immediately affect nearby receptors such as residential neighborhoods, schools or hospitals.

b. **Noise**. Construction noise resulting from the project would be short-term and would not be significant, given that surrounding land uses are industrial. Noise due to construction traffic associated with the project would be minimal, and traffic would use Charter Way, Navy Drive, and Fresno Avenue, which pass through industrial areas. No increase in noise due to operating the new completed facilities is expected.

c. **Population and Housing**. Construction activities could result in a temporary increase in employment but would not result in a need for new housing due to the available labor force in the Stockton area.

d. **Traffic**. Access roads to the project site would be adequate to serve the traffic associated with project construction. Charter Way, Navy Drive, and Fresno Avenue are all currently used by heavy trucks. There are no expected significant impacts.

e. **Earth**. During construction, the project site would be subject to some wind erosion of soils. These impacts are potentially significant without mitigation. Water erosion of soils is not considered a significant problem due to the level topography of the site, significant amounts of existing asphalt paving, the existing storm drainage system, and the presence of levees along the San Joaquin River.

f. **Water**. New construction would not affect the adjacent levee or the San Joaquin River. Surface runoff would increase slightly due to additional impervious surface area. This surface runoff is not expected to be significant and would be handled by the existing plant drainage system, which is discharged into the headworks for treatment with the raw sewage.

Groundwater volume at the project site could be affected by construction of the clarifiers associated with the nitrification facility. Construction of the clarifiers may involve dewatering of the site for excavation. There will not be any water quality impacts due to dewatering effluent because all groundwater pumped will discharge to the treatment plant and be processed along with the wastewater flow.

g. Terrestrial Life. Due to the presence of the levee along the San Joaquin River and the fact that any new construction would occur east of this levee, special-status taxa that may reside along the river are not expected to be affected.

h. Cultural Resources. Project construction could potentially affect a prehistoric site, although it is considered unlikely due to the previously disturbed conditions of the entire site.

8. Summary

As modeled, Alternatives 3 and 4 often meet the DO objective that otherwise would not be met under Alternatives 1 and 2, particularly during the months of September and October. Alternative 4 provides slightly higher DO levels than Alternative 3 during the months of August through October. Implementation of the proposed CVRWQCB permit and construction of the treatment plant improvements will certainly improve DO conditions in the river. Construction of permanent barriers also improves DO conditions if they are operated as modeled. Flow manipulations alone may not accomplish dissolved oxygen levels above 6.0 mg/L in the Stockton area under any conditions, however, modeling has shown treatment plant improvements and construction of permanent barriers would aid in achieving the DO objective.

Literature Cited in Chapter X

Carollo, J. 1992. Supplement Report to the Wastewater Master Plan. Prepared for the City of Stockton by John Carollo Engineers, 4 chapters.

Chen, C., D. Leva, and R. Schanz. 1993. A Report on Dissolved Oxygen in the San Joaquin River near Stockton Outfall. Prepared for the City of Stockton by Systech Engineering, Inc., Lafayette, CA. 11 pp.

Chen, C. and Schanz. 1993. City of Stockton Water Quality Model, Volume 1: Model Development and Calibration. Prepared by Phillip William & Associates, Ltd., San Francisco, CA and Systech Engineering, Lafayette, CA. 38 pp. plus Figures, Tables, and Appendices.

Chen, C., Tsai, W. 1997. Evaluation of Alternatives to Meet the Dissolved Oxygen Objectives of the Lower San Joaquin River. Prepared for the California State Water Resources Control Board, Sacramento California by Systech Engineering, Inc., Lafayette, CA. 49 pp.

DFG. 1964. Problems of the Lower San Joaquin River Influencing the 1963 Salmon Run. Prepared by California Department of Fish and Game, Department of Water Resources, and Central Valley Water Pollution Control Board. 27 pp.

DFG. 1995. Statement at SWRCB Workshop on the Need for Physical Barriers in the Southern Delta of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary to Protect Beneficial Uses of Water. Presented at the SWRCB Workshop, November 15, 1995. 15 pp.

DWR and USBR. 1996. Draft Environmental Report/Environmental Impact Statement on the Interim South Delta Program (Volume I). Prepared by Entrix, Inc. and Resource Insights for the Department of Water Resources and U.S. Bureau of Reclamation. Sacramento, California. July 1996. 700 pp.

Engineering-Science, Inc. 1994. Expanded Initial Study for the Stockton Regional Wastewater Control Facility: Staged Expansion Program Stages I and II Capacity Restoration. Prepared for the City of Stockton. 9 Sections.

Hallock, R., R. Eldwell, and D. Fry, Jr. 1970. Migration of Adult King Salmon, *Oncorhynchus Tshawytcha*, in the San Joaquin River Delta as Demonstrated by the Use of Sonic Tags. Department of Fish and Game, Fish Bulletin 151. 91 pp.

Stockton. 1994. Addendum to the Expanded Initial Study for the Stockton Regional Wastewater Control Facility: Staged Expansion Program Stages I and II Capacity Restoration. Prepared for the City of Stockton. 51 pp.

Stockton. 1996. Comments of the City of Stockton Regarding Alternatives to Achieve Dissolved Oxygen Objectives. Presented at the SWRCB Workshop, March 12-13 1996. 18 pp. plus exhibits 1-16.

SWRCB. 1996. Order No. WQ 96-09, In the Matter of the City of Stockton Requesting Review of Waste Discharge Requirements Order No. 94-324, NPDES Permit No. CA0079138 Issued by the California Regional Water Quality Control Board, Central Valley Region. 23 pp.

USCOE. 1990. Dissolved Oxygen Mitigation Plan: San Francisco Bay to Stockton Ship Channel. United States Army Corps of Engineers. 3 pp.

Personal Communications

Van Niuwenhuyse, Erwin. Jones and Stokes Associates, Inc., Sacramento, CA. October 9, 1997. Meeting and Draft Report.

CHAPTER XI. ECONOMICS

This chapter contains estimates of the economic impacts of implementing the flow objectives alternatives. Impacts on agricultural water users are presented in the first section of the chapter and impacts on urban water users are presented in the second section. Estimates of the impacts on regional economies resulting from reduced agricultural production follow in the third section. An overview of the economic impacts is at the end of this chapter.

A. IMPACTS ON AGRICULTURAL WATER USERS

The proposed alternatives will affect the amount of water delivered to farms by irrigation districts in the Central Valley. In addition, Alternatives 3 and 4 will affect the amount of water that farms can divert from the Sacramento and San Joaquin rivers under their water rights.

If water deliveries are reduced, farmers will likely fallow acreage and change crops. In many cases, farmers will be able to pump additional groundwater, use water transferred from other areas, use what water they have on high-valued crops, and improve their irrigation systems. These actions will offset the impacts of reduced deliveries. Nevertheless, agricultural production in the long run will be reduced because less water will be available overall. Farmers' incomes will be reduced, both because production will be reduced and because groundwater and transferred water will be more expensive than project water. Reduced production will also result in job losses in agriculture and other industries in the areas affected by the reduced deliveries. These impacts are discussed in section D of this chapter.

The cost that the alternatives will impose on farmers is measured as the impact of the flow objectives on producers' net income. Producers' net income is defined as crop production receipts less operating costs. Operating costs include labor, fuel, seed, chemicals, and groundwater pumping. In other words, producers' net income is the return to land, improvements, management, and business risk. Because producers' net income includes the return to land and improvements, impacts on producers' net income include impacts on land values.

Impacts on gross crop production are also presented. These figures do not represent the impact on agriculture because about half of gross production receipts is spent on operating costs, which fall as production is curtailed. However, impacts on gross production are useful for comparison with production trends in recent years.

1. Water Supply Impacts

The economic analysis is based on estimates of water deliveries obtained from DWRSIM modeling studies. The modeling studies specify deliveries in the 73 years of historical hydrology under D-1485 and under each of the seven alternatives for implementing the flow objectives in the Bay/Delta Plan. DWRSIM is discussed in Chapter IV. Water deliveries given by the DWRSIM

Table XI-1
Regions Used in the Economic Analysis

Region	CVPM Regions	Description
A. Shasta, Tehama	1,2	Anderson Valley, Tehama County, north part of Glenn County.
B. Glenn, Colusa	3,4	Glenn and Colusa counties, northern Yolo County, Sacramento River.
C. Feather River	5,7	East side of Sacramento Valley from central Butte County to northern Sacramento County.
D. Yolo, Solano, Delta	6,9	Yolo and Solano Counties, Delta.
E. Sacramento, San Joaquin	8	South-central Sacramento County, east San Joaquin County, northern Stanislaus County.
F. Delta-Mendota	10	Delta-Mendota Canal service area.
G. Modesto-Oakdale-Turlock	11,12	Stanislaus River water rights, Modesto ID, Oakdale ID, Turlock ID.
H. Merced-Madera	13	Merced ID, Madera, Chowchilla, Gravelly Ford.
J. Westlands	14	Westlands WD, parts of Fresno Slough, James, Tranquility, San Luis WDs.
K. Kings-Tulare-E. Fresno	15-18	Tulare Lake bed, Friant-Kern Canal service area, eastern Fresno County.
L. Kern County	19-21	Kern County portion of San Joaquin Valley floor.

The regions used in the economic analysis are groups of the regions used in the Central Valley Production Model (CVPM). See section 3 of this chapter for more information on the CVPM.

studies were aggregated into the regions used in the economic analysis. These regions are listed in Table XI-1 and shown in Figure XI-1.

An analysis of economic impacts in every year for which simulated water deliveries are available is impractical. For the purposes of this economic analysis, the years were grouped into three year types, based on water deliveries. Because economic impacts depend on water deliveries rather than hydrologic conditions, this grouping is a better basis for economic analysis than a grouping based on hydrologic conditions. The low-delivery years are the seven years of lowest water deliveries under a particular alternative. The high-delivery years are the 36 years with the highest water deliveries and the medium-delivery years are the remaining 30 years. The grouping is done independently for each alternative and each region. For example, the seven low-delivery years to Kern County under D-1485 are not the same years as the seven low-delivery years under any of the other alternatives. Water delivery impacts in each year type are the difference between deliveries under the alternative and deliveries under D-1485. Table XI-2 shows these water delivery impacts.

Figure XI -1
Map of Regions used in the Economic Analysis

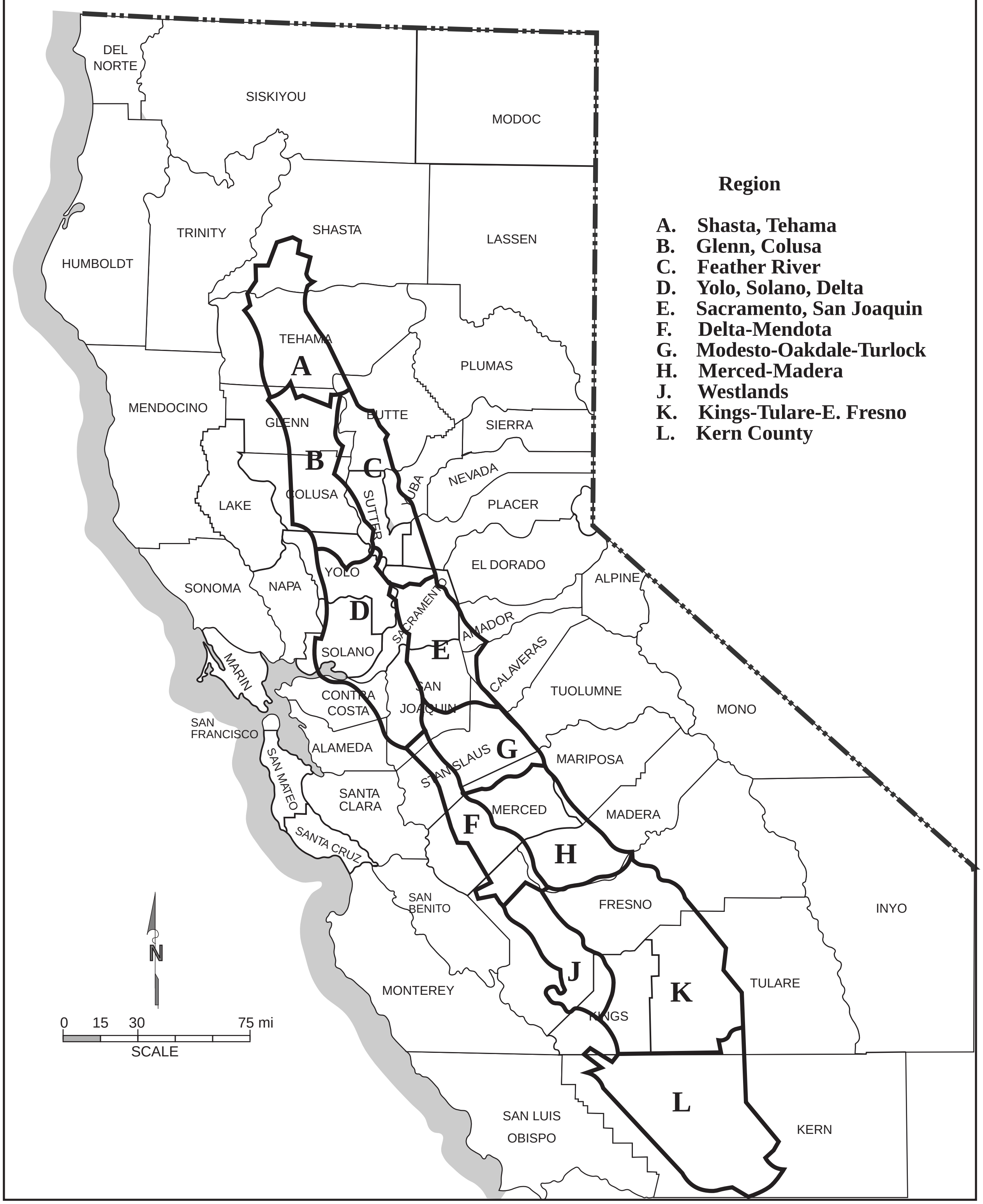


Table XI-2
Water Delivery Impacts of the Flow Alternatives as compared with the Base Case
(Water delivery impacts are shown only where an alternative affects deliveries to a region.)
(None of the alternatives affect deliveries to A or E.)

	Delivery impacts (k acre-ft)			
	Average all years	Low-delivery years	Medium delivery years	High-delivery years
B. **Glenn-Colusa (CVPM 3,4)**				
Alt. 5	-1	-15	0	0
C. **Feather River (CVPM 5,7)**				
Alt. 5	-100	-193	-95	-87
D. **Yolo-Solano-Delta (CVPM 6,9)**				
Alt. 5	14	4	23	8
F. **Delta-Mendota (CVPM 10)**				
Alt. 2	-69	-165	-79	-41
Alt. 3	-57	-140	-58	-41
Alt. 4	-58	-139	-60	-41
Alt. 5	-42	-80	-39	-37
Alt. 6	-48	-180	-62	-11
Alt. 7	-78	-184	-88	-49
Alt. 8	-80	-159	-90	-57
G. **Modesto-Oakdale-Turlock (CVPM 11, 12)**				
Alt. 3	-49	-84	-54	-39
Alt. 4	-50	-79	-54	-41
Alt. 5	-6	-67	0	0
Alt. 8	-31	-36	-29	-31
H. **Merced-Madera (CVPM 13)**				
Alt. 3	-32	-48	-40	-22
Alt. 4	-30	-44	-35	-23
Alt. 5	-18	-30	-17	-17
Alt. 8	-1	-6	0	0
J. **Westlands (CVPM 14)**				
Alt. 2	-94	-132	-106	-77
Alt. 3	-81	-109	-80	-76
Alt. 4	-81	-107	-81	-76
Alt. 5	-67	-63	-55	-78
Alt. 6	-51	-158	-63	-21
Alt. 7	-101	-144	-105	-89
Alt. 8	-117	-147	-118	-111
K. **Kings-Tulare-E. Fresno (CVPM 15-18)**				
Alt. 2	-6	-18	-11	0
Alt. 3	-5	-16	-9	0
Alt. 4	-5	-16	-9	0
Alt. 5	-425	-281	-336	-527
Alt. 6	-6	-19	-11	0
Alt. 7	-9	-18	-12	-4
Alt. 8	-6	-18	-11	0
L. **Kern County (CVPM 19-21)**				
Alt. 2	-58	-182	-81	-14
Alt. 3	-49	-168	-64	-13
Alt. 4	-49	-169	-64	-13
Alt. 5	-21	-80	-20	-10
Alt. 6	-52	-181	-78	-5
Alt. 7	-66	-172	-99	-17
Alt. 8	-61	-175	-85	-18
All regions				
Alt. 2	-227	-497	-277	-132
Alt. 3	-274	-565	-305	-191
Alt. 4	-273	-554	-303	-194
Alt. 5	-668	-805	-539	-748
Alt. 6	-158	-538	-214	-37
Alt. 7	-253	-518	-304	-159
Alt. 8	-296	-541	-333	-217

2. Assumptions and Methodology

The effect of each alternative on producers' net income was estimated by applying water delivery impacts to a relationship between water supplies and net revenues in each region established using the Central Valley Production Model (CVPM). The CVPM, developed by the University of California, the DWR and the USBR, is a mathematical programming model that estimates crop production. The model is based on the assumption that farmers select the cropping pattern that maximizes their net revenue given product prices, production costs, and the availability of inputs such as land and water.

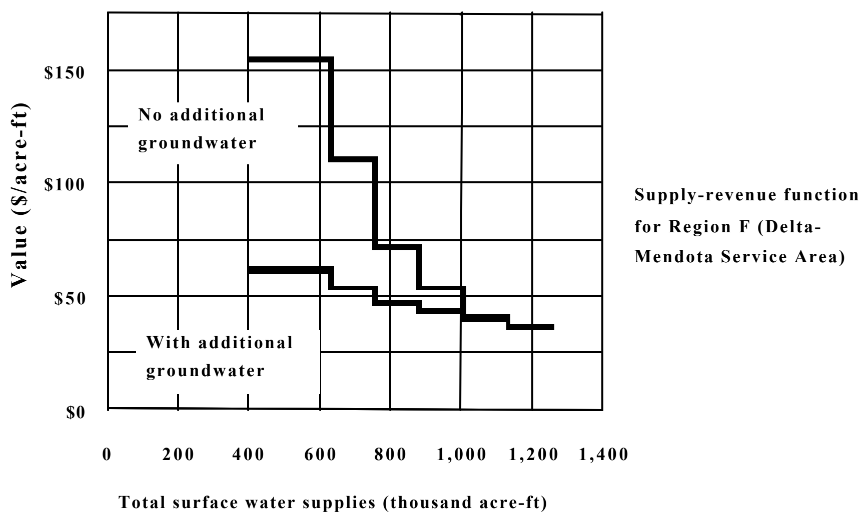
The CVPM assumes that farmers continually adjust production levels in an effort to maximize their returns on investment. In practice, farmers' flexibility is limited in the short run. Consequently, production levels indicated by the model are a long-run response to changing conditions. As used in this analysis, the model implicitly assumes that farmers adjust their production levels to average water supplies in the three year types. However, water supplies vary from year to year, so there will not actually be a movement toward the production levels that are optimum for supplies in the three year types. The actual long-run response to the standards will be an adjustment to lower, but variable, water availability. As a result, the model will tend to underestimate economic impacts because a complete long-run response to average supplies in each year type is never achieved.

Staff of CH2M Hill used the model to estimate the way revenues in each region fall as surface water supplies are reduced from the amount normally available in wet years. One set of model runs gives economic impacts in the case where farmers increase their use of groundwater as surface supplies are reduced. A second set of runs gives economic impacts in the case where no additional groundwater is available (Hatchett 1997).

These model runs established a supply-revenue function for each region showing the value of an acre-foot of water at various levels of water supply. This value is the amount by which net revenues in the region will increase or decrease as surface water supplies increase or decrease by one acre-foot. When full surface water supplies are available, the value of an acre-foot of water is relatively low, because the water is used on a wide variety of crops, including low-valued crops. But in years when surface water supplies are low, the value of an acre-foot of water is higher, because a greater proportion of the water is used on high-valued crops.

As an example, Figure XI-2 shows the supply-revenue function for Region F. When the region receives its full surface water supply of about 1.2 million acre-feet, reducing surface water supplies by an incremental amount reduces net revenues in the region by about $37 per acre-foot of reduced deliveries. In years when the region receives only 700 TAF, a further cutback by an incremental amount reduces net revenues by about $54 per acre-foot of reduced deliveries if farmers are able to use additional groundwater, or by $111 per acre-foot of reduced deliveries if no additional groundwater is available.

Figure XI-2. Value of Water at Various Levels of Water Supply



Water supply data compiled for the economic analysis in the ER for the 1995 Bay/Delta Plan was used to estimate average surface water supplies in each region in each of the three year types under D-1485 (Dale 1994). This information determines the point on the supply-revenue function that each region is in each of the three year types under baseline conditions. Impacts of each alternative on net revenues were then estimated from the water supply impacts shown in Table XI-2 using the supply-revenue functions for each region.

3. Results

Tables XI-3 and XI-4 show the effects of the flow alternatives on producers' net revenue and agricultural production. When totaled over all regions, Alternatives 2, 3, 4, and 7 have about the same effect on net income. In these alternatives, losses range from $20 to $25 million. Alternative 8 has slightly higher impacts, averaging $25 to $27 million annually, depending on whether additional groundwater is available. In dry years, losses are substantially higher and are more dependent on the availability of additional groundwater. In the seven low-delivery years, losses for the alternatives range from $50 to $58 million when additional groundwater is available, but range from $68 to $73 million if no additional groundwater is available.

Compared to Alternative 2, Alternatives 3 and 4 have less impact in the east side of the San Joaquin Valley (Regions G and H) and more impact in the Delta-Mendota area (Region F), the Westlands area (Region J), and Kern County (Region L).

Alternative 6 has higher impacts than Alternatives 2, 3, and 4, in low-delivery years. However, impacts are lower when averaged over all years, largely because Alternative 6 has very low impacts in high-delivery years. Alternative 5 has high impacts in all year types, largely because it results in higher Delta outflows than the other alternatives. In dry years, impacts are about the same as the other alternatives. However, in contrast to the other alternatives, Alternative 5 has high impacts in

Table XI-3
Impacts of Flow Alternatives on Producers' Net Income as Compared to the Base Case

	Loss in net revenue ($Million)							
	Additional groundwater use				No additional groundwater			
	Average all years	Low-delivery years	Medium delivery years	High-delivery years	Average all years	Low-delivery years	Medium delivery years	High-delivery years
B. **Glenn-Colusa (CVPM 3,4)**								
Alt. 5	0.1	0.6	0	0	0.1	0.6	0	0
C. **Feather River (CVPM 5,7)**								
Alt. 5	3.8	7.5	3.6	3.3	3.8	7.7	3.6	3.3
D. **Yolo-Solano-Delta (CVPM 6,9)**								
Alt. 5	-0.6	-0.2	-1.0	-0.3	-0.6	-0.2	-1.0	-0.3
F. **Delta-Mendota (CVPM 10)**								
Alt. 2	2.7	7.4	3.0	1.5	2.9	10.1	3.0	1.5
Alt. 3	2.2	6.2	2.2	1.5	2.4	8.3	2.2	1.5
Alt. 4	2.2	6.2	2.2	1.5	2.5	8.2	2.3	1.5
Alt. 5	1.6	3.5	1.4	1.4	1.7	4.3	1.4	1.4
Alt. 6	1.9	8.1	2.3	0.4	2.2	11.1	2.3	0.4
Alt. 7	3.1	8.3	3.4	1.8	3.4	11.4	3.4	1.8
Alt. 8	3.2	7.1	3.5	2.1	3.4	9.6	3.5	2.1
G. **Modesto-Oakdale-Turlock (CVPM 11,12)**								
Alt. 3	2.1	3.9	2.2	1.6	2.1	4.0	2.2	1.6
Alt. 4	2.1	3.7	2.2	1.7	2.1	3.8	2.2	1.7
Alt. 5	0.3	3.1	0	0	0.3	3.2	0	0
Alt. 8	1.3	1.7	1.2	1.3	1.3	1.7	1.2	1.3
H. **Merced-Madera (CVPM 13)**								
Alt. 3	1.7	2.8	2.1	1.1	1.7	3.3	2.1	1.1
Alt. 4	1.6	2.6	1.8	1.2	1.7	3.0	1.9	1.2
Alt. 5	1.0	1.7	0.9	0.9	1.0	2.0	0.9	0.9
Alt. 8	0.0	0.3	0	0	0.0	0.4	0	0
J. **Westlands (CVPM 14)**								
Alt. 2	10.3	16.3	11.4	8.3	10.6	18.8	11.4	8.3
Alt. 3	8.9	13.3	8.6	8.2	9.0	15.0	8.6	8.2
Alt. 4	8.9	13.0	8.7	8.2	9.0	14.7	8.7	8.2
Alt. 5	7.3	7.5	5.9	8.4	7.4	8.4	5.9	8.4
Alt. 6	5.8	19.8	6.8	2.3	6.1	23.0	6.8	2.3
Alt. 7	11.1	17.9	11.3	9.6	11.4	20.8	11.3	9.6
Alt. 8	12.9	18.4	12.7	11.9	13.1	21.2	12.7	11.9
K. **Kings-Tulare-E. Fresno (CVPM 15-18)**								
Alt.2	0.5	1.4	0.8	0	0.5	1.7	0.8	0
Alt.3	0.4	1.2	0.6	0	0.4	1.5	0.6	0
Alt.4	0.4	1.2	0.6	0	0.4	1.5	0.6	0
Alt.5	28.3	22.7	23.3	33.6	29.8	29.7	25.2	33.6
Alt.6	0.5	1.4	0.8	0	0.5	1.8	0.8	0
Alt.7	0.6	1.4	0.8	0.3	0.7	1.7	0.9	0.3
Alt.8	0.5	1.4	0.8	0	0.5	1.7	0.8	0
L. **Kern County (CVPM 19-21)**								
Alt.2	6.7	25.4	8.8	1.3	8.6	39.7	10.2	1.3
Alt.3	5.7	23.5	7.0	1.2	7.4	36.6	8.0	1.2
Alt.4	5.7	23.6	7.0	1.2	7.4	36.9	8.0	1.2
Alt.5	2.4	11.2	2.1	1.0	3.1	17.4	2.3	1.0
Alt.6	6.2	25.3	8.5	0.5	8.1	39.5	9.8	0.5
Alt.7	7.5	24.0	10.8	1.6	9.5	37.5	12.5	1.6
Alt.8	7.0	24.5	9.3	1.7	8.9	38.2	10.7	1.7
All regions								
Alt.2	20.2	50.5	24.0	11.1	22.7	70.3	25.4	11.1
Alt.3	20.9	50.9	22.7	13.6	23.0	68.7	23.7	13.6
Alt.4	20.9	50.3	22.5	13.8	23.1	68.1	23.7	13.8
Alt.5	44.2	57.6	36.2	48.3	46.6	73.1	38.3	48.3
Alt.6	14.4	54.6	18.4	3.2	16.9	75.4	19.7	3.2
Alt.7	22.3	51.6	26.3	13.3	25.0	71.4	28.1	13.3
Alt.8	24.8	53.4	27.5	17.0	27.2	72.8	28.9	17.0

Impacts are shown only where alternative affects a region.

Table XI-4
Impacts of Flow Alternatives on Farm Production as Compared to the Base Case

	Loss in farm production ($Million)							
	Additional groundwater use				No additional groundwater			
	Average all years	Low-delivery years	Medium delivery years	High-delivery years	Average all years	Low-delivery years	Medium delivery years	High-delivery years
B. **Glenn-Colusa (CVPM 3,4)**								
Alt. 5	0	2	0	0	0	2	0	0
C. **Feather River (CVPM 5,7)**								
Alt. 5	12	23	11	10	12	24	11	10
D. **Yolo-Solano-Delta (CVPM 6,9)**								
Alt. 5	-2	-1	-3	-1	-2	-1	-3	-1
F. **Delta-Mendota (CVPM 10)**								
Alt. 2	7	19	8	4	8	26	8	4
Alt. 3	6	16	6	4	6	21	6	4
Alt. 4	6	16	6	4	6	21	6	4
Alt. 5	4	9	4	4	5	11	4	4
Alt. 6	5	21	6	1	6	28	6	1
Alt. 7	8	21	6	1	6	28	6	1
Alt. 8	8	18	9	5	9	25	9	5
G. **Modesto-Oakdale-Turlock (CVPM 11,12)**								
Alt. 3	4	8	5	3	4	8	5	3
Alt. 4	5	8	5	4	5	8	5	4
Alt. 5	1	6	0	0	1	7	0	0
Alt. 8	3	4	3	3	3	4	3	3
H. **Merced-Madera (CVPM 13)**								
Alt. 3	3	6	4	2	3	7	4	2
Alt. 4	3	5	4	2	3	6	4	2
Alt. 5	2	3	2	2	2	4	2	2
Alt. 8	0	1	0	0	0	1	0	0
J. **Westlands (CVPM 14)**								
Alt. 2	25	40	27	20	25	46	27	20
Alt. 3	21	32	20	20	22	37	20	20
Alt. 4	22	32	21	20	22	36	21	20
Alt. 5	17	18	14	20	18	20	14	20
Alt. 6	14	48	16	5	14	56	16	5
Alt. 7	27	44	27	23	27	51	27	23
Alt. 8	30	45	30	28	31	52	30	28
K. **Kings-Tulare-E. Fresno (CVPM 15-18)**								
Alt.2	1	3	2	0	1	3	2	0
Alt.3	1	2	1	0	1	3	1	0
Alt.4	1	2	1	0	1	3	1	0
Alt.5	53	43	44	63	56	56	48	63
Alt.6	1	3	2	0	1	3	2	0
Alt.7	2	3	2	1	2	3	2	1
Alt.8	1	3	2	0	1	3	2	0
L. **Kern County (CVPM 19-21)**								
Alt.2	14	51	18	3	17	79	20	3
Alt.3	11	47	14	2	15	73	16	2
Alt.4	11	47	14	2	15	74	16	2
Alt.5	5	22	4	2	6	35	5	2
Alt.6	12	51	17	1	16	79	20	1
Alt.7	15	48	22	3	19	75	25	3
Alt.8	14	49	19	3	17	76	21	3
All regions								
Alt.2	47	113	55	27	52	154	57	27
Alt.3	46	111	50	31	51	149	52	31
Alt.4	47	110	51	32	52	148	53	32
Alt.5	93	125	76	100	98	158	81	100
Alt.6	32	123	41	7	37	166	44	7
Alt.7	52	116	60	32	57	158	63	32
Alt.8	57	120	63	39	61	161	65	39

Impacts are shown only where alternative affects a region.

medium-delivery and high-delivery years. In these years, impacts range from $36 to $48 million. Averaged over all years, the impacts of Alternative 5 are $44 to $47 million, substantially higher than any of the other alternatives.

Alternative 5 affects water use in the Feather River Basin (Region C). Depending on the year type and the availability of additional groundwater, net revenues are reduced by $3 to $8 million annually. Alternative 5 has very high impacts on the Kings-Tulare-East Fresno area (Region K), reducing net revenues by up to $34 million. In this area, the highest impacts are in high-delivery years. Alternative 5 increases impacts in the Merced-Madera area (Region H) and reduces impacts in Kern County relative to Alternative 2.

In addition to the costs cited above, farmers in the Sacramento Valley will have to pay the USBR for contracted water to replace water that is no longer available for diversion under appropriative water rights. The cost and amount of this water will be a contract issue between the USBR and the contractors.

Impacts on farm production (see Table XI-4) are approximately proportional to impacts on net revenues. In total, Alternatives 2, 3, 4, and 7 reduce farm production by about $50 million when averaged over all years. In dry years, impacts are about $100 million when additional groundwater is used and about $150 million when no additional groundwater is available. Alternative 8 has slightly higher impacts than these alternatives. Generally, impacts on farm production vary between alternatives and between regions in the same way as impacts on net revenues.

These impacts are comparable to recent fluctuations in crop production in the affected areas. Table XI-5 shows recent county crop production statistics from the California Department of Food and Agriculture. In Kern county, crop production ranged from $1,400 million to $1,800 million between 1990 and 1995. In comparison, impacts of the alternatives range up to $79 million in dry years and are $5 to $19 million when averaged over all years. As a percentage of average crop production from 1990 to 1995, impacts do not exceed five percent in dry years or one percent when averaged over all years.

Table XI-5
Recent Crop Production in Affected Areas

Counties	Crop production ($ million)					
	1990	1991	1992	1993	1994	1995
Fresno-Kings-Tulare	4,170	3,510	3,940	4,380	4,520	4,750
Kern	1,710	1,420	1,430	1,760	1,820	1,770
Nevada-Placer-Sutter-Yuba	300	380	400	410	480	460
Stanislaus-Merced-Madera	1,430	1,370	1,550	1,770	1,710	1,630

The other regions do not correspond closely to counties, but rough comparisons can be made between totals for Kings, Tulare, and Fresno counties with impacts in Regions J and K. Impacts in this area do not exceed two percent of crop production under Alternative 5 and are less than one percent of crop production under the other alternatives. Similarly, totals for, Nevada, Placer, Sutter, and Yuba counties can be compared with impacts in Region C. Under Alternative 5, impacts are six percent of crop production in dry years and about three percent of crop production averaged over all year types.

B. IMPACTS ON URBAN WATER USERS

The alternatives will affect deliveries of SWP and CVP water to water wholesaling agencies and diversions of water from the Mokelumne River by EBMUD. The water deliveries affected will be SWP deliveries to the Metropolitan Water District of Southern California (MWD) and other southern California water agencies and SWP and CVP deliveries to the Santa Clara Valley Water District (SCVWD). Opportunities for developing new water supplies are very limited. Consequently, these agencies and retail water utilities that they serve are likely to respond by arranging transfers of water from agricultural users, increasing use of recycled water, reducing water use by more extensive conservation programs, and possibly imposing rationing on their customers.

1. Methodology

Economic impacts on urban water users were estimated assuming that the only options available to water utilities are additional water transfers and rationing. Water utilities might also reclaim water or reduce demand through water conservation programs. To the extent possible, wholesaling agencies and water utilities will try to avoid rationing by arranging water transfers, since the cost of transferred water is far lower than the shortage costs resulting from water rationing. However, transfers are limited by the factors discussed in Chapter V. Economic impacts of two scenarios are estimated. In one scenario, the entire reduction in water project deliveries is assumed replaced by water transfers. The value of the impacts is estimated as the cost of the replacement water. In a second scenario, it is assumed that no additional water transfers can be made so that reduced deliveries result in water rationing. The value of impacts is estimated as the shortage costs resulting from this rationing. Shortage costs represent the value lost to consumers as a result of reducing water use below desired levels, rather than out-of pocket expenses for increased water bills. Shortage costs are a measure of the cost and inconvenience to consumers of reducing water use in response to rationing and price increases.

The impacts of each alternative were estimated using results developed for the economic analysis in the ER for the 1995 Bay/Delta Plan. The water utilities' forecasting models were used to estimate the economic impacts of reductions in water project deliveries under two alternatives under consideration by the SWRCB in 1994.

Estimates of the cost per acre-foot of replacement water used in these model runs were developed in consultation with planning staff of the MWD and the SCVWD. The cost of transfers to the MWD was estimated as $200 per acre-foot, and the cost of transfers to the SCVWD was estimated as ranging from $250 to $350 per acre-foot. The MWD's transfer cost was used as an estimate of the cost of transfers to southern California water agencies and the SCVWD's transfer cost was used as an estimate of EBMUD's transfer cost.

Shortage costs were based on a cost function developed by Larry Dale Associates (Dale 1994). The function is as follows: for shortages of up to 10 percent, shortage costs are $1,400 per acre-foot; for shortages of 10 to 20 percent, shortage costs are $1,700 per acre-foot; and for shortages over 20 percent, shortage costs are $2,000 per acre-foot.

These model results were used to establish a relationship between reductions in project deliveries and economic impacts. This relationship was applied to the delivery impacts of each alternative to estimate the impacts of the reductions in project deliveries in the alternatives.

2. Results

Under the transfer scenario, the total cost of transferred water to all affected agencies ranges from an average of $12 million in Alternative 5 to $17 million in Alternative 7. Costs are higher in dry years, ranging from $31 million in Alternative 7 to $41 million under Alternative 5. The alternatives affect each water agency differently. Alternatives 2, 3, 4, 6, 7, and 8 most affect MWD, the other southern California SWP contractors, and SCVWD. Alternative 5 reduces costs to the SWP contractors and SCVWD, but increases costs to EBMUD. Details are shown Table XI-6.

Because water agencies have good access to credit and can borrow to cover high costs occurring in dry years, the average costs over all years are the relevant measure of their costs. The costs of transfers do not increase these agencies' costs appreciably. For example, under Alternative 2, the average cost of transferred water to the MWD and the other southern California SWP contractors is $13 million. This cost is about four tenths of one percent of the total retail cost of water delivered to urban users in southern California.

For several reasons, water agencies may be unable to replace all water lost from reduced deliveries by transfers. In dry years, transfers must be arranged at short notice. The cost of arranging transfers may be significant and there may be legal restrictions on transfers. Under the second scenario with no additional transfers, shortage costs in all agencies' service areas range from $197 to $225 million in low-delivery years. These costs are additional to shortage costs occurring under baseline conditions. Over all years, shortage costs average $73 to $114 million annually. Shortage costs vary between alternatives in the same way as transfer costs do.

C. REGIONAL ECONOMIC IMPACTS

Reductions in water deliveries to agricultural users will affect all sectors of the economy. When farm production falls as a result of reduced water availability, farmers will hire fewer seasonal workers and may lay off some year-round workers. Until they find other jobs, consumer spending by these workers is likely to fall, affecting retailers and other businesses in the area. In addition, farmers will reduce purchases of equipment, materials, and services from local businesses, reducing jobs and income with these suppliers.

Table XI-6
Impacts of Flow Alternatives on Urban Water Users as Compared to the Base Case

	Average all years			Low-delivery years		
	Delivery impacts (k acre-ft)	Cost of transfers ($ million)	Shortage costs if no transfers	Delivery impacts (k acre-ft)	Cost of transfers ($ million)	Shortage costs if no transfers
East Bay MUD						
Alt.3	-3	1	5	-4	1	7
Alt.4	-3	1	5	-5	2	9
Alt.5	-22	6	32	-79	28	138
SWP & CVP deliveries to SCVWD						
Alt.2	-8	2	12	-24	8	42
Alt.3	-7	2	10	-23	8	40
Alt.4	-7	2	10	-23	8	40
Alt.5	-3	1	4	-12	4	21
Alt.6	-8	2	12	-23	8	40
Alt.7	-9	2	14	-24	8	42
Alt.8	-9	2	12	-24	8	42
SWP deliveries to MWD						
Alt.2	-46	9	64	-65	13	91
Alt.3	-40	8	56	-55	11	77
Alt.4	-40	8	57	-57	11	80
Alt.5	-21	4	29	-18	4	25
Alt.6	-42	8	59	-63	13	88
Alt.7	-46	9	64	-48	10	67
Alt.8	-41	8	58	-59	12	83
SWP deliveries to Southern Cal						
Alt.2	-22	4	30	-66	13	92
Alt.3	-17	3	24	-62	12	87
Alt.4	-18	4	25	-63	13	88
Alt.5	-6	1	8	-29	6	41
Alt.6	-21	4	29	-64	13	90
Alt.7	-25	5	36	-63	13	88
Alt.8	-22	4	31	-61	12	85
All agencies						
Alt.2	-75	15	106	-155	35	225
Alt.3	-68	14	95	-144	33	211
Alt.4	-68	14	96	-148	34	217
Alt.5	-51	12	73	-138	41	225
Alt.6	-71	15	100	-150	33	218
Alt.7	-81	17	114	-135	31	197
Alt.8	-72	15	101	-144	32	210

Job and income losses resulting from the alternatives were estimated using input-output analysis, a widely-used economic technique. The procedure is described in section D.2 of this chapter. Input-output analysis usually overestimates indirect job and income losses. One of the fundamental assumptions in input-output analysis is that trading patterns between industries are fixed. This assumption implies that suppliers always cut production and lay off workers in proportion to the amount of product supplied to farms or other industries reducing production. In reality, businesses are always adapting to changing conditions. When a farm cuts back production, some suppliers will be able to make up part of their losses in business by finding new markets in other areas. Growth in other parts of the local economy will often provide opportunities for these firms. For these and other reasons, job and income losses estimated using input-output analysis should be treated as upper limits on the actual losses expected.

1. Job and Income Impacts

Impacts of the flow alternatives on jobs are shown in Tables XI-7 and XI-8. The total number of jobs displaced in the agricultural sector ranges from 370 to 1,130 when averaged over all year types. Impacts are somewhat higher if no additional groundwater can be used. Job impacts vary between alternatives and year types in the same way impacts on producers' income do. Job impacts are highest under Alternative 5 and, when averaged over all years, and lowest under Alternative 6. It should be emphasized that these displaced jobs do not represent a permanent job loss to a region. Regional job markets are affected by growth in all sectors of the economy and migration to and from the area. Moreover, the agricultural labor force is very mobile with a high proportion of seasonal workers. A job displacement in agriculture is likely to result in a slight decrease in net migration into the area and a change in seasonal movements of workers. As a result, the effect of implementing the objectives on the number of unemployed farm workers in an area will be smaller than the job displacement indicated by this analysis, and will gradually decline as migration patterns change and the rest of the economy grows.

Job displacements in other sectors of the economy, when averaged over all year types, range from about 500 under Alternative 6 to 1,500 under Alternative 5 when additional groundwater is used. In low-delivery years, indirect job displacements range from about 1,800 to 2,000 if additional groundwater is used and from about 2,400 to 2,700 if no additional groundwater is available.

Income losses also give an indication of the extent of impacts on a region's economy. Income losses (see Table XI-9) are estimated using input-output analysis and like the estimates of employment impacts, should be treated as upper limits. Income losses as estimated by input-output analysis will occur only if displaced workers are unable to find other jobs and businesses supplying farms and their employees have very limited ability to find new markets.

Although these job and income losses will cause individual hardship, they are small in comparison to total employment and income in the affected areas. Table XI-10 shows total employment and

Table XI-7
Impacts of Flow Alternatives on Farm Employment as Compared to the Base Case

	Direct job displacement							
	Additional groundwater use				No additional groundwater			
	Average all years	Low-delivery years	Medium delivery years	High-delivery years	Average all years	Low-delivery years	Medium delivery years	High-delivery years
B. **Glenn-Colusa (CVPM 3,4)**								
Alt. 5	0	20	0	0	0	20	0	0
C. **Feather River (CVPM 5,7)**								
Alt. 5	140	270	130	120	140	280	130	120
D. **Yolo-Solano-Delta (CVPM 6,9)**								
Alt. 5	-20	-10	-30	-10	-20	-10	-30	-10
F. **Delta-Mendota (CVPM 10)**								
Alt. 2	80	220	90	50	90	300	90	50
Alt. 3	70	180	70	50	80	240	70	50
Alt. 4	70	180	70	50	80	240	70	50
Alt. 5	50	100	50	50	60	130	50	50
Alt. 6	60	240	70	10	60	320	70	10
Alt. 7	90	240	100	60	100	330	100	60
Alt. 8	90	210	100	60	100	290	100	60
G. **Modesto-Oakdale-Turlock (CVPM 11,12)**								
Alt. 3	50	90	60	30	50	90	60	30
Alt. 4	60	90	60	50	60	90	60	50
Alt. 5	10	70	0	0	10	80	0	0
Alt. 8	30	50	30	30	30	50	30	30
H. **Merced-Madera (CVPM 13)**								
Alt. 3	40	70	50	20	40	80	50	20
Alt. 4	40	60	50	20	40	70	50	20
Alt. 5	20	30	20	20	20	50	20	20
Alt. 8	0	10	0	0	0	10	0	0
J. **Westlands (CVPM 14)**								
Alt. 2	280	460	310	230	290	530	310	230
Alt. 3	240	370	230	230	250	430	230	230
Alt. 4	250	370	240	230	250	420	240	230
Alt. 5	200	210	160	230	200	230	160	230
Alt. 6	160	550	180	60	170	650	180	60
Alt. 7	310	510	310	270	320	590	310	270
Alt. 8	350	520	350	320	360	600	350	320
K. **Kings-Tulare-E. Fresno (CVPM 15-18)**								
Alt.2	10	30	20	0	10	30	20	0
Alt.3	10	20	10	0	10	30	10	0
Alt.4	10	20	10	0	10	30	10	0
Alt.5	620	500	510	730	650	650	550	730
Alt.6	10	30	20	0	10	30	20	0
Alt.7	20	30	20	10	20	30	20	10
Alt.8	10	30	20	0	10	30	20	0
L. **Kern County (CVPM 19-21)**								
Alt.2	160	590	210	30	200	910	230	30
Alt.3	130	540	160	20	160	840	180	20
Alt.4	130	540	160	20	170	850	180	20
Alt.5	50	250	50	20	70	400	60	20
Alt.6	140	590	200	10	190	910	230	10
Alt.7	170	550	250	30	220	870	290	30
Alt.8	160	570	220	30	200	880	240	30
All regions								
Alt.2	530	1,300	630	310	590	1,770	650	310
Alt.3	540	1,270	580	350	590	1,710	600	350
Alt.4	560	1,260	590	370	610	1,700	610	370
Alt.5	1,070	1,440	890	1,160	1,130	1,830	940	1,160
Alt.6	370	1,410	470	80	430	1,910	500	80
Alt.7	590	1,330	680	370	660	1,820	720	370
Alt.8	640	1,390	720	440	700	1,860	740	440

Impacts are shown only where alternative affects a region.

Table XI-8
Impacts of Flow Alternatives on Employment in Other Industries as Compared to the Base Case

	Indirect job displacement							
	Additional groundwater use				No additional groundwater			
	Average all years	Low-delivery years	Medium delivery years	High-delivery years	Average all years	Low-delivery years	Medium delivery years	High-delivery years
B. **Glenn-Colusa (CVPM 3,4)**								
Alt. 5	0	30	0	0	0	30	0	0
C. **Feather River (CVPM 5,7)**								
Alt. 5	190	380	180	170	200	390	180	170
D. **Yolo-Solano-Delta (CVPM 6,9)**								
Alt. 5	-20	-10	-40	-10	-20	-10	-40	-10
F. **Delta-Mendota (CVPM 10)**								
Alt. 2	120	310	130	70	130	420	130	70
Alt. 3	100	250	100	70	110	340	100	70
Alt. 4	100	250	100	70	110	340	100	70
Alt. 5	80	140	70	70	80	180	70	70
Alt. 6	80	340	100	10	90	450	100	10
Alt. 7	130	340	140	80	140	460	140	80
Alt. 8	120	290	140	80	140	410	140	80
G. **Modesto-Oakdale-Turlock (CVPM 11,12)**								
Alt. 3	70	130	80	40	70	130	80	40
Alt. 4	80	130	80	70	80	130	80	70
Alt. 5	10	100	0	0	10	110	0	0
Alt. 8	40	70	40	40	40	70	40	40
H. **Merced-Madera (CVPM 13)**								
Alt. 3	50	100	70	30	50	110	70	30
Alt. 4	50	80	70	30	50	100	70	30
Alt. 5	30	40	30	30	30	70	30	30
Alt. 8	0	10	0	0	0	10	0	0
J. **Westlands (CVPM 14)**								
Alt. 2	400	640	430	320	410	740	430	320
Alt. 3	340	520	320	320	350	600	320	320
Alt. 4	350	520	340	320	350	590	340	320
Alt. 5	280	290	220	320	280	320	220	320
Alt. 6	220	770	250	80	230	910	250	80
Alt. 7	430	710	430	380	440	830	430	380
Alt. 8	490	730	490	450	500	840	490	450
K. **Kings-Tulare-E. Fresno (CVPM 15-18)**								
Alt.2	20	40	30	0	20	40	30	0
Alt.3	10	30	10	0	10	40	10	0
Alt.4	10	30	10	0	10	40	10	0
Alt.5	860	700	710	1,020	910	910	770	1,020
Alt.6	20	40	30	0	20	40	30	0
Alt.7	20	40	30	10	20	40	30	10
Alt.8	20	40	30	0	20	40	30	0
L. **Kern County (CVPM 19-21)**								
Alt.2	220	830	290	40	270	1,270	320	40
Alt.3	180	760	220	30	230	1,180	250	30
Alt.4	180	760	220	30	230	1,190	250	30
Alt.5	80	350	70	30	100	560	80	30
Alt.6	200	830	280	10	260	1,270	320	10
Alt.7	240	770	350	40	310	1,220	410	40
Alt.8	220	800	310	40	280	1,230	340	40
All regions								
Alt.2	760	1,820	880	430	830	2,470	910	430
Alt.3	750	1,790	800	490	820	2,400	830	490
Alt.4	770	1,770	820	520	830	2,390	850	520
Alt.5	1,510	2,020	1,240	1,630	1,590	2,560	1,310	1,630
Alt.6	520	1,980	660	100	600	2,670	700	100
Alt.7	820	1,860	950	510	910	2,550	1,010	510
Alt.8	890	1,940	1,010	610	980	2,600	1,040	610

Impacts are shown only where alternative affects a region.

Table XI-9
Impacts of Flow Alternatives on Regional Income as Compared to the Base Case

	Loss in personal income ($Million)							
	Additional groundwater use				No additional groundwater			
	Average all years	Low-delivery years	Medium delivery years	High-delivery years	Average all years	Low-delivery years	Medium delivery years	High-delivery years
B. **Glenn-Colusa (CVPM 3,4)**								
Alt. 5	0	1	0	0	0	1	0	0
C. **Feather River (CVPM 5,7)**								
Alt. 5	7	14	7	6	7	14	7	6
D. **Yolo-Solano-Delta (CVPM 6,9)**								
Alt. 5	-1	-1	-2	-1	-1	-1	-2	-1
F. **Delta-Mendota (CVPM 10)**								
Alt. 2	4	11	5	2	5	15	5	2
Alt. 3	4	10	4	2	4	12	4	2
Alt. 4	4	10	4	2	4	12	4	2
Alt. 5	3	5	2	2	3	7	2	2
Alt. 6	3	12	4	1	3	17	4	1
Alt. 7	5	12	5	3	5	17	5	3
Alt. 8	5	11	5	3	5	15	5	3
G. **Modesto-Oakdale-Turlock (CVPM 11,12)**								
Alt. 3	3	5	3	2	3	5	3	2
Alt. 4	3	5	3	2	3	5	3	2
Alt. 5	0	4	0	0	0	4	0	0
Alt. 8	2	2	2	2	2	2	2	2
H. **Merced-Madera (CVPM 13)**								
Alt. 3	2	4	2	1	2	4	2	1
Alt. 4	2	3	2	1	2	4	2	1
Alt. 5	1	2	1	1	1	2	1	1
Alt. 8	0	1	0	0	0	1	0	0
J. **Westlands (CVPM 14)**								
Alt. 2	15	24	16	12	15	27	16	12
Alt. 3	13	19	12	12	13	22	12	12
Alt. 4	13	19	12	12	13	21	12	12
Alt. 5	10	11	8	12	10	12	8	12
Alt. 6	8	29	10	3	9	33	10	3
Alt. 7	16	26	16	14	16	30	16	14
Alt. 8	18	27	18	17	18	31	18	17
K. **Kings-Tulare-E. Fresno (CVPM 15-18)**								
Alt.2	1	2	1	0	1	2	1	0
Alt.3	0	1	1	0	0	2	1	0
Alt.4	0	1	1	0	0	2	1	0
Alt.5	32	26	26	37	33	33	29	37
Alt.6	1	2	1	0	1	2	1	0
Alt.7	1	2	1	1	1	2	1	1
Alt.8	1	2	1	0	1	2	1	0
L. **Kern County (CVPM 19-21)**								
Alt.2	8	30	11	2	10	47	12	2
Alt.3	7	28	8	1	9	43	10	1
Alt.4	7	28	8	1	9	44	10	1
Alt.5	3	13	2	1	4	21	3	1
Alt.6	7	30	10	1	10	47	12	1
Alt.7	9	29	13	2	11	45	15	2
Alt.8	8	29	11	2	10	45	12	2
All regions								
Alt.2	28	67	33	16	31	91	34	16
Alt.3	28	66	30	18	30	89	31	18
Alt.4	28	65	30	19	31	88	31	19
Alt.5	55	74	45	59	58	94	48	59
Alt.6	19	73	24	4	22	99	26	4
Alt.7	31	69	36	19	34	94	37	19
Alt.8	34	71	37	23	36	96	39	23

Impacts are shown only where alternative affects a region.

Table XI-10
Employment and Income in the Affected Areas

	1990	1991	1992	1993	1994
Farm employment					
Fresno-Kings-Tulare	53,000	53,000	48,000	53,000	51,000
Kern	14,000	15,000	14,000	17,000	17,000
Nevada-Placer-Sutter-Yuba	8,000	8,000	7,000	7,000	7,000
Stanislaus-Merced-Madera	27,000	28,000	27,000	27,000	27,000
Nonfarm employment					
Fresno-Kings Tulare	478,000	475,000	481,000	492,000	506,000
Kern	243,000	248,000	243,000	241,000	245,000
Nevada-Placer-Sutter-Yuba	174,000	180,000	181,000	182,000	188,000
Stanislaus-Merced-Madera	259,000	260,000	260,000	262,000	265,000
Total personal income ($M)					
Fresno-Kings-Tulare	16,700	17,100	18,400	19,200	19,600
Kern	8,600	9,000	9,400	9,800	10,100
Nevada-Placer-Sutter-Yuba	6,900	7,500	8,000	8,300	8,800
Stanislaus-Merced-Madera	10,000	10,200	10,900	11,300	11,700

income for groups of counties roughly corresponding to the regions most affected by the alternatives. These figures show that the impacts of the alternatives are too small to have any significant region-wide effects.

2. Details of Estimation Methods

Wage losses in agriculture were estimated from changes in agricultural production using a ratio of labor costs to sales derived from statistics published in the *1987 Census of Agriculture* (U.S. Department of Commerce 1989). Payroll-to-receipts ratios ranged from 11 percent for farms primarily growing cash grains to 32 percent for farms primarily growing vegetables, fruits, and tree nuts. This analysis used the ratio for general crop farms, which was 21 percent. Employee benefits in agriculture are lower than in other industries, so wages represent nearly all of labor costs. Wages were estimated as 80 percent of labor costs. The number of year-round equivalent direct jobs displaced was estimated from the wage loss using average weekly earnings for crop production workers in the San Joaquin Valley (Employment Development Department no date).

Impacts on farm income were estimated by multiplying impacts on total crop production by the ratio of farm income and agricultural production for the San Joaquin Valley in the years 1986–1992. Farm income consists of agricultural wages and salaries plus income of farm proprietors. The ratio was estimated from crop production as reported by the California Department of Food and Agriculture and farm income as estimated by the U.S. Bureau of Economic Analysis.

The regional effects of reduced farm production were estimated using input-output analysis. Multipliers were estimated using the Implan system (1991 database), developed by the Minnesota Implan Group, Stillwater, Minnesota.

The job multiplier gives an estimate of the total number of jobs supported by each job in crop production. The multiplier includes the job in crop production. Thus, the multiplier for the San Joaquin Valley indicates that each job in crop production supports 1.4 jobs with suppliers and in businesses serving employees of farms and businesses supplying farms. The indirect job displacements shown in Table XI-8 were estimated using this figure.

The income multiplier gives an estimate of the total amount of income in the region created by each dollar in income in agriculture. Again, since the multiplier includes the income in agriculture, the multiplier for the San Joaquin Valley indicates that every million dollars in wages and salaries and proprietors' income in agriculture supports 1.7 million in personal income in the rest of the economy.

D. SUMMARY

The proposed flow alternatives will affect water deliveries to farms in the Central Valley and to water utilities in the San Francisco Bay Area and southern California. As a result, crop production will be reduced and water utilities will have to seek other sources of water or take measures to reduce water use by their customers. Depending on the alternative, water deliveries to agriculture are reduced by an average of 158 to 668 TAF per year compared to deliveries under D-1485. Average deliveries to urban water users are reduced by 51 to 75 TAF per year.

As a result of these reductions in deliveries, average net income in agriculture is reduced by an amount ranging from $14 million to $53 million annually. Economic impacts are higher in dry years because, under most alternatives, water supply impacts are higher and because water tends to be used on more valuable crops. In dry years, defined as the ten percent of years with lowest water deliveries, the proposed alternatives reduce net income in agriculture by $50 to $75 million compared to D-1485.

Reduced agricultural production will result in job losses in agriculture and businesses serving farmers and farm workers. Depending on the alternative, average job losses in agriculture range from about 400 to 1,100. Job losses in other industries range from 500 to 1,600. In dry years, job losses are higher, raging from 1,300 to 1,900 in agriculture and from 1,800 to 2,700 in other industries.

Although these job losses may cause individual hardship and may affect some communities adversely, they are too small to have any significant regional impacts and are likely to be absorbed as other sectors of the economy grow. For example, in Kern County, Alternatives 2 and 8 have the most severe impacts. However, even in dry years, these impacts do not exceed one percent of total employment in the county. Alternative 5 results in a loss of 670 jobs in dry years in the area diverting water from the Feather River and its tributaries, but this is less than half of one percent of total employment in Nevada, Placer, Sutter, and Yuba counties.

Impacts on urban water users depend largely on the ability of utilities to secure supplies of transferred water. If all of the water supplies are replaced by transferred water, the total cost to utilities will average $12 million to $17 million annually. Payments to farmers for transferred water will offset the income losses from reductions in water deliveries to agriculture. However, if water utilities respond to the standards by imposing rationing on their customers, the resulting shortage costs are estimated to range from $70 to $110 million annually.

Literature Cited in Chapter XI

Employment Development Department. No date. California Agricultural Employment and Earnings Bulletin.

U.S. Bureau of the Census. 1989. *1987 Census of Agriculture*, State Data, California, Table 51.

Personal Communications

Dale, Larry 1994. Principal, Larry Dale Associates, Point Richmond, California.

Hatchett, Stephen 1997. Economist, CH2M Hill, Sacramento, California.

XII. MANDATORY FINDINGS UNDER CEQA

A. CUMULATIVE IMPACTS

Cumulative impacts are defined in the CEQA Guidelines as two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts. The individual effects may be changes resulting from a single project or a number of separate projects. The cumulative impact from several projects is the change in the environment that results from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable probable future projects. Cumulative impacts can result from individually minor but collectively significant impacts (CEQA Guidelines § 15355). In a CEQA evaluation, the proposed action must be considered with the combined effects of the cumulative actions in a single analysis.

In this case, the principal impacts of implementation of the proposed decision can be traced to the changes in the operation of reservoirs in the Sacramento-San Joaquin river system, changes in diversions from those rivers or their tributaries, or changes in water available for export from the region. Therefore, significant cumulative impacts include the impacts of other projects or activities that reduce the water available to areas upstream of the Delta and to export areas, or actions that affect the operation of the SWP and CVP.

The discussion of the cumulative impacts of implementing the 1995 Bay/Delta Plan combined with other actions is divided into the following sections: (1) future actions with potential for cumulative effects; and (2) cumulative impact assessment.

1. Future Actions with Potential for Cumulative Effects

This section describes actions that may occur in the foreseeable future and discusses the effect of those actions. These actions are at various stages of development, and there is no certainty that all of them will be completed. Many of the actions described below could have specific impacts due to construction alone, including: (1) disturbing habitat and special status species, (2) limiting normal recreation and shoreline activities, and (3) reduced aesthetic value in the vicinity of the project. These construction-related impacts are not addressed in the following discussion. Instead, the focus of the descriptions is on the general effects of implementing the action or operating the project.

a. <u>American River Watershed Project</u>. Lead Agency: USCOE.

Project Description: Major features proposed by the study include construction of Auburn Dam, continued reoperation of Folsom Dam to provide a minimum of 400 TAF and a maximum of 670 TAF of storage for flood control, stabilization of levees along the American River downstream of Folsom Dam, and raising 12 miles of levees along the Sacramento River near Sacramento International Airport.

Project Impacts: The Auburn Dam will inundate various plant and animal species upstream of the dam and displace those species capable of re-establishing in other locations after construction is complete. The dam facility will block fish passage for those fish that normally spawn upstream of the proposed dam site. Releases may cause wide variations in daily flows, temperatures, and water levels. The Auburn Dam has the potential to change the timing of flows to the Bay/Delta; it will capture flow that would otherwise run off into the Delta during high-flow periods, and flow releases may increase Delta inflow during low-flow periods.

Reoperation of Folsom Dam has the potential to inundate or strand various species, displace species or habitat, and permanently alter habitat. The reoperation also could lead to wide variations in water levels, temperatures, and flows, and change the quantity and timing of flows to the Bay/Delta Estuary.

Stabilizing and raising levees is likely to have construction-related impacts, but is not expected to affect Bay/Delta watershed hydrology.

b. **CALFED**. Lead Agencies: State members: Resources Agency, DWR, DFG, California Environmental Protection Agency, and SWRCB. Federal members: U.S. Department of the Interior (USDOI), USBR, USFWS, USEPA, and NMFS.

Project Description: In 1994, State and federal agencies responsible for managing resources in the Bay/Delta signed the Bay/Delta Accord which, among other things, established a joint state and federal long-term solution finding process for Bay/Delta resource management. The participating agencies are referred to as the CALFED agencies.

The CALFED Bay/Delta Program established a three-phase approach to developing and implementing a long-term solution to problems affecting the Delta. During Phase I (June 1995 through August 1996) the Program defined the problems, developed a range of solutions, and identified three preliminary alternatives to be further analyzed in Phase II. In Phase II, the Program refined the preliminary alternatives, conducted a comprehensive programmatic environmental review, and issued a Draft Programmatic EIS/EIR in March 1998. Because a Preferred Program Alternative was subsequently identified, CALFED revised the document with an analysis of the Preferred Program Alternative and reissued the Draft Programmatic EIS/EIR in June 1999.

The Preferred Program Alternative will be implemented in stages during Phase III. This phase will include any necessary studies and site-specific environmental review and permitting. Because of the size and complexity of the program alternatives, implementation is likely to take place over a period of 20-30 years.

Each of the CALFED alternatives includes eight program elements: Ecosystem Restoration, Water Quality, Levee System Integrity, Water Use Efficiency, Water Transfer, Watershed, Storage, and Conveyance. The alternatives are programmatic in nature, defining broad approaches to meet Program purposes, and the descriptions of the Program elements, except for Conveyance, do not vary among the alternatives. The elements are described in the CALFED Revised Phase II Report (December 18, 1998).

The three conveyance approaches are: (1) existing system conveyance where little or no modifications are made to the flow capacity of existing Delta channels; (2) a through-Delta conveyance where a variety of modifications to Delta channels could be made to increase the conveyance efficiency; and (3) dual Delta conveyance using a combination of improved through-Delta conveyance and conveyance isolated from Delta channels.

The Preferred Program Alternative consists of a through-Delta conveyance approach, coupled with ecosystem restoration, water quality improvements, levee system improvements, increased water use efficiency, improved water transfer opportunities, watershed restoration, and a Water Management Strategy that includes an integrated storage program. The Preferred Program Alternative provides for a system of research and monitoring to determine whether modifications or additional actions are needed.

Project Impacts: The Preferred Program Alternative is expected to have potentially significant beneficial and adverse consequences in the Bay/Delta watershed. The most significant potential consequences are related to water supply/water management, water quality, ground water, fisheries and aquatic ecosystems, and vegetation and wildlife. Details of the project impacts are disclosed in the programmatic EIR/EIS.

c. <u>Central Valley Project Improvement Act</u>. Lead Agency: USBR.

Project Description: The Central Valley Project Improvement Act (CVPIA) reauthorizes the USDOI's Central Valley Project under P.L. 102-575. The CVPIA adds fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic uses, and fish and wildlife enhancement as a project purpose equal to power generation. The CVPIA includes the following three measures that are likely to affect Bay/Delta watershed hydrology significantly.

- Section 3406(b)(2) of the CVPIA directs the Secretary of the Interior to dedicate and manage annually 800 TAF of CVP yield (referred to as "(b)(2) water)" for the primary purpose of implementing the fish, wildlife, and habitat restoration purposes and measures authorized in the Act. This quantity of water is reduced to 600 TAF in critically dry conditions. The USDOI issued an Administrative Proposal on the Management of Section

3406(b)(2) Water (November 20, 1997) presenting the USDOI's conclusions as to how it intended to comply with the statutory mandate to dedicate and manage the water each year. The Administrative Proposal was returned to the USDOI by a reviewing court for changes in accordance with the court's opinion. The final decision was released on October 5, 1999. On July 15, 1999, the USDOI proposed a new decision to implement section 3406(b)(2).

- The CVPIA requires the Secretary of the Interior to provide, either directly or through contractual agreements with appropriate parties, firm water supplies of suitable quality to maintain and improve wetland habitat areas on: units of the National Wildlife Refuge System in the Central Valley of California; the Gray Lodge, Los Banos, Volta, North Grasslands, and Mendota state wildlife management areas; and the Grasslands Resources Conservation District in the Central Valley of California.

- Section 3406(b)(23) of the CVPIA allocates a minimum of 340,000 acre-feet per year for the purposes of fishery restoration, propagation, and maintenance, and further requires that the Trinity River Flow Evaluation Study be completed in a manner which ensures the development of recommendations for the restoration and maintenance of the Trinity River fishery. The Draft Trinity River Flow Evaluation, released in January 1998, contains daily flow recommendations for the Trinity River which range, depending on water year type, from 300 cfs to 10,564 cfs. If these daily flow recommendations are adopted, releases from Trinity Lake into the Trinity River will range from 368,621 acre feet in a critically dry year to 815,226 acre feet in an extremely wet year, excluding unscheduled releases associated with large storm events.

Project Impacts: The CVPIA is expected to have significant fishery and hydrologic impacts in the Bay/Delta watershed. Alternatives for implementing the CVPIA are the subject of a programmatic draft EIS which was released in October 1997.

d. Conjunctive Use Programs. Lead Agency: DWR.

Project Description: To meet SWP contractors' increasing need for water, the DWR is investigating the potential for entering into programs with various water agencies whereby the DWR would finance facilities in exchange for water that would be made available through conjunctive use. Surface water would be made available from the SWP to the participants for in-lieu groundwater recharge in above-normal and wet years. In dry years, the participants would release a portion of their surface water supplies to the SWP and use stored groundwater instead of surface water. Projects are being considered in several areas in the Central Valley.

Project Impacts: Conjunctive use offers a relatively low-cost method to store water in times of above-average supply for use during dry periods. However, groundwater pumping during extended drought could initiate land subsidence in some locations. Flows into the Delta could decrease in wetter years because of upstream diversions to groundwater storage. Exports from the Delta and flows into the Delta could increase in drier years as stored groundwater is used.

e. Delta Wetlands Project. Lead Agencies: USCOE and SWRCB.

Project Description: Delta Wetlands Properties is the project proponent for the Delta Wetlands project, which includes diversion and storage of water on two Delta islands owned by the company (Bacon Island and Webb Tract, the "reservoir islands") and seasonal diversion of water for creation and enhancement of wetlands and management of wildlife habitat on two islands owned primarily by the company (Bouldin Island and Holland Tract, the "habitat islands"). Delta Wetlands would improve and strengthen levees on all four islands and install two additional intake siphon stations and a new pump station on each of the reservoir islands. The project would divert water onto the reservoir islands during periods of availability to be stored for later sale. The purchased water would be either exported or allowed to flow out of the Delta to meet water quality or flow requirements.

Total maximum initial water storage capacity of the Delta Wetlands reservoir islands as proposed would be 238 TAF. Total physical storage capacity may increase in 50 years to 260 TAF as a result of soil subsidence. Mean annual diversions and discharges are estimated in the draft EIR/EIS for the project to be 222-225 TAF and 188-202 TAF, respectively, based on the historical hydrologic record for 1922-1991 and assuming current Delta standards, facilities, and upstream/export demands for water. Diversion rates onto the reservoir islands would vary with pool elevation and water availability. The maximum rate of diversion onto either Webb Tract or Bacon Island would be 4,500 cfs (9,000 acre feet per day) when diversions begin (when head differential is greatest). The combined daily average diversion rate for all the islands (including diversions to the habitat islands) would be 4,000 cfs. At this average rate, both reservoir islands could be filled in approximately one month.

Water would be discharged from storage on the reservoir islands during periods of demand in any month, subject to Delta regulatory limitations and export pumping capacities, at a combined maximum daily average of 6,000 cfs. The combined monthly average discharge rate of the reservoir islands would not exceed 4,000 cfs. At this average rate, both reservoir islands could be emptied in approximately one month.

Project Impacts: Operation of the project will have a significant effect on Bay/Delta hydrology. A detailed description of the project impacts can be found in the draft EIR for the project (SWRCB and USCOE 1995).

f. **<u>Eastside Reservoir</u>**. Lead Agency: Metropolitan Water District (MWD).

Project Description: The purpose of the project is to secure six months of emergency storage in southern California in the event of a major earthquake and to provide additional water supplies for drought protection and peak summer needs. The Eastside Reservoir site is located in the Domenigoni and Diamond valleys, four miles southwest of the City of Hemet. Storage capacity of the reservoir will be 800 TAF. The reservoir will be 4.5 miles long, more than 2 miles wide, and have a surface area of 4,500 acres. The water source for the project is the Colorado River Aqueduct, delivered through the San Diego Canal into the reservoir forebay. Also, SWP water from Lake Silverwood will flow by gravity into the reservoir through the new 12-foot-diameter, 45-mile-long Inland Feeder, connecting with the new 9-mile-long Eastside Pipeline.

Project Impacts: The new reservoir will inundate habitat and displace species upstream of the site. The project will allow the SWP to increase exports, which will alter Bay/Delta hydrology. Water supply reliability in the MWD service area will be improved. A detailed description of the project impacts can be found in the EIR for the project (MWD 1991).

g. **<u>EBMUD Supplemental Water Supply Program</u>**. Lead Agency: EBMUD.

Project Description: The EBMUD Board of Directors adopted its Water Supply Management Program Action Plan in September 1995. The Action Plan included two alternatives for taking delivery of American River water pursuant to EBMUD's contract with the USBR. EBMUD contracted with the USBR in 1970 for 150,000 AF/year from Folsom Lake, to be delivered via the Folsom South Canal (FSC) to an as-yet-unbuilt connection to the Mokelumne Aqueducts.

The EBMUD and the USBR issued a draft EIR/EIS on the Supplemental Water Supply Project in November 1997, which addresses two primary project alternatives. The first alternative is an EBMUD-only project that involves deliveries from the American River near Nimbus Dam, via the FSC to a new pipeline connection between the FSC in southern Sacramento County and EBMUD's Mokelumne Aqueducts in San Joaquin County. The second alternative is a joint project between EBMUD, the City of Sacramento, and the County of Sacramento. Under this alternative, water would be diverted from the lower American River near the confluence with the Sacramento River and conveyed to the City's water treatment plant. Water for EBMUD would then be conveyed through new pipelines from the treatment plant to the FSC and from the FSC to the Mokelumne Aqueducts.

A key difference between the two alternatives is the location of the diversion points on the American River. The first alternative would provide higher quality water from farther upstream, but would be subject to court-ordered flows that would allow less water to be delivered to EBMUD in dry years. A joint Sacramento project would guarantee water even in the driest years and still provide high-quality water taken from the American River delivery point farther downstream.

In 1997, San Joaquin County interests proposed a groundwater storage project that would allow EBMUD to store surface water from the American River in San Joaquin County aquifers. The project would provide more out-of-service area storage and improved supply reliability during droughts for EBMUD and would also provide significant benefits to San Joaquin County water users. However, a conjunctive use alternative was not included in the 1997 draft EIR/EIS.

Project Impacts: The American River diversion may present risk to fish of impingement and entrainment at diversion facilities. Diversion of American River water will affect the quantity of Bay/Delta inflows, especially for CVP exports; however, water supply reliability will be improved for the EBMUD service areas.

h. **Inland Feeder Project**. Lead Agency: MWD.

Project Description: The Inland Feeder Project will more than double the water delivery capacity of the east branch of the California Aqueduct from the SWP, providing Southern California with approximately 2 TAF per day of additional delivery capacity. The project begins in the Devil Canyon area north of the City of San Bernardino and ties into the MWD's Colorado River Aqueduct south of Lake Perris, near the City of San Jacinto. The water source is the SWP through the east branch of the California Aqueduct from Lake Silverwood. Estimated project cost is $1.1 billion. One of the purposes of this project is to feed water into the Eastside Reservoir, which is currently under construction.

Project Impacts: The project will allow an increase in Bay/Delta exports, which will alter Delta hydrology. Water supply reliability will be improved for the project area.

i. **Interim South Delta Program (ISDP)**. Lead Agency: DWR.

Project Description: The purpose of the Interim South Delta Program is to (1) improve water levels and circulation in southern Delta channels for local agricultural diversions; and (2) improve southern Delta hydraulic conditions in order to increase diversions into Clifton Court Forebay to maximize the frequency of full pumping capacity at Banks Pumping Plant.

In July 1982, South Delta Water Agency (SDWA) filed a lawsuit against the State of California and the federal government, in part alleging that operations of SWP and CVP pumps violate South Delta Water Agency's rights by lowering water levels, reversing flows, and diminishing the influence of the tides. The DWR, USBR, and SDWA recently agreed to a draft contract that settles the 1982 lawsuit and includes provisions to test and construct barriers in certain southern Delta channels to provide the SDWA with an adequate agricultural water supply.

The DWR, USBR, and USACE are proposing the installation of three permanent flow control structures and one fish control barrier through the ISDP. The program also calls for operating the SWP pumps at full capacity; installing additional forebay intake structures; and limited channel dredging along a 5-mile stretch of Old River. In May 1999 the ISDP was rolled into the CALFED South Delta Improvements Program.

Project Impacts: Operating the pumps at full capacity will enable the SWP to increase exports from the Delta. The increased exports and the operation of the barrier and flow control structures will alter Delta hydrology and water quality. The increase in diversions to Clifton Court Forebay may be unscreened and therefore have an impact on fish residing in or passing through the Delta. Fish salvage at the export pumps may also increase. The project will increase water supply reliability in the SWP service area.

Operation of the barrier and flow control structures will alter habitat. The structures may lead to increased straying, blocked passage, and increased predation if fish are reluctant to pass the structures. Navigation and recreation will be restricted, and aesthetic value may be reduced. For a detailed description of project impacts, see the ISDP Draft EIR/EIS (DWR and USBR 1996).

j. **Los Angeles Aqueduct**. Lead Agency: Los Angeles Department of Water and Power (LADWP).

Description: The LADWP owns and operates the Los Angeles Aqueduct (LAA) which diverts both surface and groundwater from the Owens Valley and surface water from the Mono Basin. The first pipeline of the LAA was completed in 1913 and began conveying water from the Owens Valley to the City of Los Angeles. The aqueduct was extended north to the Mono Basin where diversion began in 1940. A second pipeline was completed in 1970, bringing the combined capacity of the LAA to about 550 TAF/yr and average annual diversions from the Mono-Owens region to about 400 TAF/yr.

LADWP's diversions from the Owens Valley and Mono Basin resulted in the degradation of the region's environmental resources and have been the subject of extensive litigation. Recent actions by the courts and regulatory agencies have resulted in restrictions on the amount of water that the City of Los Angeles can divert and agreements for environmental restoration. These actions include the 1994 SWRCB Decision 1631 on Mono Lake, the 1997 agreement between Inyo County and the City of Los Angeles for rewatering the lower Owens River, and the 1997 implementation plan adopted by the Great Basin Unified Air Pollution Control District.

The California Supreme Court ruled in 1983 that the SWRCB has authority to reexamine past water allocation decisions and the responsibility to protect public trust resources where feasible. Amendments to LADWP's water right licenses for diversions from the Mono Basin are set forth in D-1631. The order sets instream flow requirements for fish in the four streams from which LADWP diverts water. The order prohibits exports of water from the basin until Mono Lake surface elevation reaches 6,377 feet. Diversions are then restricted to 16 TAF/yr until the lake reaches the 6,391-foot level (estimated to take about 20 years). In order to maintain the 6,391-foot level, long-term diversions will be restricted to about 31 TAF/yr, or one-third of the historical diversions from the Mono Basin.

Inyo County filed suit against the City of Los Angeles in 1972, claiming that increased groundwater pumping was harming the Owens Valley environment. After 25 years of litigation, an agreement was executed in 1997 between Los Angeles and Inyo County which resolved the concerns of several organizations and state agencies over the Lower Owens River Project (LORP) and other provisions of the 1991 environmental impact report for groundwater management in the Owens Valley. The agreement requires LADWP and Inyo County to implement numerous environmental projects and studies. The LORP, which is identified as mitigation for impacts that occurred between 1970 and 1990, includes four significant physical features. These include: (1) provision for year-round flows in the lower Owens River (with a pumpback station just above the Owens River delta to return some of the water to the LAA), (2) provision of flows past the pumpback station to create new wetlands in the Owens River delta, (3) enhancement of off-river lakes and ponds, and (4) development of a new 1,500-acre waterfowl habitat area.

After the City of Los Angeles began diverting water from the Owens Valley, Owens Lake became a dry lakebed. On windy days, airborne particulates from the dry lakebed violate air quality standards. In 1997, the Great Basin Unified Air Pollution Control District ordered the City of Los Angeles to implement specified control measures at Owens Lake to mitigate the dust problem. These measures could reduce the city's potential diversion by up to 50 TAF/yr. Upon appeal, a compromise was reached when LADWP agreed to begin work at Owens Lake by 2001 and to ensure that federal clean air standards would be met by 2006. LADWP's dust control strategy may include treating over 14,000 acres of lakebed through a combination of shallow flooding, vegetation planting, and gravel placement.

Project Impacts: The actions described above are designed to reverse or mitigate for the impacts resulting from the diversion and export of water from the Owens Valley and Mono Basin. They are also designed to protect and enhance fish, wildlife, recreation and other environmental resources in the region. The reduction in Mono Basin exports and the inbasin use of water in the Owens Valley for dust control and the LORP will have a direct effect on water supplies available to the City of Los Angeles. The reduction in water supply from the LAA is likely to be offset through a combination of conservation, reclamation, recycling, and additional supplies from MWD.

k. Los Banos Grandes Reservoir. Lead Agency: DWR.

