DELTA WETLANDS
E I R / E I S

Volume II
APPENDICES

State Water Resources Control Board
Division of Water Rights

U. S. Army Corps of Engineers
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APPENDICES

Volume II

Draft

Environmental Impact Report and Environmental Impact Statement

DELTA WETLANDS
P r o j e c t

Prepared for:

State Water Resources Control Board
Division of Water Rights

and

U. S. Army Corps of Engineers
Sacramento District

Prepared by:

Jones & Stokes Associates, Inc.
Sacramento, California

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Environmental Impact Report
and
Environmental Impact Statement
for the
Delta Wetlands Project

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List of Acronyms and Abbreviations

1978 Delta Plan	1978 Water Quality Control Plan for the Sacramento-San Joaquin Delta and Suisun Marsh
1991 Delta Plan	1991 Delta Water Quality Control Plan for Salinity, Temperature, and Dissolved Oxygen
1995 WQCP	1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary
μg/l	micrograms per liter
μg/mg	micrograms per milligram
$\mu g/m^3$	micrograms per cubic meter
μS	microsiemens
μS/cm	microsiemens per centimeter
AB	Assembly Bill
ACHP	Advisory Council on Historic Preservation
af	acre-foot
af/kWh	acre-feet per kilowatt-hour
Anlab	Analytical Laboratory
AOP	annual operating plan
APE	area of potential effect
ARB	California Air Resources Board
ARMR	Archaeological Resource Management Report
Arvin-Edison	Arvin-Edison Water Storage District
BA	biological assessment
BAAQMD	Bay Area Air Quality Management District
Bay-Delta	San Francisco Bay/Sacramento-San Joaquin Delta
bhp	brake horsepower
BLM	U.S. Bureau of Land Management
Br^-	bromide
Br^-/Cl^-	ratio of bromide concentration to chloride concentration
Br-THM	bromine portion of trihalomethane molecules
Bti	*Bacillus thuringiensis israelensis*
Ca^{2+}	calcium ion
CALFED	California Governor's Water Policy Council and Federal Ecosystem Directorate
Caltrans	California Department of Transportation
CCCCDD	Contra Costa County Community Development Department
CCCGP	Contra Costa County General Plan
CCMAD	Contra Costa Mosquito Abatement District
CCR	California Code of Regulations
CCWD	Contra Costa Water District
CDC	California Department of Conservation
CDFA	California Department of Food and Agriculture
CDFP	cross-Delta flow parameter
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CH_4	methane
$CHBr_3$	bromoform
$CHCl_3$	chloroform
$CHCl_2Br$	dichlorobromomethane

$CHClBr_2$	dibromochloromethane
Cl^-	chloride
Cl_2/DOC	ratio of chlorination to dissolved organic carbon concentration
Cl^-/EC	ratio of chloride concentration to electrical conductivity
Cl-THM	chlorine portion of trihalomethane molecules
Cl_2	chlorine
cm	centimeters
CNPS	California Native Plant Society
CO	carbon monoxide
CO_2	carbon dioxide
COA	Coordinated Operations Agreement
Corps	U.S. Army Corps of Engineers
COTP	California-Oregon Transmission Project
CT	concentration time
C-THM	carbon portion, or carbon equivalent, of total trihalomethane concentration
CVHJV	Central Valley Habitat Joint Venture
CVOCO	Central Valley Operations Coordinating Office
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVRWQCB	Central Valley Regional Water Quality Control Board
D-1485	Water Right Decision 1485
DailySOS	Daily Standards and Operations Simulation model
DBP	disinfection byproduct
DCC	Delta Cross Channel
Delta	Sacramento-San Joaquin Delta
DeltaDWQ	Delta Drainage Water Quality model
DeltaSOS	Delta Standards and Operations Simulation model
DeltaMOVE	Delta Movement of Organisms Vulnerable to Entrainment model
DFA	California Department of Food and Agriculture
DFG	California Department of Fish and Game
DHS	California Department of Health Services
DIDI	Delta Island Drainage Investigations
DMC	Delta-Mendota Canal
DO	dissolved oxygen
DOC	dissolved organic carbon
DPR	California Department of Parks and Recreation
draft D-1630	draft Water Right Decision 1630
draft WQCP	draft Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary
DRP	data recovery plan
DSOD	Division of Safety of Dams
DW	Delta Wetlands
DWR	California Department of Water Resources
EA	environmental assessment
EBMUD	East Bay Municipal Utility District
EC	electrical conductivity
EIR/EIS	environmental impact report/environmental impact statement
EO	executive order
EPA	U.S. Environmental Protection Agency
ERC	emission reduction credit
ET	evapotranspiration
FEMA	Federal Emergency Management Agency
fps	feet per second

FR	Federal Register
FTE	full-time equivalent
g/m^2	grams per square meter
g/m^3	grams per cubic meter
g/cm^3	grams per cubic centimeter
HDPE	high-density polyethylene
HEP	habitat evaluation procedures
HLA	Harding Lawson Associates
HMAC	Habitat Management Advisory Committee
HMP	habitat management plan
HPMP	historic properties management plan
HSI	habitat suitability index
HU	habitat unit
I-5	Interstate 5
IDHAMP	Interagency Delta Health Aspects Monitoring Program
IEP	Interagency Ecological Program
IFM	important farmland mapping
Interior	U.S. Department of the Interior
JSA	Jones & Stokes Associates
K^+	potassium ion
kg	kilogram
km	kilometer
kV	kilovolt
kWh	kilowatt hour
l/cm	liters per centimeter
LAFCO	Local Agency Formation Commission
LCC	land capability classification
LOS	level of service
m	meter
MAD	mosquito abatement district
MAF	million acre-feet
MAF/yr	million acre-feet per year
MCL	maximum contaminant level
MDO	Minimum Delta Outflow computer subroutine
Mg^{2+}	magnesium ion
mgd	million gallons per day
mg/g	milligrams per gram
mg/l	milligrams per liter
ml	milliliter
MLD	Most Likely Descendants
mm	millimeter
MOA	memorandum of agreement
MOU	Memorandum of Understanding
mph	miles per hour
mS/cm	millisiemens per centimeter
MSD	marine sanitation device
msl	mean sea level
MWD	Metropolitan Water District of Southern California
MWQI	Municipal Water Quality Investigations
Na^+	sodium ion
NAHC	California Native American Heritage Commission
NBHA	North Bouldin Habitat Area
NDDB	Natural Diversity Data Base

NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
nm	nanometer
NMFS	National Marine Fisheries Service
NO_3^-	nitrate
NOAA	National Oceanic and Atmospheric Administration
NOI	notice of intent
NOP	notice of preparation
NO_x	oxides of nitrogen
NRCS	U.S. Natural Resources Conservation Service
NRHP	National Register of Historic Places
NSR	New Source Review
NTU	nephelometric turbidity units
OHP	Office of Historic Preservation
PA	programmatic agreement
PAR	PAR Environmental Services
PBS	Public Broadcasting System
PCPA	Pesticide Contamination Prevention Act
PG&E	Pacific Gas and Electric Company
PM10	particulate matter smaller than or equal to 10 microns in diameter
PO_4^{3-}	phosphate
POC	particulate organic carbon
ppb	parts per billion
ppd	pounds per day
ppm	parts per million
ppm/ft	parts per million per foot
ppt	parts per thousand
PREC	Pesticide Registration and Evaluation Committee
RBDD	Red Bluff Diversion Dam
Reclamation	U.S. Bureau of Reclamation
redox	reduction-oxidation
RIMS II	Regional Input-Output Modeling System
RMA	Resource Management Associates
ROG	reactive organic gases
SAFCA	Sacramento Area Flood Control Agency
SB	Senate Bill
SCS	U.S. Soil Conservation Service
SDS	simulated distribution system
SESO	Sacramento Endangered Species Office
SFBAAB	San Francisco Bay Area Air Basin
SHPO	State Historic Preservation Officer
SIP	State Implementation Plan
SJCCDD	San Joaquin County Community Development Department
SJCGP	San Joaquin County General Plan
SJCMAD	San Joaquin County Mosquito Abatement District
SJVAB	San Joaquin Valley Air Basin
SJVUAPCD	San Joaquin Valley Unified Air Pollution Control District
SLC	California State Lands Commission
SMAQMD	Sacramento Metropolitan Air Quality Management District
SNV	specific numerical value
SO_4^{2-}	sulfate
SR	State Route
SS	suspended sediments

SWP	State Water Project
SWRCB	California State Water Resources Control Board
SWTR	Surface Water Treatment Rule
TAF	thousand acre-feet
TAF/yr	thousand acre-feet per year
TDS	total dissolved solids
TFPC	total formation potential carbon
THM	trihalomethane
THMFP	trihalomethane formation potential
TOC	total organic carbon
tpy	tons per year
TSMP	Toxic Substances Monitoring Program
USC	U.S. Government Code of Regulations
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UVA	ultraviolet light absorpance
UVM	ultrasonic velocity meter
V/C	volume-to-capacity ratio
VELB	valley elderberry longhorn beetle
WAPA	Western Area Power Administration
WTP model	water treatment plant model

Appendix 1. SWRCB Public Notice for the Delta Wetlands Water Right Applications

STATE OF CALIFORNIA GEORGE DEUKMEJIAN, Governor
STATE WATER RESOURCES CONTROL BOARD
DIVISION OF WATER RIGHTS
P.O. BOX 2000, Sacramento, CA 95810
901 P Street, Sacramento, CA 95814

NOTICE OF APPLICATIONS TO APPROPRIATE WATER

APPLICATIONS 29061, 29062, 29063 AND 29066

Notice is hereby given that on July 9, 1987

Bedford Properties
c/o John L. Winther, P.O. Box 1267, Lafayette, CA 94549

Applied to the State Water Resources Control Board for permits to appropriate water, subject to vested rights. The Board has determined that the applications are in compliance with Section 65943 of the Government Code.

APPLICATION 29061

DESCRIPTION OF PROJECT

The applicant proposes to construct a 96,070 acre-foot capacity offstream reservoir with a surface area of 4,630 acres. The proposed reservoir will cover all that portion of Bouldin Island south of State Highway 12. Water will be diverted to the reservoir by gravity flow from Little Potato Slough, Mokelumne River, San Joaquin River and Potato Slough via various existing siphons and gates in the existing levees and a proposed set of five 48-inch diameter pipe siphons. The maximum rate of diversion to offstream storage will not exceed 3,000 cubic feet per second (cfs). The offstream reservoir and all initial points of diversion are located in San Joaquin County. The water is used for municipal, irrigation and domestic uses all within a portion of the service areas of the California Department of Water Resources, State Water Project and U.S. Bureau of Reclamation, Central Valley Project, as shown on maps on file with the State Water Resources Control Board.

APPLICATION INFORMATION

Main Point of Diversion

Water to be appropriated from Little Potato Slough tributary to
San Joaquin River Delta Channels
Point of Diversion within NE¼ of NW¼ of projected Section 26, T3N, R4E, MDB&M

Other Points of Diversions
(Existing & Movable Siphons, and Gates)

Water to be appropriated from Mokelumne River tributary to
San Joaquin River Delta Channels
Points of Diversion are along the west shore line of Bouldin Island starting from a point within the SW¼ of NE¼ of projected Section 7, to a point within the NE¼ of SE¼ of projected Section 19, all within T3N, R4E, MDB&M

Water to be appropriated from San Joaquin River tributary to
Suisun Bay
Points of Diversion are along the west shore line of Bouldin Island starting from a point within the NE¼ of SE¼ of projected Section 19, to a point within the NE¼ of NE¼ of projected Section 30, all within T3N, R4E, MDB&M

Water to be appropriated from Potato Slough tributary to
San Joaquin River Delta Channels
Points of Diversion are along the south shore line of Bouldin Island starting from a point within the NE¼ of NE¼ of projected Section 30, to a point within the NW¼ of NE¼ of projected Section 35, all within T3N, R4E, MDB&M

Water to be appropriated from Little Potato Slough tributary to
San Joaquin River Delta Channels
Points of Diversion are along the east shore line of Bouldin Island starting from a point within the NW¼ of NE¼ of projected Section 35, to a point within the NE¼ of NE¼ of projected Section 14, all within T3N, R4E, MDB&M

In the County of San Joaquin
Amount applied for: 96,070 acre-feet per annum by storage
Water to be used for: Municipal, Irrigation and Domestic
Diversion season named: December 15 to May 1

APPLICATION 29062

DESCRIPTION OF PROJECT

The applicant proposes to construct a 106,900 acre-foot capacity offstream reservoir with a surface area of 5,260 acres. The proposed reservoir will cover all of the property located within Webb Tract. Water will be diverted to the reservoir by gravity flow from Old River, False River, Fishermans Cut, and San Joaquin River via various existing siphons and gates in the existing levees and a proposed set of ten 48-inch diameter pipe siphons. The maximum rate of diversion to offstream storage will not exceed 5,000 cubic feet per second (cfs). The offstream reservoir and all initial points of diversion are located in Contra Costa County. The water will be used for municipal, irrigation, and domestic uses all within a portion of the service areas of the California Department of Water Resources,State Water Project and U.S. Bureau of Reclamation, Central Valley Project, as shown on maps on file with the State Water Resources Control Board.

APPLICATION INFORMATION

Main Point of Diversion

Water to be appropriated from False River tributary to
San Joaquin River Delta Channels
Point of Diversion within SE¼ of NW¼ of projected Section 36, T3N, R3E, MDB&M

Other Points of Diversions
(Existing & Movable Siphons, and Gates)

Water to be appropriated from Old River tributary to
San Joaquin River Delta Channels
Points of Diversion are along the southeast shore line of Webb Tract starting from a point within the NW¼ of SE¼ of projected Section 30, to a point within the SW¼ of NW¼ of projected Section 31, all within T3N, R4E, MDB&M

Water to be appropriated from False River tributary to
San Joaquin River Delta Channels
Points of Diversion are along the south shore line of Webb Tract starting from a point within the SW¼ of NW¼ of projected Section 31, T3N, R4E, MDB&M, to a point within the SW¼ of SE¼ of projected Section 33, T3N, R3E, MDB&M

Water to be appropriated from Fishermans Cut tributary to
San Joaquin River Delta Channels
Points of Diversion are along the west shore line of Webb Tract starting from a point within the SW¼ of SE¼ of projected Section 33, to a point within the NW¼ of NE¼ of projected Section 28, all within T3N, R3E, MDB&M

Water to be appropriated from San Joaquin River tributary to
Suisun Bay
Points of Diversion are along the north and east shore line of Webb Tract starting from a point within the NW¼ of NE¼ of projected Section 28, T3N, R3E, MDB&M, to a point within the NW¼ of SE¼ of projected Section 30, T3N, R4E, MDB&M

In the County of Contra Costa
Amount applied for: 106,900 acre-feet per annum by storage
Water to be used for: Municipal, Irrigation and Domestic purposes
Diversion season named: December 15 to May 1

APPLICATION 29063

DESCRIPTION OF PROJECT

The applicant proposes to construct a 69,050 acre-foot capacity offstream reservoir with a surface area of 4,100 acres. The proposed reservoir will cover all of the property located within Holland Tract. Water will be diverted to the reservoir by gravity flow from Holland Cut, Rock Slough, Sand Mound Slough, and Roosevelt Cut via various existing siphons and gates in the existing levees and a proposed set of four 48-inch diameter pipe siphons. The maximum rate of diversion to offstream storage will not exceed 3,000 cubic feet

per second (cfs). The offstream reservoir and all initial points of diversions are located in Contra Costa County. The water will be used for municipal, irrigation, and domestic uses all within a portion of the service areas of the California Department of Water Resources, State Water Project and U.S. Bureau of Reclamation, Central Valley Project, as shown on maps on file with the State Water Resources Control Board.

APPLICATION INFORMATION

Main Point of Diversion

Water to be appropriated from Holland Cut tributary to
Old River, thence San Joaquin River Delta Channels
Point of Diversion within NW¼ of SW¼ of projected Section 19, T2N, R4E, MDB&M

Other Points of Diversions
(Existing & Movable Siphons, and Gates)

Water to be appropriated from Holland Cut tributary to
Old River, thence San Joaquin River Delta Channels
Points of Diversion are along the east shore line of Holland Tract starting from a point within the SW¼ of SW¼ of projected Section 7, to a point within the NW¼ of SW¼ of projected Section 31, all within T2N, R4E, MDB&M

Water to be appropriated from Rock Slough tributary to
Old River, thence San Joaquin River Delta Channels
Points of Diversion are along the south shore line of Holland Tract starting from a point within the NW¼ of SW¼ of projected Section 31, T2N, R4E, MDB&M, to a point within the SW¼ of NW¼ of projected Section 35, T2N, R3E, MDB&M

Water to be appropriated from Sand Mound Slough tributary to
Old River, thence San Joaquin River Delta Channels
Points of Diversion are along the west shore line of Holland Tract starting from a point within the SW¼ of NW¼ of projected Section 35, to a point within the NW¼ of SW¼ of projected Section 23, all within T2N, R3E, MDB&M

Water to be appropriated from Roosevelt Cut tributary to
Old River, thence San Joaquin River Delta Channels
Points of Diversion are along the north shore line of Holland Tract starting from a point within the NW¼ of SW¼ of projected Section 23, T2N, R3E, MDB&M, to a point within the SW¼ of SW¼ of projected Section 7, T2N, R4E, MDB&M

In the County of Contra Costa
Amount applied for: 69,050 acre-feet per annum by storage
Water to be used for: Municipal, Irrigation, and Domestic purposes
Diversion season named: December 15 to May 1

APPLICATION 29066

DESCRIPTION OF PROJECT

The applicant proposes to construct a 110,570 acre-foot capacity offstream reservoir with a surface area of 5,450 acres. The proposed reservoir will cover all of the property located within Bacon Island. Water will be diverted to the reservoir by gravity flow from Middle River, Santa Fe Dredge Cut, Old River and Connection Slough via various existing siphons and gates in the existing levees and a proposed set of ten 48-inch diameter pipe siphons. The maximum rate of diversion to offstream storage will not exceed 5,000 cubic feet per second (cfs). The offstream reservoir and all initial points of diversion are located in San Joaquin County. The water will be used for municipal, irrigation, and domestic uses all within a portion of the service areas of the California Department of Water Resources, State Water Project and U.S. Bureau of Reclamation, Central Valley Project, as shown on maps on file with the State Water Resources Control Board.

APPLICATION INFORMATION

Main Point of Diversion

Water to be appropriated from Connection Slough tributary to
Middle River, thence San Joaquin River Delta Channels
Point of Diversion within NW¼ of SW¼ of projected Section 21, T2N, R4E, MDB&M

Other Points of Diversion
(Existing & Movable Siphons, and Gates)

Water to be appropriated from Middle River tributary to
San Joaquin River Delta Channels
Points of Diversion are along the east shore line of Bacon Island starting from a point within the SE¼ of SW¼ of projected Section 22, T2N, R4E, MDB&M, to a point within the NE¼ of NE¼ of projected Section 16, T1N, R4E, MDB&M

Water to be appropriated from Santa Fe Dredge Cut tributary to
Old River, thence San Joaquin River Delta Channels
Points of Diversion are along the south shore line of Bacon Island starting from a point within the NE¼ of NE¼ of projected Section 16, to a point within the NW¼ of NE¼ of projected Section 17, all within T1N, R4E, MDB&M

Water to be appropriated from Old River tributary to
San Joaquin River Delta Channels
Points of Diversion are along the west shore line of Bacon Island starting from a point within the NW¼ of NE¼ of projected Section 17, T1N, R4E, MDB&M, to a point within the SW¼ of SW¼ of projected Section 20, T2N, R4E, MDB&M

Water to be appropriated from Connection Slough tributary to
Middle River, thence San Joaquin River Delta Channels
Points of Diversion are along the north shore line of Bacon Island starting from a point within the SW¼ of SW¼ of projected Section 20, to a point within the SE¼ of SW¼ of projected Section 22, all within T2N, R4E, MDB&M

In the County of San Joaquin
Amount applied for: 110,570 acre-feet per annum by storage
Water to be used for: Municipal, Irrigation, and Dometic purposes
Diversion season named: December 15 to May 1

ENVIRONMENTAL INFORMATION

The State Water Resources Control Board (State Board) is lead agency, pursuant to the California Environmental Quality Act (CEQA), and is responsible for preparing appropriate environmental documents for the proposed project in compliance with CEQA. Since the project may have significant environmental effects, the State Board has determined that preparation of an Environmental Impact Report (EIR) for the project will be required. Furthermore, the State Board will likely collaborate with the U.S. Army Corps of Engineers in preparing a joint EIR/Environmental Impact Statement (EIS) for the project to satisfy the additional requirements of the National Environmental Policy Act (NEPA). All inquiries relative to environmental review matters concerning this project should be directed to Mr. Jim Canaday, State Water Resources Control Board, Division of Water Rights, P.O. Box 2000, Sacramento, CA 95810.

RELATIVE TO PROTESTS

Protests may be based on possible injury to vested rights or an allegation that the proposed appropriations would not be within the Board's jurisdiction, would not be in the public interest, would have an adverse environmental impact, would result in waste, unreasonable method of use, or unreasonable method of diversion,would impair public trust uses, or would be contrary to law. Any person desiring to protest the Board's issuance of permits pursuant to these applications shall within 60 days from date of issuance of this notice shown below (or within such further time as may, for good cause shown, be allowed) file a written protest with the State Water Resources Control Board, P. O. Box 2000, Sacramento, California 95810 in care of the contact person specified below. Protest forms will be furnished free of charge upon request. A copy of any protest shall be sent to the applicant.

CONTACT PERSON:

- For protest forms, call (916) 322-4503.
- For information in regard to protest and time extension, call O. P. Gulati (916) 324-5630.
- For information in regard to CEQA, call Jim Canaday (916) 324-5648.

Dated: DEC 0 4 1987

STATE OF CALIFORNIA

PETE WILSON, Governor

STATE WATER RESOURCES CONTROL BOARD
THE PAUL R. BONDERSON BUILDING
901 P STREET
SACRAMENTO, CA 95814

Mailing Address
DIVISION OF WATER RIGHTS
P.O. BOX 2000, Sacramento, CA 95812-2000

NOTICE OF APPLICATIONS TO APPROPRIATE WATER AND PETITIONS TO CHANGE PENDING APPLICATIONS

(1) NEW APPLICATIONS 30267, 30268, 30269 and 30270,

(2) PETITIONS TO CHANGE APPLICATIONS 29061, 29062, 29063 and 29066:

Notice is hereby given that on July 21, 1993

Delta Wetlands
John L. Winther, President
3697 Mt. Diablo Blvd., Suite 120
Lafayette, CA 94549

(1) applied to the State Water Resources Control Board (State Water Board) for additional permits to appropriate water subject to prior rights under Section 1200 et seq. of the California Water Code. These new applications request: (a) direct diversion rights, (b) additional storage amounts, and (c) a longer season of diversion than the earlier applications. The State Water Board has determined that the applications are in compliance with Section 65943 of the Government Code, and

(2) petitioned the State Water Board under Section 1700 et seq. of the Water Code to change the initial applications by: (a) changing and adding points of diversion, (b) adding points of rediversion, (c) adding the Bay/Delta Estuary to the place of use, and (d) adding Industrial, Fish and Wildlife Preservation and Enhancement, and Water Quality uses to the purpose(s) of use specified in the earlier applications. The purpose of the change petitions is to conform the above items in the initial applications to the new applications as described below.

The purpose(s) of this notice are: (1) to give persons concerned about Delta Wetlands Applications 30267, 30268, 30269 and 30270 to appropriate water from the various Delta Channels an opportunity to protest State Water Board approval of the applications, and (2) to give persons concerned about Delta Wetlands' petitions to change its pending applications an opportunity to protest State Water Board approval of Applications 29061, 29062, 29063 and 29066 as amended by the petitions. Protests filed pursuant to the December 4, 1987 notice of Applications 29061, 29062, 29063, and 29066 need not be resubmitted.

The allowable bases for acceptance of protests, procedures related to the filing of protests, and the name, telephone number, and mailing address of contact persons designated to answer questions concerning these applications and petitions are provided later in this notice.

BACKGROUND

Bedford Properties (Delta Wetlands) filed Applications 29061, 29062, 29063 and 29066 on July 9, 1987 for seasonal storage of unappropriated water on four islands in the Sacramento/San Joaquin Delta. The islands involved in the Delta Wetlands Project (Project) are Bouldin Island, Webb Tract, Holland Tract and Bacon Island located as shown on the map on page 10 of this notice.

In December of 1990 a draft Environmental Impact Report (EIR)/Environmental Impact Statement (EIS) for the Project was circulated by the lead agencies. The State Water Board is lead agency under the California Environmental Quality Act (CEQA) and the U.S. Army Corps of Engineers (COE) is lead agency under the National Environmental Policy Act (NEPA).

Delta Wetlands filed Applications 30267, 30268, 30269 and 30270, and petitions to change pending Applications 29061, 29062, 29063 and 29066 on July 21, 1993. The revised project description is given below, followed by specifics of the new applications and the petitions to change the previous applications. The lead agencies are preparing a new draft EIR/EIS which they will circulate for comment before the State Water Board considers approval of the applications.

DELTA WETLANDS PROJECT DESCRIPTION

During times when water in excess of the rights of senior water right holders and in excess of fish and wildlife requirements is present in the Delta, water will be diverted onto the islands using several existing siphons and two new siphon stations proposed for construction on each island. New diversions will be screened to comply with requirements of the fishery agencies. The interior of the levees will be strengthened to accommodate the proposed use of the islands as reservoirs.

Throughout the year, but primarily from January through September annually, water will be discharged upon demand from new pumping stations proposed for construction on each island. The water will be rediverted at State and/or Federal pumping facilities and/or used for Water Quality or Fish and Wildlife Preservation and Enhancement purposes.

Reservoir water will be available for purchase by water purveyors and/or users within the CVP and SWP service areas or the Bay Delta Estuary. It may be used for Irrigation, Domestic, Municipal, Industrial, Fish & Wildlife Preservation & Enhancement or Water Quality uses. The proposed operation may result in several cycles of reservoir filling and emptying. Water from one Delta Wetland Island may also be released for rediversion onto other Delta Wetlands Islands in order to optimize project operations. Normally, by the end of September, all appropriative water will have been discharged from the islands. The islands will then be managed for enhancement of waterfowl habitat uses until the next diversion season begins and appropriative water again becomes available for diversion.

EXPLANATION OF DIRECT DIVERSION VS STORAGE RE: THE DELTA WETLANDS PROJECT

Applications 29061, 29062, 29063 and 29066 are for storage of water as defined in 23 CCR Section 658 on Delta Wetlands' islands during the December 15 to May 1 collection season. New Applications 30267, 30268, 30269, and 30270 add additional storage with a year-round collection season. For the purposes of this notice and for water right licensing purposes, storage of water means the initial filling of the reservoirs during each collection season and reservoir refill held in storage for at least 30 days.

Applications 30267, 30268, 30269 and 30270 are for: (a) additional storage of water year-round, plus (b) direct diversion or regulation of water on Delta Wetlands' islands year-round as defined in 23 CCR Section 657. For the purposes of this notice and for water right licensing purposes, regulation of water means to refill a reservoir and hold the water for less than 30 days.

DESCRIPTION OF THE BOULDIN ISLAND ELEMENT

The applicant proposes to develop a 108,000 acre-foot (AF) capacity offstream storage/regulatory reservoir on Bouldin Island with a surface area of about 4,657 acres. The proposed reservoir will cover that portion of the island south of State Highway # 12 with about 23 feet of water. About 2,000 AF of water will be stored north of Highway # 12 with an average depth of about 2 feet. The water will be diverted to the reservoir by gravity and pumped flow from: (A) the Mokelumne River, (B) Little Potato Slough, (C) Potato Slough, and (D) the San Joaquin River. The primary means of diversion will be by two sets of nine proposed, 48" diameter screened pipe siphons, to be located on sources (A) and (B) as described below. Various existing siphons and gates in the existing levees as identified below may be used to divert water from sources (A), (B), (C) and (D). The installed capacity of all diversion facilities on Bouldin Island will be 3,504 cubic feet per second (cfs). The reservoir and all existing and proposed points of diversion on Bouldin Island are in San Joaquin County. The requested purpose(s) of use are for Irrigation, Domestic, Municipal, Industrial, Fish & Wildlife Preservation & Enhancement or Water Quality uses. The place(s) of use proposed for Bouldin Island diversions are within the CVP service area, the SWP service area, and the Bay Delta Estuary as shown on maps on file with the State Water Board.

SPECIFICS OF NEW APPLICATION 30267

Sources of water to be appropriated are from:

(A) the **Mokelumne River**, tributary to San Joaquin River Delta Channels
(1) at a new point of diversion within SE1/4 of NW1/4 of projected Section 20, T3N, R4E, Mount Diablo Base and Meridian (MDB&M)

(2) at 22 existing points of diversion along the north and west shore line of Bouldin Island starting from a point within the SW1/4 of NE1/4 of projected Section 7, to a point within the NE1/4 of SE1/4 of projected Section 19, all within T3N, R4E, MDB&M

(B) **Little Potato Slough**, tributary to San Joaquin River Delta Channels
(1) at a new point of diversion within NE1/4 of SE1/4 of projected Section 23, T3N, R4E, MDB&M

(2) at 6 existing points of diversion along the east shore line of Bouldin Island starting from a point within the NW1/4 of NE1/4 of projected Section 35, to a point within the NE1/4 of NE1/4 of projected Section 14, all within T3N, R4E, MDB&M

(C) **Potato Slough**, tributary to San Joaquin River Delta Channels
at 16 existing points of diversion along the south shore line of Bouldin Island starting from a point within the NW1/4 of NE1/4 of projected Section 30, to a point within the NW1/4 of NE1/4 of projected Section 35, all within T3N, R4E, MDB&M.

(D) **San Joaquin River**, tributary to Suisun Bay
at an existing point of diversion along the west shore line of Bouldin Island between a point within the NE1/4 of SE1/4 of projected Section 19, and a point within the NE1/4 of NE1/4 of projected Section 30, all within T3N, R4E, MDB&M.

Rediversion of **Bouldin Island** reservoir water:
(1) at the State Water Project Banks Pumping Plant (SWP Banks) within the NW1/4 of SE1/4 of projected Section 20, T1S, R4E, MDB&M

(2) at the Central Valley Project Tracy Pumping Plant (CVP Tracy) within the NE1/4 of SW1/4 of projected Section 29, T1S, R4E, MDB&M

(3) at the CVP Contra Costa Canal entrance within the SE1/4 of NE1/4 of Section 33, T2N, R3E, MDB&M

(4) at all points of diversion requested in Application 30268

(5) at all points of diversion requested in Application 30269

(6) at all points of diversion requested in Application 30270.

In the County of San Joaquin

Amount applied for: 110,000 acre-feet per annum (afa) by storage
2,500 cfs by direct diversion, up to 216,000 afa.

Water to be used for: Irrigation, Domestic, Municipal, Industrial, Fish & Wildlife Preservation & Enhancement or Water Quality uses.

Diversion season named: January 1 to December 31.

Place of Use: within the CVP service area, the SWP service area, and the Bay Delta Estuary as shown on maps on file with the State Water Board.

DESCRIPTION OF PETITIONED CHANGES TO PENDING APPLICATION 29061

Changes in Points of Diversion and Rediversion:

(1) delete the primary point of diversion in Application 29061

(2) add: (1) the primary points of diversion, (2) the existing points of diversion, and (3) the points of rediversion specified in Application 30267 described above.

Change the place of use to
within the CVP service area, the SWP service area, and the Bay Delta Estuary as shown on maps on file with the State Water Board.

Change the purpose of use to
Irrigation, Domestic, Municipal, Industrial, Fish & Wildlife Preservation & Enhancement or Water Quality uses.

DESCRIPTION OF THE WEBB TRACT ELEMENT

The applicant proposes to develop a 131,000 acre-foot (AF) capacity storage/regulatory reservoir on Webb Tract with a surface area of about 5,345 acres. The proposed reservoir will cover the island with about 25 feet of water. The water will be diverted to the reservoir by gravity and pumped flow from: (A) False River, (B) San Joaquin River, and (C) Old River. The primary means of diversion will be by two sets of nine proposed, 48" diameter screened pipe siphons, to be located on sources (A) and (B) as described below. Various existing siphons and gates in the existing levees as identified below may be used to divert water from sources (A), (B), and (C). The installed capacity of all diversion facilities on Webb Tract will be 4,733 cfs. The reservoir and all existing and proposed points of diversion on Webb Tract are in Contra Costa County. The requested purpose(s) of use are for Irrigation, Domestic, Municipal, Industrial, Fish & Wildlife Preservation & Enhancement or Water Quality uses. The place(s) of use proposed for Webb Tract diversions are within the CVP service area, the SWP service area, and the Bay Delta Estuary as shown on maps on file with the State Water Board.

SPECIFICS OF NEW APPLICATION 30268

Sources of water to be appropriated are from:

(A) False River, tributary to San Joaquin River Delta Channels
(1) at a new point of diversion within SW1/4 of NE1/4 of projected Section 36, T3N, R3E, MDB&M

(2) at 6 existing points of diversion along the south shore line of Webb Tract starting from a point within the SW1/4 of NW1/4 of projected Section 31 of T3N, R4E, MDB&M, to a point within the SW1/4 of SE1/4 of projected Section 33 within T3N, R3E, MDB&M

(B) San Joaquin River, tributary to Suisun Bay
(1) at a new point of diversion within NE1/4 of SW1/4 of projected Section 19, T3N, R4E, MDB&M

(2) at 11 existing points of diversion along the north and east shore lines of Webb Tract starting from a point within the NW1/4 of NE1/4 of projected Section 28, to a point within the NW1/4 of SE1/4 of projected Section 30, all within T3N, R3E, MDB&M

(C) Old River, tributary to San Joaquin River Delta Channels
at an existing Point of Diversion along the southeast shore line of Webb Tract between a point within the NW1/4 of SE1/4 of projected Section 30, and a point within the SW1/4 of NW1/4 of projected Section 31, within T3N, R4E, MDB&M.

Rediversion of Webb Tract reservoir water:

(1) at SWP Banks within the NW1/4 of SE1/4 of projected Section 20, T1S, R4E, MDB&M

(2) at CVP Tracy within the NE1/4 of SW1/4 of projected Section 29, T1S, R4E, MDB&M

(3) at the Contra Costa Canal intake within the SE1/4 of NE1/4 of Section 33 T2N, R3E, MDB&M

(4) at all points of diversion requested in Application 30267 as described above

(5) at all points of diversion requested in Application 30269 as described below

(6) at all points of diversion requested in Application 30270 as described below.

In the County of Contra Costa

Amount applied for:	155,000 acre-feet per annum (afa) by storage 3,000 cfs by direct diversion, up to 262,000 afa.
Water to be used for:	Irrigation, Domestic, Municipal, Industrial, Fish & Wildlife Preservation & Enhancement or Water Quality uses.
Diversion season named:	January 1 to December 31.
Place of Use:	within the CVP service area, the SWP service area, and the Bay Delta Estuary as shown on maps on file with the State Water Board.

DESCRIPTION OF PETITIONED CHANGES TO PENDING APPLICATION 29062

Changes in points of diversion and rediversion:

(1) delete the primary point of diversion in Application 29062

(2) add the: (1) primary points of diversion, (2) existing points of diversion, and (3) points of rediversion specified in Application 30268 as described above.

Change the place of use to

within the CVP service area, the SWP service area, and the Bay Delta Estuary as shown on maps on file with the State Water Board.

Change the purpose of use to

Irrigation, Domestic, Municipal, Industrial, Fish & Wildlife Preservation & Enhancement or Water Quality uses.

DESCRIPTION OF THE HOLLAND TRACT ELEMENT

The applicant proposes to develop a 80,000 AF capacity storage/regulatory reservoir on Holland Tract with a surface area of about 4,152 acres. The proposed reservoir will cover the island with about 21 feet of water. The water will be diverted to the reservoir by gravity and pumped flow from: (A) Roosevelt Cut, (B) Holland Cut-Old River, (C) Rock Slough, and (D) Sand Mound Slough. The primary means of diversion will be by two sets of nine proposed, 48" diameter screened pipe siphons, to be located on sources (A) and (B) as described below. Various existing siphons and gates in the existing levees as identified below may be used to divert water from sources (A), (B), (C), and (D). The installed capacity of all diversion facilities on Holland Tract will be 3,254 cubic feet per second (cfs). The reservoir and all existing and proposed points of diversion on Holland Tract are in Contra Costa County. The requested purpose(s) of use are for Irrigation, Domestic, Municipal, Industrial, Fish & Wildlife Preservation & Enhancement or Water Quality uses. The place(s) of use proposed for Holland Tract diversions are

within the CVP service area, the SWP service area, and the Bay Delta Estuary as shown on maps on file with the State Water Board.

SPECIFICS OF NEW APPLICATION 30269

Sources of water to be appropriated are from:

(A) Roosevelt Cut, tributary to Old River, thence San Joaquin River Delta Channels

(1) at a new point of diversion within the SW1/4 of SE1/4 of Section 12, T2N, R3E, MDB&M

(2) at 4 existing points of diversion along the north/west shore line of Holland Tract starting from a point within the NW1/4 of SW1/4 of projected Section 23, T2N, R3E, MDB&M, to a point within the SW1/4 of SW1/4 of projected Section 7, within T2N, R4E, MDB&M.

(B) Holland Cut-Old River, tributary to San Joaquin River Delta channels

(1) at a point of diversion within SE1/4 of NW1/4 of projected Section 19, T2N, R4E, MDB&M

(2) at 7 existing points of diversion along the east shore line of Holland Tract starting from a point within the SW1/4 of SW1/4 of projected Section 7, to a point within the NW1/4 of SW1/4 of projected Section 31, all within T2N, R4E, MDB&M

(C) Rock Slough, tributary to Old River, thence San Joaquin River Delta channels

at 5 existing points of diversion along the south shore line of Holland Tract starting from a point within the NW1/4 of SW1/4 of projected Section 31, T2N, R4E, MDB&M, to a point within the SW1/4 of NW1/4 of projected Section 7, within T2N, R3E, MDB&M

(D) Sand Mound Slough, tributary to Old River, thence San Joaquin River Delta Channels

at a 5 points of diversion along the north/west shore line of Holland Tract starting from a point within the SW1/4 of NW1/4 of projected Section 35, to a point within the NW/4 of SW/4 of projected Section 23, all within T2N, R3E, MDB&M

Rediversion of Holland Tract reservoir water:

(1) at SWP Banks within the NW1/4 of SE1/4 of projected Section 20, T1S, R4E, MDB&M

(2) at CVP Tracy within the NE1/4 of SW1/4 of projected Section 29, T1S, R4E, MDB&M

(3) at the Contra Costa Canal intake within the SE1/4 of NE1/4 of Section 33 T2N, R3E, MDB&M

(4) at all points of diversion requested in Application 30267 as described above

(5) at all points of diversion requested in Application 30268 as described above

(6) at all points of diversion requested in Application 30270 as described below.

In the County of Contra Costa

Amount applied for: 90,000 acre-feet per annum (afa) by storage
2,500 cfs by direct diversion, up to 160,000 afa.

Water to be used for: Irrigation, Domestic, Municipal, Industrial, Fish & Wildlife Preservation & Enhancement or Water Quality uses.

Diversion season named: January 1 to December 31.

Place of Use: within the CVP service area, the SWP service area, and the Bay Delta Estuary as shown on maps on file with the State Water Board.

DESCRIPTION OF PETITIONED CHANGES TO PENDING APPLICATION 29063

Changes in points of diversion and rediversion

(1) delete the primary point of diversion in Application 29063

(2) add: the primary points of diversion, (2) the existing points of diversion, and (3) the points of rediversion specified in Application 30269 described above.

Change the place of use to

within the CVP service area, the SWP service area, and the Bay Delta Estuary as shown on maps on file with the State Water Board.

Change the purpose of use to

Irrigation, Domestic, Municipal, Industrial, Fish & Wildlife Preservation & Enhancement or Water Quality uses.

DESCRIPTION OF THE BACON ISLAND ELEMENT

The applicant proposes to develop a 129,000 AF capacity storage/regulatory reservoir on Bacon Island with a surface area of about 5,456 acres. The proposed reservoir will cover the island with about 24 feet of water. The water will be diverted to the reservoir by gravity and pumped flow from: (A) Connection Slough, (B) Middle River, (C) Santa Fe Dredge Cut , (D) Old River. The primary means of diversion will be by two sets of nine proposed, 48" diameter screened pipe siphons to be located on sources (A) and (B) as described below. Various existing siphons and gates in the existing levees as identified below may divert water from sources (A), (B), (C) and (D). The installed capacity of all diversion facilities on Bacon Island will be 4,809 cfs. The reservoir and all existing and proposed points of diversion on Bacon Island are in San Joaquin County. The requested purpose(s) of use are for Irrigation, Domestic, Municipal, Industrial, Fish & Wildlife Preservation & Enhancement or Water Quality uses. The place(s) of use proposed for Bacon Island diversions are within the CVP service area, the SWP service area, and the Bay Delta Estuary as shown on maps on file with the State Water Board.

SPECIFICS OF NEW APPLICATION 30270

Sources of water to be appropriated are from:

(A) Old River, tributary to San Joaquin River Delta channels

(1) at a new point of diversion within NE1/4 of NE1/4 of projected Section 30, T2N, R4E, MDB&M

(2) at ~10 existing points of Diversion along the west shore line of Bacon Island starting from a point within the NW1/4 of NE1/4 of projected Section 17, T1N, R4E, MDB&M, to a point within the SW1/4 of SW1/4 of projected Section 20, within T2N, R4E, MDB&M.

(B) Middle River, tributary to San Joaquin River Delta channels

(1) at a new point of diversion within NW1/4 of NW1/4 of projected Section 27, T2N, R4E, MDB&M

(2) at 11 existing points of diversion along the east shore line of Bacon Island starting from a point within the SE1/4 of SW1/4 of projected Section 22 within T2N, R4E, MDB&M, to a point within the NE1/4 of NE1/4 of projected Section 16, within T1N, R4E, MDB&M

(C) Santa Fe Dredge Cut, tributary to Old River, thence San Joaquin River Delta channels
at 3 existing points of diversion along the south shore line of Bacon Island starting from a point within the NE1/4 of NE1/4 of projected Section 16, to a point within the NW1/4 of NE1/4 of projected Section 17, all within T1N, R4E, MDB&M

(D) Connection Slough, tributary to Middle River, thence San Joaquin River Delta channels
at 4 existing points along the north shore line of Bacon Island starting from a point within the SW1/4 of SW1/4 of projected Section 20, to a point within the SE1/4 of SW1/4 of projected Section 22, all within T2N R4E, MDB&M

Rediversion of Bacon Island reservoir water:
(1) at SWP Banks within the NW1/4 of SE1/4 of projected Section 20, T1S, R4E, MDB&M

(2) at CVP Tracy within the NE1/4 of SW1/4 of projected Section 29, T1S, R4E, MDB&M

(3) at the Contra Costa Canal intake within the SE1/4 of NE1/4 of Section 33 T2N, R3E, MDB&M

(4) at all points of diversion requested in Application 30267 as described above

(5) at all points of diversion requested in Application 302688 as described above

(6) at all points of diversion requested in Application 30269 as described above.

In the County of San Joaquin
Amount applied for: 147,000 acre-feet per annum (afa) by storage
3,000 cfs by direct diversion, up to 258,000 afa.

Water to be used for: Irrigation, Domestic, Municipal, Industrial, Fish & Wildlife Preservation & Enhancement or Water Quality uses.

Diversion season named: January 1 to December 31.

Place of Use: within the CVP service area, the SWP service area, and the Bay Delta Estuary as shown on maps on file with the State Water Board.

DESCRIPTION OF PETITIONED CHANGES TO PENDING APPLICATION 29066

Changes in points of diversion and rediversion:
(1) delete the primary point to diversion in Application 29066

(2) add : (1) the primary points of diversion, (2) the existing points of diversion, and (3) the points of rediversion specified in Application 32070 described above.

Change the place of use to
within the CVP service area, the SWP service area, and the Bay Delta Estuary as shown on maps on file with the State Water Board.

Change the purpose of use to
Irrigation, Domestic, Municipal, Industrial, Fish & Wildlife Preservation & Enhancement or Water Quality uses.

ENVIRONMENTAL INFORMATION

The State Water Board is lead agency under CEQA and is responsible for preparing appropriate environmental documents for the Delta Wetlands Project with respect to the appropriative water right permit process. The US Army Corps of Engineers is lead agency under NEPA and is responsible for preparing appropriate environmental documents for the Delta Wetlands Project with respect to the federal Rivers and Harbors Act Section 10 & Clean Water Act Section 404 permits required for construction the project.

In December of 1990 a draft Environmental Impact Report (EIR)/Environmental Impact Statement (EIS) for the project was circulated by the lead agencies. Operation of the project will comply with State and federal endangered species laws. The lead agencies are preparing a new draft EIR/EIS which will be circulated for comment prior to considering approval of the applications.

Inquiries relative to the CEQA process for the Delta Wetlands Project water rights permits should be addressed to: Mr. Jim Sutton at (916) 657 2190, or c/o Division of Water Rights, Environmental Section, P.O. Box 2000, Sacramento, CA 95812-2000. Inquiries relative to the NEPA process for the Delta Wetlands Project COE Section 10 & 404 permits should be addressed to: Mr. Larry Vinzant at (916) 557 5263, or c/o US Army Corps of Engineers, Regulatory Section, 1325 J Street, Sacramento, CA 95814-2922.

RELATIVE TO PROTESTS

Any person desiring to protest the Board's approval of the petitions and issuance of permits pursuant to the new applications and pending applications shall by 4 p.m. on October 5, 1993 (or within such further time as may, for good cause shown, be allowed), file written protest with the State Water Board, Division of Water Rights, c/o Dave Cornelius, P.O. Box 2000, Sacramento, CA 95812-2000. The State Water Board will provide forms and copies of the applicable regulations for the filing of protest(s) upon request.

Any protest shall set forth: (1) the name and address of the protestant, (2) the reason(s) for the protestant's objection(s) to the petitions and/or applications, (3) any conditions on which the objection(s) could be satisfied.

Any protest based on injury to vested right(s) shall be supported by a complete statement of fact(s): (1) identifying the protestant's claim of right(s), and (2) how the petitions or new applications will result in injury to the protestant.

Any protest alleging that the petitions or the new applications will: (1) be contrary to law, (2) adversely affect uses protected by the public trust, (3) cause adverse environmental impact(s), and /or (4) not best serve the public interest, shall be supported by a complete statement of facts supporting the foregoing allegations and describing how the petitions or applications relate to the allegation(s).

Protests filed pursuant to the December 4, 1987 notice of Applications 29061, 29062, 29063, and 29066 need not be resubmitted.

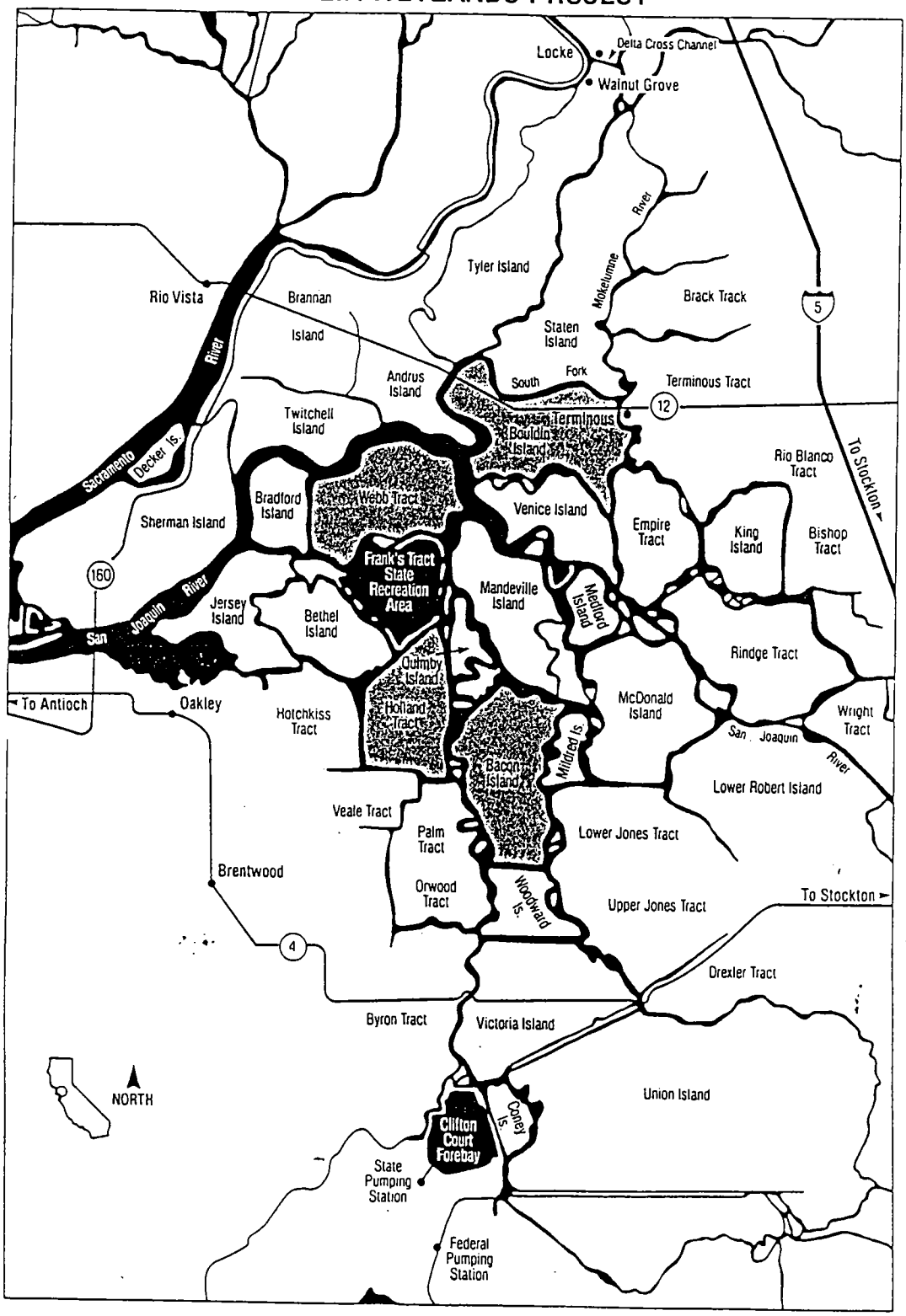
Copies of any protest must also be sent to the following parties:

Regulatory Section US Army Corps of Engineers c/o Larry Vinzant 1325 J Street Sacramento, CA 95814-2922	Delta Wetlands, Inc. c/o Jim Easton, 7801 Folsom Blvd., Ste. 106 Sacramento, CA 95826 Phone (916) 386-4200

Questions concerning the petitions or the new applications may be directed to Dave Cornelius at (916) 657 1924 or FAX (916) 657 1485.

Date: August 6, 1993

DELTA WETLANDS PROJECT



STATE OF CALIFORNIA - CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

PETE WILSON, *Governor*

STATE WATER RESOURCES CONTROL BOARD
PAUL R. BONDERSON BUILDING
901 P STREET
SACRAMENTO, CALIFORNIA 95814

Mailing Address
DIVISION OF WATER RIGHTS
P.O BOX 2000, Sacramento, CA 95812-2000

Date: APRIL 07 1995

NOTICE OF PETITION(S) ON PENDING APPLICATIONS 30267, 30268, 30269 and 30270

Notice is hereby given that on November 24, 1994

Delta Wetlands, Inc.
John L. Winther, President
3697 Mt. Diablo Blvd., Suite 120
Lafayette, CA 94549

Petitioned the State Water Resources Control Board (SWRCB) under section 1701 et seq. of the Water Code and section 791 et seq. of Title 23 California Code of Regulations (CCR) to change Applications 30267, 30268, 30269 and 30270 (as noticed August 6, 1993) **only by adding on-island point(s) of diversion** to facilitate reappropriation of water previously diverted onto the islands under other rights.

The purpose of this notice is to give persons concerned about Delta Wetland's proposed addition of the on-island point(s) of diversion to Applications 30267, 30268, 30269 and 30270 an opportunity to protest the SWRCB's inclusion of the proposed additional point(s) of diversion in any permits issued following hearing on the project.

The allowable bases for acceptance of protests under this notice (relative to addition of the points of diversion), procedures related to the filing of protests, and the name, telephone number, and mailing address of contact persons designated to answer questions concerning these new petitions are provided later in this notice.

BACKGROUND

Bedford Properties (Delta Wetlands) filed Applications 29061, 29062, 29063 and 29066 on July 9, 1987 for seasonal storage of unappropriated water on four islands in the Sacramento/San Joaquin Delta. The islands involved in the Delta Wetlands Project (Project) are Bouldin Island, Webb Tract, Holland Tract and Bacon Island, located as shown on the map on the last page of the enclosure with this notice.

The SWRCB is lead agency for this project under the California Environmental Quality Act (CEQA) and the U.S. Army Corps of Engineers (COE) is lead agency under the National Environmental Policy Act (NEPA). In December of 1990 a draft Environmental Impact Report (DEIR)/Environmental Impact Statement (EIS) for the Project under the initial applications were circulated by the lead agencies. The 1990 DEIR/EIS discussed reappropriation of water to storage, but did not identify a legal mechanism for appropriation or a point where the water would be diverted.

On July 21, 1993 Delta Wetlands filed Applications 30267, 30268, 30269 and 30270, and petitions to change pending Applications 29061, 29062, 29063 and 29066. Those applications and petitions were noticed on August 6, 1993. Copies of the August 6 notice are available upon request from Dave Cornelius at (916) 657-1924 or by writing the Division of Water Rights at the address listed below. However, please note in the notice, the period for protesting the 1993 applications and 1993 change petitions closed October 5, 1993.

On July 15, 1994 Delta Wetlands filed a revised project description outlining a two island project alternative. A copy of the revised project description including a map showing the various locations of the islands is enclosed. Specifics of the new petitions to add on-island points of diversion under the new applications are provided later in this notice.

EXPLANATION OF DIRECT DIVERSION VS STORAGE RE: THE DELTA WETLANDS PROJECT

Licensed Applications 2948, 2951, 2952, and 2954 authorize direct diversion only from March 1 - November 1 or regulation of water as defined in 23 CCR section 657. Applications 30267, 30268, 30269, and 30270 propose both direct diversion and storage year-round as defined in 23 CCR section 658. **The November 1994 petitions propose appropriation to storage, water that previously was appropriated by direct diversion under the licenses and/or appropriation of water that previously was diverted under claim of riparian right, at the points of diversion listed below. The previously diverted water would be appropriated on the islands in lieu of pumping it off the islands and replacing it with new water diverted from delta channels.**

In other words, if petitions are approved, water on the islands would be deemed appropriated at the on-island diversion points when water is available for appropriation from the delta under the priority of the 1993 applications.

DESCRIPTION OF PETITIONS

The November 28, 1994 petitions for change request addition of on-island points of diversion to facilitate the appropriation or reappropriation of water diverted onto the islands and used under claim of riparian right or under licensed Applications 2948 (Bouldin Island), 2951 (Holland Tract), 2952 (Webb Tract), and 2954 (Bacon Island) to storage under these application(s). The petitioner has requested diversion at the proposed on-island diversion points at the rate of capacity of the respective drainage pump(s) installed on that island. Water will be appropriated at the on-island diversion points only when water is available for appropriation under the priority of the 1993 applications (July 23, 1993), subject to all terms and conditions included in any permits issued by the State Water Board. The sources of the water, and specific locations of the proposed on-island points of diversion are listed below for each island as identified on maps on file with the SWRCB.

The amount(s) of water applied for, the purpose(s) of use, the season of diversion and place(s) of use would remain unchanged under the petitions.

SPECIFICS OF CHANGES TO APPLICATION 30267 FOR BOULDIN ISLAND STORAGE

Sources of water to be appropriated are the Bouldin Island Channels, previously diverted from:

(A) the **Mokelumne River**, tributary to San Joaquin River Delta Channels
(B) **Little Potato Slough**, tributary to San Joaquin River Delta Channels
(C) **Potato Slough**, tributary to San Joaquin River Delta Channels
(D) **San Joaquin River**, tributary to Suisun Bay.

The proposed additional points of diversion (PODs) on Bouldin Island are at existing Pump Station "A" within the NE¼ of the SE¼ of Section 20, T3N, R4E, MDB&M, and at existing Pump Station "B" within the SE¼ of the SE¼ of Section 22, T3N, R4E, MDB&M, both in San Joaquin County.

The rate of collection to storage requested for the new PODs would not exceed the capacity of the drainage pumps on Bouldin Island (currently about 200 cfs).

SPECIFICS OF THE CHANGE TO APPLICATION 30268 FOR WEBB TRACT STORAGE

Sources of water to be appropriated are Webb Tract Channels, previously appropriated from:

(A) **False River**, tributary to San Joaquin River Delta Channels
(B) **San Joaquin River**, tributary to Suisun Bay
(C) **Old River**, tributary to San Joaquin River Delta Channels.

The proposed additional POD on Webb Tract is at the proposed discharge pump Station to be located within the SE¼ of the NW¼ of Section 34, T3N, R3E, MDB&M in Contra Costa County.

The rate of collection to storage requested for the new POD is 4000 cfs, the capacity of the proposed discharge pump station on Webb Tract.

SPECIFICS OF CHANGES TO APPLICATION 30269 FOR HOLLAND TRACT STORAGE

Sources of water to be appropriated are Holland Tract Channels, previously diverted from:

(A) **Roosevelt Cut**, tributary to Old River, thence San Joaquin River Delta Channels
(B) **Holland Cut-Old River**, tributary to San Joaquin River Delta Channels
(C) **Rock Slough**, tributary to Old River, thence San Joaquin River Delta Channels.
(D) **Sand Mound Slough**, tributary to Old River, thence San Joaquin River Delta Channels.

The proposed additional PODs on Holland Track are at existing Pump Station "A" located within the NW¼ of the SW¼ of Section 12, T3N, R3E, MDB&M, at existing Pump Station "B" located within the SW¼ of NW¼ of Section 34, T3N, R4E, MDB&M, and at existing Pump Station "C" located within the NW¼ of the SW¼ of Section 20, T2N, R4E, MDB&M in Contra Costa County.

The rate of collection to storage requested for the new PODs would not exceed the capacity of the drainage pumps on Holland Tract (currently 200 cfs).

SPECIFICS OF CHANGES TO APPLICATION 30270 FOR BACON ISLAND STORAGE

Sources of water to be appropriated are Bacon Island Channels, previously diverted from:

(A) **Old River**, tributary to San Joaquin River Delta Channels
(B) **Middle River**, tributary to San Joaquin River Delta Channels
(C) **Santa Fe Dredge Cut**, tributary to Old River, thence San Joaquin
(D) **Connection Slough**, tributary to Middle River, thence San Joaquin River Delta Channels.

The proposed additional POD on Bacon Island is at the proposed discharge pumping Station located within the SE¼ of the SE¼ of Section 8, T1N, R4E, MDB&M in San Joaquin County.

The rate of collection to storage requested for the new POD is 4000 cfs, the capacity of the proposed discharge pump on Bacon Island.

ENVIRONMENTAL INFORMATION

The SWRCB is lead agency under CEQA and is responsible for preparing appropriate environmental documents for the Delta Wetlands Project with respect to the appropriative water right permit process. The US Army Corps of Engineers is lead agency under NEPA and is responsible for preparing appropriate environmental documents for the Delta Wetlands Project with respect to the federal Rivers and Harbors Act Section 10 & Clean Water Act Section 404 permits required for construction of the project.

In December of 1990 a draft Environmental Impact Report (EIR)/Environmental Impact Statement (EIS) for the project was circulated by the lead agencies. Operation of the project will comply with State and federal endangered species laws. The lead agencies are preparing a new draft EIR/EIS which is expected to be circulated for comment in 1995.

Inquiries relative to the CEQA process for the Delta Wetlands Project water rights permits should be addressed to: Mr. Jim Sutton at (916) 657-2190, or c/o Division of Water Rights, Environmental Section, P.O. Box 2000, Sacramento, CA 95812-2000. Inquiries relative to the NEPA process for the Delta Wetlands Project COE Section 10 and 404 permits should be addressed to: Mr. Jim Monroe at (916) 557-5266, or c/o US Army Corps of Engineers, Regulatory Section, 1325 J Street, Sacramento, CA 95814-2922.

RELATIVE TO PROTESTS

Any person desiring to protest the Board's approval of the petitions to include the PODs in any permits issued pursuant to the pending applications shall by 4 p.m. on May 8, 1995 (or within such further time as may, for good cause shown, be allowed), file written protest(s) with the Division of Water Rights, c/o Dave Cornelius, P.O. Box 2000, Sacramento, CA 95812-2000. The SWRCB will provide forms and copies of the applicable regulations for the filing of protest(s) upon request.

Any protest shall set forth: (1) the name and address of the protestant, (2) the reason(s) for the protestant's objection(s) to the petitions and/or applications, (3) any conditions on which the objection(s) could be satisfied.

Any protest based on injury to vested right(s) shall be supported by a complete statement of fact(s): (1) identifying the protestant's claim of right(s), and (2) how the addition of the requested on-island points of diversion will result in injury to the protestant.

Any protest alleging that the petitions or the new applications will: (1) be contrary to law, (2) adversely affect uses protected by the public trust, (3) cause adverse environmental impact(s), and /or (4) not best serve the public interest, shall be supported by a complete statement of facts supporting the foregoing allegations and describing how the petitions or applications relate to the allegation(s).

Protests accepted pursuant to the December 4, 1987 notice of Applications 29061, 29062, 29063, and 29066 remain valid and should not be resubmitted. Protests accepted pursuant to the August 6, 1993 notice of Applications 30267, 30268, 30269, and 30270 and the 1993 petitions remain valid and should not be resubmitted. The revised project as described in the June 15, 1994 enclosure and issues raised in the protests will be addressed in the DEIR/EIS.

The Applicant is expected to respond to most of the specific issues in the accepted protests after the lead agencies release the DEIR/EIS and prior to the hearing.

Copies of any protest must also be sent to the following parties:

Regulatory Section
US Army Corps of Engineers
c/o Jim Monroe
1325 J Street
Sacramento, CA 95814-2922

Delta Wetlands, Inc.
c/o Jim Easton
7801 Folsom Blvd., Ste. 110
Sacramento, CA 95826
Phone (916) 386-4200

Questions concerning the petitions may be directed to Dave Cornelius at (916) 657-1924 or FAX (916) 657-1485.

Date: APRIL 07 1995

ENCLOSURE

DELTA WETLANDS PROJECT
June 15, 1994

DESCRIPTION

General Description: The Delta Wetlands project is a proposed water supply project utilizing four Delta islands: Bouldin Islands, Holland Tract, Webb Tract and Bacon Island. Under the project proponent's preferred alternative, Bouldin Island and Holland Tract will be dedicated for habitat purposes with only incidental water supply benefits. Webb Tract and Bacon Island are to be used as year-round water supply reservoirs.

Water Yield: The Delta Wetlands project will divert and store surplus Delta flows for later release and possible export. The proposed storage capacity of the reservoir islands is 238 thousand acre-feet (TAF). The annual yield of the project is subject to a multitude of assumptions and variables but is expected to develop an average of more than 200 TAF of water per year. The project is also well positioned to facilitate water transfers or banking programs.

Reservoir Islands: The two reservoir islands, Webb Tract and Bacon Island may divert water at any time of the year under the preferred alternative; however, water will most likely be available in the winter and spring during periods of high Delta flows. Diversions onto the reservoir islands will be subject to permit conditions to protect senior water right holders, as well as critical life stages of Delta fisheries in the vicinity of the points of diversions. Water will be diverted onto the reservoir islands by a series of 36" siphons and each siphon will be fitted with an individual fish screen to avoid fish entrainment. The reservoirs will be capable of rapid filling with a maximum diversion capacity of 4,500 cfs per reservoir and could be filled in as few as three weeks. The stored water will be pumped from the islands to the adjacent Delta channels for beneficial use. The reservoir islands will not fill every year, but under certain circumstances, may be able to fill and drain more than once during the same year or may carry over storage from one year to the next. The beneficial use of the water could be for export from the Delta or could support Delta water quality or flow standards.

Habitat Islands: The two habitat islands, Bouldin Island and 3,014 acres on Holland Tract will be operated primarily for wildlife benefits, although a small amount of water storage may also be developed. The habitat will include a mosaic of habitat types managed primarily for migratory waterfowl and two listed terrestrial species (greater sandhill crane and Swainson's hawk), but will also provide year-round benefits for many other wildlife species. A habitat management plan (HMP) has been prepared to describe in detail the implementation and operations on the habitat islands.

PROJECT FEATURES

Terrestrial Habit: One hundred and fifty years ago, there were five million acres of wetlands in California. Today, less than 500,000 acres remain. The flooded islands will provide about 9,000 acres of important new habitat every year. The production of waterfowl food will be many times greater than existing conditions on the islands. The 9,000 acres dedicated to a new habitat on Bouldin Island and Holland Tract will provide an opportunity to develop new habitat wildlife and waterfowl, including several endangered species. Because the wetlands will be in a wet or semi-moist condition year-round, invertebrate food for wildlife will be more abundant. Also nesting opportunities on Bouldin Island and Holland Tract will be greatly enhanced.

Fisheries: The current agricultural diversions for irrigation will be reduced or eliminated if the project is approved. Eliminating these unscreened diversions will benefit fisheries, such as striped bass and Delta smelt. Current entrapment of eggs and larvae will be reduced.

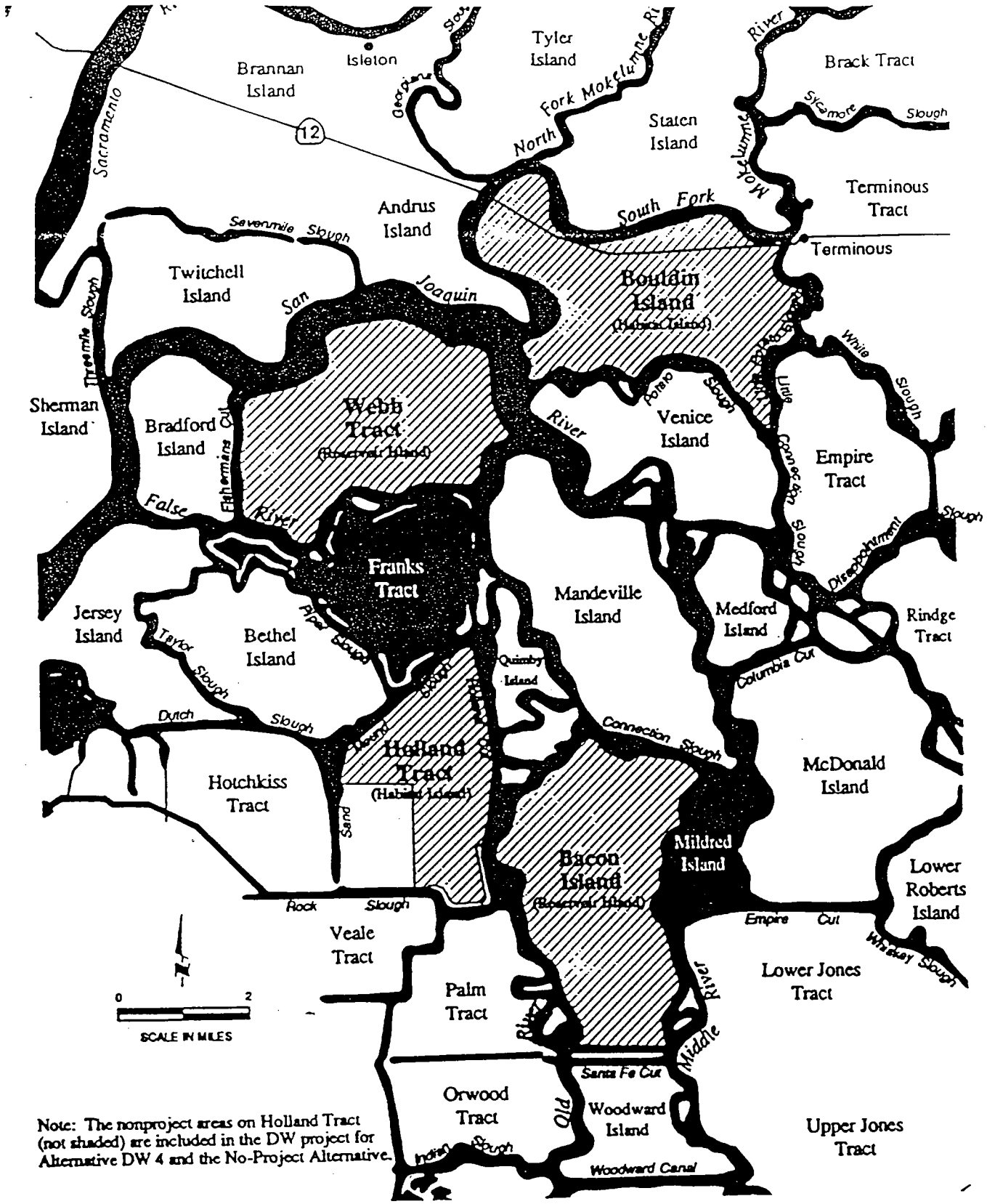
Levee Stability: The perimeter levees on all four islands will be habilitated to meet the current state recommended levee standards described in Department of Water Resources Bulletin No. 192-82. The inside surface of the reservoir island levees on Bacon Island and Webb Tract will be protected from wave erosion by the installation of rock revetment. Converting these islands to managed habitat areas and reservoirs will reduce subsidence by decreasing oxidation of peat soils. Strengthened levees and reduced subsidence will improve overall levee stability on all four project islands.

Seepage Control: Any potential seepage from the water storage islands to adjacent islands will be intercepted by a series of interceptor wells around the perimeter of the reservoir islands at all potentially critical locations. The interceptor wells will be installed and operating prior to the storage of water above normal agricultural levels. An off-island monitoring well program will be included to measure the effectiveness of the onsite interception system.

Water Quality: Water will generally be diverted onto the reservoir islands when the Delta is in a surplus condition and Delta water quality is good. It will be pumped off of the reservoir islands when there is a demand for water, which generally coincides with lower water availability and poorer water quality. The net effect is that the project, on balance, should improve water quality in the Delta.

Wetlands and Fishery Research: Two dollars per acre-foot of exported water will be directed to wetlands and fishery research.

DEIR/EIS Schedule: The draft environmental document is scheduled for public distribution in the summer of 1994.



Note: The nonproject areas on Holland Tract (not shaded) are included in the DW project for Alternative DW 4 and the No-Project Alternative.

Source: Adapted from California Department of Water Resources 1993.

Figure 2-1.
DW Project Islands

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

Appendix 2. Supplemental Description of the Delta Wetlands Project Alternatives

Appendix 2. Supplemental Description of the Delta Wetlands Project Alternatives

INTRODUCTION

This appendix provides detailed information to augment the description of the Delta Wetlands (DW) project alternatives presented in Chapter 2, "Delta Wetlands Project Alternatives". The following sections provide specifications for DW water storage facilities, including siphon and pump stations, fish screens, and levees; present an overview of patterns of water storage operations under the alternatives; describe recreation facilities and plans; discuss buildings and other structures on the DW project islands that are related to project operations; and describe the agreements, plans, and programs that relate to Delta water project operations and efforts to secure a more reliable high-quality water supply from the Delta.

DW WATER STORAGE FACILITIES

Siphon Stations

Design

Under Alternatives 1 and 2, two new siphon stations with 16 siphons each (spaced 40 feet apart) would be installed on each reservoir island (Bacon Island and Webb Tract). Under Alternative 3, two new siphon stations with 12 siphons each would also be installed on both Bouldin Island and Holland Tract. Each station would include a boat dock (maximum 10 berths) for use by maintenance personnel; a maintenance facility, including a vehicle parking area and living quarters or office space constructed on a pile foundation; and an access ramp near the maintenance facility for equipment loading from the levee road. A minimum of two hinged gangway access ramps would also be constructed adjacent to siphon units for repair access. Each siphon station would be constructed along approximately 900 feet of the perimeter levee and would cover approximately 150,000 square feet (about 3.4 acres). Figure 2-1 of this appendix provides a siphon station plan view.

Siphon Units

Figure 2-2 of this appendix shows a conceptual siphon unit profile. Each siphon unit would consist of the following components:

- a siphon inlet equipped with a fish screen module submerged in the adjacent channel;
- a 36-inch-diameter rigid pipe constructed along the exterior slope of the perimeter levee from the inlet structure to the levee top and installed through the top of the levee to the interior slope;
- a 36-inch-diameter flexible, high-density polyethylene pipe constructed along the interior slope from the levee top into the island interior;
- an expansion chamber supported by a floating platform connected to the flexible pipe in the island's interior; and
- a siphon unit control valve and optional booster pump.

Guard piles would be constructed in the channels beyond the inlets to protect the siphon units. A standpipe for attaching the vacuum pump used to start each of the siphons would be located at the highest elevation of each siphon pipe where it crosses the levee. During operation start-up and shut-down, siphon units would be started and stopped sequentially in each station to avoid creation of bore waves and surges in adjacent channels. Maximum water velocities in the siphon barrels would be approximately 27-29 feet per second (fps).

The flexible pipe constructed along the interior slope of the levee would connect the rigid pipe to the siphon discharges on the island interior. Concrete tracks constructed on the interior slope would support the flexible

pipes. The pipes would be equipped with flow meters as required.

The siphon discharges on the reservoir island interiors would be connected to the expansion chambers supported by floating platforms. The expansion chambers would allow the siphon pipes to expand from a 36-inch diameter to a 36- by 120-inch rectangular opening to disperse high-velocity flows and reduce erosion of the reservoir bottoms. Sheet piling or riprap on the island floors also would be used to prevent erosion around the discharge ends. Siphon discharges would be equipped with hinged flap gates to prevent backflow.

In the final stages of reservoir filling, the siphons would be subject to a maximum total head condition ranging from 8 feet at low tide with a full reservoir to a vacuum of 6 feet at high tide with a partially full reservoir. Booster pumps, powered by 50- to 75-horsepower motors, could be installed on the pipes in the floating siphon support platforms to lift water several feet above mean sea level in the final stages of diversions. The booster pumps are an option to facilitate siphon capacity and may not always be included in the siphon design.

Expansion chambers would be fitted to the discharge ends of the siphons on the interiors of the islands, and contraction chambers would be fitted to the inlet ends in Delta channels. These chambers would increase the efficiency of siphon operation and decrease exit velocity of water from the siphon onto the islands. Sheet piling or riprap would be used to prevent erosion around the discharge ends of the siphons.

Fish Screens

Fish screens would be installed around the intake end of each existing and new siphon pipe (Figures 2-2 and 2-3 of this appendix). The purpose of screen design and operation would be to prevent entrainment and impingement of most adult and juvenile fish that are present in the Delta. Final fish screen design characteristics, such as approach velocity, mesh size, flow uniformity, and cleaning frequency, would be negotiated with the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and California Department of Fish and Game (DFG) to ensure effective operation under all Delta conditions.

The proposed fish screen design consists of a barrel-type screen on the inlet side of each siphon with a hinged flange connection at the water surface for cleaning (Figure 2-3 of this appendix). Each siphon opening would be enclosed by stainless steel woven wire mesh screen (7 by 0.035 = seven openings per inch in screen of 0.035-inch-diameter number 304 stainless steel wire) with a pore diagonal of 0.1079 inch. Siphon pipes, with their individual screen modules, would be spaced approximately 40 feet apart on center.

DW proposes to design the screens for a maximum average approach velocity of 0.33 fps (or less, if required). The average approach velocity would decrease rapidly as the islands filled because the head differential of the siphons would decrease with island filling. The fish screens would be sufficiently strong to withstand handling and cleaning and would withstand at least a 24-inch head differential in water levels.

The screens would be monitored daily to determine the need for cleaning and to assess damage from floating logs, boats, or other causes. The fish screens are designed with a hinged flange that allows the screens to be rotated out of the water for cleaning and repair (Figure 2-3). The screens would also include panels that allow access to the interior of the screens for cleaning. Spare screen modules would be available to replace damaged screens and thus ensure the reliable performance of the screens. Algae and other clogging debris would be removed from the screens as required by agreement with DFG, USFWS, and NMFS. Removal methods may include regularly raising the screen modules out of the water and using high-pressure water or steam to clean the screens.

A monitoring program may be implemented to estimate fish entrainment losses if the information is needed to evaluate direct diversion effects. Sampling protocol would be subject to fishery agency requirements for the Delta. The monitoring efforts could be coordinated with other regional monitoring efforts.

Pump Stations

Design

The pump stations for Alternatives 1 and 2 would consist of clusters of 32 new pumps on Webb Tract and 40 new pumps on Bacon Island with 36-inch-diameter pipes discharging to adjacent Delta channels. Under Alternative 3, pump stations would include up to 32 new pumps each on Holland Tract and Bouldin Island and 40 new pumps each on Webb Tract and Bacon Island. More pumps would be added to Webb Tract under Alternative 3 to provide for rapid discharge on half of the reservoir islands. Typical spacing for the pumps would be 25 feet on center. Each station also would include a

boat dock (maximum 10 berths) on the Delta channel side for use by maintenance personnel, a maintenance facility and vehicle parking area constructed on a pile foundation on the interior side of the levee, and an access ramp near the maintenance facility for equipment loading from the levee road into the island interior. A minimum of one gangway access ramp per eight pumps would be installed adjacent to pump units for repair and maintenance access. Each pump station would be constructed along approximately 1,000 or 1,250 feet of the perimeter levee (the length depending on the number of pump units per station) and would cover approximately 180,000 or 220,000 square feet (about 4 or 5 acres). Figure 2-4 of this appendix presents a pump station plan view.

Pump Units

Figure 2-5 of this appendix shows a conceptual design of a pump unit. Each pump unit would consist of the following components:

- a discharge pump (diesel- or electric-powered) supported by a floating platform equipped with a trash screen bottom to minimize the amount of debris entering the pipe from the reservoir island;
- a 36-inch-diameter flexible, high-density polyethylene discharge pipe constructed along the interior slope of the perimeter levee from the discharge pump unit to the levee top;
- a 36-inch-diameter rigid pipe with a siphon breaker installed through the levee top and along the exterior slope of the levee down into the channel; and
- an expansion chamber connected to the discharge end of the rigid pipe in the adjacent Delta channel.

An assortment of axial-flow and mixed-flow pumps would be used to accommodate the variety of head conditions occurring throughout reservoir drawdown. Head conditions would vary from a maximum total head condition of 31 feet at high tide with an empty reservoir to a vacuum of approximately 6 feet with a full reservoir. The floating platforms would be equipped with trash racks and trash screens to minimize the amount of debris that enters the inlet pipes.

The rigid discharge pipes would connect the flexible pipes constructed along the interior levee slope to the floating pump platforms. Concrete tracks would provide support for the flexible pipes. A siphon breaker and relief valve would be installed at the highest elevation of each discharge pipe to prevent backflow when pumps are not operating. Flow meters would be installed as required.

Outside each island perimeter levee, the 36-inch-diameter rigid pipes passing through the top of the levee would continue along the exterior levee slope into the Delta channel where the discharge ends would connect with expansion chambers. The expansion chambers would allow the pipes to expand from a 36-inch diameter to a 36- by 120-inch rectangular opening. Guard piles would be constructed in the channel beyond the expansion chambers to protect the units, and riprap would be placed on the channel bottom to protect against erosion from the units.

Operation and Power Source

Pump units would most likely be powered by electricity because it is available on both reservoir islands; however, diesel fuel, electricity, natural gas, or a combination of the three are possible power sources. If electrical power is used for pump stations, DW pump operations may need to avoid peak electrical demand periods during summer, requiring up to 25% more pumping capacity from an alternate power source or through other facilities (e.g., portable pumps). If diesel fuel is used either as the primary or secondary power source, a diesel fuel distribution system would be located on the levee tops with a distribution system of pipes and hoses to deliver fuel to the pump motors. A fuel spill recovery system would be implemented at all areas using diesel fuel.

As a supplement to discharge pumping activity, portable pumps or components may be used on the reservoir islands to meet varying discharge requirements but not to exceed the maximum specified discharge rate. The portable components would serve as replacement components and would not add to the permanent facility installation.

Levee Improvements

Under Alternatives 1, 2, and 3, perimeter levees on the reservoir islands would be raised to hold water at a maximum elevation of +6 feet. A typical levee would have 2:1 exterior slopes and a crest approximately 22 feet wide (including thickness for erosion protection [rock revetment] on the interior slope) at approximately +9 feet elevation. The perimeter levee's existing interior slopes would be modified with either a constant-slope buttress

or a broken-slope buttress design, as depicted in Figure 2-6 of this appendix. The constant-slope buttress design would be inclined at a slope of approximately 5:1 without toe berms. The broken-slope buttress design would have initial interior slopes of approximately 3:1 down to near an elevation of -3 feet and toe berms at a 10:1 slope at the base of the levee. Rock revetment would be placed on levee slopes to control wind and wave erosion. Seepage interceptor wells would be installed in critical areas on the islands' perimeter levees to offset any changes from existing seepage rates from the reservoir island caused by the DW project.

DW would construct and maintain a series of low, broad earthen levees on the island bottoms to manage shallow water during periods of nonstorage. These levees would be operated during periods of nonstorage to allow no more than 35% of the shallow water habitat to be dry, no more than 15% of the shallow water to be under water more than 24 inches deep, and the balance (50%) to have an average water depth of 12 inches. Pipes with flashboard risers and broad-crested weirs would be used to control water elevations.

Most of the material for levee improvements would be borrowed from the reservoir islands; erosion control material (e.g., rock revetment) would be quarried from existing regional quarry sites. Borrow requirements for the project consist of excavation for levee buttressing, inner levee construction, and levee maintenance. Excavation for construction of drainage canals and circulation ditches on the islands would also provide some of the borrow material. Borrow pits would initially be shallow but would be used regularly in the future for maintenance requirements.

Exact locations of borrow sites would vary according to material requirements for construction and maintenance. Borrow area locations are primarily a function of existing soil conditions and would be determined during site-specific engineering surveys. The borrow pits would generally be more than 400 feet inward from the top of a levee to avoid structural impacts on the levee and at least 2,000 feet inward from the final toe of an improved levee where seepage restrictions are required. Chapter 3D, "Flood Control", provides details of estimated amounts of borrow and rock revetment material needed for perimeter and inner levee improvement for Alternatives 1, 2, and 3.

DW WATER STORAGE OPERATIONS

Patterns of Operations

By converting conventional agricultural land use to a combination of water storage and wetland habitat management, the DW project would modify Delta water budgets. Tables 2-1, 2-2, and 2-3 of this appendix show the simulated pattern of water storage operations on the reservoir islands for Alternatives 1, 2, and 3, respectively, based on the 70-year hydrologic record (1922-1991) and assuming current Delta standards and water project operations.

These tables show the monthly percentiles for simulated diversions, end-of-month storage volumes, and discharges. Percentiles represent the percentages of years in which the cell-entry value is not exceeded. For example, Table 2-1 shows that under Alternative 1, no diversions were simulated to occur in October in 60% of years. DW diversions would be between 0 and 3 thousand acre-feet (TAF) in 10% of years, between 3 TAF and 63 TAF in 10% of years, between 63 TAF and 185 TAF in 10% of years, and between 185 TAF and 238 TAF in 10% of years.

Chapter 3A, "Water Supply and Water Project Operations", and Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives", show more details of simulated DW project operations as monthly percentiles and annual totals. These tables show that the pattern of water storage operations is generally characterized by large diversion, storage, and discharge amounts in small percentages of years.

Initial Staging for Water Diversions

During start-up of the DW project, water diversions would be staged over 1 year to allow time for implementation of accurate seepage control and facility monitoring and to ensure levee stability (see Chapter 3D, "Flood Control"). A typical example of diversion staging might be initial flooding to an elevation of -5 feet, followed by an additional 5 feet of water. After project monitoring (e.g., monitoring of levee stability, seepage rates, and fish), additional water would be added until the islands are filled to capacity or partially filled, based on available supply. Water diversions during initial staging would not exceed the diversion limits designed for the project.

RECREATION FACILITIES AND PLANS

Under the DW project alternatives, DW would construct private recreation facilities on all four project islands. The maximum size of these facilities is described below. Each facility would be constructed on approximately 5 acres along a perimeter levee, providing boat access from neighboring water channels and vehicle access from levee roads.

A conceptual recreation facility layout is shown in Figures 2-7 and 2-8 of this appendix. Each recreation facility would include the following components:

- living quarters (estimate of 10,000 square feet) consisting of a maximum of 40 bedrooms, bathrooms, a kitchen, and dining facilities;
- a 40-car parking lot (estimate of 9,000 square feet) constructed adjacent to the levee crest access road on a pile foundation;
- a 30-berth floating boat dock and gangway constructed on the channel side of the levee to provide permanent and temporary boat berthing for recreationists (estimate of berths 40 feet long) and access to the living quarters from Delta channels; and
- a 36-berth floating boat dock and gangway (estimate of berths 20 feet long) constructed on the interior side of the levee to provide access from the living quarters to hunting areas and other recreation areas on the DW project islands.

The interior boat docks on the habitat islands would be located in permanent water to connect with a network of ditches, canals, and open water that make up the circulation systems on the island bottoms.

The recreation facilities would be used year round by private guests who come to the DW project islands to hunt, boat, fish, and participate in other recreational activities. Use of the recreation facilities would probably be highest during the summer months and during the hunt season. See Chapter 3J, "Recreation and Visual Resources", for more information on recreational use of the DW project islands and the proposed facilities.

The recreation facilities would be built in compliance with the local building codes of San Joaquin County (Bacon and Bouldin Islands) or Contra Costa County (Holland and Webb Tracts). Sewage disposal would comply with the requirements of the Central Valley Regional Water Quality Control Board (CVRWQCB) and local jurisdictions. Pumpout facilities would not be provided for sewage disposal from docked boats at the DW project islands. Drinking water would be imported as needed or supplied using onsite treatment subject to county and state standards. A private solid waste collection and disposal service authorized to operate in Contra Costa County and San Joaquin County would be contracted to serve the recreation facilities, and propane and electrical power would be used at the facilities. Boat-fueling facilities would not be provided to boats docked on the exterior of the islands, but a fuel tank would serve small boats used on the interior of the islands for hunting and maintenance. See Chapter 3E, "Utilities and Highways", for more information on services and utilities for the recreation facilities.

The design details, square footage, and berth lengths given above and shown in Figures 2-7 and 2-8 are preliminary and are used for analysis of the facilities in this EIR/EIS. Specific design features for a particular facility may be subject to change prior to application being made for construction and operation entitlements and permits from regulating agencies (e.g., Contra Costa or San Joaquin County, the State Lands Commission, and the Corps). The analyses presented in this EIR/EIS assume a maximum facility size; actual facility design will not exceed the EIR/EIS assumptions.

BUILDINGS AND OTHER STRUCTURES

Operation and maintenance facilities on the reservoir islands would be located at the pump and siphon station sites. Each pump or siphon station would include a 5,000-square-foot maintenance facility and parking lot constructed on a pile foundation, as described above. A small number of living quarters for some employees and an area for onsite offices may be developed in the maintenance facility areas. The operations buildings would include storage and equipment areas. Other developed areas include the recreation facilities described above, existing developments on Holland Tract in the nonproject areas, and the Bouldin Island airstrip.

RELATED AGREEMENTS, PROGRAMS, AND STUDIES

The agreements, programs, and studies described below are related to environmental conditions in the

Delta and to the quantity and/or quality of available water supply in the Delta. These programs and studies therefore address the general public need for additional water supply in the Delta. The discussion of related Delta programs is based in part on California Department of Water Resources' (DWR's) California Water Plan Update (DWR 1994) and on DWR's draft report Relationships between the Projects under Review by the U.S. Environmental Protection Agency (EPA) (DWR 1991).

Implementation of most of the programs described in this section remains uncertain. These related programs are long-term projects proposed, for the most part, by local and state agencies that have the appropriate financial and planning resources and public support to invest in long-range programs. The programs are not presented as potential alternatives to the DW project, but to provide a context for analyzing potential alternatives for creating a supply of high-quality water in the Delta for later sale for beneficial uses as Delta export and/or outflow and to provide the framework for analyzing cumulative impacts of the DW project alternatives in the context of other proposed Delta projects. The need for the DW project would continue even with implementation of the related water programs.

SWRCB Bay-Delta Proceedings

In 1978, the California State Water Resources Control Board (SWRCB) adopted a water quality control plan, known as the Delta Plan, and Water Right Decision 1485 (D-1485). The Delta Plan contained water quality objectives for the protection of beneficial uses of the Delta and Suisun Marsh.

SWRCB reviewed, broadened, and refined the water quality standards of the San Francisco Bay/Sacramento-San Joaquin Delta (Bay-Delta) estuary during the Bay-Delta hearings. These proceedings, which began in 1987, established reasonable levels of protection for beneficial uses for flow, salinity, temperature, and pollutants. A water quality control plan for salinity, temperature, and dissolved oxygen was completed and adopted by SWRCB in 1991, but was disapproved by EPA because EPA did not believe the plan provided adequate protection for estuarine habitat.

SWRCB subsequently evaluated flow requirements for San Francisco Bay and the Delta and conducted hearings in June, July, and August 1992 to determine whether existing water rights should be amended to achieve, or progress toward achieving, flow and quality standards. On December 9, 1992, SWRCB released interim water quality standards in draft Water Right Decision 1630 (D-1630) to protect fish and wildlife in the Delta and maintain beneficial uses according to the Governor's Water Policy. SWRCB chose not to adopt D-1630.

In response to SWRCB's decision not to adopt interim standards and to the filing of a lawsuit, EPA announced that it would propose draft standards for the Bay-Delta estuary. On January 6, 1994, EPA proposed draft standards for protection of fishery-related beneficial uses in the Delta. SWRCB reviewed EPA's draft standards and conducted public workshops to seek comments and recommendations for standards.

On December 15, 1994, a Bay/Delta Framework Agreement was signed by federal agencies; state agencies; and urban, agricultural, and environmental interests. This agreement:

- identified the amount of water that can be required to be allocated by water rights holders for endangered species protection during average and drought years;
- committed federal agencies not to require additional water allocations for endangered species for a 3-year period;
- placed a limit on the percentage of water that can be exported from the Delta, expressed as percentage of inflow (generally 35% of Delta inflow from February through June and 65% during July through January);
- committed EPA to withdraw its final water quality standards, which were published in January 1995, once SWRCB finalized its water quality control plan;
- dedicated various water users to providing $180 million to fund a variety of improvements to Delta diversion infrastructure; and
- commissioned SWRCB to assign responsibility among the various holders of Delta water rights for maintaining minimum flows during different parts of the year.

Soon after the Framework Agreement was signed in June 1994, SWRCB issued the draft Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (WQCP). This plan set water quality objectives for different points in the estuary, including both numerical salinity objectives and narrative

flow and other criteria. These criteria, finalized on May 22, 1995, replaced EPA's draft standards.

CALFED Bay-Delta Program

The Governor's Water Policy (issued in 1992) directed the initiation of the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) processes to investigate long-term solutions to "fix the Delta". The Bay-Delta Oversight Council was established in December 1992 to guide the search for a long-term solution.

In June 1994, the state and federal governments entered into a Framework Agreement to establish a comprehensive program for coordination on environmental protection and water supply dependability in the Bay-Delta estuary and its watershed. Collectively, these participating agency directors are referred to as CALFED.

Under the Framework Agreement, CALFED will improve coordination of water supply operations with endangered species protection and compliance with water quality standards. CALFED will also develop a long-term solution to fish and wildlife, water supply reliability, flood control, and water quality problems in the Bay-Delta estuary.

CVP and SWP Endangered Species Consultations

On November 30, 1990, winter-run chinook salmon was listed as a threatened species under the federal Endangered Species Act (the species' listing was subsequently changed to endangered on February 3, 1994). Delta smelt was listed as a threatened species on April 5, 1993, and listings of other Delta species (e.g., longfin smelt, Sacramento splittail, and steelhead trout) are being considered. Winter-run chinook salmon and delta smelt are also listed under the California Endangered Species Act. Under the federal Endangered Species Act, a "take" is prohibited unless a specified level of take is authorized by NMFS (winter-run chinook salmon) or USFWS (other Delta species considered for listing) in an incidental take statement. Take is a loosely defined term that includes harassment of and harm to a species, entrainment, directly and indirectly caused mortality, and actions that adversely modify or destroy the species' habitat.

NMFS, USFWS, and DFG have consulted with the U.S. Bureau of Reclamation (Reclamation) and DWR on joint Central Valley Project (CVP)/State Water Project (SWP) operations. Long-term restrictions on project operations to protect winter-run chinook salmon were issued by NMFS in its biological opinion issued February 12, 1993. DFG subsequently adopted NMFS's long-term biological opinion.

NMFS, USFWS, Reclamation, DWR, and DFG are implementing recovery efforts to protect and restore the winter-run chinook salmon, including restricting in-river and ocean harvest, reducing losses to diversions along the Sacramento River (e.g., intakes to Anderson-Cottonwood and Glenn-Colusa Irrigation Districts), implementing artificial propagation, and establishing a captive breeding program. In September 1992, NMFS formed a recovery team to develop a federal recovery plan (required by the federal Endangered Species Act) for winter-run chinook salmon. (DWR 1994.)

Pursuant to the December 15, 1994 agreement between the state and federal governments regarding the water quality standards for the Delta, USFWS issued a biological opinion for long-term protection of delta smelt on March 6, 1995, for CVP and SWP operations. The biological opinion for winter-run chinook salmon was revised in May 1995 and was issued by NMFS in summer 1995.

Coordinated Operations Agreement

The Coordinated Operations Agreement (COA), signed in 1986, provides for joint management of the CVP and SWP by Reclamation and DWR to ensure that water quality objectives established by SWRCB will be achieved. The COA provides not only for an equitable sharing of Delta water supplies, but also for conjunctive operation of the CVP and SWP to allow the projects to maximize benefits to both parties. Under the COA, Reclamation also agreed to meet future water quality standards established by SWRCB, unless the Secretary of the Interior determines that the standards are inconsistent with congressional intent.

Subarticle 10(h) of the COA was approved by Congress in 1988 and provides for negotiations of a wheeling contract between DWR and Reclamation whereby DWR could meet some of its future delivery obligations using federal water, and Reclamation could increase deliveries south of the Delta by using state facilities. Reclamation may have some water available for delivery on an interim basis to areas south of the Delta but has limited pumping and conveyance capacity. DWR, however, has excess

pumping and conveyance capacity but limited water supplies.

Scoping meetings for this proposal were held in 1989. A scoping report was released in January 1991. Preparation of a draft environmental impact report/environmental impact statement (EIR/EIS) on this proposal is being delayed until a decision is made on Delta water rights and Bay-Delta water quality and flow standards, and until guidelines for implementing the Central Valley Project Improvement Act (CVPIA) have been adopted (see "Central Valley Project Improvement Act" below).

Banks Pumping Plant Fish Protection Agreement

DWR installed four additional pumping units at SWP's Harvey O. Banks Delta Pumping Plant near Clifton Court Forebay. These units became operational in 1993 and increase total pumping capacity from 6,400 cubic feet per second (cfs) to 10,300 cfs. These pumps provide DWR with standby capacity and allow DWR to pump the quantity of water specified in its U.S. Army Corps of Engineers (Corps) permit over a shorter period. The Corps permit requirements limit pumping to 6,680 cfs plus one-third of San Joaquin River flow at Vernalis during the mid-December to mid-March period whenever those flows exceed 1,000 cfs. An exceedance of this limit would require modification of the existing authorization from the Corps or an individual permit.

To mitigate fish losses at Delta export facilities, both the SWP and the CVP have entered into agreements with DFG. During the environmental review process for installation of the four additional pumps at Banks Pumping Plant, DFG and DWR began negotiating an agreement for the preservation of fish potentially affected by the operation of the pumps. A unique aspect in the development of this agreement was the assistance provided by an advisory group made up of representatives from United Anglers, the Pacific Coast Federation of Fishermen's Associations, the Planning and Conservation League, and the State Water Contractors. (DWR 1994.)

The Fish Protection Agreement, signed by the directors of DFG and DWR in December 1986, identifies the steps needed to offset adverse fishery impacts of Banks Pumping Plant operations. The agreement establishes a procedure to calculate direct fishery losses annually and requires DWR to pay for mitigation projects that would offset the losses. Losses of striped bass, chinook salmon, and steelhead trout are to be mitigated first. Mitigation of losses of other species are to follow as impacts are identified and appropriate mitigation measures are found. In recognition of the fact that direct losses today would probably be greater if fish populations had not been depleted by past operations, DWR also provided a one-time $15 million mitigation fund. (DWR 1994.)

Central Valley Project Improvement Act

Title 34 of the Reclamation Projects Authorization and Adjustment Act of 1992 (HR 429, now noted as Public Law 102-575) is known as the CVPIA. The act makes significant changes to the management of this federal reclamation project and creates a complex set of new programs and requirements applicable to the project. The act covers five primary areas: limitations on new and renewed CVP contracts, water conservation and other water management actions, water transfers, fish and wildlife restoration actions, and establishment of an environmental restoration fund (DWR 1994).

The act establishes a $50 million annual habitat restoration fund and instructs Reclamation to allocate 800 TAF of water annually (600 TAF in a dry year) to the environment by 2002. The act also secures approximately 500 TAF in annual water supplies for Trinity River flows, Central Valley wildlife refuges, and the Grasslands Water District. With certain conditions, the act provides that those receiving CVP water can transfer all or a portion of that water to others. The act restricts new contracts for water supplies from the CVP for any purpose other than to benefit fish and wildlife, and the act requires the establishment of an office for CVP water conservation best management practices.

Reclamation, in its role as operator of the CVP, and USFWS, as directed by the Secretary of the Interior, are beginning to establish the interim guidelines and procedures necessary to implement the act's provisions; however, it will take a number of years to complete all the actions called for in the legislation (DWR 1994). Reclamation is working to complete a programmatic EIS analyzing implementation of the environmental restoration components of the act.

DWR Delta Water Management Programs

DWR is developing water management programs for the south, north, and west Delta. These programs will address the water resource problems unique to each region of the Delta, in the context of the entire Delta, state-

wide water supply projects, and the Governor's Water Policy.

North Delta Program

The North Delta Program study area encompasses the Delta region north of the San Joaquin River from Three-mile Slough eastward. Limited channel capacity in the north Delta has contributed to two major problems: reverse flow in the San Joaquin River (a consequence of SWP and CVP exports from the Delta) and repeated flooding of local leveed tracts. The intent of the North Delta Program is to allow greater floodflows to pass safely, while lowering flood levels throughout the area by dredging channels and building new setback levees to provide greater flood protection for Thornton and Walnut Grove and other Delta islands. Increasing channel capacity and reducing or eliminating reverse flows would create a more efficient means of transferring water through the north and central Delta, therefore providing additional water supply for SWP users and improving water quality. The North Delta Program will be investigated as a long-term solution and possibly as an interim action. (DWR 1994.)

South Delta Program

The South Delta Program area encompasses Union and Roberts Islands, Stewart Tract, and other lands near Tracy (DWR 1988a). The program's objective is to reconcile the water supply priorities of Reclamation, the CVP, and the SWP with needs for improved water quality while maintaining recreational opportunities in the south Delta. Water quality problems in the south Delta primarily relate to deleterious effects of water diversions by the CVP and SWP and by agriculture.

The Interim South Delta Water Management Program was initiated in response to an October 1986 agreement between DWR, Reclamation, and the South Delta Water Agency. The Interim South Delta Preferred Alternative includes:

- adding an intake structure for the SWP at Clifton Court Forebay;
- performing limited channel dredging in Old River north of the forebay;
- providing four flow-control structures to control water levels, circulation, and flow in the South Delta channels and to assist salmon migration in the San Joaquin River; and
- obtaining a Corps permit to allow the SWP to increase its existing pumping capacity of the Banks Pumping Plant up to 10,300 cfs during high-flow periods.

The Interim South Delta Water Management Program could augment the water supply of the SWP by an average of approximately 60 TAF per year (TAF/yr). (DWR 1994.)

West Delta Program

The West Delta Program addresses four major issues: flood control, water quality, wildlife concerns, and water supply reliability. The objectives of the West Delta Program are to:

- improve levees for flood control,
- protect Delta water quality,
- acquire island properties for development of diverse waterfowl and wildlife habitats,
- meet water supply and water quality needs of Sherman Island,
- minimize soil erosion and land subsidence,
- protect the reliability of the SWP and the CVP,
- identify potential wildlife habitat mitigation opportunities for present and future development projects,
- protect highways and utilities, and
- provide additional recreational opportunities.

Conversion of land from agriculture to managed wildlife habitat on Sherman and Twitchell Islands is the primary focus of the West Delta Program. Because of their location, 10,000-acre Sherman Island and 3,500-acre Twitchell Island are important for protecting the reliability and quality of the Delta water supply, providing wildlife habitat, and protecting highways and utilities.

DWR published an initial study and negative declaration on the proposed Sherman Island Wildlife Management Plan (DWR 1990b), under which the 10,000-acre Sherman Island would be operated as a wildlife management area by DFG. A framework agreement was signed by DWR and DFG on June 24, 1991, on the suitability of Sherman and Twitchell Islands to serve as mitigation for

the Clifton Court Forebay enlargement component or another feature of the South Delta Program.

DWR Delta Levee Maintenance Program

Subventions Program

Maintenance and improvement of levees in the Delta are normally conducted by local reclamation districts using matching funds from DWR or the Federal Emergency Management Agency (FEMA). The procedures and funding for levee work have recently been altered by Senate Bill 34 (SB 34) (the Delta Flood Protection Act of 1988), which increases state funding for flood protection. The DWR subventions program was changed in the following ways by SB 34:

- annual funds available rose from $2 million to $6 million;
- state cost sharing for local assistance programs increased from 50% to 75%;
- reimbursements were made available for levee improvements and maintenance, items formerly disallowed by FEMA; and
- requirements were established for DFG approval of reclamation district plans to ensure that no net loss of wildlife habitat occurs.

Special Projects

In addition to the subventions program adjustments outlined above, SB 34 called for DWR to prepare plans and priorities for flood protection and subsidence studies and monitoring on eight western Delta islands and the towns of Walnut Grove and Thornton. Of the DW islands, Webb and Holland Tracts are included in the eight islands, for which $6 million will be provided annually. The eight islands, if permanently flooded, would pose a significant threat to Delta water quality because of increased evaporation and increased upstream movement of ocean salts and substantial loss of available Delta water supply (DWR 1988b, 1990a). Recent activities include planning and designing major levee rehabilitation projects for Twitchell Island and New Hope Tract; repairing vulnerable levee sites on Sherman Island, Twitchell Island, Bethel Island, and Webb Tract; and conducting other special projects and studies to determine the causes of Delta land subsidence (DWR 1994).

Delta Ecological Studies

DWR, DFG, Reclamation, and SWRCB are participating in an Interagency Ecological Program (IEP) in the Delta. The study program is intended to improve understanding of fish and wildlife requirements in the Bay-Delta estuary and establish operating criteria for the CVP and SWP export pumps to protect fish and wildlife.

Several specific topics are examined in the IEP. The populations, habitat requirements, and effects of flows on striped bass, salmon, and the species of concern and methods of reducing fish kills by pumps and diversions have been explored. Water quality issues have also been investigated, especially algal blooms, drought effects, and improved water quality modeling. Efforts have focused on the Delta, Suisun Marsh, and San Francisco Bay to determine the actions needed to maintain habitat quality in those ecosystems.

DWR Offstream Storage South of the Delta

To increase the amount of water available to SWP customers, DWR has proposed constructing several offstream storage facilities south of the Delta.

Los Banos Grandes

DWR proposed to construct the Los Banos Grandes project, an offstream reservoir complex located on Los Banos Creek in western Merced County, to serve as a south-of-the-Delta water banking unit for the SWP. Los Banos Grandes would store Delta winter flows pumped from the Delta through the California Aqueduct during the wet months (November to April). Los Banos Grandes would be infeasible without the South Delta Program. (DWR 1991.)

A draft EIR was released to the public for review in December 1990. The review and comment period ended September 30, 1991. Los Banos Grandes requires a Section 404 permit from the Corps under the Clean Water Act. A notice of intent to prepare a draft EIS was released in February 1991 with the Corps as the lead agency under NEPA. However, due to the recent Endangered Species Act actions in the Delta and changes to water quality standards, the feasibility of the project is being reassessed. The actual sizing and schedule is highly dependent on the selection of a long-term solution for

resolving fishery issues and facilitating efficient water transfer through the Delta.

Kern Water Bank

The Kern Water Bank is defined as the collective opportunity to store and extract SWP water in the Kern County groundwater basin under a contract between DWR on behalf of the SWP and the Kern County Water Agency. The Kern Water Bank consists of eight potential elements or separate components. Seven of the elements would be sponsored by local water districts, and the eighth element would be DWR's Kern Fan Element. A programmatic EIR was completed for the Kern Fan Element in 1986. However, DWR is awaiting an assessment of the availability of future water supply for the project. For now, the planning program is focused on completion of a habitat conservation plan, incidental-take permits for terrestrial species in the Kern Fan Element area, and analysis of project economics. Once an adequate water supply is identified, the Kern Fan Element will be reassessed, final environmental documentation will be issued, and a program for further evaluation of local elements will be considered. If feasible, the Kern Fan Element would be developed to store as much as 1 million acre-feet (MAF) of water and contribute as much as 140 TAF per year to the SWP in drought years.

SWP Coastal Branch Project, Phase II

The Coastal Branch Project, Phase II, will complete the Coastal Branch of the SWP's California Aqueduct. The 102-mile buried pipeline would transport SWP water to San Luis Obispo and Santa Barbara County Flood Control and Water Conservation Districts. This project would deliver a total of about 5 TAF/yr to San Luis Obispo County and 42 TAF/yr to Santa Barbara County.

The final EIR for the Coastal Branch Project was released in May 1991 and the notice of determination was filed in July 1992. Construction began in late 1993 and is scheduled to be completed in early 1997 (DWR 1994).

CCWD Los Vaqueros Project

The Los Vaqueros Project, under construction by Contra Costa Water District (CCWD), will consist of a 100 TAF reservoir within the Kellogg Creek watershed and associated appurtenant facilities, including a new supplemental Delta intake location, conveyance pipelines, a transfer reservoir, pumping plants, and other facilities necessary for project operation. Water diverted from the new Delta intake location will be pumped to the Los Vaqueros Reservoir site during periods when Delta water quality is good. In late summer and fall, when Delta water quality deteriorates, reservoir water to be used within CCWD's service area will be released and blended with Delta water from direct diversions from Rock Slough to reduce salinity.

CCWD has a contract with Reclamation, under Reclamation's existing water right for CVP water, for 195 TAF/yr, which would be adequate to meet CCWD's future water needs. Because of physical constraints in CCWD's delivery system, current diversions are limited to approximately 135 TAF/yr. Currently, CCWD diverts approximately 120-130 TAF/yr of water from Rock Slough, the amount diverted depending on the water-year type. CCWD can also divert up to 26,780 af/yr of water from Mallard Slough in the Delta, although water is rarely diverted because of poor water quality. The Los Vaqueros Project would change the timing of CCWD's diversions and could affect the proportion of water diverted from the Delta during various times of the year.

A draft EIR/EIS for the Los Vaqueros Project was issued for public review on March 3, 1992. After public review, a final Stage II EIR/EIS for the Los Vaqueros Project was published on September 27, 1993, and a Section 404 permit was issued by the Corps in May 1994. A water right decision on the project was issued by SWRCB in June 1994.

Montezuma Wetlands Project

The Montezuma Wetlands Project, a privately financed project, would use deposited dredged materials on a diked bayland site adjacent to the Suisun Marsh in Solano County to restore 1,822 acres of tidal wetlands (including some seasonal wetland features). The proposal calls for constructing facilities to receive up to 20 million cubic yards of approved dredged materials from ports and navigation channels in the San Francisco Bay estuary and to distribute the dredged materials over the site to raise the subsided land surface to an elevation range at which marsh habitat could become established.

The project's potential benefits include restoration of a tidal marsh ecosystem at a scale unprecedented for the region, which could support abundant wildlife, fish, estuarine production, and a diversity of marsh species (including special-status species) and habitats. The

project would also provide significant capacity for disposal of sediments dredged from Bay Area ports or navigation channels. The project's potential adverse impacts include loss of established seasonal wetlands and endangered species populations and a possible release of contaminants from dredged materials into the marsh system.

A draft EIR/EIS for the Montezuma Wetlands Project was issued by Solano County and the Corps in October 1994 (Corps and Solano County 1994). The public review period for the EIR/EIS ended on December 19, 1994. A final EIR/EIS is expected to be completed in July 1995 (Glas pers. comm.).

Delta Water Transfers

Water obtained under a water right can be transferred by the water right holder to another party. Water transfers can be used to help meet water supply shortages with possibly fewer environmental impacts and less cost than construction projects. Short-term (1 year or less) temporary transfers require SWRCB approval but are exempt from CEQA compliance, whereas long-term transfers require full CEQA compliance.

SWRCB must approve water transfers that require changes in terms or conditions of existing water right permits. SWRCB does not intend to approve long-term transfers through the Delta until a full assessment of cumulative environmental impacts is prepared.

DWR (1994) describes the functioning of the 1992 State Drought Water Bank, a temporary water transfer program, and provisions of the CVPIA regarding water transfers.

Reoperation of Folsom Dam and Reservoir

Reclamation and the Sacramento Area Flood Control Agency (SAFCA) are considering options involving the reoperation of Folsom Reservoir to permit the containment of a 100-year or larger flood event in the American River watershed. The options are interim measures until the Corps completes a study of permanent reoperation of Folsom Reservoir and a plan is authorized by Congress. Two interim reoperation options, which would maintain maximum flood storage capacities at Folsom Reservoir of 670 TAF and 800 TAF, respectively, were analyzed by Reclamation and SAFCA in an environmental assessment/EIR (EA/EIR). The EA/EIR found that substantial impacts on water supply, hydropower, and other resources dependent on water surface elevations in the reservoir can be avoided or mitigated (SAFCA and Reclamation 1994).

This study evaluates the impacts of increasing the dedicated flood control space in Folsom Reservoir. Study results will be used to decide whether Folsom Dam and Reservoir will be reoperated on a permanent basis to provide increased levels of flood protection to the Sacramento area. If reoperation occurs, storage space now used for water supply, power production, and recreation would be used instead for flood control mitigation. A draft reoperation plan and draft EIS will be issued in 1995. When completed and authorized by Congress, the plan will replace Reclamation's and SAFCA's interim reoperation plan described above.

East Bay Municipal Utility District Activities

American River Diversions

The East Bay Municipal Utility District (EBMUD) contracted with Reclamation in 1970 to purchase up to 150 TAF/yr from the American River watershed for delivery by diversion into the Folsom-South Canal at Nimbus Dam, immediately below Folsom Reservoir. In 1972, the Environmental Defense Fund and others filed a lawsuit that seeks to prevent EBMUD from diverting water from the American River; Reclamation was not a party to this lawsuit. In late 1984, the court appointed SWRCB as referee and directed the board to conduct an investigation and prepare a report on 21 specific legal, technical, and public trust issues.

In June 1988, SWRCB issued its final report responding to the instructions of the court. SWRCB recommended that EBMUD be allowed to divert water from the Folsom-South Canal subject to specified river flow limitations.

A final decision was issued in May 1990 by the court. According to this decision, EBMUD may divert 150 TAF/yr of water from the Folsom-South Canal pursuant to the contract of December 22, 1970. Instream flow requirements are set at 2,000 cfs for October 15 through February, 3,000 cfs for March through June, and 1,750 cfs for July through October 15. However, the current EBMUD board has decided not to divert water from the American River at this time.

Water Supply Management Program

In 1989, EBMUD developed a Water Supply Management Program to identify the actions and projects necessary to provide a dependable water supply to communities of the eastern San Francisco Bay Area. One action proposed by the program was the construction of a 145-TAF terminal reservoir called Buckhorn Reservoir. In January 1989, EBMUD released the final EIR and the technical report for the district's program. The final EIR was the subject of litigation, and EBMUD decided to reevaluate the proposed project and other facility improvements.

A new EIR/EIS for the updated Water Supply Management Program and water supply improvement projects was prepared by EBMUD and the Corps. The present program includes six options: one involving raising Pardee Reservoir, two groundwater banking options using either American River or Mokelumne River water, a Delta diversion option using American River water under the EBMUD contract with Reclamation, a conservation-only option, and an option for groundwater use only. EBMUD has identified a need for 130 TAF of water in 2020.

After several hearings and extensive evaluation, EBMUD's board of directors designated two of the six composite programs as preferred alternatives. The main element of each alternative is the use of groundwater storage. One of the preferred alternatives would store available surface water in an underground basin during wet years and draw from the storage during dry years for agricultural irrigation to augment flows in the lower Mokelumne River or pump into the aqueducts for use by EBMUD's customers. Another preferred alternative includes the same components mentioned above, plus a supplemental water supply from the American River. (DWR 1994.)

Activities of the Metropolitan Water District of Southern California

Arvin-Edison/Metropolitan Water District Storage and Exchange Program

The Arvin-Edison Water Storage District (Arvin-Edison), in partnership with the Metropolitan Water District of Southern California (MWD), is proposing a water storage and exchange program that would extend through 2035. During years of storage (when additional SWP water is available), MWD would store SWP water in Arvin-Edison's groundwater basin. During years of recovery, MWD would receive a portion of Arvin-Edison's CVP supplies in exchange for water MWD previously placed in storage in Arvin-Edison. The proposed alternative would result in the additional diversion of approximately 1 MAF from the Delta over the approximately 45-year life of the program. (EIP Associates 1992.) A draft EIR/EIS was issued in January 1992. However, recent actions to protect aquatic species in the Delta and implementation of the CVPIA have restricted operations in the Delta. Consequently, MWD and Arvin-Edison are currently reassessing the project (DWR 1994).

Domenigoni Reservoir Project

The proposed reservoir in western Riverside County would be constructed in Domenigoni Valley near the junction of the Colorado River Aqueduct, the San Diego Canal, and the SWP East Branch Aqueduct. The reservoir would have a capacity of 800 TAF. The reservoir would receive water, when available, from various sources through the Colorado River Aqueduct and SWP delivery facilities with some shift of SWP deliveries from summer to winter. The project would provide emergency storage, carryover, seasonal storage; preserve operating reliability; provide substantial wildlife mitigation; and optimize groundwater recharge programs. (DWR 1994.)

A draft EIR was issued in June 1991, and a final EIR was issued in October 1991. The final EIR was certified early in 1992, and mitigation and construction design is ongoing. The current MWD schedule indicates that the project would be operational by the end of this decade. However, it could take about 5 or more years to fill the reservoir, so the full benefit of the reservoir may not be realized until after 2004 (DWR 1994).

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Appendix 2, Table 2–1. Monthly Percentiles for Simulated Diversions, End–of–Month Storage Volumes, and Discharges for Alternative 1

Percentile	October	November	December	January	February	March	April	May	June	July	August	September
DW diversion (TAF)												
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	1	0	0	0	0	0	0	0	0
50	0	0	1	1	2	3	0	0	0	0	0	0
60	0	1	1	1	2	3	0	0	0	5	0	0
70	3	1	1	14	2	3	0	0	0	5	0	0
80	63	54	24	65	2	3	4	6	0	5	0	0
90	185	238	107	204	137	5	4	6	2	5	4	44
100	238	238	238	238	222	238	11	18	7	8	7	238
Mean	39	41	31	42	24	13	1	2	1	3	1	22
DW storage (TAF)												
0	0	0	0	(0)	0	0	(0)	(0)	0	(0)	(0)	(0)
10	0	0	0	0	0	0	0	0	0	(0)	(0)	(0)
20	0	0	0	0	14	56	7	0	0	0	0	0
30	0	0	0	61	174	218	151	110	86	0	0	0
40	0	0	2	236	233	232	196	148	131	5	0	0
50	0	0	148	238	236	235	229	176	155	34	0	0
60	0	196	225	238	238	238	234	209	185	88	0	0
70	39	238	238	238	238	238	234	227	194	138	0	0
80	201	238	238	238	238	238	238	232	225	161	6	0
90	238	238	238	238	238	238	238	238	233	183	80	164
100	238	238	238	238	238	238	238	238	238	238	238	238
Mean	65	105	122	162	175	181	167	148	135	75	23	26
DW discharge for export (TAF)												
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	27	0
70	0	0	0	0	0	0	0	25	0	70	61	0
80	0	0	0	0	0	0	37	29	8	160	116	0
90	0	0	22	0	0	0	46	51	35	202	164	71
100	0	31	205	166	222	165	79	113	168	230	230	201
Mean	0	1	13	2	10	5	12	16	8	56	49	18

Source: Results from DeltaSOS simulation of Alternative 1 based on hydrologic record for 1922–1991 (70 years) (see Appendix A3).

Appendix 2, Table 2–2. Monthly Percentiles for Simulated Diversions, End–of–Month Storage Volumes, and Discharges for Alternative 2

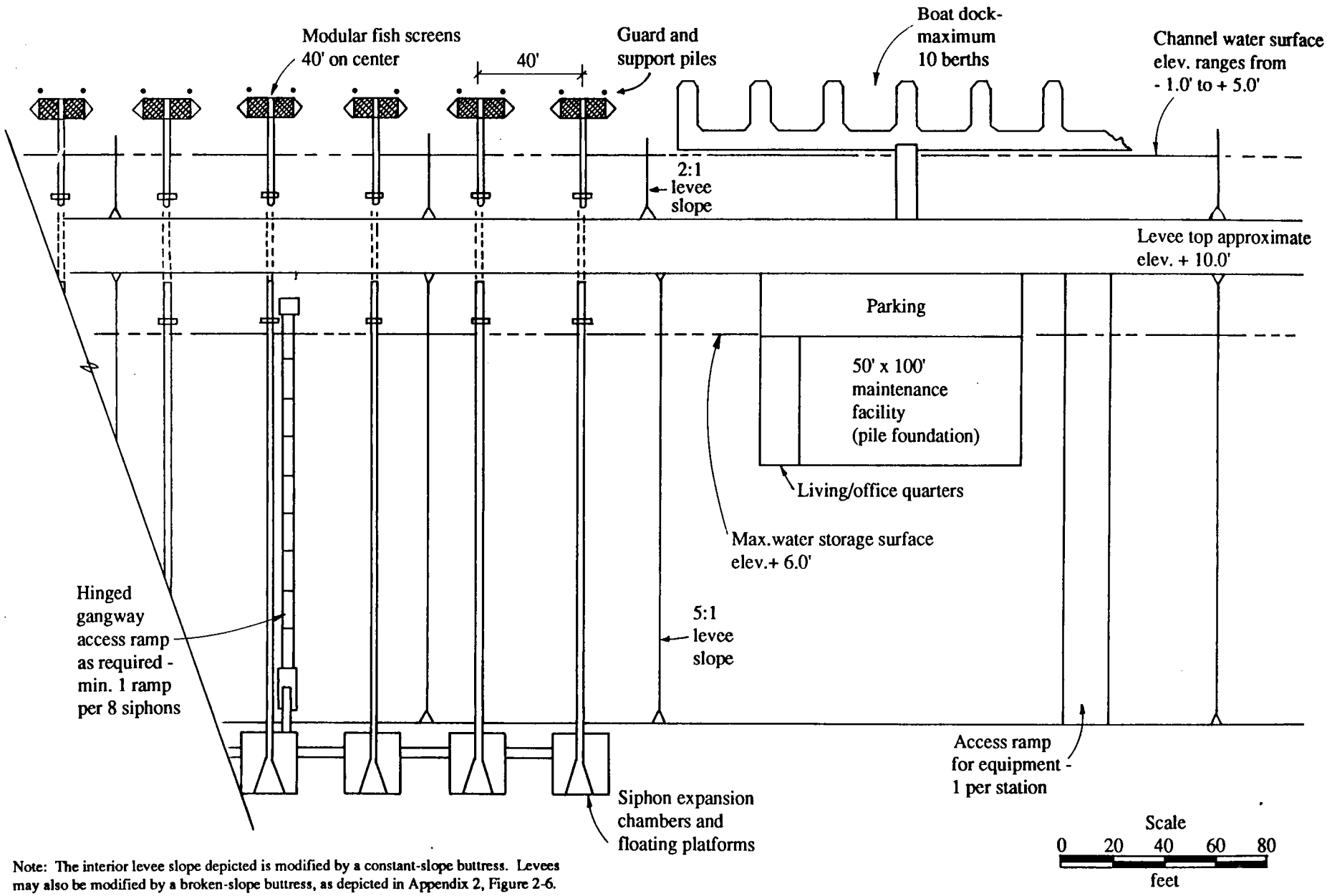
Percentile	October	November	December	January	February	March	April	May	June	July	August	September
DW diversion (TAF)												
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	1	0	0	0	0	0	0	0	0
60	0	0	1	1	2	3	0	0	0	5	0	0
70	3	1	1	1	2	3	0	0	0	5	0	0
80	63	1	1	6	2	3	0	0	0	5	0	0
90	185	54	24	61	2	3	4	6	0	5	0	0
100	238	238	107	204	137	40	4	6	2	5	4	44
Mean	39	238	238	238	222	238	186	19	7	8	7	238
		41	31	40	24	14	5	2	1	3	1	22
DW storage (TAF)												
0	0	0	0	(0)	(0)	(0)	0	0	(0)	(0)	(0)	(0)
10	0	0	0	0	0	0	0	0	(0)	0	(0)	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	61	14	0	0	0	0	0	0	0
50	0	0	2	226	145	15	30	8	0	0	0	0
60	0	0	174	238	222	226	200	99	0	5	0	0
70	39	196	233	238	238	238	225	169	0	5	0	0
80	201	238	238	238	238	238	234	204	62	5	0	0
90	238	238	238	238	238	238	238	232	147	28	0	0
100	238	238	238	238	238	238	238	238	233	137	4	164
Mean	65	238	238	238	238	238	238	238	238	238	238	238
		105	125	161	147	133	130	111	61	30	9	26
DW discharge for export (TAF)												
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	16	7	0	0	0
90	0	0	0	0	59	11	0	28	132	27	0	0
100	0	0	8	0	186	142	25	54	195	160	57	0
Mean	0	31	205	167	222	235	63	231	225	230	230	170
		1	11	3	37	27	5	17	46	30	18	5

Source: Results from DeltaSOS simulation of Alternative 2 based on hydrologic record for 1922–1991 (70 years) (see Appendix A3).

Appendix 2, Table 2–3. Monthly Percentiles for Simulated Diversions, End–of–Month Storage Volumes, and Discharges for Alternative 3

Percentile	October	November	December	January	February	March	April	May	June	July	August	September
DW diversion (TAF)												
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	2	0	0	0	0	0	0	0	0
50	0	0	2	2	3	6	0	0	0	0	0	0
60	0	3	2	6	3	6	0	0	0	10	0	0
70	6	14	50	39	3	6	0	0	0	10	0	0
80	150	145	68	98	39	6	9	12	0	10	0	0
90	231	339	259	204	178	47	9	12	2	10	8	46
100	368	356	368	368	333	368	178	30	14	16	14	356
Mean	61	68	59	60	42	20	7	3	1	5	1	26
DW storage (TAF)												
0	0	0	0	(0)	(0)	(0)	0	0	(0)	(0)	(0)	(0)
10	0	0	0	0	0	(0)	0	0	(0)	0	0	0
20	0	0	0	0	1	0	0	0	0	0	0	0
30	0	0	0	102	107	0	0	0	0	0	0	0
40	0	0	5	275	265	123	129	102	0	10	0	0
50	0	0	248	369	337	364	360	234	37	10	0	0
60	0	197	369	406	406	406	387	312	95	31	0	0
70	42	357	402	406	406	406	397	368	209	66	0	0
80	201	406	406	406	406	406	406	394	298	160	8	0
90	406	406	406	406	406	406	406	406	394	275	64	166
100	406	406	406	406	406	406	406	406	406	406	406	406
Mean	94	161	208	263	259	232	227	206	127	76	21	34
DW discharge for export (TAF)												
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	9	0	17	60	0	20	0
80	0	0	0	0	66	68	2	26	195	90	54	0
90	0	0	8	0	196	158	25	51	278	164	211	41
100	26	28	230	167	333	305	61	184	291	368	321	233
Mean	0	1	11	4	43	42	5	17	70	48	48	11

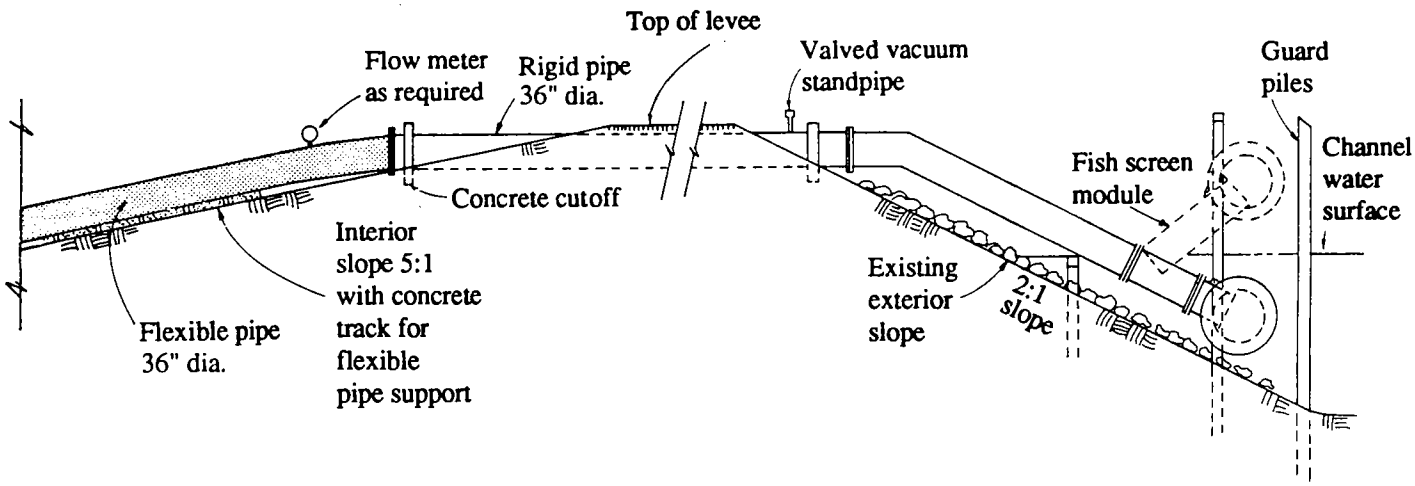
Source: Results from DeltaSOS simulation of Alternative 3 based on hydrologic record for 1922–1991 (70 years) (see Appendix A3).

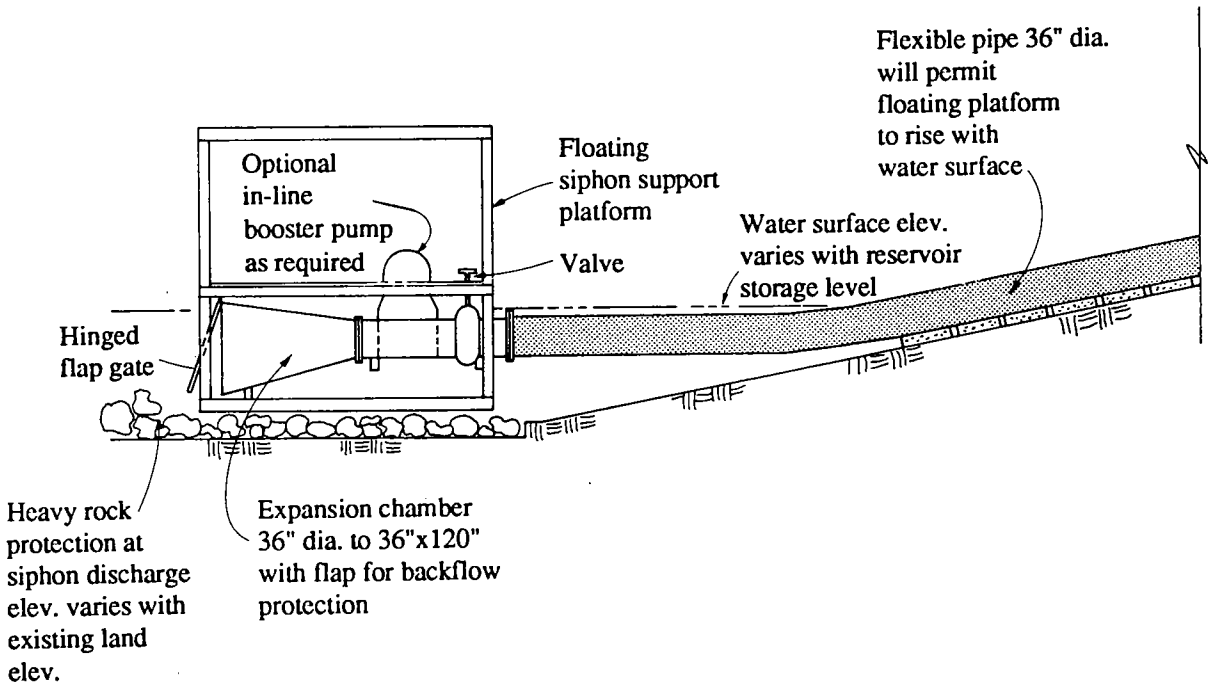


Note: The interior levee slope depicted is modified by a constant-slope buttress. Levees may also be modified by a broken-slope buttress, as depicted in Appendix 2, Figure 2-6.

Appendix 2, Figure 2-1.
Siphon Station Plan View

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



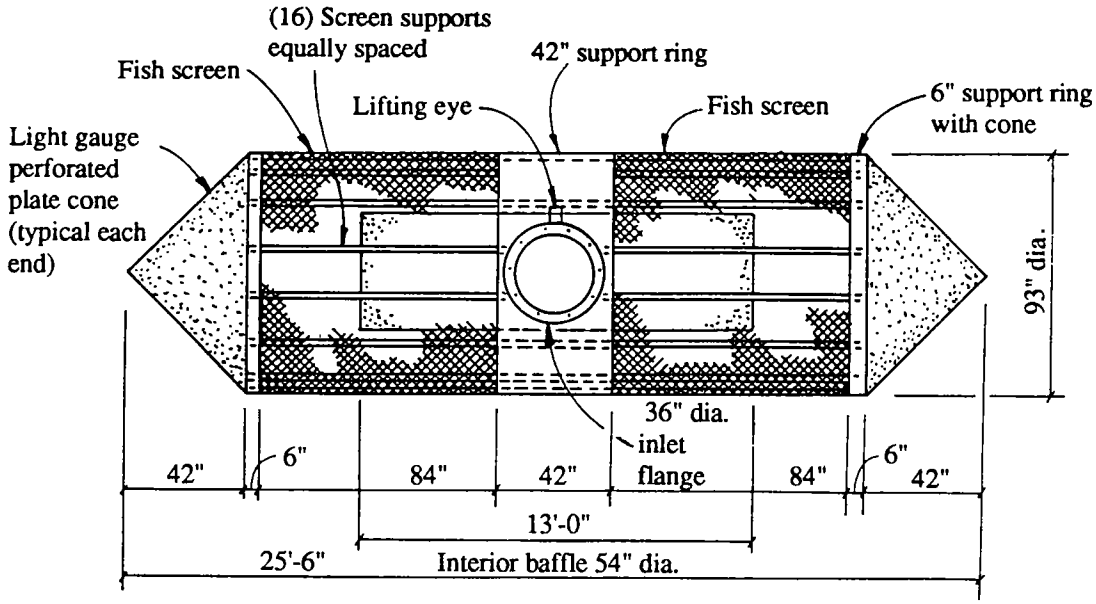


Scale
0 5 10 15
feet

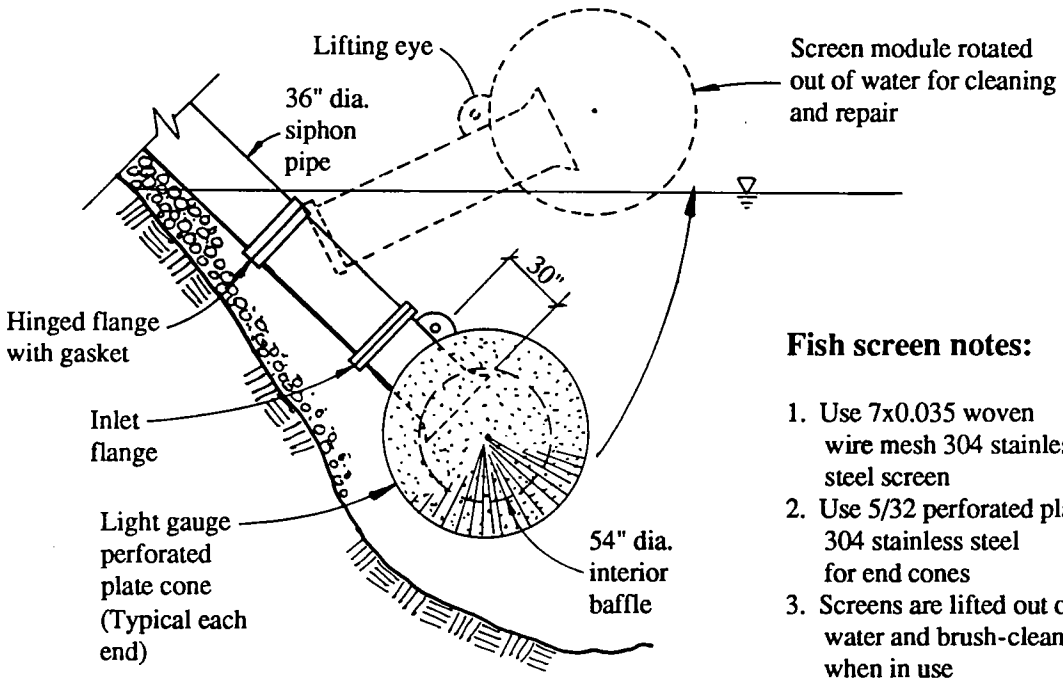
Note: The interior levee slope depicted is modified by a constant-slope buttress. Levees may also be modified by a broken-slope buttress, as depicted in Appendix 2, Figure 2-6.

Appendix 2, Figure 2-2.
Conceptual Siphon Unit

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



Front view



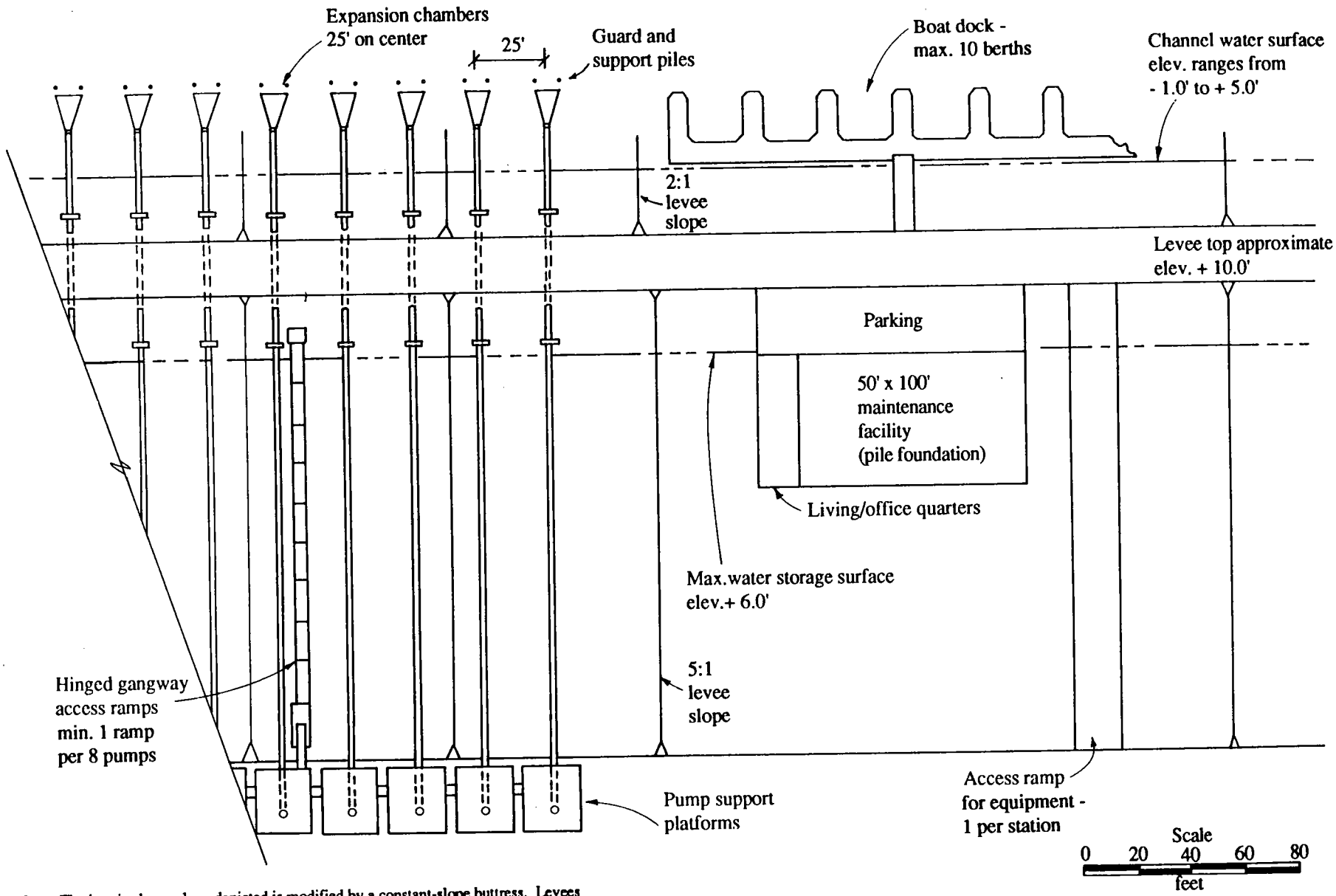
Side view

Fish screen notes:

1. Use 7x0.035 woven wire mesh 304 stainless steel screen
2. Use 5/32 perforated plate 304 stainless steel for end cones
3. Screens are lifted out of water and brush-cleaned when in use
4. Screens are removed from water when not in use
5. Interior baffle, 16 gauge stainless steel with 1" dia. perforations, 25% open

Appendix 2, Figure 2-3.
Fish Screen Design

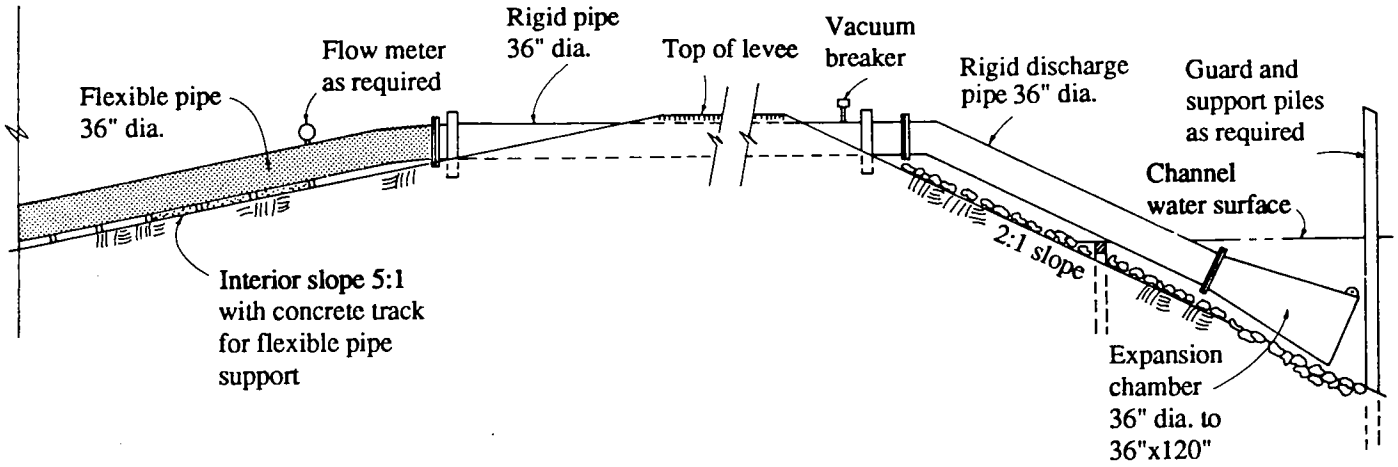
DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

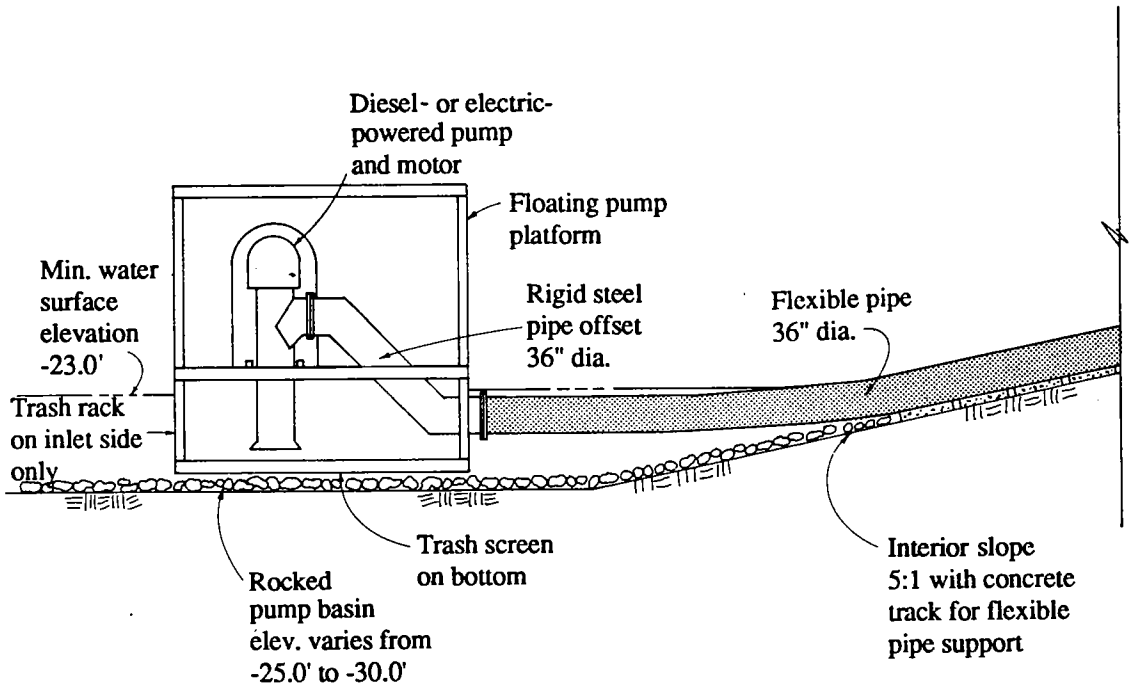


Note: The interior levee slope depicted is modified by a constant-slope buttress. Levees may also be modified by a broken-slope buttress, as depicted in Appendix 2, Figure 2-6.

Appendix 2, Figure 2-4.
Pump Station Plan View

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



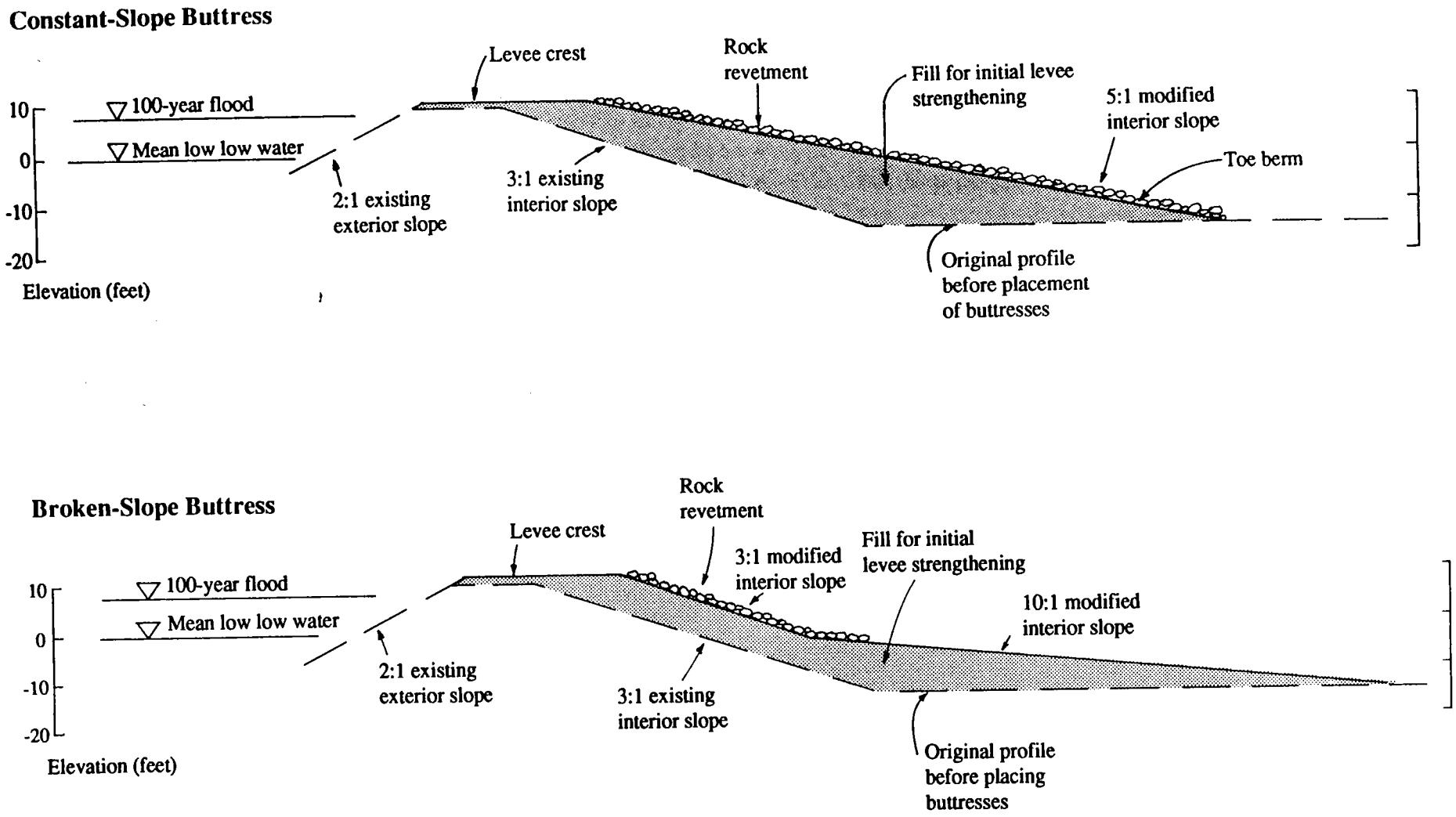


Scale
0 5 10 15
feet

Note: The interior levee slope depicted is modified by a constant-slope buttress. Levees may also be modified by a broken-slope buttress, as depicted in Appendix 2, Figure 2-6.

Appendix 2, Figure 2-5.
Conceptual Pump Unit

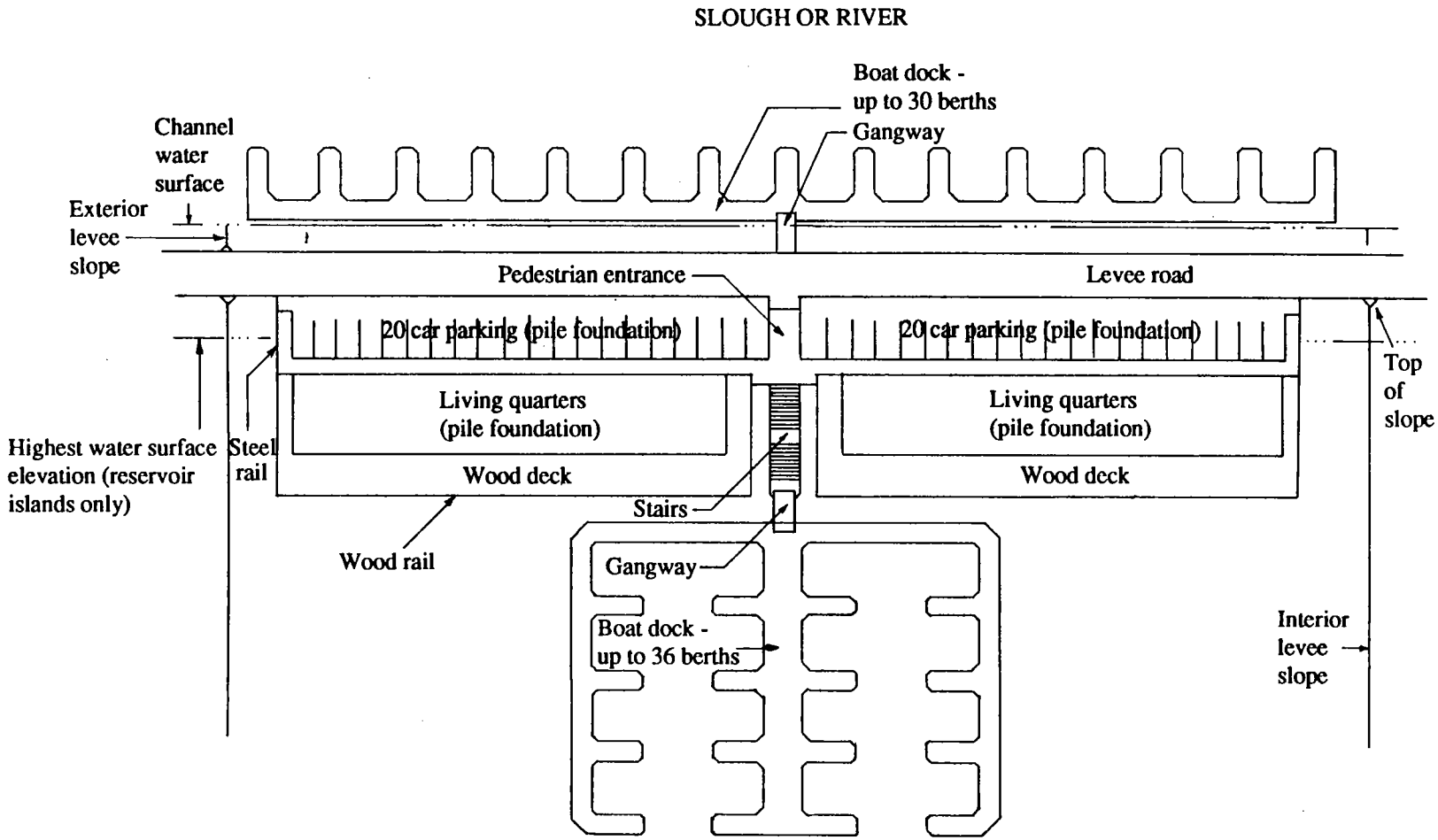
DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



Source: Harding Lawson Associates 1993.

Appendix 2, Figure 2-6.
Examples of Levee Modification on Reservoir Islands

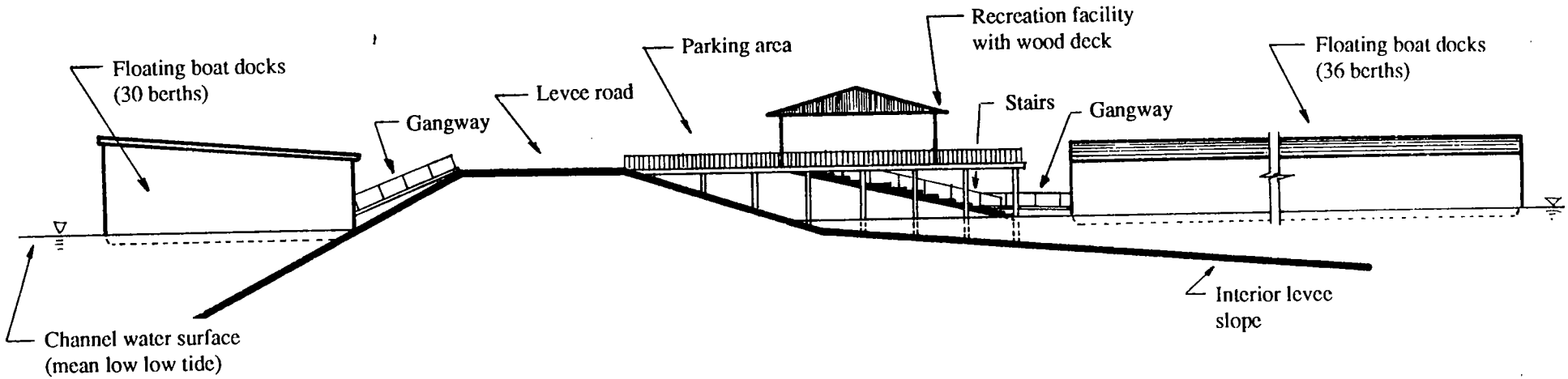
DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



Note: A network of ditches and canals leading from interior boat docks would provide access for small boats to island interiors on each of the habitat islands and reservoir islands.

Appendix 2, Figure 2-7.
Conceptual Recreation Facility - Plan View

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



0 30

Approximate scale in feet

Note: A network of ditches and canals leading from interior boat docks would provide access for small boats to island interiors on each of the habitat islands and reservoir islands.

Appendix 2, Figure 2-8.
Conceptual Recreation Facility - Cross Section

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

Appendix A1. Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project

Appendix A1. Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project

SUMMARY

This appendix describes the two monthly Delta water budgets required for modeling Delta Wetlands (DW) project operations using the Delta Standards and Operations Simulation (DeltaSOS) model, which was developed by Jones & Stokes Associates (JSA) to represent possible DW operations under various scenarios for Delta conditions and standards. The Delta boundary water budget for DeltaSOS simulations represents systemwide hydrology, including operations of upstream reservoirs, inflows to the Delta, Delta channel depletions, Delta exports, and Delta outflow. The DW island water budget represents water use on the DW project islands and includes rainfall, consumptive use, and channel depletion.

The boundary water budget is based on results from DWRSIM, the Delta operations model used by California Department of Water Resources (DWR). The DeltaSOS water budget terms are based on DWRSIM simulations that assumed compliance with the objectives specified in the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (1995 WQCP) and land use demands projected to exist in 1995. DWRSIM was used by California State Water Resources Control Board (SWRCB) to evaluate the 1995 WQCP objectives and is the most commonly used model to evaluate California water management alternatives.

The reliability of the DWRSIM simulations was confirmed by comparison of DWRSIM input assumptions and output with historical streamflow and reservoir storage measurements and unimpaired streamflow estimates. The general agreement between these historical and simulated values supports the adequacy of the DWRSIM simulations that were used to describe the Delta boundary water budget; the simulations therefore provide a reasonable basis for evaluating DW project operations and potential environmental impacts under a variety of operating criteria, existing Delta standards, and hydrologic conditions using DeltaSOS.

The DW island water budget is based on the general water budget estimated for the portion of the Delta islands constituting irrigated Delta lowlands. The average monthly values for DW island water budget terms are based on DeltaDWQ model results for water years 1967-1991 (as presented in Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model"). Some of the basic data needed to estimate the DW island water budget terms are measurable (presented in this appendix); other values must be estimated indirectly. The estimated water budget for the DW project islands is adequate for DeltaSOS modeling of DW project impacts.

The DeltaSOS model uses the calculated change in the DW island water budget between intensified agricultural use and DW project operations to adjust the channel depletion values from DWRSIM. DeltaSOS is then used to simulate monthly DW project operations, as controlled by the DWRSIM initial Delta boundary water budget, appropriate Delta objectives and requirements, and selected DW operating criteria.

INTRODUCTION

Purpose of This Appendix

The purpose of this appendix is to describe the monthly Delta water budgets used as input to the DeltaSOS model. DeltaSOS simulations were used to assess potential impacts of each of the DW project alternatives on water supply, Delta channel hydrodynamics, water quality, and fisheries (see Chapters 3A, 3B, 3C, and 3F, respectively).

Two monthly Delta water budgets are needed to evaluate likely effects of DW project operations. One consists of Delta boundary (systemwide) estimates of Delta inflows, exports, and outflow; the boundary water budget is based on results from DWR's Delta operations model, DWRSIM. The other water budget represents water use estimated for operations on the DW project islands and consists of estimates for rainfall, evaporation or crop evapotranspiration (ET), soil moisture, seepage, applied irrigation and salt leaching water, and drainage water. Both the Delta boundary and DW island monthly water budgets are described in this appendix, and their reliability for use in the DeltaSOS model are confirmed.

Reliability of Operations Modeling of the DW Project

The DeltaSOS model was developed by JSA to represent possible DW operations in the context of various scenarios for Delta conditions and standards. DeltaSOS operations modeling of the DW project uses results of DWRSIM study "1995-C6B-SWRCB-409", performed in January 1995 by DWR to evaluate proposed 1995 WQCP objectives. These simulations assume current Delta facilities and operational constraints and the 1995 level of development, in addition to 1995 WQCP objectives. These DWRSIM results were used as the initial Delta water budget for DeltaSOS simulations of channel flows, outflow, exports, and DW operations under a wide variety of hydrologic conditions for each of the DW project alternatives, based on the 70-year hydrologic record for water years 1922-1991. DeltaSOS is described in Appendix A2, "DeltaSOS: Delta Standards and Operations Simulation Model". Details of the application of DeltaSOS to evaluation of the DW project alternatives and DeltaSOS results are provided in Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives".

DeltaSOS does not simulate operations of upstream Sacramento or San Joaquin River reservoirs nor the operations of south-of-Delta aqueducts or reservoirs. Direct simulation of likely effects of full integration of the proposed DW project with State Water Project (SWP) and Central Valley Project (CVP) operations is not possible with DeltaSOS.

DWRSIM results provide a simplified representation of CVP and SWP operations that were used as a basis for assessing water supply effects of the proposed DW project. "Delta Monthly Water Budget Simulated by DWRSIM", below, describes DWRSIM simulations of operations of upstream reservoirs and presents the historical operations of these reservoirs for water years 1967-1991 for confirmation of modeling results. Historical Delta inflows, exports, and outflows for water years 1967-1991 are also documented in this section. This 25-year period was selected for confirmation of DWRSIM simulations because nearly all CVP and SWP facilities were operating during these years. Demands for Delta exports increased substantially during this period to approximately 6 million acre-feet per year (MAF/yr) in 1989 and 1990. All references to hydrologic data and simulation results are based on water years (October-September).

Operations modeling for the DW project is designed to provide a measure of the relative effects of various DW project alternatives under constant sets of systemwide assumptions. DeltaSOS is used to simulate Delta conditions that are consistent with assumed systemwide hydrology and export demands and that satisfy assumed objectives governing Delta conditions. Relative environmental effects can then be evaluated by comparing DeltaSOS results for operation of each DW project alternative with those for operations under the No-Project Alternative. The comparison of relative effects between the simulation cases for the DW project alternatives and the No-Project Alternative is the primary focus for impact analysis. The fact that the set of systemwide assumptions on hydrology and demands used in DWRSIM and DeltaSOS have unknown or uncertain accuracy is therefore not crucial for the purposes of comparative impact analysis between alternatives. It is important, nevertheless, to demonstrate that DWRSIM results provide a reasonable representation of conditions that can be expected in the Delta under the 1995 WQCP objectives and operating criteria for the SWP and the CVP. The impacts that are simulated and discussed in this EIR/EIS are representative of the range of effects that would be expected under actual operations of the DW project.

DeltaSOS is a tool for evaluating Delta environmental impacts on a monthly average time scale under a wide range of hydrologic conditions. The likely effects of daily Delta conditions on operations of the proposed DW project are described in Appendix A4, "Possible Effects of Daily Delta Conditions on Delta Wetlands Project Operations and Impact Assessments". Both monthly and daily simulation results will be used for establishing final project capacities or operating constraints.

DELTA MONTHLY WATER BUDGET SIMULATED BY DWRSIM

DWRSIM Model Description

DWRSIM is the DWR monthly planning model for California, which simulates potential operations of the major SWP and CVP project facilities with specified operational constraints, such as 1995 WQCP objectives and export limits (DWR 1985). The DWRSIM model was based on a general HEC-3 reservoir system analysis program but has been extensively modified to simulate many unique features of the CVP and SWP facilities and operations (DWR 1986). Several additional features have been added to properly represent the 1995 WQCP objectives. The DWRSIM model was used by SWRCB to evaluate the likely water supply effects of the WQCP compared with existing Delta operating objectives, and is one of the most widely used water resource planning models for California (SWRCB 1995).

Streams and Facilities Modeled in DWRSIM

Figure A1-1 shows the major streams and facilities that are included in the DWRSIM model. The two major streams tributary to the Delta are the Sacramento River and San Joaquin River. The DWRSIM simulates some, but not all, of the major tributary facilities. The simulation of upstream facility operations is important because some of these operations are controlled by Delta outflow requirements and export limits. The reservoir releases are also governed by flood control storage rules, instream flow requirements, power generation constraints, and upstream diversion targets. The following overview of these upstream facilities included in DWRSIM will help the reader understand and evaluate the DWRSIM-simulated Delta boundary water budget.

Because the major upstream SWP storage facility is Oroville Reservoir, located on the Feather River, the Feather River is simulated in DWRSIM. Oroville Reservoir, with a capacity of about 3.5 MAF, releases water for Feather River diversions, Delta outflow requirements, and Delta exports into the California Aqueduct. Thermalito Forebay and Afterbay act as regulating reservoirs for peaking power releases from Oroville Reservoir. Oroville-Thermalito can be operated as a pumped-back facility for peaking power generation.

The Yuba River, a major tributary of the Feather River, is not modeled by DWRSIM because operations of the major storage reservoir, New Bullards Bar, are controlled by Yuba County Water Agency. The monthly operations of several local water resource facilities, such as New Bullards Bar, are assumed to remain unchanged by potential SWP operations, and are specified as fixed time-series inputs to DWRSIM.

The Trinity River is included in DWRSIM because major CVP facilities have been constructed on the Trinity River to store water and divert it to the Sacramento River. Clair Engle Reservoir has a capacity of about 2.5 MAF. Lewiston Reservoir acts as a regulating reservoir for peaking power releases from Clair Engle Reservoir and as the diversion intake for the Judge Francis Carr tunnel and power plant, which releases into Whiskeytown Reservoir. Whiskeytown Reservoir, with a capacity of about 225 thousand acre-feet (TAF) on Clear Creek, provides seasonal storage and diversions to the Spring Creek power plant, which releases into Keswick Reservoir on the Sacramento River.

Shasta Reservoir, with a capacity of about 4.5 MAF, is the largest CVP storage facility and releases water for Sacramento Valley diversions, Delta outflow requirements, and Delta exports into the Delta-Mendota Canal (DMC). Keswick Reservoir acts as a regulating reservoir for Shasta Reservoir and Spring Creek peaking hydropower releases. Major diversions from the Sacramento River are simulated at the Red Bluff Diversion Dam for the CVP Corning and Tehema-Colusa Canals. Several major diversions on the Sacramento River that are not associated with CVP or SWP "contractors", such as the Glenn-Colusa Irrigation District, are simulated in DWRSIM with relatively fixed monthly diversion targets.

Folsom Reservoir, with a storage capacity of about 1 MAF, is another important CVP storage facility, located on the American River. Lake Natoma acts as a regulating reservoir for peaking power releases from Folsom Reservoir. Downstream releases supply local diversions, instream flows, Delta outflow requirements, and Delta exports into the DMC.

All the remaining tributary streams, including the entire San Joaquin River, are specified as fixed monthly time-series inputs in DWRSIM. Because of the 1995 WQCP pulse-flow requirements for the San Joaquin River and investigations of potential increased instream flows on the Stanislaus River below the CVP New Melones Reservoir (2.4-MAF capacity), DWR has developed a separate simulation model for the Stanislaus River. However, this is used to generate a monthly San Joaquin River inflow sequence for DWRSIM input. None of the San Joaquin River tributary reservoirs are simulated in DWRSIM. Westside streams, such as Stony, Cache, and Putah Creeks, are simulated in DWRSIM; monthly estimates of flows from these streams are included as local inflow inputs.

San Luis Reservoir, located south of the Delta adjacent to the California Aqueduct and the DMC is a joint CVP and SWP storage facility with a capacity of about 2 MAF. It is operated to store Delta exports for later release during the irrigation season. It is an important feature of the SWP and CVP projects because it allows Delta exports to be pumped during periods of high Delta inflows prior to the peak seasonal demands for irrigation water.

The DWRSIM model also includes the pumping, diversion, and storage facilities along the California Aqueduct. While the total demands for Delta exports are important, simulations of these individual south-of-Delta facilities are not necessary for purposes of Delta simulations and evaluations of likely DW operations.

The next section describes the hydrologic inputs used in DWRSIM and compares simulated upstream reservoir operations with historical reservoir operations for the period of water years 1967-1991, when most SWP and CVP facilities were constructed and operating.

Overview of DWRSIM Modeling Assumptions

DWRSIM operations modeling requires input assumptions about monthly inflows, monthly channel depletions, and demands for diversions for the combined SWP and CVP systems and other nonproject demands. Assumptions about inflows can be confirmed with estimates of unimpaired flow in each of the major rivers. Depletions and diversions are generally not measured, however, so these assumptions can only be indirectly confirmed by comparing the results from DWRSIM simulations with measured downstream flows. The following sections describe the DWRSIM hydrologic inputs and describe Delta inflows, outflows, and exports simulated by this DWRSIM study. Records of historical flows and reservoir operations for 1967-1991 provide general confirmation of these DWRSIM results for the period when most SWP and CVP facilities were completed and operating.

DWRSIM inputs and simulated outputs sometimes differ from historical measurements and unimpaired flow estimates because not all historical conditions can be modeled with a single simulation that assumes a particular set of facilities and water demands.

Table A1-1 presents average values for DWRSIM inputs, DWRSIM-simulated outputs, estimates of unimpaired flows, and historical flow measurements at upstream and Delta locations. Corresponding annual values for each year of the 70-year hydrologic record are presented in Table A1-2 and in Figures A1-2 through A1-25, and are described in the following sections. These historical data demonstrate the adequacy of the DWRSIM simulations used to describe the Delta boundary water budget. The DWRSIM results therefore provide a reasonable basis for comparative evaluation of DW project operations and potential environmental impacts.

Upstream Flows and Reservoir Operations

This section presents four types of monthly data for various parameters of upstream hydrology:

- values assumed as input to DWRSIM;
- values simulated as output by DWRSIM study 1995-C6B-SWRCB-409;
- unimpaired flow values (natural flow), defined as flow measurements adjusted to compensate for measured storage changes and estimated diversion upstream of the measurement station; and
- historical measured flow values, with no compensation for upstream water development.

The DWRSIM hydrologic input data set incorporates estimates of unimpaired runoff from streams tributary to the Delta combined with estimates of upstream depletions and reservoir storage effects. Land use in the basin influences the upstream depletion estimates. The depletion estimates used to develop the DWRSIM input data were

based on assumed land use patterns representing the current 1995 level of development. Total annual hydrology inputs for DWRSIM were often slightly less than or equal to unimpaired flow estimates. Unimpaired flow estimates represent the maximum possible flow at a location, and thus should be larger than both historical and simulated values, unless there are major diversions between rivers. DWRSIM input data for each major reservoir can be compared with unimpaired streamflow estimates at each reservoir location to identify the magnitude of upstream diversions and storage adjustments.

The major hydrologic inputs for DWRSIM are the reservoir inflows and local inflows from each tributary stream. Table A1-2 presents the annual upstream unimpaired flows and DWRSIM inputs for the Trinity River and Sacramento River tributaries for water years 1922-1991. The annual inflows are used to classify each water year according to various water-year-type classification schemes. Delivery deficiencies, instream flows, and Delta outflow requirements may depend on the year type. The Shasta inflow is used in several CVP water contracts. The 1995 WQCP uses a "40-30-30" weighted classification (see footnote 2 of Table 1 of the 1995 WQCP) of the Sacramento Valley Four-River Runoff Index, which is the sum of the runoff of the Sacramento River at Bend Bridge and the Feather, Yuba, and American Rivers. The water-year period runs from October to September, but the year type cannot be accurately determined until March or April, when the bulk of precipitation has been recorded as rain or snowpack measurements.

Table A1-2 indicates that there is considerable variation in Trinity River and Sacramento River runoff from one water year to the next. The DWRSIM model simulates the operation of the CVP and SWP reservoir system and Delta exports for the historical sequence of inflows, as though they were to be repeated in the future with current reservoirs, diversion demands, specified instream flow requirements and Delta objectives. The DeltaSOS model is used to simulate potential operation of the DW project within the historical hydrologic variability and likely future operations of the SWP and CVP facilities.

Figure A1-2 shows annual values for DWRSIM model inputs for Clair Engle Reservoir inflows on the Trinity River for water years 1922-1991. Unimpaired flow estimates for the Trinity River at Lewiston are shown for comparison. The overall average for the DWRSIM Trinity River inflows for 1922-1991 is 1,218 thousand acre-feet per year (TAF/yr), which is very close to the estimate of unimpaired average annual flow at Lewiston of 1,245 TAF/yr. Annual inflow estimates for Clair Engle Reservoir ranged from 227 TAF/yr in 1977 to 2,887 TAF/yr in 1983.

Figure A1-3 shows annual values for DWRSIM inputs and unimpaired flow estimates for Trinity River flows below Clair Engle Reservoir for 1922-1991. Trinity River minimum flows of 340 TAF/yr are currently required downstream of Clair Engle Reservoir (under evaluation by U.S. Fish and Wildlife Service). Most of the remaining inflow is diverted to the Sacramento River by CVP facilities, although flows have spilled to the Trinity River in some wet years. The 1922-1991 average simulated Trinity River flow was 369 TAF.

The CVP Trinity River diversions directly affect Sacramento River flows and Delta inflows. The simulated average annual diversion for 1922-1991 is 882 TAF/yr, and Trinity River diversions averaged 1,027 TAF/yr for historical values and 1,024 TAF/yr for DWRSIM results for 1967-1991 (Table A1-1). Figure A1-4 shows the historical and simulated values for monthly Trinity River diversions via the J. F. Carr Tunnel to Whiskeytown Reservoir for 1967-1991. The 1967-1991 monthly DWRSIM results generally follow the seasonal pattern of the historical diversions. Historical monthly average diversions ranged from no diversions in winter of some years to about 3,500 cubic feet per second (cfs) in fall 1969. Monthly simulations by DWRSIM never exceed 3,300 cfs nor fall below 250 cfs.

Simulated values for most years generally follow historical records for end-of-month Clair Engle Reservoir storage for 1967-1991 (Figure A1-5). Simulated values differ from historical records during dry years, when reservoir operations are most sensitive to the simulated operations criteria. Typically, Clair Engle Reservoir is operated with a maximum storage of 2,500 TAF and an annual drawdown of approximately 750 TAF. Minimum carryover storage in 1967-1991 was 250 TAF at the end of water year 1977. During periods of drought, annual drawdown increased to approximately 1,000 TAF. Differences between simulated and historical Trinity River diversions correspond with differences in simulated and historical Clair Engle Reservoir storage patterns.

The historical and simulated reservoir operations can be summarized with the September end-of-month carryover storage for each water year. Table A1-3 gives the historical and simulated carryover storage for Clair Engle Reservoir and the other major reservoirs simulated by DWRSIM. The simulated carryover storage would be expected to be most similar to the historical values during the 1967-1991 period, when most CVP and SWP facilities were constructed and operating. However, many of

the simulated flood control requirements, instream flow requirements, and Delta WQCP objectives for outflow or export are different from the historical conditions and constraints.

Figure A1-6 compares DWRSIM inputs and unimpaired flow estimates for annual inflows to Shasta Reservoir for 1922-1991. The 1922-1991 average annual model input for Shasta Reservoir inflow was 5,555 TAF/yr, and the average annual unimpaired flow estimate was 5,560 TAF/yr (Table A1-2). Estimates of annual inflow to Shasta Reservoir ranged from about 2,500 TAF/yr (1924, 1931, 1977) to more than 10,000 TAF/yr (1974, 1983). The 1967-1991 average was 5,985 TAF/yr.

Figure A1-7 shows end-of-month Shasta Reservoir storage for 1967-1991, as simulated by DWRSIM and as measured historically. Historical and simulated values generally correspond, except during the drought period of 1976-1977, when simulated storage values exceeded historical levels by approximately 1,000 TAF. Storage capacity at Shasta Reservoir is approximately 4,500 TAF, and annual drawdowns during 1967-1991 were between 1,000 TAF and 1,500 TAF. Maximum drawdown during the 1967-1991 period was about 2,000 TAF in 1981, which was classified as a dry year. During the 1976-1977 drought, Shasta Reservoir storage declined to a low of about 600 TAF. Shasta Reservoir carryover storage was about 1,500 TAF during 1987-1991 drought conditions. Simulated carryover storage remained greater than 1,000 TAF (Table A1-3).

Simulated and historical monthly flows in the Sacramento River at Bend Bridge (near Red Bluff) were similar for 1967-1991 (Figure A1-8). The average annual flows were 9,478 TAF and 9,450 TAF for the simulated and historical flows, respectively (Table A1-1). The unimpaired flow estimate at Bend Bridge for 1967-1991 (8,721 TAF) is considerably lower than the simulated and historical values because diversions from the Trinity River Basin to the Sacramento Valley are not included in the Bend Bridge unimpaired flow estimate. The average annual unimpaired flow estimate of runoff from tributary streams between Shasta Reservoir and Bend Bridge was about 2,736 TAF for the 1967-1991 period. These tributary inflows cannot be regulated by any existing reservoirs.

Monthly average flows at Bend Bridge during 1967-1991 varied from 5,000 cfs to about 75,000 cfs (Figure A1-8). Flows in the upper Sacramento River are normally highest in summer because of releases to meet irrigation demands, but during years with very high inflows to Shasta Reservoir, large flow-control releases in late winter and early spring were necessary and resulted in very high peak flows.

Figure A1-9 shows DWRSIM inputs and unimpaired flow estimates for annual Oroville Reservoir inflows for water years 1922-1991. The unimpaired inflow estimates averaged 4,306 TAF/yr; DWRSIM input values averaged 3,889 TAF/yr (Table A1-2). This difference is attributable to assumed upstream uses and diversions. DWRSIM (Table A1-2) indicates that annual inflow estimates vary from 750 TAF (1977) to more than 7,500 TAF (1938, 1974, 1982, 1983).

Figure A1-10 shows end-of-month Oroville Reservoir storage for 1967-1991 simulated by DWRSIM and measured historically. Generally, the reservoir is filled to approximately 3,500 TAF (reservoir capacity) in spring and lowered approximately 750 TAF in summer. During periods of drought, drawdown is greater and storage declines. The lowest carryover storage during 1967-1991 was about 900 TAF in water year 1977. Carryover storage fluctuated between about 1,000 TAF and 2,000 TAF during the 1987-1991 drought period. Simulated carryover storage was similar to historical in most years (Table A1-3).

Figure A1-11 shows the annual 1922-1991 inflow for the Yuba and Bear Rivers assumed in DWRSIM compared with the unimpaired flow estimates of the Yuba River at Smartville and the Bear River at Wheatland. The DWRSIM input for average annual Yuba River inflow was 2,899 TAF/yr, and the unimpaired flow estimate for average annual flow for the Yuba and Bear Rivers was 2,573 TAF/yr for 1922-1991 (Table A1-2). DWRSIM inflows are higher than unimpaired flow estimates because of local gains along the Yuba and Bear Rivers (below Smartville and Wheatland) during wet periods.

Figure A1-12 compares DWRSIM inputs and unimpaired flow estimates for annual Folsom Reservoir inflows for water years 1922-1991. The unimpaired flow estimates average 2,586 TAF/yr, and annual DWRSIM inputs average 2,700 TAF/yr (Table A1-1). The higher value for DWRSIM American River inflows can be generally attributed to power-generating diversions from other basins. Upstream storage differences may produce differences between model inputs and unimpaired flow estimates. DWRSIM-estimated Folsom Reservoir annual inflows varied from about 450 TAF (1977) to 6,500 TAF (1983) (Table A1-2).

Figure A1-13 shows the simulated and historical end-of-month Folsom Reservoir storage for 1967-1991. Flood control operations require that Folsom Reservoir storage is less than 600 TAF in winter. Folsom Reservoir is generally filled to 975 TAF (reservoir capacity) during spring, then lowered to the flood control storage of about 600 TAF in fall. The lowest historical carryover storage during the 1967-1991 period was 150 TAF in 1977, and carryover storage was less than 200 TAF in 1988 and 1990. Simulated carryover storage remained above 100 TAF, except in 1977 (Table A1-3).

Figure A1-14 compares the monthly simulated and historical American River flows at Fair Oaks for 1967-1991. Flows are a function of upstream reservoir operations, local diversions, and minimum required American River flows. American River monthly average flows for 1967-1991 ranged from about 500 cfs in water year 1977 to 32,000 cfs in water year 1986.

Delta Inflows

The combination of these simulated upstream reservoir operations and local inflows, minus the simulated diversions along these upstream tributaries, produce the simulated Delta inflows. Table A1-4 shows the annual historical and DWRSIM-simulated Delta inflows for water years 1922-1991. Some Sacramento River inflow is diverted into the Yolo Bypass during high-flow periods. Eastside streams include the Cosumnes, Mokelumne, and Calaveras Rivers. The San Joaquin River inflow at Vernalis includes contributions from the Stanislaus, Tuolumne, and Merced Rivers. Local runoff from rainfall events in the Delta can provide substantial inflow in some years.

Figure A1-15 shows the historical and DWRSIM-simulated annual Sacramento River and Yolo Bypass inflows to the Delta for 1922-1991. Effects of local inflows, Sacramento Valley irrigation diversions, and other consumptive uses are aggregated in these combined Sacramento and Yolo Bypass inflows. Historical flow records for Freeport commenced in 1949; data prior to 1949 are from DWR's DAYFLOW estimates (1930-1948) combined with estimates based on DWR's unimpaired monthly flow estimates (1922-1929). DAYFLOW is a database of measured daily Delta inflows and exports, and estimated outflows and consumptive use values. The average annual historical Sacramento River and Yolo Bypass flows for 1967-1991 were 17,280 TAF/yr and 3,218 TAF/yr, respectively, and the DWRSIM-simulated average inflows for 1967-1991 were 17,454 TAF/yr and 2,899 TAF/yr, respectively (Table A1-4). The year-to-year variations in historical measurements and DWRSIM simulations generally correspond well.

Figure A1-16 shows the monthly historical and DWRSIM-simulated Sacramento River and Yolo Bypass flows for 1967-1991. The historical Sacramento River flow is limited to about 80,000 cfs (channel capacity), with excess flow diverted into the Yolo Bypass. Monthly average flows of the Yolo Bypass and the Sacramento River combined during 1967-1991 have varied from about 10,000 cfs to approximately 210,000 cfs. Differences between historical and simulated monthly flows can be attributed to changes in upstream reservoir operations and upstream diversions that are reflected in the historical record but not in the simulations.

Both the San Joaquin River and eastside streams are fixed inputs for DWRSIM simulations. Figure A1-17 shows the annual DWRSIM inputs with unimpaired flow estimates and historical measurements of flows in the San Joaquin River at Vernalis for 1922-1991. Annual DWRSIM inputs for San Joaquin River flows ranged from about 950 TAF (1990) to 15,726 TAF (1983) and averaged 2,401 TAF (Table A1-4). Assumed input flows are substantially lower than estimated annual average unimpaired flows because of upstream storage and irrigation diversions assumed in the simulations (Table A1-3).

Figure A1-18 shows the DWRSIM inputs and historical measurements for monthly San Joaquin River flows for 1967-1991. Historical monthly flows range from almost no flow to peaks of greater than 40,000 cfs. DWRSIM input flows are similar to historical values during this period because most of the water facilities assumed in DWRSIM modeling were operating. The annual average historical Vernalis flow for 1967-1991 was 3,521 TAF; simulated inputs averaged 3,077 TAF (Table A1-4).

Figure A1-19 compares DWRSIM inputs, historical measurements, and unimpaired flow estimates for annual flows for eastside streams for 1922-1991. The average annual DWRSIM input for eastside stream inflow was 835 TAF/yr, and the annual average unimpaired inflow was 1,065 TAF/yr for 1922-1991 (Table A1-1).

Figure A1-20 shows the mean monthly DWRSIM inputs and DAYFLOW historical estimates for eastside stream inflows to the Delta for 1967-1991. The historical monthly eastside streamflows range from almost no flow to about 20,000 cfs. Average annual historical eastside stream inflow to the Delta during 1967-1991 was

1,163 TAF, the unimpaired flow estimate was 1,157 TAF, and the average annual DWRSIM input was 1,088 TAF (Table A1-4).

The final DWRSIM input for inflow to the Delta is local Delta runoff, estimated from Delta precipitation records and assuming complete runoff. An estimate of Delta net channel depletion is also used in DWRSIM and is calculated by subtraction of local Delta runoff estimates from Delta evapotranspiration (ET) estimates. Figure A1-21 shows the mean monthly net Delta channel depletion input to DWRSIM compared with mean monthly DAYFLOW estimates of historical Delta precipitation, ET (consumptive use), and Delta net channel depletion for 1967-1991. The monthly DAYFLOW and DWRSIM estimates of net channel depletion are similar. DWRSIM mean monthly estimated net channel depletion ranged from -8,000 cfs in water year 1986 (net runoff) to 4,500 cfs during summer (July) of each year. Average annual DWRSIM and DAYFLOW estimates of net channel depletions were 842 TAF/yr and 739 TAF/yr, respectively, for 1967-1991 (Table A1-1).

Delta Exports and Outflow

Table A1-5 gives the annual average historical and simulated Delta exports and outflow for water years 1922-1991.

DWRSIM simulates Delta exports and Delta outflow after determining the amount of Delta inflows required for Delta channel depletion. Delta export pumping occurs in four locations: CVP pumping at Tracy, SWP pumping at Banks, Contra Costa Water District (CCWD) diversions at Rock Slough, and North Bay Aqueduct pumping at Barker Slough.

DWRSIM simulates Delta exports to meet downstream monthly demands and to fill San Luis Reservoir for meeting seasonal demands, subject to 1995 WQCP Delta objectives for outflow and pumping limits. The magnitude of downstream demands is a major input assumption of DWRSIM that governs the amount of simulated Delta exports.

DWRSIM was modified for the 1995 WQCP simulations to use a variable SWP demand that depends on Kern River flow and Los Angeles rainfall (SWRCB 1995). The Metropolitan Water District of Southern California (MWD) demand varies from a maximum of 1,450 TAF in dry years to a minimum of 800 TAF in wet years. The SWP agricultural demand varies from a maximum of 1,220 TAF in dry years to a minimum of 915 TAF in wet years. The CVP Delta demands were specified as a constant 1995 level of export demand of 3,295 TAF. The CCWD demand was specified as 145 TAF/yr. However, because of incorporation into DWRSIM of limitations associated with the Coordinated Operation Agreement (COA) and WQCP Delta objectives, the DWRSIM-simulated CVP Delta exports for 1922-1991 averaged only 2,758 TAF/yr. The variable SWP demands resulted in an average simulated SWP Delta export of 2,955 TAF/yr. The simulated average annual total Delta export was 5,712 TAF/yr.

Figure A1-22 shows annual Delta CVP and SWP exports and CCWD diversions for 1922-1991 as simulated by DWRSIM and from DAYFLOW historical estimates. Historical annual exports increased to approximately 6,000 TAF during the late 1980s. DWRSIM-simulated demands totaled about 6,000 TAF throughout the simulated period, and were divided almost equally between CVP and SWP exports. CCWD diversions were fixed in DWRSIM simulations, with an average annual export value of about 146 TAF/yr.

Figure A1-23 shows mean monthly Delta exports for 1967-1991 as simulated by DWRSIM and from DAYFLOW historical measurements. Historical exports increased steadily throughout the 1967-1991 period. Simulated exports are thus much higher than historical exports in the earlier parts of the 1967-1991 period because DWRSIM-simulated exports are based on currently operating facilities and demands with 1995 WQCP Delta objectives.

Figure A1-24 shows DWRSIM-simulated and DAYFLOW estimated annual Delta outflows for 1922-1991. Simulated values are lower than estimated historical outflows in the earlier years but match better in recent years because DWRSIM simulations assume 1995 level of facilities, land use, and export demands, which approximate operations in recent years. DAYFLOW estimated Delta outflow averaged 20,368 TAF/yr for 1967-1991, and DWRSIM-simulated Delta outflow averaged 17,993 TAF/yr (Table A1-5).

Figure A1-25 shows mean monthly Delta outflow for 1967-1991, as simulated by DWRSIM and from DAYFLOW historical estimates. Differences between the simulated and historical values can be attributed to differences between simulated and historical Delta inflows, exports, or required Delta outflow standards. Historical mean monthly Delta outflows have ranged from less than 5,000 cfs to more than 250,000 cfs (water year 1983).

This section has described the DWRSIM inputs and simulated results for Delta inflows, which are based on the specified reservoir operations, instream flows, and the 1995 WQCP objectives. The comparisons with historical data for the 1967-1991 period, when most CVP and SWP facilities were constructed and operating, provides evidence that the basic DWRSIM simulations of the upstream CVP and SWP reservoirs and Delta operations are reliable. Because the impact assessments for DW operations will use incremental analysis between simulated conditions for the No-Project Alternative and each alternative, the absolute accuracy of the DWRSIM results is not crucial to the outcome of the DW impact assessments for water supply, hydrodynamics, water quality, and fisheries.

DELTA ISLAND WATER BUDGET

DW project operations would change the Delta water budget by converting No-Project Alternative intensive agricultural land use to a combination of water storage and wetland habitat management. The changes in the water budget for the DW project islands are used to modify the Delta channel depletion values from DWRSIM. The modified values are then used in DeltaSOS simulations of monthly DW project operations, as controlled by the DWRSIM initial water budget and appropriate Delta standards and selected DW operating criteria.

The Delta is traditionally divided into uplands and lowlands, based on elevation (DWR 1993). The agricultural water budget for the Delta lowlands (where the DW project islands are located) is compared with the assumed water budget for the DW project islands in this section.

Delta Agricultural Water Budget Terms

Table A1-6 gives estimated Delta areas for each major land use category. Delta uplands and lowlands include areas of open water and riparian, urban, irrigated, and natural-idle land. The natural-idle portion of the Delta is assumed not to contribute to the Delta agricultural water budget because rainfall is assumed to be retained until ET depletes the available moisture for the year.

Table A1-6 also shows assumed land use for the proposed DW habitat islands, which will include both irrigated croplands and seasonal flooded wetlands. The DW reservoir islands will generally be used for water storage but may support shallow-water wetlands in years with no available water for diversion and storage.

Delta agricultural water budget terms include rainfall, evaporation or crop ET, soil moisture storage, seepage, applied irrigation and salt leaching water, and drainage water. Table A1-7 provides estimated monthly values (in inches of water) for each water budget term for the Delta agricultural water budget. The open water, riparian, and urban areas are separated from irrigated Delta uplands and irrigated Delta lowlands.

Contributing areas and annual water volumes (TAF/yr) are also given in Table A1-7. Monthly water values can be determined by multiplying the monthly water depth (in feet) by the acreages contributing to each term.

Basic data needed to estimate the Delta island water budget terms include monthly rainfall and monthly average ET rates (estimated from crop acreages and assumed crop ET rates). Estimates of irrigation leaching fraction (i.e., ratio of drainage to applied water), seepage rates, minimum and maximum monthly soil moisture depths, and monthly drainage depths for salt leaching are more difficult to obtain. An assumed leaching fraction of 50% is used to estimate irrigation diversions and resulting drainage flows for the Delta lowlands. Under this assumption, for each inch of crop ET, 2 inches of water would be applied as irrigation water and 1 inch would appear as drainage. These assumed Delta island water budget terms are based on DeltaDWQ model results given in Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model".

For the Delta lowlands, a constant seepage of 1 inch per month is assumed to flow directly into drainage ditches and is therefore not used to satisfy crop ET. Delta lowlands also have a significant amount of water applied for salt leaching that is drained during winter to remove accumulated salts from the soil crop root zone. Leaching water is assumed to be applied in December, January, and February (6 inches per year) to approximate salt leaching water practices on the Delta lowland islands.

For example, the estimated water budget for the irrigated portion of the Delta lowlands (Table A1-7) in October has the following monthly average terms: rainfall of 0.8 inch, 4.0 inches of soil moisture (no change from end of September soil moisture), 1.4 inches of ET, 1.0 inch of seepage, and 1.2 inches of applied water (twice the water required to supply the 0.6 inch of net ET

[1.4 ET - 0.8 rainfall], with drainage of 1.6 inches (1.0 seepage + 0.6 excess applied water). Soil moisture provides a possible storage term, but it is simulated to vary between a specified minimum and maximum value. The actual monthly water budget may be different each year because rainfall, soil moisture changes, and irrigation and seepage are estimated.

As shown in Table A1-7, Delta rainfall averages about 16 inches per year, which supplies about 121 TAF/yr in the water-riparian-urban portion of the Delta, 194 TAF/yr in the irrigated uplands area, and about 465 TAF/yr in the irrigated lowlands area of the Delta (23 TAF/yr falls on the DW project islands). The total Delta rainfall volume is therefore approximately 780 TAF/yr. In comparison, DWRSIM uses an average of 830 TAF/yr as the runoff gains to the Delta.

Table A1-7 indicates that water evaporation consumes about 291 TAF/yr from the water-riparian-urban portion of the Delta. Additionally, the assumed crop ET requires about 427 TAF/yr on the irrigated uplands and about 890 TAF/yr on the irrigated lowlands (44 TAF/yr from the DW project islands). The Delta consumptive use total is therefore approximately 1,608 TAF/yr. In comparison, DWRSIM uses an average of 1,682 TAF/yr.

Table A1-7 indicates that net channel depletion, which is the difference between consumptive use and rainfall, is about 170 TAF/yr for the water-riparian-urban portion of the Delta, about 234 TAF/yr for the irrigated uplands, and about 425 TAF/yr for the irrigated lowlands (21 TAF/yr for the DW project islands). Total Delta channel depletion, estimated from this approximate monthly water budget, is therefore approximately 830 TAF/yr, somewhat less than the average Delta channel depletion of 852 TAF/yr assumed in DWRSIM. No reliable method exists for determining actual Delta runoff from rainfall or actual consumptive use.

DW Project Island Water Budget

The DW project islands are located in the Delta lowlands, so the water budget for agricultural use of the DW islands would be the same as the assumed Delta lowland water budget. Table A1-8 shows the agricultural water budget terms for the DW project islands, which include approximately 17,000 acres of irrigated cropland under the No-Project Alternative. The irrigated portions of the DW project islands represent about 5% of the irrigated Delta lowlands, so the water volume terms are expected to be about 5% of the Delta lowland water volume terms.

Table A1-8 indicates that rainfall on the irrigated portion of the DW islands would average about 23 TAF/yr. Crop ET under the No-Project Alternative would consume about 44 TAF/yr, so channel depletion for the DW islands would average 21 TAF/yr. Table A1-8 indicates that seepage onto the DW islands would amount to approximately 17 TAF/yr, applied salt leaching water would average about 9 TAF/yr, and applied irrigation water would amount to about 51 TAF/yr. The resulting drainage from the seepage, applied salt leaching water, and excess irrigation water (50% leaching fraction) would total about 56 TAF/yr.

The best available data for confirming the agricultural drainage estimates for the DW project islands are drainage pump power records. Electricity usage is converted to flow volumes using pump efficiency test results obtained from Pacific Gas and Electric Company (PG&E), expressed as acre-feet per kilowatt-hour (af/kWh). DW obtained monthly PG&E power consumption records and estimated pumping volumes for the four DW project islands for 1986-1992. Table A1-9 presents these monthly and annual pumping values for the DW project islands, in inches per month of drainage from the entire island area.

The estimated monthly drainage volumes for the DW islands were quite variable between islands as well as between months. Monthly pumping estimates have varied from less than 1 inch to more than 10 inches. Annual estimates for individual islands have varied from 11 inches to more than 75 inches. Drainage volumes have generally followed a double-peak pattern, with high pumping in winter because of excess rainfall and salt leaching practices and high summer pumping because of excess irrigation. A more detailed discussion of these drainage patterns in presented in Appendix C4.

Estimated pumping on Bacon Island during the irrigation season was usually quite high, averaging greater than 6 inches per month for 5 months each year. High summer pumping is apparently caused by the water management required for the row crops grown on Bacon Island. Pumping for Bouldin Island in 1990 and for Webb and Holland Tracts in 1990 and 1991 was lower than normal because of reduced agricultural use during levee rehabilitation and participation in the DWR emergency water bank program (Appendix C4).

These available pumping records are quite variable and only provide a rough estimate of the magnitude of the

estimated drainage term in the DW project islands agricultural water budget. The variation between years and between islands suggests that the assumed water budgets are simplified representations of actual conditions. This estimated water budget for the DW project islands provides an adequate basis for water supply and environmental impact assessment purposes because the impact assessments are based on the incremental differences between conditions under the No-Project Alternative and those under the DW alternatives.

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Table A1-1. Comparison of Average Annual DWRSIM Inputs and Results with Unimpaired Flow Estimates and Historical Flow Measurements

Location	1922–1991 Period (TAF/yr)					1967–1991 Period (TAF/yr)				
	DWRSIM Input [a]	DWRSIM–Simulated Output [b]	Unimpaired Flow Estimate [c]	Historical Measurement [d]	DAYFLOW Estimate [e]	DWRSIM Input [a]	DWRSIM–Simulated Output [b]	Unimpaired Flow Estimate [c]	Historical Measurement [d]	DAYFLOW Estimate [e]
Upstream Flows										
Trinity River at Lewiston (Clair Engle Reservoir inflows)	1,218		1,245	793		1,334		1,339	314	
Trinity River diversions (J.F. Carr Tunnel)		882		1,061 [f]			1,024		1,027	
Shasta Reservoir inflows	5,555		5,560			5,989		5,985		
Sacramento River at Bend Bridge		8,565	8,067	8,103			9,478	8,721	9,450	
Feather River at Gridley (Oroville Reservoir inflows)	3,889		4,306	3,501 [g]		4,174		4,623	3,468	
Yuba River at Smartville and Bear River at Wheatland	2,899		2,573	2,040 [h]		3,419		2,680	2,018	
American River at Fair Oaks (Folsom Reservoir inflows)	2,700		2,586	2,598		2,847		2,736	2,769	
Sacramento Valley Four–River Index			17,223 [i]					18447		
Delta Flows										
Sacramento River at Freeport		15,998		16,923			17,454		17,280	
Yolo Bypass		2,118			2,752		2,899			3,218
San Joaquin River at Vernalis	2,401		6,017	3,293		3,077		6,669	3,521	
Eastside streams	835		1,067	1,077		1,088		1,157	1,163	
Delta channel depletion	881				923	842				739
Delta exports		5,712		1,688			5,547		4,031	
Delta outflow		14,562			20,616		17,993			20,368

Notes: NA = no data available or not applicable

[a] Flow values used as input to DWRSIM Study 1995–C6B–SWRCB–409.
[b] Simulated output from DWRSIM Study 1995–C6B–SWRCB–409.
[c] Unimpaired flow values from DWR's California Data Exchange Center database.
[d] Historical measured flows from U.S. Geological Survey HYDRODATA database.
[e] DAYFLOW estimates for 1930–1991 by DWR (extended to 1992 by JSA).
[f] Data period is 1963–1991.
[g] Data period is 1965–1991.
[h] Data period is 1942–1991.
[i] Sacramento R. at Bend Bridge + Feather R. + Yuba R. at Smartville + American R. at Fair Oaks.

Table A1-2. Annual Historical and DWRSIM Inputs for Trinity River and Sacramento River Tributary Flows for Water Years 1922-1991

A. Historical Flows

Water Year	Trinity Unimp Flow (TAF)	Shasta Unimp. Inflow (TAF)	Carr PP Hist. Flow (TAF)	Red Bluff Unimp. Flow (TAF)	Feather Unimp. Inflow (TAF)	Yuba + Bear Unimp. Flow (TAF)	Amer. R. Unimp. Inflow (TAF)	Four-River Index (TAF)
1922	782	4,636	0	6,702	5,067	3,454	3,290	18,041
1923	686	3,649	0	5,288	3,091	2,463	2,745	13,190
1924	268	2,476	0	3,295	1,301	674	546	5,747
1925	1,518	5,153	0	8,258	3,124	2,456	2,756	16,296
1926	820	3,781	0	5,780	3,139	1,906	1,405	11,961
1927	1,837	7,061	0	11,123	5,749	4,161	3,704	24,167
1928	1,056	5,115	0	7,631	4,154	2,737	2,504	16,709
1929	528	3,217	0	4,425	1,846	1,136	1,148	8,430
1930	818	4,196	0	6,109	3,949	2,034	1,652	13,529
1931	403	2,540	0	3,300	1,444	715	717	6,104
1932	716	3,674	0	5,049	3,307	2,355	2,593	13,057
1933	802	3,460	0	4,577	1,994	1,197	1,268	8,915
1934	686	3,333	0	4,522	2,025	1,115	1,129	8,667
1935	970	4,935	0	7,515	4,275	2,603	2,587	16,622
1936	1,026	4,688	0	7,102	4,306	3,028	3,415	17,421
1937	996	4,121	0	5,996	3,167	2,195	2,341	13,369
1938	2,105	9,605	0	14,781	8,600	4,617	4,523	31,942
1939	572	3,459	0	4,365	1,855	1,026	1,046	8,172
1940	1,616	7,054	0	10,530	5,687	3,261	3,407	22,487
1941	2,549	8,744	0	14,380	6,518	3,638	3,157	27,208
1942	1,809	7,688	0	11,386	6,694	3,934	3,937	25,442
1943	1,112	5,884	0	8,509	5,618	3,593	3,869	21,127
1944	653	3,680	0	4,700	2,862	1,578	1,457	10,410
1945	1,056	4,902	0	6,773	3,778	2,436	2,551	15,242
1946	1,409	5,882	0	8,128	4,166	2,705	2,853	17,538
1947	735	3,918	0	5,092	2,547	1,542	1,423	10,433
1948	1,200	5,393	0	7,619	3,840	2,225	2,233	15,696
1949	1,094	4,312	0	6,018	2,591	1,697	1,852	11,943
1950	855	4,151	0	5,757	3,866	2,508	2,677	14,533
1951	1,617	6,343	0	9,128	5,712	4,143	4,634	23,020
1952	1,816	7,781	0	11,528	7,955	4,713	4,965	28,562
1953	1,612	6,514	0	9,617	5,195	2,803	2,649	20,008
1954	1,596	6,585	0	9,355	4,248	2,194	2,002	17,531
1955	734	4,111	0	5,657	2,465	1,454	1,560	10,963
1956	2,014	8,792	0	13,235	7,918	4,475	4,602	29,681
1957	1,090	5,398	0	7,205	3,651	2,201	2,144	14,970
1958	2,731	9,848	0	15,403	7,049	4,063	4,117	30,134
1959	1,045	5,115	0	6,789	2,868	1,373	1,236	12,139
1960	1,027	4,737	0	6,476	3,233	1,885	1,686	13,097
1961	1,231	5,104	0	7,220	2,653	1,240	1,050	12,055
1962	1,053	5,332	0	7,568	3,702	2,202	2,098	15,322
1963	1,612	7,039	700	9,959	6,315	3,744	3,588	23,162
1964	795	3,895	1,230	5,204	2,582	1,657	1,629	10,895
1965	1,686	6,964	1,101	10,327	6,878	4,373	4,457	25,519
1966	1,345	5,311	1,255	7,304	2,855	1,601	1,393	12,977
1967	1,653	7,409	1,278	10,517	6,276	3,757	3,957	24,044
1968	1,019	4,784	1,414	6,933	3,471	1,758	1,709	13,697
1969	1,750	7,708	1,032	11,880	7,069	4,231	4,449	27,066
1970	1,584	7,873	1,366	11,671	6,239	3,264	3,150	23,955
1971	1,666	7,311	1,212	10,750	5,944	3,239	2,968	22,514
1972	1,153	5,062	1,174	6,586	3,223	1,874	1,867	13,387
1973	1,393	6,200	1,217	9,699	4,750	3,120	3,013	20,125
1974	2,637	10,765	1,799	15,828	8,332	4,545	4,257	32,383
1975	1,404	6,426	1,032	9,433	4,862	2,664	2,622	19,298
1976	669	3,602	1,035	4,747	1,844	727	797	8,053
1977	201	2,634	1,306	3,410	995	390	349	5,124
1978	2,052	7,843	217	12,036	5,682	3,397	3,220	23,920
1979	851	4,031	775	5,650	3,024	1,957	2,041	12,442
1980	1,477	6,425	879	9,756	5,537	3,636	3,867	22,344
1981	871	4,118	708	6,408	2,488	1,206	1,131	11,132
1982	2,027	9,059	1,095	13,341	9,051	5,702	6,164	33,513
1983	2,989	10,835	1,694	17,258	9,440	5,428	6,387	37,801
1984	1,550	6,633	1,206	9,464	5,738	3,522	3,884	22,234
1985	841	3,971	673	5,518	2,650	1,475	1,581	11,074
1986	1,616	7,694	904	11,168	6,904	4,108	4,707	26,341
1987	883	3,952	606	5,290	2,182	938	884	9,237
1988	939	3,909	964	5,375	1,996	989	850	9,135
1989	1,060	4,727	786	6,594	3,682	2,483	2,240	14,735
1990	716	3,605	628	4,723	2,142	1,322	1,120	9,219
1991	486	3,051	664	3,991	2,058	1,276	1,184	8,403
Average								
'22 - '91	1,245	5,560	1,061	8,067	4,306	2,573	2,586	17,223
'67 - '91	1,339	5,985	1,027	8,721	4,623	2,680	2,736	18,447

B. DWRSIM Inputs

Clair Engle Inflow (TAF)	Shasta Inflow (TAF)	Carr PP Diversion (TAF)	Red Bluff Flow (TAF)	Oroville Inflow (TAF)	Yuba + Bear Flow (TAF)	Folsom Inflow (TAF)
759	4,563	765	5,710	4,666	3,723	3,353
666	3,636	664	6,531	2,838	1,910	2,885
268	2,448	756	5,131	1,412	1,113	902
1,459	5,122	753	6,939	2,707	1,932	2,560
795	3,764	664	6,220	2,756	1,697	1,728
1,764	6,990	671	10,264	4,934	4,702	3,620
1,025	5,124	674	8,722	3,798	2,841	2,686
516	3,184	681	5,213	1,781	1,169	1,452
794	4,152	725	6,100	3,324	2,040	1,576
395	2,537	403	4,451	1,534	979	1,044
696	3,616	350	5,454	2,790	1,667	2,391
779	3,441	442	4,454	1,842	1,124	1,520
668	3,330	349	4,906	1,920	1,121	1,371
938	4,857	575	6,441	3,536	2,671	2,394
1,001	4,658	517	6,189	3,731	3,600	3,516
966	4,113	602	6,050	2,703	2,906	2,484
2,017	9,568	664	14,599	7,686	6,042	4,622
557	3,464	684	6,239	2,072	904	1,453
1,570	7,084	804	10,185	5,019	4,698	3,289
2,438	8,729	1,163	14,381	5,859	4,168	3,275
1,739	7,672	1,559	12,524	6,255	4,459	4,038
1,075	5,883	865	9,013	5,262	3,466	4,028
636	3,684	728	5,955	2,545	1,634	1,745
1,022	4,881	673	6,326	3,360	2,102	2,528
1,358	5,870	761	8,532	3,758	2,439	2,952
716	3,914	679	5,779	2,362	1,382	1,714
1,158	5,391	665	6,905	3,262	2,059	2,147
1,057	4,317	714	6,743	2,300	1,484	1,981
831	4,144	664	5,887	3,434	2,190	2,769
1,556	6,341	761	9,297	5,192	4,829	4,780
1,752	7,818	1,140	11,839	7,236	5,581	5,047
1,549	6,518	1,198	10,369	4,807	2,264	2,827
1,544	6,602	1,375	10,739	3,997	2,187	2,172
721	4,109	806	6,465	2,292	1,355	1,659
1,939	8,824	1,037	12,958	6,987	4,330	4,638
1,052	5,400	821	7,810	3,527	1,962	2,313
2,610	9,845	1,752	16,430	6,234	4,719	4,175
1,011	5,126	1,022	8,217	2,809	1,645	1,584
1,001	4,764	796	6,744	2,887	1,246	1,613
1,227	5,101	756	7,417	2,302	1,172	1,370
982	5,326	715	7,459	3,187	1,877	1,917
1,594	7,039	947	10,089	5,789	4,545	3,677
739	3,906	926	6,885	2,338	1,634	1,751
1,657	6,956	876	9,559	6,123	4,018	4,531
1,317	5,331	1,019	8,451	2,705	1,870	1,708
1,637	7,390	1,162	10,598	5,634	4,261	3,801
1,059	4,827	1,069	8,224	3,331	1,683	1,861
1,758	7,707	977	11,961	6,376	5,338	4,462
1,563	7,876	1,414	13,187	5,559	5,336	3,419
1,683	7,300	1,242	11,049	5,182	3,699	3,057
1,175	5,082	972	7,493	2,834	1,883	2,001
1,405	6,195	1,071	10,212	4,013	4,670	3,110
2,660	10,751	1,999	17,187	7,729	6,039	4,415
1,406	6,412	1,057	9,966	4,503	3,271	2,739
695	3,600	949	6,479	1,825	1,243	1,145
227	2,624	969	5,529	750	833	449
2,032	7,835	671	9,632	4,780	3,035	2,953
854	4,034	664	6,495	2,935	2,284	2,193
1,484	6,482	701	9,706	4,840	5,293	3,971
862	4,109	738	7,324	2,365	1,463	1,402
1,996	9,060	1,134	13,508	8,284	8,534	6,164
2,887	10,837	1,792	18,879	8,880	6,920	6,540
1,516	6,654	1,432	10,746	5,320	5,530	4,147
841	3,977	992	7,270	2,585	1,494	1,790
1,602	7,696	808	11,158	6,199	5,260	4,669
870	3,951	845	6,920	1,733	1,294	1,097
936	3,925	765	6,677	1,885	982	953
1,045	4,740	771	5,936	3,164	2,319	2,149
687	3,607	693	5,754	1,831	1,386	1,335
463	3,046	719	5,070	1,811	1,429	1,363
1,218	5,555	882	8,565	3,889	2,899	2,700
1,334	5,989	1,024	9,478	4,174	3,419	2,847

Table A1–3. Historical and DWRSIM–Simulated Carryover Storage for Water Years 1922–1991

A. Historical Carryover

Water Year	Clair Engle Storage (TAF)	Shasta Storage (TAF)	Oroville Storage (TAF)	Folsom Storage (TAF)	San Luis Storage (TAF)	New Melones Storage (TAF)
1922						
1923						
1924						
1925						
1926						
1927						
1928						
1929						
1930						
1931						
1932						
1933						
1934						
1935						
1936						
1937						
1938						
1939						
1940						
1941						
1942						
1943						
1944						
1945						
1946						
1947						
1948						
1949						
1950						
1951						
1952						
1953						
1954		3,057				
1955		2,455				
1956		3,569		533		
1957		3,485		535		
1958		3,473		550		
1959		2,504		312		
1960		2,756		518		
1961		2,333		389		
1962	1,793	2,908		454		
1963	2,196	3,242		466		
1964	1,559	2,202		536		
1965	1,997	3,612		671		
1966	1,880	3,263		653		
1967	1,969	3,506		799		
1968	1,388	2,670	1,678	551		
1969	1,905	3,528	2,780	814	1,981	
1970	1,871	3,440	2,542	549	1,720	
1971	2,106	3,275	2,730	686	1,736	
1972	1,913	3,267	2,612	659	1,482	
1973	1,904	3,317	2,729	742	1,691	
1974	1,996	3,658	2,397	773	1,852	
1975	2,041	3,570	2,858	773	1,032	
1976	1,503	1,295	1,828	416	678	3
1977	242	631	915	147	274	3
1978	1,870	3,428	2,744	700	1,719	44
1979	1,661	3,141	2,672	710	1,213	116
1980	1,879	3,321	2,611	670	1,483	277
1981	1,702	2,480	2,354	600	263	124
1982	2,115	3,486	2,775	756	23	1,358
1983	2,164	3,617	2,818	752	1,940	2,024
1984	1,889	3,240	2,529	681	812	1,841
1985	1,762	1,978	2,132	587	763	1,508
1986	1,901	3,211	2,661	653	1,481	1,948
1987	1,813	2,108	1,979	430	688	1,443
1988	1,479	1,586	1,529	218	488	989
1989	1,376	2,096	2,150	571	365	672
1990	1,162	1,637	1,163	178	488	378
1991	670	1,340	1,399	506	654	296
Average						
'22 – '91	1,724	2,834	2,274	571	1,079	814
'67 – '91	1,691	2,753	2,274	597	1,079	814

B. DWRSIM–Simulated Carryover

Clair Engle Storage (TAF)	Shasta Storage (TAF)	Oroville Storage (TAF)	Folsom Storage (TAF)	San Luis Storage (TAF)	New Melones Storage (TAF)
1,694	3,700	3,303	841	621	1,305
1,343	2,780	2,279	461	431	1,091
491	1,277	868	99	129	721
864	2,781	1,072	465	365	584
642	2,503	908	156	371	396
1,421	3,563	3,003	759	556	890
1,429	2,706	1,851	291	469	1,055
909	2,235	1,073	115	151	831
634	2,516	1,534	370	452	721
280	1,560	1,064	100	229	473
295	1,141	1,574	738	437	765
301	1,365	1,281	291	211	580
282	1,169	984	100	212	300
313	2,225	1,524	314	564	635
462	3,047	2,576	653	555	586
498	3,257	2,699	643	573	521
1,560	3,700	3,350	925	1,203	1,837
1,078	2,203	1,715	99	327	1,496
1,511	2,976	1,956	545	454	1,458
2,194	3,700	3,348	882	960	1,761
2,068	3,700	3,344	906	920	1,823
1,929	3,568	2,896	744	571	1,749
1,479	2,616	2,238	388	364	1,366
1,478	3,222	2,487	643	384	1,321
1,753	3,079	2,196	569	496	1,030
1,434	2,640	1,304	291	394	641
1,597	3,619	1,449	708	283	651
1,601	3,131	1,041	542	404	548
1,419	3,140	1,286	683	299	419
1,888	3,253	2,250	614	395	683
2,091	3,700	3,350	961	1,595	1,742
2,115	3,700	3,291	824	723	1,548
1,956	3,242	1,976	413	534	1,222
1,518	2,814	1,056	329	476	842
2,062	3,700	3,113	919	957	1,397
1,941	3,486	2,181	580	458	1,137
2,117	3,700	3,350	935	1,353	1,741
1,761	2,857	2,035	285	419	1,320
1,615	2,923	1,459	273	412	1,008
1,739	2,997	954	269	414	696
1,668	3,314	1,201	547	414	440
2,001	3,700	2,873	750	651	886
1,473	2,540	1,835	171	467	719
1,965	3,700	2,518	776	603	800
1,943	3,108	1,962	349	453	654
2,093	3,700	3,350	940	1,643	1,601
1,759	3,112	2,069	319	401	1,267
2,050	3,700	3,162	915	1,519	2,273
1,909	3,165	2,333	474	420	1,532
2,057	3,700	2,904	850	667	1,364
1,935	3,337	1,870	456	438	1,053
1,958	3,470	2,418	580	603	952
2,088	3,700	3,338	934	1,096	1,136
2,078	3,700	3,135	877	918	1,079
1,483	2,612	2,225	171	542	785
393	1,072	771	59	654	459
1,476	3,700	3,327	786	775	917
1,335	3,240	2,591	521	578	806
1,795	3,700	3,118	834	871	1,755
1,546	2,938	1,972	257	361	1,436
2,056	3,700	3,351	966	1,469	2,273
2,263	3,700	3,351	975	1,821	2,273
2,015	3,700	2,824	668	686	1,758
1,488	2,648	1,771	260	404	1,618
1,900	3,256	2,731	722	695	2,118
1,558	2,234	1,429	99	366	1,695
1,358	1,460	904	100	124	1,309
1,274	2,567	1,180	320	378	1,144
902	1,971	965	100	153	814
300	1,413	1,143	175	164	591
1,484	2,962	2,141	524	592	1,120
1,643	3,020	2,329	534	710	1,360

Table A1–4. Annual Historical and DWRSIM–Simulated Delta Inflows for Water Years 1922–1991

A. Historical Flows

Water Year	Freeport Historical Flow (TAF)	Yolo Bypass Historical Flow (TAF)	Vernalis Historical Flow (TAF)	Eastside Historical Flow (TAF)	Delta Rainfall (TAF)
1922	18,998	1,302	6,732	1,840	548
1923	13,989	0	4,043	1,440	562
1924	4,373	0	486	106	146
1925	15,363	2,485	3,749	1,474	626
1926	11,747	721	1,939	461	446
1927	23,001	5,200	5,076	1,641	599
1928	16,199	2,092	2,709	1,034	432
1929	7,472	0	937	266	288
1930	13,190	906	1,266	466	607
1931	5,148	36	678	159	523
1932	12,218	432	3,669	930	731
1933	7,722	64	1,383	418	531
1934	8,041	228	928	432	558
1935	16,043	2,072	4,034	1,043	765
1936	15,512	3,357	4,986	1,602	984
1937	13,670	1,228	5,510	1,231	958
1938	25,878	14,152	10,879	2,188	1,002
1939	7,080	170	1,714	422	581
1940	18,267	6,974	4,765	1,340	948
1941	23,698	11,510	7,310	1,292	1,026
1942	22,795	6,733	6,188	1,565	1,121
1943	19,660	3,145	6,079	1,826	1,044
1944	9,069	124	1,798	515	751
1945	13,155	735	4,446	1,185	837
1946	15,903	2,101	3,627	1,091	748
1947	9,491	72	1,334	369	510
1948	14,552	301	1,550	703	660
1949	11,793	260	1,242	613	636
1950	13,948	357	1,796	993	606
1951	21,766	3,445	4,735	2,321	927
1952	28,056	3,945	7,136	2,477	1,096
1953	18,121	2,752	1,893	859	660
1954	17,110	1,213	1,713	717	589
1955	10,591	76	978	557	788
1956	22,328	9,860	6,287	2,359	1,159
1957	13,150	778	1,440	684	759
1958	26,058	10,012	6,059	2,396	1,573
1959	12,059	635	1,249	366	794
1960	10,771	618	550	255	559
1961	11,488	169	438	103	713
1962	13,089	1,123	1,505	683	820
1963	20,422	4,170	2,839	1,334	1,247
1964	11,591	67	1,119	307	643
1965	19,965	6,193	3,803	1,644	926
1966	13,392	377	1,698	639	686
1967	24,233	3,661	5,559	1,723	1,294
1968	13,377	668	1,423	520	653
1969	23,362	6,281	10,168	2,391	1,260
1970	20,289	8,500	3,076	1,415	895
1971	22,811	1,306	1,779	902	941
1972	12,470	30	1,112	365	437
1973	20,758	3,887	2,392	1,429	1,244
1974	30,663	7,566	2,773	1,551	995
1975	19,941	951	2,826	1,125	828
1976	10,963	15	1,523	206	460
1977	5,497	1	416	30	445
1978	17,691	2,844	4,490	1,146	1,368
1979	13,034	154	2,625	1,020	941
1980	19,248	6,502	5,986	1,830	1,045
1981	11,499	126	1,763	286	725
1982	30,101	7,229	5,477	3,038	1,655
1983	34,049	14,962	15,438	4,557	1,713
1984	22,384	4,689	6,260	1,807	863
1985	12,192	172	2,101	470	743
1986	18,112	10,608	5,235	2,124	1,454
1987	10,031	35	1,808	384	683
1988	9,653	115	1,164	143	718
1989	12,244	44	1,057	221	795
1990	9,860	21	914	169	619
1991	7,540	75	655	221	847
Average					
'22 – '91	16,923	2,752	3,293	1,077	819
'67 – '91	17,280	3,218	3,521	1,163	945

B. DWRSIM–Simulated Flows

Sacto. R. Inflow (TAF)	Yolo Bypass Inflow (TAF)	SJR Inflow (TAF)	Eastside Inflow (TAF)	Total River Inflows (TAF)
15,237	202	3,037	1,038	19,514
14,489	194	2,491	816	17,990
8,586	69	1,259	201	10,116
12,064	809	1,462	630	14,965
11,614	344	1,511	390	13,858
19,015	3,222	1,892	724	24,853
18,455	991	1,706	577	21,730
8,696	100	1,304	299	10,398
10,768	164	1,140	329	12,400
6,775	68	1,255	205	8,303
8,618	157	1,655	586	11,016
7,535	83	1,388	264	9,270
8,173	146	1,201	304	9,824
12,496	1,209	2,051	637	16,394
13,335	1,413	2,141	1,059	17,949
12,426	246	2,804	940	16,416
28,179	8,591	5,428	1,662	43,860
10,712	70	1,695	286	12,763
17,638	4,572	1,896	756	24,862
23,780	9,163	3,677	809	37,429
25,353	5,099	2,986	1,154	34,592
20,972	1,639	3,151	1,550	27,313
11,388	191	1,642	394	13,615
12,566	335	2,244	745	15,891
16,177	1,462	2,071	795	20,506
10,949	109	1,557	291	12,905
13,098	41	1,418	364	14,921
11,993	193	1,423	455	14,065
12,811	111	1,532	508	14,962
21,672	1,900	2,583	1,790	27,945
28,323	2,379	3,023	1,770	35,496
18,839	2,492	1,965	533	23,828
19,873	746	1,572	368	22,559
11,447	172	1,365	435	13,419
21,768	8,268	3,270	1,485	34,792
15,092	399	1,785	412	17,688
26,266	8,873	3,396	1,657	40,193
14,716	383	1,732	339	17,170
11,339	317	1,217	304	13,177
11,459	206	1,139	216	13,021
12,372	711	1,484	460	15,027
20,611	2,943	1,934	741	26,229
12,397	148	1,358	315	14,218
19,519	4,554	2,323	1,222	27,618
13,901	319	1,962	399	16,582
22,181	2,615	3,304	1,298	29,398
15,971	709	1,660	432	18,772
23,660	5,750	5,442	1,935	36,787
21,543	8,061	3,283	1,196	34,082
20,939	1,152	1,732	707	24,531
13,210	192	1,515	357	15,275
19,810	3,467	2,175	1,161	26,612
29,264	7,121	2,238	1,255	39,878
20,440	920	2,310	894	24,564
10,456	86	1,160	220	11,923
6,824	105	1,016	149	8,095
16,859	2,457	2,267	840	22,423
13,993	130	2,300	688	17,112
18,292	5,602	4,818	1,325	30,037
13,093	110	1,912	343	15,457
29,591	6,745	5,387	3,093	44,815
35,577	13,561	15,726	4,914	69,778
23,213	4,153	6,450	2,167	35,984
13,038	192	1,859	459	15,548
18,958	8,880	4,814	2,385	35,036
10,952	78	1,645	337	13,012
9,416	137	1,014	242	10,810
11,782	80	1,006	323	13,190
8,675	100	940	215	9,930
8,612	76	958	269	9,915
15,998	2,118	2,401	835	21,351
17,454	2,899	3,077	1,088	24,518

Table A1–5. Annual Historical and DWRSIM–Simulated Delta Outflows and Exports for Water Years 1922–1991

A. Historical Flows

Water Year	Net Channel Depletion (TAF)	CCWD Exports (TAF)	CVP Exports (TAF)	SWP Exports (TAF)	CVP + SWP Exports (TAF)	Delta Outflow (TAF)
1922	877					28,798
1923	863					19,471
1924	1,279					4,965
1925	799					23,071
1926	979					14,868
1927	826					34,918
1928	993					22,033
1929	1,137					8,675
1930	804					15,017
1931	881					5,132
1932	669					16,577
1933	868					8,706
1934	842					8,786
1935	633					22,551
1936	416					25,057
1937	443					21,206
1938	399					52,716
1939	831					8,551
1940	481					30,867
1941	417					43,400
1942	335					36,944
1943	428					30,287
1944	737					10,772
1945	686					18,843
1946	805					21,908
1947	1071					10,189
1948	951					16,145
1949	991					12,597
1950	1036	21				15,236
1951	718	30	161		162	30,552
1952	550	30	164		165	40,375
1953	963	34	778		787	22,362
1954	1049	42	1,004		1,020	19,140
1955	848	47	1,113		1,128	10,040
1956	527	44	721		721	39,743
1957	925	54	1,180		1,180	13,920
1958	111	48	657		657	43,765
1959	890	68	1,336		1,336	12,039
1960	1127	76	1,384		1,384	9,707
1961	971	78	1,483		1,483	9,687
1962	864	72	1,350		1,350	14,139
1963	437	62	1,338		1,338	26,969
1964	1044	82	1,644		1,644	10,384
1965	759	72	1,467		1,467	29,347
1966	999	84	1,593		1,593	13,449
1967	390	72	1,252		1,252	33,515
1968	1033	96	1,995	473	2,468	12,507
1969	424	78	1,844	1,031	2,875	38,883
1970	789	94	1,652	416	2,067	30,290
1971	743	75	1,917	913	2,830	23,191
1972	1249	104	2,348	1,093	3,441	9,261
1973	440	93	1,846	1,518	3,364	24,609
1974	689	79	2,445	1,915	4,360	37,482
1975	856	79	2,353	1,552	3,904	20,043
1976	1226	111	3,013	1,827	4,839	6,583
1977	1239	99	1,281	797	2,078	2,539
1978	316	77	2,270	2,080	4,350	21,467
1979	743	91	2,287	2,182	4,470	11,555
1980	641	87	2,007	2,516	4,523	28,501
1981	960	107	2,591	2,130	4,722	7,908
1982	30	75	1,976	2,644	4,621	41,230
1983	−29	79	2,505	1,894	4,399	64,643
1984	824	98	2,194	1,647	3,841	30,592
1985	941	113	2,791	2,680	5,471	8,453
1986	230	110	2,619	2,667	5,286	30,493
1987	1001	131	2,760	2,283	5,043	6,105
1988	968	135	2,897	2,714	5,611	4,409
1989	889	134	2,870	3,097	5,967	6,599
1990	1060	136	2,703	3,109	5,811	3,967
1991	834	106	1,409	1,771	3,180	4,371
Average						
'22 – '91	768	81	1,785	1,873	2,883	20,616
'67 – '91	739	98	2,233	1,873	4,031	20,368

B. DWRSIM–Simulated Flows

Net Channel Depletion (TAF)	CCWD Exports (TAF)	CVP Exports (TAF)	SWP Exports (TAF)	CVP + SWP Exports (TAF)	Delta Outflow (TAF)	WQCP Required Outflow (TAF)
835	144	3,049	3,136	6,185	12,296	6,103
823	144	2,893	3,298	6,191	10,778	5,833
1,223	151	2,363	2,179	4,542	4,155	4,063
762	153	2,923	2,812	5,735	8,267	5,195
937	144	2,827	2,907	5,734	6,997	5,006
786	144	3,025	3,217	6,242	17,631	6,980
953	144	2,987	3,341	6,327	14,252	6,665
1,094	151	2,234	2,330	4,564	4,548	4,418
981	153	2,373	2,636	5,009	6,220	5,052
1,113	151	1,900	1,427	3,327	3,677	3,657
838	160	2,274	1,874	4,148	5,825	5,190
1,103	160	1,877	1,801	3,678	4,288	4,050
1,065	160	1,907	1,829	3,737	4,829	4,532
817	153	2,861	3,064	5,925	9,453	6,455
745	144	2,962	3,191	6,154	10,852	6,248
699	144	2,997	2,881	5,879	9,641	5,287
520	144	3,020	3,207	6,227	36,915	8,125
1,148	144	2,532	2,556	5,089	6,328	4,357
593	144	3,045	3,375	6,420	17,651	7,246
453	144	2,981	3,294	6,275	30,503	7,010
700	144	3,038	2,912	5,949	27,744	6,671
830	144	3,034	2,524	5,558	20,726	7,309
993	144	2,807	3,122	5,928	6,496	4,952
920	144	2,960	3,174	6,134	8,640	5,277
1,023	144	2,936	3,355	6,290	12,995	6,279
1,116	144	2,795	3,238	6,033	5,558	5,072
1,038	144	2,909	3,391	6,301	7,384	5,487
1,065	144	2,839	2,853	5,692	7,117	4,921
1,063	144	2,928	3,223	6,151	7,554	5,599
770	144	2,981	3,785	6,766	20,212	6,326
611	144	3,090	3,836	6,927	27,761	7,985
976	144	2,779	2,525	5,304	17,350	6,080
1,104	144	2,993	3,380	6,373	14,884	7,021
974	144	2,694	3,322	6,016	6,230	5,051
638	144	3,008	3,816	6,824	27,133	6,221
1,034	144	2,836	3,450	6,286	10,171	5,661
383	144	3,156	3,891	7,047	32,566	7,267
1,065	144	2,589	2,588	5,176	10,730	5,294
1,085	144	2,761	3,095	5,856	6,038	5,203
1,053	144	2,698	3,078	5,776	5,995	5,097
923	144	2,800	2,996	5,797	8,109	5,063
698	144	3,113	3,539	6,652	18,682	7,329
1,124	144	2,649	3,265	5,914	6,983	5,143
883	144	2,984	3,667	6,651	19,887	6,670
1,042	144	2,830	3,572	6,402	8,940	5,602
562	144	3,056	3,809	6,865	21,774	7,553
1,038	144	2,498	2,284	4,783	12,753	5,557
616	144	3,079	3,350	6,430	29,543	7,967
842	144	2,569	2,462	5,031	28,011	5,637
906	144	3,093	3,720	6,813	16,614	7,094
1,178	144	2,815	3,528	6,343	7,556	5,409
454	144	2,971	3,637	6,608	19,352	6,821
793	144	3,174	3,654	6,829	32,058	6,944
922	144	2,986	3,508	6,494	16,950	6,627
1,218	151	2,367	2,631	4,999	5,503	4,416
1,193	160	1,658	1,394	3,053	3,657	3,657
517	153	2,569	1,938	4,507	17,204	7,933
860	144	2,915	2,890	5,804	10,250	5,844
667	144	2,847	2,827	5,673	23,499	6,568
1,085	144	2,795	2,793	5,588	8,587	5,109
403	144	3,150	4,116	7,266	36,948	7,099
51	144	2,783	2,631	5,414	64,112	6,197
950	144	2,406	2,170	4,576	30,259	5,676
940	144	2,768	3,166	5,934	8,477	5,068
492	144	2,846	3,422	6,268	28,078	6,155
1,119	144	2,739	3,069	5,808	5,888	4,819
1,034	144	2,296	2,150	4,446	5,143	4,505
1,081	144	2,601	2,677	5,278	6,644	4,816
1,065	151	2,321	1,744	4,065	4,615	4,506
1,065	160	2,493	1,315	3,808	4,853	4,088
881	146	2,758	2,955	5,712	14,562	5,802
842	146	2,712	2,835	5,547	17,933	5,843

Table A1–6. Estimated Acreage of Delta Land Use Categories

Land Use Area	Land Use Category	Area (acres)
Delta Uplands (DWR Depletion Study)	Open Water	6,000
	Riparian	2,000
	Urban	15,700
	Irrigated Crops	142,500
	Natural and Idle	49,900
	Total	216,100
Delta Lowlands (DWR Depletion Study)	Open Water	48,000
	Riparian	7,000
	Urban	10,500
	Irrigated Crops	342,400
	Natural and Idle	54,200
	Total	462,100
DW Reservoir Islands (Bacon and Webb Tract)	Total	11,008
DW Habitat Islands (Bouldin Island and Holland Tract)	Riparian–Marsh–Water	1,102
	Upland–Developed	1,077
	Irrigated Crops	3,046
	Seasonal Wetlands	3,895
	Total	9,120

Notes: DWR depletion analysis based on Bulletin 160–83 land use projections for 1995 level of development (DWR 1983).
DW reservoir and habitat islands are included in Delta lowlands for No–Project Alternative conditions.