Project Description: The Los Banos Grandes facilities would consist of an offstream storage reservoir located near the San Luis Dam and Reservoir, with associated pumping and generating plants and conveyance channels. Water would be stored south of the Delta when winter flows are high. These flows would be pumped from the Banks pumping plant in the Delta through the California Aqueduct and then to the Los Banos Grandes reservoir for storage. Operation of the reservoir would be similar to that of the San Luis Reservoir, except that Los Banos Grandes would reserve about two-thirds of its stored water each year to provide supplies during periods of water shortage. The project would improve SWP reliability by increasing the dependable yield of the project by more than 250 TAF, an estimate made prior to the adoption of the 1995 Bay/Delta Plan.

The DWR has investigated other potential south-of-the-Delta storage sites on the west side of the San Joaquin Valley. The list includes ten watersheds with 20 potential dam locations identified. Evaluation of the Los Banos Grandes site included cost estimates, a threatened and endangered species survey, a pilot program to investigate re-establishment of sycamore woodland habitat, and a study to evaluate the effects of canals on the movement of kit fox throughout the study area commissioned by the DWR and conducted by the DFG. DWR is not actively studying this project at this time; however, it is included in CALFED's list of alternatives for offstream storage south of the Delta.

Project Impacts: Increased exports from the Delta will occur, which will alter Bay/Delta hydrology. Water supply reliability should be improved for SWP service areas south of the Delta. A new reservoir will alter and inundate habitat and displace species upstream of the reservoir.

l. **Los Vaqueros Project**. Lead Agency: Contra Costa Water District.

Project Description: The objectives of the project are to improve water quality; minimize seasonal water quality changes of delivered water, especially in late-summer periods when salinity concentrations rise in the Delta; and improve reliability of water supplies during extended emergencies. Facilities included in the project include the Los Vaqueros Dam and Reservoir (a 200-foot high earthen dam and a 100 TAF reservoir); the Old River pumping plant (250 cfs) and pipeline facilities (a 7-mile pipeline); a transfer reservoir and pipeline (a 4-million-gallon reservoir and 5-mile pipeline); the Los Vaqueros Pipeline (9 miles); and relocation of Vasco Road and several utilities.

Project Impacts: The project should result in higher diversions from the Delta in high flow periods and lower diversions in low flow periods. This change in diversion patterns will affect Bay/Delta hydrology. Numerous construction-related impacts will occur. For a detailed description of this project, see the Los Vaqueros Reservoir EIR (CCWD 1992). This project was completed in March 1998.

m. **Mandeville Island Project**. Lead Agency: SWRCB.

Project Description: CCRC Farms and the Tuscany Institute are the proponents for the project, which would involve diversion and storage of water on Mandeville Island in the Delta. The project is very similar to the Delta Wetlands project that is described earlier in this section.

The applicant seeks to divert 330 TAF of water per year at a rate of 2,600 cfs from four separate diversion points, including: Connection Slough, Old River, Middle River, and San Joaquin River. The water would be diverted by 40 siphons and 31 pump stations. The proposed reservoir would have a surface area of 5,280 acres with an average depth of about 24 feet.

Project Impacts: Project impacts would be very similar to the impacts of the Delta Wetlands project.

n. **Montezuma Wetlands Project**. Lead Agency: Solano County/USCOE.

Project Description: Levine-Fricke proposes to deposit dredged materials on a diked bayland site near Collinsville in Solano County, adjacent to the Suisun Marsh, to restore 1,822 acres of tidal wetlands on a 2,394-acre site. The site is currently used as grazing lands and includes approximately 1,620 acres of nontidal, federally-regulated wetlands and 202 acres of uplands. The proposal calls for constructing facilities to receive up to 20 million cubic yards of approved dredge materials from ports and navigation channels in the San Francisco Bay and to distribute the materials over the site. This deposition would return the subsided land surface to an elevation range at which marsh could establish. The top 3 feet of dredged sediment would have contaminant levels that have passed tests for suitability in a tidal wetland environment. After the subsided baylands are filled, the levees would be breached to enable tides to ebb and flow over the constructed foundation of tidal channels and low marsh plains. The marsh design includes high marsh and marsh ponds that would seldom be reached by tides. Project construction is proposed to be in four phases to minimize temporary losses of wetlands during construction and to facilitate engineered placement of dredged materials. Each completed phase would be hydrologically independent with a single connection to Montezuma Slough or the Sacramento River. Phases would range in size from about 240 acres to 600 acres.

Project Impacts: This project is not expected to affect Delta hydrology. The deposit of dredged materials may lead to burial, disturbance, or displacement of various species at the project site.

o. **Pardee Reservoir Enlargement Project**. Lead Agency: EBMUD.

Project Description: The project would raise Pardee Dam by 57 feet, thereby increasing the capacity of the reservoir by 150 TAF. Additional elements of the project include modifying the powerhouse, modifying or replacing the outlet tower, constructing a secondary dam in the Jackson Creek arm, modifying the recreation and shoreline facilities, and constructing a new Highway 49 bridge crossing. No environmental documentation for this project is planned for the near future.

Project Impacts: The increased storage capacity will increase exports from Pardee Dam to the EBMUD service area through the Mokelumne Aqueduct. These exports may decrease overall Delta inflows from the Mokelumne River. However, minimum instream flows for the lower

Mokelumne River would be expected to increase due to the gain-sharing provision of the Mokelumne River Joint Settlement Agreement that was approved by the USFWS, DFG, and EBMUD and subsequently approved by the FERC. Increasing the size of the main dam and reservoir capacity at Pardee Reservoir may inundate various plant and animal species upstream of the dam and displace those species capable of re-establishing in other locations once construction is complete.

p. **Red Bluff Diversion Dam Fish Passage Project**. Lead Agency: USBR.

Project Description: The USBR is evaluating possible long-term solutions to fish passage and water delivery problems at the Red Bluff Diversion Dam on the Sacramento River. The "eight-months gates-up" operation under the NMFS biological opinion has substantially reduced, but not eliminated, fish passage problems at the Dam and has created water delivery problems during planting and harvest seasons. A research pumping facility was installed in 1993 and 1994 to evaluate potential means of pumping water while using existing drum screens. Engineering and biological evaluations are still in progress, and interim measures have been developed to supply water during the "gates-up" period. Field and laboratory studies of fish ladder alternatives are in progress, as is a hydrological study to guide analysis of alternatives.

Project Impacts: This project may improve conditions for migration of anadromous fish. It is not expected to have any impacts on Bay/Delta hydrology.

q. **Reallocation of Colorado River Water**. Lead Agency: USDOI.

Description: During the past decade, the MWD has operated the Colorado River Aqueduct at or near capacity of about 1.2 MAF annually. Currently, however, the DWR estimates that the MWD's contractual supplies and firm rights to Colorado River water amount to only about 724 TAF (DWR 1994d). The excess deliveries came from surplus water when available and from supplies apportioned to, but unused by, Arizona and Nevada. These supplies are either unreliable or unlikely to be available in the future.

Impacts: Reductions in Colorado River supplies will exacerbate the effect in the MWD service area of reductions in Bay/Delta supplies caused by implementation of the Bay/Delta Plan. MWD will also likely seek additional supplies in the Bay/Delta watershed, which will alter Bay/Delta hydrology.

r. **Rice Field Flooding**. Lead Agency: Various water right holders.

Description: Historically, many farmers in the Sacramento Valley flooded their harvested rice fields in order to attract waterfowl for hunting. Due to the air quality restrictions on burning rice straw, additional rice acreage is now being flooded for rice straw decomposition. Most flooding of harvested rice fields begins in mid-October and continues into November. Flooded conditions are usually maintained through March. Fields used for waterfowl hunting have higher water demands than those used for rice straw decomposition alone. Fields used for waterfowl hunting require an additional flow of water through the flooded fields to prevent the potential for waterfowl diseases caused by stagnant water. A study by the DWR to evaluate fall and winter water use in the Sacramento Valley found that the estimated applied water requirement was about 2 AF/acre and that the ETAW was approximately 40 percent of applied water.

As an example of how rice field flooding may affect water use and availability in the Sacramento Valley, the Glenn-Colusa Irrigation District has filed an application for a water right permit for diversion of water from the Sacramento River (A-30838). The application requests a direct diversion of 1,200 cfs, from November 1 to March 31 of every year, for a total of 189 TAF annually. The application lists the purpose of use as rice straw decomposition, wildlife enhancement, recreation, and irrigation. In the project description, GCID estimates that it will require 150 TAF of water to maintain an average of 75,000 acres annually at a depth of 8 inches.

Project Impacts: Rice field flooding has created additional winter habitat used by millions of waterfowl that travel the Pacific Flyway. Water for winter rice field flooding is generally diverted in months when there is excess water in the Delta, but these diversions could be curtailed under Term 91 in very dry conditions. Water demands for flooding to decompose rice straw may decrease in the future if growers are able to find commercial uses for the rice straw or acceptable alternatives for its elimination.

s. **Sacramento Area Water Forum Process**. Lead Agency: The City and County of Sacramento through the City-County Office of Metropolitan Water Planning.

Project Description: The Sacramento Area Water Forum is a diverse group of water managers, business and agricultural leaders, environmentalists, citizen groups, and local governments in Sacramento County which was formed in 1993 to evaluate water resources and future water supply needs in the Sacramento metropolitan region. The group was joined in 1995 by water managers from Placer and El Dorado counties. The Water Forum has formulated a Water Forum Proposal (WFP) for the effective long-term management of the region's water resources. The proposal is incorporated in the Water Forum Action Plan, which was released in January 1999.

The WFP is based on the two coequal objectives of the Water Forum: (1) provide a reliable and safe water supply for the region's economic health and planned development through the year 2030; and (2) preserve the fishery, wildlife, recreational, and aesthetic values of the lower American River. The proposal contains seven elements which together form a package of linked actions designed to make more water available for consumption while protecting the natural resources of the lower American River from environmental damage. The seven elements include:

- increased surface water diversions;
- actions to meet customers' needs while reducing diversion impacts on the lower American River in drier years;

- support for an improved pattern of fishery flow releases from Folsom Reservoir;
- lower American River habitat management;
- water conservation;
- ground water management; and,
- Water Forum successor effort.

Project Impacts: The Water Forum issued a draft EIR for the WFP in January 1999. Element 1 of the WFP provides for increased diversions from the lower American River. The remaining six elements, in one way or another, are intended to reduce the adverse impacts of those increased diversions. The draft EIR identifies potentially significant impacts to certain fisheries, recreational opportunities, and cultural resources in the lower American River and Folsom Reservoir. Potential impacts outside the American River system include impacts to water supply, water quality, and power supply. The project is considered to be growth inducing in the water service study area.

t. State and Federal ESA. Lead Agency: State and Federal Resource Agencies.

Description: The State and federal ESAs require consideration of the effects of actions on organisms--plants and animals--listed as threatened or endangered. An endangered species is one in danger of extinction in all or a significant portion of its range; a threatened species is one likely to become endangered.

The acts are designed to protect threatened and endangered species by: (1) listing endangered and threatened species; (2) ensuring State and federal agencies adopt measures to protect the species during the design, construction, and operation of projects; and (3) prohibiting the taking of endangered species. One important aspect of the acts is preserving habitat critical to the survival of the threatened or endangered species. Fish species occurring in the Delta that are listed or proposed for listing under the state and federal endangered species acts are shown in Table III-17.

Requirements of the acts presently affect water resources planning in the Delta. Requirements established for protection of winter-run chinook salmon and delta smelt, referred to as biological opinions, controlled many of the operational decisions of the SWP and the CVP in the Bay/Delta Estuary in the last four years. On December 15, 1994, State and federal agencies signed the Principles for Agreement in which the signatories agreed to accept the requirements in the Bay/Delta Plan for the next three years, after which the requirements may be revised. Accordingly, the biological opinions for delta smelt and winter-run chinook salmon have been redrafted and are largely consistent with the requirements in the plan.

The listing of spring-run chinook under CESA in 1998 may result in additional changes in water resources requirements.

Impacts: The hydrology throughout the Bay/Delta watershed can be affected by the State and federal ESA in the future. If the requirements in the plan do not stabilize populations of endangered species in the Delta, more restrictive ESA requirements may be established. Additional species could also be listed in the future.

u. **Water Transfers**. Lead Agency: DWR.

Project Description: Prior to 1991, most water transfers in California were negotiated by the DWR on a limited basis. SWP facilities were used to transfer water (1) for SWP long-term contractors and (2) to other agencies in California--most notably to CVP contractors. With the most recent drought, however, California implemented a statewide policy of transferring water.

In 1991 and 1992, California began its first large-scale water transfer program when Governor Wilson established the 1991 Drought Water Bank. Because of the success of this program, increasing interest is being expressed in water transfers as a water management tool for alleviating short-term shortages as well as for augmenting long-term supplies.

Project Impacts: The water transfer capacity through the Delta from July through October is identified in Chapter V of this report. The increase in Delta inflows and exports that could occur due to water transfers will affect Delta hydrology.

v. **West Delta Program**. Lead Agency: DWR.

Project Description: This program will result in strengthening and reconstruction of levees on several islands in the western Delta. Land on these islands will be converted from farmland to managed wildlife habitat. The habitat that is developed may be used to mitigate for the construction and operation of future SWP facilities.

Many levees in the western Delta are in jeopardy, as indicated by a prolonged history of periodic failure. Consequences of levee failures include seriously degraded water quality for all uses, as well as contributing to potential levee failures on interior Delta islands. From a water supply standpoint, this project will provide more security to existing supplies, rather than develop additional supplies. It will prevent the reduction of existing supplies that would result from future levee failures.

Project Impacts: Taking agricultural land out of production will alter water demands in the Bay/Delta, which will alter Delta hydrology. Habitat values in the converted areas should improve. Although converting farmland to managed wildlife habitat under the proposed project would have positive effects, the project is likely to alter or permanently remove some existing habitat.

2. Cumulative Impact Assessment

The hydrology for the Cumulative Impact Assessment was modeled using DWRSIM. The DWRSIM study assumes full compliance with the 1995 Bay/Delta Plan, and the assumptions described in Chapter IV are still applicable. Additional assumptions include: (1) the ISDP is in place, including SWP Banks Pumping Plant capacity of 10,350 cfs; (2) combined use of points of diversion is allowed for the SWP and the CVP, limited only by the combined physical capacities of the pumping plants; (3) Eastside Reservoir is in operation; (4) Los Vaqueros Reservoir is in operation; and (5) year 2020 level of development is used. As described in section 1 of this chapter, other projects and actions may be relevant to the cumulative impact assessment but they were not included in the modeling because insufficient detail is available.

The following impact analysis compares the modeled hydrologies of the Cumulative Impact Assessment to those of the No Project Alternative and the Bay/Delta Plan Alternative. The No Project Alternative is the base case and is described as Flow Alternative 1 in Chapter II of this report. The Bay/Delta Plan Alternative assumes full compliance with the 1995 Bay/Delta Plan. Both the No Project Alternative and the Bay/Delta Plan Alternative assume a 1995 level of development and operating criteria described in Chapter IV. All three alternatives assign primary responsibility for meeting the objectives to the SWP and the CVP.

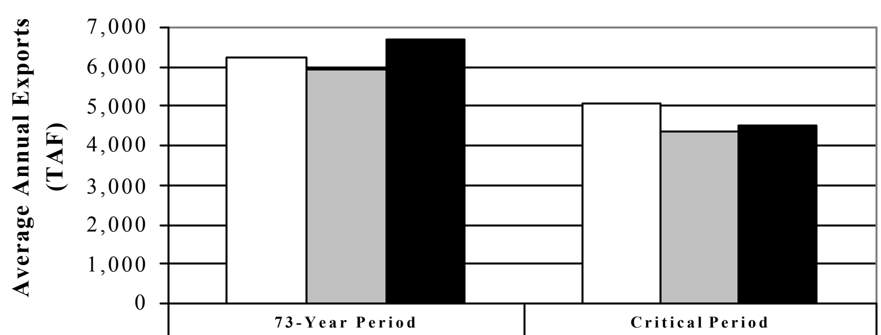
For modeling purposes, both the Cumulative Impact Assessment and the Bay/Delta Plan Alternative require the release of additional water from reservoirs on tributaries to the San Joaquin River in order to fully comply with the objectives. During the 73-year period, this quantity averages 23 TAF for the Bay/Delta Plan Alternative and 26 TAF for the Cumulative Impact Assessment. Because these reservoirs are surrogates for parties who would be assigned responsibility for meeting the objectives if the Day/Delta Plan is implemented, this analysis will not address impacts to those reservoirs.

The analysis of cumulative impacts focuses on the potential changes to: (a) Delta exports, (b) carryover storage, (c) transfer capacity, (d) Delta outflow, (e) fisheries, (f) salinity, and (g) water temperature. The analysis of fishery impacts includes the effects on salmon smolt survival and striped bass populations in the Delta, and the relationship of upstream river flows and reservoir levels to habitat quality. The analysis of salinity impacts includes the changes in X2 (2 ppt isohaline) position and salinity levels throughout the Delta.

a. Delta Exports. The 1995 Bay/Delta Plan limits the rate of Delta export pumping to a percentage of Delta inflow as described in Chapter V. For the purpose of calculating the export/inflow ratio, exports include SWP Banks Pumping Plant exports and CVP Tracy Pumping Plant exports. Other project exports include the Contra Costa Canal, North Bay Aqueduct, and the City of Vallejo; however, these diversions are not included in the export/inflow ratio calculations.

Figure XII-1 shows the average annual exports as modeled under the No Project Alternative, the Bay/Delta Plan Alternative, and the Cumulative Impact Assessment for both the 73-year period and the critical period. The cumulative impact to exports can be illustrated by comparing the Delta exports under the Cumulative Impact Assessment to the exports under the No Project and Bay/Delta Plan alternatives. For the 73-year period, average annual exports are greater under the Cumulative Impact Assessment than under the No Project Alternative or the Bay/Delta Plan Alternative. During the critical period, average annual exports in the Cumulative Impact Assessment are less than in the No Project Alternative, but slightly greater than in the Bay/Delta Plan Alternative. Most of this reduced export capacity can be made up through increased transfers as described below.

Figure XII-1
Average Annual Exports



	73-Year Period	Critical Period
No Project	6,256	5,102
Bay/Delta Plan	5,980	4,378
Cumulative Impact	6,715	4,474

Critical Period is May 1928 through October 1934

b. <u>Carryover Storage</u>. Carryover storage is the amount of water retained in a reservoir at the end of September of each year. The purpose of carryover storage is to help meet future demand in the event that the next year is dry. The amount of water dedicated to carryover storage is balanced against the amount needed to meet immediate delivery needs, hydropower generation needs and instream flow requirements of a project, according to operation rules that differ for each reservoir.

To determine the cumulative impacts on carryover storage, average September storage amounts for the SWP and CVP reservoirs included in the Cumulative Impact Assessment were compared to the No Project and Bay/Delta Plan alternatives. Reservoirs in this analysis include Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir. Other reservoirs are not included because their operation is not affected under the modeling studies used for this analysis. Table XII-1 shows the average annual carryover storage volumes for the 73-year period and the critical period for the reservoirs considered. The table also shows the difference in average annual carryover storage when comparing the Cumulative Impact Assessment to each alternative.

Table XII-1
Carryover Storage in Central Valley Reservoirs

73-Year Average (TAF)

Study	Shasta	Oroville	Folsom	New Melones
No Project	2,910	2,310	481	1,543
Bay/Delta Plan	2,893	2,195	445	1,286
Cumulative Impact	2,849	2,167	464	1,325
Change from:*				
No Project to Cumulative Impact	-61	-143	-17	-218
B/D Plan to Cumulative Impact	-44	-28	19	39

Critical Period Average (TAF)

Study	Shasta	Oroville	Folsom	New Melones
No Project	1,944	1,608	261	1,104
Bay/Delta Plan	1,893	1,469	182	620
Cumulative Impact	1,790	1,591	261	714
Change from*				
No Project to Cumulative Impact	-154	-17	0	-390
B/D Plan to Cumulative Impact	-103	122	79	94

* Negative value indicates a reduction in carryover storage

Generally, there is less carryover storage in the Cumulative Impact Assessment than in the No Project Alternative. This is true for the 73-year period average as well as the critical period average. Folsom shows a small decrease in carryover storage in the 73-year period and no difference in the critical period. The decrease at Lake Oroville is slight in the critical period.

In comparing the Cumulative Impact Assessment to the Bay/Delta Plan Alternative, there is less carryover storage during the 73-year period at Shasta Lake and Lake Oroville, while there is more carryover storage at Folsom and New Melones Reservoirs. There is less carryover storage in the critical period at Shasta Lake, and more carryover storage at Oroville, Folsom and New Melones Reservoirs.

c. **Transfer Capacity**. The capacity of the projects to accommodate water transfers principally depends on two factors: unused pumping capacity at the Banks and Tracy pumping plants and limits on exports in the 1995 Bay/Delta Plan. The method for determining transfer capacity is described in Chapter V, section D. For this evaluation, July through October is assumed to be the most likely period for water transfers to occur. This assumption is based on historical Delta operations, the objectives in the 1995 Bay/Delta Plan (which are more restrictive of exports from February through June), and the increased possibility of fishery impacts in other periods.

The total transfer capacity for the period July through October, as calculated for the Cumulative Impact Assessment and the No Project and Bay/Delta Plan alternatives, is shown in Figure XII-2. The total transfer capacity for this period is greater in the Cumulative Impact Assessment than in the No Project Alternative or the Bay/Delta Plan Alternative. This is true for the 72-year average (1922-1993) and the critical period average. This is because the Cumulative Impact Assessment allows for both combined use of two points of diversion by the SWP and CVP and full use of SWP pumping capacity. The long-term average does not include 1994 because the analysis uses the calendar period July-October, and October 1994 is part of water year 1995 (which is not included in the simulation studies).

Average monthly transfer capacity for July-October is shown in Table XII-2. For the 72-year average, monthly transfer capacity is greater in July and August in the Cumulative Impact Assessment than in the No Project Alternative or the Bay/Delta Plan Alternative and less in September. Transfer capacity in October is somewhat lower in the Cumulative Impact Assessment than in the No Project Alternative, but virtually the same as the Bay/Delta Plan Alternative.

For the critical period, monthly transfer capacity in the Cumulative Impact Assessment is greater in July and August than in the No Project Alternative or the Bay/Delta Plan Alternative, less in September than in the No Project Alternative, and greater in October than in the Bay/Delta Plan Alternative. There is no significant difference in average monthly transfer capacity between the Cumulative Impact Assessment and the Bay/Delta Plan Alternative in September or the No Project Alternative in October.

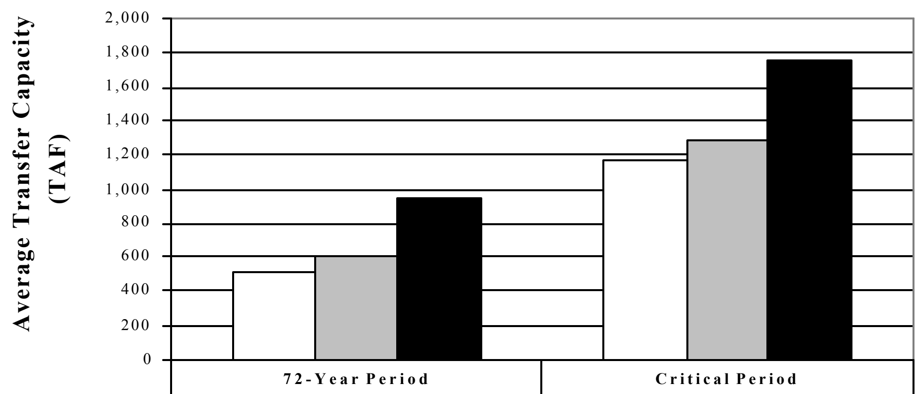
d. **Delta Outflow**. Delta outflow is one of the flow objectives included in the 1995 Bay/Delta Plan. The principal purpose of the flow objective is for protection of fish and wildlife. Table XII-3 shows the average monthly Delta outflow for the 73-year period and the critical period for each study.

For the 73-year period, Delta outflow in the Cumulative Impact Assessment is 8-10 percent less than the No Project Alternative in the months of June, November, December, and January, and 24 percent less in October; however, outflow is 10 percent higher in April and 6 percent higher in August. Delta outflow in the Cumulative Impact Assessment is 8-14 percent less than the Bay/Delta Plan Alternative between September and January and in June.

For the critical period, Delta outflow in the Cumulative Impact Assessment is significantly higher than the No Project Alternative in September and from February through July, particularly February-March and May-June. Outflow is significantly less than the No Project Alternative in August and from October through January. Delta outflow in the Cumulative Impact Assessment is 7-12 percent less than the Bay/Delta Plan Alternative in October, January, and June; however, outflow is 6 percent higher in August.

Figure XII-2

Transfer Capacity July through October



	72-Year Period	Critical Period
No Project	513	1,171
Bay/Delta Plan	612	1,286
Cumulative Impact	941	1,755

Critical Period is May 1928 through October 1934

Table XII-2

Transfer Capacity*, July - October (TAF)

72-year Average (1922-1993)

Study	Jul	Aug	Sep	Oct	Total
No Project	64	117	167	165	513
Bay/Delta Plan	149	221	118	124	612
Cumulative Impac	276	453	88	123	941

Critical Period (1928-1934)

Study	Jul	Aug	Sep	Oct	Total
No Project	108	341	358	364	1171
Bay/Delta Plan	338	404	270	268	1280
Cumulative Impac	539	591	253	372	1755

* Average monthly excess pumping capacity at Banks and Tracy pumping plants

Table XII-3
Delta Outflow

73-Year Period Average Monthly Flow (TAF)

Study	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Project	505	594	1,364	2,379	2,794	2,583	1,453	1,132	767	407	238	247
Bay/Delta Plan	449	628	1,346	2,345	2,846	2,636	1,636	1,142	789	411	249	278
Cumulative Impacts	385	547	1,232	2,150	2,783	2,571	1,603	1,122	706	410	253	242
Change from*												
No Project to Cumulative Impact	-120	-46	-132	-229	-10	-12	150	-10	-61	3	15	-5
B/D Plan to Cumulative Impact	-64	-81	-115	-194	-63	-65	-34	-20	-83	-1	4	-36

Critical Period Average Monthly Flow (TAF)

Study	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Project	351	182	369	652	475	499	487	295	252	244	298	158
Bay/Delta Plan	257	286	346	519	650	784	553	514	444	299	239	180
Cumulative Impacts	235	285	335	458	663	771	554	517	413	299	254	180
Change from*												
No Project to Cumulative Impact	-116	103	-34	-194	188	272	67	222	161	54	-44	22
B/D Plan to Cumulative Impact	-22	-1	-11	-61	13	-13	1	2	-31	0	15	0

* Negative value indicates a reduction in Delta outflow

For the critical period, Delta outflow in the Cumulative Impact Assessment is significantly higher than the No Project Alternative in September and from February through July, particularly February-March and May-June. Outflow is significantly less than the No Project Alternative in August and from October through January. Delta outflow in the Cumulative Impact Assessment is 7-12 percent less than the Bay/Delta Plan Alternative in October, January, and June; however, outflow is 6 percent higher in August.

e. **Fisheries**. Cumulative impacts to fisheries were assessed for the Delta and for the upstream rivers and reservoirs. To characterize impacts to Delta fisheries, effects on juvenile chinook salmon, steelhead, and striped bass were evaluated. To characterize impacts to aquatic habitat in upstream areas, the Range of Variability Analysis was used (Richter 1997). To characterize impacts to reservoir fisheries, estimated end-of-month storage was used to predict changes in habitat quality.

Chinook Salmon. The USFWS salmon smolt survival model, described in Chapter IV, was used to estimate juvenile chinook salmon survival through the Delta. Survival indices calculated for the Cumulative Impact Assessment were compared with the Bay/Delta Plan and No Project alternatives. For the Sacramento River, survival indices were predicted for fall-run, late fall-run, and winter-run smolts, and spring-run young-of-the-year and yearlings. For the San Joaquin River, indices were predicted for fall-run smolts, with and without the Old River Barrier operation.

Results of the model for the Sacramento River are shown in Figure XII-3. For all salmon runs, predicted survival indices for the Cumulative Impact Assessment were slightly lower than for the Bay-Delta Plan, but were higher than for the No Project Alternative. Differences between the No

Project and other alternatives result primarily from differences in the operation of the Delta Cross Channel gates. The gates are open more often under the No Project Alternative; smolt survival decreases if smolts are diverted off the mainstream of the river and into the central Delta. Differences between the Bay/Delta Plan and Cumulative Impact Assessment result from changes in flow and exports.

Results of the model for the San Joaquin River are shown in Figure XII-4. Predicted survival indices for all alternatives were lower without the Old River Barrier, but differences among the alternatives were similar with and without the barrier. Survival indices for the Cumulative Impact Assessment were slightly lower than for the Bay/Delta Plan, but were higher than for the No Project Alternative.

Steelhead. Changes in flow, Delta exports, and Delta Cross Channel gate closure have the potential to affect juvenile steelhead during the period of emigration through the Delta. Emigration occurs from December through May, with peak migration occurring from February through April (DWR and USBR 1999). The primary differences among the No Project, Bay/Delta Plan, and Cumulative Impacts Assessment that may affect juvenile steelhead include Delta exports and closure of the Delta Cross Channel gates.

In the February through April period, Delta exports are lower under the Bay/Delta Plan than under the No Project Alternative, but higher in the Cumulative Impacts Assessment than under the Plan. Due to these changes in exports, survival of juvenile steelhead may be higher under the Bay/Delta Plan compared to the No Project Alternative, but may be reduced under the Cumulative Impacts Assessment compared to the Bay/Delta Plan.

The increased closure of the Delta Cross Channel gates in the February through April period under the Bay/Delta Plan and Cumulative Impacts Assessment may improve survival of emigrating juvenile steelhead compared to the No Project Alternative.

Striped Bass. Changes in flow and Delta exports due to cumulative impacts will primarily affect the young-of-the-year striped bass lifestage. The effects of the No Project, Bay/Delta Plan, and Cumulative Impacts alternatives on young-of-the-year striped bass abundance were evaluated using a multiple regression relating total young-of-the-year striped bass abundance at 38 mm. to the mean April – July San Joaquin River flow past Jersey Point, $\log_{10}$ net Delta outflow, and total Delta exports (including CVP, SWP, Contra Costa Canal, and miscellaneous Delta diversions) (Lee Miller, DFG, personal communication). The regression is described in Chapter IV; regression calculations are shown in Volume 2, Appendix 5.

Figure XII-3
Sacramento River Salmon Survival Index

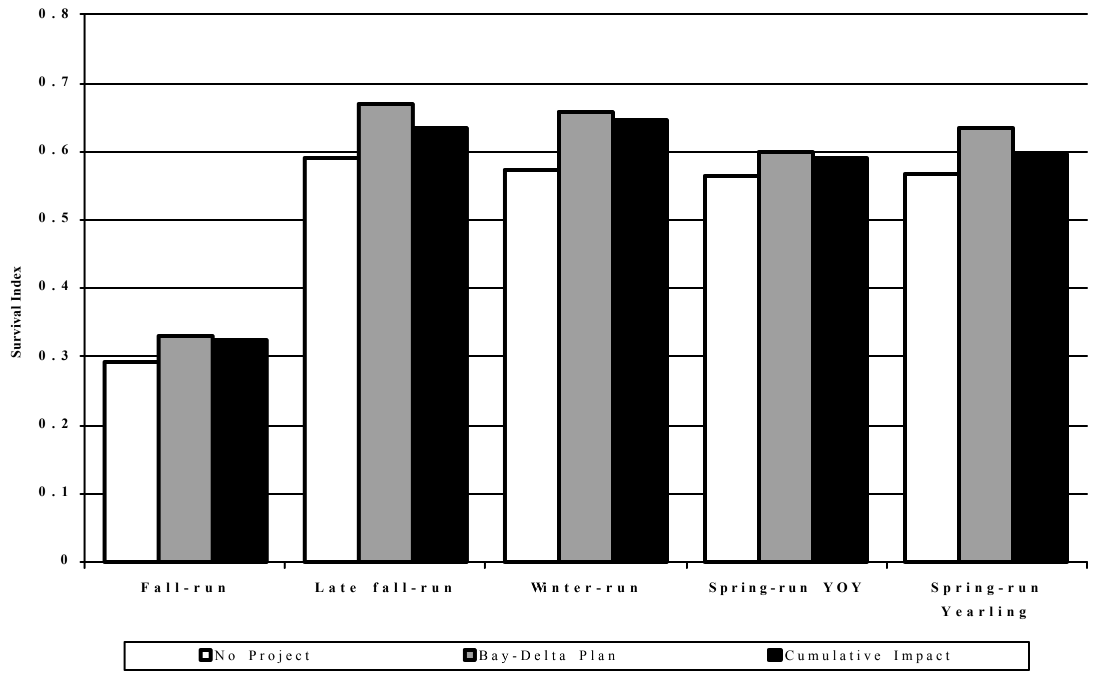


Figure XII-4
San Joaquin River Fall-run Salmon Smolt Survival Index

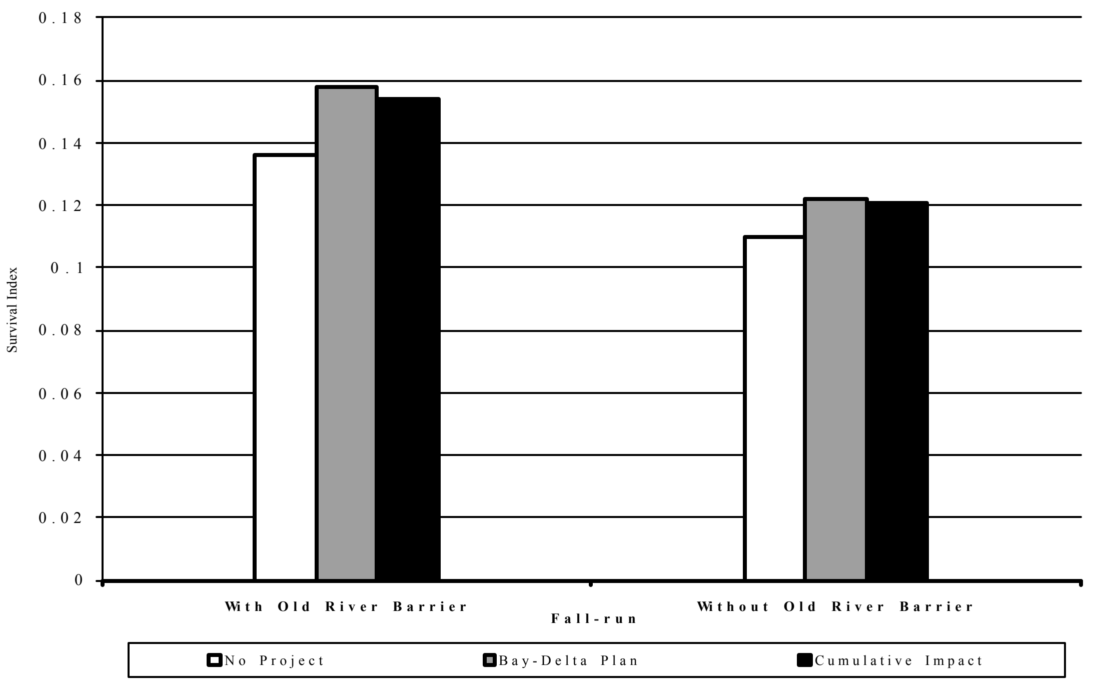
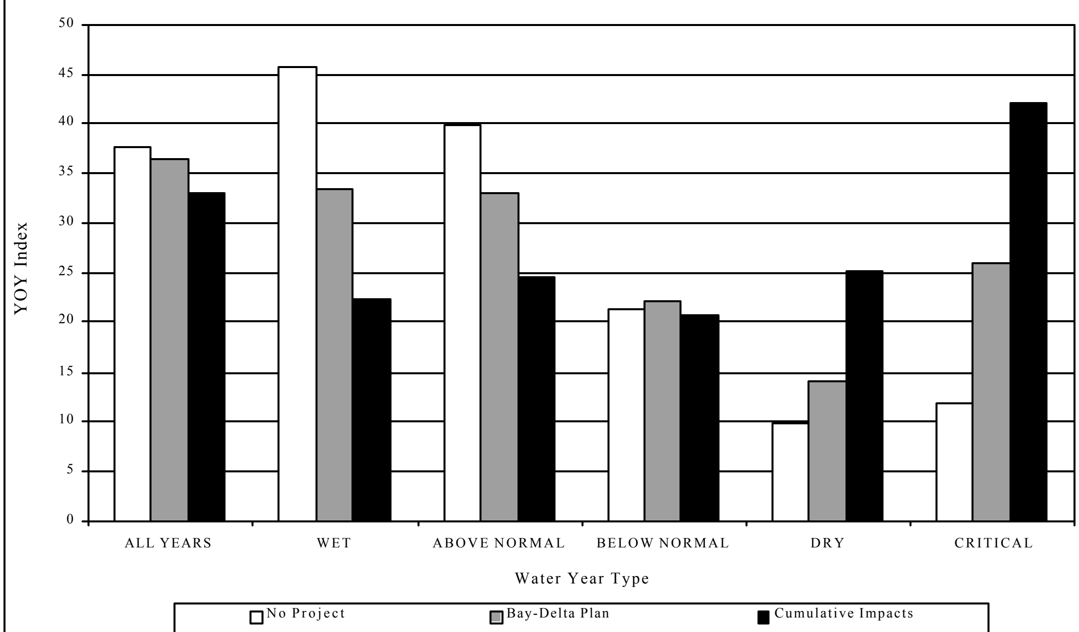


Figure XII-5 shows the predicted young-of-the-year index for the No Project, Bay/Delta Plan, and Cumulative Impacts alternatives, by water year type and all years combined. In wet and above normal water years, the predicted index was lower for the Bay/Delta Plan than for the No Project base case, and the index for Cumulative Impacts was lower than for the Bay/Delta Plan. In below normal water years, the predicted index for the three conditions were similar. In dry and critical water years, indices were lowest for the No Project condition, intermediate for the Bay/Delta Plan, and highest for the Cumulative Impacts condition. For all years combined, the predicted index for the Bay/Delta Plan was slightly lower than for the base case; the index for Cumulative Impacts was slightly lower than for the Bay/Delta Plan.

FIGURE XII-5
Predicted Striped Bass YOY Index Cumulative Impacts



The observed differences in the abundance indices are primarily due to changes in total Delta exports. Of the flow/export variables included in the regression, mean April – July total Delta exports had a dominant effect on the predicted abundance indices. Mean April – July total Delta exports predicted in DWRSIM for all scenarios were lower in dry and critical years than in other water year types. In these water years, exports in the Cumulative Impacts condition were also lower than for the No Project or Bay/Delta Plan conditions. Lower exports in these conditions resulted in higher predictions of young-of-the-year striped bass abundance.

The predicted changes in young-of-the-year abundance may result in lower recruitment to the adult striped bass population. Striped bass losses due to cumulative impacts could be mitigated through funding of additional stocking. The DFG is considering a stocking program for striped bass, but federal resource agencies have expressed concern regarding the effect of a stocking program on smelt and winter-run chinook salmon. These concerns are currently being addressed under the Section 10 permitting process of the ESA.

Upstream Aquatic Habitat. The Range of Variability Approach (RVA) developed by Richter et al (1997) was used to assess the cumulative impacts to upstream aquatic habitat compared to the No Project and Bay/Delta Plan alternatives. This approach, described in Chapter VI, is based on aquatic ecology theory concerning the critical role of hydrologic variability, and associated characteristics of duration and timing, in sustaining aquatic ecosystems.

The Range of Variability Analysis method was used to assess cumulative impacts at locations where estimates of unimpaired flow data were available on the mainstream Sacramento and San Joaquin rivers:

- Sacramento River near Red Bluff
- San Joaquin River at Vernalis

Since estimated unimpaired flows were available only on a monthly time step, a subset of the 32 hydrologic parameters recommended in the RVA analysis was calculated for the available period of record (1922 – 1993). Hydrologic parameters used in the analysis included the magnitude of monthly flows, the magnitude of annual extreme flow conditions, and the timing of annual extreme flow conditions.

Simulated flows for the period of record (1922 – 1993) for each of the alternatives (DWRSIM analysis) were compared with flow target ranges based on unimpaired flows to evaluate the relative suitability of the alternatives in meeting ecological objectives. For the flow simulations, locations from the DWRSIM analysis were selected that were closest to sites on each river where estimated unimpaired flow data were available. The rate of non-attainment of the flow management targets was calculated for each site and flow parameter.

Table XII-4 summarizes the Range of Variability Analysis for the Cumulative Impact Assessment, Bay/Delta Plan and No Project Alternatives at the two sites. Differences in the rate of non-attainment of the target ranges between these conditions are minor. Results of the Range of Variability Analysis Cumulative Impacts Cases where flow parameters showed a greater than 10 percent deviation in the non-attainment rate between the alternatives are described below.

Table XII-4

Results of the Range of Variability Analysis Cumulative Impacts

San Joaquin River at Vernalis

	Unimpaired Conditions (1922 - 93)						No Project					Bay/Delta Plan									
			Range Limits		RVA Target Range				Range Limits					Range Limits					Range Limits		
IHA Group 1	Mean	SD	Low	High	Low	High	Mean	SD	Low	High	Rate of Non-Attainment	Mean	SD	Low	High	Rate of Non-Attainment	Mean	SD	Low	High	Rate of Non-Attainment
Monthly Flow Magnitude (cfs)																					
October	903	990	147	6,940	147	1,893	3,153	2,566	1,457	12,688	44%	3,091	2,270	1,254	12,441	78%	3,108	2,292	1,252	12,445	76%
November	2,389	3,816	219	25,842	219	6,206	2,081	1,718	1,387	13,552	3%	1,993	1,697	1,183	13,552	3%	2,003	1,691	1,186	13,555	3%
December	4,570	6,526	277	35,973	277	11,095	2,947	3,631	1,331	21,495	6%	2,768	3,475	1,124	21,495	4%	2,785	3,471	1,125	21,502	4%
January	6,124	6,659	375	33,464	375	12,783	4,452	5,067	1,288	24,859	8%	4,183	4,877	1,088	24,860	8%	4,206	4,898	1,088	24,863	8%
February	9,234	8,104	433	41,685	1,130	17,338	6,930	7,373	1,404	36,536	8%	6,486	6,946	1,159	36,536	7%	6,492	6,958	1,163	36,538	7%
March	10,519	7,465	1,059	42,098	3,054	17,984	6,240	7,231	1,406	41,110	51%	6,140	7,015	1,202	41,110	49%	6,124	7,029	1,208	41,111	49%
April	15,561	6,986	3,434	43,300	8,575	22,547	5,496	5,043	1,529	27,032	88%	5,852	4,864	1,990	27,030	88%	5,844	4,871	1,990	27,031	88%
May	23,634	11,360	4,334	58,048	12,274	34,993	4,695	5,194	1,217	26,213	90%	5,441	4,900	1,871	26,139	90%	5,432	4,910	1,871	26,214	90%
June	18,505	12,626	1,279	63,838	5,879	31,131	3,756	5,465	1,030	36,445	82%	3,930	5,157	1,253	36,445	82%	3,920	5,204	1,246	36,448	82%
July	6,393	6,344	587	35,044	587	12,737	1,805	1,811	945	13,585	1%	2,029	1,707	1,133	13,585	1%	2,032	1,708	1,122	13,588	1%
August	1,636	1,750	179	11,909	179	3,387	1,363	198	992	1,730	0%	1,638	197	1,163	1,921	0%	1,643	195	1,188	1,923	0%
September	813	1,004	118	5,825	118	1,817	1,879	738	1,356	6,851	44%	1,842	710	1,160	6,498	43%	1,843	710	1,184	6,501	43%
IHA Group 2																					
Mean Annual Extremes (cfs)																					
Annual 30-day minimum	484	518	118	4,394	118	1,003	1,315	205	945	1,730	97%	1,449	232	1,088	1,921	100%	1,453	236	1,088	1,923	100%
Annual 30-day maximum	25,044	12,103	5,034	63,838	12,941	37,148	9,131	8,463	1,698	41,110	78%	8,798	8,185	1,990	41,110	81%	8,816	8,190	1,990	41,111	81%
IHA Group 3																					
Timing of Annual Extremes																					
Month of annual minimum	9	1	8	1	8	10	8	2	1	12	67%	8	4	1	12	85%	7	4	1	12	82%
Month of annual maximum	5	1	12	6	4	6	2	2	10	6	68%	5	3	1	12	54%	5	3	1	12	54%

Sacramento River near Red Bluff

	Unimpaired Conditions (1922 - 93)						No Project					Bay/Delta Plan					Cumulative Impacts				
			Range Limits		RVA Target Range				Range Limits					Range Limits					Range Limits		
IHA Group 1	Mean	SD	Low	High	Low	High	Mean	SD	Low	High	Rate of Non-Attainment	Mean	SD	Low	High	Rate of Non-Attainment	Mean	SD	Low	High	Rate of Non-Attainment
Monthly Flow Magnitude (cfs)																					
October	4,966	1,777	2,933	14,630	3,189	6,742	7,285	2,822	3,682	14,636	36%	7,353	2,902	3,682	14,221	36%	7,367	2,789	3,682	14,221	43%
November	7,711	5,372	3,300	35,471	3,300	13,083	8,916	5,602	3,721	41,079	13%	9,105	5,511	4,352	41,303	13%	8,963	5,429	3,754	40,429	13%
December	13,396	10,489	3,649	47,214	3,649	23,885	12,443	9,546	4,261	45,352	17%	12,473	9,717	4,224	45,352	18%	12,394	9,676	3,990	45,352	18%
January	17,837	13,990	3,861	73,900	3,861	31,826	15,381	13,827	4,733	78,039	11%	15,251	13,833	3,903	78,039	11%	15,215	13,802	3,905	78,039	11%
February	22,291	15,087	4,852	79,618	7,204	37,378	18,428	15,133	4,528	67,087	29%	18,501	14,804	4,582	66,086	25%	18,336	14,791	4,582	65,733	28%
March	19,883	11,768	4,659	76,197	8,114	31,651	15,455	13,149	4,037	68,665	44%	15,581	12,966	4,555	68,665	39%	15,355	13,036	4,775	68,665	43%
April	16,423	8,718	4,293	40,438	7,705	25,141	11,542	7,317	5,292	42,993	38%	11,554	7,320	4,880	42,993	35%	11,559	7,316	5,048	42,993	36%
May	10,988	4,487	3,959	24,927	6,500	15,475	10,719	3,256	6,178	20,157	15%	10,533	3,202	6,031	20,157	10%	10,474	3,214	6,031	20,157	10%
June	7,267	2,479	3,603	14,360	3,603	9,745	10,949	1,822	6,788	16,681	82%	12,057	2,246	7,157	17,593	86%	11,059	1,771	7,281	16,681	81%
July	4,873	1,029	3,030	7,739	3,843	5,902	12,794	2,082	6,837	16,145	100%	12,213	1,738	7,544	15,329	100%	12,710	1,931	7,544	16,524	100%
August	4,162	746	2,867	5,898	3,416	4,908	10,551	1,384	6,812	13,406	100%	9,823	1,495	6,227	13,406	100%	10,044	1,659	6,301	13,406	100%
September	4,342	816	2,811	5,993	3,526	5,158	6,269	2,157	4,099	13,905	65%	6,306	2,393	4,057	13,905	57%	7,265	1,849	5,630	13,905	100%
IHA Group 2																					
Mean Annual Extremes (cfs)																					
Annual 30-day minimum	4,029	703	2,811	5,898	3,326	4,732	5,420	1,427	3,682	12,290	75%	5,438	1,589	3,682	12,290	68%	6,061	1,534	3,682	12,290	82%
Annual 30-day maximum	30,007	16,299	5,507	79,618	13,709	46,306	26,230	16,781	9,424	78,039	43%	26,097	16,701	8,859	78,039	33%	25,932	16,703	8,377	78,039	38%
IHA Group 3																					
Timing of Annual Extremes																					
Month of annual minimum	9	1	7	11	8	10	10	1	8	3	19%	9	2	1	12	13%	9	3	1	12	31%
Month of annual maximum	2	1	11	5	1	3	3	3	10	8	42%	4	3	1	12	40%	5	3	1	12	46%

For the Sacramento River, no differences occurred in any of the flow parameters between the Cumulative Impact Assessment, the Bay/Delta Plan, and No Project alternatives, except for the timing of the annual minimum flow. Under the Bay-Delta Plan and No Project alternatives, the timing of the annual minimum flow was more similar to unimpaired conditions than in the Cumulative Impact Assessment.

For the San Joaquin River, no differences occurred in any of the flow parameters between the Cumulative Impact and Bay/Delta Plan alternatives. These alternatives differed slightly from the No Project alternative; in some cases, these alternatives were more similar to unimpaired flow conditions and in some cases, they resulted in a shift away from unimpaired conditions.

In October, monthly flow magnitudes under the Bay/Delta Plan and Cumulative Impacts alternatives resulted in a shift away from unimpaired conditions compared to the No Project alternative. The timing of the annual 30-day minimum flow under the Bay/Delta Plan and Cumulative Impacts alternatives also resulted in a shift away from unimpaired conditions compared to the No Project alternative. The timing of the annual 30-day maximum flow under the Bay/Delta Plan and Cumulative Impacts alternatives resulted in a shift toward unimpaired conditions.

Reservoir Fisheries. To assess the cumulative impacts to upstream reservoir fisheries, DWRSIM modeling of end-of-month surface elevations for four of the SWP and CVP reservoirs was used to calculate the relative potential quality of reservoir fishery habitat. The method of analysis, described in more detail in Chapter VI, provides a basis for comparison of the effects of reservoir operation under the various alternatives being studied.

Survival of fry and juveniles is higher with stable and maximum reservoir pool levels, because they rear primarily in nearshore, shallow areas. Two critical factors influence spawning and rearing habitat conditions: (1) starting elevation, and (2) change in reservoir elevation during the spawning season. In this analysis, each month is scored by: (1) the water surface elevation relative to maximum pool at the beginning of the month; and (2) the change in elevation during that month. These two scores are summed for the months of concern, March through September. The summed scores are then multiplied together to arrive at a reservoir habitat index value. The analysis assumes that the higher the index, the greater the quantity and quality of habitat.

The following CVP and SWP reservoirs were included in this analysis: Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir. Other reservoirs were unaffected by the modeling. The analysis characterizes reservoir operations under the No Project and Bay/Delta Plan alternatives and the Cumulative Impact Assessment, for the 73-year period and the critical period, and indicates the potential impacts to warmwater aquatic species. The results of the analysis of reservoir habitat conditions are shown in Table XII-5.

Table XII-5
Reservoir Habitat Index

73-Year Average

Study	Shasta	Oroville	Folsom	New Melones
No Project	459	388	438	298
Bay/Delta Plan	460	385	426	258
Cumulative Impact	458	384	428	266

Critical Period Average

Study	Shasta	Oroville	Folsom	New Melones
No Project	202	184	250	219
Bay/Delta Plan	202	191	213	186
Cumulative Impact	197	204	228	190

For the 73-year period, the index values for the Cumulative Impact Assessment are lower at Folsom and New Melones than under the No Project Alternative, with little or no difference at the other reservoirs. The index values for the Cumulative Impact Assessment are slightly higher at New Melones than under the Bay/Delta Plan Alternative, with little or no difference at the other reservoirs.

For the critical period, the index values for the Cumulative Impact Assessment are somewhat lower at Folsom and New Melones than under the No Project Alternative, and less so at Shasta; however, they are higher at Oroville. The index values for the Cumulative Impact Assessment are slightly lower at Shasta than under the Bay/Delta Plan Alternative, but they are somewhat higher at Oroville, Folsom, and New Melones.

Overall, the results indicate that under the cumulative impact conditions, there may be significant effects on some CVP reservoirs, but these effects are caused by implementation of the Bay/Delta Plan alone -- not the additional projects included in the Cumulative Impact Assessment. As described in Chapter VI, these impacts are generally temporary and mitigable. If significant effects on reservoir fish populations are observed, mitigation could include additional fish planting, habitat improvement through planting vegetation, or addition of habitat structures.

f. **Salinity**. Two analysis methods were used to assess the cumulative impacts on salinity in the Bay/Delta Estuary. In each analysis, the results of the Cumulative Impact Assessment are compared to the No Project and Bay/Delta Plan alternatives. In the first analysis, the X2 (2 ppt isohaline) position is compared, and in the second, electrical conductivity (EC) is compared at several stations throughout the Delta.

X2. The 1995 Bay/Delta Plan includes objectives pertaining to the location of X2 within the Bay/Delta Estuary. DWRSIM was used to determine the position of X2 for each of the flow alternatives and for the Cumulative Impact Assessment. For this analysis, the position of X2 as predicted for the Cumulative Impact Assessment is compared to the position under the No Project and Bay/Delta Plan alternatives.

Table XII-6 shows monthly average X2 positions for the 73-year period and the critical period. The table also shows the change in position when comparing the Cumulative Impact Assessment to each alternative. Positive changes indicate westward movement of the X2 line, which is desirable for aquatic species in the Estuary; negative changes indicate a shift toward the Delta.

Table XII-6
Computed Isohaline (X2) Position*

73-Year Period Average Monthly X2 Position (km)

Study	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Project	83.0	82.4	77.2	70.4	66.4	66.1	70.8	73.3	76.6	80.9	85.7	88.1
Bay/Delta Plan	83.8	81.3	77.0	70.9	65.3	64.7	67.8	71.4	74.1	79.4	84.7	86.6
Cumulative Impact	84.8	82.6	78.4	72.5	66.0	65.2	68.0	71.5	75.3	79.8	84.7	87.1
Change												
No Project - Cum. Impact	-1.8	-0.2	-1.2	-2.1	0.4	0.9	2.8	1.8	1.3	1.1	1.0	1.0
B/D Plan - Cum. Impact	-1.0	-1.2	-1.4	-1.6	-0.8	-0.5	-0.3	-0.1	-1.2	-0.4	0.0	-0.5

Critical Period Average Monthly X2 Position (km)

Study	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Project	85.4	88.8	84.9	79.1	79.8	82.6	81.1	83.5	85.9	87.3	85.9	90.0
Bay/Delta Plan	87.8	86.2	84.7	81.1	77.3	76.0	77.2	78.1	79.6	83.5	86.4	89.1
Cumulative Impact	88.4	86.3	84.8	81.8	77.5	76.1	77.3	78.1	80.1	83.7	85.9	89.0
Change												
No Project - Cum. Impact	-3.0	2.6	0.2	-2.8	2.4	6.5	3.9	5.4	5.8	3.6	-0.1	1.0
B/D Plan - Cum. Impact	-0.6	0.0	-0.1	-0.8	-0.1	-0.2	0.0	0.0	-0.6	-0.2	0.4	0.1

* X2 position is stated as the number of kilometers upstream from the Golden Gate Bridge

For the 73-year period, the X2 position in the Cumulative Impact Assessment is downstream of the No Project Alternative position from February through September, with the greatest change occurring in April (+2.8 km). The X2 position is upstream from October through January, with the greatest change occurring in January (-2.1 km). The X2 position in the Cumulative Impact Assessment is upstream of the Bay/Delta Plan Alternative position in all months but August (no change), with the greatest change occurring in January (-1.6 km).

For the critical period, the X2 position in the Cumulative Impact Assessment is downstream of the No Project Alternative position from February through July and in September, November, and December, with the greatest change occurring in March (+6.5 km). The X2 position is upstream in October, January, and August, with the greatest change occurring in October (-3.0 km). The X2 position in the Cumulative Impact Assessment is slightly upstream of the Bay/Delta Plan Alternative position in all months but August and September, with the greatest change occurring in January (-0.8 km).

The placement of the X2 isohaline for the Cumulative Impact Assessment downstream from the corresponding X2 position for the No Project Alternative in February through June is a positive result.

EC Within the Delta. This analysis compares the salinity or chloride levels at various locations as predicted using DWRDSM (discussed in Chapter IV) for the Cumulative Impact Assessment and the No Project and Bay/Delta Plan alternatives. Figures XII-6 through XII-51 show expected EC or chloride levels at the following locations: Contra Costa Canal at Pumping Plant No. 1/Rock Slough; Sacramento River at Emmaton; San Joaquin River at Jersey Point; San Joaquin River at San Andreas Landing; South Fork of the Mokelumne River at Terminous; San Joaquin River at Prisoners Point; San Joaquin River at Vernalis; San Joaquin River at Brandt Bridge site; Old River near Tracy Road Bridge; and Old River near Middle River. Salinity output are end-of-month values resulting from monthly average flow inputs for water years 1976 through 1991. Chloride levels are reported at the Contra Costa Canal intake; the other locations are reported as EC.

Where possible, water quality objectives for each station have been noted on the figures. EC objectives for the four stations in the southern Delta are the same for all year types, while EC objectives at other stations change based on the year type. The water quality objectives for the western and interior Delta monitoring locations are dependent on Sacramento River water-year classification. The first figure for each station shows the average EC (or chloride concentration) for wet years during the 16-year period, followed by above normal, below normal, dry, and critically dry years. Year types follow the Sacramento Valley “40-30-30” and San Joaquin Valley “60-20-20” hydrologic classification conventions in the 1995 Plan (see Figures II-1 and II-2). Below normal years under the San Joaquin 60-20-20 hydrologic classification do not occur during the model study period (1976 – 1991). Consequently below normal year types are omitted for southern Delta stations.

The results for the western and central Delta are very similar to the results for the salinity modeling described in Chapter VI. Salinity and chloride levels at these locations are generally higher in December and January than for the No Project or Bay/Delta Plan alternatives, and chloride objectives are significantly exceeded at the Contra Costa Pumping Plant. As described in Chapter VI, this is the result of differences in the DWRSIM and DWRDSM models. In real operation, the SWP and the CVP would have to release carriage water, if necessary to avoid violations of the objectives, in order to maintain their operations. Such releases would reduce the chloride and EC levels throughout the western and central Delta. In general, the Cumulative Impact Assessment shows improved or similar chloride and EC levels in other months. Therefore, because of the assumption that carriage water will be released if necessary, there should not be any significant negative impact on EC or chloride levels associated with the cumulative impact conditions.

In the southern Delta, the EC effects observed are due principally to the difference in objectives between the Bay/Delta Plan and the No Project Alternative and to the operation of the barriers in the ISDP. The Bay/Delta Plan has Vernalis EC objectives of 0.7 mmhos/cm from April through August and 1.0 mmhos/cm from September through March; the No Project Alternative has a requirement for New Melones Reservoir to maintain a TDS of 500 ppm at Vernalis. Operation of the ISDP reduces EC levels principally at the Old River locations from April through November. The improved EC conditions in the southern Delta under the cumulative impact conditions during the principal irrigation season provide a benefit to agricultural uses.

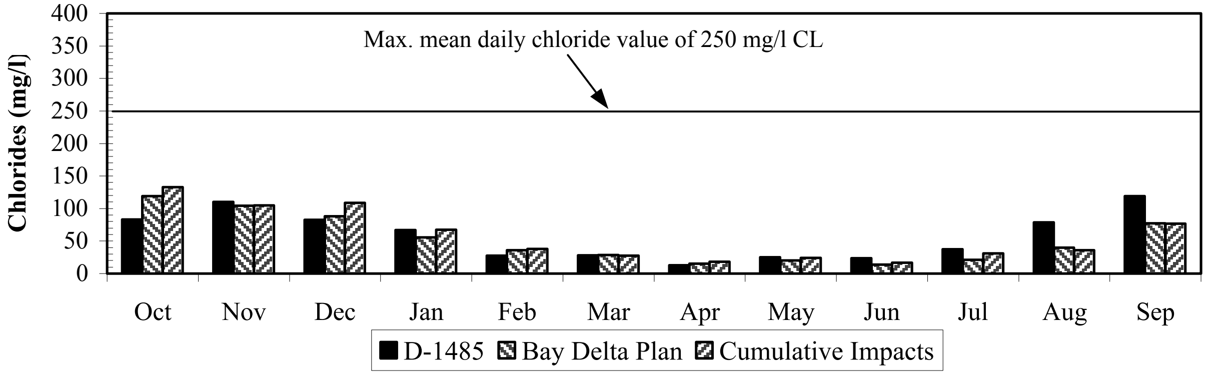
g. Water Temperature. The minor changes in Delta outflow in the Cumulative Impact Assessment are unlikely to result in significant changes in water temperature in the Delta. In upstream areas, the minor differences in streamflow releases under the Cumulative Impact Assessment are also unlikely to result in substantial changes in temperature in these areas.

B. MITIGATION MEASURES

The impacts of implementing the Bay/Delta Plan objectives are discussed in the preceding chapters. Mitigation measures for significant adverse impacts are included in Chapters VI through X. Unless specifically noted otherwise, the mitigation measures identified in these chapters are unlikely to reduce the identified impacts to less than significant levels. The flow objectives contained in the Bay/Delta Plan increase the protection provided to fish and wildlife uses of the Estuary while maintaining existing water quality protection for other uses of water. The higher level of protection for the fish and wildlife beneficial uses of water from the Estuary may result in curtailment of inbasin diversions and will result in decreased water availability in export areas, and changes in reservoir levels and river flows in upstream areas. Consequently, mitigation measures beyond those previously identified likely will focus on actions that encourage the efficient use of available water supplies or provide flexibility in the operation of existing water projects. The following section discusses the general actions that may be taken by water right holders and water users in response to the reductions in water supply. These actions include conservation, ground water management (conjunctive use), water transfers, reclamation, combined use of points of diversion, offstream storage projects, and the ISDP.

The SWRCB is not proposing to initiate any of these measures as a part of implementing the 1995 Bay/Delta Plan. Rather, these measures are among the actions that others might take as a means of offsetting a reduction in water supply that may result from the curtailment of surface water diversions. Some of these measures may have potential to result in significant environmental impacts associated with their implementation. The following discussion does not include an analysis of those impacts.

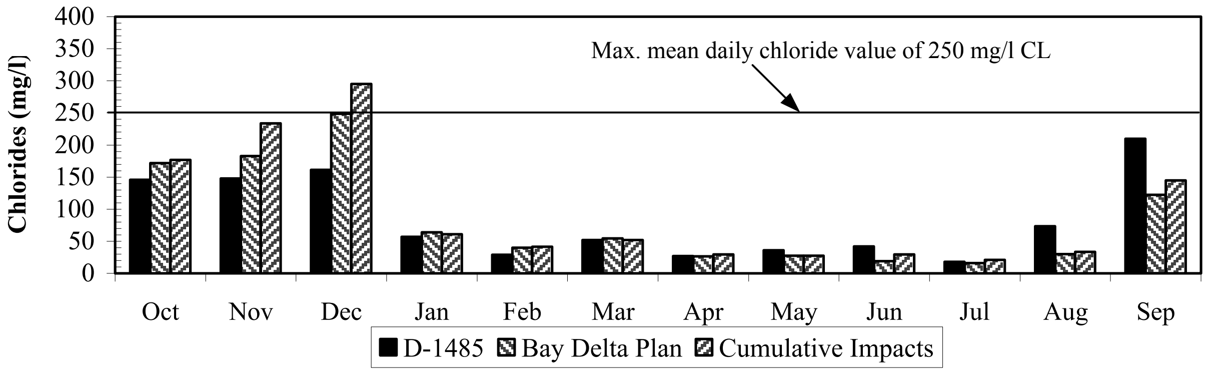
Figure XII-6
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Wet Years



For a Wet water year; 240 (66%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

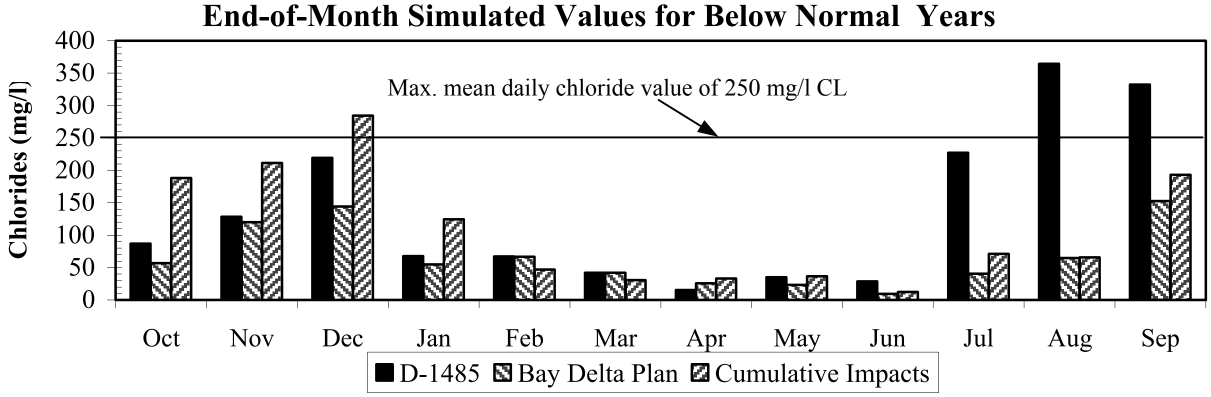
Figure XII-7
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Above Normal Years



For a Above Normal water year; 190 (52%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

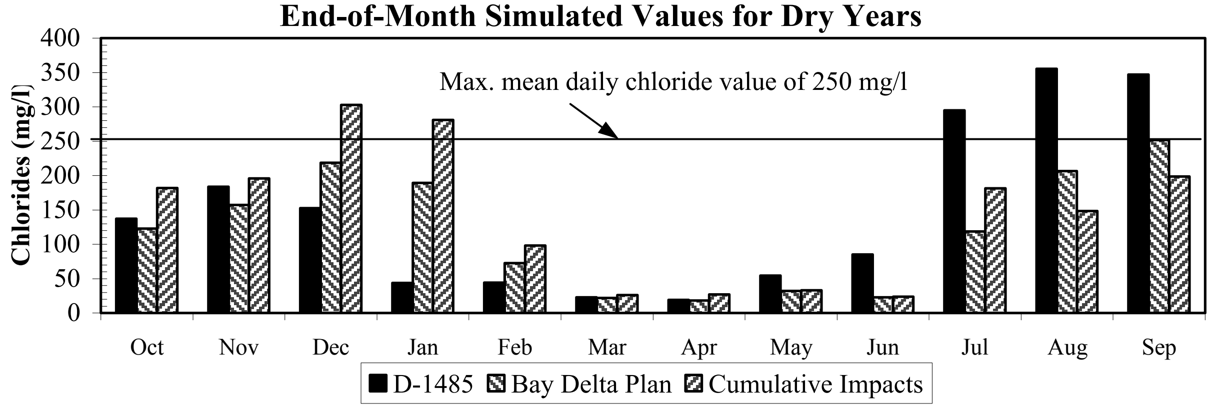
Figure XII-8
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Below Normal Years



For a Below Normal water year; 175 (48%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **below normal** year (1979)

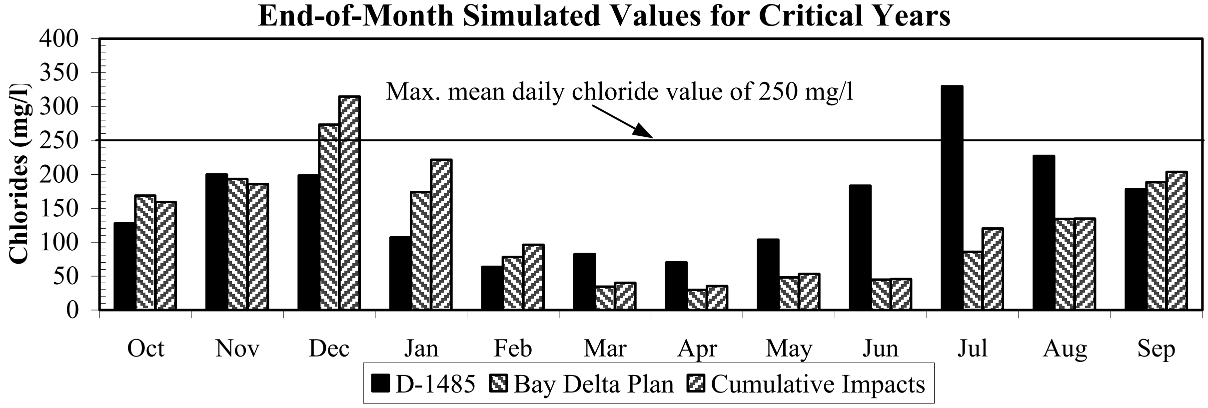
Figure XII-9
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Dry Years



For a Dry water year; 165 (45%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

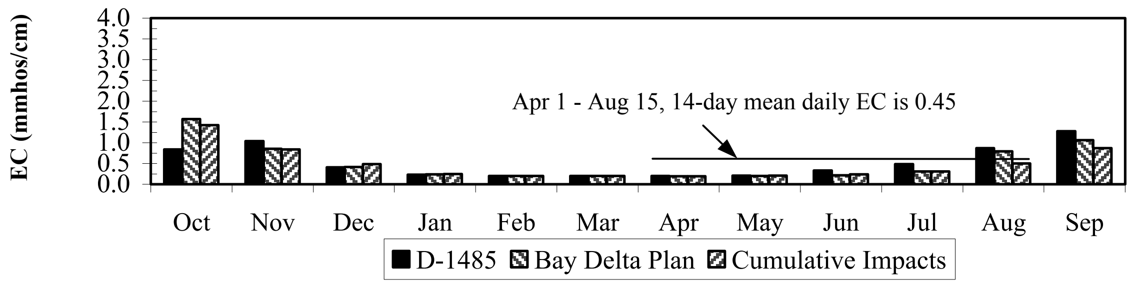
Figure XII-10
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Critical Years



For a Critical water year; 155 (42%) days <= 150 mg/l
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

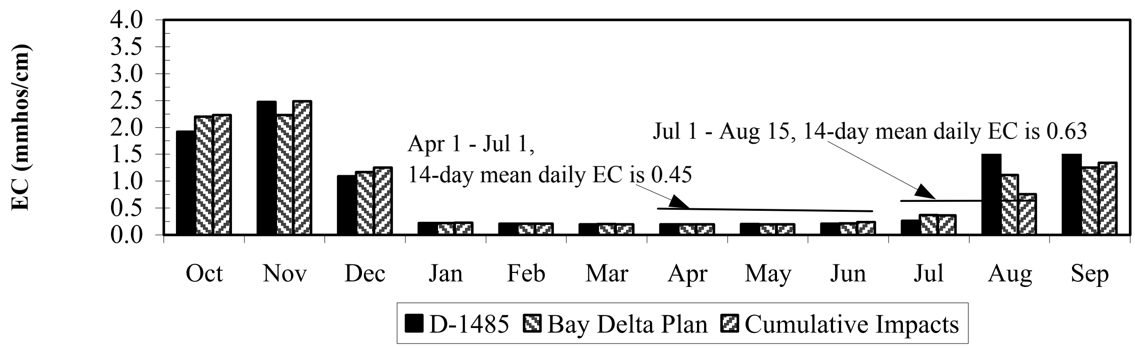
Figure XII-11
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Wet Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

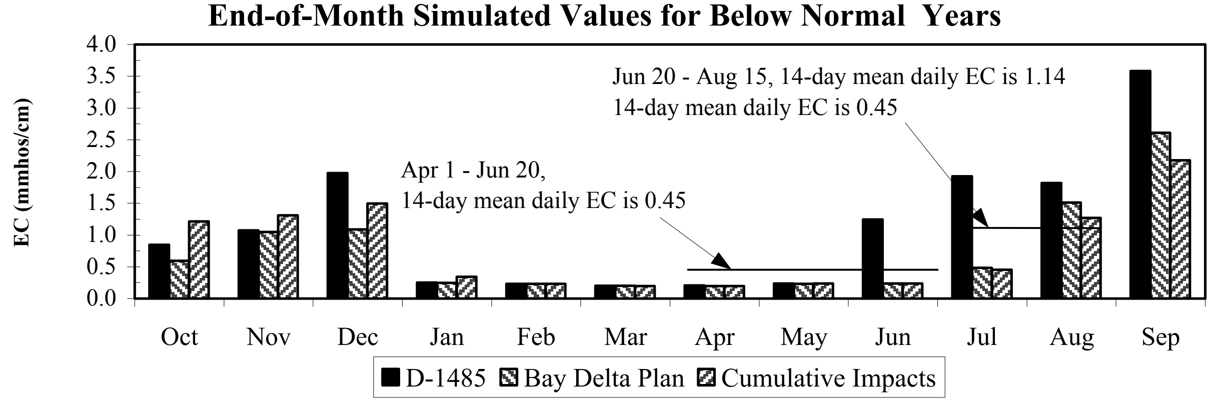
Figure XII-12
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Above Normal Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

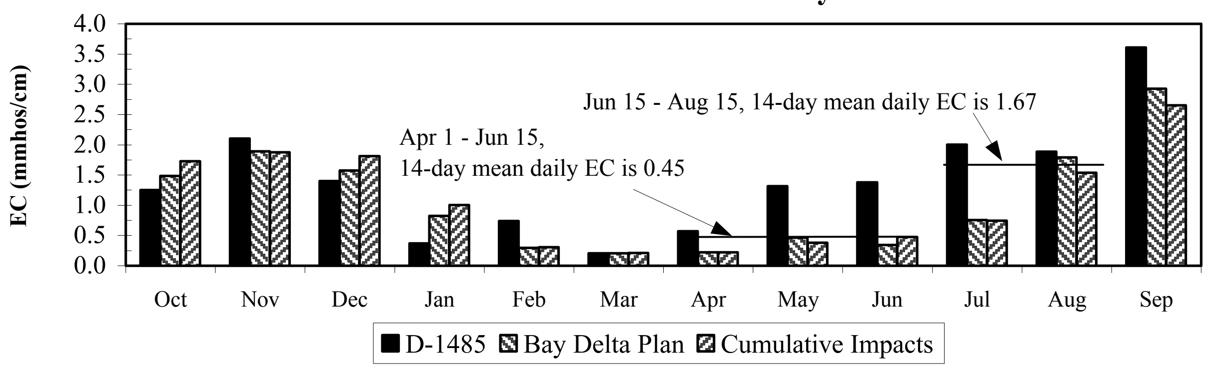
Figure XII-13
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Below Normal Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **below normal** year (1979)

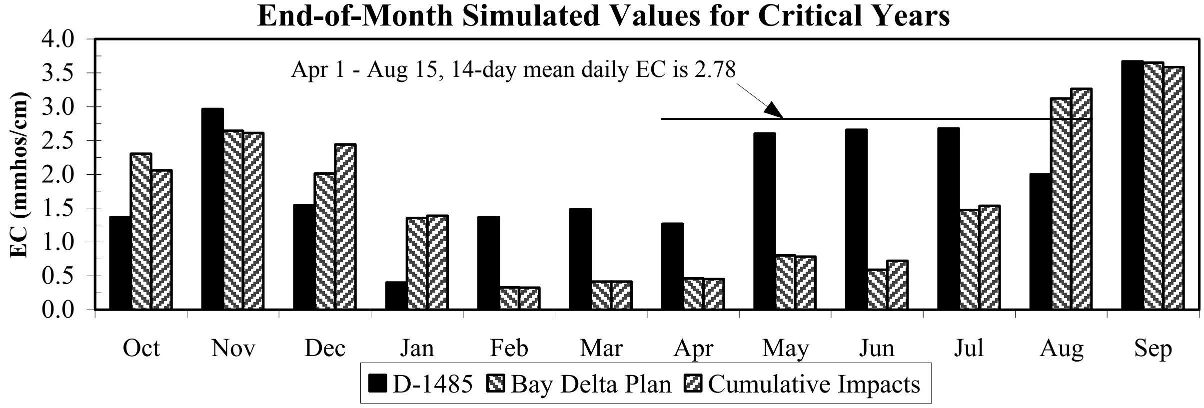
Figure XII-14
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Dry Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

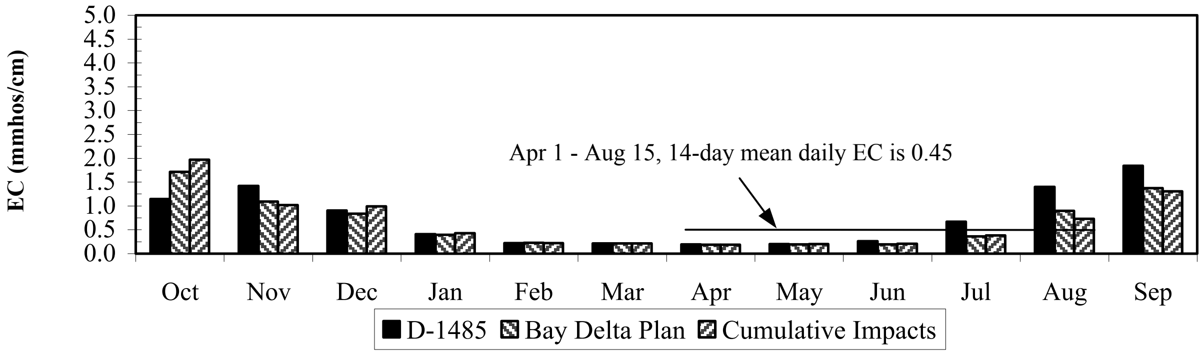
Figure XII-15
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Critical Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

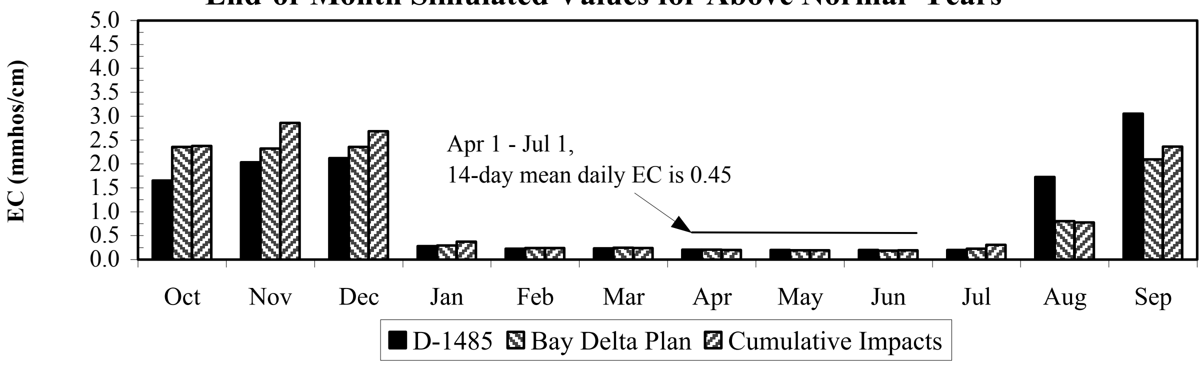
Figure XII-16
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Wet Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

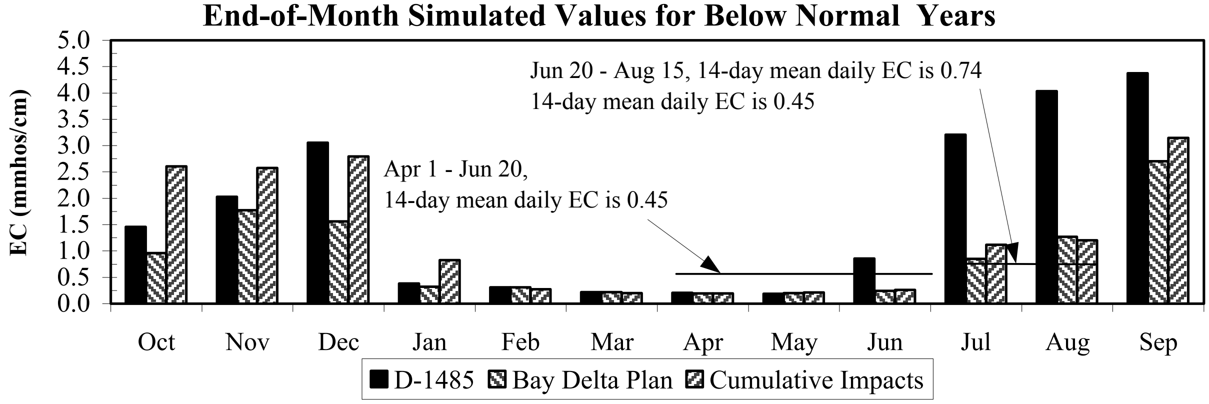
Figure XII-17
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Above Normal Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

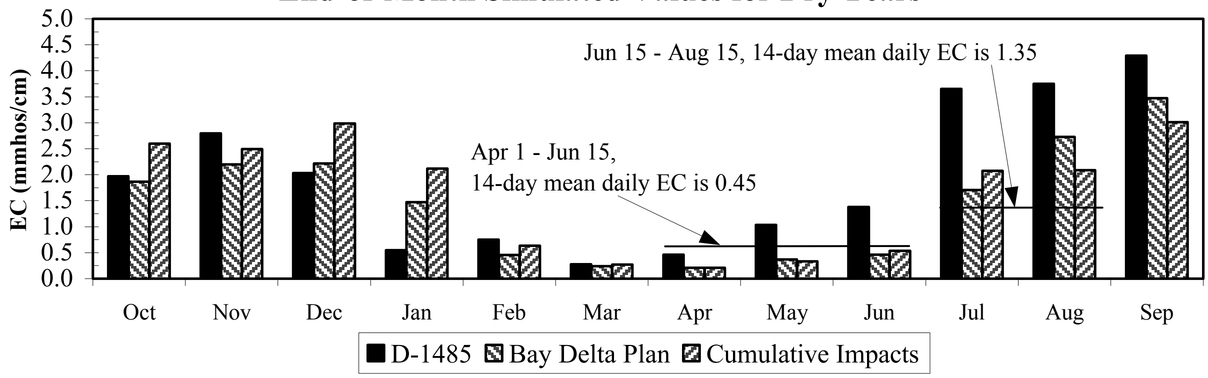
Figure XII-18
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Below Normal Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **below normal** year (1979)

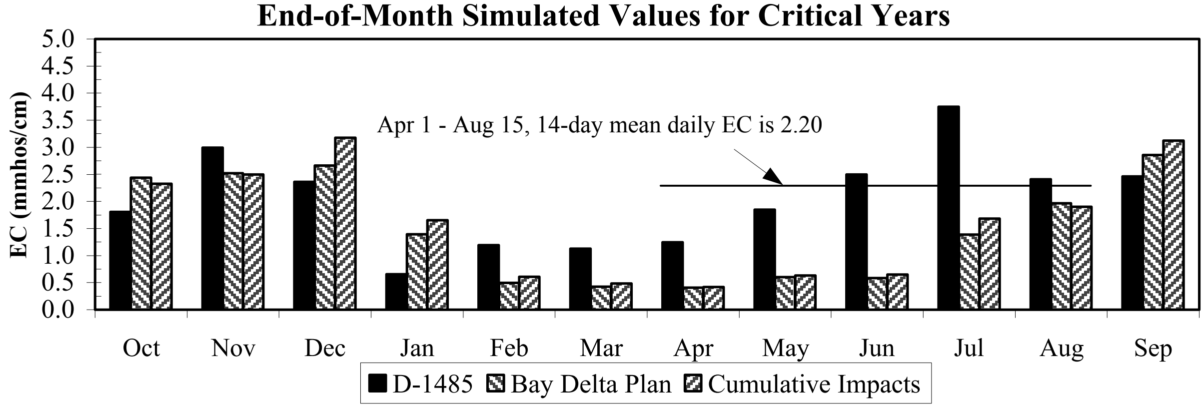
Figure XII-19
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Dry Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

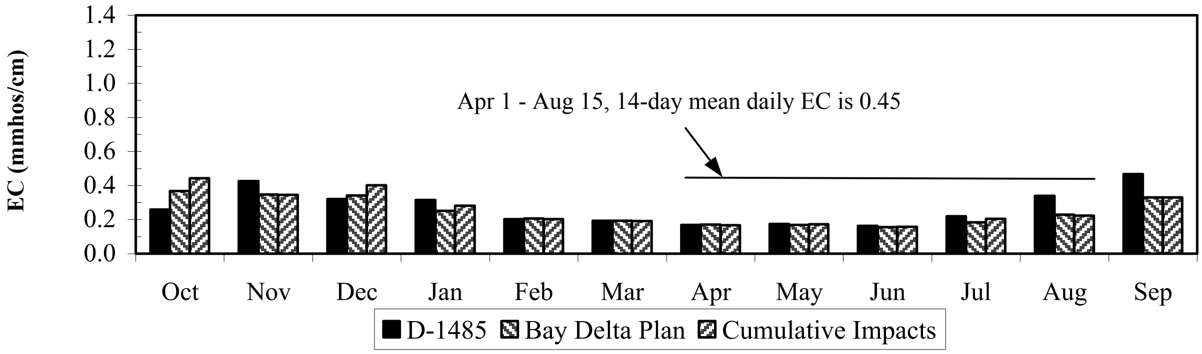
Figure XII-20
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Critical Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

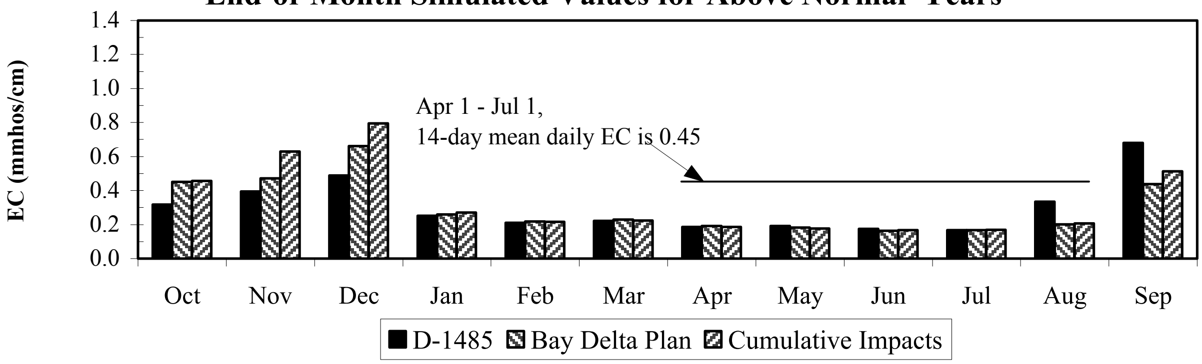
Figure XII-21
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Wet Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

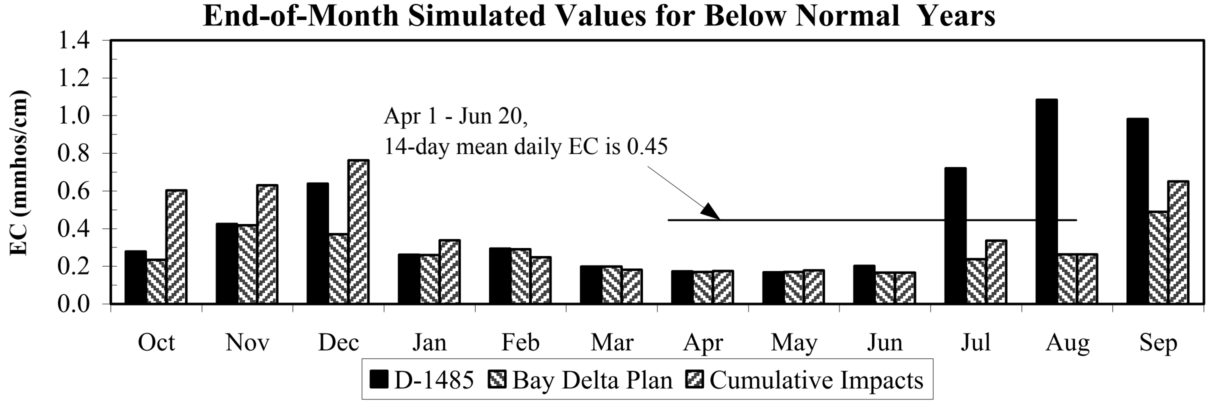
Figure XII-22
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Above Normal Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

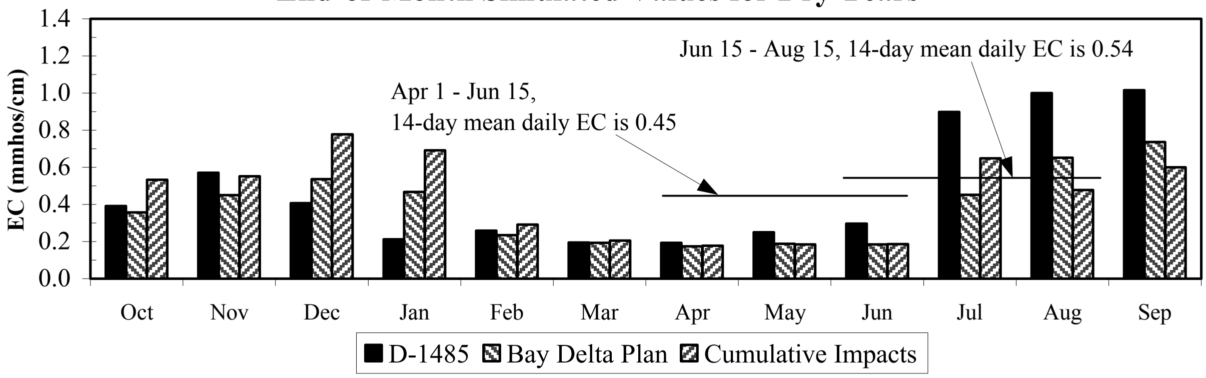
Figure XII-23
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Below Normal Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **below normal** year (1979)

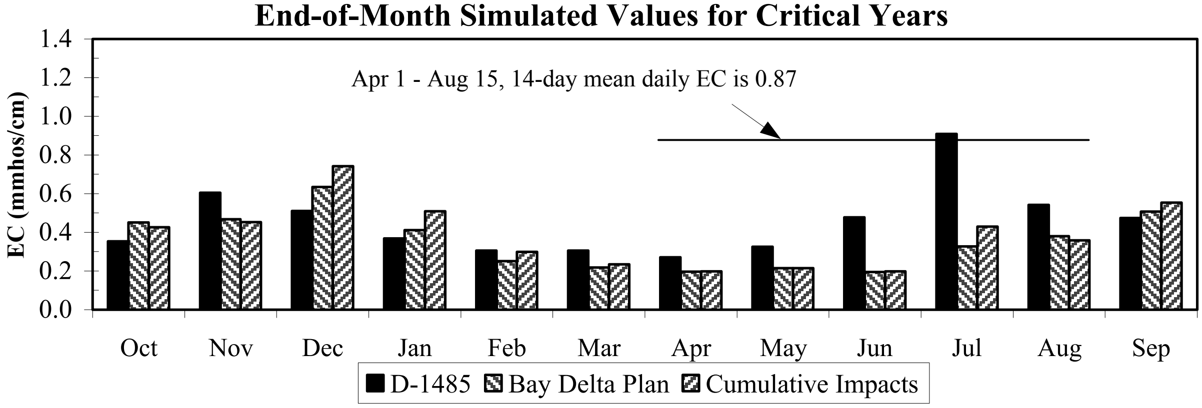
Figure XII-24
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Dry Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

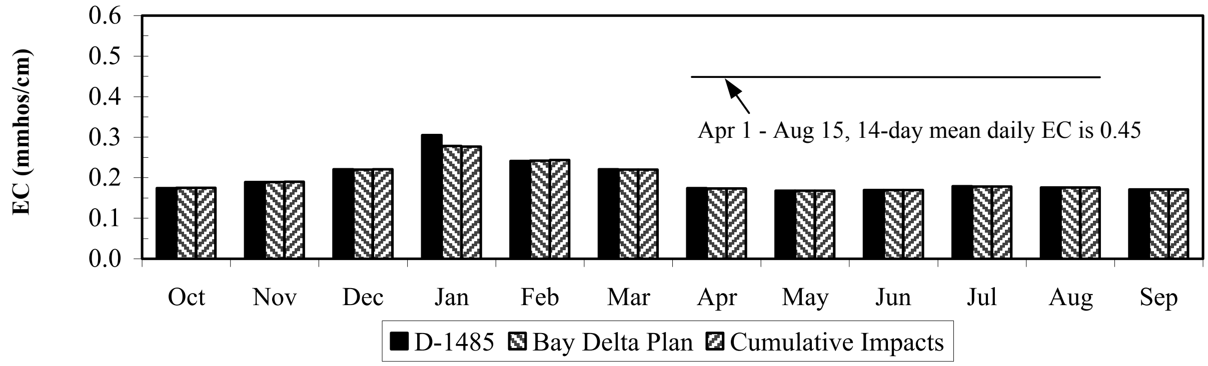
Figure XII-25
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Critical Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

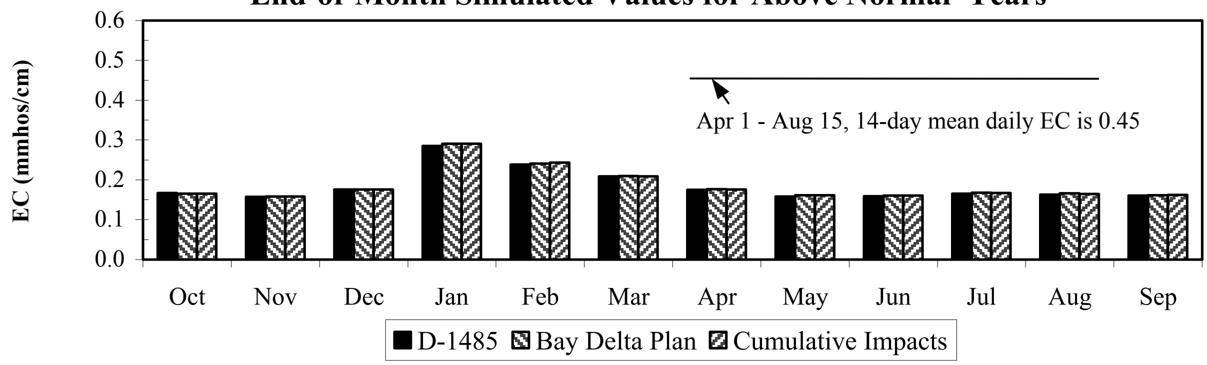
Figure XII-26
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Wet Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

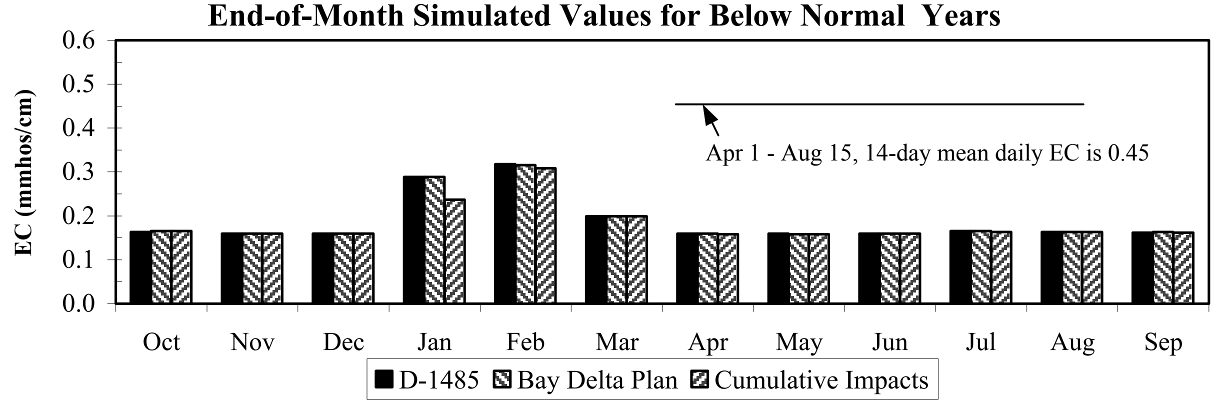
Figure XII-27
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Above Normal Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

Figure XII-28
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Below Normal Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **below normal** year (1979)

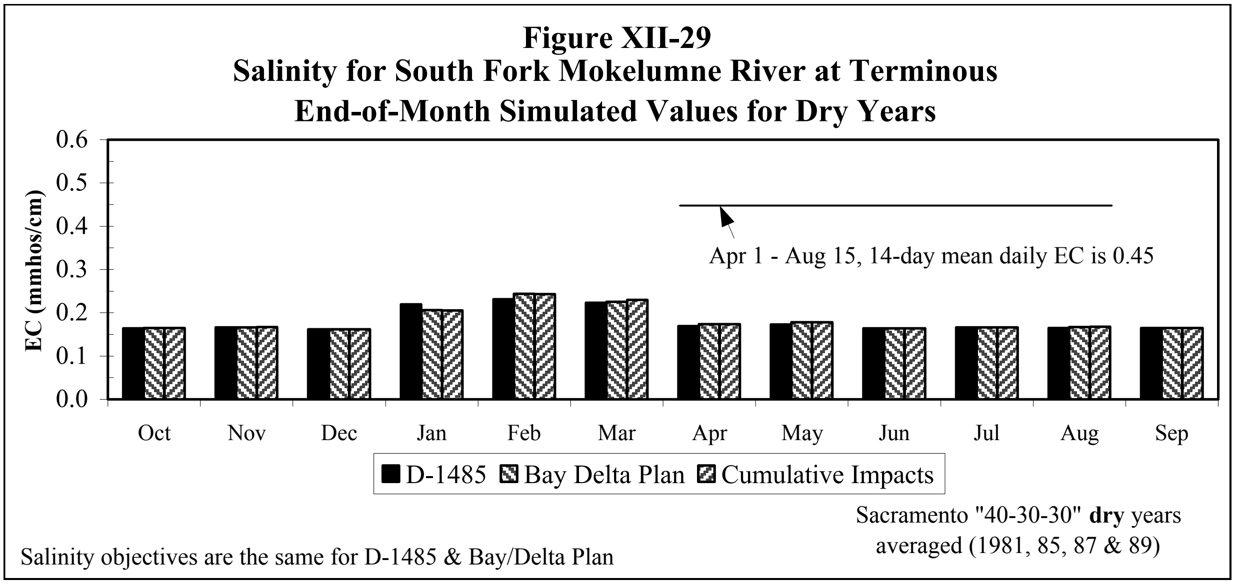


Figure XII-29
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Dry Years
EC (mmhos/cm)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Apr 1 - Aug 15, 14-day mean daily EC is 0.45
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
D-1485
Bay Delta Plan
Cumulative Impacts
Sacramento "40-30-30" dry years averaged (1981, 85, 87 & 89)
Salinity objectives are the same for D-1485 & Bay/Delta Plan

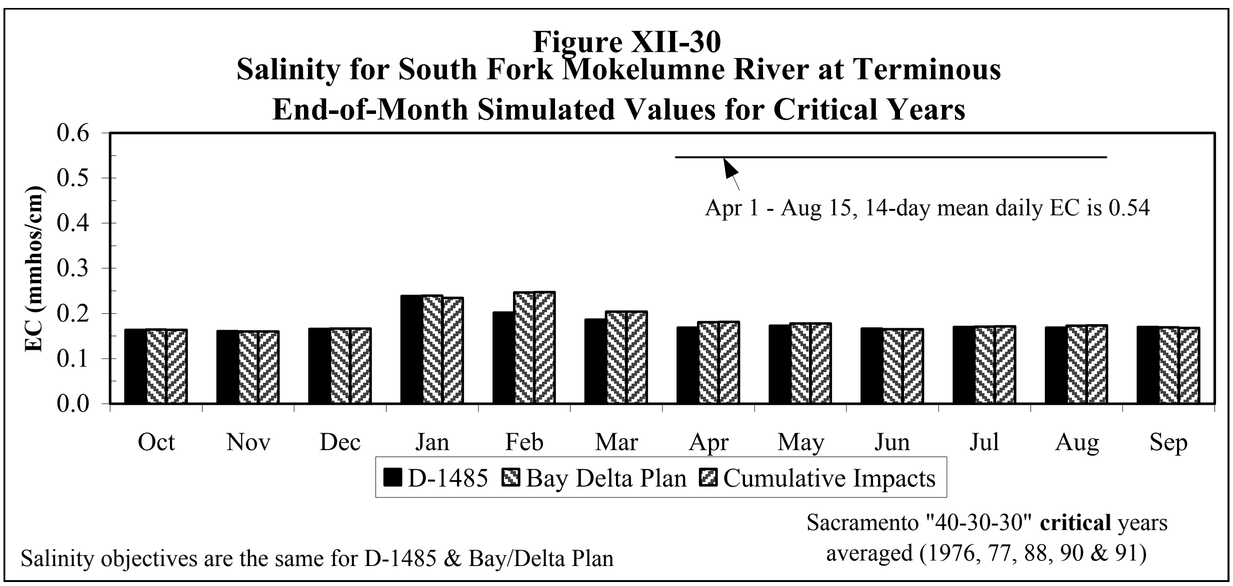
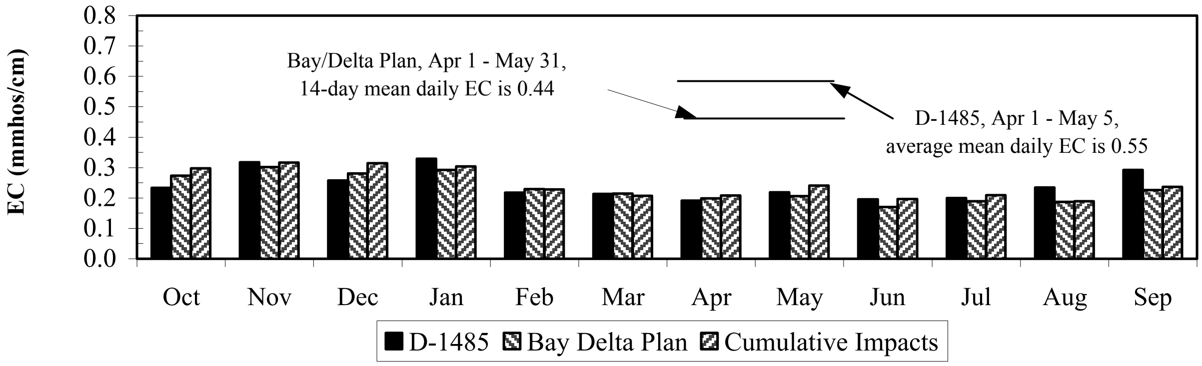


Figure XII-30
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Critical Years
EC (mmhos/cm)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Apr 1 - Aug 15, 14-day mean daily EC is 0.54
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
D-1485
Bay Delta Plan
Cumulative Impacts
Sacramento "40-30-30" critical years averaged (1976, 77, 88, 90 & 91)
Salinity objectives are the same for D-1485 & Bay/Delta Plan

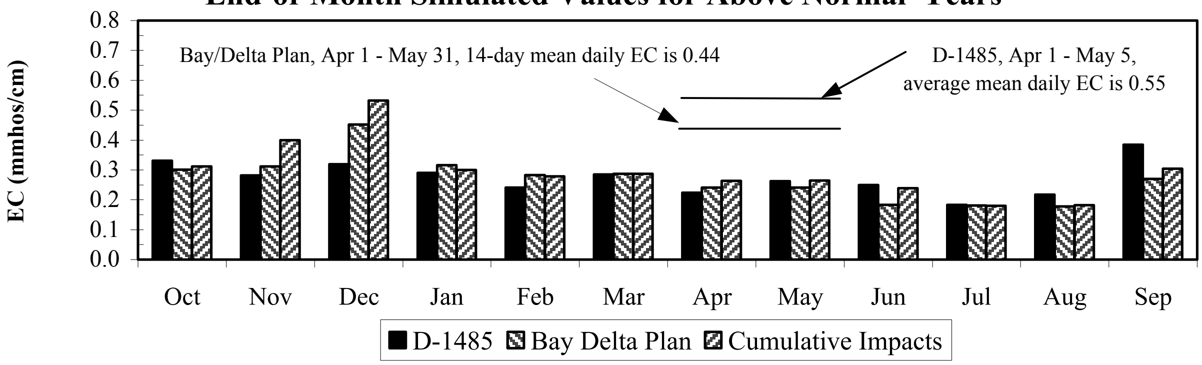
Figure XII-31
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Wet Years



The 14 - day mean daily salinity objectives for Bay/Delta Plan are 0.44 EC from Apr 1 - May 31, and for D-1485 is 0.55 EC from Apr 1 - May 5

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

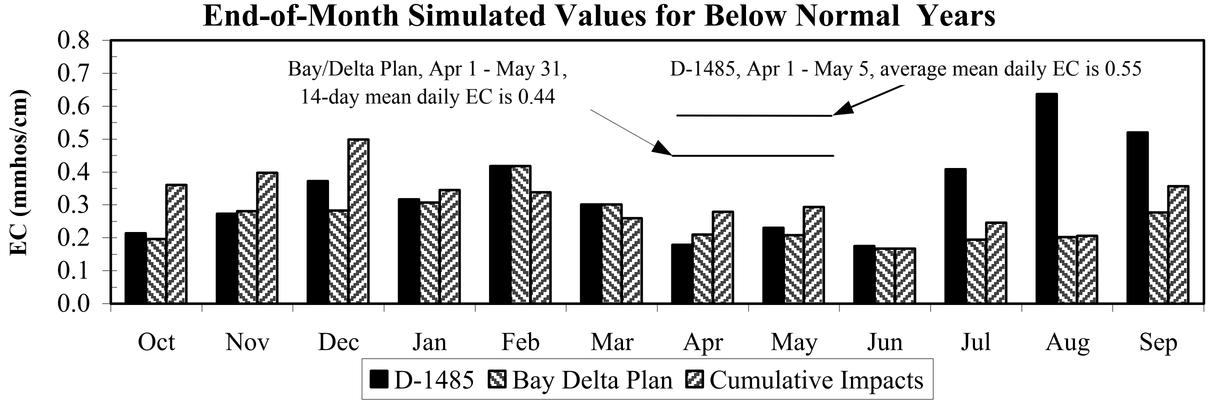
Figure XII-32
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Above Normal Years



The 14 - day mean daily salinity objectives for Bay/Delta Plan are 0.44 EC from Apr 1 - May 31, and for D-1485 is 0.55 EC from Apr 1 - May 5

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

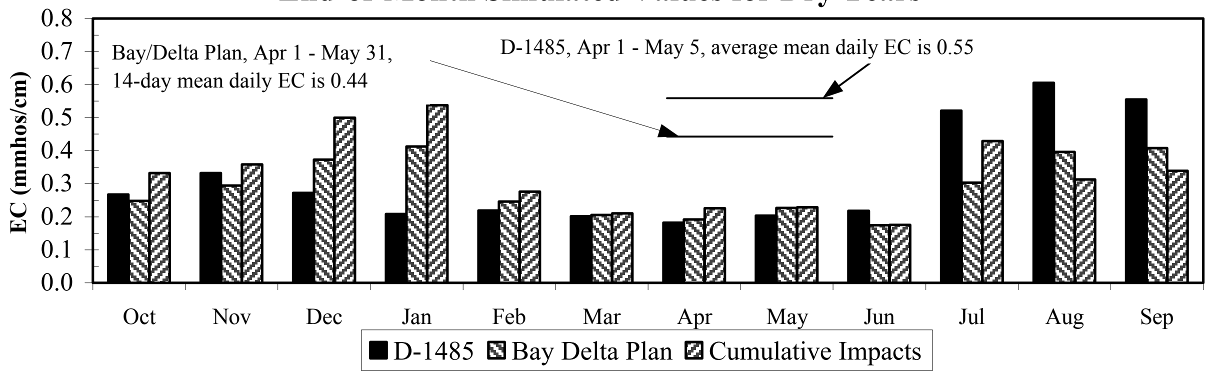
Figure XII-33
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Below Normal Years



The 14 - day mean daily salinity objectives for Bay/Delta Plan are 0.44 EC from Apr 1 - May 31, and for D-1485 is 0.55 EC from Apr 1 - May 5

Sacramento "40-30-30" **below normal** year (1979)

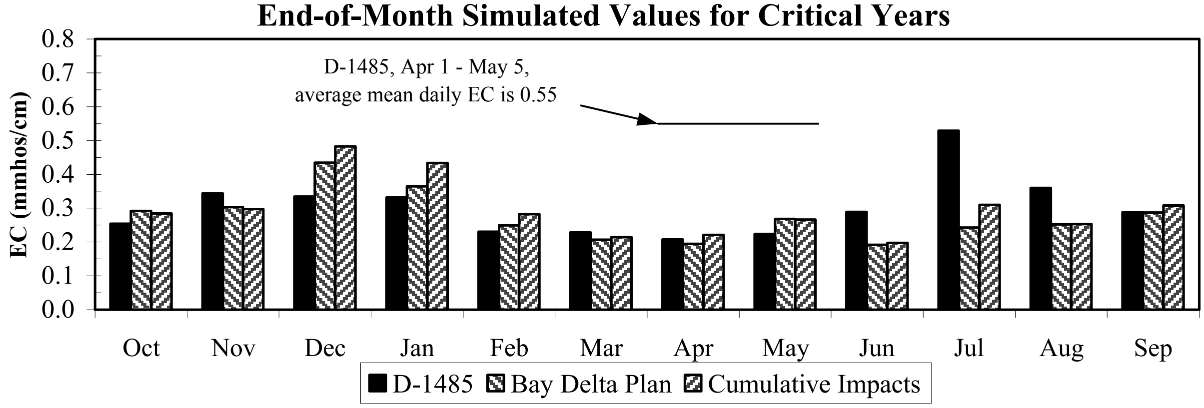
Figure XII-34
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Dry Years



The 14 - day mean daily salinity objectives for Bay/Delta Plan are 0.44 EC from Apr 1 - May 31, and for D-1485 is 0.55 EC from Apr 1 - May 5

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

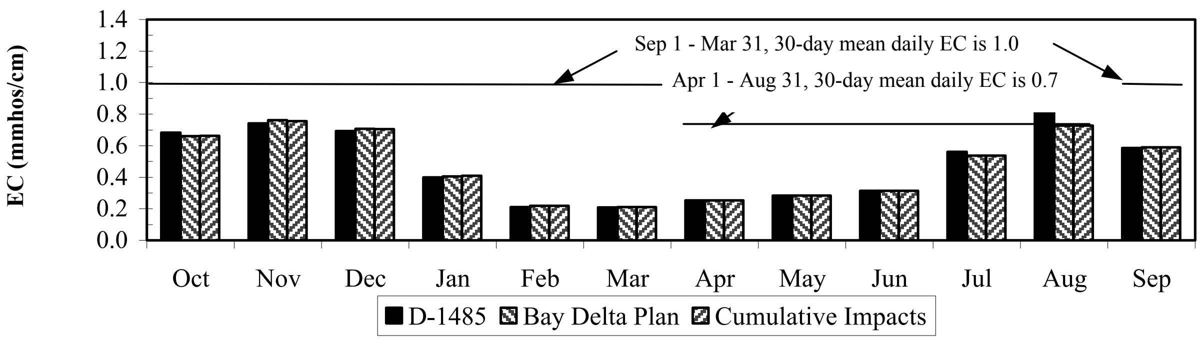
Figure XII-35
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Critical Years



Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

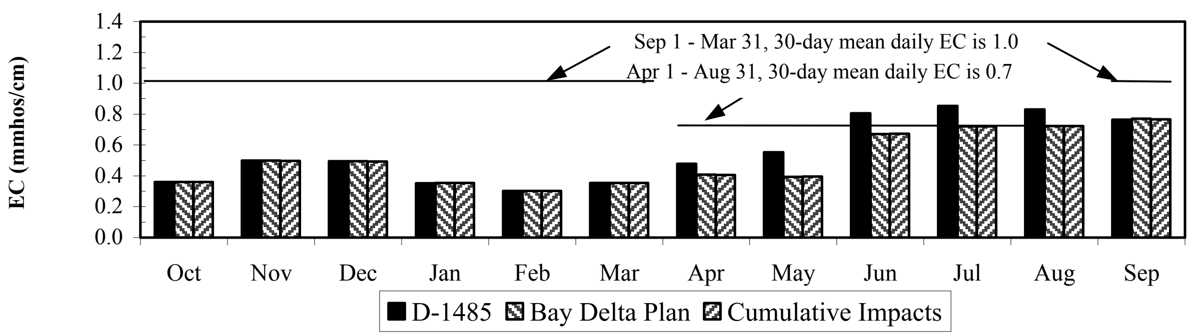
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Figure XII-36
Salinity for San Joaquin River at Airport Bridge (Vernalis)
End-of-Month Simulated Values for Wet Years



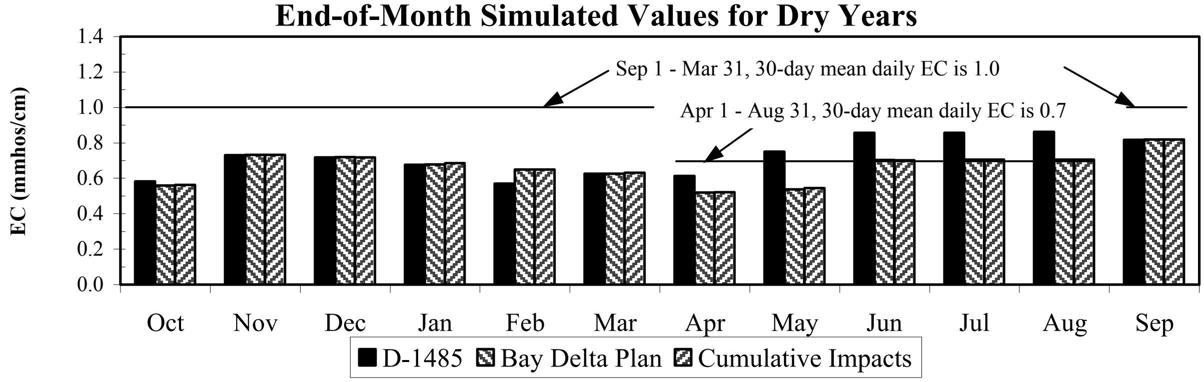
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1978, 80, 82, 83 & 86).

Figure XII-37
Salinity for San Joaquin River at Airport Bridge (Vernalis)
End-of-Month Simulated Values for Above Normal Years



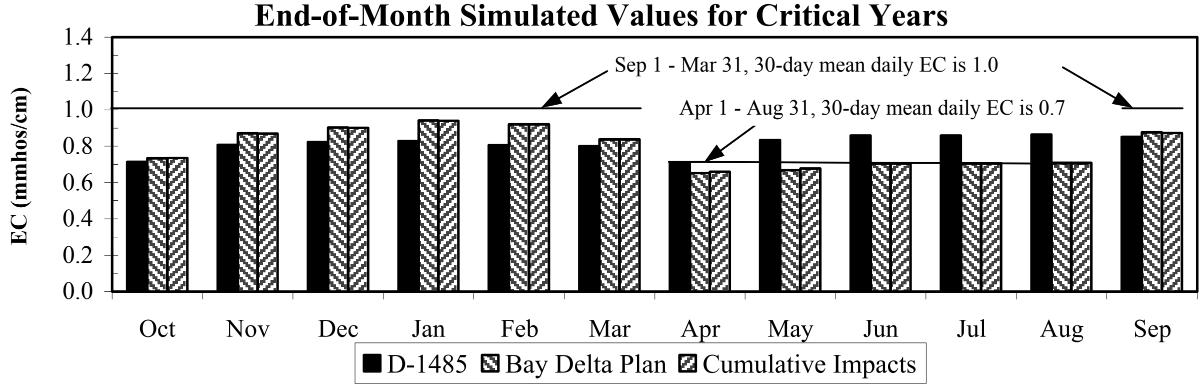
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1979 & 84).

Figure XII-38
Salinity for San Joaquin River at Airport Bridge (Vernalis)
End-of-Month Simulated Values for Dry Years



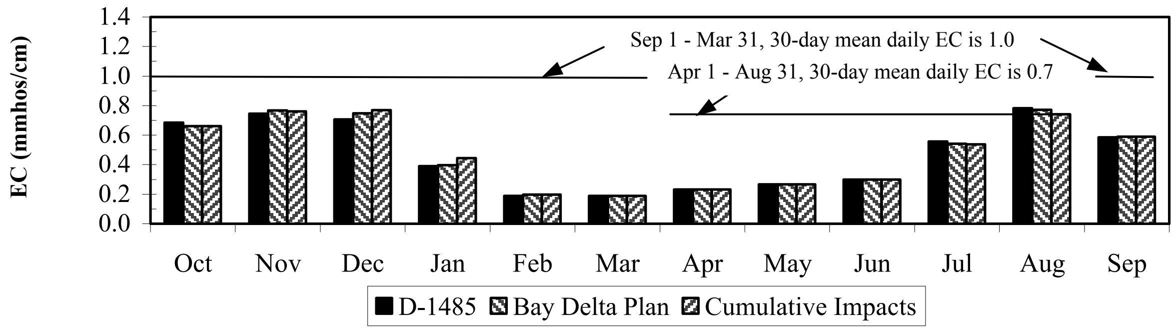
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" dry years averaged (1981 & 85).

Figure XII-39
Salinity for San Joaquin River at Airport Bridge (Vernalis)
End-of-Month Simulated Values for Critical Years



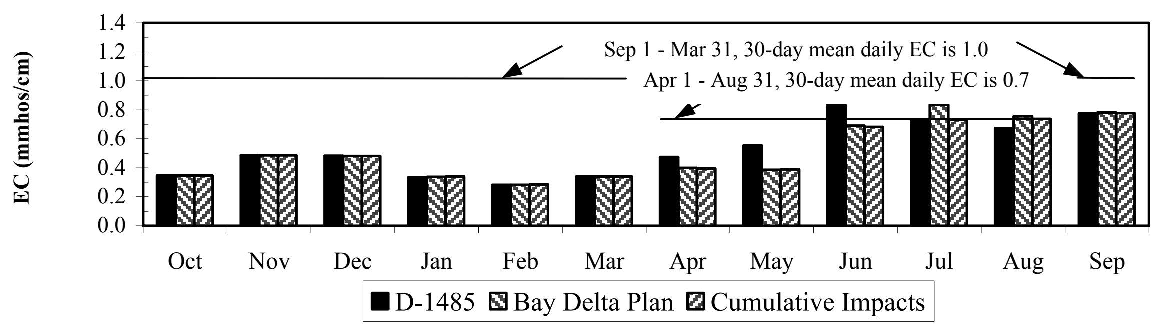
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" critical years averaged (1976, 77, 87, 88, 89, 90 & 91).

Figure XII-40
Salinity for San Joaquin River at Brandt Bridge
End-of-Month Simulated Values for Wet Years



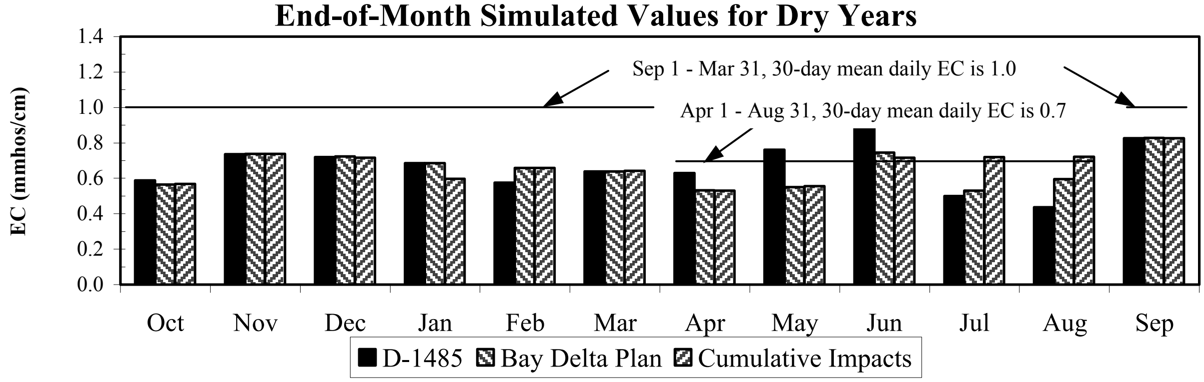
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1978, 80, 82, 83 & 86).

Figure XII-41
Salinity for San Joaquin River at Brandt Bridge
End-of-Month Simulated Values for Above Normal Years



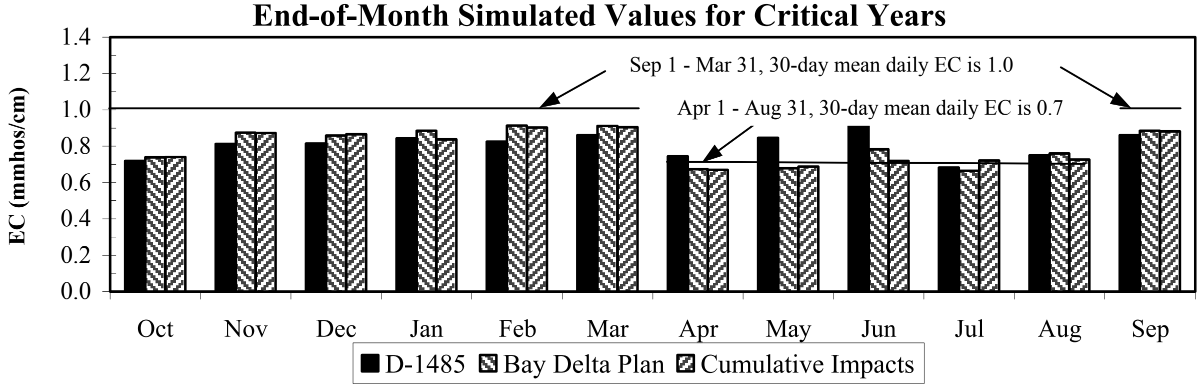
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1979 & 84).

Figure XII-42
Salinity for San Joaquin River at Brandt Bridge
End-of-Month Simulated Values for Dry Years



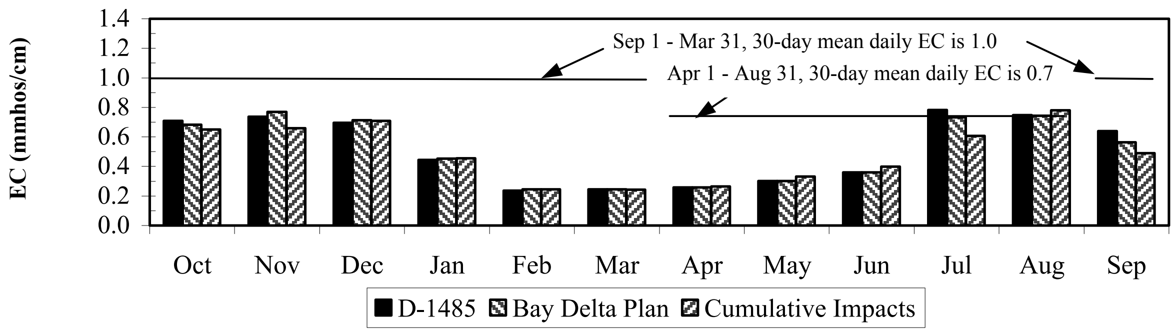
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" dry years averaged (1981 & 85).

Figure XII-43
Salinity for San Joaquin River at Brandt Bridge
End-of-Month Simulated Values for Critical Years



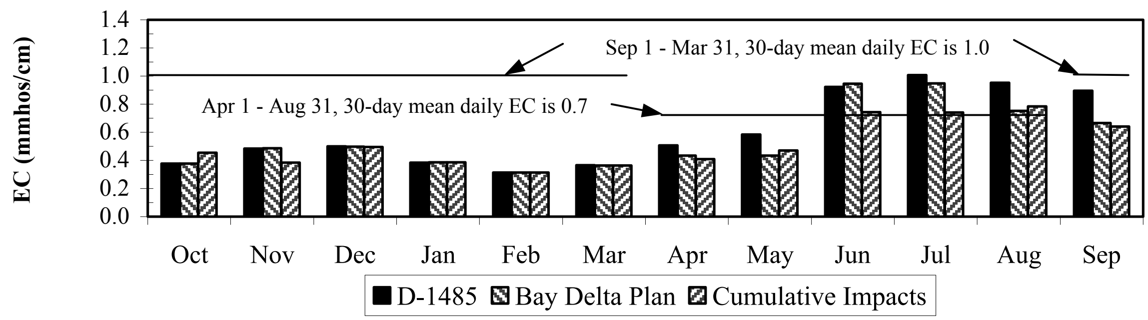
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" critical years averaged (1976, 77, 87, 88, 89, 90 & 91).

Figure XII-44
Salinity for Old River at Tracy Road Bridge
End-of-Month Simulated Values for Wet Years



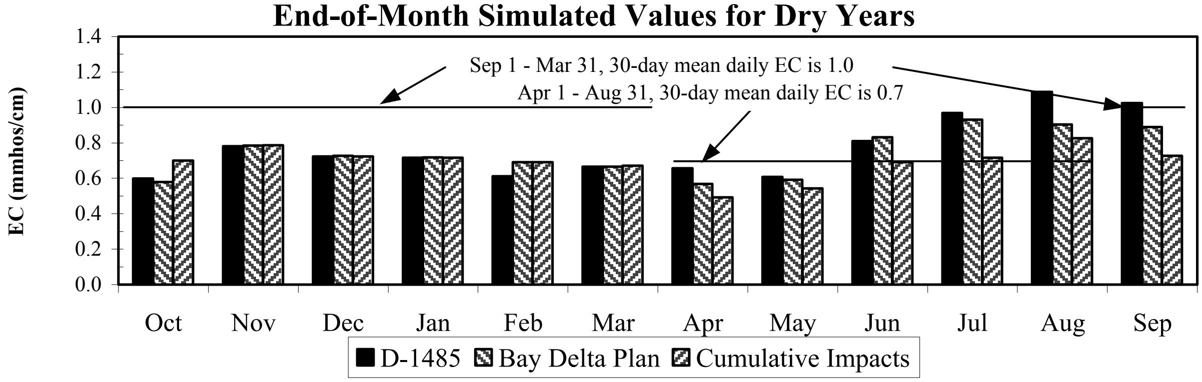
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1978, 80, 82, 83 & 86).

Figure XII-45
Salinity for Old River at Tracy Road Bridge
End-of-Month Simulated Values for Above Normal Years



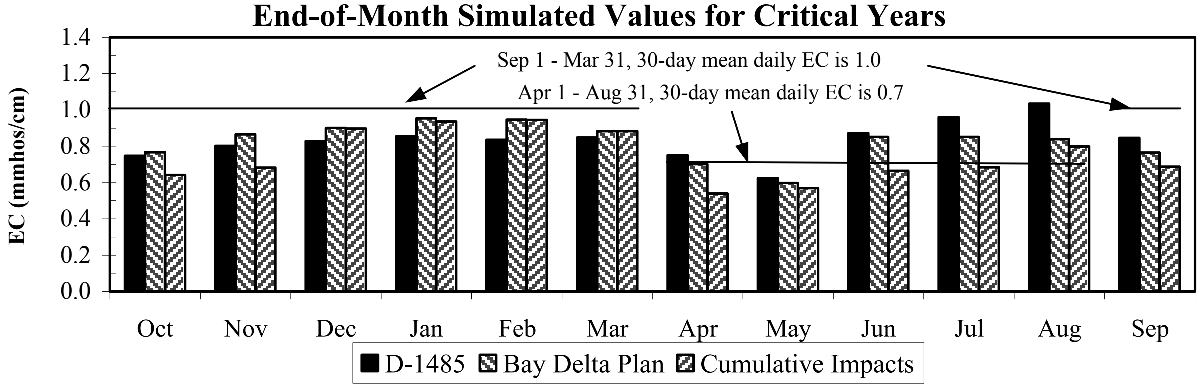
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1979 & 84).

Figure XII-46
Salinity for Old River at Tracy Road Bridge
End-of-Month Simulated Values for Dry Years



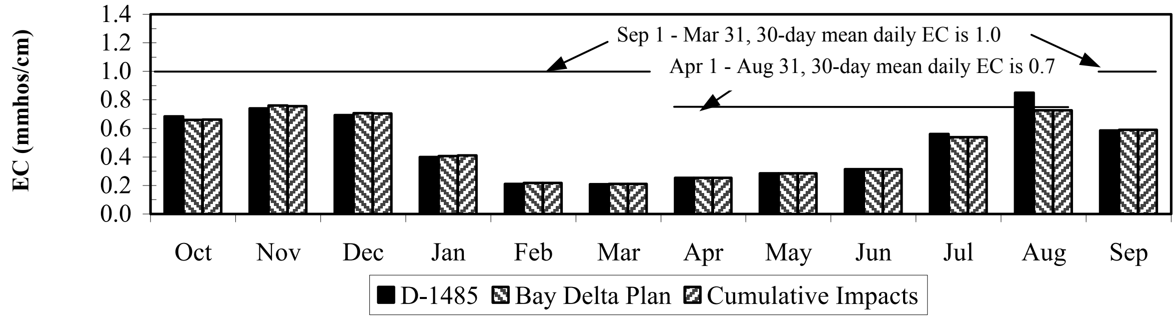
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" dry years averaged (1981 & 85).

Figure XII-47
Salinity for Old River at Tracy Road Bridge
End-of-Month Simulated Values for Critical Years



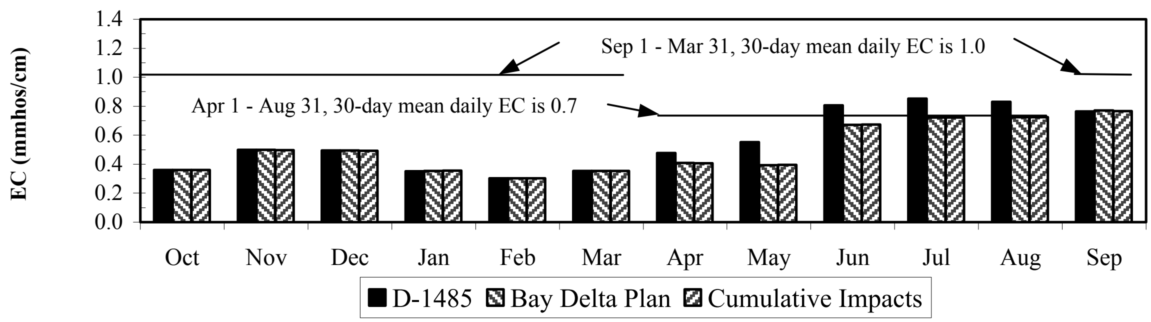
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" critical years averaged (1976, 77, 87, 88, 89, 90 & 91).

Figure XII-48
Salinity for Old River Near Middle River
End-of-Month Simulated Values for Wet Years



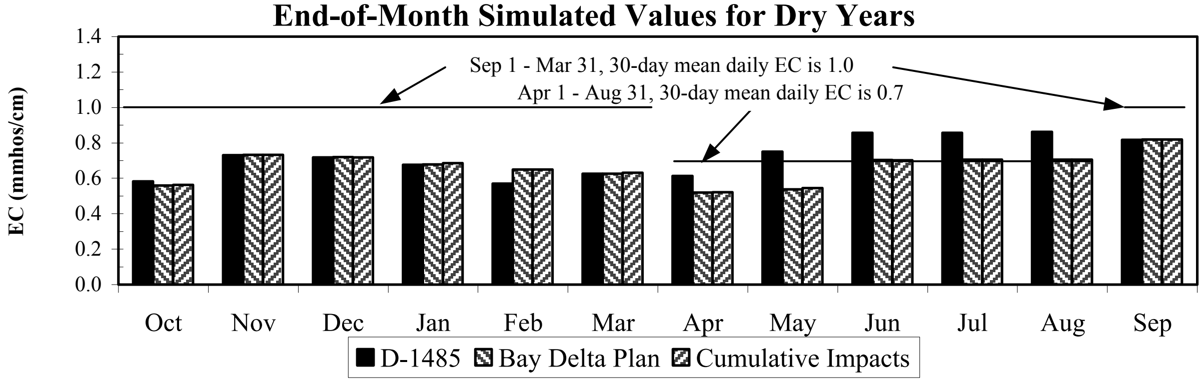
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1978, 80, 82, 83 & 86).

Figure XII-49
Salinity for Old River Near Middle River
End-of-Month Simulated Values for Above Normal Years



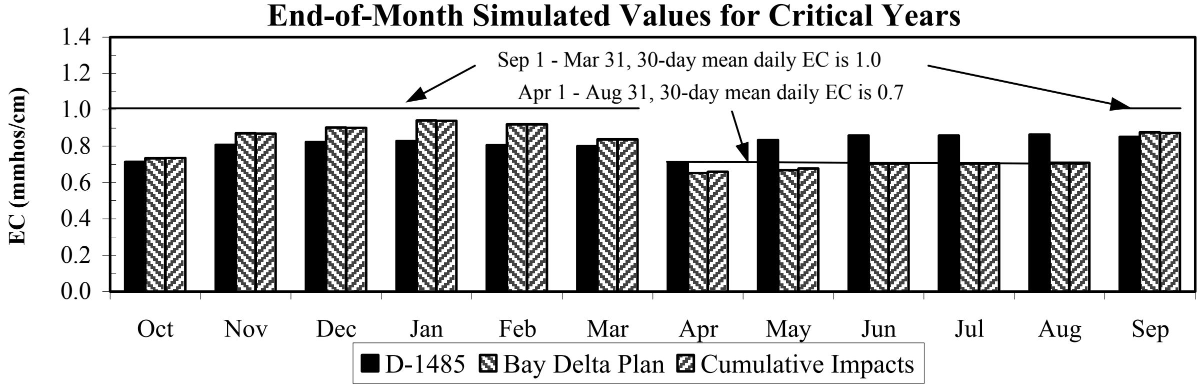
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1979 & 84).

Figure XII-50
Salinity for Old River Near Middle River
End-of-Month Simulated Values for Dry Years



Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" dry years averaged (1981 & 85).

Figure XII-51
Salinity for Old River Near Middle River
End-of-Month Simulated Values for Critical Years



Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" critical years averaged (1976, 77, 87, 88, 89, 90 & 91).

However, most programs that would implement any of these measures would require a specific environmental impact analysis of the particular action and disclosure of any significant environmental impacts identified in that analysis.

1. Conservation

The history and the measures associated with urban and agricultural water conservation are different. Therefore, urban and agricultural water conservation are discussed separately.

a. Urban Water Conservation. In 1988, during the Bay/Delta Proceedings, interested parties gave the SWRCB widely divergent estimates of water conservation potential in California. To resolve these differences, urban water agencies, environmental groups, and State agencies actively participated in a three-year effort which culminated in the publication of the 1991 Memorandum of Understanding Regarding Urban Water Conservation in California. This memorandum identified 16 Best Management Practices (BMPs) for urban water conservation; it committed the signatories to implementing the BMPs; and it established the California Urban Water Conservation Council (CUWCC) to both oversee implementation of the existing BMPs and evaluate new BMPs. Over 100 water agencies, plus over 50 public advocacy groups and other interested parties, have signed the memorandum.

The CUWCC developed a strategic plan in 1996 that included evaluating the BMPs and revising them to make them easier to quantify. The revised BMPs were adopted by the CUWCC in September 1997. The revisions included restructuring the original 16 BMPs to 14 (including two new) BMPs, revising implementation schedules and coverage requirements, and adding new evaluation criteria. Implementation of some BMPs was extended beyond the original 10-year term of the existing MOU. The revised list of BMPs is provided below; a more detailed description can be found in the MOU.

BMP	Description
1	Water Audit Programs for Single-Family Residential and Multifamily Residential Customers
2	Residential Plumbing Retrofit
3	System Water Audits, Leak Detection and Repair
4	Metering with Commodity Rates for All New Connections and Retrofit of Existing Connections
5	Large Landscape Conservation Programs and Incentives
6	High-Efficiency Washing Machine Rebate Programs (New)
7	Public Information Programs
8	School Education Programs
9	Conservation Programs for Commercial, Industrial, and Institutional Accounts
10	Wholesale Agency Assistance Programs (New)
11	Conservation Pricing
12	Conservation Coordinator (formerly BMP 14)
13	Water Waste Prohibition
14	Residential ULFT Replacement Programs (formerly BMP 16)

Water conservation will play a significant role in managing California's urban water needs. The widespread acceptance of urban BMPs in California ensures that their implementation will be the industry standard for water conservation programs. However, the SWRCB recognizes that, as water use continues to become more efficient, agencies will lose flexibility in dealing with shortages.

b. Agricultural Water Conservation. There are three principal pieces of legislation that encourage agricultural water conservation: The California Agricultural Water Management Planning Act of 1986 (Stats. 1986, C. 954, Water Code §10800 et seq.), The federal Reclamation Reform Act of 1982, and the Agricultural Water Suppliers Efficient Water Management Practices Act (Stats. 1990, C. 739, Water Code §10900 et seq.). These pieces of legislation are discussed in section A.3 of Chapter VIII.

In addition to legislative programs, agricultural water conservation is also encouraged through the San Joaquin Valley Drainage Program (SJVDP), which was established as a joint Federal and State effort in 1984. The SJVDP published its recommended plan in September 1990 (SJVDP 1990). The recommended plan should guide management of the agricultural drainage problem, and one of the major elements of the plan is increased conservation efforts. In December 1991, eight State and Federal agencies, including the SWRCB, signed a Memorandum of Understanding to coordinate activities implementing the plan.

2. Groundwater Management

Groundwater basin management includes: protecting the natural recharge and using supplemental recharge; varying the amount and location of extraction over time; using groundwater storage conjunctively with surface water from local and imported sources; and protecting and maintaining the groundwater quality (DWR 1994b). Because groundwater will be used to replace much of the shortfall in surface water supplies, limitations on Delta exports will exacerbate groundwater overdraft in regions receiving some portion of their supplies from the Delta. Effective groundwater management can minimize overdraft problems and provide sustainable water supplies.

Managing groundwater in California has generally been considered a local responsibility. This view is strongly held by landowners and has been upheld by the Legislature, which has enacted a number of statutes establishing local groundwater agencies. State agencies have encouraged local agencies to develop effective groundwater management programs to maximize their overall water supply and to avoid lengthy and expensive lawsuits resulting in adjudicated basins.

Conjunctive use is an essential element of groundwater management. Conjunctive use programs are designed to increase the total useable water supply by jointly managing surface and groundwater supplies as a single source. The basin is recharged, both directly and indirectly, in years of above average precipitation so that ground water can be extracted in years of below average precipitation when surface water supplies are below normal. There are some instances, however, where conjunctive use is employed for annual regulation of supplies. These programs involve recharge with surface water or reclaimed water supplies and same-year extraction for use. An example of a large scale conjunctive use program is the Kern Water Bank which could be developed to store as much as one MAF and contribute as much as 140 TAF per year in drought years (DWR 1994b). The DWR is currently studying other conjunctive use programs in the American River basin and the Sacramento Valley.

In the future, the number of conjunctive use projects is expected to increase and become more comprehensive because of the need for more water and the higher cost of new surface water facilities. Conjunctive use programs generally promise to be less costly than new traditional surface water projects because they increase the efficiency of water supply systems and cause fewer negative environmental impacts than new surface water reservoirs (DWR 1994b).

3. Water Transfers

Currently, water transfers are a promising way of closing the gap between water demands and dependable water supplies over the next ten years. There are fewer environmental impacts associated with transfers than with construction of conventional projects, and although difficult to implement, transfers can be implemented more quickly and usually at less cost than construction of additional facilities. Unfortunately, water transfers are not available on a statewide basis because some regions of the State are physically isolated from water conveyance facilities.

Under existing law, holders of both pre-1914 and modern appropriative water rights can transfer water. Holders of pre-1914 appropriative rights may transfer water without seeking approval of the SWRCB, provided others are not injured. Holders of modern appropriative rights may transfer water, but the SWRCB must approve any transfer requiring a change in terms and conditions of the water right permit or license, such as place of use, purpose of use, or point of diversion. Water transfers must also comply with any applicable local ordinances. Water held pursuant to riparian rights is transferable if the new use will preserve or enhance public trust uses (Water Code §1707). There is a recent practice in which downstream appropriators contract with riparian users to leave water in a stream for potential downstream diversion under the appropriator's water right. Water obtained pursuant to a water supply contract is also transferable. However, most water supply contracts require the consent of the entity delivering the water.

Transfers of ground water, and ground water substitution arrangements whereby ground water is pumped as a substitute for transferred surface water, are in some cases subject to statutory restrictions designed to protect ground water basins against long-term overdraft and to preserve local control of ground water management.

Short-term (one year or less) temporary transfers of water under Water Code section 1725 et seq. are exempt from compliance with CEQA, provided SWRCB approval is obtained. The SWRCB must find no injury to any other legal users of the water and no unreasonable effect on fish, wildlife, or other instream beneficial uses. CEQA compliance is required for long-term transfers. Because of complex environmental problems in the Delta, the SWRCB has announced that it will not approve long-term transfers that increase Delta pumping until completion of an environmental evaluation of the cumulative impacts. If the parties to a transfer intend to use facilities belonging to the SWP, the CVP, or other entity for transporting the water, they must make arrangements with the owner of the facility. In addition, permits from fish and wildlife agencies may be required if a proposed transfer will affect threatened or endangered species.

The CVPIA also contains provisions intended to increase the use of water transfers by providing that all individuals and districts receiving CVP water (including that under water right settlement and exchange contracts) may transfer it to any other entity for any project or purpose recognized as a beneficial use under State law. The Secretary of the Interior must approve all transfers. The approval of the affected district is required for any transfer involving over 20 percent of the CVP water subject to long-term contract with the district. Section 3405(a)(1) also sets forth a number of conditions on the transfers, including conditions designed to protect the CVP's ability to deliver contractually obligated water or meet fish and wildlife obligations because of limitations in conveyance or pumping capacity. The conditions also require transfers to be consistent with State law, including CEQA. Transfers are deemed to be a beneficial use by the transferor, and are only permitted if they will have no significant long-term adverse impact on ground water conditions within the transferor district, and will have no unreasonable impact on the water supply, operations, or financial condition of the district.

4. Water Recycling

Water recycling, formerly referred to as waste water reclamation, has been used as a source of nonpotable water in California for nearly a century. In recent years, more stringent treatment requirements for disposal of municipal and industrial wastewater have reduced the incremental cost of obtaining the higher level of treatment required for use of recycled water. The higher level of treatment allows recycled water to be safely used for a wider variety of applications. Increased use of recycled water can lessen the demand for new fresh water supplies.

The feasibility of recycling water is somewhat dependent on the quality of the source water. Current technology allows municipal wastewater treatment systems in some regions to consistently produce safe water supplies at competitive costs. The degree of treatment depends on the intended use, with public health being the primary concern. As a minimum, wastewater is treated to a secondary level to remove dissolved organic materials. Secondary effluent can be treated to a tertiary level by additional filtering and disinfecting, but the costs can be high in comparison to other fresh water supply augmentation options.

Water reuse in California was estimated to be over 380 TAF in 1993. Most of the recycling occurs in the South Coast, Central Coast, and Tulare Lake regions. Ground water recharge accounts for nearly half of all recycled water used. Other uses of recycled water include agricultural irrigation, landscape irrigation, environmental (wildlife habitat), industrial, recreational, and seawater intrusion barriers (DWR, 1994b).

5. Combined Use of SWP/CVP Points of Diversion in the Delta

Currently, a water imbalance exists in the two major water projects. The CVP occasionally has an excess water supply north of the Delta, but it doesn't have sufficient conveyance capacity to transport it to its ultimate place of use south of the Delta. The SWP on the other hand has surplus capacity in its conveyance facilities but an insufficient upstream water supply. Therefore, the excess capacity in the SWP facilities could be used to transport more CVP water to the San Joaquin Valley without impairing the SWP, and a share of the CVP water supply could be sold to the SWP for use in its service area. The CVP has limited rights under its water right permits to use the SWP diversion facilities in the Delta. D-1485 authorizes the CVP to use SWP facilities to make up deficiencies caused by the export restrictions in May and June established by the decision. The SWP water rights do not identify the CVP export facilities as an authorized point of diversion or rediversion.

In addition to the water supply issues, combined use of CVP and SWP points of diversion and rediversion has the potential to decrease fishery impacts. The two diversions are at different locations and different fish species are entrained at the diversions at different times. A combined point of diversion would allow pumping to shift between diversion points based on the density of fish near the diversion points. SWRCB Order WR 98-9 authorizes combined use of SWP and CVP points of diversion to benefit fish. Order WR 98-9 is a temporary order that expires on December 31, 1999.

The USBR has petitioned the SWRCB to add the Clifton Court Forebay as a point of diversion and rediversion in the water right permits of the CVP and to remove the 4,600 cfs rate of diversion restriction on pumping through the Delta Mendota Canal. Chapter XIII of this draft EIR discusses the environmental impacts of authorizing combined use of points of diversion.

6. Offstream Storage Projects

Enhanced water supply reliability in the future can be achieved, in part, by construction of additional offstream storage. There are several major offstream storage projects presently under development or consideration: Eastside Reservoir, Los Vaqueros Reservoir, Los Banos Grandes Reservoir, Delta Wetlands, and Mandeville Island. The Eastside Reservoir, currently under construction by the Metropolitan Water District, could provide 0.26 MAF of drought year net water supplies

(DWR 1994). Los Vaqueros Reservoir, which will be used to improve water quality in the Contra Costa Water District and provide emergency storage, has recently been completed and is now operating. Los Banos Grandes Reservoir, a proposed feature of the SWP, would be located south of San Luis Reservoir, and it could provide 0.3 MAF of average and 0.26 MAF of drought year net water supplies under D-1485 conditions. Delta Wetlands is a proposed storage project in the Delta with a capacity of approximately 238 TAF. Surplus flows would be diverted onto two islands, Bacon Island and Webb Tract, and subsequently wheeled through the SWP or CVP export pumps or released to meet Delta outflow requirements. Recently, a water right application for a similar project was filed to impound 330 TAF on Mandeville Island.

7. ISDP

The ISDP is being undertaken by the DWR to increase the yield and flexibility of operation of the SWP and to improve the conditions for local diverters. The principal features of the ISDP can be divided into five components: (1) construct and operate a new intake structure at the SWP Clifton Court Forebay; (2) perform channel dredging along a reach of Old River just north of Clifton Court Forebay to improve channel capacity; (3) increase diversions into Clifton Court up to a maximum of 20,430 acre-feet per day on a monthly averaged basis; (4) construct and operate a barrier seasonally in both the spring and fall to improve fishery conditions for salmon migrating along the San Joaquin River; and (5) construct and operate three flow control structures to improve existing water level and circulation patterns for agricultural users in the southern Delta. This program could augment SWP supplies by about 60 TAF per year (DWR 1994b).

C. GROWTH-INDUCING EFFECTS

Implementing the Bay/Delta Plan will reduce the amount of water available to water utilities in areas served by the CVP, the SWP, and other parties charged by the SWRCB with responsibility for meeting the objectives of the Plan. To the extent that historic patterns are any indication of future trends, reduced water availability is unlikely to affect growth in these areas.

Growth patterns have historically been influenced by market conditions far more than by any other factor. Water shortages have rarely done more than slow the progress of adequately financed development proposals. Growth moratoriums have occasionally been imposed due to inadequate water supplies but, in most cases, enough water has been found to sustain most economically viable growth. Because the costs of water supply augmentation projects can usually be spread over a large user base, the cost of new supplies has seldom been high enough to significantly reduce the profitability of new development projects.

Land fallowed in response to irrigation water cutbacks could become available for other uses, including development. Because development is primarily driven by demand, however, the availability of fallowed land is not expected to result in significant new growth. Without a tangible demand for new housing, an increase in the amount of available, affordable land will not stimulate the construction of new housing.

D. RELATIONSHIP BETWEEN SHORT-TERM USES AND THE MAINTENANCE OF LONG-TERM PRODUCTIVITY

The principal issue associated with the relationship between short-term uses and the maintenance of long-term productivity is groundwater overdraft. As discussed in Chapter VI, implementation of the Bay/Delta Plan will aggravate groundwater overdraft problems. Additionally, changes in the use of water may well occur, from agricultural uses to municipal uses, or from one type of agricultural use or crop to another, in the short- and long-term.

Implementation of the Plan has the potential to affect water levels in reservoirs, flows in the rivers, water management operations, and the quantity of water deliveries to various districts in the short- and long-term. Surface water is, however, renewable from precipitation. Also, the Plan will be reviewed every 3 years to evaluate the effectiveness of the objectives and the water supply needs of the State.

The Bay/Delta Plan will provide better protection to aquatic habitat-related beneficial uses in the Estuary, and long-term increases in fresh- and brackish-water aquatic and terrestrial habitats in the Delta should result. If the Plan is not implemented, there will probably be further declines in those resources and additional species may be listed under the federal and State ESAs.

E. IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES

Most of the environmental impacts identified in this report are reversible. The principal hydrologic effects of implementing the Bay/Delta Plan will be to change Delta outflow, reservoir levels, and deliveries to export areas. These parameters presently fluctuate a great deal due to the variable hydrology in the Central Valley. If the Plan's objectives are implemented and then rescinded at a future date, the hydrology will be dependent on the regulatory conditions in effect at that time. However, there are three irreversible impacts that might occur as a result of this situation: land use changes, fossil fuel combustion, and land subsidence. These irreversible changes are discussed below.

The most likely irreversible land use change that might occur as a result of the objectives is accelerated agricultural land retirement. Without a firm agricultural water supply, the conversion of this land to some other use may occur, especially if the land is adjacent to an urban area. The extent to which this land use change will actually occur is dependent on decisions by local authorities.

The second irreversible impact is increased fossil fuel combustion. The dedication of additional water to the environment will decrease the availability of water in some upstream reservoirs for summer peak power generation, as discussed in Chapter VI. In addition, the development of replacement water through groundwater pumping and reclamation is power intensive. Fossil fuel combustion will likely be an element in replacing lost power and meeting new power requirements as a result of the Plan.

The third irreversible impact is land subsidence. As discussed in Chapter VI, implementation of the Plan's objectives is likely to result in increased groundwater pumping, which can cause land subsidence. Land subsidence can damage surface structures, and it can result in permanent loss of aquifer capacity.

Literature Cited in Chapter XII

CALFED. 1996a. No-Action Alternative and Cumulative Impact Analysis Screening Report. CALFED Bay-Delta Program. Sacramento, California. September 18, 1996. 240 pp.

CALFED. 1996b. Addendum to the No-Action Alternative and Cumulative Impact Analysis Screening Report. CALFED Bay-Delta Program. Sacramento, California. December 31, 1996. 38 pp.

CCRC Farms/Tuscany Research Institute. 1994. Application to Appropriate Water. Environmental Information. CCRC Farms, a General Partnership, and Tuscany Research Institute. Las Vegas, Nevada. November 10, 1994. 5 pp.

CCWD. 1992. Stage 2 Environmental Impact Report/Environmental Impact Statement for the Los Vaqueros Project, Contra Costa County, California (Volumes I and II). Final. Contra Costa Water District and U.S. Bureau of Reclamation, with Technical Assistance from: Jones & Stokes Associates Inc; MontgomeryWatson Americas; Woodward-Clyde Consultants; and Sonoma State University. Concord and Sacramento, California. October 1993. 672 pp. (plus figures); 386 pp.

CUWA. 1994. Proposals for a Coordinated Estuarine Protection Program for the San Francisco Bay-Sacramento and San Joaquin River Delta Estuary. August 1994.

DWR. 1994a. Management of the California State Water Project (Bulletin 132-93). Department of Water Resources. Sacramento, California. September 1994. 396 pp.

DWR. 1994b. California Water Plan Update, Bulletin 160-93, Department of Water Resources. October 1994.

DWR and USBR. 1996. Draft Environmental Impact Report/Environmental Impact Statement on the Interim South Delta Program (Volume I). Prepared by Entrix, Inc. and Resource Insights for the Department of Water Resources and U.S. Bureau of Reclamation. Sacramento, California. July 1996. 700 pp.

DWR and USBR. 1999. Biological Assessment – Effects of the Central Valley Project and State Water Project Operations from October 1998 through March 2000 on Steelhead and Spring-Run Chinook Salmon. January 1999.

Howard, Tom. 1997. Update on the Delta Process. State Water Resources Control Board. Sacramento, California. May 1997. 4 pp.

MWD. 1991. Draft Environmental Impact Report for the Eastside Reservoir Project. Los Angeles, California. October 1991.

Richter, B.D., Baumgartner, J.V., Wigington, R., and D.P. Braun. 1997. How Much Water Does a River Need? Freshwater Biology 37: 231-249.

SJVDP. 1990. A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley. 183 pp.

SWRCB. 1994. Preliminary Environmental Review Checklist. State Water Resources Control Board, Division of Water Rights, Environmental Section. Sacramento, California. December 1994. 3 pp.

SWRCB. 1995. Environmental Report: Appendix 1 to Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. State Water Resources Control Board. Sacramento, California. May 1995. 520 pp.

SWRCB and USCOE. 1995. Draft Environmental Impact Report and Environmental Impact Statement for the Delta Wetlands Project (Volume I). Prepared by Jones & Stokes Associates, Inc. for the State Water Resources Control Board and the U.S. Army Corps of Engineers. Sacramento, California. September 11, 1995. 729 pp.

USFWS. 1995. Working Paper on Restoration Needs; Habitat Restoration Actions to Double Natural Production of Anadromous Fish in the Central Valley of California. May 1995. Prepared for the USFWS Under the Direction of the Anadromous Fish Restoration Program Core Group. Volume 3, 387 pp. plus appendices.

CHAPTER XIII. ALTERNATIVES FOR IMPLEMENTING THE JOINT POINTS OF DIVERSION

A. PURPOSE

The purpose of this chapter is to disclose and analyze the significant environmental effects of alternatives for implementing the DWR's and the USBR's petition for joint use of SWP and CVP points of diversion (Joint POD) in the Delta. Specifically, the alternatives examine the joint use of the SWP's Harvey O. Banks Pumping Plant and the CVP's Tracy Pumping Plant.

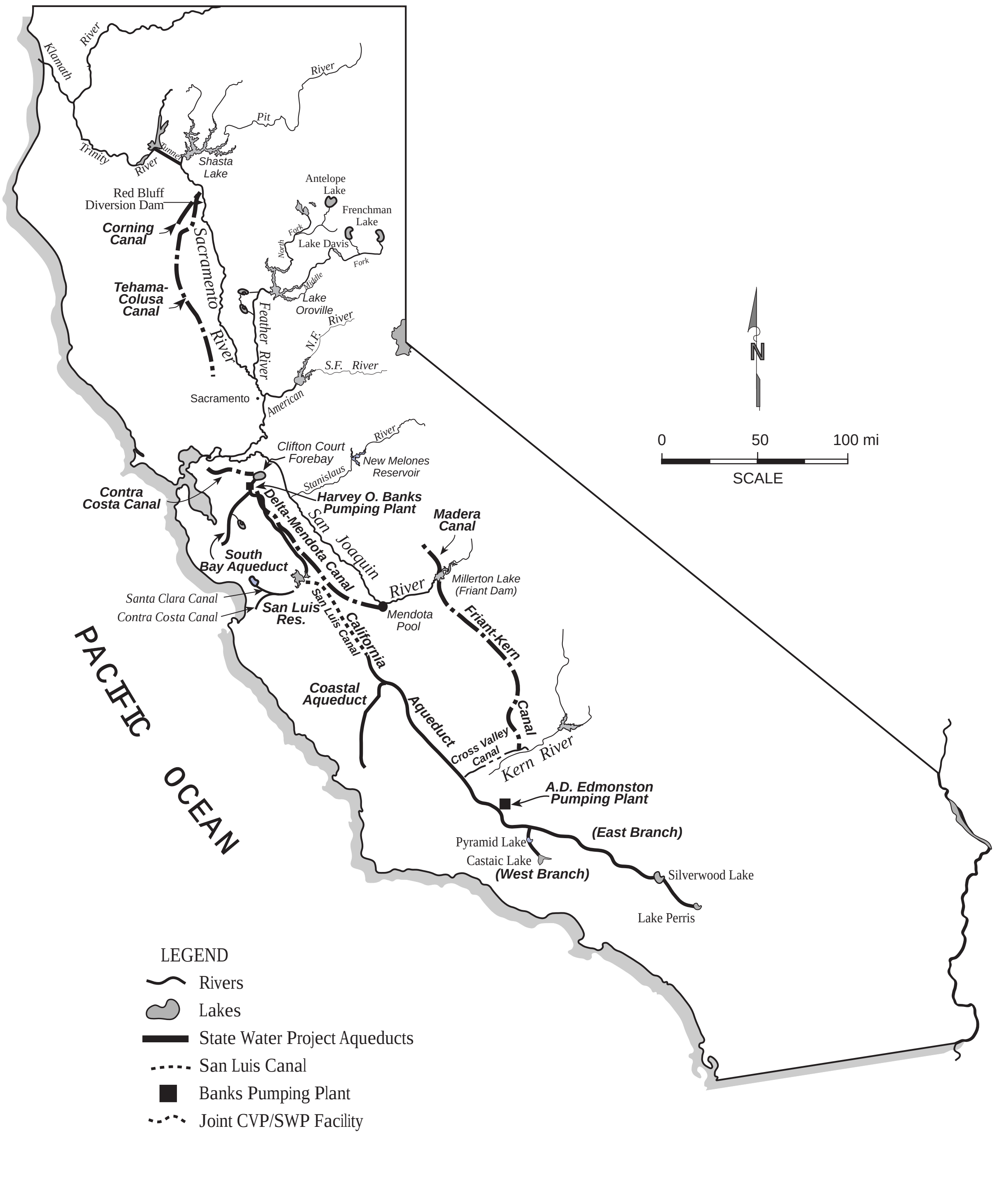
B. BACKGROUND INFORMATION ON JOINT POD

The CVP, operated by the USBR, and the SWP, operated by the DWR, are the largest water development projects in California and supply water to much of the state. They are also the largest water right holders in the state. The main export facilities of the projects are located in the southern Delta, and these facilities pump water south through the Delta-Mendota Canal and the California Aqueduct. This water is then directly used or placed into storage in San Luis Reservoir (see Figure XIII-1). The SWP can also move water farther south to storage facilities in southern California. The primary storage reservoirs of the CVP are Shasta Lake (Sacramento River), Trinity Reservoir (Trinity River), and Folsom Lake (American River), which are located north of the Delta. In times when water is not directly available in the Delta, stored water is released from these reservoirs to meet the CVP demands south of the Delta.