Table A1–7. Estimated Monthly Water Budget Terms for the Delta

	Monthly Amount (inches)												Annual Total (inches)	Contributing Area (acres)	Annual Volume (TAF)
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP			
Water, Riparian, and Urban Area															
Rainfall	0.8	2.2	2.6	3.2	2.5	2.7	1.2	0.4	0.1	0.1	0.1	0.4	16.3	89,200	121
Water evaporation	3.7	1.7	0.9	1.0	1.9	3.4	5.1	6.9	7.9	9.0	8.0	5.9	55.4	63,000	291
Irrigated Delta Uplands Area															
Rainfall	0.8	2.2	2.6	3.2	2.5	2.7	1.2	0.4	0.1	0.1	0.1	0.4	16.3	142,500	194
Soil moisture	2.0	3.0	4.0	4.0	4.0	4.0	2.5	2.0	2.0	2.0	2.0	2.0	33.5		
Uplands evapotranspiration	1.8	1.2	0.6	0.7	1.5	2.1	2.7	4.1	5.6	6.9	5.4	3.3	36.0	142,500	427
Applied water	2.1	0.0	0.0	0.0	0.0	0.0	0.0	6.5	11.1	13.6	10.6	5.7	49.6	142,500	589
Drainage water	1.0	0.0	1.0	2.5	1.0	0.6	0.0	3.3	5.5	6.8	5.3	2.9	29.9	142,500	355
Irrigated Delta Lowlands Area															
Rainfall	0.8	2.2	2.6	3.2	2.5	2.7	1.2	0.4	0.1	0.1	0.1	0.4	16.3	342,400	465
Soil moisture	4.0	5.1	7.1	8.0	8.0	8.0	6.5	4.0	4.0	4.0	4.0	4.0			
Lowlands evapotranspiration	1.4	1.1	0.6	0.7	1.5	2.1	2.7	3.8	4.9	5.8	4.3	2.3	31.2	342,400	890
Seepage	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	12.0	342,400	342
Salt leaching water	0.0	0.0	2.0	2.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	342,400	171
Applied water	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.9	9.5	11.3	8.3	3.9	36.1	342,400	1,030
Drainage water	1.6	1.0	1.0	4.6	4.0	3.6	1.0	1.9	5.8	6.7	5.2	2.9	39.2	342,400	1,119

Notes: Flooded depth is assumed to average 1 foot.
Drainage is assumed to be at least 50% of previous month's flooded volume for circulation.
Long–term average monthly rainfall is assumed; variations from year to year will occur.
Soil moisture is assumed to supply water for evapotranspiration or store excess rainfall.
The soil moisture from the previous month plus the rainfall plus the seepage plus the applied water minus the ET minus the end–of–month soil moisture will equal the drainage.

Table A1–8. Estimated Monthly Water Budget Terms for DW Islands

	Month												Annual Total (inches)	Contributing Area (acres)	Annual Volume (TAF)
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP			
DW Project Islands Intensified Agricultural Use															
Rainfall (inches)	0.8	2.2	2.6	3.2	2.5	2.7	1.2	0.4	0.1	0.1	0.1	0.4	16.3	17,000	23
Soil moisture (inches)	4.0	5.1	7.1	8.0	8.0	8.0	6.5	4.0	4.0	4.0	4.0	4.0			
Lowlands evapotranspiration (inches)	1.4	1.1	0.6	0.7	1.5	2.1	2.7	3.8	4.9	5.8	4.3	2.3	31.2	17,000	44
Seepage (inches)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	12.0	17,000	17
Salt leaching water (inches)	0.0	0.0	2.0	2.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	17,000	9
Applied water (inches)	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.9	9.5	11.3	8.3	3.9	36.1	17,000	51
Drainage water (inches)	1.6	1.0	1.0	4.6	4.0	3.6	1.0	1.9	5.8	6.7	5.2	2.9	39.2	17,000	56
DW Project Islands Wildlife Habitat Use															
Water and marsh (acres)	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060			
Flooded area (acres)	2,000	3,400	5,000	4,500	4,300	1,400	500	0	0	0	0	1,200			
Irrigated area (acres)	5,000	3,600	2,000	2,500	2,700	5,600	6,500	7,000	7,000	7,000	7,000	5,800			
Rainfall (inches)	0.8	2.2	2.6	3.2	2.5	2.7	1.2	0.4	0.1	0.1	0.1	0.4	16.3		
Water evaporation (inches)	3.7	1.7	0.9	1.0	1.9	3.4	5.1	6.9	7.9	9.0	8.0	5.9	55.4		
Lowlands evapotranspiration (inches)	1.4	1.1	0.6	0.7	1.5	2.1	2.7	3.8	4.9	5.8	4.3	2.3	31.2		
Soil moisture	4.0	5.1	7.1	8.0	8.0	8.0	6.5	4.0	4.0	4.0	4.0	4.0			
Seepage volume (TAF)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5			6
Change in flooded volume (TAF)	0.8	1.4	1.6	(0.5)	(0.2)	(2.9)	(0.9)	(0.5)	0.0	0.0	0.0	1.2			0
Net evaporation (TAF)	1.0	(0.2)	(0.9)	(1.3)	(0.5)	(0.1)	0.5	1.1	3.5	4.1	3.1	2.0			12
Applied water (TAF)	1.9	1.7	1.9	0.2	1.1	0.0	0.0	0.4	3.0	3.6	2.6	2.7			19
Drainage water (TAF)	0.6	1.0	1.7	2.5	2.3	2.2	0.7	0.3	0.0	0.0	0.0	0.0			11

Notes: Flooded depth is assumed to average 1 foot.
Drainage is assumed to be at least 50% of previous month's flooded volume for circulation.
Long-term average monthly rainfall is assumed; variations from year to year will occur.
Soil moisture is assumed to supply water for evapotranspiration or store excess rainfall.
Rainfall plus seepage plus applied water minus the change in soil moisture minus evaporation minus ET will equal the drainage.

Table A1–9. DW Project Islands Drainage Pumping Estimates for 1986–1992 based on PG&E Pumping Tests (af/kWh) and Power Consumption Records

Water Year	Month	Bouldin Island 5,985 acres (AF)	Bouldin Island 5,985 acres (inches)	Bacon Island 5,539 acres (AF)	Bacon Island 5,539 acres (inches)	Webb Tract 5,469 acres (AF)	Webb Tract 5,469 acres (inches)	Holland Tract 4,187 acres (AF)	Holland Tract 4,187 acres (inches)
1986	OCT	87	0.2						
	NOV	2,217	4.4						
	DEC	3,387	6.8						
	JAN	2,125	4.3						
	FEB	2,771	5.6						
	MAR	3,944	7.9						
	APR	558	1.1						
	MAY	1,292	2.6						
	JUN	1,553	3.1						
	JUL	2,688	5.4						
	AUG	2,939	5.9						
	SEP	1,102	2.2						
1987	OCT	245	0.5						
	NOV	1,932	3.9						
	DEC	3,419	6.9						
	JAN	2,074	4.2						
	FEB	3,736	7.5						
	MAR	1,377	2.8						
	APR	837	1.7						
	MAY	909	1.8						
	JUN	804	1.6						
	JUL	1,113	2.2						
	AUG	1,740	3.5						
	SEP	1,125	2.3						
1988	OCT	621	1.2	1,834	4.0				
	NOV	1,248	2.5	655	1.4				
	DEC	1,785	3.6	3,243	7.0				
	JAN	2,701	5.4	2,185	4.7				
	FEB	574	1.2	590	1.3				
	MAR	501	1.0	721	1.6				
	APR	758	1.5	1,852	4.0				
	MAY	378	0.8	2,981	6.5				
	JUN	542	1.1	1,506	3.3				
	JUL	1,064	2.1	5,624	12.2				
	AUG	780	1.6	4,679	10.1				
	SEP	54	0.1	3,412	7.4				
1989	OCT	449	0.9	2,085	4.5				
	NOV	1,177	2.4	216	0.5				
	DEC	2,960	5.9	1,042	2.3				
	JAN	3,929	7.9	4,265	9.2				
	FEB	690	1.4	2,292	5.0				
	MAR	272	0.5	1,294	2.8				
	APR	647	1.3	1,755	3.8				
	MAY	702	1.4	4,091	8.9				
	JUN	1,451	2.9	4,309	9.3				
	JUL	2,072	4.2	3,486	7.6				
	AUG	1,775	3.6	3,618	7.8				
	SEP	408	0.8	3,932	8.5				

Table A1–9. Continued

Water Year	Month	Bouldin Island 5,985 acres (AF)	Bouldin Island 5,985 acres (inches)	Bacon Island 5,539 acres (AF)	Bacon Island 5,539 acres (inches)	Webb Tract 5,469 acres (AF)	Webb Tract 5,469 acres (inches)	Holland Tract 4,187 acres (AF)	Holland Tract 4,187 acres (inches)
1990	OCT	81	0.2	1,520	3.3	0	0.0	216	0.6
	NOV	304	0.6	923	2.0	36	0.1	269	0.8
	DEC	51	0.1	3,843	8.3	46	0.1	840	2.4
	JAN	1,226	2.5	2,286	5.0	1,545	3.4	525	1.5
	FEB	486	1.0	1,698	3.7	830	1.8	506	1.4
	MAR	757	1.5	972	2.1	733	1.6	477	1.3
	APR	1,376	2.8	1,594	3.5	733	1.6	473	1.3
	MAY	458	0.9	2,938	6.4	730	1.6	488	1.4
	JUN	367	0.7	3,640	7.9	81	0.2	301	0.9
	JUL	1,169	2.3	3,380	7.3	188	0.4	146	0.4
	AUG	821	1.6	3,532	7.7	188	0.4	171	0.5
	SEP	138	0.3	4,079	8.8	85	0.2	124	0.4
1991	OCT	798	1.6	1,465	3.2	233	0.5	218	0.6
	NOV	2,596	5.2	897	1.9	1,230	2.7	722	2.0
	DEC	2,596	5.2	5,316	11.5	2,223	4.9	549	1.6
	JAN	1,873	3.8	2,197	4.8	2,042	4.5	1,317	3.7
	FEB	1,831	3.7	1,845	4.0	1,487	3.3	1,701	4.8
	MAR	1,831	3.7	1,281	2.8	1,360	3.0	544	1.5
	APR	368	0.7	786	1.7	245	0.5	160	0.5
	MAY	158	0.3	4,268	9.2	78	0.2	157	0.4
	JUN	724	1.5	4,153	9.0	80	0.2	293	0.8
	JUL	1,650	3.3	4,153	9.0	52	0.1	64	0.2
	AUG	2,757	5.5	4,995	10.8	44	0.1	675	1.9
	SEP	65	0.1	3,940	8.5	69	0.2	347	1.0
1992	OCT	128	0.3	1,424	3.1	203	0.4	284	0.8
	NOV	1,547	3.1	442	1.0	788	1.7	232	0.7
	DEC	1,940	3.9	4,051	8.8	1,871	4.1	290	0.8
	JAN	1,811	3.6	1,936	4.2	1,891	4.1	616	1.7
	FEB	3,287	6.6	1,826	4.0	1,279	2.8	1,001	2.8
	MAR	3,287	6.6	1,826	4.0	2,699	5.9	906	2.6
	APR	264	0.5	1,275	2.8	2,349	5.2	508	1.4
	MAY	122	0.2	5,147	11.2	456	1.0	359	1.0
	JUN	1,061	2.1	4,295	9.3	291	0.6	391	1.1
	JUL	1,614	3.2	2,486	5.4	416	0.9	436	1.2
	AUG	1,245	2.5	3,433	7.4	582	1.3	430	1.2
	SEP	1,250	2.5	3,807	8.2	413	0.9	287	0.8
Annual Totals									
1986		24,663	49						
1987		19,311	39						
1988		11,006	22	29,282	63				
1989		16,532	33	32,385	70				
1990		7,234	15	30,405	66	5,195	11	4,536	13
1991		17,247	35	35,296	76	9,143	20	6,747	19
1992		17,556	35	31,948	69	13,238	29	5,740	16
Average		16,221	33	31,863	69	9,192	20	5,674	16

Combined DW Islands (21,180 acres)

Annual Pumping (inches)	1990	27
	1991	39
	1992	39

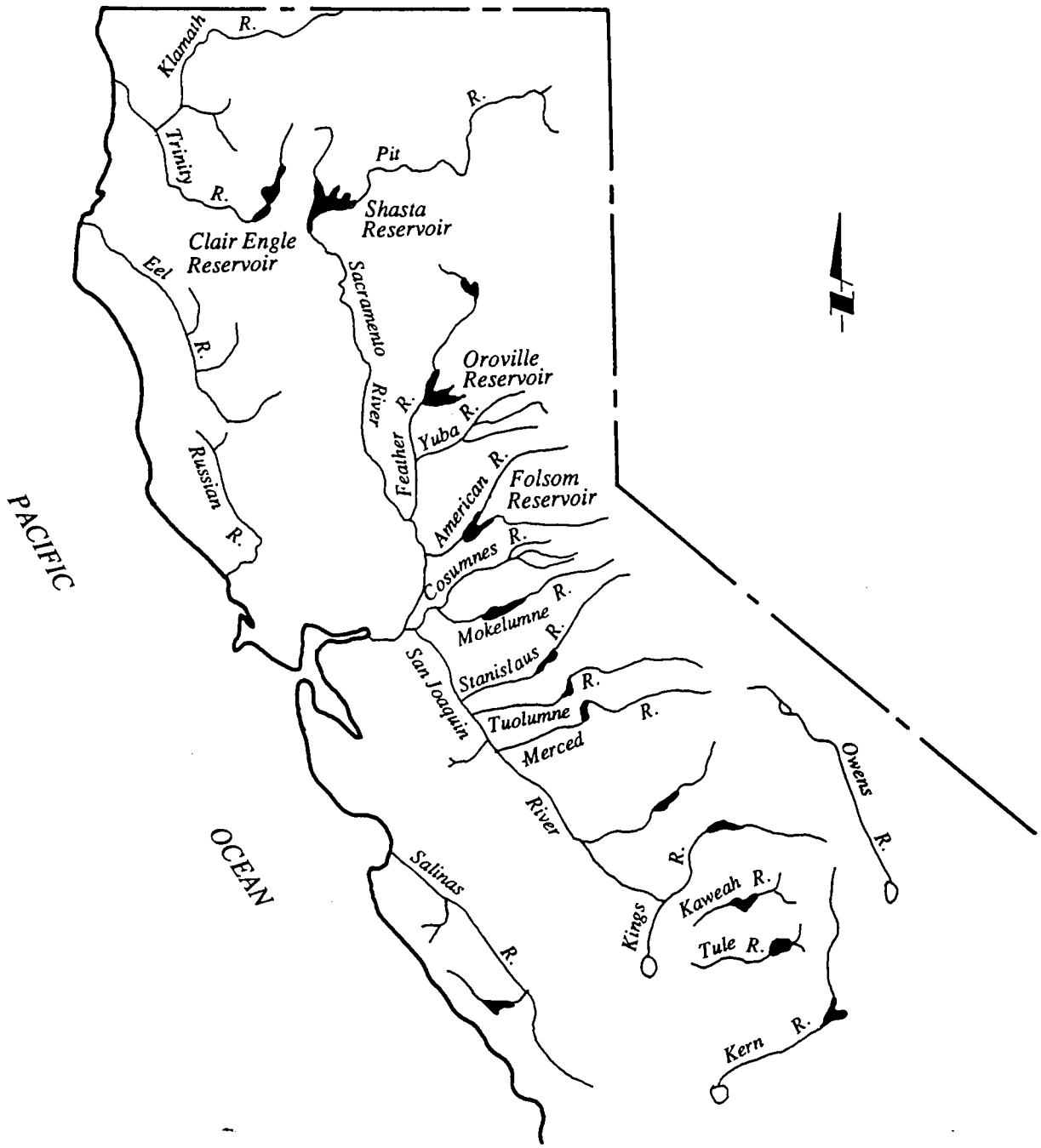


Figure A1-1.
Delta Tributaries and Upstream Reservoirs Included in the DWRSIM Statewide Water Supply Planning Model

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

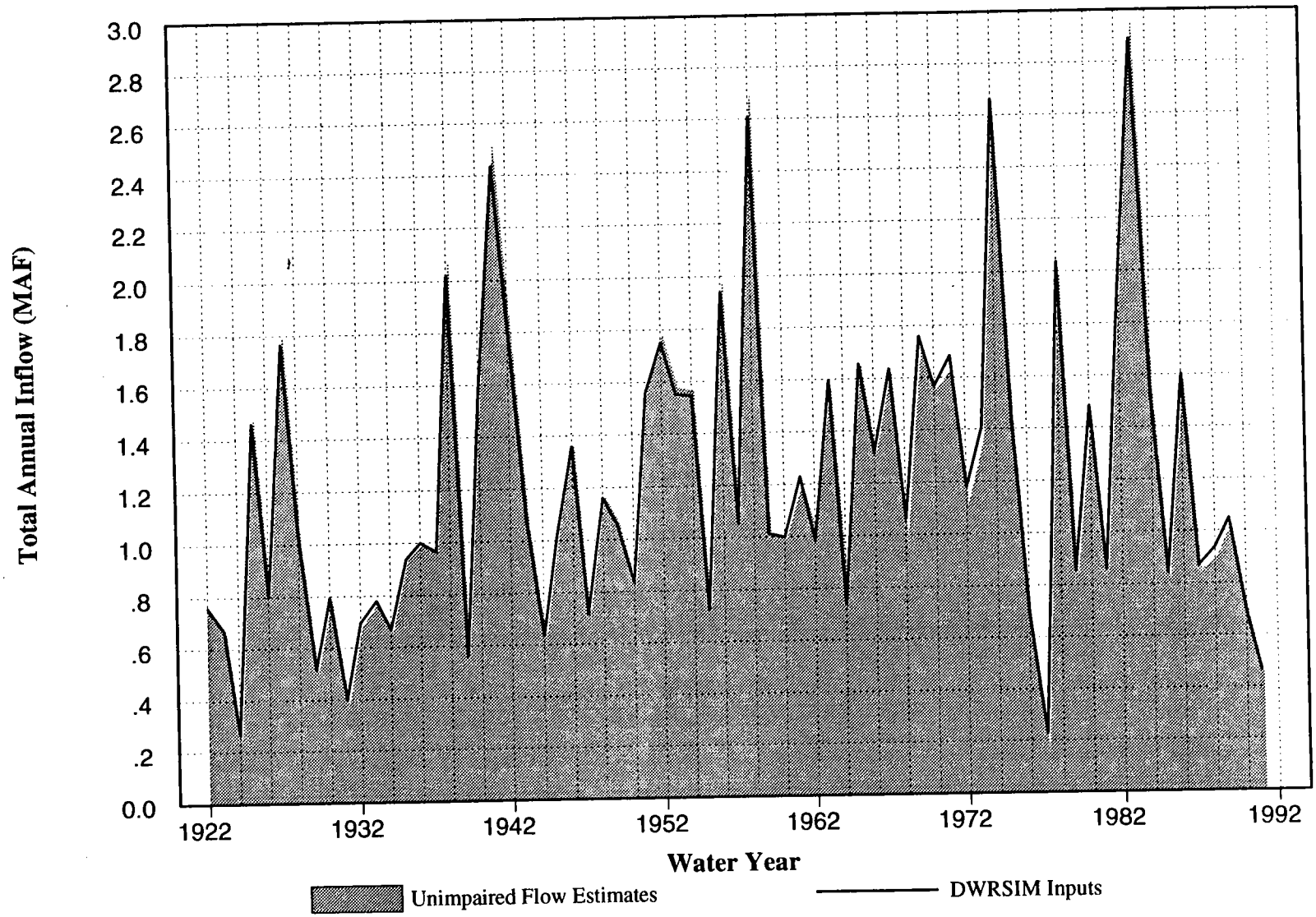


Figure A1-2.
Unimpaired Flow Estimates and DWRSIM Inputs for Total Annual Inflows to Clair Engle Reservoir for 1922-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

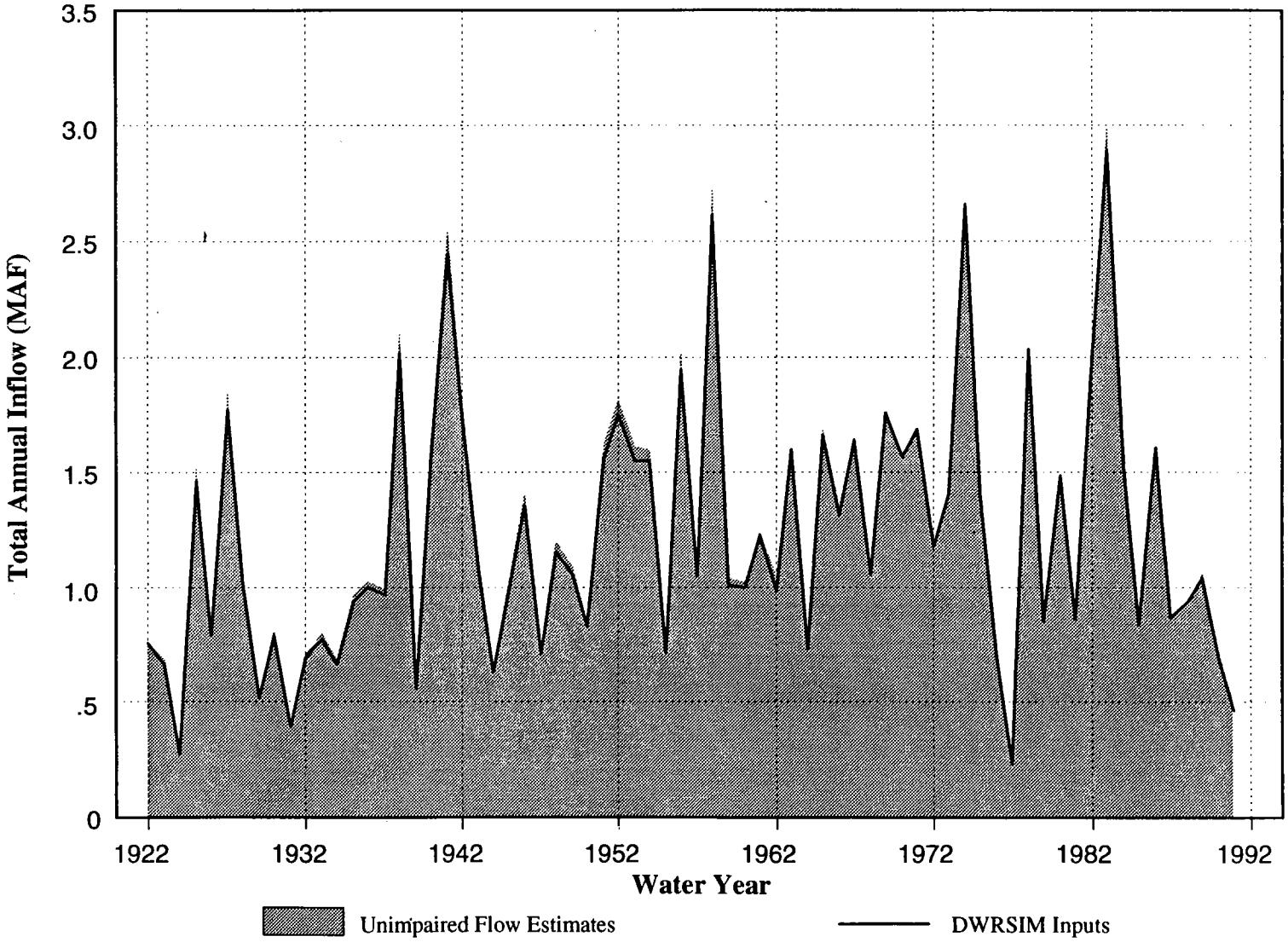


Figure A1-3.
Unimpaired Flow Estimates and DWRSIM Inputs for Total Annual Flows in the Trinity River for 1922-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

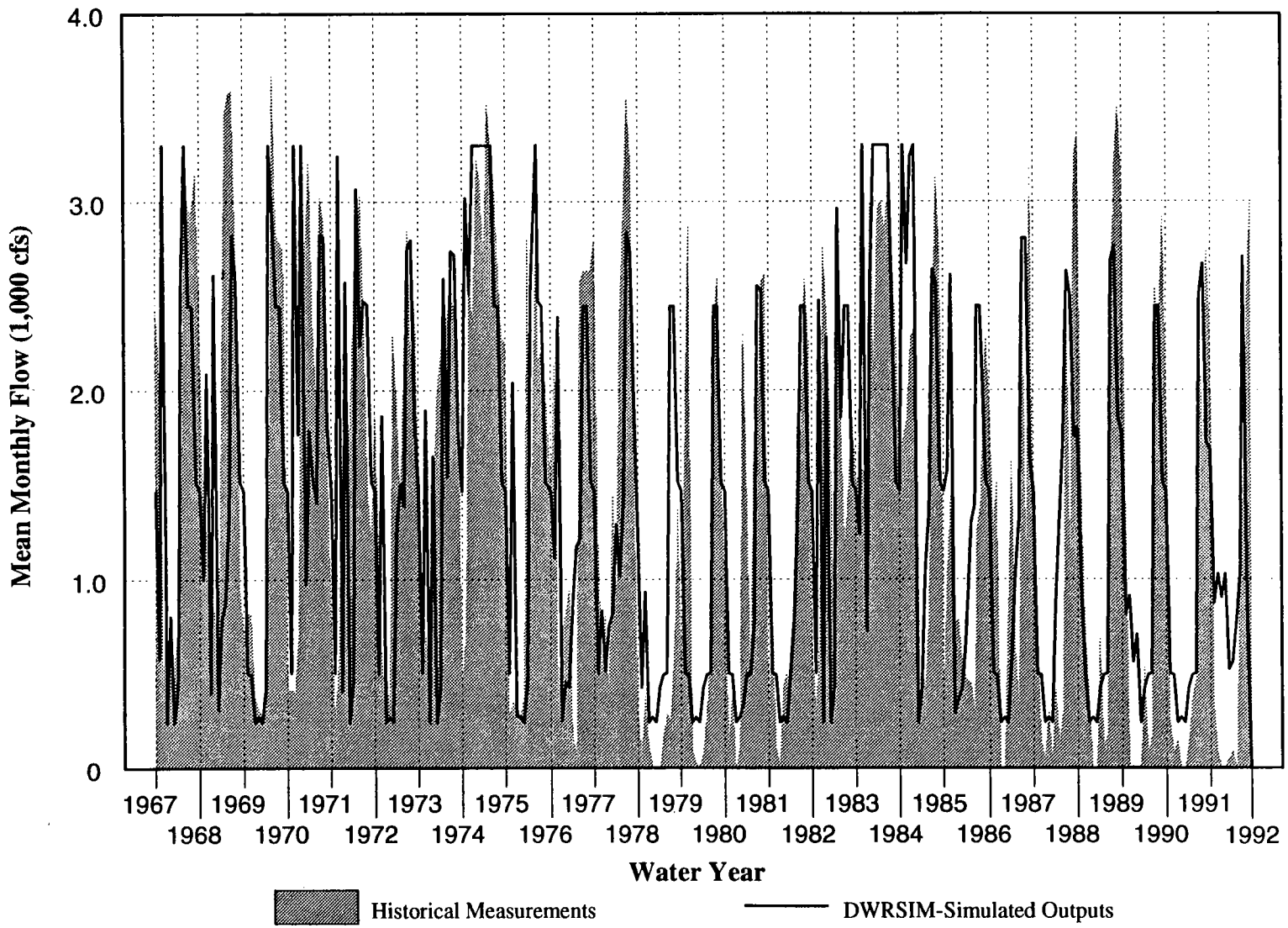


Figure A1-4.
Historical Measured and DWRSIM-Simulated Mean Monthly Diversions from the Trinity River Basin for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

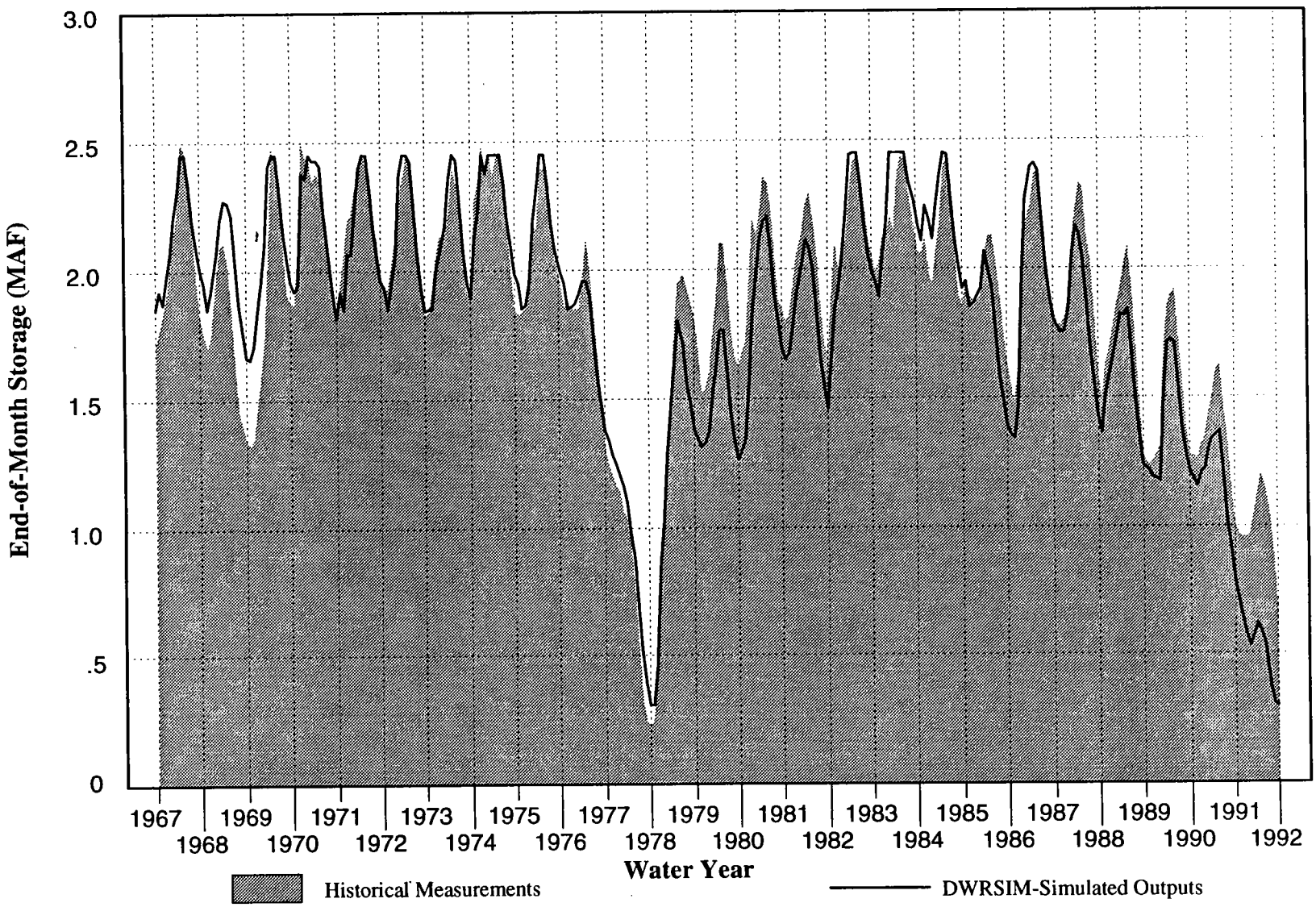


Figure A1-5.
Historical Measured and DWRSIM-Simulated End-of-Month Storage in Clair Engle Reservoir for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

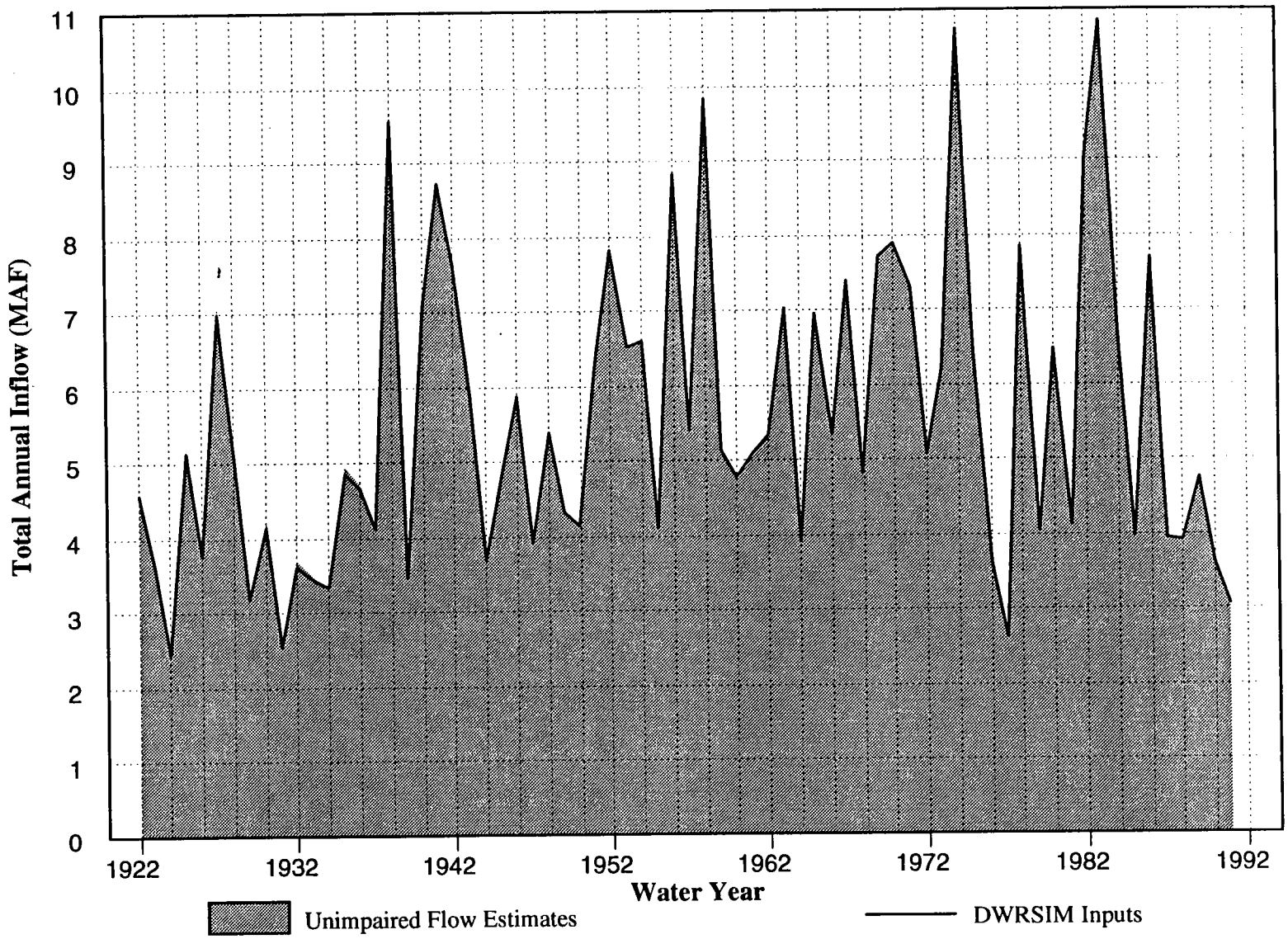


Figure A1-6.
Unimpaired Flow Estimates and DWRSIM Inputs for Total Annual Inflows to Shasta Reservoir for 1922-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

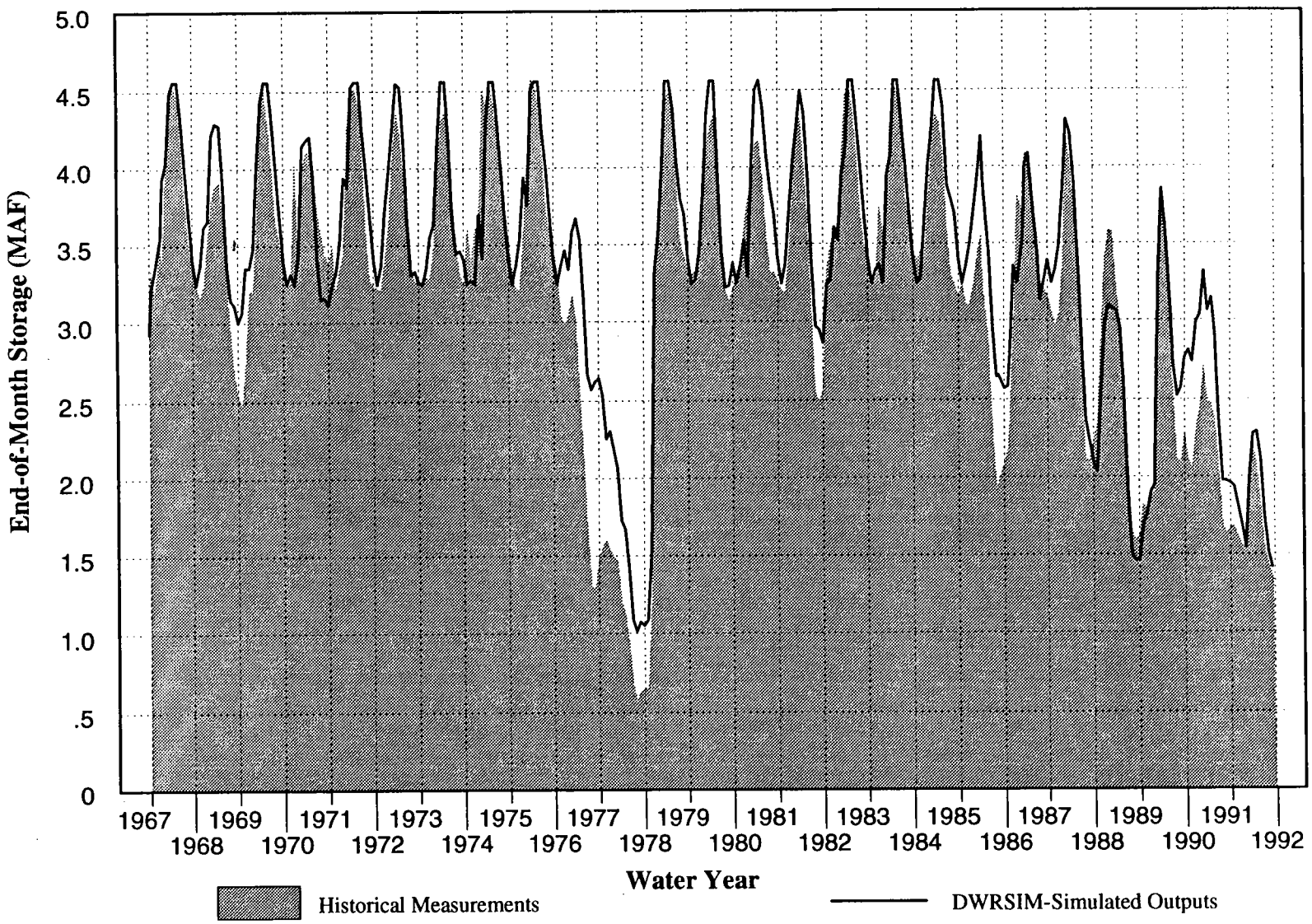


Figure A1-7.
Historical Measured and DWRSIM-Simulated End-of-Month Storage in Shasta Reservoir for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

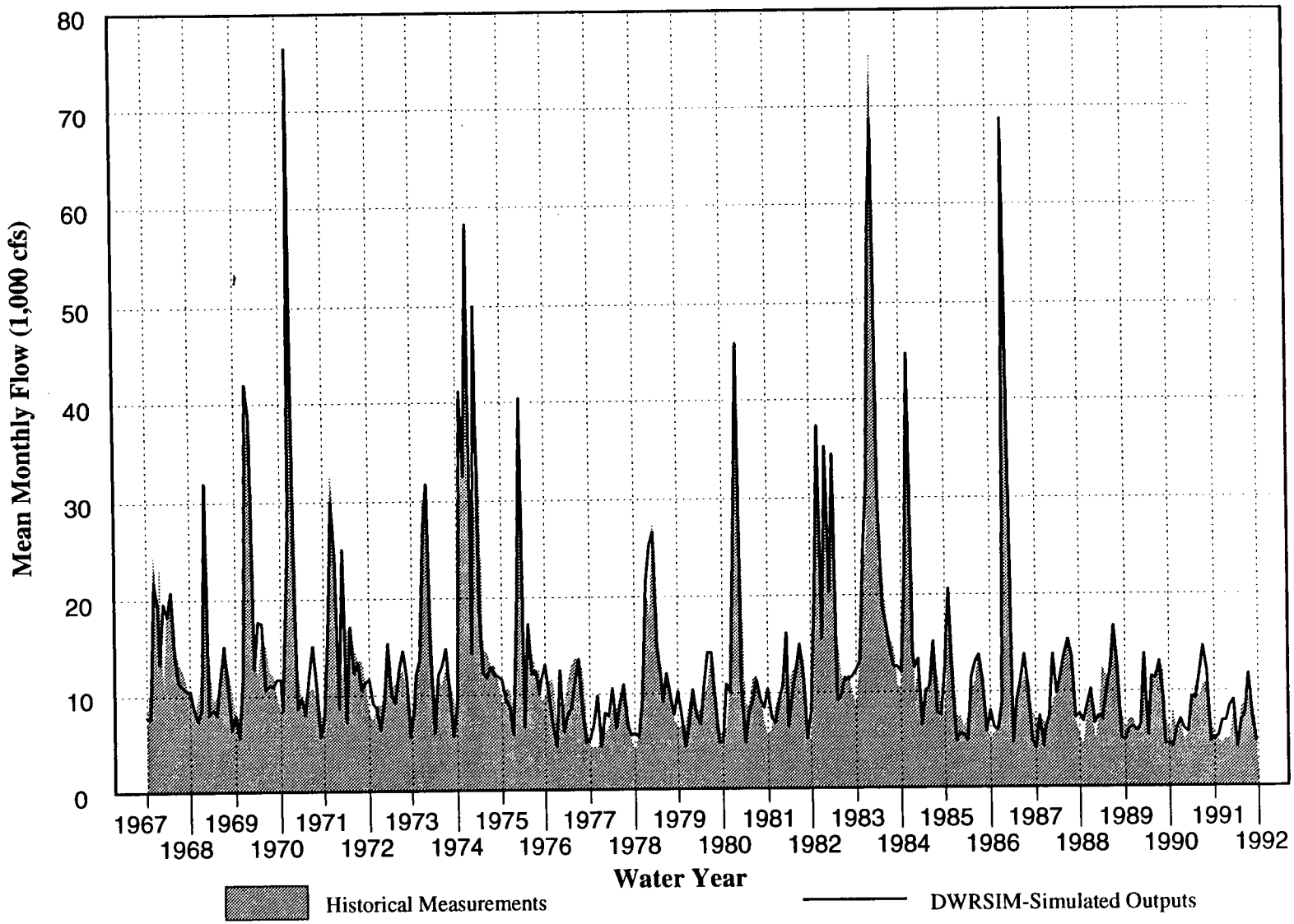


Figure A1-8.
Historical Measured and DWRSIM-Simulated Mean Monthly Flows in the Sacramento River at Bend Bridge for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

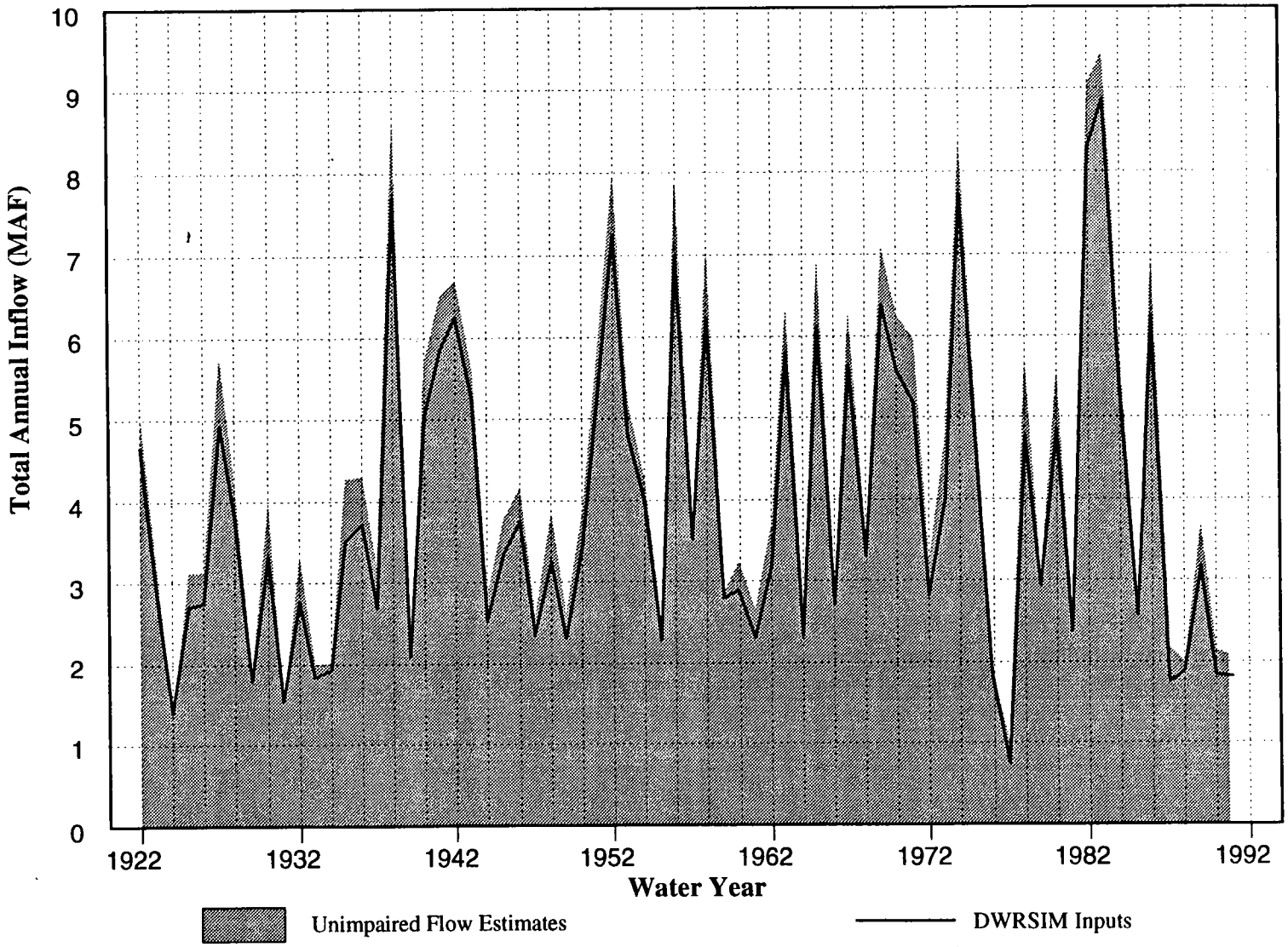


Figure A1-9.
Unimpaired Flow Estimates and DWRSIM Inputs for Total Annual Inflows to Oroville Reservoir for 1922-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

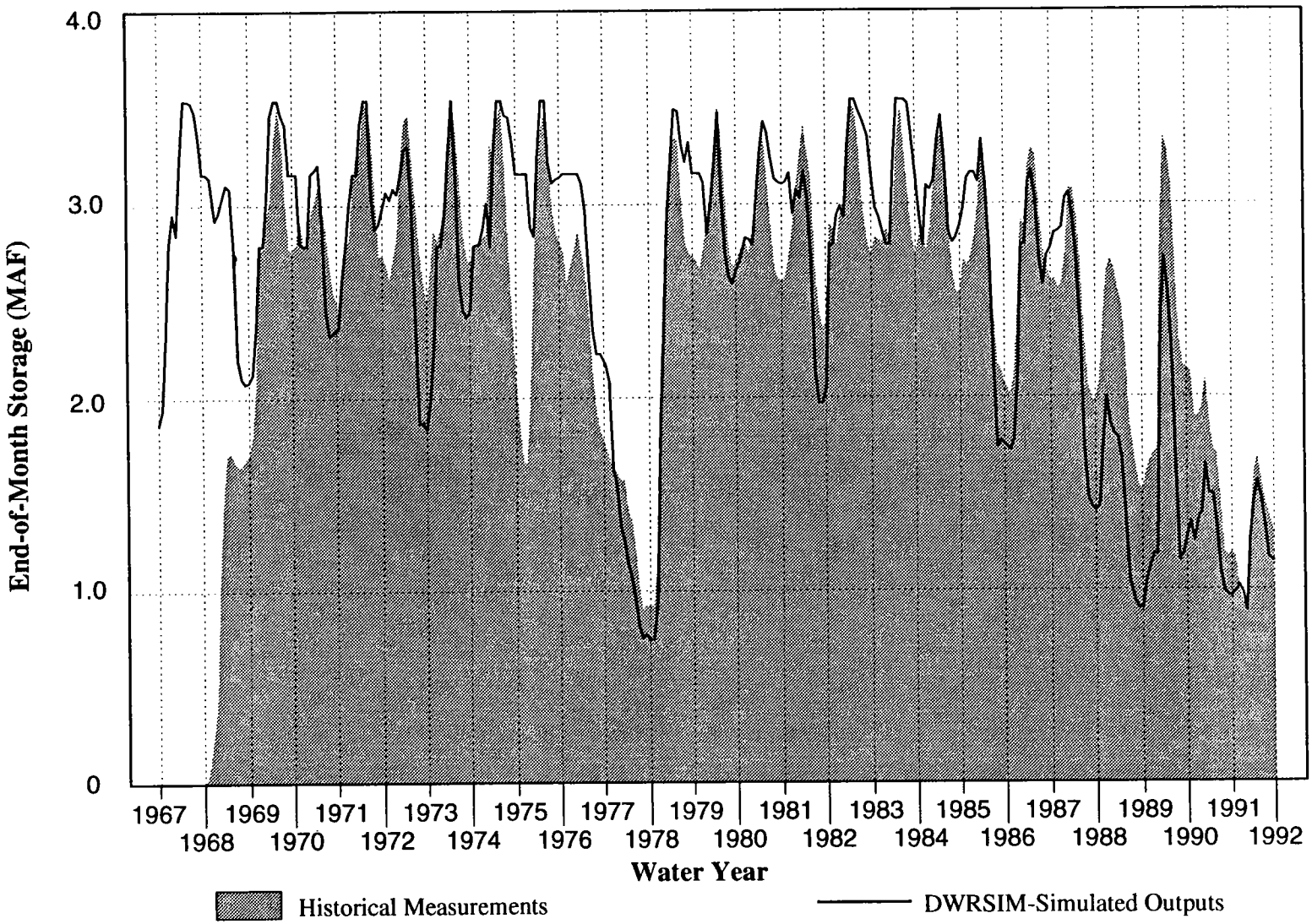


Figure A1-10.
Historical Measured and DWRSIM-Simulated End-of-Month Storage in Oroville Reservoir for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

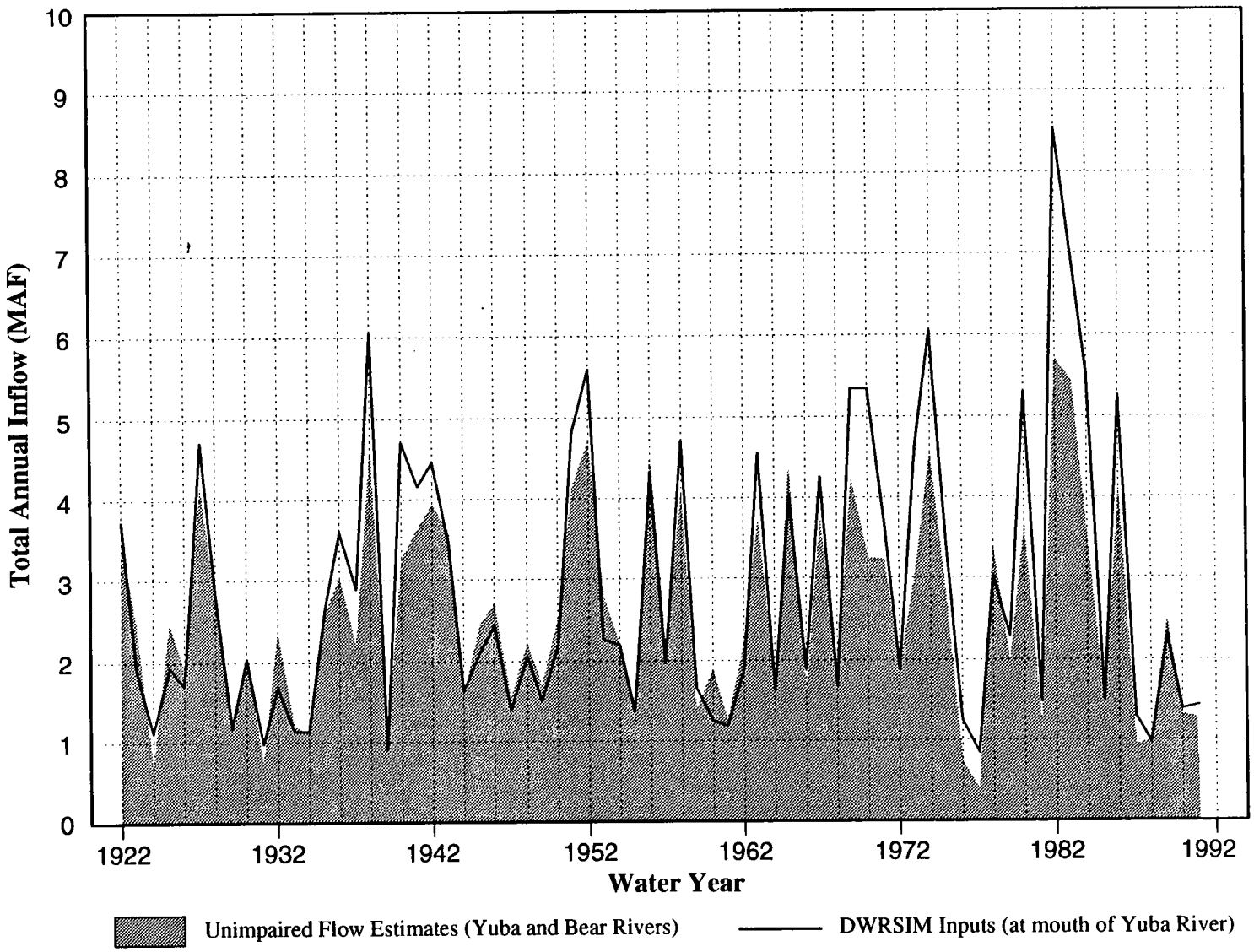


Figure A1-11.
Unimpaired Flow Estimates for the Yuba and Bear Rivers, and DWRSIM Inputs for Total Annual Gains to the Feather River for 1922-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

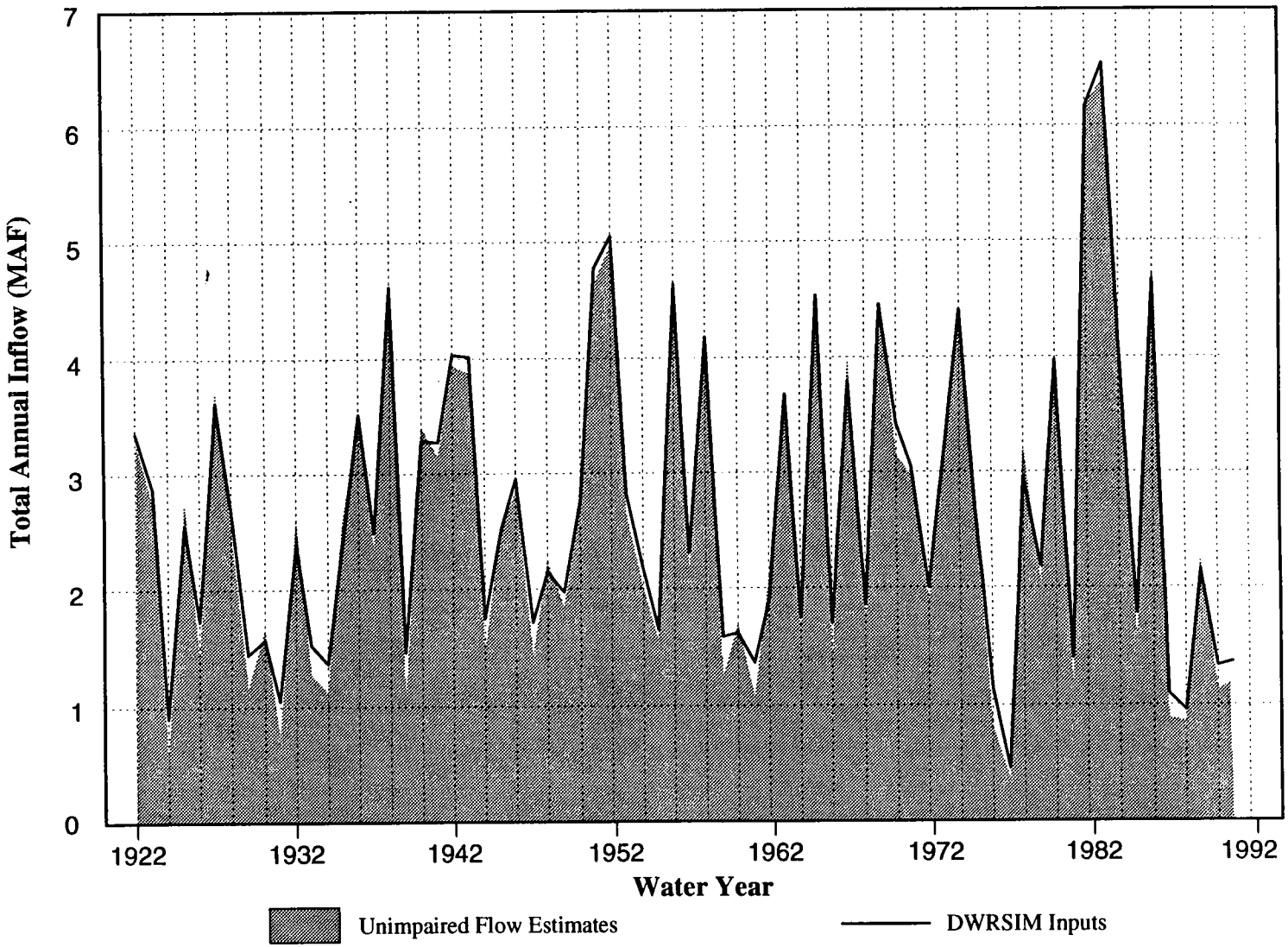


Figure A1-12.
Unimpaired Flow Estimates and DWRSIM Inputs for Total Annual Inflows to Folsom Reservoir for 1922-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

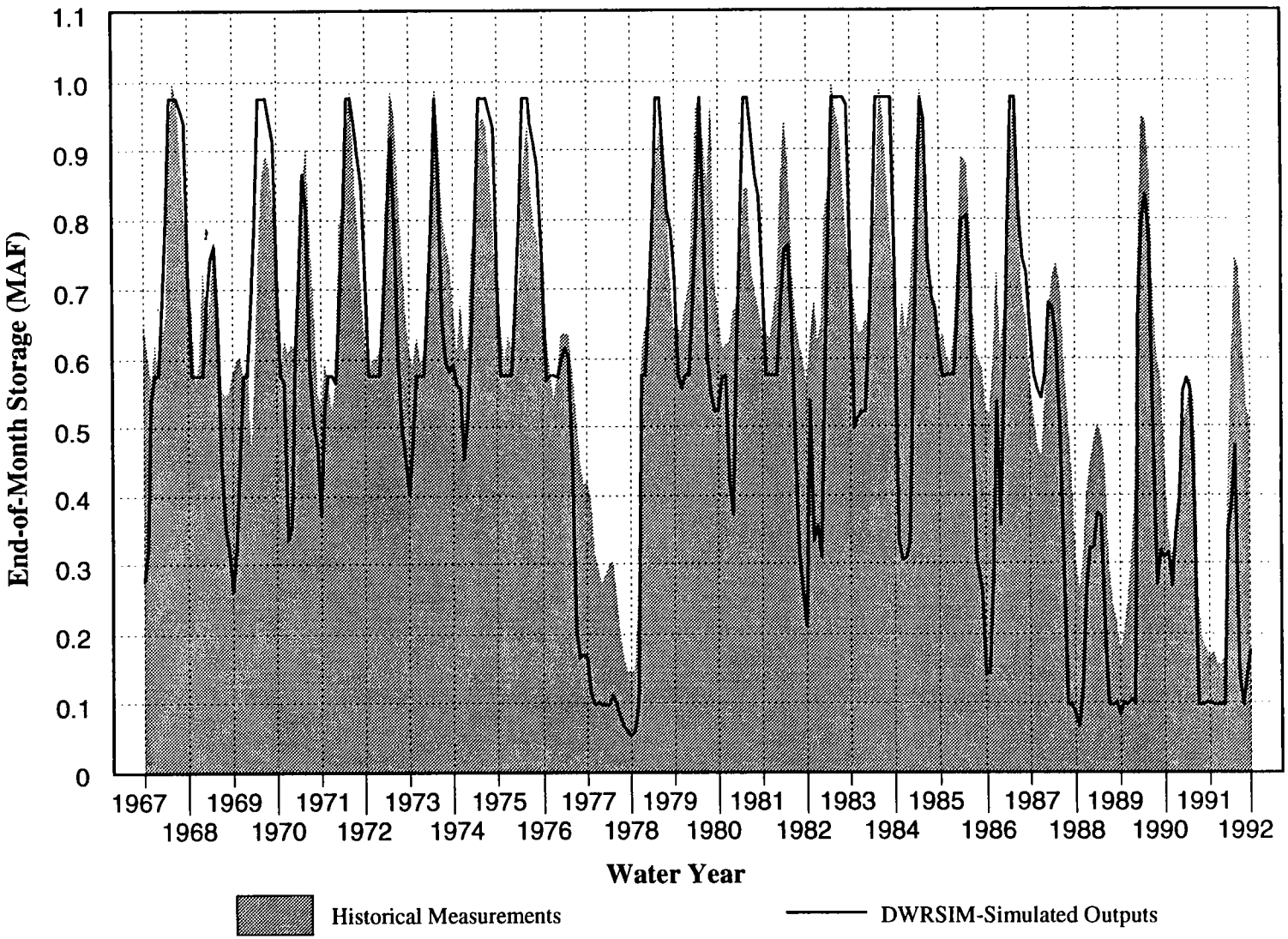


Figure A1-13.
Historical Measured and DWRSIM-Simulated End-of-Month Storage in Folsom Reservoir for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

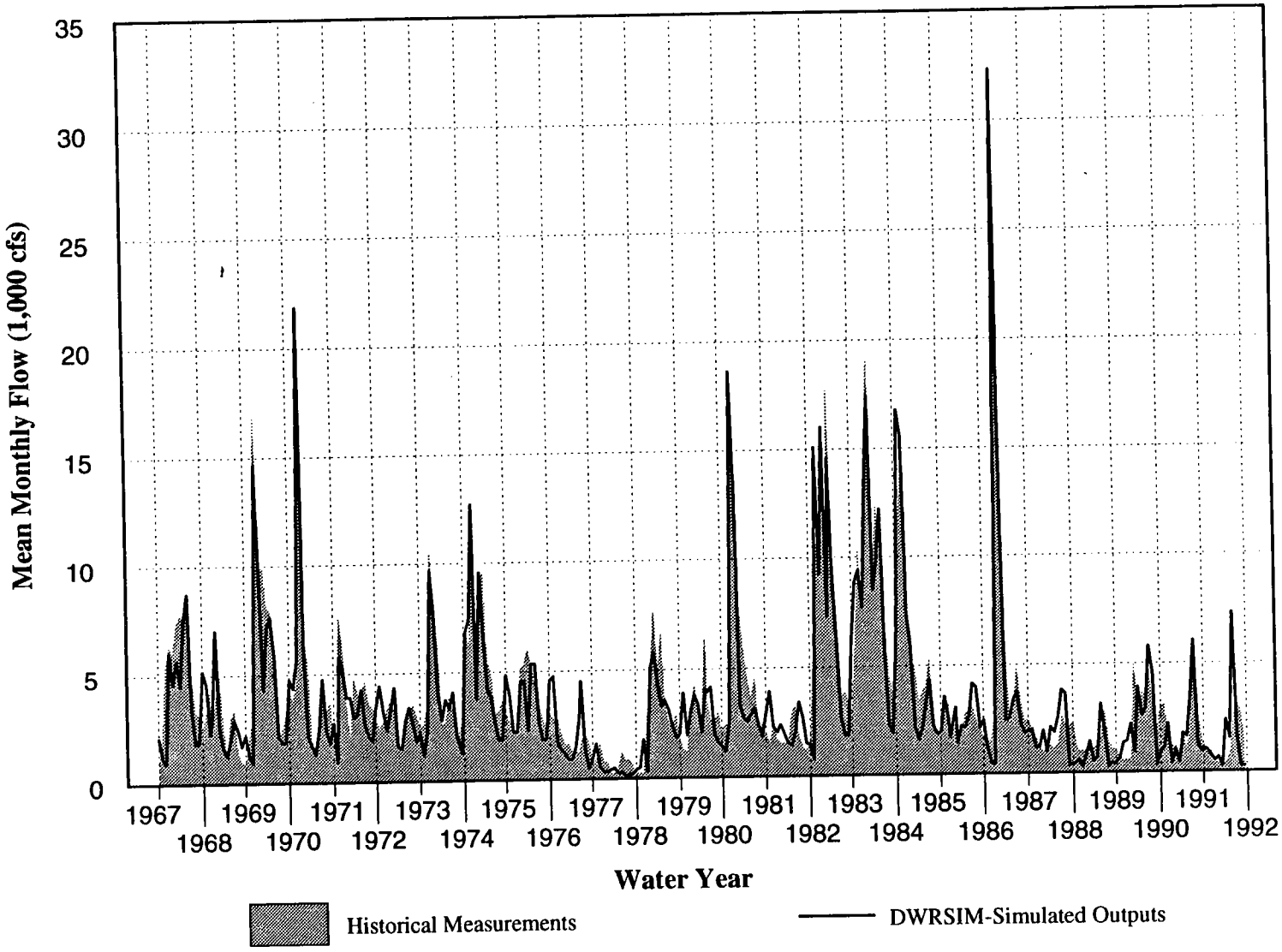
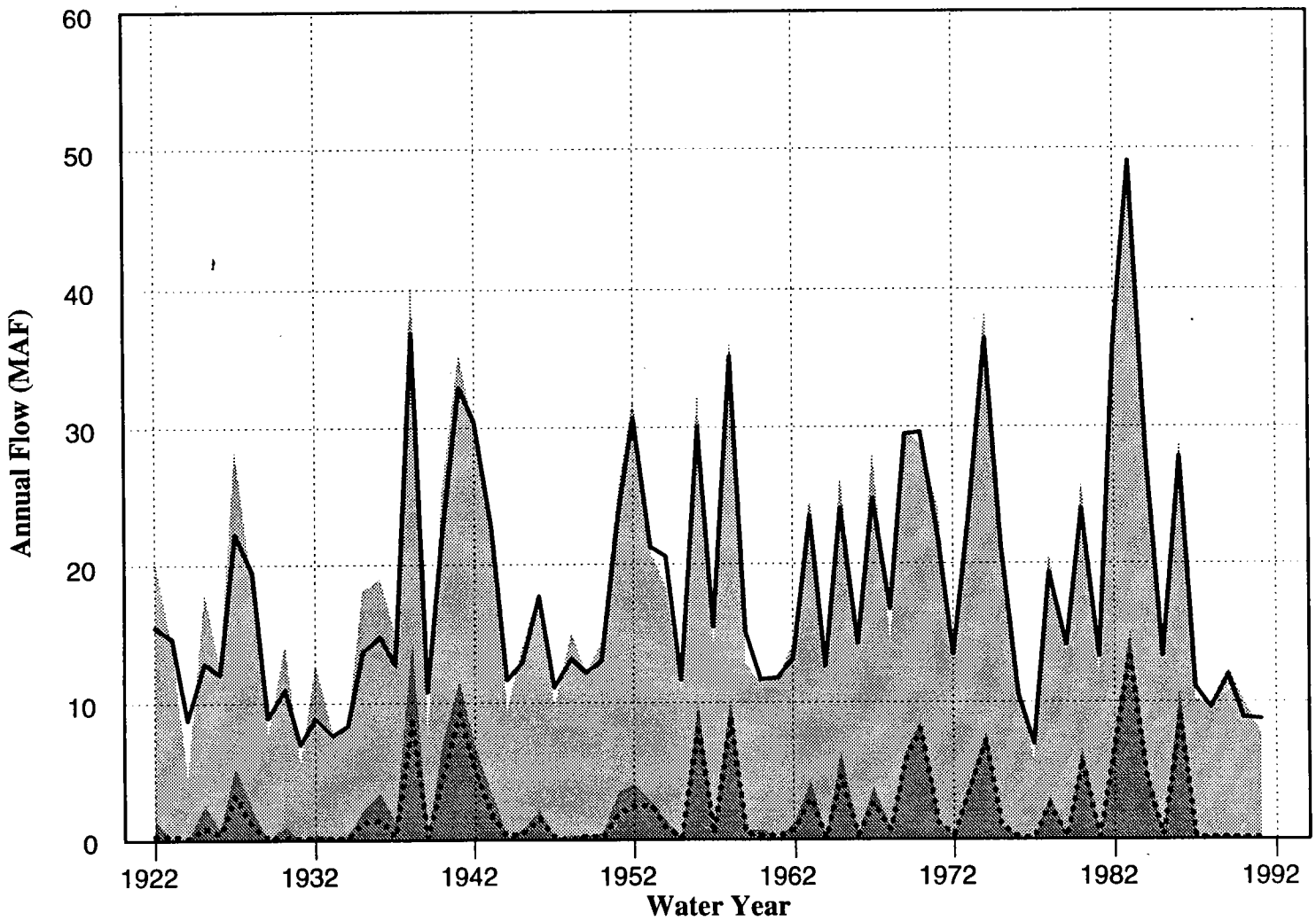


Figure A1-14.
Historical Measured and DWRSIM-Simulated Mean Monthly Flows in the American River at Fair Oaks for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



Historical Yolo Bypass Measurements

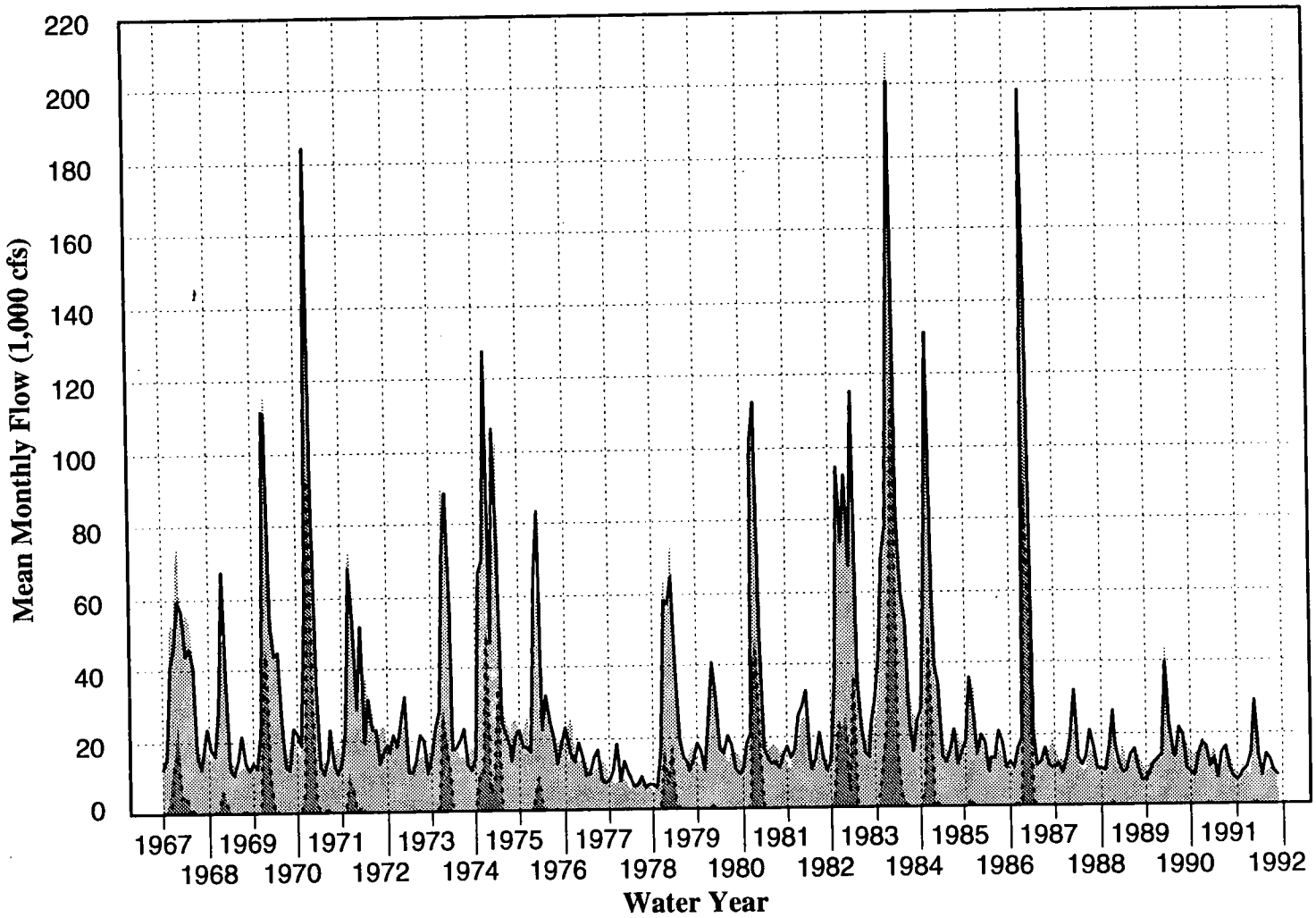
Historical Sacramento River + Yolo Bypass Measurements

DWRSIM-Simulated Yolo Bypass Flow

DWRSIM-Simulated Sacramento River + Yolo Bypass Flow

Figure A1-15.
Historical Measured and DWRSIM-Simulated Total Annual Delta Inflows from Yolo Bypass and the Sacramento River at Freeport for 1922-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



Historical Yolo Bypass Measurements

Historical Sacramento River + Yolo Bypass Measurements

DWRSIM-Simulated Yolo Bypass Flows

DWRSIM-Simulated Sacramento River + Yolo Bypass Flows

Figure A1-16.
Historical Measured and DWRSIM-Simulated Mean Monthly Flows in Yolo Bypass and the Sacramento River at Freeport for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

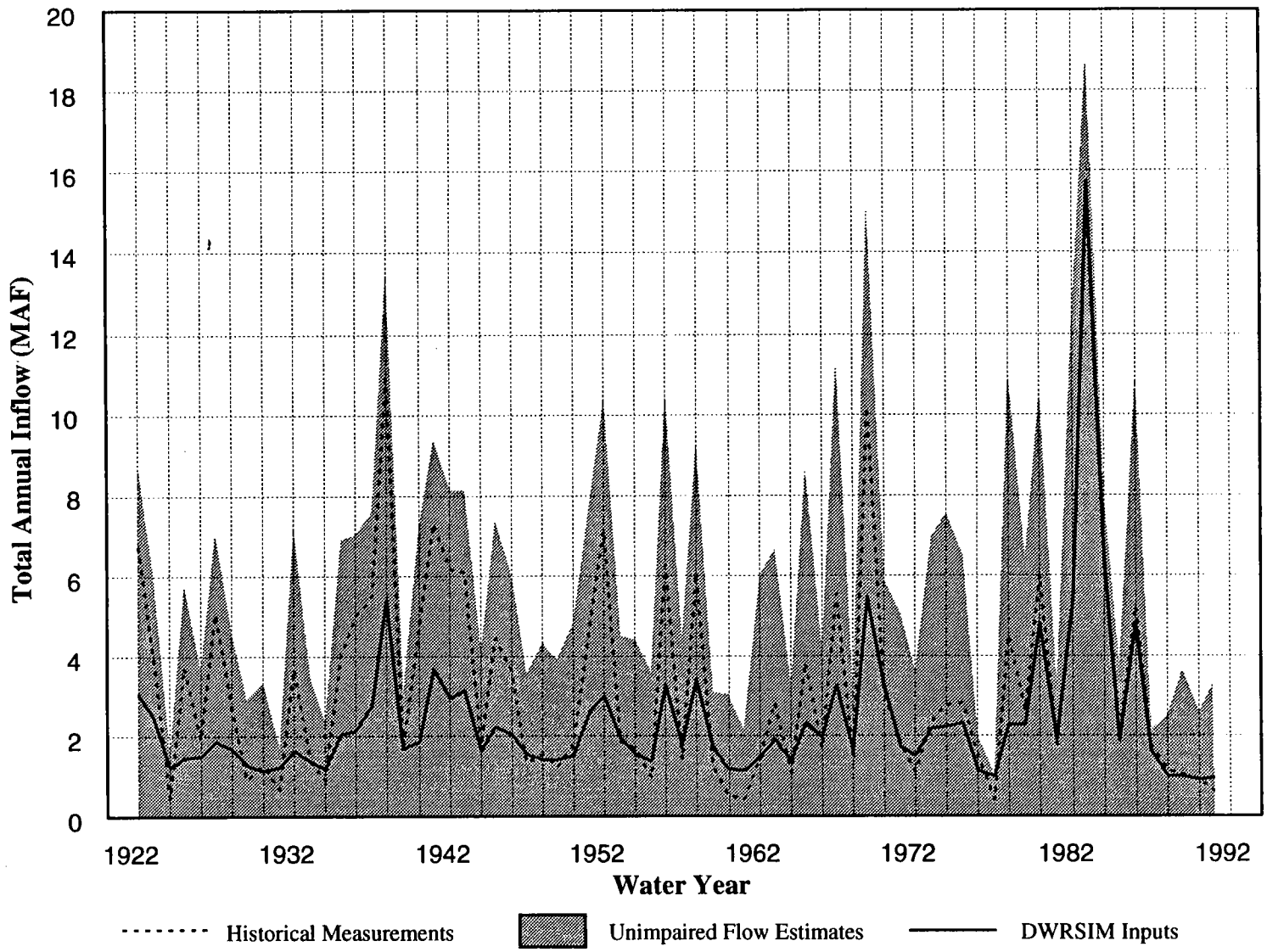


Figure A1-17.
Historical Measurements, Unimpaired Flow Estimates, and DWRSIM Inputs for Total Annual Flows in the San Joaquin River at Vernalis for 1922-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

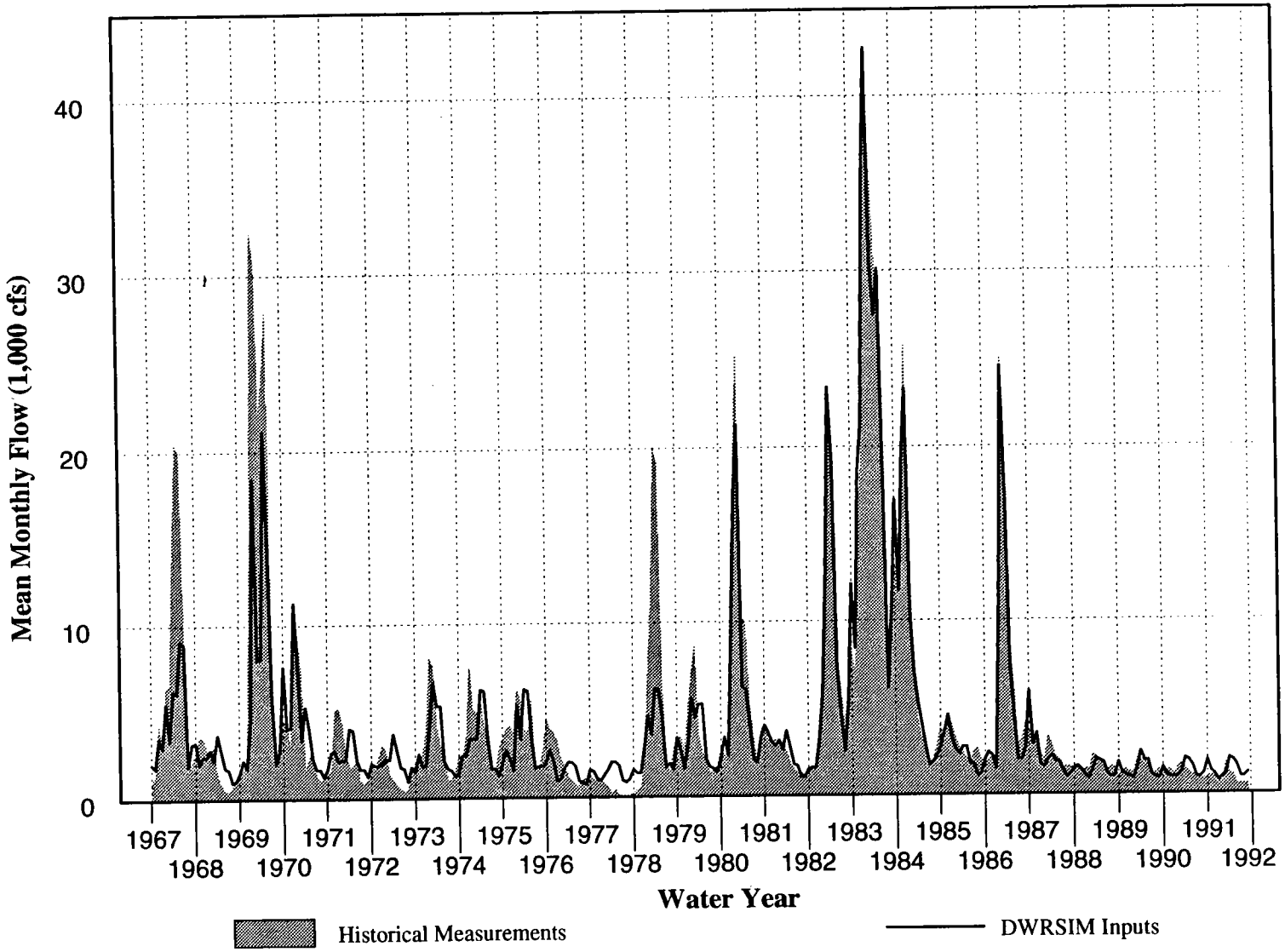


Figure A1-18.
Historical Measurements and DWRSIM Inputs for Mean Monthly Flows in the San Joaquin River at Vernalis for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

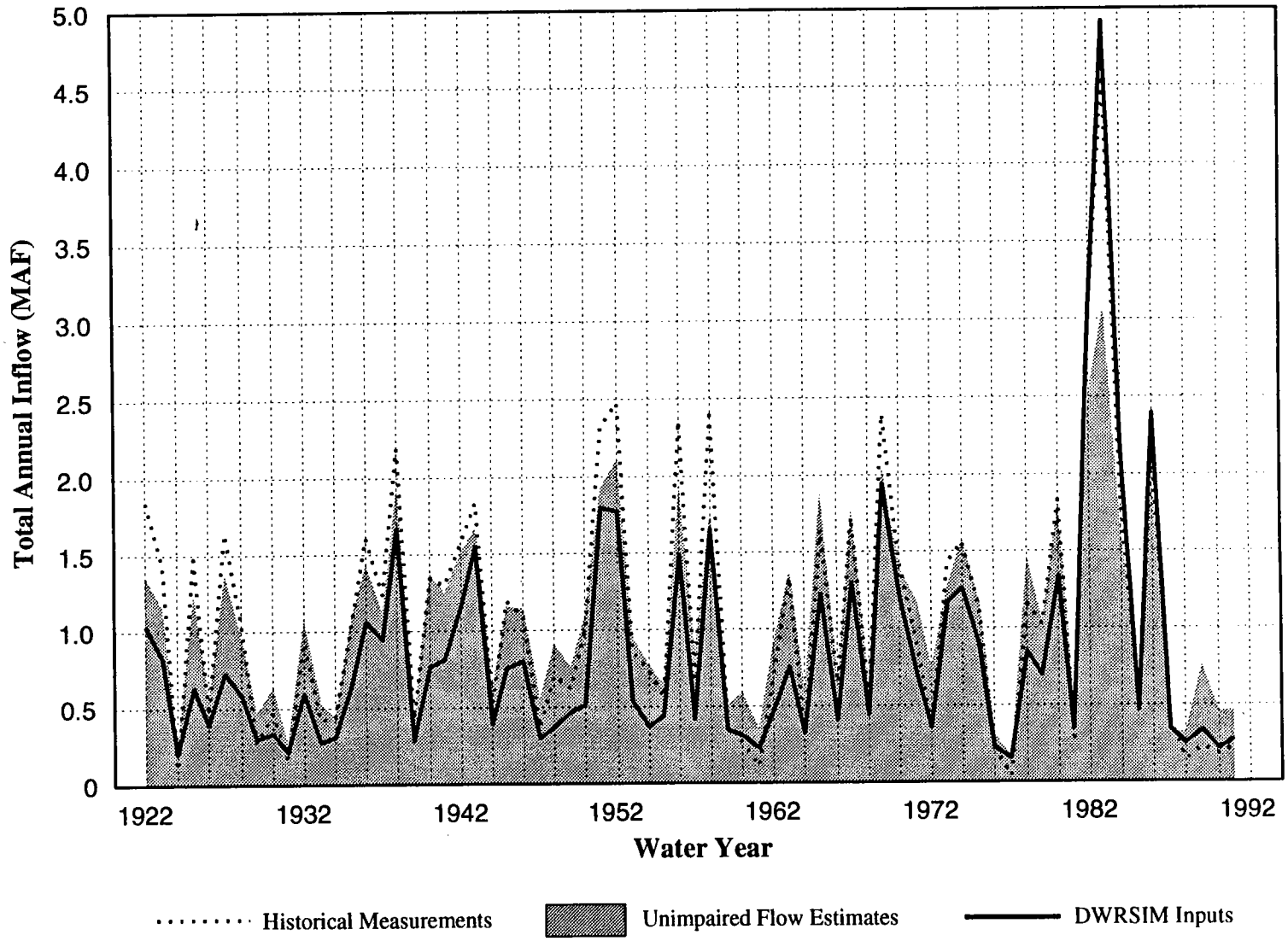


Figure A1-19.
Historical Measurements, Unimpaired Flow Estimates, and DWRSIM Inputs for Total Annual Inflows to the Delta from Eastside Streams for 1922-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

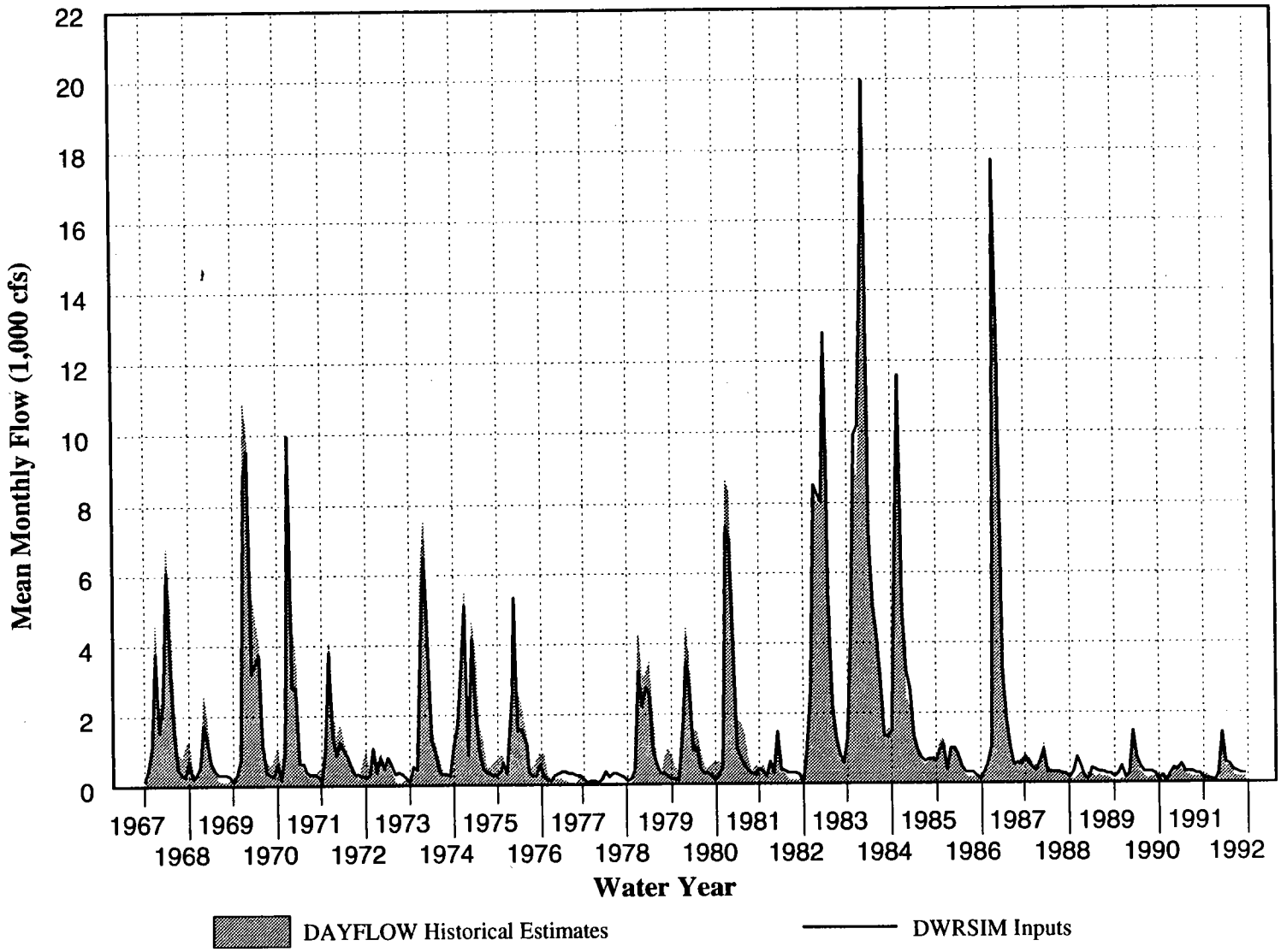
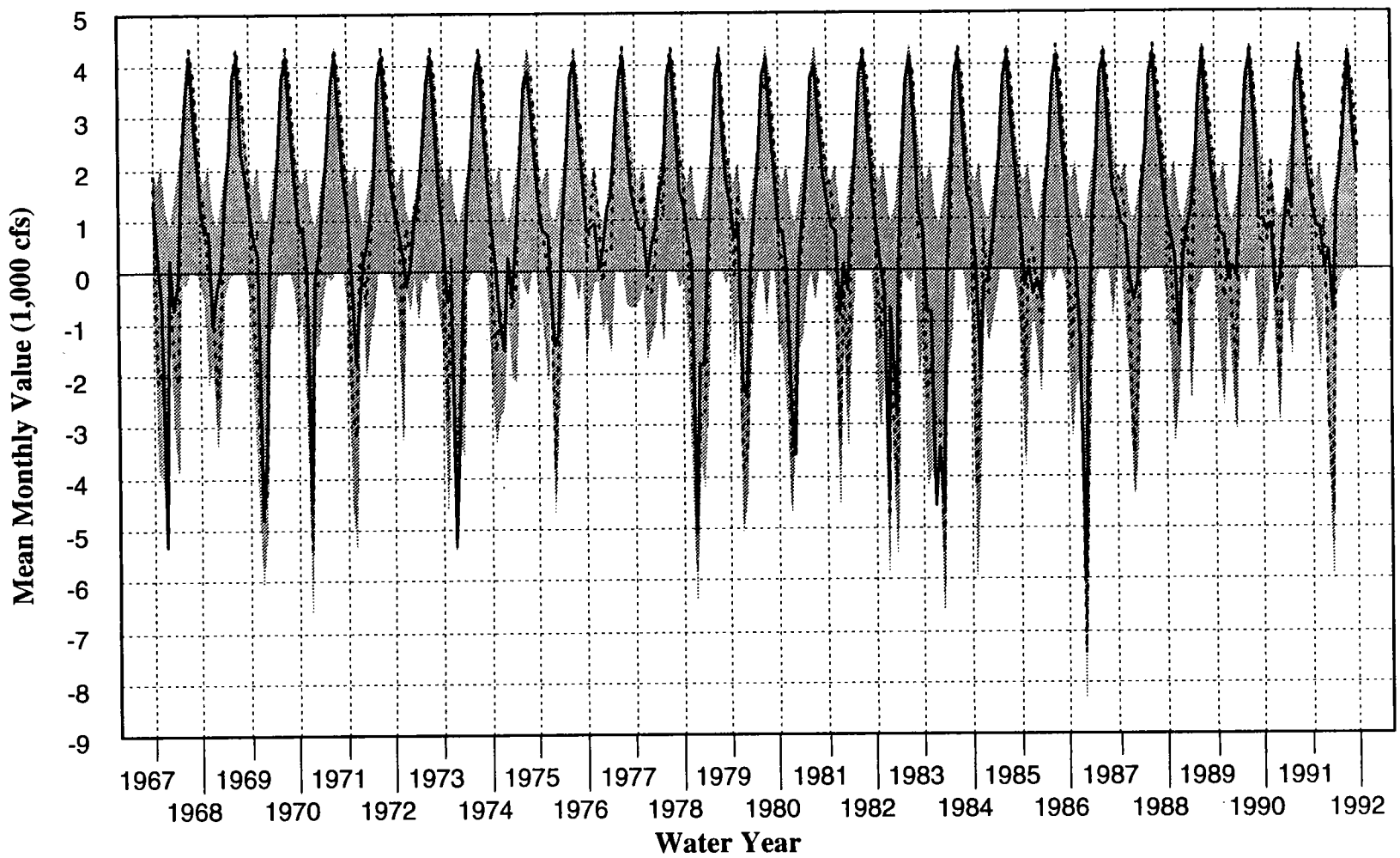


Figure A1-20.
DAYFLOW Historical Measurements and DWRSIM Inputs for Mean Monthly Inflows to the Delta from Eastside Streams for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



DAYFLOW Estimates for Consumptive Use (positive) and Precipitaion (negative)

DWRSIM Net Channel Depletion Inputs

DAYFLOW Channel Depletion Estimates

Figure A1-21.
Mean Monthly DAYFLOW Estimated Consumptive Use, Precipitation and Net Channel Depletion and DWRSIM Net Channel Depletion Inputs for the Delta for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

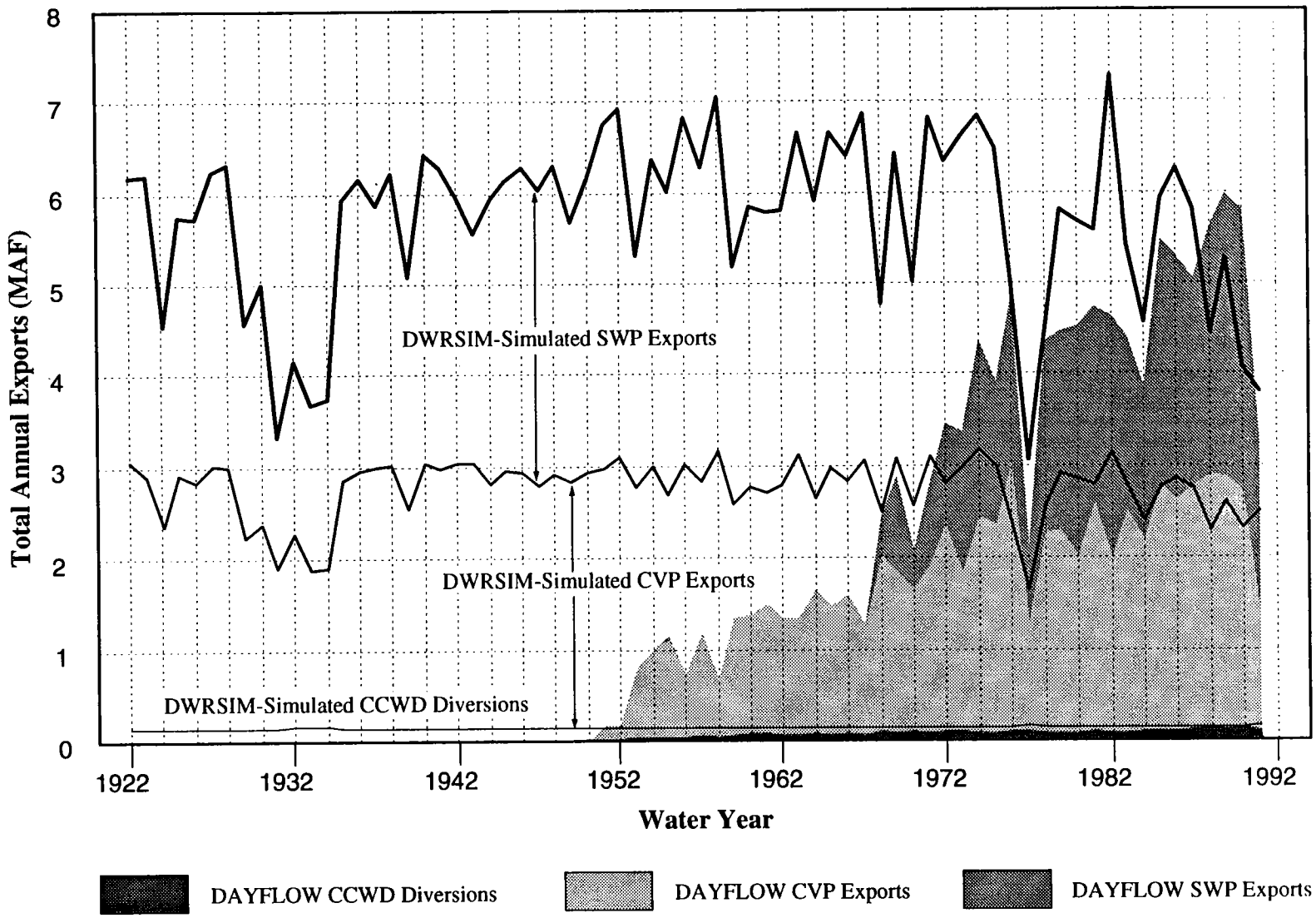


Figure A1-22.
DAYFLOW Historical and DWRSIM-Simulated Total Annual CVP and SWP Delta Exports and CCWD Diversions for 1922-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

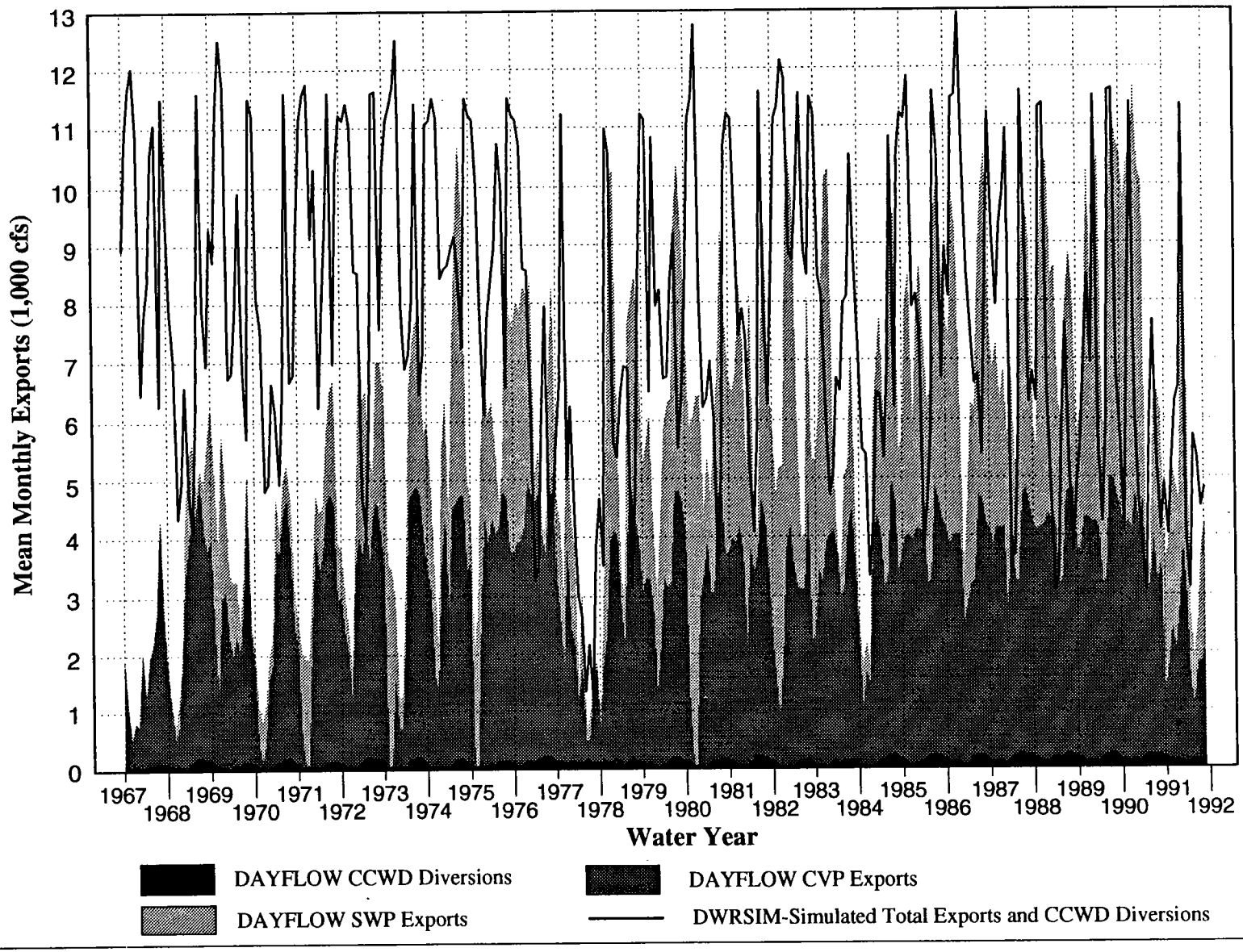


Figure A1-23.
DAYFLOW Historical and DWRSIM-Simulated Mean Monthly Delta CVP and SWP Exports and CCWD Diversions for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

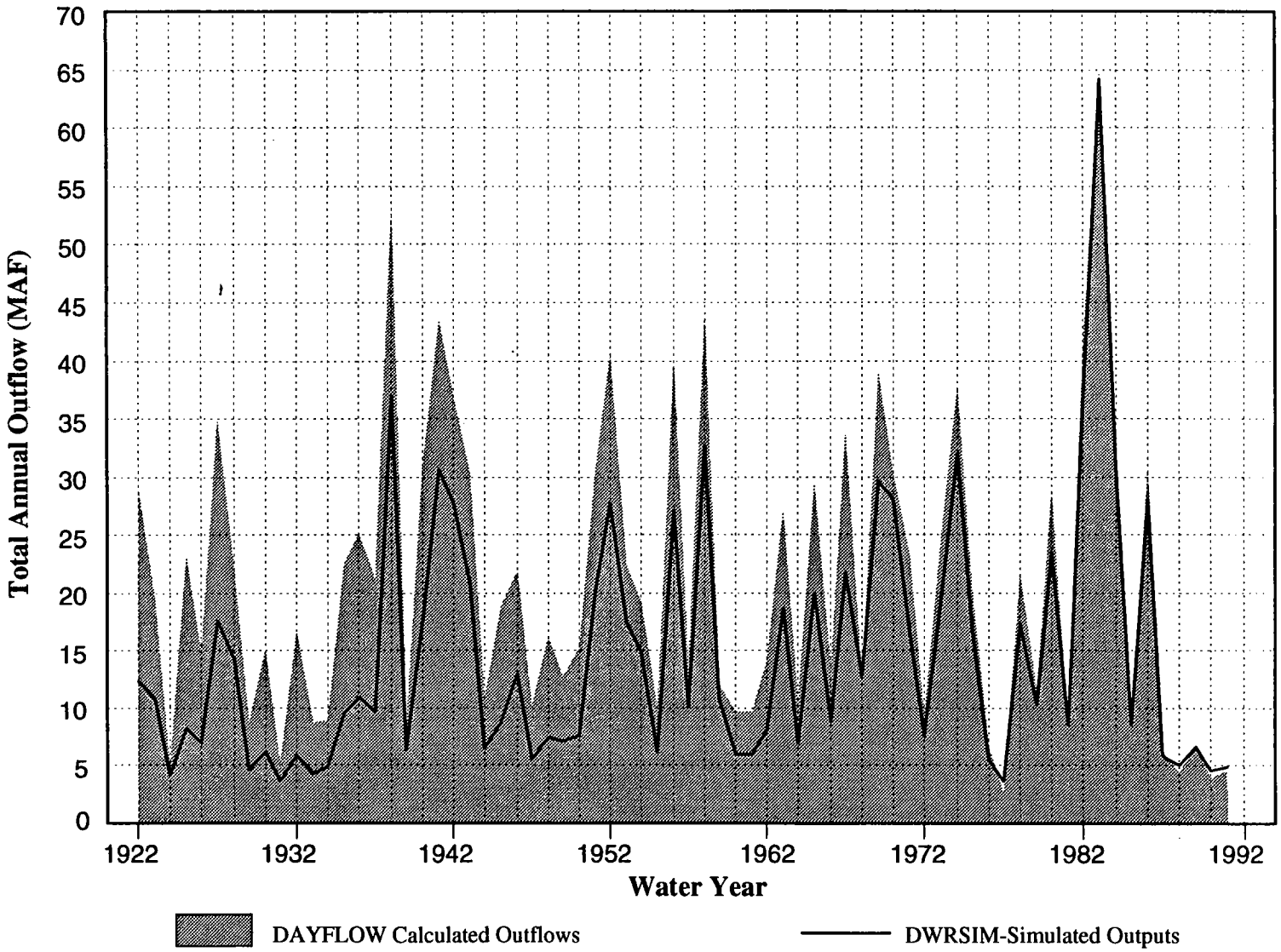


Figure A1-24.
DAYFLOW Calculated and DWRSIM-Simulated Total Annual Delta Outflows for 1922-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

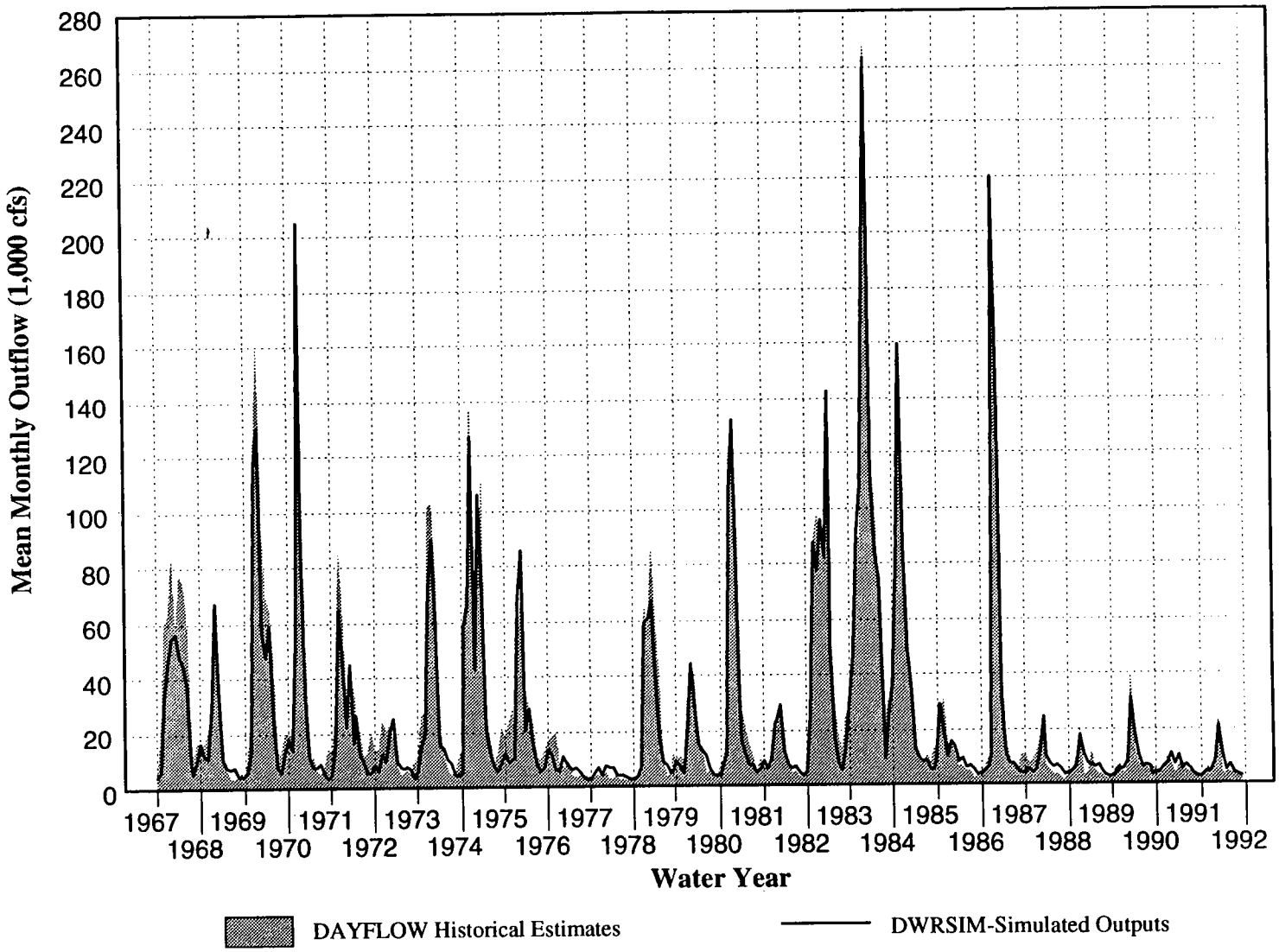


Figure A1-25.
DAYFLOW Historical and DWRSIM-Simulated Mean Monthly Delta Outflows for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

Appendix A2. DeltaSOS: Delta Standards and Operations Simulation Model

Appendix A2. DeltaSOS: Delta Standards and Operations Simulation Model

SUMMARY

This appendix describes the application of the Delta Standards and Operations Simulation (DeltaSOS) model developed for evaluating compliance of Delta water management operations with likely Delta standards. The discussion summarizes the sources of the initial Delta water budget terms required for DeltaSOS simulations and describes DeltaSOS input matrices of flow values associated with Delta standards for water quality and fish protection. The set of input matrices offers DeltaSOS users a choice of Delta standards against which to test likely future Delta operations. The Delta standards are specified as monthly values for each of five selected water-year types for each of the following:

- *Sacramento River flow at Freeport,*
- *diversions from the Sacramento River at Hood,*
- *Delta Cross Channel (DCC) and Georgiana Slough operations,*
- *Sacramento River flow at Rio Vista,*
- *San Joaquin River flow at Vernalis,*
- *operation of a barrier at the head of Old River,*
- *QWEST flow,*
- *operation of the Suisun Marsh salinity control gate,*
- *Delta outflow,*
- *1995 Bay-Delta Water Quality Control Plan (WQCP) outflow standards for estuarine habitat,*
- *Delta export pumping at the State Water Project (SWP) Banks Pumping Plant and the Central Valley Project (CVP) Tracy Pumping Plant, and*
- *operation of an in-Delta storage facility.*

This appendix describes the relationships between these variables and Delta water quality requirements, and describes DeltaSOS input matrix values for WQCP standards.