The SWP and the CVP water right permits include instantaneous diversion and rediversion rates (10,350 cfs for the SWP at Banks Pumping Plant and 4,600 cfs at Tracy Pumping Plant) as well as rates of diversion to storage in San Luis Reservoir (10,350 cfs for the SWP and 4,200 cfs for the CVP). The CVP's Tracy Pumping Plant has a capacity of 4,600 cfs. Historically, flexibility in the pumping and transport system allowed maintenance and repair work to be performed without significantly affecting the ability to meet water supply demands. Recently, however, changes in the regulatory environment have eliminated that flexibility. At present, the Tracy Pumping Plant is generally operated either at its full capacity or at the maximum capacity set forth in Biological Opinions established under the Endangered Species Act (ESA) or SWRCB Order WR 98-09.

The SWP's Banks Pumping Plant has capacity to pump up to 10,350 cfs. However, the U.S. Army Corps of Engineers Public Notice 5820-A (PN 5820-A) limits daily diversions into Clifton Court Forebay to 13,870 acre-feet and limits 3-day average diversions to 13,250 AF/day, except in winter when San Joaquin River flow is high. From December 15 to March 15, DWR may divert an additional amount equal to one-third of the total flow at Vernalis when flows at Vernalis exceed 1,000 cfs. The conditions of PN 5820-A effectively limit the operating capacity of Banks Pumping Plant to 6,680 cfs much of the time. At

Figure XIII-1
Location Map for Select Features of the Central Valley Project and the State Water Project



certain times of the year, and under certain operational conditions, the available capacity is not fully utilized by the SWP. At those times, there is excess capacity available at the Banks Pumping Plant that could be used by the CVP.

The actions and events that have increased the need for the USBR to seek assistance from the SWP to wheel[1] CVP water through DWR's Banks Pumping Plant have been progressive. Pumping restrictions for environmental purposes began in 1979 when the SWRCB implemented Water Right Decision 1485 (D-1485). This decision limited pumping at the Tracy Pumping Plant to 3,000 cfs in May and June for the protection of striped bass. The quantity of water that was foregone by this limitation could not always be recaptured solely through the use of the Tracy Pumping Plant because of the timing of demands and the Tracy Pumping Plant's limited pumping capacity. The SWRCB recognized this limitation and authorized CVP use of the Banks Pumping Plant in Condition 3 of D-1485, which states:

> *To the extent that operational constraints on the Central Valley Project to minimize diversion of young striped bass from the Delta during May and June reduce project exports, permittee, the United States Bureau of Reclamation, shall be allowed through coordinated operations to make up such deficiencies during later periods of the year by direct diversion or by re-diversion of releases of stored water through State Water Project facilities.*

After D-1485 was implemented, and with increasing demands on the CVP, the Tracy Pumping Plant's flexibility became limited. Maintenance activities were difficult to perform while meeting full demands and generally were not possible without use of SWP facilities to wheel CVP water. Several temporary actions to allow wheeling for purposes other than those specified in D-1485 were filed with the SWRCB and approved.

The CVP has used the SWP's pumping facility in the Delta to deliver water to four entities (Cross Valley Canal (CVC), Musco Olive, Tracy Golf Course, and the VA Cemetery) for a number of years even though the use of the SWP's pumps for this purpose is not authorized under the current water right permits. While these CVP contractors cannot be served conveniently by using only CVP facilities, the SWP facilities have had available capacity for wheeling CVP water. The CVC contractors, with a total contract allotment of 128,300 acre-feet per year, receive the majority of the water that has been wheeled by the SWP. Average annual deliveries to the CVC for the period 1982-1993 were 75,432 acre-feet.

On December 7, 1981, the USBR filed a petition requesting a permanent change to CVP water rights by the addition of the Banks Pumping Plant as a point of diversion and re-diversion under those rights. This request was repeated in a subsequent petition filed on September 24, 1985, concerning the consolidated place of use. The SWRCB notified the USBR that it would defer action on the USBR's petition and integrate that action into a comprehensive Bay/Delta water rights hearing that would begin in 1987.

[1] Wheeling involves the pumping and conveyance of CVP-held water through SWP facilities into San Luis Reservoir where it can then be delivered to CVP users.

The SWRCB began the Bay/Delta hearings in 1987. A draft plan issued in November 1988 was withdrawn in January 1989. In May 1991, after additional hearings, the SWRCB adopted the 1991 Bay/Delta Plan, but this water quality control plan did not address the water right issue of combined use of points of diversion. A draft decision, D-1630, was released in December 1992, but was subsequently withdrawn. The series of events that followed the withdrawal of D-1630 included the development of a process that resulted in the 1994 Principles of Agreement and the 1995 Bay/Delta Plan. A summary of this process is provided in Chapter I.

On February 28, 1995, the DWR and the USBR filed a joint petition requesting the SWRCB to amend the water right permits of the SWP and CVP to allow operation to meet the objectives in the 1995 Bay/Delta Plan without violating the terms of D-1485 and to permit combined use of points of diversion. The SWRCB adopted Water Right Order 95-6 (WR 95-6) on June 8, 1995, conditionally approving the petition. WR 95-6 was an interim order that was to expire either (1) upon adoption by the SWRCB of a comprehensive water right decision that allocates final responsibilities for meeting the 1995 Bay/Delta Plan objectives or (2) on December 31, 1998, whichever came first. On December 3, 1998, the effective term of WR 95-6 was extended until December 31, 1999, when the SWRCB adopted Order WR 98-09.

The implementation of the new standards contained in the 1995 Bay/Delta Plan placed additional constraints on the operation of the CVP. WR 95-6 and WR 98-09 also authorized short-term combined use of the points of diversion of the SWP and the CVP subject to the condition that such use must improve fish protection and not result in an increase in average exports above the exports in the absence of the coordinated operations.

The Joint POD alternatives described in the next section are designed to incrementally increase the quantity of CVP water wheeled by the SWP under the joint point concept. Seven alternatives for the use of Joint POD, one alternative representing full implementation of the 1995 Bay/Delta Plan, and the “no project alternative” are summarized in this chapter. Five of the Joint POD alternatives that allow wheeling build upon Joint POD Alternative 2, which represents full implementation of the 1995 Bay/Delta Plan. One Joint POD alternative builds on Flow Alternative 7, the “Letter of Intent” alternative; and, one Joint POD alternative builds on Flow Alternative 8, the San Joaquin River Agreement alternative. (See Chapter II for a description of the Flow Alternatives.

The environmental effects of implementing the Joint POD alternatives are evaluated using a two-step process. River flows, Delta outflow, Delta salinity distribution, and reservoir levels resulting from implementation of the alternatives were modeled using DWRSIM and DWRDSM models (Chapter IV). The modeled hydrology is then compared to the flow and reservoir needs of fish, other aquatic resources, vegetation, and wildlife to determine the key environmental effects of implementing each alternative. Comparisons are made with the base condition to maintain consistency with the analyses presented in previous chapters. Additional comparisons are made, where possible, with Alternative 2, to analyze any incremental effects of other alternatives that allow wheeling.

C. DESCRIPTION OF ALTERNATIVES

A broad range of alternatives is analyzed to encompass all potential impacts. No preferred Joint POD alternative is identified in this final EIR. Any decision of the SWRCB on the Joint POD, whether it reflects one of the alternatives in the EIR, a combination of the EIR's alternatives, or a variant of one of the EIR's alternatives, will fall within the range of alternative actions described and analyzed. The potential impacts of any decision should be adequately identified and analyzed in this report and the decision will not result in addition of significant new information

The Joint POD alternatives are described below. In general, the Joint POD alternatives build on each other, with subsequent alternatives incorporating features of the previous alternatives, but allowing increasing exports. For purposes of this analysis, all but two of the alternatives assume that the SWP and the CVP are responsible for meeting the objectives in the 1995 Bay/Delta Plan. The flow objectives at Vernalis in Joint POD Alternatives 6 and 9 are different from those specified in the Bay/Delta Plan. In actuality, any of these alternatives could be combined with any of the flow alternatives described in Chapter II. For modeling purposes, Joint POD alternatives 1 through 6 and 9 include the installation and operation of temporary barriers in the south Delta, and Joint POD Alternatives 7 and 8 include the installation and operation of permanent barriers.

1. Joint POD Alternative 1 (No Project)

Under Joint POD Alternative 1 (base case), D-1485 objectives are in effect. The CVP is authorized to use the SWP's point of diversion in the Delta only to make up export deficiencies occurring in May and June caused by export restrictions in D-1485. This alternative is identical to Flow Alternative 1.

2. Joint POD Alternative 2

Under Joint POD Alternative 2, the 1995 Bay/Delta Plan objectives are in effect. Joint use of points of diversion is not authorized. This alternative differs from Flow Alternative 2, which is described in Chapter II and analyzed in Chapter VI, because in this alternative all objectives are met; however, in Flow Alternative 2, salinity objectives at Vernalis are not always met.

3. Joint POD Alternative 3

Under Joint POD Alternative 3, the 1995 Bay/Delta Plan objectives are in effect. The CVP is authorized to use the SWP's point of diversion in the Delta to deliver up to 129 TAF of contract water to the CVC, Musco Olive, Tracy Golf Course, and the Veterans' Administration Cemetery. Combined use of the SWP and the CVP points of diversion in the Delta is limited by the terms and conditions in SWP and CVP water right permits that specify diversion rates of the projects in the Delta. Use of the SWP point of diversion is further limited by USCOE PN 5820-A, as amended.

4. Joint POD Alternative 4

Under Joint POD Alternative 4, the 1995 Bay/Delta Plan objectives are in effect, and the Joint POD is authorized for the uses of water identified in Joint POD Alternative 3. Additionally, the Joint POD is authorized for uses of water to provide a net benefit to fish and wildlife. Any pumping losses incurred by either of the projects as a result of reductions to benefit fish may be made up within twelve months using either or both pumping plants. This alternative is modeled by assuming that exports are reduced during the April 15 through May 15 pulse flow to half the flows at Vernalis and that the reductions are made up through combined use of points of diversion in other months when pumping opportunities occur. Combined use of the SWP and the CVP points of diversion in the Delta is limited by the permitted diversion rates of the projects and by PN 5820-A, as amended.

5. Joint POD Alternative 5

This alternative builds on Joint POD Alternative 3; however, the use of water authorized under the Joint POD is not restricted to deliveries to the entities specified in that alternative. The 1995 Bay/Delta Plan objectives are in effect. Combined use of the SWP and the CVP points of diversion in the Delta is limited only by the permitted diversion rates of the projects in the Delta and by PN 5820-A, as amended.

6. Joint POD Alternative 6

The 1995 Bay/Delta Plan objectives are in effect except that minimum San Joaquin River flows at Vernalis are as specified in the Letter of Intent, as in Flow Alternative 7. Combined use of the SWP and the CVP points of diversion in the Delta is limited by the terms and conditions in SWP and CVP water right permits that specify diversion rates of the projects in the Delta. Use of the SWP point of diversion is further limited by PN 5820-A, as amended.

7. Joint POD Alternative 7

This alternative builds on Joint POD Alternative 5. The 1995 Bay/Delta Plan objectives are in effect. Joint use of the SWP and the CVP points of diversion in the Delta is limited by the permitted diversion rates of the projects in the Delta. The SWP and the CVP permits include instantaneous diversion and rediversion rates as well as rates of diversion to storage in San Luis Reservoir. The restrictions imposed by PN 5820-A are not in effect. For modeling purposes, the ISDP barriers are assumed to be installed and operated.

8. Joint POD Alternative 8

This alternative builds on Joint POD Alternative 7. The 1995 Bay/Delta Plan objectives are in effect. Joint use of the SWP and the CVP points of diversion in the Delta is limited only by the combined physical capacities of the pumping plants and by each project's annual authorized diversion. For modeling purposes, the ISDP barriers are assumed to be installed and operated. This alternative is modeled using the CVP's 2020 level of demand (3.6 MAF) and a method of operation designed to maximize deliveries and the use of Joint POD. This was done to create an alternative where maximum use of the Joint POD is authorized.

9. Joint POD Alternative 9

This alternative is the same as Alternative 5 except that the Vernalis pulse flows and export limits are replaced by the target values in the San Joaquin River Agreement. New Melones Reservoir is operated according to the New Melones Interim Plan of Operation. If water in excess of base flows during the San Joaquin River pulse flow period is needed to meet the Vernalis target flows, the San Joaquin tributaries group provides up to 110 TAF. Combined use of the SWP and the CVP points of diversion in the Delta is limited by the permitted diversion rates of the projects in the Delta. Use of the SWP point of diversion is further limited by the PN 5820-A, as amended.

D. WATER SUPPLY IMPACTS

This section describes the water supply impacts of the Joint POD alternatives. With two exceptions, these alternatives affect only the SWP and the CVP. The exceptions, Alternatives 6 and 9, assume implementation of the Letter of Intent and the San Joaquin River Agreement, respectively. These two alternatives have a water supply impact on some San Joaquin Basin water users. The water supply impact of implementation of these two alternatives is, however, already evaluated in Chapter VI. Consequently, this section and all following sections of this chapter will analyze only the changes to the SWP and the CVP system that result from combined use of points of diversion in the Delta.

The following discussion is divided into four sections: (1) SWP and CVP delivery impacts, (2) SWP wheeling for the CVP, (3) carryover storage in SWP and CVP reservoirs, and (4) transfer capacity.

1. SWP and CVP Delivery Impacts

Water delivery changes to SWP and CVP contractors for the 73-year average and the critical period are summarized in Table XIII-1. As modeled, the SWP receives no benefit for the combined use of points of diversion because the SWP never uses the CVP pumping facilities. In real operation, the SWP may occasionally use the CVP facilities if necessary for fish protection, but such an operation is likely to be rare.

Comparison of the deliveries under Joint POD Alternative 2 to the deliveries under Joint POD Alternatives 3 through 9 shows some effect on the SWP of the combined use of points of diversion, but this is due both to changes in availability of water in the Delta because of altered upstream CVP operations and to variability within the model. Comparison of the corresponding alternatives for the CVP, however, shows a substantial potential water supply benefit over the 73-year modeled hydrology for combined use of points of diversion. Over this period, the average annual water supply increase for the CVP ranges from 45 TAF to 247 TAF. The lower end of the range applies when combined use is limited by the export restrictions in the San Joaquin River Agreement (Alternative 9).

Table XIII-1
Water Delivery Changes (TAF)

73-Year Period Annual Average

	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8	Alt 9
SWP Deliveries	2,872	2,763	2,760	2,750	2,750	2,746	2,780	2,775	2,750
compared to Alt 1	--	-109	-112	-122	-122	-126	-92	-97	-122
compared to Alt 2	--	--	-3	-13	-13	-17	17	12	-13
CVP Deliveries	2,770	2,591	2,666	2,683	2,726	2,690	2,744	2,838	2,636
compared to Alt 1	--	-179	-104	-87	-44	-80	-26	68	-134
compared to Alt 2	--	--	75	92	135	99	153	247	45

1928-1934 Critical Period Average

	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8	Alt 9
SWP Deliveries	2,520	2,035	2,036	2,043	2,032	2,032	2,065	2,017	2,049
compared to Alt 1	--	-485	-484	-477	-488	-488	-455	-503	-471
compared to Alt 2	--	--	1	8	-3	-3	30	-18	14
CVP Deliveries	2,224	1,987	2,014	2,015	2,040	1,958	2,031	2,014	1,994
compared to Alt 1	--	-237	-210	-209	-184	-266	-193	-210	-230
compared to Alt 2	--	--	27	28	53	-29	44	27	7

When combined use under 1995 Bay/Delta Plan operation is authorized up to the diversion limits set forth in PN 5820-A (Flow Alternative 5), the annual average water supply increase is 135 TAF. When combined use under 1995 Bay/Delta Plan operation is authorized up to the physical export capacity of the projects, the annual average water supply increase is 247 TAF. The ISDP, or some closely related project, is probably necessary before the projects can increase pumping rates above the diversion limits set forth in PN 5820-A.

Table XIII-1 also shows that there is much less potential benefit to the CVP of combined use of points of diversion in the critical period. In dry periods, there is insufficient water available to realize appreciable benefits from combined use of points of diversion.

2. SWP Wheeling for the CVP

Table XIII-2 identifies the annual average quantity of water that is wheeled by the SWP at Banks pumping plant for the CVP under each alternative over the 73-year period and the critical period. A comparison of the alternatives is provided for both the base case and Alternative 2. Table XIII-2 shows that substantial wheeling is presently authorized under Alternative 1, the base case condition. Over the 73-year period, wheeling for Alternatives 3 through 9 ranges from 88 TAF to 347 TAF.

A comparison of Tables XIII-1 and XIII-2 shows that the average annual quantity of water wheeled relative to Alternative 2 is substantially more than the increased average annual CVP water supply relative to Alternative 2. For example, in Alternative 8 the increased annual average water supply deliveries are 247 TAF, but an annual average of 347 TAF is wheeled. The difference between these two quantities is due to altered operation of the CVP, which is able to fill its share of San Luis Reservoir earlier in the year through combined use of points of diversion and reduce pumping later in the season.

Table XIII-3 shows the monthly distribution of wheeled water under the alternatives for the 73-year average and the critical period. Under the base case operation, the water is wheeled in July and August. In Alternatives 3 through 9, the water is wheeled in every month except May, but the quantity of wheeled water is relatively small in March, April and June.

Table XIII-2
SWP Wheeling for CVP at Banks Pumping Plant (TAF)

73-Year Period Annual Average

	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8	Alt 9
SWP Wheeling	105	0	88	218	232	228	327	347	202
compared to Alt 1	--	-105	-17	113	127	123	222	242	97
compared to Alt 2	--	--	88	218	232	228	327	347	202

1928-1934 Critical Period Average

	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8	Alt 9
SWP Wheeling	44	0	36	47	45	33	64	51	38
compared to Alt 1	--	-44	-8	3	1	-11	20	7	-6
compared to Alt 2	--	--	36	47	45	33	64	51	38

3. Carryover Storage in SWP and CVP Reservoirs

Carryover storage is the amount of water retained in a reservoir at the end of September of each year. Carryover storage helps meet future demand in the event that the next year is dry. The amount of water dedicated to carryover storage is balanced against the amount needed to meet immediate delivery needs, hydropower generation needs, and instream flow requirements of a project, according to operation rules that differ for each reservoir. For the SWP and the CVP reservoirs, the operation rules have been determined through optimization studies. Reservoir operations are modeled in DWRSIM according to these rules.

Reservoirs in this analysis include Shasta, Oroville, Folsom and New Melones.
Tables XIII-4 and XIII-5 show carryover storage volumes in these reservoirs for the 73-year period and the critical period for the alternatives and for the base case. The differences in carryover storage between the alternatives and the base case (Alternative 1) are graphically represented in Figures XIII-2 through XIII-5. The differences in carryover storage between Alternatives 3 through 9 and Alternative 2 are graphically represented in Figures XIII-6 through XIII-9. The tables and figures indicate that carryover storage in the CVP reservoirs in the Sacramento Basin declines slightly for Alternatives 3 through 9 as wheeling quantities increase. This decline is due to the extra water being exported to CVP contractors through combined use of points of diversion. Unlike the Sacramento Basin CVP reservoirs, New Melones Reservoir carryover storage does not change due to combined use because this reservoir is not used to provide water for export. Carryover storage in New Melones

Reservoir is substantially improved for Alternative 6 and to a lesser extent Alternative 9 because reservoir releases for inbasin uses decline under the requirements in the Letter of Intent and the San Joaquin River Agreement, respectively.

Table XIII-3
SWP Wheeling of CVP Water (TAF)

73-Year Period Average Monthly Wheeling

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0	0	0	0	0	0	0	0	0	43	62	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	16	3	10	11	1	13	0	0	0	6	25	3
4	21	10	30	55	17	8	0	0	1	12	43	22
5	24	11	30	60	12	7	0	0	1	16	61	10
6	19	10	26	62	19	6	5	0	1	10	60	9
7	41	27	62	41	10	6	2	0	7	37	86	8
8	26	8	21	111	12	7	2	0	0	42	116	3
9	18	9	32	59	15	4	0	0	1	10	38	16

Critical Period Average Monthly Wheeling

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0	0	0	0	0	0	0	0	0	14	27	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	18	0	0	0	0	0	0	0	0	6	6	3
4	20	0	0	0	0	0	0	0	0	7	1	16
5	22	0	0	0	0	0	0	0	0	8	5	7
6	22	0	0	0	0	0	0	0	3	4	0	2
7	13	0	0	4	10	0	0	0	0	9	27	0
8	16	0	0	0	0	0	0	0	0	6	25	0
9	16	0	0	0	2	0	0	0	0	1	0	17

4. Transfer Capacity

The capacity to use the SWP and the CVP export facilities to transfer water was analyzed using the method described in Chapter V. This method assumes that the July through October period is the most likely period for water transfers to occur and the ability of the projects to accommodate water transfers depends on two factors: (1) unused pumping capacity at Banks and Tracy pumping plants and (2) the requirement that not more than 65 percent of Delta inflow can be exported during this period. The analysis does not consider other possible operational restrictions, such as storage or conveyance capacity south of the Delta. Lastly, the analysis assumes that parties selling water would release from storage, or bypass water, and this water would enter the Delta at the rate at which it was to be transferred.

Table XIII-4
Carryover Storage in Central Valley Reservoirs
73-Year Period Annual Average
(TAF)

Alternative	Shasta	Oroville	Folsom	New Melones
Alt. 1	2,910	2,310	481	1,543
Alt. 2	2,893	2,195	445	1,286
Alt. 3	2,863	2,182	434	1,291
Alt. 4	2,837	2,160	421	1,287
Alt. 5	2,836	2,188	423	1,292
Alt. 6	2,816	2,171	415	1,608
Alt. 7	2,827	2,182	422	1,292
Alt. 8	2,799	2,186	401	1,292
Alt 9	2,867	2,161	433	1,393

Table XIII-5
Carryover Storage in Central Valley Reservoirs
Critical Period Annual Average
(TAF)

Alternative	Shasta	Oroville	Folsom	New Melones
Alt. 1	1,944	1,608	261	1,104
Alt. 2	1,893	1,469	182	620
Alt. 3	1,836	1,408	182	624
Alt. 4	1,830	1,427	170	625
Alt. 5	1,848	1,412	186	625
Alt. 6	1,872	1,478	178	1,150
Alt. 7	1,837	1,484	187	625
Alt. 8	1,833	1,487	170	625
Alt 9	1,861	1,439	188	750

The results of the analysis are provided in Figures XIII-10 and XIII-11. The transfer capacity for Alternative 2 increases in comparison to Alternative 1 because the higher flow objectives in Alternative 2 deplete upstream reservoirs which reduces the ability of the projects to release water for export through the Delta in the July through October period. The transfer capacities of Alternatives 3, 4, 5, and 9 decline in comparison to Alternative 2 because the SWP is using some of its excess capacity to export CVP water. The transfer capacities of Alternatives 7 and 8 increase substantially because of the higher maximum SWP export level under these alternatives.

E. ENVIRONMENTAL EFFECTS OF IMPLEMENTING JOINT POD ALTERNATIVES IN THE DELTA

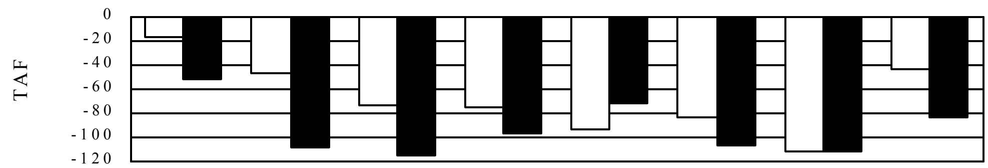
The evaluation of the environmental effects of implementing the Joint POD alternatives in the Delta is divided into the following sections: (1) hydrology, (2) salinity, and (3) fish and aquatic resources.

1. Hydrology

The principal factors affecting Delta hydrology are the tides, river inflow from the Sacramento and San Joaquin river systems, net Delta outflow and total SWP/CVP Delta exports. Tables XIII-6 through XIII-13 list the base case and Alternative 2 monthly flows of the Sacramento River at Freeport, the San Joaquin River at Vernalis, net Delta outflow and Delta export pumping for the 73-year period and the critical period. Below the base case and Alternative 2 flows are the reductions and increases in flows resulting from the Joint POD alternatives. Reductions in flow are expressed as negative values. Tables XIII-14 and XIII-15 list the modeled Export/Inflow ratios for the base cases and the Joint POD alternatives.

Figure XIII-2

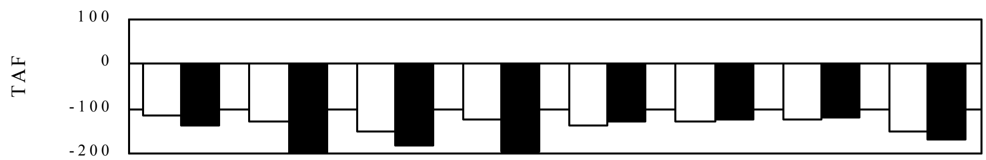
Shasta Lake Carryover Storage Impacts Compared to Alt 1



	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9
□ 73-Year Period Avg.	-17	-47	-73	-75	-94	-83	-111	-43
■ Critical Period Avg.	-51	-108	-115	-96	-72	-107	-112	-83

Figure XIII-3

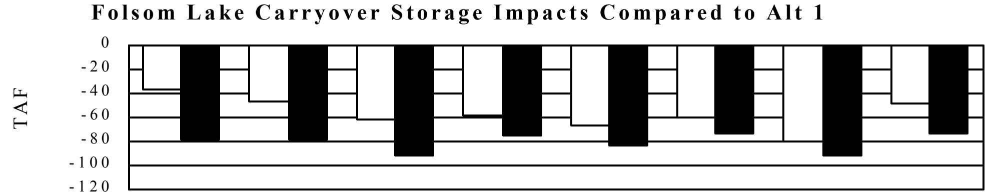
Lake Oroville Carryover Storage Impacts Compared to Alt 1



	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9
□ 73-Year Period Avg.	-115	-128	-150	-122	-139	-128	-124	-149
■ Critical Period Avg.	-139	-200	-181	-196	-130	-124	-121	-169

Figure XIII-4

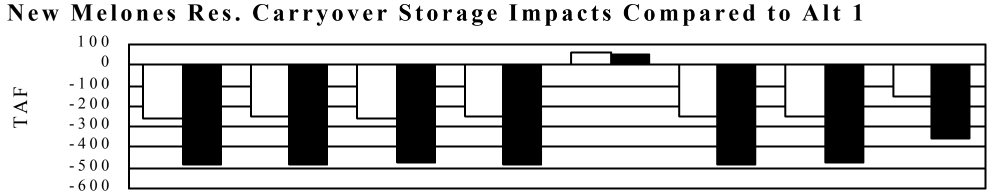
Folsom Lake Carryover Storage Impacts Compared to Alt 1



	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9
□ 73-Year Period Avg.	-36	-47	-61	-58	-66	-60	-80	-48
■ Critical Period Avg.	-79	-79	-91	-75	-83	-74	-91	-73

Figure XIII-5

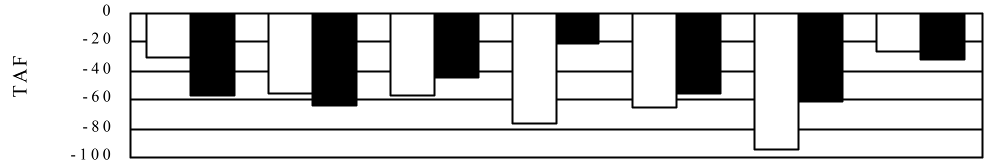
New Melones Res. Carryover Storage Impacts Compared to Alt 1



	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9
□ 73-Year Period Avg.	-257	-252	-256	-250	65	-251	-251	-150
■ Critical Period Avg.	-483	-480	-478	-479	47	-479	-478	-354

Figure XIII-6

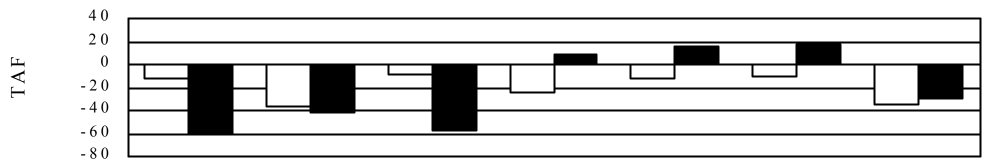
Shasta Lake Carryover Storage Impacts Compared to Alt 2



	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9
□ 73-Year Period Avg.	-30	-56	-57	-77	-65	-94	-26
■ Critical Period Avg.	-57	-64	-45	-21	-56	-61	-32

Figure XIII-7

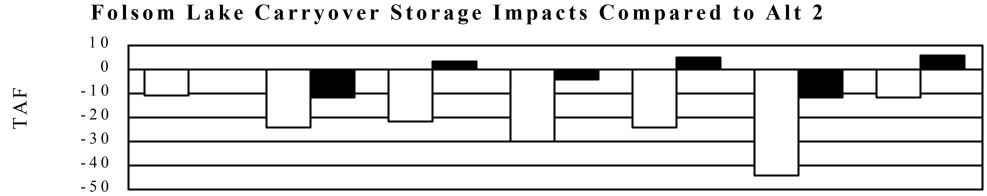
Lake Oroville Carryover Storage Impacts Compared to Alt 2



	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9
□ 73-Year Period Avg.	-13	-36	-8	-25	-13	-10	-34
■ Critical Period Avg.	-61	-42	-57	9	15	18	-30

Figure XIII-8

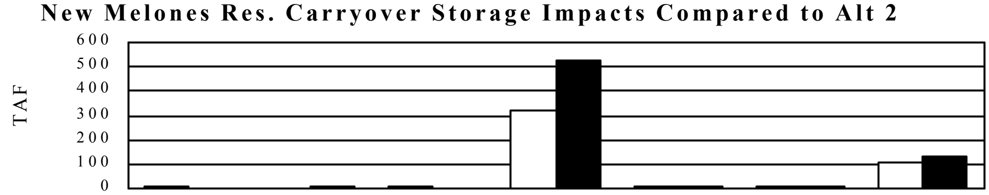
Folsom Lake Carryover Storage Impacts Compared to Alt 2



	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9
□ 73-Year Period Avg.	-11	-24	-22	-30	-24	-44	-12
■ Critical Period Avg.	0	-12	3	-4	5	-12	6

Figure XIII-9

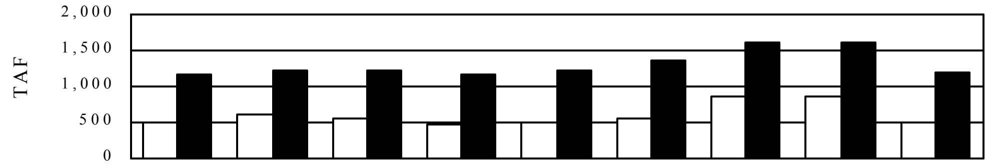
New Melones Res. Carryover Storage Impacts Compared to Alt 2



	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9
□ 73-Year Period Avg.	5	0	6	321	6	6	107
■ Critical Period Avg.	4	5	4	530	5	5	130

Figure XIII-10

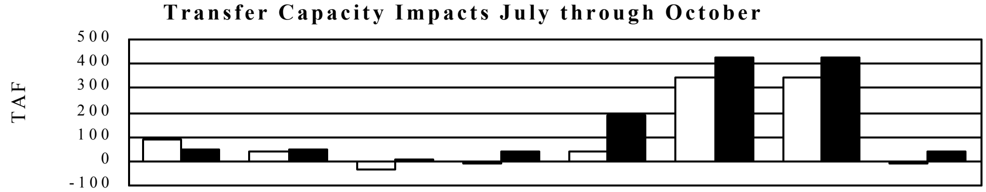
Average Transfer Capacity July through October



	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9
□ 72-Year Period Avg.	513	605	553	481	507	554	854	853	501
■ Critical Period Avg.	1,171	1,219	1,220	1,178	1,209	1,361	1,598	1,601	1,207

Figure XIII-11

Transfer Capacity Impacts July through October



	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9
□ 72-Year Period Avg.	92	40	-32	-6	41	341	340	-12
■ Critical Period Avg.	48	49	7	38	190	427	430	36

Comparison of the hydrology parameters of Alternatives 3 through 9 to Alternative 2 shows that overall there is not a large change in Delta hydrology due to combined use of points of diversion. The following observations, however, can be drawn from the tables.

1. In comparison to Alternative 2, average monthly exports over the 73-year period (Table XIII-12) under Alternatives 3 through 9 increase from July through January, except in September, due to SWP wheeling of CVP water. Exports then decrease for these alternatives in February and March because the CVP fills its share of San Luis Reservoir early.

2. The net Delta outflow pattern (Table XIII-10) is the opposite of the export pattern. Generally, net Delta outflow under Alternatives 3 through 9 decreases from July through January and increases in February and March, compared to Alternative 2.

3. The combined use of points of diversion does not affect flows at Vernalis. The flow changes at this location (Table XIII-8) are due to changes in the requirements.

Table XIII-6

Sacramento River Flow at Freeport, 73-Year Period

Alternative 1 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
14,211	17,053	24,238	32,539	38,481	35,441	23,335	19,893	16,904	16,385	13,951	11,812

Change in Flow from Alternative 1 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-693	-28	-662	-691	102	253	262	-252	2862	670	-1644	169
3	-510	-197	-782	-751	-100	123	242	-285	2849	937	-1216	20
4	-736	-420	-843	-924	-264	123	-35	-444	3095	1205	-649	179
5	-619	-299	-892	-790	-212	126	226	-319	2844	1050	-740	-77
6	-785	-591	-1025	-892	-402	74	1145	-901	3408	1032	-522	-190
7	-680	-470	-944	-741	-267	-87	228	-291	2868	2528	-1314	-545
8	-590	-715	-1048	-807	-378	-138	214	-257	2900	2645	-772	-725
9	-701	-361	-813	-770	-185	132	-73	-477	2930	1215	-661	37

Alternative 2 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
13,518	17,026	23,576	31,848	38,583	35,694	23,598	19,641	19,766	17,055	12,307	11,982

Change in Flow from Alternative 2 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3	184	-169	-120	-60	-202	-130	-20	-33	-13	267	428	-150
4	-43	-393	-181	-233	-366	-130	-298	-192	234	536	995	10
5	74	-271	-231	-99	-314	-128	-37	-67	-18	380	905	-246
6	-92	-563	-363	-201	-504	-179	882	-649	546	362	1123	-360
7	13	-442	-282	-50	-369	-340	-34	-39	6	1858	330	-715
8	103	-687	-386	-116	-480	-391	-48	-6	39	1975	873	-894
9	-8	-334	-151	-79	-287	-121	-336	-225	68	545	983	-133

Table XIII-7

Sacramento River Flow at Freeport, Critical Period

Alternative 1 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10,186	8,893	12,867	16,315	15,126	14,694	10,534	10,121	11,029	14,321	12,063	8,107

Change in Flow from Alternative 1 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-1213	426	-735	-697	-1123	813	972	1519	3330	-913	-2158	283
3	-920	356	-664	-613	-934	-33	1053	1429	3239	-332	-2005	221
4	-890	317	-773	-781	-1246	-65	546	994	3971	-42	-1875	432
5	-869	303	-705	-697	-1057	-98	1062	1471	3328	-184	-2068	288
6	-806	207	-767	-737	-1183	41	2972	353	3839	-1252	-2391	271
7	-978	328	-718	-653	-973	-22	1053	1468	3558	335	-2679	74
8	-946	353	-670	-651	-1006	-43	992	1457	3659	286	-2623	106
9	-1013	333	-783	-781	-1321	57	387	957	3818	-102	-1982	435

Alternative 2 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
8,973	9,319	12,133	15,618	14,003	15,507	11,506	11,640	14,359	13,408	9,904	8,391

Change in Flow from Alternative 2 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3	293	-70	70	84	189	-846	81	-91	-91	581	153	-62
4	323	-109	-38	-84	-123	-878	-426	-525	641	871	283	149
5	344	-123	30	0	66	-911	90	-49	-2	730	91	5
6	407	-218	-33	-41	-60	-773	2000	-1166	509	-339	-232	-12
7	235	-98	16	43	150	-835	81	-51	228	1248	-520	-209
8	267	-73	65	46	117	-857	20	-63	329	1199	-465	-178
9	200	-93	-49	-84	-198	-756	-585	-562	488	811	177	151

Table XIII-8

San Joaquin River Flow at Vernalis, 73-Year Period

Alternative 1 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3,169	2,076	2,927	4,413	6,808	6,177	5,448	4,653	3,722	1,798	1,361	1,874

Change in Flow from Alternative 1 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-60	-86	-177	-267	-436	-100	350	739	177	226	276	-37
3	-55	-78	-170	-256	-439	-113	351	741	181	230	280	-31
4	-61	-80	-170	-258	-457	-129	370	759	192	231	281	-29
5	-53	-76	-167	-253	-435	-112	351	741	184	233	284	-27
6	382	41	165	155	163	71	-48	260	266	228	-11	-191
7	-55	-77	-166	-248	-420	-112	352	729	184	234	284	-25
8	-51	-74	-163	-247	-422	-123	361	730	179	235	283	-28
9	-57	-104	-67	-105	-306	-6	432	938	195	154	-63	-67

Alternative 2 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3,108	1,990	2,750	4,146	6,372	6,077	5,797	5,392	3,900	2,024	1,638	1,837

Change in Flow from Alternative 2 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3	6	8	8	11	-3	-12	1	2	3	4	4	6
4	0	6	8	9	-21	-29	20	20	15	4	5	8
5	8	10	10	14	1	-12	2	2	7	7	7	10
6	442	126	342	422	599	171	-398	-479	88	2	-287	-154
7	5	9	11	19	16	-11	2	-10	7	8	8	12
8	10	12	14	20	13	-23	11	-9	2	9	6	9
9	-75	110	100	7	-94	29	300	328	133	-21	-107	3

Table XIII-9

San Joaquin River Flow at Vernalis, Critical Period

Alternative 1 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1,870	1,442	1,675	1,778	2,983	2,231	2,409	1,770	1,277	1,099	1,138	1,464

Change in Flow from Alternative 1 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	60	-129	-149	-141	-297	-30	210	827	281	258	272	-36
3	60	-126	-146	-138	-300	-30	210	827	283	258	274	-31
4	58	-126	-146	-138	-302	-30	210	827	283	258	274	-31
5	60	-126	-146	-138	-300	-30	210	827	283	258	276	-31
6	70	-95	-46	19	71	68	106	346	226	223	-225	-238
7	60	-126	-146	-138	-300	-30	213	827	283	260	274	-31
8	60	-129	-146	-138	-302	-30	210	827	281	249	272	-38
9	-57	-104	-67	-105	-306	-6	432	938	195	154	-63	-67

Alternative 2 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1,931	1,314	1,526	1,637	2,686	2,201	2,619	2,598	1,558	1,357	1,410	1,428

Change in Flow from Alternative 2 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3	0	3	3	3	-3	0	0	0	2	0	2	5
4	-2	3	3	3	-6	0	0	0	2	0	2	5
5	0	3	3	3	-3	0	0	0	2	0	5	5
6	9	34	103	160	367	98	-104	-481	-55	-35	-497	-202
7	0	3	3	3	-3	0	3	0	2	2	2	5
8	0	0	3	3	-6	0	0	0	0	-9	0	-2
9	-118	24	82	36	-9	24	222	110	-86	-104	-335	-31

Table XIII-10

Delta Outflow, 73-Year Period

Alternative 1 Average Monthly Flow (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	8,216	9,974	22,176	38,689	49,942	42,012	24,417	18,415	12,891	6,627	3,870	4,145

Change in Flow from Alternative 1 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-911	582	-282	-555	944	857	3084	165	376	59	178	527
3	-983	390	-584	-829	817	728	3096	168	380	59	168	432
4	-1191	90	-972	-1564	868	1198	3769	751	505	35	156	332
5	-1177	233	-995	-1471	1206	1174	3092	126	373	35	180	355
6	-830	-11	-910	-1259	1370	1315	1987	795	743	45	147	253
7	-1801	-673	-1742	-686	1779	1132	2887	14	166	-7	149	-105
8	-1534	-717	-1317	-2511	1552	976	2943	15	181	45	194	-107
9	-1315	229	-910	-1402	1091	1371	3981	842	469	33	165	371

Alternative 2 Average Monthly Flow (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	7,305	10,556	21,893	38,134	50,886	42,869	27,501	18,580	13,267	6,686	4,048	4,672

Change in Flow from Alternative 2 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3	-72	-191	-302	-274	-127	-129	11	3	4	0	-10	-95
4	-279	-491	-689	-1009	-76	341	684	586	129	-25	-22	-195
5	-266	-349	-713	-916	262	317	8	-39	-3	-25	2	-172
6	82	-593	-628	-704	426	458	-1097	630	367	-14	-32	-273
7	-890	-1255	-1460	-131	835	275	-197	-151	-210	-67	-30	-632
8	-623	-1299	-1035	-1956	608	119	-141	-149	-195	-15	15	-634
9	-404	-353	-627	-847	147	514	897	677	93	-26	-13	-156

Table XIII-11

Delta Outflow, Critical Period

Alternative 1 Average Monthly Flow (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	5,708	3,050	5,998	10,604	8,443	8,118	8,190	4,800	4,228	3,973	4,842	2,650

Change in Flow from Alternative 1 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-1531	1759	-374	-2163	3148	4632	1101	3566	3229	883	-957	379
3	-1545	1759	-374	-2133	3271	4467	1104	3573	3229	883	-957	384
4	-1545	1759	-388	-2198	2818	4348	1207	3559	3460	883	-971	384
5	-1545	1756	-388	-2168	3079	4372	1109	3576	3229	883	-957	384
6	-1380	1532	-366	-2095	3061	4310	983	3722	3724	883	-911	379
7	-1554	1756	-634	-3234	3118	4567	1109	3580	3308	883	-957	379
8	-1564	1756	-599	-3169	3263	4527	1123	3583	3311	883	-957	379
9	-1779	1754	-363	-2180	2766	4399	1249	3548	3399	883	-830	385

Alternative 2 Average Monthly Flow (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	4,177	4,809	5,624	8,441	11,591	12,751	9,291	8,366	7,457	4,856	3,885	3,030

Change in Flow from Alternative 2 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3	-14	0	0	30	123	-165	3	7	0	0	0	5
4	-14	0	-14	-35	-330	-285	106	-7	230	0	-14	5
5	-14	-3	-14	-5	-69	-260	8	9	0	0	0	5
6	151	-227	8	68	-87	-323	-118	156	495	0	46	0
7	-23	-3	-260	-1071	-30	-65	8	14	79	0	0	0
8	-33	-3	-225	-1006	115	-106	22	16	82	0	0	0
9	-248	-5	11	-17	-382	-234	148	-18	170	0	127	5

Table XIII-12

Total Delta Exports, 73-Year Period

Alternative 1 Average Monthly Exports (TAF)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
	534	578	624	611	544	526	527	358	323	526	592	514	6,256

Change in Exports from Alternative 1 (TAF)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2	8	-42	-34	-25	-72	-45	-150	15	152	44	-101	-26	-276
3	24	-40	-23	-11	-76	-46	-152	13	151	61	-74	-29	-202
4	23	-35	-3	23	-89	-75	-207	-32	159	79	-38	-14	-209
5	30	-36	-4	26	-104	-73	-152	13	151	70	-45	-30	-155
6	22	-32	3	32	-90	-75	-60	-101	158	57	-56	-45	-188
7	64	7	39	-19	-138	-83	-140	21	165	163	-79	-31	-30
8	53	-5	6	90	-132	-77	-144	23	166	167	-48	-41	59
9	25	-34	1	23	-104	-84	-205	-25	153	75	-47	-23	-246

Alternative 2 Average Monthly Exports (TAF)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
	542	536	590	586	472	482	377	373	474	570	491	487	5980

Change in Exports from Alternative 2 (TAF)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
3	16	2	12	14	-4	-1	-2	-2	-1	17	27	-3	74
4	15	6	32	48	-17	-31	-57	-47	7	35	63	13	66
5	21	5	30	51	-32	-28	-3	-2	-1	25	56	-4	120
6	14	9	37	57	-18	-31	90	-116	6	13	45	-19	88
7	56	49	73	6	-67	-38	10	6	13	119	23	-4	245
8	45	37	41	115	-60	-33	6	8	14	123	53	-15	334
9	17	8	35	48	-32	-40	-55	-40	2	31	54	4	31

Table XIII-13

Total Delta Exports, Critical Period

Alternative 1 Average Monthly Exports (TAF)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
	335	410	573	591	657	573	231	334	295	480	366	326	5171

Change in Exports from Alternative 1 (TAF)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2	22	-87	-32	81	-255	-237	4	-80	15	-102	-64	-11	-747
3	40	-92	-27	85	-252	-279	8	-86	10	-67	-54	-15	-728
4	42	-94	-33	78	-244	-274	-28	-112	40	-49	-45	-3	-720
5	44	-95	-29	82	-248	-277	8	-84	16	-57	-58	-11	-709
6	38	-85	-28	84	-233	-259	124	-191	15	-124	-110	-23	-792
7	38	-93	-14	150	-245	-284	8	-85	24	-26	-96	-23	-646
8	40	-92	-14	146	-256	-284	3	-85	30	-29	-93	-22	-654
9	42	-91	-30	79	-248	-268	-28	-108	32	-55	-79	-2	-757

Alternative 2 Average Monthly Exports (TAF)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
	356	323	542	672	402	336	234	254	311	378	302	315	4424

Change in Exports from Alternative 2 (TAF)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
3	19	-5	5	3	4	-42	5	-6	-5	36	10	-4	19
4	21	-7	-1	-3	11	-36	-32	-32	25	54	19	9	28
5	22	-7	3	0	8	-40	5	-4	0	45	6	0	38
6	16	2	4	3	22	-21	121	-110	-1	-21	-47	-12	-45
7	16	-6	17	69	10	-47	5	-4	9	76	-32	-12	102
8	18	-5	18	65	0	-46	0	-5	15	73	-29	-11	94
9	21	-4	1	-2	7	-31	-31	-28	16	47	-15	9	-11

Table XIII-14

Delta Export/Inflow Ratio, 73-Year Period

Base Case Average Monthly E/I Ratio*

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.48	0.55	0.45	0.33	0.28	0.27	0.36	0.28	0.28	0.43	0.55	0.58

1995 WQCP Monthly E/I Objective

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0.65	0.65	0.65	0.65	0.35**	0.35**	0.35**	0.35**	0.35**	0.65	0.65	0.65

Joint POD Alternatives Average Monthly E/I Ratio

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	0.52	0.50	0.44	0.35	0.21	0.22	0.22	0.24	0.32	0.43	0.48	0.55
3	0.53	0.50	0.45	0.35	0.21	0.22	0.22	0.24	0.32	0.44	0.50	0.55
4	0.53	0.51	0.46	0.37	0.21	0.21	0.19	0.21	0.32	0.45	0.51	0.56
5	0.53	0.51	0.46	0.38	0.20	0.21	0.22	0.24	0.32	0.44	0.51	0.55
6	0.52	0.52	0.46	0.38	0.21	0.21	0.28	0.16	0.32	0.43	0.50	0.54
7	0.56	0.54	0.48	0.36	0.19	0.21	0.23	0.25	0.32	0.47	0.50	0.56
8	0.55	0.53	0.47	0.41	0.19	0.21	0.23	0.25	0.32	0.47	0.51	0.55
9	0.53	0.51	0.46	0.37	0.20	0.20	0.19	0.22	0.32	0.44	0.51	0.55

*There is no E/I objective under D-1485

**Is increased to 0.45 if the Eight River Index for January is less than or equal to 1.0 MAF

Table XIII-15

Delta Export/Inflow Ratio, Critical Period

Base Case Average Monthly E/I Ratio*

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.41	0.60	0.58	0.49	0.62	0.58	0.27	0.42	0.37	0.47	0.39	0.51

1995 WQCP Monthly E/I Objective

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0.65	0.65	0.65	0.65	0.35**	0.35**	0.35**	0.35**	0.35**	0.65	0.65	0.65

Joint POD Alternatives Average Monthly E/I Ratio

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	0.49	0.46	0.58	0.59	0.39	0.30	0.25	0.26	0.29	0.34	0.33	0.49
3	0.50	0.45	0.58	0.59	0.39	0.27	0.26	0.26	0.28	0.35	0.34	0.48
4	0.50	0.45	0.58	0.59	0.40	0.28	0.22	0.24	0.31	0.37	0.34	0.49
5	0.50	0.45	0.58	0.59	0.39	0.28	0.26	0.26	0.29	0.36	0.33	0.49
6	0.49	0.47	0.58	0.59	0.40	0.29	0.35	0.16	0.27	0.31	0.27	0.48
7	0.50	0.45	0.59	0.64	0.40	0.27	0.26	0.26	0.29	0.37	0.32	0.48
8	0.50	0.45	0.59	0.64	0.39	0.27	0.26	0.26	0.29	0.37	0.32	0.48
9	0.52	0.45	0.58	0.59	0.40	0.28	0.22	0.24	0.30	0.36	0.29	0.49

*There is no E/I objective under D-1485

**Is increased to 0.45 if the Eight River Index for January is less than or equal to 1.0 MAF

2. Salinity

This section analyzes salinity conditions under the eight Joint POD alternatives and the base case. Joint use of points of diversion are not authorized under Alternative 2, however for simplicity it will be referred to as a Joint POD alternative in this section. Two analyses are discussed below to illustrate the alternatives' effects on salinity in the Estuary. In the first analysis, the position of X2, the two parts per thousand (ppt) isohaline position, for each of the Joint POD alternatives is compared with the X2 position of the base case. In the second analysis, the electrical conductivity (EC) of the alternatives at six stations throughout the Delta is compared to that of the base case.

a. **X2**. X2 is defined as the distance from the Golden Gate bridge in kilometers (km) of the two ppt isohaline at a depth of one meter from the bottom of the channel. The 1995 Bay/Delta Plan provides that the Delta outflow objectives are met from February through June if the location of the X2 isohaline is downstream of specified locations for a certain number of days per month.

DWRSIM was used to determine the location of the X2 isohaline position for each of the eight Joint POD alternatives and the base case. The model predicts the location of X2 as a function of the current and previous months' flows (see section A of Chapter IV). Table XIII-16 shows the monthly average X2 positions for Alternative 1 for the 73-year flow record as predicted by the model. The table also compares the base case monthly average X2 positions to the X2 positions for each of the Joint POD alternatives. The significance of the changes in the X2 position are related to their effects on aquatic resources in the Delta. Positive changes indicate westward movement of the X2 line, which is generally desirable for aquatic species in the Estuary; negative changes indicate a shift toward the Delta.

There are only minor differences in the X2 position among Joint POD Alternatives 2 through 9. This result is expected because monthly average Delta outflow varies little among these alternatives. Compared to the base case, Alternatives 2 through 9 move in the upstream direction in January, October, and December, and move downstream approximately one to three kilometers from February through September. The greatest downstream movement occurs in April and June. Alternative 2 results in the most downstream X2 position of the eight alternatives for six consecutive months (September through February). This movement of the X2 location is due to implementation of the flow alternatives described in Chapter VI, not implementation of the Joint POD alternatives. No significant adverse effects to the environment are expected due to the change in the X2 position.

b. **EC Within the Delta**. DWRDSM was used to determine the effect of the Joint POD alternatives on EC in the Delta. DWRDSM uses the hydrology generated by DWRSIM studies as input. Thus, modeling assumptions for DWRSIM, discussed in Chapter IV, also apply to this salinity analysis. DWRDSM is not intended to provide absolute predictions of future Delta hydrodynamic and EC conditions; rather, the model is best used as a tool to compare Delta conditions under alternative actions.

Table XIII-16
Modeled Isohaline (X2) Position

73-Year Period Average Monthly X2 Position from the Golden Gate Bridge (km)

Alternative 1

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
83.0	82.4	77.2	70.4	66.4	66.1	70.8	73.3	76.6	80.9	85.7	88.1

Change in X2 Position (km)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2 vs 1	-0.8	1.1	0.2	-0.5	1.1	1.4	3.0	1.9	2.5	1.5	1.0	1.5
3 vs 1	-1.0	0.9	-0.1	-0.7	1.1	1.4	3.0	1.9	2.5	1.5	1.0	1.4
4 vs 1	-1.2	0.6	-0.4	-1.1	0.9	1.4	3.3	2.3	2.7	1.6	1.0	1.2
5 vs 1	-1.2	0.7	-0.4	-1.1	1.0	1.5	3.0	1.9	2.5	1.5	1.0	1.3
6 vs 1	-1.0	0.5	-0.4	-1.0	1.0	1.5	2.6	2.1	2.8	1.6	1.0	1.1
7 vs 1	-1.8	-0.1	-1.0	-1.1	1.1	1.4	3.0	1.8	2.4	1.4	1.0	0.8
8 vs 1	-1.7	0.0	-0.7	-1.6	0.9	1.3	3.0	1.9	2.4	1.4	1.0	0.7
9 vs 1	-1.2	0.8	-0.3	-1.0	1.0	1.5	3.4	2.3	2.6	1.5	1.0	1.3

Alternative 2

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
83.8	81.3	77.0	70.9	65.3	64.7	67.8	71.4	74.1	79.4	84.7	86.6

Change in Exports from Alternative 2 (TAF)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3 vs 2	-0.2	-0.2	-0.3	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
4 vs 2	-0.4	-0.5	-0.6	-0.6	-0.2	0.0	0.3	0.4	0.2	0.1	0.0	-0.3
5 vs 2	-0.4	-0.4	-0.6	-0.6	-0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.2
6 vs 2	-0.2	-0.6	-0.6	-0.5	-0.1	0.1	-0.4	0.2	0.3	0.1	0.0	-0.4
7 vs 2	-1.0	-1.2	-1.2	-0.6	0.0	0.0	0.0	-0.1	-0.1	-0.1	0.0	-0.7
8 vs 2	-0.9	-1.1	-0.9	-1.1	-0.2	-0.1	0.0	0.0	-0.1	-0.1	0.0	-0.8
9 vs 2	-0.4	-0.3	-0.5	-0.5	-0.1	0.1	0.4	0.4	0.2	0.0	0.0	-0.2

This analysis examines the results of the simulations at 13 locations in the Delta: three locations in the western Delta (Contra Costa Canal at Pumping Plant #1/Rock Slough, Sacramento River at Emmaton, and San Joaquin River at Jersey Point), three locations in the Central Delta (South Fork Mokelumne River at Terminous, San Joaquin River at San Andreas Landing and San Joaquin River at Prisoners Point) and seven locations in the southern Delta (Contra Costa Los Vaqueros intake, San Joaquin River at Vernalis, San Joaquin River at Tracy Road Bridge, San Joaquin River at Brandt Bridge, Old River at Middle River, Banks Pumping Plant and Tracy Pumping Plant). Figures XIII-12 through XIII-72 show expected EC conditions at these locations, except for Contra Costa Canal Pumping Plant # 1, Contra Costa Los Vaqueros intake, Banks Pumping Plant, and Tracy Pumping Plant where chloride concentrations are reported. The figures compare the eight alternatives and the base case for water years 1976 through 1991.

Where possible, objectives have been noted on the figures. EC objectives for stations in the southern Delta are the same for all year types, while EC objectives at the other stations change based on the year type. One figure is provided for each of the water-year types. The first figure for each station shows the average EC (or chloride concentration) for wet years during the sixteen-year period, the second figure shows the average for above normal years, and so on.

Year types are as defined in the 1995 Bay/Delta Plan. The 40-30-30 Sacramento Basin year type classification system is used for the western and central Delta stations, as well as the Contra Costa/Los Vaqueros intake and Banks and Tracy pumping plants, and the 60-20-20 San Joaquin Basin year type classification is used for the southern Delta stations (San Joaquin River at Vernalis, San Joaquin River at Brandt Bridge, Old River at Tracy Road Bridge, and Old River near Middle River). Since there are no below normal year types occuring during the 1976 - 1991 study period under the 60-20-20 San Joaquin Basin Index convention, below normal year graphs are omitted for the southern Delta stations.

Modeled chloride concentrations at Contra Costa Canal Pumping Plant #1 are shown in Figures XIII-12 through XIII-16. A feature of these plots is that the maximum mean daily chloride objective is exceeded in some periods by all of the alternatives. This result is due to differences between the methods used by DWRSIM and DWRDSM to calculate salinity or chloride concentrations. DWRSIM, the operations model, uses a relationship between outflow and chloride or EC to determine concentrations of these parameters at selected western Delta stations, including the Contra Costa Pumping Plant # 1. DWRSIM makes reservoir releases as necessary to meet objectives at these locations, and DWRSIM output indicates that these objectives are always met. The hydrologic output from DWRSIM is used as input to DWRDSM, which uses a more complicated method for calculating salinity and chloride concentrations. The method used by DWRDSM considers other factors such as exports, barrier operations and tide cycles. Thus, output from DWRDSM may show violations of the chloride objective even when DWRSIM output indicates objectives are met.

In summary, the DWRDSM output indicates a need for carriage water, but the DWRSIM model does not presently include a method for calculating carriage water. Although the DWRDSM output predicts that salinity objectives at certain locations would be violated, in actual operations, the projects would be operated to meet salinity and chloride objectives in the western Delta for all of the alternatives, and violations would not be expected to occur. Because of the conditions described above, salinity information depicted in Figures XIII-12 through XIII-72 is generally discussed relative to base case salinity, rather than to the objectives.

Contra Costa Canal at Pumping Plant No.1. Figure XIII-12 shows that, in wet years, chloride levels under each of the alternatives are well below the 250 mg/l maximum mean daily chloride objective. Alternatives 2 through 9 result in lower chloride levels in June through September, and higher chloride levels relative to the base case in October.

In above normal years, Figure XIII-13 shows that Alternatives 2 through 9 result in higher chloride levels in November and December relative to the base, and lower chloride levels in June, August and September. High chloride levels for Alternatives 7 and 8 are also evident in the fall months because of the higher authorized export rates.

Below normal years show the most dramatic differences between the base case and the alternatives. As shown in Figure XIII-14, average chloride levels in July, August and September for each of the alternatives are approximately 50, 100, and 150 mg/l, respectively, contrasted with the base case which has chloride levels of 227, 364, and 332 mg/l for the same months. Higher chloride levels in the fall months for Alternatives 7 and 8 are also evident.

A similar pattern emerges in dry years (Figure XIII-15), with Alternatives 2 through 9 having lower chloride levels than the base case in June through September. Base case chloride levels are dramatically lower in January. Chloride levels are higher for Alternatives 7 and 8 in July and October than for the other alternatives due to higher exports.

In critical years (Figure XIII-16), the eight alternatives show dramatic improvement over the base case from March through August. In July particularly, chloride levels for Alternatives 2 through 9 are approximately 100 mg/l while base case chloride levels are 330 mg/l. The base case results in lower chloride levels in all other months except November.

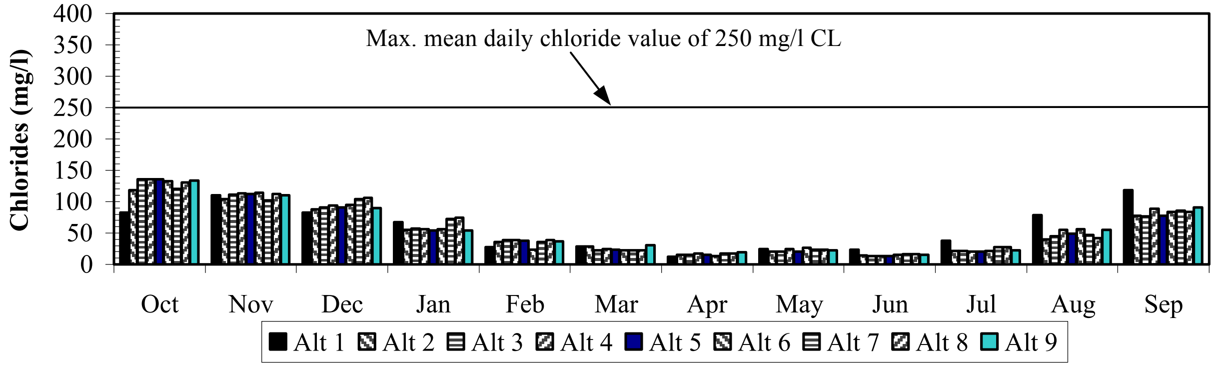
Los Vaqueros Intake on Old River. Figures XIII-17 through XIII-21 show modeled chlorides for Contra Costa Water District's Los Vaqueros Reservoir intake on Old River. In wet years there are no appreciable differences between the base case and the eight Joint POD alternatives. In above normal years, the base case is somewhat higher than the other alternatives in September, but lower in December. In below normal years (Figure XIII-19) chloride levels for the alternatives during July, August, and September are around 50, 75, and 100 mg/l, respectively, while the base case chlorides are 115, 210, and 185 for the same period. Alternatives 7 and 8 are highest during October, November, and December because of higher authorized export rates.

In dry years (Figure XIII-20), the base case salinity is considerably higher from June through September, and considerably lower in December, January and February. In critical years, the base case is higher in June, July and August, and lower in December, January and February.

The 1995 Bay/Delta Plan does not set water quality objectives for the Los Vaqueros intake. However, State Health and Safety regulations and USEPA regulations specify a drinking water standard of 250 mg/l chlorides. The SWRCB may, in a future triennial review of the Basin Plan for the Bay/Delta, set a chloride objective for the Los Vaqueros intake. None of the modeled Joint POD alternatives appear to exceed the chloride standard at this location.

Banks Pumping Plant and Tracy Pumping Plant. Figures XIII-22 through XIII-26 show modeled chlorides for the SWP Banks pumping plant. Figures XIII-27 through XIII-31 show modeled chlorides for the CVP Tracy pumping plant. Because of the close proximity of their respective intakes, the results are similar.

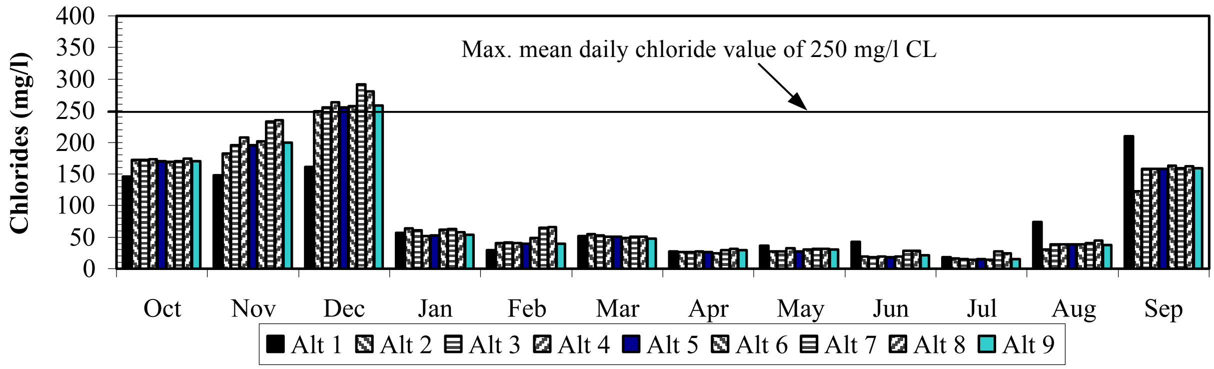
Figure XIII-12
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Wet Years



For a Wet water year; 240 (66%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

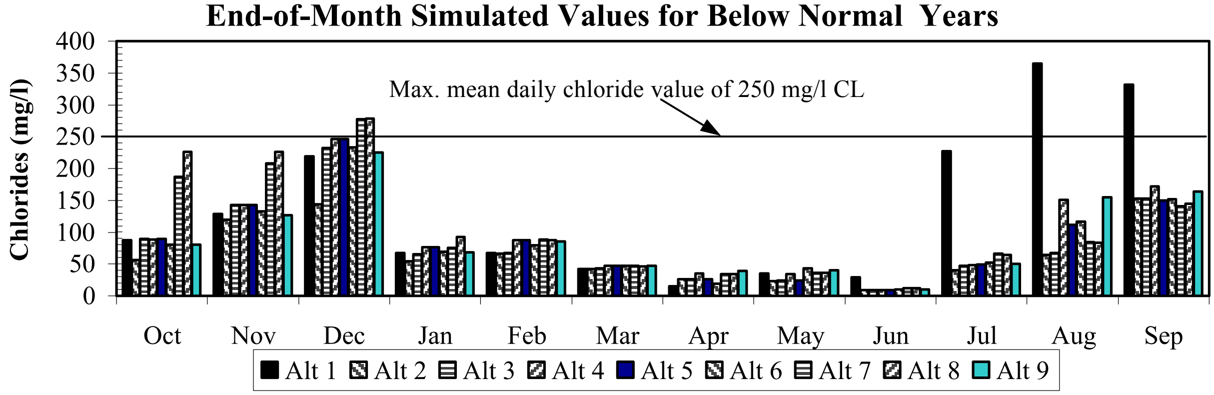
Figure XIII-13
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Above Normal Years



For a Above Normal water year; 190 (52%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

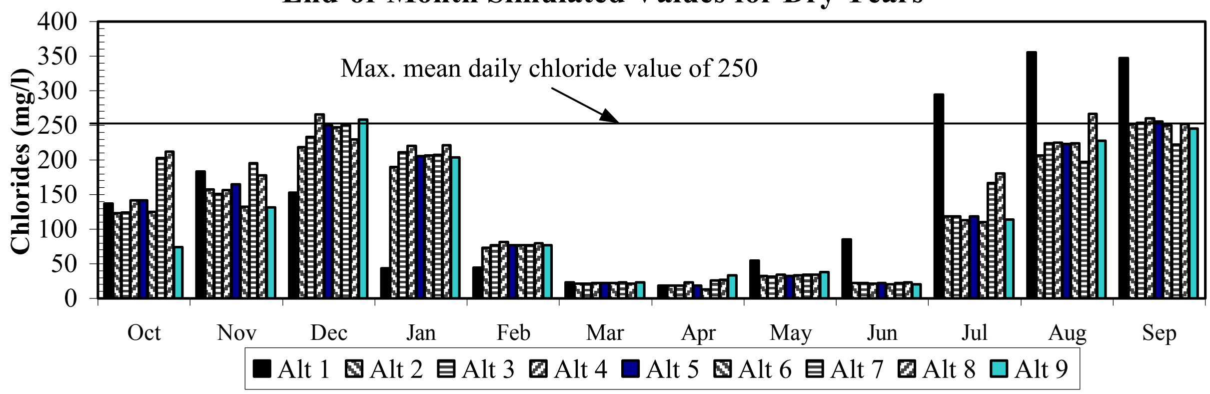
Figure XIII-14
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Below Normal Years



For a Below Normal water year; 175 (48%) days <= 150 mg/l
Salinity objectives are the same for D-1485 & Bay/Delta

Sacramento "40-30-30" **below normal** year (1979)

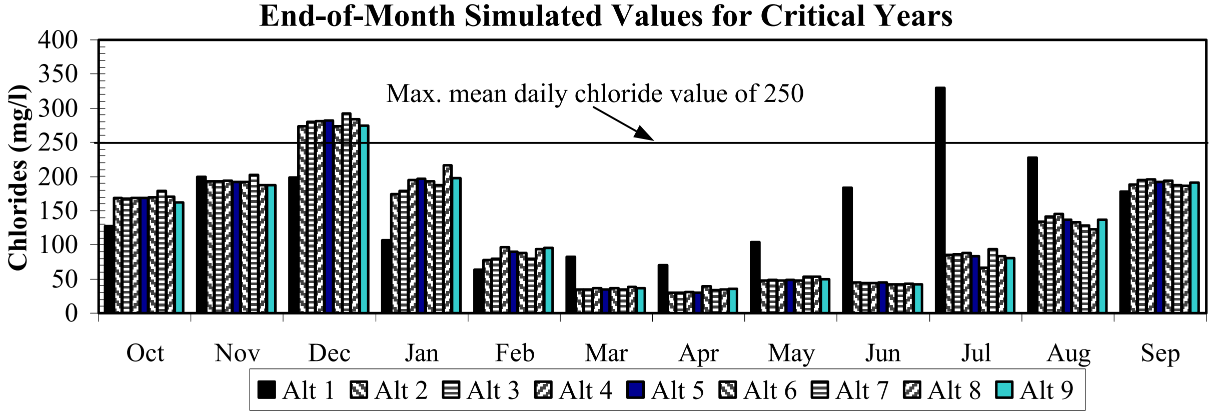
Figure XIII-15
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Dry Years



For a Dry water year; 165 (45%) days <= 150 mg/l CL
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

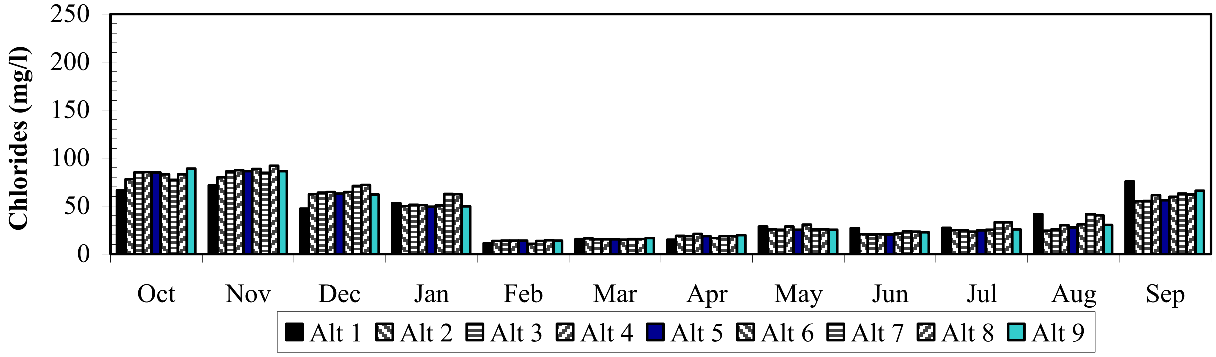
Figure XIII-16
Salinity for Contra Costa Canal at Pumping Plant #1
End-of-Month Simulated Values for Critical Years



For a Critical water year; 155 (42%) days <= 150 mg/l
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

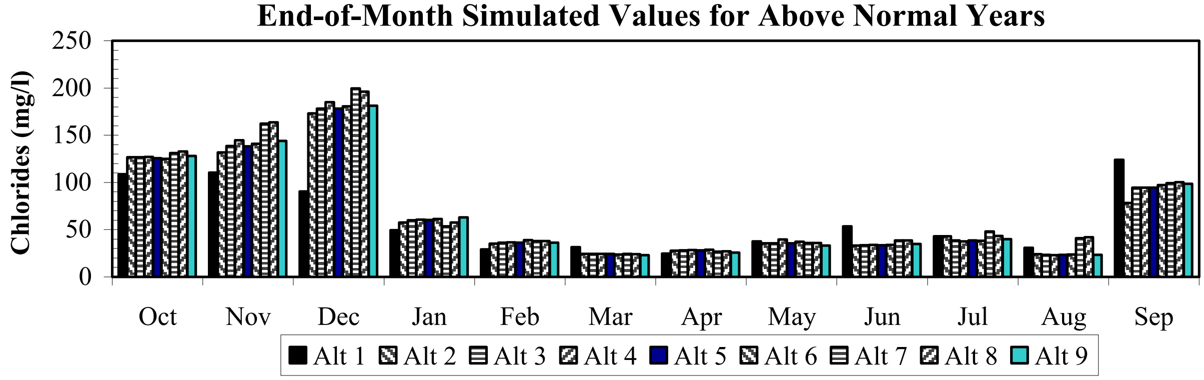
Figure XIII-17
Chloride Levels for Los Vaqueros Intake on Old River
End-of-Month Simulated Values for Wet Years



Water quality objectives have not been established at the location.

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

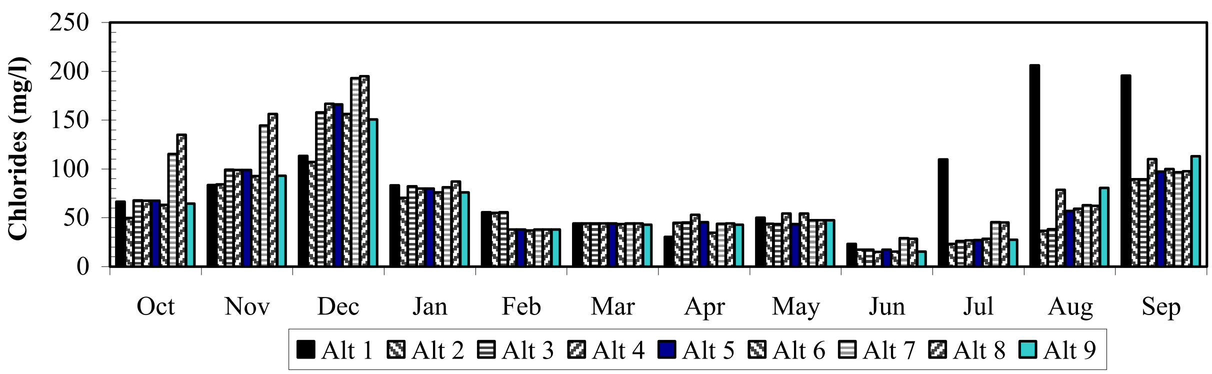
Figure XIII-18
Chloride Levels Los Vaqueros Intake on Old River
End-of-Month Simulated Values for Above Normal Years



Water quality objectives have not been established at the location.

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

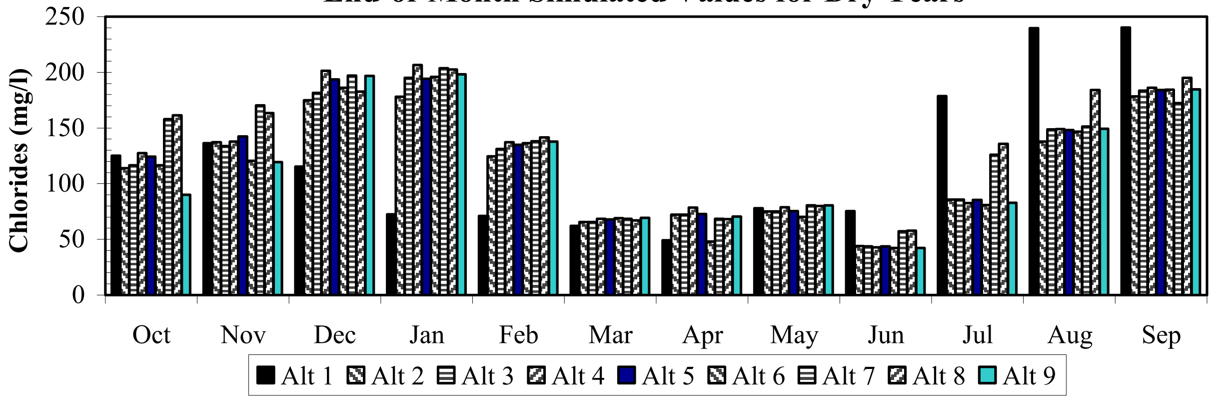
Figure XIII-19
Chloride Levels for Los Vaqueros Intake on Old River
End-of-Month Simulated Values for Below Normal Years



Water quality objectives have not been established at the location.

Sacramento "40-30-30" **below normal** year (1979)

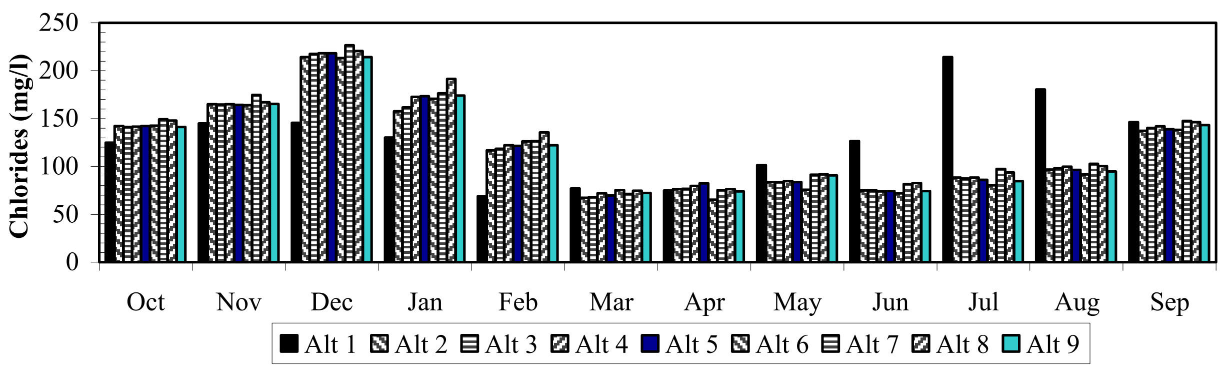
Figure XIII-20
Chloride Levels for Los Vaqueros Intake on Old River
End-of-Month Simulated Values for Dry Years



Water quality objectives have not been established at the location.