INTRODUCTION

Use of DeltaSOS, a simulation and analysis tool, is necessary to reliably describe the effects of several types of existing and proposed Delta standards on likely future operations of the Delta. Environmental assessment of an in-Delta storage project, such as the proposed Delta Wetlands (DW) project, depends on reliable descriptions of these likely future Delta conditions. The DeltaSOS monthly model provides a general analysis tool for evaluating a wide range of possible future Delta standards and likely future operations that will comply with these standards.

DeltaSOS is built on these general concepts:

- Applicable Delta standards for water quality and fish protection are specified as monthly flow values at 12 locations for each of five selected water-year types (wet, above normal, below normal, dry, and critically dry).

- An initial monthly Delta water budget for 1922-1991 is specified, consisting of terms for Sacramento and San Joaquin River inflows, Yolo Bypass and eastside stream inflows, Delta channel depletion (including North Bay Aqueduct exports), combined CVP and SWP exports, Contra Costa Water District (CCWD) diversions, and initial Delta outflow at Collinsville.

- Incremental changes in Delta operations required to meet each of the specified Delta standards are calculated and compared with the initial specified Delta water budget for each month of simulation. Revised Delta water budget terms that satisfy the specified standards are reported.

This appendix briefly describes the DeltaSOS spreadsheet model to allow interested parties to review simulation results obtained for water management operations that correspond to specified Delta standards and facilities.

POSSIBLE HYDROLOGIC INPUTS

DeltaSOS does not simulate upstream storage reservoirs but provides a description of Delta conditions and operations corresponding to a wide range of possible Delta standards.

DeltaSOS requires an initial monthly water budget of the Delta for water years 1922-1991 to calculate monthly conditions in the Delta. Initial monthly Delta inflows and exports can be estimated from three general sources: historical records (California Department of Water Resources' [DWR's] DAYFLOW data set), simulation results from a monthly SWP or CVP operations planning model (DWRSIM, PROSIM, or SANJASM), or results from a previous Delta simulation by the DeltaSOS model. Results from the SWP or CVP operations planning model can be combined with DeltaSOS results to provide a complete description of water supply and Delta conditions corresponding to selected Delta standards. An iterative process might be used to resolve differences between the planning model results and specific in-Delta requirements identified with DeltaSOS. The monthly water budget terms used in DeltaSOS are described in Appendix A1, "Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project", and are summarized below.

Historical Flows

The historical monthly Delta water budget is provided by DWR in the DAYFLOW data set, available beginning with water year 1930. DAYFLOW is an accounting of historical measured Delta inflows and exports and estimates of Delta consumptive use and outflow. JSA has used DWR estimates of unimpaired flows for 1922-1929 to extend the historical record of Delta inflows to encompass 70 years. Because the historical record includes effects of changing water use patterns and water resource facilities, adjustments could be made to historical upstream diversion estimates and storage patterns to reflect present facilities and operations.

Simulation Results from Operations Planning Models

Results from a monthly operations planning model, such as DWRSIM, PROSIM, or SANJASM, constitute the second possible source of values for an initial monthly Delta water budget. The DAYFLOW and unimpaired flow data do not reflect Delta operations (e.g., Delta exports and releases of flows from upstream facilities) that would occur with present-day facilities and demand for exports; therefore, monthly operations planning models are used to estimate Delta operations under the hydrologic conditions represented by the historical record. Results from these models provide an estimate of

likely Delta conditions under a particular set of assumed facilities, operations rules, water demands, and applicable Delta standards. Monthly inputs are used in DeltaSOS for Sacramento River, San Joaquin River, eastside stream, and Yolo Bypass inflows; CCWD diversions; CVP and SWP exports (combined); Delta channel depletion; Delta outflow; and estimated "carriage water" requirements.

Iterative DeltaSOS Results

A modified monthly Delta water budget produced by DeltaSOS to satisfy a set of proposed Delta standards may be used as the initial conditions for investigating the incremental effects of slightly different Delta standards. The DeltaSOS model includes an option to reset the initial monthly Delta water budget terms to the most recent revised values of the terms calculated to satisfy the previously specified set of Delta standards. This option is used to update the initial water budget terms for Sacramento and San Joaquin River inflows, Delta exports, and Delta outflow. The calculated Delta conditions will reflect these changed input values.

Classification of Water-Year Type

DeltaSOS allows the classification of water-year type for the Sacramento and San Joaquin River basins to be selected and specified as part of the monthly inputs. Selection of the year-type classification scheme is important because Delta standards can differ substantially for each water-year type. The year-type classification specified in Water Right Decision 1485 (D-1485) includes a "subnormal snowmelt" year type that replaces wet, above-normal, and below-normal types when the snowpack is below normal. Required D-1485 Delta outflows for May-July are substantially modified under this year-type classification. The 1995 WQCP uses a slightly different year-type classification, called the 40-30-30 scheme. The selected year type is specified as an input.

DeltaSOS allows the San Joaquin River year type to vary independently of the Sacramento River year type, as specified in the 1995 WQCP. The Vernalis inflow requirements and Old River barrier operations in DeltaSOS depend on San Joaquin River water-year type.

Under most year-type classification schemes, the water-year type cannot be accurately determined until approximately halfway into a new water year (i.e., March or April). DeltaSOS establishes a new year type in February of each year to properly match relatively large spring outflow requirements with the contemporary year type. DeltaSOS simulates October-January flows according to the previous year-type standards.

The 1995 WQCP outflow requirements depend on the previous month's runoff, rather than the annual year-type classification. These monthly runoff values are provided as inputs to DeltaSOS, as discussed below under "Delta Outflow".

DELTA STANDARDS SIMULATED IN DELTASOS

Delta standards consist of numerical criteria or limits that are specified in narrative decisions of the California State Water Resources Control Board (SWRCB), Endangered Species Act biological opinions, and agreements between and other documents from various regulatory or water management agencies. SWRCB established its currently applicable Delta standards in the 1995 WQCP. SWRCB listed these standards according to the resource use they are protecting at certain locations and specified values for selected parameters (minimum flow, pumping limit, salinity, electrical conductivity [EC], or chloride) during certain periods of the year (dates or days per year) for particular year types. Additional Delta requirements that must also be satisfied are contained in SWRCB water right decisions and have been introduced in the Coordinated Operations Agreement (COA) of DWR and the U.S. Bureau of Reclamation (Reclamation), recent actions related to the Endangered Species Act, and other legislative mandates (CVP Improvement Act).

DeltaSOS uses input matrices of monthly Delta standards specifying required monthly flows (minimum or maximum) at a location for each month for each year type. Translating the wide variety of possible Delta standards into a matrix of required flows can be difficult and requires interpretation of hydrologic and water quality factors. Assumptions about important parameters and relationships, such as flow-salinity relationships, are sometimes necessary. Specifying average monthly flow requirements at appropriate Delta locations for the full set of applicable standards provides an objective basis for systematically analyzing likely future Delta conditions. DeltaSOS can thus describe flow conditions that satisfy the specified set of Delta standards at an averaged monthly time scale appropriate for planning studies.

The following sections define the input matrices used in DeltaSOS to specify possible standards or requirements at the 12 Delta locations shown in Figure A2-1. Delta salinity standards are not directly simulated in DeltaSOS and must be protected indirectly using specified minimum monthly flow requirements (see "Carriage Water Calculations" below). Table A2-1 provides an example of the DeltaSOS control matrices. The matrices shown in Table A2-1 are samples of matrices that may be used, and the values may not match actual Delta standards required by the 1995 WQCP and other current regulations.

Sacramento River Flows at Freeport

The input matrix for minimum Sacramento River flows at Freeport can be used to specify requirements for pulse flows to assist migrating fish or transport eggs and larvae from the Sacramento River through the Delta to Suisun Bay. Pulse flows that may be required for less than a month must be averaged with requirements for the remainder of the month to establish monthly values of the DeltaSOS matrix. The 1995 WQCP does not contain Freeport minimum flow requirements.

Diversions from the Sacramento River at Hood

Facilities do not currently exist at Hood to allow diversion of exports from the Sacramento River. Hood diversions therefore are not included in simulations of DW project operations for evaluating potential environmental impacts. DeltaSOS includes a switch, however, to allow simulation of possible diversions at Hood into an isolated facility to transfer water directly to the CVP and SWP pumps or to divert water into the Mokelumne River channels. If this option is used, three matrices of input standards are needed to specify operational controls for the Hood diversions and the transfer facility.

Hood diversions as simulated in DeltaSOS would be limited by two different control matrices. A maximum diversion rate limiting the diversions at Hood can be specified for each month of each water-year type. A second control matrix specifies the allowable fraction of Sacramento River flow that could be diverted at Hood. In combination, these two control matrices can simulate a wide range of operational limits for possible Hood diversions. A third matrix in DeltaSOS can be used to specify required releases from the transfer facility to provide inflows to sloughs that connect with the Mokelumne River or the San Joaquin River or to these rivers themselves.

DeltaSOS does not allow Hood diversions to exceed the specified maximum diversion rate or the maximum specified fraction of Sacramento River inflow. Hood diversions are also limited indirectly in DeltaSOS by the need to satisfy requirements for Delta outflow and Rio Vista flows. Thus, five separate standards in DeltaSOS can be used to limit simulated Hood diversions.

Delta Cross Channel and Georgiana Slough Operations

Operations of the DCC gates are controlled on a daily basis and may depend on either the Sacramento River inflow or Delta outflow at Chipps Island. A flood control standard operating procedure closes the DCC to protect DCC structure and the Mokelumne River channel levees whenever Sacramento River inflow (below Hood) is greater than 25,000 cubic feet per second (cfs). The 1995 WQCP contains provisions to close the DCC 50% of the time during November-January and requires complete DCC closure from February 1 to May 20. The DCC is closed 4 days each week from May 21 to June 15.

Approximating the DCC daily operation requirements with a monthly average closure criterion introduces some inaccuracy for months that have average flows near the DCC closure criterion. If the monthly flows are either very low or very high compared with the criterion, however, the closure condition specified as a monthly average flow is a good approximation of the average of the daily closure conditions. Simulating the periods with partial DCC closure is not possible in DeltaSOS.

DeltaSOS requires two flow-standard matrices to simulate the DCC closure standards because they depend on flows at two different Delta locations. The first matrix specifies the maximum monthly Sacramento River flow below Hood for the DCC to remain open. The flood control standard is simulated at 25,000 cfs. Mandatory closure of the DCC for a month is specified in DeltaSOS with a value of 0 cfs in the input matrix.

The second DCC flow matrix specifies the maximum Delta outflow for the DCC to remain open (i.e., at higher outflows, the DCC will be closed). For example, D-1485 standards required the DCC to be closed if Delta outflow was greater than 12,000 cfs in the months of January-April. Delta outflow in the initial Delta water budget is

used to determine DCC closure based on this standard. If the initial Delta outflow is below the outflow standard (such that the DCC remains open) but exports are reduced to comply with specified standards (e.g., pumping limits), DeltaSOS may allow the revised Delta outflow to increase above the specified Delta outflow for DCC closure. In this case, DeltaSOS will not satisfy the DCC closure standard for Delta outflow. The 1995 WQCP does not contain a DCC closure criterion for Delta outflow.

Another flow matrix specifies the maximum monthly Sacramento River flow below Hood for simulated Georgiana Slough gates to remain open. These potential gates have not been constructed. A matrix value of 100,000 cfs will simulate Georgiana Slough maintained in an open configuration because Sacramento River channel capacity in the vicinity of DCC and Georgiana Slough is less than 100,000 cfs.

Sacramento River Flows at Rio Vista

The 1995 WQCP specifies minimum flows at Rio Vista to protect migrating salmon. Sacramento River flows at Rio Vista are equivalent to flows at Freeport, minus any Hood diversions, minus the DCC and Georgiana Slough flows, minus an assumed fraction (25%) of Delta channel depletions that occur between Freeport and Rio Vista, plus any Yolo Bypass inflows. Rio Vista is upstream of the Threemile Slough connection to the lower San Joaquin River.

Sutter and Steamboat Slough diversions from the Sacramento River below Hood rejoin the Sacramento River at Rio Vista. The diversions are calculated in DeltaSOS, but no gates or tidal controls for Sutter or Steamboat Sloughs are simulated in DeltaSOS.

QWEST Flows

QWEST is a variable calculated to be equivalent to the net flow moving from near the mouth of the Mokelumne River and Old River (Franks Tract) toward Antioch in the San Joaquin River, False River, and Dutch Slough channels. Requirements for QWEST minimum flows are a new feature of Delta standards, first introduced in SWRCB's proposed Water Right Decision 1630 (D-1630). Subsequently, QWEST limits were specified as protection measures for fish in 1993 and 1994 biological opinions under the federal Endangered Species Act for both winter-run salmon and Delta smelt. Minimum QWEST flows are specified to minimize the net upstream movement of passive larval and juvenile fish life stages from the Antioch region (western Delta) into the central Delta where they would become vulnerable to potential entrainment losses at the export pumps and agricultural diversions, as well as other potentially adverse environmental conditions (e.g., mortality, straying, and limited food resources). There are no QWEST limits, however, in the 1995 WQCP.

The U.S. Geological Survey (USGS) has recently installed an ultrasonic velocity meter (UVM) to measure San Joaquin River tidal flow at Jersey Point, downstream of the junction with Threemile Slough and downstream of the False River flow from Franks Tract (Figure A2-1). A similar UVM is being installed by USGS in Threemile Slough. The USGS measurements at Jersey Point and Threemile Slough can be used to calculate QWEST values as estimated in DAYFLOW. DAYFLOW estimates of QWEST flows do not include the contribution of Sacramento River flow from Threemile Slough. Flows measured by USGS at Jersey Point will be slightly less than San Joaquin River flows at Antioch because (according to the RMA Delta model) approximately 5% of net San Joaquin River flow moves through Dutch Slough between Franks Tract and Big Break, thus entering the San Joaquin River downstream of Jersey Point (Figure A2-1).

In DeltaSOS, the user can apply QWEST standards either with or without Threemile Slough flows included in the QWEST calculation. Prior calculations of QWEST values have been based on DAYFLOW estimates, with Threemile Slough flows excluded. Including Threemile Slough flows in the QWEST calculations would allow regulation of DeltaSOS-simulated San Joaquin River flows in the vicinity of Antioch using the values specified in the QWEST standard.

In the DeltaSOS standards input matrix, the QWEST variable is given a value of -15,000 cfs in months with no QWEST flow limits. This input value thus represents a minimum possible QWEST flow with full export pumping even when there are no inflows to the central Delta.

San Joaquin River Flows at Vernalis

Minimum required San Joaquin River flows at Vernalis can be indirectly estimated from maximum allowable values for salinity (EC or total dissolved solids

[TDS]) as generally specified in Condition 5 of SWRCB D-1422, which governs the water rights for New Melones Reservoir and from an assumed EC-flow relationship to approximate flows equivalent to the Vernalis salinity standards. For example, the D-1422 TDS standard of 500 parts per million (ppm) is equivalent to an EC value of about 833 μS/cm (0.833 mS/cm), assuming the generally observed EC/TDS ratio of 1.67, which requires a flow of approximately 1,000 cfs at Vernalis. DWR uses a slightly different flow-EC relationship, which requires 1,500 cfs to satisfy the 500-mg/l TDS standard. The 1995 WQCP requires maximum Vernalis EC of 0.7 mS/cm in the irrigation season (April-August) and of 1.0 mS/cm during the remainder of the year. The Vernalis flows equivalent to these EC values can be estimated from an assumed EC-flow relationship.

The 1995 WQCP includes fish transport flows for the San Joaquin River during February-June. These flows depend on San Joaquin River year type and increase by a specified increment whenever Delta outflow is greater than 11,400 cfs (when the X2 position is downstream of Chipps Island, as described below under "WQCP Outflow Standards for Estuarine Habitat"). A 30-day pulse-flow period is also specified in April-May. DeltaSOS calculates the San Joaquin River pulse flow and base inflow during April and May from the average monthly input flows.

Head of Old River Barrier

DeltaSOS estimates diversion flows from the San Joaquin River into Old River based on results of the Resource Management Associates (RMA) Delta hydrodynamic model. Flow into Old River is potentially blocked by a barrier at the head of Old River. Temporary barriers have been placed in fall to reduce diversions to Old River and thus to increase flows in the San Joaquin River past Stockton. Increased flows in the San Joaquin River may increase dissolved oxygen concentrations in fall and improve conditions for salmon migration in spring.

DeltaSOS requires a control matrix that specifies the maximum monthly San Joaquin River flow at Vernalis for the barrier at the head of Old River to remain closed. DeltaSOS will simulate opening of the barrier for flood control purposes if San Joaquin River flow exceeds the specified threshold. At a threshold value of 10,000 cfs, DeltaSOS will simulate closure of the barrier unless the San Joaquin River flow is greater than 10,000 cfs at Vernalis. A value of 0 cfs will simulate opening of the barrier during the month for any San Joaquin River flow. Note that this has an effect that is opposite that of the DCC closure matrix.

Delta Outflow

Chipps Island, just below the confluence of the Sacramento and San Joaquin Rivers near Pittsburg, is the traditional location for specification of minimum Delta outflow requirements. Prior to the recent introduction of requirements for flushing flows, QWEST limits, and Suisun Marsh salinity standards, all Delta salinity and flow requirements could be approximately combined into minimum Delta outflow requirements at Chipps Island. DWR has used a computer subroutine called Minimum Delta Outflow (MDO) to estimate the monthly Delta outflow requirements for use as minimum flow constraints in DWRSIM modeling of SWP and CVP operations. (MDO is now incorporated within DWRSIM.)

For DeltaSOS inputs of standards, various Delta outflow and salinity requirements can be approximated as a single matrix of monthly flows, using the specified salinities and salinity-outflow relationships such as those assumed by DWR in the MDO program. In cases in which different salinity standards apply at different Delta locations (i.e., Chipps Island, Emmaton, or Jersey Point), the flows required to maintain the specified salinities are compared and the largest necessary flow (i.e., controlling standard) is used as the minimum outflow requirement. When standards apply for only part of a month or when cumulative standards apply (e.g., 150 mg/l chloride at Rock Slough for a certain number of days for each water-year type), the monthly flow value is estimated as the average of the daily controlling values.

The matrix of minimum Delta outflows at Chipps Island can be derived from a combination of specified flows for fish transport, EC standards to protect Suisun Marsh, and EC standards at Emmaton and Jersey Point to protect agricultural uses. Each EC standard at each location must be interpreted as an outflow standard based on an assumed EC-outflow relationship. For example, the Emmaton EC standard of 0.45 mS/cm has been interpreted to be an outflow requirement of about 7,600 cfs.

One of the Suisun Marsh EC standards in D-1485 requires a flow of 12,000 cfs for 2 out of 4 months (January-April) in above-normal and below-normal years. This type of Delta standard cannot be specified as fixed monthly flow requirements in DeltaSOS. An

additional matrix (OUTQ) is used to represent this D-1485 Suisun Marsh EC standard in DeltaSOS.

OUTQ specifies the required number of months within the selected control period that must have an outflow greater than the specified flow for each year type. The OUTQ matrix includes three specified outflow values. Because the 1995 WQCP monthly outflow requirements depend on the previous month's runoff, the OUTQ matrix is not used and all OUTQ matrix values are set at 0.

1995 WQCP Outflow Standards for Estuarine Habitat

The 1995 WQCP includes additional Delta outflow requirements for the February-June control period to limit salinity in the estuarine habitat of Suisun Bay. The 1995 WQCP standards require that the specified salinity standard (which is assumed to be equivalent to a certain specified Delta outflow) be met for a certain number of days each month during the February-June control period. The proposed standards have been formulated in terms of the number of days that the mean daily salinity gradient value of 2 parts per thousand (ppt) TDS (3 mS/cm EC), designated X2, must be downstream of three control locations: the confluence of the Sacramento and San Joaquin Rivers near Collinsville, Chipps Island, and Roe Island. Furthermore, the outflow requirements are adjusted based on actual hydrologic conditions during the previous month.

DeltaSOS uses the assumed steady-state Delta outflows that would maintain the X2 position for a specified number of days at each of these locations (WQCP, Table 3, Footnote 11) to estimate the required monthly outflow and equivalent required X2 position. The X2 position can be maintained at Collinsville (81 km) with an outflow of 7,100 cfs; at Chipps Island (74 km) with 11,400 cfs; and at Roe Island (64 km) with 29,200 cfs. The number of days for which X2 is maintained at each location depends on the previous month's runoff (the sum of the unimpaired runoff of eight specified rivers, published as DWR's Eight-River Index). The 1995 WQCP states that the X2 position must be maintained at Roe Island only if the previous month's position (14-day average EC at Roe Island on the last day of the month) was downstream of Roe Island. This is simulated in DeltaSOS with a specified trigger X2 position slightly upstream of Roe Island (66.3 km used). If the previous month's X2 was downstream of the trigger position, higher flows are required than if the previous month's X2 position was upstream of this trigger position. These two sets of outflow requirements are specified in tables that identify the required outflow for each month as a function of the previous month's runoff (Table A2-2). The 1995 WQCP outflow requirements for January also depend on previous month's runoff.

The X2 position is assumed to depend on the previous month's X2 position and the current month's Delta outflow as follows (Kimmerer and Monismith 1992):

$$X2\ (km) = 122.2 + 0.3278 \cdot X2\ (\text{previous month}) - 17.65 \cdot \log(\text{outflow [cfs]})$$

The following is therefore the steady-state equation for X2 as a function of outflow:

$$X2\ (km) = 181.8 - 26.26 \cdot \log(\text{outflow [cfs]})$$

The required X2 position is estimated from the steady-state equation using the monthly outflow obtained from the look-up tables. The steady-state Delta outflow is adjusted using the previous month's X2 position as follows:

$$\text{Required outflow} = \text{steady-state outflow} \cdot (1 - 0.044 \cdot [\text{required X2} - \text{previous X2}])$$

According to this equation, each kilometer of difference between the previous month's X2 position and the required X2 position is equivalent to about a 4% change in required outflow. DeltaSOS assumes that this adjustment in required outflow is made for the upstream previous month's X2 (increased outflow needed), as well as downstream previous month's X2 (reduced outflow needed).

The 1995 WQCP provides a relaxation of these X2 position standards in May and June of years with runoff of less than 8.1 million acre-feet (MAF). DeltaSOS applies this relaxation in below-normal (7.8 MAF) and drier year types.

DeltaSOS also includes a switch that allows the specified Delta outflow to be applied either at Chipps Island or at Collinsville, upstream of Montezuma Slough. If the outflow standard is applied at Collinsville, the effects of Montezuma Slough diversions on satisfying the required Delta outflow standards are eliminated. If the Delta outflow standards are simulated at Collinsville, however, possible effects of the Montezuma Slough diversions on flow and salinity at Chipps Island should be carefully considered. Because the Suisun Marsh salinity

control gate has only been operated since 1989, net diversion flow into Montezuma Slough has not been accounted for in DAYFLOW and may not yet be represented in MDO and DWRSIM results.

An additional method of specifying required Delta outflow is possible with DeltaSOS. The monthly DWRSIM results for minimum Delta outflow (including all possible requirements) can be obtained and specified in the DeltaSOS input column for "carriage water" (see discussion below). If this option is used, the required Delta outflow matrix, as well as the OUTQ matrix, should be reset to zeros, and the carriage water switch should be set at 1.0. This option will make the total outflow requirements identical to those calculated by DWRSIM but will not allow changes in the required outflow objectives to be simulated. This was the option used for simulating the DW project alternatives; outflow requirements were identical to those simulated with DWRSIM.

Delta Export Pumping at Banks and Tracy Pumping Plants

DeltaSOS represents combined CVP (Tracy Pumping Plant) and SWP (Banks Pumping Plant) Delta export pumping limits in another Delta standard matrix. The CVP Tracy export pumping capacity is 4,600 cfs, but the Delta-Mendota Canal (DMC) capacity is limited to 4,200 cfs in December-March without deliveries for irrigation. For evaluation of 1995 WQCP standards, SWP export capacity is assumed by DWR to be 6,680 cfs. The combined CVP and SWP export pumping capacity is therefore 11,280 cfs for April-November and 10,880 cfs for December-March.

DWR currently operates the four new pumps at the SWP Banks Pumping Plant within the general provisions of U.S. Army Corps of Engineers (Corps) regulations under Section 10 of the Rivers and Harbors Act of 1899. Corps public notice 5820A (amended October 13, 1981) includes a provision to allow pumping of 33% of the total San Joaquin River daily inflow, if the inflow exceeds 1,000 cfs during the period of December 15 to March 15, up to the SWP export capacity of 10,300 cfs. Increased water elevations in the southern Delta during periods of high San Joaquin River inflow are apparently the basis for allowing increased SWP exports.

The net effect of daily San Joaquin River inflows and daily Clifton Court Forebay gate capacity (as currently operated) on increased monthly average export pumping is somewhat uncertain. Actual pumping rates during periods of high San Joaquin River inflow in 1993 led DWR to increase the estimated monthly simulated maximum to 8,500 cfs.

In DeltaSOS, the San Joaquin River inflow provision is simulated by allowing a specified fraction of monthly San Joaquin River inflow, if greater than a specified minimum (1,000 cfs), to be exported in addition to the specified export pumping limits. In these months, DeltaSOS simulates the total allowable pumping as the specified pumping limit plus the specified allowable export of the San Joaquin River flow, up to the maximum capacity given in the last column of the export pumping matrix. The January-February capacity with 8,500 cfs of SWP pumping is 12,700 cfs. The December and March capacity is 11,700 cfs.

Full capacity for combined CVP and SWP export pumping could be simulated with matrix values of 14,500 cfs (December-March) and 14,900 cfs (balance of year). DeltaSOS does not allocate the Delta pumping between the CVP and SWP projects and therefore does not require rules to satisfy COA provisions. CCWD diversions are specified as inputs and are not adjusted in DeltaSOS; CCWD diversions are considered separately from CVP exports at the Tracy Pumping Plant.

The DeltaSOS export pumping limits apply solely to allowable direct diversions from the southern Delta. Such direct southern Delta diversions would be in addition to the exports of the Hood diversions (if simulated) less any required releases of Hood diversions back to the Delta (if simulated). The specified pumping limits control direct exports, and net Hood diversions (if simulated) can augment total export, as constrained by the physical pumping limits specified in the monthly pumping matrix.

In addition to these permitted Delta export pumping capacities, the 1995 WQCP sets monthly export pumping limits for the CVP and SWP pumping plants as a specified fraction of Delta inflow. These export pumping limit fractions are specified in another DeltaSOS input matrix. The February fraction of 0.35 is increased to 0.45 if the January runoff value is less than 1 MAF. These "percent of inflow" criteria are an additional constraint on pumping; often Delta outflow requirements or permitted pumping capacity will limit exports to less than the allowable percent of inflow. A sixth column is used to specify the allowable export fraction for discharges made from the in-Delta storage facilities for export.

The WQCP places additional limits on pumping during a 30-day April-May pulse-flow period. During

this period, the maximum export pumping is limited to the San Joaquin River inflow. In DeltaSOS simulations, it is assumed that the pulse flow is split equally between April and May. The pulse flow, as specified in the Vernalis flow input matrix, controls pumping during half of April and May. Pumping during the other half of April and May is limited to 35% of Delta inflow. DeltaSOS splits the monthly San Joaquin River inflow into the pulse flow and base flow for estimating allowable exports and available water for diversions to in-Delta storage.

Operation of the Suisun Marsh Salinity Control Gate

The Suisun Marsh salinity control gate was constructed to maintain more suitable salinity in Suisun Marsh by allowing diversion of Sacramento River flow into the marsh on ebb tide and blocking movement of water from the marsh to the Sacramento River during flood tide. This tidal gate operation scheme produces a net flow into Montezuma Slough from the Sacramento River at Collinsville. In the DeltaSOS input standards matrix, the user specifies whether the gate is operating (1 = operating) each month of each year type.

DeltaSOS estimates net flow through Montezuma Slough as a function of total Delta outflow at Collinsville, based on results from the RMA Delta hydrodynamic model. The RMA Delta model indicates that approximately 2% of total Delta outflow at Collinsville enters Suisun Marsh through Montezuma Slough when the gates are open (i.e., not operating) throughout the tidal cycle. The RMA hydrodynamic model results indicate that when the Suisun Marsh salinity control gate is operated, a net flow of about 2,200 cfs plus 0.5% of total Delta outflow enter Suisun Marsh through Montezuma Slough. This net Montezuma Slough flow can be a significant portion of total Delta outflow at relatively low outflow values.

The Delta salinity effects of the diversion of Delta outflow into Montezuma Slough have not been estimated. With regard to salinity control at Chipps Island, DWR estimates that the effective diversion of outflow through Montezuma Slough may only be 15% of the actual diversion, because most of the diversion flow returns as outflow into Suisun Bay (Russell pers. comm.).

DeltaSOS allows an effective Montezuma Slough diversion fraction to be specified by the user. DeltaSOS also provides a switch to allow Montezuma Slough diversions to be reduced if an outflow deficit is calculated, thus preventing diversions of Delta outflow to Montezuma Slough from causing a potential Delta outflow deficit.

In-Delta Storage Facility

DeltaSOS simulates the possible operations of in-Delta water storage facilities that would be operated to divert excess Delta inflows to temporary or seasonal storage in the Delta, and to then discharge the stored water for Delta outflow or for export during periods with available CVP or SWP pumping capacity.

DeltaSOS requires five input matrices to simulate possible operations of an in-Delta storage facility. The first matrix specifies the maximum end-of-month storage volume (in units of thousands of acre-feet [TAF]). This matrix can be used to specify seasonal as well as year-round storage volumes for each water-year type.

A second input matrix specifies the monthly assumed evaporation losses from the storage facility (TAF units). The matrix specifies the assumed monthly reductions in Delta channel depletion that result from conversion of Delta islands from agricultural production to a water storage facility. Anticipated adjustments in Delta water use patterns, such as addition of seasonal wetland flooding, are also specified in this column.

A third input matrix is used to specify the maximum average monthly diversion rate (cfs units) when storage capacity and available Delta inflow exist. (Water allowable for export under the 1995 WQCP is the lesser of the amount specified by the export limits [under the "percent of inflow" criterion] and the amount remaining after outflow requirements have been satisfied. Available inflow [inflow available for diversion] is any portion of allowable export that cannot be pumped with the permitted CVP and SWP pumping rate.) DeltaSOS uses a separate monthly column of parameters to specify the fraction of calculated available Delta inflow that can be diverted to the simulated in-Delta storage facility, with a specified minimum excess Delta inflow that acts as a buffer for Delta storage operations.

The fourth input matrix for in-Delta storage facility operations specifies the maximum monthly discharge rate. Discharge from Delta storage could be used for increasing Delta outflow or for increasing Delta export pumping. DeltaSOS calculates discharge from storage for Delta export according to the specified DeltaSOS parameters.

The fifth input matrix for in-Delta storage facility operations specifies any required discharge for Delta outflow. If storage is available, this specified release is required before DeltaSOS allows any export of the water from the in-Delta storage facility.

CALCULATED EFFECTS OF DELTA STANDARDS ON DELTA OPERATIONS

DeltaSOS tests each input matrix against calculated Delta channel flows for each month of the simulation period. If a specified standard is not satisfied, some action within the Delta would be required to meet the specified standard. DeltaSOS identifies several options for satisfying the specified standards if they are not met. DeltaSOS then calculates the incremental effects of each specified standard on Delta conditions.

The following sections describe the possible options in DeltaSOS for satisfying Delta standards and calculating the resulting incremental effects for each standard. Each output column in DeltaSOS is described. Table A2-3 provides a summary description of each DeltaSOS input and output variable.

Freeport Inflows

Freeport minimum flows are used to specify required flows to assist the migration of salmon and the transport of striped bass eggs and larvae. The only realistic way to provide these flows, when they do not occur naturally from storm runoff, is to increase upstream reservoir releases. DeltaSOS calculates the increase in the initial Sacramento River inflow that would be needed to provide the specified Freeport flows. The flow requirement, the incremental flow needed to satisfy the requirement, and the resulting Sacramento flow are reported in DeltaSOS output columns.

DeltaSOS itself does not simulate upstream reservoir storage and releases and does not adjust subsequent Delta inflows. Therefore, the increased inflows calculated by DeltaSOS are, in a sense, "imaginary water". As long as the required additional inflows are relatively small, however, additional inflows to satisfy flushing-flow requirements can likely be provided by modified upstream reservoir storage operations.

If DeltaSOS uses a planning model simulation that already includes these specified Sacramento flows in its initial Delta water budget, further adjustment in the Sacramento River inflow values will not be needed. If such a planning model simulation is not available, DeltaSOS provides a tool for estimating the magnitude of various potential flushing-flow requirements at Freeport.

Hood Diversions and Transfer Facility Operation

In DeltaSOS simulations, potential diversions from the Sacramento River at Hood can be limited by four operational constraints. Because diversions at Hood would reduce Sacramento River flow downstream, diversions from the Sacramento River into Sutter and Steamboat Sloughs, diversions into the DCC and Georgiana Slough, and Rio Vista flows would be reduced. Hood diversions, Sacramento River flow below the Hood diversions, and releases of Hood diversions back to the Delta are reported in DeltaSOS output columns.

Sacramento River Diversions to Steamboat and Sutter Sloughs, the DCC, and Georgiana Slough

Once DeltaSOS determines the DCC and Georgiana Slough gate status according to the gate control input matrices, DeltaSOS calculates Steamboat and Sutter Slough diversions, DCC flow, and DCC plus Georgiana Slough flow to the central Delta. The Steamboat and Sutter Slough, DCC, and Georgiana Slough channel flow calculations in DeltaSOS are based on results from the RMA Delta hydrodynamic model that show the division of flow from the Sacramento River to these side channels. The flow splits used in DeltaSOS are similar but not identical to the linear estimates used in DAYFLOW for the DCC and Georgiana Slough.

Rio Vista Minimum Flows

DeltaSOS calculates the Sacramento River flow at Rio Vista as the Sacramento River flow not diverted at Hood (if simulated) and not diverted into the DCC and Georgiana Slough, plus inflow from the Yolo Bypass. Diversions into Sutter and Steamboat Sloughs reenter the Sacramento River at Rio Vista. If the Rio Vista flow standard is not satisfied and the DCC is not already

closed, DeltaSOS reduces the estimated DCC flow to increase the flow remaining in the Sacramento River. Because of the hydraulic relationship between DCC and Georgiana Slough flows, however, the DCC reduction must be greater than the required Rio Vista increase. Because Georgiana Slough diverts about 25% of Sacramento River flow, approximately 25% of the DCC diversion reduction will be diverted into Georgiana Slough. Calculated DCC reductions are reported in an output column along with the Rio Vista flows.

If a flow deficit remains at Rio Vista with the DCC closed, DeltaSOS does not further increase Sacramento River inflows. The Rio Vista flow deficit is reported as a separate column in the simulation results and could be used to adjust the Sacramento River inflow. The effects of operation of a potential Georgiana Slough gate can be simulated by changing the input matrix for the simulated Georgiana Slough gate. If the Rio Vista flow deficits are large, however, use of an initial water budget based on another planning model simulation may be required to better satisfy the specified Rio Vista flow standards.

Vernalis Inflows

Additional inflow that may be needed to satisfy the D-1422 TDS standard of 500 mg/l, additional EC standards, or flushing-flow requirements will have to be released from upstream reservoirs. The Vernalis flow requirement, the incremental increase in the initial San Joaquin River inflow needed to satisfy the requirement, and the resulting Vernalis flow are reported in DeltaSOS output columns.

Because DeltaSOS cannot simulate changes in upstream reservoir storage and cannot adjust subsequent San Joaquin River inflows, DeltaSOS is required to simulate "imaginary water". Use of an initial Delta water budget for DeltaSOS based on a planning model simulation that already includes these specified Vernalis flows will avoid further adjustment in the San Joaquin River inflow values.

QWEST Flows

DeltaSOS estimates initial QWEST flow after the adjusted DCC and Georgiana Slough flows have been calculated. QWEST as estimated in DAYFLOW is equal to the sum of the flows in the San Joaquin River, the eastside streams, the DCC, and Georgiana Slough; minus the SWP and CVP exports and CCWD diversions; and minus about 65% of the estimated Delta channel depletions. If DeltaSOS simulates Hood diversions, those diversions may also change QWEST values by reducing DCC and Georgiana Slough diversions, reducing direct exports, and releasing water to southern Delta channels. The initial QWEST flow and the QWEST requirement are reported in DeltaSOS output columns.

If DeltaSOS estimates the QWEST flow to exceed the minimum monthly QWEST standard, no adjustments are required. If the QWEST estimate is less than the QWEST standard, however, DeltaSOS calculates the export pumping reduction required to satisfy the QWEST minimum flow for each month and reports these reductions in an output column. A combination of DCC closure requirements and relatively high QWEST limits could result in large export pumping reductions.

Delta Outflow

DeltaSOS calculates the total Delta outflow at Collinsville, recognizing export reductions resulting from specified QWEST standards. The net effective diversion through the Suisun Marsh salinity control gate into Montezuma Slough is estimated from the total Delta outflow at Collinsville. Remaining Delta outflow at Chipps Island is calculated as the difference. DeltaSOS then compares the outflow past Collinsville or Chipps Island with the applicable minimum outflow standard. The minimum required outflow consists of a combination of the monthly standard matrix, calculations using the OUTQ matrix, and the X2-position standards for estuarine habitat. The initial Collinsville and Chipps Island outflow, along with the required Delta outflow, are reported as DeltaSOS output columns.

When calculated outflow is less than the required minimum value, DeltaSOS provides two options for satisfying the outflow deficits. The first option consists of modifying the operation of the Suisun Marsh salinity control gate to increase Delta outflow if the specified outflow standard is to be met at Chipps Island. The second option is to reduce exports to a specified minimum value to provide greater Delta outflow. Both the revised Montezuma Slough flow and reductions in export pumping for outflow are reported in DeltaSOS output columns.

Outflow deficits may remain, especially if the specified outflow requirements differ greatly from those used in the initial water budget for DeltaSOS (e.g., from planning model results). The outflow deficit may also be

reduced by export pumping limits. Any remaining outflow deficits are reported in a DeltaSOS output column.

DeltaSOS cannot determine the ability of upstream reservoirs to supply the additional releases needed to satisfy remaining calculated outflow deficits. DeltaSOS can, however, evaluate the incremental requirements of various outflow standards.

Export Pumping Adjustments

DeltaSOS calculates the CVP and SWP export pumping limits as the combination of fixed pumping limits, allowable increases in SWP pumping of San Joaquin River inflow, and "percent of inflow" criteria. The 1995 WQCP restrictions during the April-May San Joaquin River pulse-flow period are also calculated in DeltaSOS. If Hood diversions are simulated, the total export limits are considered to apply to direct export pumping from the southern Delta. The full specified export pumping capacity is assumed to be available for total exports, the combination of direct pumping and Hood diversions. The "percent of inflow" export limits and the export reductions needed to satisfy the combined pumping limits are reported in DeltaSOS output columns.

DeltaSOS includes an option to increase initial export pumping rates if available water can be exported within the specified pumping limits. The possibility of increased export pumping is based on assumptions that annual export demands are likely to be greater than amounts of water available for export in the future, and that south-of-Delta facilities needed to store exported water are likely to become available.

DeltaSOS simulation of maximum possible Delta exports is based on the assumption that all available water within the specified export pumping limits will be exported as long as QWEST and Delta outflow standards remain satisfied. DeltaSOS reports the additional export of available water as positive values in the monthly net export change column of DeltaSOS output. These simulated maximum possible exports may not be realistic during wet years if available south-of-Delta storage is full and full deliveries of water are being made. The direct export and total export (including Hood diversions) are reported in output columns. The revised QWEST flow and Delta outflow are reported as DeltaSOS columns.

Simulating the export of all available water eliminates the possibility of a new in-Delta storage facility diverting water that could have been pumped by the CVP or SWP pumps, which have senior water rights. DeltaSOS simulates the maximum possible export pumping within the specified standards and choices for reducing outflow deficits prior to allowing diversions to or discharges from an in-Delta storage facility for export.

The planning models may simulate increased required Delta outflow with assumed carriage water requirements needed to satisfy export salinity standards. Carriage water estimates may limit the increased allowable export pumping. The following section explains the DWR carriage water calculations.

Carriage Water Calculations

Carriage water is a concept traditionally used to represent additional Delta outflow required to maintain acceptable chloride concentrations in export water as Delta exports are increased. With relatively low San Joaquin and eastside stream inflow, Sacramento River inflow must be increased to supply increased exports and maintain the required Delta outflow.

Flow is transported along three pathways from the Sacramento River to supply increased export pumping. Some of the Sacramento flow is diverted into the DCC and Georgiana Slough. For example, the following is DWR's DAYFLOW equation with the DCC represented as open:

$$\text{DCC and Georgiana Slough flow (cfs)} = 2{,}090 + 0.293 \cdot \text{Freeport flow (cfs)}$$

The remaining Sacramento River flow at Rio Vista is therefore:

$$\text{Rio Vista flow (cfs)} = 0.707 \cdot \text{Freeport flow (cfs)} - 2{,}090$$

Similar equations are used by DWR when the DCC is closed; less water is diverted from the Sacramento River when the DCC is closed:

$$\text{Georgiana Slough flow (cfs)} = 829 + 0.133 \cdot \text{Freeport flow (cfs)}$$

and

$$\text{Rio Vista flow (cfs)} = 0.867 \cdot \text{Freeport flow (cfs)} - 829$$

Increased export pumping that is not supplied from the DCC and Georgiana Slough must enter the central Delta from the Sacramento River through Threemile Slough or from the lower San Joaquin River channel as reversed flow from Antioch. This required flow is referred to as reverse QWEST flow needed to supply the exports.

DWR carriage water calculations are based on the assumption that 80% of the required reverse QWEST flow comes from Antioch while 20% comes through Threemile Slough (DWR 1987). The RMA Delta hydrodynamic model results indicate, however, that Threemile Slough flow is more accurately described by the following equation:

$$\text{Threemile Slough flow (cfs)} = 0.23 \cdot \text{Rio Vista flow} - 0.31 \cdot \text{QWEST}$$

The assumed hydraulic behavior of Threemile Slough flow is an important aspect of DWR's carriage water calculations. The UVM recently installed by USGS in Threemile Slough will soon provide a continuous record of tidal flows, so that net flow can be estimated directly. In the meantime, available results from the RMA Delta model are considered reliable because they are based on measured channel geometry and friction coefficients that have generally accepted values. Similar results are obtained from the Fischer Delta Model (Denton pers. comm.).

DWR estimates that carriage water may be required whenever QWEST is negative. As exports are increased, a larger fraction of exports must be supplied from the vicinity of Antioch or Emmaton, with the possibility that the salinity of exports will be higher than that of Sacramento River diversions to the DCC and Georgiana Slough. The RMA model results indicate that Threemile Slough flow may, however, supply the entire reversed QWEST flow without any reversed flow between Antioch and Jersey Point.

The relationship between monthly average CCWD chloride concentration measurements and effective Delta outflow is well described with a negative exponential equation (Denton 1993). The effective outflow is a relatively simple way to include the effects of antecedent (previous) outflow conditions, similar to the G-model described by CCWD (1994). This month's effective outflow can be estimated as a function of this month's outflow and last month's effective outflow:

$$\text{Effective outflow (cfs)} = \text{EO (previous month)} + (\text{outflow [cfs]} - \text{EO})\,(1 - \exp[-\text{EO}/15{,}000])$$

The monthly CCWD intake chloride data can be summarized as follows:

$$\text{CCWD intake } Cl^- \text{ (mg/l)} = 1{,}667 \cdot \exp(-.0005 \cdot \text{EO}) + 15$$

The observed CCWD chloride data, as summarized by this equation, indicate that the effective Delta outflow must be maintained at about 4,000 cfs throughout the year to satisfy the 250-mg/l chloride standard, with a variable number of months of 5,000-cfs outflow required to satisfy the 150 mg/l chloride requirements in the 1995 WQCP. These estimates are much lower than the "carriage water" requirements currently calculated by DWR-SIM, and do not increase with pumping or with negative QWEST flows. DeltaSOS can assume any specified fraction of DWR-estimated carriage water requirements, which are included as DeltaSOS inputs.

Available Flow for In-Delta Diversions

Once the adjustments in direct exports have been calculated, DeltaSOS calculates the available water for possible diversion to an in-Delta storage facility. Available water is calculated as the allowable export determined using the "percent of Delta inflow" criterion that is not needed to satisfy outflow requirements or QWEST standards and that cannot be pumped at the SWP and CVP pumping plants because of pumping rate limits. The available water for diversion is calculated as the minimum of excess Delta outflow, excess QWEST flow, and excess allowable export according to the "percent of inflow" and San Joaquin River pulse-flow restrictions. The available water for diversion is reported as a DeltaSOS output column.

In-Delta Storage Facility Operation

DeltaSOS calculates the operation of an in-Delta storage facility according to the control input matrices described above. The possible diversions to increase storage are limited by the available flow for diversion, the remaining in-Delta storage capacity, and the specified maximum diversion rate.

The possible discharges for export pumping are limited by the available in-Delta storage, the specified discharge flow capacity, the aqueduct conveyance

capacity that can be specified in the DeltaSOS inputs, and the selected options for calculating allowable export of in-Delta storage discharges.

The possible discharges for Delta outflow are simulated according to the specified input matrix controlling releases for outflow, and the selected options for calculating allowable export of the in-Delta storage discharges, which may require additional releases for outflow.

DeltaSOS reports end-of-month storage (TAF), diversions, discharges for export, and discharges for outflow in output columns. Final total export, QWEST flow, and Delta outflow are reported as output columns. The DeltaSOS flow estimates for Threemile Slough, Antioch, and head of Old River diversions from the San Joaquin River and the combined Old River and Middle River flows are also given as output columns. The final output columns of DeltaSOS provide calculations of the X2 position (km) and estimated Delta export chloride concentration (mg/l).

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Table A2–1. DeltaSOS User–Defined Standards for the 1995 WQCP

Minimum required Sacramento River flow at Freeport (cfs)

	Wet	Above Normal	Below Normal	Dry	Critical
Oct	0	0	0	0	0
Nov	0	0	0	0	0
Dec	0	0	0	0	0
Jan	0	0	0	0	0
Feb	0	0	0	0	0
Mar	0	0	0	0	0
Apr	0	0	0	0	0
May	0	0	0	0	0
Jun	0	0	0	0	0
Jul	0	0	0	0	0
Aug	0	0	0	0	0
Sep	0	0	0	0	0

Sacramento River trigger for the Delta Cross Channel (cfs) (closed if Sac flow below Hood>value)

	Wet	Above Normal	Below Normal	Dry	Critical	
Oct	25,000	25,000	25,000	25,000	25,000	
Nov	0	0	0	0	0	Half–time
Dec	0	0	0	0	0	Half–time
Jan	0	0	0	0	0	Half–time
Feb	0	0	0	0	0	
Mar	0	0	0	0	0	
Apr	0	0	0	0	0	
May	0	0	0	0	0	
Jun	25,000	25,000	25,000	25,000	25,000	
Jul	25,000	25,000	25,000	25,000	25,000	
Aug	25,000	25,000	25,000	25,000	25,000	
Sep	25,000	25,000	25,000	25,000	25,000	

Minimum Rio Vista flow (cfs)

	Wet	Above Normal	Below Normal	Dry	Critical
Oct	4,000	4,000	4,000	4,000	3,000
Nov	4,500	4,500	4,500	4,500	3,500
Dec	4,500	4,500	4,500	4,500	3,500
Jan	0	0	0	0	0
Feb	0	0	0	0	0
Mar	0	0	0	0	0
Apr	0	0	0	0	0
May	0	0	0	0	0
Jun	0	0	0	0	0
Jul	0	0	0	0	0
Aug	0	0	0	0	0
Sep	3,000	3,000	3,000	3,000	3,000

Minimum QWEST flow (cfs)

	Wet	Above Normal	Below Normal	Dry	Critical
Oct	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Nov	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Dec	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Jan	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Feb	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Mar	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Apr	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
May	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Jun	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Jul	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Aug	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Sep	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)

Table A2–1. Continued

Minimum San Joaquin River flow at Vernalis (cfs)

	Wet	Above Normal	Below Normal	Dry	Critical	
	7,330	5,730	4,620	4,020	3,110	Pulse–flow requirements
Oct	1,500	1,500	1,500	1,500	1,000	
Nov	900	900	900	900	900	
Dec	900	900	900	900	900	
Jan	900	900	900	900	900	
Feb	2,130	2,130	1,420	1,420	900	
Mar	2,130	2,130	1,420	1,420	900	
Apr	2,130	2,130	1,420	1,542	900	
May	2,130	2,130	1,420	1,420	900	
Jun	2,130	2,130	1,420	1,420	900	
Jul	900	900	900	900	900	
Aug	900	900	900	900	900	
Sep	900	900	900	900	900	
	1,290	1,290	860	860	430	Additional flow if X2<Chipps

Maximum percentage of San Joaquin River flow available for SWP export (%)

	Wet	Above Normal	Below Normal	Dry	Critical
Oct	0	0	0	0	0
Nov	0	0	0	0	0
Dec	17	17	17	17	17
Jan	33	33	33	33	33
Feb	33	33	33	33	33
Mar	17	17	17	17	17
Apr	0	0	0	0	0
May	0	0	0	0	0
Jun	0	0	0	0	0
Jul	0	0	0	0	0
Aug	0	0	0	0	0
Sep	0	0	0	0	0

San Joaquin River trigger for Old River gates (cfs) (open if SJR flow at Vernalis>value)

	Wet	Above Normal	Below Normal	Dry	Critical
Oct	10,000	10,000	10,000	10,000	10,000
Nov	0	0	0	0	0
Dec	0	0	0	0	0
Jan	0	0	0	0	0
Feb	0	0	0	0	0
Mar	0	0	0	0	0
Apr	10,000	10,000	10,000	10,000	10,000
May	10,000	10,000	10,000	10,000	10,000
Jun	0	0	0	0	0
Jul	0	0	0	0	0
Aug	0	0	0	0	0
Sep	0	0	0	0	0

Minimum Delta outflow (cfs)

	Wet	Above Normal	Below Normal	Dry	Critical
Oct	4,000	4,000	4,000	4,000	3,000
Nov	4,500	4,500	4,500	4,500	3,500
Dec	4,500	4,500	4,500	4,500	3,500
Jan	4,500	4,500	4,500	4,500	4,500
Feb	7,100	7,100	7,100	7,100	7,100
Mar	7,100	7,100	7,100	7,100	7,100
Apr	7,580	7,580	7,580	7,580	7,100
May	7,580	7,580	7,580	7,580	4,000
Jun	7,580	7,580	6,845	6,120	4,000
Jul	8,000	8,000	6,500	5,000	4,000
Aug	4,000	4,000	4,000	3,500	3,500
Sep	3,000	3,000	3,000	3,000	3,000

Table A2–1. Continued

Maximum Delta export (cfs)

	Wet	Above Normal	Below Normal	Dry	Critical	DW Exemption	Assumed Capacity
Oct	11,280	11,280	11,280	11,280	11,280	11,280	11,280
Nov	11,280	11,280	11,280	11,280	11,280	11,280	11,280
Dec	10,880	10,880	10,880	10,880	10,880	10,880	11,700
Jan	10,880	10,880	10,880	10,880	10,880	10,880	12,700
Feb	10,880	10,880	10,880	10,880	10,880	10,880	12,700
Mar	10,880	10,880	10,880	10,880	10,880	10,880	11,700
Apr	11,280	11,280	11,280	11,280	11,280	11,280	11,280
May	11,280	11,280	11,280	11,280	11,280	11,280	11,280
Jun	11,280	11,280	11,280	11,280	11,280	11,280	11,280
Jul	11,280	11,280	11,280	11,280	11,280	11,280	11,280
Aug	11,280	11,280	11,280	11,280	11,280	11,280	11,280
Sep	11,280	11,280	11,280	11,280	11,280	11,280	11,280

Maximum percentage of inflow available for export (%)

	Wet	Above Normal	Below Normal	Dry	Critical	DW
Oct	65	65	65	65	65	65
Nov	65	65	65	65	65	65
Dec	65	65	65	65	65	65
Jan	65	65	65	65	65	65
Feb	35	35	35	35	35	35
Mar	35	35	35	35	35	35
Apr	35	35	35	35	35	35
May	35	35	35	35	35	35
Jun	35	35	35	35	35	35
Jul	65	65	65	65	65	65
Aug	65	65	65	65	65	65
Sep	65	65	65	65	65	65

Status of Suisun Marsh salinity control gates (0 = open, 1 = operating)

	Wet	Above Normal	Below Normal	Dry	Critical
Oct	1	1	1	1	1
Nov	1	1	1	1	1
Dec	1	1	1	1	1
Jan	1	1	1	1	1
Feb	1	1	1	1	1
Mar	1	1	1	1	1
Apr	0	0	0	0	0
May	0	0	0	0	0
Jun	0	0	0	0	0
Jul	0	0	0	0	0
Aug	0	0	0	0	0
Sep	0	0	0	0	0

Maximum capacity of in–Delta storage facility (TAF)

	Wet	Above Normal	Below Normal	Dry	Critical	2–Island Evaporation	4–Island Evaporation
Oct	238	238	238	238	238	3.3	6.5
Nov	238	238	238	238	238	1.5	3.0
Dec	238	238	238	238	238	0.8	1.6
Jan	238	238	238	238	238	0.9	1.8
Feb	238	238	238	238	238	1.7	3.4
Mar	238	238	238	238	238	3.0	6.0
Apr	238	238	238	238	238	4.5	9.0
May	238	238	238	238	238	6.1	12.2
Jun	238	238	238	238	238	7.0	14.0
Jul	238	238	238	238	238	8.0	16.0
Aug	238	238	238	238	238	7.1	14.2
Sep	238	238	238	238	238	5.2	10.4

Table A2–1. Continued

Evaporation from in–Delta storage facility (TAF)

	Wet	Above Normal	Below Normal	Dry	Critical	Net CU Reductions	2–Island Net CU	4–Island Net CU
Oct	3.3	3.3	3.3	3.3	3.3	0.0	–0.6	2.5
Nov	1.5	1.5	1.5	1.5	1.5	0.0	–0.7	1.8
Dec	0.8	0.8	0.8	0.8	0.8	0.0	–1.3	0.9
Jan	0.9	0.9	0.9	0.9	0.9	0.0	0.9	1.1
Feb	1.7	1.7	1.7	1.7	1.7	0.0	1.3	2.3
Mar	3.0	3.0	3.0	3.0	3.0	0.0	4.5	3.4
Apr	4.5	4.5	4.5	4.5	4.5	0.0	3.0	4.4
May	6.1	6.1	6.1	6.1	6.1	0.0	3.7	6.2
Jun	7.0	7.0	7.0	7.0	7.0	0.0	4.1	7.8
Jul	8.0	8.0	8.0	8.0	8.0	0.0	4.8	9.2
Aug	7.1	7.1	7.1	7.1	7.1	0.0	3.7	7.1
Sep	5.2	5.2	5.2	5.2	5.2	0.0	1.5	4.1

Maximum diversion to in–Delta storage facility (cfs)

	Wet	Above Normal	Below Normal	Dry	Critical	Required Delta Outflow	Required QWEST Flow
Oct	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Nov	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Dec	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Jan	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Feb	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Mar	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Apr	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
May	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Jun	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Jul	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Aug	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Sep	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)

Maximum discharge from in–Delta storage facility (cfs)

	Wet	Above Normal	Below Normal	Dry	Critical	Required Delta Outflow	Required QWEST Flow
Oct	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Nov	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Dec	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Jan	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Feb	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Mar	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Apr	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
May	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Jun	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Jul	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Aug	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Sep	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)

Discharge to outflow from in–Delta storage facility (cfs)

	Wet	Above Normal	Below Normal	Dry	Critical
Oct	0	0	0	0	0
Nov	0	0	0	0	0
Dec	0	0	0	0	0
Jan	0	0	0	0	0
Feb	0	0	0	0	0
Mar	0	0	0	0	0
Apr	0	0	0	0	0
May	0	0	0	0	0
Jun	0	0	0	0	0
Jul	0	0	0	0	0
Aug	0	0	0	0	0
Sep	0	0	0	0	0

Table A2–2. Delta Outflow Requirements under the 1995 WQCP Estuarine Salinity Standards

A. Previous Month's X2 Upstream of Roe Island Trigger Position

Monthly 8–River Index[a] (TAF)	Outflow (cfs)					
	Jan	Feb	Mar	Apr	May	Jun
0	4,500	7,100	7,100	7,100	7,100	7,100
250	4,500	7,100	7,100	7,100	7,100	7,100
500	4,500	11,400	7,100	7,100	7,100	7,100
750	4,500	11,400	7,100	7,100	7,100	7,100
1,000	6,000	11,400	8,765	7,387	7,100	7,100
1,250	6,000	11,400	11,400	7,960	7,100	7,100
1,500	6,000	11,400	11,400	8,963	7,100	7,100
1,750	6,000	11,400	11,400	9,967	7,100	7,100
2,000	6,000	11,400	11,400	10,683	7,239	7,100
2,250	6,000	11,400	11,400	10,970	7,516	7,100
2,500	6,000	11,400	11,400	11,257	8,626	7,243
2,750	6,000	11,400	11,400	11,257	9,874	7,387
3,000	6,000	11,400	11,400	11,400	10,845	7,673
3,250	6,000	11,400	11,400	11,400	11,123	8,247
3,500	6,000	11,400	11,400	11,400	11,261	8,963
3,750	6,000	11,400	11,400	11,400	11,400	9,680
4,000	6,000	11,400	11,400	11,400	11,400	10,397
4,250	6,000	11,400	11,400	11,400	11,400	10,683
4,500	6,000	11,400	11,400	11,400	11,400	10,970
4,750	6,000	11,400	11,400	11,400	11,400	11,113
5,000	6,000	11,400	11,400	11,400	11,400	11,257
5,250	6,000	11,400	11,400	11,400	11,400	11,257
5,500	6,000	11,400	11,400	11,400	11,400	11,400
5,750	6,000	11,400	11,400	11,400	11,400	11,400
6,000	6,000	11,400	11,400	11,400	11,400	11,400
6,250	6,000	11,400	11,400	11,400	11,400	11,400
6,500	6,000	11,400	11,400	11,400	11,400	11,400
6,750	6,000	11,400	11,400	11,400	11,400	11,400
7,000	6,000	11,400	11,400	11,400	11,400	11,400
7,250	6,000	11,400	11,400	11,400	11,400	11,400
7,500	6,000	11,400	11,400	11,400	11,400	11,400
7,750	6,000	11,400	11,400	11,400	11,400	11,400
8,000	6,000	11,400	11,400	11,400	11,400	11,400
8,250	6,000	11,400	11,400	11,400	11,400	11,400
8,500	6,000	11,400	11,400	11,400	11,400	11,400
8,750	6,000	11,400	11,400	11,400	11,400	11,400
9,000	6,000	11,400	11,400	11,400	11,400	11,400
9,250	6,000	11,400	11,400	11,400	11,400	11,400
9,500	6,000	11,400	11,400	11,400	11,400	11,400
9,750	6,000	11,400	11,400	11,400	11,400	11,400
10,000	6,000	11,400	11,400	11,400	11,400	11,400

B. Previous Month's X2 Downstream of Roe Island Trigger Position

Monthly 8–River Index[a] (TAF)	Outflow (cfs)					
	Jan	Feb	Mar	Apr	May	Jun
0	4,500	7,100	7,100	7,100	7,100	7,100
250	4,500	7,889	7,100	7,100	7,100	7,100
500	4,500	10,257	7,813	7,100	7,100	7,100
750	4,500	13,414	8,526	7,100	7,100	7,100
1,000	6,000	19,029	11,061	7,387	7,100	7,100
1,250	6,000	20,936	14,845	8,553	7,100	7,100
1,500	6,000	22,843	16,568	9,557	7,100	7,100
1,750	6,000	24,114	18,290	11,153	7,100	7,100
2,000	6,000	24,750	20,013	13,057	7,239	7,100
2,250	6,000	25,386	21,161	13,937	8,090	7,100
2,500	6,000	26,021	22,310	16,003	9,200	7,243
2,750	6,000	26,657	23,458	17,190	11,023	7,387
3,000	6,000	27,293	24,606	18,520	13,142	7,673
3,250	6,000	27,293	25,181	19,707	14,568	8,247
3,500	6,000	27,293	25,755	20,893	16,429	8,963
3,750	6,000	27,929	26,329	22,080	18,290	9,680
4,000	6,000	27,929	26,903	23,267	20,013	10,397
4,250	6,000	27,929	26,903	23,860	21,735	11,277
4,500	6,000	27,929	27,477	25,047	23,458	12,157
4,750	6,000	28,564	27,477	25,640	24,606	12,893
5,000	6,000	28,564	27,477	26,233	25,755	13,630
5,250	6,000	28,564	28,052	26,233	26,329	14,817
5,500	6,000	28,564	28,052	26,827	27,477	16,740
5,750	6,000	28,564	28,052	27,420	27,477	19,113
6,000	6,000	28,564	28,052	27,420	28,052	20,893
6,250	6,000	28,564	28,626	27,420	28,052	22,673
6,500	6,000	28,564	28,626	28,013	28,626	24,453
6,750	6,000	28,564	28,626	28,013	28,626	25,640
7,000	6,000	28,564	28,626	28,013	28,626	26,827
7,250	6,000	28,564	28,626	28,013	28,626	27,420
7,500	6,000	28,564	28,626	28,607	28,626	28,013
7,750	6,000	28,564	28,626	28,607	29,200	28,013
8,000	6,000	28,564	28,626	28,607	29,200	28,607
8,250	6,000	29,200	28,626	28,607	29,200	28,607
8,500	6,000	29,200	28,626	28,607	29,200	28,607
8,750	6,000	29,200	28,626	28,607	29,200	29,200
9,000	6,000	29,200	28,626	28,607	29,200	29,200
9,250	6,000	29,200	28,626	28,607	29,200	29,200
9,500	6,000	29,200	29,200	28,607	29,200	29,200
9,750	6,000	29,200	29,200	29,200	29,200	29,200
10,000	6,000	29,200	29,200	29,200	29,200	29,200

[a] Previous month's runoff volume from DWR's 8–River Index.

Table A2-3. Summary Description of DeltaSOS Model Input and Output Variables

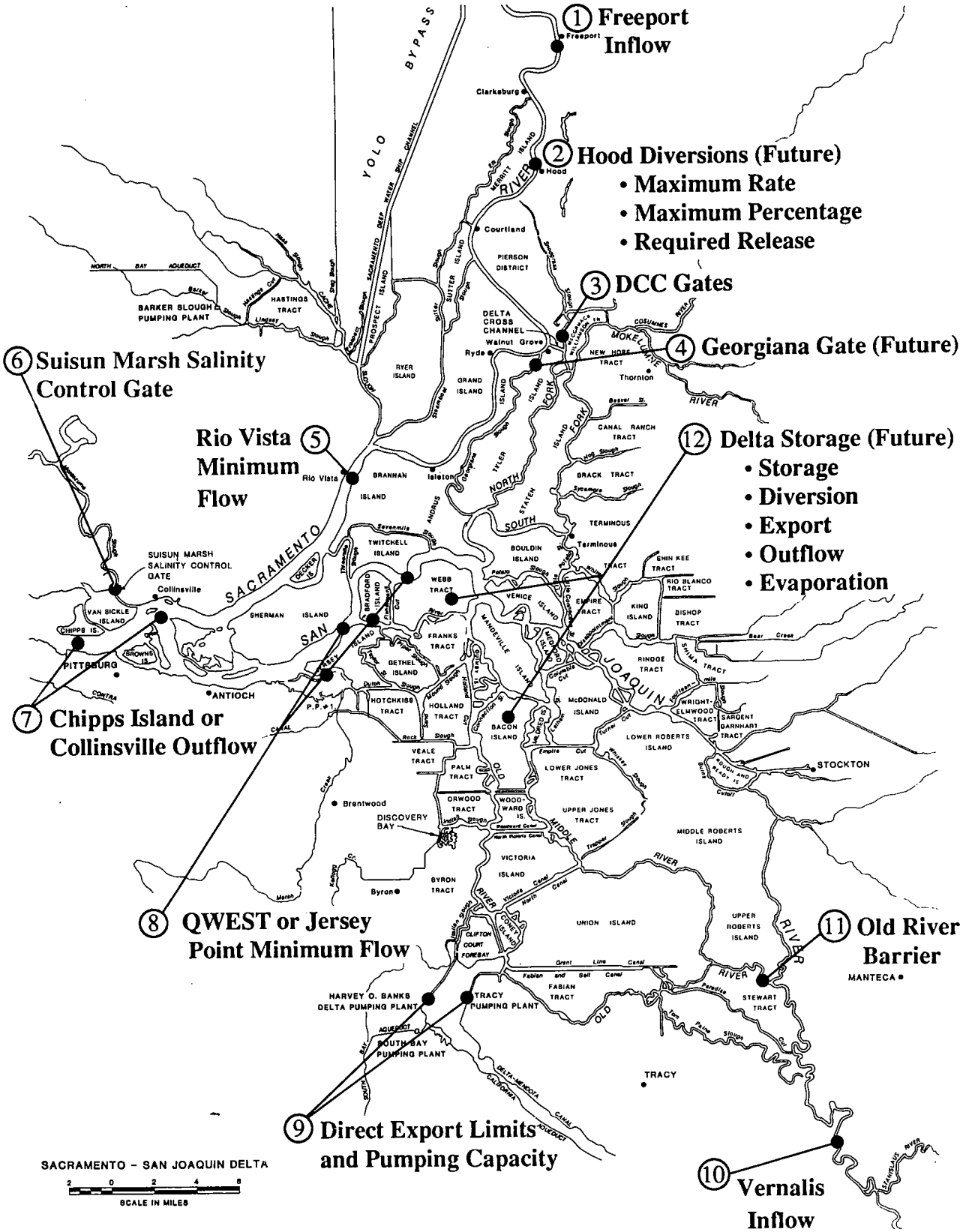
Column Label	Description
Fixed Inputs	
Sacramento Valley Four-River Index (TAF) for previous month	Sum of unimpaired flows for Sacramento River at Bend Bridge and the Feather, Yuba, and American Rivers
San Joaquin Valley Four-River Index (TAF) for previous month	Sum of unimpaired flows for San Joaquin River at Friant Dam and the Merced, Tuolumne, and Stanislaus Rivers
Central Valley Eight-River Index (TAF) for previous month	Sum of Sacramento Valley Four-River Index and San Joaquin Valley Four-River Index
Natural Delta (unimpaired) outflow estimate (cfs)	DWR's estimate of unimpaired Delta outflow with no upstream storage or diversions
Initial Delta Water Budget Inputs	
Sacramento River Basin year type	Hydrologic classification for the water year; classified as wet (1), above normal (2), below normal (3), dry (4), or critical (5) based on annual Sacramento Valley unimpaired runoff for Sacramento River at Bend Bridge and the Feather, Yuba, and American Rivers
Subnormal snowmelt	A "1" denotes water year with subnormal snowmelt (D-1485 year-type classification)
San Joaquin River Basin year type	Hydrologic classification for the water year; classified as wet (1), above normal (2), below normal (3), dry (4), or critical (5) based on annual San Joaquin Valley unimpaired runoff for the San Joaquin River at Friant Dam and the Merced, Tuolumne, and Stanislaus Rivers
SWP Banks and CVP Tracy Pumping Plants (cfs)	Sum of Delta exports from SWP Banks and CVP Tracy Pumping Plants
Sacramento River inflow (cfs)	Sacramento River flow at Freeport
Yolo Bypass inflow (cfs)	Yolo Bypass flow to the Delta
CCWD intake (cfs)	CCWD diversions from the Delta
Eastside inflow (cfs)	Sum of flows from the Mokelumne, Calaveras, and Cosumnes Rivers and miscellaneous streams to the Delta
San Joaquin River inflow (cfs)	San Joaquin River at Vernalis
Delta channel depletion (cfs)	Estimated evapotranspiration losses minus rainfall gains for Delta
Delta outflow (cfs)	Total Delta outflow at confluence of Sacramento and San Joaquin Rivers
Carriage water or required Delta outflow (cfs)	Initial estimate of Delta outflow requirements in addition to those specified in Delta outflow standards
Aqueduct wheeling capacity (cfs)	Initial estimate of total available (unused) export aqueduct capacity

Column Label	Description
DeltaSOS Outputs	
DCC Status	A "1" denotes that the DCC gates are simulated to be open
Required SAC flow	Freeport minimum flow required to assist migration of salmon and the transport of striped bass eggs and larvae
Added SAC flow	Additional Sacramento River flow required to meet specified Freeport standards
New SAC flow	The sum of input Sacramento River flow and any additional flow required to meet Freeport standards
Required SJR flow	Vernalis flow required to satisfy salinity standard or flushing-flow requirements
Added SJR flow	Additional San Joaquin River flow required to meet specified Vernalis standards
New SJR flow	The sum of the input San Joaquin River flow and any additional flow required to meet Vernalis standards
Hood Diversion	Diversion from the Sacramento River at Hood specified by Hood diversion control matrices and also limited by Rio Vista and Delta outflow standards
SAC below Hood Flow	Sacramento River flow below the Hood diversion
Hood Releases	Required releases from the Hood diversion to the Mokelumne and San Joaquin River channels
Steam & Sutter Flow	Sacramento River diversion to Steamboat and Sutter Sloughs
DCC Rio Vista Reduction	Reduction of DCC flow (DCC gates partially closed) to increase Sacramento River flow to meet Rio Vista standards
Revised DCC Flow	Calculated DCC flow after any required closure to meet Rio Vista standards
Revised Georgiana & DCC	Combined DCC and Georgiana Slough flow calculated after revisions are made to DCC gate operation
Revised Rio Vista Flow	Sacramento River flow at Rio Vista, including Yolo Bypass inflow
Rio Vista Deficit	Remaining deficit between Rio Vista flow and specified standards
QWEST w/Initial Export	Initial estimate of QWEST flow using calculated DCC & Georgiana flow and initial exports
Required QWEST Flow	QWEST flow required by specified standards
Reduced Export for QWEST	Required reduction of exports to meet specified QWEST standards
Initial Collinsville Outflow	Delta outflow at Collinsville adjusted for export reductions for QWEST standards
Initial Chipps Outflow	Delta outflow at Collinsville minus calculated Montezuma Slough diversion
Required Delta Outflow	Delta outflow required by specified standards

Column Label	Description
Montezuma Flow	Montezuma Slough flow, with reductions required to meet required Delta outflow
Reduced Export for Outflow	Required reduction of exports to meet specified QWEST standards
Export Pumping Limits	Maximum allowable export pumping limits, as controlled by fixed capacity limits and "percent of inflow" criteria, including San Joaquin River pulse-flow restrictions in the 1995 WQCP
Reduced Export for Limits	Required reduction of exports to meet specified export pumping limits
Outflow Deficit	Remaining deficient between Delta outflow and specified Delta outflow standards
Net Export Change	Net calculated change in exports to satisfy specified standards, including allowable increases to specified pumping capacity
Direct Export	Calculated exports diverted from south Delta channels
Total Export	Calculated total exports, including direct export diversions and Hood diversions
Revised QWEST Flow	Revised QWEST flow, including all export adjustments
Revised Delta Outflow	Revised Delta outflow, including all export adjustments
Available Flow	Possible DW diversions that would still meet QWEST and outflow standards within the "percent of inflow" criteria and San Joaquin River pulse-flow restrictions in the 1995 WQCP
Delta Storage (TAF)	End-of-month storage of in-Delta storage facility (e.g., the DW project reservoir islands)
Delta Storage Diversion	Calculated diversions to in-Delta storage facility
Delta Storage Export	Calculated discharges from in-Delta storage facility for export at Delta export pumps
Delta Storage Outflow	Calculated discharges from in-Delta storage facility for Delta outflow
Final Total Export	Calculated total exports, including discharges for export from in-Delta storage facility
Final QWEST Flow	Final QWEST flow, including in-Delta storage diversions and discharges for outflow
Final Delta Outflow	Final Delta outflow, including in-Delta storage diversions and discharges for outflow
3-Mile Slough Flow	Calculated Threemile Slough flow from Sacramento River to San Joaquin River
Antioch Flow	Calculated San Joaquin River flow at Antioch
Old River Diversion Flow	Calculated head of Old River diversion from San Joaquin River
Old River & Middle River Flow	Calculated flow in Old and Middle River channels, between San Joaquin River and export pumping plants
X2 Salinity Position	Estimate of the 2-ppt salinity position (km), relative to the Golden Gate Bridge

Table A2-3. Continued

Column Label	Description
Export Chloride	Estimate of export chloride concentration (mg/l) obtained from DeltaSOS calculation of seawater intrusion



Source: Adapted from California Department of Water Resources 1993

Figure A2-1.
Locations Where Delta Standards Can Be Specified in the DeltaSOS Model

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

Appendix A3. DeltaSOS Simulations of the Delta Wetlands Project Alternatives

Appendix A3. DeltaSOS Simulations of the Delta Wetlands Project Alternatives

SUMMARY

This appendix describes simulations of the Delta Wetlands (DW) project alternatives and of the no-project condition representing the baseline with which DW project effects may be compared for impact assessment. Simulations for the DW alternatives and the No-Project Alternative were each performed with the Delta Standards and Operations Simulation (DeltaSOS) model using the objectives for Delta outflow and Delta export limits specified in the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (1995 WQCP). Simulations were performed also for cumulative conditions; in addition to the 1995 WQCP objectives, these simulations allow for exports at full capacity at the State Water Project (SWP) Banks Pumping Plant.

The appendix describes the initial Delta water budget for the DeltaSOS simulations, specifies DeltaSOS input parameters (switches) for the DW project simulations, and describes the DeltaSOS standard matrix values for the simulations. Results of the DeltaSOS simulations for the No-Project Alternative, the DW project alternatives (Alternatives 1, 2, and 3), and cumulative conditions for the No-Project Alternative and the DW project alternatives are presented.

INTRODUCTION

The DeltaSOS model was used to simulate operations under each of the DW project alternatives (Alternatives 1, 2, and 3) for impact assessment purposes. The No-Project Alternative was also simulated with DeltaSOS to provide a baseline condition, including the same Delta operating conditions, with which operations under each alternative could be compared. As described in Chapter 3, "Affected Environment and Environmental Consequences - Overview of Impact Analysis Approach", the simulations were performed based on the assumption that operations of the DW project and the No-Project Alternative would be consistent with the 1995 WQCP objectives for Delta outflow and Delta export limits and with current U.S. Army Corps of Engineers (Corps) limits on SWP pumping (6,680 cubic feet per second [cfs]). For assessment of cumulative impacts, DeltaSOS simulations were also performed for operations that would be consistent with the 1995 WQCP, but allowing for SWP export pumping at the full physical capacity of 10,300 cfs for Banks Pumping Plant.

Because the 70-year hydrologic record for the Delta is the best description of likely future hydrologic conditions, hydrologic data from this record serve as the basis of simulations of future Delta operations. The results of the simulations are therefore shown as corresponding to the water years of the hydrologic record (1922-1991) and represent estimates of operations under hydrologic conditions replicating those of this period of record.

The two following sections:

- discuss the modeling assumptions for the DeltaSOS simulations of DW project effects and
- describe and illustrate DeltaSOS simulation results for the No-Project Alternative and the DW project alternatives.

DELTA CONDITIONS FOR THE SIMULATED NO-PROJECT ALTERNATIVE AND DW PROJECT ALTERNATIVES

DeltaSOS simulations require an initial Delta water budget, user-specified input parameters (switches) that govern simulated Delta operations, and specified matrices of Delta standards. The reader is referred to Appendix A1 for more information on the initial Delta water budget

used for the DeltaSOS simulations. The user-defined switches and standard matrices are described in detail in Appendix 2, "DeltaSOS: Delta Standards and Operations Simulation Model".

DWRSIM-Simulated Initial Delta Water Budget for DeltaSOS Simulations

The lead agencies for the DW project environmental impact report/environmental impact statement (EIR/EIS) determined that the simulations for the DW project impact assessment should be performed assuming implementation of the 1995 WQCP objectives as interpreted by California Department of Water Resources (DWR) for modeling the water supply effects of the WQCP using DWRSIM, DWR's Delta operations model. The lead agencies consider the DWRSIM results to be the best available representation of likely future Delta conditions under the 1995 WQCP objectives.

DWR performed the DWRSIM simulation of WQCP water supply effects, referred to as DWRSIM study 1995-C6B-SWRCB-409, in January 1995. The results of this simulation were used for estimating the initial Delta water budget for DeltaSOS and evaluating water supply impacts of the DW alternatives using the DeltaSOS model. The DWRSIM modeling assumptions necessary to represent the 1995 WQCP objectives in a monthly water supply planning model have been described in California State Water Resources Control Board (SWRCB) (1995) and DWR (1995). Following are major DWRSIM assumptions for the 1995 WQCP simulations:

- Upstream hydrology, depletions, and diversions were based on the 1995 level of development, as presented in DWR Bulletin 160-93, "California Water Plan Update" (DWR 1994). See Appendix A1 for more details.

- Water-year classification was based on the "40-30-30 Sacramento Valley Four-River Index" and the "60-20-20 San Joaquin Valley Four-River Index". The outflow requirements during February-June depend on the previous month's "Eight-River Index" runoff volume. These water-year classification schemes are slightly different from those used for the standards specified in SWRCB's Water Right Decision 1485 (D-1485), which established the Delta operating criteria in effect until approval of the WQCP.

- Delta outflow requirements were the combination of fixed monthly requirements, estuarine habitat requirements (expressed in terms of "X2", the position of the 2-parts-per-thousand [ppt] salinity gradient), and requirements for additional carriage water to satisfy the chloride objectives for Delta exports of 250 milligrams per liter (mg/l). Because the X2 requirements in the WQCP depend on the previous month's runoff, the required outflow must be calculated for each month. Minimum outflow objectives are maintained during low runoff periods. See Appendix A2 for more details.

- The Central Valley Project (CVP) Delta export demand was assumed to be 3.15 million acre-feet per year (MAF/yr), with 145 thousand acre-feet per year (TAF/yr) in Contra Costa Water District (CCWD) diversions. However, these CVP demands were not always satisfied in drier years in DWRSIM simulations. The SWP Delta export demands were assumed to vary with Kern River runoff and Los Angeles rainfall conditions. The range of possible SWP export demands was 2.6-3.6 MAF/yr, with an average of 2.85 MAF/yr. The maximum combined Delta export demand of 6.7 MAF/yr was specified in about 45% of simulated years.

  When hydrologic shortages were simulated along with these variable demands, DWRSIM estimated the SWP and CVP deliveries based on the terms of the Coordinated Operation Agreement (COA). The simulated average annual Delta export, based on these variable demands and hydrologic shortages, was 5.7 MAF/yr, with 2.8 MAF/yr simulated as SWP delivery and 2.9 MAF/yr simulated as CVP delivery. Because DeltaSOS does not separate CVP and SWP exports, the total for Delta exports was used for water supply impact assessment.

- San Joaquin River inflows, estimated with another DWR model called STANSIM, met the WQCP Vernalis water quality objectives and the Vernalis pulse-flow objectives (with a maximum of 70 TAF/yr of releases in addition to the existing instream flow requirements). In some years of the simulations, the Vernalis pulse-flow objectives were satisfied with additional water from upstream tributaries (Tuolumne and Merced Rivers). This additional San Joaquin River inflow averaged 72 TAF/yr but

was required in only a few years. See Appendix A2 for more details on simulation of the pulse-flow requirements.

- Combined SWP and CVP Delta exports were limited as specified in the WQCP to a percentage of the simulated Delta river inflow (which does not include rainfall runoff). These percentages are 35% in February-June, and 65% for the remainder of the year. The February percentage is 45% if the January Eight-River index is less than 1.0 MAF. Export pumping during the pulse-flow period was limited to the pulse flow during half of April and half of May. SWP pumping capacity was assumed to increase in December-March as allowed in the Corps permit, whenever San Joaquin River flow exceeded 1,000 cfs. See Appendix A2 for more details.

- Several other modeling assumptions, such as carryover storage requirements, were used for these DWRSIM simulations of the 1995 WQCP. These are not directly related to Delta operations and are considered to be accurate representations of current SWP and CVP operating constraints that are appropriate for simulations of the DW project alternatives and the No-Project Alternative for impact assessment.

Table A3-1 shows the annual average values from the 70-year 1922-1991 hydrologic record for the initial Delta water budget terms as simulated by DWRSIM for the 1995 WQCP. Annual simulated values were compared with historical data (Appendix A1) and appear to provide a reasonably accurate representation of historical conditions. Simulated values match historical records most closely at the end of the historical period, when both development of facilities and level of demand approximated the simulated conditions.

Monthly values simulated by DWRSIM for the 70-year period of record were used as the initial Delta water budget values for DeltaSOS simulations of the No-Project Alternative and the DW project alternatives. The full range of historical variation in hydrologic conditions is therefore included in these DeltaSOS simulations.

Table A3-1 indicates that simulated SWP and CVP Delta export pumping averaged 5,712 TAF/yr over the 70-year period, with an additional 146 TAF/yr of CCWD diversions. Simulated Sacramento River and Yolo Bypass inflows averaged 15,998 TAF/yr and 2,118 TAF/yr, respectively. Eastside stream and San Joaquin River inflows averaged 835 TAF/yr and 2,401 TAF/yr, respectively. Delta depletion, together with North Bay Aqueduct and City of Vallejo export pumping, averaged 931 TAF/yr. Simulated Delta outflow averaged 14,562 TAF/yr and DWRSIM-estimated outflow requirements averaged 5,802 TAF/yr. The historical records are summarized in Table A1-1 in Appendix A1 for the 70-year 1922-1991 period. The large year-to-year variations in hydrology are similar for the simulated and historical annual values. Simulated water resource operations have a greater effect on monthly values than on average annual values.

User-Specified Input Parameters for DW Project Simulations

Table A3-2 identifies the choices for each DeltaSOS switch in the DW project simulations. These choices are explained in the following discussions.

Hood Diversions to Exports? (0=No, 1=Yes). This switch is set at 0 and the three Hood diversion control matrices are not used because there are no simulated Hood diversions.

Delta Standards Outflow Point. (0=Collinsville, 1=Chipps Island). DeltaSOS simulations for DW project impact assessments used Collinsville, upstream of the Suisun Marsh salinity control gate, as the Delta outflow control location so that potential effects of the gates on total outflow requirements could be disregarded.

Add Carriage Water to Required Outflow? (0=No, 1=Yes). DeltaSOS uses DWRSIM estimates of required Delta outflow (including all 1995 WQCP objectives). DWRSIM simulations include a considerable amount of carriage water in addition to required monthly Delta outflow values to prevent salinity intrusion at the export locations in late summer and fall. DeltaSOS simulations for the DW project impact assessment used the DWRSIM estimates of total required outflow that include carriage water and X2 requirements to prevent the carriage water inflow from being exported by the SWP or CVP pumps or diverted to the DW reservoir islands in the simulations and to prevent any difference between the estimates of X2 requirements.

Include Channel Depletion in Inflow? (0=No, 1=Yes). The 1995 WQCP uses only river inflows in the calculation of allowable exports, so this DeltaSOS switch is set to 0.

Open Montezuma Gates to Meet Outflow? (0=No, 1=Yes). Because DeltaSOS simulations for DW project impact assessment used Collinsville as the Delta outflow control location, opening the Suisun Marsh salinity control gate does not help meet outflow requirements in these simulations. Therefore, this switch is set to 0 for all DW simulations.

Cut Pumping to Meet Outflow? (0=No, 1=Yes). DeltaSOS simulations for DW project impact assessment set this switch to 1 as a way to meet Delta outflow requirements at Collinsville. However, because DWRSIM outflow requirements are used in DeltaSOS, no outflow adjustments are required. The user-specified minimum monthly pumping during cutbacks was set at 1,500 cfs for all DW project simulations, as specified in the 1995 WQCP.

Outflow Deficit Limits Delta Storage Exports? (0=No, 1=Yes). This switch is set to 0 for all DeltaSOS simulations for DW project impact assessment, allowing DW discharge water to be exported during any simulated periods of Delta outflow deficits. However, because there are no outflow deficits simulated, the switch has no effects on DW project simulations.

Delta Storage Export Limit Exemption? (0=No, 1=Yes). This switch is used to indicate whether DW project discharges are exempt from specified export pumping limits. This switch is set to 0 (no exemption) for DW simulations under 1995 WQCP objectives.

SWP/CVP Export All Available? (0=No, 1=Yes). DeltaSOS can simulate an increase in Delta exports if simulated pumping capacity remains within the specified export limits. The extra pumping is limited to water that is in excess of specified Delta outflow objectives. This switch is set to 1 for all DeltaSOS simulations of DW project alternatives. Therefore, DeltaSOS simulates all potential CVP and SWP pumping prior to estimating water available for DW diversion or pumping capacity available for export of DW discharges. The south-of-Delta demands and storage capacity for water are not evaluated by DeltaSOS; simulated exports in some years will likely exceed the needs for water.

This assumption of maximum CVP and SWP exports within the export limits specified in the 1995 WQCP may cause DeltaSOS to simulate more Delta export than can be fully used in some years. However, this DeltaSOS assumption avoids the potential situation in which DW diversions and discharges would be simulated to occur in the same month (water being discharged from storage from one island and being diverted to fill an empty reservoir island at the same time). It seems likely that in the event that more water were needed for south-of-Delta beneficial uses than initially simulated with DWRSIM, additional SWP or CVP export pumping of available water in the Delta would occur prior to discharge from DW storage for export pumping. Details of this DeltaSOS adjustment to DWRSIM-simulated exports are presented below under the discussion "DeltaSOS Adjustments of DWRSIM-Simulated CVP and SWP Exports" in the section "DeltaSOS Simulation Results for the DW Project Alternatives".

Limit Delta Storage Export to Percent of Inflow? (0=No, 1=Yes). This switch is set to 1 for all DW alternatives. DW alternatives with DW exports not subject to the 1995 WQCP "percent inflow" limits and allowed up to the permitted pumping rate (Alternatives 2 and 3) were simulated by changing the DW export "fraction of inflow" matrix values to 1.0.

Effective Montezuma Diversion Factor. This factor governs the effective change in Delta outflow, relative to salinity control, of the diversions into Montezuma Slough when the Suisun Marsh salinity control gate is operating. This factor is set at 1.0 for DeltaSOS simulations for DW project impact assessment. Because Collinsville is used as the Delta outflow control point for the DW simulations, this setting does not affect export pumping or outflow.

Starting Month for Delta Outflow Restrictions (1=Oct) and Ending Month for Delta Outflow Restrictions (1=Oct). These switches are used to specify the control period for the OUTQ Delta outflow standards. These standards require specified flows for a specified number of months within the control period, but they do not specify the individual months when the flows are required. These switches are set at 1 and 12 but have no effect because the OUTQ matrix values are zero and the DWRSIM estimates of required Delta outflow are used in DeltaSOS.

QWEST Estimated with Threemile Included? (0=No, 1=Yes). All DeltaSOS simulations for DW project alternatives set this switch to 0 so that Threemile Slough flows are not included in QWEST objectives. This switch has no effect because there are no QWEST objectives in the 1995 WQCP.

Minimum San Joaquin River Flow for Extra SWP Pumping. The Corps permit for SWP export pumping contains a provision allowing additional pumping (greater than 6,680 cfs) using the four recently installed pumps whenever San Joaquin River inflow is

greater than 1,000 cfs during the period of December 15 to March 15. This flow threshold applies to daily flows; however, DeltaSOS allows this threshold to be specified for monthly simulations, and DeltaSOS simulations for DW project impact assessments set the threshold at 1,000 cfs.

Minimum Pumping during Cutbacks. DeltaSOS simulations for DW project impact assessment used a minimum export pumping value of 1,500 cfs. This switch has no effect because there are no export reductions required in the DWRSIM initial estimates.

Roe Island Outflow Trigger (km). This input is used to estimate the outflow requirements, which are increased if the previous end-of-month estimate of X2 is downstream of this specified location. This value has no effect because the DWRSIM estimates of outflow requirements are used in DeltaSOS.

Initial X2 Position. This corresponds to the X2 position at the beginning of the simulation period (end of September 1921) because the X2 position is calculated as a sequence that depends on the previous month's value.

Estimate X2 Outflow Requirements? (0=No, 1=Yes). This switch is set to 0 for the DW simulations but can be used to allow rapid comparison of DeltaSOS calculations of incremental X2 outflow requirements. This switch has no effect because DWRSIM estimates of outflow requirements are used for the DW alternatives.

Monthly Minimums and Fractions of Available Water for DW Diversion. DeltaSOS estimates water available for DW diversion by calculating excess Delta outflow and excess QWEST flow. Monthly minimums and fractions of excess flows can be specified in DeltaSOS to limit DW project diversions to provide a buffer of excess available flows.

A minimum excess flow is not specified for simulations of the DW project alternatives. Setting the monthly fractions of available water to 0 is the quickest method for simulating the No-Project Alternative because this will prevent any simulations of DW operations. (The reduction in consumptive use should be also changed to 0 in the matrix for DW storage evaporation.)

DeltaSOS Standard Matrices for the DW Project Simulations

DeltaSOS simulations also require as input specified standard matrices. Each of the required matrices to simulate the 1995 WQCP objectives is explained in Appendix A2 and summarized here.

Table A3-3 gives the Delta standard matrices used for simulating the DW project alternatives and the No-Project Alternative with DeltaSOS, assuming 1995 WQCP objectives. The first matrix ("Minimum required Sacramento River flow at Freeport") is set to zero because no Sacramento River flushing flows are included.

The second matrix of Table A3-3 ("Sacramento River trigger for the Delta Cross Channel") indicates that the Delta Cross Channel (DCC) is closed from November to May for winter-run salmon protection and for flood control whenever Sacramento River inflow is greater than 25,000 cfs. Minimum Rio Vista flows are specified for September-December.

The "Minimum QWEST flow" matrix of Table A3-3 indicates that there are no QWEST flow objectives in the 1995 WQCP, so the QWEST matrix values are -15,000 cfs.

The minimum San Joaquin River flows are developed from a combination of WQCP objectives. The Vernalis electrical conductivity (EC) objective is 0.7 millisiemens per centimeter (mS/cm) in the April-August irrigation season and 1.0 mS/cm for the remainder of the year. The flow necessary to maintain these EC values can be approximated with a flow-EC regression using available EC and flow data; this has been simulated with DWR's STANSIM model and used in the DWRSIM results. The DeltaSOS minimum of 900 cfs is considerably less than the flows necessary to meet the EC objectives and will therefore not cause any additional San Joaquin inflow adjustment to be made in DeltaSOS. The minimum February-June flow requirements depend on the San Joaquin Four-River Index year-type classification. Whenever the monthly X2 is downstream of Chipps Island (11,400-cfs Delta outflow equivalent), these required San Joaquin River flows are increased by the amount of flow given at the bottom of each year-type column (i.e., 1,290 cfs in wet and above-normal water years). The pulse-flow requirements in half of April and half of May depend on year type and are also incremented if the Delta outflow is sufficient to maintain X2 downstream of Chipps Island.

The allowable increase in SWP pumping capacity under the Corps permit is simulated in DeltaSOS to match the DWRSIM assumptions. The monthly San Joaquin River flows increase the monthly SWP capacity by the percentage given in the matrix, 17% in December and March and 33% in January and February. The barrier at the head of Old River to protect migrating salmon is simulated to be closed in October and in April and May, as specified in the 1995 WQCP.

The "Minimum Delta outflow" matrix of Table A3-3 indicates that the Delta outflow matrices have been set to 0 because the DWRSIM-simulated Delta outflow requirements are being used directly in DeltaSOS (input as "carriage water" requirements). This avoids any conflicts between the variable X2 requirements and carriage water estimates that DWRSIM simulates and estimates that might be calculated in DeltaSOS.

The combined Delta export capacity is assumed to be 11,280 cfs for April-November and to be reduced to 10,880 cfs in December-March. However, as described above, San Joaquin River inflow can raise the combined capacity to 11,700 cfs in December and March, and to 12,700 cfs in January and February, as assumed in DWRSIM. The physical capacity of the combined pumps is actually 14,900 cfs during April-November and 14,500 cfs during December-March. These maximum physical capacity limits were used in the simulations for cumulative conditions, as described in a later section.

The 1995 WQCP objectives limit SWP and CVP exports to a specified percentage of the Delta river inflows. These percentages (35% for February-June, 65% for the remaining months) do not depend on year type. The February percentage increases to 45% if the January Eight-River Index runoff is less than 1.0 MAF. The sixth column is used to specify the percentages used for DW discharges for export. This column is the same as the SWP and CVP export percentages for some DW alternatives but is changed to 100% to allow DW discharges for export to the pumping capacity.

Montezuma Slough tidal gates are assumed to operate during October-March, with April and May gate operation eliminated because of concerns about winter-run salmon predation.

Five matrices presented on the third and fourth pages of Table A3-3 specify operating parameters for in-Delta water storage used in simulating DW project alternatives, when appropriate. (These five matrices are ignored by DeltaSOS in simulating the No-Project Alternative.) The first in-Delta water storage control matrix specifies assumed end-of-month reservoir storage capacities. Year-round storage is assumed for all DW alternatives, so the value of 238 TAF for two reservoir islands or 406 TAF for maximum storage on four reservoirs is used. The next matrix specifies assumed monthly evaporation losses from the DW reservoir islands and assumed reductions in Delta consumptive use caused by forgoing irrigation of the DW islands (see Appendix A1). The monthly diversion rates, discharge rates, and required outflow release rates are specified in the final three DW control matrices.

DELTASOS SIMULATION RESULTS FOR THE DW PROJECT ALTERNATIVES

DeltaSOS simulation results for the No-Project Alternative and the DW project alternatives can be reviewed in detail in actual DeltaSOS model spreadsheets on a computer screen. Selected results are described and summarized in the following sections. These results allow comparison between each DW project alternative and the No-Project Alternative and are used for DW project impact assessments for water supply, hydrodynamics, water quality, and fisheries in Chapters 3A, 3B, 3C, and 3F, respectively.

DeltaSOS Adjustments of DWRSIM-Simulated CVP and SWP Exports

As discussed above, DeltaSOS simulates all potential CVP and SWP pumping prior to estimating water available for DW diversion or pumping capacity available for export of DW diversions. This requires that DeltaSOS adjust the initial DWRSIM results to increase the combined CVP and SWP exports to the maximum possible within the export limits specified by the 1995 WQCP.

DWRSIM initial results sometimes showed simulated available water for diversions and also unused export pumping capacity. If DW alternatives were simulated without adjustment of the DWRSIM results, DW operations would likely be overestimated. It seems likely that should more water be needed for south-of-Delta beneficial uses than was initially simulated with DWRSIM, additional amounts of available water would be exported by the SWP or the CVP before DW discharges for export would occur. The DeltaSOS adjustment of DWRSIM exports reduces the available water for DW diversion and reduces the opportunity for DW discharge

for export. This adjustment provides the most reasonable estimate of likely DW operations and eliminates the potential situation in which DW diversions and discharges would be simulated to occur in the same month (water being discharged from storage from one island and being diverted to fill an empty reservoir island at the same time).

This assumption results in greater SWP and CVP exports being simulated by DeltaSOS than by DWRSIM and may cause DeltaSOS to simulate more Delta export than can be fully used in some years. This water may not actually be exported in wet years without additional surface water or groundwater storage facilities being available. The DeltaSOS simulations for the DW project therefore may include slightly more SWP and CVP export pumping than would likely occur under these hydrologic conditions. On the other hand, the DeltaSOS-simulated maximum CVP and SWP export pumping would be allowable under the 1995 WQCP objectives and might occur in the future if demands increase and storage facilities are added.

This DeltaSOS assumption of maximum SWP and CVP export pumping will reduce the potential DW diversions and DW discharges for export in some years when the initial DWRSIM results indicated less combined pumping. Nevertheless, this appears to be the most reasonable assumption for realistic impact assessment of the DW project for water supply, hydrodynamics, water quality, and fishery resources. Appendix A4, "Possible Effects of Daily Delta Conditions on Delta Wetlands Project Operations and Impact Assessments", provides a discussion of the possibility for DW diversions and discharges to occur at different times within the same month because of hydrologic variation within a month.

Table A3-4a shows the monthly DWRSIM-simulated combined CVP and SWP Delta export pumping rates (in cfs) for water years 1922-1991. The total annual water-year export volume (in TAF) and monthly average pumping rates (in cfs) are also shown. Table A3-4b shows the monthly increase in combined exports simulated with DeltaSOS. This simulated increase is limited by outflow objectives and the percentage of Delta river inflow specified in the 1995 WQCP. Table A3-4c indicates the maximum possible export simulated by DeltaSOS.

Table A3-4b indicates that DWRSIM-simulated exports were generally at the maximum possible under 1995 WQCP objectives during summer (June-September), when export demands are highest. DWRSIM-simulated exports were less than the maximum possible in some months when export demands (and San Luis Reservoir maximum filling rate) limited export. In these months, DeltaSOS adjustments were the largest. Table A3-4b indicates that the average annual adjustment in CVP and SWP combined exports was 442 TAF/yr, increasing the average exports from 5.71 MAF/yr to 6.15 MAF/yr.

Table A3-4c indicates that SWP and CVP export pumping was at the maximum permitted rate in some months, but exports in the majority of months were limited by the outflow or export limit objectives in the 1995 WQCP. For 1983, the adjusted DeltaSOS export pumping was at the maximum monthly rate each month, for a maximum annual total permitted export pumping volume of 8,377 TAF.

Results for the No-Project Alternative

Annual Average Results for the No-Project Alternative

Table A3-5 presents annual average flow volumes (TAF) simulated by DeltaSOS for the No-Project Alternative. The water year and water-year types, as defined by the 1995 WQCP for the Sacramento and San Joaquin River Basins are indicated for reference (1= wet, 5 = critical). There are no required Sacramento River inflows, so the added Sacramento River flows were 0. The annual Sacramento River inflow ranged from 6,775 TAF for 1931 to 35,577 TAF for 1983, with a mean annual flow of 15,998 TAF/yr. The required San Joaquin River flow ranged from 790 TAF to 1,759 TAF in wet years. The additional San Joaquin River flow needed to satisfy the 1995 WQCP objectives was estimated by DeltaSOS to average 27 TAF/yr. The adjusted San Joaquin River inflow averaged 2,428 TAF/yr.

Steamboat and Sutter Slough diversions from the Sacramento River averaged 5,091 TAF/yr, slightly less than one-third of the Sacramento River inflow. The adjustments in DCC flows to satisfy the Rio Vista objectives were relatively small. The DCC flow averaged only 1,347 TAF/yr because of the extended closure period specified in the 1995 WQCP. The combined DCC and Georgiana Slough diversions averaged 4,090 TAF/yr, approximately 25% of the Sacramento River flow. The simulated Rio Vista flow averaged 13,793 TAF/yr, with 2,118 TAF/yr from the Yolo Bypass (not shown).

The QWEST flow with the DWRSIM-simulated exports averaged 862 TAF/yr, but many years were simulated with an average negative QWEST flow volume. No reductions in export for QWEST requirements were simulated because there are no QWEST objectives in the 1995 WQCP. The Delta outflow (Collinsville) with the DWRSIM exports averaged 14,562 TAF/yr. Average diversions into Suisun Marsh through Montezuma Slough of 930 TAF/yr reduced the Chipps Island outflow to 13,631 TAF/yr. There were no simulated export reductions to satisfy outflow requirements, because the DWRSIM outflow requirements were used in DeltaSOS.

DeltaSOS estimates the 1995 WQCP export limits as a percentage of monthly inflow, without reference to the permitted export pumping rate or outflow requirements, to average 10,292 TAF/yr. In a few months, slight adjustments were required to be made to the DeltaSOS specified export limits (usually associated with the extra SWP pumping estimates). The average export adjustment made to the maximum allowable 1995 WQCP exports within the permitted pumping rate was 442 TAF/yr. The adjusted annual exports totaled 6,154 TAF/yr. The adjusted QWEST flow was reduced to 420 TAF/yr, and the adjusted outflow was reduced to 14,120 TAF/yr.

The available water volume would be excess water not needed to satisfy 1995 WQCP objectives, with CVP and SWP pumping at the permitted rate. This water could be diverted by the DW project if sufficient diversion capacity and storage capacity were available. No DW operations were simulated for the No-Project Alternative, so the "final" export, QWEST flow, and outflow remained unchanged after the export adjustments were made. The simulated Threemile Slough flow averaged 3,084 TAF/yr from the Sacramento River to the San Joaquin River. Old River diversions from the San Joaquin River averaged 1,370 TAF/yr, about 56% of the San Joaquin River flow. The simulated San Joaquin River flow at Antioch averaged 3,504 TAF/yr.

While these annual totals indicate the general movement of water within the Delta and show the year-to-year fluctuations in Delta hydrology, the monthly DeltaSOS-simulated flows are also of interest. These seasonal flow patterns are summarized in the next section for the No-Project Alternative.

Monthly Percentile Tables for the No-Project Alternative

Table A3-6 (six pages) presents frequency percentiles for monthly values from the DeltaSOS simulation of the No-Project Alternative. Each output column from Table A3-5 is summarized in monthly percentiles in Table A3-6. The monthly percentiles provide an important seasonal summary of the simulation values.

These monthly "stacks" are the distribution of simulated monthly flows for each calendar month for the 70 simulated years, given in 10% increments (7 years) and do not represent a sequence of monthly values. The sequence of simulated flows can be found in the DeltaSOS spreadsheet. The monthly distribution of flows provided in the percentile tables gives an overview of the simulated flows in a particular calendar month.

As an example of how the tables are read, on the first page of Table A3-6, monthly percentiles for "Sacramento River inflow" indicate that the lowest October flow in the No-Project Alternative simulation was 7,061 cfs. Ten percent of the years (7 of 70 years) had an October flow of less than 8,521 cfs, 50% of the years (35 of 70 years) had an October flow of less than 13,235 cfs, and the maximum October flow was 29,964 cfs. The average (mean) October flow was 14,883 cfs.

As another example, on the second page of Table A3-6, monthly percentiles for "Delta Cross Channel flow" indicate that the DCC was always closed in November to May. In addition, the DCC was closed at least 1 year in October and at least 10% of the years in June because the Sacramento River flow exceeded the flood control threshold of 25,000 cfs.

On the fourth page of Table A3-6, the monthly adjustments in Delta export are summarized. For a few months, minor reductions were simulated to meet DeltaSOS estimates of the export limits (DeltaSOS uses cfs units, while DWRSIM uses TAF units). The majority of the adjustments in export were simulated to occur during November-May. In January, for example, significant adjustments were made for less than 30% of the years, because 70% of the January adjustments were less than 15 cfs.

The fourth page of Table A3-6 also shows the simulated "available water for diversion". Although there was at least one year with some available water in each calendar year, most of the available water was simulated for November-March. This table indicates the magnitude of the available water. For example, in January there was

simulated available water in more than 60% of the years, and 50% of the years had available average January flows of greater than 6,475 cfs, which is greater than the DW project monthly average diversion capacity. The table indicates that when available water for diversion is simulated, the flow is usually relatively high compared with the DW diversion capacity.

The fifth page of Table A3-6 shows no simulated DW operations for the No-Project alternative, and the final CVP and SWP combined export pumping. This table can be used to identify the frequency of capacity being available for potential DW discharges for export within the permitted pumping rate through comparison of the maximum export pumping simulated for each month compared with the frequency distribution that represents the allowable pumping rate for simulated Delta inflows under the 1995 WQCP objectives.

Monthly and Annual Graphs for the No-Project Alternative

DeltaSOS produces several types of graphs that display monthly and annual simulation results. This section presents selected graphs to summarize DeltaSOS results for the No-Project Alternative. Monthly values are presented on three pages representing three segments of the 70-year hydrologic record: 1922-1944, 1945-1967, and 1968-1991.

Figure A3-1 shows simulated monthly Delta outflow and required Delta outflow as estimated by DWRSIM. The difference between the two curves represents surplus Delta outflow for the input hydrology and 1995 WQCP objectives. Required Delta outflow is greater during wetter year types and represents a considerable portion of the outflow in dry years.

Figure A3-2 shows simulated values for monthly Delta export pumping. Adjusted exports are those simulated by DeltaSOS based on estimating additional water available for export within specified monthly pumping limits and other Delta objectives (without considering downstream demands and storage capacity). Export adjustment is the difference between initial exports simulated by DWRSIM and adjusted exports simulated by DeltaSOS. The greatest amount of additional export is simulated by DeltaSOS during spring. However, there may not be a demand for these additional simulated exports.

Figure A3-3 shows annual Delta outflow and required Delta outflow (in MAF) as simulated by DeltaSOS for the No-Project Alternative. There was no surplus Delta outflow simulated in some years, but surplus outflow of several MAF was simulated in most other years.

Figure A3-4 shows the simulated annual values for initial (DWRSIM) Delta exports and adjusted annual exports (after all objectives are satisfied and all available water is pumped). DeltaSOS simulated no additional export pumping in some years, but 9 years were simulated with more than 1,000 TAF of additional export. The maximum possible export for most years is less than 7 MAF; 15 years had exports greater than 7 MAF, and 1983 is the only year with simulated exports greater than 8 MAF. The DW project alternatives were simulated for comparison with these adjusted no-project Delta conditions, although the need for these additional exports for beneficial uses was not evaluated with DeltaSOS.

DeltaSOS Results for Alternative 1

Alternative 1 consists of potential year-round diversion and storage of water on two reservoir islands. Wetland vegetation and waterfowl habitat may be provided incidentally in years when the DW reservoir islands are partially full or empty during the appropriate months. A relatively small volume of incidental storage will occur on habitat islands for wetland management (see Chapter 2, "Delta Wetlands Project Alternatives").

Diversions to the reservoir islands (238-TAF capacity) would occur during any month with available surplus flows. DW proposes a maximum monthly average diversion rate of 4,000 cfs to fill the two reservoir islands in 1 month. Maximum siphon capacity would be 9,000 cfs when diversions begin and head differential between the channel and island bottom is at a maximum. The simulated monthly average discharge rate is 4,000 cfs. The maximum discharge rate is about 6,000 cfs when the DW reservoir islands are full.

For DeltaSOS simulations of Alternative 1, it is assumed that discharges of water from the DW islands would be exported in any month when unused capacity within the permitted pumping rate exists at the SWP and CVP pumps and the export limits do not prevent use of that capacity. Such unused capacity could exist when the amount of available water (i.e., total inflow less Delta channel depletion and Delta outflow requirements) is less than the amount specified by the export limits.

Simulated Monthly DW Operations for Alternative 1

Table A3-7 presents the monthly DW operations (diversions, end-of-month storage, and discharges) simulated by DeltaSOS for Alternative 1. This three-page tabular format allows the DW operations in a particular year of interest to be identified. This table presents the most complete record of simulated DW operations for Alternative 1.

Table A3-7a presents the monthly simulated diversions to storage (cfs), arranged as monthly flow values for each simulated water year, from 1922 through 1991. The annual total diversions (TAF) are shown in the right hand column, and the average monthly diversion flows (cfs) are given at the bottom of the table.

Table A3-7b presents the monthly simulated discharges from storage (cfs), arranged as monthly flows for each simulated water year, from 1922 through 1991. The annual total discharges (TAF) are shown in the right-hand column, and the average monthly discharge flows (cfs) are given at the bottom of the table.

Table A3-7c presents the combined end-of-month storage (TAF) for the DW reservoir islands. The seasonal storage in wetlands and ponds on the habitat islands is not included in these values. The storage is increased by diversions and is reduced by evaporation and discharges from the reservoir islands. The average end-of-month storage volumes are given at the bottom of the table.

Annual Average Results for Alternative 1

Table A3-8 presents the annual average values for DeltaSOS-simulated Delta conditions for the proposed DW project under the 1995 WQCP objectives. Only the third page, giving the simulated DW operations, is significantly different from the simulation results for the No-Project Alternative.

Simulated DW operations for Alternative 1 average 222 TAF/yr of diversions, with 188 TAF/yr of discharge for export. The DW project would not have operated in several years (9 of 70 years) because water available for diversions was limited. In other years, however, the simulated DW discharge for export is greater than the 238-TAF storage capacity of the two reservoir islands because of multiple diversion and discharge periods in the same year (6 of 70 years). The maximum simulated annual discharge for export was 444 TAF in 1957. DeltaSOS does not, however, evaluate the need for these additional exports.

Monthly Percentile Tables for Alternative 1

Table A3-9 presents monthly percentiles of simulated values for the proposed project. The first panel of Table A3-9 gives monthly percentiles for DW diversions to storage. This panel summarizes the monthly diversions shown in Table A3-7a. Diversions are simulated in only about 20% of the fall and winter months because water may not be available for diversion or because the DW reservoir islands may already be full. The seasonal pattern of DW diversions is shown, and the mean diversion for each month indicates the overall importance of that month for DW diversions. October-January is the most important period for diversion.

The second panel of monthly percentiles shows end-of-month storage on the DW reservoir islands for the 70-year hydrologic record. Water would generally be diverted onto the DW reservoir islands during winter and discharged during summer. For example, the reservoirs are simulated to be empty in October for 70% of the years, empty in January and February about 20% of the years, and essentially empty in August and September in at least 90% of the years.

Monthly percentiles do not indicate the sequence of months of DW storage in a particular year. Therefore, the 70-year simulation of monthly storage values shown in Table A3-7 must be examined directly to determine how often the DW reservoirs would be empty for a series of months (e.g., from June through August for wetland plant growth).

The third monthly percentile panel gives the DW discharges for export for each month. Discharges for export are simulated in about 30% of the years for July and August. Discharges are not simulated in months when stored water is not available for discharge or when additional pumping capacity is not available for export of DW discharges. The seasonal pattern of DW discharges is shown, and the mean discharge for each month indicates the overall importance of that month for DW discharges. July and August are the most important months for discharges.

The fourth panel of monthly percentiles shows the pattern of DW releases for Delta outflow for each month. The values in this panel are zeroes because under the DW project alternatives, DW releases are not simulated for Delta outflow; water is held in the DW reservoirs until it

can be discharged for export. DW water may be discharged for Delta outflow if this beneficial use is selected by the water purchaser.

The fifth panel of Table A3-9 presents monthly percentiles for simulated total Delta export pumping for each month, including DW discharges for export. For example, export pumping in April is simulated at the maximum allowable rate (11,280 cfs) for less than 10% of the years. Export of DW discharges would occur during months when the SWP and CVP pumping is limited by Delta outflow requirements.

Monthly and Annual Graphs for Alternative 1

Figure A3-5 shows simulated monthly values of water available for DW diversions and of diversions to DW storage. This figure shows the fraction of available water that is simulated to be diverted for DW storage. Because the amount of available water is often greater than 4,000 cfs (the maximum monthly diversion needed to fill the 238-TAF capacity of two reservoir islands), only a small portion of the available water is diverted in most months.

Figure A3-6 shows the simulated pattern of monthly DW storage. Storage over several months is the most common pattern, but several years show multiple diversion and discharge periods, indicated by a rapidly fluctuating storage pattern.

Figure A3-7 shows simulated total Delta exports (including DW discharges) and the DW discharges for export.

Figure A3-8 shows simulated annual values for DW operations under Alternative 1. Simulated annual diversions and discharges are not always equivalent, indicating that water was stored in DW reservoirs from one year to the next.

Figure A3-9 shows simulated annual Delta exports under Alternative 1, including initial DWRSIM exports, exports adjusted by DeltaSOS, and final exports including DW discharge water. The figure also shows the additional exports from DW discharges.

Effects of DW diversions on reduced annual Delta outflow are not detectable in annual values, so the annual Delta outflow patterns are those shown in Figure A3-3.

Results for Alternative 2

DW diversion operations under this alternative would be the same as under Alternative 1. In DeltaSOS simulations of Alternative 2, it is assumed that releases of water from the DW islands would be exported by the SWP and CVP pumps when unused capacity within the permitted pumping rate exists at the SWP and CVP pumps. DW discharges would be allowed to be exported in any month when such capacity exists, without regard for the export limits (percentage of total Delta inflow). Under this alternative, it is assumed that export of DW discharges is limited by the WQCP Delta outflow requirements and the permitted combined pumping rate of the export pumps but is not subject to the WQCP "percent of inflow" export limit.

Simulated Monthly DW Operations for Alternative 2

Table A3-10 presents the monthly DW operations (diversions, end-of-month storage, and discharges) simulated by DeltaSOS for Alternative 2. This three-page tabular format allows the DW operations in a particular year of interest to be identified. This table presents the most complete record of simulated DW operations for Alternative 2.

Table A3-10a presents the monthly simulated diversions to storage (cfs), arranged as monthly flow values for each simulated water year, from 1922 through 1991. The annual total diversions (TAF) are shown in the right-hand column, and the average monthly diversion flows (cfs) are given at the bottom of the table. The diversions are similar to those simulated for Alternative 1 because the simulated pattern of available water for DW diversion is the same. However, DW diversions simulated for March and April were higher than those simulated for Alternative 1 because of some increased discharges under Alternative 2 (see below).

Table A3-10b presents the monthly simulated discharges from storage (cfs), arranged as monthly flows for each simulated water year, from 1922 through 1991. The annual total discharges (TAF) are shown in the right-hand column, and the average monthly discharge flows (cfs) are given at the bottom of the table. Results for a few months were different than for Alternative 1 because of the increased simulated DW discharge opportunity. Discharges in February and March were higher under Alternative 2 than under Alternative 1. Simulated June discharges were higher under Alternative 2 than under Alternative 1, but July and August discharges were lower

because the amount of DW storage capacity available was usually simulated to be about the same for the two alternatives.

Table A3-10c presents the combined end-of-month storage (TAF) for the DW reservoir islands. The seasonal storage in wetlands and ponds on the habitat islands is not included in these values. The DW storage is increased by diversions and is reduced by evaporation and discharges from the reservoir islands. The average end-of-month storage volumes are given at the bottom of the table. The simulations show that the reservoir islands would empty earlier in the summer under Alternative 2 than under Alternative 1.

Table A3-11 shows DeltaSOS simulation results for Alternative 2. The results show average annual diversions of 225 TAF/yr and 202 TAF/yr of discharge for export. DW maximum storage for each water year was often 238 TAF, but simulations for 11 out of 70 years had DW storage of less than 100 TAF. Table A3-12 shows the monthly percentiles for simulated DW operations under Alternative 2. Diversions (see first panel) of 2,000-4,000 cfs are simulated to generally occur early in a water year (October-March), with discharges (see third panel) of 2,000-4,000 cfs during the middle or late part of the water year (February-March and June-July). The DW project would not have operated in several years because of limited water available for diversions (less than 100 TAF of diversions in 17 of 70 years).

Figure A3-10 shows simulated annual DW diversions and discharges for Alternative 2. DW operations under Alternative 2 are simulated generally to occur in the same years as operations simulated under Alternative 1, but the maximum discharges are slightly more because of the simulated increases in opportunities for DW discharges for export.

Figure A3-11 shows simulated annual exports for Alternative 2. The initial (DWRSIM-simulated), DeltaSOS-adjusted, and final exports are shown, along with the additional DW discharges for export.

Results for Alternative 3

Under Alternative 3, water would be diverted for storage in reservoirs on all four DW project islands. In DeltaSOS simulations of this alternative, DW initial storage volume is assumed to be 406 TAF. The maximum monthly DW diversion rate to the four islands is simulated to be 6,000 cfs, which would allow most of the DW storage volume to be filled in a single month. The maximum monthly average DW discharge rate is 6,000 cfs for simulation purposes. The diversion and discharge modeling assumptions for this alternative are the same as for Alternative 2, but the assumed diversion and discharge rates are higher.

Simulated Monthly DW Operations for Alternative 3

Table A3-13 presents the monthly DW operations (diversions, end-of-month storage, and discharges) simulated by DeltaSOS for Alternative 3. Table A3-13a presents the monthly simulated diversions to storage (cfs), arranged as monthly flow values for each simulated water year, from 1922 through 1991. The annual total diversions (TAF) are shown in the right-hand column, and the average monthly diversion flows (cfs) are given at the bottom of the table. The diversions simulated for Alternative 3 are much larger than those simulated for Alternative 2 because the simulated DW storage capacity is greater. Some monthly diversions are simulated at 6,000 cfs, but other periods require two months of diversions to fill the simulated DW storage capacity.

Table A3-13b presents the monthly simulated discharges from storage (cfs), arranged as monthly flows for each simulated water year, from 1922 through 1991. The annual total discharges (TAF) are shown in the right-hand column, and the average monthly discharge flows (cfs) are given at the bottom of the table. The simulated discharges are greater for Alternative 3 than for Alternative 2, but are simulated to occur in the same months because the same DW export capacity was simulated for Alternatives 2 and 3. Some monthly average discharges were simulated at 6,000 cfs, while other periods required lower discharges for more than one month.

Table A3-13c presents the combined end-of-month storage (TAF) for the four DW reservoir islands under Alternative 3. The seasonal storage in wetlands and ponds in habitat areas on Bouldin Island are not included in these values. The storage is increased by diversions, and is reduced by evaporation and discharges from the reservoir islands. The average end-of-month storage volumes are given at the bottom of the table.

Table A3-14 shows DeltaSOS mean annual simulation output for Alternative 3. Simulated average annual operations for Alternative 3 were 356 TAF/yr of diversions and 302 TAF/yr of discharge for export. These values are much greater than those for Alternative 2 because of the increased reservoir capacity. The increased storage does not change simulated DW

operations, however, during years with limited water available for diversions.

Table A3-15 shows the monthly percentiles for simulated DW operations for Alternative 3. Diversions of 2,000-6,000 cfs are simulated generally to occur early in a water year (October-February), with discharges of 2,000-4,000 cfs during spring (February-March) and summer (June-August). The DW project still would not have operated, however, in several years because of limited water available for diversions (less than 100 TAF of diversions in 13 of 70 years) or no available export pumping capacity for DW discharges.

Figure A3-12 shows simulated annual DW diversions and discharges for Alternative 3. DW operations are simulated generally to occur in the same years under Alternative 3 as under Alternative 2, but the diversions and discharges are much greater, with about 4 years of more than 500 TAF/yr in exports simulated.

Figure A3-13 shows simulated annual exports for Alternative 3. The DWRSIM-simulated, DeltaSOS-adjusted, and final exports are shown, along with the additional DW discharges for export. The simulated final exports for several years are greater than 7.5 MAF/yr, with more than 8 MAF in 3 years. DeltaSOS does not, however, evaluate the need for these additional exports.

DELTASOS RESULTS FOR DW PROJECT ALTERNATIVES UNDER CUMULATIVE CONDITIONS

The assumptions for simulations of cumulative conditions were the same as for the simulations detailed above, except that the full SWP pumping capacity was assumed to be available in any month for Delta exports. This availability of full pumping capacity may require approval and implementation of DWR's South Delta Project and a revised Corps permit. Cumulative conditions for the No-Project Alternative and DW project alternatives were simulated by DeltaSOS with the same initial DWRSIM inputs, but allowing for greater adjustment of the original DWRSIM exports. The initial DWRSIM combined SWP and CVP Delta exports are given in Table A3-4a.

Table A3-16a presents the simulated monthly DeltaSOS adjustments of the initial DWRSIM exports (cfs) for each water year from 1922 to 1991, with the annual total adjustments in exports (TAF) shown in the right-hand column and the average monthly change in exports (cfs) given at the bottom of the table. The adjustments in the DWRSIM-simulated exports averaged 1,018 TAF/yr, with several years (13 out of 70 years) having more than a 2,000-TAF simulated increase in exports. Although these exports might be possible within the restrictions of the 1995 WQCP objectives, DeltaSOS does not evaluate the need for these additional exports.

The DeltaSOS-adjusted exports for the cumulative conditions are presented in Table A3-16b. Maximum Delta export pumping was simulated as possible under the 1995 WQCP objectives for 1983 (except for 750 cfs in August), giving a maximum potential export of greater than 10,500 TAF/yr. The 70-year average annual simulated export was 6,730 TAF/yr for cumulative conditions. Annual exports were less than 7.0 MAF/yr in about half the simulated years; export were greater than 7.0 MAF in 33 out of the 70 years, and greater than 8.0 MAF/yr in 12 out of the 70 years. Although these exports might be possible under the 1995 WQCP objectives, DeltaSOS does not evaluate the need for these additional exports.

Results for the No-Project Alternative under Cumulative Conditions

Annual Average Results for the No-Project Alternative under Cumulative Conditions

Table A3-17 (three pages) presents annual average values for Delta conditions simulated by DeltaSOS for the No-Project Alternative under cumulative conditions. Many of the simulated Delta channel flows are the same as reported above for the No-Project Alternative. Only those channel flows affected by exports are different from those simulated for the No-Project Alternative.

DeltaSOS-simulated available water for DW diversions averaged 1,995 TAF/yr for the cumulative No-Project Alternative. The simulated increase in SWP export pumping capacity reduced available water by an average of 577 TAF/yr compared with available water simulated for the No-Project Alternative.

Monthly Percentile Tables for the No-Project Alternative under Cumulative Conditions

Table A3-18 (six pages) presents frequency percentiles for monthly values from the DeltaSOS simulation of the No-Project Alternative under cumulative conditions.

The frequency percentiles for simulated monthly combined CVP and SWP exports indicates that the maximum SWP pumping capacity was used frequently in the fall and winter months, but only rarely in summer months. For example, in October the total exports for No-Project Alternative cumulative conditions (bottom panel on page 5 of Table A3-18) were simulated to be greater than 11,921 cfs for about 30% of the years, and full SWP pumping capacity (11,900 cfs combined pumping) was used in at least 10% of the years. These frequencies were greater during November-March. Other factors were limiting exports during spring and summer (i.e., April-May San Joaquin pulse-flow export restrictions, outflow requirements, inflow percentage limits on exports), so the increased simulated export pumping capacity did not change the simulated exports in most years during these months.

Monthly and Annual Graphs for the No-Project Alternative under Cumulative Conditions

Figure A3-14 shows simulated monthly Delta exports for the No-Project Alternative under cumulative conditions. The figure also shows additional export adjustments that could be made within monthly pumping limits and be consistent with the 1995 WQCP objectives (without considering downstream demands and storage capacity). The greatest amount of extra pumping is simulated by DeltaSOS in winter during periods of high Delta inflow.

The additional exports are simulated in DeltaSOS to provide a proper basis for estimating the potential water supply effects of the DW project alternatives. Only water that could not have been exported by the SWP or the CVP was assumed to be available for DW diversions. Only export pumping capacity that could not have been used by the CVP and the SWP was assumed to be available for export of DW discharges.

Results for Alternative 1 under Cumulative Conditions

Simulated Monthly DW Operations for Alternative 1 under Cumulative Conditions

Table A3-19 presents the monthly DW operations (diversions, discharges, and end-of-month storage) simulated by DeltaSOS for Alternative 1 under cumulative conditions. Table A3-19a presents the monthly simulated diversions to storage (cfs), arranged as monthly flow values for each simulated water year, from 1922 through 1991. The annual total diversions (TAF) are shown in the right-hand column, and the average monthly diversion flows (cfs) are given at the bottom of the table. The simulated diversions are slightly less than those simulated for Alternative DW 1 because the simulated water available for DW diversion is less for some months. Simulations for several years (22 out of 70 years) show diversions of less than 100 TAF.

Table A3-19b presents the monthly simulated discharges from storage (cfs), arranged as monthly flows for each simulated water year, for the Alternative 1 under cumulative conditions. The annual total discharges (TAF) are shown in the right-hand column, and the average monthly discharge flows (cfs) are given at the bottom of the table. The simulated discharges are also slightly less than those simulated for Alternative 1 and occur predominantly in July.

Table A3-19c presents the combined end-of-month storage (TAF) for the DW reservoir islands for Alternative 1 under cumulative conditions. The seasonal storage in wetlands and ponds on the habitat islands is not included in these values. The storage is increased by diversions and is reduced by evaporation and discharges from the reservoir islands. The average end-of-month storage volumes are given at the bottom of the table.

Annual Average Results for Alternative 1 under Cumulative Conditions

Table A3-20 shows that simulated diversions for Alternative 1 under cumulative conditions averaged 191 TAF/yr, and simulated discharges for export averaged 166 TAF/yr. The DW project would not have diverted water in some years because of limited water available for diversions. In a few years, however, the simulated DW discharge for export is greater than the 238-TAF reservoir capacity because of multiple diversion and discharge periods in the same year.

Monthly Percentile Tables for Alternative 1 under Cumulative Conditions

Table A3-21 summarizes the DeltaSOS simulations of DW operations. DW diversions are simulated to occur in the months with available water. DW discharges are simulated to occur primarily in July.

Monthly and Annual Graphs for Alternative 1 under Cumulative Conditions

Figure A3-15 shows simulated annual DW operations for Alternative 1 under cumulative conditions. Diversions and discharges do not correspond in years when stored water is carried over from one year to the next.

Figure A3-16 shows simulated annual Delta exports for Alternative 1 under cumulative conditions. DWRSIM-simulated, DeltaSOS-adjusted, and final exports (with DW discharges) are shown, along with the additional DW discharges for export.

Results for Alternative 2 under Cumulative Conditions

Simulated DW operations for Alternative 2 under cumulative conditions were similar to those simulated for Alternative 2, with several periods of reduced available water for diversions. Table A3-22 presents the monthly simulated diversions, discharges, and DW storage values Alternative 2 under cumulative conditions.

Table A3-23 shows that simulated diversions for Alternative 2 under cumulative conditions averaged 211 TAF/yr, and simulated discharges for export averaged 197 TAF/yr. These values are about the same as those reported for Alternative 2.

Table A3-24 shows the monthly percentiles of simulated DW operations for Alternative 2 under cumulative conditions. Diversions were simulated generally to occur early in a water year (October-February), with discharges to export during the middle part of a year (February-March) or summer (June-July). The DW reservoir islands are always simulated as being empty at the end of June or July. The DW project would have diverted less than 100 TAF of water in many years (22/70) because of limited water available for diversions.

Figure A3-17 shows simulated annual DW diversions and discharges for Alternative 2 under cumulative conditions.

Figure A3-18 shows simulated annual exports for Alternative 2 under cumulative conditions. DWRSIM-simulated, DeltaSOS-adjusted, and final exports (with DW discharges for export) are shown, along with the additional DW exports.

Results for Alternative 3 under Cumulative Conditions

Simulated DW operations for Alternative 3 under cumulative conditions were similar to those simulated for Alternative 3, with several periods of reduced available water for diversion. Table A3-25 presents the monthly simulated diversions, discharges, and DW storage values for Alternative 3 under cumulative conditions.

Table A3-26 presents the annual simulated DW operations for Alternative 3 under cumulative conditions. The annual average DW diversions were simulated at 314 TAF/yr, and the average DW discharges for export were simulated at 282 TAF/yr.

Table A3-27 shows the monthly percentiles for simulated DW operations for Alternative 3 under cumulative conditions.

Figure A3-19 shows the simulated annual DW diversions and discharges for Alternative 3 under cumulative conditions.

Figure A3-20 shows the simulated annual exports for Alternative 3 under cumulative conditions. DWRSIM-simulated, DeltaSOS-adjusted, and final exports (with DW discharges for export) are shown, along with the additional DW exports.

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_____. Department of Water Resources. 1995. SWRCB draft WQCP planning simulation model assumptions. January. Sacramento, CA.

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Table A3–1. DeltaSOS Mean Annual Input Data from the 1995 WQCP DWRSIM Results

Water Year	Sac Basin Year Type	SJR Basin Year Type	Banks & Tracy Pumping (TAF)	Sacramento Inflow (TAF)	Yolo Bypass Flow (TAF)	CCWD Pumping (TAF)	Eastside Inflow (TAF)	SJR Basin Inflow (TAF)	Delta Depletion (TAF)	Delta Outflow (TAF)	Required Outflow (TAF)
1922	2	1	6,185	15,237	202	144	1,038	3,037	889	12,296	6,103
1923	3	2	6,191	14,489	194	144	816	2,491	877	10,778	5,833
1924	5	5	4,542	8,586	69	151	201	1,259	1,268	4,155	4,063
1925	4	3	5,735	12,064	809	153	630	1,462	810	8,267	5,195
1926	4	4	5,734	11,614	344	144	390	1,511	984	6,997	5,006
1927	1	2	6,242	19,015	3,222	144	724	1,892	836	17,631	6,980
1928	2	3	6,327	18,455	991	144	577	1,706	1,007	14,252	6,665
1929	5	5	4,564	8,696	100	151	299	1,304	1,135	4,548	4,418
1930	4	5	5,009	10,768	164	153	329	1,140	1,018	6,220	5,052
1931	5	5	3,327	6,775	68	151	205	1,255	1,147	3,677	3,657
1932	4	2	4,148	8,618	157	160	586	1,655	884	5,825	5,190
1933	5	4	3,678	7,535	83	160	264	1,388	1,144	4,288	4,050
1934	5	5	3,737	8,173	146	160	304	1,201	1,098	4,829	4,532
1935	3	2	5,925	12,496	1,209	153	637	2,051	863	9,453	6,455
1936	3	2	6,154	13,335	1,413	144	1,059	2,141	799	10,852	6,248
1937	3	1	5,879	12,426	246	144	940	2,804	753	9,641	5,287
1938	1	1	6,227	28,179	8,591	144	1,662	5,428	574	36,915	8,125
1939	4	4	5,089	10,712	70	144	286	1,695	1,202	6,328	4,357
1940	2	2	6,420	17,638	4,572	144	756	1,896	647	17,651	7,246
1941	1	1	6,275	23,780	9,163	144	809	3,677	507	30,503	7,010
1942	1	1	5,949	25,353	5,099	144	1,154	2,986	754	27,744	6,671
1943	1	1	5,558	20,972	1,639	144	1,550	3,151	884	20,726	7,309
1944	4	3	5,928	11,388	191	144	394	1,642	1,046	6,496	4,952
1945	3	2	6,134	12,566	335	144	745	2,244	974	8,640	5,277
1946	3	2	6,290	16,177	1,462	144	795	2,071	1,076	12,995	6,279
1947	4	4	6,033	10,949	109	144	291	1,557	1,170	5,558	5,072
1948	3	3	6,301	13,098	41	144	364	1,418	1,092	7,384	5,487
1949	4	3	5,692	11,993	193	144	455	1,423	1,112	7,117	4,921
1950	3	3	6,151	12,811	111	144	508	1,532	1,113	7,554	5,599
1951	2	2	6,766	21,672	1,900	144	1,790	2,583	824	20,212	6,326
1952	1	1	6,927	28,323	2,379	144	1,770	3,023	664	27,761	7,985
1953	1	3	5,304	18,839	2,492	144	533	1,965	1,030	17,350	6,080
1954	2	3	6,373	19,873	746	144	368	1,572	1,158	14,884	7,021
1955	4	4	6,016	11,447	172	144	435	1,365	1,028	6,230	5,051
1956	1	1	6,824	21,768	8,268	144	1,485	3,270	691	27,133	6,221
1957	2	3	6,286	15,092	399	144	412	1,785	1,088	10,171	5,661
1958	1	1	7,047	26,266	8,873	144	1,657	3,396	437	32,566	7,267
1959	3	4	5,176	14,716	383	144	339	1,732	1,119	10,730	5,294
1960	4	5	5,856	11,339	317	144	304	1,217	1,139	6,038	5,203
1961	4	5	5,776	11,459	206	144	216	1,139	1,107	5,995	5,097
1962	3	3	5,797	12,372	711	144	460	1,484	977	8,109	5,063
1963	1	2	6,652	20,611	2,943	144	741	1,934	752	18,682	7,329
1964	4	4	5,914	12,397	148	144	315	1,358	1,177	6,983	5,143
1965	1	1	6,651	19,519	4,554	144	1,222	2,323	937	19,887	6,670
1966	3	3	6,402	13,901	319	144	399	1,962	1,096	8,940	5,602
1967	1	1	6,865	22,181	2,615	144	1,298	3,304	615	21,774	7,553
1968	3	4	4,783	15,971	709	144	432	1,660	1,092	12,753	5,557
1969	1	1	6,430	23,660	5,750	144	1,935	5,442	669	29,543	7,967
1970	1	2	5,031	21,543	8,061	144	1,196	3,283	896	28,011	5,637
1971	1	3	6,813	20,939	1,152	144	707	1,732	960	16,614	7,094
1972	3	4	6,343	13,210	192	144	357	1,515	1,231	7,556	5,409
1973	2	2	6,608	19,810	3,467	144	1,161	2,175	508	19,352	6,821
1974	1	1	6,829	29,264	7,121	144	1,255	2,238	847	32,058	6,944
1975	1	1	6,494	20,440	920	144	894	2,310	976	16,950	6,627
1976	5	5	4,999	10,456	86	151	220	1,160	1,270	5,503	4,416
1977	5	5	3,053	6,824	105	160	149	1,016	1,225	3,657	3,657
1978	2	1	4,507	16,859	2,457	153	840	2,267	560	17,204	7,933
1979	3	2	5,804	13,993	130	144	688	2,300	913	10,250	5,844
1980	2	1	5,673	18,292	5,602	144	1,325	4,818	721	23,499	6,568
1981	4	4	5,588	13,093	110	144	343	1,912	1,139	8,587	5,109
1982	1	1	7,266	29,591	6,745	144	3,093	5,387	457	36,948	7,099
1983	1	1	5,414	35,577	13,561	144	4,914	15,726	105	64,112	6,197
1984	1	2	4,576	23,213	4,153	144	2,167	6,450	1,004	30,259	5,676
1985	4	4	5,934	13,038	192	144	459	1,859	993	8,477	5,068
1986	1	1	6,268	18,958	8,880	144	2,385	4,814	546	28,078	6,155
1987	4	5	5,808	10,952	78	144	337	1,645	1,172	5,888	4,819
1988	5	5	4,446	9,416	137	144	242	1,014	1,077	5,143	4,505
1989	4	5	5,278	11,782	80	144	323	1,006	1,124	6,644	4,816
1990	5	5	4,065	8,675	100	151	215	940	1,099	4,615	4,506
1991	5	5	3,808	8,612	76	160	269	958	1,094	4,853	4,088
Average			5,712	15,998	2,118	146	835	2,401	931	14,562	5,802

Water–year types: 1=wet, 2=above normal, 3=below normal, 4=dry, 5=critically dry

Table A3–2. DeltaSOS User–Defined Input Parameters for the 1995 WQCP Simulations

USER–DEFINED INPUTS FOR DELTA OPERATIONS:	Value	Range Names
Hood Diversions to Exports? (0= No, 1= Yes)	0	HOOD
Delta Standards Outflow Point (0= Collinsville, 1= Chipps Island)	0	OUTPT
Add Carriage Water to Required Outflow? (0= No, 1= Yes)	1	CARRY
Include Channel Depletion in Inflow? (0= No, 1= Yes)	0	CDIN
Open Montezuma Gates to Meet Outflow? (0= No, 1= Yes)	0	MSSG
Cut Pumping to Meet Outflow? (0= No, 1= Yes)	1	EPA
Outflow Deficit Limits Delta Storage Export? (0= No, 1= Yes)	0	WHEEL
Delta Storage Export Limit Exemption? (0= No, 1= Yes)	0	FULL
SWP/CVP Export All Available (0= No, 1= Yes)	1	TAKE
Limit Delta Storage Export to Percent of Inflow (0= No, 1= Yes)	1	DWEX
Effective Montezuma Diversion Factor	1.00	MDF
Starting Month for Delta Outflow Restrictions (1= Oct)	1	SDO
Ending Month for Delta Outflow Restrictions (1= Oct)	12	EDO
QWEST Estimated with Threemile Included? (0= No, 1= Yes)	0	TMS
Minimum SJR for Extra SWP Pumping	1,000	MINSJR
Minimum Pumping during Cutbacks	2,000	MINPUMP
Roe Island Outflow Trigger (km)	66.3	ROE
Initial X2 Position (km)	85	INX2
Estimate X2 Outflow Requirements? (0= No, 1= Yes)	0	CALX2

MONTH	Fraction of Available Water FRACT	Minimum of Available Water MINIMUM
OCT	1.0	0
NOV	1.0	0
DEC	1.0	0
JAN	1.0	0
FEB	1.0	0
MAR	1.0	0
APR	1.0	0
MAY	1.0	0
JUN	1.0	0
JUL	1.0	0
AUG	1.0	0
SEP	1.0	0

Diversion = FRACT*(Available–MIN)

Table A3–3. DeltaSOS User–Defined Standards for the 1995 WQCP

Minimum required Sacramento River flow at Freeport (cfs)

	Wet	Above Normal	Below Normal	Dry	Critical
Oct	0	0	0	0	0
Nov	0	0	0	0	0
Dec	0	0	0	0	0
Jan	0	0	0	0	0
Feb	0	0	0	0	0
Mar	0	0	0	0	0
Apr	0	0	0	0	0
May	0	0	0	0	0
Jun	0	0	0	0	0
Jul	0	0	0	0	0
Aug	0	0	0	0	0
Sep	0	0	0	0	0

Sacramento River trigger for the Delta Cross Channel (cfs) (closed if Sac flow below Hood>value)

	Wet	Above Normal	Below Normal	Dry	Critical	
Oct	25,000	25,000	25,000	25,000	25,000	
Nov	0	0	0	0	0	Half–time
Dec	0	0	0	0	0	Half–time
Jan	0	0	0	0	0	Half–time
Feb	0	0	0	0	0	
Mar	0	0	0	0	0	
Apr	0	0	0	0	0	
May	0	0	0	0	0	
Jun	25,000	25,000	25,000	25,000	25,000	
Jul	25,000	25,000	25,000	25,000	25,000	
Aug	25,000	25,000	25,000	25,000	25,000	
Sep	25,000	25,000	25,000	25,000	25,000	

Minimum Rio Vista flow (cfs)

	Wet	Above Normal	Below Normal	Dry	Critical
Oct	4,000	4,000	4,000	4,000	3,000
Nov	4,500	4,500	4,500	4,500	3,500
Dec	4,500	4,500	4,500	4,500	3,500
Jan	0	0	0	0	0
Feb	0	0	0	0	0
Mar	0	0	0	0	0
Apr	0	0	0	0	0
May	0	0	0	0	0
Jun	0	0	0	0	0
Jul	0	0	0	0	0
Aug	0	0	0	0	0
Sep	3,000	3,000	3,000	3,000	3,000

Minimum QWEST flow (cfs)

	Wet	Above Normal	Below Normal	Dry	Critical
Oct	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Nov	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Dec	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Jan	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Feb	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Mar	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Apr	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
May	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Jun	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Jul	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Aug	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Sep	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)

Table A3–3. Continued

Minimum San Joaquin River flow at Vernalis (cfs)

	Wet	Above Normal	Below Normal	Dry	Critical	
	7,330	5,730	4,620	4,020	3,110	Pulse–flow requirements
Oct	1,500	1,500	1,500	1,500	1,000	
Nov	900	900	900	900	900	
Dec	900	900	900	900	900	
Jan	900	900	900	900	900	
Feb	2,130	2,130	1,420	1,420	900	
Mar	2,130	2,130	1,420	1,420	900	
Apr	2,130	2,130	1,420	1,542	900	
May	2,130	2,130	1,420	1,420	900	
Jun	2,130	2,130	1,420	1,420	900	
Jul	900	900	900	900	900	
Aug	900	900	900	900	900	
Sep	900	900	900	900	900	
	1,290	1,290	860	860	430	Additional flow if X2<Chipps

Maximum percentage of San Joaquin River flow available for SWP export (%)

	Wet	Above Normal	Below Normal	Dry	Critical
Oct	0	0	0	0	0
Nov	0	0	0	0	0
Dec	17	17	17	17	17
Jan	33	33	33	33	33
Feb	33	33	33	33	33
Mar	17	17	17	17	17
Apr	0	0	0	0	0
May	0	0	0	0	0
Jun	0	0	0	0	0
Jul	0	0	0	0	0
Aug	0	0	0	0	0
Sep	0	0	0	0	0

San Joaquin River trigger for Old River gates (cfs) (open if SJR flow at Vernalis>value)

	Wet	Above Normal	Below Normal	Dry	Critical
Oct	10,000	10,000	10,000	10,000	10,000
Nov	0	0	0	0	0
Dec	0	0	0	0	0
Jan	0	0	0	0	0
Feb	0	0	0	0	0
Mar	0	0	0	0	0
Apr	10,000	10,000	10,000	10,000	10,000
May	10,000	10,000	10,000	10,000	10,000
Jun	0	0	0	0	0
Jul	0	0	0	0	0
Aug	0	0	0	0	0
Sep	0	0	0	0	0

Minimum Delta outflow (cfs)

	Wet	Above Normal	Below Normal	Dry	Critical
Oct	0	0	0	0	0
Nov	0	0	0	0	0
Dec	0	0	0	0	0
Jan	0	0	0	0	0
Feb	0	0	0	0	0
Mar	0	0	0	0	0
Apr	0	0	0	0	0
May	0	0	0	0	0
Jun	0	0	0	0	0
Jul	0	0	0	0	0
Aug	0	0	0	0	0
Sep	0	0	0	0	0

Table A3–3. Continued

Maximum Delta export (cfs)

	Wet	Above Normal	Below Normal	Dry	Critical	DW Exemption	Assumed Capacity
Oct	11,280	11,280	11,280	11,280	11,280	11,280	11,280
Nov	11,280	11,280	11,280	11,280	11,280	11,280	11,280
Dec	10,880	10,880	10,880	10,880	10,880	10,880	11,700
Jan	10,880	10,880	10,880	10,880	10,880	10,880	12,700
Feb	10,880	10,880	10,880	10,880	10,880	10,880	12,700
Mar	10,880	10,880	10,880	10,880	10,880	10,880	11,700
Apr	11,280	11,280	11,280	11,280	11,280	11,280	11,280
May	11,280	11,280	11,280	11,280	11,280	11,280	11,280
Jun	11,280	11,280	11,280	11,280	11,280	11,280	11,280
Jul	11,280	11,280	11,280	11,280	11,280	11,280	11,280
Aug	11,280	11,280	11,280	11,280	11,280	11,280	11,280
Sep	11,280	11,280	11,280	11,280	11,280	11,280	11,280

Maximum percentage of inflow available for export (%)

	Wet	Above Normal	Below Normal	Dry	Critical	DW
Oct	65	65	65	65	65	65
Nov	65	65	65	65	65	65
Dec	65	65	65	65	65	65
Jan	65	65	65	65	65	65
Feb	35	35	35	35	35	35
Mar	35	35	35	35	35	35
Apr	35	35	35	35	35	35
May	35	35	35	35	35	35
Jun	35	35	35	35	35	35
Jul	65	65	65	65	65	65
Aug	65	65	65	65	65	65
Sep	65	65	65	65	65	65

Status of Suisun Marsh salinity control gates (0 = open, 1 = operating)

	Wet	Above Normal	Below Normal	Dry	Critical
Oct	1	1	1	1	1
Nov	1	1	1	1	1
Dec	1	1	1	1	1
Jan	1	1	1	1	1
Feb	1	1	1	1	1
Mar	1	1	1	1	1
Apr	0	0	0	0	0
May	0	0	0	0	0
Jun	0	0	0	0	0
Jul	0	0	0	0	0
Aug	0	0	0	0	0
Sep	0	0	0	0	0

Maximum DW storage capacity (TAF)

	Wet	Above Normal	Below Normal	Dry	Critical	2–Island Evaporation	4–Island Evaporation
Oct	238	238	238	238	238	3.3	6.5
Nov	238	238	238	238	238	1.5	3.0
Dec	238	238	238	238	238	0.8	1.6
Jan	238	238	238	238	238	0.9	1.8
Feb	238	238	238	238	238	1.7	3.4
Mar	238	238	238	238	238	3.0	6.0
Apr	238	238	238	238	238	4.5	9.0
May	238	238	238	238	238	6.1	12.2
Jun	238	238	238	238	238	7.0	14.0
Jul	238	238	238	238	238	8.0	16.0
Aug	238	238	238	238	238	7.1	14.2
Sep	238	238	238	238	238	5.2	10.4

Table A3–3. Continued

DW storage evaporation (TAF)

	Wet	Above Normal	Below Normal	Dry	Critical	Net CU Reductions	2–Island Net CU	4–Island Net CU
Oct	3.3	3.3	3.3	3.3	3.3	0.0	−0.6	2.5
Nov	1.5	1.5	1.5	1.5	1.5	0.0	−0.7	1.8
Dec	0.8	0.8	0.8	0.8	0.8	0.0	−1.3	0.9
Jan	0.9	0.9	0.9	0.9	0.9	0.0	0.9	1.1
Feb	1.7	1.7	1.7	1.7	1.7	0.0	1.3	2.3
Mar	3.0	3.0	3.0	3.0	3.0	0.0	4.5	3.4
Apr	4.5	4.5	4.5	4.5	4.5	0.0	3.0	4.4
May	6.1	6.1	6.1	6.1	6.1	0.0	3.7	6.2
Jun	7.0	7.0	7.0	7.0	7.0	0.0	4.1	7.8
Jul	8.0	8.0	8.0	8.0	8.0	0.0	4.8	9.2
Aug	7.1	7.1	7.1	7.1	7.1	0.0	3.7	7.1
Sep	5.2	5.2	5.2	5.2	5.2	0.0	1.5	4.1

Maximum DW diversion (cfs)

	Wet	Above Normal	Below Normal	Dry	Critical	Required Delta Outflow	Required QWEST Flow
Oct	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Nov	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Dec	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Jan	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Feb	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Mar	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Apr	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
May	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Jun	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Jul	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Aug	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Sep	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)

Maximum DW discharge (cfs)

	Wet	Above Normal	Below Normal	Dry	Critical	Required Delta Outflow	Required QWEST Flow
Oct	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Nov	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Dec	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Jan	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Feb	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Mar	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Apr	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
May	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Jun	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Jul	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Aug	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)
Sep	4,000	4,000	4,000	4,000	4,000	3,000	(15,000)

DW discharge to outflow (cfs)

	Wet	Above Normal	Below Normal	Dry	Critical
Oct	0	0	0	0	0
Nov	0	0	0	0	0
Dec	0	0	0	0	0
Jan	0	0	0	0	0
Feb	0	0	0	0	0
Mar	0	0	0	0	0
Apr	0	0	0	0	0
May	0	0	0	0	0
Jun	0	0	0	0	0
Jul	0	0	0	0	0
Aug	0	0	0	0	0
Sep	0	0	0	0	0

Table A3-4a. Adjustments to DWRSIM Delta Exports:
Initial DWRSIM Exports (cfs)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (TAF)
1922	6,550	6,936	11,472	12,146	12,821	10,357	8,002	8,756	11,277	3,357	4,477	6,502	5,909
1923	11,027	10,941	11,678	9,491	4,073	6,094	7,714	6,266	6,528	11,287	11,287	6,367	5,923
1924	8,063	7,488	11,006	11,574	8,040	4,123	2,792	2,970	4,364	6,480	4,894	3,592	4,442
1925	8,500	6,640	8,870	7,297	11,762	7,948	6,702	5,186	6,542	11,287	8,405	6,050	5,487
1926	9,170	6,932	7,643	11,483	11,762	6,252	6,048	5,126	5,524	11,287	7,966	5,969	5,490
1927	8,909	10,941	11,194	11,346	11,366	7,957	8,094	8,044	6,458	7,379	5,802	6,114	5,990
1928	9,387	10,941	11,363	11,774	8,317	8,570	7,372	5,834	6,312	11,287	7,563	6,299	6,064
1929	6,853	8,671	10,447	9,696	8,462	4,051	3,042	3,208	5,706	9,560	2,784	3,270	4,483
1930	7,526	5,921	9,097	11,467	6,634	11,233	3,589	3,538	5,521	10,025	3,388	5,196	4,812
1931	5,125	4,536	5,711	10,047	6,382	4,262	3,170	2,667	4,267	5,068	537	3,456	3,236
1932	6,131	5,384	11,235	11,466	7,580	3,147	5,096	4,103	2,463	3,426	3,449	5,359	3,941
1933	5,085	5,071	6,016	11,380	7,285	4,810	3,759	3,490	5,464	4,369	853	3,466	3,586
1934	4,430	3,667	8,872	11,508	6,392	6,514	3,660	2,996	5,676	4,096	670	3,538	3,640
1935	4,288	7,524	8,069	11,763	6,332	10,528	8,094	8,356	7,232	11,287	8,985	5,889	5,687
1936	7,316	6,839	7,641	11,863	12,821	11,700	7,180	6,072	6,492	11,287	6,951	5,972	5,910
1937	6,715	6,436	9,923	11,101	12,821	12,038	8,026	6,758	5,821	6,808	5,083	6,039	5,631
1938	7,040	10,941	11,351	12,351	8,442	7,195	6,762	8,128	10,257	4,910	4,730	11,243	5,666
1939	11,027	10,745	7,734	6,619	5,117	5,394	4,174	3,874	5,616	11,287	7,510	5,360	4,882
1940	8,282	6,316	7,371	11,706	12,142	11,726	8,094	6,834	6,312	11,287	10,233	6,245	6,160
1941	8,071	7,372	11,453	12,450	12,821	10,470	8,042	7,802	8,448	3,051	4,473	9,692	5,808
1942	11,027	10,941	7,714	7,318	7,774	7,168	8,549	8,756	11,263	3,090	4,477	10,665	5,424
1943	11,027	10,941	8,451	7,457	8,023	7,200	8,549	6,755	6,041	6,754	5,054	5,998	5,314
1944	9,711	10,399	7,368	11,423	12,388	8,365	4,020	3,974	6,624	11,287	6,764	6,074	5,680
1945	8,969	10,941	11,420	11,287	10,924	8,523	5,882	5,056	7,468	9,096	5,883	6,359	5,868
1946	10,559	10,941	11,521	11,968	7,309	9,016	5,884	5,356	7,026	11,287	7,099	6,440	6,020
1947	8,225	8,384	11,304	10,935	10,454	8,216	4,338	3,896	5,432	11,287	11,287	6,380	5,766
1948	9,681	7,999	7,768	10,908	6,428	6,020	6,442	7,708	8,266	11,287	11,287	10,786	5,768
1949	11,027	9,195	8,590	8,687	7,038	11,538	4,946	4,852	6,202	10,058	5,789	6,545	5,415
1950	9,168	7,076	6,630	11,566	11,762	8,645	5,928	5,394	7,002	11,287	11,287	6,346	5,886
1951	11,027	10,941	11,853	12,729	10,612	8,652	6,244	6,974	6,294	11,287	9,071	6,609	6,485
1952	9,088	10,941	11,304	12,729	12,449	7,510	7,257	8,302	9,852	8,454	5,837	11,243	6,367
1953	9,948	7,887	7,688	4,818	4,822	6,543	5,948	7,490	10,551	7,678	5,864	8,801	4,892
1954	11,027	10,941	10,684	8,617	8,140	8,387	7,372	6,762	6,250	11,287	9,586	6,720	6,086
1955	7,849	10,941	11,253	11,636	9,443	4,524	3,534	3,938	6,550	11,287	11,287	7,614	5,675
1956	7,994	7,771	11,301	12,729	12,672	8,442	7,588	8,756	10,011	8,475	6,274	11,243	6,264
1957	11,027	10,778	7,452	11,375	8,292	7,670	5,786	5,596	6,742	11,287	11,287	7,038	5,980
1958	11,027	10,941	11,372	11,810	11,057	8,055	8,859	8,756	10,769	5,892	7,175	11,243	6,487
1959	11,027	7,978	7,793	7,159	5,733	6,424	3,764	3,928	5,924	11,287	7,941	6,958	4,875
1960	8,999	6,801	11,154	9,364	11,792	7,956	3,798	3,398	5,618	11,287	10,483	6,543	5,580
1961	8,732	8,172	10,870	9,056	11,685	7,300	3,570	3,408	5,568	11,287	9,614	6,601	5,496
1962	8,462	6,874	10,368	7,553	12,255	10,191	4,190	4,916	5,922	11,287	7,334	6,858	5,502
1963	11,027	10,941	11,266	11,463	9,220	8,674	8,098	8,356	7,036	10,061	6,061	8,196	6,276
1964	11,027	10,941	10,271	11,259	6,438	5,072	3,624	3,930	5,614	11,287	11,287	7,408	5,586
1965	7,200	10,360	11,308	12,729	11,966	8,487	8,550	8,674	6,322	11,287	6,992	6,517	6,377
1966	11,027	10,941	11,556	12,073	8,468	7,804	5,072	4,860	5,914	11,287	10,628	6,633	6,121
1967	8,718	10,672	11,526	11,916	10,784	6,352	7,644	8,128	10,257	10,775	5,927	11,243	6,306
1968	9,342	7,641	6,876	4,239	4,835	6,480	4,666	3,870	5,924	11,287	7,538	6,684	4,499
1969	9,074	8,547	11,249	12,373	11,632	6,647	6,727	7,690	9,600	6,578	5,360	11,243	5,871
1970	11,027	7,887	7,427	4,700	4,822	6,543	5,990	4,706	6,268	11,287	6,324	6,526	4,757
1971	9,054	10,941	11,411	11,618	9,028	10,190	6,116	7,704	9,028	11,287	6,640	10,061	6,326
1972	11,027	10,941	11,264	10,891	8,473	8,443	4,578	3,924	5,870	11,287	11,287	7,294	6,022
1973	10,113	10,941	11,250	11,573	12,382	7,836	6,772	6,930	7,786	11,110	6,124	6,866	6,314
1974	10,863	10,941	11,352	11,037	8,319	8,492	8,550	8,701	8,864	8,065	6,913	11,243	6,270
1975	11,027	10,941	9,893	7,640	6,018	7,644	8,266	8,756	10,439	9,670	6,241	11,243	5,935
1976	11,027	10,941	10,586	8,462	8,468	6,038	3,070	3,268	5,896	7,623	3,547	4,042	4,874
1977	5,434	6,433	11,057	4,844	6,067	4,197	2,825	2,394	1,076	1,817	941	3,580	2,956
1978	4,415	3,326	10,812	10,363	5,453	5,280	6,313	6,696	6,613	2,839	4,473	8,219	4,131
1979	11,027	10,941	6,331	10,707	7,836	8,114	6,604	6,512	8,100	8,864	5,187	6,117	5,555
1980	7,828	10,941	11,332	12,621	8,081	6,096	6,262	6,772	5,681	3,232	4,873	10,445	5,163
1981	11,027	10,941	9,165	7,318	7,774	7,239	5,026	3,874	5,534	11,287	7,551	6,005	5,345
1982	8,382	10,941	11,217	12,015	11,725	8,742	8,607	9,742	11,277	8,589	8,123	11,243	6,708
1983	11,027	8,298	7,936	6,107	4,628	4,948	6,594	6,273	7,679	7,796	10,177	8,388	5,028
1984	7,062	5,299	5,242	3,218	4,144	6,341	6,270	5,104	6,664	10,505	5,856	10,243	4,078
1985	11,027	10,941	11,708	7,800	8,028	7,408	3,696	4,418	5,480	11,287	10,258	6,439	5,666
1986	8,726	7,912	11,320	11,410	12,821	10,247	8,347	7,354	6,322	6,447	5,051	8,075	5,901
1987	11,027	8,936	7,785	9,199	9,758	10,838	3,800	3,456	5,534	11,287	8,755	6,020	5,565
1988	6,587	6,114	11,175	11,273	6,370	4,724	2,964	3,114	5,768	7,321	4,885	3,498	4,355
1989	4,627	5,403	6,928	8,317	6,836	11,402	5,466	4,050	5,500	11,287	11,287	6,501	5,006
1990	5,470	3,927	7,841	11,255	6,076	4,468	3,620	2,804	5,804	7,330	5,021	3,857	3,953
1991	4,665	3,854	5,073	6,171	6,384	11,142	3,790	2,873	5,453	5,022	4,228	4,544	3,654
Average	8,785	8,654	9,631	10,061	8,789	7,666	5,854	5,699	6,842	8,898	6,832	7,101	5,402

Table A3–4b. Adjustments to DWRSIM Delta Exports:
DeltaSOS Adjustments (cfs)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (TAF)
1922	1	0	(55)	(45)	(121)	1,343	919	1,194	3	2	0	1	195
1923	253	339	(51)	3,209	0	1	714	535	(2)	(7)	(7)	1	300
1924	0	(2)	(1)	(40)	0	2	(1)	0	(3)	(1)	(1)	0	(3)
1925	0	0	0	(2)	(129)	0	678	464	1	(7)	0	1	61
1926	0	(2)	1	(39)	(129)	(0)	562	2	0	(7)	0	0	23
1927	0	339	(60)	(37)	731	3,504	1,056	479	(1)	0	0	1	362
1928	0	339	(56)	(42)	3,003	2,698	808	1	1	(7)	0	0	406
1929	1	(1)	0	(1)	(0)	(1)	0	(1)	(1)	0	0	1	(0)
1930	(1)	(1)	1	(39)	1	(104)	0	0	(1)	1	2	(1)	(9)
1931	0	0	0	(1)	(1)	1	(1)	1	(1)	(1)	0	0	(0)
1932	1	1	(59)	(39)	2,166	0	1	0	0	1	(1)	0	125
1933	1	(1)	(1)	0	(0)	0	0	0	0	0	1	2	0
1934	1	(1)	1	(39)	1	1	0	0	0	0	1	(1)	(2)
1935	0	(1)	0	(42)	(1)	1	1,056	0	(1)	(7)	(1)	1	61
1936	1	(1)	1	(43)	(121)	(239)	677	541	(1)	(7)	(1)	(1)	49
1937	1	(1)	(1)	(0)	(121)	(338)	920	(268)	(1)	1	0	0	12
1938	0	339	(57)	(47)	4,258	4,505	3,188	3,152	1,023	0	0	37	988
1939	253	535	3,666	4,417	2,637	(1)	1	(1)	(1)	(7)	(1)	2	693
1940	0	(2)	1	(41)	(133)	(265)	1,056	1	1	(7)	0	0	37
1941	0	0	(56)	(49)	(121)	1,230	3,238	2,148	0	2	1	1	385
1942	253	339	3,864	5,130	4,926	4,155	1,401	1,194	(1)	1	0	1	1,281
1943	253	339	2,928	5,057	4,677	4,500	1,401	(1)	1	0	1	1	1,154
1944	(1)	0	0	(1)	(136)	1,097	0	(1)	(1)	(7)	0	1	57
1945	1	(1)	(56)	(1)	1,776	2,938	583	629	(1)	1	(1)	0	354
1946	0	339	(53)	(44)	0	0	584	(1)	(0)	(7)	(1)	1	49
1947	1	(1)	(1)	0	0	1	0	0	0	(7)	(7)	0	(1)
1948	0	0	(1)	2	0	1	380	672	(0)	(7)	(7)	0	63
1949	0	(1)	0	(1)	0	(269)	553	0	0	(1)	0	0	17
1950	1	(2)	(1)	(40)	(129)	(1)	624	1	(1)	(7)	(7)	0	26
1951	2	339	(153)	(29)	1,970	2,809	609	513	0	(7)	1	1	365
1952	1	339	(58)	(29)	13	3,989	2,693	1,648	1,428	(1)	0	37	606
1953	1,332	3,393	3,705	7,448	5,786	2,157	625	392	(0)	(1)	0	0	1,496
1954	253	339	0	2,843	3,493	2,881	1,008	0	0	(7)	1	0	651
1955	2	339	(59)	(41)	0	1	406	372	(0)	(7)	(7)	1	61
1956	(2)	0	(58)	(29)	28	3,019	888	1,194	(1)	0	(1)	37	306
1957	253	(1)	(1)	0	3,604	3,598	0	451	0	(7)	(7)	1	475
1958	253	339	(57)	(42)	1,449	3,645	2,421	1,194	511	(1)	(1)	37	587
1959	253	3,302	663	4,672	6,499	1	0	(1)	(1)	(7)	(1)	1	927
1960	1	(1)	(61)	(1)	(129)	(0)	1	0	(0)	(7)	(1)	0	(12)
1961	1	(1)	(2)	(1)	(128)	(0)	1	0	0	(7)	1	0	(8)
1962	1	0	0	1	(134)	(0)	(1)	0	0	(7)	1	1	(8)
1963	253	339	(59)	(39)	2,789	2,789	1,052	794	(0)	0	(1)	1	477
1964	253	339	(1)	303	0	1	0	(2)	(1)	(7)	(7)	1	53
1965	1	(1)	(58)	(29)	43	(1)	1,400	(1)	(1)	(7)	1	1	81
1966	253	339	(53)	89	2,669	2,724	551	(1)	(0)	(7)	0	0	396
1967	1	(2)	(54)	(43)	1,908	5,109	2,306	1,822	1,023	505	0	37	760
1968	1,938	3,639	4,422	7,460	6,991	4,788	0	(1)	(1)	(7)	(1)	1	1,761
1969	0	(2)	(59)	(48)	1,068	5,053	3,223	3,590	1,680	(1)	(1)	37	876
1970	253	3,393	4,156	8,000	7,878	4,918	1	380	(1)	(7)	0	0	1,746
1971	1	339	(56)	(40)	0	1,078	534	676	(1)	(7)	(1)	1	152
1972	253	175	(59)	677	1,499	2,825	2	0	(1)	(7)	(7)	0	323
1973	2	339	(59)	(40)	(117)	3,864	648	513	1	0	(1)	1	310
1974	0	339	(57)	962	3,690	2,970	1,400	736	0	0	(1)	37	607
1975	253	339	1,372	3,756	6,593	3,817	937	1,194	0	(1)	(1)	37	1,102
1976	253	339	0	15	716	(0)	2	(1)	0	0	0	0	80
1977	0	(1)	1	0	0	1	0	1	0	1	0	0	0
1978	(1)	0	1	1,467	6,967	6,209	3,637	1,831	0	0	0	0	1,212
1979	253	339	(1)	1,142	4,864	3,532	636	527	(1)	1	(1)	1	680
1980	1	339	(57)	79	4,619	5,604	1,802	(256)	1	1	0	0	731
1981	253	189	2,234	4,511	3,484	4,101	1	(1)	(1)	(7)	(1)	1	890
1982	0	339	(60)	(44)	975	2,958	2,673	1,538	3	(1)	0	37	507
1983	253	2,982	3,764	6,593	8,072	6,752	4,686	5,007	3,601	3,484	1,103	2,892	2,964
1984	4,218	5,981	6,458	9,482	8,556	5,359	611	1,380	(1)	0	1	0	2,533
1985	253	339	(50)	3,997	210	(1)	322	(1)	(1)	(7)	1	0	305
1986	1	(1)	(58)	(38)	(121)	1,453	2,933	(544)	(1)	(1)	0	0	218
1987	223	(2)	(1)	0	0	383	0	(1)	(1)	(7)	0	0	36
1988	1	(1)	(61)	(37)	0	(1)	1	0	(2)	(1)	1	(1)	(6)
1989	2	0	1	0	(0)	(272)	586	(1)	(0)	(7)	(7)	(1)	18
1990	0	0	1	(36)	(1)	1	1	0	(1)	1	(1)	1	(2)
1991	1	1	(1)	(1)	0	(63)	(1)	0	(1)	0	0	(1)	(4)
Average	179	453	507	1,144	1,698	1,754	843	510	132	54	15	46	442

Table A3–4c. Adjustments to DWRSIM Delta Exports:
DeltaSOS Adjusted Exports (cfs)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (TAF)
1922	6,551	6,936	11,417	12,101	12,700	11,700	8,921	9,950	11,280	3,359	4,477	6,503	6,380
1923	11,280	11,280	11,627	12,700	4,073	6,095	8,428	6,801	6,526	11,280	11,280	6,368	6,491
1924	8,063	7,486	11,005	11,534	8,040	4,125	2,791	2,970	4,361	6,479	4,893	3,592	4,539
1925	8,500	6,640	8,870	7,295	11,633	7,948	7,380	5,650	6,543	11,280	8,405	6,051	5,796
1926	9,170	6,930	7,644	11,444	11,633	6,252	6,610	5,128	5,524	11,280	7,966	5,969	5,757
1927	8,909	11,280	11,134	11,309	12,097	11,461	9,150	8,523	6,457	7,379	5,802	6,115	6,604
1928	9,387	11,280	11,307	11,732	11,320	11,268	8,180	5,835	6,313	11,280	7,563	6,299	6,734
1929	6,854	8,670	10,447	9,695	8,462	4,050	3,042	3,207	5,705	9,560	2,784	3,271	4,564
1930	7,525	5,920	9,098	11,428	6,635	11,129	3,589	3,538	5,520	10,026	3,390	5,195	5,000
1931	5,125	4,536	5,711	10,046	6,381	4,263	3,169	2,668	4,266	5,067	537	3,456	3,327
1932	6,132	5,385	11,176	11,427	9,746	3,147	5,097	4,103	2,463	3,427	3,448	5,359	4,272
1933	5,086	5,070	6,015	11,380	7,285	4,810	3,759	3,490	5,464	4,369	854	3,468	3,678
1934	4,431	3,666	8,873	11,469	6,393	6,515	3,660	2,996	5,676	4,096	671	3,537	3,734
1935	4,288	7,523	8,069	11,721	6,331	10,529	9,150	8,356	7,231	11,280	8,984	5,890	5,986
1936	7,317	6,838	7,642	11,820	12,700	11,461	7,857	6,613	6,491	11,280	6,950	5,971	6,202
1937	6,716	6,435	9,922	11,101	12,700	11,700	8,946	6,490	5,820	6,809	5,083	6,039	5,890
1938	7,040	11,280	11,294	12,304	12,700	11,700	9,950	11,280	11,280	4,910	4,730	11,280	7,215
1939	11,280	11,280	11,400	11,036	7,754	5,393	4,175	3,873	5,615	11,280	7,509	5,362	5,781
1940	8,282	6,314	7,372	11,665	12,009	11,461	9,150	6,835	6,313	11,280	10,233	6,245	6,456
1941	8,071	7,372	11,397	12,401	12,700	11,700	11,280	9,950	8,448	3,053	4,474	9,693	6,660
1942	11,280	11,280	11,578	12,448	12,700	11,323	9,950	9,950	11,262	3,091	4,477	10,666	7,230
1943	11,280	11,280	11,379	12,514	12,700	11,700	9,950	6,754	6,042	6,754	5,055	5,999	6,712
1944	9,710	10,399	7,368	11,422	12,252	9,462	4,020	3,973	6,623	11,280	6,764	6,075	5,986
1945	8,970	10,940	11,364	11,286	12,700	11,461	6,465	5,685	7,467	9,097	5,882	6,359	6,487
1946	10,559	11,280	11,468	11,924	7,309	9,016	6,468	5,355	7,026	11,280	7,098	6,441	6,340
1947	8,226	8,383	11,303	10,935	10,454	8,217	4,338	3,896	5,432	11,280	11,280	6,380	6,032
1948	9,681	7,999	7,767	10,910	6,428	6,021	6,822	8,380	8,266	11,280	11,280	10,786	6,364
1949	11,027	9,194	8,590	8,686	7,038	11,269	5,499	4,852	6,202	10,057	5,789	6,545	5,709
1950	9,169	7,074	6,629	11,526	11,633	8,644	6,552	5,395	7,001	11,280	11,280	6,346	6,177
1951	11,029	11,280	11,700	12,700	12,582	11,461	6,853	7,487	6,294	11,280	9,072	6,610	7,131
1952	9,089	11,280	11,246	12,700	12,462	11,499	9,950	9,950	11,280	8,453	5,837	11,280	7,533
1953	11,280	11,280	11,393	12,266	10,608	8,700	6,573	7,882	10,551	7,677	5,864	8,801	6,801
1954	11,280	11,280	10,684	11,460	11,633	11,268	8,380	6,762	6,250	11,280	9,587	6,720	7,024
1955	7,851	11,280	11,194	11,595	9,443	4,525	3,940	4,310	6,550	11,280	11,280	7,615	6,077
1956	7,992	7,771	11,243	12,700	12,700	11,461	8,476	9,950	10,010	8,475	6,273	11,280	7,129
1957	11,280	10,777	7,451	11,375	11,896	11,268	5,786	6,047	6,742	11,280	11,280	7,039	6,761
1958	11,280	11,280	11,315	11,768	12,506	11,700	11,280	9,950	11,280	5,891	7,174	11,280	7,634
1959	11,280	11,280	8,456	11,831	12,232	6,425	3,764	3,927	5,923	11,280	7,940	6,959	6,103
1960	9,000	6,800	11,093	9,363	11,663	7,956	3,799	3,398	5,618	11,280	10,482	6,543	5,844
1961	8,733	8,171	10,868	9,055	11,557	7,300	3,571	3,408	5,568	11,280	9,615	6,601	5,768
1962	8,463	6,874	10,368	7,554	12,121	10,191	4,189	4,916	5,922	11,280	7,335	6,859	5,788
1963	11,280	11,280	11,207	11,424	12,009	11,463	9,150	9,150	7,036	10,061	6,060	8,197	7,129
1964	11,280	11,280	10,270	11,562	6,438	5,073	3,624	3,928	5,613	11,280	11,280	7,409	5,967
1965	7,201	10,359	11,250	12,700	12,009	8,486	9,950	8,673	6,321	11,280	6,993	6,518	6,732
1966	11,280	11,280	11,503	12,162	11,137	10,528	5,623	4,859	5,914	11,280	10,628	6,633	6,798
1967	8,719	10,670	11,472	11,873	12,692	11,461	9,950	9,950	11,280	11,280	5,927	11,280	7,625
1968	11,280	11,280	11,298	11,699	11,826	11,268	4,666	3,869	5,923	11,280	7,537	6,685	6,544
1969	9,074	8,545	11,190	12,325	12,700	11,700	9,950	11,280	11,280	6,577	5,359	11,280	7,306
1970	11,280	11,280	11,583	12,700	12,700	11,461	5,991	5,086	6,267	11,280	6,324	6,526	6,777
1971	9,055	11,280	11,355	11,578	9,028	11,268	6,650	8,380	9,027	11,280	6,639	10,062	6,965
1972	11,280	11,116	11,205	11,568	9,972	11,268	4,580	3,924	5,869	11,280	11,280	7,294	6,666
1973	10,115	11,280	11,191	11,533	12,265	11,700	7,420	7,443	7,787	11,110	6,123	6,867	6,919
1974	10,863	11,280	11,295	11,999	12,009	11,462	9,950	9,437	8,864	8,065	6,912	11,280	7,436
1975	11,280	11,280	11,265	11,396	12,611	11,461	9,203	9,950	10,439	9,669	6,240	11,280	7,596
1976	11,280	11,280	10,586	8,477	9,184	6,038	3,072	3,267	5,896	7,623	3,547	4,042	5,079
1977	5,434	6,432	11,058	4,844	6,067	4,198	2,825	2,395	1,076	1,818	941	3,580	3,053
1978	4,414	3,326	10,813	11,830	12,420	11,489	9,950	8,527	6,613	2,839	4,473	8,219	5,719
1979	11,280	11,280	6,330	11,849	12,700	11,646	7,240	7,039	8,099	8,865	5,186	6,118	6,485
1980	7,829	11,280	11,275	12,700	12,700	11,700	8,064	6,516	5,682	3,233	4,873	10,445	6,404
1981	11,280	11,130	11,399	11,829	11,258	11,340	5,027	3,873	5,534	11,280	7,550	6,006	6,477
1982	8,382	11,280	11,157	11,971	12,700	11,700	11,280	11,280	11,280	8,588	8,123	11,280	7,773
1983	11,280	11,280	11,700	12,700	12,700	11,700	11,280	11,280	11,280	11,280	11,280	11,280	8,377
1984	11,280	11,280	11,700	12,700	12,700	11,700	6,881	6,484	6,663	10,505	5,857	10,243	7,109
1985	11,280	11,280	11,658	11,797	8,238	7,407	4,018	4,417	5,479	11,280	10,259	6,439	6,239
1986	8,727	7,911	11,262	11,372	12,700	11,700	11,280	6,810	6,321	6,446	5,051	8,075	6,486
1987	11,250	8,934	7,784	9,199	9,758	11,221	3,800	3,455	5,534	11,280	8,755	6,020	5,844
1988	6,588	6,113	11,114	11,236	6,370	4,723	2,965	3,114	5,766	7,320	4,886	3,497	4,440
1989	4,629	5,403	6,929	8,317	6,836	11,130	6,052	4,049	5,500	11,280	11,280	6,500	5,296
1990	5,470	3,927	7,842	11,219	6,075	4,469	3,621	2,804	5,803	7,331	5,020	3,858	4,063
1991	4,666	3,855	5,072	6,170	6,384	11,079	3,789	2,873	5,452	5,022	4,228	4,543	3,804
Average	8,965	9,107	10,138	11,205	10,487	9,420	6,697	6,209	6,974	8,952	6,847	7,147	6,154

Table A3–5. DeltaSOS Mean Annual Simulation Output for the No–Project Alternative

Water Year	Sac Basin Year Type	SJR Basin Year Type	Added Sac Flow (TAF)	New Sac Flow (TAF)	Required SJR Flow (TAF)	Added SJR Flow (TAF)	New SJR Flow (TAF)	Steam & Sutter Flow (TAF)	DCC Rio Vista Reduction (TAF)	Revised DCC Flow (TAF)	Revised Georgiana & DCC (TAF)	Revised Rio Vista Flow (TAF)	QWEST w/ Initial Export (TAF)
1922	2	1	0	15,237	1,682	0	3,037	4,804	0	949	3,631	11,586	799
1923	3	2	0	14,489	1,663	73	2,564	4,395	0	1,567	4,039	10,425	440
1924	5	5	0	8,586	820	4	1,264	2,261	32	1,115	2,902	5,437	(1,155)
1925	4	3	0	12,064	1,213	29	1,491	3,509	0	1,438	3,630	9,040	(692)
1926	4	4	0	11,614	1,159	0	1,511	3,338	0	1,419	3,554	8,157	(1,062)
1927	1	2	0	19,015	1,663	71	1,963	6,229	0	1,355	4,501	17,527	187
1928	2	3	0	18,455	1,295	30	1,736	6,051	0	1,477	4,542	14,653	(300)
1929	5	5	0	8,696	820	2	1,306	2,314	42	1,147	2,939	5,573	(911)
1930	4	5	0	10,768	816	28	1,168	3,052	0	1,269	3,310	7,368	(1,046)
1931	5	5	0	6,775	790	2	1,257	1,651	91	875	2,453	4,103	(312)
1932	4	2	0	8,618	1,244	0	1,655	2,274	0	1,142	2,924	5,630	283
1933	5	4	0	7,535	1,004	0	1,388	1,931	97	908	2,579	4,753	(350)
1934	5	5	0	8,173	820	4	1,205	2,172	66	916	2,658	5,386	(447)
1935	3	2	0	12,496	1,555	54	2,105	3,700	29	1,301	3,554	9,935	(397)
1936	3	2	0	13,335	1,663	80	2,221	3,996	0	1,365	3,727	10,821	111
1937	3	1	0	12,426	1,682	56	2,860	3,671	0	1,290	3,547	8,936	780
1938	1	1	0	28,179	1,759	0	5,428	9,982	0	1,057	5,533	31,093	5,880
1939	4	4	0	10,712	1,004	0	1,695	3,007	0	1,498	3,498	6,983	(535)
1940	2	2	0	17,638	1,663	78	1,973	5,687	0	1,469	4,408	17,640	75
1941	1	1	0	23,780	1,759	0	3,677	8,157	0	1,370	5,188	27,629	2,926
1942	1	1	0	25,353	1,759	0	2,986	8,822	0	1,151	5,211	25,051	2,769
1943	1	1	0	20,972	1,759	78	3,229	6,984	0	1,426	4,820	17,571	3,244
1944	4	3	0	11,388	1,140	45	1,688	3,253	0	1,423	3,528	7,790	(1,189)
1945	3	2	0	12,566	1,507	77	2,321	3,714	0	1,386	3,653	9,005	(269)
1946	3	2	0	16,177	1,507	0	2,071	5,102	0	1,435	4,178	13,192	(90)
1947	4	4	0	10,949	1,056	50	1,607	3,089	0	1,438	3,480	7,285	(1,609)
1948	3	3	0	13,098	1,140	3	1,421	3,868	0	1,630	3,917	8,948	(1,455)
1949	4	3	0	11,993	1,140	49	1,472	3,503	0	1,421	3,616	8,292	(1,064)
1950	3	3	0	12,811	1,192	0	1,532	3,774	0	1,525	3,793	8,851	(1,185)
1951	2	2	0	21,672	1,663	80	2,663	7,244	0	1,526	5,004	18,363	1,932
1952	1	1	0	28,323	1,759	0	3,023	9,970	0	1,183	5,647	24,889	2,938
1953	1	3	0	18,839	1,295	0	1,965	6,162	0	1,240	4,362	16,711	742
1954	2	3	0	19,873	1,295	29	1,601	6,490	0	1,575	4,778	15,551	(551)
1955	4	4	0	11,447	1,056	9	1,374	3,263	0	1,488	3,587	7,775	(1,441)
1956	1	1	0	21,768	1,759	0	3,270	7,335	0	1,499	5,011	24,852	2,350
1957	2	3	0	15,092	1,244	27	1,812	4,642	0	1,623	4,175	11,044	(765)
1958	1	1	0	26,266	1,759	1	3,397	9,182	0	1,243	5,417	29,612	2,997
1959	3	4	0	14,716	1,159	69	1,800	4,523	0	1,536	4,064	10,754	88
1960	4	5	0	11,339	872	30	1,247	3,228	0	1,455	3,546	7,825	(1,673)
1961	4	5	0	11,459	842	40	1,179	3,280	0	1,434	3,545	7,844	(1,739)
1962	3	3	0	12,372	1,110	45	1,530	3,632	0	1,418	3,656	9,182	(975)
1963	1	2	0	20,611	1,585	0	1,934	6,877	0	1,184	4,566	18,800	(43)
1964	4	4	0	12,397	1,056	36	1,394	3,615	0	1,540	3,756	8,495	(1,394)
1965	1	1	0	19,519	1,759	80	2,404	6,453	0	1,378	4,592	19,247	734
1966	3	3	0	13,901	1,244	49	2,011	4,172	0	1,502	3,913	10,033	(984)
1967	1	1	0	22,181	1,759	0	3,304	7,439	0	1,144	4,729	19,913	1,922
1968	3	4	0	15,971	1,211	49	1,709	5,020	0	1,525	4,226	12,181	681
1969	1	1	0	23,660	1,759	0	5,442	8,066	0	1,543	5,297	23,945	5,665
1970	1	2	0	21,543	1,585	74	3,357	7,316	0	1,506	5,006	24,373	3,727
1971	1	3	0	20,939	1,295	0	1,732	6,908	0	1,583	4,932	16,920	(210)
1972	3	4	0	13,210	1,107	0	1,515	3,920	0	1,524	3,842	9,253	(1,574)
1973	2	2	0	19,810	1,663	78	2,252	6,529	0	1,487	4,717	18,433	970
1974	1	1	0	29,264	1,759	2	2,240	10,392	0	1,580	6,144	30,030	2,113
1975	1	1	0	20,440	1,682	0	2,310	6,784	0	1,674	4,962	16,153	894
1976	5	5	0	10,456	820	9	1,169	2,943	4	1,324	3,307	6,917	(1,287)
1977	5	5	0	6,824	790	0	1,016	1,703	36	821	2,391	4,233	(453)
1978	2	1	0	16,859	1,729	0	2,267	5,405	31	1,187	4,063	15,113	2,146
1979	3	2	0	13,993	1,663	78	2,378	4,235	0	1,449	3,884	10,011	330
1980	2	1	0	18,292	1,759	0	4,818	6,032	0	1,267	4,358	19,356	4,215
1981	4	4	0	13,093	1,211	49	1,962	3,885	0	1,436	3,756	9,162	(461)
1982	1	1	0	29,591	1,759	3	5,389	10,473	0	1,562	6,157	30,065	6,928
1983	1	1	0	35,577	1,759	0	15,726	12,980	0	1,050	6,551	42,561	21,566
1984	1	2	0	23,213	1,585	74	6,524	7,985	0	1,190	4,958	22,157	8,203
1985	4	4	0	13,038	1,107	50	1,909	3,861	0	1,485	3,790	9,191	(615)
1986	1	1	0	18,958	1,682	0	4,814	6,463	0	1,300	4,534	23,167	4,966
1987	4	5	0	10,952	846	16	1,661	3,102	0	1,383	3,437	7,300	(1,295)
1988	5	5	0	9,416	790	6	1,020	2,563	38	1,161	3,048	6,236	(986)
1989	4	5	0	11,782	842	31	1,036	3,442	31	1,324	3,490	8,090	(1,334)
1990	5	5	0	8,675	790	4	944	2,288	52	1,143	2,939	5,561	(837)
1991	5	5	0	8,612	816	37	995	2,286	29	1,072	2,863	5,552	(589)
Average			0	15,998	1,336	27	2,428	5,091	8	1,347	4,090	13,793	862

Notes: Definitions of the categories are provided in Table A2–3 in Appendix A2.
Water–year types: 1=wet, 2=above normal, 3=below normal, 4=dry, 5=critically dry
Negative values shown in parentheses.

Table A3–5. Continued

Water Year	Reduced Export for QWEST (TAF)	Initial Collinsville Outflow (TAF)	Initial Chipps Outflow (TAF)	Required Delta Outflow (TAF)	Revised Montez. Flow (TAF)	Reduced Export for Outflow (TAF)	Export Limits (TAF)	Reduced Export for Limits (TAF)	Net Export Change (TAF)	Adjusted Total Export (TAF)	Revised QWEST Flow (TAF)	Revised Collinsville Outflow (TAF)
1922	0	12,296	11,366	6,103	930	0	8,364	13	195	6,380	604	12,101
1923	0	10,778	9,892	5,833	886	0	9,521	4	300	6,491	140	10,478
1924	0	4,155	3,351	4,063	804	1	5,401	2	(3)	4,539	(1,152)	4,158
1925	0	8,267	7,406	5,195	861	0	7,312	8	61	5,796	(753)	8,206
1926	0	6,997	6,151	5,006	847	0	6,939	11	23	5,757	(1,085)	6,974
1927	0	17,631	16,661	6,980	969	0	10,720	6	362	6,604	(175)	17,268
1928	0	14,252	13,331	6,665	921	0	10,032	6	406	6,734	(706)	13,846
1929	0	4,548	3,735	4,418	812	0	5,435	0	(0)	4,564	(911)	4,548
1930	0	6,220	5,389	5,052	831	0	6,182	9	(9)	5,000	(1,037)	6,229
1931	0	3,677	2,877	3,657	800	0	4,306	0	(0)	3,327	(312)	3,677
1932	0	5,825	4,994	5,190	830	0	5,625	6	125	4,272	158	5,700
1933	0	4,288	3,478	4,050	810	0	4,694	0	0	3,678	(351)	4,288
1934	0	4,829	4,014	4,532	815	0	4,803	2	(2)	3,734	(445)	4,831
1935	0	9,453	8,560	6,455	893	0	7,432	3	61	5,986	(457)	9,392
1936	0	10,852	9,969	6,248	883	0	8,419	25	49	6,202	62	10,803
1937	0	9,641	8,767	5,287	874	0	7,752	44	12	5,890	768	9,629
1938	0	36,915	35,711	8,125	1,204	0	18,482	6	988	7,215	4,892	35,927
1939	0	6,328	5,496	4,357	832	0	6,865	1	693	5,781	(1,228)	5,635
1940	0	17,651	16,673	7,246	979	0	10,409	27	37	6,456	39	17,614
1941	0	30,504	29,379	7,010	1,125	0	16,412	14	385	6,660	2,540	30,118
1942	0	27,745	26,663	6,671	1,081	0	16,125	0	1,281	7,230	1,487	26,463
1943	0	20,726	19,743	7,309	983	0	13,363	0	1,154	6,712	2,090	19,572
1944	0	6,496	5,662	4,952	834	0	6,788	9	57	5,986	(1,246)	6,439
1945	0	8,639	7,782	5,277	858	0	7,966	3	354	6,487	(622)	8,286
1946	0	12,995	12,095	6,279	899	0	11,206	6	49	6,340	(139)	12,946
1947	0	5,558	4,732	5,072	827	0	6,751	1	(1)	6,032	(1,609)	5,559
1948	0	7,384	6,519	5,487	865	0	7,141	1	63	6,364	(1,517)	7,322
1949	0	7,117	6,275	4,921	843	0	6,947	16	17	5,709	(1,081)	7,100
1950	0	7,554	6,701	5,599	853	0	7,295	11	26	6,177	(1,212)	7,528
1951	0	20,212	19,240	6,326	972	0	14,970	11	365	7,131	1,567	19,847
1952	0	27,760	26,641	7,985	1,119	0	15,787	5	606	7,533	2,332	27,154
1953	0	17,350	16,395	6,080	955	0	12,676	0	1,496	6,801	(755)	15,854
1954	0	14,884	13,944	7,021	940	0	10,339	0	651	7,024	(1,203)	14,233
1955	0	6,231	5,397	5,051	833	0	7,346	7	61	6,077	(1,502)	6,170
1956	0	27,133	26,075	6,221	1,058	0	17,795	5	306	7,129	2,044	26,827
1957	0	10,171	9,291	5,661	880	0	8,552	1	475	6,761	(1,240)	9,695
1958	0	32,566	31,393	7,267	1,173	0	16,086	6	587	7,634	2,410	31,978
1959	0	10,730	9,856	5,294	874	0	8,800	0	927	6,103	(839)	9,803
1960	0	6,038	5,206	5,203	832	0	6,803	12	(12)	5,844	(1,661)	6,050
1961	0	5,995	5,164	5,097	830	0	6,750	8	(8)	5,768	(1,731)	6,003
1962	0	8,109	7,257	5,063	852	0	7,528	9	(8)	5,788	(967)	8,118
1963	0	18,682	17,669	7,329	1,012	0	11,162	6	477	7,129	(520)	18,205
1964	0	6,984	6,145	5,143	839	0	7,804	1	53	5,967	(1,447)	6,931
1965	0	19,887	18,896	6,670	991	0	14,496	6	81	6,732	652	19,806
1966	0	8,940	8,078	5,602	862	0	8,613	4	396	6,798	(1,380)	8,544
1967	0	21,774	20,726	7,553	1,048	0	13,108	6	760	7,625	1,162	21,014
1968	0	12,753	11,860	5,557	894	0	9,256	0	1,761	6,544	(1,080)	10,992
1969	0	29,543	28,420	7,967	1,123	0	16,813	6	876	7,306	4,789	28,667
1970	0	28,011	26,973	5,637	1,038	0	18,655	0	1,746	6,777	1,982	26,265
1971	0	16,614	15,663	7,094	951	0	12,449	6	152	6,965	(362)	16,462
1972	0	7,556	6,710	5,409	846	0	7,849	4	323	6,666	(1,896)	7,234
1973	0	19,352	18,386	6,821	966	0	12,919	13	310	6,919	660	19,041
1974	0	32,058	30,933	6,944	1,125	0	19,746	3	607	7,436	1,506	31,451
1975	0	16,950	15,990	6,627	960	0	10,903	0	1,102	7,596	(208)	15,848
1976	0	5,503	4,682	4,416	821	0	6,343	0	80	5,079	(1,367)	5,423
1977	0	3,657	2,858	3,657	799	0	4,264	0	0	3,053	(453)	3,657
1978	0	17,203	16,242	7,933	962	0	10,117	0	1,212	5,719	934	15,992
1979	0	10,250	9,372	5,844	878	0	8,242	0	680	6,485	(350)	9,570
1980	0	23,499	22,497	6,568	1,001	0	14,443	19	731	6,404	3,484	22,768
1981	0	8,587	7,733	5,109	855	0	7,849	0	890	6,477	(1,351)	7,698
1982	0	36,948	35,709	7,099	1,239	0	20,240	6	507	7,773	6,421	36,441
1983	0	64,116	62,564	6,197	1,552	0	31,346	0	2,964	8,377	18,602	61,152
1984	0	30,260	29,197	5,676	1,062	0	20,548	0	2,533	7,109	5,669	27,727
1985	0	8,476	7,623	5,068	853	0	8,383	4	305	6,239	(921)	8,171
1986	0	28,078	27,026	6,155	1,052	0	14,333	46	218	6,486	4,748	27,860
1987	0	5,888	5,059	4,819	829	0	6,602	0	36	5,844	(1,331)	5,852
1988	0	5,142	4,325	4,505	817	0	5,648	6	(6)	4,440	(980)	5,148
1989	0	6,644	5,801	4,816	843	0	6,313	17	18	5,296	(1,352)	6,626
1990	0	4,615	3,801	4,506	814	0	5,037	2	(2)	4,063	(835)	4,617
1991	0	4,853	4,038	4,088	816	0	4,808	4	(4)	3,804	(585)	4,857
Average	0	14,562	13,631	5,802	930	0	10,292	7	442	6,154	420	14,120

Table A3–5. Continued

Water Year	Available for DW Diversion (TAF)	Delta Storage (TAF)	Delta Storage Diversion (TAF)	Delta Storage Export (TAF)	Delta Storage Outflow (TAF)	Final Total Export (TAF)	Final QWEST Flow (TAF)	Final Delta Outflow (TAF)	3–Mile Slough Flow (TAF)	Old River Diversion Flow (TAF)	Final Antioch Flow (TAF)
1922	1,073	0	0	0	0	6,380	604	12,101	2,512	1,587	3,115
1923	2,231	0	0	0	0	6,491	140	10,478	2,386	1,369	2,526
1924	2	0	0	0	0	4,539	(1,152)	4,158	1,628	825	476
1925	770	0	0	0	0	5,796	(753)	8,206	2,343	852	1,590
1926	427	0	0	0	0	5,757	(1,085)	6,974	2,242	877	1,157
1927	2,854	0	0	0	0	6,604	(175)	17,268	4,140	1,038	3,966
1928	2,464	0	0	0	0	6,734	(706)	13,846	3,637	996	2,931
1929	0	0	0	0	0	4,564	(911)	4,548	1,585	851	673
1930	281	0	0	0	0	5,000	(1,037)	6,229	2,043	764	1,005
1931	0	0	0	0	0	3,327	(312)	3,677	1,054	831	743
1932	148	0	0	0	0	4,272	158	5,700	1,263	943	1,421
1933	0	0	0	0	0	3,678	(351)	4,288	1,218	853	867
1934	121	0	0	0	0	3,734	(445)	4,831	1,395	805	950
1935	612	0	0	0	0	5,986	(457)	9,392	2,459	1,131	2,002
1936	1,424	0	0	0	0	6,202	62	10,803	2,503	1,192	2,565
1937	934	0	0	0	0	5,890	768	9,629	1,842	1,494	2,610
1938	8,833	0	0	0	0	7,215	4,892	35,927	5,715	3,087	10,607
1939	548	0	0	0	0	5,781	(1,228)	5,635	2,013	995	785
1940	2,650	0	0	0	0	6,456	39	17,614	4,100	1,046	4,139
1941	5,967	0	0	0	0	6,660	2,540	30,118	5,644	2,157	8,185
1942	5,141	0	0	0	0	7,230	1,487	26,463	5,374	1,534	6,861
1943	4,699	0	0	0	0	6,712	2,090	19,572	3,441	1,611	5,531
1944	45	0	0	0	0	5,986	(1,246)	6,439	2,207	984	960
1945	880	0	0	0	0	6,487	(622)	8,286	2,294	1,254	1,672
1946	2,348	0	0	0	0	6,340	(139)	12,946	3,119	1,135	2,980
1947	1	0	0	0	0	6,032	(1,609)	5,559	2,202	958	594
1948	19	0	0	0	0	6,364	(1,517)	7,322	2,561	806	1,044
1949	449	0	0	0	0	5,709	(1,081)	7,100	2,272	842	1,191
1950	319	0	0	0	0	6,177	(1,212)	7,528	2,443	866	1,231
1951	5,184	0	0	0	0	7,131	1,567	19,847	3,789	1,430	5,356
1952	6,017	0	0	0	0	7,533	2,332	27,154	5,071	1,548	7,403
1953	2,568	0	0	0	0	6,801	(755)	15,854	4,132	1,084	3,377
1954	2,571	0	0	0	0	7,024	(1,203)	14,233	4,002	908	2,799
1955	701	0	0	0	0	6,077	(1,502)	6,170	2,283	844	781
1956	5,266	0	0	0	0	7,129	2,044	26,827	5,153	1,711	7,197
1957	931	0	0	0	0	6,761	(1,240)	9,695	2,963	964	1,723
1958	6,692	0	0	0	0	7,634	2,410	31,978	6,148	2,019	8,557
1959	1,805	0	0	0	0	6,103	(839)	9,803	2,770	997	1,931
1960	156	0	0	0	0	5,844	(1,661)	6,050	2,345	802	684
1961	222	0	0	0	0	5,768	(1,731)	6,003	2,371	763	640
1962	822	0	0	0	0	5,788	(967)	8,118	2,444	892	1,476
1963	3,051	0	0	0	0	7,129	(520)	18,205	4,546	1,021	4,025
1964	1,256	0	0	0	0	5,967	(1,447)	6,931	2,434	869	987
1965	3,152	0	0	0	0	6,732	652	19,806	4,282	1,246	4,935
1966	1,213	0	0	0	0	6,798	(1,380)	8,544	2,771	1,110	1,392
1967	4,457	0	0	0	0	7,625	1,162	21,014	4,278	1,729	5,440
1968	2,129	0	0	0	0	6,544	(1,080)	10,992	3,178	943	2,098
1969	6,435	0	0	0	0	7,306	4,789	28,667	4,081	3,097	8,870
1970	5,612	0	0	0	0	6,777	1,982	26,265	5,060	1,632	7,042
1971	2,998	0	0	0	0	6,965	(362)	16,462	4,058	993	3,696
1972	601	0	0	0	0	6,666	(1,896)	7,234	2,751	902	855
1973	4,137	0	0	0	0	6,919	660	19,041	4,090	1,204	4,750
1974	6,240	0	0	0	0	7,436	1,506	31,451	6,528	1,154	8,034
1975	2,723	0	0	0	0	7,596	(208)	15,848	3,831	1,176	3,623
1976	567	0	0	0	0	5,079	(1,367)	5,423	2,041	755	674
1977	0	0	0	0	0	3,053	(453)	3,657	1,129	676	676
1978	2,712	0	0	0	0	5,719	934	15,992	3,230	1,158	4,165
1979	1,050	0	0	0	0	6,485	(350)	9,570	2,443	1,220	2,093
1980	5,330	0	0	0	0	6,404	3,484	22,768	3,420	2,567	6,904
1981	777	0	0	0	0	6,477	(1,351)	7,698	2,559	1,068	1,208
1982	8,661	0	0	0	0	7,773	6,421	36,441	4,996	3,355	11,417
1983	21,445	0	0	0	0	8,377	18,602	61,152	4,091	9,324	22,693
1984	8,816	0	0	0	0	7,109	5,669	27,727	3,388	3,669	9,058
1985	1,574	0	0	0	0	6,239	(921)	8,171	2,431	1,103	1,511
1986	6,120	0	0	0	0	6,486	4,748	27,860	3,913	2,756	8,660
1987	67	0	0	0	0	5,844	(1,331)	5,852	2,119	919	788
1988	418	0	0	0	0	4,440	(980)	5,148	1,761	685	781
1989	228	0	0	0	0	5,296	(1,352)	6,626	2,310	646	957
1990	60	0	0	0	0	4,063	(835)	4,617	1,558	633	723
1991	4	0	0	0	0	3,804	(585)	4,857	1,478	634	892
Average	2,572	0	0	0	0	6,154	420	14,120	3,084	1,370	3,504

Table A3–6. Monthly Percentiles for DeltaSOS Simulations for the No–Project Alternative

Added Sacramento River inflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Sacramento River inflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	7,061	6,109	9,315	8,254	11,098	10,037	8,048	6,120	6,807	8,808	5,799	7,127
10	8,521	8,705	11,222	12,430	13,896	12,393	9,755	8,869	13,397	12,587	8,916	7,402
20	10,336	10,557	12,482	13,398	15,973	14,909	11,824	10,598	13,747	14,209	10,687	9,332
30	11,298	11,141	14,318	15,674	19,556	19,999	12,871	10,927	14,216	16,305	11,377	9,951
40	12,599	12,398	15,340	17,189	26,157	22,470	13,660	12,536	14,576	17,952	12,298	10,418
50	13,235	14,986	15,966	23,855	33,032	29,013	16,641	14,307	15,378	20,715	12,690	10,674
60	14,049	16,748	17,880	27,227	38,969	32,372	19,089	15,112	15,853	20,917	13,531	11,337
70	16,315	18,590	26,185	34,299	50,420	38,408	21,535	19,632	17,456	21,204	15,120	11,470
80	20,271	21,117	32,528	47,425	61,379	47,850	37,669	30,496	20,583	21,494	17,359	14,725
90	22,815	31,259	57,571	66,163	70,537	65,427	45,150	41,227	26,443	22,569	19,130	18,106
100	29,964	64,593	85,103	91,517	108,473	97,768	78,803	60,752	51,139	23,363	20,168	24,376
Mean	14,883	17,738	24,595	30,990	38,331	34,402	22,815	19,775	18,021	18,504	13,419	12,052

Required San Joaquin River flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	1,000	900	900	900	900	900	2,005	2,005	900	900	900	900
10	1,000	900	900	900	900	900	2,005	2,005	900	900	900	900
20	1,500	900	900	900	900	1,330	2,435	2,435	900	900	900	900
30	1,500	900	900	900	1,420	1,420	3,641	2,720	1,420	900	900	900
40	1,500	900	900	900	1,420	2,280	3,880	3,880	1,420	900	900	900
50	1,500	900	900	900	2,130	2,280	3,880	3,880	2,130	900	900	900
60	1,500	900	900	900	2,280	3,420	5,220	5,220	2,280	900	900	900
70	1,500	900	900	900	3,420	3,420	5,220	5,220	3,420	900	900	900
80	1,500	900	900	900	3,420	3,420	6,020	6,020	3,420	900	900	900
90	1,500	900	900	900	3,420	3,420	6,020	6,020	3,420	900	900	900
100	1,500	900	900	900	3,420	3,420	6,020	6,020	3,420	900	900	900
Mean	1,407	900	900	900	2,167	2,425	4,261	4,153	2,253	900	900	900

Additional San Joaquin River inflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	13	55	0	0	0	0
90	44	0	0	0	0	0	445	485	1,217	0	0	0
100	44	0	0	108	900	0	833	1,231	1,289	0	61	305
Mean	7	0	0	2	23	0	89	113	202	0	1	6

New San Joaquin River flow at Vernalis (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	1,456	1,114	1,018	900	900	1,168	2,005	2,005	1,420	973	900	900
10	1,500	1,410	1,254	1,185	1,507	1,424	2,005	2,005	1,786	1,288	961	1,015
20	1,500	1,689	1,494	1,620	2,280	1,735	2,435	2,435	1,810	1,539	989	1,049
30	1,558	1,886	1,661	1,757	2,372	2,280	3,641	2,766	1,822	1,670	1,021	1,109
40	1,695	2,032	1,915	2,086	2,866	2,280	3,988	3,880	1,870	1,675	1,132	1,155
50	1,826	2,287	2,145	2,460	3,421	2,288	3,988	3,933	2,280	1,685	1,473	1,210
60	1,975	2,393	2,291	2,876	3,737	3,420	5,343	5,220	2,819	1,717	1,670	1,336
70	2,000	2,541	2,509	3,164	4,926	3,420	5,343	5,279	3,420	1,831	1,888	1,573
80	2,763	2,687	3,044	4,199	5,974	4,083	6,195	6,105	3,426	1,974	1,960	1,850
90	3,954	2,938	3,667	5,597	8,381	8,398	6,195	6,105	6,759	2,080	2,135	2,814
100	16,954	11,669	19,380	23,241	35,143	42,741	30,300	27,493	30,126	18,015	6,171	10,520
Mean	2,500	2,462	2,773	3,540	4,886	4,753	5,358	5,048	3,580	2,155	1,538	1,698

Note: Negative values shown in parentheses.