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

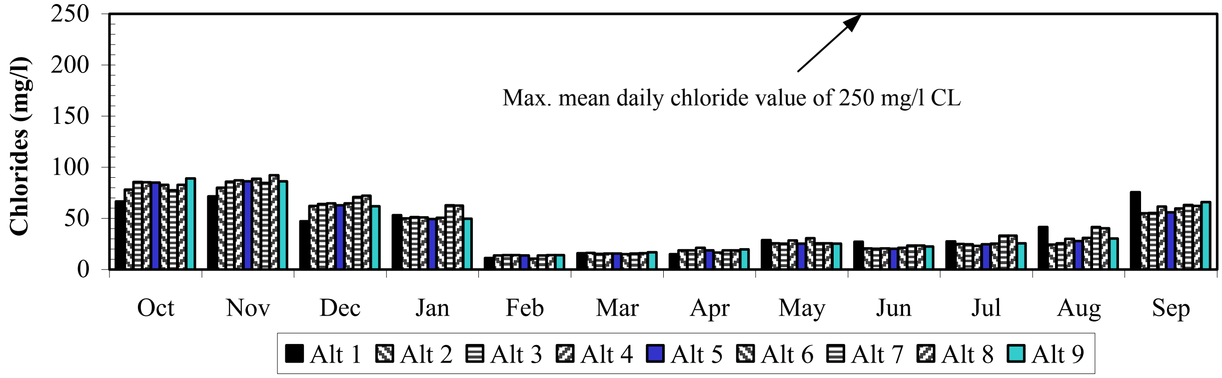
Figure XIII-21
Chloride Levels for Los Vaqueros Intake on Old River
End-of-Month Simulated Values for Critical Years



Water quality objectives have not been established at the location.

Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

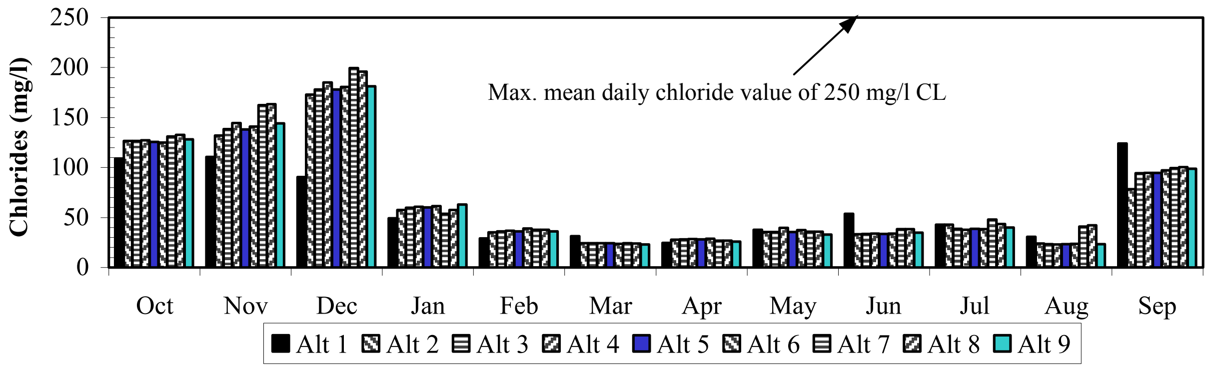
Figure XIII-22
Salinity for Banks Pumping Plant
End-of-Month Simulated Values for Wet Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

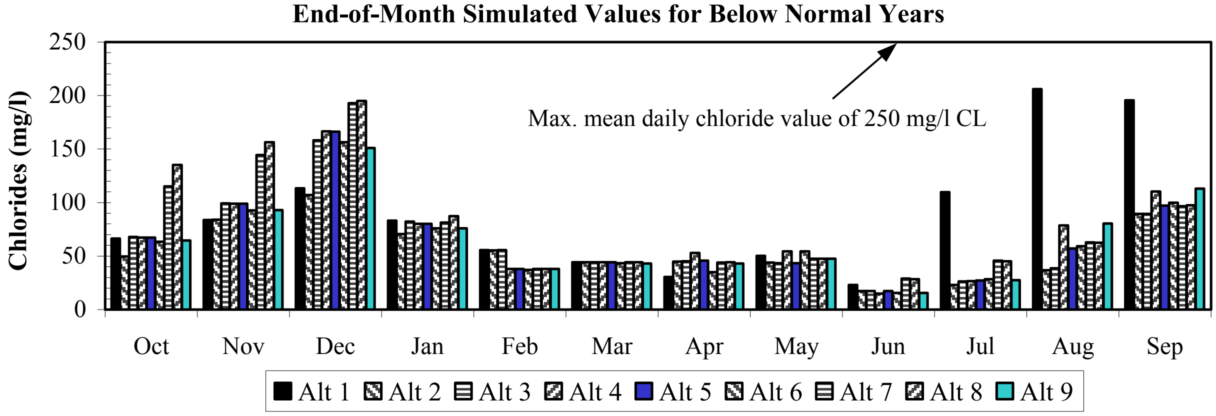
Figure XIII-23
Salinity for Banks Pumping Plant
End-of-Month Simulated Values for Above Normal Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

Figure XIII-24
Salinity for Banks Pumping Plant
End-of-Month Simulated Values for Below Normal Years



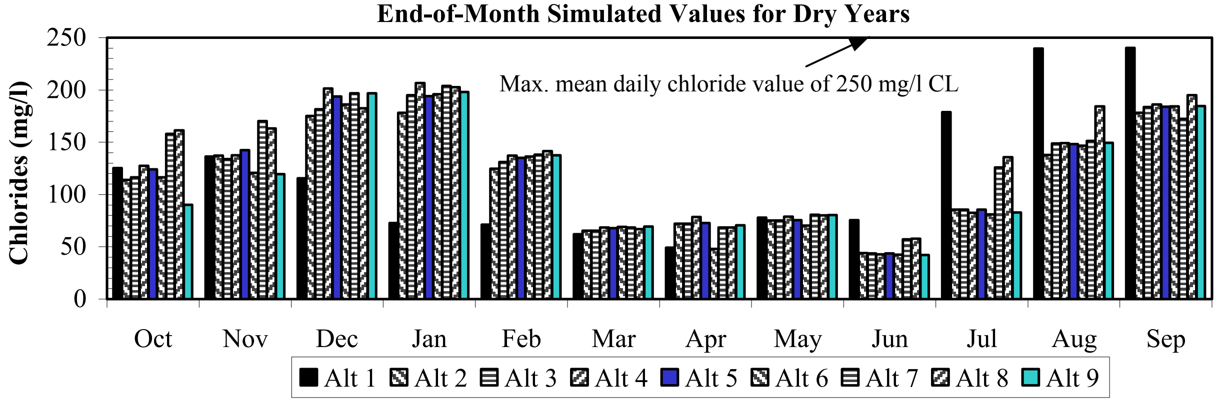
Sacramento "40-30-30" **below normal** year (1979)

Salinity objectives are the same for D-1485 & Bay/Delta Plan

Figure XIII-25

Salinity for Banks Pumping Plant

End-of-Month Simulated Values for Dry Years



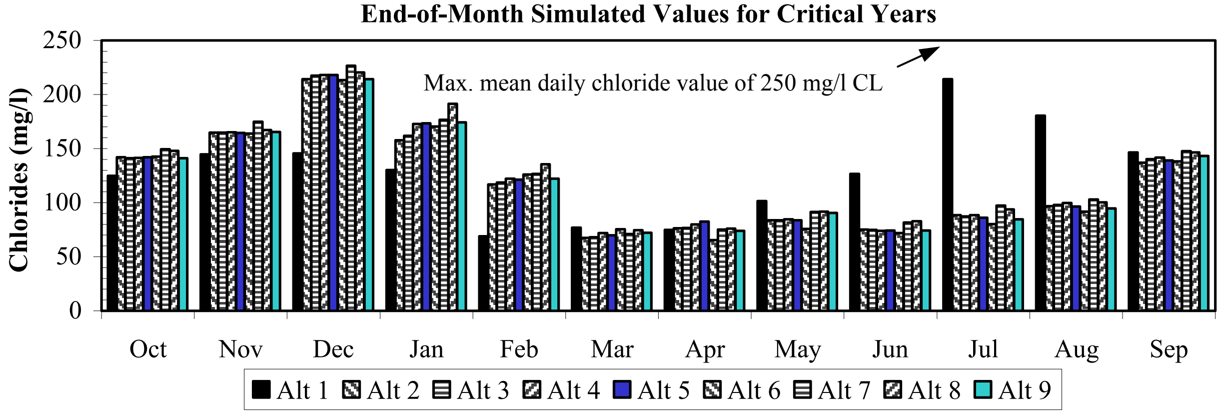
Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

Figure XIII-26

Salinity for Banks Pumping Plant

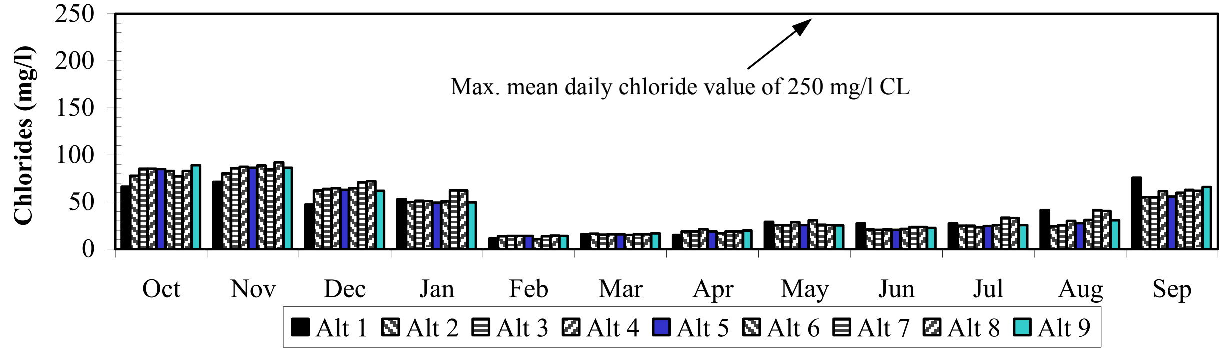
End-of-Month Simulated Values for Critical Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

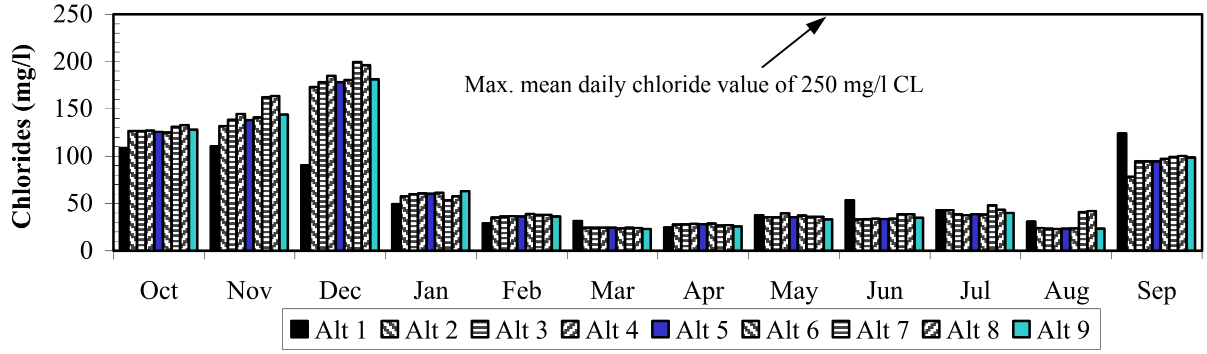
Figure XIII-27
Salinity for Tracy Pumping Plant
End-of-Month Simulated Values for Wet Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

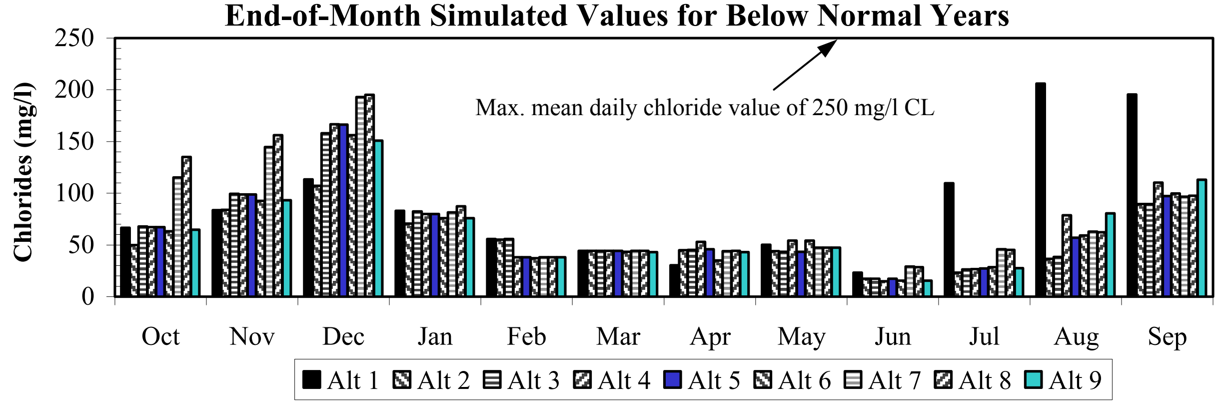
Figure XIII-28
Salinity for Tracy Pumping Plant
End-of-Month Simulated Values for Above Normal Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

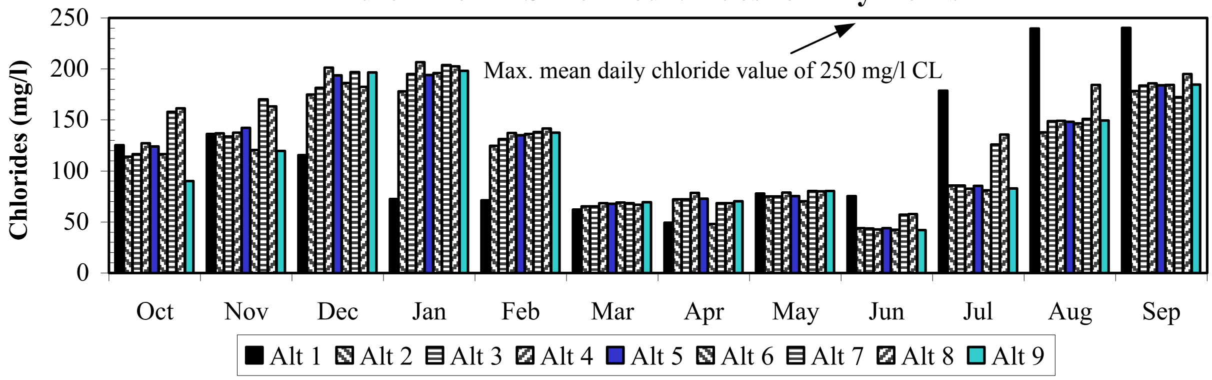
Figure XIII-29
Salinity for Tracy Pumping Plant
End-of-Month Simulated Values for Below Normal Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **below normal** year (1979)

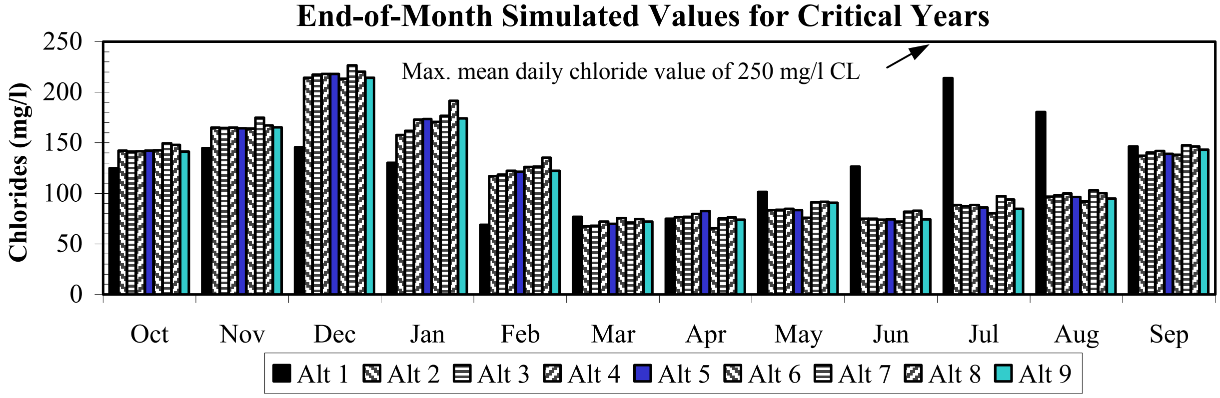
Figure XIII-30
Salinity for Tracy Pumping Plant
End-of-Month Simulated Values for Dry Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

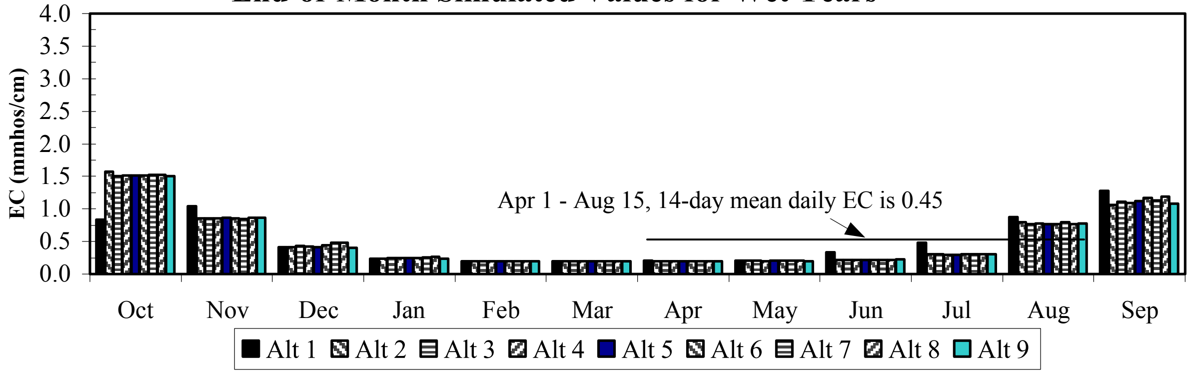
Figure XIII-31
Salinity for Tracy Pumping Plant
End-of-Month Simulated Values for Critical Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

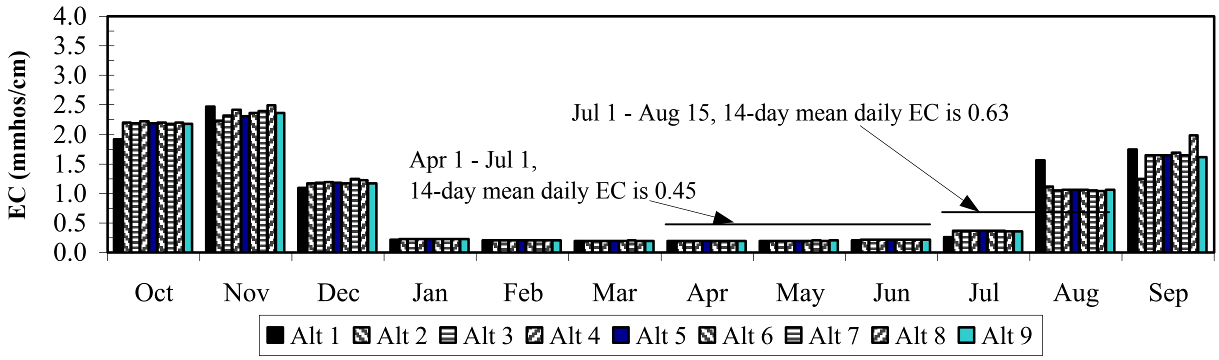
Figure XIII-32
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Wet Years



Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

Salinity objectives are the same for D-1485 & Bay/Delta Plan

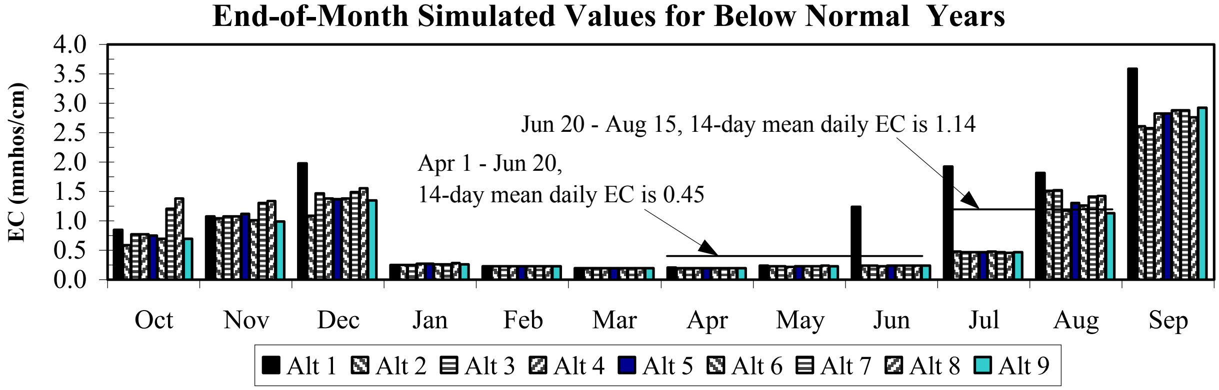
Figure XIII-33
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Above Normal Years



Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

Salinity objectives are the same for D-1485 & Bay/Delta Plan

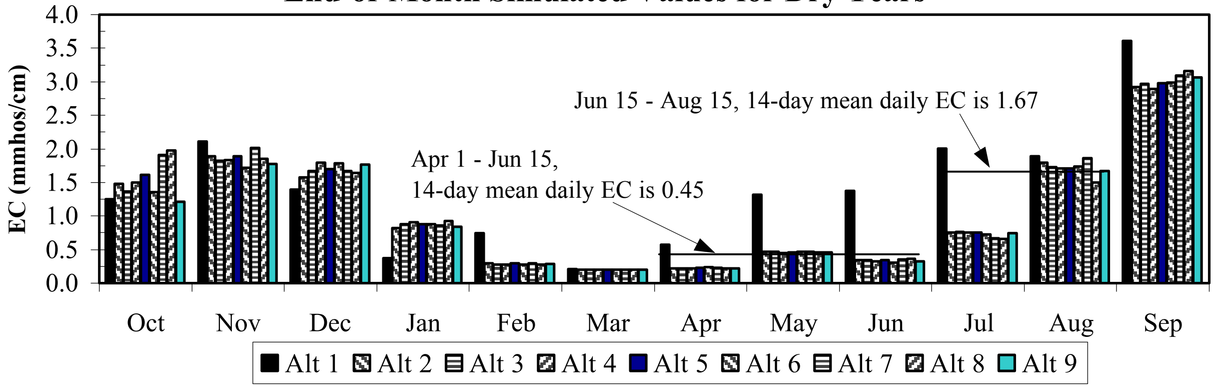
Figure XIII-34
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Below Normal Years



Sacramento "40-30-30" **below normal** year (1979)

Salinity objectives are the same for D-1485 & Bay/Delta Plan

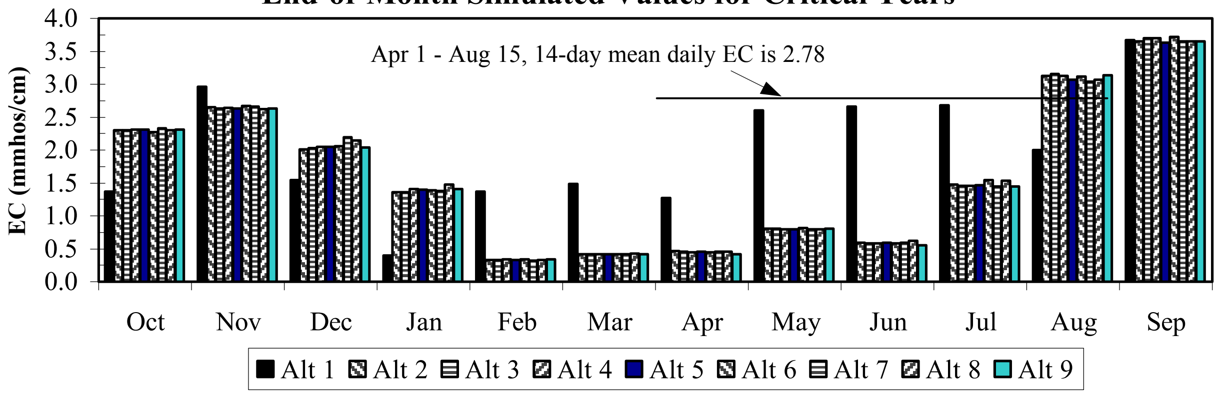
Figure XIII-35
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Dry Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

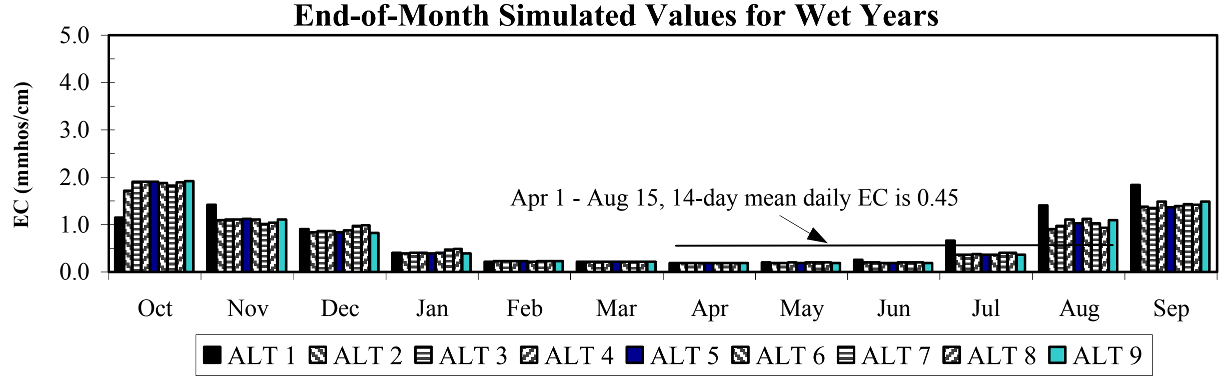
Figure XIII-36
Salinity for Sacramento River at Emmaton
End-of-Month Simulated Values for Critical Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

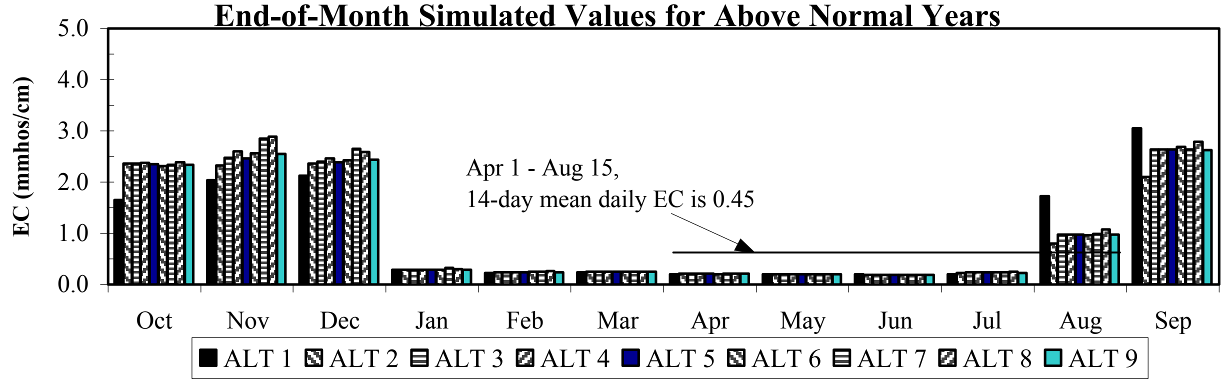
Figure XIII-37
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Wet Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

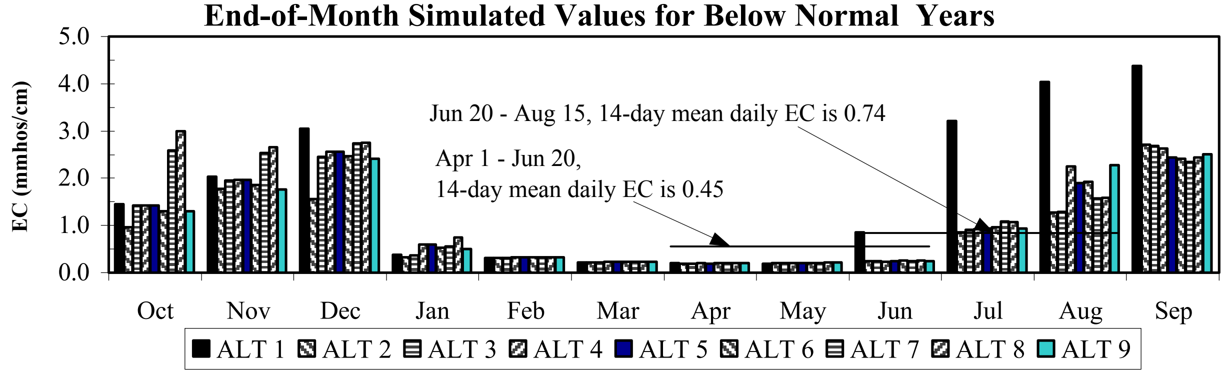
Figure XIII-38
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Above Normal Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

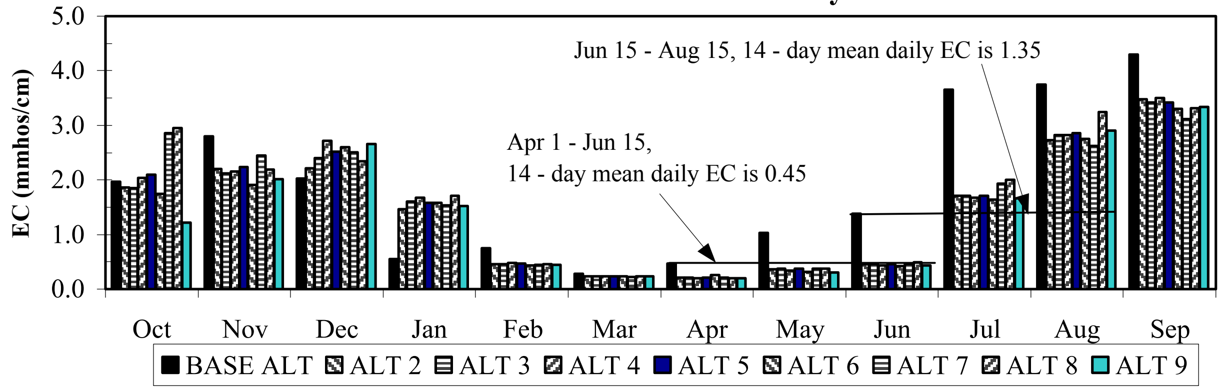
Figure XIII-39
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Below Normal Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **below normal** year (1979)

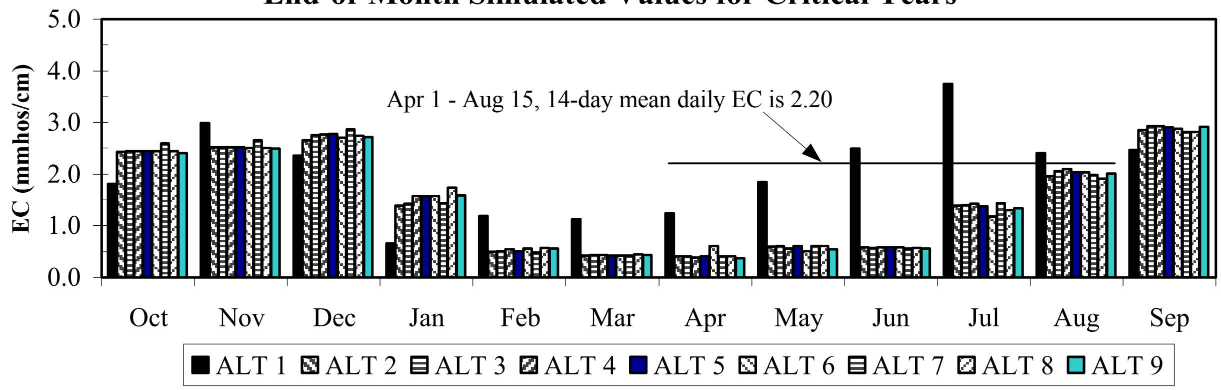
Figure XIII-40
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Dry Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

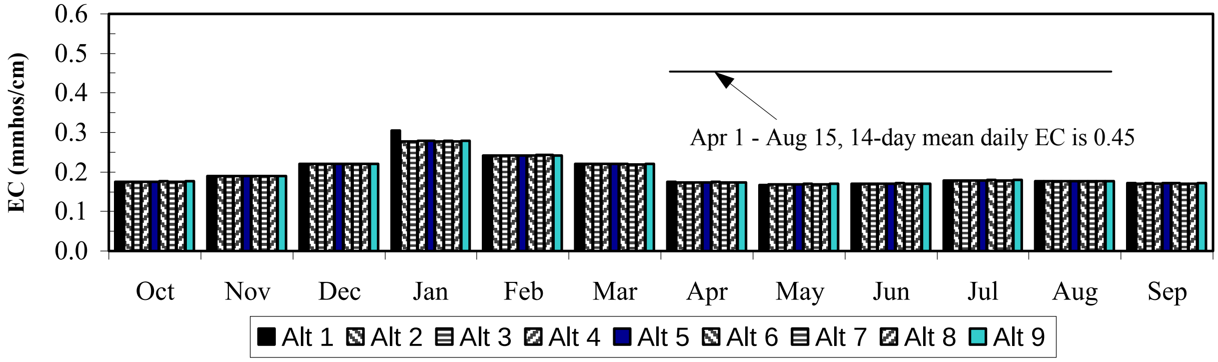
Figure XIII-41
Salinity for San Joaquin River at Jersey Point
End-of-Month Simulated Values for Critical Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" critical years averaged (1976, 77, 88, 90 & 91)

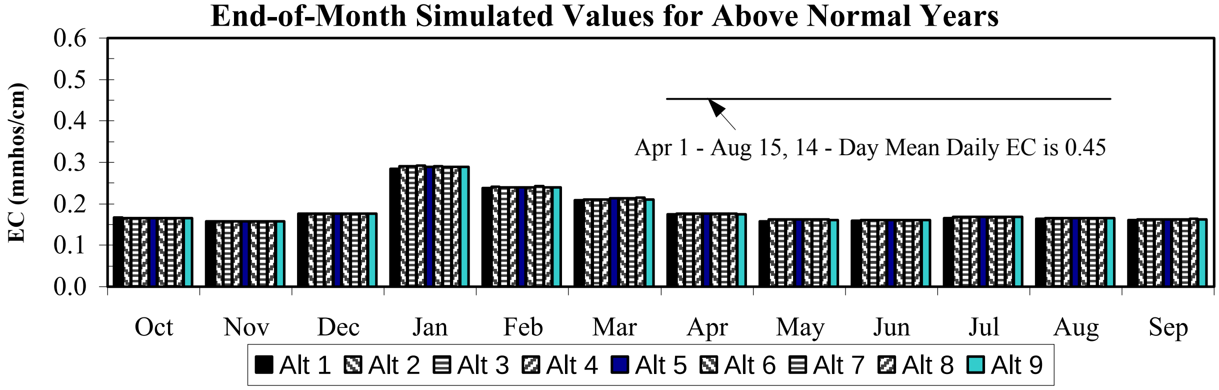
Figure XIII-42
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Wet Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

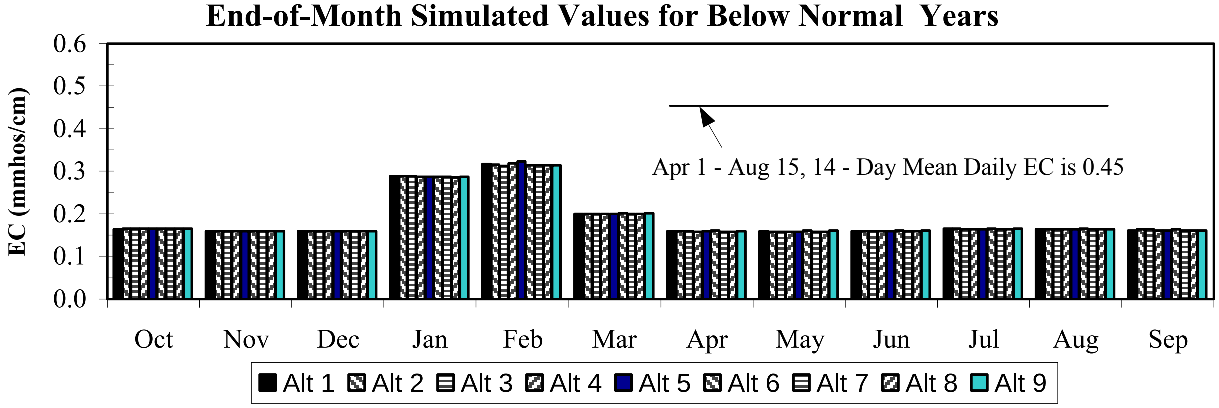
Figure XIII-43
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Above Normal Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

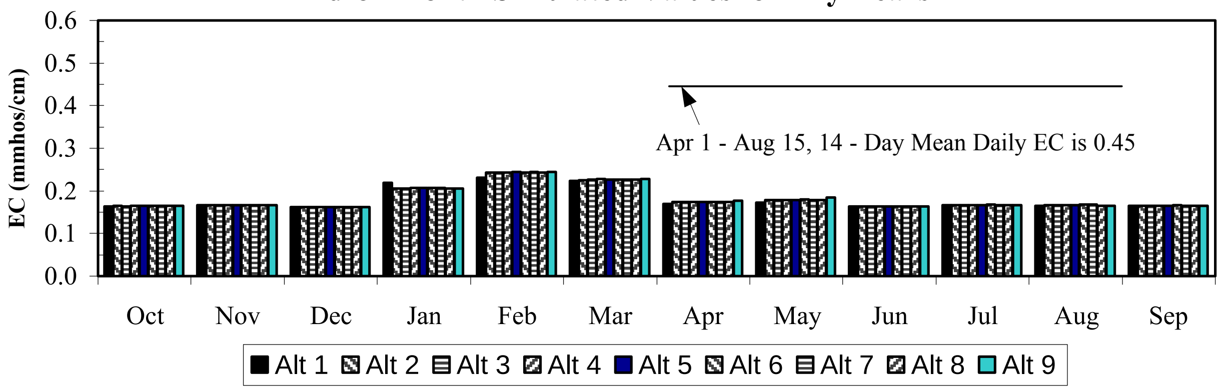
Figure XIII-44
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Below Normal Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **below normal** year (1979)

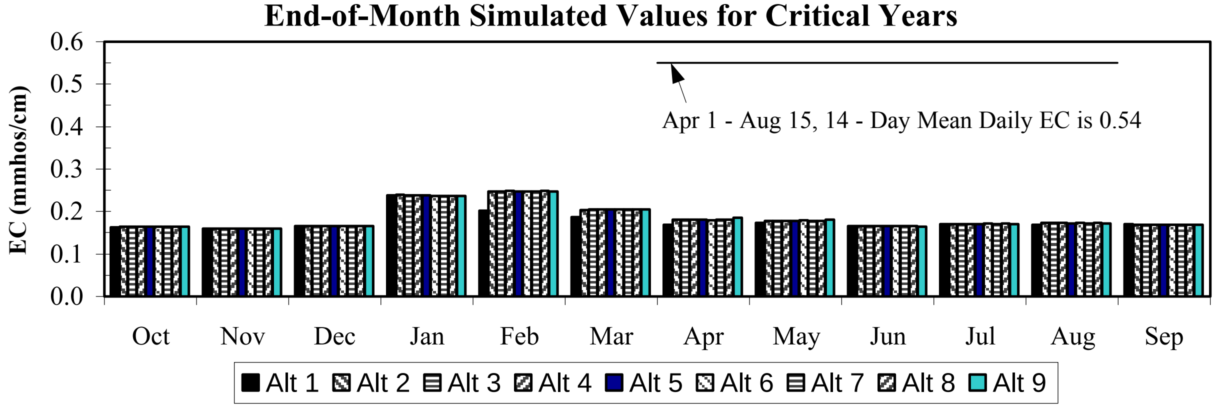
Figure XIII-45
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Dry Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

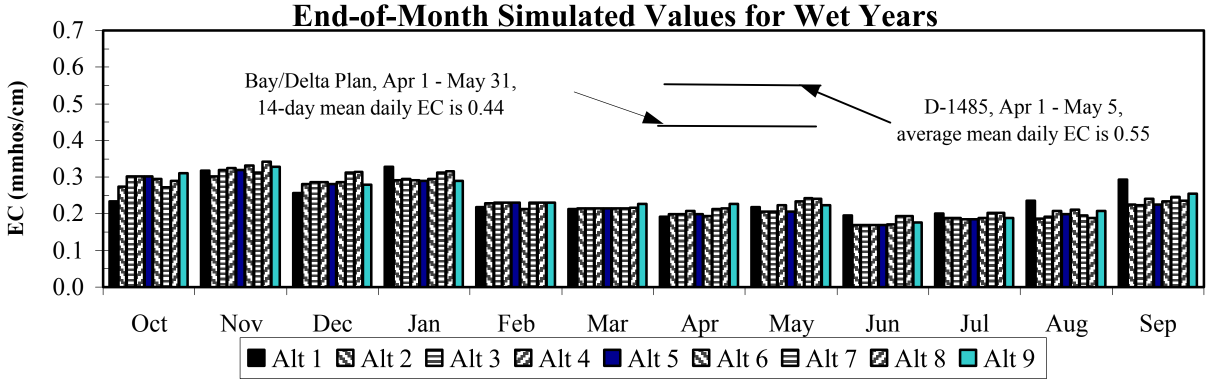
Figure XIII-46
Salinity for South Fork Mokelumne River at Terminous
End-of-Month Simulated Values for Critical Years



Salinity objectives are the same for D-1485 & Bay/Delta Plan

Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

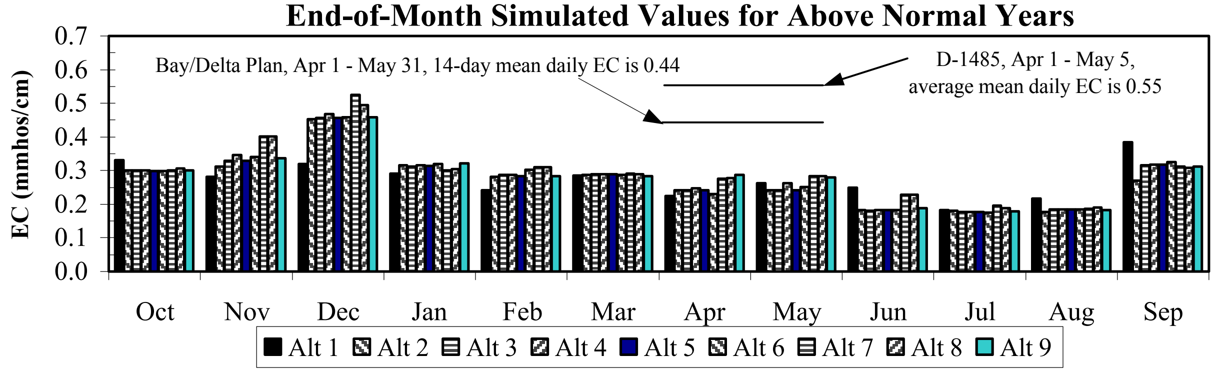
Figure XIII-47
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Wet Years



The 14 - day mean daily salinity objectives for Bay/Delta Plan are 0.44 EC from Apr 1 - May 31, and for D-1485 is 0.55 EC from Apr 1 - May 5

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

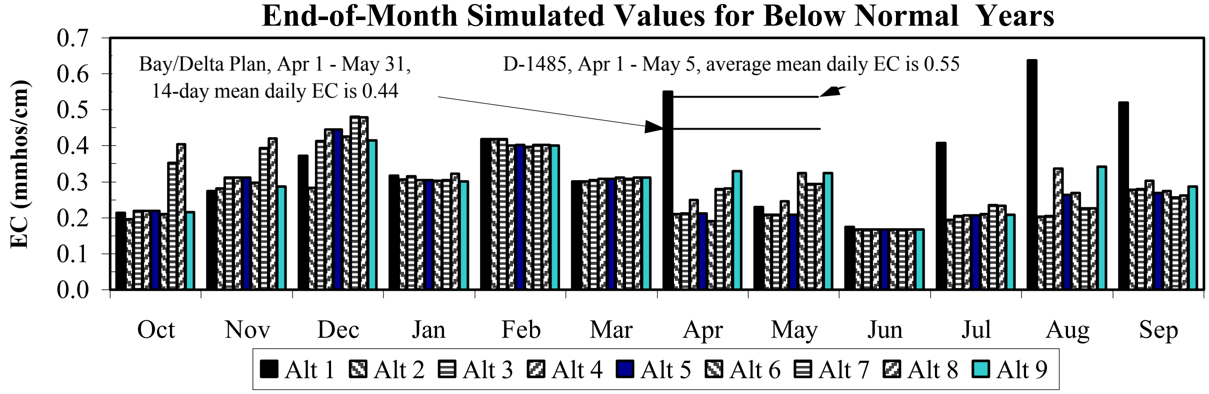
Figure XIII-48
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Above Normal Years



The 14 - day mean daily salinity objectives for Bay/Delta Plan are 0.44 EC from Apr 1 - May 31, and for D-1485 is 0.55 EC from Apr 1 - May 5

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

Figure XIII-49
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Below Normal Years



The 14 - day mean daily salinity objectives for Bay/Delta Plan are 0.44 EC from Apr 1 - May 31, and for D-1485 is 0.55 EC from Apr 1 - May 5

Sacramento "40-30-30" **below normal** year (1979)

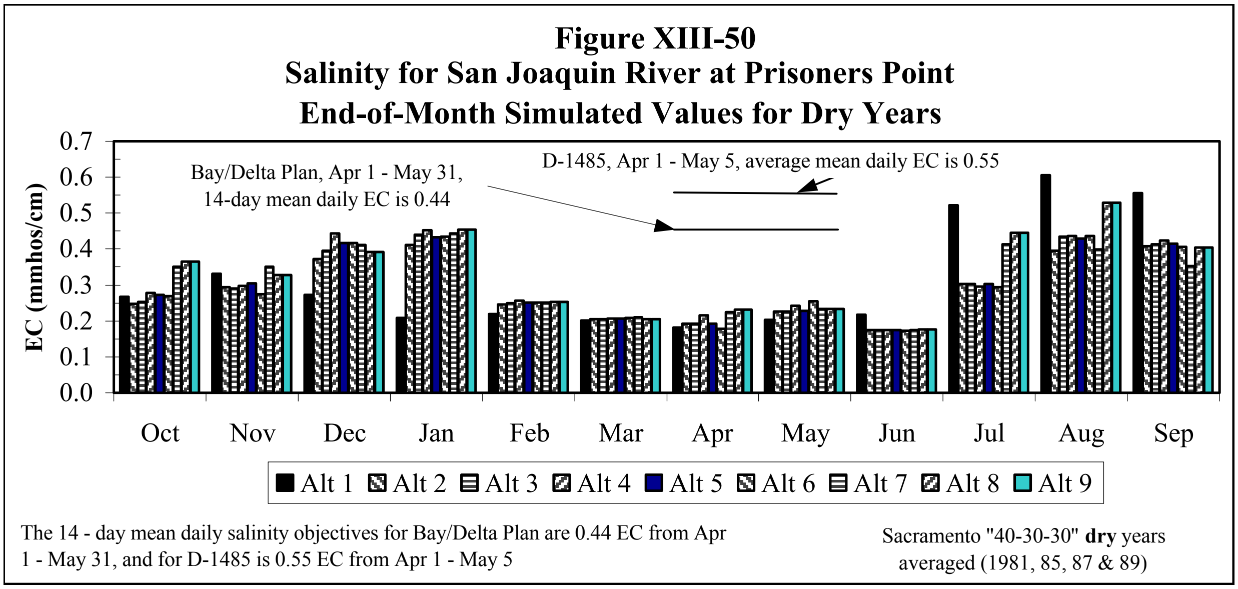


Figure XIII-50
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Dry Years
EC (mmhos/cm)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Bay/Delta Plan, Apr 1 - May 31, 14-day mean daily EC is 0.44
D-1485, Apr 1 - May 5, average mean daily EC is 0.55
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Alt 1
Alt 2
Alt 3
Alt 4
Alt 5
Alt 6
Alt 7
Alt 8
Alt 9
The 14 - day mean daily salinity objectives for Bay/Delta Plan are 0.44 EC from Apr 1 - May 31, and for D-1485 is 0.55 EC from Apr 1 - May 5
Sacramento "40-30-30" dry years averaged (1981, 85, 87 & 89)

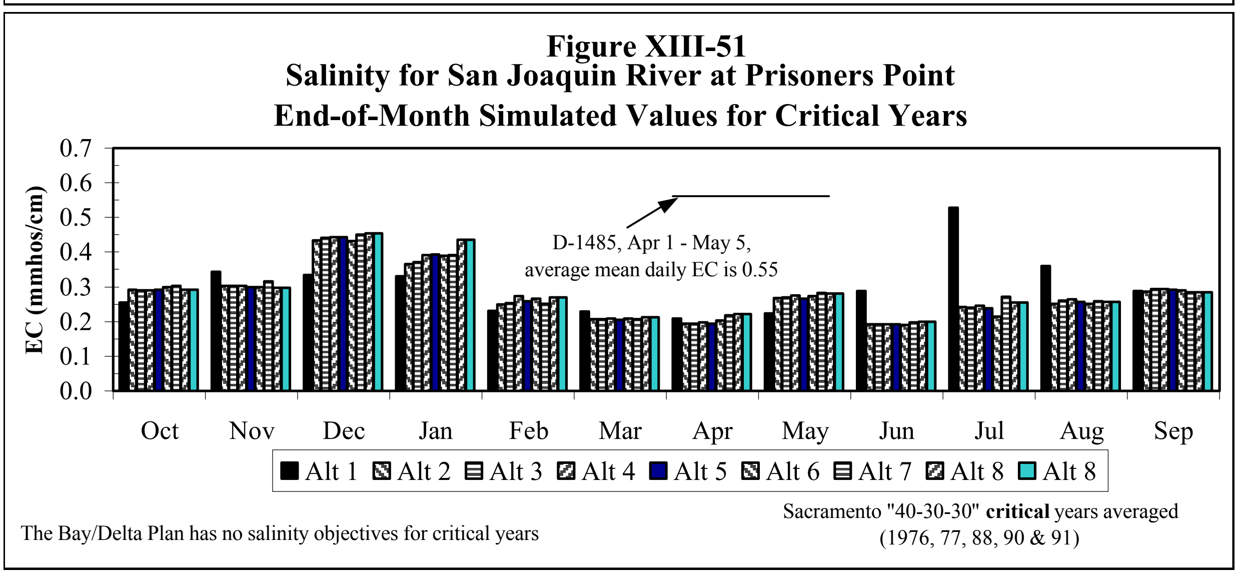
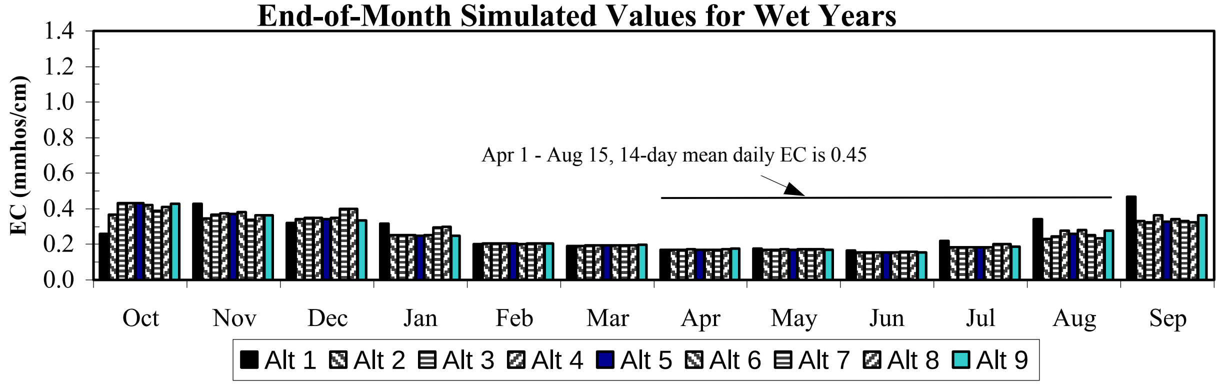


Figure XIII-51
Salinity for San Joaquin River at Prisoners Point
End-of-Month Simulated Values for Critical Years
EC (mmhos/cm)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
D-1485, Apr 1 - May 5, average mean daily EC is 0.55
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Alt 1
Alt 2
Alt 3
Alt 4
Alt 5
Alt 6
Alt 7
Alt 8
Alt 8
The Bay/Delta Plan has no salinity objectives for critical years
Sacramento "40-30-30" critical years averaged (1976, 77, 88, 90 & 91)

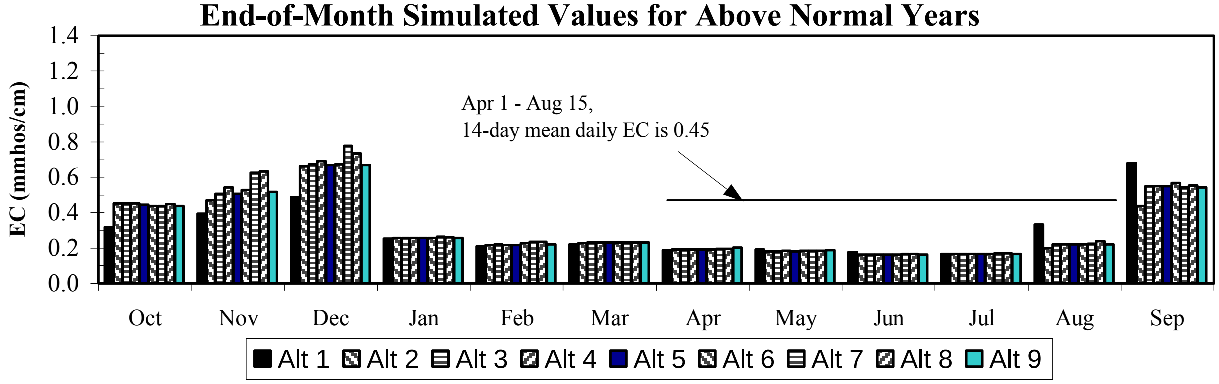
Figure XIII-52
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Wet Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **wet** years averaged (1982, 83, 84 & 86)

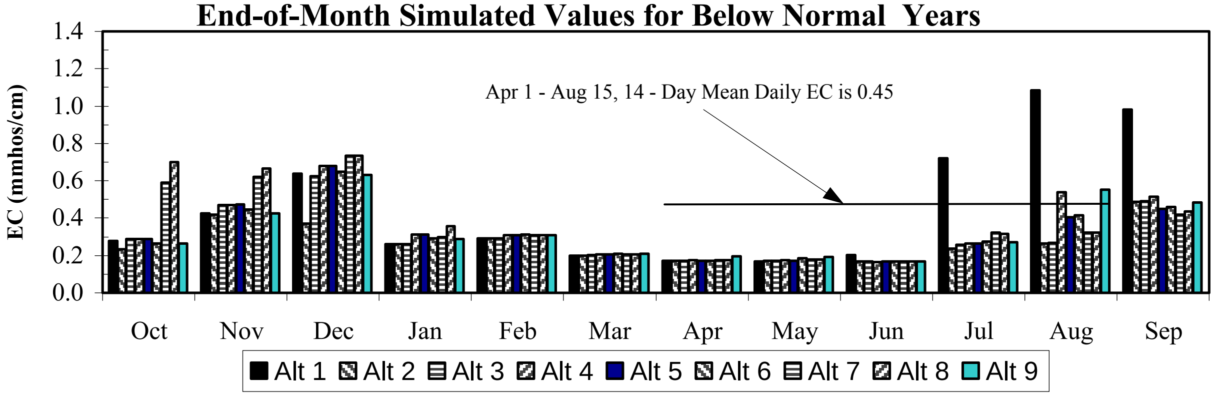
Figure XIII-53
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Above Normal Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **above normal** years averaged (1978 & 80)

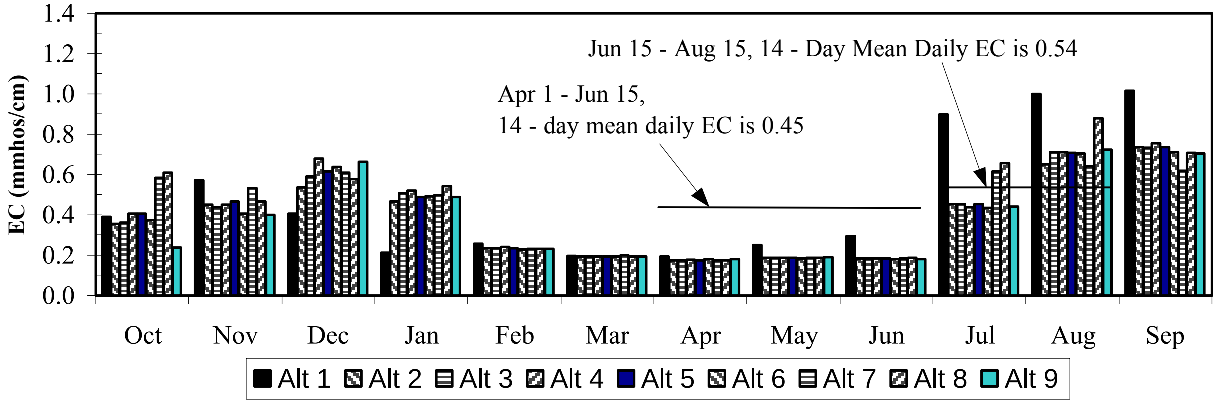
Figure XIII-54
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Below Normal Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan. The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **below normal** year (1979)

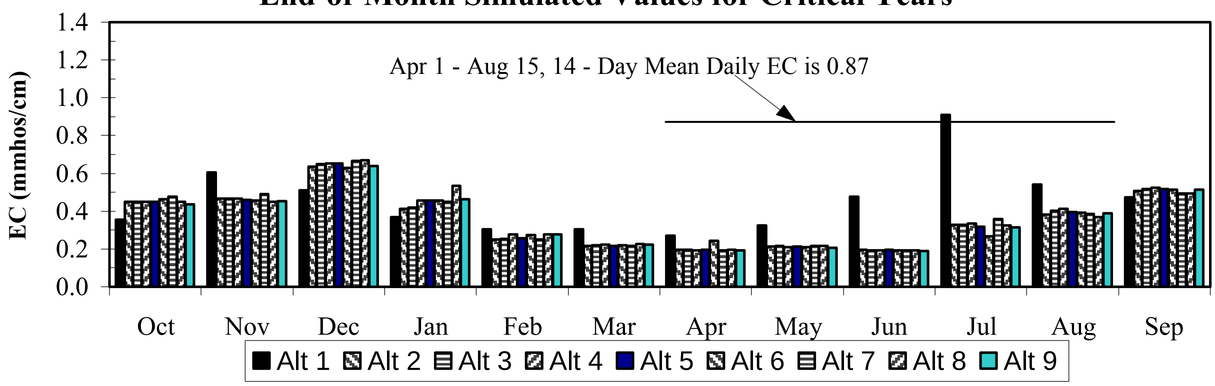
Figure XIII-55
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Dry Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan.
The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

Sacramento "40-30-30" **dry** years averaged (1981, 85, 87 & 89)

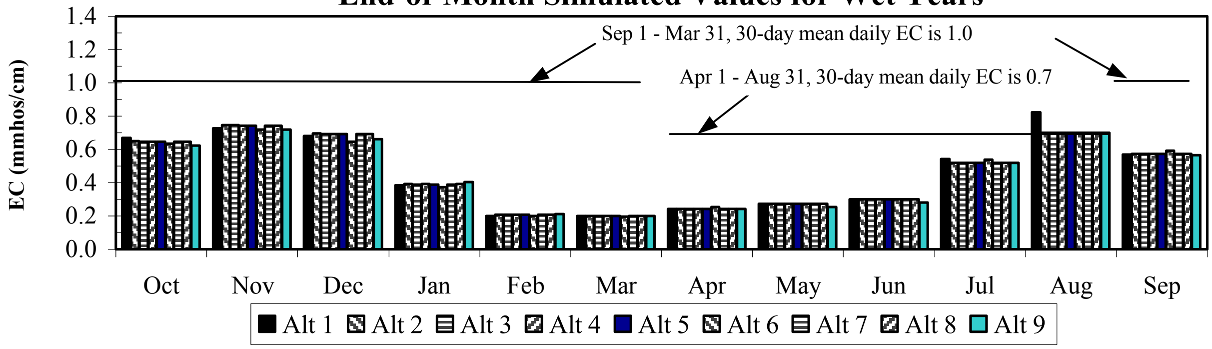
Figure XIII-56
Salinity for San Joaquin River at San Andreas Landing
End-of-Month Simulated Values for Critical Years



The agricultural salinity objectives are the same for D-1485 & Bay/Delta Plan.
The fish and wildlife Bay/Delta Plan salinity objective for Apr-May is 0.44 mmhos/cm

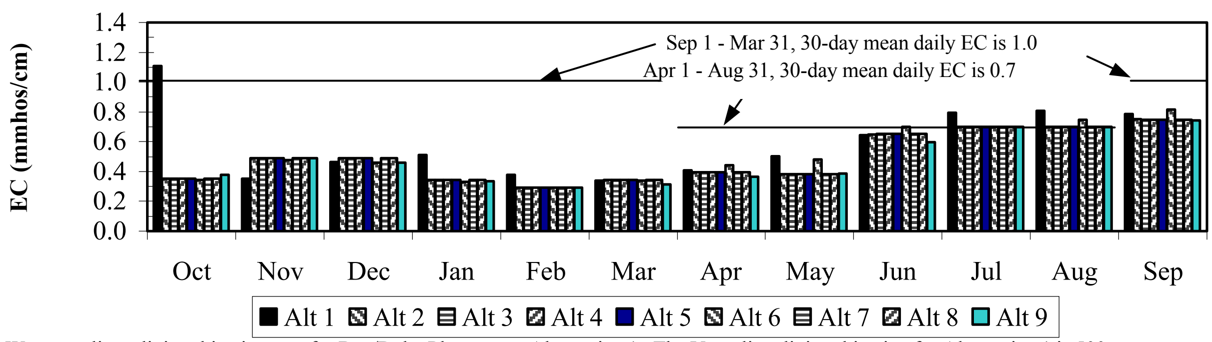
Sacramento "40-30-30" **critical** years averaged (1976, 77, 88, 90 & 91)

Figure XIII-57
Salinity for San Joaquin River at Airport Bridge (Vernalis)
End-of-Month Simulated Values for Wet Years



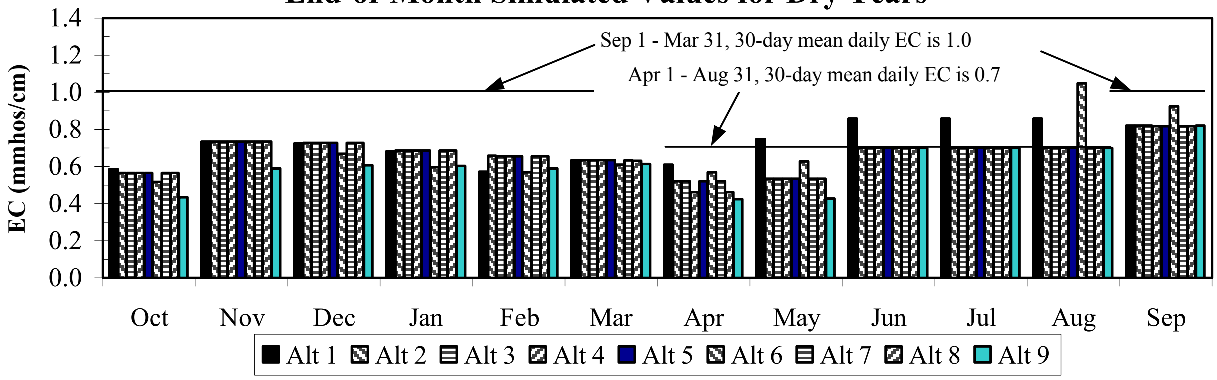
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1978, 80, 82, 83 & 86).

Figure XIII-58
Salinity for San Joaquin River at Airport Bridge (Vernalis)
End-of-Month Simulated Values for Above Normal Years



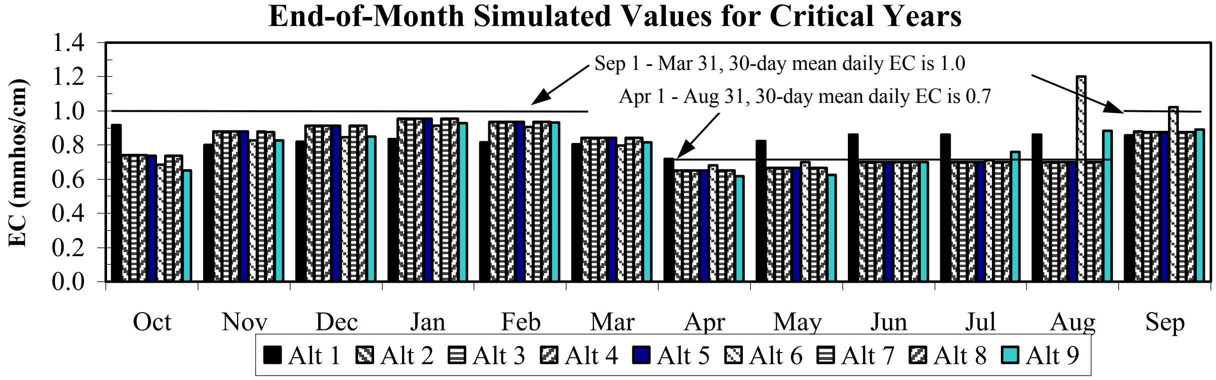
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1979 & 84).

Figure XIII-59
Salinity for San Joaquin River at Airport Bridge (Vernalis)
End-of-Month Simulated Values for Dry Years



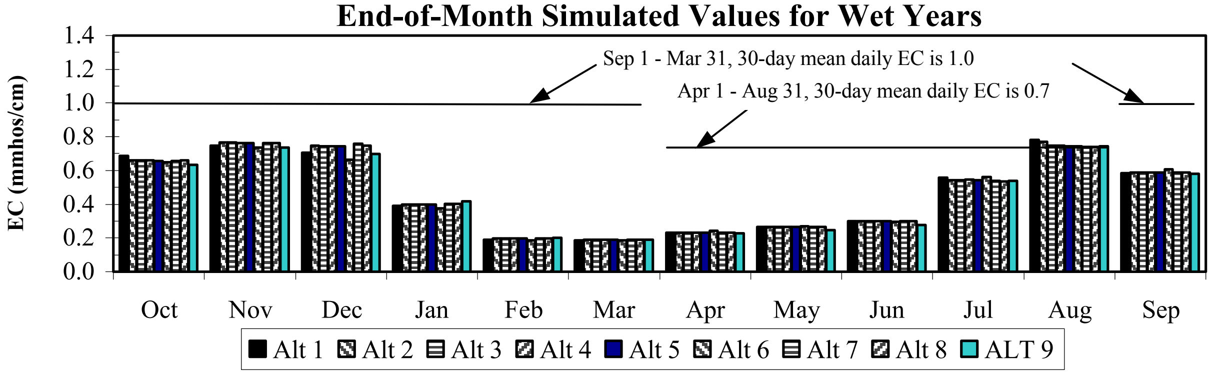
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" dry years averaged (1981 & 85).

Figure XIII-60
Salinity for San Joaquin River at Airport Bridge (Vernalis)
End-of-Month Simulated Values for Critical Years



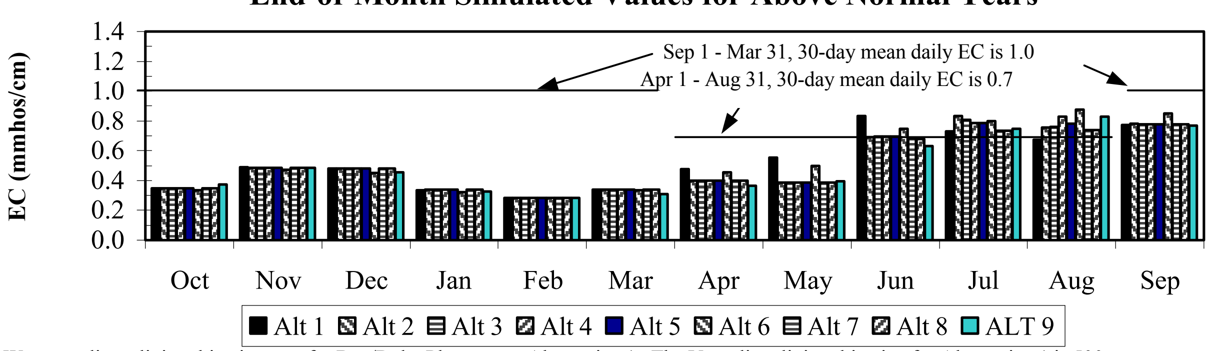
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" critical years averaged (1976, 77, 87, 88, 89, 90 & 91).

Figure XIII-61
Salinity for San Joaquin River at Brandt Bridge
End-of-Month Simulated Values for Wet Years



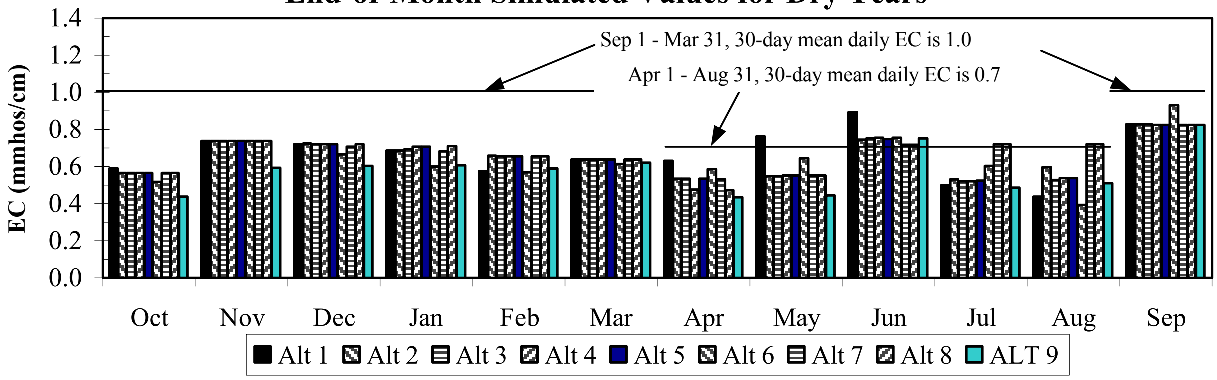
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1978, 80, 82, 83 & 86).

Figure XIII-62
Salinity for San Joaquin River at Brandt Bridge
End-of-Month Simulated Values for Above Normal Years



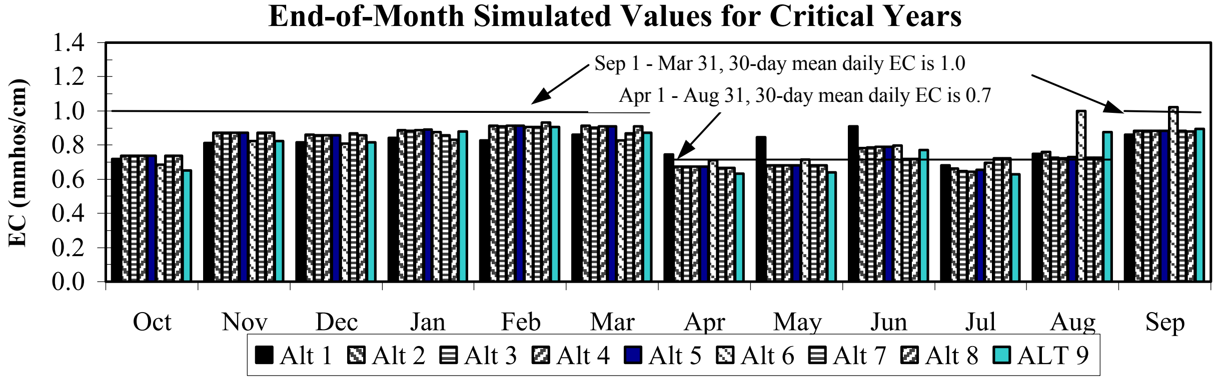
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1979 & 84).

Figure XIII-63
Salinity for San Joaquin River at Brandt Bridge
End-of-Month Simulated Values for Dry Years



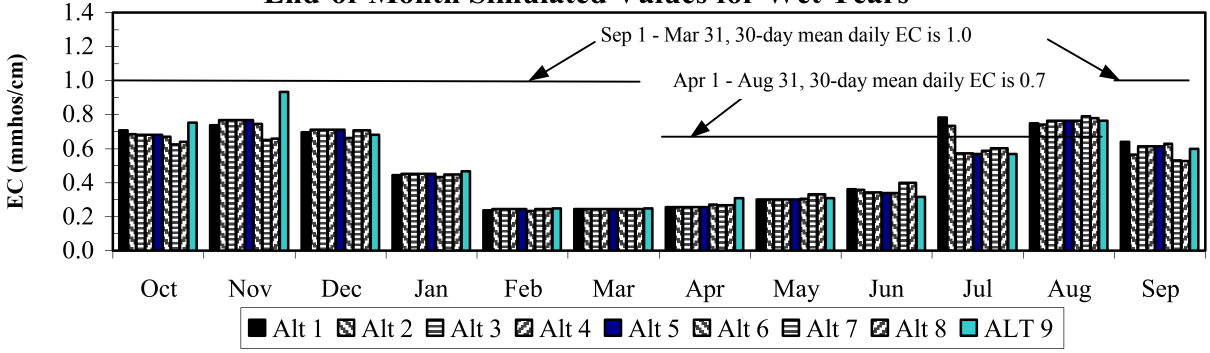
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" dry years averaged (1981 & 85).

Figure XIII-64
Salinity for San Joaquin River at Brandt Bridge
End-of-Month Simulated Values for Critical Years



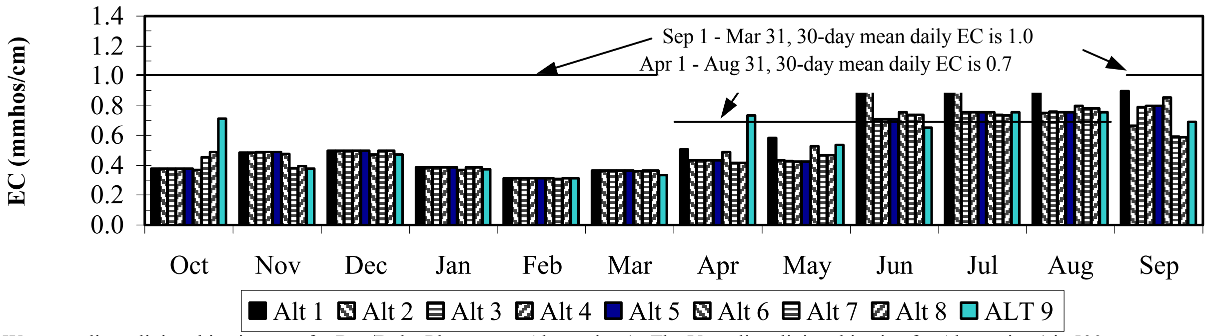
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" critical years averaged (1976, 77, 87, 88, 89, 90 & 91).

Figure XIII-65
Salinity for Old River at Tracy Road Bridge
End-of-Month Simulated Values for Wet Years



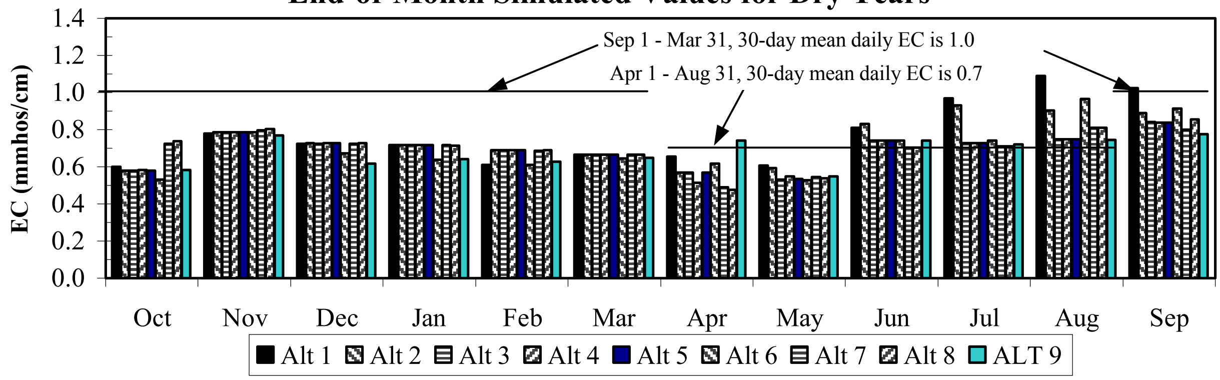
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1978, 80, 82, 83 & 86).

Figure XIII-66
Salinity for Old River at Tracy Road Bridge
End-of-Month Simulated Values for Above Normal Years



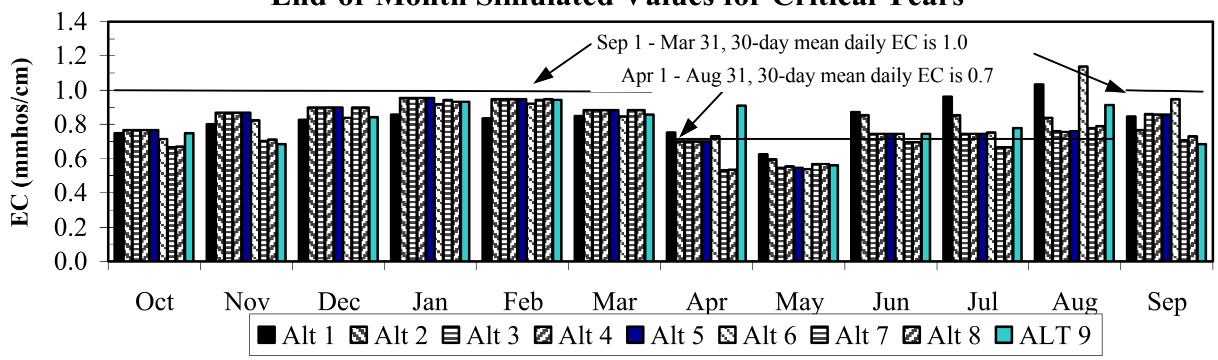
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1979 & 84).