Table A3–6. Continued

Sutter and Steamboat Slough flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	1,235	1,202	2,528	2,109	3,208	2,806	2,026	1,207	1,193	1,616	1,067	1,247
10	1,545	2,289	3,255	3,705	4,245	3,691	2,698	2,354	3,018	2,746	1,644	1,299
20	2,037	3,004	3,724	4,062	5,005	4,616	3,480	3,020	3,138	3,297	2,142	1,753
30	2,330	3,225	4,400	4,896	6,316	6,479	3,868	3,144	3,300	4,042	2,354	1,925
40	2,750	3,693	4,774	5,450	8,768	7,391	4,159	3,744	3,426	4,642	2,650	2,061
50	2,963	4,645	5,003	7,906	11,396	9,850	5,249	4,396	3,709	5,667	2,780	2,138
60	3,242	5,288	5,702	9,172	13,728	11,140	6,145	4,691	3,879	5,743	3,064	2,342
70	4,045	5,962	8,779	11,888	18,384	13,505	7,045	6,344	4,460	5,850	3,617	2,384
80	5,502	6,891	11,200	17,148	23,011	17,323	13,213	10,417	5,618	5,959	4,425	3,478
90	6,454	10,710	21,386	25,078	26,989	24,758	16,217	14,631	8,876	6,361	5,077	4,699
100	10,213	24,397	33,495	36,422	44,317	39,307	30,656	22,743	18,683	6,659	5,463	7,040
Mean	3,683	5,696	8,402	10,936	13,842	12,270	7,686	6,485	4,853	4,875	3,105	2,666

Delta Cross Channel flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	3,345	2,172	2,057
10	2,268	0	0	0	0	0	0	0	0	4,310	3,378	2,333
20	3,706	0	0	0	0	0	0	0	4,467	4,643	3,868	3,502
30	3,899	0	0	0	0	0	0	0	4,537	5,034	4,037	3,675
40	4,177	0	0	0	0	0	0	0	4,645	5,319	4,247	3,799
50	4,396	0	0	0	0	0	0	0	4,694	5,771	4,333	3,865
60	4,569	0	0	0	0	0	0	0	4,863	5,803	4,508	4,027
70	4,791	0	0	0	0	0	0	0	4,942	5,848	4,818	4,059
80	5,421	0	0	0	0	0	0	0	5,117	5,894	5,218	4,743
90	6,020	0	0	0	0	0	0	0	5,737	6,062	5,515	5,345
100	6,345	0	0	0	0	0	0	0	6,429	6,185	5,683	6,341
Mean	4,270	0	0	0	0	0	0	0	4,332	5,369	4,387	4,002

Delta Cross Channel & Georgiana Slough flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	3,887	1,992	2,413	2,276	2,640	2,506	2,249	1,994	4,067	5,057	3,445	3,763
10	4,345	2,335	2,655	2,807	2,989	2,802	2,470	2,356	5,657	6,450	5,104	4,023
20	5,571	2,571	2,813	2,927	3,248	3,115	2,731	2,577	6,703	6,946	5,803	5,279
30	5,848	2,645	3,042	3,211	3,697	3,753	2,862	2,618	6,809	7,539	6,048	5,527
40	6,254	2,803	3,169	3,400	4,545	4,068	2,960	2,820	6,948	7,979	6,357	5,704
50	6,577	3,125	3,247	4,246	5,462	4,922	3,331	3,040	7,054	8,686	6,483	5,799
60	6,835	3,345	3,486	4,686	6,279	5,373	3,638	3,141	7,282	8,737	6,744	6,034
70	7,169	3,575	4,549	5,635	7,910	6,201	3,948	3,707	7,415	8,809	7,210	6,080
80	8,137	3,895	5,394	7,477	9,526	7,538	6,098	5,120	7,848	8,882	7,823	7,097
90	9,081	5,223	8,959	10,245	10,908	10,134	7,151	6,595	8,634	9,149	8,284	8,019
100	9,601	10,008	13,153	14,157	16,843	15,142	12,176	9,433	9,735	9,345	8,549	9,595
Mean	6,683	3,497	4,434	5,313	6,322	5,774	4,186	3,772	7,164	8,073	6,589	6,080

Sacramento River flow at Rio Vista (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	2,953	4,089	6,740	6,042	8,592	7,418	5,496	4,319	1,994	2,906	1,675	2,941
10	3,705	6,207	8,441	9,927	10,978	9,634	7,016	5,990	5,807	5,515	3,226	2,957
20	4,408	7,857	9,545	10,788	12,944	11,705	8,982	7,677	6,092	6,265	4,197	3,621
30	5,117	8,492	11,261	12,575	16,117	16,549	9,852	7,924	6,481	7,766	4,642	3,992
40	5,926	9,475	12,520	14,429	23,651	20,796	10,464	9,184	6,771	9,072	5,387	4,308
50	6,535	12,227	12,891	20,909	28,856	24,838	13,056	10,759	7,197	11,094	5,884	4,635
60	6,960	13,337	14,281	24,113	39,701	27,217	15,832	11,813	7,589	11,178	6,376	5,068
70	8,623	14,780	21,605	31,283	49,850	33,893	18,356	15,423	8,705	11,515	7,521	5,636
80	11,520	17,656	39,472	53,373	63,284	48,640	35,917	24,958	11,103	11,690	8,856	7,196
90	13,457	26,189	60,815	90,087	102,991	79,036	56,006	35,056	20,983	12,792	10,253	9,773
100	33,546	59,943	119,018	171,272	182,736	188,332	103,086	50,877	43,121	13,014	11,291	14,422
Mean	8,152	14,567	24,121	34,262	43,101	35,247	22,163	15,764	10,077	9,535	6,269	5,674

QWEST Flow with initial exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	(4,063)	(6,213)	(7,116)	(6,374)	(4,446)	(3,380)	399	(424)	(5,589)	(4,023)	(3,950)	(3,113)
10	(1,864)	(5,670)	(6,034)	(5,310)	(2,794)	(1,987)	578	(98)	319	(3,591)	(3,475)	(1,612)
20	(1,528)	(5,019)	(5,306)	(4,581)	(1,707)	(1,154)	853	69	507	(3,549)	(2,471)	(1,195)
30	(1,409)	(4,388)	(4,674)	(4,291)	(1,160)	(861)	1,316	160	574	(3,367)	(1,657)	(841)
40	(1,093)	(3,728)	(4,266)	(3,460)	303	(542)	1,487	377	611	(3,024)	(710)	(725)
50	(835)	(3,364)	(3,821)	(2,509)	1,914	369	1,858	773	706	(2,723)	(207)	(578)
60	(446)	(2,986)	(3,255)	(969)	4,225	2,114	2,231	987	824	(1,759)	150	(440)
70	(6)	(2,672)	(2,125)	1,041	7,201	3,977	2,616	1,317	1,052	(380)	480	(371)
80	165	(2,422)	1,605	6,408	11,209	10,138	5,595	2,132	1,629	465	1,012	(261)
90	1,674	(821)	4,215	13,748	14,314	14,661	10,832	4,836	2,730	2,642	1,501	240
100	15,066	23,073	39,958	37,172	59,433	74,009	40,633	33,442	31,816	19,443	2,475	11,767
Mean	(277)	(2,759)	(1,341)	1,715	5,708	5,204	4,426	2,407	1,607	(1,304)	(590)	(493)

Table A3–6. Continued

Export reductions to meet QWEST standards (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Delta outflow at Collinsville (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	2,991	3,537	4,531	4,505	7,799	6,898	5,840	4,506	3,997	4,000	3,414	3,007
10	3,348	4,504	5,232	5,788	9,614	8,555	7,818	6,036	6,117	4,994	3,416	3,008
20	4,002	5,044	5,684	6,289	11,400	10,947	10,252	7,578	6,703	6,699	4,384	3,153
30	4,196	5,293	6,355	7,862	15,513	15,073	10,545	7,579	6,895	7,158	5,032	3,398
40	4,678	5,647	6,833	10,476	22,775	18,364	11,260	10,011	7,578	7,230	5,302	3,632
50	5,023	6,383	7,187	16,808	27,301	24,849	15,372	11,258	7,580	7,826	5,740	3,817
60	5,354	7,859	9,483	22,569	44,691	29,666	18,031	12,903	8,328	8,001	5,741	4,143
70	6,403	10,957	17,107	30,748	59,049	41,729	20,862	17,576	9,270	8,002	5,742	4,359
80	9,792	14,090	40,647	72,356	70,178	59,498	40,512	26,201	11,632	8,004	6,042	5,518
90	15,199	22,851	68,851	102,271	116,586	93,737	63,869	39,710	16,998	9,381	6,722	8,323
100	37,421	83,001	159,166	205,170	219,767	262,789	142,618	83,413	74,553	32,036	9,719	26,031
Mean	7,758	11,740	22,764	36,125	48,912	40,457	26,478	17,951	11,307	7,812	5,388	4,998

Delta outflow at Chipps Island (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	695	1,236	2,221	2,195	5,458	4,566	5,921	4,613	4,114	4,117	3,542	3,143
10	1,049	2,194	2,915	3,466	7,257	6,207	7,861	6,113	6,193	5,092	3,544	3,144
20	1,697	2,729	3,363	3,963	9,026	8,577	10,247	7,625	6,767	6,763	4,494	3,287
30	1,889	2,976	4,028	5,521	13,101	12,665	10,534	7,626	6,956	7,213	5,129	3,527
40	2,366	3,326	4,501	8,111	20,295	15,925	11,235	10,011	7,625	7,284	5,394	3,756
50	2,708	4,056	4,852	14,384	24,779	22,350	15,267	11,233	7,627	7,868	5,823	3,938
60	3,036	5,518	7,127	20,091	42,007	27,122	17,874	12,846	8,361	8,040	5,824	4,257
70	4,075	8,587	14,680	28,194	56,232	39,073	20,650	17,428	9,284	8,041	5,825	4,469
80	7,433	11,691	38,001	69,415	67,257	56,677	39,917	25,885	11,600	8,043	6,119	5,605
90	12,790	20,370	65,943	99,052	113,234	90,597	62,819	39,131	16,862	9,393	6,786	8,356
100	34,805	79,961	155,418	200,994	215,455	258,077	140,032	81,981	73,294	31,606	9,724	25,718
Mean	5,417	9,363	20,284	33,521	46,190	37,813	26,156	17,796	11,282	7,854	5,478	5,095

Required Delta outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	2,992	3,537	4,505	4,505	5,960	6,356	5,841	4,505	4,000	4,001	3,415	3,008
10	3,347	4,504	4,532	5,713	7,670	7,068	7,579	6,036	6,117	4,993	3,415	3,008
20	4,001	4,931	4,885	5,980	8,175	8,765	8,641	7,579	6,703	6,698	4,384	3,074
30	4,001	5,194	5,444	6,001	9,456	9,971	9,569	7,579	6,896	7,157	5,033	3,352
40	4,306	5,464	5,771	6,001	11,276	10,891	10,265	8,034	7,579	7,230	5,302	3,622
50	4,519	5,647	6,139	6,001	11,400	11,400	10,545	9,454	7,579	7,825	5,741	3,791
60	4,904	6,062	6,355	6,001	11,400	12,241	11,259	10,268	8,282	8,002	5,741	4,037
70	5,091	6,312	6,591	6,294	14,676	15,373	12,161	11,259	8,889	8,002	5,741	4,190
80	5,354	6,434	6,832	6,891	19,623	16,464	13,890	14,465	9,994	8,002	5,966	5,436
90	5,615	6,804	7,163	7,210	22,072	19,282	15,372	17,320	12,026	9,358	6,577	5,781
100	7,995	8,016	7,580	8,542	28,559	27,430	22,321	28,043	21,174	9,549	7,521	6,333
Mean	4,625	5,715	6,003	6,275	13,148	12,825	11,353	10,645	8,827	7,442	5,331	4,103

Montezuma Slough flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	2,296	2,301	2,310	2,310	2,341	2,332	(81)	(107)	(117)	(117)	(128)	(136)
10	2,299	2,310	2,317	2,322	2,357	2,348	(43)	(77)	(76)	(98)	(128)	(136)
20	2,305	2,315	2,321	2,326	2,374	2,370	5	(47)	(64)	(64)	(110)	(134)
30	2,307	2,317	2,327	2,341	2,412	2,408	11	(47)	(61)	(55)	(97)	(129)
40	2,312	2,321	2,332	2,365	2,480	2,439	25	0	(47)	(54)	(92)	(124)
50	2,315	2,327	2,335	2,424	2,522	2,499	105	25	(47)	(42)	(83)	(121)
60	2,318	2,341	2,356	2,478	2,684	2,544	157	57	(33)	(39)	(83)	(114)
70	2,328	2,370	2,427	2,554	2,817	2,656	212	148	(14)	(39)	(83)	(110)
80	2,359	2,399	2,646	2,941	2,921	2,821	595	316	32	(39)	(77)	(87)
90	2,409	2,481	2,908	3,219	3,352	3,140	1,050	579	136	(12)	(64)	(33)
100	2,616	3,040	3,748	4,176	4,312	4,712	2,586	1,432	1,259	430	(5)	313
Mean	2,340	2,377	2,480	2,604	2,723	2,644	321	155	25	(43)	(90)	(98)

Table A3–6. Continued

Net change in exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	(2)	(2)	(153)	(49)	(136)	(338)	(1)	(544)	(3)	(7)	(7)	(1)
10	0	(2)	(59)	(43)	(129)	(63)	0	(1)	(1)	(7)	(7)	0
20	0	(1)	(58)	(40)	(117)	(0)	0	(1)	(1)	(7)	(1)	0
30	0	(1)	(56)	(39)	0	0	1	0	(1)	(7)	(1)	0
40	1	0	(51)	(29)	0	1	380	0	(1)	(7)	(1)	0
50	1	0	(1)	(1)	1	383	584	1	(0)	(1)	0	1
60	1	339	0	0	975	2,698	648	380	0	(1)	0	1
70	253	339	0	15	2,166	2,958	920	527	0	0	0	1
80	253	339	1	1,467	3,604	3,817	1,400	794	0	0	0	1
90	253	339	2,928	4,672	5,786	4,788	2,673	1,538	3	1	1	37
100	4,218	5,981	6,458	9,482	8,556	6,752	4,686	5,007	3,601	3,484	1,103	2,892
Mean	179	453	507	1,144	1,698	1,754	843	510	132	54	15	46

Export limits (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	5,697	5,051	6,904	6,130	6,075	4,250	3,212	2,782	3,191	6,696	4,635	5,495
10	6,791	6,948	8,718	9,146	6,635	5,073	3,941	3,451	5,520	9,986	6,952	5,698
20	8,076	8,268	9,549	11,101	7,754	6,095	4,568	3,856	5,615	11,313	8,486	7,225
30	8,845	8,975	11,012	11,681	9,746	8,217	5,037	4,310	5,869	12,531	8,939	7,610
40	9,462	9,555	11,869	13,474	11,258	10,191	5,701	5,362	6,085	13,625	9,636	7,730
50	10,095	11,604	12,309	18,120	15,028	12,287	6,573	5,878	6,624	14,885	9,804	8,059
60	10,793	12,774	13,050	20,989	20,184	13,992	7,380	6,581	6,841	14,934	10,180	8,423
70	12,371	14,219	19,023	26,125	24,401	17,475	8,921	7,882	7,036	15,296	10,976	9,092
80	14,542	15,592	32,504	51,223	27,435	23,524	12,799	9,437	8,550	15,367	12,576	11,736
90	17,753	22,475	51,845	68,989	43,998	36,367	16,500	12,708	11,317	16,360	13,404	14,088
100	29,881	57,610	105,728	133,645	79,382	92,174	38,212	29,841	30,225	28,830	15,044	23,568
Mean	11,662	13,820	21,256	29,141	20,700	16,863	8,962	7,503	7,838	13,790	10,050	9,229

Revised QWEST flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	(4,316)	(6,506)	(7,117)	(6,376)	(4,607)	(3,979)	(8)	(529)	(5,589)	(4,016)	(3,943)	(3,113)
10	(1,927)	(6,009)	(6,034)	(5,501)	(3,133)	(2,476)	556	(175)	318	(3,584)	(3,468)	(1,612)
20	(1,554)	(5,629)	(5,554)	(4,913)	(2,329)	(1,918)	836	(19)	509	(3,542)	(2,472)	(1,196)
30	(1,409)	(4,941)	(4,936)	(4,371)	(1,682)	(1,414)	989	125	572	(3,360)	(1,656)	(841)
40	(1,128)	(4,000)	(4,378)	(3,958)	(930)	(766)	1,233	229	585	(3,017)	(709)	(725)
50	(896)	(3,727)	(4,123)	(3,340)	391	(552)	1,448	376	705	(2,722)	(206)	(578)
60	(533)	(3,244)	(3,376)	(2,180)	2,396	(269)	1,564	676	809	(1,759)	151	(440)
70	(128)	(2,946)	(2,371)	(835)	5,231	1,702	1,792	820	959	(380)	480	(372)
80	147	(2,599)	(225)	5,235	7,505	6,274	4,458	1,727	1,543	465	1,012	(276)
90	918	(1,013)	3,831	13,548	11,956	13,431	7,805	3,642	2,730	2,630	1,482	240
100	10,848	17,092	33,500	30,579	51,361	67,257	36,876	28,435	28,215	15,959	2,031	8,875
Mean	(456)	(3,212)	(1,848)	570	4,011	3,450	3,583	1,897	1,475	(1,357)	(604)	(540)

Revised Delta outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	2,992	3,537	4,532	4,505	7,800	6,897	5,841	4,505	4,000	4,001	3,415	3,008
10	3,347	4,504	5,233	5,788	9,282	8,555	7,579	6,036	6,118	4,993	3,415	3,008
20	4,001	5,044	5,565	6,171	11,400	10,946	10,013	7,579	6,704	6,698	4,384	3,152
30	4,198	5,295	6,315	6,955	13,465	15,072	10,399	7,579	6,896	7,165	5,033	3,397
40	4,675	5,647	6,712	9,472	20,954	18,364	11,259	10,012	7,579	7,237	5,302	3,632
50	5,023	6,383	7,186	16,850	27,430	22,627	14,490	11,235	7,579	7,833	5,741	3,818
60	5,354	7,460	8,499	21,455	41,156	27,716	17,354	12,376	8,327	8,002	5,741	4,142
70	6,150	9,608	17,164	29,456	53,600	38,131	20,075	16,226	9,271	8,002	5,741	4,358
80	9,539	12,002	39,257	72,396	67,389	55,634	38,030	25,407	11,632	8,002	6,042	5,517
90	14,567	22,512	68,904	97,186	115,855	92,507	62,706	38,516	16,995	9,373	6,729	8,286
100	33,203	77,020	152,708	197,170	219,888	256,037	139,945	78,406	70,952	28,552	8,616	23,139
Mean	7,578	11,288	22,257	34,981	47,215	38,703	25,635	17,441	11,175	7,758	5,373	4,951

Available water for diversion (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	1,928	0	0	0	0	0	0	0	0
50	0	0	405	6,475	3,132	240	0	0	0	0	0	0
60	0	1,208	1,686	9,289	8,175	2,292	0	0	0	7	0	0
70	641	2,939	7,708	12,865	12,683	6,207	0	0	0	8	0	0
80	3,262	4,312	14,775	20,235	15,427	11,824	3,011	297	0	8	0	0
90	6,473	11,181	18,831	28,548	25,402	21,579	6,864	2,758	37	8	7	2,724
100	18,601	32,092	48,500	45,579	53,947	80,474	26,932	18,561	18,945	17,550	2,875	12,288
Mean	1,913	3,214	6,322	10,174	9,199	7,138	2,063	1,035	672	273	42	638

Table A3–6. Continued

Delta storage diversion (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Delta storage (TAF)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Delta storage discharge for export (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Delta storage discharge for outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Final CVP Tracy and SWP Banks exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	4,288	3,326	5,072	4,844	4,073	3,147	2,791	2,395	1,076	1,818	537	3,271
10	5,125	5,385	7,368	8,686	6,384	4,525	3,571	3,114	5,464	3,427	3,448	3,592
20	6,854	6,640	7,842	10,935	7,285	6,095	3,789	3,538	5,568	6,446	4,730	5,890
30	7,992	7,372	9,922	11,372	9,184	7,956	4,189	3,928	5,766	7,379	5,083	6,051
40	8,500	8,383	10,868	11,428	11,137	10,191	5,623	4,859	5,923	8,865	5,864	6,359
50	9,055	10,670	11,176	11,562	11,633	11,268	6,573	5,685	6,313	10,505	6,324	6,518
60	9,710	11,280	11,246	11,732	12,009	11,323	7,380	6,754	6,543	11,280	7,174	6,685
70	11,280	11,280	11,298	11,849	12,462	11,461	8,476	7,487	7,026	11,280	7,966	7,409
80	11,280	11,280	11,393	12,266	12,700	11,499	9,203	8,673	8,448	11,280	9,615	10,062
90	11,280	11,280	11,503	12,700	12,700	11,700	9,950	9,950	11,280	11,280	11,280	11,280
100	11,280	11,280	11,700	12,700	12,700	11,700	11,280	11,280	11,280	11,280	11,280	11,280
Mean	8,965	9,107	10,138	11,205	10,487	9,420	6,697	6,209	6,974	8,952	6,847	7,147

Table A3–6. Continued

Final QWEST flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	(4,316)	(6,506)	(7,117)	(6,376)	(4,607)	(3,979)	(8)	(529)	(5,589)	(4,016)	(3,943)	(3,113)
10	(1,927)	(6,009)	(6,034)	(5,501)	(3,133)	(2,476)	556	(175)	318	(3,584)	(3,468)	(1,612)
20	(1,554)	(5,629)	(5,554)	(4,913)	(2,329)	(1,918)	836	(19)	509	(3,542)	(2,472)	(1,196)
30	(1,409)	(4,941)	(4,936)	(4,371)	(1,682)	(1,414)	989	125	572	(3,360)	(1,656)	(841)
40	(1,128)	(4,000)	(4,378)	(3,958)	(930)	(766)	1,233	229	585	(3,017)	(709)	(725)
50	(896)	(3,727)	(4,123)	(3,340)	391	(552)	1,448	376	705	(2,722)	(206)	(578)
60	(533)	(3,244)	(3,376)	(2,180)	2,396	(269)	1,564	676	809	(1,759)	151	(440)
70	(128)	(2,946)	(2,371)	(835)	5,231	1,702	1,792	820	959	(380)	480	(372)
80	147	(2,599)	(225)	5,235	7,505	6,274	4,458	1,727	1,543	465	1,012	(276)
90	918	(1,013)	3,831	13,548	11,956	13,431	7,805	3,642	2,730	2,630	1,482	240
100	10,848	17,092	33,500	30,579	51,361	67,257	36,876	28,435	28,215	15,959	2,031	8,875
Mean	(456)	(3,212)	(1,848)	570	4,011	3,450	3,583	1,897	1,475	(1,357)	(604)	(540)

Final Delta outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	2,992	3,537	4,532	4,505	7,800	6,897	5,841	4,505	4,000	4,001	3,415	3,008
10	3,347	4,504	5,233	5,788	9,282	8,555	7,579	6,036	6,118	4,993	3,415	3,008
20	4,001	5,044	5,565	6,171	11,400	10,946	10,013	7,579	6,704	6,698	4,384	3,152
30	4,198	5,295	6,315	6,955	13,465	15,072	10,399	7,579	6,896	7,165	5,033	3,397
40	4,675	5,647	6,712	9,472	20,954	18,364	11,259	10,012	7,579	7,237	5,302	3,632
50	5,023	6,383	7,186	16,850	27,430	22,627	14,490	11,235	7,579	7,833	5,741	3,818
60	5,354	7,460	8,499	21,455	41,156	27,716	17,354	12,376	8,327	8,002	5,741	4,142
70	6,150	9,608	17,164	29,456	53,600	38,131	20,075	16,226	9,271	8,002	5,741	4,358
80	9,539	12,002	39,257	72,396	67,389	55,634	38,030	25,407	11,632	8,002	6,042	5,517
90	14,567	22,512	68,904	97,186	115,855	92,507	62,706	38,516	16,995	9,373	6,729	8,286
100	33,203	77,020	152,708	197,170	219,888	256,037	139,945	78,406	70,952	28,552	8,616	23,139
Mean	7,578	11,288	22,257	34,981	47,215	38,703	25,635	17,441	11,175	7,758	5,373	4,951

Threemile Slough flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	634	1,104	2,237	1,892	1,881	1,671	7	758	(283)	(1,968)	(246)	580
10	868	1,952	2,947	3,647	2,925	2,282	1,284	1,312	644	445	484	614
20	1,109	2,689	3,424	3,883	3,487	3,036	1,604	1,702	1,156	1,133	645	922
30	1,428	2,908	4,192	4,612	4,520	4,185	1,850	1,781	1,214	1,871	955	1,039
40	1,730	3,381	4,524	5,004	5,704	4,916	2,162	1,989	1,332	2,445	1,144	1,151
50	1,915	4,585	4,822	5,490	6,564	5,872	2,556	2,296	1,408	3,237	1,350	1,268
60	2,096	4,911	5,348	6,234	8,176	6,766	3,176	2,660	1,443	3,717	1,621	1,382
70	2,408	5,245	5,798	7,324	10,074	8,109	3,726	3,014	1,638	3,731	2,130	1,558
80	2,815	5,707	8,238	10,846	13,501	9,535	6,095	4,528	2,038	3,819	2,936	2,094
90	3,185	6,689	12,260	16,064	15,910	14,215	10,015	6,405	3,069	3,915	3,477	2,796
100	9,173	12,956	18,191	31,946	31,138	22,824	14,939	9,223	7,191	3,988	3,788	3,549
Mean	2,043	4,402	6,202	7,808	8,790	7,135	4,043	3,080	1,887	2,648	1,651	1,492

Old River diversion flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	73	1,126	1,053	959	959	1,166	100	100	1,343	1,018	959	959
10	75	1,336	1,228	1,178	1,401	1,345	100	100	1,581	1,252	1,008	1,051
20	75	1,519	1,392	1,475	1,881	1,548	122	122	1,596	1,422	1,030	1,077
30	78	1,643	1,501	1,562	1,935	1,881	182	138	1,603	1,507	1,055	1,122
40	85	1,732	1,661	1,765	2,219	1,881	199	194	1,633	1,510	1,140	1,157
50	91	1,885	1,800	1,986	2,531	1,885	199	197	1,881	1,517	1,378	1,196
60	99	1,947	1,887	2,225	2,706	2,530	267	261	2,193	1,537	1,507	1,285
70	100	2,033	2,015	2,387	3,355	2,530	267	264	2,530	1,609	1,644	1,444
80	138	2,117	2,320	2,959	3,923	2,896	310	305	2,534	1,697	1,688	1,621
90	198	2,260	2,667	3,719	5,230	5,240	310	305	4,348	1,761	1,794	2,190
100	10,012	7,039	11,400	13,638	20,705	25,321	17,802	16,135	17,698	10,617	4,030	6,404
Mean	352	1,968	2,134	2,561	3,323	3,259	1,011	876	2,597	1,774	1,398	1,484

Antioch flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	17	(1,365)	(1,531)	(1,399)	408	1,317	1,638	1,131	1,210	(28)	(305)	(20)
10	488	(976)	(1,145)	(851)	1,185	1,541	2,276	1,514	1,797	129	11	532
20	550	(741)	(946)	(635)	1,838	2,326	2,706	1,784	1,835	296	322	618
30	577	(398)	(579)	(358)	3,173	2,814	2,959	1,902	2,033	392	629	632
40	643	(192)	(409)	247	3,684	3,450	3,168	2,405	2,158	641	795	648
50	724	(55)	(159)	2,135	6,505	4,415	4,111	2,992	2,231	907	1,054	657
60	807	115	130	3,874	12,327	6,176	4,524	3,563	2,361	971	1,333	676
70	1,047	431	2,031	6,719	13,548	8,591	5,490	4,305	2,764	1,241	1,483	736
80	2,045	758	9,000	19,128	20,299	15,762	12,118	6,131	3,374	1,893	1,745	849
90	3,972	3,622	17,428	27,941	32,348	26,653	17,768	10,672	6,250	3,162	1,887	1,108
100	12,689	25,709	50,745	57,405	67,702	90,080	49,350	31,220	29,424	13,991	2,698	9,455
Mean	1,587	1,191	4,354	8,378	12,801	10,585	7,627	4,977	3,362	1,291	1,046	952

Table A3–7a. DeltaSOS–Simulated DW Operations
for Alternative 1: DW Diversions to Storage (cfs)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (TAF)
1922	0	0	1,744	2,047	135	49	0	172	118	0	0	0	257
1923	3,871	25	13	15	0	0	0	0	0	86	67	0	246
1924	0	0	0	55	0	0	0	0	0	0	0	0	3
1925	0	0	0	0	4,000	0	0	0	0	86	0	0	246
1926	0	0	0	869	3,354	0	0	0	0	85	0	0	260
1927	0	4,000	13	432	31	49	76	0	0	0	0	0	277
1928	0	4,000	13	15	0	76	0	0	0	86	0	0	252
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	3,871	0	76	0	0	0	0	0	0	238
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	863	1,593	0	0	0	0	0	0	0	0	148
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	2,005	0	0	0	0	0	0	0	0	121
1935	0	0	0	3,871	0	0	155	0	0	86	0	0	248
1936	0	0	0	3,871	30	49	0	0	0	86	0	0	243
1937	0	0	0	0	4,000	307	0	0	0	0	0	0	259
1938	0	4,000	13	15	31	49	76	99	118	0	0	2,749	431
1939	1,263	25	13	0	0	0	0	0	0	86	0	0	84
1940	0	0	0	3,871	30	49	76	0	0	85	0	0	248
1941	0	0	3,871	15	31	49	76	99	0	0	0	0	249
1942	3,871	25	13	15	31	0	126	99	0	0	0	0	252
1943	3,871	25	13	15	31	49	76	0	0	0	0	0	246
1944	0	0	0	0	742	0	0	0	0	86	0	0	50
1945	0	0	1,686	0	2,465	49	0	0	0	0	0	0	253
1946	0	3,606	394	15	0	0	0	0	0	86	0	0	247
1947	0	0	0	0	0	0	0	0	0	85	67	0	9
1948	0	0	0	0	0	0	0	297	0	85	67	0	27
1949	0	0	0	0	0	3,871	0	0	0	0	0	0	233
1950	0	0	0	3,326	634	0	0	0	0	87	68	0	248
1951	0	4,000	13	15	31	49	0	0	0	85	0	0	253
1952	0	1,196	2,726	111	30	49	76	99	118	0	0	4,000	506
1953	53	25	13	15	0	0	0	0	0	0	0	0	6
1954	3,262	654	0	1,065	31	49	76	0	0	87	0	0	315
1955	0	103	3,784	102	0	0	0	0	0	86	66	0	249
1956	0	0	3,871	15	30	49	0	172	0	0	0	204	262
1957	3,726	0	0	0	3,132	1,091	0	0	0	86	67	0	488
1958	2,610	1,328	13	15	31	49	76	99	118	0	0	3,853	493
1959	195	25	0	3,293	31	0	0	0	0	85	0	0	219
1960	0	0	41	0	2,520	0	0	0	0	86	0	0	159
1961	0	0	0	0	3,684	0	0	0	0	85	0	0	227
1962	0	0	0	0	4,000	0	0	0	0	86	0	0	246
1963	3,871	25	13	222	31	49	76	99	0	0	0	0	264
1964	1,710	2,258	0	1,479	0	0	0	0	0	86	68	0	337
1965	0	0	3,871	15	31	0	192	0	0	86	0	0	253
1966	631	3,373	13	15	0	0	0	0	0	86	0	0	248
1967	0	0	3,871	15	31	49	76	99	118	130	0	3,879	498
1968	170	25	13	15	30	49	0	0	0	85	0	0	23
1969	0	0	3,871	15	31	49	76	99	118	0	0	4,000	497
1970	53	25	13	15	31	49	0	0	0	87	0	0	16
1971	0	4,000	13	15	0	3,210	0	250	0	85	0	0	456
1972	2,451	0	1,627	229	0	76	0	0	0	86	66	0	273
1973	0	4,000	13	268	31	49	0	0	0	0	0	0	263
1974	0	4,000	13	15	31	49	76	0	0	0	0	3,000	433
1975	1,020	25	13	15	31	49	0	172	0	0	0	734	124
1976	3,213	25	0	0	0	0	0	0	0	0	0	0	195
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	3,871	31	49	76	0	0	0	0	0	243
1979	3,019	193	0	3,871	31	49	0	0	0	0	0	0	432
1980	0	2,939	1,040	30	30	49	0	0	0	0	0	0	246
1981	2,867	0	1,198	15	0	76	0	0	0	86	0	0	256
1982	0	4,000	13	367	31	49	76	99	37	0	0	4,000	522
1983	53	25	13	15	31	49	76	99	118	130	115	87	49
1984	53	25	13	15	30	49	0	0	0	0	0	0	11
1985	3,019	906	13	0	0	0	0	0	0	86	0	0	242
1986	0	0	384	2,491	1,149	49	76	0	0	0	0	0	250
1987	0	0	0	0	0	1,106	0	0	0	85	0	0	72
1988	0	0	41	3,845	0	0	0	0	0	0	0	0	234
1989	0	0	0	0	0	3,769	0	0	0	86	67	0	236
1990	0	0	0	990	0	0	0	0	0	0	0	0	60
1991	0	0	0	0	0	64	0	0	0	0	0	0	4
Average	641	698	502	691	438	216	24	29	12	43	10	379	222

Table A3-7b. DeltaSOS-Simulated DW Operations
for Alternative 1: DW Discharge to Export Wheeling (cfs)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (TAF)
1922	0	0	0	0	0	0	0	0	0	3,741	0	0	225
1923	0	0	0	0	4,000	0	0	0	0	0	0	0	241
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	154	0	2,815	72	183
1926	0	0	0	0	0	0	0	461	0	0	2,914	0	203
1927	0	0	417	0	0	0	0	0	529	3,015	0	0	239
1928	0	0	0	0	0	0	0	589	137	0	2,704	0	207
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	276	1,100	397	0	1,176	426	0	203
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	2,365	0	0	0	0	0	0	142
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	90	664	430	44	308	0	0	92
1935	0	0	0	0	0	0	0	1,129	0	0	2,236	51	206
1936	0	0	0	0	0	0	0	0	588	0	2,856	0	208
1937	0	0	0	0	0	0	0	0	2,822	724	0	0	214
1938	0	0	0	0	0	0	0	0	0	3,741	0	0	225
1939	0	0	0	0	0	0	677	483	0	0	2,196	0	202
1940	0	0	0	0	0	0	0	703	586	0	987	1,195	209
1941	0	0	0	0	0	0	0	0	0	3,627	0	0	219
1942	0	0	0	0	0	0	0	0	0	3,627	0	0	219
1943	0	0	0	0	0	0	0	1,843	857	855	0	0	214
1944	0	0	0	0	0	0	592	0	0	0	0	0	36
1945	0	0	0	0	0	0	0	171	0	2,105	1,063	0	201
1946	0	0	0	0	4,000	0	0	9	0	0	0	0	242
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	5	0
1949	0	0	0	0	0	0	0	1,454	0	1,145	740	0	201
1950	0	0	0	0	0	0	0	609	0	0	0	2,844	208
1951	0	0	0	0	0	0	0	0	587	0	2,148	644	204
1952	0	0	97	0	0	0	0	0	0	2,749	876	0	224
1953	0	0	0	0	388	0	0	0	0	3,027	0	0	206
1954	0	0	1,037	0	0	0	0	544	153	0	1,633	1,126	271
1955	0	0	87	0	67	0	0	0	0	0	0	3,379	213
1956	0	0	0	0	0	0	0	0	0	2,727	784	0	212
1957	0	515	3,335	0	0	0	865	0	136	0	0	2,520	444
1958	0	0	0	0	0	0	0	0	0	3,741	0	0	225
1959	0	0	3,265	0	0	2,691	1,093	0	0	0	0	0	425
1960	0	0	0	26	0	0	1,126	411	0	0	363	0	116
1961	0	0	0	0	0	0	1,143	412	0	0	1,314	0	173
1962	0	0	0	0	0	0	1,332	593	0	0	1,236	0	190
1963	0	0	208	0	0	0	0	0	0	1,141	2,370	0	224
1964	0	0	1,451	0	261	0	616	479	0	0	0	2,080	294
1965	0	0	0	0	0	63	0	1,041	587	0	1,888	0	216
1966	0	0	0	0	0	0	0	1,461	0	0	592	1,252	199
1967	0	0	0	0	0	0	0	0	0	0	3,755	0	226
1968	0	0	0	0	0	0	637	1,245	0	0	1,563	0	208
1969	0	0	0	0	0	0	0	0	0	3,741	0	0	225
1970	0	0	0	0	0	0	157	52	0	0	3,222	0	207
1971	0	0	0	0	3,469	0	80	0	0	0	3,596	0	431
1972	0	176	215	0	0	0	625	480	0	0	0	2,399	235
1973	0	0	254	0	0	0	0	0	587	92	2,679	0	218
1974	0	0	0	0	0	0	0	0	0	3,137	275	0	206
1975	0	0	0	0	0	0	0	0	0	1,533	1,978	0	212
1976	0	0	1,135	2,708	0	0	0	0	0	0	0	0	232
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	245	3,291	0	0	213
1979	0	0	3,169	0	0	0	0	0	588	2,337	433	0	393
1980	0	0	16	0	0	0	0	0	514	2,957	0	0	210
1981	0	162	0	0	0	0	676	1,250	0	0	1,521	0	217
1982	0	0	352	0	0	0	0	0	0	2,614	933	0	235
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	697	2,642	0	201
1985	0	0	0	0	0	0	768	456	0	0	961	1,125	199
1986	0	0	0	0	0	0	0	0	0	3,527	0	0	213
1987	0	0	0	0	0	0	866	95	0	0	0	0	58
1988	0	0	0	26	0	0	587	425	0	2,359	0	0	205
1989	0	0	0	0	0	0	0	827	0	0	0	2,562	204
1990	0	0	0	0	0	0	658	104	0	0	0	0	46
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	0	12	215	39	174	78	204	259	130	910	796	304	188

Table A3-7c. DeltaSOS-Simulated DW Operations
for Alternative 1: DW End-of-Month Storage (TAF)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	0	0	107	232	238	238	234	238	238	0	0	0
1923	238	238	238	238	14	11	7	1	0	5	4	0
1924	0	0	0	3	2	0	0	0	0	0	0	0
1925	0	0	0	0	222	219	215	209	192	190	9	(0)
1926	0	0	0	53	238	235	231	196	189	186	(0)	0
1927	0	238	212	238	238	238	238	232	193	(0)	0	0
1928	0	238	238	238	236	238	234	191	176	173	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	238	236	221	151	121	114	33	(0)	0
1931	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	53	150	148	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	123	122	113	69	37	27	(0)	0	0
1935	0	0	0	238	236	233	238	162	155	153	8	(0)
1936	0	0	0	238	238	238	234	227	185	183	0	0
1937	0	0	0	0	222	238	234	227	52	(0)	0	0
1938	0	238	238	238	238	238	238	238	238	0	0	164
1939	238	238	238	237	235	232	188	152	145	142	0	0
1940	0	0	0	238	238	238	238	189	147	144	76	(0)
1941	0	0	238	238	238	238	238	238	231	(0)	0	0
1942	238	238	238	238	238	235	238	238	231	(0)	0	0
1943	238	238	238	238	238	238	238	119	61	(0)	0	0
1944	0	0	0	0	43	40	(0)	0	0	5	0	0
1945	0	0	104	103	238	238	234	217	210	72	0	0
1946	0	215	238	238	14	11	7	(0)	0	5	0	0
1947	0	0	0	0	0	0	0	0	0	5	4	0
1948	0	0	0	0	0	0	0	18	11	8	6	(0)
1949	0	0	0	0	0	238	234	138	131	53	0	0
1950	0	0	0	205	238	235	231	187	180	177	174	(0)
1951	0	238	238	238	238	238	234	227	185	183	44	(0)
1952	0	71	232	238	238	238	238	238	238	61	0	238
1953	238	238	238	238	215	212	207	201	194	(0)	0	0
1954	201	238	173	238	238	238	238	198	182	180	72	(0)
1955	0	6	233	238	233	230	225	219	212	209	206	(0)
1956	0	0	238	238	238	238	234	238	231	55	(0)	12
1957	238	206	0	0	174	238	182	176	161	158	155	(0)
1958	160	238	238	238	238	238	238	238	238	0	0	229
1959	238	238	36	238	238	70	(0)	0	0	5	0	0
1960	0	0	2	(0)	145	142	70	39	32	29	0	0
1961	0	0	0	0	205	202	129	98	91	88	0	0
1962	0	0	0	0	222	219	135	93	86	83	(0)	0
1963	238	238	225	238	238	238	238	238	231	153	(0)	0
1964	105	238	148	238	221	218	177	142	135	132	129	0
1965	0	0	238	238	238	231	238	168	126	123	(0)	0
1966	39	238	238	238	236	233	229	133	126	123	80	(0)
1967	0	0	238	238	238	238	238	238	238	238	0	231
1968	238	238	238	238	238	238	196	113	106	103	(0)	0
1969	0	0	238	238	238	238	238	238	238	0	0	238
1970	238	238	238	238	238	238	224	215	208	205	0	0
1971	0	238	238	238	44	238	229	238	231	228	(0)	0
1972	151	139	225	238	236	238	196	161	154	151	148	0
1973	0	238	222	238	238	238	234	227	185	172	0	0
1974	0	238	238	238	238	238	238	232	225	24	0	179
1975	238	238	238	238	238	238	234	238	231	129	0	44
1976	238	238	167	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	238	238	238	238	232	210	(0)	0	0
1979	186	196	0	238	238	238	234	227	185	34	0	0
1980	0	175	237	238	238	238	234	227	190	0	0	0
1981	176	165	238	238	236	238	193	110	103	101	(0)	0
1982	0	238	216	238	238	238	238	238	233	64	(0)	238
1983	238	238	238	238	238	238	238	238	238	238	238	238
1984	238	238	238	238	238	238	234	227	220	170	(0)	0
1985	186	238	238	237	235	232	182	148	141	138	72	(0)
1986	0	0	24	176	238	238	238	232	225	(0)	0	0
1987	0	0	0	0	0	68	12	(0)	0	5	0	0
1988	0	0	2	236	235	232	192	160	153	(0)	0	0
1989	0	0	0	0	0	232	227	170	163	161	158	(0)
1990	0	0	0	61	59	56	12	(0)	0	0	0	0
1991	0	0	0	0	0	4	0	0	0	0	0	0
Average	65	105	122	162	175	181	167	148	135	75	23	26

Table A3–8. DeltaSOS Mean Annual Simulation Output for Alternative 1

Water Year	Sac Basin Year Type	SJR Basin Year Type	Added Sac Flow (TAF)	New Sac Flow (TAF)	Required SJR Flow (TAF)	Added SJR Flow (TAF)	New SJR Flow (TAF)	Steam & Sutter Flow (TAF)	DCC Rio Vista Reduction (TAF)	Revised DCC Flow (TAF)	Revised Georgiana & DCC (TAF)	Revised Rio Vista Flow (TAF)	QWEST w/ Initial Export (TAF)
1922	2	1	0	15,237	1,682	0	3,037	4,804	0	949	3,631	11,586	824
1923	3	2	0	14,489	1,663	73	2,564	4,395	0	1,567	4,039	10,425	465
1924	5	5	0	8,586	820	4	1,264	2,261	32	1,115	2,902	5,437	(1,130)
1925	4	3	0	12,064	1,213	29	1,491	3,509	0	1,438	3,630	9,040	(667)
1926	4	4	0	11,614	1,107	0	1,511	3,338	0	1,419	3,554	8,157	(1,037)
1927	1	2	0	19,015	1,663	71	1,963	6,229	0	1,355	4,501	17,527	212
1928	2	3	0	18,455	1,295	30	1,736	6,051	0	1,477	4,542	14,653	(275)
1929	5	5	0	8,696	820	2	1,306	2,314	42	1,147	2,939	5,573	(886)
1930	4	5	0	10,768	816	28	1,168	3,052	0	1,269	3,310	7,368	(1,021)
1931	5	5	0	6,775	790	2	1,257	1,651	91	875	2,453	4,103	(287)
1932	4	2	0	8,618	1,244	0	1,655	2,274	0	1,142	2,924	5,630	308
1933	5	4	0	7,535	1,004	0	1,388	1,931	97	908	2,579	4,753	(326)
1934	5	5	0	8,173	820	4	1,205	2,172	66	916	2,658	5,386	(423)
1935	3	2	0	12,496	1,477	0	2,051	3,700	29	1,301	3,554	9,935	(372)
1936	3	2	0	13,335	1,585	80	2,221	3,996	0	1,365	3,727	10,821	136
1937	3	1	0	12,426	1,682	56	2,860	3,671	0	1,290	3,547	8,936	804
1938	1	1	0	28,179	1,759	0	5,428	9,982	0	1,057	5,533	31,093	5,905
1939	4	4	0	10,712	1,004	0	1,695	3,007	0	1,498	3,498	6,983	(510)
1940	2	2	0	17,638	1,585	78	1,973	5,687	0	1,469	4,408	17,640	100
1941	1	1	0	23,780	1,759	0	3,677	8,157	0	1,370	5,188	27,629	2,950
1942	1	1	0	25,353	1,759	0	2,986	8,822	0	1,151	5,211	25,051	2,793
1943	1	1	0	20,972	1,759	78	3,229	6,984	0	1,426	4,820	17,571	3,269
1944	4	3	0	11,388	1,140	45	1,688	3,253	0	1,423	3,528	7,790	(1,164)
1945	3	2	0	12,566	1,507	77	2,321	3,714	0	1,386	3,653	9,005	(244)
1946	3	2	0	16,177	1,585	74	2,146	5,102	0	1,435	4,178	13,192	(65)
1947	4	4	0	10,949	1,056	50	1,607	3,089	0	1,438	3,480	7,285	(1,585)
1948	3	3	0	13,098	1,140	3	1,421	3,868	0	1,630	3,917	8,948	(1,430)
1949	4	3	0	11,993	1,140	49	1,472	3,503	0	1,421	3,616	8,292	(1,039)
1950	3	3	0	12,811	1,192	0	1,532	3,774	0	1,525	3,793	8,851	(1,161)
1951	2	2	0	21,672	1,663	80	2,663	7,244	0	1,526	5,004	18,363	1,957
1952	1	1	0	28,323	1,759	0	3,023	9,970	0	1,183	5,647	24,889	2,963
1953	1	3	0	18,839	1,295	0	1,965	6,162	0	1,240	4,362	16,711	767
1954	2	3	0	19,873	1,295	29	1,601	6,490	0	1,575	4,778	15,551	(526)
1955	4	4	0	11,447	1,056	9	1,374	3,263	0	1,488	3,587	7,775	(1,416)
1956	1	1	0	21,768	1,759	0	3,270	7,335	0	1,499	5,011	24,852	2,374
1957	2	3	0	15,092	1,244	27	1,812	4,642	0	1,623	4,175	11,044	(740)
1958	1	1	0	26,266	1,759	1	3,397	9,182	0	1,243	5,417	29,612	3,022
1959	3	4	0	14,716	1,159	69	1,800	4,523	0	1,536	4,064	10,754	112
1960	4	5	0	11,339	846	30	1,247	3,228	0	1,455	3,546	7,825	(1,648)
1961	4	5	0	11,459	842	40	1,179	3,280	0	1,434	3,545	7,844	(1,714)
1962	3	3	0	12,372	1,110	45	1,530	3,632	0	1,418	3,656	9,182	(951)
1963	1	2	0	20,611	1,585	0	1,934	6,877	0	1,184	4,566	18,800	(18)
1964	4	4	0	12,397	1,056	36	1,394	3,615	0	1,540	3,756	8,495	(1,369)
1965	1	1	0	19,519	1,759	80	2,404	6,453	0	1,378	4,592	19,247	758
1966	3	3	0	13,901	1,244	49	2,011	4,172	0	1,502	3,913	10,033	(959)
1967	1	1	0	22,181	1,759	0	3,304	7,439	0	1,144	4,729	19,913	1,947
1968	3	4	0	15,971	1,211	49	1,709	5,020	0	1,525	4,226	12,181	706
1969	1	1	0	23,660	1,759	0	5,442	8,066	0	1,543	5,297	23,945	5,690
1970	1	2	0	21,543	1,585	74	3,357	7,316	0	1,506	5,006	24,373	3,752
1971	1	3	0	20,939	1,295	0	1,732	6,908	0	1,583	4,932	16,920	(185)
1972	3	4	0	13,210	1,107	0	1,515	3,920	0	1,524	3,842	9,253	(1,549)
1973	2	2	0	19,810	1,663	78	2,252	6,529	0	1,487	4,717	18,433	995
1974	1	1	0	29,264	1,759	2	2,240	10,392	0	1,580	6,144	30,030	2,138
1975	1	1	0	20,440	1,682	0	2,310	6,784	0	1,674	4,962	16,153	919
1976	5	5	0	10,456	820	9	1,169	2,943	4	1,324	3,307	6,917	(1,263)
1977	5	5	0	6,824	790	0	1,016	1,703	36	821	2,391	4,233	(428)
1978	2	1	0	16,859	1,729	0	2,267	5,405	31	1,187	4,063	15,113	2,171
1979	3	2	0	13,993	1,585	78	2,378	4,235	0	1,449	3,884	10,011	355
1980	2	1	0	18,292	1,759	0	4,818	6,032	0	1,267	4,358	19,356	4,240
1981	4	4	0	13,093	1,159	49	1,962	3,885	0	1,436	3,756	9,162	(436)
1982	1	1	0	29,591	1,759	3	5,389	10,473	0	1,562	6,157	30,065	6,953
1983	1	1	0	35,577	1,759	0	15,726	12,980	0	1,050	6,551	42,561	21,590
1984	1	2	0	23,213	1,585	74	6,524	7,985	0	1,190	4,958	22,157	8,228
1985	4	4	0	13,038	1,107	50	1,909	3,861	0	1,485	3,790	9,191	(591)
1986	1	1	0	18,958	1,682	0	4,814	6,463	0	1,300	4,534	23,167	4,991
1987	4	5	0	10,952	846	16	1,661	3,102	0	1,383	3,437	7,300	(1,270)
1988	5	5	0	9,416	790	6	1,020	2,563	38	1,161	3,048	6,236	(961)
1989	4	5	0	11,782	842	31	1,036	3,442	31	1,324	3,490	8,090	(1,309)
1990	5	5	0	8,675	790	4	944	2,288	52	1,143	2,939	5,561	(812)
1991	5	5	0	8,612	816	37	995	2,286	29	1,072	2,863	5,552	(564)
Average			0	15,998	1,331	27	2,428	5,091	8	1,347	4,090	13,793	887

Notes: Definitions of the categories are provided in Table A2–3 in Appendix A2.
Water–year types: 1=wet, 2=above normal, 3=below normal, 4=dry, 5=critically dry
Negative values shown in parentheses.

Table A3–8. Continued

Water Year	Reduced Export for QWEST (TAF)	Initial Collinsville Outflow (TAF)	Initial Chipps Outflow (TAF)	Required Delta Outflow (TAF)	Revised Montez. Flow (TAF)	Reduced Export for Outflow (TAF)	Export Limits (TAF)	Reduced Export for Limits (TAF)	Net Export Change (TAF)	Adjusted Total Export (TAF)	Revised QWEST Flow (TAF)	Revised Collinsville Outflow (TAF)
1922	0	12,321	11,391	6,103	930	1	8,364	13	204	6,389	620	12,117
1923	0	10,803	9,917	5,833	886	0	9,521	4	294	6,485	171	10,509
1924	0	4,180	3,375	4,063	805	3	5,401	2	16	4,558	(1,146)	4,164
1925	0	8,292	7,430	5,195	862	3	7,312	8	68	5,803	(736)	8,223
1926	0	7,022	6,175	5,006	847	3	6,923	11	13	5,746	(1,050)	7,009
1927	0	17,655	16,686	6,980	970	1	10,720	6	376	6,618	(163)	17,280
1928	0	14,277	13,355	6,665	922	1	10,032	6	419	6,746	(694)	13,858
1929	0	4,573	3,760	4,418	813	3	5,435	0	19	4,583	(906)	4,553
1930	0	6,245	5,414	5,052	832	3	6,182	9	5	5,014	(1,026)	6,240
1931	0	3,702	2,901	3,657	800	3	4,306	0	14	3,341	(301)	3,688
1932	0	5,849	5,019	5,190	831	1	5,625	6	149	4,296	159	5,701
1933	0	4,313	3,503	4,050	810	3	4,694	0	18	3,696	(344)	4,295
1934	0	4,853	4,038	4,532	815	3	4,803	2	20	3,757	(443)	4,833
1935	0	9,477	8,584	6,455	893	3	7,413	3	67	5,992	(438)	9,411
1936	0	10,877	9,993	6,248	883	3	8,419	25	31	6,184	105	10,846
1937	0	9,666	8,791	5,287	874	3	7,752	44	23	5,902	781	9,643
1938	0	36,940	35,736	8,125	1,204	1	18,482	6	996	7,223	4,909	35,944
1939	0	6,353	5,520	4,357	833	0	6,865	1	705	5,793	(1,215)	5,648
1940	0	17,676	16,697	7,246	979	3	10,409	27	47	6,467	53	17,629
1941	0	30,529	29,403	7,010	1,125	1	16,412	14	394	6,669	2,557	30,135
1942	0	27,769	26,688	6,671	1,082	0	16,125	0	1,291	7,240	1,502	26,478
1943	0	20,751	19,767	7,309	984	0	13,363	0	1,172	6,730	2,097	19,579
1944	0	6,521	5,686	4,952	835	3	6,788	9	67	5,995	(1,231)	6,454
1945	0	8,664	7,806	5,277	858	1	7,966	4	332	6,466	(576)	8,332
1946	0	13,020	12,120	6,279	900	1	11,239	6	26	6,316	(90)	12,994
1947	0	5,583	4,756	5,072	827	3	6,751	1	6	6,039	(1,590)	5,578
1948	0	7,409	6,543	5,487	866	3	7,141	1	62	6,363	(1,492)	7,347
1949	0	7,142	6,299	4,921	843	3	6,947	16	29	5,720	(1,068)	7,113
1950	0	7,579	6,725	5,599	854	3	7,295	11	29	6,180	(1,190)	7,550
1951	0	20,237	19,264	6,326	972	0	14,970	11	364	7,129	1,593	19,873
1952	0	27,785	26,665	7,985	1,120	1	15,787	5	614	7,541	2,349	27,171
1953	0	17,375	16,419	6,080	956	0	12,676	0	1,508	6,812	(741)	15,867
1954	0	14,909	13,968	7,021	940	1	10,339	0	663	7,036	(1,189)	14,246
1955	0	6,255	5,422	5,051	834	0	7,346	7	63	6,079	(1,480)	6,192
1956	0	27,158	26,099	6,221	1,058	1	17,795	5	304	7,128	2,070	26,853
1957	0	10,196	9,315	5,661	880	2	8,552	1	483	6,769	(1,223)	9,712
1958	0	32,590	31,417	7,267	1,173	0	16,086	6	596	7,642	2,426	31,995
1959	0	10,755	9,880	5,294	875	0	8,800	0	942	6,118	(829)	9,813
1960	0	6,062	5,230	5,203	832	3	6,803	11	(1)	5,855	(1,648)	6,063
1961	0	6,020	5,189	5,097	831	3	6,750	8	1	5,777	(1,715)	6,018
1962	0	8,134	7,281	5,063	853	3	7,528	9	2	5,798	(952)	8,132
1963	0	18,707	17,694	7,329	1,013	0	11,162	6	487	7,138	(505)	18,220
1964	0	7,008	6,169	5,143	839	1	7,804	1	61	5,975	(1,430)	6,947
1965	0	19,912	18,920	6,670	991	1	14,496	6	97	6,748	661	19,814
1966	0	8,964	8,102	5,602	862	0	8,613	4	404	6,807	(1,364)	8,560
1967	0	21,799	20,750	7,553	1,049	1	13,108	6	762	7,627	1,185	21,037
1968	0	12,778	11,884	5,557	894	0	9,256	0	1,773	6,556	(1,067)	11,005
1969	0	29,568	28,445	7,967	1,123	1	16,813	6	883	7,313	4,807	28,685
1970	0	28,036	26,997	5,637	1,039	0	18,655	0	1,757	6,789	1,995	26,278
1971	0	16,639	15,687	7,094	952	1	12,449	6	161	6,974	(346)	16,478
1972	0	7,581	6,735	5,409	846	0	7,849	4	330	6,673	(1,879)	7,251
1973	0	19,377	18,410	6,821	966	0	12,919	13	324	6,932	671	19,053
1974	0	32,083	30,958	6,944	1,126	1	19,746	3	615	7,444	1,523	31,468
1975	0	16,975	16,015	6,627	960	0	10,903	0	1,111	7,604	(192)	15,864
1976	0	5,528	4,706	4,416	821	1	6,343	0	96	5,095	(1,359)	5,432
1977	0	3,682	2,882	3,657	800	3	4,264	0	24	3,076	(452)	3,658
1978	0	17,228	16,266	7,933	962	3	10,117	0	1,221	5,728	950	16,008
1979	0	10,275	9,397	5,844	878	1	8,242	0	693	6,498	(338)	9,582
1980	0	23,524	22,522	6,568	1,002	1	14,443	19	711	6,384	3,529	22,813
1981	0	8,612	7,757	5,109	855	0	7,849	0	901	6,488	(1,337)	7,711
1982	0	36,973	35,733	7,099	1,240	1	20,240	6	515	7,781	6,438	36,458
1983	0	64,141	62,588	6,197	1,553	0	31,346	0	2,964	8,377	18,627	61,177
1984	0	30,285	29,222	5,676	1,063	0	20,548	0	2,502	7,078	5,725	27,782
1985	0	8,501	7,647	5,068	854	0	8,383	4	317	6,251	(908)	8,184
1986	0	28,103	27,051	6,155	1,052	1	14,333	46	227	6,495	4,764	27,876
1987	0	5,913	5,083	4,819	829	2	6,602	0	47	5,854	(1,317)	5,866
1988	0	5,167	4,349	4,505	818	3	5,648	5	10	4,456	(971)	5,157
1989	0	6,669	5,825	4,816	844	2	6,313	17	22	5,300	(1,331)	6,647
1990	0	4,640	3,825	4,506	814	3	5,037	2	12	4,077	(824)	4,628
1991	0	4,878	4,062	4,088	816	3	4,808	4	16	3,824	(581)	4,862
Average	0	14,587	13,656	5,802	931	1	10,292	7	450	6,162	437	14,137

Table A3–8. Continued

Water Year	Available for DW Diversion (TAF)	Delta Storage (TAF)	Delta Storage Diversion (TAF)	Delta Storage Export (TAF)	Delta Storage Outflow (TAF)	Final Total Export (TAF)	Final QWEST Flow (TAF)	Final Delta Outflow (TAF)	3–Mile Slough Flow (TAF)	Old River Diversion Flow (TAF)	Final Antioch Flow (TAF)	Old & Middle Flow (TAF)
1922	1,073	238	257	225	0	6,614	363	11,860	2,587	1,587	2,950	(5,526)
1923	2,239	238	246	241	0	6,726	(75)	10,263	2,454	1,369	2,379	(5,852)
1924	3	3	3	0	0	4,558	(1,149)	4,161	1,627	825	478	(4,391)
1925	774	222	246	183	0	5,987	(982)	7,977	2,415	852	1,433	(5,612)
1926	432	238	260	203	0	5,950	(1,309)	6,750	2,312	877	1,003	(5,610)
1927	2,854	238	277	239	0	6,857	(441)	17,003	4,224	1,038	3,783	(6,297)
1928	2,473	238	252	207	0	6,953	(946)	13,606	3,712	996	2,766	(6,504)
1929	0	0	0	0	0	4,583	(906)	4,553	1,583	851	677	(4,338)
1930	281	238	238	203	0	5,218	(1,264)	6,002	2,114	764	850	(5,013)
1931	0	0	0	0	0	3,341	(301)	3,688	1,051	831	750	(3,120)
1932	148	150	148	142	0	4,439	11	5,553	1,309	943	1,320	(4,009)
1933	0	0	0	0	0	3,696	(344)	4,295	1,216	853	872	(3,461)
1934	121	123	121	92	0	3,849	(564)	4,712	1,432	805	868	(3,644)
1935	617	238	248	206	0	6,198	(686)	9,163	2,531	1,100	1,845	(5,596)
1936	1,433	238	243	208	0	6,392	(138)	10,603	2,566	1,192	2,428	(5,663)
1937	934	238	259	214	0	6,115	522	9,383	1,920	1,494	2,442	(5,066)
1938	8,837	238	431	225	0	7,448	4,478	35,514	5,845	3,087	10,323	(4,735)
1939	552	238	84	202	0	5,995	(1,299)	5,564	2,035	995	736	(5,626)
1940	2,660	238	248	209	0	6,676	(195)	17,381	4,173	1,046	3,978	(6,032)
1941	5,968	238	249	219	0	6,887	2,307	29,885	5,717	2,157	8,025	(5,077)
1942	5,142	238	252	219	0	7,459	1,251	26,227	5,448	1,534	6,698	(6,371)
1943	4,700	238	246	214	0	6,944	1,851	19,334	3,516	1,611	5,367	(5,831)
1944	50	43	50	36	0	6,031	(1,281)	6,405	2,217	984	936	(5,609)
1945	880	238	253	201	0	6,667	(829)	8,079	2,359	1,254	1,530	(5,947)
1946	2,353	238	247	242	0	6,558	(338)	12,747	3,181	1,139	2,843	(5,993)
1947	9	5	9	0	0	6,039	(1,599)	5,568	2,199	958	600	(5,693)
1948	27	18	27	0	0	6,364	(1,519)	7,320	2,562	806	1,043	(6,138)
1949	449	238	233	201	0	5,922	(1,301)	6,880	2,341	842	1,040	(5,669)
1950	327	238	248	208	0	6,388	(1,438)	7,302	2,514	866	1,076	(6,111)
1951	5,187	238	253	204	0	7,333	1,341	19,621	3,860	1,430	5,201	(6,376)
1952	6,016	238	506	224	0	7,765	1,842	26,665	5,224	1,548	7,067	(6,626)
1953	2,567	238	6	206	0	7,018	(747)	15,861	4,130	1,084	3,382	(6,489)
1954	2,577	238	315	271	0	7,307	(1,504)	13,931	4,097	908	2,592	(7,006)
1955	709	238	249	213	0	6,292	(1,729)	5,943	2,354	844	625	(6,003)
1956	5,267	238	262	212	0	7,339	1,809	26,592	5,226	1,711	7,035	(6,049)
1957	940	238	488	444	0	7,213	(1,711)	9,224	3,111	964	1,400	(6,828)
1958	6,698	238	493	225	0	7,868	1,933	31,501	6,297	2,019	8,230	(6,167)
1959	1,811	238	219	425	0	6,543	(1,048)	9,595	2,835	997	1,787	(6,138)
1960	159	145	159	116	0	5,971	(1,807)	5,903	2,390	802	583	(5,769)
1961	227	205	227	173	0	5,950	(1,942)	5,791	2,437	763	495	(5,773)
1962	827	222	246	190	0	5,989	(1,199)	7,886	2,516	892	1,318	(5,631)
1963	3,055	238	264	224	0	7,363	(770)	17,955	4,624	1,021	3,854	(6,786)
1964	1,263	238	337	294	0	6,270	(1,768)	6,610	2,534	869	766	(6,015)
1965	3,157	238	253	216	0	6,964	408	19,562	4,359	1,246	4,767	(6,237)
1966	1,218	238	248	199	0	7,006	(1,612)	8,312	2,844	1,110	1,232	(6,478)
1967	4,461	238	498	226	0	7,853	687	20,539	4,427	1,729	5,113	(6,515)
1968	2,134	238	23	208	0	6,763	(1,090)	10,982	3,181	943	2,091	(6,401)
1969	6,436	238	497	225	0	7,538	4,309	28,188	4,231	3,097	8,541	(4,853)
1970	5,616	238	16	207	0	6,995	1,978	26,262	5,062	1,632	7,040	(5,866)
1971	3,002	238	456	431	0	7,405	(802)	16,022	4,196	993	3,393	(6,939)
1972	609	238	273	235	0	6,908	(2,152)	6,978	2,832	902	679	(6,642)
1973	4,138	238	263	218	0	7,150	408	18,790	4,169	1,204	4,577	(6,293)
1974	6,244	238	433	206	0	7,649	1,091	31,036	6,658	1,154	7,749	(6,978)
1975	2,724	238	124	212	0	7,816	(316)	15,740	3,864	1,176	3,549	(7,174)
1976	567	238	195	232	0	5,326	(1,554)	5,237	2,099	755	546	(5,230)
1977	0	0	0	0	0	3,076	(452)	3,658	1,128	676	676	(3,050)
1978	2,713	238	243	213	0	5,941	708	15,765	3,301	1,158	4,009	(5,160)
1979	1,050	238	432	393	0	6,891	(770)	9,150	2,575	1,220	1,805	(6,180)
1980	5,331	238	246	210	0	6,594	3,282	22,566	3,483	2,567	6,766	(4,459)
1981	782	238	256	217	0	6,706	(1,592)	7,456	2,635	1,068	1,042	(6,237)
1982	8,660	238	522	235	0	8,016	5,916	35,935	5,154	3,355	11,070	(4,988)
1983	21,447	238	49	0	0	8,377	18,578	61,128	4,099	9,324	22,677	760
1984	8,815	238	11	201	0	7,280	5,714	27,771	3,374	3,669	9,088	(4,156)
1985	1,578	238	242	199	0	6,450	(1,150)	7,942	2,503	1,103	1,353	(5,888)
1986	6,120	238	250	213	0	6,707	4,514	27,626	3,986	2,756	8,500	(4,314)
1987	72	68	72	58	0	5,912	(1,389)	5,794	2,137	919	748	(5,606)
1988	417	237	234	205	0	4,660	(1,205)	4,923	1,831	685	626	(4,551)
1989	236	232	236	204	0	5,504	(1,567)	6,411	2,377	646	810	(5,451)
1990	60	61	60	46	0	4,123	(884)	4,568	1,573	633	690	(4,081)
1991	4	4	4	0	0	3,824	(585)	4,858	1,477	634	893	(3,788)
Average	2,575	198	222	188	0	6,350	215	13,915	3,148	1,370	3,363	(5,499)

Table A3–9. Monthly Percentiles for DeltaSOS Simulations for Alternative 1

DW diversion (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	15	0	0	0	0	0	0	0	0
50	0	0	13	15	30	49	0	0	0	0	0	0
60	0	25	13	15	31	49	0	0	0	85	0	0
70	53	25	13	222	31	49	0	0	0	86	0	0
80	1,020	906	384	1,065	31	49	76	99	0	86	0	0
90	3,019	4,000	1,744	3,326	2,465	76	76	99	37	86	67	734
100	3,871	4,000	3,871	3,871	4,000	3,871	192	297	118	130	115	4,000
Mean	641	698	502	691	438	216	24	29	12	43	10	379

DW storage (TAF)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	(0)	0	0	(0)	(0)	0	(0)	(0)	(0)
10	0	0	0	0	0	0	0	0	0	(0)	(0)	(0)
20	0	0	0	0	14	56	7	0	0	0	0	0
30	0	0	0	61	174	218	151	110	86	0	0	0
40	0	0	2	236	233	232	196	148	131	5	0	0
50	0	0	148	238	236	235	229	176	155	34	0	0
60	0	196	225	238	238	238	234	209	185	88	0	0
70	39	238	238	238	238	238	234	227	194	138	0	0
80	201	238	238	238	238	238	238	232	225	161	6	0
90	238	238	238	238	238	238	238	238	233	183	80	164
100	238	238	238	238	238	238	238	238	238	238	238	238
Mean	65	105	122	162	175	181	167	148	135	75	23	26

DW discharge for export (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	433	0
70	0	0	0	0	0	0	0	411	0	1,141	987	0
80	0	0	0	0	0	0	616	480	136	2,614	1,888	0
90	0	0	352	0	0	0	768	827	586	3,291	2,679	1,195
100	0	515	3,335	2,708	4,000	2,691	1,332	1,843	2,822	3,741	3,755	3,379
Mean	0	12	215	39	174	78	204	259	130	910	796	304

DW discharge for outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Final CVP Tracy and SWP Banks exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	4,278	3,314	5,051	4,859	6,075	4,123	2,842	2,455	1,145	1,896	597	3,296
10	5,115	5,373	7,351	9,055	6,407	4,723	3,810	3,327	5,500	6,208	3,607	3,617
20	6,844	6,628	8,569	11,036	7,754	6,095	4,662	3,956	5,568	7,611	4,790	5,966
30	7,982	7,360	10,426	11,372	9,746	8,217	4,975	4,464	5,804	10,052	5,143	6,100
40	8,490	8,371	11,114	11,428	11,320	10,191	5,753	5,424	6,202	11,280	6,824	6,405
50	9,045	10,658	11,281	11,562	11,663	11,268	6,573	6,064	6,595	11,280	8,279	6,626
60	9,700	11,280	11,315	11,732	12,097	11,340	7,380	6,581	6,968	11,280	9,116	7,589
70	11,280	11,280	11,399	11,849	12,506	11,461	8,428	7,882	7,148	11,280	10,296	9,087
80	11,280	11,280	11,472	12,266	12,700	11,499	9,203	9,437	8,756	11,280	11,280	10,268
90	11,280	11,280	11,658	12,700	12,700	11,700	9,950	9,950	11,280	11,280	11,280	11,280
100	11,280	11,280	11,700	12,700	12,700	11,700	11,280	11,280	11,280	11,280	11,280	11,280
Mean	8,958	9,113	10,343	11,247	10,664	9,506	6,886	6,484	7,125	9,902	7,694	7,472

Table A3-10a. DeltaSOS-Simulated DW Operations
for Alternative 2: DW Diversions to Storage (cfs)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (TAF)
1922	0	0	1,744	2,047	135	49	0	172	118	0	0	0	257
1923	3,871	25	13	15	0	0	0	0	0	86	67	0	246
1924	0	0	0	55	0	0	0	0	0	0	0	0	3
1925	0	0	0	0	4,000	0	0	0	0	86	0	0	246
1926	0	0	0	869	3,354	0	0	0	0	85	0	0	260
1927	0	4,000	13	161	31	49	76	0	0	0	0	0	261
1928	0	4,000	13	15	0	657	0	0	0	86	0	0	287
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	3,871	0	179	0	0	0	0	0	0	244
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	863	1,593	0	0	0	0	0	0	0	0	148
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	2,005	0	0	0	0	0	0	0	0	121
1935	0	0	0	3,871	0	0	1,869	0	0	86	0	0	351
1936	0	0	0	3,871	30	49	0	0	0	86	0	0	243
1937	0	0	0	0	4,000	307	0	0	0	0	0	0	259
1938	0	4,000	13	15	31	49	76	99	118	0	0	2,749	431
1939	1,263	25	13	0	0	0	0	0	0	86	0	0	84
1940	0	0	0	3,871	30	49	76	0	0	85	0	0	248
1941	0	0	3,871	15	31	49	76	99	0	0	0	0	249
1942	3,871	25	13	15	31	0	269	99	0	0	0	0	260
1943	3,871	25	13	15	31	49	76	0	0	0	0	0	246
1944	0	0	0	0	742	0	0	0	0	86	0	0	50
1945	0	0	1,686	0	2,465	49	0	0	0	0	0	0	253
1946	0	3,606	394	15	0	0	0	0	0	86	0	0	247
1947	0	0	0	0	0	0	0	0	0	85	67	0	9
1948	0	0	0	0	0	0	0	297	0	85	67	0	27
1949	0	0	0	0	0	3,871	0	0	0	0	0	0	233
1950	0	0	0	3,326	634	0	0	0	0	87	68	0	248
1951	0	4,000	13	15	31	49	0	0	0	85	0	0	253
1952	0	1,196	2,726	48	30	49	76	99	118	0	0	4,000	503
1953	53	25	13	15	0	0	0	0	0	0	0	0	6
1954	3,262	654	0	645	31	49	76	0	0	87	0	0	289
1955	0	103	3,784	100	0	0	0	0	0	86	66	0	249
1956	0	0	3,871	15	30	49	0	312	0	0	0	204	270
1957	3,726	0	0	0	3,132	1,091	0	0	0	86	67	0	488
1958	2,610	1,328	13	15	31	49	76	99	118	0	0	3,853	493
1959	195	25	0	2,852	31	0	0	0	0	85	0	0	192
1960	0	0	41	0	2,520	0	0	0	0	86	0	0	159
1961	0	0	0	0	3,684	0	0	0	0	85	0	0	227
1962	0	0	0	0	4,000	0	0	0	0	86	0	0	246
1963	3,871	25	13	87	31	49	76	99	0	0	0	0	256
1964	1,710	2,258	0	1,059	0	0	0	0	0	86	68	0	312
1965	0	0	3,871	15	31	0	3,125	0	0	86	0	0	429
1966	631	3,373	13	15	0	0	0	0	0	86	0	0	248
1967	0	0	3,871	15	31	49	76	99	118	130	0	3,879	498
1968	170	25	13	15	30	49	0	0	0	85	0	0	23
1969	0	0	3,871	15	31	49	76	99	118	0	0	4,000	497
1970	53	25	13	15	31	49	0	0	0	87	0	0	16
1971	0	4,000	13	15	0	2,408	0	223	0	85	0	0	406
1972	2,451	0	1,627	90	0	1,020	0	0	0	86	66	0	322
1973	0	4,000	13	103	31	49	0	0	0	0	0	0	253
1974	0	4,000	13	15	31	49	76	0	0	0	0	3,000	433
1975	1,020	25	13	15	31	49	0	172	0	0	0	734	124
1976	3,213	25	0	0	0	0	0	0	0	0	0	0	195
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	3,871	31	49	76	0	0	0	0	0	243
1979	3,019	193	0	3,871	31	49	0	0	0	0	0	0	432
1980	0	2,939	1,040	20	30	49	0	0	0	0	0	0	246
1981	2,867	0	1,198	15	0	696	0	0	0	86	0	0	293
1982	0	4,000	13	138	31	49	76	99	37	0	0	4,000	509
1983	53	25	13	15	31	49	76	99	118	130	115	87	49
1984	53	25	13	15	30	49	0	0	0	0	0	0	11
1985	3,019	906	13	0	0	0	0	0	0	86	0	0	242
1986	0	0	384	2,491	1,149	49	76	0	0	0	0	0	250
1987	0	0	0	0	0	1,106	0	0	0	85	0	0	72
1988	0	0	41	3,845	0	0	0	0	0	0	0	0	234
1989	0	0	0	0	0	3,769	0	0	0	86	67	0	236
1990	0	0	0	990	0	0	0	0	0	0	0	0	60
1991	0	0	0	0	0	64	0	0	0	0	0	0	4
Average	641	698	502	658	438	236	92	31	12	43	10	379	225

Table A3–10b. DeltaSOS–Simulated DW Operations
for Alternative 2: DW Discharge to Export Wheeling (cfs)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (TAF)
1922	0	0	0	0	0	0	0	0	0	3,741	0	0	225
1923	0	0	0	0	4,000	181	0	0	0	0	0	0	252
1924	0	0	0	0	30	0	0	0	0	0	0	0	2
1925	0	0	0	0	0	3,319	0	0	0	0	0	0	200
1926	0	0	0	0	0	3,822	0	0	0	0	0	0	230
1927	0	0	146	0	0	0	0	0	3,780	0	0	0	237
1928	0	0	0	0	621	0	0	383	3,308	0	0	0	260
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	4,000	181	110	0	0	0	0	0	259
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	2,263	248	0	0	0	0	0	0	151
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	2,189	0	0	0	0	0	0	0	132
1935	0	0	0	0	4,000	181	0	734	891	0	0	0	350
1936	0	0	0	0	0	0	0	407	3,283	0	0	0	222
1937	0	0	0	0	0	0	0	2,456	1,166	0	0	0	218
1938	0	0	0	0	0	0	0	0	0	3,741	0	0	225
1939	0	0	0	800	3,353	0	0	0	0	0	0	0	250
1940	0	0	0	0	0	0	0	457	3,308	0	0	0	227
1941	0	0	0	0	0	0	0	0	2,832	886	0	0	224
1942	0	0	0	0	0	139	0	0	0	3,627	0	0	227
1943	0	0	0	0	0	0	0	1,502	2,228	0	0	0	225
1944	0	0	0	0	0	646	0	0	0	0	0	0	39
1945	0	0	0	0	0	0	555	693	0	2,105	4	0	202
1946	0	0	0	0	4,000	181	0	0	0	0	0	0	252
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	114	0	0	0	7
1949	0	0	0	0	0	0	0	945	2,727	0	0	0	221
1950	0	0	0	0	0	2,636	0	396	0	0	0	340	203
1951	0	0	0	0	0	0	167	0	3,537	0	0	0	223
1952	0	0	34	0	0	0	0	0	0	2,749	876	0	220
1953	0	0	0	0	1,202	2,568	0	0	0	0	0	0	227
1954	0	0	617	0	0	0	0	354	3,414	0	0	0	264
1955	0	0	86	0	2,166	1,838	0	0	0	0	0	0	246
1956	0	0	0	0	0	0	144	0	0	2,727	784	0	220
1957	0	515	3,335	0	0	0	562	0	3,142	0	0	0	455
1958	0	0	0	0	0	0	0	0	0	3,741	0	0	225
1959	0	0	2,824	0	0	3,822	0	0	0	0	0	0	400
1960	0	0	0	26	0	2,309	0	0	0	0	0	0	141
1961	0	0	0	0	0	3,278	0	0	0	0	0	0	198
1962	0	0	0	0	0	1,089	1,053	386	810	0	0	0	201
1963	0	0	73	0	0	0	0	0	2,114	1,141	324	0	220
1964	0	0	1,031	0	4,000	52	0	0	0	0	0	0	306
1965	0	0	0	0	0	2,902	0	677	3,080	0	0	0	401
1966	0	0	0	0	911	742	0	949	0	0	592	164	202
1967	0	0	0	0	0	0	0	0	0	0	3,755	0	226
1968	0	0	0	0	0	0	414	880	0	0	2,144	0	207
1969	0	0	0	0	0	0	0	0	0	3,741	0	0	225
1970	0	0	0	0	0	0	540	664	0	0	2,239	0	207
1971	0	0	0	0	2,581	0	52	0	0	0	3,596	0	375
1972	0	176	75	0	1,661	0	407	312	0	0	0	2,161	289
1973	0	0	89	0	0	0	0	0	3,424	92	0	0	217
1974	0	0	0	0	0	0	0	0	2,416	1,190	0	0	217
1975	0	0	0	0	0	0	0	0	841	1,533	1,165	0	213
1976	0	0	715	2,721	406	0	0	0	0	0	0	0	231
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	67	3,711	0	0	0	228
1979	0	0	3,169	0	0	0	0	0	3,112	443	0	0	405
1980	0	0	5	0	0	0	556	1,548	1,549	0	0	0	220
1981	0	162	0	0	686	0	439	880	0	0	2,120	0	258
1982	0	0	123	0	0	0	0	0	0	2,614	933	0	221
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	139	536	0	697	1,972	0	201
1985	0	0	0	183	3,530	408	0	0	0	0	0	0	248
1986	0	0	0	0	0	0	0	3,771	0	0	0	0	227
1987	0	0	0	0	0	0	563	266	0	0	0	0	50
1988	0	0	0	26	4,000	26	0	0	0	0	0	0	244
1989	0	0	0	0	0	0	0	537	0	0	0	2,861	205
1990	0	0	0	0	1,065	0	0	0	0	0	0	0	64
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	0	12	176	54	667	437	81	283	783	497	293	79	202

Table A3-10c. DeltaSOS-Simulated DW Operations for Alternative 2: DW End-of-Month Storage (TAF)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	0	0	107	232	238	238	234	238	238	0	0	0
1923	238	238	238	238	14	0	0	0	0	5	4	0
1924	0	0	0	3	(0)	0	0	0	0	0	0	0
1925	0	0	0	0	222	15	11	4	0	5	0	0
1926	0	0	0	53	238	(0)	0	0	0	5	0	0
1927	0	238	229	238	238	238	238	232	0	0	0	0
1928	0	238	238	238	201	238	234	204	(0)	5	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	238	14	11	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	53	150	18	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	123	0	0	0	0	0	0	0	0
1935	0	0	0	238	14	0	111	60	(0)	5	0	0
1936	0	0	0	238	238	238	234	202	(0)	5	0	0
1937	0	0	0	0	222	238	234	76	(0)	0	0	0
1938	0	238	238	238	238	238	238	238	238	0	0	164
1939	238	238	238	188	0	0	0	0	0	5	0	0
1940	0	0	0	238	238	238	238	204	0	5	0	0
1941	0	0	238	238	238	238	238	238	62	(0)	0	0
1942	238	238	238	238	238	226	238	238	231	(0)	0	0
1943	238	238	238	238	238	238	238	140	0	0	0	0
1944	0	0	0	0	43	0	0	0	0	5	0	0
1945	0	0	104	103	238	238	200	152	145	7	(0)	0
1946	0	215	238	238	14	0	0	0	0	5	0	0
1947	0	0	0	0	0	0	0	0	0	5	4	0
1948	0	0	0	0	0	0	0	18	4	5	4	0
1949	0	0	0	0	0	238	234	169	(0)	0	0	0
1950	0	0	0	205	238	73	68	38	31	28	25	0
1951	0	238	238	238	238	238	224	217	0	5	0	0
1952	0	71	236	238	238	238	238	238	238	61	0	238
1953	238	238	238	238	170	9	4	0	0	0	0	0
1954	201	238	199	238	238	238	238	210	0	5	0	0
1955	0	6	233	238	116	0	0	0	0	5	4	0
1956	0	0	238	238	238	238	225	238	231	55	(0)	12
1957	238	206	0	0	174	238	200	194	0	5	4	0
1958	160	238	238	238	238	238	238	238	238	0	0	229
1959	238	238	64	238	238	(0)	0	0	0	5	0	0
1960	0	0	2	(0)	145	(0)	0	0	0	5	0	0
1961	0	0	0	0	205	(0)	0	0	0	5	0	0
1962	0	0	0	0	222	152	85	55	(0)	5	0	0
1963	238	238	234	238	238	238	238	238	105	27	(0)	0
1964	105	238	174	238	6	0	0	0	0	5	4	0
1965	0	0	238	238	238	57	238	190	(0)	5	0	0
1966	39	238	238	238	186	137	133	68	61	58	15	(0)
1967	0	0	238	238	238	238	238	238	238	238	0	231
1968	238	238	238	238	238	238	209	149	142	139	(0)	0
1969	0	0	238	238	238	238	238	238	238	0	0	238
1970	238	238	238	238	238	238	201	154	147	145	0	0
1971	0	238	238	238	93	238	230	238	231	228	(0)	0
1972	151	139	233	238	141	200	172	147	140	137	134	(0)
1973	0	238	233	238	238	238	234	227	17	3	0	0
1974	0	238	238	238	238	238	238	232	81	(0)	0	179
1975	238	238	238	238	238	238	234	238	181	79	(0)	44
1976	238	238	193	25	(0)	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	238	238	238	238	228	(0)	0	0	0
1979	186	196	0	238	238	238	234	227	35	0	0	0
1980	0	175	238	238	238	238	200	99	(0)	0	0	0
1981	176	165	238	238	198	238	207	147	140	137	(0)	0
1982	0	238	230	238	238	238	238	238	233	64	(0)	238
1983	238	238	238	238	238	238	238	238	238	238	238	238
1984	238	238	238	238	238	238	225	186	179	128	0	0
1985	186	238	238	226	28	(0)	0	0	0	5	0	0
1986	0	0	24	176	238	238	238	0	0	0	0	0
1987	0	0	0	0	0	68	30	8	1	5	0	0
1988	0	0	2	236	5	0	0	0	0	0	0	0
1989	0	0	0	0	0	232	227	188	181	178	175	0
1990	0	0	0	61	(0)	0	0	0	0	0	0	0
1991	0	0	0	0	0	4	0	0	0	0	0	0
Average	65	105	125	161	147	133	130	111	61	30	9	26

Table A3-11. DeltaSOS Mean Annual Simulation Output for Alternative 2

Water Year	Sac Basin Year Type	SJR Basin Year Type	Added Sac Flow (TAF)	New Sac Flow (TAF)	Required SJR Flow (TAF)	Added SJR Flow (TAF)	New SJR Flow (TAF)	Steam & Sutter Flow (TAF)	DCC Rio Vista Reduction (TAF)	Revised DCC Flow (TAF)	Revised Georgiana & DCC (TAF)	Revised Rio Vista Flow (TAF)	QWEST w/ Initial Export (TAF)
1922	2	1	0	15,237	1,682	0	3,037	4,804	0	949	3,631	11,586	824
1923	3	2	0	14,489	1,663	73	2,564	4,395	0	1,567	4,039	10,425	465
1924	5	5	0	8,586	820	4	1,264	2,261	32	1,115	2,902	5,437	(1,130)
1925	4	3	0	12,064	1,213	29	1,491	3,509	0	1,438	3,630	9,040	(667)
1926	4	4	0	11,614	1,107	0	1,511	3,338	0	1,419	3,554	8,157	(1,037)
1927	1	2	0	19,015	1,663	71	1,963	6,229	0	1,355	4,501	17,527	212
1928	2	3	0	18,455	1,295	30	1,736	6,051	0	1,477	4,542	14,653	(275)
1929	5	5	0	8,696	820	2	1,306	2,314	42	1,147	2,939	5,573	(886)
1930	4	5	0	10,768	816	28	1,168	3,052	0	1,269	3,310	7,368	(1,021)
1931	5	5	0	6,775	790	2	1,257	1,651	91	875	2,453	4,103	(287)
1932	4	2	0	8,618	1,244	0	1,655	2,274	0	1,142	2,924	5,630	308
1933	5	4	0	7,535	1,004	0	1,388	1,931	97	908	2,579	4,753	(326)
1934	5	5	0	8,173	820	4	1,205	2,172	66	916	2,658	5,386	(423)
1935	3	2	0	12,496	1,477	0	2,051	3,700	29	1,301	3,554	9,935	(372)
1936	3	2	0	13,335	1,585	80	2,221	3,996	0	1,365	3,727	10,821	136
1937	3	1	0	12,426	1,682	56	2,860	3,671	0	1,290	3,547	8,936	804
1938	1	1	0	28,179	1,759	0	5,428	9,982	0	1,057	5,533	31,093	5,905
1939	4	4	0	10,712	1,004	0	1,695	3,007	0	1,498	3,498	6,983	(510)
1940	2	2	0	17,638	1,585	78	1,973	5,687	0	1,469	4,408	17,640	100
1941	1	1	0	23,780	1,759	0	3,677	8,157	0	1,370	5,188	27,629	2,950
1942	1	1	0	25,353	1,759	0	2,986	8,822	0	1,151	5,211	25,051	2,793
1943	1	1	0	20,972	1,759	78	3,229	6,984	0	1,426	4,820	17,571	3,269
1944	4	3	0	11,388	1,140	45	1,688	3,253	0	1,423	3,528	7,790	(1,164)
1945	3	2	0	12,566	1,507	77	2,321	3,714	0	1,386	3,653	9,005	(244)
1946	3	2	0	16,177	1,585	74	2,146	5,102	0	1,435	4,178	13,192	(65)
1947	4	4	0	10,949	1,056	50	1,607	3,089	0	1,438	3,480	7,285	(1,585)
1948	3	3	0	13,098	1,140	3	1,421	3,868	0	1,630	3,917	8,948	(1,430)
1949	4	3	0	11,993	1,140	49	1,472	3,503	0	1,421	3,616	8,292	(1,039)
1950	3	3	0	12,811	1,192	0	1,532	3,774	0	1,525	3,793	8,851	(1,161)
1951	2	2	0	21,672	1,663	80	2,663	7,244	0	1,526	5,004	18,363	1,957
1952	1	1	0	28,323	1,759	0	3,023	9,970	0	1,183	5,647	24,889	2,963
1953	1	3	0	18,839	1,295	0	1,965	6,162	0	1,240	4,362	16,711	767
1954	2	3	0	19,873	1,295	29	1,601	6,490	0	1,575	4,778	15,551	(526)
1955	4	4	0	11,447	1,056	9	1,374	3,263	0	1,488	3,587	7,775	(1,416)
1956	1	1	0	21,768	1,759	0	3,270	7,335	0	1,499	5,011	24,852	2,374
1957	2	3	0	15,092	1,244	27	1,812	4,642	0	1,623	4,175	11,044	(740)
1958	1	1	0	26,266	1,759	1	3,397	9,182	0	1,243	5,417	29,612	3,022
1959	3	4	0	14,716	1,159	69	1,800	4,523	0	1,536	4,064	10,754	112
1960	4	5	0	11,339	846	30	1,247	3,228	0	1,455	3,546	7,825	(1,648)
1961	4	5	0	11,459	842	40	1,179	3,280	0	1,434	3,545	7,844	(1,714)
1962	3	3	0	12,372	1,110	45	1,530	3,632	0	1,418	3,656	9,182	(951)
1963	1	2	0	20,611	1,585	0	1,934	6,877	0	1,184	4,566	18,800	(18)
1964	4	4	0	12,397	1,056	36	1,394	3,615	0	1,540	3,756	8,495	(1,369)
1965	1	1	0	19,519	1,759	80	2,404	6,453	0	1,378	4,592	19,247	758
1966	3	3	0	13,901	1,244	49	2,011	4,172	0	1,502	3,913	10,033	(959)
1967	1	1	0	22,181	1,759	0	3,304	7,439	0	1,144	4,729	19,913	1,947
1968	3	4	0	15,971	1,211	49	1,709	5,020	0	1,525	4,226	12,181	706
1969	1	1	0	23,660	1,759	0	5,442	8,066	0	1,543	5,297	23,945	5,690
1970	1	2	0	21,543	1,585	74	3,357	7,316	0	1,506	5,006	24,373	3,752
1971	1	3	0	20,939	1,295	0	1,732	6,908	0	1,583	4,932	16,920	(185)
1972	3	4	0	13,210	1,107	0	1,515	3,920	0	1,524	3,842	9,253	(1,549)
1973	2	2	0	19,810	1,663	78	2,252	6,529	0	1,487	4,717	18,433	995
1974	1	1	0	29,264	1,759	2	2,240	10,392	0	1,580	6,144	30,030	2,138
1975	1	1	0	20,440	1,682	0	2,310	6,784	0	1,674	4,962	16,153	919
1976	5	5	0	10,456	820	9	1,169	2,943	4	1,324	3,307	6,917	(1,263)
1977	5	5	0	6,824	790	0	1,016	1,703	36	821	2,391	4,233	(428)
1978	2	1	0	16,859	1,729	0	2,267	5,405	31	1,187	4,063	15,113	2,171
1979	3	2	0	13,993	1,585	78	2,378	4,235	0	1,449	3,884	10,011	355
1980	2	1	0	18,292	1,759	0	4,818	6,032	0	1,267	4,358	19,356	4,240
1981	4	4	0	13,093	1,159	49	1,962	3,885	0	1,436	3,756	9,162	(436)
1982	1	1	0	29,591	1,759	3	5,389	10,473	0	1,562	6,157	30,065	6,953
1983	1	1	0	35,577	1,759	0	15,726	12,980	0	1,050	6,551	42,561	21,590
1984	1	2	0	23,213	1,585	74	6,524	7,985	0	1,190	4,958	22,157	8,228
1985	4	4	0	13,038	1,107	50	1,909	3,861	0	1,485	3,790	9,191	(591)
1986	1	1	0	18,958	1,682	0	4,814	6,463	0	1,300	4,534	23,167	4,991
1987	4	5	0	10,952	846	16	1,661	3,102	0	1,383	3,437	7,300	(1,270)
1988	5	5	0	9,416	790	6	1,020	2,563	38	1,161	3,048	6,236	(961)
1989	4	5	0	11,782	842	31	1,036	3,442	31	1,324	3,490	8,090	(1,309)
1990	5	5	0	8,675	790	4	944	2,288	52	1,143	2,939	5,561	(812)
1991	5	5	0	8,612	816	37	995	2,286	29	1,072	2,863	5,552	(564)
Average			0	15,998	1,331	27	2,428	5,091	8	1,347	4,090	13,793	887

Notes: Definitions of the categories are provided in Table A2-3 in Appendix A2.
Water-year types: 1=wet, 2=above normal, 3=below normal, 4=dry, 5=critically dry
Negative values shown in parentheses.

Table A3–11. Continued

Water Year	Reduced Export for QWEST (TAF)	Initial Collinsville Outflow (TAF)	Initial Chipps Outflow (TAF)	Required Delta Outflow (TAF)	Revised Montez Flow (TAF)	Reduced Export for Outflow (TAF)	Export Limits (TAF)	Reduced Export for Limits (TAF)	Net Export Change (TAF)	Adjusted Total Export (TAF)	Revised QWEST Flow (TAF)	Revised Collinsville Outflow (TAF)
1922	0	12,321	11,391	6,103	930	1	8,364	13	204	6,389	620	12,117
1923	0	10,803	9,917	5,833	886	0	9,521	4	294	6,485	171	10,509
1924	0	4,180	3,375	4,063	805	3	5,401	2	16	4,558	(1,146)	4,164
1925	0	8,292	7,430	5,195	862	3	7,312	8	68	5,803	(736)	8,223
1926	0	7,022	6,175	5,006	847	3	6,923	11	13	5,746	(1,050)	7,009
1927	0	17,655	16,686	6,980	970	1	10,720	6	376	6,618	(163)	17,280
1928	0	14,277	13,355	6,665	922	1	10,032	6	419	6,746	(694)	13,858
1929	0	4,573	3,760	4,418	813	3	5,435	0	19	4,583	(906)	4,553
1930	0	6,245	5,414	5,052	832	3	6,182	9	5	5,014	(1,026)	6,240
1931	0	3,702	2,901	3,657	800	3	4,306	0	14	3,341	(301)	3,688
1932	0	5,849	5,019	5,190	831	1	5,625	6	149	4,296	159	5,701
1933	0	4,313	3,503	4,050	810	3	4,694	0	18	3,696	(344)	4,295
1934	0	4,853	4,038	4,532	815	3	4,803	2	20	3,757	(443)	4,833
1935	0	9,477	8,584	6,455	893	3	7,413	3	67	5,992	(438)	9,411
1936	0	10,877	9,993	6,248	883	3	8,419	25	31	6,184	105	10,846
1937	0	9,666	8,791	5,287	874	3	7,752	44	23	5,902	781	9,643
1938	0	36,940	35,736	8,125	1,204	1	18,482	6	996	7,223	4,909	35,944
1939	0	6,353	5,520	4,357	833	0	6,865	1	705	5,793	(1,215)	5,648
1940	0	17,676	16,697	7,246	979	3	10,409	27	47	6,467	53	17,629
1941	0	30,529	29,403	7,010	1,125	1	16,412	14	394	6,669	2,557	30,135
1942	0	27,769	26,688	6,671	1,082	0	16,125	0	1,291	7,240	1,502	26,478
1943	0	20,751	19,767	7,309	984	0	13,363	0	1,172	6,730	2,097	19,579
1944	0	6,521	5,686	4,952	835	3	6,788	9	67	5,995	(1,231)	6,454
1945	0	8,664	7,806	5,277	858	1	7,966	4	332	6,466	(576)	8,332
1946	0	13,020	12,120	6,279	900	1	11,239	6	26	6,316	(90)	12,994
1947	0	5,583	4,756	5,072	827	3	6,751	1	6	6,039	(1,590)	5,578
1948	0	7,409	6,543	5,487	866	3	7,141	1	62	6,363	(1,492)	7,347
1949	0	7,142	6,299	4,921	843	3	6,947	16	29	5,720	(1,068)	7,113
1950	0	7,579	6,725	5,599	854	3	7,295	11	29	6,180	(1,190)	7,550
1951	0	20,237	19,264	6,326	972	0	14,970	11	364	7,129	1,593	19,873
1952	0	27,785	26,665	7,985	1,120	1	15,787	5	614	7,541	2,349	27,171
1953	0	17,375	16,419	6,080	956	0	12,676	0	1,508	6,812	(741)	15,867
1954	0	14,909	13,968	7,021	940	1	10,339	0	663	7,036	(1,189)	14,246
1955	0	6,255	5,422	5,051	834	0	7,346	7	63	6,079	(1,480)	6,192
1956	0	27,158	26,099	6,221	1,058	1	17,795	5	304	7,128	2,070	26,853
1957	0	10,196	9,315	5,661	880	2	8,552	1	483	6,769	(1,223)	9,712
1958	0	32,590	31,417	7,267	1,173	0	16,086	6	596	7,642	2,426	31,995
1959	0	10,755	9,880	5,294	875	0	8,800	0	942	6,118	(829)	9,813
1960	0	6,062	5,230	5,203	832	3	6,803	11	(1)	5,855	(1,648)	6,063
1961	0	6,020	5,189	5,097	831	3	6,750	8	1	5,777	(1,715)	6,018
1962	0	8,134	7,281	5,063	853	3	7,528	9	2	5,798	(952)	8,132
1963	0	18,707	17,694	7,329	1,013	0	11,162	6	487	7,138	(505)	18,220
1964	0	7,008	6,169	5,143	839	1	7,804	1	61	5,975	(1,430)	6,947
1965	0	19,912	18,920	6,670	991	1	14,496	6	97	6,748	661	19,814
1966	0	8,964	8,102	5,602	862	0	8,613	4	404	6,807	(1,364)	8,560
1967	0	21,799	20,750	7,553	1,049	1	13,108	6	762	7,627	1,185	21,037
1968	0	12,778	11,884	5,557	894	0	9,256	0	1,773	6,556	(1,067)	11,005
1969	0	29,568	28,445	7,967	1,123	1	16,813	6	883	7,313	4,807	28,685
1970	0	28,036	26,997	5,637	1,039	0	18,655	0	1,757	6,789	1,995	26,278
1971	0	16,639	15,687	7,094	952	1	12,449	6	161	6,974	(346)	16,478
1972	0	7,581	6,735	5,409	846	0	7,849	4	330	6,673	(1,879)	7,251
1973	0	19,377	18,410	6,821	966	0	12,919	13	324	6,932	671	19,053
1974	0	32,083	30,958	6,944	1,126	1	19,746	3	615	7,444	1,523	31,468
1975	0	16,975	16,015	6,627	960	0	10,903	0	1,111	7,604	(192)	15,864
1976	0	5,528	4,706	4,416	821	1	6,343	0	96	5,095	(1,359)	5,432
1977	0	3,682	2,882	3,657	800	3	4,264	0	24	3,076	(452)	3,658
1978	0	17,228	16,266	7,933	962	3	10,117	0	1,221	5,728	950	16,008
1979	0	10,275	9,397	5,844	878	1	8,242	0	693	6,498	(338)	9,582
1980	0	23,524	22,522	6,568	1,002	1	14,443	19	711	6,384	3,529	22,813
1981	0	8,612	7,757	5,109	855	0	7,849	0	901	6,488	(1,337)	7,711
1982	0	36,973	35,733	7,099	1,240	1	20,240	6	515	7,781	6,438	36,458
1983	0	64,141	62,588	6,197	1,553	0	31,346	0	2,964	8,377	18,627	61,177
1984	0	30,285	29,222	5,676	1,063	0	20,548	0	2,502	7,078	5,725	27,782
1985	0	8,501	7,647	5,068	854	0	8,383	4	317	6,251	(908)	8,184
1986	0	28,103	27,051	6,155	1,052	1	14,333	46	227	6,495	4,764	27,876
1987	0	5,913	5,083	4,819	829	2	6,602	0	47	5,854	(1,317)	5,866
1988	0	5,167	4,349	4,505	818	3	5,648	5	10	4,456	(971)	5,157
1989	0	6,669	5,825	4,816	844	2	6,313	17	22	5,300	(1,331)	6,647
1990	0	4,640	3,825	4,506	814	3	5,037	2	12	4,077	(824)	4,628
1991	0	4,878	4,062	4,088	816	3	4,808	4	16	3,824	(581)	4,862
Average	0	14,587	13,656	5,802	931	1	10,292	7	450	6,162	437	14,137

Table A3–11. Continued

Water Year	Available for DW Diversion (TAF)	Delta Storage (TAF)	Delta Storage Diversion (TAF)	Delta Storage Export (TAF)	Delta Storage Outflow (TAF)	Final Total Export (TAF)	Final QWEST Flow (TAF)	Final Delta Outflow (TAF)	3–Mile Slough Flow (TAF)	Old River Diversion Flow (TAF)	Final Antioch Flow (TAF)	Old & Middle Flow (TAF)
1922	1,073	238	257	225	0	6,614	363	11,860	2,587	1,587	2,950	(5,526)
1923	2,239	238	246	252	0	6,737	(75)	10,263	2,454	1,369	2,379	(5,862)
1924	3	3	3	2	0	4,559	(1,149)	4,161	1,627	825	478	(4,393)
1925	774	222	246	200	0	6,003	(982)	7,977	2,415	852	1,433	(5,629)
1926	432	238	260	230	0	5,976	(1,309)	6,750	2,312	877	1,003	(5,637)
1927	2,854	238	261	237	0	6,854	(424)	17,019	4,219	1,038	3,794	(6,295)
1928	2,473	238	287	260	0	7,006	(981)	13,571	3,723	996	2,742	(6,557)
1929	0	0	0	0	0	4,583	(906)	4,553	1,583	851	677	(4,338)
1930	281	238	244	259	0	5,273	(1,270)	5,996	2,116	764	845	(5,069)
1931	0	0	0	0	0	3,341	(301)	3,688	1,051	831	750	(3,120)
1932	148	150	148	151	0	4,447	11	5,553	1,309	943	1,320	(4,018)
1933	0	0	0	0	0	3,696	(344)	4,295	1,216	853	872	(3,461)
1934	121	123	121	132	0	3,889	(564)	4,712	1,432	805	868	(3,683)
1935	617	238	351	350	0	6,342	(789)	9,060	2,563	1,100	1,774	(5,740)
1936	1,433	238	243	222	0	6,407	(138)	10,603	2,566	1,192	2,428	(5,678)
1937	934	238	259	218	0	6,120	522	9,383	1,920	1,494	2,442	(5,071)
1938	8,837	238	431	225	0	7,448	4,478	35,514	5,845	3,087	10,323	(4,735)
1939	552	238	84	250	0	6,043	(1,299)	5,564	2,035	995	736	(5,674)
1940	2,660	238	248	227	0	6,694	(195)	17,381	4,173	1,046	3,978	(6,050)
1941	5,968	238	249	224	0	6,893	2,307	29,885	5,717	2,157	8,025	(5,083)
1942	5,142	238	260	227	0	7,467	1,242	26,218	5,450	1,534	6,692	(6,379)
1943	4,700	238	246	225	0	6,955	1,851	19,334	3,516	1,611	5,367	(5,841)
1944	50	43	50	39	0	6,034	(1,281)	6,405	2,217	984	936	(5,612)
1945	880	238	253	202	0	6,668	(829)	8,079	2,359	1,254	1,530	(5,948)
1946	2,353	238	247	252	0	6,568	(338)	12,747	3,181	1,139	2,843	(6,003)
1947	9	5	9	0	0	6,039	(1,599)	5,568	2,199	958	600	(5,693)
1948	27	18	27	7	0	6,370	(1,519)	7,320	2,562	806	1,043	(6,145)
1949	449	238	233	221	0	5,942	(1,301)	6,880	2,341	842	1,040	(5,689)
1950	327	238	248	203	0	6,383	(1,438)	7,302	2,514	866	1,076	(6,106)
1951	5,187	238	253	223	0	7,352	1,341	19,621	3,860	1,430	5,201	(6,396)
1952	6,016	238	503	220	0	7,761	1,846	26,669	5,223	1,548	7,070	(6,623)
1953	2,567	238	6	227	0	7,039	(747)	15,861	4,130	1,084	3,382	(6,511)
1954	2,577	238	289	264	0	7,300	(1,479)	13,956	4,089	908	2,610	(7,000)
1955	709	238	249	246	0	6,326	(1,729)	5,943	2,354	844	625	(6,037)
1956	5,267	238	270	220	0	7,348	1,800	26,583	5,229	1,711	7,029	(6,057)
1957	940	238	488	455	0	7,224	(1,711)	9,224	3,111	964	1,400	(6,839)
1958	6,698	238	493	225	0	7,868	1,933	31,501	6,297	2,019	8,230	(6,167)
1959	1,811	238	192	400	0	6,518	(1,021)	9,621	2,827	997	1,806	(6,113)
1960	159	145	159	141	0	5,996	(1,807)	5,903	2,390	802	583	(5,794)
1961	227	205	227	198	0	5,974	(1,942)	5,791	2,437	763	495	(5,798)
1962	827	222	246	201	0	6,000	(1,199)	7,886	2,516	892	1,318	(5,642)
1963	3,055	238	256	220	0	7,358	(761)	17,964	4,621	1,021	3,860	(6,782)
1964	1,263	238	312	306	0	6,281	(1,743)	6,635	2,526	869	784	(6,027)
1965	3,157	238	429	401	0	7,150	232	19,385	4,414	1,246	4,646	(6,423)
1966	1,218	238	248	202	0	7,009	(1,612)	8,312	2,844	1,110	1,232	(6,482)
1967	4,461	238	498	226	0	7,853	687	20,539	4,427	1,729	5,113	(6,515)
1968	2,134	238	23	207	0	6,763	(1,090)	10,982	3,181	943	2,091	(6,400)
1969	6,436	238	497	225	0	7,538	4,309	28,188	4,231	3,097	8,541	(4,853)
1970	5,616	238	16	207	0	6,996	1,978	26,262	5,062	1,632	7,040	(5,866)
1971	3,002	238	406	375	0	7,349	(752)	16,072	4,180	993	3,428	(6,884)
1972	609	238	322	289	0	6,962	(2,201)	6,929	2,847	902	646	(6,696)
1973	4,138	238	253	217	0	7,149	418	18,800	4,166	1,204	4,584	(6,292)
1974	6,244	238	433	217	0	7,661	1,091	31,036	6,658	1,154	7,749	(6,989)
1975	2,724	238	124	213	0	7,818	(316)	15,740	3,864	1,176	3,549	(7,176)
1976	567	238	195	231	0	5,326	(1,554)	5,237	2,099	755	546	(5,230)
1977	0	0	0	0	0	3,076	(452)	3,658	1,128	676	676	(3,050)
1978	2,713	238	243	228	0	5,955	708	15,765	3,301	1,158	4,009	(5,174)
1979	1,050	238	432	405	0	6,903	(770)	9,150	2,575	1,220	1,805	(6,192)
1980	5,331	238	246	220	0	6,605	3,283	22,567	3,483	2,567	6,766	(4,470)
1981	782	238	293	258	0	6,747	(1,630)	7,418	2,647	1,068	1,017	(6,278)
1982	8,660	238	509	221	0	8,002	5,930	35,949	5,150	3,355	11,080	(4,974)
1983	21,447	238	49	0	0	8,377	18,578	61,128	4,099	9,324	22,677	760
1984	8,815	238	11	201	0	7,280	5,714	27,771	3,374	3,669	9,088	(4,156)
1985	1,578	238	242	248	0	6,499	(1,150)	7,942	2,503	1,103	1,353	(5,937)
1986	6,120	238	250	227	0	6,722	4,514	27,626	3,986	2,756	8,500	(4,328)
1987	72	68	72	50	0	5,904	(1,389)	5,794	2,137	919	748	(5,598)
1988	417	237	234	244	0	4,700	(1,205)	4,923	1,831	685	626	(4,590)
1989	236	232	236	205	0	5,504	(1,567)	6,411	2,377	646	810	(5,452)
1990	60	61	60	64	0	4,141	(884)	4,568	1,573	633	690	(4,099)
1991	4	4	4	0	0	3,824	(585)	4,858	1,477	634	893	(3,788)
Average	2,575	198	225	202	0	6,364	212	13,912	3,149	1,370	3,361	(5,514)

Table A3-12. Monthly Percentiles for DeltaSOS Simulations for Alternative 2

DW diversion (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	15	0	0	0	0	0	0	0	0
50	0	0	13	15	30	49	0	0	0	0	0	0
60	0	25	13	15	31	49	0	0	0	85	0	0
70	53	25	13	90	31	49	0	0	0	86	0	0
80	1,020	906	384	990	31	49	76	99	0	86	0	0
90	3,019	4,000	1,744	3,326	2,465	657	76	99	37	86	67	734
100	3,871	4,000	3,871	3,871	4,000	3,871	3,125	312	118	130	115	4,000
Mean	641	698	502	658	438	236	92	31	12	43	10	379

DW storage (TAF)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	(0)	(0)	(0)	0	0	(0)	(0)	(0)	(0)
10	0	0	0	0	0	0	0	0	(0)	0	(0)	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	61	14	0	0	0	0	0	0	0
40	0	0	2	226	145	15	30	8	0	0	0	0
50	0	0	174	238	222	226	200	99	0	5	0	0
60	0	196	233	238	238	238	225	169	0	5	0	0
70	39	238	238	238	238	238	234	204	62	5	0	0
80	201	238	238	238	238	238	238	232	147	28	0	0
90	238	238	238	238	238	238	238	238	233	137	4	164
100	238	238	238	238	238	238	238	238	238	238	238	238
Mean	65	105	125	161	147	133	130	111	61	30	9	26

DW discharge for export (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	266	114	0	0	0
80	0	0	0	0	1,065	181	0	457	2,228	443	0	0
90	0	0	123	0	3,353	2,309	414	880	3,283	2,614	933	0
100	0	515	3,335	2,721	4,000	3,822	1,053	3,771	3,780	3,741	3,755	2,861
Mean	0	12	176	54	667	437	81	283	783	497	293	79

DW discharge for outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Final CVP Tracy and SWP Banks exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	4,278	3,314	5,051	4,859	6,090	3,469	2,842	2,455	1,145	1,896	597	3,296
10	5,115	5,373	7,351	9,055	7,140	4,750	3,622	3,174	5,500	4,447	3,508	3,617
20	6,844	6,628	8,569	11,101	9,758	6,363	3,840	3,781	5,568	6,887	4,790	5,915
30	7,982	7,360	10,426	11,380	11,332	10,265	4,414	4,296	5,804	8,729	5,143	6,076
40	8,490	8,371	11,114	11,444	11,633	11,268	5,623	5,362	6,321	10,396	6,183	6,393
50	9,045	10,658	11,265	11,568	11,941	11,268	6,573	6,047	7,001	11,280	7,118	6,568
60	9,700	11,280	11,280	11,768	12,048	11,461	7,380	7,176	8,380	11,280	7,889	6,822
70	11,280	11,280	11,295	11,873	12,462	11,461	8,476	8,380	9,733	11,280	9,116	8,100
80	11,280	11,280	11,393	12,266	12,700	11,499	9,203	9,410	10,551	11,280	10,293	10,087
90	11,280	11,280	11,503	12,700	12,700	11,700	9,950	9,950	11,280	11,280	11,280	11,280
100	11,280	11,280	11,700	12,700	12,700	11,700	11,280	11,280	11,280	11,280	11,280	11,280
Mean	8,958	9,113	10,304	11,261	11,156	9,864	6,764	6,508	7,778	9,489	7,192	7,248

Table A3-13a. DeltaSOS-Simulated DW Operations for Alternative 3: DW Diversions to Storage (cfs)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (TAF)
1922	0	0	1,744	2,047	3,207	98	0	345	235	0	0	0	462
1923	4,297	2,434	26	29	0	0	0	0	0	158	123	0	426
1924	0	0	0	59	0	0	0	0	0	0	0	0	4
1925	0	0	0	0	6,000	0	0	0	0	158	0	0	371
1926	0	0	0	869	6,000	0	0	0	0	157	0	0	423
1927	0	4,137	721	2,080	61	98	151	0	0	0	0	0	437
1928	0	6,000	822	29	0	733	0	0	0	158	0	0	467
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	4,477	0	179	0	0	0	0	0	0	281
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	863	1,593	0	0	0	0	0	0	0	0	148
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	2,005	0	0	0	0	0	0	0	0	121
1935	0	0	0	6,000	0	0	1,869	0	0	158	0	0	484
1936	0	0	0	6,000	704	98	0	0	0	158	0	0	419
1937	0	0	0	0	6,000	1,281	0	0	0	0	0	0	439
1938	0	6,000	822	29	61	98	151	198	235	0	0	2,793	626
1939	4,006	50	26	0	0	0	0	0	0	158	0	0	255
1940	0	0	0	6,000	704	98	151	0	0	157	0	0	428
1941	0	0	6,000	632	61	98	151	198	0	0	0	0	430
1942	5,435	1,257	26	29	61	0	395	198	0	0	0	0	446
1943	6,000	673	26	29	61	98	151	0	0	0	0	0	424
1944	0	0	0	0	742	0	0	0	0	158	0	0	54
1945	0	0	1,686	0	5,537	98	0	0	0	0	0	0	441
1946	0	3,606	3,140	29	0	0	0	0	0	158	0	0	418
1947	0	0	0	0	0	0	0	0	0	157	123	0	17
1948	0	0	0	0	0	0	0	297	0	157	123	0	35
1949	0	0	0	0	0	6,000	0	0	0	0	0	0	362
1950	0	0	0	3,326	1,946	0	0	0	0	159	124	0	335
1951	0	6,000	822	29	61	98	0	0	0	157	0	0	432
1952	0	1,238	5,431	63	59	98	151	198	235	0	0	4,399	715
1953	2,452	50	26	29	0	0	0	0	0	0	0	0	154
1954	3,262	3,502	0	583	61	98	151	0	0	159	0	0	471
1955	0	145	6,000	603	0	0	0	0	0	158	122	0	423
1956	0	0	6,000	632	59	98	0	484	0	0	0	248	453
1957	6,000	0	0	0	3,132	2,393	0	0	0	158	123	0	711
1958	2,610	2,273	1,868	29	61	98	151	198	235	0	0	3,853	685
1959	2,980	50	0	2,844	61	0	0	0	0	157	0	0	367
1960	0	0	76	0	2,520	0	0	0	0	158	0	0	166
1961	0	0	0	0	3,684	0	0	0	0	157	0	0	231
1962	0	0	0	0	6,000	0	0	0	0	158	0	0	371
1963	6,000	673	26	102	61	98	151	198	0	0	0	0	440
1964	1,761	5,054	0	1,054	0	0	0	0	0	158	124	0	491
1965	0	0	6,000	632	61	0	3,000	0	0	158	0	0	594
1966	682	6,000	189	29	0	0	0	0	0	158	0	0	425
1967	0	0	6,000	632	61	98	151	198	235	260	0	3,879	694
1968	1,990	50	26	29	59	98	0	0	0	157	0	0	145
1969	0	0	5,519	1,113	61	98	151	198	235	0	0	6,000	806
1970	902	50	26	29	61	98	0	0	0	159	0	0	80
1971	0	6,000	822	29	0	2,468	0	372	0	157	0	0	593
1972	2,451	0	4,227	104	0	1,020	0	0	0	158	122	0	487
1973	0	5,702	1,111	118	61	98	0	0	0	0	0	0	427
1974	0	6,000	822	29	61	98	151	0	0	0	0	3,044	615
1975	3,763	50	26	29	61	98	0	345	0	0	0	778	310
1976	5,388	637	0	0	0	0	0	0	0	0	0	0	363
1977	0	0	7	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	6,000	729	98	151	0	0	0	0	0	420
1979	3,019	235	0	6,000	729	98	0	0	0	0	0	0	607
1980	0	2,939	3,785	35	59	98	0	0	0	0	0	0	417
1981	2,867	0	1,350	2,606	0	773	0	0	0	158	0	0	467
1982	0	6,000	822	153	61	98	151	198	37	0	0	6,000	815
1983	735	50	26	29	61	98	151	198	235	260	231	175	136
1984	106	50	26	29	59	98	0	0	0	0	0	0	22
1985	3,019	3,754	26	0	0	0	0	0	0	158	0	0	419
1986	0	0	420	2,491	4,181	98	151	0	0	0	0	0	442
1987	0	0	0	0	0	1,106	0	0	0	157	0	0	76
1988	0	0	76	6,000	0	0	0	0	0	0	0	0	366
1989	0	0	0	0	0	3,769	0	0	0	158	123	0	244
1990	0	0	0	990	0	0	0	0	0	0	0	0	60
1991	0	0	0	0	0	64	0	0	0	0	0	0	4
Average	996	1,152	964	976	761	322	110	55	24	80	19	445	356

Table A3-13b. DeltaSOS-Simulated DW Operations
for Alternative 3: DW Discharge to Export Wheeling (cfs)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (TAF)
1922	0	0	0	0	0	0	0	0	0	6,000	112	0	368
1923	0	0	0	0	6,000	1,031	0	0	0	0	0	0	424
1924	0	0	0	0	3	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	3,319	0	0	1,478	0	0	0	289
1926	0	0	0	0	0	4,975	0	259	340	0	0	0	336
1927	0	0	146	0	0	0	0	0	4,692	1,376	0	0	374
1928	0	0	0	0	621	0	0	342	4,836	0	675	0	390
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	4,885	0	34	0	0	0	0	0	296
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	2,263	157	0	0	0	0	0	0	146
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	2,159	0	0	0	0	0	0	0	130
1935	0	0	0	0	4,827	1,045	0	693	1,018	0	0	0	457
1936	0	0	0	0	0	0	0	407	4,658	0	782	0	352
1937	0	0	0	0	0	0	0	2,456	3,694	0	0	0	371
1938	0	0	0	0	0	0	0	0	0	6,000	112	0	368
1939	0	0	0	800	4,359	1,683	0	0	0	0	0	0	412
1940	0	0	0	0	0	0	0	416	4,836	0	747	0	361
1941	0	0	0	0	0	0	0	0	2,832	3,375	0	0	374
1942	0	0	0	0	0	139	0	0	0	6,000	0	0	370
1943	0	0	0	0	0	0	0	1,461	4,873	0	0	0	382
1944	0	0	0	0	0	597	0	0	0	0	0	0	36
1945	0	0	0	0	0	0	555	652	0	2,033	2,317	0	335
1946	0	0	0	0	4,658	2,242	0	0	0	0	0	0	416
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	71	0	0	0	4
1949	0	0	0	0	0	0	0	905	4,674	0	0	0	336
1950	0	0	0	0	0	2,463	0	355	0	0	0	1,201	242
1951	0	0	0	0	0	0	167	0	4,855	0	837	0	353
1952	0	0	34	0	0	0	0	0	0	2,677	3,435	0	370
1953	0	0	0	0	1,184	2,568	0	0	0	1,980	0	0	345
1954	0	0	528	0	0	0	0	313	4,899	0	791	0	393
1955	0	0	86	0	1,837	4,791	0	0	0	0	0	0	404
1956	0	0	0	0	0	0	144	0	0	2,655	3,229	0	363
1957	0	473	3,740	299	0	0	538	0	4,407	0	0	894	624
1958	0	0	0	0	0	0	0	0	0	5,239	873	0	368
1959	0	0	2,788	0	0	4,787	959	272	0	0	0	0	531
1960	0	0	0	47	0	2,260	0	0	0	0	0	0	139
1961	0	0	0	0	0	3,230	0	0	0	0	0	0	195
1962	0	0	0	0	0	1,089	1,030	345	2,396	0	0	0	293
1963	0	0	73	0	0	0	0	0	2,114	1,069	2,769	0	363
1964	0	0	999	0	5,154	1,628	0	0	0	0	0	0	469
1965	0	0	0	0	0	2,920	0	636	4,828	0	275	0	522
1966	0	0	0	0	911	742	0	909	0	0	536	2,445	334
1967	0	0	0	0	0	0	0	0	0	0	5,237	0	316
1968	0	0	0	0	0	0	390	839	0	0	3,627	705	335
1969	0	0	0	0	0	0	0	0	0	4,553	1,559	0	368
1970	0	0	0	0	0	0	517	630	0	0	4,568	0	344
1971	0	0	0	0	2,563	0	29	0	0	0	4,525	1,149	498
1972	0	134	75	0	1,661	0	383	271	0	0	0	3,917	388
1973	425	0	89	0	0	0	0	0	3,362	20	2,266	0	371
1974	0	0	0	0	0	0	0	0	2,416	3,065	283	0	347
1975	0	0	0	0	0	0	0	0	841	1,461	3,609	0	356
1976	0	0	651	2,717	2,055	1,104	0	0	0	0	0	0	393
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	67	4,536	1,460	0	0	365
1979	0	0	3,172	0	0	0	0	0	3,050	2,265	323	0	531
1980	0	0	5	0	0	0	556	1,548	4,076	0	0	0	373
1981	0	120	0	0	686	0	416	839	0	0	3,614	695	384
1982	0	0	123	0	0	0	0	0	0	2,542	3,041	0	344
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	139	536	0	625	4,244	0	334
1985	0	0	0	183	3,530	3,050	0	0	0	0	0	0	407
1986	0	0	0	0	0	0	0	3,000	3,283	0	0	0	379
1987	0	0	0	0	0	0	539	225	0	0	0	0	46
1988	0	0	0	44	4,501	1,639	0	0	0	0	0	0	373
1989	0	0	0	0	0	0	0	497	0	0	0	2,397	174
1990	0	0	0	0	1,035	0	0	0	0	0	0	0	62
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	6	10	179	58	784	678	91	270	1,187	777	777	191	302

Table A3-13c. DeltaSOS-Simulated DW Operations
for Alternative 3: DW End-of-Month Storage (TAF)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	0	0	107	231	406	406	397	406	406	21	0	0
1923	264	406	406	406	69	(0)	0	0	0	10	8	0
1924	0	0	0	4	(0)	0	0	0	0	0	0	0
1925	0	0	0	0	333	123	114	102	(0)	10	0	0
1926	0	0	0	53	383	71	62	34	(0)	10	0	0
1927	0	246	280	406	406	406	406	394	101	0	0	0
1928	0	357	406	406	367	406	397	364	62	56	(0)	0
1929	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	275	1	11	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	53	149	16	(0)	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	123	(0)	0	0	0	0	0	0	0
1935	0	0	0	369	97	27	129	75	(0)	10	0	0
1936	0	0	0	369	406	406	397	360	69	62	(0)	0
1937	0	0	0	0	333	406	397	234	(0)	0	0	0
1938	0	357	406	406	406	406	406	406	406	21	0	166
1939	406	406	406	355	110	(0)	0	0	0	10	0	0
1940	0	0	0	369	406	406	406	368	66	60	(0)	0
1941	0	0	369	406	406	406	406	406	223	(0)	0	0
1942	334	406	406	406	406	391	406	406	392	7	0	0
1943	369	406	406	406	406	406	406	304	(0)	0	0	0
1944	0	0	0	0	43	(0)	0	0	0	10	0	0
1945	0	0	104	102	406	406	364	312	298	157	0	0
1946	0	215	406	406	144	(0)	0	0	0	10	0	0
1947	0	0	0	0	0	0	0	0	0	10	8	0
1948	0	0	0	0	0	0	0	18	(0)	10	8	0
1949	0	0	0	0	0	369	360	292	0	0	0	0
1950	0	0	0	205	309	152	143	109	95	88	82	(0)
1951	0	357	406	406	406	406	387	375	72	66	0	0
1952	0	74	404	406	406	406	406	406	406	225	0	262
1953	406	406	406	406	337	173	164	152	138	(0)	0	0
1954	201	406	372	406	406	406	406	375	69	63	0	0
1955	0	9	371	406	301	0	0	0	0	10	7	0
1956	0	0	369	406	406	406	388	406	392	213	0	15
1957	377	346	115	94	265	406	365	353	77	70	64	(0)
1958	160	293	406	406	406	406	406	406	406	68	(0)	229
1959	406	406	233	406	406	106	40	11	0	10	0	0
1960	0	0	5	(0)	145	(0)	0	0	0	10	0	0
1961	0	0	0	0	205	(0)	0	0	0	10	0	0
1962	0	0	0	0	333	260	190	157	(0)	10	0	0
1963	369	406	402	406	406	406	406	406	266	184	0	0
1964	108	406	343	406	106	0	0	0	0	10	8	0
1965	0	0	369	406	406	220	390	339	37	31	0	0
1966	42	396	406	406	352	300	291	223	209	203	156	(0)
1967	0	0	369	406	406	406	406	406	406	406	70	290
1968	406	406	406	406	406	406	374	310	296	290	52	0
1969	0	0	339	406	406	406	406	406	406	110	0	357
1970	406	406	406	406	406	406	366	315	301	295	(0)	0
1971	0	357	406	406	260	406	395	406	392	386	93	14
1972	159	148	401	406	307	364	332	303	289	283	276	33
1973	0	339	401	406	406	406	397	385	171	154	0	0
1974	0	357	406	406	406	406	406	394	236	32	0	181
1975	406	406	406	406	406	406	397	406	342	236	0	46
1976	371	406	364	195	74	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	369	406	406	406	390	106	0	0	0
1979	186	197	0	369	406	406	397	385	189	34	0	0
1980	0	175	406	406	406	406	364	257	(0)	0	0	0
1981	176	166	248	406	364	406	372	308	294	288	52	(0)
1982	0	357	398	406	406	406	406	406	394	222	21	367
1983	406	406	406	406	406	406	406	406	406	406	406	406
1984	406	406	406	406	406	406	389	344	330	275	(0)	0
1985	186	406	406	393	194	(0)	0	0	0	10	0	0
1986	0	0	26	177	406	406	406	209	(0)	0	0	0
1987	0	0	0	0	0	68	27	1	0	10	0	0
1988	0	0	5	369	107	0	0	0	0	0	0	0
1989	0	0	0	0	0	232	223	180	166	160	153	0
1990	0	0	0	61	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	4	0	0	0	0	0	0
Average	94	161	208	263	259	232	227	206	127	76	21	34

Table A3–14. DeltaSOS Mean Annual Simulation Output for Alternative 3

Water Year	Sac Basin Year Type	SJR Basin Year Type	Added Sac Flow (TAF)	New Sac Flow (TAF)	Required SJR Flow (TAF)	Added SJR Flow (TAF)	New SJR Flow (TAF)	Steam & Sutter Flow (TAF)	DCC Rio Vista Reduction (TAF)	Revised DCC Flow (TAF)	Revised Georgiana & DCC (TAF)	Revised Rio Vista Flow (TAF)	QWEST w/ Initial Export (TAF)
1922	2	1	0	15,237	1,682	0	3,037	4,804	0	949	3,631	11,586	850
1923	3	2	0	14,489	1,663	73	2,564	4,395	0	1,567	4,039	10,425	491
1924	5	5	0	8,586	820	4	1,264	2,261	32	1,115	2,902	5,437	(1,104)
1925	4	3	0	12,064	1,213	29	1,491	3,509	0	1,438	3,630	9,040	(642)
1926	4	4	0	11,614	1,107	0	1,511	3,338	0	1,419	3,554	8,157	(1,011)
1927	1	2	0	19,015	1,663	71	1,963	6,229	0	1,355	4,501	17,527	238
1928	2	3	0	18,455	1,295	30	1,736	6,051	0	1,477	4,542	14,653	(250)
1929	5	5	0	8,696	820	2	1,306	2,314	42	1,147	2,939	5,573	(861)
1930	4	5	0	10,768	816	28	1,168	3,052	0	1,269	3,310	7,368	(995)
1931	5	5	0	6,775	790	2	1,257	1,651	91	875	2,453	4,103	(261)
1932	4	2	0	8,618	1,244	0	1,655	2,274	0	1,142	2,924	5,630	334
1933	5	4	0	7,535	1,004	0	1,388	1,931	97	908	2,579	4,753	(300)
1934	5	5	0	8,173	820	4	1,205	2,172	66	916	2,658	5,386	(397)
1935	3	2	0	12,496	1,477	0	2,051	3,700	29	1,301	3,554	9,935	(346)
1936	3	2	0	13,335	1,585	80	2,221	3,996	0	1,365	3,727	10,821	161
1937	3	1	0	12,426	1,682	56	2,860	3,671	0	1,290	3,547	8,936	830
1938	1	1	0	28,179	1,759	0	5,428	9,982	0	1,057	5,533	31,093	5,930
1939	4	4	0	10,712	1,004	0	1,695	3,007	0	1,498	3,498	6,983	(484)
1940	2	2	0	17,638	1,585	78	1,973	5,687	0	1,469	4,408	17,640	126
1941	1	1	0	23,780	1,759	0	3,677	8,157	0	1,370	5,188	27,629	2,976
1942	1	1	0	25,353	1,759	0	2,986	8,822	0	1,151	5,211	25,051	2,819
1943	1	1	0	20,972	1,759	78	3,229	6,984	0	1,426	4,820	17,571	3,294
1944	4	3	0	11,388	1,140	45	1,688	3,253	0	1,423	3,528	7,790	(1,138)
1945	3	2	0	12,566	1,507	77	2,321	3,714	0	1,386	3,653	9,005	(218)
1946	3	2	0	16,177	1,585	74	2,146	5,102	0	1,435	4,178	13,192	(39)
1947	4	4	0	10,949	1,056	50	1,607	3,089	0	1,438	3,480	7,285	(1,559)
1948	3	3	0	13,098	1,140	3	1,421	3,868	0	1,630	3,917	8,948	(1,404)
1949	4	3	0	11,993	1,140	49	1,472	3,503	0	1,421	3,616	8,292	(1,013)
1950	3	3	0	12,811	1,192	0	1,532	3,774	0	1,525	3,793	8,851	(1,135)
1951	2	2	0	21,672	1,663	80	2,663	7,244	0	1,526	5,004	18,363	1,983
1952	1	1	0	28,323	1,759	0	3,023	9,970	0	1,183	5,647	24,889	2,988
1953	1	3	0	18,839	1,295	0	1,965	6,162	0	1,240	4,362	16,711	792
1954	2	3	0	19,873	1,295	29	1,601	6,490	0	1,575	4,778	15,551	(501)
1955	4	4	0	11,447	1,004	0	1,365	3,263	0	1,488	3,587	7,775	(1,391)
1956	1	1	0	21,768	1,759	0	3,270	7,335	0	1,499	5,011	24,852	2,400
1957	2	3	0	15,092	1,244	27	1,812	4,642	0	1,623	4,175	11,044	(714)
1958	1	1	0	26,266	1,759	1	3,397	9,182	0	1,243	5,417	29,612	3,048
1959	3	4	0	14,716	1,159	69	1,800	4,523	0	1,536	4,064	10,754	138
1960	4	5	0	11,339	846	30	1,247	3,228	0	1,455	3,546	7,825	(1,622)
1961	4	5	0	11,459	842	40	1,179	3,280	0	1,434	3,545	7,844	(1,688)
1962	3	3	0	12,372	1,110	45	1,530	3,632	0	1,418	3,656	9,182	(925)
1963	1	2	0	20,611	1,585	0	1,934	6,877	0	1,184	4,566	18,800	7
1964	4	4	0	12,397	1,056	36	1,394	3,615	0	1,540	3,756	8,495	(1,343)
1965	1	1	0	19,519	1,759	80	2,404	6,453	0	1,378	4,592	19,247	784
1966	3	3	0	13,901	1,244	49	2,011	4,172	0	1,502	3,913	10,033	(934)
1967	1	1	0	22,181	1,759	0	3,304	7,439	0	1,144	4,729	19,913	1,973
1968	3	4	0	15,971	1,211	49	1,709	5,020	0	1,525	4,226	12,181	732
1969	1	1	0	23,660	1,759	0	5,442	8,066	0	1,543	5,297	23,945	5,716
1970	1	2	0	21,543	1,585	74	3,357	7,316	0	1,506	5,006	24,373	3,778
1971	1	3	0	20,939	1,295	0	1,732	6,908	0	1,583	4,932	16,920	(159)
1972	3	4	0	13,210	1,107	0	1,515	3,920	0	1,524	3,842	9,253	(1,523)
1973	2	2	0	19,810	1,663	78	2,252	6,529	0	1,487	4,717	18,433	1,021
1974	1	1	0	29,264	1,759	2	2,240	10,392	0	1,580	6,144	30,030	2,164
1975	1	1	0	20,440	1,682	0	2,310	6,784	0	1,674	4,962	16,153	945
1976	5	5	0	10,456	820	9	1,169	2,943	4	1,324	3,307	6,917	(1,237)
1977	5	5	0	6,824	790	0	1,016	1,703	36	821	2,391	4,233	(402)
1978	2	1	0	16,859	1,729	0	2,267	5,405	31	1,187	4,063	15,113	2,197
1979	3	2	0	13,993	1,585	78	2,378	4,235	0	1,449	3,884	10,011	381
1980	2	1	0	18,292	1,759	0	4,818	6,032	0	1,267	4,358	19,356	4,265
1981	4	4	0	13,093	1,159	49	1,962	3,885	0	1,436	3,756	9,162	(410)
1982	1	1	0	29,591	1,759	3	5,389	10,473	0	1,562	6,157	30,065	6,979
1983	1	1	0	35,577	1,759	0	15,726	12,980	0	1,050	6,551	42,561	21,616
1984	1	2	0	23,213	1,585	74	6,524	7,985	0	1,190	4,958	22,157	8,253
1985	4	4	0	13,038	1,107	50	1,909	3,861	0	1,485	3,790	9,191	(565)
1986	1	1	0	18,958	1,682	0	4,814	6,463	0	1,300	4,534	23,167	5,017
1987	4	5	0	10,952	846	16	1,661	3,102	0	1,383	3,437	7,300	(1,245)
1988	5	5	0	9,416	790	6	1,020	2,563	38	1,161	3,048	6,236	(935)
1989	4	5	0	11,782	842	31	1,036	3,442	31	1,324	3,490	8,090	(1,283)
1990	5	5	0	8,675	790	4	944	2,288	52	1,143	2,939	5,561	(786)
1991	5	5	0	8,612	816	37	995	2,286	29	1,072	2,863	5,552	(538)
Average			0	15,998	1,330	27	2,428	5,091	8	1,347	4,090	13,793	912

Notes: Definitions of the categories are provided in Table A2–3 in Appendix A2.
Water–year types: 1=wet, 2=above normal, 3=below normal, 4=dry, 5=critically dry
Negative values shown in parentheses.

Table A3–14. Continued

Water Year	Reduced Export for QWEST (TAF)	Initial Collinsville Outflow (TAF)	Initial Chipps Outflow (TAF)	Required Delta Outflow (TAF)	Revised Montez. Flow (TAF)	Reduced Export for Outflow (TAF)	Export Limits (TAF)	Reduced Export for Limits (TAF)	Net Export Change (TAF)	Adjusted Total Export (TAF)	Revised QWEST Flow (TAF)	Revised Collinsville Outflow (TAF)
1922	0	12,347	11,416	6,103	931	0	8,364	13	220	6,405	630	12,127
1923	0	10,829	9,942	5,833	887	0	9,521	4	302	6,493	189	10,527
1924	0	4,206	3,401	4,063	805	0	5,401	2	37	4,579	(1,141)	4,169
1925	0	8,317	7,456	5,195	862	0	7,312	8	86	5,821	(727)	8,232
1926	0	7,048	6,200	5,006	847	0	6,923	11	29	5,762	(1,040)	7,019
1927	0	17,681	16,711	6,980	970	0	10,720	6	393	6,635	(155)	17,289
1928	0	14,303	13,380	6,665	922	0	10,032	6	434	6,761	(683)	13,869
1929	0	4,598	3,785	4,418	813	0	5,435	0	40	4,604	(901)	4,558
1930	0	6,271	5,439	5,052	832	0	6,182	9	27	5,036	(1,022)	6,244
1931	0	3,728	2,927	3,657	801	0	4,306	0	36	3,363	(297)	3,692
1932	0	5,875	5,044	5,190	831	0	5,625	6	171	4,319	163	5,704
1933	0	4,339	3,528	4,050	811	0	4,694	0	44	3,722	(344)	4,295
1934	0	4,879	4,064	4,532	816	0	4,803	2	43	3,780	(440)	4,836
1935	0	9,503	8,610	6,455	894	0	7,413	3	83	6,008	(429)	9,420
1936	0	10,902	10,019	6,248	884	0	8,419	25	48	6,202	113	10,854
1937	0	9,691	8,817	5,287	875	0	7,752	44	45	5,923	786	9,647
1938	0	36,966	35,761	8,125	1,205	0	18,482	6	1,006	7,233	4,924	35,959
1939	0	6,379	5,545	4,357	833	0	6,865	1	715	5,803	(1,199)	5,664
1940	0	17,702	16,722	7,246	979	0	10,409	27	67	6,487	59	17,635
1941	0	30,554	29,429	7,010	1,126	0	16,412	14	410	6,684	2,567	30,145
1942	0	27,795	26,713	6,671	1,082	0	16,125	0	1,301	7,250	1,518	26,494
1943	0	20,777	19,793	7,309	984	0	13,363	0	1,188	6,746	2,106	19,589
1944	0	6,547	5,712	4,952	835	0	6,788	9	84	6,013	(1,223)	6,463
1945	0	8,690	7,832	5,277	858	0	7,966	4	351	6,485	(569)	8,340
1946	0	13,046	12,145	6,279	900	0	11,239	6	38	6,329	(77)	13,007
1947	0	5,609	4,781	5,072	828	0	6,751	1	20	6,053	(1,579)	5,589
1948	0	7,435	6,569	5,487	866	0	7,141	1	73	6,374	(1,477)	7,362
1949	0	7,168	6,324	4,921	844	0	6,947	16	49	5,741	(1,062)	7,118
1950	0	7,605	6,751	5,599	854	0	7,295	11	42	6,193	(1,177)	7,563
1951	0	20,263	19,290	6,326	973	0	14,970	11	376	7,142	1,606	19,886
1952	0	27,811	26,691	7,985	1,120	0	15,787	5	625	7,551	2,364	27,187
1953	0	17,401	16,445	6,080	956	0	12,676	0	1,519	6,823	(727)	15,882
1954	0	14,935	13,994	7,021	941	0	10,339	0	677	7,050	(1,178)	14,257
1955	0	6,281	5,447	5,051	834	0	7,342	7	67	6,084	(1,458)	6,214
1956	0	27,183	26,125	6,221	1,059	0	17,795	5	317	7,141	2,083	26,866
1957	0	10,221	9,341	5,661	881	0	8,552	1	496	6,782	(1,210)	9,726
1958	0	32,616	31,443	7,267	1,173	0	16,086	6	603	7,650	2,444	32,013
1959	0	10,781	9,906	5,294	875	0	8,800	0	953	6,129	(814)	9,828
1960	0	6,088	5,256	5,203	832	0	6,803	12	15	5,871	(1,637)	6,073
1961	0	6,045	5,214	5,097	831	0	6,750	8	19	5,794	(1,707)	6,027
1962	0	8,160	7,307	5,063	853	0	7,528	9	20	5,816	(944)	8,140
1963	0	18,732	17,719	7,329	1,013	0	11,162	6	497	7,149	(490)	18,235
1964	0	7,034	6,195	5,143	839	0	7,804	1	71	5,985	(1,414)	6,963
1965	0	19,937	18,946	6,670	992	0	14,496	6	114	6,765	670	19,823
1966	0	8,990	8,128	5,602	863	0	8,613	4	413	6,815	(1,346)	8,578
1967	0	21,825	20,776	7,553	1,049	0	13,108	6	771	7,636	1,202	21,053
1968	0	12,804	11,909	5,557	895	0	9,256	0	1,783	6,565	(1,051)	11,021
1969	0	29,594	28,470	7,967	1,124	0	16,813	6	896	7,326	4,819	28,698
1970	0	28,062	27,022	5,637	1,039	0	18,655	0	1,767	6,798	2,011	26,295
1971	0	16,665	15,713	7,094	952	0	12,449	6	173	6,986	(332)	16,492
1972	0	7,607	6,760	5,409	847	0	7,849	4	339	6,682	(1,862)	7,268
1973	0	19,403	18,436	6,821	967	0	12,919	13	341	6,949	680	19,062
1974	0	32,109	30,983	6,944	1,126	0	19,746	3	626	7,454	1,538	31,484
1975	0	17,001	16,040	6,627	961	0	10,903	0	1,118	7,612	(173)	15,882
1976	0	5,553	4,732	4,416	822	0	6,343	0	112	5,111	(1,349)	5,441
1977	0	3,708	2,908	3,657	800	0	4,264	0	50	3,103	(452)	3,658
1978	0	17,254	16,291	7,933	963	0	10,117	0	1,243	5,749	954	16,012
1979	0	10,301	9,422	5,844	878	0	8,242	0	709	6,514	(328)	9,591
1980	0	23,549	22,547	6,568	1,002	0	14,443	19	728	6,401	3,537	22,821
1981	0	8,638	7,782	5,109	856	0	7,849	0	913	6,501	(1,323)	7,725
1982	0	36,998	35,758	7,099	1,240	0	20,240	6	526	7,792	6,453	36,473
1983	0	64,167	62,613	6,197	1,553	0	31,346	0	2,964	8,377	18,653	61,203
1984	0	30,310	29,247	5,676	1,063	0	20,548	0	2,513	7,089	5,741	27,798
1985	0	8,527	7,673	5,068	854	0	8,383	4	327	6,261	(891)	8,200
1986	0	28,129	27,076	6,155	1,053	0	14,333	46	243	6,511	4,774	27,886
1987	0	5,938	5,109	4,819	830	0	6,602	0	61	5,869	(1,306)	5,877
1988	0	5,193	4,375	4,505	818	0	5,648	6	30	4,476	(965)	5,163
1989	0	6,694	5,850	4,816	844	0	6,313	17	35	5,313	(1,318)	6,660
1990	0	4,665	3,851	4,506	815	0	5,037	2	34	4,099	(820)	4,632
1991	0	4,904	4,087	4,088	816	0	4,808	4	41	3,848	(579)	4,863
Average	0	14,612	13,681	5,802	931	0	10,291	7	464	6,177	448	14,148

Table A3–14. Continued

Water Year	Available for DW Diversion (TAF)	Delta Storage (TAF)	Delta Storage Diversion (TAF)	Delta Storage Export (TAF)	Delta Storage Outflow (TAF)	Final Total Export (TAF)	Final QWEST Flow (TAF)	Final Delta Outflow (TAF)	3–Mile Slough Flow (TAF)	Old River Diversion Flow (TAF)	Final Antioch Flow (TAF)	Old & Middle Flow (TAF)
1922	1,073	406	462	368	0	6,773	167	11,664	2,648	1,587	2,816	(5,685)
1923	2,247	406	426	424	0	6,916	(236)	10,101	2,504	1,369	2,268	(6,042)
1924	4	4	4	0	0	4,579	(1,144)	4,166	1,626	825	482	(4,412)
1925	779	333	371	289	0	6,110	(1,099)	7,861	2,452	852	1,353	(5,735)
1926	436	383	423	336	0	6,098	(1,463)	6,596	2,360	877	897	(5,759)
1927	2,857	406	437	374	0	7,009	(591)	16,852	4,271	1,038	3,680	(6,450)
1928	2,476	406	467	390	0	7,151	(1,150)	13,402	3,776	996	2,626	(6,702)
1929	0	0	0	0	0	4,604	(901)	4,558	1,581	851	681	(4,359)
1930	281	275	281	296	0	5,333	(1,303)	5,963	2,126	764	823	(5,128)
1931	0	0	0	0	0	3,363	(297)	3,692	1,050	831	753	(3,142)
1932	148	149	148	146	0	4,464	15	5,556	1,308	943	1,323	(4,035)
1933	0	0	0	0	0	3,722	(344)	4,295	1,216	853	872	(3,486)
1934	121	123	121	130	0	3,910	(560)	4,716	1,431	805	871	(3,704)
1935	621	369	484	457	0	6,465	(912)	8,937	2,602	1,100	1,690	(5,863)
1936	1,436	406	419	352	0	6,554	(306)	10,435	2,618	1,192	2,312	(5,825)
1937	934	406	439	371	0	6,294	347	9,208	1,974	1,494	2,321	(5,245)
1938	8,844	406	626	368	0	7,601	4,298	35,334	5,901	3,087	10,199	(4,888)
1939	559	406	255	412	0	6,215	(1,454)	5,409	2,084	995	629	(5,846)
1940	2,663	406	428	361	0	6,848	(370)	17,206	4,228	1,046	3,858	(6,204)
1941	5,971	406	430	374	0	7,058	2,136	29,714	5,771	2,157	7,907	(5,249)
1942	5,146	406	446	370	0	7,620	1,072	26,048	5,504	1,534	6,576	(6,532)
1943	4,700	406	424	382	0	7,128	1,682	19,165	3,569	1,611	5,251	(6,014)
1944	54	43	54	36	0	6,049	(1,277)	6,408	2,216	984	939	(5,627)
1945	880	406	441	335	0	6,819	(1,010)	7,898	2,416	1,254	1,406	(6,099)
1946	2,359	406	418	416	0	6,744	(495)	12,590	3,230	1,139	2,735	(6,180)
1947	17	10	17	0	0	6,053	(1,596)	5,572	2,198	958	603	(5,707)
1948	35	18	35	4	0	6,378	(1,512)	7,327	2,560	806	1,048	(6,153)
1949	449	369	362	336	0	6,077	(1,424)	6,757	2,379	842	955	(5,824)
1950	335	309	335	242	0	6,435	(1,511)	7,228	2,537	866	1,026	(6,158)
1951	5,197	406	432	353	0	7,495	1,174	19,455	3,912	1,430	5,087	(6,538)
1952	6,021	406	715	370	0	7,922	1,649	26,471	5,285	1,548	6,934	(6,783)
1953	2,569	406	154	345	0	7,169	(881)	15,728	4,172	1,084	3,291	(6,640)
1954	2,581	406	471	393	0	7,444	(1,649)	13,786	4,142	908	2,493	(7,143)
1955	719	406	423	404	0	6,488	(1,881)	5,790	2,402	839	521	(6,204)
1956	5,272	406	453	363	0	7,504	1,630	26,413	5,283	1,711	6,912	(6,214)
1957	947	406	711	624	0	7,405	(1,921)	9,014	3,176	964	1,256	(7,020)
1958	6,701	406	685	368	0	8,018	1,759	31,328	6,352	2,019	8,110	(6,318)
1959	1,815	406	367	531	0	6,660	(1,181)	9,461	2,877	997	1,696	(6,254)
1960	166	145	166	139	0	6,010	(1,803)	5,907	2,389	802	586	(5,807)
1961	231	205	231	195	0	5,989	(1,938)	5,795	2,436	763	498	(5,812)
1962	832	333	371	293	0	6,109	(1,315)	7,769	2,553	892	1,237	(5,752)
1963	3,057	406	440	363	0	7,512	(930)	17,795	4,674	1,021	3,744	(6,935)
1964	1,274	406	491	469	0	6,454	(1,905)	6,472	2,577	869	672	(6,199)
1965	3,163	406	594	522	0	7,287	77	19,230	4,463	1,246	4,539	(6,560)
1966	1,225	406	425	334	0	7,149	(1,772)	8,152	2,894	1,110	1,123	(6,622)
1967	4,468	406	694	316	0	7,952	508	20,360	4,483	1,729	4,991	(6,613)
1968	2,138	406	145	335	0	6,901	(1,196)	10,876	3,214	943	2,018	(6,538)
1969	6,436	406	806	368	0	7,694	4,013	27,892	4,324	3,097	8,337	(5,009)
1970	5,623	406	80	344	0	7,142	1,931	26,215	5,076	1,632	7,008	(6,013)
1971	3,009	406	593	498	0	7,484	(925)	15,899	4,234	993	3,309	(7,018)
1972	617	406	487	388	0	7,070	(2,349)	6,781	2,893	902	544	(6,805)
1973	4,138	406	427	371	0	7,321	253	18,634	4,218	1,204	4,470	(6,463)
1974	6,251	406	615	347	0	7,802	924	30,869	6,711	1,154	7,634	(7,130)
1975	2,727	406	310	356	0	7,968	(484)	15,572	3,917	1,176	3,433	(7,327)
1976	567	406	363	393	0	5,505	(1,712)	5,078	2,149	755	437	(5,408)
1977	0	0	0	0	0	3,103	(453)	3,657	1,129	676	676	(3,077)
1978	2,713	406	420	365	0	6,115	534	15,591	3,356	1,158	3,890	(5,334)
1979	1,052	406	607	531	0	7,045	(936)	8,984	2,627	1,220	1,691	(6,333)
1980	5,331	406	417	373	0	6,774	3,121	22,405	3,534	2,567	6,655	(4,639)
1981	786	406	467	384	0	6,884	(1,790)	7,258	2,697	1,068	906	(6,416)
1982	8,665	406	815	344	0	8,136	5,639	35,658	5,241	3,355	10,880	(5,108)
1983	21,455	406	136	0	0	8,377	18,517	61,067	4,118	9,324	22,635	760
1984	8,820	406	22	334	0	7,423	5,718	27,775	3,373	3,669	9,091	(4,299)
1985	1,584	406	419	407	0	6,668	(1,311)	7,781	2,553	1,103	1,243	(6,106)
1986	6,124	406	442	379	0	6,889	4,332	27,444	4,043	2,756	8,374	(4,495)
1987	76	68	76	46	0	5,915	(1,382)	5,801	2,135	919	753	(5,609)
1988	419	369	366	373	0	4,848	(1,331)	4,797	1,871	685	540	(4,738)
1989	244	232	244	174	0	5,487	(1,562)	6,416	2,375	646	813	(5,434)
1990	60	61	60	62	0	4,161	(880)	4,572	1,572	633	692	(4,119)
1991	4	4	4	0	0	3,848	(583)	4,859	1,477	634	894	(3,812)
Average	2,579	321	356	302	0	6,479	92	13,792	3,186	1,369	3,279	(5,628)

Table A3–15. Monthly Percentiles for DeltaSOS Simulations for Alternative 3

DW diversion (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	29	0	0	0	0	0	0	0	0
50	0	0	26	29	59	98	0	0	0	0	0	0
60	0	50	26	102	61	98	0	0	0	157	0	0
70	106	235	822	632	61	98	0	0	0	158	0	0
80	2,452	2,434	1,111	1,593	704	98	151	198	0	158	0	0
90	3,763	5,702	4,227	3,326	3,207	773	151	198	37	158	123	778
100	6,000	6,000	6,000	6,000	6,000	6,000	3,000	484	235	260	231	6,000
Mean	996	1,152	964	976	761	322	110	55	24	80	19	445

DW storage (TAF)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	(0)	(0)	(0)	0	0	(0)	(0)	(0)	(0)
10	0	0	0	0	0	(0)	0	0	(0)	0	0	0
20	0	0	0	0	1	0	0	0	0	0	0	0
30	0	0	0	102	107	0	0	0	0	0	0	0
40	0	0	5	275	265	123	129	102	0	10	0	0
50	0	0	248	369	337	364	360	234	37	10	0	0
60	0	197	369	406	406	406	387	312	95	31	0	0
70	42	357	402	406	406	406	397	368	209	66	0	0
80	201	406	406	406	406	406	406	394	298	160	8	0
90	406	406	406	406	406	406	406	406	394	275	64	166
100	406	406	406	406	406	406	406	406	406	406	406	406
Mean	94	161	208	263	259	232	227	206	127	76	21	34

DW discharge for export (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	139	0	271	1,018	0	323	0
80	0	0	0	0	1,184	1,104	29	416	3,283	1,460	873	0
90	0	0	123	0	3,530	2,568	416	839	4,674	2,677	3,435	695
100	425	473	3,740	2,717	6,000	4,975	1,030	3,000	4,899	6,000	5,237	3,917
Mean	6	10	179	58	784	678	91	270	1,187	777	777	191

DW discharge for outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Final CVP Tracy and SWP Banks exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	4,329	3,356	5,087	4,862	6,108	3,360	2,865	2,496	1,207	1,968	653	3,340
10	5,166	5,415	7,387	9,055	7,109	4,810	3,645	3,215	5,500	5,172	3,564	3,661
20	6,895	6,670	8,605	11,101	10,454	7,142	3,873	3,781	5,613	7,470	4,957	5,959
30	8,033	7,402	10,462	11,380	11,632	11,079	4,797	4,300	5,864	9,807	5,199	6,144
40	8,541	8,413	11,176	11,460	11,663	11,268	5,623	5,456	6,550	11,280	7,214	6,449
50	9,096	10,700	11,259	11,578	12,009	11,268	6,573	6,047	8,152	11,280	8,082	6,614
60	9,751	11,280	11,280	11,768	12,097	11,461	7,380	7,176	9,645	11,280	8,944	7,028
70	11,280	11,280	11,298	11,873	12,462	11,461	8,476	8,380	11,280	11,280	10,217	8,266
80	11,280	11,280	11,393	12,266	12,700	11,574	9,203	9,410	11,280	11,280	11,280	10,514
90	11,280	11,280	11,503	12,700	12,700	11,700	9,950	9,950	11,280	11,280	11,280	11,280
100	11,280	11,280	11,700	12,700	12,700	11,700	11,280	11,280	11,280	11,280	11,280	11,280
Mean	8,998	9,134	10,323	11,267	11,275	10,104	6,783	6,517	8,199	9,806	7,723	7,398

Table A3–16a. Adjustments to DWRSIM Delta Exports for Cumulative Conditions: DeltaSOS Adjustments (cfs)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (TAF)
1922	1	0	1,689	2,001	1,679	3,635	919	3,004	3,534	2	0	1	992
1923	3,873	3,959	2,822	5,009	0	1	714	535	(2)	1	0	1	1,019
1924	0	(2)	(1)	1	0	2	(1)	0	(3)	(1)	(1)	0	(0)
1925	0	0	0	(2)	2,738	0	678	464	1	1	0	1	234
1926	0	(2)	1	830	2,738	(0)	282	2	0	0	0	0	232
1927	0	3,959	646	3,154	3,134	6,543	2,866	479	(1)	0	0	1	1,252
1928	0	3,959	946	2,726	3,003	5,930	808	1	1	1	0	0	1,047
1929	1	(1)	0	(1)	(0)	(1)	0	(1)	(1)	0	0	1	(0)
1930	(1)	(1)	1	3,033	1	76	0	0	(1)	1	2	(1)	187
1931	0	0	0	(1)	(1)	1	(1)	1	(1)	(1)	0	0	(0)
1932	1	1	804	1,554	2,166	0	1	0	0	1	(1)	0	273
1933	1	(1)	(1)	0	(0)	0	0	0	0	0	1	2	0
1934	1	(1)	1	1,966	1	1	0	0	0	0	1	(1)	119
1935	0	(1)	0	2,737	(1)	1	2,866	0	(1)	1	(1)	1	338
1936	1	(1)	1	2,637	1,679	1	677	541	(1)	1	(1)	(1)	333
1937	1	(1)	(1)	(0)	1,679	2,462	920	(268)	(1)	1	0	0	289
1938	0	3,959	3,149	2,149	6,058	7,305	4,998	5,817	4,643	0	0	2,761	2,461
1939	3,873	2,424	3,889	4,417	2,637	(1)	1	(1)	(1)	1	(1)	2	1,039
1940	0	(2)	1	2,794	2,358	2,774	2,866	1	1	0	0	0	650
1941	0	0	3,047	2,050	1,679	4,030	5,120	3,958	0	2	1	1	1,198
1942	3,873	3,959	6,786	7,182	6,726	4,155	3,211	3,000	(1)	1	0	1	2,343
1943	3,873	3,959	6,049	7,043	6,477	7,300	1,655	(1)	1	0	1	1	2,191
1944	(1)	0	0	(1)	607	1,097	0	(1)	(1)	1	0	1	103
1945	1	(1)	1,630	(1)	3,576	3,176	583	629	(1)	1	(1)	0	578
1946	0	3,945	2,979	2,532	0	0	584	(1)	(0)	1	(1)	1	605
1947	1	(1)	(1)	0	0	1	0	0	0	0	0	0	0
1948	0	0	(1)	2	0	1	380	969	(0)	0	0	0	81
1949	0	(1)	0	(1)	0	2,962	553	0	0	(1)	0	0	212
1950	1	(2)	(1)	2,934	1,817	(1)	624	1	(1)	2	1	0	324
1951	2	3,959	2,647	1,771	3,888	3,969	609	513	0	0	1	1	1,046
1952	1	1,547	3,196	1,771	2,051	6,990	4,503	3,458	5,048	(1)	0	3,657	1,941
1953	4,952	5,218	6,812	9,682	5,786	2,157	625	392	(0)	(1)	0	0	2,146
1954	3,515	3,959	0	5,883	6,360	6,113	2,818	0	0	2	1	0	1,726
1955	2	454	3,247	2,864	(0)	1	406	372	(0)	1	(1)	1	443
1956	(2)	0	3,199	1,771	1,828	6,058	888	3,004	(1)	0	(1)	216	1,022
1957	3,873	(1)	(1)	0	6,208	6,830	0	451	0	1	0	1	1,046
1958	2,863	2,582	3,128	2,690	3,443	6,445	5,449	3,004	4,131	(1)	(1)	3,657	2,253
1959	3,873	4,932	663	7,341	8,767	1	0	(1)	(1)	0	(1)	1	1,541
1960	1	(1)	1	(1)	2,391	(0)	1	0	(0)	1	(1)	0	144
1961	1	(1)	(2)	(1)	2,815	(0)	1	0	0	0	1	0	170
1962	1	0	0	1	2,245	(0)	(1)	0	0	1	1	1	135
1963	3,873	3,749	3,234	461	5,280	3,170	2,862	1,276	(0)	0	(1)	1	1,440
1964	1,973	3,959	(1)	3,241	0	1	0	(2)	(1)	1	1	1	553
1965	1	(1)	3,192	1,771	1,794	(1)	3,210	(1)	(1)	1	1	1	601
1966	894	3,959	1,423	2,427	2,669	2,724	551	(1)	(0)	1	0	0	882
1967	1	(2)	2,974	2,584	3,716	8,148	4,116	3,632	4,643	1,801	0	3,657	2,125
1968	5,558	5,559	5,480	10,261	9,665	7,735	0	(1)	(1)	0	(1)	1	2,666
1969	0	(2)	3,251	2,127	2,868	7,853	5,033	7,210	4,617	(1)	(1)	3,657	2,206
1970	3,873	7,013	7,073	9,800	9,678	7,957	1	380	(1)	2	0	0	2,758
1971	1	3,959	3,089	2,882	0	4,310	534	1,125	(1)	0	(1)	1	958
1972	2,704	175	3,236	2,606	1,499	3,844	2	0	(1)	1	(1)	0	847
1973	2	3,959	3,250	2,927	2,118	6,664	648	513	1	0	(1)	1	1,210
1974	0	3,959	3,148	3,463	6,181	6,008	3,210	736	0	0	(1)	3,012	1,790
1975	3,873	2,724	3,732	4,041	8,482	6,856	937	2,136	0	(1)	(1)	746	2,020
1976	3,873	3,959	0	15	716	(0)	2	(1)	0	0	0	0	516
1977	0	(1)	1	0	0	1	0	1	0	1	0	0	0
1978	(1)	0	1	4,137	9,047	9,220	5,447	1,831	0	0	0	0	1,788
1979	3,272	544	(1)	3,793	6,664	5,194	636	527	(1)	1	(1)	1	1,243
1980	1	3,278	3,168	1,879	6,419	8,404	1,802	(256)	1	1	0	0	1,488
1981	3,120	189	3,584	7,182	3,484	5,612	1	(1)	(1)	1	(1)	1	1,396
1982	0	3,959	3,283	2,485	2,775	5,758	6,293	5,158	40	(1)	0	3,657	2,013
1983	3,873	6,602	6,564	8,393	9,872	9,552	8,306	8,627	7,221	7,104	3,978	6,512	5,218
1984	7,838	9,601	9,258	11,282	10,356	8,159	611	1,380	(1)	0	1	0	3,524
1985	3,272	3,959	2,792	3,997	210	(1)	322	(1)	(1)	1	1	0	877
1986	1	(1)	347	2,453	1,679	4,253	5,943	(544)	(1)	(1)	0	0	851
1987	223	(2)	(1)	0	0	1,489	0	(1)	(1)	0	0	0	103
1988	1	(1)	1	3,227	0	(1)	1	0	(2)	(1)	1	(1)	194
1989	2	0	1	0	(0)	3,098	586	(1)	(0)	1	0	(1)	222
1990	0	0	1	953	(1)	1	1	0	(1)	1	(1)	1	58
1991	1	1	(1)	(1)	0	1	(1)	0	(1)	0	0	(1)	(0)
Average	1,183	1,769	1,849	2,699	2,881	3,086	1,395	915	484	128	57	451	1,018

Table A3–16b. Adjustments to DWRSIM Delta Exports for Cumulative Conditions: DeltaSOS Adjusted Exports (cfs)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (TAF)
1922	6,551	6,936	13,161	14,147	14,500	13,992	8,921	11,760	14,811	3,359	4,477	6,503	7,177
1923	14,900	14,900	14,500	14,500	4,073	6,095	8,428	6,801	6,526	11,288	11,287	6,368	7,210
1924	8,063	7,486	11,005	11,575	8,040	4,125	2,791	2,970	4,361	6,479	4,893	3,592	4,542
1925	8,500	6,640	8,870	7,295	14,500	7,948	7,380	5,650	6,543	11,288	8,405	6,051	5,969
1926	9,170	6,930	7,644	12,313	14,500	6,252	6,330	5,128	5,524	11,287	7,966	5,969	5,966
1927	8,909	14,900	11,840	14,500	14,500	14,500	10,960	8,523	6,457	7,379	5,802	6,115	7,494
1928	9,387	14,900	12,309	14,500	11,320	14,500	8,180	5,835	6,313	11,288	7,563	6,299	7,374
1929	6,854	8,670	10,447	9,695	8,462	4,050	3,042	3,207	5,705	9,560	2,784	3,271	4,564
1930	7,525	5,920	9,098	14,500	6,635	11,309	3,589	3,538	5,520	10,026	3,390	5,195	5,196
1931	5,125	4,536	5,711	10,046	6,381	4,263	3,169	2,668	4,266	5,067	537	3,456	3,327
1932	6,132	5,385	12,039	13,020	9,746	3,147	5,097	4,103	2,463	3,427	3,448	5,359	4,420
1933	5,086	5,070	6,015	11,380	7,285	4,810	3,759	3,490	5,464	4,369	854	3,468	3,678
1934	4,431	3,666	8,873	13,474	6,393	6,515	3,660	2,996	5,676	4,096	671	3,537	3,855
1935	4,288	7,523	8,069	14,500	6,331	10,529	10,960	8,356	7,231	11,288	8,984	5,890	6,263
1936	7,317	6,838	7,642	14,500	14,500	11,701	7,857	6,613	6,491	11,288	6,950	5,971	6,487
1937	6,716	6,435	9,922	11,101	14,500	14,500	8,946	6,490	5,820	6,809	5,083	6,039	6,167
1938	7,040	14,900	14,500	14,500	14,500	14,500	11,760	13,945	14,900	4,910	4,730	14,004	8,687
1939	14,900	13,169	11,623	11,036	7,754	5,393	4,175	3,873	5,615	11,288	7,509	5,362	6,127
1940	8,282	6,314	7,372	14,500	14,500	14,500	10,960	6,835	6,313	11,287	10,233	6,245	7,070
1941	8,071	7,372	14,500	14,500	14,500	14,500	13,162	11,760	8,448	3,053	4,474	9,693	7,473
1942	14,900	14,900	14,500	14,500	14,500	11,323	11,760	11,756	11,262	3,091	4,477	10,666	8,293
1943	14,900	14,900	14,500	14,500	14,500	14,500	10,204	6,754	6,042	6,754	5,055	5,999	7,749
1944	9,710	10,399	7,368	11,422	12,995	9,462	4,020	3,973	6,623	11,288	6,764	6,075	6,031
1945	8,970	10,940	13,050	11,286	14,500	11,699	6,465	5,685	7,467	9,097	5,882	6,359	6,712
1946	10,559	14,886	14,500	14,500	7,309	9,016	6,468	5,355	7,026	11,288	7,098	6,441	6,895
1947	8,226	8,383	11,303	10,935	10,454	8,217	4,338	3,896	5,432	11,287	11,287	6,380	6,033
1948	9,681	7,999	7,767	10,910	6,428	6,021	6,822	8,677	8,266	11,287	11,287	10,786	6,382
1949	11,027	9,194	8,590	8,686	7,038	14,500	5,499	4,852	6,202	10,057	5,789	6,545	5,903
1950	9,169	7,074	6,629	14,500	13,579	8,644	6,552	5,395	7,001	11,289	11,288	6,346	6,475
1951	11,029	14,900	14,500	14,500	14,500	12,621	6,853	7,487	6,294	11,287	9,072	6,610	7,812
1952	9,089	12,488	14,500	14,500	14,500	14,500	11,760	11,760	14,900	8,453	5,837	14,900	8,868
1953	14,900	13,105	14,500	14,500	10,608	8,700	6,573	7,882	10,551	7,677	5,864	8,801	7,451
1954	14,542	14,900	10,684	14,500	14,500	14,500	10,190	6,762	6,250	11,289	9,587	6,720	8,099
1955	7,851	11,395	14,500	14,500	9,443	4,525	3,940	4,310	6,550	11,288	11,286	7,615	6,459
1956	7,992	7,771	14,500	14,500	14,500	14,500	8,476	11,760	10,010	8,475	6,273	11,459	7,846
1957	14,900	10,777	7,451	11,375	14,500	14,500	5,786	6,047	6,742	11,288	11,287	7,039	7,332
1958	13,890	13,523	14,500	14,500	14,500	14,500	14,308	11,760	14,900	5,891	7,174	14,900	9,299
1959	14,900	12,910	8,456	14,500	14,500	6,425	3,764	3,927	5,923	11,287	7,940	6,959	6,717
1960	9,000	6,800	11,155	9,363	14,183	7,956	3,799	3,398	5,618	11,288	10,482	6,543	6,000
1961	8,733	8,171	10,868	9,055	14,500	7,300	3,571	3,408	5,568	11,287	9,615	6,601	5,945
1962	8,463	6,874	10,368	7,554	14,500	10,191	4,189	4,916	5,922	11,288	7,335	6,859	5,932
1963	14,900	14,690	14,500	11,924	14,500	11,844	10,960	9,632	7,036	10,061	6,060	8,197	8,092
1964	13,000	14,900	10,270	14,500	6,438	5,073	3,624	3,928	5,613	11,288	11,288	7,409	6,467
1965	7,201	10,359	14,500	14,500	13,760	8,486	11,760	8,673	6,321	11,288	6,993	6,518	7,252
1966	11,921	14,900	12,979	14,500	11,137	10,528	5,623	4,859	5,914	11,288	10,628	6,633	7,285
1967	8,719	10,670	14,500	14,500	14,500	14,500	11,760	11,760	14,900	12,576	5,927	14,900	8,990
1968	14,900	13,200	12,356	14,500	14,500	14,215	4,666	3,869	5,923	11,287	7,537	6,685	7,449
1969	9,074	8,545	14,500	14,500	14,500	14,500	11,760	14,900	14,217	6,577	5,359	14,900	8,636
1970	14,900	14,900	14,500	14,500	14,500	14,500	5,991	5,086	6,267	11,289	6,324	6,526	7,789
1971	9,055	14,900	14,500	14,500	9,028	14,500	6,650	8,829	9,027	11,287	6,639	10,062	7,771
1972	13,731	11,116	14,500	13,497	9,972	12,287	4,580	3,924	5,869	11,288	11,286	7,294	7,190
1973	10,115	14,900	14,500	14,500	14,500	14,500	7,420	7,443	7,787	11,110	6,123	6,867	7,818
1974	10,863	14,900	14,500	14,500	14,500	14,500	11,760	9,437	8,864	8,065	6,912	14,255	8,619
1975	14,900	13,665	13,625	11,681	14,500	14,500	9,203	10,892	10,439	9,669	6,240	11,989	8,513
1976	14,900	14,900	10,586	8,477	9,184	6,038	3,072	3,267	5,896	7,623	3,547	4,042	5,515
1977	5,434	6,432	11,058	4,844	6,067	4,198	2,825	2,395	1,076	1,818	941	3,580	3,053
1978	4,414	3,326	10,813	14,500	14,500	14,500	11,760	8,527	6,613	2,839	4,473	8,219	6,295
1979	14,299	11,485	6,330	14,500	14,500	13,308	7,240	7,039	8,099	8,865	5,186	6,118	7,047
1980	7,829	14,219	14,500	14,500	14,500	14,500	8,064	6,516	5,682	3,233	4,873	10,445	7,161
1981	14,147	11,130	12,749	14,500	11,258	12,851	5,027	3,873	5,534	11,288	7,550	6,006	6,984
1982	8,382	14,900	14,500	14,500	14,500	14,500	14,900	14,900	11,317	8,588	8,123	14,900	9,279
1983	14,900	14,900	14,500	14,500	14,500	14,500	14,900	14,900	14,900	14,900	14,155	14,900	10,631
1984	14,900	14,900	14,500	14,500	14,500	14,500	6,881	6,484	6,663	10,505	5,857	10,243	8,100
1985	14,299	14,900	14,500	11,797	8,238	7,407	4,018	4,417	5,479	11,288	10,259	6,439	6,811
1986	8,727	7,911	11,667	13,863	14,500	14,500	14,291	6,810	6,321	6,446	5,051	8,075	7,119
1987	11,250	8,934	7,784	9,199	9,758	12,327	3,800	3,455	5,534	11,287	8,755	6,020	5,911
1988	6,588	6,113	11,176	14,500	6,370	4,723	2,965	3,114	5,766	7,320	4,886	3,497	4,640
1989	4,629	5,403	6,929	8,317	6,836	14,500	6,052	4,049	5,500	11,288	11,287	6,500	5,500
1990	5,470	3,927	7,842	12,208	6,075	4,469	3,621	2,804	5,803	7,331	5,020	3,858	4,123
1991	4,666	3,855	5,072	6,170	6,384	11,143	3,789	2,873	5,452	5,022	4,228	4,543	3,808
Average	9,968	10,424	11,479	12,759	11,671	10,752	7,249	6,614	7,326	9,026	6,889	7,552	6,730

Table A3–17. DeltaSOS Mean Annual Simulation Output for the No–Project Cumulative Conditions

Water Year	Sac Basin Year Type	SJR Basin Year Type	Added Sac Flow (TAF)	New Sac Flow (TAF)	Required SJR Flow (TAF)	Added SJR Flow (TAF)	New SJR Flow (TAF)	Steam & Sutter Flow (TAF)	DCC Rio Vista Reduction (TAF)	Revised DCC Flow (TAF)	Revised Georgiana & DCC (TAF)	Revised Rio Vista Flow (TAF)	QWEST w/ Initial Export (TAF)
1922	2	1	0	15,237	1,682	0	3,037	4,804	0	949	3,631	11,586	799
1923	3	2	0	14,489	1,663	73	2,564	4,395	0	1,567	4,039	10,425	440
1924	5	5	0	8,586	820	4	1,264	2,261	32	1,115	2,902	5,437	(1,155)
1925	4	3	0	12,064	1,213	29	1,491	3,509	0	1,438	3,630	9,040	(692)
1926	4	4	0	11,614	1,107	0	1,511	3,338	0	1,419	3,554	8,157	(1,062)
1927	1	2	0	19,015	1,663	71	1,963	6,229	0	1,355	4,501	17,527	187
1928	2	3	0	18,455	1,244	30	1,736	6,051	0	1,477	4,542	14,653	(300)
1929	5	5	0	8,696	820	2	1,306	2,314	42	1,147	2,939	5,573	(911)
1930	4	5	0	10,768	816	28	1,168	3,052	0	1,269	3,310	7,368	(1,046)
1931	5	5	0	6,775	790	2	1,257	1,651	91	875	2,453	4,103	(312)
1932	4	2	0	8,618	1,244	0	1,655	2,274	0	1,142	2,924	5,630	283
1933	5	4	0	7,535	1,004	0	1,388	1,931	97	908	2,579	4,753	(350)
1934	5	5	0	8,173	820	4	1,205	2,172	66	916	2,658	5,386	(447)
1935	3	2	0	12,496	1,477	0	2,051	3,700	29	1,301	3,554	9,935	(397)
1936	3	2	0	13,335	1,663	80	2,221	3,996	0	1,365	3,727	10,821	111
1937	3	1	0	12,426	1,682	56	2,860	3,671	0	1,290	3,547	8,936	780
1938	1	1	0	28,179	1,759	0	5,428	9,982	0	1,057	5,533	31,093	5,880
1939	4	4	0	10,712	1,004	0	1,695	3,007	0	1,498	3,498	6,983	(535)
1940	2	2	0	17,638	1,585	78	1,973	5,687	0	1,469	4,408	17,640	75
1941	1	1	0	23,780	1,759	0	3,677	8,157	0	1,370	5,188	27,629	2,926
1942	1	1	0	25,353	1,759	0	2,986	8,822	0	1,151	5,211	25,051	2,769
1943	1	1	0	20,972	1,759	78	3,229	6,984	0	1,426	4,820	17,571	3,244
1944	4	3	0	11,388	1,140	45	1,688	3,253	0	1,423	3,528	7,790	(1,189)
1945	3	2	0	12,566	1,507	77	2,321	3,714	0	1,386	3,653	9,005	(269)
1946	3	2	0	16,177	1,507	0	2,071	5,102	0	1,435	4,178	13,192	(90)
1947	4	4	0	10,949	1,056	50	1,607	3,089	0	1,438	3,480	7,285	(1,609)
1948	3	3	0	13,098	1,140	3	1,421	3,868	0	1,630	3,917	8,948	(1,455)
1949	4	3	0	11,993	1,140	49	1,472	3,503	0	1,421	3,616	8,292	(1,064)
1950	3	3	0	12,811	1,192	0	1,532	3,774	0	1,525	3,793	8,851	(1,185)
1951	2	2	0	21,672	1,663	80	2,663	7,244	0	1,526	5,004	18,363	1,932
1952	1	1	0	28,323	1,759	0	3,023	9,970	0	1,183	5,647	24,889	2,938
1953	1	3	0	18,839	1,295	0	1,965	6,162	0	1,240	4,362	16,711	742
1954	2	3	0	19,873	1,295	29	1,601	6,490	0	1,575	4,778	15,551	(551)
1955	4	4	0	11,447	1,004	0	1,365	3,263	0	1,488	3,587	7,775	(1,441)
1956	1	1	0	21,768	1,759	0	3,270	7,335	0	1,499	5,011	24,852	2,350
1957	2	3	0	15,092	1,244	27	1,812	4,642	0	1,623	4,175	11,044	(765)
1958	1	1	0	26,266	1,759	1	3,397	9,182	0	1,243	5,417	29,612	2,997
1959	3	4	0	14,716	1,159	69	1,800	4,523	0	1,536	4,064	10,754	88
1960	4	5	0	11,339	846	30	1,247	3,228	0	1,455	3,546	7,825	(1,673)
1961	4	5	0	11,459	842	40	1,179	3,280	0	1,434	3,545	7,844	(1,739)
1962	3	3	0	12,372	1,110	45	1,530	3,632	0	1,418	3,656	9,182	(975)
1963	1	2	0	20,611	1,585	0	1,934	6,877	0	1,184	4,566	18,800	(43)
1964	4	4	0	12,397	1,056	36	1,394	3,615	0	1,540	3,756	8,495	(1,394)
1965	1	1	0	19,519	1,759	80	2,404	6,453	0	1,378	4,592	19,247	734
1966	3	3	0	13,901	1,244	49	2,011	4,172	0	1,502	3,913	10,033	(984)
1967	1	1	0	22,181	1,759	0	3,304	7,439	0	1,144	4,729	19,913	1,922
1968	3	4	0	15,971	1,211	49	1,709	5,020	0	1,525	4,226	12,181	681
1969	1	1	0	23,660	1,759	0	5,442	8,066	0	1,543	5,297	23,945	5,665
1970	1	2	0	21,543	1,585	74	3,357	7,316	0	1,506	5,006	24,373	3,727
1971	1	3	0	20,939	1,295	0	1,732	6,908	0	1,583	4,932	16,920	(210)
1972	3	4	0	13,210	1,107	0	1,515	3,920	0	1,524	3,842	9,253	(1,574)
1973	2	2	0	19,810	1,663	78	2,252	6,529	0	1,487	4,717	18,433	970
1974	1	1	0	29,264	1,759	2	2,240	10,392	0	1,580	6,144	30,030	2,113
1975	1	1	0	20,440	1,682	0	2,310	6,784	0	1,674	4,962	16,153	894
1976	5	5	0	10,456	820	9	1,169	2,943	4	1,324	3,307	6,917	(1,287)
1977	5	5	0	6,824	790	0	1,016	1,703	36	821	2,391	4,233	(453)
1978	2	1	0	16,859	1,729	0	2,267	5,405	31	1,187	4,063	15,113	2,146
1979	3	2	0	13,993	1,585	78	2,378	4,235	0	1,449	3,884	10,011	330
1980	2	1	0	18,292	1,759	0	4,818	6,032	0	1,267	4,358	19,356	4,215
1981	4	4	0	13,093	1,159	49	1,962	3,885	0	1,436	3,756	9,162	(461)
1982	1	1	0	29,591	1,759	3	5,389	10,473	0	1,562	6,157	30,065	6,928
1983	1	1	0	35,577	1,759	0	15,726	12,980	0	1,050	6,551	42,561	21,566
1984	1	2	0	23,213	1,585	74	6,524	7,985	0	1,190	4,958	22,157	8,203
1985	4	4	0	13,038	1,107	50	1,909	3,861	0	1,485	3,790	9,191	(615)
1986	1	1	0	18,958	1,682	0	4,814	6,463	0	1,300	4,534	23,167	4,966
1987	4	5	0	10,952	846	16	1,661	3,102	0	1,383	3,437	7,300	(1,295)
1988	5	5	0	9,416	790	6	1,020	2,563	38	1,161	3,048	6,236	(986)
1989	4	5	0	11,782	842	31	1,036	3,442	31	1,324	3,490	8,090	(1,334)
1990	5	5	0	8,675	790	4	944	2,288	52	1,143	2,939	5,561	(837)
1991	5	5	0	8,612	816	37	995	2,286	29	1,072	2,863	5,552	(589)
Average			0	15,998	1,329	26	2,427	5,091	8	1,347	4,090	13,793	862

Notes: Definitions of the categories are provided in Table A2–3 in Appendix A2.
Water–year types: 1=wet, 2=above normal, 3=below normal, 4=dry, 5=critically dry
Negative values shown in parentheses.

Table A3–17. Continued

Water Year	Reduced Export for QWEST (TAF)	Initial Collinsville Outflow (TAF)	Initial Chipps Outflow (TAF)	Required Delta Outflow (TAF)	Revised Montez. Flow (TAF)	Reduced Export for Outflow (TAF)	Export Limits (TAF)	Reduced Export for Limits (TAF)	Net Export Change (TAF)	Adjusted Total Export (TAF)	Revised QWEST Flow (TAF)	Revised Collinsville Outflow (TAF)
1922	0	12,296	11,366	6,103	930	0	8,364	0	992	7,177	(193)	11,304
1923	0	10,778	9,892	5,833	886	0	9,521	0	1,019	7,210	(579)	9,759
1924	0	4,155	3,351	4,063	804	1	5,401	0	(0)	4,542	(1,154)	4,155
1925	0	8,267	7,406	5,195	861	0	7,312	0	234	5,969	(926)	8,033
1926	0	6,997	6,151	5,006	847	0	6,923	0	232	5,966	(1,294)	6,765
1927	0	17,631	16,661	6,980	969	0	10,720	0	1,252	7,494	(1,065)	16,379
1928	0	14,252	13,331	6,665	921	0	10,032	0	1,047	7,374	(1,347)	13,205
1929	0	4,548	3,735	4,418	812	0	5,435	0	(0)	4,564	(911)	4,548
1930	0	6,220	5,389	5,052	831	0	6,182	0	187	5,196	(1,233)	6,033
1931	0	3,677	2,877	3,657	800	0	4,306	0	(0)	3,327	(312)	3,677
1932	0	5,825	4,994	5,190	830	0	5,625	0	273	4,420	10	5,552
1933	0	4,288	3,478	4,050	810	0	4,694	0	0	3,678	(351)	4,288
1934	0	4,829	4,014	4,532	815	0	4,803	0	119	3,855	(566)	4,710
1935	0	9,453	8,560	6,455	893	0	7,413	0	338	6,263	(734)	9,115
1936	0	10,852	9,969	6,248	883	0	8,419	0	333	6,487	(223)	10,518
1937	0	9,641	8,767	5,287	874	0	7,752	16	289	6,167	491	9,352
1938	0	36,915	35,711	8,125	1,204	0	18,482	0	2,461	8,687	3,419	34,455
1939	0	6,328	5,496	4,357	832	0	6,865	0	1,039	6,127	(1,574)	5,289
1940	0	17,651	16,673	7,246	979	0	10,409	0	650	7,070	(575)	17,001
1941	0	30,504	29,379	7,010	1,125	0	16,412	0	1,198	7,473	1,727	29,305
1942	0	27,745	26,663	6,671	1,081	0	16,125	0	2,343	8,293	425	25,401
1943	0	20,726	19,743	7,309	983	0	13,363	0	2,191	7,749	1,053	18,536
1944	0	6,496	5,662	4,952	834	0	6,788	0	103	6,031	(1,292)	6,394
1945	0	8,639	7,782	5,277	858	0	7,966	0	578	6,712	(847)	8,062
1946	0	12,995	12,095	6,279	899	0	11,206	0	605	6,895	(695)	12,390
1947	0	5,558	4,732	5,072	827	0	6,751	0	0	6,033	(1,609)	5,558
1948	0	7,384	6,519	5,487	865	0	7,141	0	81	6,382	(1,536)	7,303
1949	0	7,117	6,275	4,921	843	0	6,947	0	212	5,903	(1,275)	6,906
1950	0	7,554	6,701	5,599	853	0	7,295	0	324	6,475	(1,509)	7,230
1951	0	20,212	19,240	6,326	972	0	14,970	0	1,046	7,812	886	19,166
1952	0	27,760	26,641	7,985	1,119	0	15,787	0	1,941	8,868	997	25,819
1953	0	17,350	16,395	6,080	955	0	12,676	0	2,146	7,451	(1,405)	15,204
1954	0	14,884	13,944	7,021	940	0	10,339	0	1,726	8,099	(2,278)	13,158
1955	0	6,231	5,397	5,051	833	0	7,342	0	443	6,459	(1,884)	5,788
1956	0	27,133	26,075	6,221	1,058	0	17,795	0	1,022	7,846	1,328	26,111
1957	0	10,171	9,291	5,661	880	0	8,552	0	1,046	7,332	(1,811)	9,125
1958	0	32,566	31,393	7,267	1,173	0	16,086	0	2,253	9,299	744	30,313
1959	0	10,730	9,856	5,294	874	0	8,800	0	1,541	6,717	(1,453)	9,189
1960	0	6,038	5,206	5,203	832	0	6,803	0	144	6,000	(1,817)	5,894
1961	0	5,995	5,164	5,097	830	0	6,750	0	170	5,945	(1,908)	5,825
1962	0	8,109	7,257	5,063	852	0	7,528	0	135	5,932	(1,111)	7,974
1963	0	18,682	17,669	7,329	1,012	0	11,162	0	1,440	8,092	(1,484)	17,242
1964	0	6,984	6,145	5,143	839	0	7,804	0	553	6,467	(1,947)	6,431
1965	0	19,887	18,896	6,670	991	0	14,496	0	601	7,252	133	19,286
1966	0	8,940	8,078	5,602	862	0	8,613	0	882	7,285	(1,867)	8,057
1967	0	21,774	20,726	7,553	1,048	0	13,108	0	2,125	8,990	(203)	19,649
1968	0	12,753	11,860	5,557	894	0	9,256	0	2,666	7,449	(1,985)	10,087
1969	0	29,543	28,420	7,967	1,123	0	16,813	0	2,206	8,636	3,459	27,337
1970	0	28,011	26,973	5,637	1,038	0	18,655	0	2,758	7,789	969	25,253
1971	0	16,614	15,663	7,094	951	0	12,449	0	958	7,771	(1,168)	15,656
1972	0	7,556	6,710	5,409	846	0	7,849	0	847	7,190	(2,421)	6,709
1973	0	19,352	18,386	6,821	966	0	12,919	0	1,210	7,818	(240)	18,142
1974	0	32,058	30,933	6,944	1,125	0	19,746	0	1,790	8,619	323	30,268
1975	0	16,950	15,990	6,627	960	0	10,903	0	2,020	8,513	(1,125)	14,930
1976	0	5,503	4,682	4,416	821	0	6,343	0	516	5,515	(1,803)	4,987
1977	0	3,657	2,858	3,657	799	0	4,264	0	0	3,053	(453)	3,657
1978	0	17,203	16,242	7,933	962	0	10,117	0	1,788	6,295	358	15,415
1979	0	10,250	9,372	5,844	878	0	8,242	0	1,243	7,047	(913)	9,007
1980	0	23,499	22,497	6,568	1,001	0	14,443	15	1,488	7,161	2,727	22,011
1981	0	8,587	7,733	5,109	855	0	7,849	0	1,396	6,984	(1,857)	7,191
1982	0	36,948	35,709	7,099	1,239	0	20,240	0	2,013	9,279	4,916	34,935
1983	0	64,116	62,564	6,197	1,552	0	31,346	0	5,218	10,631	16,348	58,898
1984	0	30,260	29,197	5,676	1,062	0	20,548	0	3,524	8,100	4,679	26,736
1985	0	8,476	7,623	5,068	853	0	8,383	0	877	6,811	(1,492)	7,600
1986	0	28,078	27,026	6,155	1,052	0	14,333	33	851	7,119	4,115	27,227
1987	0	5,888	5,059	4,819	829	0	6,602	0	103	5,911	(1,398)	5,785
1988	0	5,142	4,325	4,505	817	0	5,648	0	194	4,640	(1,180)	4,948
1989	0	6,644	5,801	4,816	843	0	6,313	0	222	5,500	(1,556)	6,422
1990	0	4,615	3,801	4,506	814	0	5,037	0	58	4,123	(894)	4,557
1991	0	4,853	4,038	4,088	816	0	4,808	0	(0)	3,808	(589)	4,853
Average	0	14,562	13,631	5,802	930	0	10,291	1	1,018	6,730	(156)	13,544

Table A3–17. Continued

Water Year	Available for DW Diversion (TAF)	Delta Storage (TAF)	Delta Storage Diversion (TAF)	Delta Storage Export (TAF)	Delta Storage Outflow (TAF)	Final Total Export (TAF)	Final QWEST Flow (TAF)	Final Delta Outflow (TAF)	3–Mile Slough Flow (TAF)	Old River Diversion Flow (TAF)	Final Antioch Flow (TAF)
1922	276	0	0	0	0	7,177	(193)	11,304	2,761	1,587	2,568
1923	1,512	0	0	0	0	7,210	(579)	9,759	2,612	1,369	2,033
1924	0	0	0	0	0	4,542	(1,154)	4,155	1,629	825	475
1925	597	0	0	0	0	5,969	(926)	8,033	2,398	852	1,471
1926	201	0	0	0	0	5,966	(1,294)	6,765	2,307	877	1,013
1927	1,964	0	0	0	0	7,494	(1,065)	16,379	4,419	1,038	3,355
1928	1,823	0	0	0	0	7,374	(1,347)	13,205	3,838	996	2,491
1929	0	0	0	0	0	4,564	(911)	4,548	1,585	851	673
1930	85	0	0	0	0	5,196	(1,233)	6,033	2,104	764	871
1931	0	0	0	0	0	3,327	(312)	3,677	1,054	831	743
1932	0	0	0	0	0	4,420	10	5,552	1,309	943	1,320
1933	0	0	0	0	0	3,678	(351)	4,288	1,218	853	867
1934	0	0	0	0	0	3,855	(566)	4,710	1,433	805	867
1935	335	0	0	0	0	6,263	(734)	9,115	2,546	1,100	1,812
1936	1,139	0	0	0	0	6,487	(223)	10,518	2,592	1,192	2,370
1937	657	0	0	0	0	6,167	491	9,352	1,929	1,494	2,420
1938	7,361	0	0	0	0	8,687	3,419	34,455	6,176	3,087	9,596
1939	203	0	0	0	0	6,127	(1,574)	5,289	2,121	995	547
1940	2,037	0	0	0	0	7,070	(575)	17,001	4,292	1,046	3,717
1941	5,154	0	0	0	0	7,473	1,727	29,305	5,899	2,157	7,627
1942	4,079	0	0	0	0	8,293	425	25,401	5,706	1,534	6,132
1943	3,663	0	0	0	0	7,749	1,053	18,536	3,766	1,611	4,819
1944	0	0	0	0	0	6,031	(1,292)	6,394	2,221	984	929
1945	656	0	0	0	0	6,712	(847)	8,062	2,365	1,254	1,518
1946	1,793	0	0	0	0	6,895	(695)	12,390	3,293	1,135	2,598
1947	0	0	0	0	0	6,033	(1,609)	5,558	2,203	958	593
1948	0	0	0	0	0	6,382	(1,536)	7,303	2,567	806	1,031
1949	254	0	0	0	0	5,903	(1,275)	6,906	2,333	842	1,057
1950	21	0	0	0	0	6,475	(1,509)	7,230	2,536	866	1,027
1951	4,503	0	0	0	0	7,812	886	19,166	4,003	1,430	4,889
1952	4,681	0	0	0	0	8,868	997	25,819	5,490	1,548	6,486
1953	1,918	0	0	0	0	7,451	(1,405)	15,204	4,336	1,084	2,931
1954	1,496	0	0	0	0	8,099	(2,278)	13,158	4,339	908	2,061
1955	319	0	0	0	0	6,459	(1,884)	5,788	2,403	839	519
1956	4,550	0	0	0	0	7,846	1,328	26,111	5,377	1,711	6,705
1957	361	0	0	0	0	7,332	(1,811)	9,125	3,142	964	1,331
1958	5,027	0	0	0	0	9,299	744	30,313	6,670	2,019	7,414
1959	1,191	0	0	0	0	6,717	(1,453)	9,189	2,962	997	1,509
1960	0	0	0	0	0	6,000	(1,817)	5,894	2,393	802	576
1961	45	0	0	0	0	5,945	(1,908)	5,825	2,427	763	518
1962	679	0	0	0	0	5,932	(1,111)	7,974	2,489	892	1,378
1963	2,088	0	0	0	0	8,092	(1,484)	17,242	4,847	1,021	3,364
1964	756	0	0	0	0	6,467	(1,947)	6,431	2,590	869	644
1965	2,633	0	0	0	0	7,252	133	19,286	4,445	1,246	4,578
1966	726	0	0	0	0	7,285	(1,867)	8,057	2,924	1,110	1,057
1967	3,092	0	0	0	0	8,990	(203)	19,649	4,706	1,729	4,503
1968	1,224	0	0	0	0	7,449	(1,985)	10,087	3,462	943	1,477
1969	5,106	0	0	0	0	8,636	3,459	27,337	4,498	3,097	7,957
1970	4,600	0	0	0	0	7,789	969	25,253	5,378	1,632	6,347
1971	2,192	0	0	0	0	7,771	(1,168)	15,656	4,310	993	3,142
1972	76	0	0	0	0	7,190	(2,421)	6,709	2,916	902	495
1973	3,238	0	0	0	0	7,818	(240)	18,142	4,372	1,204	4,132
1974	5,056	0	0	0	0	8,619	323	30,268	6,899	1,154	7,222
1975	1,805	0	0	0	0	8,513	(1,125)	14,930	4,118	1,176	2,993
1976	131	0	0	0	0	5,515	(1,803)	4,987	2,178	755	374
1977	0	0	0	0	0	3,053	(453)	3,657	1,129	676	676
1978	2,135	0	0	0	0	6,295	358	15,415	3,411	1,158	3,769
1979	488	0	0	0	0	7,047	(913)	9,007	2,620	1,220	1,707
1980	4,573	0	0	0	0	7,161	2,727	22,011	3,657	2,567	6,384
1981	271	0	0	0	0	6,984	(1,857)	7,191	2,718	1,068	861
1982	7,155	0	0	0	0	9,279	4,916	34,935	5,468	3,355	10,384
1983	19,190	0	0	0	0	10,631	16,348	58,898	4,798	9,324	21,146
1984	7,825	0	0	0	0	8,100	4,679	26,736	3,699	3,669	8,378
1985	1,002	0	0	0	0	6,811	(1,492)	7,600	2,610	1,103	1,118
1986	5,487	0	0	0	0	7,119	4,115	27,227	4,111	2,756	8,225
1987	0	0	0	0	0	5,911	(1,398)	5,785	2,140	919	742
1988	218	0	0	0	0	4,640	(1,180)	4,948	1,823	685	643
1989	24	0	0	0	0	5,500	(1,556)	6,422	2,374	646	817
1990	0	0	0	0	0	4,123	(894)	4,557	1,577	633	682
1991	0	0	0	0	0	3,808	(589)	4,853	1,479	634	890
Average	1,995	0	0	0	0	6,730	(156)	13,544	3,264	1,369	3,108

Table A3–18. Monthly Percentiles for DeltaSOS Simulations for the No–Project Cumulative Conditions

Added Sacramento River inflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Sacramento River inflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	7,061	6,109	9,315	8,254	11,098	10,037	8,048	6,120	6,807	8,808	5,799	7,127
10	8,521	8,705	11,222	12,430	13,896	12,393	9,755	8,869	13,397	12,587	8,916	7,402
20	10,336	10,557	12,482	13,398	15,973	14,909	11,824	10,598	13,747	14,209	10,687	9,332
30	11,298	11,141	14,318	15,674	19,556	19,999	12,871	10,927	14,216	16,305	11,377	9,951
40	12,599	12,398	15,340	17,189	26,157	22,470	13,660	12,536	14,576	17,952	12,298	10,418
50	13,235	14,986	15,966	23,855	33,032	29,013	16,641	14,307	15,378	20,715	12,690	10,674
60	14,049	16,748	17,880	27,227	38,969	32,372	19,089	15,112	15,853	20,917	13,531	11,337
70	16,315	18,590	26,185	34,299	50,420	38,408	21,535	19,632	17,456	21,204	15,120	11,470
80	20,271	21,117	32,528	47,425	61,379	47,850	37,669	30,496	20,583	21,494	17,359	14,725
90	22,815	31,259	57,571	66,163	70,537	65,427	45,150	41,227	26,443	22,569	19,130	18,106
100	29,964	64,593	85,103	91,517	108,473	97,768	78,803	60,752	51,139	23,363	20,168	24,376
Mean	14,883	17,738	24,595	30,990	38,331	34,402	22,815	19,775	18,021	18,504	13,419	12,052

Required San Joaquin River flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	1,000	900	900	900	900	900	2,005	2,005	900	900	900	900
10	1,000	900	900	900	900	900	2,005	2,005	900	900	900	900
20	1,500	900	900	900	900	1,330	2,435	2,435	900	900	900	900
30	1,500	900	900	900	1,420	1,420	3,641	2,720	1,420	900	900	900
40	1,500	900	900	900	1,420	2,280	3,880	3,880	1,420	900	900	900
50	1,500	900	900	900	2,130	2,280	3,880	3,880	2,130	900	900	900
60	1,500	900	900	900	2,280	3,420	5,220	5,220	2,280	900	900	900
70	1,500	900	900	900	3,420	3,420	5,220	5,220	3,420	900	900	900
80	1,500	900	900	900	3,420	3,420	6,020	6,020	3,420	900	900	900
90	1,500	900	900	900	3,420	3,420	6,020	6,020	3,420	900	900	900
100	1,500	900	900	900	3,420	3,420	6,020	6,020	3,420	900	900	900
Mean	1,407	900	900	900	2,167	2,425	4,261	4,153	2,253	900	900	900

Additional San Joaquin River inflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	13	55	0	0	0	0
90	44	0	0	0	0	0	445	485	1,217	0	0	0
100	44	0	0	108	550	0	833	1,231	1,289	0	61	305
Mean	7	0	0	2	8	0	89	113	202	0	1	6

New San Joaquin River flow at Vernalis (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	1,456	1,114	1,018	900	900	1,168	2,005	2,005	1,420	973	900	900
10	1,500	1,410	1,254	1,185	1,507	1,424	2,005	2,005	1,786	1,288	961	1,015
20	1,500	1,689	1,494	1,620	2,280	1,735	2,435	2,435	1,810	1,539	989	1,049
30	1,558	1,886	1,661	1,757	2,372	2,280	3,641	2,766	1,822	1,670	1,021	1,109
40	1,695	2,032	1,915	2,086	2,830	2,280	3,988	3,880	1,870	1,675	1,132	1,155
50	1,826	2,287	2,145	2,460	3,421	2,288	3,988	3,933	2,280	1,685	1,473	1,210
60	1,975	2,393	2,291	2,876	3,737	3,420	5,343	5,220	2,819	1,717	1,670	1,336
70	2,000	2,541	2,509	3,164	4,926	3,420	5,343	5,279	3,420	1,831	1,888	1,573
80	2,763	2,687	3,044	4,199	5,974	4,083	6,195	6,105	3,426	1,974	1,960	1,850
90	3,954	2,938	3,667	5,597	8,381	8,398	6,195	6,105	6,759	2,080	2,135	2,814
100	16,954	11,669	19,380	23,241	35,143	42,741	30,300	27,493	30,126	18,015	6,171	10,520
Mean	2,500	2,462	2,773	3,540	4,871	4,753	5,358	5,048	3,580	2,155	1,538	1,698

Note: Negative values shown in parentheses.

Table A3–18. Continued

Sutter and Steamboat Slough flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	1,235	1,202	2,528	2,109	3,208	2,806	2,026	1,207	1,193	1,616	1,067	1,247
10	1,545	2,289	3,255	3,705	4,245	3,691	2,698	2,354	3,018	2,746	1,644	1,299
20	2,037	3,004	3,724	4,062	5,005	4,616	3,480	3,020	3,138	3,297	2,142	1,753
30	2,330	3,225	4,400	4,896	6,316	6,479	3,868	3,144	3,300	4,042	2,354	1,925
40	2,750	3,693	4,774	5,450	8,768	7,391	4,159	3,744	3,426	4,642	2,650	2,061
50	2,963	4,645	5,003	7,906	11,396	9,850	5,249	4,396	3,709	5,667	2,780	2,138
60	3,242	5,288	5,702	9,172	13,728	11,140	6,145	4,691	3,879	5,743	3,064	2,342
70	4,045	5,962	8,779	11,888	18,384	13,505	7,045	6,344	4,460	5,850	3,617	2,384
80	5,502	6,891	11,200	17,148	23,011	17,323	13,213	10,417	5,618	5,959	4,425	3,478
90	6,454	10,710	21,386	25,078	26,989	24,758	16,217	14,631	8,876	6,361	5,077	4,699
100	10,213	24,397	33,495	36,422	44,317	39,307	30,656	22,743	18,683	6,659	5,463	7,040
Mean	3,683	5,696	8,402	10,936	13,842	12,270	7,686	6,485	4,853	4,875	3,105	2,666

Delta Cross Channel flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	3,345	2,172	2,057
10	2,268	0	0	0	0	0	0	0	0	4,310	3,378	2,333
20	3,706	0	0	0	0	0	0	0	4,467	4,643	3,868	3,502
30	3,899	0	0	0	0	0	0	0	4,537	5,034	4,037	3,675
40	4,177	0	0	0	0	0	0	0	4,645	5,319	4,247	3,799
50	4,396	0	0	0	0	0	0	0	4,694	5,771	4,333	3,865
60	4,569	0	0	0	0	0	0	0	4,863	5,803	4,508	4,027
70	4,791	0	0	0	0	0	0	0	4,942	5,848	4,818	4,059
80	5,421	0	0	0	0	0	0	0	5,117	5,894	5,218	4,743
90	6,020	0	0	0	0	0	0	0	5,737	6,062	5,515	5,345
100	6,345	0	0	0	0	0	0	0	6,429	6,185	5,683	6,341
Mean	4,270	0	0	0	0	0	0	0	4,332	5,369	4,387	4,002

Delta Cross Channel & Georgiana Slough flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	3,887	1,992	2,413	2,276	2,640	2,506	2,249	1,994	4,067	5,057	3,445	3,763
10	4,345	2,335	2,655	2,807	2,989	2,802	2,470	2,356	5,657	6,450	5,104	4,023
20	5,571	2,571	2,813	2,927	3,248	3,115	2,731	2,577	6,703	6,946	5,803	5,279
30	5,848	2,645	3,042	3,211	3,697	3,753	2,862	2,618	6,809	7,539	6,048	5,527
40	6,254	2,803	3,169	3,400	4,545	4,068	2,960	2,820	6,948	7,979	6,357	5,704
50	6,577	3,125	3,247	4,246	5,462	4,922	3,331	3,040	7,054	8,686	6,483	5,799
60	6,835	3,345	3,486	4,686	6,279	5,373	3,638	3,141	7,282	8,737	6,744	6,034
70	7,169	3,575	4,549	5,635	7,910	6,201	3,948	3,707	7,415	8,809	7,210	6,080
80	8,137	3,895	5,394	7,477	9,526	7,538	6,098	5,120	7,848	8,882	7,823	7,097
90	9,081	5,223	8,959	10,245	10,908	10,134	7,151	6,595	8,634	9,149	8,284	8,019
100	9,601	10,008	13,153	14,157	16,843	15,142	12,176	9,433	9,735	9,345	8,549	9,595
Mean	6,683	3,497	4,434	5,313	6,322	5,774	4,186	3,772	7,164	8,073	6,589	6,080

Sacramento River flow at Rio Vista (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	2,953	4,089	6,740	6,042	8,592	7,418	5,496	4,319	1,994	2,906	1,675	2,941
10	3,705	6,207	8,441	9,927	10,978	9,634	7,016	5,990	5,807	5,515	3,226	2,957
20	4,408	7,857	9,545	10,788	12,944	11,705	8,982	7,677	6,092	6,265	4,197	3,621
30	5,117	8,492	11,261	12,575	16,117	16,549	9,852	7,924	6,481	7,766	4,642	3,992
40	5,926	9,475	12,520	14,429	23,651	20,796	10,464	9,184	6,771	9,072	5,387	4,308
50	6,535	12,227	12,891	20,909	28,856	24,838	13,056	10,759	7,197	11,094	5,884	4,635
60	6,960	13,337	14,281	24,113	39,701	27,217	15,832	11,813	7,589	11,178	6,376	5,068
70	8,623	14,780	21,605	31,283	49,850	33,893	18,356	15,423	8,705	11,515	7,521	5,636
80	11,520	17,656	39,472	53,373	63,284	48,640	35,917	24,958	11,103	11,690	8,856	7,196
90	13,457	26,189	60,815	90,087	102,991	79,036	56,006	35,056	20,983	12,792	10,253	9,773
100	33,546	59,943	119,018	171,272	182,736	188,332	103,086	50,877	43,121	13,014	11,291	14,422
Mean	8,152	14,567	24,121	34,262	43,101	35,247	22,163	15,764	10,077	9,535	6,269	5,674

QWEST Flow with initial exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	(4,063)	(6,213)	(7,116)	(6,374)	(4,446)	(3,380)	399	(424)	(5,589)	(4,023)	(3,950)	(3,113)
10	(1,864)	(5,670)	(6,034)	(5,310)	(2,794)	(1,987)	578	(98)	319	(3,591)	(3,475)	(1,612)
20	(1,528)	(5,019)	(5,306)	(4,581)	(1,707)	(1,154)	853	69	507	(3,549)	(2,471)	(1,195)
30	(1,409)	(4,388)	(4,674)	(4,291)	(1,160)	(861)	1,316	160	574	(3,367)	(1,657)	(841)
40	(1,093)	(3,728)	(4,266)	(3,460)	303	(542)	1,487	377	611	(3,024)	(710)	(725)
50	(835)	(3,364)	(3,821)	(2,509)	1,914	369	1,858	773	706	(2,723)	(207)	(578)
60	(446)	(2,986)	(3,255)	(969)	4,225	2,114	2,231	987	824	(1,759)	150	(440)
70	(6)	(2,672)	(2,125)	1,041	7,201	3,977	2,616	1,317	1,052	(380)	480	(371)
80	165	(2,422)	1,605	6,408	11,209	10,138	5,595	2,132	1,629	465	1,012	(261)
90	1,674	(821)	4,215	13,748	14,314	14,661	10,832	4,836	2,730	2,642	1,501	240
100	15,066	23,073	39,958	37,172	59,433	74,009	40,633	33,442	31,816	19,443	2,475	11,767
Mean	(277)	(2,759)	(1,341)	1,715	5,708	5,204	4,426	2,407	1,607	(1,304)	(590)	(493)

Table A3–18. Continued

Export reductions to meet QWEST standards (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Delta outflow at Collinsville (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	2,991	3,537	4,531	4,505	7,799	6,898	5,840	4,506	3,997	4,000	3,414	3,007
10	3,348	4,504	5,232	5,788	9,614	8,555	7,818	6,036	6,117	4,994	3,416	3,008
20	4,002	5,044	5,684	6,289	11,400	10,947	10,252	7,578	6,703	6,699	4,384	3,153
30	4,196	5,293	6,355	7,862	15,513	15,073	10,545	7,579	6,895	7,158	5,032	3,398
40	4,678	5,647	6,833	10,476	22,775	18,364	11,260	10,011	7,578	7,230	5,302	3,632
50	5,023	6,383	7,187	16,808	27,301	24,849	15,372	11,258	7,580	7,826	5,740	3,817
60	5,354	7,859	9,483	22,569	44,691	29,666	18,031	12,903	8,328	8,001	5,741	4,143
70	6,403	10,957	17,107	30,748	59,049	41,729	20,862	17,576	9,270	8,002	5,742	4,359
80	9,792	14,090	40,647	72,356	70,178	59,498	40,512	26,201	11,632	8,004	6,042	5,518
90	15,199	22,851	68,851	102,271	116,586	93,737	63,869	39,710	16,998	9,381	6,722	8,323
100	37,421	83,001	159,166	205,170	219,767	262,789	142,618	83,413	74,553	32,036	9,719	26,031
Mean	7,758	11,740	22,764	36,125	48,912	40,457	26,478	17,951	11,307	7,812	5,388	4,998

Delta outflow at Chipps Island (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	695	1,236	2,221	2,195	5,458	4,566	5,921	4,613	4,114	4,117	3,542	3,143
10	1,049	2,194	2,915	3,466	7,257	6,207	7,861	6,113	6,193	5,092	3,544	3,144
20	1,697	2,729	3,363	3,963	9,026	8,577	10,247	7,625	6,767	6,763	4,494	3,287
30	1,889	2,976	4,028	5,521	13,101	12,665	10,534	7,626	6,956	7,213	5,129	3,527
40	2,366	3,326	4,501	8,111	20,295	15,925	11,235	10,011	7,625	7,284	5,394	3,756
50	2,708	4,056	4,852	14,384	24,779	22,350	15,267	11,233	7,627	7,868	5,823	3,938
60	3,036	5,518	7,127	20,091	42,007	27,122	17,874	12,846	8,361	8,040	5,824	4,257
70	4,075	8,587	14,680	28,194	56,232	39,073	20,650	17,428	9,284	8,041	5,825	4,469
80	7,433	11,691	38,001	69,415	67,257	56,677	39,917	25,885	11,600	8,043	6,119	5,605
90	12,790	20,370	65,943	99,052	113,234	90,597	62,819	39,131	16,862	9,393	6,786	8,356
100	34,805	79,961	155,418	200,994	215,455	258,077	140,032	81,981	73,294	31,606	9,724	25,718
Mean	5,417	9,363	20,284	33,521	46,190	37,813	26,156	17,796	11,282	7,854	5,478	5,095

Required Delta outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	2,992	3,537	4,505	4,505	5,960	6,356	5,841	4,505	4,000	4,001	3,415	3,008
10	3,347	4,504	4,532	5,713	7,670	7,068	7,579	6,036	6,117	4,993	3,415	3,008
20	4,001	4,931	4,885	5,980	8,175	8,765	8,641	7,579	6,703	6,698	4,384	3,074
30	4,001	5,194	5,444	6,001	9,456	9,971	9,569	7,579	6,896	7,157	5,033	3,352
40	4,306	5,464	5,771	6,001	11,276	10,891	10,265	8,034	7,579	7,230	5,302	3,622
50	4,519	5,647	6,139	6,001	11,400	11,400	10,545	9,454	7,579	7,825	5,741	3,791
60	4,904	6,062	6,355	6,001	11,400	12,241	11,259	10,268	8,282	8,002	5,741	4,037
70	5,091	6,312	6,591	6,294	14,676	15,373	12,161	11,259	8,889	8,002	5,741	4,190
80	5,354	6,434	6,832	6,891	19,623	16,464	13,890	14,465	9,994	8,002	5,966	5,436
90	5,615	6,804	7,163	7,210	22,072	19,282	15,372	17,320	12,026	9,358	6,577	5,781
100	7,995	8,016	7,580	8,542	28,559	27,430	22,321	28,043	21,174	9,549	7,521	6,333
Mean	4,625	5,715	6,003	6,275	13,148	12,825	11,353	10,645	8,827	7,442	5,331	4,103

Montezuma Slough flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	2,296	2,301	2,310	2,310	2,341	2,332	(81)	(107)	(117)	(117)	(128)	(136)
10	2,299	2,310	2,317	2,322	2,357	2,348	(43)	(77)	(76)	(98)	(128)	(136)
20	2,305	2,315	2,321	2,326	2,374	2,370	5	(47)	(64)	(64)	(110)	(134)
30	2,307	2,317	2,327	2,341	2,412	2,408	11	(47)	(61)	(55)	(97)	(129)
40	2,312	2,321	2,332	2,365	2,480	2,439	25	0	(47)	(54)	(92)	(124)
50	2,315	2,327	2,335	2,424	2,522	2,499	105	25	(47)	(42)	(83)	(121)
60	2,318	2,341	2,356	2,478	2,684	2,544	157	57	(33)	(39)	(83)	(114)
70	2,328	2,370	2,427	2,554	2,817	2,656	212	148	(14)	(39)	(83)	(110)
80	2,359	2,399	2,646	2,941	2,921	2,821	595	316	32	(39)	(77)	(87)
90	2,409	2,481	2,908	3,219	3,352	3,140	1,050	579	136	(12)	(64)	(33)
100	2,616	3,040	3,748	4,176	4,312	4,712	2,586	1,432	1,259	430	(5)	313
Mean	2,340	2,377	2,480	2,604	2,723	2,644	321	155	25	(43)	(90)	(98)

Table A3–18. Continued

Net change in exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	(2)	(2)	(2)	(2)	(1)	(1)	(1)	(544)	(3)	(1)	(1)	(1)
10	0	(2)	(1)	(1)	(0)	(0)	0	(1)	(1)	(1)	(1)	0
20	0	(1)	0	0	0	0	0	(1)	(1)	0	(1)	0
30	0	(1)	0	461	1	1	1	0	(1)	0	(1)	0
40	1	0	1	1,771	1,679	1	322	0	(1)	0	0	0
50	1	0	663	2,427	2,118	2,724	584	1	(0)	0	0	1
60	1	1,547	2,792	2,690	2,738	3,844	648	380	0	1	0	1
70	894	3,959	3,148	2,934	3,443	5,612	920	527	0	1	0	1
80	3,515	3,959	3,236	3,997	6,058	6,543	2,866	1,276	0	1	1	1
90	3,873	3,959	3,889	7,182	6,726	7,735	4,998	3,004	40	1	1	2,761
100	7,838	9,601	9,258	11,282	10,356	9,552	8,306	8,627	7,221	7,104	3,978	6,512
Mean	1,183	1,769	1,849	2,699	2,881	3,086	1,395	915	484	128	57	451

Export limits (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	5,697	5,051	6,904	6,130	6,075	4,250	3,212	2,782	3,191	6,696	4,635	5,495
10	6,791	6,948	8,718	9,146	6,630	5,073	3,941	3,451	5,520	9,986	6,952	5,698
20	8,076	8,268	9,549	11,101	7,754	6,095	4,568	3,856	5,615	11,313	8,486	7,225
30	8,845	8,975	11,012	11,681	9,746	8,217	5,037	4,310	5,869	12,531	8,939	7,610
40	9,462	9,555	11,869	13,474	11,258	10,191	5,701	5,362	6,085	13,625	9,636	7,730
50	10,095	11,604	12,309	18,120	15,028	12,287	6,552	5,878	6,624	14,885	9,804	8,059
60	10,793	12,774	13,050	20,989	20,184	13,992	7,380	6,581	6,841	14,934	10,180	8,423
70	12,371	14,219	19,023	26,125	24,401	17,475	8,921	7,882	7,036	15,296	10,976	9,092
80	14,542	15,592	32,504	51,223	27,435	23,524	12,799	9,437	8,550	15,367	12,576	11,736
90	17,753	22,475	51,845	68,989	43,998	36,367	16,500	12,708	11,317	16,360	13,404	14,088
100	29,881	57,610	105,728	133,645	79,382	92,174	38,212	29,841	30,225	28,830	15,044	23,568
Mean	11,662	13,820	21,256	29,141	20,694	16,863	8,958	7,503	7,838	13,790	10,050	9,229

Revised QWEST flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	(7,936)	(9,916)	(8,246)	(7,715)	(7,261)	(5,288)	(8)	(529)	(5,589)	(4,024)	(3,949)	(5,416)
10	(4,225)	(8,252)	(7,562)	(6,912)	(3,550)	(3,702)	520	(271)	222	(3,592)	(3,475)	(3,368)
20	(2,863)	(7,719)	(6,754)	(6,376)	(2,764)	(3,192)	834	(39)	472	(3,550)	(2,472)	(1,456)
30	(1,994)	(7,237)	(5,960)	(5,461)	(2,265)	(1,927)	964	100	565	(3,368)	(1,656)	(1,001)
40	(1,527)	(6,017)	(5,538)	(4,804)	(1,463)	(1,529)	1,156	219	582	(3,026)	(939)	(786)
50	(1,355)	(4,651)	(4,484)	(4,371)	(723)	(862)	1,384	335	692	(2,722)	(210)	(647)
60	(1,088)	(3,480)	(3,822)	(3,806)	1,268	(551)	1,489	635	766	(1,759)	104	(475)
70	(689)	(2,972)	(3,252)	(2,721)	3,332	97	1,763	774	957	(380)	464	(403)
80	(183)	(2,618)	(2,124)	2,376	5,986	3,474	2,648	1,215	1,158	465	970	(293)
90	161	(1,059)	884	11,748	10,156	10,631	5,995	3,105	2,507	2,630	1,482	231
100	7,228	13,472	30,700	28,779	49,561	64,457	33,256	24,815	24,595	12,339	2,031	5,255
Mean	(1,460)	(4,528)	(3,190)	(984)	2,827	2,118	3,031	1,492	1,123	(1,431)	(646)	(944)

Revised Delta outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	2,992	3,537	4,532	4,505	7,800	6,897	5,841	4,505	4,000	4,001	3,415	3,008
10	3,347	4,504	5,210	5,788	9,282	8,555	7,579	6,036	6,118	4,993	3,415	3,008
20	4,001	5,044	5,565	6,171	11,400	10,946	10,013	7,579	6,704	6,698	4,384	3,152
30	4,198	5,295	6,172	6,909	13,465	15,072	10,399	7,579	6,896	7,157	5,033	3,397
40	4,675	5,647	6,416	7,908	20,813	18,364	11,259	10,012	7,579	7,230	5,302	3,632
50	5,023	6,070	6,792	14,082	25,901	22,222	14,490	11,235	7,579	7,825	5,741	3,818
60	5,354	6,383	7,163	18,654	39,356	25,424	17,354	12,376	8,327	8,002	5,741	4,142
70	5,824	6,804	13,979	26,787	51,792	34,899	20,075	16,226	9,271	8,002	5,741	4,358
80	6,520	8,382	36,150	69,429	64,898	52,834	36,220	24,925	11,632	8,002	5,966	5,517
90	10,947	18,892	65,872	95,087	114,021	89,707	60,896	36,706	16,958	9,373	6,577	6,212
100	29,583	73,400	149,908	195,370	218,088	253,237	136,325	74,786	67,332	24,932	7,521	19,519
Mean	6,575	9,971	20,915	33,426	46,031	37,371	25,083	17,036	10,824	7,684	5,331	4,547

Available water for diversion (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	3,620	528	0	0	0	0	0	0	0
60	0	0	0	6,489	5,684	0	0	0	0	0	0	0
70	0	0	4,523	10,660	9,901	2,975	0	0	0	0	0	0
80	0	692	11,748	17,376	12,935	9,024	634	0	0	0	0	0
90	2,853	7,561	15,884	26,748	23,407	18,540	5,054	948	0	0	0	0
100	14,981	28,472	45,700	43,779	52,147	77,674	23,312	14,941	15,325	13,930	0	8,668
Mean	909	1,897	4,980	8,620	8,015	5,806	1,506	630	320	199	0	233

Table A3–18. Continued

Delta storage diversion (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Delta storage (TAF)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Delta storage discharge for export (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Delta storage discharge for outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Final CVP Tracy and SWP Banks exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	4,288	3,326	5,072	4,844	4,073	3,147	2,791	2,395	1,076	1,818	537	3,271
10	5,125	5,385	7,368	8,686	6,384	4,525	3,571	3,114	5,464	3,427	3,448	3,592
20	6,854	6,640	7,842	10,935	7,285	6,095	3,789	3,538	5,568	6,446	4,730	5,890
30	7,992	7,372	9,922	11,575	9,184	7,956	4,189	3,928	5,766	7,379	5,083	6,051
40	8,500	8,383	10,868	13,474	11,137	10,191	5,623	4,859	5,923	8,865	5,864	6,359
50	9,055	10,670	11,667	14,500	14,500	11,701	6,552	5,685	6,313	10,505	6,324	6,518
60	9,710	12,488	13,050	14,500	14,500	13,992	7,380	6,754	6,543	11,287	7,174	6,685
70	11,921	14,219	14,500	14,500	14,500	14,500	8,921	7,487	7,026	11,288	7,966	7,409
80	14,542	14,900	14,500	14,500	14,500	14,500	10,960	8,829	8,448	11,288	9,615	10,062
90	14,900	14,900	14,500	14,500	14,500	14,500	11,760	11,760	11,317	11,288	11,287	14,004
100	14,900	14,900	14,500	14,500	14,500	14,500	14,900	14,900	14,900	14,900	14,155	14,900
Mean	9,968	10,424	11,479	12,759	11,671	10,752	7,249	6,614	7,326	9,026	6,889	7,552

Table A3–18. Continued

Final QWEST flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	(7,936)	(9,916)	(8,246)	(7,715)	(7,261)	(5,288)	(8)	(529)	(5,589)	(4,024)	(3,949)	(5,416)
10	(4,225)	(8,252)	(7,562)	(6,912)	(3,550)	(3,702)	520	(271)	222	(3,592)	(3,475)	(3,368)
20	(2,863)	(7,719)	(6,754)	(6,376)	(2,764)	(3,192)	834	(39)	472	(3,550)	(2,472)	(1,456)
30	(1,994)	(7,237)	(5,960)	(5,461)	(2,265)	(1,927)	964	100	565	(3,368)	(1,656)	(1,001)
40	(1,527)	(6,017)	(5,538)	(4,804)	(1,463)	(1,529)	1,156	219	582	(3,026)	(939)	(786)
50	(1,355)	(4,651)	(4,484)	(4,371)	(723)	(862)	1,384	335	692	(2,722)	(210)	(647)
60	(1,088)	(3,480)	(3,822)	(3,806)	1,268	(551)	1,489	635	766	(1,759)	104	(475)
70	(689)	(2,972)	(3,252)	(2,721)	3,332	97	1,763	774	957	(380)	464	(403)
80	(183)	(2,618)	(2,124)	2,376	5,986	3,474	2,648	1,215	1,158	465	970	(293)
90	161	(1,059)	884	11,748	10,156	10,631	5,995	3,105	2,507	2,630	1,482	231
100	7,228	13,472	30,700	28,779	49,561	64,457	33,256	24,815	24,595	12,339	2,031	5,255
Mean	(1,460)	(4,528)	(3,190)	(984)	2,827	2,118	3,031	1,492	1,123	(1,431)	(646)	(944)

Final Delta outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	2,992	3,537	4,532	4,505	7,800	6,897	5,841	4,505	4,000	4,001	3,415	3,008
10	3,347	4,504	5,210	5,788	9,282	8,555	7,579	6,036	6,118	4,993	3,415	3,008
20	4,001	5,044	5,565	6,171	11,400	10,946	10,013	7,579	6,704	6,698	4,384	3,152
30	4,198	5,295	6,172	6,909	13,465	15,072	10,399	7,579	6,896	7,157	5,033	3,397
40	4,675	5,647	6,416	7,908	20,813	18,364	11,259	10,012	7,579	7,230	5,302	3,632
50	5,023	6,070	6,792	14,082	25,901	22,222	14,490	11,235	7,579	7,825	5,741	3,818
60	5,354	6,383	7,163	18,654	39,356	25,424	17,354	12,376	8,327	8,002	5,741	4,142
70	5,824	6,804	13,979	26,787	51,792	34,899	20,075	16,226	9,271	8,002	5,741	4,358
80	6,520	8,382	36,150	69,429	64,898	52,834	36,220	24,925	11,632	8,002	5,966	5,517
90	10,947	18,892	65,872	95,087	114,021	89,707	60,896	36,706	16,958	9,373	6,577	6,212
100	29,583	73,400	149,908	195,370	218,088	253,237	136,325	74,786	67,332	24,932	7,521	19,519
Mean	6,575	9,971	20,915	33,426	46,031	37,371	25,083	17,036	10,824	7,684	5,331	4,547

Threemile Slough flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	634	1,104	2,237	1,892	1,881	1,671	950	758	(283)	(833)	(246)	605
10	868	1,952	2,947	3,647	2,925	2,282	1,284	1,312	669	445	484	618
20	1,109	2,689	3,424	3,883	3,487	3,036	1,604	1,734	1,156	1,148	645	922
30	1,457	2,908	4,274	4,825	4,520	4,205	1,850	1,787	1,232	1,871	955	1,056
40	1,735	3,381	4,666	5,596	5,930	5,045	2,162	2,020	1,376	2,445	1,144	1,167
50	1,965	4,585	4,981	6,054	7,354	6,343	2,556	2,307	1,420	3,237	1,432	1,279
60	2,112	5,290	5,532	7,069	8,741	6,786	3,176	2,668	1,472	3,719	1,622	1,413
70	2,815	5,951	6,675	8,324	10,784	9,061	3,726	3,129	1,704	3,733	2,213	1,681
80	3,704	6,841	9,187	11,749	14,281	10,413	6,662	4,528	2,102	3,822	2,936	2,094
90	4,200	7,824	13,176	16,628	16,474	15,092	10,582	6,971	3,069	3,915	3,479	3,295
100	10,307	14,090	19,239	32,510	31,702	23,701	15,506	9,791	8,326	3,990	3,790	4,481
Mean	2,358	4,815	6,623	8,295	9,161	7,553	4,216	3,207	1,997	2,671	1,664	1,619

Old River diversion flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	73	1,126	1,053	959	959	1,166	100	100	1,343	1,018	959	959
10	75	1,336	1,228	1,178	1,401	1,345	100	100	1,581	1,252	1,008	1,051
20	75	1,519	1,392	1,475	1,881	1,548	122	122	1,596	1,422	1,030	1,077
30	78	1,643	1,501	1,562	1,935	1,881	182	138	1,603	1,507	1,055	1,122
40	85	1,732	1,661	1,765	2,199	1,881	199	194	1,633	1,510	1,140	1,157
50	91	1,885	1,800	1,986	2,531	1,885	199	197	1,881	1,517	1,378	1,196
60	99	1,947	1,887	2,225	2,706	2,530	267	261	2,193	1,537	1,507	1,285
70	100	2,033	2,015	2,387	3,355	2,530	267	264	2,530	1,609	1,644	1,444
80	138	2,117	2,320	2,959	3,923	2,896	310	305	2,534	1,697	1,688	1,621
90	198	2,260	2,667	3,719	5,230	5,240	310	305	4,348	1,761	1,794	2,190
100	10,012	7,039	11,400	13,638	20,705	25,321	17,802	16,135	17,698	10,617	4,030	6,404
Mean	352	1,968	2,134	2,561	3,314	3,259	1,011	876	2,597	1,774	1,398	1,484

Antioch flow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	(833)	(2,878)	(2,037)	(1,716)	408	1,317	1,638	1,131	1,210	(33)	(309)	(935)
10	(252)	(2,174)	(1,503)	(1,315)	1,152	1,541	2,276	1,514	1,797	124	11	(20)
20	456	(1,728)	(1,188)	(762)	1,599	2,326	2,706	1,784	1,835	291	322	540
30	535	(1,126)	(1,063)	(635)	2,733	2,796	2,959	1,902	2,033	386	629	622
40	560	(741)	(579)	(339)	3,684	3,390	3,168	2,405	2,158	641	775	632
50	603	(278)	(399)	247	5,355	3,775	4,111	2,992	2,231	907	961	652
60	705	(118)	(164)	1,931	10,770	4,819	4,524	3,563	2,361	966	1,323	663
70	800	(19)	113	4,844	11,837	6,583	5,490	4,305	2,764	1,241	1,475	678
80	913	431	6,866	17,091	18,900	13,694	10,051	5,889	3,374	1,893	1,701	755
90	1,486	1,136	15,268	26,705	31,112	24,566	16,525	9,430	4,609	3,156	1,807	852
100	10,204	23,223	48,823	56,170	66,466	88,158	46,864	28,734	26,939	11,506	2,163	6,970
Mean	898	287	3,433	7,311	11,988	9,671	7,247	4,699	3,120	1,240	1,017	674

Table A3–19a. DeltaSOS–Simulated DW Operations
for Alternative 1 Cumulative Conditions: DW Diversions to Storage (cfs)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (TAF)
1922	0	0	0	0	2,790	0	0	1,572	0	0	0	0	263
1923	677	692	2,562	15	0	0	0	0	0	0	0	0	238
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	4,000	0	0	0	0	0	0	0	241
1926	0	0	0	0	3,343	0	0	0	0	0	0	0	201
1927	0	517	0	3,871	31	49	76	0	0	0	0	0	274
1928	0	4,000	0	28	0	76	0	0	0	0	0	0	247
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	1,406	0	0	0	0	0	0	0	0	85
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	3,871	0	0	59	0	0	0	0	0	237
1936	0	0	0	3,871	30	0	0	0	0	0	0	0	235
1937	0	0	0	0	4,000	307	0	0	0	0	0	0	259
1938	0	4,000	13	15	31	49	76	99	118	0	0	0	265
1939	3,364	0	0	0	0	0	0	0	0	0	0	0	203
1940	0	0	0	3,871	30	49	76	0	0	0	0	0	242
1941	0	0	3,871	15	31	49	76	99	0	0	0	0	249
1942	1,815	675	1,440	15	31	0	126	0	0	0	0	0	247
1943	2,847	1,083	13	15	31	49	0	0	0	0	0	0	243
1944	0	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	4,000	0	0	0	0	0	0	0	241
1946	0	0	3,871	15	0	0	0	0	0	0	0	0	234
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	3,871	0	0	0	0	0	0	233
1950	0	0	0	353	0	0	0	0	0	0	0	0	21
1951	0	4,000	13	15	31	0	0	0	0	0	0	0	244
1952	0	0	3,871	15	30	49	76	99	118	0	0	779	303
1953	2,853	0	355	15	0	0	0	0	0	0	0	0	194
1954	0	2,926	0	3,871	31	49	76	0	0	0	0	0	419
1955	0	0	3,871	15	0	0	0	0	0	0	0	0	234
1956	0	0	3,871	15	30	49	0	172	0	0	0	0	249
1957	2,486	0	0	0	528	2,975	0	0	0	0	0	0	361
1958	0	0	3,871	15	31	49	76	99	118	0	0	233	271
1959	3,178	0	0	3,871	31	0	0	0	0	0	0	0	427
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	741	0	0	0	0	0	0	0	45
1962	0	0	0	0	4,000	0	0	0	0	0	0	0	241
1963	3,871	0	37	0	47	0	1,068	0	0	0	0	0	303
1964	0	4,000	0	3,227	0	0	0	0	0	0	0	0	435
1965	0	0	3,871	15	0	0	220	0	0	0	0	0	247
1966	0	4,000	0	28	0	0	0	0	0	0	0	0	243
1967	0	0	3,871	15	31	49	76	99	118	0	0	259	272
1968	3,106	0	0	620	30	0	0	0	0	0	0	0	226
1969	0	0	2,209	1,676	31	49	76	99	0	0	0	2,504	400
1970	1,501	25	13	15	31	49	0	0	0	0	0	0	98
1971	0	2,459	1,504	15	0	3,210	0	0	0	0	0	0	433
1972	0	0	1,260	0	0	0	0	0	0	0	0	0	76
1973	0	2,082	1,869	15	31	49	0	0	0	0	0	0	244
1974	0	4,000	13	15	31	49	76	0	0	0	0	0	252
1975	1,388	0	0	0	2,836	49	0	0	0	0	0	0	257
1976	1,768	409	0	0	0	0	0	0	0	0	0	0	131
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	3,871	31	49	76	0	0	0	0	0	243
1979	0	0	0	3,871	31	0	0	0	0	0	0	0	235
1980	0	0	839	3,046	30	49	0	0	0	0	0	0	239
1981	0	0	0	3,871	0	0	0	0	0	0	0	0	233
1982	0	4,000	13	15	31	49	76	99	0	0	0	3,888	492
1983	161	25	13	15	31	49	76	99	118	130	0	914	98
1984	53	25	13	15	30	49	0	0	0	0	0	0	11
1985	0	4,000	13	0	0	0	0	0	0	0	0	0	242
1986	0	0	0	0	4,000	307	0	0	0	0	0	0	259
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	3,620	0	0	0	0	0	0	0	0	218
1989	0	0	0	0	0	399	0	0	0	0	0	0	24
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	415	613	617	702	443	173	35	36	8	2	0	123	191

Table A3-19b. DeltaSOS-Simulated DW Operations
for Alternative 1 Cumulative Conditions: DW Discharge to Export Wheeling (cfs)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (TAF)
1922	0	0	0	0	0	0	0	0	0	3,627	0	0	219
1923	0	0	0	0	4,000	0	0	0	0	0	0	0	241
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	154	2,998	0	0	190
1926	0	0	0	0	0	0	0	461	0	2,093	0	0	154
1927	0	0	487	0	0	0	0	0	529	3,015	0	0	243
1928	0	0	0	0	0	0	0	589	137	2,733	0	0	208
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	1,100	93	0	0	0	0	72
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	2,428	0	1,007	0	0	207
1936	0	0	0	0	0	1,323	0	0	588	1,513	0	0	206
1937	0	0	0	0	0	0	0	0	2,822	724	0	0	214
1938	0	0	0	0	0	0	0	0	0	3,741	0	0	225
1939	0	622	0	0	0	0	677	483	0	1,079	0	0	172
1940	0	0	0	0	0	0	0	703	586	2,258	0	0	214
1941	0	0	0	0	0	0	0	0	0	3,627	0	0	219
1942	0	0	0	0	0	0	0	0	0	3,527	0	0	213
1943	0	0	0	0	0	0	0	1,843	857	782	0	0	210
1944	0	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	0	0	0	171	0	2,977	0	0	190
1946	0	0	0	0	4,000	0	0	9	0	0	0	0	242
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	1,454	0	2,000	0	0	208
1950	0	0	0	0	0	0	0	104	0	0	0	0	6
1951	0	0	0	0	0	0	0	0	587	2,837	0	0	206
1952	0	0	0	0	0	0	0	0	0	3,741	0	0	225
1953	0	0	0	0	388	0	0	0	0	3,027	0	0	206
1954	0	0	2,819	0	0	0	0	544	153	2,835	0	0	383
1955	0	0	0	0	0	0	0	0	0	3,378	0	0	204
1956	0	0	0	0	0	0	0	0	0	3,627	0	0	219
1957	0	2,543	0	0	0	0	865	0	136	2,018	0	0	335
1958	0	0	0	0	0	0	0	0	0	3,741	0	0	225
1959	0	0	3,313	0	0	2,691	1,093	0	0	0	0	0	428
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	565	0	0	0	0	0	34
1962	0	0	0	0	0	0	1,332	593	0	1,265	0	0	192
1963	0	0	0	0	0	912	0	0	0	3,527	0	0	267
1964	0	0	3,199	0	0	0	616	479	0	2,302	0	0	397
1965	0	0	0	0	0	63	0	1,041	587	1,918	0	0	217
1966	0	0	0	0	0	0	0	1,461	0	1,917	0	0	204
1967	0	0	0	0	0	0	0	0	0	2,246	1,379	0	218
1968	0	0	0	0	0	0	637	1,245	0	1,544	0	0	206
1969	0	0	0	0	0	0	0	0	0	3,627	0	0	219
1970	0	0	0	0	0	0	157	52	0	3,250	0	0	208
1971	0	0	0	0	3,469	0	80	0	0	3,377	0	0	417
1972	0	0	0	0	0	0	625	391	0	0	0	0	61
1973	0	0	0	0	0	0	0	0	587	2,886	0	0	209
1974	0	0	0	0	0	0	0	0	0	3,527	0	0	213
1975	0	0	0	0	0	0	0	0	0	3,454	0	0	208
1976	0	0	2,126	0	0	0	0	0	0	0	0	0	128
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	245	3,291	0	0	213
1979	0	0	0	0	0	0	0	0	588	2,837	0	0	206
1980	0	0	0	0	0	0	0	0	514	2,957	0	0	209
1981	0	0	0	0	0	0	676	1,250	0	1,474	0	0	205
1982	0	0	0	0	0	0	0	0	0	3,627	0	0	219
1983	0	0	0	0	0	0	0	0	0	0	685	0	41
1984	0	0	0	0	0	0	0	0	0	3,454	0	0	208
1985	0	0	0	0	0	0	768	456	0	2,163	0	0	204
1986	0	0	0	0	0	0	0	0	0	3,454	0	0	208
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	587	425	0	2,134	0	0	190
1989	0	0	0	0	0	0	0	227	0	0	0	0	14
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	0	45	171	0	169	71	140	236	130	1,759	29	0	166

Table A3–19c. DeltaSOS–Simulated DW Operations
for Alternative 1 Cumulative Conditions: DW End–of–Month Storage (TAF)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	0	0	0	0	155	152	147	238	231	(0)	0	0
1923	42	81	238	238	14	11	7	1	0	0	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	222	219	215	209	192	0	0	0
1926	0	0	0	0	186	183	178	144	137	(0)	0	0
1927	0	31	0	238	238	238	238	232	193	(0)	0	0
1928	0	238	237	238	236	238	234	191	176	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	86	85	82	12	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	238	236	233	232	77	70	(0)	0	0
1936	0	0	0	238	238	154	149	143	101	(0)	0	0
1937	0	0	0	0	222	238	234	227	52	(0)	0	0
1938	0	238	238	238	238	238	238	238	238	0	0	0
1939	207	168	167	167	165	162	117	81	74	(0)	0	0
1940	0	0	0	238	238	238	238	189	147	(0)	0	0
1941	0	0	238	238	238	238	238	238	231	(0)	0	0
1942	112	150	238	238	238	235	238	232	225	(0)	0	0
1943	175	238	238	238	238	238	234	114	56	0	0	0
1944	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	222	219	215	198	191	0	0	0
1946	0	0	238	238	14	11	7	(0)	0	0	0	0
1947	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	238	234	138	131	(0)	0	0
1950	0	0	0	22	20	17	12	0	0	0	0	0
1951	0	238	238	238	238	235	231	224	182	0	0	0
1952	0	0	238	238	238	238	238	238	238	0	0	46
1953	218	217	238	238	215	212	207	201	194	(0)	0	0
1954	0	174	0	238	238	238	238	198	182	(0)	0	0
1955	0	0	238	238	236	233	229	223	216	0	0	0
1956	0	0	238	238	238	238	234	238	231	(0)	0	0
1957	153	0	0	0	29	209	153	147	132	0	0	0
1958	0	0	238	238	238	238	238	238	238	0	0	14
1959	206	204	(0)	238	238	70	(0)	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	41	38	(0)	0	0	0	0	0
1962	0	0	0	0	222	219	135	93	86	0	0	0
1963	238	237	238	237	238	179	238	232	225	(0)	0	0
1964	0	238	40	238	236	233	192	157	150	0	0	0
1965	0	0	238	238	236	229	238	168	126	0	0	0
1966	0	238	237	238	236	233	229	133	126	0	0	0
1967	0	0	238	238	238	238	238	238	238	92	(0)	15
1968	203	202	201	238	238	235	193	110	103	0	0	0
1969	0	0	136	238	238	238	238	238	231	(0)	0	149
1970	238	238	238	238	238	238	224	215	208	0	0	0
1971	0	146	238	238	44	238	229	223	216	(0)	0	0
1972	0	0	77	77	75	72	30	(0)	0	0	0	0
1973	0	124	238	238	238	238	234	227	185	0	0	0
1974	0	238	238	238	238	238	238	232	225	(0)	0	0
1975	85	84	83	82	238	238	234	227	220	(0)	0	0
1976	109	132	(0)	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	238	238	238	238	232	210	(0)	0	0
1979	0	0	0	238	238	235	231	224	182	(0)	0	0
1980	0	0	52	238	238	238	234	227	190	0	0	0
1981	0	0	0	238	236	233	189	106	99	(0)	0	0
1982	0	238	238	238	238	238	238	238	231	(0)	0	231
1983	238	238	238	238	238	238	238	238	238	238	189	238
1984	238	238	238	238	238	238	234	227	220	(0)	0	0
1985	0	238	238	237	235	232	182	148	141	0	0	0
1986	0	0	0	0	222	238	234	227	220	(0)	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	223	221	218	178	146	139	(0)	0	0
1989	0	0	0	0	0	25	20	(0)	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0
Average	35	69	96	139	153	157	147	130	118	5	3	10

Table A3–20. DeltaSOS Mean Annual Simulation Output for Alternative 1 Cumulative Conditions

Water Year	Sac Basin Year Type	SJR Basin Year Type	Added Sac Flow (TAF)	New Sac Flow (TAF)	Required SJR Flow (TAF)	Added SJR Flow (TAF)	New SJR Flow (TAF)	Steam & Sutter Flow (TAF)	DCC Rio Vista Reduction (TAF)	Revised DCC Flow (TAF)	Revised Georgiana & DCC (TAF)	Revised Rio Vista Flow (TAF)	QWEST w/ Initial Export (TAF)
1922	2	1	0	15,237	1,682	0	3,037	4,804	0	949	3,631	11,586	824
1923	3	2	0	14,489	1,663	73	2,564	4,395	0	1,567	4,039	10,425	465
1924	5	5	0	8,586	820	4	1,264	2,261	32	1,115	2,902	5,437	(1,130)
1925	4	3	0	12,064	1,213	29	1,491	3,509	0	1,438	3,630	9,040	(667)
1926	4	4	0	11,614	1,107	0	1,511	3,338	0	1,419	3,554	8,157	(1,037)
1927	1	2	0	19,015	1,585	71	1,963	6,229	0	1,355	4,501	17,527	212
1928	2	3	0	18,455	1,244	30	1,736	6,051	0	1,477	4,542	14,653	(275)
1929	5	5	0	8,696	820	2	1,306	2,314	42	1,147	2,939	5,573	(886)
1930	4	5	0	10,768	816	28	1,168	3,052	0	1,269	3,310	7,368	(1,021)
1931	5	5	0	6,775	790	2	1,257	1,651	91	875	2,453	4,103	(287)
1932	4	2	0	8,618	1,244	0	1,655	2,274	0	1,142	2,924	5,630	308
1933	5	4	0	7,535	1,004	0	1,388	1,931	97	908	2,579	4,753	(326)
1934	5	5	0	8,173	820	4	1,205	2,172	66	916	2,658	5,386	(423)
1935	3	2	0	12,496	1,477	0	2,051	3,700	29	1,301	3,554	9,935	(372)
1936	3	2	0	13,335	1,585	80	2,221	3,996	0	1,365	3,727	10,821	136
1937	3	1	0	12,426	1,682	56	2,860	3,671	0	1,290	3,547	8,936	804
1938	1	1	0	28,179	1,759	0	5,428	9,982	0	1,057	5,533	31,093	5,905
1939	4	4	0	10,712	1,004	0	1,695	3,007	0	1,498	3,498	6,983	(510)
1940	2	2	0	17,638	1,585	78	1,973	5,687	0	1,469	4,408	17,640	100
1941	1	1	0	23,780	1,759	0	3,677	8,157	0	1,370	5,188	27,629	2,950
1942	1	1	0	25,353	1,759	0	2,986	8,822	0	1,151	5,211	25,051	2,793
1943	1	1	0	20,972	1,759	78	3,229	6,984	0	1,426	4,820	17,571	3,269
1944	4	3	0	11,388	1,140	45	1,688	3,253	0	1,423	3,528	7,790	(1,164)
1945	3	2	0	12,566	1,507	77	2,321	3,714	0	1,386	3,653	9,005	(244)
1946	3	2	0	16,177	1,585	74	2,146	5,102	0	1,435	4,178	13,192	(65)
1947	4	4	0	10,949	1,056	50	1,607	3,089	0	1,438	3,480	7,285	(1,585)
1948	3	3	0	13,098	1,140	3	1,421	3,868	0	1,630	3,917	8,948	(1,430)
1949	4	3	0	11,993	1,140	49	1,472	3,503	0	1,421	3,616	8,292	(1,039)
1950	3	3	0	12,811	1,192	0	1,532	3,774	0	1,525	3,793	8,851	(1,161)
1951	2	2	0	21,672	1,663	80	2,663	7,244	0	1,526	5,004	18,363	1,957
1952	1	1	0	28,323	1,759	0	3,023	9,970	0	1,183	5,647	24,889	2,963
1953	1	3	0	18,839	1,295	0	1,965	6,162	0	1,240	4,362	16,711	767
1954	2	3	0	19,873	1,244	29	1,601	6,490	0	1,575	4,778	15,551	(526)
1955	4	4	0	11,447	1,004	0	1,365	3,263	0	1,488	3,587	7,775	(1,416)
1956	1	1	0	21,768	1,759	0	3,270	7,335	0	1,499	5,011	24,852	2,374
1957	2	3	0	15,092	1,244	27	1,812	4,642	0	1,623	4,175	11,044	(740)
1958	1	1	0	26,266	1,759	1	3,397	9,182	0	1,243	5,417	29,612	3,022
1959	3	4	0	14,716	1,159	69	1,800	4,523	0	1,536	4,064	10,754	112
1960	4	5	0	11,339	846	30	1,247	3,228	0	1,455	3,546	7,825	(1,648)
1961	4	5	0	11,459	842	40	1,179	3,280	0	1,434	3,545	7,844	(1,714)
1962	3	3	0	12,372	1,110	45	1,530	3,632	0	1,418	3,656	9,182	(951)
1963	1	2	0	20,611	1,585	0	1,934	6,877	0	1,184	4,566	18,800	(18)
1964	4	4	0	12,397	1,004	3	1,361	3,615	0	1,540	3,756	8,495	(1,369)
1965	1	1	0	19,519	1,759	80	2,404	6,453	0	1,378	4,592	19,247	758
1966	3	3	0	13,901	1,244	49	2,011	4,172	0	1,502	3,913	10,033	(959)
1967	1	1	0	22,181	1,759	0	3,304	7,439	0	1,144	4,729	19,913	1,947
1968	3	4	0	15,971	1,159	49	1,709	5,020	0	1,525	4,226	12,181	706
1969	1	1	0	23,660	1,759	0	5,442	8,066	0	1,543	5,297	23,945	5,690
1970	1	2	0	21,543	1,585	74	3,357	7,316	0	1,506	5,006	24,373	3,752
1971	1	3	0	20,939	1,295	0	1,732	6,908	0	1,583	4,932	16,920	(185)
1972	3	4	0	13,210	1,107	0	1,515	3,920	0	1,524	3,842	9,253	(1,549)
1973	2	2	0	19,810	1,663	78	2,252	6,529	0	1,487	4,717	18,433	995
1974	1	1	0	29,264	1,759	2	2,240	10,392	0	1,580	6,144	30,030	2,138
1975	1	1	0	20,440	1,682	0	2,310	6,784	0	1,674	4,962	16,153	919
1976	5	5	0	10,456	820	9	1,169	2,943	4	1,324	3,307	6,917	(1,263)
1977	5	5	0	6,824	790	0	1,016	1,703	36	821	2,391	4,233	(428)
1978	2	1	0	16,859	1,729	0	2,267	5,405	31	1,187	4,063	15,113	2,171
1979	3	2	0	13,993	1,585	78	2,378	4,235	0	1,449	3,884	10,011	355
1980	2	1	0	18,292	1,759	0	4,818	6,032	0	1,267	4,358	19,356	4,240
1981	4	4	0	13,093	1,159	49	1,962	3,885	0	1,436	3,756	9,162	(436)
1982	1	1	0	29,591	1,759	3	5,389	10,473	0	1,562	6,157	30,065	6,953
1983	1	1	0	35,577	1,759	0	15,726	12,980	0	1,050	6,551	42,561	21,590
1984	1	2	0	23,213	1,585	74	6,524	7,985	0	1,190	4,958	22,157	8,228
1985	4	4	0	13,038	1,107	50	1,909	3,861	0	1,485	3,790	9,191	(591)
1986	1	1	0	18,958	1,682	0	4,814	6,463	0	1,300	4,534	23,167	4,991
1987	4	5	0	10,952	846	16	1,661	3,102	0	1,383	3,437	7,300	(1,270)
1988	5	5	0	9,416	790	6	1,020	2,563	38	1,161	3,048	6,236	(961)
1989	4	5	0	11,782	842	31	1,036	3,442	31	1,324	3,490	8,090	(1,309)
1990	5	5	0	8,675	790	4	944	2,288	52	1,143	2,939	5,561	(812)
1991	5	5	0	8,612	816	37	995	2,286	29	1,072	2,863	5,552	(564)
Average			0	15,998	1,326	26	2,427	5,091	8	1,347	4,090	13,793	887

Notes: Definitions of the categories are provided in Table A2–3 in Appendix A2.
Water–year types: 1=wet, 2=above normal, 3=below normal, 4=dry, 5=critically dry
Negative values shown in parentheses.