Figure XIII-67
Salinity for Old River at Tracy Road Bridge
End-of-Month Simulated Values for Dry Years



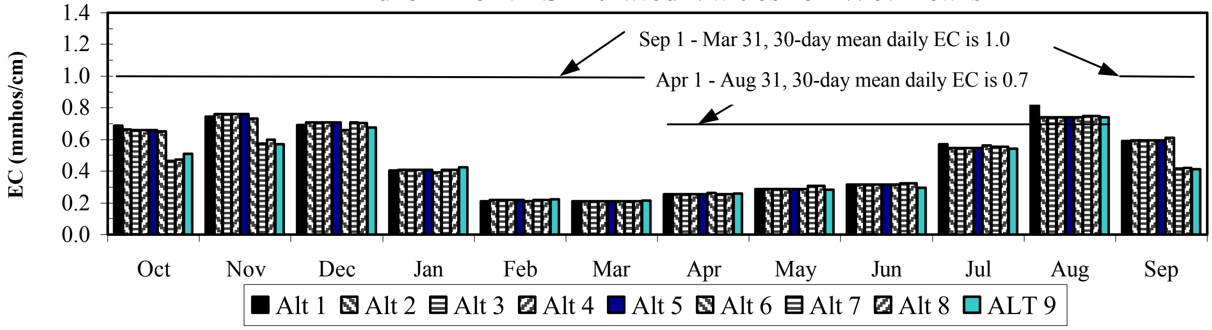
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" dry years averaged (1981 & 85).

Figure XIII-68
Salinity for Old River at Tracy Road Bridge
End-of-Month Simulated Values for Critical Years



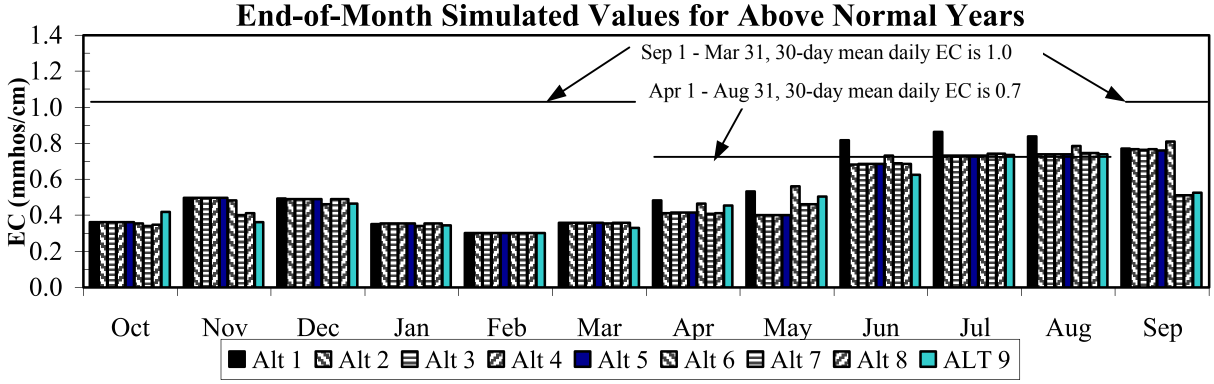
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" critical years averaged (1976, 77, 87, 88, 89, 90 & 91).

Figure XIII-69
Salinity for Old River Near Middle River
End-of-Month Simulated Values for Wet Years



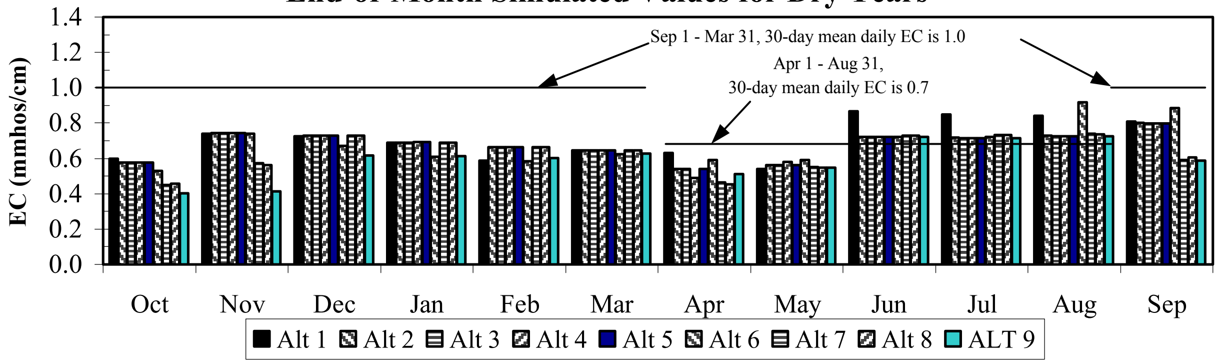
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" wet years averaged (1978, 80, 82, 83 & 86).

Figure XIII-70
Salinity for Old River Near Middle River
End-of-Month Simulated Values for Above Normal Years



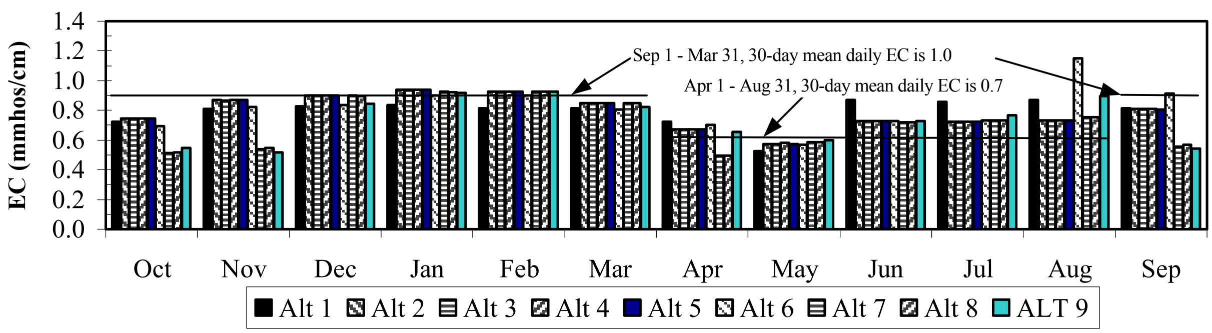
Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" above normal years averaged (1979 & 84)

Figure XIII-71
Salinity for Old River Near Middle River
End-of-Month Simulated Values for Dry Years



Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" dry years averaged (1981 & 85)

Figure XIII-72
Salinity for Old River Near Middle River
End-of-Month Simulated Values for Critical Years



Water quality salinity objectives are for Bay/Delta Plan except Alternative 1. The Vernalis salinity objective for Alternative 1 is 500 ppm TDS (approximately equals 0.86 mmhos/cm) year-round.
San Joaquin "60-20-20" critical years averaged (1976, 77, 87, 88, 89, 90 & 91)

In wet years, there are no appreciable differences among the alternatives with respect to chloride concentrations at the Banks and Tracy pumping plants. In above normal years, chloride levels under the base case are higher in September and lower in December. In below normal years, the base case is considerably higher than the other alternatives in July, August, and September. Alternatives 7 and 8 result in the highest chloride levels in October, November, and December, mostly due to higher exports allowed under these alternatives.

Chlorides come closest to exceeding the maximum chloride limit of 250 mg/l in dry years. This occurs under the base case in July, August, and September for both locations. Alternatives 2 through 8 are not as high as the base case, but are, nevertheless, higher (around 180 mg/l in September) than what is seen in September of other year types. In December and January chloride levels under the alternatives are even higher, in contrast with the base case which stays down between 75 and 110 mg/l.

In dry years (Figures XIII-25 and XIII-30), the base case salinity is higher from June through September and lower in December, January and February.

Sacramento River at Emmaton. Figures XIII-32, XIII-33, and XIII-34 show predicted salinity for Emmaton in the western Delta in wet, above normal, and below normal years. These figures show no appreciable differences among the alternatives from January through May. Alternatives 2 through 9 result in lower salinity in June through September in wet years, in August of above normal years, and June through September and December of below normal years. The base case salinity is lower in October of wet and above normal years.

In dry years (Figure XIII-35), Alternatives 2 through 9 result in lower salinity in February and in April through September, and higher salinity in October, December, and January. In critical years (Figure XIII-36), Alternatives 2 through 9 salinities are lower in February through July and November. Base case salinity is lower in January, August, October, December and January.

The effects of the non-base case alternatives on salinity are practically indistinguishable from each other at this location with the exception of higher salinities for Joint POD Alternatives 7 and 8 in some fall months in below normal and dry year types.

San Joaquin River at Jersey Point. Salinity conditions at Jersey Point are very similar to the conditions at Emmaton. Figures XIII-37, XIII-38, and XIII-39 show virtually no differences among the alternatives from February through June in wet years, from January through July in above normal years, and February through May in below normal years. Alternatives 2 through 9 exhibit lower salinity in June, July, August, and September of wet and below normal years, and August and September of above normal years, with below normal years showing the most dramatic differences in these months.

Figure XIII-40 shows Alternatives 2 through 9 as having lower salinity compared to the base case in April through September of dry years. Figure XIII-41 shows Alternatives 2 through 9 as having lower salinity from February through August and November and somewhat higher salinity in January, September, October, and December of critical years.

South Fork Mokelumne River at Terminous. This station is a Bay/Delta boundary condition in the DWRDSM model and reflects water quality from the DWRSIM model runs used as input. Figures XIII-42 through XIII-46 show that (1) there is relatively high quality water coming down the Mokelumne River in all year types (salinity is a little higher in January and February), (2) all of the alternatives, including the base case, use the same DWRSIM hydrology and water quality parameters for this river system, and (3) closure of the Delta Cross Channel gates in winter months increases salinity.

San Joaquin River at Prisoners Point. Figures XIII-47 through XIII-51 show modeled salinity at this location. The base case alternative has slightly higher salinity in January, August, and September, and slightly lower salinity in October and December of wet years. For above normal years, base case salinity is higher in June, September, and October, and lower in November through February and April. In below normal and dry years, the base case salinity is considerably higher in July, August and September. In critically dry years, the base case salinity is higher in June, July, and August.

Practically no distinction can be made among Alternatives 2 through 9 at this location, with the exception of higher salinities for Alternatives 7 and 8 in some fall months.

San Joaquin River at San Andreas Landing. Salinity conditions at San Andreas Landing are very similar to the conditions on the San Joaquin River at Prisoners Point.

San Joaquin River at Vernalis. Figures XIII-57 through XIII-60 show the EC at this station for four year types. Below normal years under the San Joaquin basin 60-20-20 index convention did not occur during the model study period (1976 - 1991) and therefore the figure for below normal years is omitted for this and the three other southern Delta stations (San Joaquin River at Brandt Bridge, Old River near Middle River and Old River at Tracy Road Bridge). The principal factor controlling the salinity differences between the base case and the alternatives is the different Vernalis objectives that apply. The salinity objectives at Vernalis in the Bay/Delta Plan are 0.7 mmhos/cm from April through August and 1.0 mmhos/cm for September through March. The salinity objective in the base case is 500 ppm (0.86 mmhos/cm) year-round. Because of the difference in objectives, Vernalis salinity is generally lower under the base case in September through March and higher in April through August.

Alternative 6 shows higher salinity than the other alternatives in August and September for dry and critical year types because the Letter of Intent limits releases from New Melones Reservoir for salinity control to 70 TAF. Alternative 9 also limits releases for salinity control, but the limits are based on storage in and expected inflow to New Melones

Reservoir. The effect of these limits can be seen in July and August of critically dry years. No limits on releases of water for salinity control apply to the other alternatives.

San Joaquin River at Brandt Bridge. Figures XIII-61 through XIII-64 show the salinity for the San Joaquin River at Brandt Bridge. The salinities at this location are similar to salinities at Vernalis. Salinity under Alternative 6 is higher in September of dry years and August and September of critical years as dilution water available in New Melones reservoir available for salinity control is depleted.

Old River at Tracy Road Bridge. Figures XIII-65 through XIII-68 show the EC at this station for the four year types. The EC at this location is similar to the EC at Vernalis with two exceptions. First, the EC is usually a little higher because of local agricultural drainage. Second, the EC for Alternatives 7 and 8 are lower in some months than other alternatives because the permanent southern Delta barriers are assumed to be installed. For Alternatives 1 through 6 and 9, the temporary barriers are installed. The temporary barrier at Old River is operated from May through September, while the permanent barrier at Old River is closed from April through October (see Table XIII-15).

Old River near Middle River. Figures XIII-69 through XIII-72 show the EC at this station for the four year types. Salinity at this location is also affected by local agricultural drainage and barrier operation. The effects of limits on the release of water from New Melones under Alternative 6 are evident in August and September of dry and critical years. Alternatives 7, 8 and 9 result in salinities lower than the rest of the alternatives in September and October of wet years, September of above normal years, and September, October and November of dry and critical years.

Summary. The salinity and chloride patterns for Joint POD Alternatives 2 through 9 differ substantially from the base case. In general, Alternatives 2 through 9 exhibit lower salinity in the late spring and summer but higher salinity in the fall and early winter compared to the base case. The principal differences among the alternatives are caused either by differences in the Flow Alternatives, which are already described in Chapter VI, or by implementation of the ISDP. Specifically, within the Joint POD alternatives, salinity differences occur because of implementation of requirements in D-1485 (Joint POD Alternative 1), the Bay/Delta Plan (Joint POD Alternatives 2 through 5, 7, and 8), the Letter of Intent (Joint POD Alternative 6), the San Joaquin River Agreement (Joint POD Alternative 9), and the ISDP (Joint POD Alternatives 7 and 8).

Regardless of the cause of salinity variations among the alternatives, in all of the alternatives, the SWP and the CVP will operate to ensure that the objectives in the western and central Delta are achieved. Therefore, there should be no significant effects associated with implementation of the Joint POD alternatives in comparison to the base case for these areas.

In the southern Delta, the salinity is generally lower than the base case for Alternatives 2-9 during the irrigation season (April through August) because of the more restrictive Vernalis salinity objective in the Bay/Delta Plan for this period. The exception to this observation is Alternative 6 in dry and critical years because salinity control releases under this alternative are limited to 70 TAF. If the SWRCB selects this alternative, the cap on salinity releases may have to be revised to avoid significant impacts.

3. Water Levels

The following section is organized in two parts: (a) impacts to water levels; and (b) mitigation for impacts.

a. Minimum Water Levels. Figures XIII-74 through XIII-85 depict water levels under the nine alternatives at twelve locations shown on Figure XIII-73. Locations were selected upstream and downstream of barrier sites in addition to other sites in the southern Delta and Stockton. Each time period along the x-axis represents a constant condition during which the barrier combination does not change. The heights of the bars show minimum water levels averaged over the 16-year period between 1976 and 1991. When a barrier is installed or removed, the change creates a new condition and a new time period begins. Table XIII-17 shows the schedule of barrier operation under the alternatives.

Table XIII-17
Schedule of Barrier Installation

Time Period	JPOD Alternatives 1-6, 9 South Delta Temporary Barriers [1,3]	JPOD Alternatives 7 and 8 South Delta Permanent Barriers [2,3]
October	Head of Old River	Old River, Middle River, Head of Old River
November	Head of Old River	Head of Old River
December	No Barriers	None Operating
January	No Barriers	None Operating
February	No Barriers	None Operating
March	No Barriers	None Operating
April 1 - 15	No Barriers	Old River, Middle River
April 16 - 30	No Barriers	Old River, Middle River, Head of Old River
May	Old River, Middle River, Head of Old River	Old River, Middle River, Head of Old River
June	Old River, Middle River	Old River, Middle River, Grant Line Canal
July	Old River, Middle River	Old River, Middle River, Grant Line Canal
August	Old River, Middle River	Old River, Middle River, Grant Line Canal
September	Old River, Middle River, Head of Old River	Old River, Middle River, Head of Old River

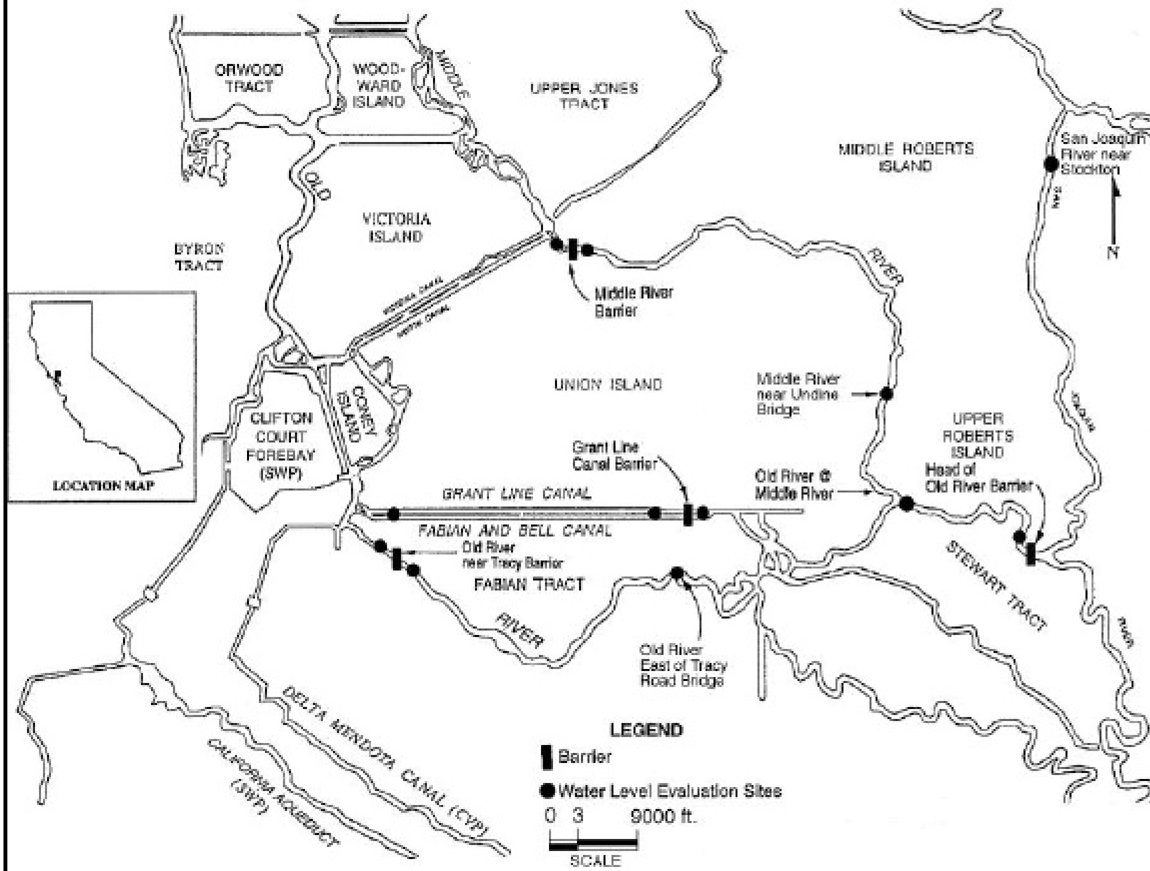
1 If San Joaquin River flow exceeds 5,000 cfs, the temporary Head of Old River barrier is removed.
2 If San Joaquin River flow exceeds 8,600 cfs, the permanent Head of Old River barrier is opened.
3 If San Joaquin River flow exceeds 20,000 cfs, temporary barriers are removed and permanent barriers are opened.

Middle River Barrier Site. Model output shown in Figure XIII-74 shows predicted water levels downstream of the Middle River barrier site. Outputs indicate almost no difference in minimum water levels downstream of the barrier site among alternatives. Upstream of the Middle River barrier site (Figure XIII-75), minimum water levels go up one to two feet when barriers are installed. Under Alternatives 7 and 8, the Middle River permanent barrier closes in April, and minimum water levels rise about two feet under these two alternatives. In May, under Alternatives 1 through 6 and 9, a temporary barrier at Middle River is installed and water levels rise almost as much. Water levels are a little higher with the ISDP permanent barrier closed than they are with the temporary barrier installed because the model assumes water will spill over the temporary barriers during high water level periods, but such spills will not occur with the permanent barriers. In June, the Grant Line Canal permanent barrier closes and water backed up behind the Grant Line barrier also raises minimum water levels behind the Middle River barrier causing water levels under Alternatives 7 and 8 to rise another three feet. In September, the Grant Line barrier is reopened and minimum water levels under Alternatives 7 and 8 drop down to approximately the same level as the other alternatives. From November to March, there are no barriers under any of the alternatives, except for the Head of Old River fish barrier in November, and minimum water level elevations are about the same among alternatives.

Old River Barrier Site. Figure XIII-76 shows water levels downstream of the Old River barrier site. As at the Middle River site, the barrier has very little effect on downstream water levels. Immediately upstream of the Old River barrier site, the Old River permanent barrier installation under Alternatives 7 and 8 in April raises minimum water levels upstream as shown in Figure XIII-77. The Old River temporary barrier under the other alternatives also raises minimum water levels when it gets installed in May. In June, the Grant Line canal permanent barrier, in conjunction with the Old River barrier and Middle River barrier causes a significant increase in minimum water levels under Alternatives 7 and 8, about 3.5 feet. Minimum water levels under Alternatives 7 and 8 return to approximately the same levels as the other alternatives in September when the Grant Line barrier is reopened. In October, minimum water levels under Alternatives 7 and 8 remain about one foot higher than the other alternatives because the Old River permanent barrier is still in while the Old River temporary barrier is removed. From November through March, all barriers are removed, except for the Head of Old River barrier in November, and water levels among the alternatives are about the same.

Grant Line Canal Barrier Site. Figure XIII-78 shows output for a site downstream of the Grant Line Canal barrier site. The DWRDSM model assumptions for Alternatives 7 and 8 places the permanent Grant Line Canal barrier on the east end of Grant Line Canal, near Tracy Road bridge. The other alternatives do not assume any barrier operation on Grant Line Canal. The figures show that Alternatives 7 and 8 result in minimum water level elevations one half foot to one foot lower than the other alternatives in June, July and August when the barrier is closed, and may have an adverse effect on water diversion downstream of the Grant Line barrier. This effect can be eliminated by moving the barrier to the west end of Grant Line Canal. Upstream of the barrier, minimum water levels are about four feet higher in June and July and about three feet higher in August than the other alternatives during the same months (Figure XIII-79).

Figure XIII - 73
Locations Examined for Water Level Changes Under Joint Point Alternatives



<u>Other Locations</u>. Figure XIII-80 shows predicted minimum water levels at a site further downstream of the Grant Line Canal barrier site than Figure XIII-78. The salinities at these locations are very similar except that the drop in minimum water levels associated with closure of the Grant Line Barrier in June, July, and August under Alternatives 7 and 8 is not as pronounced towards the west end of Grant Line Canal.

Figure XIII-81 shows minimum water levels for a location further upstream from the Tracy barrier site. Minimum water levels follow the same pattern as Figure XIII-77 (Old River Upstream of Barrier) except that water levels are about one-half to one foot higher from January to March for all of the alternatives. The Old River permanent barrier, in conjunction with the other permanent ISDP barriers, particularly the Grant Line Canal barrier, results in a dramatic increase in minimum water levels in the summer under Alternatives 7 and 8.

Figure XIII-74
Average Minimum Water Levels by Period at Middle River Downstream of Barrier

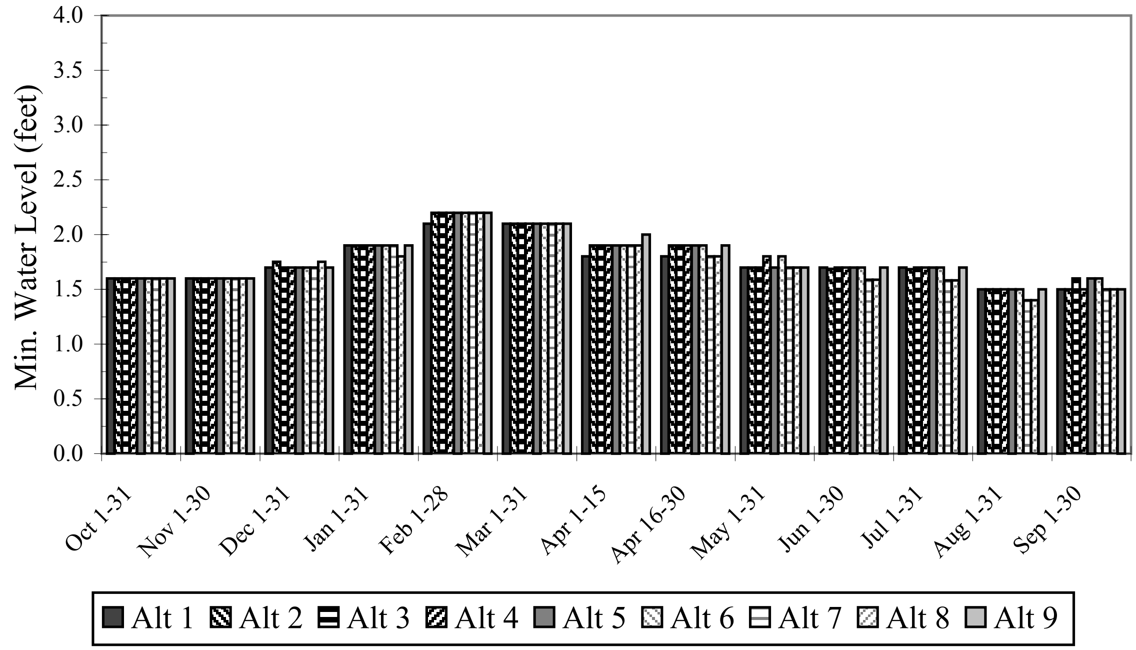


Figure XIII-75
Average Minimum Water Levels by Period at Middle River Upstream of Barrier

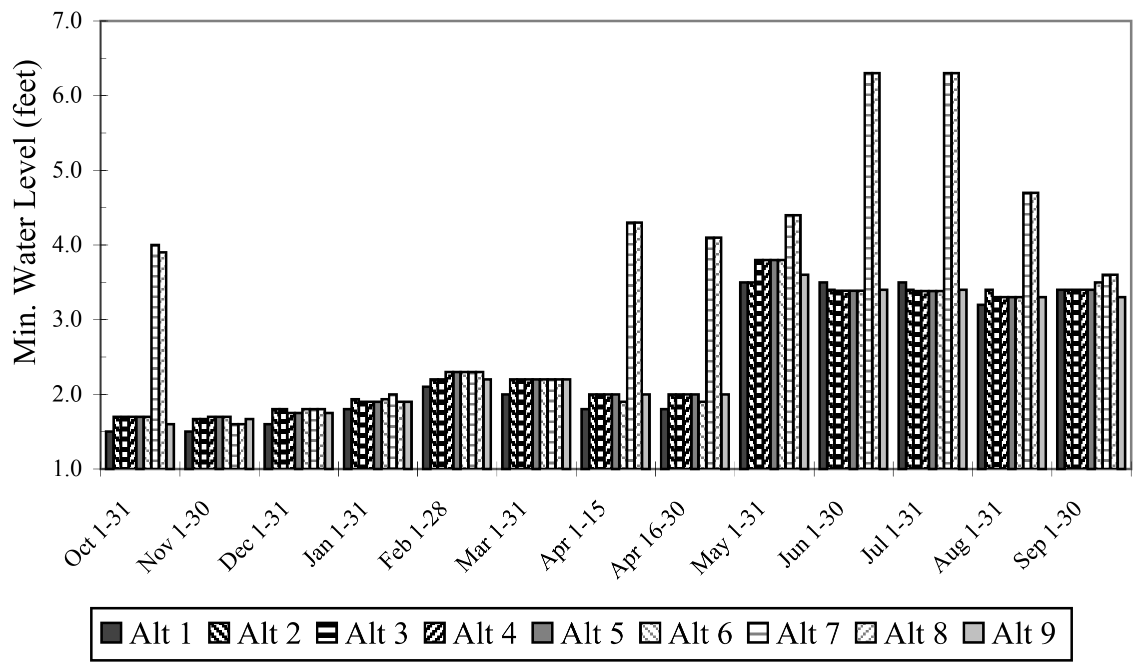


Figure XIII-76
Average Minimum Water Levels by Period at
Old River Downstream of Barrier

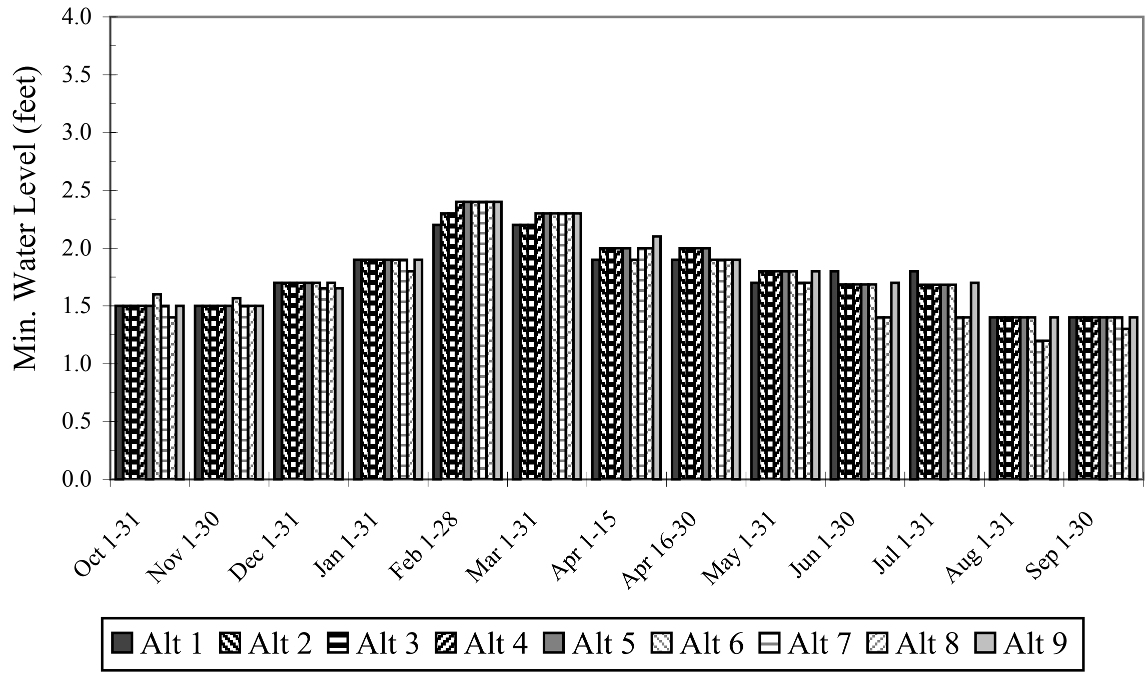


Figure XIII-77
Average Minimum Water Levels by Period at
Old River Upstream of Barrier

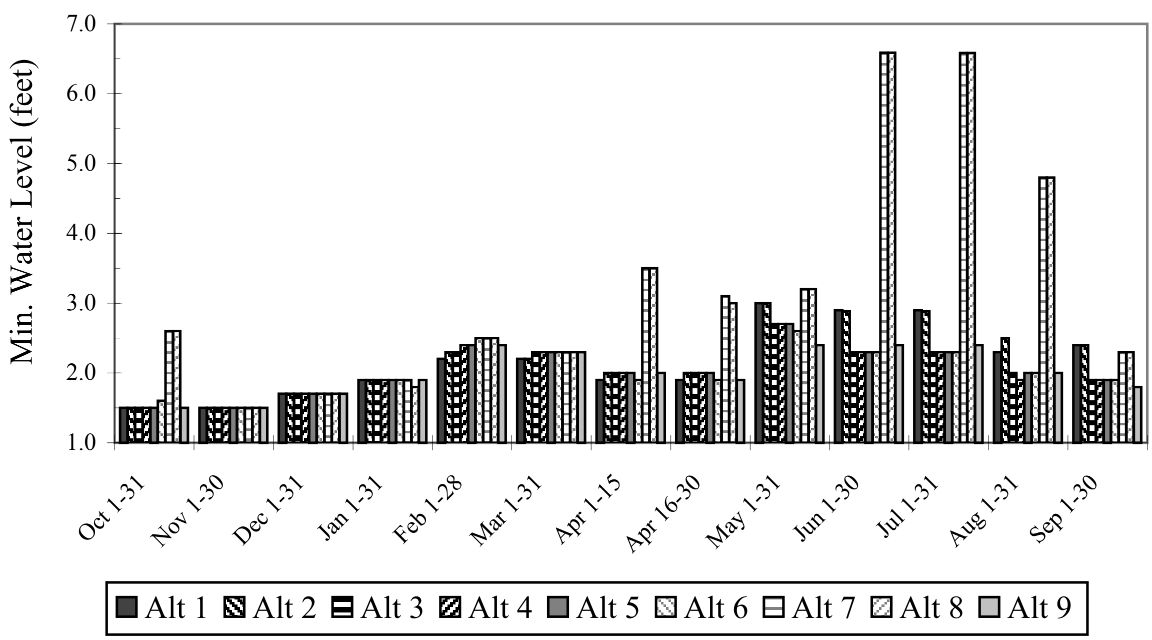


Figure XIII-78
Average Minimum Water Levels by Period at
Grant Line West of Tracy Road Bridge

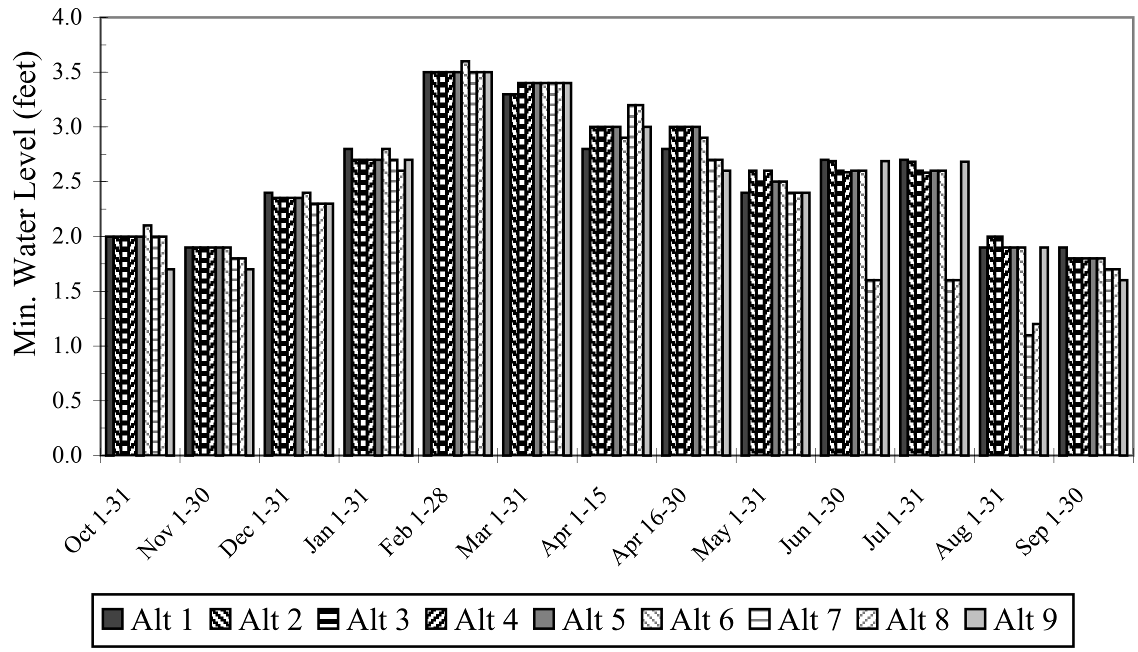


Figure XIII-79
Average Minimum Water Levels by Period at
Grant Line East of Tracy Road Bridge

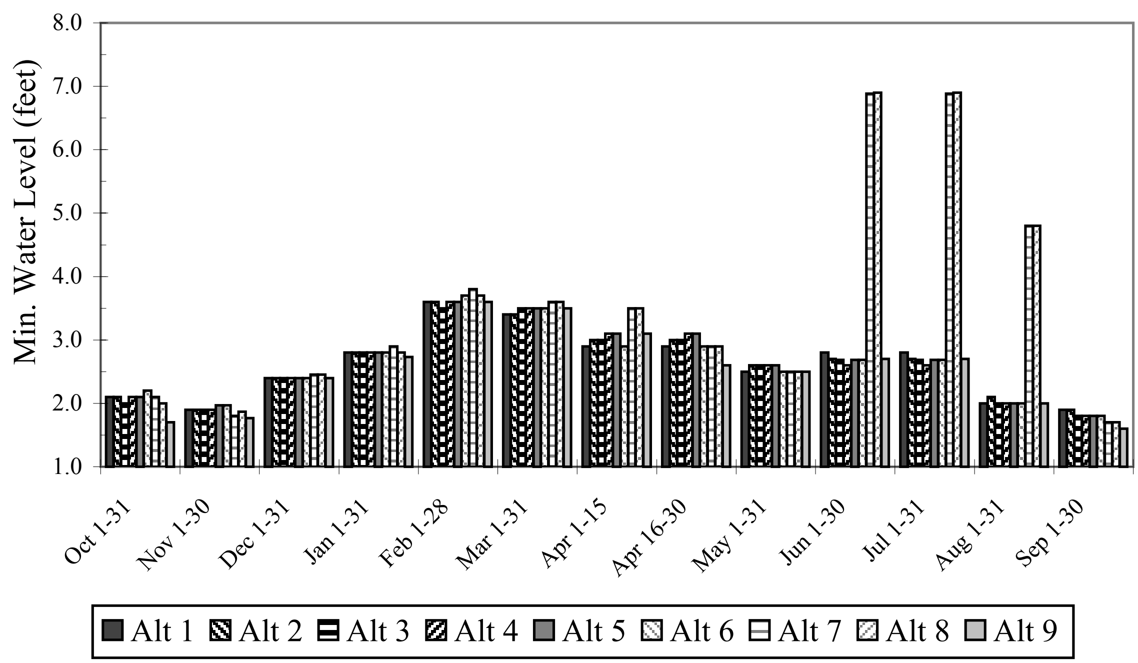


Figure XIII-80
Average Minimum Water Levels by Period at Grant Line
Upstream of Grant Line & Old River Confluence

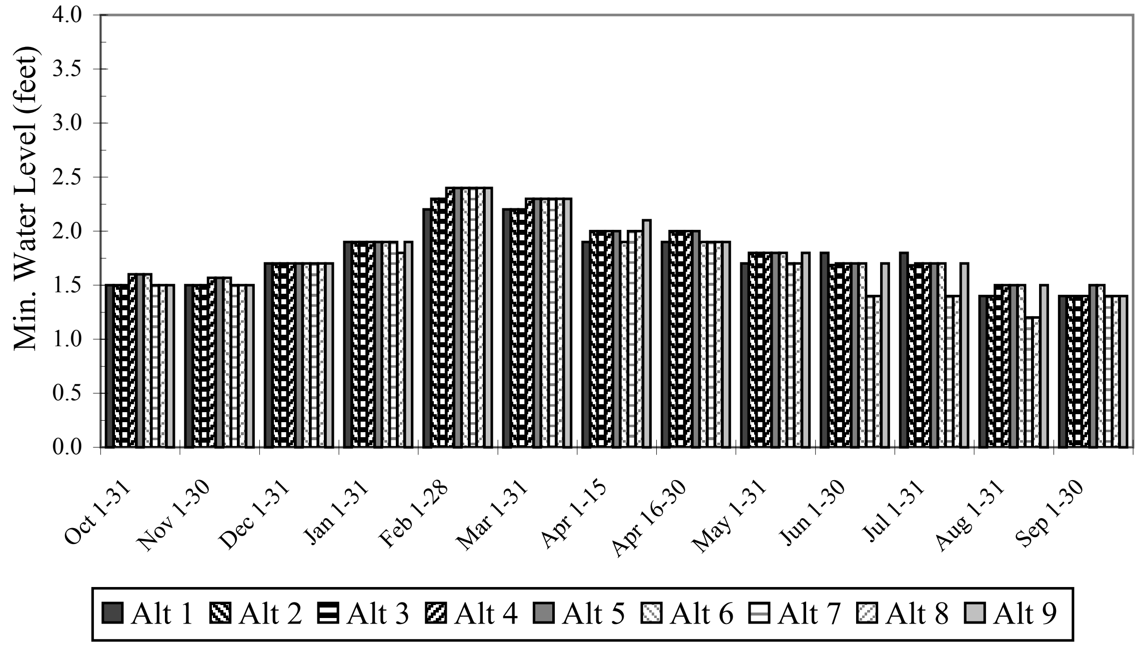


Figure XIII-81
Average Minimum Water Levels by Period at
Old River East of Tracy Road Bridge

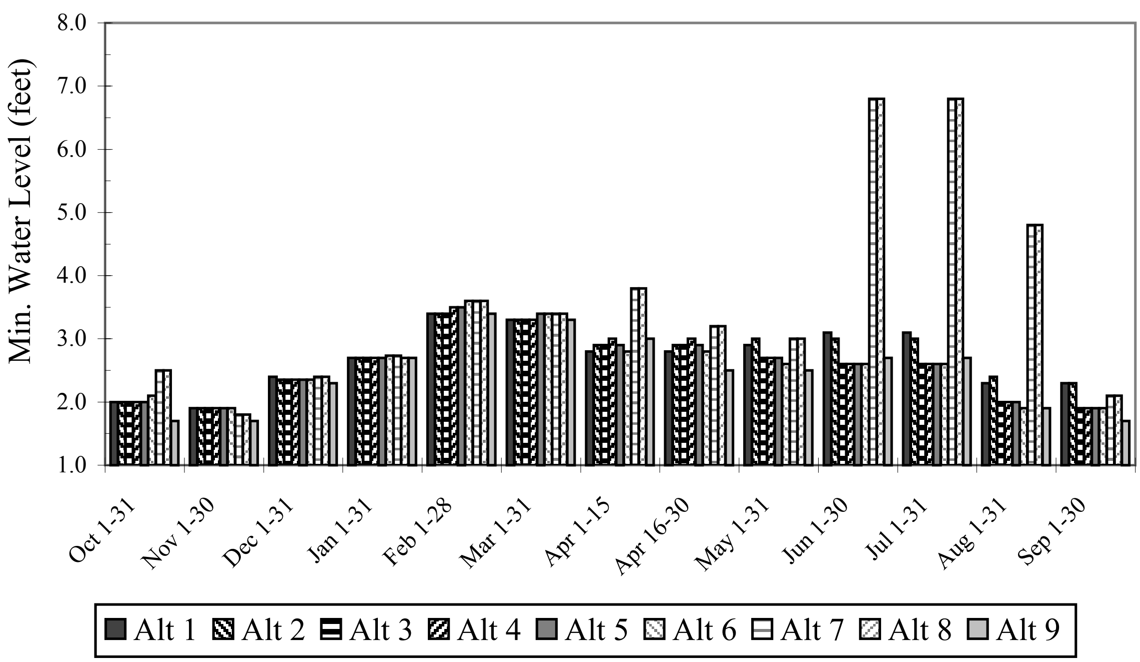


Figure XIII-82
Average Minimum Water Levels by Period at
Middle River Near Undine Bridge

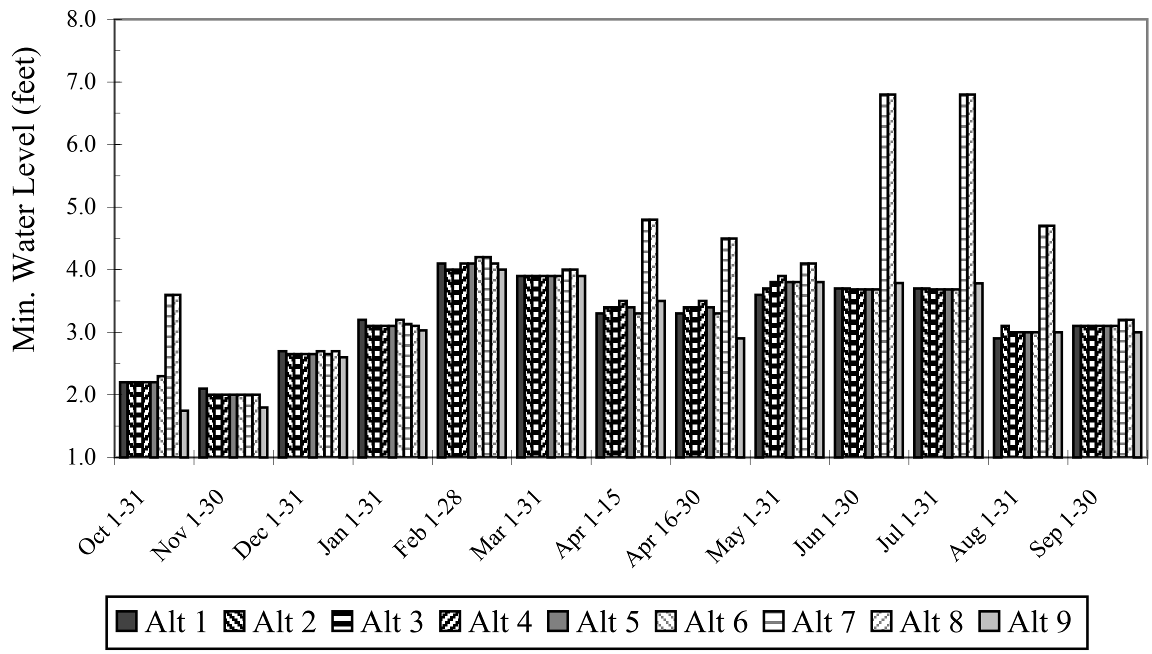


Figure XIII-83
Average Minimum Water Levels by Period at Old River
Upstream of Old River & Middle River Confluence

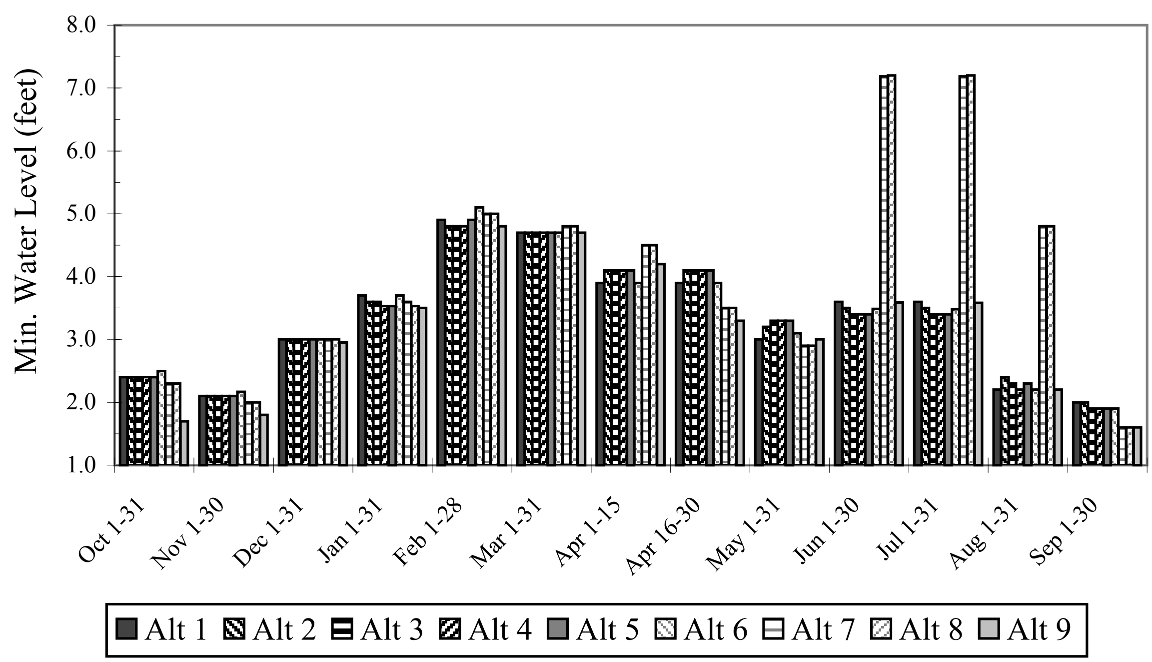


Figure XIII-84

Average Minimum Water Levels by Period at Old River Downstream of Old River Barrier

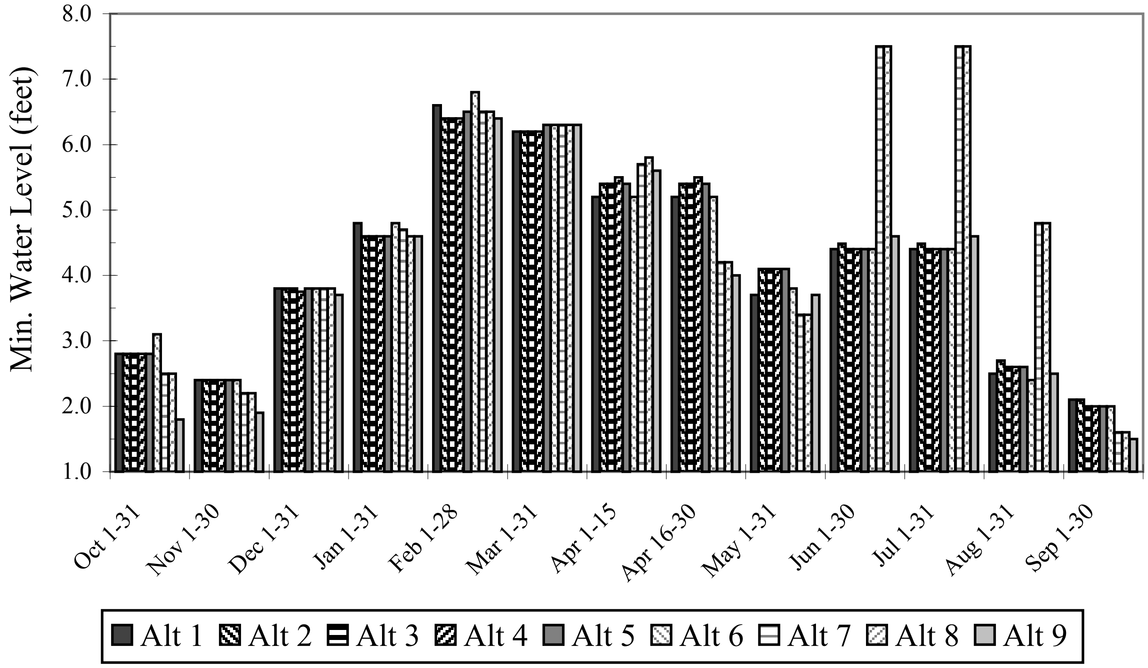
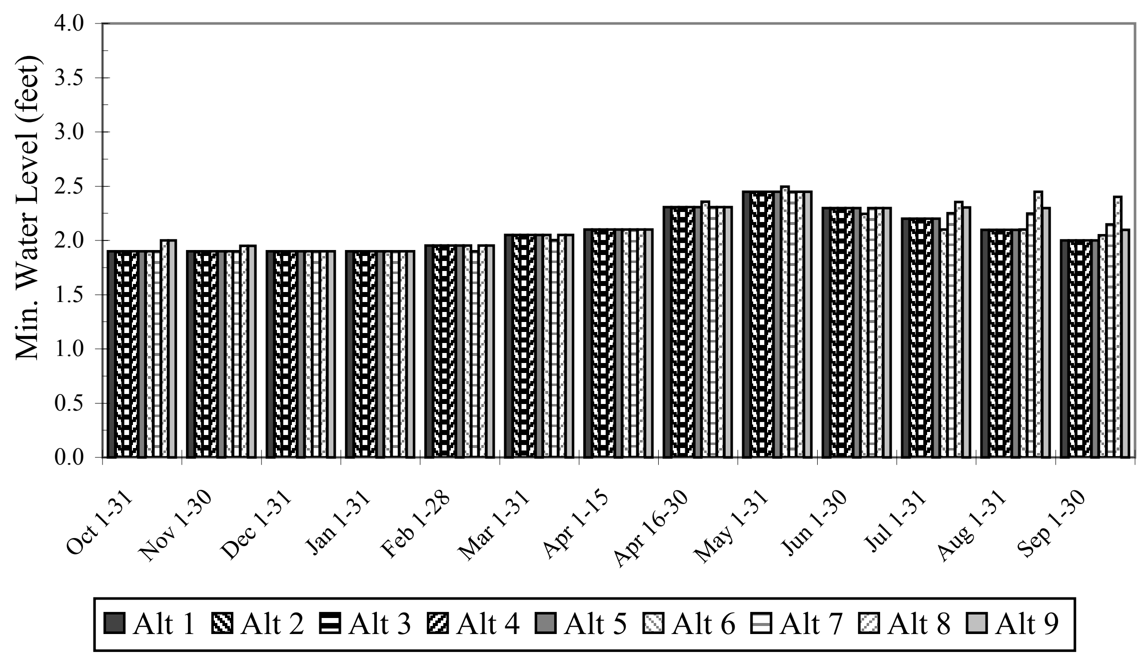


Figure XIII-85

Average Minimum Water Levels by Period at Stockton on the San Joaquin River



Minimum water levels for a location further upstream of the Middle River barrier site are shown in Figure XIII-82. Minimum water levels are similar to those in Figure XIII-75 (Middle River upstream of barrier) except that minimum water levels are about one foot higher from late fall through winter when hydraulics are not being driven by barrier operation. Alternatives 7 and 8 provide the highest minimum water levels from April through October.

Figures XIII-83 and XIII-84 show that minimum water levels at the confluence of Middle River and Old River follow the same pattern as Old River downstream of the Head of Old River Barrier, except that minimum water levels at the upstream location are about 1.5 feet higher overall. Here again, the ISDP barriers, particularly the Grant Line barrier have a big effect in June, July and August on minimum water levels. The Head of Old River Barrier is installed (or closed, in the case of Alternatives 7 and 8) from September to November and then again in May for one month, causing minimum water levels to drop during those months up to a foot or more. Under the DWRDSM assumptions, the temporary Head of Old River Barrier is removed when San Joaquin River flows exceed 5,000 cfs, and the permanent Head of Old River barrier is opened when flows exceed 8,600 cfs. Consequently, there is some variation among alternatives in those months when the Head of Old River Barrier is installed.

Figure XIII-85 shows that barrier construction and operation does not have a significant effect on water levels in the San Joaquin River near Stockton.

In summary, many southern Delta locations show significant improvements in minimum water levels at certain times of the year as a result of barrier and flow operations under Alternatives 7 and 8 compared to the other alternatives and base case. The following locations have monthly minimum water levels of at least two (+2) feet higher under Alternatives 7 and 8 than the other alternatives: Middle River upstream of Barrier in April, June, July, and October; Old River upstream of Barrier in June, July, and August; Grant Line Canal east of Tracy Road Bridge in June, July, and August; Old River east of Tracy Road Bridge in June, July, and August; Middle River near Undine Bridge in June and July; Old River upstream of the Old River and Middle River confluence in June, July, and August; and Old River downstream of the Old River and San Joaquin River confluence in June, July, and August.

In certain months, at certain locations, Alternatives 7 and 8 will cause elevations which are lower than the other alternatives. A monthly minimum water level of negative (-) 0.5 feet or lower (with respect to base case water levels) is considered to have a significant adverse impact and occurs under Alternatives 7 and 8 on Grant Line west of Tracy Road Bridge in June, July, and August.

b. Mitigation for Impacts to Water Levels. The installation of the Grant Line Canal barrier would reduce water levels downstream of the barrier creating adverse environmental effects. This effect can be mitigated by moving the Grant Line Barrier as far as feasible to the west on Grant Line Canal.

4. Fish and Aquatic Resources

Effects on aquatic resources resulting from the implementation of the 1995 Bay/Delta Plan are analyzed and disclosed in the ER and this EIR. The purpose of this section is to evaluate the additional effects that implementation of Joint POD alternatives would have on aquatic resources in the Delta.

Modifications to pumping patterns, reservoir releases, and other operations of the water management system resulting from the combined use of points of diversion have the potential to affect aquatic resources system wide. Other impacts from temperature changes, food limitations, habitat losses, introduced species, harvest, and contaminants in the Delta discussed in Chapter VI, are not expected to change significantly for any of the Joint POD alternatives. Alternative 2 represent the effects attributable to implementation of the 1995 Bay/Delta Plan. Alternatives 3 through 9 demonstrate the effects of various levels of wheeling in addition to the effects of implementing the 1995 Bay/Delta Plan.

Of the factors identified above, the Joint POD alternatives are expected to have the most significant potential impacts on entrainment losses and other export-related effects in the Delta. Entrainment in some months is expected to increase due to increased Delta exports. Average exports would increase from July to January, except in September, compared to Alternative 2 (see Table XIII-12). Increased reverse flows associated with the alternatives may shift more organisms toward the central Delta where they would be more vulnerable to entrainment at the export facilities. However, higher exports from the SWP and CVP are considered most harmful during the spring when eggs, larvae, and juveniles of many Bay/Delta species are present. All of the alternatives would reduce exports in February and March compared to Alternative 2 with some reductions in April, May, and June.

Impacts of these export changes would vary by species. Some anadromous species like winter-run chinook salmon may respond positively because the smolt life stage, the most vulnerable to entrainment, would have completed their outmigration by the time exports increase in the summer. However, adverse impacts on winter-run chinook could result from increased exports in the November through January period.

For spring-run chinook salmon, increases in fall and winter pumping may adversely affect yearlings migrating through the Delta and young-of-the-year rearing in the Delta. However, there may be benefits to young-of-the-year spring-run that are rearing and outmigrating through the Delta during the period of reduced export pumping in the late winter and spring. These impacts and benefits may not offset each other. Joint POD-related impacts to spring-run in the fall/winter may primarily affect the Mill and Deer Creek populations, since they tend to emigrate as yearlings. Benefits from reduced spring exports may primarily affect spring-run from other stream populations.

Joint POD Alternative 4 provides greater protection for aquatic resources than Joint POD Alternatives 3 and 5 through 9 because the combined use of points of diversion is used primarily for the benefit of aquatic resources. Based on historical operations, the combined use of points of diversion would probably be used in the fall and winter under this alternative to make up for export restrictions in the spring. Therefore, even this alternative can adversely affect specific aquatic resources if their most critical period in the Delta does not coincide with the window of export reductions.

If operations under Joint POD Alternatives 3 through 9 result in increased entrainment, regulatory constraints could be applied to operations to reduce, offset or avoid impacts. Measures that could be used include switching diversions between SWP and CVP facilities if entrainment is high at one of the facilities, modification of required export/inflow ratios, re-operation of the Delta Cross Channel gates, or reduction or termination of increased exports resulting from joint use of the SWP and CVP points of diversion.

Delta outflow is also expected to change with the implementation of the Joint POD alternatives but the effects are not expected to be as significant as entrainment effects. Delta outflow generally decreases compared to Alternative 2 between July and January and increases during February and March, with increases and decreases in April, May, and June. In general, Alternatives 4 and 9 provide greater increases in outflow in the spring months (March through June) when the abundance of many Delta species shows a significant positive relationship with Delta outflow.

The effects of the Joint POD alternatives on aquatic resources in the Delta are described in this section. The aquatic resource models described in Chapter IV and Chapter VI are used. For purposes of discussion, results are grouped into four categories: (1) special status species; (2) species that characterize potential effects on food webs; (3) abundance/outflow relationships; and (4) net reverse flows. Chinook salmon, steelhead, striped bass, and delta smelt are the special status species considered. Copepods and phytoplankton are evaluated to assess food web effects. Abundance/outflow relationships were evaluated for longfin smelt, Sacramento splittail, starry flounder, and *Crangon franciscorum*.

Chinook Salmon. The USFWS salmon smolt survival model, described in Chapter IV, was used to evaluate the effects of the Joint POD alternatives on survival of chinook salmon smolts outmigrating through the Delta. Survival indices for the following chinook salmon runs/lifestages were modeled:

- Sacramento River fall-run, late fall-run, and winter-run (smolts), and spring-run (young-of-the-year and yearlings)
- San Joaquin River fall-run smolts (with and without the Head of Old River barrier)

Survival indices were predicted over the hydrologic period of record (1922-1992). Model calculations are shown in Volume 2, Appendix 5.

Figures XIII-86 through XIII-92 show the predicted indices for through-Delta migration of each chinook salmon run by Joint POD alternative and water year type. For all runs, predicted survival indices were generally lower in drier water years. Indices predicted for Joint POD Alternatives 2 through 9, in general, were higher than for Alternative 1. For the Sacramento River runs, there were no discernable differences between the Joint POD Alternatives that allow wheeling and Alternative 2 for any of the runs. For these runs, the smolt survival increases under Alternatives 2 through 9 result primarily from the increased closure of the Delta Cross Channel gates. Under Joint POD Alternative 1, the Delta Cross Channel is open more often, potentially diverting juvenile salmon into the central Delta where lower survival is predicted.

For Sacramento River fall-run smolts (Figure XIII-86), survival indices in a wet water year were similar between all of the Joint POD Alternatives. In all other water year types, survival indices for Joint POD Alternatives 2 through 9 were higher than in Alternative 1. The difference between Alternatives 2 through 9 and Alternative 1 increased in drier water years.

For late fall-run, winter-run smolts, and yearling spring-run (Figures XIII-87, 88, and 89), predicted survival indices were higher under Joint POD Alternatives 2 through 9 than in Alternative 1 in all water year types. The difference between Alternatives 2 through 9 and Alternative 1 increased in drier water years.

For young-of-the-year spring-run (Figure XIII-90), survival indices in wet and above normal water years were similar for all of the Joint POD alternatives. In below normal, dry, and critical years, predicted survival indices under Alternatives 2 through 9 were higher than under Alternative 1.

For San Joaquin fall-run (Figures XIII-91 and 92), predicted survival indices were higher with the operation of the Head of Old River barrier than without the barrier, but the relationships between the Joint POD alternatives and the base cases were similar with and without the barrier. In a wet year, predicted indices were similar under Alternatives 1 through 8 and higher under Alternative 9. In all other water year types, predicted survival indices were higher under Joint POD Alternatives 2 through 9 than under Alternative 1. Among Alternatives 2 through 9, indices were generally lower under Alternative 6 and higher under Alternatives 4 and 9 than the other alternatives.

These differences in predicted survival of San Joaquin River fall-run are due to changes in San Joaquin River flow at Vernalis and total Delta exports in April and May. Higher flows and lower exports generally resulted in higher predicted survival indices. In general, flows at Vernalis were increased during this period under Joint POD Alternatives 2 through 5 and 7 through 9 compared to Alternative 1, due to implementation of the Bay-Delta Plan. Spring flows at Vernalis were higher under Alternatives 4 and 9, and lower under Alternative 6, than under Alternative 2. Total Delta exports in April and May were lower under Alternatives 2 through 9 than under Alternative 1. Under Alternatives 4 and 9, total Delta exports were lower than under Alternative 2.

Figure XIII-86

Sacramento River Fall-Run Salmon Smolt Survival Index

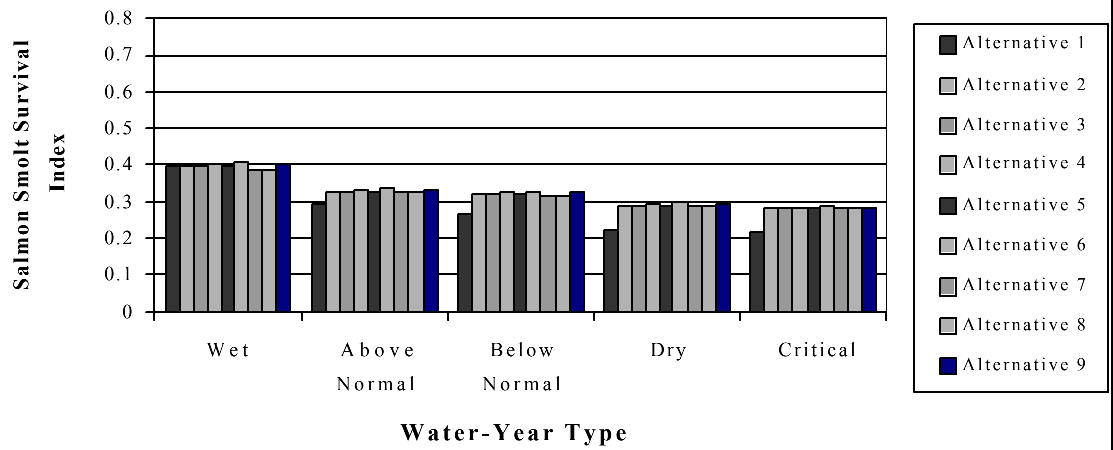


Figure XIII-87

Sacramento River Late Fall-Run Salmon Smolt Survival Index

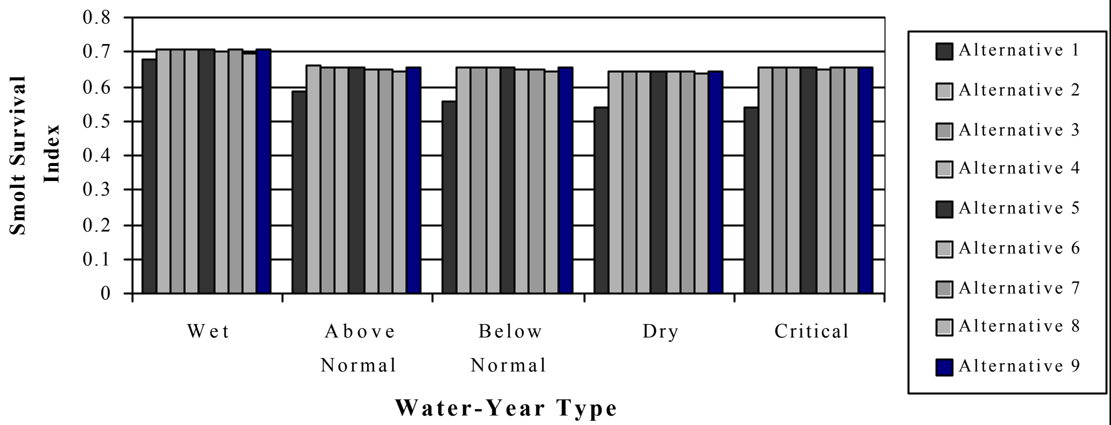


Figure XIII-88

Sacramento River Winter-Run Salmon Smolt Survival Index

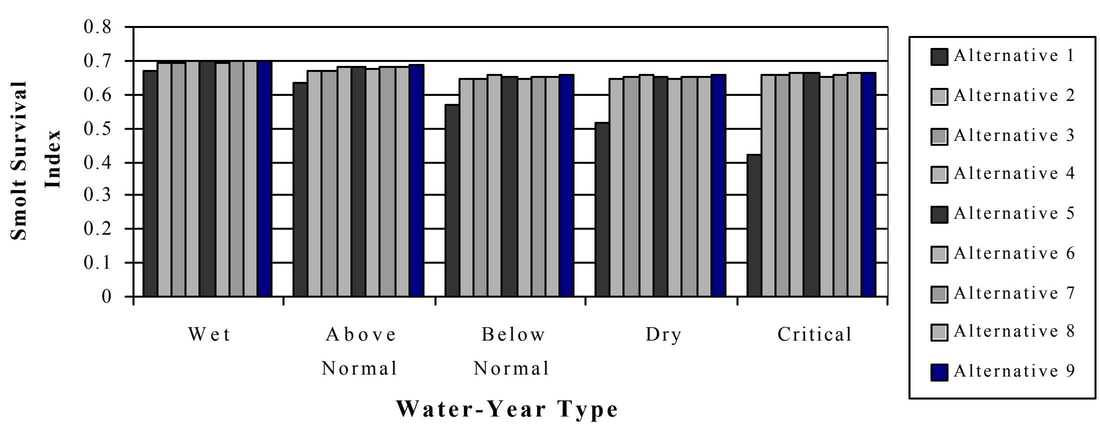


Figure XIII-89

Sacramento River Yearling Spring-Run Salmon Survival Index

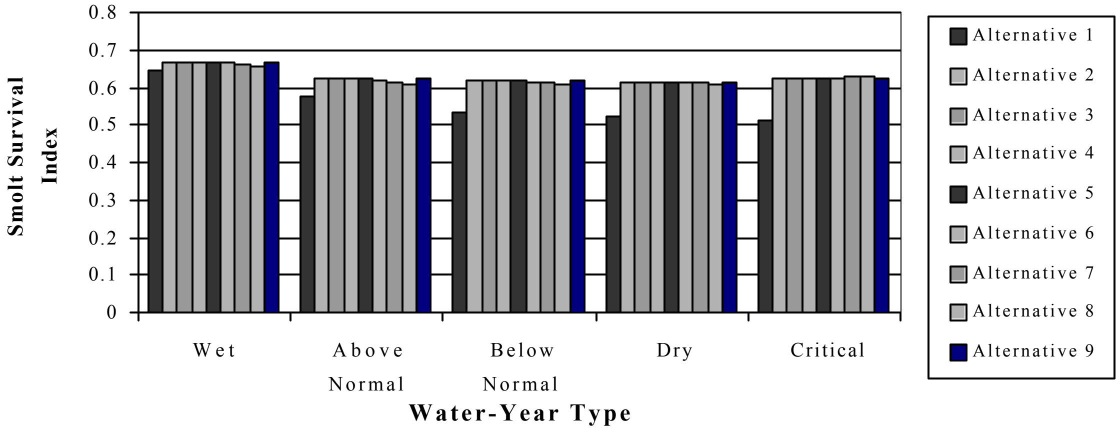


Figure XIII-90

Sacramento River Young-of-the-Year Spring-Run Salmon Smolt Survival Index

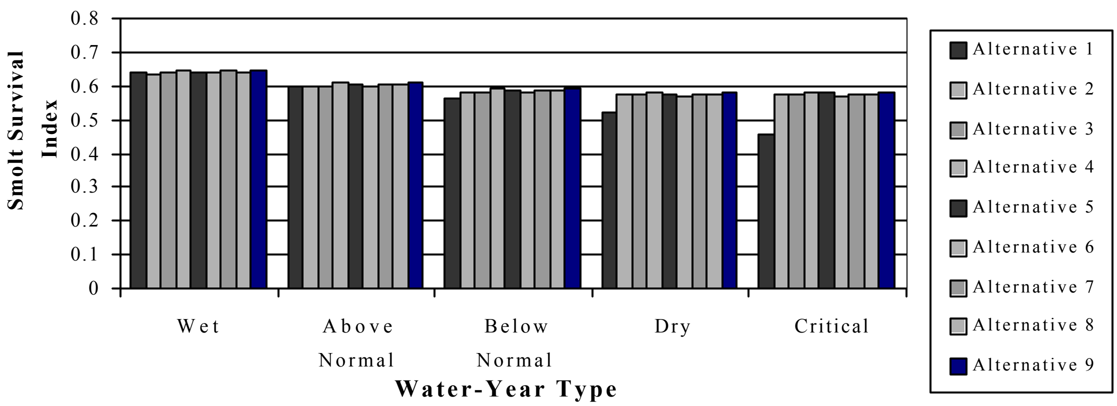


Figure XIII-91

San Joaquin River Fall-Run Salmon Smolt Survival Index with Barrier

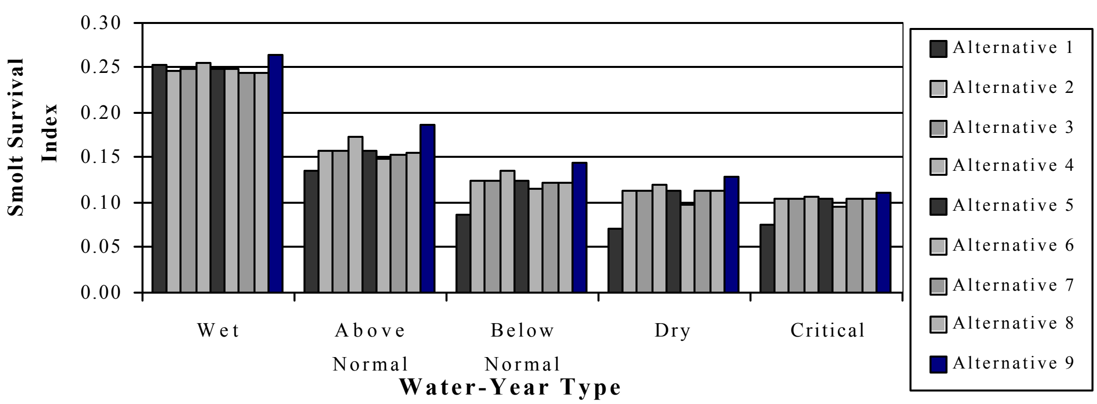
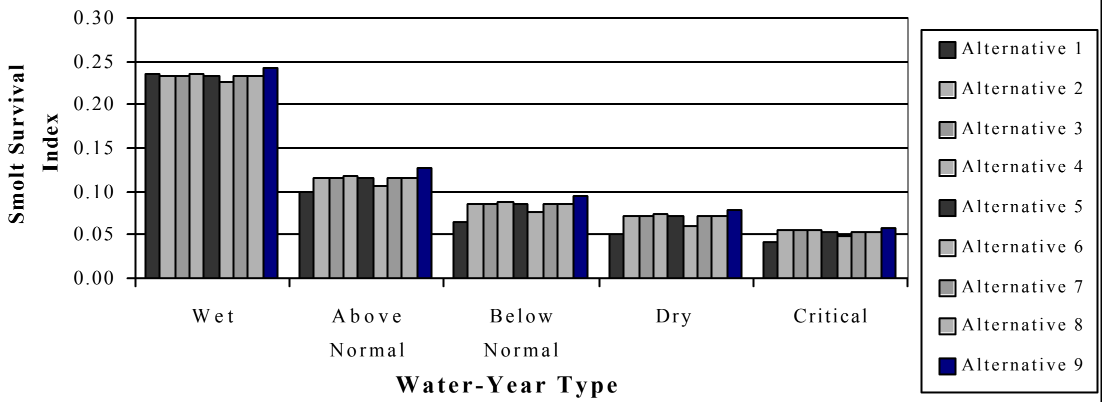


Figure XIII-92

San Joaquin River Fall-Run Salmon Smolt Survival Index without Barrier



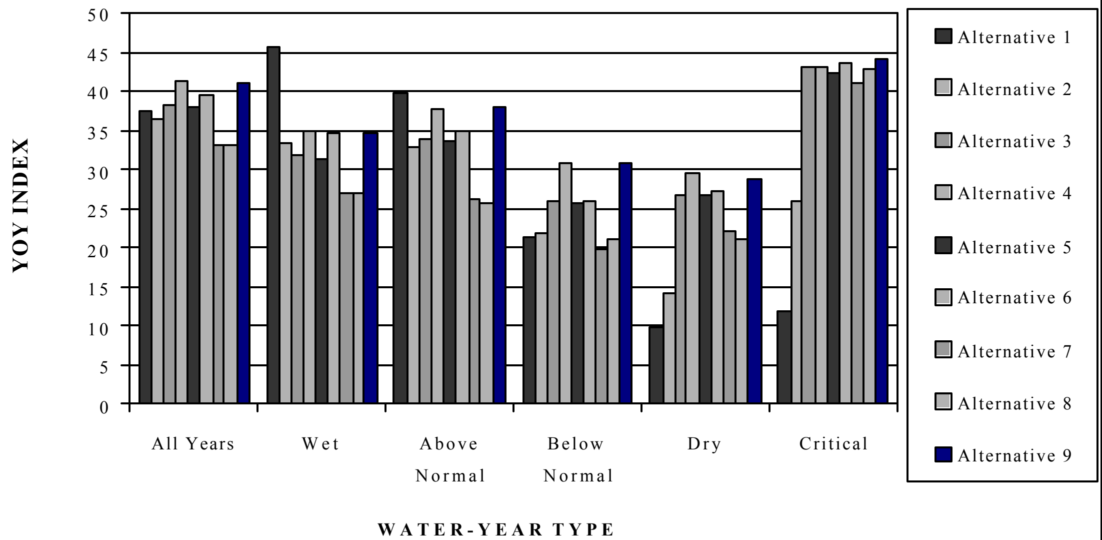
Steelhead. The Joint POD alternatives have the potential to affect juvenile steelhead during the period of emigration through the Delta. Emigration through the Delta occurs from December through May, with peak migration occurring from February through April (DWR and USBR 1999). The primary factors affected by the Joint POD alternatives that may affect survival of juvenile steelhead in the Delta include Delta inflows, exports, and closure of the Delta Cross Channel gates.

In general, survival of juvenile steelhead emigrating through the Delta in the February through April period may improve slightly under Joint POD Alternatives 3 through 9 compared to Alternatives 1 and 2. Delta exports will generally be lower in the February through April period under Joint POD Alternatives 2 through 9 compared to Alternative 1, and under Joint POD Alternatives 3 through 9 compared to Alternative 2. Also, the Delta Cross Channel gates will be closed more often in the February through April period under Joint POD Alternatives 2 through 9 compared to the Alternative 1.

Striped Bass. Changes in flow and Delta exports due to the Joint POD alternatives will primarily affect the young-of-the-year striped bass lifestage. The effects of the Joint POD alternatives on young-of-the-year striped bass abundance were modeled using a multiple regression relating total young-of-the-year striped bass abundance at 38 mm. to the mean April – July San Joaquin River flow past Jersey Point, $\log_{10}$ net Delta outflow, and total Delta exports (including CVP, SWP, Contra Costa Canal, and miscellaneous Delta diversions) (Lee Miller, DFG, personal communication). The regression is described in Chapter IV; regression calculations are shown in Volume 2, Appendix 5.

Figure XIII-93 shows the predicted young-of-the-year index for the Joint POD alternatives, by water year type and all years of record combined. The differences between Joint POD alternatives 1 and 2 show the effects of implementing the Bay-Delta Plan. In wetter water years, predicted abundance indices are higher under Alternative 1 than Alternative 2; in drier years, indices are higher under Alternative 2 than Alternative 1. In wet and above normal water years, predicted indices for Joint POD Alternatives 4, 6, and 9 were slightly higher than Alternative 2; indices for Joint POD Alternatives 7 and 8 were lower than for

FIGURE XIII-93
PREDICTED STRIPED BASS YOY INDEX



Alternative 2. In dry and critical water years, predicted indices for Joint POD Alternatives 3 through 9 were higher than Alternatives 1 and 2.

In all water years combined, predicted indices for Alternatives 3 and 5 were similar to the base cases (Alternatives 1 and 2); indices for Alternatives 4, 6, and 9 were slightly higher, and Alternatives 7 and 8 were lower than the base cases.

The observed differences in the abundance indices are primarily due to changes in total Delta exports. Of the flow/export variables included in the regression, mean April – July total Delta exports had a dominant effect on the predicted abundance indices.

The predicted changes in young-of-the-year abundance under Alternatives 7 and 8 may have a slight adverse impact on recruitment to the adult striped bass population compared to the base cases. Striped bass losses under these alternatives could be mitigated through funding of additional stocking.

Delta Smelt. Implementation of Joint POD Alternatives 2 through 9 may slightly improve conditions for delta smelt compared to the D-1485 base case condition. Implementation of these alternatives would generally reduce Delta exports during the spring when delta smelt are most vulnerable to entrainment. Delta smelt are more abundant when X2 is located in Suisun Bay. The location of X2 in Suisun Bay may allow access to considerably more suitable shallow-water habitats than in the river channels upstream (IEP 1996b). The pattern and magnitude of changes to X2 for Joint POD alternatives can largely be attributed to the implementation of the 1995 Bay/Delta Plan. The mean monthly position of X2 for Joint POD alternatives that allow wheeling is not significantly different from the position predicted for Alternative 2 (Table XIII-16).

Delta Food Webs. Negative correlations have been found between export pumping and phytoplankton community composition and chlorophyll *a* concentrations (Lehman 1992). Jassby and Powell (1994) found that diversion and Delta outflow together account for 86 percent of the variability in chlorophyll *a* concentrations in the entrapment zone. Effects on higher trophic levels are not as obvious. Zooplankton populations, such as rotifers and copepods, may be entrained at rates that can affect local populations, but there is probably no overall population effect because only a small proportion of the total population is entrained (IEP 1996a).

Joint POD alternatives that allow wheeling would generally increase exports and reduce Delta outflow from July through January, which may result in localized impacts on populations of lower trophic organisms compared to Joint POD Alternative 2. However, exports would be reduced and Delta outflow increased in the spring months under Joint POD Alternatives 3 – 9, which may improve conditions for lower trophic level organisms.

Abundance/Outflow Model Results. Results of the abundance/outflow models for Joint POD alternatives are shown in Figures XIII-94 through XIII-97. Predicted abundance indices for Joint POD Alternatives 2 – 9 are similar, and slightly higher than for Alternative 1, for all species considered. There are no significant differences between JPOD alternatives that allow wheeling and Alternative 2.

Net Reverse Flows. Net reverse flows occur when the net flow in Delta channels is toward the Delta rather than downstream towards Suisun Bay. These reverse flows may have adverse effects on aquatic resources in the Delta. Reverse flows may result in increased straying of adult fish. Reverse flows may also entrain eggs, larvae, and juvenile fish into the southern and central Delta where rearing conditions may be less suitable, predation may be higher, and fish may be more vulnerable to entrainment at the export facilities and at local diversions. Table XIII-18 lists QWEST flows from the DWRSIM studies used as a measure of reverse flows in Delta channels. To a certain extent, QWEST can be used as a measure of reverse flow conditions in Delta channels. As QWEST decreases, net reverse flows in some Delta channels will increase. The model output shows that QWEST flows for the Joint POD alternatives are relatively mixed for each alternative in the 73-year annual average with no clear best alternative. QWEST generally increases from the base case for all alternatives in February, March, April, August and September. In May, the QWEST varies. In June, July, and between October and January, QWEST for the alternatives generally decreases from the base case. For the critical period annual averages, QWEST generally increases from the base case for all alternatives in February, March, and June through September. During critical periods, the Joint POD alternatives result in decreased QWEST (increased net reverse flows) from October through January with November being mixed.

Summary of Effects on Fish and Aquatic Resources. For most species, conditions under Joint POD Alternatives 2 through 9 would be beneficial compared to D-1485 conditions (Alternative 1). However, some of the benefits of implementation of the 1995 Bay/Delta Plan may be reduced by the adverse effects of implementing the Joint POD alternatives.

Figure XIII-94
Predicted Abundance Indices for Longfin Smelt

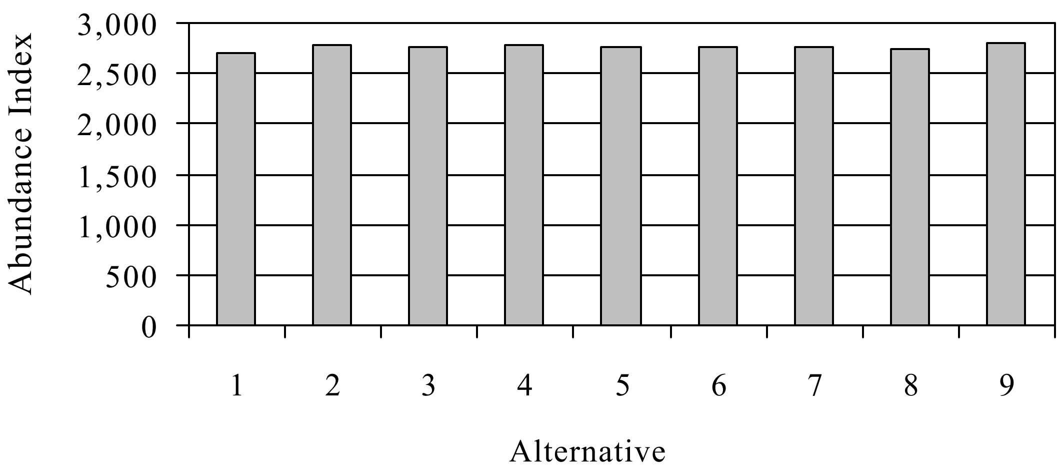


Figure XIII-95
Predicted Abundance Indices for Sacramento Splittail

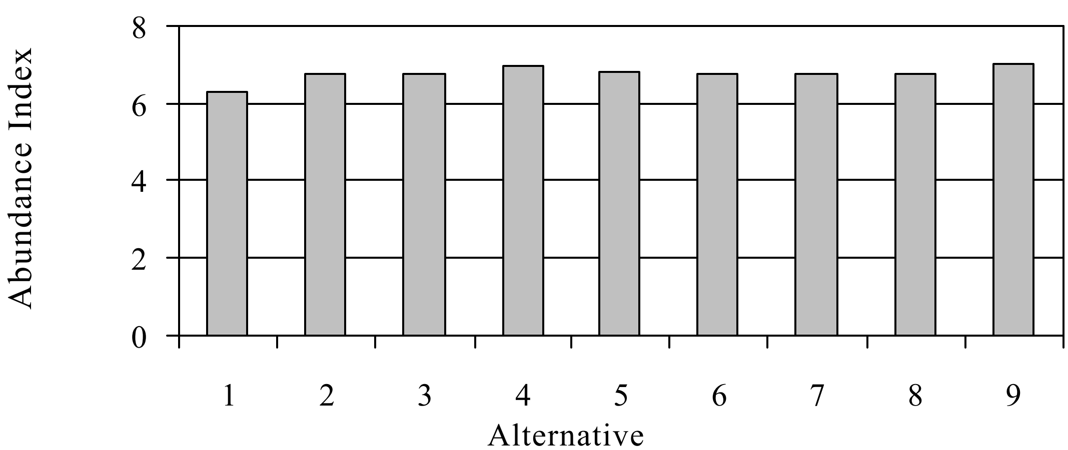


Figure XIII-96
Predicted Abundance Indices for One-Year-Old Starry Flounder

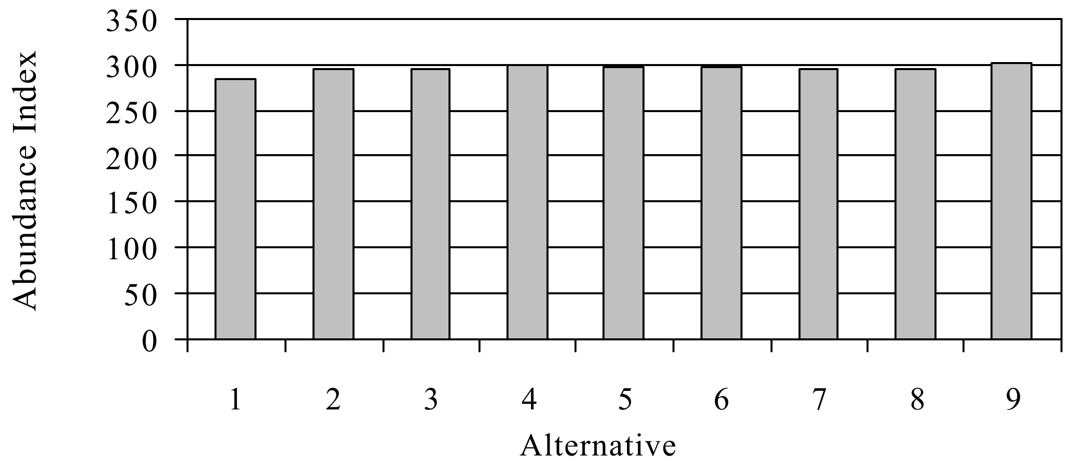


Figure XIII-97
Predicted Abundance Indices for Immature *Crangon franciscorum*

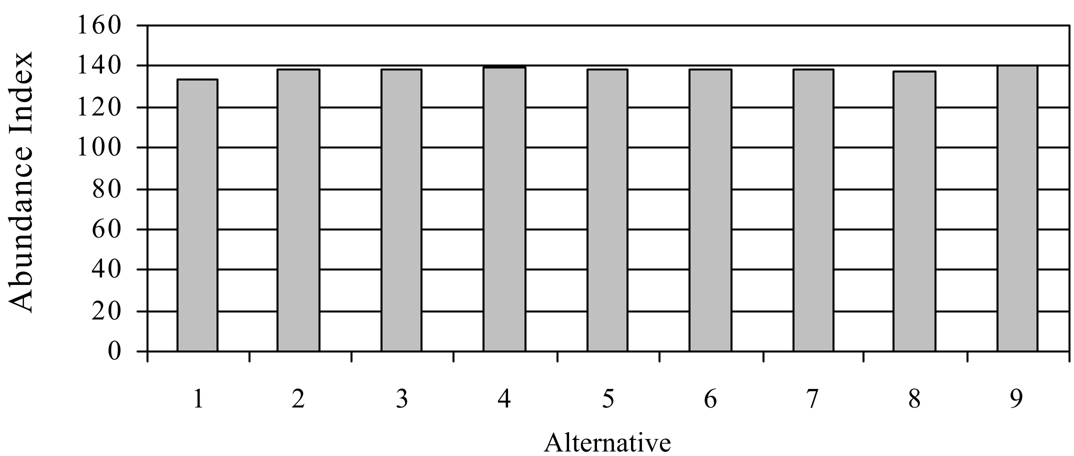


Table XIII-18
QWEST Flows (cfs)

73-Year Annual Average												
Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	243	-1,133	786	4,357	7,453	6,367	3,335	3,539	3,245	-1,665	-3,111	-1,710
2	-186	-1,481	–153	3,657	7,597	6,319	4,600	2,826	1,119	-2,081	-1,771	-1,313
3	-313	-1,538	-318	3,434	7,646	6,303	4,629	2,856	1,134	-2,270	-2,085	-1,303
4	-362	-1,666	-688	2,923	7,839	6,772	5,543	3,577	1,077	-2,484	-2,497	-1,516
5	-430	-1,623	-632	2,827	8,134	6,745	4,639	2,845	1,130	-2,374	-2,409	-1,313
6	34	-1,634	-433	3,153	8,462	6,931	2,470	4,019	1,088	-2,352	-2,597	-1,336
7	-1,011	-2,339	-1,371	3,570	8,761	6,888	4,434	2,709	905	-3,534	-2,033	-1,444
8	-880	-2,186	-822	1,797	8,629	6,776	4,502	2,682	895	-3,565	-2,373	-1,317
9	-510	-1,572	-650	2,902	7,943	6,937	5,826	3,741	1,163	-2,493	-2,480	-1,379
Critical Period Annual Average												
Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	720	-884	-1,299	-365	-1,144	717	2,404	424	-339	-2,771	-702	-397
2	-105	-614	-2,625	-3,204	-185	1,724	806	-213	53	-1,254	-140	-255
3	-318	-645	-2,829	-3,249	-221	2,083	747	-130	121	-1,661	-249	-212
4	-340	-658	-2,765	-3,736	-83	2,286	1,368	229	-188	-1,868	-353	-360
5	-355	-647	-2,813	-3,757	-58	2,331	748	-162	56	-1,767	-202	-258
6	-216	-769	-2,736	-3,667	-162	2,359	-1,056	954	178	-1,012	71	-247
7	-300	-1,172	-3,287	-4,076	28	2,438	673	-154	-32	-1,387	230	-109
8	-333	-1,113	-3,012	-4,611	181	2,417	747	-140	-105	-1,344	192	-131
9	-95	-328	-2,616	-3,643	-402	518	1,204	316	-132	-1,824	-139	-363

Joint POD Alternatives 3 through 9 may result in increased entrainment and other export-related effects in the Delta in the July to January period (except September) due to increased Delta exports. Survival of yearling spring-run chinook salmon emigrating through the Delta may be reduced because their emigration period (fall and winter) coincides with the period of increased exports. However, exports would be reduced in the spring months under Joint POD Alternatives 3 through 9 compared to Joint POD Alternatives 1 and 2, potentially reducing entrainment in the critical period for spawning, rearing, and outmigration of many aquatic species in the Delta.

If operations under Joint POD Alternatives 3 through 9 result in increased entrainment, regulatory constraints could be applied to operations on a real-time basis to reduce, offset or avoid impacts. Measures that could be used include switching diversions between SWP and CVP facilities if entrainment is high at one of the facilities, modification of required export/inflow ratios, re-operation of the Delta Cross Channel gates, or reduction or termination of increased exports resulting from joint use of the SWP and CVP points of diversion.

The abundance of many Delta species shows a significant positive relationship with Delta outflow in the spring months. Delta outflow is expected to change with the implementation of the Joint POD alternatives but the effects are not expected to be as significant as entrainment effects. Delta outflow generally decreases compared to the Bay/Delta Plan base case between July and January and increases during February and March, with increases and decreases in April, May, and June.

In general, Joint POD Alternatives 2 through 9 are predicted to have slight beneficial effects on through-Delta survival of juvenile chinook salmon and steelhead, and on abundance of delta smelt, Sacramento splittail, starry flounder, longfin smelt, and *Crangon franciscorum*, compared to the D-1485 base case (Alternative 1). In addition, for most of these species, no significant adverse effects were predicted for the Joint POD alternatives that allow wheeling compared to Alternative 2.

Joint POD Alternative 4 may provide greater protection for aquatic resources than Alternatives 3 and 5 through 9 because the combined use of points of diversion is used primarily for the benefit of aquatic resources.

Joint POD Alternatives 7 and 8 are predicted to have slight adverse impacts on young-of-the-year striped bass abundance compared to the base cases (Alternatives 1 and 2). Potential impacts on striped bass under Joint POD Alternatives 7 and 8 could be mitigated through funding of additional stocking.

F. ENVIRONMENTAL EFFECTS OF IMPLEMENTING JOINT POD ALTERNATIVES IN THE UPSTREAM AREAS

The evaluation of the environmental effects of implementing the Joint POD alternatives in the upstream areas is divided into the following sections: (1) hydrology, (2) water temperature, (3) aquatic habitat, (4) geology, (5) energy, (6) recreation, (7) cultural resources, and (8) economics.

1. Hydrology

This section discusses impacts of the Joint POD alternatives on upstream hydrology. For this analysis, average monthly flows at selected points on Central Valley rivers were compared for each of the Joint POD alternatives. The flows were modeled using DWRSIM, and the analysis focuses on the change in flow on the rivers below the major SWP and CVP reservoirs. The selected points include: the Sacramento River at Red Bluff, Feather River at Gridley, Sacramento River at Verona, American River at Nimbus Dam, and the Stanislaus River at the San Joaquin River.

Tables XIII-19 through XIII-28 illustrate the change in flow among the alternatives at the selected locations. Average monthly flows are compared for the 73-year period and the critical period. Each table presents a comparison of Joint POD Alternatives 2 through 9 to Alternative 1 (base case) and a comparison of Joint POD Alternatives 3 through 9 to Alternative 2. The latter comparison demonstrates the effects of combined use of points of diversion. Most flow changes seen in the comparison to Alternative 1 are the result of the implementation of the Plan's flow objectives. Those impacts are analyzed in Chapter VI.

Tables XIII-19 and XIII-20 show Sacramento River flows at Red Bluff. In comparing Joint POD Alternatives 3 through 9 to Alternative 2, there are no dramatic changes in flows, but overall for the 73-year period, flows are lower for Alternatives 3 through 9 from September through March and in May, and higher in April and June through August. During the critical period, flows are lower for Alternatives 3 through 9 from November through March and in May, and higher in April, June, July and October.

Tables XIII-21 and XIII-22 show Feather River flows at Gridley. Releases from Lake Oroville by the SWP appear to vary considerably under the various Joint POD alternatives, although most of the changes from Alternative 2 are relatively small. However, under Joint POD Alternatives 7 and 8, there is a significant increase in flow in July and a similar decrease in August.

Tables XIII-23 and XIII-24 show Sacramento River flows at Verona. Flows at this point reflect the combined, and sometimes offsetting, effects of changes in releases from Shasta and Oroville. Flows under Joint POD Alternatives 3 through 9 are generally lower than Alternative 2 from November through May and higher from June through August for the 73-year period. For the critical period, flows are lower than Alternative 2 from November through March, and higher than Alternative 2 during June and July.

Tables XIII-25 and XIII-26 show American River flows at Nimbus Dam. Releases from Folsom Lake under Joint POD Alternatives 3 through 9 are generally lower than Alterative 2 in September and from November through May, and higher in July, August and October. During the critical period, flows are considerably lower in March.

Tables XIII-27 and XIII-28 show Stanislaus River flows above the confluence with the San Joaquin River. Only Joint POD Alternatives 6 and 9 show significant changes from Alternative 2. These differences result from changes in the New Melones Reservoir operation with the Letter of Intent (Alternative 6) and the San Joaquin River Agreement (Alternative 9). Under Alternative 6, flows would be lower in comparison to Alternative 2 in April-May and August-September; flows would be higher from October through March and in June. Under Alternative 9, flows are lower in comparison to Alternative 2 in July-August, and in October; flows are higher from November through January, March through June, and in September.

Table XIII-19
Sacramento River Flow at Red Bluff, 73-Year Period

Alternative 1 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
7,227	8,978	12,377	15,272	18,163	15,350	11,477	10,672	10,936	12,776	10,506	6,236

Change in Flow from Alternative 1 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	72	229	30	-127	220	138	15	-184	1161	-583	-688	38
3	142	79	-37	-158	82	104	33	-220	1186	-439	-451	-15
4	40	-71	-66	-215	49	50	-66	-275	1371	-336	-284	92
5	5	-41	-130	-177	63	-4	42	-242	1193	-280	-120	-19
6	-95	-218	-190	-207	-37	63	433	-497	1590	-438	11	-94
7	-34	-80	-147	-162	17	-84	36	-274	1200	-101	143	-234
8	30	-244	-214	-194	-74	-87	15	-296	1162	-25	547	-296
9	85	-4	-3	-132	92	45	-67	-241	1227	-371	-351	0

Alternative 2 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
7,349	9,207	12,407	15,145	18,383	15,488	11,492	10,488	12,097	12,193	9,818	6,274

Change in Flow from Alternative 2 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3	70	-151	-67	-32	-138	-34	19	-36	25	144	238	-53
4	-32	-300	-96	-89	-171	-89	-81	-91	209	246	404	54
5	-67	-270	-161	-50	-157	-143	27	-58	32	303	568	-57
6	-166	-447	-220	-80	-257	-76	418	-313	428	144	699	-132
7	-106	-310	-177	-35	-203	-222	21	-90	39	482	832	-271
8	-42	-473	-244	-67	-294	-225	1	-112	1	558	1235	-334
9	13	-233	-33	-5	-128	-93	-82	-57	66	212	337	-38

Table XIII-20
Sacramento River Flow at Red Bluff, Critical Period

Alternative 1 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
4,793	4,790	6,785	6,904	6,948	6,470	6,907	7,604	8,252	9,739	9,772	5,191

Change in Flow from Alternative 1 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-190	180	-81	-84	-49	325	51	343	683	811	-1,352	111
3	-35	-40	-81	-84	-39	10	453	290	752	976	-1,420	135
4	-49	34	-123	-125	-90	-36	124	234	1,010	1,124	-1,457	213
5	-56	-85	-123	-125	-81	-38	446	303	840	1,043	-1,400	162
6	-129	-157	-164	-167	-132	-61	730	113	1,318	752	-1,604	131
7	-144	-139	-123	-125	-90	-29	468	282	895	1,069	-1,222	87
8	-35	-69	-123	-125	-46	-18	414	248	934	947	-1,166	67
9	-52	-60	-123	-126	-90	-50	61	266	913	1,063	-1,735	290

Alternative 2 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
4,603	4,970	6,704	6,820	6,899	6,795	6,958	7,947	8,935	10,550	8,420	5,302

Change in Flow from Alternative 2 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3	155	-220	0	0	9	-316	402	-54	69	165	-68	24
4	141	-146	-42	-42	-42	-361	73	-109	327	313	-105	102
5	134	-266	-42	-42	-33	-363	395	-40	156	232	-48	50
6	61	-337	-83	-83	-83	-368	679	-230	635	-58	-252	20
7	46	-319	-42	-42	-42	-354	418	-61	211	258	130	-25
8	155	-249	-42	-42	3	-343	363	-95	250	136	186	-44
9	138	-240	-42	-42	-41	-375	10	-77	230	252	-383	179

Table XIII-21

Feather River at Gridley, 73-Year Period

Alternative 1 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2,941	2,623	4,525	5,627	6,472	6,280	3,160	3,948	3,351	4,398	3,727	1,818

Change in Flow from Alternative 1 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-578	-218	-461	-424	79	26	222	-173	867	1601	-576	-189
3	-553	-205	-457	-424	65	-2	181	-187	857	1640	-565	-174
4	-600	-213	-520	-508	23	38	70	-257	775	1761	-277	-131
5	-488	-128	-463	-450	39	99	193	-170	834	1514	-666	-140
6	-561	-249	-539	-476	-39	-6	552	-390	843	1696	-518	-132
7	-520	-236	-464	-412	13	-5	177	-140	864	2725	-1587	-247
8	-514	-232	-460	-408	68	-18	175	-148	880	2675	-1593	-250
9	-662	-273	-568	-481	32	66	30	-306	833	1824	-199	-141

Alternative 2 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2,363	2,405	4,064	5,203	6,551	6,306	3,383	3,775	4,218	5,999	3,151	1,628

Change in Flow from Alternative 2 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3	25	13	5	0	-14	-27	-41	-14	-10	39	12	15
4	-23	5	-59	-84	-56	13	-152	-83	-92	160	299	58
5	90	90	-2	-26	-40	74	-29	3	-33	-87	-89	49
6	16	-31	-78	-52	-119	-32	330	-216	-24	95	59	57
7	58	-18	-2	13	-66	-30	-45	33	-3	1124	-1010	-57
8	64	-14	2	16	-11	-43	-48	26	13	1073	-1017	-61
9	-84	-55	-107	-57	-47	40	-193	-133	-34	223	377	49

Table XIII-22

Feather River Flow at Gridley, Critical Period

Alternative 1 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2,841	1,868	2,496	1,185	1,522	1,645	1,661	1,789	3,018	4,382	2,486	1,556

Change in Flow from Alternative 1 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-1,161	73	-167	-155	-126	220	764	714	633	-445	-48	-374
3	-1,175	78	-172	-155	-105	132	569	706	616	35	21	-496
4	-1,168	84	-169	-155	-126	136	199	419	605	210	248	-496
5	-1,181	70	-173	-155	-105	136	575	707	619	96	-6	-497
6	-1,146	-14	-192	-155	-145	155	1,781	212	418	-620	143	-440
7	-1,151	97	-186	-155	-105	183	621	804	711	646	-986	-444
8	-1,148	104	-185	-155	-103	188	613	778	766	637	-983	-468
9	-1,248	99	-177	-155	-145	170	278	241	670	253	414	-512

Alternative 2 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1,680	1,941	2,329	1,030	1,396	1,865	2,425	2,503	3,651	3,937	2,438	1,181

Change in Flow from Alternative 2 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3	-14	5	-5	0	21	-87	-195	-8	-17	479	69	-122
4	-7	0	-1	0	0	-84	-364	-295	-28	655	297	-122
5	-19	-3	-5	0	21	-83	-188	-7	-14	540	43	-122
6	16	-87	-25	0	-19	-65	1,017	-502	-215	-175	192	-66
7	10	24	-19	0	21	-37	-143	90	78	1,091	-938	-70
8	13	31	-18	0	24	-32	-151	64	133	1,081	-935	-93
9	-87	26	-10	0	-19	-51	-486	-473	37	698	462	-137

Table XIII-23

Sacramento River at Verona, 73-Year Period

Alternative 1 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
11,776	13,579	19,218	26,962	31,867	30,444	19,148	15,623	12,712	12,853	10,543	9,488

Change in Flow from Alternative 1 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-509	8	-435	-553	349	165	236	-355	2,030	1,019	-1,264	-152
3	-414	-129	-498	-585	197	104	213	-404	2,044	1,202	-1,015	-190
4	-563	-286	-590	-726	122	89	3	-529	2,147	1,425	-560	-40
5	-487	-172	-598	-630	152	96	234	-409	2,028	1,235	-785	-160
6	-659	-470	-733	-686	-27	58	984	-884	2,434	1,258	-506	-227
7	-557	-319	-614	-576	79	-87	212	-411	2,066	2,624	-1,443	-481
8	-487	-479	-677	-604	43	-103	189	-441	2,044	2,650	-1,046	-547
9	-580	-281	-575	-616	174	113	-39	-545	12,061	1,454	-549	-142

Alternative 2 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
11,267	13,587	18,782	26,409	32,216	30,610	19,384	15,268	14,741	13,872	9,279	9,336

Change in Flow from Alternative 2 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3	95	-137	-62	-32	-152	-61	-23	-49	14	183	249	-37
4	-54	-295	-155	-173	-227	-76	-233	-174	118	406	704	112
5	23	-180	-162	-76	-197	-69	-2	-55	-2	216	479	-7
6	-150	-478	-298	-133	-375	-107	748	-529	405	239	758	-75
7	-48	-328	-179	-22	-270	-253	-24	-57	36	1606	-179	-328
8	22	-487	-242	-51	-306	-268	-47	-87	14	1631	218	-395
9	-71	-289	-139	-63	-175	-53	-275	-190	32	435	715	10

Table XIII-24

Sacramento River Flow at Verona, Critical Period

Alternative 1 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
8,494	7,232	9,837	13,840	12,231	12,084	8,111	7,686	8,336	10,246	9,066	7,032

Change in Flow from Alternative 1 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-1,357	253	-250	-240	-153	542	809	1,055	1,319	369	-1,405	-259
3	-1,216	38	-254	-240	-122	139	1,016	993	1,370	1,013	-1,404	-357
4	-1,223	119	-292	-281	-194	98	518	651	1,618	1,337	-1,213	-279
5	-1,242	-16	-296	-281	-164	95	1,015	1,007	1,461	1,142	-1,410	-331
6	-1,280	-171	-358	-323	-255	91	2,505	322	1,738	135	-1,465	-305
7	-1,301	-42	-310	-281	-173	151	1,084	1,084	1,608	1,718	-2,213	-354
8	-1,189	36	-309	-281	-126	167	1,022	1,023	1,702	1,586	-2,154	-396
9	-1,307	39	-302	-281	-213	116	334	503	1,585	1,319	-1,325	-218

Alternative 2 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
7,137	7,485	9,587	13,601	12,078	12,626	8,920	8,740	9,654	10,615	7,660	6,773

Change in Flow from Alternative 2 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3	141	-215	-5	0	30	-403	207	-62	52	644	1	-98
4	134	-134	-43	-42	-42	-444	-291	-404	299	968	192	-20
5	115	-269	-47	-42	-11	-447	207	-47	142	773	-5	-72
6	77	-424	-108	-83	-102	-451	1,696	-733	420	-234	-59	-46
7	57	-295	-60	-42	-20	-391	275	29	289	1,349	-807	-95
8	168	-217	-60	-42	27	-375	213	-31	383	1,217	-748	-138
9	50	-214	-52	-42	-60	-426	-476	-551	267	950	81	41

Table XIII-25

American River Flow at Nimbus, 73-Year Period

Alternative 1 Average Monthly Flow (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	2,159	2,696	3,651	4,374	5,145	4,001	3,695	3,359	3,895	3,513	2,762	1,898

Change in Flow from Alternative 1 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-189	-37	-227	-140	46	91	29	102	832	-348	-379	319
3	-101	-68	-285	-169	-6	22	31	119	804	-265	-200	206
4	-178	-134	-253	-201	-98	38	-37	84	949	-219	-88	216
5	-138	-127	-295	-163	-73	33	-6	89	816	-185	46	80
6	-131	-122	-292	-209	-89	19	162	-18	975	-225	-15	34
7	-128	-151	-331	-168	-57	4	17	120	803	-96	128	-67
8	-214	-316	-434	-265	-197	-106	-80	44	669	-205	80	-353
9	-126	-82	-261	-155	-69	23	-32	66	868	-238	-111	176

Alternative 2 Average Monthly Flow (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	1,970	2,659	3,424	4,234	5,191	4,092	3,724	3,461	4,727	3,165	2,383	2,216

Change in Flow from Alternative 2 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3	88	-31	-58	-28	-52	-69	2	17	-28	83	179	-113
4	12	-97	-25	-60	-144	-53	-66	-17	117	129	292	-102
5	51	-90	-68	-23	-119	-57	-35	-13	-16	163	426	-239
6	58	-85	-65	-69	-135	-71	133	-120	143	123	364	-285
7	61	-114	-104	-28	-103	-86	-11	18	-29	252	508	-386
8	-25	-279	-207	-124	-243	-197	-109	-58	-162	144	460	-672
9	63	-45	-12	-15	-115	-68	-61	-36	36	110	268	-142

Table XIII-26

American River Flow at Nimbus, Critical Period

Alternative 1 Average Monthly Flow (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	1,571	1,314	1,277	1,212	2,039	1,868	2,622	1,791	2,715	4,210	2,412	576

Change in Flow from Alternative 1 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	143	177	-481	-462	-892	275	162	461	2,009	-1,280	-754	537
3	292	317	-407	-378	-733	-166	38	433	1,867	-1,348	-602	575
4	331	200	-481	-503	-976	-157	27	343	2,354	-1,380	-663	707
5	371	320	-405	-420	-816	-189	46	460	1,866	-1,328	-661	614
6	468	374	-406	-420	-852	-45	463	27	2,100	-1,389	-926	572
7	318	373	-407	-378	-724	-167	-34	383	1,949	-1,386	-470	426
8	152	252	-409	-420	-856	-266	-118	313	1,798	-1,469	-635	357
9	289	295	-480	-504	-1,032	-57	54	449	2,231	-1,424	-659	648

Alternative 2 Average Monthly Flow (cfs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	1,713	1,490	796	750	1,147	2,143	2,784	2,252	4,725	2,930	1,658	1,113

Change in Flow from Alternative 2 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3	149	140	74	83	160	-441	-125	-28	-142	-68	152	38
4	189	24	0	-42	-84	-433	-136	-118	344	-100	91	170
5	228	144	76	42	76	-464	-116	-1	-143	-48	93	77
6	326	197	75	42	40	-321	301	-434	90	-108	-172	35
7	175	197	74	83	169	-442	-196	-78	-60	-106	284	-111
8	9	75	72	42	36	-541	-280	-148	-212	-189	119	-180
9	147	119	1	-42	-140	-332	-108	-12	221	-144	95	111

Table XIII-27

Stanislaus River Flow at Mouth, 73-Year Period

Alternative 1 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
853	523	588	739	1,048	736	1,124	789	877	634	601	597

Change in Flow from Alternative 1 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-106	-63	-135	-203	-329	-70	337	572	178	240	289	-14
3	-103	-58	-134	-197	-334	-80	337	572	178	239	287	-14
4	-105	-59	-135	-198	-352	-92	354	588	177	238	289	-14
5	-103	-58	-134	-196	-333	-80	336	571	176	237	288	-14
6	396	46	164	158	176	75	-132	224	267	235	-6	-183
7	-106	-59	-132	-196	-325	-80	336	570	177	237	284	-14
8	-102	-58	-133	-196	-325	-91	345	571	170	239	285	-14
9	-176	68	2	-176	-330	-5	358	734	381	216	178	-9

Alternative 2 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
746	460	452	536	718	666	1,461	1,362	1,055	874	890	583

Change in Flow from Alternative 2 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3	4	5	2	6	-5	-10	0	0	0	-1	-2	0
4	1	4	0	5	-23	-21	18	16	-1	-2	0	0
5	4	5	2	7	-3	-10	-1	-1	-2	-2	-1	0
6	502	108	300	361	506	145	-469	-348	89	-5	-295	-169
7	1	3	3	7	5	-9	-1	-2	-1	-3	-5	0
8	5	5	3	7	4	-20	8	-1	-8	-1	-4	0
9	-69	131	138	27	0	65	21	161	206	-24	-111	5

Table XIII-28

Stanislaus River Flow at Mouth, Critical Period

Alternative 1 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
374	451	407	333	307	344	840	609	653	646	646	588

Change in Flow from Alternative 1 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2	-22	-119	-142	-106	-65	-16	11	276	249	281	293	-14
3	-22	-119	-142	-106	-65	-16	14	274	248	281	293	-14
4	-22	-119	-142	-106	-65	-16	12	274	248	281	293	-14
5	-22	-119	-142	-106	-65	-16	14	276	248	282	293	-14
6	114	-78	-36	26	104	90	49	284	262	254	-203	-210
7	-22	-119	-142	-106	-65	-16	14	276	248	281	293	-14
8	-22	-119	-142	-106	-65	-16	10	279	247	280	293	-14
9	29	-96	-63	-68	-20	7	121	417	294	179	-42	-44

Alternative 2 Average Monthly Flow (cfs)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
352	332	265	227	242	328	852	884	902	927	939	574

Change in Flow from Alternative 2 (cfs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
3	0	0	0	0	0	0	3	-1	0	0	0	0
4	0	0	0	0	0	0	0	-1	-1	0	0	0
5	0	0	0	0	0	0	3	0	0	0	0	0
6	136	41	106	132	170	106	38	9	14	-27	-496	-196
7	0	0	0	0	0	0	3	0	-1	0	-1	0
8	0	0	0	0	0	0	-1	3	-1	-1	-1	0
9	51	23	80	38	45	23	109	142	45	-102	-335	-30

2. Water Temperature

The effects of implementation of the Joint POD alternatives on water temperature in upstream areas were analyzed to evaluate potential effects on habitat for fish and aquatic resources. The water temperature model developed by the USBR (USBR 1990, 1993, 1997; described in Chapter IV) was used to assess the effects of the Joint POD alternatives on water temperature in four major streams in the Sacramento-San Joaquin River system, the Sacramento, Feather, American, and Stanislaus rivers. Monthly project operations, modeled with DWRSIM, were input to the temperature model for the 72-year hydrologic period of record (1922-93). The model was used to predict mean monthly water temperatures at eight to twelve locations on each stream.

The following sites were selected for detailed analysis of temperature effects (in order from upstream to downstream):

- Sacramento River – Below Keswick Dam, Ball's Ferry, Jelly's Ferry, and Vina
- Feather River – Downstream of the Afterbay, Honcut Creek, and Mouth
- American River – Below Nimbus Dam, Watt Avenue, and Mouth
- Stanislaus River – Below Goodwin Dam, Orange Blossom Bridge, and Mouth

Representative water years were selected for analysis from the period of record for wet, above normal, below normal, dry, and critical water year types. Representative years selected were years closest to the median monthly temperature values for each water year type. For the Sacramento River system, water years 1942, 1928, 1979, 1964, and 1992, respectively, were selected to represent the five water year types. For the Stanislaus River, water years 1980, 1963, 1950, and 1976 were selected to represent wet, above normal, below normal, and critical water year types, respectively. Dry water years were not analyzed for the Stanislaus River because no impacts were identified in other water year types.
Volume 2, Appendix 5 includes predicted mean monthly water temperatures for the above-described stations and water years.

The precision of the model was estimated at approximately ±1.0° F among the alternatives (J. Rowell, personal communication). In this analysis, water temperatures predicted for Joint POD alternatives 2, 4, 5, 8 and 9 were compared with values predicted for Alternative 1 (base case) for each location and representative water year. Predicted temperature values for Joint POD alternatives within 1.0° F of those predicted for the base case were considered within the error of model predictions.

a. **<u>Sacramento River</u>**. Water temperatures predicted under the Joint POD alternatives were not different from those predicted for the base cases (Alternatives 1 and 2) at any location in wet or above normal water years. In below normal years, predicted temperatures in September at Ball's Ferry and Vina under Alternatives 5, 8, and 9 were approximately 1.5 °F higher than in Alternatives 1 and 2. In dry years, predicted temperatures in September at Ball's Ferry and Vina under Alternative 2 were approximately 1.5 °F higher than in Alternative 1.

In critical years, predicted temperatures in August at Ball's Ferry, Bend Bridge, and Vina under Alternatives 2, 4, 5, 8 and 9 were approximately 2 – 3 °F higher than in Alternative 1. Also in critical years, temperatures in September at Keswick under Alternatives 4, 5, and 8 were approximately 1.5 – 5 °F higher than in Alternatives 1 and 2; temperatures at Ball's Ferry and Bend Bridge in September of critical years were 1 – 3 °F higher under Alternatives 5 and 8 than in Alternatives 1 and 2.

These modeled temperature differences due to implementation of the Joint POD alternatives are unlikely to result in significant impacts to fishery resources. SWRCB Order WR 90-5 specifies temperature objectives for the mainstem Sacramento River. Temperature criteria also have been established for the protection of winter-run chinook salmon spawning, egg incubation, and rearing in the mainstem Sacramento River in the biological opinion for the operation of the CVP and SWP (NMFS 1993). The Sacramento River Temperature Task Group, consisting of representatives from the SWRCB, USBR, USFWS, WAPA, USCOE and NMFS, meets on a regular basis during the temperature control season (May through October); typical discussions include an assessment of the temperature control operations and forecast of operations for the remainder of the season. Operational adjustments are made on a real-time basis to reduce temperature impacts on winter-run chinook salmon and other species. Operation of the temperature control device at Shasta Dam is increasing the ability to control water temperatures for anadromous fish protection in the mainstem Sacramento River.

b. Feather River. In general, water temperature changes predicted by the model were due to implementation of the Water Quality Plan (Alternative 2), but varied little with the addition of joint use of points of diversion in Alternatives 3 through 9.

Water temperatures predicted under the Joint POD alternatives were not different from those predicted for the base cases at any location in wet water years. At all sites, predicted water temperatures in an above normal water year were approximately 1 – 2° F higher in August under Alternative 8 than in the base cases. In a below normal water year, predicted temperatures in August under Alternatives 4, 5, 8 and 9 were approximately 1 – 3° F higher than in Alternative 1, but were similar to Alternative 2.

In a dry water year, predicted temperatures in April under Alternatives 2, 4, 5, 8 and 9 were approximately 2° F higher than in Alternative 1 at the two downstream sites; in May in a dry water year, temperatures under Alternatives 2, 4, 5, 8 and 9 were approximately 2 – 3° F higher than in Alternative 1 at all sites. In a critical water year, temperatures predicted under the Joint POD alternatives were not different from those predicted for the base cases at any location.

These modeled water temperature increases in the lower river are not likely to result in significant impacts to fishery resources compared to the base case condition.

Fall and spring-run chinook salmon and steelhead spawn and rear in the lower Feather River. Fall-run chinook salmon typically emigrate from the lower river from January through March and therefore are not affected by elevated water temperatures. Spring-run chinook salmon spawn in the low flow channel from late August through October; steelhead rear in the low flow channel year-round.

Temperatures in the lower river are controlled through operation of a temperature control device. The DFG/DWR Hatchery Water Supply Temperature Agreement (August 26, 1983) established minimum and maximum criteria for temperatures at the intake to Feather River Hatchery at the Thermalito Diversion Dam. These requirements, in addition to providing suitable rearing temperatures at the hatchery, provide suitable temperature releases for coldwater species in the lower river.

The NMFS is currently completing evaluation of the short-term effects of operation of the CVP and SWP on steelhead trout and spring-run chinook salmon. A biological opinion will be issued in the near future which is likely to include water temperature conditions to protect spring-run chinook salmon spawning and steelhead rearing in the low flow channel of the Feather River.

c. American River. In a wet water year, predicted temperatures at all sites were approximately 2° F higher in July under Alternative 8 than in Alternative 1. In an above normal year, temperatures at all sites were approximately 1 - 3° F higher in September under Alternative 8 than in Alternatives 1 and 2. In a below normal year, temperatures at all sites were approximately 1 – 2° F higher in September under Alternatives 5, 8, and 9 than in the base cases. In a dry water year, temperatures predicted under the alternatives were not different from those predicted for the base cases at any location.

In a critical year, storage at Folsom Reservoir is lower in the summer months under the JPOD alternatives compared to the base cases, resulting in some cases in elevated water temperatures. Predicted temperatures under the Joint POD alternatives differed from the base cases in May, July, and August. Predicted temperatures at the two upstream sites were approximately 1 - 2° F higher in May under Alternative 8 compared to Alternatives 1 and 2. Temperatures in July under Alternatives 4, 5, and 9 ranged approximately 3 – 4° F higher than in Alternative 1 at all sites, but were similar to Alternative 2. Also in July, temperatures under Alternative 8 were approximately 5 °F higher than in Alternatives 2, 4, 5, and 9 at all sites. In August, temperatures under Alternatives 4, 5, 8 and 9 were approximately 2 - 4° F higher than in Alternative 1 at all sites, but were similar to Alternative 2.

These modeled water temperature increases in the lower river are not likely to result in significant impacts to fishery resources compared to the base case condition for the following reasons: 1) even under the base case condition, suitable habitat is not available year-round for all salmonid lifestages, 2) the model did not include real-time operational adjustments that are made to reduce water temperature impacts, 3) the model did not include the planned construction and operation of a multi-level release structure at Folsom Dam, which is expected to allow the release of cooler water in the late summer months.

Under the base case condition, warm summer and fall water temperatures on the lower American River have been identified as a limiting factor to juvenile steelhead rearing in the river (USFWS 1995). Water temperatures in the lower American River from July to October are commonly higher than optimum levels for survival of juvenile steelhead. Steelhead generally do not survive the extended warm waters in many years and move prematurely out of the American River to seek cooler water. High water temperatures have significantly limited natural steelhead production in the lower river (McEwan and Nelson 1991). Elevated temperatures in the late summer are also suspected to delay fall-run chinook spawning in the lower river and may impede reproductive success (USFWS 1995).

The temperature modeling assumed that no operational changes would be made to control temperatures in the lower river. However, the USBR, DFG, USFWS, and NMFS meet routinely to discuss operational changes to benefit fishery resources in the lower American River. Flow and water temperature needs for fisheries are taken into consideration for operations on a real-time basis. A temperature target of 65°F at Watt Avenue is used to protect juvenile steelhead rearing in the lower river. Operational adjustments are often made to reduce impacts on water temperatures in the late summer months of dry and critical water years.

The predicted effects on water temperature in the lower American River in July and August also assume that no new facilities would be constructed. The planned construction and operation of a multi-level release structure at Folsom Dam is expected to permit the release of cooler water in the late summer and fall than was indicated by the model simulations. The NMFS is currently completing evaluation of the short-term effects of operation of the CVP and SWP on steelhead trout. A biological opinion will be issued in the near future which is likely to include conditions to reduce adverse effects of water temperature on steelhead in the lower American River.

d. Stanislaus River. In the Stanislaus River, no adverse effects on water temperature were predicted under the Joint POD alternatives in any water year type. In some cases, the Joint POD alternatives are predicted to result in improved temperature conditions in the lower river for coldwater species by lowering water temperatures in the spring months compared to the base case.

3. Aquatic Habitat

River flow and reservoir storage may be directly affected by water operations under the proposed Joint POD alternatives. The frequency, magnitude, and timing of natural flow regimes of rivers tributary to the Delta have been changed significantly by water supply operations. These changes influence aquatic habitat in rivers by changing the streambed and river channel geometry, riparian habitat, substrate composition, and water temperatures. Water supply operations also affect the frequency, duration, magnitude and timing of drawdown in reservoirs. The upstream aquatic habitat impact assessment focuses on the frequency, timing, and magnitude of these changes to instream flows and reservoir surface elevations.

a. Rivers. The Range of Variability Approach (RVA) developed by Richter et al (1997) was used to assess the impact of the Joint POD alternatives on aquatic habitat in rivers in the Sacramento-San Joaquin system. This approach, described in Chapter VI, is based on aquatic ecology theory concerning the critical role of hydrologic variability, and associated characteristics of duration and timing, in sustaining aquatic ecosystems.

The RVA method was used to assess the relative effects of the Joint POD alternatives on stream ecosystems below the major SWP and CVP reservoirs at the following locations where estimates of unimpaired flow data were available:

- Sacramento River near Red Bluff
- Feather River near Oroville
- American River at Fair Oaks
- Stanislaus River at Melones Reservoir

Since estimated unimpaired flows were available only on a monthly time step, a subset of the 32 hydrologic parameters recommended in the RVA analysis was calculated for the available period of record (1922 – 1993). Hydrologic parameters used in the analysis are summarized in Table XIII-29, and include the magnitude of monthly flows, the magnitude of annual extreme flow conditions, and the timing of annual extreme flow conditions.

Table XIII-29
Summary of Hydrologic Parameters Used in Assessment of the Impacts of the Joint POD alternatives.

Flow Statistics Group	Regime Characteristics	Hydrologic Parameters
Magnitude of monthly flow conditions	Magnitude	Mean monthly flows
Magnitude of annual extreme flow conditions	Annual Extremes	Mean annual minimum monthly flow Mean annual maximum monthly flow
Timing of annual extreme flow conditions	Timing	Month of annual minimum flow Month of annual maximum flow

From the estimated unimpaired flows, management targets were established for each of the flow parameters (± 1 standard deviation from the mean). For those parameters where a skewed distribution resulted in a standard deviation that exceeded the minimum or maximum value, the actual unimpaired minimum or maximum value was used as the lower or upper target range boundary.

Simulated flows for the period of record (1922 – 1993) for each of the Joint POD alternatives (DWRSIM analysis) were then compared with flow target ranges to evaluate the relative suitability of the alternatives in meeting ecological objectives. For the flow simulations, locations from the DWRSIM analysis were selected that were closest to sites on each river where estimated unimpaired flow data were available. The rate of non-attainment of the flow management targets was calculated for each site and flow parameter.

Table XIII-30 summarizes the RVA for the Stanislaus River at Melones Reservoir. Analyses for all sites are shown in Volume 2, Appendix 5.

Cases where flow parameters showed a greater than 10 percent deviation in the non-attainment rate between the Joint POD alternatives and the base cases (Alternatives 1 and 2) are described below. In some cases, the difference in the rate of non-attainment showed a slight positive effect, moving closer to unimpaired conditions; in other cases, the difference showed a slight adverse effect, moving away from unimpaired conditions.

Sacramento River. No differences in the rate of non-attainment greater than 10 percent were observed between the Joint POD alternatives and the base cases in any of the flow parameters.

Feather River. In October, flows in the Feather River were lower under Alternatives 2 through 9 than under Alternative 1, resulting in lower rates of non-attainment and a shift toward unimpaired conditions. In June, flows were higher under Alternatives 2 through 9 than under Alternative 1, also resulting in lower rates of non-attainment and a shift toward unimpaired conditions. In August, flows were lower under Alternatives 7 and 8 than under Alternatives 1 and 2, also resulting in lower rates of non-attainment and a shift toward unimpaired conditions. However, in January, flows were lower under Alternatives 2 through 9 than under Alternative 1, resulting in slightly higher rates of non-attainment and a shift away from unimpaired conditions.

American River. No differences in the rate of non-attainment greater than 10 percent were observed in monthly flow magnitudes or magnitudes of mean annual extremes among the Joint POD alternatives and between the Joint POD alternatives and the base case. Under Alternatives 2 through 9, the timing of the annual maximum was shifted toward unimpaired conditions compared to Alternative 1.

Stanislaus River. In February, flows were increased under Alternative 6 compared to Alternatives 1 and 2, resulting in a lower rate of non-attainment and a shift toward unimpaired conditions. Under Alternative 9, the lower end of the range of monthly flows simulated for February increased slightly compared to Alternatives 1 and 2, also resulting in a lower rate of non-attainment and a shift toward unimpaired conditions.

In August, flows were increased or slightly decreased under Alternatives 2 through 9 compared to Alternative 1, resulting in higher rates of non-attainment and a shift away from unimpaired conditions. Under Alternative 6, flows are decreased in August compared to Alternative 2, resulting in a lower rate of non-attainment and a shift toward unimpaired conditions.

Table XIII-30. Results of the Range of Variability Analysis Stanislaus River at New Melones Reservoir Joint POD Alternatives

	Unimpaired Conditions (1922 - 93)						Alternative 1					Alternative 2				
			Range limits		RVA Target Range				Range limits		Rate of Non-			Range limits		Rate of Non-
IHA Group 1	Mean	SD	Low	High	Low	High	Mean	SD	Low	High	Attainment	Mean	SD	Low	High	Attainment
Monthly Flow Magnitude (cfs)																
October	160	179	0	1,434	0	339	601	1,292	63	5,362	15%	491	1,083	63	5,362	19%
November	475	878	34	6,162	34	1,353	381	466	198	3,360	3%	319	471	198	3,360	3%
December	858	1,309	49	6,712	49	2,166	463	754	130	4,744	4%	325	653	130	4,744	3%
January	1,178	1,354	49	6,240	49	2,533	651	949	130	4,918	7%	446	861	130	4,918	6%
February	1,651	1,507	18	9,596	144	3,158	965	1,204	124	4,986	22%	622	937	124	4,969	28%
March	2,003	1,229	212	6,696	775	3,232	544	988	130	5,292	85%	470	924	130	5,292	92%
April	3,222	1,263	589	7,290	1,958	4,485	750	433	471	1,467	100%	1,093	645	471	3,243	92%
May	4,558	2,247	717	9,694	2,311	6,805	449	328	255	2,067	100%	1,026	615	255	2,707	94%
June	2,914	2,033	185	10,640	881	4,947	585	909	255	4,595	90%	758	659	255	4,595	83%
July	836	807	0	4,659	30	1,643	352	244	265	2,231	1%	591	237	265	2,231	1%
August	200	193	0	1,254	6	393	317	44	283	407	10%	604	73	283	702	99%
September	108	113	0	640	0	221	264	102	249	1,110	100%	253	67	0	758	99%
IHA Group 2																
Mean Annual Extremes (cfs)																
Annual 30-day minimum	69	67	0	488	2	135	115	60	63	289	19%	119	81	0	631	15%
Annual 30-day maximum	4,922	2,280	717	10,640	2,642	7,202	1,547	1,543	471	5,362	78%	1,681	1,232	517	5,362	83%
IHA Group 3																
Timing of Annual Extremes																
Month of annual minimum	9	1	7	2	8	10	11	2	8	3	31%	8	4	1	12	47%
Month of annual maximum	4	1	12	6	3	5	3	2	10	6	44%	5	2	1	10	50%

	Alternative 3					Alternative 4					Alternative 5				
			Range limits		Rate of Non-			Range limits		Rate of Non-			Range limits		Rate of Non-
IHA Group 1	Mean	SD	Low	High	Attainment	Mean	SD	Low	High	Attainment	Mean	SD	Low	High	Attainment
Monthly Flow Magnitude (cfs)															
October	495	1,082	63	5,362	21%	493	1,083	63	5,362	21%	495	1,082	63	5,362	21%
November	324	472	198	3,360	3%	323	472	198	3,360	3%	324	472	198	3,360	3%
December	327	653	130	4,744	3%	325	653	130	4,744	3%	327	653	130	4,744	3%
January	452	864	130	4,918	6%	451	864	130	4,918	6%	453	865	130	4,918	6%
February	617	940	124	4,969	29%	600	938	124	4,969	31%	619	941	124	4,969	29%
March	460	929	130	5,292	92%	448	884	130	5,292	92%	460	929	130	5,292	92%
April	1,093	644	471	3,243	92%	1,111	642	471	3,243	92%	1,092	643	471	3,243	92%
May	1,026	613	255	2,702	94%	1,043	613	255	2,702	94%	1,025	612	255	2,705	94%
June	758	662	255	4,595	83%	757	645	255	4,595	82%	756	663	255	4,595	83%
July	590	237	265	2,231	1%	590	237	265	2,231	1%	589	237	265	2,231	1%
August	603	72	283	702	99%	605	73	283	703	99%	604	74	283	710	99%
September	253	67	0	758	99%	253	67	0	758	99%	253	67	0	758	99%
IHA Group 2															
Mean Annual Extremes (cfs)															
Annual 30-day minimum	119	81	0	631	15%	118	80	0	631	15%	119	81	0	631	15%
Annual 30-day maximum	1,682	1,234	518	5,362	83%	1,695	1,193	518	5,362	83%	1,682	1,235	518	5,362	83%
IHA Group 3															
Timing of Annual Extremes															
Month of annual minimum	8	4	1	12	47%	8	4	1	12	47%	8	4	1	12	47%
Month of annual maximum	5	2	1	10	50%	5	2	1	10	49%	5	2	1	10	50%

Table XIII-30 continued. Results of the Range of Variability Analysis
Stanislaus River at New Melones Reservoir
Joint POD Alternatives

IHA Group 1	Alt 6 Mean	Alt 6 SD	Alt 6 Range limits Low	Alt 6 Range limits High	Alt 6 Rate of Non-Attainment	Alt 7 Mean	Alt 7 SD	Alt 7 Range limits Low	Alt 7 Range limits High	Alt 7 Rate of Non-Attainment
Monthly Flow Magnitude (cfs)										
October	998	1,607	224	5,866	24%	492	1,083	63	5,362	19%
November	428	472	225	3,363	3%	323	471	198	3,360	3%
December	628	906	224	5,731	4%	328	654	130	4,744	3%
January	811	1,004	224	4,924	8%	453	865	130	4,918	6%
February	1,134	1,280	225	5,973	7%	627	940	124	4,969	28%
March	616	955	224	5,361	83%	460	929	130	5,292	92%
April	619	142	452	1,579	100%	1,092	643	471	3,243	92%
May	673	381	444	3,238	99%	1,024	613	255	2,704	94%
June	849	1,122	200	6,351	90%	756	663	255	4,595	83%
July	586	306	75	2,590	1%	589	237	265	2,231	1%
August	314	213	50	631	44%	600	74	283	703	99%
September	84	144	49	1,230	3%	253	67	0	758	99%
IHA Group 2										
Mean Annual Extremes (cfs)										
Annual 30-day minimum	71	69	49	631	3%	119	81	0	631	15%
Annual 30-day maximum	1,994	1,808	624	6,351	69%	1,682	1,235	518	5,362	83%
IHA Group 3										
Timing of Annual Extremes										
Month of annual minimum	9	1	7	9	8%	8	4	1	12	47%
Month of annual maximum	6	3	1	12	82%	5	2	1	10	50%

IHA Group 1	Alt 8 Mean	Alt 8 SD	Alt 8 Range limits Low	Alt 8 Range limits High	Alt 8 Rate of Non-Attainment	Alt 9 Mean	Alt 9 SD	Alt 9 Range limits Low	Alt 9 Range limits High	Alt 9 Rate of Non-Attainment
Monthly Flow Magnitude (cfs)										
October	496	1,083	63	5,362	21%	418	456	125	1,501	29%
November	324	472	198	3,360	3%	451	416	208	1,501	13%
December	328	654	130	4,744	3%	463	484	208	3,187	1%
January	453	865	130	4,918	6%	473	571	146	3,487	3%
February	627	939	124	4,969	28%	621	724	146	4,825	1%
March	449	882	130	5,292	92%	534	852	146	6,502	85%
April	1,101	648	471	3,241	92%	1,124	396	475	1,591	100%
May	1,026	613	255	2,709	94%	1,196	572	455	3,837	96%
June	750	661	255	4,595	85%	970	1,073	241	8,460	78%
July	591	238	265	2,231	1%	573	271	254	2,545	1%
August	601	75	283	727	99%	504	150	268	685	72%
September	253	67	0	758	99%	270	100	224	1,067	100%
IHA Group 2										
Mean Annual Extremes (cfs)										
Annual 30-day minimum	119	81	0	631	15%	218	83	125	635	82%
Annual 30-day maximum	1,678	1,208	520	5,362	83%	1,368	1,050	584	8,460	94%
IHA Group 3										
Timing of Annual Extremes										
Month of annual minimum	8	4	1	12	47%	9	2	3	10	17%
Month of annual maximum	5	2	1	10	51%	6	2	3	12	43%

Under Alternative 6, the magnitude of the annual 30-day maximum flow was higher compared to Alternatives 1 and 2, resulting in a slightly lower rate of non-attainment and a shift toward unimpaired conditions. Under Alternative 9, the magnitude of the annual 30-day minimum was higher, and the magnitude of the annual 30-day maximum was lower, than under Alternatives 1 and 2, resulting in higher rates of non-attainment and a shift away from unimpaired conditions.

The timing of the annual minimum flow was more variable under Alternatives 2 through 5, 7, and 8 than Alternative 1, resulting in a shift away from unimpaired conditions. Under Alternatives 6 and 9, the timing of the annual minimum flow was closer to unimpaired conditions than under Alternative 1. The timing of the annual maximum flow under Alternative 6 was shifted later in the year and was more variable than under Alternatives 1 and 2, resulting in a shift away from unimpaired conditions.

Summary. Differences in the rate of non-attainment of the target ranges between the Joint POD alternatives and the base cases and among the alternatives are minor. Rates of non-attainment are high in some months for all of the Joint POD alternatives, since the pattern of regulated flow releases in the system differs significantly from the unimpaired condition. However, the pattern of non-attainment of the targets generally is similar among the Joint POD alternatives. No significant impacts on riverine aquatic habitat in upstream areas are therefore expected. No mitigation is required.

b. Reservoirs. Habitat conditions in relation to initial reservoir elevation and fluctuations were analyzed for each of the five major reservoirs in the CVP and SWP project areas. These reservoirs include: Lake Shasta, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir. Habitat conditions evaluated include the spawning and rearing habitat quality for warmwater fisheries including largemouth bass, smallmouth bass, and spotted bass. A discussion of the assumptions and analytical methods used in the analysis can be found in Chapter VI. The methodology assumes that increases in the quantity and quality of habitat are indicated by increases in the index. Decreases indicate a decrease in habitat value. Modeled reservoir elevations may be expected to have a margin of error of 10 to 20 percent. Therefore, effects of the various alternatives are considered significant only if the differences from the base case are greater than 10 percent.

The results of the analysis of Joint POD Alternatives are shown in Tables XIII-31 and XIII-32 as the 73-Year Average Index and the Critical Period Index. Changes in the 73-year average reservoir index from use of the Joint POD occur primarily at Shasta, Folsom, New Melones, and San Luis Reservoirs which are part of the CVP. Significant decreases are predicted at Folsom Reservoir for Alternative 8 and at New Melones Reservoir for all Joint POD Alternatives except Alternative 6 and Alternative 9. The decreases at New Melones Reservoir are caused by implementation of the 1995 Bay/Delta Plan. Beneficial effects are also predicted at San Luis Reservoir for all alternatives that allow wheeling. Little or no change occurs in the 73-year average reservoir indices at the other reservoirs analyzed.

Significant decreases in the critical period reservoir index are predicted at Folsom Lake under all Joint POD alternatives except Alternative 7 and at New Melones Reservoir for all alternatives except Alternative 6 and Alternative 9. The decreases at Folsom Lake are primarily a cumulative impact of implementing both the 1995 Bay/Delta Plan and the Joint POD. A significant increase in the critical period reservoir index is predicted to occur at San Luis Reservoir for Alternative 6. Minor or no changes are predicted at all other reservoirs for all alternatives.

Table XIII-31

Average Reservoir Habitat Index for 73-Years Under the Joint POD Alternatives

Alternative	73-Year Average Index								
	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8	Alt 9
Shasta	459	460	454	448	450	436	448	444	452
Oroville	388	385	383	378	385	377	391	391	377
Folsom	438	426	418	410	412	405	411	393 [D]	419
New Melones	298	258 [D]	261 [D]	259 [D]	260 [D]	340 [I]	259 [D]	260 [D]	313
San Luis	265	287	326 [I]	305 [I]	331 [I]	331 [I]	373 [I]	342 [I]	310 [I]
Totals	1,848	1,794	1,842	1,800	1,838	1,889	1,882	1,830	1,870

[I] – Increase greater than 10 percent
[D] - Decrease greater than 10 percent

Table XIII-32
Critical Period Reservoir Habitat Index
Under the Joint POD Alternatives

Alternative	Critical Period Index								
	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8	Alt 9
Shasta	202	202	201	200	201	203	201	198	200
Oroville	184	191	190	189	191	188	193	189	190
Folsom	250	213 [D]	222 [D]	222 [D]	223 [D]	214 [D]	229	219 [D]	226
New Melones	219	186 [D]	187 [D]	186 [D]	186 [D]	219	186 [D]	187 [D]	201
San Luis	191	187	197	184	192	235 [I]	199	195	180
Totals	1,046	979	997	981	993	1,059	1,008	988	996

[I] - Increase greater than 10 percent
[D] - Decrease greater than 10 percent

Impacts of the Joint POD Alternatives on reservoir habitat conditions are generally temporary and mitigable. If significant effects on reservoir fish populations are observed, mitigation could include additional fish planting, habitat improvement through planting of shoreline vegetation, or addition of habitat structures.

c. Riparian Wetland Habitat. The condition of riparian vegetation and wetland habitat in the riparian zone of major rivers was assessed using simulated river water surface elevation (stage) at 6 locations. Average monthly stage was calculated for the base case and each alternative for average, wet and dry year conditions[1]. Differences among alternatives are expressed as a percent change from the base case. Low summer stages represent drought conditions and high year-round stages indicate inundation mortality. Modeled surface water elevations may be expected to have a margin of error of plus or minus 10 to 20 percent. Differences among alternatives are considered to be significant only if greater than 20 percent. A complete description of the analysis approach and methodology is contained in Chapter VI.

Tables XIII-33 through XIII-38 present the results of this analysis. Values that exceed the 20 percent significance threshold are indicated in bold type and in italics if there is negative impact. River stages increase significantly at Natoma in June of dry years for Alternatives 2, 4, 6 and 9 and in dry Septembers for Alternative 2. On the Sacramento River at Verona, stages are significantly higher under all alternatives in June and for the January to June period under Alternative 2. Significant reductions in river stage occur at Verona during the January to May period of wet years under Alternative 2. On the Feather River, the river stage index for dry years is higher in June for all alternatives; higher in July for Alternatives 7 and 8; higher in April for Alternative 6; lower in May for Alternatives 6 and 9; and lower in August for Alternatives 7 and 8. For wet years, the Feather River stage index is significantly higher in July for Alternatives 4, 6, 7, 8 and 9, and lower in August for Alternatives 7 and 8. In general, the effects of Joint POD alternatives could not be distinguished from the effects resulting from implementation of the 1995 Bay/Delta Plan alone.

In the San Joaquin River basin, impacts to the river stage index at Newman and Vernalis are as described in Chapter VI. The Joint POD alternatives impose no new operating constraints on reservoirs in the basin, hence implementation of any given alternative creates a condition which is indistinguishable from implementation of the 1995 Bay/Delta Plan.

The lower river stages predicted on the Feather River under dry conditions are small enough that riparian wetlands and vegetation would adjust without specific mitigation. Increased stages predicted at various locations in May and June would have a beneficial impact. In general, the effects of the Joint POD alternatives could not be distinguished from the effects resulting from implementation of the 1995 Bay/Delta Plan alone.

[1] "Wet" years are the average of wet and above normal years as defined in the 1995 Bay/Delta Plan for the Sacramento and San Joaquin river basins. "Dry" years are the average of below normal, dry, and critically dry year types.

Table XIII-33

American River at Natoma Vegetation Impact Analysis

73-Year Average Monthly River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	3.7	3.9	4.4	4.7	5.1	4.7	4.6	4.3	4.8	4.6	4.1	3.3

Percent Change in Average Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-4.3	-1.2	-4.6	-2.9	0.1	1.3	0.4	2.0	11.1	-5.2	-8.3	10.3
Alt 3	-2.2	-2.0	-5.4	-3.2	-0.4	0.3	0.5	2.4	10.7	-4.1	-5.4	8.0
Alt 4	-3.9	-3.1	-5.1	-3.8	-1.8	0.3	-0.8	1.8	12.5	-3.6	-3.9	8.2
Alt 5	-3.1	-3.0	-5.6	-3.0	-1.4	0.2	-0.2	1.9	10.9	-3.1	-1.6	4.4
Alt 6	-3.0	-3.1	-5.8	-3.8	-1.7	0.0	2.9	-0.3	12.8	-3.4	-2.5	2.9
Alt 7	-2.9	-3.4	-6.2	-3.2	-1.2	-0.2	0.1	2.4	10.7	-2.0	0.0	-0.4
Alt 8	-5.3	-6.9	-8.0	-4.9	-3.2	-1.7	-1.2	1.2	9.1	-3.8	-0.8	-8.0
Alt 9	-2.6	-1.9	-4.7	-2.8	-1.3	0.2	-0.7	1.3	11.5	-3.8	-3.9	6.7

Average Monthly Dry Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	3.6	3.6	3.7	3.6	4.0	3.8	3.8	3.5	4.1	4.5	3.9	2.5

Percent Change in Dry Year Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-2.0	-0.7	-6.6	-5.5	-0.1	2.8	0.0	3.6	**20.4**	-4.5	-15.4	**21.0**
Alt 3	0.7	-0.5	-7.0	-6.2	-1.3	0.5	0.3	4.3	19.6	-3.1	-12.3	17.8
Alt 4	-0.8	-1.4	-6.1	-7.5	-4.3	0.4	-1.8	2.9	**22.8**	-2.6	-10.7	18.9
Alt 5	-0.4	-1.4	-6.4	-5.8	-3.5	0.4	-1.1	3.2	19.9	-1.7	-8.1	12.1
Alt 6	0.5	-0.3	-6.5	-7.2	-4.2	0.0	4.2	-0.8	**22.8**	-2.6	-10.0	11.0
Alt 7	-0.5	-1.9	-7.1	-6.1	-2.9	-0.4	-0.4	4.2	19.4	-0.8	-6.2	4.8
Alt 8	-3.8	-5.5	-8.4	-8.4	-6.3	-3.1	-2.3	3.0	17.2	-3.6	-7.4	-0.3
Alt 9	-0.5	-0.2	-5.7	-5.2	-3.3	0.4	-1.6	1.9	**21.7**	-2.9	-10.1	14.7

Average Monthly Wet Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	3.8	4.3	5.3	6.2	6.7	5.9	5.6	5.4	5.6	4.8	4.4	4.4

Percent Change in Wet Year Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-7.2	-1.8	-2.7	-0.9	0.3	0.0	0.7	0.6	1.9	-6.0	0.2	2.2
Alt 3	-6.0	-3.6	-3.8	-0.9	0.2	0.1	0.6	0.7	1.9	-5.4	2.9	0.5
Alt 4	-7.8	-4.9	-4.2	-1.0	0.2	0.1	0.2	0.8	2.1	-4.9	4.4	0.2
Alt 5	-6.6	-4.9	-4.9	-0.8	0.3	0.0	0.7	0.6	1.9	-4.9	6.3	-1.4
Alt 6	-7.4	-6.2	-5.2	-1.0	0.3	0.0	1.8	0.1	2.8	-4.6	6.5	-3.3
Alt 7	-5.9	-5.1	-5.4	-0.9	0.3	0.0	0.7	0.7	2.0	-3.6	7.5	-4.5
Alt 8	-7.4	-8.4	-7.5	-2.3	-0.7	-0.4	-0.2	-0.3	0.9	-4.0	7.1	-13.8
Alt 9	-5.4	-3.7	-3.8	-0.9	0.3	0.0	0.2	0.8	1.3	-4.9	3.6	0.7

Table XIII-34

Feather River at Gridley Vegetation Impact Analysis

73-Year Average Monthly River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	2.9	2.6	3.4	3.8	4.1	4.1	2.7	3.1	3.1	3.7	3.2	2.1

Percent Change in Average Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-12.7	-4.2	-7.2	-5.8	1.6	0.7	5.6	-3.3	15.5	17.2	-12.2	-6.7
Alt 3	-12.1	-3.7	-7.0	-5.9	1.6	0.2	4.6	-3.7	15.3	17.7	-12.0	-6.2
Alt 4	-13.1	-4.1	-7.8	-7.0	0.8	0.8	2.2	-4.9	13.9	19.1	-7.5	-4.7
Alt 5	-10.7	-2.4	-7.0	-6.1	1.3	1.6	4.9	-3.2	14.8	16.2	-13.7	-5.0
Alt 6	-12.1	-4.8	-8.1	-6.4	0.2	0.3	13.3	-7.1	15.2	18.1	-11.3	-4.7
Alt 7	-11.6	-4.4	-7.1	-5.8	1.0	-0.1	4.5	-2.7	15.5	**27.8**	***-28.5***	-8.4
Alt 8	-11.3	-4.3	-7.1	-5.8	1.5	-0.2	4.5	-2.8	15.7	**27.2**	***-28.4***	-8.6
Alt 9	-14.5	-5.3	-8.5	-6.6	0.9	1.2	1.3	-5.9	15.0	19.8	-5.7	-5.1

Average Monthly Dry Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	2.8	2.4	2.8	2.6	2.7	2.6	1.9	2.6	2.7	3.8	3.4	2.1

Percent Change in Dry Year Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-16.1	-3.0	-7.4	-7.4	4.2	1.7	11.5	-16.7	**27.9**	16.3	-8.3	-8.7
Alt 3	-15.2	-2.0	-6.9	-7.4	4.6	0.9	8.8	-17.0	**27.5**	17.1	-8.2	-7.9
Alt 4	-15.8	-2.8	-7.2	-8.5	2.4	2.2	4.2	-18.3	**25.3**	16.5	-5.0	-5.9
Alt 5	-14.0	-1.7	-6.5	-7.1	4.0	4.3	9.7	-16.0	**26.6**	14.5	-11.2	-5.7
Alt 6	-15.6	-3.6	-7.0	-8.5	2.3	2.1	**26.7**	***-21.3***	**25.8**	13.7	-10.0	-5.2
Alt 7	-14.5	-2.5	-7.4	-7.0	4.1	0.7	9.2	-15.1	**27.8**	**30.4**	***-25.9***	-12.6
Alt 8	-13.9	-2.4	-7.5	-6.9	4.7	1.0	9.3	-15.3	**28.2**	**29.5**	***-26.0***	-13.0
Alt 9	-17.1	-4.0	-8.4	-8.2	3.2	2.8	2.4	***-20.3***	**26.7**	17.7	-3.0	-7.0

Average Monthly Wet Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	2.9	2.9	4.3	5.4	6.1	6.1	3.8	3.9	3.5	3.4	3.0	2.2

Percent Change in Wet Year Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-8.4	-5.6	-7.0	-4.7	0.1	0.0	1.8	8.6	2.3	18.6	-18.3	-4.0
Alt 3	-8.2	-5.6	-7.2	-4.9	-0.2	-0.2	1.8	8.2	2.3	18.7	-18.0	-4.0
Alt 4	-9.5	-5.6	-8.3	-6.0	-0.1	0.0	0.9	6.9	1.8	**22.9**	-11.3	-3.3
Alt 5	-6.4	-3.1	-7.4	-5.4	-0.3	0.0	1.7	8.1	2.3	18.6	-17.6	-4.0
Alt 6	-7.6	-6.2	-9.1	-5.1	-1.0	-0.7	4.4	5.6	4.0	**24.8**	-13.3	-4.1
Alt 7	-7.8	-6.5	-6.8	-5.1	-0.8	-0.6	1.4	8.3	2.4	**23.9**	***-32.5***	-3.0
Alt 8	-8.0	-6.4	-6.7	-5.0	-0.4	-0.8	1.4	8.2	2.4	**23.7**	***-32.2***	-3.0
Alt 9	-11.1	-6.8	-8.7	-5.6	-0.4	0.3	0.5	6.8	2.6	**23.0**	-9.9	-2.8

Table XIII-35
Sacramento River at Red Bluff Vegetation Impact Analysis

73-Year Average Monthly River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	5.3	6.0	7.2	8.1	9.0	8.2	7.0	6.8	7.0	7.7	6.8	4.9

Percent Change in Average Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	0.5	1.8	0.0	-0.6	1.2	0.9	0.1	-1.1	6.5	-2.8	-4.2	0.1
Alt 3	1.2	0.8	-0.3	-0.7	0.7	0.8	0.2	-1.3	6.6	-2.1	-2.8	-0.3
Alt 4	0.4	-0.3	-0.5	-1.0	0.5	0.5	-0.4	-1.6	7.6	-1.6	-1.8	0.8
Alt 5	0.1	-0.1	-0.8	-0.8	0.6	0.2	0.2	-1.4	6.7	-1.3	-0.9	-0.4
Alt 6	-0.8	-1.3	-1.1	-0.9	0.3	0.5	2.6	-3.0	8.8	-2.1	-0.1	-1.1
Alt 7	-0.2	-0.3	-0.8	-0.7	0.4	-0.2	0.2	-1.6	6.7	-0.4	0.6	-2.6
Alt 8	0.3	-1.4	-1.2	-0.9	0.1	-0.3	0.0	-1.8	6.5	-0.1	3.0	-3.0
Alt 9	0.7	0.1	-0.2	-0.6	0.7	0.4	-0.4	-1.5	6.8	-1.8	-2.2	-0.2

Average Monthly Dry Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	5.1	5.4	5.5	5.8	6.6	6.1	5.8	6.1	6.7	7.5	6.7	4.4

Percent Change in Dry Year Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-0.1	2.7	-0.4	-0.9	2.9	2.4	-0.8	-1.9	9.9	-1.0	-6.6	-1.8
Alt 3	0.4	2.1	-0.5	-1.0	1.9	1.8	-0.3	-2.4	10.1	-0.1	-5.6	-1.6
Alt 4	-0.7	0.9	-0.6	-1.2	1.4	1.1	-1.1	-3.3	11.7	0.6	-4.9	0.4
Alt 5	-1.1	0.9	-0.7	-0.9	1.6	1.1	-0.5	-2.6	10.2	1.1	-4.1	-1.2
Alt 6	-1.6	-0.3	-1.0	-1.0	1.2	1.2	3.1	-4.5	12.8	-0.6	-3.3	-2.3
Alt 7	-1.1	0.7	-0.5	-0.7	1.1	0.0	-0.4	-3.0	10.2	1.8	-2.1	-3.3
Alt 8	-0.7	-0.3	-0.9	-1.0	0.6	-0.3	-0.7	-3.3	10.0	1.7	0.3	-2.2
Alt 9	-0.3	0.7	-0.6	-0.6	1.7	1.1	-1.2	-2.9	11.0	0.2	-5.2	-2.0

Average Monthly Wet Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	5.7	6.8	9.5	11.2	12.3	10.9	8.6	7.8	7.3	8.0	6.9	5.6

Percent Change in Wet Year Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	1.2	0.9	0.3	-0.4	0.0	-0.1	0.9	-0.2	2.2	-5.1	-1.1	2.1
Alt 3	2.3	-0.7	-0.2	-0.6	-0.2	0.0	0.7	-0.2	2.3	-4.6	0.9	1.0
Alt 4	1.6	-1.6	-0.4	-0.8	-0.1	0.0	0.2	0.1	2.5	-4.3	2.2	1.3
Alt 5	1.6	-1.3	-0.8	-0.7	-0.1	-0.4	0.9	-0.2	2.3	-4.3	3.3	0.5
Alt 6	0.2	-2.4	-1.2	-0.8	-0.4	-0.1	2.2	-1.4	3.7	-4.0	4.1	0.1
Alt 7	0.8	-1.5	-1.1	-0.7	-0.1	-0.3	0.8	-0.1	2.3	-3.3	4.3	-1.8
Alt 8	1.6	-2.6	-1.4	-0.8	-0.2	-0.2	0.7	-0.1	2.1	-2.3	6.5	-4.0
Alt 9	1.9	-0.5	0.1	-0.6	0.0	-0.1	0.3	0.1	1.5	-4.2	1.7	1.8

Table XIII-36
Sacramento River at Verona Vegetation Impact Analysis

73-Year Average Monthly River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	9.1	9.8	12.2	15.5	17.4	16.9	12.2	10.7	9.5	9.7	8.5	7.9

Percent Change in Average Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-3.3	0.4	-1.7	-1.5	1.1	0.6	1.0	-2.1	11.5	5.0	-8.6	-1.2
Alt 3	-2.6	-0.3	-1.9	-1.6	0.8	0.5	1.0	-2.4	11.6	6.0	-7.0	-1.5
Alt 4	-3.5	-1.0	-2.2	-2.0	0.6	0.4	0.1	-3.0	12.2	7.2	-4.0	-0.3
Alt 5	-3.0	-0.6	-2.3	-1.7	0.7	0.5	1.0	-2.4	11.5	6.2	-5.4	-1.2
Alt 6	-4.0	-2.0	-2.8	-1.8	0.2	0.3	4.2	-4.8	13.7	6.1	-3.7	-1.7
Alt 7	-3.5	-1.2	-2.3	-1.5	0.5	-0.1	0.9	-2.4	11.7	12.8	-9.7	-3.6
Alt 8	-3.1	-2.0	-2.6	-1.6	0.4	-0.1	0.8	-2.5	11.6	12.9	-7.2	-4.0
Alt 9	-3.6	-1.0	-2.1	-1.6	0.7	0.5	-0.2	-3.2	11.7	7.3	-3.9	-1.1

Average Monthly Dry Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	8.7	8.6	9.5	11.5	13.2	12.5	8.9	8.0	7.9	9.2	8.5	7.0

Percent Change in Dry Year Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-2.8	6.0	19.4	**24.6**	**31.7**	**27.3**	**37.8**	**34.3**	**32.1**	10.4	-10.3	4.6
Alt 3	-4.1	1.1	-2.2	-1.8	2.0	1.3	1.2	-8.0	**21.3**	8.8	-8.6	-3.1
Alt 4	-5.0	0.1	-2.3	-2.2	1.4	1.1	-0.2	-9.3	**22.5**	9.4	-6.3	-1.1
Alt 5	-4.8	0.3	-2.2	-1.7	1.7	1.4	1.3	-8.0	**21.1**	9.0	-8.0	-2.2
Alt 6	-5.6	-1.0	-2.5	-2.0	1.2	1.0	7.2	-11.5	**23.9**	6.7	-6.8	-2.9
Alt 7	-4.9	0.0	-2.3	-1.6	1.5	0.3	1.2	-8.1	**21.5**	18.2	-12.4	-5.5
Alt 8	-4.6	-0.8	-2.6	-1.8	1.3	0.2	1.1	-8.4	**21.5**	17.6	-9.9	-4.7
Alt 9	-5.0	-0.4	-2.5	-1.7	1.6	1.2	-0.7	-9.6	**22.1**	9.6	-6.1	-3.0

Average Monthly Wet Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	9.6	11.5	15.9	20.9	23.3	22.7	16.8	14.4	11.6	10.5	8.5	9.0

Percent Change in Wet Year Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	-3.8	-5.3	-18.8	***-20.9***	***-22.4***	-19.2	***-25.2***	***-29.6***	-7.4	-1.5	-6.3	-7.4
Alt 3	-0.8	-1.7	-1.8	-1.4	-0.2	-0.1	0.8	1.8	2.6	2.6	-4.8	0.2
Alt 4	-1.6	-2.1	-2.1	-1.8	-0.1	-0.1	0.3	1.7	2.7	4.5	-0.9	0.5
Alt 5	-0.8	-1.4	-2.3	-1.6	-0.1	-0.3	0.9	1.8	2.6	2.9	-1.9	-0.2
Alt 6	-2.0	-3.0	-3.0	-1.6	-0.5	-0.2	2.1	0.3	4.3	5.4	0.5	-0.5
Alt 7	-1.7	-2.4	-2.2	-1.5	-0.3	-0.3	0.7	1.9	2.7	6.4	-6.1	-1.7
Alt 8	-1.2	-3.2	-2.5	-1.5	-0.2	-0.3	0.7	1.9	2.6	7.2	-3.4	-3.3
Alt 9	-1.8	-1.7	-1.8	-1.6	-0.1	-0.1	0.2	1.7	2.0	4.6	-1.0	0.9

Table XIII-37
San Joaquin River at Vernalis Vegetation Impact Analysis

73-Year Average Monthly River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	6.9	5.7	6.4	7.7	9.7	9.2	8.9	8.0	6.9	5.2	4.8	5.6

Percent Change in Average Monthly River Stage Compared to the Base Case

Alt 2	0.4	-2.2	-3.2	-3.5	-2.9	-0.4	4.6	11.2	5.6	7.6	9.7	-1.0
Alt 3	0.5	-2.0	-3.1	-3.3	-3.0	-0.6	4.6	11.2	5.7	7.7	9.9	-0.9
Alt 4	0.4	-2.0	-3.1	-3.4	-3.1	-0.7	4.8	11.4	6.0	7.8	9.9	-0.8
Alt 5	0.5	-2.0	-3.0	-3.3	-2.9	-0.6	4.6	11.2	5.7	7.9	10.0	-0.7
Alt 6	5.3	0.9	2.6	1.7	1.8	1.0	0.2	4.2	5.1	7.4	-1.6	-5.7
Alt 7	0.5	-2.0	-3.0	-3.2	-2.7	-0.6	4.6	11.0	5.7	7.9	10.0	-0.7
Alt 8	0.5	-1.9	-2.9	-3.2	-2.8	-0.7	4.7	11.1	5.6	7.9	10.0	-0.7
Alt 9	0.4	1.1	0.0	-2.4	-4.0	-0.2	7.8	14.5	6.2	6.7	5.6	-1.0

Average Monthly Dry Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	6.8	5.4	5.4	5.5	6.4	6.2	6.5	5.5	4.6	4.4	4.5	5.1

Percent Change in Dry Year Monthly River Stage Compared to the Base Case

Alt 2	-2.7	-2.4	0.0	2.4	13.0	10.5	17.0	**28.7**	16.6	13.3	12.9	0.9
Alt 3	-2.6	-2.1	0.1	2.6	12.6	9.9	17.0	**28.7**	16.7	13.5	13.1	1.1
Alt 4	-2.8	-2.1	0.1	2.5	12.2	9.7	17.6	**29.3**	17.6	13.5	13.1	1.2
Alt 5	-2.6	-2.0	0.2	2.6	12.7	9.9	17.0	**28.7**	16.7	13.6	13.2	1.3
Alt 6	2.5	0.5	5.6	7.9	18.0	11.5	12.3	18.8	16.0	13.0	-5.5	-5.5
Alt 7	-2.6	-2.1	0.2	2.6	13.0	9.9	17.0	**28.3**	16.7	13.6	13.2	1.3
Alt 8	-3.2	-2.3	-0.8	1.2	11.0	8.7	15.7	**26.6**	16.3	13.7	12.7	0.7
Alt 9	-1.5	1.8	3.7	3.7	10.8	9.3	**21.0**	**32.4**	15.3	11.2	4.7	-0.1

Average Monthly Wet Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	7.0	6.1	7.7	10.3	13.3	12.6	11.7	10.9	9.5	6.2	5.1	6.1

Percent Change in Wet Year Monthly River Stage Compared to the Base Case

Alt 2	3.9	-2.0	-5.8	-7.0	-11.7	-6.5	-3.3	1.0	-0.5	2.9	6.5	-2.9
Alt 3	3.9	-2.0	-5.6	-6.9	-11.6	-6.5	-3.2	1.1	-0.4	3.0	6.6	-2.7
Alt 4	3.9	-2.0	-5.6	-6.9	-11.6	-6.6	-3.2	1.1	-0.5	3.0	6.7	-2.7
Alt 5	4.0	-1.9	-5.6	-6.8	-11.5	-6.5	-3.2	1.1	-0.4	3.1	6.7	-2.6
Alt 6	8.4	1.2	0.2	-2.1	-7.2	-5.0	-7.4	-4.3	-1.0	2.8	2.4	-5.9
Alt 7	4.0	-1.9	-5.6	-6.8	-11.4	-6.5	-3.2	1.1	-0.4	3.1	6.7	-2.6
Alt 8	5.7	-0.3	-2.1	-1.9	-6.9	-2.0	1.1	5.7	3.9	5.1	8.0	-0.7
Alt 9	3.0	1.4	-0.7	-2.3	-8.8	-1.7	2.7	7.7	5.6	5.2	7.9	-0.4

Table XIII-38

San Joaquin River at Newman Vegetation Impact Analysis

73-Year Average Monthly River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	7.3	5.7	6.2	7.0	8.6	7.6	6.4	7.0	6.4	5.1	4.9	5.8

Percent Change in Average Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	0.6	-0.8	-1.0	-0.6	-1.0	0.1	0.7	4.0	4.0	0.0	-0.6	-0.9
Alt 3	0.6	-0.7	-0.8	-0.6	-1.0	0.1	0.8	4.0	4.0	0.1	-0.4	-0.8
Alt 4	0.5	-0.7	-0.7	-0.6	-1.0	0.1	0.8	4.1	4.1	0.4	-0.4	-0.7
Alt 5	0.7	-0.6	-0.7	-0.6	-0.9	0.1	0.8	4.1	4.1	0.2	-0.3	-0.6
Alt 6	-0.4	-0.3	-0.2	-0.3	-0.1	-0.2	-0.3	-0.3	-0.3	-0.4	-0.4	-0.5
Alt 7	0.7	-0.6	-0.7	-0.6	-0.8	0.1	0.8	0.8	3.9	0.2	-0.1	-0.6
Alt 8	0.7	-0.5	-0.4	-0.5	-0.9	0.1	0.9	0.9	3.9	0.3	-0.1	-0.6
Alt 9	-3.5	-1.5	-1.6	-1.9	-3.6	-0.7	2.0	2.0	0.9	-1.8	-0.5	-1.0

Average Monthly Dry Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	7.2	5.4	5.0	5.1	6.1	5.8	4.8	4.7	4.6	4.8	4.9	5.5

Percent Change in Dry Year Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	0.2	0.8	3.8	7.2	13.6	4.8	8.5	18.3	4.1	-1.8	-1.5	-0.7
Alt 3	0.2	0.9	4.0	7.3	13.6	4.6	8.6	18.4	4.3	-1.5	-1.3	-0.5
Alt 4	0.0	0.9	4.0	7.3	13.6	4.7	8.6	18.5	5.0	-1.4	-1.3	-0.4
Alt 5	0.3	0.9	4.1	7.3	13.7	4.7	8.6	18.4	4.5	-1.3	-1.2	-0.4
Alt 6	-0.2	0.9	4.1	7.8	14.7	4.4	6.0	8.5	3.4	-1.6	-1.4	-0.6
Alt 7	0.3	0.9	4.1	7.4	13.7	4.7	8.6	17.8	4.5	-1.3	-1.0	-0.3
Alt 8	-0.1	0.9	3.2	5.9	11.9	4.3	7.8	17.3	4.4	-0.6	-0.9	-0.4
Alt 9	-4.7	0.2	2.5	5.2	9.9	4.2	8.5	11.1	2.1	-0.9	-1.2	-0.7

Average Monthly Wet Year River Stage (ft)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 1	7.3	6.1	7.5	9.3	11.4	9.7	8.2	9.5	8.5	5.4	4.9	6.2

Percent Change in Wet Year Monthly River Stage Compared to the Base Case (percent)

Alternative	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Alt 2	1.1	-2.3	-4.7	-5.6	-10.1	-3.1	-4.6	-4.1	-2.6	0.6	0.5	-1.2
Alt 3	1.1	-2.2	-4.4	-5.5	-10.0	-3.1	-4.6	-4.0	-2.5	0.8	0.7	-1.1
Alt 4	1.1	-2.3	-4.4	-5.5	-10.0	-3.1	-4.5	-4.0	-2.5	0.8	0.6	-1.0
Alt 5	1.1	-2.1	-4.4	-5.5	-10.0	-3.1	-4.5	-4.0	-2.4	1.0	0.8	-1.0
Alt 6	-0.5	-1.5	-3.6	-5.3	-9.3	-3.3	-4.6	-5.2	-2.8	0.9	0.9	-0.3
Alt 7	1.1	-2.1	-4.4	-5.5	-9.8	-3.1	-4.5	-4.0	-2.4	1.0	0.9	-0.9
Alt 8	1.9	-1.0	-0.6	-0.8	-5.8	0.5	-0.8	0.1	1.7	1.5	0.9	0.0
Alt 9	-1.6	-2.3	-2.2	-2.7	-9.3	-0.8	0.7	-1.0	-0.3	1.1	0.5	-0.5

4. Geology

This analysis of geology addresses lands and soils, subsidence, soil quality, agricultural production, and soil erosion.

a. <u>Background and Assumptions</u>. The evaluation of lands and soils is based on water availability to agricultural lands. Urban water users tend to have priority for limited water supplies in dry years. Agricultural users tend to pump more groundwater in areas where it is available at a reasonable cost. Extensive groundwater overdraft has limited water supply in many areas. This analysis assumes the cumulative water supply over the period 1921-1994 is an indicator for agriculture and that relative differences in water supply between alternatives will result in differences in groundwater overdraft potential and agricultural production.

Subsidence has been widespread in the San Joaquin Valley and occurs locally in the Sacramento Valley. Water level declines due to groundwater overdraft have caused the subsidence in most areas. Although much of this damage has already occurred, further damage is possible if overdraft continues to dewater aquifers. This analysis assumes that any alternative that reduces agricultural water supplies will lead to groundwater overdraft and increase subsidence potential. Damage to agriculture from subsidence includes reducing irrigation canal capacity and increasing the need to relevel fields to maintain a uniform gradient.

Soil quality refers to factors such as organic matter content, friability, permeability, and water holding capacity. Soil salinity and sodicity are also important components of soil quality. Irrigation tends to maintain or improve soil quality in irrigated areas; however, soil salinity and sodicity problems can also develop. Any alternative that reduces surface water supply will encourage the use of groundwater for irrigation. In some areas, this will tend to lead to an increase in soil salinity and, in some areas, sodicity because groundwater is nearly always more saline than surface water supplies. The following land types are most affected: westside alluvial fans, basin and basin rim areas, and old eastside terraces. Any alternative that reduces agricultural water supply will lead to increases in groundwater use and will generally increase soil salinity and sodicity and reduce soil quality.

The study area is very dependent on irrigation water for crop production. In years when water is short, these shortages tend to be felt most by agricultural users. In areas where good supplies of groundwater are available, agricultural production is reduced slightly; however, in areas where adequate supplies of groundwater are not available, or are too deep to pump economically, agricultural production is severely reduced. Because of groundwater conditions and priority of service in certain districts, the alluvial fans on the west side of the San Joaquin Valley tend to be affected significantly, and large tracts of idle lands are present during drought years.

Wind erosion potential increases significantly in dry years because more lands are idle and ground cover is sparse because of inadequate water supply. Chronic water shortages could increase water erosion potential if lands are abandoned or if management intensity is reduced. Damages are most likely to occur in steeper areas where orchards have been developed and adequate groundwater is unavailable.

b. Impact Analysis. Based on the delivery reductions shown in Table XIII-1, a qualitative assessment of the impacts of the the Joint POD alternatives to lands compared to Alternative 2 are shown in Table XIII-39. Groundwater overdraft estimates and potential water level declines were calculated for the different alternatives and are shown in Table XIII-40.

Joint POD Alternative 1. Joint POD Alternative 1 reflects D-1485 conditions for 1921-1994. Only Alternative 8 is more beneficial to land and soil resources. California agriculture development has taken place because of water deliveries available under this alternative.

Joint POD Alternative 2. When compared to Alternative 1, Joint POD Alternative 2 results in a reduced water supply for agriculture. The cumulative reduction in water supply amounts to about 21 million acre-feet over the 1921-1994 period. Average annual water supplies for agriculture would be reduced about 6.7 percent. If irrigators decided to pump groundwater to make up the deficit, then groundwater levels may decline on average by 1.2 feet per year.

Table XIII-39 Summary of Impacts of Joint POD Alternatives on Lands (compared to Alternative 2)

Joint POD Alternative	Soil Quality: Soil Salinity and Sodicity	Erosion: Wind and Water	Agricultural Production	Subsidence Potential
1	Slightly beneficial	Slightly beneficial	Slight increase	Slightly beneficial
2	—	—	—	—
3	Very slightly beneficial	Very slightly beneficial	Very slight increase	Very slightly beneficial
4	Very slightly beneficial	Very slightly beneficial	Very slight increase	Very slightly beneficial
5	Very slightly beneficial	Very slightly beneficial	Very slight increase	Very slightly beneficial
6	Very slightly beneficial	Very slightly beneficial	Very slight increase	Very slightly beneficial
7	Slightly beneficial	Slightly beneficial	Slight increase	Slightly beneficial
8	Slightly beneficial	Slightly beneficial	Slight increase	Slightly beneficial
9	Very slightly beneficial	Very slightly beneficial	Very slight increase	Very slightly beneficial

In areas where groundwater is available, irrigators would probably pump more groundwater in the short term; however, in the long term, the agricultural production would be reduced as cropping patterns and irrigated acreage come into balance with the reduced water supply. (Refer to the agricultural economics section of this report for further information on agriculture production.)

Compared to Alternative 1, Alternative 2 would tend to decrease soil quality by increasing soil salinity and sodicity because groundwater nearly always contains more salt than surface water.

Table XIII-40 Groundwater Overdraft and Water Level Decline Resulting from Joint POD Alternatives for the 73-Year Period

Alternative	Cumulative Deliveries MAF[1]	Shortage (Overdraft) MAF	Average Annual Overdraft TAF[2]	Percent of Average Ag. Deliveries	Annual Average Groundwater Level Decline[3] (ft)	Agriculture Ranking
1	412	—	—	—	—	—
2	391	21	288	6.7	1.2	8 (worst)
3	396	16	216	5.0	0.92	6
4	397	15	209	4.9	0.86	4
5	400	12	166	3.9	0.78	3
6	397	15	206	4.9	0.86	4
7	403	9	118	2.7	0.52	2
8	410	2	29	0.7	0.11	1 (best)
9	393	19	260	6.1	1.08	7

[1] Million acre-feet.
[2] Thousand acre-feet.
[3] Calculated based on 1.6 million acres agricultural service area and aquifer specific yield of 15 percent. Regional ground water flow systems not considered.
73-year period ground water level decline = (Shortage/1.6)/0.15
Assumptions: All shortages accrue to agriculture.
Average agriculture deliveries - 4.3 million acre-feet.

Soil erosion potential would increase because more land would be idled and thus be susceptible to wind erosion, especially where adequate supplies of groundwater are not available.

Subsidence potential would increase because overdraft under this alternative could dewater some aquifers. Following dewatering, there is a potential for a reduction in pore space due to aquifer consolidation.

Joint POD Alternatives 3, 4, 5, 6, and 9. When compared to Alternative 2, Joint POD Alternatives 3, 4, 5, 6, and 9 would cumulatively increase agricultural water supply in the export areas by 3 million to 9 million acre-feet over the 73-year period. Agricultural production would increase, soil quality would improve, and soil erosion potential would decrease. Subsidence potential would decrease. These alternatives are very slightly beneficial when compared to Alternative 2.

Joint POD Alternatives 7 and 8. Joint POD Alternatives 7 and 8 would result in agricultural water supplies similar to Alternative 1. When compared to Alternative 2, these alternatives would result in improved soil quality, reduced subsidence and erosion potential, and increased agricultural production. Alternative 8 tends to maximize benefits to agriculture, land, and soil resources.

5. Energy

Joint POD alternatives will affect energy production and consumption. This section discusses the impact of implementing the alternatives on: (1) hydroelectric power availability, (2) groundwater pumping, and (3) fossil fuel consumption. Standard outputs of energy generation and consumption from DWR's planning model, DWRSIM, were used to evaluate effects on power availability.

a. Hydroelectric Power Availability. Hydroelectric power is an important component in California's energy budget. Hydroelectric generation plants provide approximately 24 percent of the State's generation capacity. In a typical year, in excess of $1.3 billion of power, as measured by replacement costs, is produced (McCann 1994). Electric utilities seek to maximize the value of their hydroelectric power production. Power produced during peak energy demand periods is more valuable than that produced during lower demand periods. Utilities generally employ hydropower to meet peak loads because it provides a low cost energy source that can be turned on and off quickly. Peak load periods in California typically occur in the summer when electrical demands for groundwater pumping, air conditioning, and industrial needs are the greatest. Changes in the operation of hydropower reservoirs that limit or reduce the availability of water during the peak demand period may result in reductions in hydroelectric plant's ability to meet peak load requirements. This loss of flexibility accelerates the need for additional peaking resources and increases utility costs.

The SWP and the CVP are both producers and consumers of hydroelectric power. Hydroelectric power plants at the reservoirs produce the power and pumping plants at export facilities consume it. The SWP includes 22 dams and reservoirs, eight hydroelectric plants and 17 pumping plants. The CVP includes 19 dams and reservoirs, seven hydroelectric power plants, two pump/generation plants, and 39 pumping plants. The CVP is a net energy producer, having greater production capacity than consumption. The SWP is a net energy consumer, primarily because of the number and size of pumped lifts required along the length of the California Aqueduct. Together, the SWP and CVP produce more energy than is consumed. The Joint POD alternatives permit increased pumping by the SWP, resulting in higher consumption. This higher consumption decreases the availability of energy otherwise produced and utilized outside the SWP and CVP projects. This loss accelerates the need for additional resources and may increase utility costs.

Net SWP, CVP, and combined SWP and CVP energy generation were evaluated. The values reported are a composite index resulting from the complex interaction among the many factors and model assumptions that affect the simulated operations of the SWP and CVP. At any given time it can be difficult to determine the cause of differences among alternatives. The net values reported were calculated by subtracting energy consumption from energy generation for each alternative and then comparing the index to that calculated for Alternative 1. Positive effects on this index generally occur with increases in reservoir releases used for generation or from reductions in pumping and consumption. Negative effects on this index generally occur with decreased reservoir releases and increases in pumping.

Net CVP Hydropower Generation. Table XIII-41 shows the average monthly difference in net CVP energy generation for Joint POD Alternatives 2 through 9 compared to Alternative 1 (base case) for the 73-year period of analysis. This information is graphically represented in Figure XIII-98. The comparison of Alternative 2 with Alternative 1 demonstrates the effect of full implementation of the 1995 Bay/Delta Plan. The increase in the long-term average annual net CVP generation is consistent with similar flow objective alternatives analyzed in Chapter VI, Section 7 and with Beck (1994) who reported that slightly increased amounts of energy are available to the CVP from implementation of the Bay/Delta Plan due to reduced export pumping. Alternatives 3 through 9 show a similar pattern of change in mean monthly net CVP energy generation to that which occurs with implementation of the 1995 Bay/Delta Plan represented by Alternative 2. Increases occur from February through May, when reservoir releases are increased and pumping is curtailed to meet 1995 Bay/Delta Plan objectives. Decreases occur in June and from September through January when the conditions necessary to permit wheeling exist. Of the alternatives that permit joint use of points of diversion, the annual difference over the 73-year period of record shows that net energy generation for Alternatives 3 through 8 would be less than the mean for Alternative 1. Alternative 8, which assumes maximum wheeling, is expected to result in the greatest decrease in net CVP energy generation. Based on a 73-year annual average, Alternative 9 is the only wheeling alternative expected to increase net CVP energy generation. The CVP remains a net energy producer for all alternatives considered.

Net SWP Hydropower Generation. Table XIII-42 shows the average monthly difference in net SWP energy generation for Alternatives 2 through 9 compared to Alternative 1 for the 73-year period analysis. All Joint POD alternatives result in an increase in net SWP energy generation. The greatest increase is predicted to occur with Alternative 2, which represents implementation of the 1995 Bay/Delta Plan. The predicted increases are less for the alternatives that allow wheeling. The smallest net increase is predicted to occur with Alternative 7. This information is graphically represented in Figure XIII-99.

Net Combined SWP and CVP Hydropower Generation. The effects on combined net SWP and CVP energy generation are shown in Table XIII-43 and Figure XIII-100. Alternative 2 shows the greatest increase in net energy generation because of gains in both SWP and CVP net generation with implementation of the 1995 Bay/Delta Plan. The gains predicted for the SWP are greater than the reductions predicted for the CVP, resulting in a net increase in combined generation for Alternatives 3, 4, 5, 6, and 9. Net combined energy generation is predicted to be reduced under Alternatives 7 and 8 which assume combined use would be permitted up to the SWP's maximum pumping capacity of 10,300 cfs.

Impacts on Other Facilities. The analysis of the flow alternatives in Chapter VI indicates that the implementation of the 1995 Bay/Delta Plan will affect hydropower operations other than the SWP and the CVP. However, the implementation of any of the Joint POD alternatives that allow wheeling would affect only the hydropower operations of the SWP and the CVP.

Table XIII-41

Net CVP Energy Generation

Base Case Average Monthly Net Generation (GWHrs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	213.6	186.8	231.4	243.5	271.7	286.1	316.6	489.3	559.7	516.9	361.0	202.4

Change in Net Generation from the Base Case (GWHrs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2	-19.1	3.5	-9.4	-18.2	5.2	12.3	67.6	1.5	-19.9	10.6	19.2	-10.7	42.6
3	-27.4	-4.5	-22.5	-29.2	-1.7	5.2	67.1	2.8	-17.1	9.7	8.9	-15.9	-24.6
4	-31.6	-13.8	-38.4	-57.5	3.3	26.9	93.4	20.7	-15.7	7.1	2.0	-20.4	-24.1
5	-36.1	-14.2	-40.7	-59.8	13.3	26.9	70.1	3.6	-15.4	5.7	-3.4	-20.2	-70.1
6	-18.8	-15.6	-30.2	-49.5	13.3	28.9	20.5	30.1	-9.7	11.1	-3.5	-20.2	-43.5
7	-53.1	-25.2	-65.9	-39.2	29.0	25.7	64.3	1.1	-23.5	-4.7	-16.2	-26.8	-134.7
8	-40.5	-20.6	-40.2	-116.7	20.3	17.7	61.4	0.3	-10.9	-2.5	-25.4	-31.5	-188.5
9	-32.6	-7.8	-33.4	-57.5	13.3	32.9	92.4	20.7	-16.7	5.1	4.0	-19.4	0.9

Note: Negative numbers indicate less energy is produced (net) under the alternatives than the base case.

Figure XIII-98
Net CVP Energy Generation
73-year monthly average compared to Alternative 1 (Base Case)

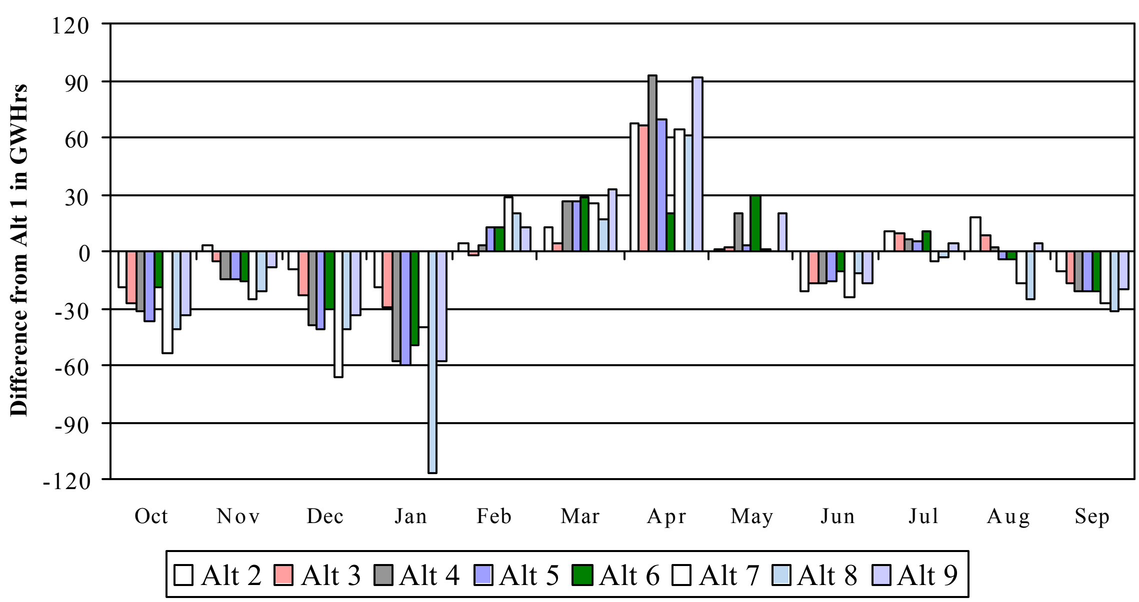


Table XIII-42

Net SWP Energy Generation

Base Case Average Monthly Net Generation (GWHrs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-366.5	-442.8	-380.6	-280.1	-234.4	-234.3	-282.0	-213.6	-242.6	-269.3	-330.7	-436.1

Change in Net Generation from the Base Case (GWHrs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2	-25.0	-2.7	-1.0	24.3	47.1	25.0	54.5	-8.1	13.9	49.8	7.6	18.6	202.0
3	-25.2	-1.2	-3.8	20.6	47.4	21.2	55.2	-8.3	13.9	49.3	4.4	19.4	193.0
4	-22.5	-0.2	-8.4	12.1	39.4	22.3	64.0	1.6	10.6	52.3	7.7	19.1	198.0
5	-23.3	2.5	-7.5	14.5	42.3	25.6	55.8	-6.3	15.4	48.3	1.0	23.2	191.5
6	-23.2	1.9	-18.0	8.8	43.6	18.2	47.3	8.4	15.9	54.9	7.2	21.8	186.8
7	-56.6	-26.3	-23.9	21.6	54.2	19.9	46.5	-17.6	-0.3	51.9	-27.5	-6.4	35.5
8	-54.4	-20.0	-19.5	9.5	54.2	21.5	46.5	-18.1	0.5	51.0	-31.0	0.4	40.6
9	-27.5	-4.2	-16.4	14.1	40.4	24.3	62.0	-4.4	14.6	54.3	11.7	20.1	189.0

Note: Negative numbers indicate less energy is produced (net) under the alternatives than the base case.

Figure XIII-99

Net SWP Energy Generation

73-year monthly average compared to Alternative 1 (Base Case)

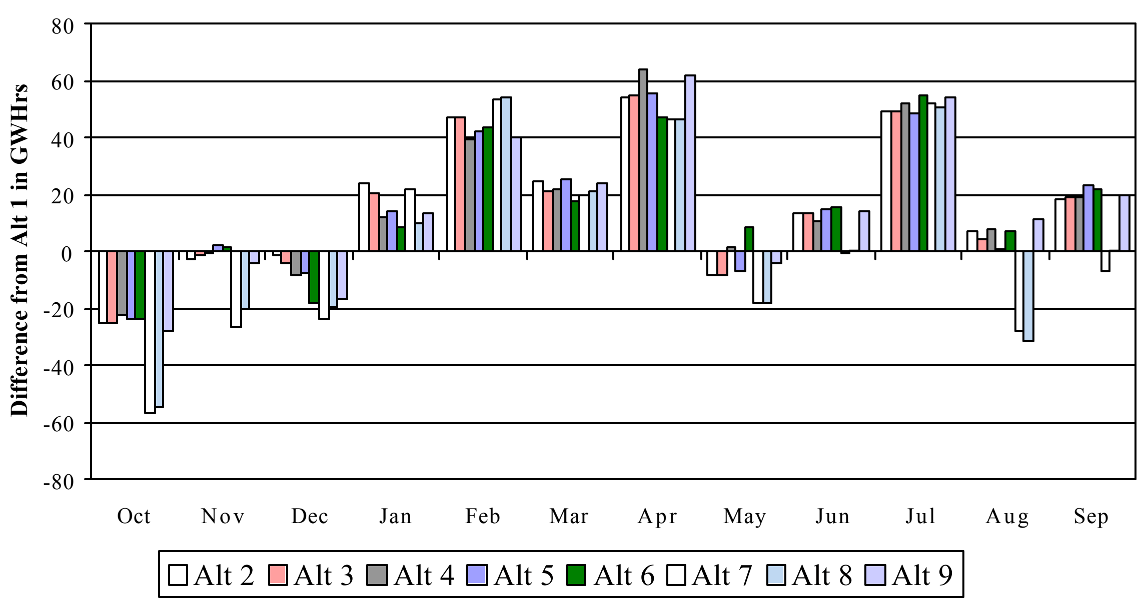


Table XIII-43

Net SWP and CVP Energy Generation

Base Case Average Monthly Net Generation (GWHrs)

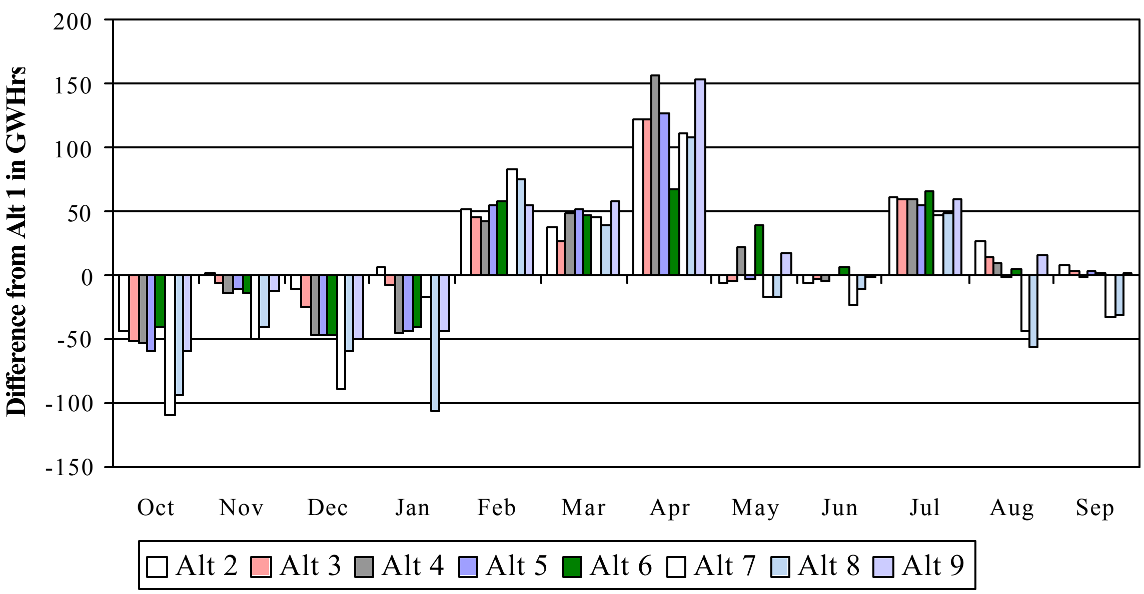
Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-152.9	-256.0	-149.2	-36.6	37.3	51.8	34.6	275.8	317.1	247.5	30.3	-233.7

Change in Net Generation from the Base Case (GWHrs)

Alt	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2	-44.0	0.8	-10.4	6.1	52.3	37.3	122.1	-6.6	-6.0	60.4	26.7	7.9	246.7
3	-52.6	-5.7	-26.3	-8.6	45.7	26.3	122.3	-5.4	-3.2	59.0	13.4	3.4	168.4
4	-54.1	-14.0	-46.8	-45.4	42.7	49.2	157.4	22.2	-5.1	59.5	9.7	-1.3	173.9
5	-59.5	-11.7	-48.1	-45.3	55.6	52.5	125.9	-2.7	0.0	54.0	-2.4	3.1	121.4
6	-42.0	-13.8	-48.2	-40.7	56.9	47.1	67.9	38.4	6.2	66.0	3.8	1.7	143.3
7	-109.7	-51.5	-89.8	-17.6	83.1	45.6	110.7	-16.5	-23.9	47.2	-43.7	-33.2	-99.2
8	-94.9	-40.6	-59.8	-107.1	74.5	39.2	107.9	-17.7	-10.4	48.5	-56.3	-31.1	-147.9
9	-60.1	-12.0	-49.8	-43.4	53.7	57.2	154.4	16.2	-2.1	59.5	15.7	0.7	189.9

Note: Negative numbers indicate less energy is produced (net) under the alternatives than the base case.

Figure XIII-100
Net SWP and CVP Energy Generation
73-year monthly average compared to Alternative 1 (Base Case)



Mitigation. Reductions in summer hydroelectric power production reduce the amount of energy available for meeting summer-time peak loads. Increasing generation from fossil fuel power plants or from other sources including nuclear, geothermal, biomass, solar thermal, solar photovoltaic and wind generation may make up such reductions. However, non-mitigable impacts would occur with increases in energy generation from fossil fuel sources.

b. Groundwater Pumping. The analysis of alternatives in Chapter VI indicates that the implementation of the 1995 Bay/Delta Plan may cause deficiencies in surface water deliveries. The reductions in surface water supplies have a potential to cause an increase in groundwater pumping. Increased groundwater pumping may lower groundwater levels, resulting in higher pumping lifts and, thus, further increase energy consumption. Implementation of alternatives that include wheeling would reduce the loss of surface water supplies and offset increases in groundwater pumping.

Mitigation. The increase in energy consumption due to groundwater pumping can be partially mitigated through off-peak pumping operations.

c. Fossil Fuels. No attempt was made to estimate the effect of the Joint POD alternatives on fossil fuel consumption. A qualitative assessment of the effects is difficult because decreased hydropower generation will be offset to some extent by decreased groundwater pumping. Overall, it is possible that fossil fuel consumption will increase significantly, but if this occurs, the effect is unmitigable, as described in Chapter VI.

Mitigation. The effect of increasing fossil fuel generation is not entirely mitigable, however other sources of energy generation are available including nuclear, geothermal, biomass, solar thermal, solar photovoltaic and wind generation.

6. Recreation

This section presents the results of the assessment of impacts to recreation that would occur with implementation of the Joint POD. The assessment of recreation impacts analyzes how changes in reservoir storage would affect opportunities for water-related activities at key recreation facilities. Recreation impacts are assessed for the major reservoirs that are operated by the SWP and the CVP. The reservoirs include Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir.

The methodology for this assessment of recreation impacts is the same as described in Chapter VI for analyzing the impacts of implementing the 1995 Bay/Delta Plan. The recreation impact analysis considers the frequency of occurrence with which end-of-month storage (converted to surface elevation) falls below or, in some cases, exceeds the various threshold levels established for each reservoir. Tables XIII-44 through XIII-47 summarize the frequency of occurrence in absolute numbers and as a percentage of the total number of months in the study period.

In general, the end-of-month storage under Joint POD Alternatives 2 through 9 falls below the threshold levels established for each reservoir more often than under Joint POD Alternative 1. However, the differences illustrate the effects of the Bay/Delta Plan over the D-1485 objectives, and not the effects of the Joint POD.

Table XIII-44
Recreation Impact Assessment for Shasta Lake

Main Area
Peak Season (May - Sept.)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Period/Alternative	Total Months	844 ft. total	844 ft. %	947 ft. total	947 ft. %	987 ft. total	987 ft. %
73-YEAR PERIOD	365						
Alternative 1 (Base Case)		0	0%	17	5%	64	18%
Alternative 2		0	0%	22	6%	72	20%
Alternative 3		0	0%	25	7%	75	21%
Alternative 4		0	0%	23	6%	76	21%
Alternative 5		0	0%	26	7%	75	21%
Alternative 6		0	0%	22	6%	76	21%
Alternative 7		0	0%	25	7%	76	21%
Alternative 8		0	0%	27	7%	78	21%
Alternative 9		0	0%	21	6%	68	19%
CRITICAL PERIOD	35						
Alternative 1 (Base Case)		0	0%	9	26%	22	63%
Alternative 2		0	0%	8	23%	23	66%
Alternative 3		0	0%	11	31%	24	69%
Alternative 4		0	0%	10	29%	24	69%
Alternative 5		0	0%	10	29%	24	69%
Alternative 6		0	0%	8	23%	24	69%
Alternative 7		0	0%	10	29%	24	69%
Alternative 8		0	0%	10	29%	24	69%
Alternative 9		0	0%	9	26%	21	60%

Main Area
Off-Season (Oct.- April)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Period/Alternative	Total Months	844 ft. total	844 ft. %	947 ft. total	947 ft. %
73-YEAR PERIOD	511				
Alternative 1 (Base Case)		0	0%	26	5%
Alternative 2		0	0%	36	7%
Alternative 3		0	0%	41	8%
Alternative 4		0	0%	41	8%
Alternative 5		0	0%	42	8%
Alternative 6		0	0%	35	7%
Alternative 7		0	0%	39	8%
Alternative 8		0	0%	39	8%
Alternative 9		0	0%	35	7%
CRITICAL PERIOD	43				
Alternative 1 (Base Case)		0	0%	14	33%
Alternative 2		0	0%	15	35%
Alternative 3		0	0%	16	37%
Alternative 4		0	0%	16	37%
Alternative 5		0	0%	16	37%
Alternative 6		0	0%	15	35%
Alternative 7		0	0%	16	37%
Alternative 8		0	0%	16	37%
Alternative 9		0	0%	14	33%

Critical Elevation Thresholds:
- <844 ft. msl - last boat ramp out of operation
- <947 ft. msl - limited lake surface area (boating constrained)
- <987 ft. msl - marina relocated

Table XIII-45
Recreation Impact Assessment for Lake Oroville

Peak Season (April - Sept.)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Period/Alternative	Total Months	700 ft.		710 ft.		750 ft.		819 ft.		840 ft.	
73-YEAR PERIOD	438	total	%	total	%	total	%	total	%	total	%
Alternative 1 (Base Case)		13	3%	24	5%	46	11%	133	30%	176	40%
Alternative 2		17	4%	25	6%	64	15%	157	36%	191	44%
Alternative 3		19	4%	29	7%	68	16%	158	36%	196	45%
Alternative 4		20	5%	29	7%	68	16%	160	37%	199	45%
Alternative 5		20	5%	29	7%	65	15%	161	37%	192	44%
Alternative 6		17	4%	27	6%	63	14%	167	38%	198	45%
Alternative 7		18	4%	28	6%	69	16%	169	39%	201	46%
Alternative 8		18	4%	25	6%	68	16%	169	39%	201	46%
Alternative 9		16	4%	28	6%	65	15%	149	34%	182	42%
CRITICAL PERIOD	41										
Alternative 1 (Base Case)		2	5%	4	10%	12	29%	34	83%	36	88%
Alternative 2		1	2%	3	7%	21	51%	36	88%	36	88%
Alternative 3		4	10%	7	17%	24	59%	35	85%	36	88%
Alternative 4		4	10%	6	15%	23	56%	34	83%	36	88%
Alternative 5		4	10%	6	15%	23	56%	35	85%	36	88%
Alternative 6		2	5%	4	10%	19	46%	36	88%	36	88%
Alternative 7		2	5%	3	7%	20	49%	36	88%	36	88%
Alternative 8		2	5%	3	7%	20	49%	36	88%	36	88%
Alternative 9		3	7%	7	17%	22	54%	29	71%	31	76%

Off-Season (Oct.- March)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Period/Alternative	Total Months	710 ft.		750 ft.	
73-YEAR PERIOD	438	total	%	total	%
Alternative 1 (Base Case)		39	9%	77	18%
Alternative 2		42	10%	87	20%
Alternative 3		52	12%	89	20%
Alternative 4		53	12%	89	20%
Alternative 5		51	12%	88	20%
Alternative 6		40	9%	88	20%
Alternative 7		52	12%	87	20%
Alternative 8		51	12%	88	20%
Alternative 9		47	11%	85	19%
CRITICAL PERIOD	37				
Alternative 1 (Base Case)		9	24%	18	49%
Alternative 2		8	22%	25	68%
Alternative 3		15	41%	25	68%
Alternative 4		14	38%	25	68%
Alternative 5		15	41%	24	65%
Alternative 6		8	22%	23	62%
Alternative 7		10	27%	22	59%
Alternative 8		10	27%	23	62%
Alternative 9		12	32%	24	65%

Critical Elevation Thresholds:
- <700 ft. msl - decline in campground/picnicking use
- <710 ft. msl - limited boat ramp availability/marina relocation
- <750 ft. msl - limited lake surface area (boating constrained)
- <819 ft. msl - beach area closed
- <840 ft. msl - decline in beach use

Table XIII-46
Recreation Impact Assessment for Folsom Lake

Peak Season (April - Sept.)

Period/Alternative	Total Months	Frequency with which Reservoirs are below Critical Elevation Thresholds (or >450 ft.) 360 ft. total	360 ft. %	400 ft. total	400 ft. %	405 ft. total	405 ft. %	430 ft. total	430 ft. %	> 450 ft. total	> 450 ft. %
73-YEAR PERIOD	438										
Alternative 1 (Base Case)		39	9%	76	17%	85	19%	167	38%	101	23%
Alternative 2		56	13%	106	24%	113	26%	180	41%	99	23%
Alternative 3		61	14%	105	24%	114	26%	189	43%	99	23%
Alternative 4		61	14%	111	25%	122	28%	193	44%	97	22%
Alternative 5		58	13%	110	25%	120	27%	195	45%	98	22%
Alternative 6		61	14%	118	27%	127	29%	202	46%	92	21%
Alternative 7		61	14%	110	25%	124	28%	198	45%	96	22%
Alternative 8		68	16%	118	27%	131	30%	204	47%	88	20%
Alternative 9		55	13%	98	22%	109	25%	172	39%	171	39%
CRITICAL PERIOD	41										
Alternative 1 (Base Case)		13	32%	20	49%	22	54%	30	73%	3	7%
Alternative 2		18	44%	28	68%	28	68%	34	83%	1	2%
Alternative 3		18	44%	27	66%	27	66%	34	83%	2	5%
Alternative 4		18	44%	28	68%	29	71%	34	83%	2	5%
Alternative 5		18	44%	27	66%	28	68%	34	83%	2	5%
Alternative 6		18	44%	30	73%	30	73%	35	85%	1	2%
Alternative 7		18	44%	28	68%	29	71%	34	83%	2	5%
Alternative 8		18	44%	28	68%	30	73%	34	83%	2	5%
Alternative 9		14	34%	24	59%	26	63%	30	73%	8	20%

Off-Season (Oct.- March)

Period/Alternative	Total Months	Frequency with which Reservoirs are below Critical Elevation Thresholds 360 ft. total	360 ft. %	400 ft. total	400 ft. %
73-YEAR PERIOD	438				
Alternative 1 (Base Case)		29	7%	128	29%
Alternative 2		39	9%	127	29%
Alternative 3		48	11%	139	32%
Alternative 4		46	11%	145	33%
Alternative 5		46	11%	143	33%
Alternative 6		54	12%	152	35%
Alternative 7		46	11%	140	32%
Alternative 8		54	12%	156	36%
Alternative 9		42	10%	141	32%
CRITICAL PERIOD	37				
Alternative 1 (Base Case)		4	11%	26	70%
Alternative 2		12	32%	26	70%
Alternative 3		15	41%	28	76%
Alternative 4		15	41%	28	76%
Alternative 5		15	41%	27	73%
Alternative 6		19	51%	28	76%
Alternative 7		15	41%	27	73%
Alternative 8		16	43%	28	76%
Alternative 9		13	35%	27	73%

Critical Elevation Thresholds:
- <360 ft. msl - last boat ramp out of operation
- <400 ft. msl - limited lake surface area (boating constrained)
- <405 ft. msl - marina closes
- <430 ft. msl - decline in campground/picnicking use
- >450 ft. msl - beach area inundated

Table XIII-47
Recreation Impact Assessment for New Melones Reservoir

Peak Season (April - Sept.)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Period/Alternative	Total Months	850 ft. total	850 ft. %	860 ft. total	860 ft. %	880 ft. total	880 ft. %	900 ft. total	900 ft. %
73-YEAR PERIOD	438								
Alternative 1 (Base Case)		8	2%	9	2%	11	3%	15	3%
Alternative 2		18	4%	22	5%	34	8%	47	11%
Alternative 3		18	4%	22	5%	34	8%	46	11%
Alternative 4		18	4%	22	5%	34	8%	46	11%
Alternative 5		18	4%	22	5%	34	8%	46	11%
Alternative 6		4	1%	4	1%	10	2%	13	3%
Alternative 7		18	4%	22	5%	34	8%	46	11%
Alternative 8		18	4%	22	5%	34	8%	46	11%
Alternative 9		11	3%	13	3%	20	5%	27	6%
CRITICAL PERIOD	41								
Alternative 1 (Base Case)		0	0%	0	0%	0	0%	1	2%
Alternative 2		8	20%	10	24%	14	34%	20	49%
Alternative 3		8	20%	10	24%	14	34%	20	49%
Alternative 4		8	20%	10	24%	14	34%	20	49%
Alternative 5		8	20%	10	24%	14	34%	20	49%
Alternative 6		0	0%	0	0%	1	2%	3	7%
Alternative 7		8	20%	10	24%	14	34%	20	49%
Alternative 8		8	20%	10	24%	14	34%	20	49%
Alternative 9		3	7%	5	12%	8	20%	12	29%

Off-Season (Oct.- March)

Frequency with which Reservoirs are below Critical Elevation Thresholds

Period/Alternative	Total Months	850 ft. total	850 ft. %	860 ft. total	860 ft. %
73-YEAR PERIOD	438				
Alternative 1 (Base Case)		9	2%	10	2%
Alternative 2		22	5%	26	6%
Alternative 3		22	5%	25	6%
Alternative 4		22	5%	25	6%
Alternative 5		22	5%	25	6%
Alternative 6		4	1%	4	1%
Alternative 7		22	5%	25	6%
Alternative 8		22	5%	25	6%
Alternative 9		15	3%	18	4%
CRITICAL PERIOD	37				
Alternative 1 (Base Case)		0	0%	0	0%
Alternative 2		7	19%	8	22%
Alternative 3		7	19%	8	22%
Alternative 4		7	19%	8	22%
Alternative 5		7	19%	8	22%
Alternative 6		0	0%	0	0%
Alternative 7		7	19%	8	22%
Alternative 8		7	19%	8	22%
Alternative 9		2	5%	3	8%

Critical Elevation Thresholds:
- <850 ft. msl - last boat ramp out of operation
- <860 ft. msl - limited lake surface area and decline in campground/picnicking use
- <880 ft. msl - marina closes
- <900 ft. msl - decline in beach use

There is little difference in recreation impacts between Joint POD Alternative 2 and Joint POD Alternatives 3 through 9. Joint POD Alternatives 3 through 9 generally have a slightly higher frequency of occurrence with which end-of-month storage falls below the various thresholds than Joint POD Alternative 2. An exception to this is seen at New Melones Reservoir under Joint POD Alternatives 6 and 9. Here, the frequency of occurrence with which end-of-month storage falls below the various thresholds is similar to Alternative 1 and lower than the other alternatives, particularly in the critical period. However, this is a result of implementing the New Melones operation associated with the Letter of Intent and San Joaquin River Agreement for Alternatives 6 and 9, respectively, and not the result of the Joint POD.

Potential impacts to recreation on the rivers below the major reservoirs as a result of implementing the 1995 Bay/Delta Plan were assessed in Chapter VI. In general, increased flows would result in beneficial impacts to recreation. River flows are not expected to change dramatically as a result of the Joint POD alternatives and would be within the normal range experienced on those rivers. The principal effect of the Joint POD alternatives on river flows is to shift the timing of releases somewhat, and these changes will not result in significant impacts to recreation. Based on the analysis of impacts to water levels, the Joint POD alternatives will not result in significant impacts to recreation in the Delta.

7. Cultural Resources

This section presents the results of the assessment of impacts to cultural resources that would occur with implementation of the Joint POD alternatives.

Federal law requires federal agencies to consider the effect of their undertakings on cultural resources. The National Historic Preservation Act of 1966, as amended (NHPA), is the basic federal law governing preservation of cultural resources of national, regional, state and local significance. Specifically, section 106 of the NHPA requires each federal agency to consider the effect of its actions on "any district, site, building, structure or object that is included in or eligible for inclusion in the National Register." Eligible cultural resources may also include traditional cultural properties, which are generally defined as specific locations that are significant due to their association with cultural practices or beliefs of a living community that are (1) rooted in the community's history and (2) are important in maintaining the continuing cultural identity of the community" (National Park Service, Bulletin 38). Procedures for meeting section 106 requirements are defined in federal regulations, at 36 CFR section 800, et seq. Other federal legislation further promotes and requires the protection of historic and archaeological resources by the federal government. Among these laws are the Archaeological Resources Protection Act and the Native American Graves Protection and Repatriation Act for federal lands.

a. <u>Impacts</u>. All the proposed alternatives deal with changing project operations to affect varying degrees of use of the joint points of diversion. The reservoirs to be affected include Lake Shasta, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir. Rivers include the Sacramento, Feather, American, and Stanislaus. No construction or ground-disturbing activities are involved. The maximum water surface elevation at the subject reservoirs under all alternatives is at 100-percent capacity and will not exceed that which has occurred under historic operations (i.e., flood operations that completely fill the reservoir or operations in wet years in which the reservoirs fill in the spring snowmelt). It should be noted that New Melones Reservoir has never filled completely (i.e., the emergency overflow spillway has never been used), but as a practical matter can be considered to have filled completely with its maximum elevation being only 4 feet from the elevation of the emergency spillway. No new lands will be inundated around the reservoirs.

River flows will also not exceed high-level flows experienced under the range of normal associated reservoir operations. Inundation of cultural resources adjacent to rivers is, therefore, not expected. Implementing the alternatives would not result in changes to reservoir operations related to flood control. Flood flows in the tributaries downstream from the reservoirs are a function of hydrology and not reservoir operation.

Cropping patterns are expected to remain the same and no new lands will be brought into production as a result of the Joint POD alternatives. Therefore, there will be no impacts from changes in agricultural practices due to the alternatives. Any deficiencies in surface water deliveries are expected to be made up to some degree by groundwater pumping. In reality, the joint points of diversion project will allow for lower deficiencies than would otherwise be imposed on CVP users.

Changes will occur in the minimum pool elevations at all of the reservoirs between Alternative 1 (base case) and Alternatives 2 through 9. Therefore, the assessment of new impacts to cultural resources at the subject reservoirs is limited to comparing the minimum reservoir pool elevations of Alternative 1 to the minimum reservoir pool elevations of the other alternatives (the Area of Potential Effects). The differences between Alternative 1 and the other eight alternatives in minimum pool elevations for the affected reservoirs vary significantly (see Table XIII-48). These differences range from a minimum pool lowered by 53 feet at Folsom Lake under Alternative 8 to a minimum pool raised by 46 feet at New Melones Reservoir under Alternative 6. The reason for the unique, significant upward increase at New Melones Reservoir is described in Section C (description of alternatives) of this chapter.

An analysis of the minimum and maximum pool elevations for San Luis Reservoir is not included because under normal operating procedures, water elevations currently fluctuate about 250 feet a year. The range of fluctuations under the alternatives is expected to be similar to normal fluctuations. Therefore, no new impacts are anticipated at San Luis Reservoir. Furthermore, extensive mitigation was conducted at the site of San Luis Reservoir during construction of San Luis Dam. Surveys and a great deal of excavation were completed in the 1960s. Additional surveys have been conducted since then, including one in the early 1980s when the reservoir was drawn down to conduct repairs. A National Register district at San Luis Reservoir includes about eight sites, several of which are within the fluctuating reservoir pool.

Table XIII-48
73-Year Minimum Annual Reservoir Elevation
(ft)

Alternative	Shasta	Oroville	Folsom	New Melones
Historic	839	647	352	721
Alt 1	879	589	286	759
Differences Between Minimum Annual Reservoir Elevation and Base Case (ft)				
Alt 2	-13	-2	0	-41
Alt 3	-12	-13	0	-41
Alt 4	-5	-12	1	-41
Alt 5	-7	-5	1	-41
Alt 6	4	-28	-18	46
Alt 7	-4	-45	1	-41
Alt 8	-3	-47	-53	-41
Alt 9	2	6	1	13

73 Year Maximum Annual Reservoir Elevation (ft)

Alternative	Shasta	Oroville	Folsom	New Melones
Historic	1067	899	469	1084
Alt 1	1067	900	466	1088
Difference Between Minimum Annual Reservoir Elevation and Base Case (ft)				
Alt 2	0	0	0	0
Alt 3	0	0	0	0
Alt 4	0	0	0	0
Alt 5	0	0	0	0
Alt 6	0	0	0	0
Alt 7	0	0	0	0
Alt 8	0	0	0	0
Alt 9	0	0	0	0

For the purpose of this analysis, minimum simulated reservoir pool elevations for Alternative 1 are used as an impact threshold instead of historic reservoir elevations. The analysis uses simulated reservoir elevation from DWRSIM model output for the 73-year hydrology. It should be noted that short-term flood events are not captured in the monthly operation studies. It also must be noted for all of the alternatives, minimum pool elevations occur under very adverse hydrologic conditions, such as occurred during 1976-1977 or 1990-1991. Actual operations in the future under such adverse conditions may be different from those elevations depicted because operating decisions at the time may prevent such low drawdowns.

In addition to the data developed for the various alternatives, Table XIII-48 also includes the historic minimum and maximum pool elevations at the four reservoirs. At Lake Shasta, the historic minimum pool elevation is below the modeled minimum pool elevation for all alternatives. Thus, no lands in the reservoir basin will be exposed that have not already been exposed under historic operating conditions. At Lake Oroville, Folsom Lake, and New Melones Reservoir, the opposite condition exists; the historic minimum pool elevations are higher than the simulated minimum pool elevations under most alternatives. This indicates that the drawdowns would expose lands normally inundated within the reservoir basin.

Table XIII-49 shows the minimum and maximum annual river stages along the American, Feather, and Sacramento rivers. As can be seen from the table, there is little variation in both minimum and maximum river stages. Therefore, no new impacts to cultural resources are expected to occur.

The impact mechanisms related to reservoir operations that could potentially affect different types of cultural resources under the Joint POD alternatives are described in Chapter VI (impact mechanisms). These mechanisms include changes in reservoir pool elevations and changes in recreation, including unauthorized activities (i.e., intentional vandalism and amateur collecting). Studies on the effects of reservoir inundation on archaeological sites have concluded that the nature and extent of the effects depend on several factors, most notably the location of a cultural property within the reservoir basin. Sites within the zone of seasonal drawdown suffer the greatest impacts, primarily in the form of erosion/scouring, deflation, hydrologic sorting, and artifact displacement caused by waves and currents. Sites located lower in the reservoir, within the deep pool, were more likely to be covered with silt, which sometimes formed a protective cap. Sites at or near the high water line and sites during drawdown suffered both erosion and vandalism (Waechter et al 1994).

Due to incomplete cultural resource inventories of all reservoirs, the actual effects of water fluctuations to sites are unknown but could possibly be adverse to any cultural resources present. Of all the reservoirs, New Melones has been the most comprehensively surveyed. A number of surveys have been completed there, beginning with the Smithsonian River Basin Survey in 1949. To date, more than 627 historic and prehistoric sites have been identified within the New Melones Recreation Area. These sites range from ancient hunting camps to 19th century gold mining boom towns, together representing approximately 10,000 years of human activity. More than 106,000 pre-historic and historic artifacts, records, photographs, and other data have been recovered from more than 42 sites as part of cultural resource mitigation programs. In the permanent pool zone below 808 feet amsl, which would include the area of potential effect, 122 sites have been identified. The greatest number of documented sites (232) occur in the fluctuating pool zone between 808 and 1088 feet amsl (USBR, 1996).

Table XIII-49
73-Year Minimum Annual River Stage (ft)

Alternative	American River at Natoma	Feather River	Sacramento River at Red Bluff	Sacramento River at Verona
Alt 1	1.5	1.3	3.5	4.9
Differences Between Minimum Annual River Stage and Base Case (ft)				
Alt 2	-0.1	0.0	0.0	0.3
Alt 3	-0.1	0.0	0.0	0.3
Alt 4	-0.1	0.0	0.0	0.3
Alt 5	-0.1	0.0	0.0	0.3
Alt 6	0.0	0.0	0.0	0.2
Alt 7	-0.1	0.0	0.0	0.3
Alt 8	-0.1	0.0	0.0	0.3
Alt 9	0.0	0.0	0.0	0.3

73-Year Maximum Annual River Stage (ft)

Alternative	American River at Natoma	Feather River	Sacramento River at Red Bluff	Sacramento River at Verona
Alt 1	13.2	12.7	24.2	36.6
Difference Between Minimum Annual River Stage and Base Case (ft)				
Alt 2	0.0	0.0	0.0	0.1
Alt 3	0.0	0.0	0.0	0.1
Alt 4	0.0	0.0	0.0	0.1
Alt 5	0.0	0.0	0.0	0.1
Alt 6	0.0	0.0	0.0	0.1
Alt 7	0.0	0.0	0.0	0.1
Alt 8	0.0	0.0	0.0	0.1
Alt 9	0.0	0.0	0.0	0.1

As of 1994, there were 123 known prehistoric sites within the Folsom Reservoir basin (Waechter et al 1994). No additional surveys have taken place since then. The recorded sites occur between elevations 330 feet and 466 feet amsl, well above the minimum pool elevation of any of the alternatives. Of the recorded sites within the reservoir basin, only two had been excavated and documented. Undoubtedly, other sites exist that have not been recorded especially within the area of potential effect.

Lake Shasta, although never comprehensively surveyed, has had several individual surveys beginning in 1941-1942 during the dam construction period. The most extensive survey was conducted by the U.S. Forest Service between 1976-1978 when the reservoir reached its historic low of 839 feet amsl during a drought, which resulted in the exposure of more than three-fourths of the total pool area. As of 1986, there were a total of 115 recorded sites within the Shasta Lake pool area. These sites are located between elevation 700 feet and 1080 feet amsl (above high-water level). Only two of the sites are located within the area of potential effect (Henn and Sundahl 1986).

Considerable cultural resource surveys have also been conducted at Oroville Reservoir. An intensive archaeological program was carried out for the DWR at the Oroville Reservoir area in conjunction with construction of the reservoir. Between 1960 and 1967 when the reservoir was filled, 225 sites were recorded in the project area. At least 145 of these sites were inundated. While much information was obtained, the entire project area was not surveyed. In particular, no survey work was done at the recreation areas. Since then, some additional cultural resources survey work has been undertaken. In the early 1990s, a whole series of sites were resurveyed during low water levels. These included sites along the reservoir periphery as well as some in the basin.

b. Continuing Effects. Under any of the alternatives, sites within the reservoir pools will be subject to the same impacts as they have been historically. These impacts would include inundation and exposure during drawdowns with the resulting effects to cultural resources.

c. Impact Analysis. Overall, based on a comparison of the predicted minimum pool elevations under all alternatives against the historic ones, it appears that the greatest new impacts to cultural resources are likely to occur at Oroville, Folsom, and New Melones reservoirs. As stated above, this is because the predicted minimum pools at these three reservoirs would be below the historic minimums during the worst case scenarios. Significant new impacts at Lake Shasta are less likely because the minimum pool elevations under all alternatives are higher than the historic minimums, and the fluctuation in simulated minimum pool elevations is not that great.

Alternative 1. Alternative 1 is the base case against which Joint POD Alternatives 2 through 9 are compared. Alternative 1 would occur in the absence of a water right decision. The 1978 Bay/Delta Plan objectives are in effect and are implemented through D-1485.

Alternative 2. Alternative 2 represents the conditions that would exist when the 1995 Bay/Delta Plan flow objectives are fully implemented. Minimum pool elevations would be lower at Lake Shasta, Lake Oroville, and New Melones Reservoir; there would be no change at Folsom Lake. At Lake Oroville, the drop in pool minimum elevation would be only 2 feet; at Lake Shasta, the drop would be 13 feet; and at New Melones Reservoir, the drop would be 41 feet. These minimum pool elevations would occur between September and November. Visitation drops off significantly after Labor Day. The potential for hydrological and recreational impacts, including unauthorized activities, would likely be greatest at the latter two reservoirs.

Alternative 3. Under Alternative 3, minimum pool elevations would be lower at Lake Shasta, Lake Oroville, and New Melones Reservoir; there would be a slight increase at Folsom Lake. At Lake Shasta and Lake Oroville, the change would be 12 and 13 feet, respectively, while at New Melones Reservoir, the minimum pool elevation would drop 41 feet. These minimum pool elevations would occur between September and November. Hydrological and recreational impacts, including unauthorized activities, could occur at these three reservoirs, with the greatest impacts likely occurring at New Melones Reservoir.

Alternative 4. Under Alternative 4, minimum pool elevations would be lower at Lake Shasta, Lake Oroville, and New Melones Reservoir; at Folsom Lake, the minimum pool elevation would increase by only 1 foot. The greatest change in minimum pool elevation would occur at New Melones Reservoir, where it would drop 41 feet. At Lake Shasta, the minimum pool elevation would drop 5 feet; at Lake Oroville, it would drop 12 feet. These minimum pool elevations would occur between September and November. Hydrological and recreational impacts, including unauthorized activities, could occur at Lake Shasta, Lake Oroville, and New Melones Reservoir, with the greatest effects likely occurring at New Melones Reservoir.

Alternative 5. Under Alternative 5, minimum pool elevations would be lower at Lake Shasta, Lake Oroville and New Melones Reservoir; at Folsom Lake, the minimum pool elevation would increase by only 1 foot. The greatest change in minimum pool elevation would occur at New Melones Reservoir, where it would drop 41 feet. At Lake Shasta, the minimum pool elevation would drop 7 feet; at Lake Oroville, it would drop 5 feet. These minimum pool elevations would occur between September and November. Hydrological and recreational impacts, including unauthorized activities, could occur at Lake Shasta, Lake Oroville, and New Melones Reservoir, with the greatest effects likely occurring at New Melones Reservoir.

Alternative 6. Under Alternative 6, minimum pool elevations would drop at Lake Oroville and Folsom Lake and increase at Lake Shasta and New Melones Reservoir. The greatest changes would occur at Folsom Lake, where the minimum pool elevation would drop by 18 feet, at Lake Oroville, where the minimum pool elevation would drop by 28 feet, and at New Melones Reservoir, where it would increase by 46 feet. This minimum pool elevation is significantly different than that for the other alternatives and is a result of the reservoir operations assumed for the Stanislaus River under the Letter of Intent (see Flow Alternative 7, Chapter II) which is different than all the other alternatives. At Lake Shasta, the minimum pool elevation would increase by only 4 feet. These changes would occur between September and November, with the exception of Folsom Lake, where the minimum pool elevation would be reached in August. Hydrological and recreational impacts, including unauthorized activities, could occur at all four reservoirs, with the greatest effects likely at Lake Oroville, Folsom Lake, and New Melones Reservoir.

Alternative 7. Under Alternative 7, minimum pool elevations would drop at Lake Shasta, Lake Oroville, and New Melones Reservoir; the minimum pool elevation would increase by only 1 foot at Folsom Lake. The greatest differences would occur at Lake Oroville and New Melones Reservoir, where minimum pool elevations would drop by 45 and 41 feet, respectively. At Lake Shasta, the minimum pool elevation would drop by only 4 feet. All of these minimum pool elevations would occur between September and November. Hydrological and recreational impacts, including unauthorized activities, could occur at Lake Shasta, Lake Oroville, and New Melones Reservoir, with the greatest effects likely at Lake Oroville and New Melones Reservoir.

Alternative 8. Under Alternative 8, minimum pool elevations would drop at all four reservoirs, with the greatest decreases occurring at Lake Oroville (47 feet), Folsom Lake (53 feet), and New Melones Reservoir (41 feet). At Lake Shasta, the decrease would be only 3 feet. All of these minimum pool elevations would occur between September and November, with the exception of Folsom Lake, where the minimum pool elevation would be reached in August. Hydrological and recreational impacts, including unauthorized activities, could occur at all four reservoirs, with the greatest effects likely at Lake Oroville, Folsom Lake, and New Melones Reservoir.

Alternative 9. Under Alternative 9, minimum reservoir levels at lakes Shasta, Oroville, Folsom and New Melones are slightly higher than the base case. Therefore there is no impact at these reservoirs. Additional water is supplied under this alternative by the San Joaquin River Tributary Authority agencies to help meet the Vernalis flow objective. New Don Pedro Reservoir and Lake McClure are operated at lower levels than under the other Joint Point alternatives. For an analysis of impacts to these reservoirs, see Chapter 6.

In summary, all alternatives, with the exception of Alternative 9, have the potential to impact cultural resources at one or more reservoirs. These impacts are based on the worst case scenario (i.e., drought conditions) and would occur infrequently. Average conditions at the reservoirs would not create these new impacts.

d. Consultation with the California State Historic Preservation Officer. Under any alternative involving a federal undertaking, USBR will consult with the California State Historic Preservation Officer (SHPO) about meeting the requirements of 36 CFR 800. At present, it is not known which federal, state, and local agencies will be responsible for the different undertakings required to implement each of the proposed Joint POD alternatives. Consultation by USBR with the California SHPO will address cultural resources identification, evaluation, effects, and possible mitigation needs.

8. Economic Analysis

a. Introduction. This section summarizes the economic impacts of the Joint POD alternatives. The analysis consists of the estimation of economic impacts to agriculture, municipal and industrial (M&I) water, and recreation under the various Joint POD alternatives. The analysis was limited by the following assumptions:

- Water shortages are assumed to accrue only to agriculture south of the Delta. It is assumed that shortages of M&I water would be addressed by water transfers from irrigated lands.

- Economic losses are based on average water losses over the historic timeframe, rather than on a range of losses reflecting high, medium, and low water deliveries.

- No distinction is made between the economic value or productivity of various irrigated agricultural lands in the CVP. Rather, an average value based on marginal net revenue is applied to all irrigation water.

- No attempt was made to quantify impacts of water shortages on regional economies. Regional impacts due to reduced agricultural water deliveries are briefly addressed in narrative. No attempt was made to estimate impacts of costs of water transfers to urban users.

- Impacts on agricultural land use are briefly addressed in narrative.

- No attempt was made to quantify recreation impacts. Rather, recreation impacts at major reservoirs are briefly addressed in narrative. It was assumed that end-of-year reservoir water levels are reflective of water levels throughout the year.

b. Irrigation and M&I Water Impacts. According to delivery estimates from the DWRSIM modeling studies, water shortages resulting from the implementation of the 1995 Bay/Delta Plan would primarily occur in areas south of the Delta. For the most part, CVP delivery reductions would be to the contractors in the San Luis and Delta Mendota Water Authority service area, as they comprise the largest group of contractors south of the Delta. Water delivery impacts are shown in Table XIII-50. Average annual diversion under Alternative 1 is 5.4 MAF. Six of the alternatives (Alternatives 2 through 6, and 9) result in annual water reductions of less than 6 percent compared to Alternative 1, and two of the alternatives (Alternatives 7 and 8) result in comparatively no water reductions.

There are a number of potential reactions to water shortages. For example, irrigators could fallow acreage, change crops, pump additional groundwater, or use water transferred from other areas. The initial response of irrigators would probably be to pump additional groundwater. Eventually, this response would result in falling water tables, increased pumping costs, increased water quality problems, and land subsidence.

Urban water utilities could address shortages through transfers of water, increased use of recycled water, reduced water use through mandatory conservation programs, or imposition of rationing. Although conservation programs could address some potential losses, the most likely responses to the majority of the losses would be those of arranging transfers or rationing. However, as stated in Chapter XI of this EIR, the costs of water losses (rationing) in an M&I capacity are estimated to range from $1,400 to $2,000 per acre-foot. By contrast, the marginal net revenue attributable to an additional acre-foot of irrigation water in the CVP is estimated to vary from about $50 to $275, depending on the area and on the amount by

Table XIII-50
Estimate of Economic Impacts of Irrigation Water Losses under Joint POD Alternatives

Alternative	Average Annual Shortage (TAF)	Average Annual Shortage (%)	Economic Value of Water per Acre-foot ($)[1]	Annual Economic Losses ($million)[2]
1				
2	288	5.3	70	20.2
3	216	4.0	70	15.1
4	209	3.9	70	14.6
5	166	3.1	70	11.6
6	206	3.8	70	14.4
7	118	2.2	70	8.3
8	29	0.5	70	2.0
9	256	4.7	70	17.9

[1] When water supplies are 5-10 percent below normal.
[2] Average annual shortage (x) economic value of water per acre-foot.

which water supplies are below the amount normally available (see Chapter XI, section A.2). Also, according to the EIR, the cost to urban districts of water transfers from agriculture vary from about $200 to $350 per acre-foot, or an average of about $275. Utility managers will have strong incentives to transfer water from agricultural users rather than ration water. Similarly, irrigators would presumably part with water that provides levels of marginal net revenue below the price municipalities would pay. Thus, the simplifying assumption was made that water shortages will ultimately accrue only to agriculture. The average economic costs of water shortages resulting under each alternative were estimated by multiplying the shortages by the marginal value of irrigation water on lands south of the Delta. That value averages about $70 per acre-foot, on a weighted average delivery basis, when water supplies are 5-10 percent below normal. While this simplified approach provides only a very rough approximation of costs, it should at least provide a consistent comparison of relative costs among alternatives. The estimated annual losses for each alternative, which range from $2.0 to $20.2 million, are shown in Table XIII-50.

c. Impacts on Regional Economies. Reductions in water deliveries to agriculture have the potential, at least in the short run, to affect all sectors of the economy. Reduced farm production will generally result in the hiring of fewer workers. Unless or until those workers find new employment, consumer spending will fall, affecting retailers and other businesses.

In addition, growers will reduce purchases of equipment and materials from suppliers, resulting in reduced income and jobs.

Alternatives 3 through 9 would result in reduced shortages in comparison to Alternative 2; however, none of the shortages under Alternatives 2 through 6 would exceed 6 percent of total deliveries under Alternative 1. Alternatives 7 and 8 essentially result in little or no shortages in comparison to Alternative 1. Potential marginal net revenue losses per acre-foot of water are relatively small at such low levels of water loss. Additionally, these impacts would take place in a dynamic and mobile economy with a capacity for rapid adjustment to economic changes. Therefore, it reasonably can be assumed that impacts to regional economies under any of the alternatives would be minimal, and all alternatives would result in reduced losses as compared to Alternative 1. However, those alternatives that result in higher shortages would have a greater regional impact than the two alternatives that result in little or no loss.

No attempt was made to address the impact on urban water users of the costs of water transferred from agricultural users. However, there presumably would be some increases of costs to users.

d. Impacts on Land Use. The relatively small average water shortages under Alternatives 2 through 6, and 9 could potentially result in some adjustments in land use. These adjustments could take the form of small adjustments in cropping patterns or possibly some fallowing of lands. However, average water losses of around 5 to 6 percent should require minimal adjustment, and that adjustment would most likely involve, as necessary, small changes in cropping patterns.

Literature Cited in Chapter XIII

Beck, R.W. 1994. Impacts of Bay-Delta Water Quality Standards on CVP Power Production. Prepared for the Western Area Power Administration.

Botsford, L.W. and J. Brittnacher. 1994. Model for Projection of Striped Bass Abundance in Terms of Flows and Diversions. Prepared for the CVPIA Striped Bass Technical Team. November 1994.

California Department of Water Resources and U.S. Bureau of Reclamation. 1994. Effects of the Central Valley Project and State Water Project on Delta smelt and Sacramento Splittail. Prepared for the U.S. Fish and Wildlife Service, Ecological Services, Sacramento Field Office. Sacramento, California.

DWR and USBR. 1999. Biological Assessment – Effects of the Central Valley Project and State Water Project Operations from October 1998 through March 2000 on Steelhead and Spring-Run Chinook Salmon. January 1999.

Henn, W. and E. Sundahl. 1986. Shasta Lake Archaeological Sites Project: Study of the Effects of Reservoir Drawdown. U.S. Forest Service, Shasta-Trinity National Forests.

Interagency Ecological Program Estuarine Ecological Team. 1996a. Assessing Evidence on the Importance of Various Limiting Factors on Selected Ecological Features of the San Francisco Estuary. Report to CALFED, September 12, 1996.

Lehman, P.W. 1992. Environmental Factors Associated with Long-Term Changes in Chlorophyll Concentrations in the Sacramento-San Joaquin Delta and Suisun Bay, California. Estuaries 15(3): 335-348.

McCann, R., D. Mitchell, and L. House. 1994. Impact of Bay-Delta Water Quality Standards on California's Electric Utility Costs. Prepared for ACWA by M. Cubed, Sacramento.

McEwan, D., and J. Nelson. 1991. Steelhead restoration plan for the American River. California Department of Fish and Game, Inland Fisheries Division. Sacramento, CA.

NMFS. 1993. Biological Opinion for the Operation of the Federal Central Valley Project and the California State Water Project. National Marine Fisheries Service. February 12, 1993. 81 pp.

National Park Service. Undated. U.S. Department of Interior. National Register Bulletin No. 38, Guidelines for Evaluating and Documenting Traditional Cultural Properties.

Richter, B.D., Baumgartner, J.V., Wigington, R., and D.P. Braun. 1997. How Much Water Does a River Need? Freshwater Biology 37: 231-249.

SJRTG. 1996. Letter of Intent Among Export Interests and San Joaquin River Interests to Resolve San Joaquin River Issues Related to Protection of Bay/Delta Environmental Resources. Prepared by the San Joaquin River Tributaries Group. 10 pp.

USFWS. 1995. Working Paper on Restoration Needs; Habitat Restoration Actions to Double Natural Production of Anadromous Fish in the Central Valley of California. May 1995. Prepared for the USFWS Under the Direction of the Anadromous Fish Restoration Program Core Group. Volume 3, 387 pp. plus appendices.

USBR. 1996. New Melones Lake Resource Management Plan, Cultural Resources Element (Draft).

Waechter, S.A., S.D. Mikesell, H. McCarthy, and D.S. Byrd. 1994. Research Design for Prehistoric, Ethnographic, and Historic Cultural Resources at Folsom Reservoir, California.

Volume 2 of this Final EIR contains the five technical appendices described below. This document is available on the internet at http://www.waterrights.ca.gov/baydelta/ and on compact disc. Parties on the Bay/Delta Hearing Service List are entitled to one free printed copy. Other parties wishing a printed copy of the document should send a written request and $20.00, payable to the SWRCB. Send requests to:

Nick Wilcox
State Water Resources Control Board
Division of Water Rights
P.O. Box 2000
Sacramento, CA 95812-2000

Appendix 1. Persons Contacted and Water Right Hearing Service List
Appendix 1 contains the list of parties contacted throughout the proceeding. The SWRCB maintains three separate Bay/Delta mailing lists. In this appendix, the shorter active party list and the longer interested party list are combined. The water right hearing service list is also included. In addition to parties identified in this appendix, a postcard mailing was sent to all appropriative water right holders in the Central Valley advising that a Notice of Preparation had been prepared and was available upon request. Persons expressing interest as a result of this mailing were added to the Bay/Delta mailing list.

Appendix 2. Modeling Assumptions
Appendix 2 contains the assumptions used to model the Flow Alternatives, the Joint Point of Diversion Alternatives, and the Cumulative Impacts analysis. The descriptions of the modeling assumptions were drawn from the DWRSIM web site maintained by the Department of Water Resources. The web site containing the assumptions and all modeling output can be found at http://wwwhydro.water.ca.gov/swrcb.html.

Appendix 3. Water Right Calculations for Flow Alternatives 3 and 4
Appendix 3 contains the information used in the water right calculations for Flow Alternatives 3 and 4. The general methodology for the calculations is described in Chapter IV, section G of the final EIR.

Appendix 4. Watershed Flow Obligation Calculations for Flow Alternative 5
Appendix 4 contains data used in the calculation of watershed flow obligations under Flow Alternative 5. The general methodology for the calculation is described in Chapter II, section E.1.e.

Appendix 5. Aquatic Resources Analysis Modeling Data
Appendix 5 contains DWRSIM model output and spreadsheet calculations for: (1) the Sacramento River fall-run, late fall-run, winter-run, yearling spring-run, and young-of-the-year spring-run salmon smolt survival model, (2) the San Joaquin river fall-run salmon smolt survival model, (3) the striped bass model, (4) the water temperature analysis (5) the range of variability analysis (RVA), and (6) reservoir habitat index calculations. The salmon and striped bass models are described in Chapter IV, section F of the final EIR. The water temperature model is described in Chapter IV, section E. The RVA is described in Chapter VI, section C.3.a. The reservoir index methodology is described in Chapter VI, section C.3.b.