Table A3–20. Continued

Water Year	Reduced Export for QWEST (TAF)	Initial Collinsville Outflow (TAF)	Initial Chipps Outflow (TAF)	Required Delta Outflow (TAF)	Revised Montez. Flow (TAF)	Reduced Export for Outflow (TAF)	Export Limits (TAF)	Reduced Export for Limits (TAF)	Net Export Change (TAF)	Adjusted Total Export (TAF)	Revised QWEST Flow (TAF)	Revised Collinsville Outflow (TAF)
1922	0	12,321	11,391	6,103	930	1	8,364	0	1,001	7,185	(177)	11,320
1923	0	10,803	9,917	5,833	886	0	9,521	0	1,021	7,212	(556)	9,782
1924	0	4,180	3,375	4,063	805	3	5,401	0	19	4,561	(1,149)	4,161
1925	0	8,292	7,430	5,195	862	3	7,312	0	246	5,981	(914)	8,045
1926	0	7,022	6,175	5,006	847	3	6,923	0	243	5,976	(1,280)	6,779
1927	0	17,655	16,686	6,980	970	1	10,720	0	1,264	7,506	(1,052)	16,391
1928	0	14,277	13,355	6,665	922	1	10,032	0	1,064	7,391	(1,339)	13,213
1929	0	4,573	3,760	4,418	813	3	5,435	0	19	4,583	(906)	4,553
1930	0	6,245	5,414	5,052	832	3	6,182	0	201	5,210	(1,222)	6,044
1931	0	3,702	2,901	3,657	800	3	4,306	0	14	3,341	(301)	3,688
1932	0	5,849	5,019	5,190	831	1	5,625	0	297	4,444	11	5,553
1933	0	4,313	3,503	4,050	810	3	4,694	0	18	3,696	(344)	4,295
1934	0	4,853	4,038	4,532	815	3	4,803	0	141	3,878	(564)	4,712
1935	0	9,477	8,584	6,455	893	3	7,413	0	348	6,274	(720)	9,129
1936	0	10,877	9,993	6,248	883	3	8,419	0	325	6,478	(189)	10,552
1937	0	9,666	8,791	5,287	874	3	7,752	16	300	6,179	504	9,365
1938	0	36,940	35,736	8,125	1,204	1	18,482	0	2,470	8,697	3,435	34,470
1939	0	6,353	5,520	4,357	833	0	6,865	0	1,055	6,143	(1,565)	5,298
1940	0	17,676	16,697	7,246	979	3	10,409	0	665	7,085	(565)	17,011
1941	0	30,529	29,403	7,010	1,125	1	16,412	0	1,207	7,482	1,744	29,322
1942	0	27,769	26,688	6,671	1,082	0	16,125	0	2,353	8,302	440	25,416
1943	0	20,751	19,767	7,309	984	0	13,363	0	2,208	7,766	1,060	18,543
1944	0	6,521	5,686	4,952	835	3	6,788	0	117	6,045	(1,281)	6,405
1945	0	8,664	7,806	5,277	858	1	7,966	0	557	6,691	(800)	8,108
1946	0	13,020	12,120	6,279	900	1	11,239	0	586	6,876	(651)	12,434
1947	0	5,583	4,756	5,072	827	3	6,751	0	15	6,048	(1,599)	5,568
1948	0	7,409	6,543	5,487	866	3	7,141	0	90	6,390	(1,519)	7,320
1949	0	7,142	6,299	4,921	843	3	6,947	0	223	5,915	(1,262)	6,919
1950	0	7,579	6,725	5,599	854	3	7,295	0	335	6,486	(1,495)	7,244
1951	0	20,237	19,264	6,326	972	0	14,970	0	1,049	7,815	907	19,188
1952	0	27,785	26,665	7,985	1,120	1	15,787	0	1,948	8,875	1,014	25,837
1953	0	17,375	16,419	6,080	956	0	12,676	0	2,158	7,462	(1,391)	15,218
1954	0	14,909	13,968	7,021	940	1	10,339	0	1,743	8,115	(2,269)	13,166
1955	0	6,255	5,422	5,051	834	0	7,342	0	451	6,468	(1,868)	5,804
1956	0	27,158	26,099	6,221	1,058	1	17,795	0	1,022	7,845	1,353	26,136
1957	0	10,196	9,315	5,661	880	2	8,552	0	1,062	7,348	(1,802)	9,133
1958	0	32,590	31,417	7,267	1,173	0	16,086	0	2,260	9,307	761	30,330
1959	0	10,755	9,880	5,294	875	0	8,800	0	1,561	6,737	(1,448)	9,194
1960	0	6,062	5,230	5,203	832	3	6,803	0	159	6,015	(1,807)	5,903
1961	0	6,020	5,189	5,097	831	3	6,750	0	184	5,959	(1,898)	5,836
1962	0	8,134	7,281	5,063	853	3	7,528	0	150	5,947	(1,101)	7,984
1963	0	18,707	17,694	7,329	1,013	0	11,162	0	1,455	8,106	(1,473)	17,252
1964	0	7,008	6,169	5,143	839	1	7,793	0	567	6,481	(1,937)	6,441
1965	0	19,912	18,920	6,670	991	1	14,496	0	621	7,272	137	19,290
1966	0	8,964	8,102	5,602	862	0	8,613	0	895	7,298	(1,855)	8,069
1967	0	21,799	20,750	7,553	1,049	1	13,108	0	2,132	8,997	(185)	19,667
1968	0	12,778	11,884	5,557	894	0	9,256	0	2,683	7,466	(1,977)	10,095
1969	0	29,568	28,445	7,967	1,123	1	16,813	0	2,213	8,643	3,477	27,355
1970	0	28,036	26,997	5,637	1,039	0	18,655	0	2,775	7,806	978	25,261
1971	0	16,639	15,687	7,094	952	1	12,449	0	972	7,785	(1,157)	15,667
1972	0	7,581	6,735	5,409	846	0	7,849	0	863	7,206	(2,412)	6,718
1973	0	19,377	18,410	6,821	966	0	12,919	0	1,223	7,832	(229)	18,153
1974	0	32,083	30,958	6,944	1,126	1	19,746	0	1,800	8,628	338	30,284
1975	0	16,975	16,015	6,627	960	0	10,903	0	2,030	8,523	(1,110)	14,945
1976	0	5,528	4,706	4,416	821	1	6,343	0	532	5,531	(1,795)	4,995
1977	0	3,682	2,882	3,657	800	3	4,264	0	24	3,076	(452)	3,658
1978	0	17,228	16,266	7,933	962	3	10,117	0	1,797	6,304	374	15,431
1979	0	10,275	9,397	5,844	878	1	8,242	0	1,255	7,059	(900)	9,020
1980	0	23,524	22,522	6,568	1,002	1	14,443	15	1,468	7,141	2,772	22,056
1981	0	8,612	7,757	5,109	855	0	7,849	0	1,412	7,000	(1,848)	7,200
1982	0	36,973	35,733	7,099	1,240	1	20,240	0	2,020	9,287	4,933	34,952
1983	0	64,141	62,588	6,197	1,553	0	31,346	0	5,222	10,635	16,369	58,919
1984	0	30,285	29,222	5,676	1,063	0	20,548	0	3,493	8,069	4,735	26,792
1985	0	8,501	7,647	5,068	854	0	8,383	0	893	6,827	(1,484)	7,608
1986	0	28,103	27,051	6,155	1,052	1	14,333	33	859	7,127	4,132	27,245
1987	0	5,913	5,083	4,819	829	2	6,602	0	118	5,926	(1,389)	5,794
1988	0	5,167	4,349	4,505	818	3	5,648	0	209	4,655	(1,170)	4,958
1989	0	6,669	5,825	4,816	844	2	6,313	0	234	5,512	(1,543)	6,435
1990	0	4,640	3,825	4,506	814	3	5,037	0	72	4,137	(884)	4,568
1991	0	4,878	4,062	4,088	816	3	4,808	0	20	3,828	(585)	4,858
Average	0	14,587	13,656	5,802	931	1	10,291	1	1,029	6,741	(142)	13,558

Table A3-20. Continued

Water Year	Available for DW Diversion (TAF)	Delta Storage (TAF)	Delta Storage Diversion (TAF)	Delta Storage Export (TAF)	Delta Storage Outflow (TAF)	Final Total Export (TAF)	Final QWEST Flow (TAF)	Final Delta Outflow (TAF)	3-Mile Slough Flow (TAF)	Old River Diversion Flow (TAF)	Final Antioch Flow (TAF)	Old & Middle Flow (TAF)
1922	276	238	263	219	0	7,404	(440)	11,057	2,839	1,587	2,399	(6,316)
1923	1,512	238	238	241	0	7,453	(794)	9,544	2,679	1,369	1,885	(6,579)
1924	0	0	0	0	0	4,561	(1,149)	4,161	1,627	825	478	(4,395)
1925	597	222	241	190	0	6,171	(1,155)	7,804	2,469	852	1,315	(5,797)
1926	201	186	201	154	0	6,130	(1,481)	6,578	2,366	877	885	(5,791)
1927	1,965	238	274	243	0	7,749	(1,326)	16,118	4,501	1,038	3,175	(7,190)
1928	1,828	238	247	208	0	7,600	(1,587)	12,966	3,913	996	2,326	(7,151)
1929	0	0	0	0	0	4,583	(906)	4,553	1,583	851	677	(4,338)
1930	85	86	85	72	0	5,282	(1,307)	5,959	2,127	764	820	(5,078)
1931	0	0	0	0	0	3,341	(301)	3,688	1,051	831	750	(3,120)
1932	0	0	0	0	0	4,444	11	5,553	1,309	943	1,320	(4,014)
1933	0	0	0	0	0	3,696	(344)	4,295	1,216	853	872	(3,461)
1934	0	0	0	0	0	3,878	(564)	4,712	1,432	805	868	(3,672)
1935	335	238	237	207	0	6,481	(957)	8,892	2,616	1,100	1,659	(5,879)
1936	1,139	238	235	206	0	6,685	(424)	10,317	2,655	1,192	2,231	(5,956)
1937	657	238	259	214	0	6,392	245	9,106	2,006	1,494	2,251	(5,343)
1938	7,363	238	265	225	0	8,922	3,170	34,205	6,255	3,087	9,424	(6,209)
1939	203	207	203	172	0	6,315	(1,767)	5,096	2,182	995	414	(5,946)
1940	2,041	238	242	214	0	7,299	(808)	16,768	4,365	1,046	3,558	(6,655)
1941	5,155	238	249	219	0	7,700	1,494	29,072	5,972	2,157	7,466	(5,890)
1942	4,080	238	247	213	0	8,515	193	25,169	5,779	1,534	5,972	(7,427)
1943	3,664	238	243	210	0	7,976	817	18,300	3,840	1,611	4,657	(6,863)
1944	0	0	0	0	0	6,045	(1,281)	6,405	2,217	984	936	(5,623)
1945	656	222	241	190	0	6,880	(1,041)	7,867	2,426	1,254	1,384	(6,160)
1946	1,792	238	234	242	0	7,118	(885)	12,200	3,353	1,139	2,468	(6,553)
1947	0	0	0	0	0	6,048	(1,599)	5,568	2,199	958	600	(5,702)
1948	0	0	0	0	0	6,390	(1,519)	7,320	2,562	806	1,043	(6,165)
1949	254	238	233	208	0	6,123	(1,495)	6,685	2,402	842	906	(5,870)
1950	21	22	21	6	0	6,492	(1,517)	7,223	2,539	866	1,022	(6,215)
1951	4,502	238	244	206	0	8,021	663	18,943	4,073	1,430	4,736	(7,065)
1952	4,681	238	303	225	0	9,100	711	25,534	5,579	1,548	6,290	(7,962)
1953	1,917	238	194	206	0	7,668	(1,585)	15,023	4,392	1,084	2,807	(7,139)
1954	1,497	238	419	383	0	8,498	(2,688)	12,747	4,468	908	1,780	(8,198)
1955	319	238	234	204	0	6,671	(2,102)	5,570	2,471	839	369	(6,387)
1956	4,549	238	249	219	0	8,064	1,103	25,887	5,447	1,711	6,551	(6,773)
1957	361	209	361	335	0	7,683	(2,163)	8,773	3,252	964	1,090	(7,298)
1958	5,034	238	271	225	0	9,532	491	30,060	6,749	2,019	7,240	(7,832)
1959	1,192	238	427	428	0	7,165	(1,875)	8,768	3,094	997	1,220	(6,759)
1960	0	0	0	0	0	6,015	(1,807)	5,903	2,390	802	583	(5,812)
1961	45	41	45	34	0	5,993	(1,942)	5,791	2,437	763	495	(5,817)
1962	679	222	241	192	0	6,139	(1,342)	7,743	2,561	892	1,219	(5,782)
1963	2,087	238	303	267	0	8,374	(1,776)	16,949	4,939	1,021	3,163	(7,797)
1964	756	238	435	397	0	6,879	(2,372)	6,006	2,724	849	352	(6,645)
1965	2,633	238	247	217	0	7,490	(110)	19,043	4,521	1,246	4,411	(6,763)
1966	726	238	243	204	0	7,501	(2,097)	7,826	2,996	1,110	899	(6,974)
1967	3,091	238	272	218	0	9,215	(457)	19,395	4,785	1,729	4,328	(7,877)
1968	1,224	238	226	206	0	7,672	(2,203)	9,869	3,530	943	1,327	(7,310)
1969	5,106	238	400	219	0	8,861	3,077	26,955	4,618	3,097	7,694	(6,176)
1970	4,599	238	98	208	0	8,014	879	25,163	5,406	1,632	6,285	(6,885)
1971	2,192	238	433	417	0	8,202	(1,590)	15,234	4,442	993	2,853	(7,737)
1972	76	78	76	61	0	7,268	(2,488)	6,642	2,937	902	449	(7,002)
1973	3,239	238	244	209	0	8,041	(472)	17,910	4,445	1,204	3,973	(7,184)
1974	5,060	238	252	213	0	8,841	86	30,032	6,973	1,154	7,060	(8,170)
1975	1,805	238	257	208	0	8,731	(1,368)	14,688	4,194	1,176	2,826	(8,090)
1976	131	132	131	128	0	5,659	(1,926)	4,864	2,216	755	290	(5,563)
1977	0	0	0	0	0	3,076	(452)	3,658	1,128	676	676	(3,050)
1978	2,136	238	243	213	0	6,517	131	15,188	3,482	1,158	3,613	(5,737)
1979	488	238	235	206	0	7,266	(1,135)	8,785	2,689	1,220	1,554	(6,555)
1980	4,574	238	239	209	0	7,350	2,533	21,817	3,718	2,567	6,251	(5,215)
1981	271	238	233	205	0	7,204	(2,081)	6,967	2,788	1,068	707	(6,736)
1982	7,154	238	492	219	0	9,505	4,441	34,460	5,617	3,355	10,057	(6,477)
1983	19,189	238	98	41	0	10,676	16,271	58,821	4,822	9,324	21,093	(1,539)
1984	7,824	238	11	208	0	8,277	4,723	26,780	3,685	3,669	8,408	(5,153)
1985	1,001	238	242	204	0	7,031	(1,726)	7,366	2,683	1,103	958	(6,469)
1986	5,489	238	259	208	0	7,335	3,873	26,985	4,187	2,756	8,059	(4,941)
1987	0	0	0	0	0	5,926	(1,389)	5,794	2,137	919	748	(5,620)
1988	218	223	218	190	0	4,844	(1,388)	4,740	1,889	685	501	(4,735)
1989	24	25	24	14	0	5,526	(1,567)	6,411	2,377	646	810	(5,473)
1990	0	0	0	0	0	4,137	(884)	4,568	1,573	633	690	(4,095)
1991	0	0	0	0	0	3,828	(585)	4,858	1,477	634	893	(3,792)
Average	1,996	173	191	166	0	6,907	(333)	13,367	3,320	1,369	2,987	(6,056)

Table A3–21. Monthly Percentiles for DeltaSOS Simulations for Alternative 1 Cumulative Conditions

DW diversion (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	15	30	0	0	0	0	0	0	0
60	0	0	0	15	31	0	0	0	0	0	0	0
70	0	0	13	15	31	49	0	0	0	0	0	0
80	0	517	839	620	31	49	76	0	0	0	0	0
90	1,815	4,000	3,871	3,871	2,790	49	76	99	0	0	0	0
100	3,871	4,000	3,871	3,871	4,000	3,871	1,068	1,572	118	130	0	3,888
Mean	415	613	617	702	443	173	35	36	8	2	0	123

DW storage (TAF)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	(0)	0	0	0	(0)	(0)	0	(0)	(0)	0
10	0	0	0	0	0	0	0	0	0	(0)	0	0
20	0	0	0	0	0	0	0	0	0	(0)	0	0
30	0	0	0	0	29	70	12	0	0	(0)	0	0
40	0	0	0	77	186	183	153	110	86	0	0	0
50	0	0	0	238	222	229	207	147	132	0	0	0
60	0	0	83	238	236	235	231	198	182	0	0	0
70	0	124	238	238	238	238	234	224	193	0	0	0
80	0	204	238	238	238	238	238	232	220	0	0	0
90	203	238	238	238	238	238	238	238	231	0	0	0
100	238	238	238	238	238	238	238	238	238	238	189	238
Mean	35	69	96	139	153	157	147	130	118	5	3	10

DW discharge for export (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	1,079	0	0
50	0	0	0	0	0	0	0	0	0	2,000	0	0
60	0	0	0	0	0	0	0	0	0	2,302	0	0
70	0	0	0	0	0	0	0	52	0	2,977	0	0
80	0	0	0	0	0	0	0	456	136	3,378	0	0
90	0	0	0	0	0	0	637	703	586	3,627	0	0
100	0	2,543	3,313	0	4,000	2,691	1,332	2,428	2,822	3,741	1,379	0
Mean	0	45	171	0	169	71	140	236	130	1,759	29	0

DW discharge for outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Final CVP Tracy and SWP Banks exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	4,278	3,314	5,051	4,859	6,075	3,220	2,842	2,455	1,145	1,896	597	3,296
10	5,115	5,373	7,347	8,701	6,407	4,525	3,672	3,267	5,500	6,208	3,508	3,617
20	6,844	6,628	7,821	10,950	7,754	6,095	4,071	3,691	5,568	7,611	4,790	5,915
30	7,982	7,360	10,347	11,590	9,746	8,217	4,908	4,375	5,804	9,978	5,143	6,076
40	8,490	8,371	11,155	13,474	11,320	10,191	5,753	5,424	6,202	11,365	5,924	6,384
50	9,045	10,658	12,309	14,500	14,500	12,287	6,573	6,047	6,595	11,366	6,699	6,543
60	9,700	12,910	13,448	14,500	14,500	13,992	7,380	6,581	6,968	12,180	7,367	6,710
70	11,911	14,219	14,500	14,500	14,500	14,500	8,921	7,882	7,148	12,880	8,026	7,434
80	14,542	14,900	14,500	14,500	14,500	14,500	10,960	9,632	8,756	13,530	9,675	10,087
90	14,900	14,900	14,500	14,500	14,500	14,500	11,760	11,760	11,317	14,202	11,347	14,029
100	14,900	14,900	14,500	14,500	14,500	14,500	14,900	14,900	14,900	14,900	14,900	14,900
Mean	9,962	10,461	11,640	12,762	11,842	10,832	7,379	6,866	7,476	10,862	6,979	7,575

Table A3–22a. DeltaSOS–Simulated DW Operations
for Alternative 2 Cumulative Conditions: DW Diversions to Storage (cfs)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (TAF)
1922	0	0	0	0	2,790	0	0	1,791	0	0	0	0	276
1923	677	692	2,562	15	0	0	0	0	0	0	0	0	238
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	4,000	0	0	0	0	0	0	0	241
1926	0	0	0	0	3,343	0	0	0	0	0	0	0	201
1927	0	517	0	3,871	31	49	76	0	0	0	0	0	274
1928	0	4,000	0	2,219	0	3,051	0	0	0	0	0	0	558
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	1,406	0	0	0	0	0	0	0	0	85
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	3,871	0	0	59	0	0	0	0	0	237
1936	0	0	0	3,871	30	0	0	0	0	0	0	0	235
1937	0	0	0	0	4,000	307	0	0	0	0	0	0	259
1938	0	4,000	13	15	31	49	76	99	118	0	0	0	265
1939	3,364	0	0	0	0	0	0	0	0	0	0	0	203
1940	0	0	0	3,871	30	49	76	0	0	0	0	0	242
1941	0	0	3,871	15	31	49	76	99	0	0	0	0	249
1942	1,815	675	1,440	15	31	0	2,256	0	0	0	0	0	375
1943	2,847	1,083	13	15	31	49	0	0	0	0	0	0	243
1944	0	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	4,000	0	0	0	0	0	0	0	241
1946	0	0	3,871	15	0	0	0	0	0	0	0	0	234
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	3,871	0	0	0	0	0	0	233
1950	0	0	0	353	0	0	0	0	0	0	0	0	21
1951	0	4,000	13	15	31	0	0	0	0	0	0	0	244
1952	0	0	3,871	15	30	49	76	99	118	0	0	779	303
1953	2,853	0	2,092	15	0	0	0	0	0	0	0	0	299
1954	0	2,926	0	3,871	31	49	76	0	0	0	0	0	419
1955	0	0	3,871	15	0	0	0	0	0	0	0	0	234
1956	0	0	3,871	15	30	49	0	312	0	0	0	0	258
1957	2,486	0	0	0	528	2,975	0	0	0	0	0	0	361
1958	0	0	3,871	15	31	49	76	99	118	0	0	233	271
1959	3,178	0	0	3,871	31	0	0	0	0	0	0	0	427
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	741	0	0	0	0	0	0	0	45
1962	0	0	0	0	4,000	0	0	0	0	0	0	0	241
1963	3,871	0	241	0	2,899	0	2,795	0	0	0	0	0	591
1964	0	4,000	0	3,871	0	0	0	0	0	0	0	0	474
1965	0	0	3,871	15	0	0	1,693	0	0	0	0	0	336
1966	0	4,000	0	1,548	0	0	0	0	0	0	0	0	334
1967	0	0	3,871	15	31	49	76	99	118	0	0	259	272
1968	3,106	0	0	3,871	30	0	0	0	0	0	0	0	422
1969	0	0	2,209	1,676	31	49	76	99	0	0	0	2,504	400
1970	1,501	25	13	15	31	49	0	0	0	0	0	0	98
1971	0	2,459	1,504	15	0	3,689	0	0	0	0	0	0	462
1972	0	0	1,260	0	0	0	0	0	0	0	0	0	76
1973	0	2,082	1,869	15	31	49	0	0	0	0	0	0	244
1974	0	4,000	13	15	31	49	76	0	0	0	0	0	252
1975	1,388	0	0	0	4,000	307	0	0	0	0	0	0	343
1976	1,768	409	0	0	0	0	0	0	0	0	0	0	131
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	3,871	31	49	76	0	0	0	0	0	243
1979	0	0	0	3,871	31	0	0	0	0	0	0	0	235
1980	0	0	839	3,046	30	49	0	0	0	0	0	0	239
1981	0	0	0	3,871	0	0	0	0	0	0	0	0	233
1982	0	4,000	13	15	31	49	76	99	0	0	0	3,888	492
1983	161	25	13	15	31	49	76	99	118	130	0	914	98
1984	53	25	13	15	30	49	0	0	0	0	0	0	11
1985	0	4,000	13	0	0	0	0	0	0	0	0	0	242
1986	0	0	0	0	4,000	307	0	0	0	0	0	0	259
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	3,620	0	0	0	0	0	0	0	0	218
1989	0	0	0	0	0	399	0	0	0	0	0	0	24
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	415	613	644	811	501	226	111	41	8	2	0	123	211

Table A3-22b. DeltaSOS-Simulated DW Operations
for Alternative 2 Cumulative Conditions: DW Discharge to Export Wheeling (cfs)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (TAF)
1922	0	0	0	0	0	508	0	0	89	3,252	0	0	232
1923	0	0	0	0	4,000	181	0	0	0	0	0	0	252
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	3,564	0	0	0	0	0	0	215
1926	0	0	0	0	0	2,971	0	0	0	0	0	0	179
1927	0	0	487	0	0	0	0	0	3,780	0	0	0	257
1928	0	0	2,191	0	3,180	0	0	383	3,308	0	0	0	546
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	1,525	0	0	0	0	0	0	0	92
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	4,000	181	0	0	0	0	0	0	252
1936	0	0	0	0	0	2,726	0	407	416	0	0	0	214
1937	0	0	0	0	0	0	0	2,456	1,166	0	0	0	218
1938	0	0	0	0	0	0	0	0	0	3,741	0	0	225
1939	0	1,743	1,640	0	0	0	0	0	0	0	0	0	204
1940	0	0	0	0	0	0	0	457	3,308	0	0	0	227
1941	0	0	0	0	0	0	0	0	3,882	0	0	0	234
1942	0	0	0	0	0	3,177	0	0	494	1,934	0	0	338
1943	0	0	0	0	0	0	0	1,502	2,152	0	0	0	220
1944	0	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	0	2,801	555	53	0	0	0	0	205
1946	0	0	0	0	4,000	181	0	0	0	0	0	0	252
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	945	2,727	0	0	0	221
1950	0	0	0	0	360	0	0	0	0	0	0	0	22
1951	0	0	0	0	0	1,879	167	0	1,545	0	0	0	216
1952	0	0	0	0	0	0	0	0	0	3,741	0	0	225
1953	0	1,795	0	0	3,869	300	0	0	0	0	0	0	359
1954	0	0	2,819	0	0	0	0	354	3,414	0	0	0	397
1955	0	0	0	0	4,000	181	0	0	0	0	0	0	252
1956	0	0	0	0	0	0	144	0	1,750	1,933	0	0	231
1957	0	2,543	0	0	0	0	562	0	2,659	0	0	0	347
1958	0	0	0	0	0	0	0	0	0	3,741	0	0	225
1959	0	1,990	1,387	0	0	3,822	0	0	0	0	0	0	434
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	620	0	0	0	0	0	0	37
1962	0	0	0	0	0	3,564	0	0	0	0	0	0	215
1963	0	210	0	2,576	0	2,583	0	0	2,596	1,015	0	0	541
1964	0	0	3,858	0	4,000	52	0	0	0	0	0	0	477
1965	0	0	0	0	740	3,126	0	677	774	0	0	0	320
1966	0	0	1,521	0	3,363	757	0	0	0	0	0	0	340
1967	0	0	0	0	0	0	0	0	0	2,246	1,379	0	218
1968	0	1,700	1,620	0	0	285	414	880	0	1,840	0	0	406
1969	0	0	0	0	0	0	0	0	683	2,965	0	0	220
1970	0	0	0	0	0	0	540	664	0	2,268	0	0	209
1971	0	0	0	0	4,000	0	52	0	0	3,404	0	0	449
1972	0	0	0	1,003	229	0	0	0	0	0	0	0	74
1973	0	0	0	0	0	0	0	0	3,704	0	0	0	223
1974	0	0	0	0	0	0	0	0	3,780	0	0	0	228
1975	0	1,235	156	0	0	0	0	0	3,704	0	0	0	307
1976	0	0	2,126	0	0	0	0	0	0	0	0	0	128
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	67	3,711	0	0	0	228
1979	0	0	0	0	0	1,192	0	0	2,422	0	0	0	218
1980	0	0	0	0	0	0	556	1,548	1,549	0	0	0	220
1981	0	0	0	0	3,242	866	0	0	0	0	0	0	248
1982	0	0	0	0	0	0	0	0	3,583	159	0	0	225
1983	0	0	0	0	0	0	0	0	0	0	685	0	41
1984	0	0	0	0	0	0	139	536	0	2,784	0	0	208
1985	0	0	0	2,703	1,246	0	0	0	0	0	0	0	238
1986	0	0	0	0	0	0	0	3,698	0	0	0	0	223
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	3,840	0	0	0	0	0	0	0	231
1989	0	0	0	0	0	0	0	227	0	0	0	0	14
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	0	160	254	90	651	507	45	212	817	500	29	0	197

Table A3–22c. DeltaSOS–Simulated DW Operations
for Alternative 2 Cumulative Conditions: DW End–of–Month Storage (TAF)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	0	0	0	0	155	121	116	220	208	0	0	0
1923	42	81	238	238	14	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	222	(0)	0	0	0	0	0	0
1926	0	0	0	0	186	(0)	0	0	0	0	0	0
1927	0	31	0	238	238	238	238	232	0	0	0	0
1928	0	238	102	238	53	238	234	204	(0)	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	86	(0)	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	238	14	0	4	0	0	0	0	0
1936	0	0	0	238	238	67	63	32	(0)	0	0	0
1937	0	0	0	0	222	238	234	76	(0)	0	0	0
1938	0	238	238	238	238	238	238	238	238	0	0	0
1939	207	102	0	0	0	0	0	0	0	0	0	0
1940	0	0	0	238	238	238	238	204	0	0	0	0
1941	0	0	238	238	238	238	238	238	(0)	0	0	0
1942	112	150	238	238	238	40	169	163	127	(0)	0	0
1943	175	238	238	238	238	238	234	135	(0)	0	0	0
1944	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	222	47	9	0	0	0	0	0
1946	0	0	238	238	14	0	0	0	0	0	0	0
1947	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	238	234	169	(0)	0	0	0
1950	0	0	0	22	0	0	0	0	0	0	0	0
1951	0	238	238	238	238	119	105	99	(0)	0	0	0
1952	0	0	238	238	238	238	238	238	238	0	0	46
1953	218	110	238	238	21	(0)	0	0	0	0	0	0
1954	0	174	0	238	238	238	238	210	0	0	0	0
1955	0	0	238	238	14	0	0	0	0	0	0	0
1956	0	0	238	238	238	238	225	238	127	0	0	0
1957	153	0	0	0	29	209	171	165	0	0	0	0
1958	0	0	238	238	238	238	238	238	238	0	0	14
1959	206	86	(0)	238	238	(0)	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	41	0	0	0	0	0	0	0
1962	0	0	0	0	222	(0)	0	0	0	0	0	0
1963	238	224	238	79	238	76	238	232	70	(0)	0	0
1964	0	238	0	238	6	0	0	0	0	0	0	0
1965	0	0	238	238	195	(0)	101	53	0	0	0	0
1966	0	238	144	238	50	0	0	0	0	0	0	0
1967	0	0	238	238	238	238	238	238	238	92	(0)	15
1968	203	100	0	238	238	217	188	128	121	0	0	0
1969	0	0	136	238	238	238	238	238	190	(0)	0	149
1970	238	238	238	238	238	238	201	154	147	0	0	0
1971	0	146	238	238	14	238	230	224	217	(0)	0	0
1972	0	0	77	15	0	0	0	0	0	0	0	0
1973	0	124	238	238	238	238	234	227	(0)	0	0	0
1974	0	238	238	238	238	238	238	232	0	0	0	0
1975	85	10	(0)	0	222	238	234	227	(0)	0	0	0
1976	109	132	(0)	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	238	238	238	238	228	(0)	0	0	0
1979	0	0	0	238	238	162	157	151	0	0	0	0
1980	0	0	52	238	238	238	200	99	(0)	0	0	0
1981	0	0	0	238	56	0	0	0	0	0	0	0
1982	0	238	238	238	238	238	238	238	18	(0)	0	231
1983	238	238	238	238	238	238	238	238	238	238	189	238
1984	238	238	238	238	238	238	225	186	179	0	0	0
1985	0	238	238	71	0	0	0	0	0	0	0	0
1986	0	0	0	0	222	238	234	(0)	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	223	(0)	0	0	0	0	0	0	0
1989	0	0	0	0	0	25	20	(0)	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0
Average	35	62	86	129	120	100	102	88	37	5	3	10

Table A3–23. DeltaSOS Mean Annual Simulation Output for Alternative 2 Cumulative Conditions

Water Year	Sac Basin Year Type	SJR Basin Year Type	Added Sac Flow (TAF)	New Sac Flow (TAF)	Required SJR Flow (TAF)	Added SJR Flow (TAF)	New SJR Flow (TAF)	Steam & Sutter Flow (TAF)	DCC Rio Vista Reduction (TAF)	Revised DCC Flow (TAF)	Revised Georgiana & DCC (TAF)	Revised Rio Vista Flow (TAF)	QWEST w/ Initial Export (TAF)
1922	2	1	0	15,237	1,682	0	3,037	4,804	0	949	3,631	11,586	824
1923	3	2	0	14,489	1,663	73	2,564	4,395	0	1,567	4,039	10,425	465
1924	5	5	0	8,586	820	4	1,264	2,261	32	1,115	2,902	5,437	(1,130)
1925	4	3	0	12,064	1,213	29	1,491	3,509	0	1,438	3,630	9,040	(667)
1926	4	4	0	11,614	1,107	0	1,511	3,338	0	1,419	3,554	8,157	(1,037)
1927	1	2	0	19,015	1,585	71	1,963	6,229	0	1,355	4,501	17,527	212
1928	2	3	0	18,455	1,244	30	1,736	6,051	0	1,477	4,542	14,653	(275)
1929	5	5	0	8,696	820	2	1,306	2,314	42	1,147	2,939	5,573	(886)
1930	4	5	0	10,768	816	28	1,168	3,052	0	1,269	3,310	7,368	(1,021)
1931	5	5	0	6,775	790	2	1,257	1,651	91	875	2,453	4,103	(287)
1932	4	2	0	8,618	1,244	0	1,655	2,274	0	1,142	2,924	5,630	308
1933	5	4	0	7,535	1,004	0	1,388	1,931	97	908	2,579	4,753	(326)
1934	5	5	0	8,173	820	4	1,205	2,172	66	916	2,658	5,386	(423)
1935	3	2	0	12,496	1,477	0	2,051	3,700	29	1,301	3,554	9,935	(372)
1936	3	2	0	13,335	1,585	80	2,221	3,996	0	1,365	3,727	10,821	136
1937	3	1	0	12,426	1,682	56	2,860	3,671	0	1,290	3,547	8,936	804
1938	1	1	0	28,179	1,759	0	5,428	9,982	0	1,057	5,533	31,093	5,905
1939	4	4	0	10,712	1,004	0	1,695	3,007	0	1,498	3,498	6,983	(510)
1940	2	2	0	17,638	1,585	78	1,973	5,687	0	1,469	4,408	17,640	100
1941	1	1	0	23,780	1,759	0	3,677	8,157	0	1,370	5,188	27,629	2,950
1942	1	1	0	25,353	1,759	0	2,986	8,822	0	1,151	5,211	25,051	2,793
1943	1	1	0	20,972	1,759	78	3,229	6,984	0	1,426	4,820	17,571	3,269
1944	4	3	0	11,388	1,140	45	1,688	3,253	0	1,423	3,528	7,790	(1,164)
1945	3	2	0	12,566	1,507	77	2,321	3,714	0	1,386	3,653	9,005	(244)
1946	3	2	0	16,177	1,585	74	2,146	5,102	0	1,435	4,178	13,192	(65)
1947	4	4	0	10,949	1,056	50	1,607	3,089	0	1,438	3,480	7,285	(1,585)
1948	3	3	0	13,098	1,140	3	1,421	3,868	0	1,630	3,917	8,948	(1,430)
1949	4	3	0	11,993	1,140	49	1,472	3,503	0	1,421	3,616	8,292	(1,039)
1950	3	3	0	12,811	1,192	0	1,532	3,774	0	1,525	3,793	8,851	(1,161)
1951	2	2	0	21,672	1,663	80	2,663	7,244	0	1,526	5,004	18,363	1,957
1952	1	1	0	28,323	1,759	0	3,023	9,970	0	1,183	5,647	24,889	2,963
1953	1	3	0	18,839	1,295	0	1,965	6,162	0	1,240	4,362	16,711	767
1954	2	3	0	19,873	1,244	29	1,601	6,490	0	1,575	4,778	15,551	(526)
1955	4	4	0	11,447	1,004	0	1,365	3,263	0	1,488	3,587	7,775	(1,416)
1956	1	1	0	21,768	1,759	0	3,270	7,335	0	1,499	5,011	24,852	2,374
1957	2	3	0	15,092	1,244	27	1,812	4,642	0	1,623	4,175	11,044	(740)
1958	1	1	0	26,266	1,759	1	3,397	9,182	0	1,243	5,417	29,612	3,022
1959	3	4	0	14,716	1,159	69	1,800	4,523	0	1,536	4,064	10,754	112
1960	4	5	0	11,339	846	30	1,247	3,228	0	1,455	3,546	7,825	(1,648)
1961	4	5	0	11,459	842	40	1,179	3,280	0	1,434	3,545	7,844	(1,714)
1962	3	3	0	12,372	1,110	45	1,530	3,632	0	1,418	3,656	9,182	(951)
1963	1	2	0	20,611	1,585	0	1,934	6,877	0	1,184	4,566	18,800	(18)
1964	4	4	0	12,397	1,004	3	1,361	3,615	0	1,540	3,756	8,495	(1,369)
1965	1	1	0	19,519	1,759	80	2,404	6,453	0	1,378	4,592	19,247	758
1966	3	3	0	13,901	1,244	49	2,011	4,172	0	1,502	3,913	10,033	(959)
1967	1	1	0	22,181	1,759	0	3,304	7,439	0	1,144	4,729	19,913	1,947
1968	3	4	0	15,971	1,159	49	1,709	5,020	0	1,525	4,226	12,181	706
1969	1	1	0	23,660	1,759	0	5,442	8,066	0	1,543	5,297	23,945	5,690
1970	1	2	0	21,543	1,585	74	3,357	7,316	0	1,506	5,006	24,373	3,752
1971	1	3	0	20,939	1,295	0	1,732	6,908	0	1,583	4,932	16,920	(185)
1972	3	4	0	13,210	1,107	0	1,515	3,920	0	1,524	3,842	9,253	(1,549)
1973	2	2	0	19,810	1,663	78	2,252	6,529	0	1,487	4,717	18,433	995
1974	1	1	0	29,264	1,759	2	2,240	10,392	0	1,580	6,144	30,030	2,138
1975	1	1	0	20,440	1,682	0	2,310	6,784	0	1,674	4,962	16,153	919
1976	5	5	0	10,456	820	9	1,169	2,943	4	1,324	3,307	6,917	(1,263)
1977	5	5	0	6,824	790	0	1,016	1,703	36	821	2,391	4,233	(428)
1978	2	1	0	16,859	1,729	0	2,267	5,405	31	1,187	4,063	15,113	2,171
1979	3	2	0	13,993	1,585	78	2,378	4,235	0	1,449	3,884	10,011	355
1980	2	1	0	18,292	1,759	0	4,818	6,032	0	1,267	4,358	19,356	4,240
1981	4	4	0	13,093	1,159	49	1,962	3,885	0	1,436	3,756	9,162	(436)
1982	1	1	0	29,591	1,759	3	5,389	10,473	0	1,562	6,157	30,065	6,953
1983	1	1	0	35,577	1,759	0	15,726	12,980	0	1,050	6,551	42,561	21,590
1984	1	2	0	23,213	1,585	74	6,524	7,985	0	1,190	4,958	22,157	8,228
1985	4	4	0	13,038	1,107	50	1,909	3,861	0	1,485	3,790	9,191	(591)
1986	1	1	0	18,958	1,682	0	4,814	6,463	0	1,300	4,534	23,167	4,991
1987	4	5	0	10,952	846	16	1,661	3,102	0	1,383	3,437	7,300	(1,270)
1988	5	5	0	9,416	790	6	1,020	2,563	38	1,161	3,048	6,236	(961)
1989	4	5	0	11,782	842	31	1,036	3,442	31	1,324	3,490	8,090	(1,309)
1990	5	5	0	8,675	790	4	944	2,288	52	1,143	2,939	5,561	(812)
1991	5	5	0	8,612	816	37	995	2,286	29	1,072	2,863	5,552	(564)
Average			0	15,998	1,326	26	2,427	5,091	8	1,347	4,090	13,793	887

Notes: Definitions of the categories are provided in Table A2–3 in Appendix A2.
Water–year types: 1=wet, 2=above normal, 3=below normal, 4=dry, 5=critically dry
Negative values shown in parentheses.

Table A3–23. Continued

Water Year	Reduced Export for QWEST (TAF)	Initial Collinsville Outflow (TAF)	Initial Chipps Outflow (TAF)	Required Delta Outflow (TAF)	Revised Montez. Flow (TAF)	Reduced Export for Outflow (TAF)	Export Limits (TAF)	Reduced Export for Limits (TAF)	Net Export Change (TAF)	Adjusted Total Export (TAF)	Revised QWEST Flow (TAF)	Revised Collinsville Outflow (TAF)
1922	0	12,321	11,391	6,103	930	1	8,364	0	1,001	7,185	(177)	11,320
1923	0	10,803	9,917	5,833	886	0	9,521	0	1,021	7,212	(556)	9,782
1924	0	4,180	3,375	4,063	805	3	5,401	0	19	4,561	(1,149)	4,161
1925	0	8,292	7,430	5,195	862	3	7,312	0	246	5,981	(914)	8,045
1926	0	7,022	6,175	5,006	847	3	6,923	0	243	5,976	(1,280)	6,779
1927	0	17,655	16,686	6,980	970	1	10,720	0	1,264	7,506	(1,052)	16,391
1928	0	14,277	13,355	6,665	922	1	10,032	0	1,064	7,391	(1,339)	13,213
1929	0	4,573	3,760	4,418	813	3	5,435	0	19	4,583	(906)	4,553
1930	0	6,245	5,414	5,052	832	3	6,182	0	201	5,210	(1,222)	6,044
1931	0	3,702	2,901	3,657	800	3	4,306	0	14	3,341	(301)	3,688
1932	0	5,849	5,019	5,190	831	1	5,625	0	297	4,444	11	5,553
1933	0	4,313	3,503	4,050	810	3	4,694	0	18	3,696	(344)	4,295
1934	0	4,853	4,038	4,532	815	3	4,803	0	141	3,878	(564)	4,712
1935	0	9,477	8,584	6,455	893	3	7,413	0	348	6,274	(720)	9,129
1936	0	10,877	9,993	6,248	883	3	8,419	0	325	6,478	(189)	10,552
1937	0	9,666	8,791	5,287	874	3	7,752	16	300	6,179	504	9,365
1938	0	36,940	35,736	8,125	1,204	1	18,482	0	2,470	8,697	3,435	34,470
1939	0	6,353	5,520	4,357	833	0	6,865	0	1,055	6,143	(1,565)	5,298
1940	0	17,676	16,697	7,246	979	3	10,409	0	665	7,085	(565)	17,011
1941	0	30,529	29,403	7,010	1,125	1	16,412	0	1,207	7,482	1,744	29,322
1942	0	27,769	26,688	6,671	1,082	0	16,125	0	2,353	8,302	440	25,416
1943	0	20,751	19,767	7,309	984	0	13,363	0	2,208	7,766	1,060	18,543
1944	0	6,521	5,686	4,952	835	3	6,788	0	117	6,045	(1,281)	6,405
1945	0	8,664	7,806	5,277	858	1	7,966	0	557	6,691	(800)	8,108
1946	0	13,020	12,120	6,279	900	1	11,239	0	586	6,876	(651)	12,434
1947	0	5,583	4,756	5,072	827	3	6,751	0	15	6,048	(1,599)	5,568
1948	0	7,409	6,543	5,487	866	3	7,141	0	90	6,390	(1,519)	7,320
1949	0	7,142	6,299	4,921	843	3	6,947	0	223	5,915	(1,262)	6,919
1950	0	7,579	6,725	5,599	854	3	7,295	0	335	6,486	(1,495)	7,244
1951	0	20,237	19,264	6,326	972	0	14,970	0	1,049	7,815	907	19,188
1952	0	27,785	26,665	7,985	1,120	1	15,787	0	1,948	8,875	1,014	25,837
1953	0	17,375	16,419	6,080	956	0	12,676	0	2,158	7,462	(1,391)	15,218
1954	0	14,909	13,968	7,021	940	1	10,339	0	1,743	8,115	(2,269)	13,166
1955	0	6,255	5,422	5,051	834	0	7,342	0	451	6,468	(1,868)	5,804
1956	0	27,158	26,099	6,221	1,058	1	17,795	0	1,022	7,845	1,353	26,136
1957	0	10,196	9,315	5,661	880	2	8,552	0	1,062	7,348	(1,802)	9,133
1958	0	32,590	31,417	7,267	1,173	0	16,086	0	2,260	9,307	761	30,330
1959	0	10,755	9,880	5,294	875	0	8,800	0	1,561	6,737	(1,448)	9,194
1960	0	6,062	5,230	5,203	832	3	6,803	0	159	6,015	(1,807)	5,903
1961	0	6,020	5,189	5,097	831	3	6,750	0	184	5,959	(1,898)	5,836
1962	0	8,134	7,281	5,063	853	3	7,528	0	150	5,947	(1,101)	7,984
1963	0	18,707	17,694	7,329	1,013	0	11,162	0	1,455	8,106	(1,473)	17,252
1964	0	7,008	6,169	5,143	839	1	7,793	0	567	6,481	(1,937)	6,441
1965	0	19,912	18,920	6,670	991	1	14,496	0	621	7,272	137	19,290
1966	0	8,964	8,102	5,602	862	0	8,613	0	895	7,298	(1,855)	8,069
1967	0	21,799	20,750	7,553	1,049	1	13,108	0	2,132	8,997	(185)	19,667
1968	0	12,778	11,884	5,557	894	0	9,256	0	2,683	7,466	(1,977)	10,095
1969	0	29,568	28,445	7,967	1,123	1	16,813	0	2,213	8,643	3,477	27,355
1970	0	28,036	26,997	5,637	1,039	0	18,655	0	2,775	7,806	978	25,261
1971	0	16,639	15,687	7,094	952	1	12,449	0	972	7,785	(1,157)	15,667
1972	0	7,581	6,735	5,409	846	0	7,849	0	863	7,206	(2,412)	6,718
1973	0	19,377	18,410	6,821	966	0	12,919	0	1,223	7,832	(229)	18,153
1974	0	32,083	30,958	6,944	1,126	1	19,746	0	1,800	8,628	338	30,284
1975	0	16,975	16,015	6,627	960	0	10,903	0	2,030	8,523	(1,110)	14,945
1976	0	5,528	4,706	4,416	821	1	6,343	0	532	5,531	(1,795)	4,995
1977	0	3,682	2,882	3,657	800	3	4,264	0	24	3,076	(452)	3,658
1978	0	17,228	16,266	7,933	962	3	10,117	0	1,797	6,304	374	15,431
1979	0	10,275	9,397	5,844	878	1	8,242	0	1,255	7,059	(900)	9,020
1980	0	23,524	22,522	6,568	1,002	1	14,443	15	1,468	7,141	2,772	22,056
1981	0	8,612	7,757	5,109	855	0	7,849	0	1,412	7,000	(1,848)	7,200
1982	0	36,973	35,733	7,099	1,240	1	20,240	0	2,020	9,287	4,933	34,952
1983	0	64,141	62,588	6,197	1,553	0	31,346	0	5,222	10,635	16,369	58,919
1984	0	30,285	29,222	5,676	1,063	0	20,548	0	3,493	8,069	4,735	26,792
1985	0	8,501	7,647	5,068	854	0	8,383	0	893	6,827	(1,484)	7,608
1986	0	28,103	27,051	6,155	1,052	1	14,333	33	859	7,127	4,132	27,245
1987	0	5,913	5,083	4,819	829	2	6,602	0	118	5,926	(1,389)	5,794
1988	0	5,167	4,349	4,505	818	3	5,648	0	209	4,655	(1,170)	4,958
1989	0	6,669	5,825	4,816	844	2	6,313	0	234	5,512	(1,543)	6,435
1990	0	4,640	3,825	4,506	814	3	5,037	0	72	4,137	(884)	4,568
1991	0	4,878	4,062	4,088	816	3	4,808	0	20	3,828	(585)	4,858
Average	0	14,587	13,656	5,802	931	1	10,291	1	1,029	6,741	(142)	13,558

Table A3–23. Continued

Water Year	Available for DW Diversion (TAF)	Delta Storage (TAF)	Delta Storage Diversion (TAF)	Delta Storage Export (TAF)	Delta Storage Outflow (TAF)	Final Total Export (TAF)	Final QWEST Flow (TAF)	Final Delta Outflow (TAF)	3–Mile Slough Flow (TAF)	Old River Diversion Flow (TAF)	Final Antioch Flow (TAF)	Old & Middle Flow (TAF)
1922	276	220	276	232	0	7,417	(453)	11,044	2,843	1,587	2,390	(6,330)
1923	1,512	238	238	252	0	7,464	(794)	9,544	2,679	1,369	1,885	(6,589)
1924	0	0	0	0	0	4,561	(1,149)	4,161	1,627	825	478	(4,395)
1925	597	222	241	215	0	6,196	(1,155)	7,804	2,469	852	1,315	(5,821)
1926	201	186	201	179	0	6,155	(1,481)	6,578	2,366	877	885	(5,816)
1927	1,965	238	274	257	0	7,763	(1,326)	16,118	4,501	1,038	3,175	(7,204)
1928	1,828	238	558	546	0	7,937	(1,898)	12,654	4,010	996	2,113	(7,488)
1929	0	0	0	0	0	4,583	(906)	4,553	1,583	851	677	(4,338)
1930	85	86	85	92	0	5,302	(1,307)	5,959	2,127	764	820	(5,098)
1931	0	0	0	0	0	3,341	(301)	3,688	1,051	831	750	(3,120)
1932	0	0	0	0	0	4,444	11	5,553	1,309	943	1,320	(4,014)
1933	0	0	0	0	0	3,696	(344)	4,295	1,216	853	872	(3,461)
1934	0	0	0	0	0	3,878	(564)	4,712	1,432	805	868	(3,672)
1935	335	238	237	252	0	6,526	(957)	8,892	2,616	1,100	1,659	(5,924)
1936	1,139	238	235	214	0	6,692	(424)	10,317	2,655	1,192	2,231	(5,963)
1937	657	238	259	218	0	6,397	245	9,106	2,006	1,494	2,251	(5,348)
1938	7,363	238	265	225	0	8,922	3,170	34,205	6,255	3,087	9,424	(6,209)
1939	203	207	203	204	0	6,347	(1,767)	5,096	2,182	995	414	(5,977)
1940	2,041	238	242	227	0	7,312	(808)	16,768	4,365	1,046	3,558	(6,668)
1941	5,155	238	249	234	0	7,715	1,494	29,072	5,972	2,157	7,466	(5,906)
1942	4,080	238	375	338	0	8,640	65	25,041	5,819	1,534	5,884	(7,552)
1943	3,664	238	243	220	0	7,986	817	18,300	3,840	1,611	4,657	(6,873)
1944	0	0	0	0	0	6,045	(1,281)	6,405	2,217	984	936	(5,623)
1945	656	222	241	205	0	6,896	(1,041)	7,867	2,426	1,254	1,384	(6,175)
1946	1,792	238	234	252	0	7,128	(885)	12,200	3,353	1,139	2,468	(6,564)
1947	0	0	0	0	0	6,048	(1,599)	5,568	2,199	958	600	(5,702)
1948	0	0	0	0	0	6,390	(1,519)	7,320	2,562	806	1,043	(6,165)
1949	254	238	233	221	0	6,136	(1,495)	6,685	2,402	842	906	(5,884)
1950	21	22	21	22	0	6,507	(1,517)	7,223	2,539	866	1,022	(6,230)
1951	4,502	238	244	216	0	8,031	663	18,943	4,073	1,430	4,736	(7,075)
1952	4,681	238	303	225	0	9,100	711	25,534	5,579	1,548	6,290	(7,962)
1953	1,917	238	299	359	0	7,821	(1,690)	14,919	4,425	1,084	2,735	(7,293)
1954	1,497	238	419	397	0	8,512	(2,688)	12,747	4,468	908	1,780	(8,212)
1955	319	238	234	252	0	6,720	(2,102)	5,570	2,471	839	369	(6,436)
1956	4,549	238	258	231	0	8,076	1,095	25,878	5,450	1,711	6,545	(6,785)
1957	361	209	361	347	0	7,695	(2,163)	8,773	3,252	964	1,090	(7,310)
1958	5,034	238	271	225	0	9,532	491	30,060	6,749	2,019	7,240	(7,832)
1959	1,192	238	427	434	0	7,171	(1,875)	8,768	3,094	997	1,220	(6,766)
1960	0	0	0	0	0	6,015	(1,807)	5,903	2,390	802	583	(5,812)
1961	45	41	45	37	0	5,997	(1,942)	5,791	2,437	763	495	(5,820)
1962	679	222	241	215	0	6,162	(1,342)	7,743	2,561	892	1,219	(5,804)
1963	2,087	238	591	541	0	8,647	(2,064)	16,661	5,029	1,021	2,966	(8,071)
1964	756	238	474	477	0	6,958	(2,411)	5,967	2,736	849	325	(6,724)
1965	2,633	238	336	320	0	7,593	(199)	18,954	4,549	1,246	4,350	(6,866)
1966	726	238	334	340	0	7,638	(2,189)	7,735	3,025	1,110	836	(7,110)
1967	3,091	238	272	218	0	9,215	(457)	19,395	4,785	1,729	4,328	(7,877)
1968	1,224	238	422	406	0	7,872	(2,399)	9,673	3,591	943	1,192	(7,509)
1969	5,106	238	400	220	0	8,863	3,077	26,955	4,618	3,097	7,694	(6,177)
1970	4,599	238	98	209	0	8,015	879	25,163	5,406	1,632	6,285	(6,885)
1971	2,192	238	462	449	0	8,234	(1,619)	15,205	4,451	993	2,833	(7,769)
1972	76	78	76	74	0	7,281	(2,488)	6,642	2,937	902	449	(7,015)
1973	3,239	238	244	223	0	8,055	(472)	17,910	4,445	1,204	3,973	(7,198)
1974	5,060	238	252	228	0	8,856	86	30,032	6,973	1,154	7,060	(8,185)
1975	1,805	238	343	307	0	8,830	(1,454)	14,602	4,221	1,176	2,767	(8,189)
1976	131	132	131	128	0	5,659	(1,926)	4,864	2,216	755	290	(5,563)
1977	0	0	0	0	0	3,076	(452)	3,658	1,128	676	676	(3,050)
1978	2,136	238	243	228	0	6,532	131	15,188	3,482	1,158	3,613	(5,751)
1979	488	238	235	218	0	7,277	(1,135)	8,785	2,689	1,220	1,554	(6,566)
1980	4,574	238	239	220	0	7,361	2,533	21,817	3,718	2,567	6,251	(5,226)
1981	271	238	233	248	0	7,247	(2,081)	6,967	2,788	1,068	707	(6,779)
1982	7,154	238	492	225	0	9,512	4,441	34,460	5,617	3,355	10,057	(6,484)
1983	19,189	238	98	41	0	10,676	16,271	58,821	4,822	9,324	21,093	(1,539)
1984	7,824	238	11	208	0	8,277	4,723	26,780	3,685	3,669	8,408	(5,153)
1985	1,001	238	242	238	0	7,065	(1,726)	7,366	2,683	1,103	958	(6,503)
1986	5,489	238	259	223	0	7,349	3,873	26,985	4,187	2,756	8,059	(4,956)
1987	0	0	0	0	0	5,926	(1,389)	5,794	2,137	919	748	(5,620)
1988	218	223	218	231	0	4,886	(1,388)	4,740	1,889	685	501	(4,777)
1989	24	25	24	14	0	5,526	(1,567)	6,411	2,377	646	810	(5,473)
1990	0	0	0	0	0	4,137	(884)	4,568	1,573	633	690	(4,095)
1991	0	0	0	0	0	3,828	(585)	4,858	1,477	634	893	(3,792)
Average	1,996	173	211	197	0	6,938	(353)	13,347	3,326	1,369	2,973	(6,087)

Table A3–24. Monthly Percentiles for DeltaSOS Simulations for Alternative 2 Cumulative Conditions

DW diversion (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	15	30	0	0	0	0	0	0	0
60	0	0	0	15	31	0	0	0	0	0	0	0
70	0	0	13	15	31	49	0	0	0	0	0	0
80	0	517	1,260	1,676	31	49	76	0	0	0	0	0
90	1,815	4,000	3,871	3,871	2,899	307	76	99	0	0	0	0
100	3,871	4,000	3,871	3,871	4,000	3,871	2,795	1,791	118	130	0	3,888
Mean	415	613	644	811	501	226	111	41	8	2	0	123

DW storage (TAF)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	(0)	0	(0)	(0)	0	(0)	(0)	(0)	(0)	0
10	0	0	0	0	0	0	0	0	(0)	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	14	0	0	0	0	0	0	0
50	0	0	0	238	56	0	9	0	0	0	0	0
60	0	0	0	238	222	121	169	99	0	0	0	0
70	0	86	238	238	238	238	230	169	0	0	0	0
80	0	150	238	238	238	238	234	227	18	0	0	0
90	203	238	238	238	238	238	238	238	190	0	0	0
100	238	238	238	238	238	238	238	238	238	238	189	238
Mean	35	62	86	129	120	100	102	88	37	5	3	10

DW discharge for export (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	52	0	0	494	0	0	0
80	0	0	0	0	360	508	0	67	2,152	0	0	0
90	0	0	1,387	0	3,840	2,726	139	664	3,414	2,268	0	0
100	0	2,543	3,858	2,703	4,000	3,822	562	3,698	3,882	3,741	1,379	0
Mean	0	160	254	90	651	507	45	212	817	500	29	0

DW discharge for outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Final CVP Tracy and SWP Banks exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	4,278	3,314	5,051	4,859	6,075	3,220	2,842	2,455	1,145	1,896	597	3,296
10	5,115	5,373	7,347	8,701	6,836	4,706	3,622	3,174	5,500	4,447	3,508	3,617
20	6,844	6,628	7,821	10,950	8,462	6,276	3,840	3,598	5,568	6,832	4,790	5,915
30	7,982	7,360	9,901	11,590	10,331	9,000	4,240	4,033	5,804	8,143	5,143	6,076
40	8,490	8,371	11,134	14,147	13,939	11,285	5,623	4,976	6,267	9,710	5,924	6,384
50	9,045	10,658	12,749	14,500	14,500	13,755	6,573	5,858	6,976	11,365	6,699	6,543
60	9,700	13,308	14,106	14,500	14,500	14,500	7,380	7,176	7,467	11,365	7,367	6,710
70	11,911	14,900	14,500	14,500	14,500	14,500	8,921	8,416	9,632	11,366	8,026	7,434
80	14,542	14,900	14,500	14,500	14,500	14,500	10,960	9,437	10,590	11,366	9,675	10,087
90	14,900	14,900	14,500	14,500	14,500	14,500	11,760	11,760	14,900	11,367	11,347	14,029
100	14,900	14,900	14,500	14,500	14,500	14,500	14,900	14,900	14,900	14,900	14,900	14,900
Mean	9,962	10,577	11,723	12,852	12,324	11,268	7,284	6,842	8,164	9,603	6,979	7,575

Table A3–25a. DeltaSOS–Simulated DW Operations
for Alternative 3 Cumulative Conditions: DW Diversions to Storage (cfs)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (TAF)
1922	0	0	0	0	2,790	0	0	1,791	0	0	0	0	276
1923	677	692	5,332	29	0	0	0	0	0	0	0	0	405
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	6,000	0	0	0	0	0	0	0	362
1926	0	0	0	0	3,343	0	0	0	0	0	0	0	201
1927	0	517	0	6,000	729	98	151	0	0	0	0	0	452
1928	0	5,648	0	3,383	0	3,128	0	0	0	0	0	0	733
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	1,406	0	0	0	0	0	0	0	0	85
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	5,499	0	0	59	0	0	0	0	0	335
1936	0	0	0	6,000	704	0	0	0	0	0	0	0	404
1937	0	0	0	0	6,000	1,281	0	0	0	0	0	0	439
1938	0	6,000	822	29	61	98	151	198	235	0	0	0	458
1939	3,364	0	0	0	0	0	0	0	0	0	0	0	203
1940	0	0	0	4,529	2,276	98	151	0	0	0	0	0	425
1941	0	0	6,000	632	61	98	151	198	0	0	0	0	430
1942	1,815	675	4,210	29	61	0	2,256	0	0	0	0	0	545
1943	2,847	2,827	1,095	29	61	98	0	0	0	0	0	0	419
1944	0	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	6,000	0	0	0	0	0	0	0	362
1946	0	0	6,000	632	0	0	0	0	0	0	0	0	400
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	4,217	0	0	0	0	0	0	254
1950	0	0	0	353	0	0	0	0	0	0	0	0	21
1951	0	6,000	822	29	61	0	0	0	0	0	0	0	417
1952	0	0	6,000	632	59	98	151	198	235	0	0	779	491
1953	2,853	0	4,914	29	0	0	0	0	0	0	0	0	470
1954	0	2,926	0	6,000	729	98	151	0	0	0	0	0	597
1955	0	0	3,898	1,397	0	0	0	0	0	0	0	0	319
1956	0	0	6,000	632	59	98	0	484	0	0	0	0	438
1957	2,486	0	0	0	528	2,975	0	0	0	0	0	0	361
1958	0	0	4,523	2,109	61	98	151	198	235	0	0	233	458
1959	3,178	0	0	6,000	729	0	0	0	0	0	0	0	597
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	741	0	0	0	0	0	0	0	45
1962	0	0	0	0	6,000	0	0	0	0	0	0	0	362
1963	6,000	0	881	0	2,945	0	2,939	0	0	0	0	0	769
1964	0	6,000	0	4,970	0	0	0	0	0	0	0	0	661
1965	0	0	6,000	632	0	0	1,693	0	0	0	0	0	502
1966	0	4,949	0	3,390	0	0	0	0	0	0	0	0	502
1967	0	0	6,000	632	61	98	151	198	235	0	0	259	460
1968	3,106	0	0	6,000	704	0	0	0	0	0	0	0	591
1969	0	0	2,209	4,423	61	98	151	198	0	0	0	2,504	581
1970	4,286	50	26	29	61	98	0	0	0	0	0	0	274
1971	0	2,459	4,249	29	0	4,951	0	0	0	0	0	0	704
1972	0	0	1,260	0	0	0	0	0	0	0	0	0	76
1973	0	2,082	4,614	29	61	98	0	0	0	0	0	0	415
1974	0	6,000	822	29	61	98	151	0	0	0	0	0	431
1975	1,388	0	0	0	6,000	1,281	0	0	0	0	0	0	522
1976	1,768	409	0	0	0	0	0	0	0	0	0	0	131
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	6,000	729	98	151	0	0	0	0	0	420
1979	0	0	0	5,088	1,739	0	0	0	0	0	0	0	411
1980	0	0	839	5,793	59	98	0	0	0	0	0	0	409
1981	0	0	0	4,492	0	0	0	0	0	0	0	0	271
1982	0	6,000	822	29	61	98	151	198	0	0	0	3,888	678
1983	2,946	50	26	29	61	98	151	198	235	260	0	1,064	308
1984	106	50	26	29	59	98	0	0	0	0	0	0	22
1985	0	6,000	822	0	0	0	0	0	0	0	0	0	411
1986	0	0	0	0	6,000	1,281	0	0	0	0	0	0	439
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	3,620	0	0	0	0	0	0	0	0	218
1989	0	0	0	0	0	399	0	0	0	0	0	0	24
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	526	848	1,117	1,295	796	305	127	55	17	4	0	125	314

Table A3–25b. DeltaSOS–Simulated DW Operations
for Alternative 3 Cumulative Conditions: DW Discharge to Export Wheeling (cfs)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (TAF)
1922	0	0	0	0	0	508	0	0	89	2,787	0	0	204
1923	0	0	0	0	6,000	1,031	0	0	0	0	0	0	424
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	5,322	0	0	0	0	0	0	321
1926	0	0	0	0	0	2,922	0	0	0	0	0	0	176
1927	0	0	474	0	0	0	0	0	6,000	110	0	0	397
1928	0	0	2,191	0	3,180	0	0	342	5,878	0	0	0	698
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	1,495	0	0	0	0	0	0	0	90
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	6,000	0	0	0	0	0	0	0	362
1936	0	0	0	0	0	2,744	0	407	2,875	0	0	0	363
1937	0	0	0	0	0	0	0	2,456	3,694	0	0	0	371
1938	0	0	0	0	0	0	0	0	0	6,000	112	0	368
1939	0	1,701	1,643	0	0	0	0	0	0	0	0	0	201
1940	0	0	0	0	0	0	0	416	5,953	0	0	0	384
1941	0	0	0	0	0	0	0	0	6,000	309	0	0	380
1942	0	0	0	0	0	3,177	0	0	494	4,201	0	0	474
1943	0	0	0	0	0	0	0	1,461	4,722	0	0	0	373
1944	0	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	0	2,801	555	652	0	499	0	0	272
1946	0	0	0	0	6,000	1,031	0	0	0	0	0	0	424
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	905	2,831	0	0	0	225
1950	0	0	0	0	329	0	0	0	0	0	0	0	20
1951	0	0	0	0	0	1,879	167	0	4,022	0	0	0	366
1952	0	0	0	0	0	0	0	0	0	6,000	112	0	368
1953	0	1,795	0	0	3,851	2,972	0	0	0	0	0	0	519
1954	0	0	2,806	0	0	0	0	313	6,000	0	0	0	549
1955	0	0	0	0	5,057	545	0	0	0	0	0	0	338
1956	0	0	0	0	0	0	144	0	1,750	4,422	0	0	381
1957	0	2,518	0	0	0	0	538	0	2,336	0	0	0	325
1958	0	0	0	0	0	0	0	0	0	6,000	112	0	368
1959	0	1,990	1,296	0	0	6,000	371	0	0	0	0	0	582
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	571	0	0	0	0	0	0	34
1962	0	0	0	0	0	4,309	895	0	0	0	0	0	314
1963	0	210	0	2,576	0	2,601	0	0	2,596	3,404	0	0	686
1964	0	0	4,215	0	6,000	740	0	0	0	0	0	0	660
1965	0	0	0	0	740	5,782	0	636	596	0	0	0	467
1966	0	0	1,521	0	3,363	3,413	0	0	0	0	0	0	500
1967	0	0	0	0	0	0	0	0	0	2,174	3,938	0	368
1968	0	1,700	1,530	0	0	285	390	839	0	3,463	477	0	523
1969	0	0	0	0	0	0	0	0	683	5,454	0	0	370
1970	0	0	0	0	0	0	517	630	0	3,461	948	0	335
1971	0	0	0	0	5,431	0	29	0	0	3,463	1,942	0	655
1972	0	0	0	1,003	184	0	0	0	0	0	0	0	72
1973	0	0	0	0	0	0	0	0	6,000	0	0	0	362
1974	0	0	0	0	0	0	0	0	6,000	110	0	0	368
1975	0	1,235	118	0	0	0	0	0	4,461	1,454	0	0	438
1976	0	0	2,089	0	0	0	0	0	0	0	0	0	126
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	67	6,000	43	0	0	368
1979	0	0	0	0	0	1,192	0	0	4,899	0	0	0	367
1980	0	0	0	0	0	0	556	1,548	4,076	0	0	0	372
1981	0	0	0	0	3,242	1,411	0	0	0	0	0	0	280
1982	0	0	0	0	0	0	0	0	3,583	2,647	0	0	375
1983	0	0	0	0	0	0	0	0	0	0	629	0	38
1984	0	0	0	0	0	0	139	536	0	4,245	624	0	334
1985	0	0	0	2,703	4,224	0	0	0	0	0	0	0	417
1986	0	0	0	0	0	0	0	3,000	3,131	0	0	0	369
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	3,811	0	0	0	0	0	0	0	230
1989	0	0	0	0	0	0	0	54	0	0	0	0	3
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	0	159	255	90	841	732	61	204	1,352	861	127	0	282

Table A3–25c. DeltaSOS–Simulated DW Operations
for Alternative 3 Cumulative Conditions: DW End–of–Month Storage (TAF)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	0	0	0	0	155	118	109	207	187	0	0	0
1923	42	80	406	406	69	(0)	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	333	0	0	0	0	0	0	0
1926	0	0	0	0	186	(0)	0	0	0	0	0	0
1927	0	31	0	369	406	406	406	394	23	0	0	0
1928	0	336	200	406	220	406	397	364	(0)	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	86	(0)	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	338	2	0	4	0	0	0	0	0
1936	0	0	0	369	406	231	222	185	0	0	0	0
1937	0	0	0	0	333	406	397	234	(0)	0	0	0
1938	0	357	406	406	406	406	406	406	406	21	0	0
1939	207	103	(0)	0	0	0	0	0	0	0	0	0
1940	0	0	0	279	406	406	406	368	(0)	0	0	0
1941	0	0	369	406	406	406	406	406	35	(0)	0	0
1942	112	149	406	406	406	205	330	318	274	0	0	0
1943	175	340	406	406	406	406	397	295	(0)	0	0	0
1944	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	333	155	113	61	47	0	0	0
1946	0	0	369	406	69	(0)	0	0	0	0	0	0
1947	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	259	250	182	0	0	0	0
1950	0	0	0	22	(0)	0	0	0	0	0	0	0
1951	0	357	406	406	406	284	266	253	0	0	0	0
1952	0	0	369	406	406	406	406	406	406	21	0	46
1953	215	105	406	406	189	(0)	0	0	0	0	0	0
1954	0	174	(0)	369	406	406	406	375	4	0	0	0
1955	0	0	240	324	40	0	0	0	0	0	0	0
1956	0	0	369	406	406	406	388	406	288	0	0	0
1957	153	0	0	0	29	206	165	153	0	0	0	0
1958	0	0	278	406	406	406	406	406	406	21	0	14
1959	203	81	0	369	406	31	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	41	0	0	0	0	0	0	0
1962	0	0	0	0	333	62	(0)	0	0	0	0	0
1963	369	353	406	246	406	240	406	394	225	(0)	0	0
1964	0	357	96	400	52	(0)	0	0	0	0	0	0
1965	0	0	369	406	362	(0)	101	49	0	0	0	0
1966	0	294	199	406	216	(0)	0	0	0	0	0	0
1967	0	0	369	406	406	406	406	406	406	256	0	15
1968	200	96	0	369	406	382	350	286	272	44	(0)	0
1969	0	0	136	406	406	406	406	406	351	(0)	0	149
1970	406	406	406	406	406	406	366	315	301	72	0	0
1971	0	146	406	406	101	399	389	377	363	134	(0)	0
1972	0	0	77	14	(0)	0	0	0	0	0	0	0
1973	0	124	406	406	406	406	397	385	14	0	0	0
1974	0	357	406	406	406	406	406	394	23	0	0	0
1975	85	9	0	0	333	406	397	385	105	(0)	0	0
1976	109	130	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	369	406	406	406	390	19	(0)	0	0
1979	0	0	0	313	406	327	318	306	(0)	0	0	0
1980	0	0	52	406	406	406	364	257	(0)	0	0	0
1981	0	0	0	276	93	(0)	0	0	0	0	0	0
1982	0	357	406	406	406	406	406	406	179	0	0	231
1983	406	406	406	406	406	406	406	406	406	406	353	406
1984	406	406	406	406	406	406	389	344	330	53	(0)	0
1985	0	357	406	238	0	0	0	0	0	0	0	0
1986	0	0	0	0	333	406	397	200	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	223	(0)	0	0	0	0	0	0	0
1989	0	0	0	0	0	25	16	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0
Average	44	84	137	210	205	175	174	159	72	15	5	12

Table A3–26. DeltaSOS Mean Annual Simulation Output for Alternative 3 Cumulative Conditions

Water Year	Sac Basin Year Type	SJR Basin Year Type	Added Sac Flow (TAF)	New Sac Flow (TAF)	Required SJR Flow (TAF)	Added SJR Flow (TAF)	New SJR Flow (TAF)	Steam & Sutter Flow (TAF)	DCC Rio Vista Reduction (TAF)	Revised DCC Flow (TAF)	Revised Georgiana & DCC (TAF)	Revised Rio Vista Flow (TAF)	QWEST w/ Initial Export (TAF)
1922	2	1	0	15,237	1,682	0	3,037	4,804	0	949	3,631	11,586	850
1923	3	2	0	14,489	1,663	73	2,564	4,395	0	1,567	4,039	10,425	491
1924	5	5	0	8,586	820	4	1,264	2,261	32	1,115	2,902	5,437	(1,104)
1925	4	3	0	12,064	1,213	29	1,491	3,509	0	1,438	3,630	9,040	(642)
1926	4	4	0	11,614	1,107	0	1,511	3,338	0	1,419	3,554	8,157	(1,011)
1927	1	2	0	19,015	1,585	71	1,963	6,229	0	1,355	4,501	17,527	238
1928	2	3	0	18,455	1,244	30	1,736	6,051	0	1,477	4,542	14,653	(250)
1929	5	5	0	8,696	820	2	1,306	2,314	42	1,147	2,939	5,573	(861)
1930	4	5	0	10,768	816	28	1,168	3,052	0	1,269	3,310	7,368	(995)
1931	5	5	0	6,775	790	2	1,257	1,651	91	875	2,453	4,103	(261)
1932	4	2	0	8,618	1,244	0	1,655	2,274	0	1,142	2,924	5,630	334
1933	5	4	0	7,535	1,004	0	1,388	1,931	97	908	2,579	4,753	(300)
1934	5	5	0	8,173	820	4	1,205	2,172	66	916	2,658	5,386	(397)
1935	3	2	0	12,496	1,477	0	2,051	3,700	29	1,301	3,554	9,935	(346)
1936	3	2	0	13,335	1,585	80	2,221	3,996	0	1,365	3,727	10,821	161
1937	3	1	0	12,426	1,682	56	2,860	3,671	0	1,290	3,547	8,936	830
1938	1	1	0	28,179	1,759	0	5,428	9,982	0	1,057	5,533	31,093	5,930
1939	4	4	0	10,712	1,004	0	1,695	3,007	0	1,498	3,498	6,983	(484)
1940	2	2	0	17,638	1,585	78	1,973	5,687	0	1,469	4,408	17,640	126
1941	1	1	0	23,780	1,759	0	3,677	8,157	0	1,370	5,188	27,629	2,976
1942	1	1	0	25,353	1,759	0	2,986	8,822	0	1,151	5,211	25,051	2,819
1943	1	1	0	20,972	1,759	78	3,229	6,984	0	1,426	4,820	17,571	3,294
1944	4	3	0	11,388	1,140	45	1,688	3,253	0	1,423	3,528	7,790	(1,138)
1945	3	2	0	12,566	1,507	77	2,321	3,714	0	1,386	3,653	9,005	(218)
1946	3	2	0	16,177	1,585	74	2,146	5,102	0	1,435	4,178	13,192	(39)
1947	4	4	0	10,949	1,056	50	1,607	3,089	0	1,438	3,480	7,285	(1,559)
1948	3	3	0	13,098	1,140	3	1,421	3,868	0	1,630	3,917	8,948	(1,404)
1949	4	3	0	11,993	1,140	49	1,472	3,503	0	1,421	3,616	8,292	(1,013)
1950	3	3	0	12,811	1,192	0	1,532	3,774	0	1,525	3,793	8,851	(1,135)
1951	2	2	0	21,672	1,663	80	2,663	7,244	0	1,526	5,004	18,363	1,983
1952	1	1	0	28,323	1,759	0	3,023	9,970	0	1,183	5,647	24,889	2,988
1953	1	3	0	18,839	1,295	0	1,965	6,162	0	1,240	4,362	16,711	792
1954	2	3	0	19,873	1,244	29	1,601	6,490	0	1,575	4,778	15,551	(501)
1955	4	4	0	11,447	1,004	0	1,365	3,263	0	1,488	3,587	7,775	(1,391)
1956	1	1	0	21,768	1,759	0	3,270	7,335	0	1,499	5,011	24,852	2,400
1957	2	3	0	15,092	1,244	27	1,812	4,642	0	1,623	4,175	11,044	(714)
1958	1	1	0	26,266	1,759	1	3,397	9,182	0	1,243	5,417	29,612	3,048
1959	3	4	0	14,716	1,159	69	1,800	4,523	0	1,536	4,064	10,754	138
1960	4	5	0	11,339	846	30	1,247	3,228	0	1,455	3,546	7,825	(1,622)
1961	4	5	0	11,459	842	40	1,179	3,280	0	1,434	3,545	7,844	(1,688)
1962	3	3	0	12,372	1,110	45	1,530	3,632	0	1,418	3,656	9,182	(925)
1963	1	2	0	20,611	1,585	0	1,934	6,877	0	1,184	4,566	18,800	7
1964	4	4	0	12,397	1,004	3	1,361	3,615	0	1,540	3,756	8,495	(1,343)
1965	1	1	0	19,519	1,759	80	2,404	6,453	0	1,378	4,592	19,247	784
1966	3	3	0	13,901	1,192	49	2,011	4,172	0	1,502	3,913	10,033	(934)
1967	1	1	0	22,181	1,759	0	3,304	7,439	0	1,144	4,729	19,913	1,973
1968	3	4	0	15,971	1,159	49	1,709	5,020	0	1,525	4,226	12,181	732
1969	1	1	0	23,660	1,759	0	5,442	8,066	0	1,543	5,297	23,945	5,716
1970	1	2	0	21,543	1,585	74	3,357	7,316	0	1,506	5,006	24,373	3,778
1971	1	3	0	20,939	1,295	0	1,732	6,908	0	1,583	4,932	16,920	(159)
1972	3	4	0	13,210	1,107	0	1,515	3,920	0	1,524	3,842	9,253	(1,523)
1973	2	2	0	19,810	1,663	78	2,252	6,529	0	1,487	4,717	18,433	1,021
1974	1	1	0	29,264	1,759	2	2,240	10,392	0	1,580	6,144	30,030	2,164
1975	1	1	0	20,440	1,682	0	2,310	6,784	0	1,674	4,962	16,153	945
1976	5	5	0	10,456	820	9	1,169	2,943	4	1,324	3,307	6,917	(1,237)
1977	5	5	0	6,824	790	0	1,016	1,703	36	821	2,391	4,233	(402)
1978	2	1	0	16,859	1,729	0	2,267	5,405	31	1,187	4,063	15,113	2,197
1979	3	2	0	13,993	1,585	78	2,378	4,235	0	1,449	3,884	10,011	381
1980	2	1	0	18,292	1,759	0	4,818	6,032	0	1,267	4,358	19,356	4,265
1981	4	4	0	13,093	1,159	49	1,962	3,885	0	1,436	3,756	9,162	(410)
1982	1	1	0	29,591	1,759	3	5,389	10,473	0	1,562	6,157	30,065	6,979
1983	1	1	0	35,577	1,759	0	15,726	12,980	0	1,050	6,551	42,561	21,616
1984	1	2	0	23,213	1,585	74	6,524	7,985	0	1,190	4,958	22,157	8,253
1985	4	4	0	13,038	1,107	50	1,909	3,861	0	1,485	3,790	9,191	(565)
1986	1	1	0	18,958	1,682	0	4,814	6,463	0	1,300	4,534	23,167	5,017
1987	4	5	0	10,952	846	16	1,661	3,102	0	1,383	3,437	7,300	(1,245)
1988	5	5	0	9,416	790	6	1,020	2,563	38	1,161	3,048	6,236	(935)
1989	4	5	0	11,782	842	31	1,036	3,442	31	1,324	3,490	8,090	(1,283)
1990	5	5	0	8,675	790	4	944	2,288	52	1,143	2,939	5,561	(786)
1991	5	5	0	8,612	816	37	995	2,286	29	1,072	2,863	5,552	(538)
Average			0	15,998	1,325	26	2,427	5,091	8	1,347	4,090	13,793	912

Notes: Definitions of the categories are provided in Table A2–3 in Appendix A2.
Water–year types: 1=wet, 2=above normal, 3=below normal, 4=dry, 5=critically dry
Negative values shown in parentheses.

Table A3–26. Continued

Water Year	Reduced Export for QWEST (TAF)	Initial Collinsville Outflow (TAF)	Initial Chipps Outflow (TAF)	Required Delta Outflow (TAF)	Revised Montez. Flow (TAF)	Reduced Export for Outflow (TAF)	Export Limits (TAF)	Reduced Export for Limits (TAF)	Net Export Change (TAF)	Adjusted Total Export (TAF)	Revised QWEST Flow (TAF)	Revised Collinsville Outflow (TAF)
1922	0	12,347	11,416	6,103	931	0	8,364	0	1,016	7,201	(167)	11,330
1923	0	10,829	9,942	5,833	887	0	9,521	0	1,036	7,227	(545)	9,792
1924	0	4,206	3,401	4,063	805	0	5,401	0	40	4,582	(1,144)	4,166
1925	0	8,317	7,456	5,195	862	0	7,312	0	268	6,003	(910)	8,049
1926	0	7,048	6,200	5,006	847	0	6,923	0	263	5,997	(1,274)	6,785
1927	0	17,681	16,711	6,980	970	0	10,720	0	1,283	7,526	(1,045)	16,398
1928	0	14,303	13,380	6,665	922	0	10,032	0	1,083	7,411	(1,333)	13,219
1929	0	4,598	3,785	4,418	813	0	5,435	0	40	4,604	(901)	4,558
1930	0	6,271	5,439	5,052	832	0	6,182	0	223	5,232	(1,218)	6,048
1931	0	3,728	2,927	3,657	801	0	4,306	0	36	3,363	(297)	3,692
1932	0	5,875	5,044	5,190	831	0	5,625	0	319	4,467	15	5,556
1933	0	4,339	3,528	4,050	811	0	4,694	0	44	3,722	(344)	4,295
1934	0	4,879	4,064	4,532	816	0	4,803	0	164	3,900	(560)	4,716
1935	0	9,503	8,610	6,455	894	0	7,413	0	369	6,294	(715)	9,134
1936	0	10,902	10,019	6,248	884	0	8,419	0	345	6,499	(184)	10,557
1937	0	9,691	8,817	5,287	875	0	7,752	16	322	6,201	508	9,369
1938	0	36,966	35,761	8,125	1,205	0	18,482	0	2,483	8,710	3,447	34,483
1939	0	6,379	5,545	4,357	833	0	6,865	0	1,071	6,160	(1,556)	5,307
1940	0	17,702	16,722	7,246	979	0	10,409	0	690	7,109	(564)	17,012
1941	0	30,554	29,429	7,010	1,126	0	16,412	0	1,223	7,497	1,754	29,332
1942	0	27,795	26,713	6,671	1,082	0	16,125	0	2,363	8,313	456	25,432
1943	0	20,777	19,793	7,309	984	0	13,363	0	2,225	7,783	1,070	18,552
1944	0	6,547	5,712	4,952	835	0	6,788	0	138	6,067	(1,277)	6,408
1945	0	8,690	7,832	5,277	858	0	7,966	0	575	6,709	(793)	8,115
1946	0	13,046	12,145	6,279	900	0	11,239	0	603	6,893	(642)	12,443
1947	0	5,609	4,781	5,072	828	0	6,751	0	37	6,070	(1,596)	5,572
1948	0	7,435	6,569	5,487	866	0	7,141	0	108	6,409	(1,512)	7,327
1949	0	7,168	6,324	4,921	844	0	6,947	0	244	5,936	(1,257)	6,924
1950	0	7,605	6,751	5,599	854	0	7,295	0	355	6,506	(1,490)	7,249
1951	0	20,263	19,290	6,326	973	0	14,970	0	1,066	7,832	916	19,196
1952	0	27,811	26,691	7,985	1,120	0	15,787	0	1,962	8,888	1,027	25,850
1953	0	17,401	16,445	6,080	956	0	12,676	0	2,169	7,473	(1,376)	15,232
1954	0	14,935	13,994	7,021	941	0	10,339	0	1,761	8,134	(2,262)	13,173
1955	0	6,281	5,447	5,051	834	0	7,342	0	467	6,483	(1,858)	5,814
1956	0	27,183	26,125	6,221	1,059	0	17,795	0	1,038	7,861	1,363	26,146
1957	0	10,221	9,341	5,661	881	0	8,552	0	1,082	7,368	(1,796)	9,139
1958	0	32,616	31,443	7,267	1,173	0	16,086	0	2,271	9,317	777	30,346
1959	0	10,781	9,906	5,294	875	0	8,800	0	1,576	6,752	(1,438)	9,205
1960	0	6,088	5,256	5,203	832	0	6,803	0	181	6,037	(1,803)	5,907
1961	0	6,045	5,214	5,097	831	0	6,750	0	205	5,981	(1,894)	5,840
1962	0	8,160	7,307	5,063	853	0	7,528	0	172	5,969	(1,097)	7,988
1963	0	18,732	17,719	7,329	1,013	0	11,162	0	1,464	8,115	(1,456)	17,269
1964	0	7,034	6,195	5,143	839	0	7,793	0	587	6,501	(1,930)	6,447
1965	0	19,937	18,946	6,670	992	0	14,496	0	642	7,293	142	19,295
1966	0	8,990	8,128	5,602	863	0	8,613	0	911	7,314	(1,845)	8,079
1967	0	21,825	20,776	7,553	1,049	0	13,108	0	2,145	9,010	(173)	19,679
1968	0	12,804	11,909	5,557	895	0	9,256	0	2,697	7,480	(1,965)	10,107
1969	0	29,594	28,470	7,967	1,124	0	16,813	0	2,226	8,656	3,489	27,368
1970	0	28,062	27,022	5,637	1,039	0	18,655	0	2,788	7,820	990	25,273
1971	0	16,665	15,713	7,094	952	0	12,449	0	988	7,800	(1,147)	15,677
1972	0	7,607	6,760	5,409	847	0	7,849	0	880	7,223	(2,403)	6,727
1973	0	19,403	18,436	6,821	967	0	12,919	0	1,240	7,849	(220)	18,162
1974	0	32,109	30,983	6,944	1,126	0	19,746	0	1,813	8,642	351	30,296
1975	0	17,001	16,040	6,627	961	0	10,903	0	2,040	8,534	(1,095)	14,961
1976	0	5,553	4,732	4,416	822	0	6,343	0	549	5,548	(1,786)	5,005
1977	0	3,708	2,908	3,657	800	0	4,264	0	51	3,103	(453)	3,657
1978	0	17,254	16,291	7,933	963	0	10,117	0	1,819	6,326	378	15,435
1979	0	10,301	9,422	5,844	878	0	8,242	0	1,274	7,078	(893)	9,027
1980	0	23,549	22,547	6,568	1,002	0	14,443	15	1,485	7,158	2,780	22,064
1981	0	8,638	7,782	5,109	856	0	7,849	0	1,429	7,016	(1,839)	7,209
1982	0	36,998	35,758	7,099	1,240	0	20,240	0	2,031	9,298	4,948	34,967
1983	0	64,167	62,613	6,197	1,553	0	31,346	0	5,225	10,638	16,391	58,942
1984	0	30,310	29,247	5,676	1,063	0	20,548	0	3,503	8,079	4,750	26,807
1985	0	8,527	7,673	5,068	854	0	8,383	0	907	6,841	(1,472)	7,620
1986	0	28,129	27,076	6,155	1,053	0	14,333	33	877	7,145	4,140	27,252
1987	0	5,938	5,109	4,819	830	0	6,602	0	137	5,945	(1,382)	5,801
1988	0	5,193	4,375	4,505	818	0	5,648	0	231	4,677	(1,166)	4,962
1989	0	6,694	5,850	4,816	844	0	6,313	0	255	5,533	(1,538)	6,440
1990	0	4,665	3,851	4,506	815	0	5,037	0	93	4,159	(880)	4,572
1991	0	4,904	4,087	4,088	816	0	4,808	0	44	3,852	(583)	4,859
Average	0	14,612	13,681	5,802	931	0	10,291	1	1,046	6,759	(134)	13,566

Table A3–26. Continued

Water Year	Available for DW Diversion (TAF)	Delta Storage (TAF)	Delta Storage Diversion (TAF)	Delta Storage Export (TAF)	Delta Storage Outflow (TAF)	Final Total Export (TAF)	Final QWEST Flow (TAF)	Final Delta Outflow (TAF)	3–Mile Slough Flow (TAF)	Old River Diversion Flow (TAF)	Final Antioch Flow (TAF)	Old & Middle Flow (TAF)
1922	276	207	276	204	0	7,405	(443)	11,054	2,840	1,587	2,397	(6,317)
1923	1,512	406	405	424	0	7,651	(951)	9,387	2,728	1,369	1,778	(6,776)
1924	0	0	0	0	0	4,582	(1,144)	4,166	1,626	825	482	(4,416)
1925	597	333	362	321	0	6,324	(1,271)	7,688	2,506	852	1,234	(5,949)
1926	201	186	201	176	0	6,173	(1,476)	6,583	2,364	877	888	(5,834)
1927	1,966	406	452	397	0	7,922	(1,497)	15,946	4,555	1,038	3,058	(7,363)
1928	1,827	406	733	698	0	8,109	(2,066)	12,487	4,063	996	1,998	(7,660)
1929	0	0	0	0	0	4,604	(901)	4,558	1,581	851	681	(4,359)
1930	85	86	85	90	0	5,322	(1,303)	5,963	2,126	764	823	(5,118)
1931	0	0	0	0	0	3,363	(297)	3,692	1,050	831	753	(3,142)
1932	0	0	0	0	0	4,467	15	5,556	1,308	943	1,323	(4,037)
1933	0	0	0	0	0	3,722	(344)	4,295	1,216	853	872	(3,486)
1934	0	0	0	0	0	3,900	(560)	4,716	1,431	805	871	(3,695)
1935	335	338	335	362	0	6,656	(1,050)	8,799	2,645	1,100	1,595	(6,054)
1936	1,139	406	404	363	0	6,862	(588)	10,153	2,707	1,192	2,119	(6,133)
1937	657	406	439	371	0	6,571	70	8,931	2,061	1,494	2,131	(5,522)
1938	7,367	406	458	368	0	9,078	2,990	34,025	6,311	3,087	9,301	(6,365)
1939	203	207	203	201	0	6,361	(1,758)	5,105	2,179	995	421	(5,991)
1940	2,040	406	425	384	0	7,493	(989)	16,587	4,422	1,046	3,433	(6,849)
1941	5,158	406	430	380	0	7,877	1,323	28,901	6,026	2,157	7,349	(6,068)
1942	4,083	406	545	474	0	8,787	(89)	24,887	5,868	1,534	5,778	(7,699)
1943	3,664	406	419	373	0	8,155	651	18,133	3,892	1,611	4,543	(7,042)
1944	0	0	0	0	0	6,067	(1,277)	6,408	2,216	984	939	(5,645)
1945	656	333	362	272	0	6,980	(1,154)	7,754	2,461	1,254	1,307	(6,260)
1946	1,795	406	400	424	0	7,317	(1,041)	12,043	3,402	1,139	2,360	(6,752)
1947	0	0	0	0	0	6,070	(1,596)	5,572	2,198	958	603	(5,724)
1948	0	0	0	0	0	6,409	(1,512)	7,327	2,560	806	1,048	(6,183)
1949	254	259	254	225	0	6,161	(1,511)	6,670	2,407	842	895	(5,908)
1950	21	22	21	20	0	6,526	(1,511)	7,228	2,537	866	1,026	(6,249)
1951	4,506	406	417	366	0	8,198	500	18,780	4,124	1,430	4,624	(7,241)
1952	4,683	406	491	368	0	9,257	536	25,358	5,634	1,548	6,170	(8,118)
1953	1,920	406	470	519	0	7,992	(1,846)	14,762	4,474	1,084	2,628	(7,464)
1954	1,497	406	597	549	0	8,684	(2,859)	12,577	4,521	908	1,662	(8,383)
1955	319	324	319	338	0	6,821	(2,177)	5,495	2,495	839	318	(6,537)
1956	4,551	406	438	381	0	8,242	924	25,708	5,504	1,711	6,428	(6,951)
1957	361	206	361	325	0	7,693	(2,157)	8,778	3,250	964	1,093	(7,308)
1958	5,034	406	458	368	0	9,685	319	29,887	6,803	2,019	7,122	(7,985)
1959	1,192	406	597	582	0	7,334	(2,034)	8,608	3,145	997	1,110	(6,929)
1960	0	0	0	0	0	6,037	(1,803)	5,907	2,389	802	586	(5,834)
1961	45	41	45	34	0	6,016	(1,938)	5,795	2,436	763	498	(5,839)
1962	679	333	362	314	0	6,283	(1,459)	7,626	2,598	892	1,139	(5,925)
1963	2,090	406	769	686	0	8,801	(2,226)	16,500	5,080	1,021	2,854	(8,225)
1964	756	400	661	660	0	7,161	(2,591)	5,787	2,792	849	201	(6,927)
1965	2,635	406	502	467	0	7,761	(360)	18,794	4,599	1,246	4,240	(7,034)
1966	726	406	502	500	0	7,813	(2,347)	7,577	3,074	1,110	727	(7,286)
1967	3,093	406	460	368	0	9,379	(632)	19,219	4,840	1,729	4,208	(8,040)
1968	1,224	406	591	523	0	8,003	(2,556)	9,516	3,641	943	1,085	(7,641)
1969	5,107	406	581	370	0	9,026	2,908	26,787	4,670	3,097	7,579	(6,341)
1970	4,602	406	274	335	0	8,154	716	24,999	5,457	1,632	6,173	(7,025)
1971	2,194	406	704	655	0	8,455	(1,851)	14,973	4,524	993	2,673	(7,990)
1972	76	78	76	72	0	7,295	(2,479)	6,651	2,934	902	455	(7,029)
1973	3,239	406	415	362	0	8,210	(635)	17,747	4,496	1,204	3,861	(7,353)
1974	5,063	406	431	368	0	9,010	(81)	29,865	7,025	1,154	6,945	(8,339)
1975	1,805	406	522	438	0	8,971	(1,617)	14,438	4,272	1,176	2,655	(8,330)
1976	131	130	131	126	0	5,673	(1,917)	4,874	2,213	755	297	(5,577)
1977	0	0	0	0	0	3,103	(453)	3,657	1,129	676	676	(3,077)
1978	2,136	406	420	368	0	6,694	(43)	15,015	3,536	1,158	3,494	(5,913)
1979	488	406	411	367	0	7,445	(1,304)	8,616	2,742	1,220	1,438	(6,734)
1980	4,574	406	409	372	0	7,531	2,371	21,655	3,769	2,567	6,140	(5,396)
1981	271	276	271	280	0	7,297	(2,110)	6,939	2,797	1,068	687	(6,828)
1982	7,159	406	678	375	0	9,673	4,270	34,290	5,670	3,355	9,940	(6,645)
1983	19,194	406	308	38	0	10,676	16,083	58,633	4,881	9,324	20,964	(1,539)
1984	7,829	406	22	334	0	8,413	4,728	26,785	3,683	3,669	8,411	(5,289)
1985	1,004	406	411	417	0	7,259	(1,883)	7,209	2,733	1,103	850	(6,697)
1986	5,490	406	439	369	0	7,514	3,701	26,814	4,240	2,756	7,942	(5,120)
1987	0	0	0	0	0	5,945	(1,382)	5,801	2,135	919	753	(5,639)
1988	218	223	218	230	0	4,906	(1,384)	4,744	1,887	685	503	(4,797)
1989	24	25	24	3	0	5,536	(1,562)	6,416	2,375	646	813	(5,483)
1990	0	0	0	0	0	4,159	(880)	4,572	1,572	633	692	(4,117)
1991	0	0	0	0	0	3,852	(583)	4,859	1,477	634	894	(3,816)
Average	1,996	272	314	282	0	7,041	(448)	13,252	3,356	1,369	2,908	(6,191)

Table A3–27. Monthly Percentiles for DeltaSOS Simulations for Alternative 3 Cumulative Conditions

DW diversion (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	29	59	0	0	0	0	0	0	0
60	0	0	0	29	61	0	0	0	0	0	0	0
70	0	0	822	632	61	98	0	0	0	0	0	0
80	0	517	1,260	3,390	729	98	151	0	0	0	0	0
90	2,847	4,949	4,914	5,499	2,945	399	151	198	0	0	0	0
100	6,000	6,000	6,000	6,000	6,000	4,951	2,939	1,791	235	260	0	3,888
Mean	526	848	1,117	1,295	796	305	127	55	17	4	0	125

DW storage (TAF)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	(0)	0	(0)	(0)	(0)	0	(0)	(0)	(0)	0
10	0	0	0	0	0	(0)	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	52	0	0	0	0	0	0	0
50	0	0	0	276	189	31	16	0	0	0	0	0
60	0	0	52	369	333	240	266	207	0	0	0	0
70	0	81	278	406	406	406	389	315	14	0	0	0
80	0	149	406	406	406	406	397	385	179	0	0	0
90	200	357	406	406	406	406	406	406	330	21	0	0
100	406	406	406	406	406	406	406	406	406	406	353	406
Mean	44	84	137	210	205	175	174	159	72	15	5	12

DW discharge for export (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	683	0	0	0
80	0	0	0	0	329	1,031	0	67	3,583	1,454	0	0
90	0	0	1,296	0	3,851	2,922	167	636	5,878	3,463	112	0
100	0	2,518	4,215	2,703	6,000	6,000	895	3,000	6,000	6,000	3,938	0
Mean	0	159	255	90	841	732	61	204	1,352	861	127	0

DW discharge for outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	-0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Final CVP Tracy and SWP Banks exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	4,329	3,356	5,087	4,862	6,075	3,202	2,865	2,496	1,207	1,968	653	3,340
10	5,166	5,415	7,383	8,704	6,836	4,723	3,645	3,215	5,500	4,519	3,564	3,661
20	6,895	6,670	7,857	10,953	9,184	6,570	3,873	3,639	5,595	6,959	4,957	5,959
30	8,033	7,402	9,937	11,593	12,331	9,174	4,412	4,074	5,804	8,325	5,199	6,120
40	8,541	8,413	11,170	14,147	14,500	12,287	5,623	5,017	6,267	11,260	6,064	6,428
50	9,096	10,700	12,749	14,500	14,500	14,500	6,573	6,047	7,026	11,437	7,028	6,587
60	9,751	13,325	14,500	14,500	14,500	14,500	7,380	7,176	9,209	11,438	7,625	6,754
70	11,962	14,900	14,500	14,500	14,500	14,500	8,921	8,457	10,551	11,438	8,521	7,478
80	14,542	14,900	14,500	14,500	14,500	14,500	10,960	9,437	12,588	11,438	9,980	10,131
90	14,900	14,900	14,500	14,500	14,500	14,500	11,760	11,760	14,900	13,615	11,403	14,073
100	14,900	14,900	14,500	14,500	14,500	14,500	14,900	14,900	14,900	14,900	14,900	14,900
Mean	9,997	10,602	11,742	12,853	12,516	11,491	7,310	6,856	8,717	10,034	7,132	7,615

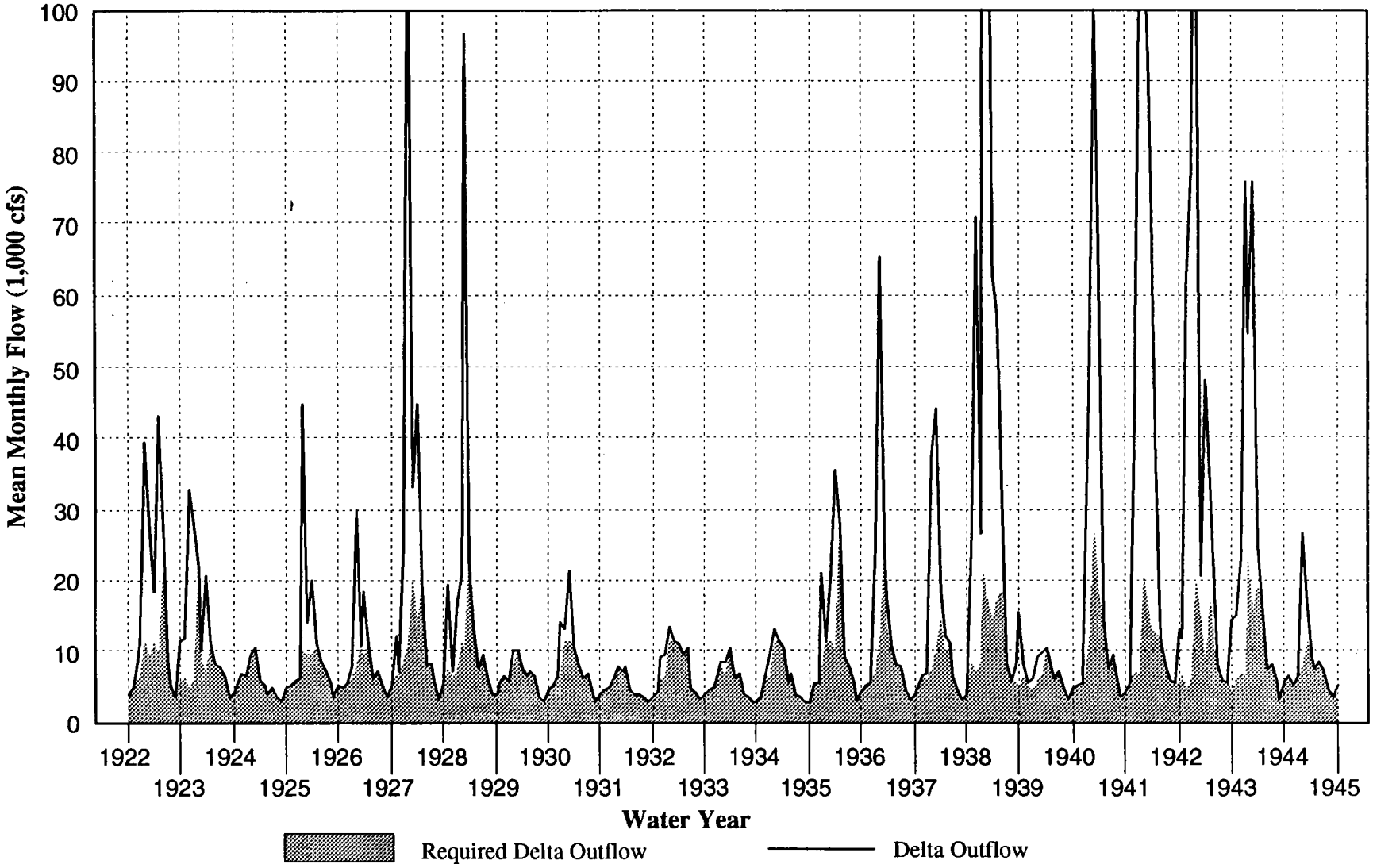

Figure A3-1A.
DeltaSOS-Simulated Mean Monthly Delta Outflow and Required Delta Outflow for 1922-1944 for the No-Project Alternative

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

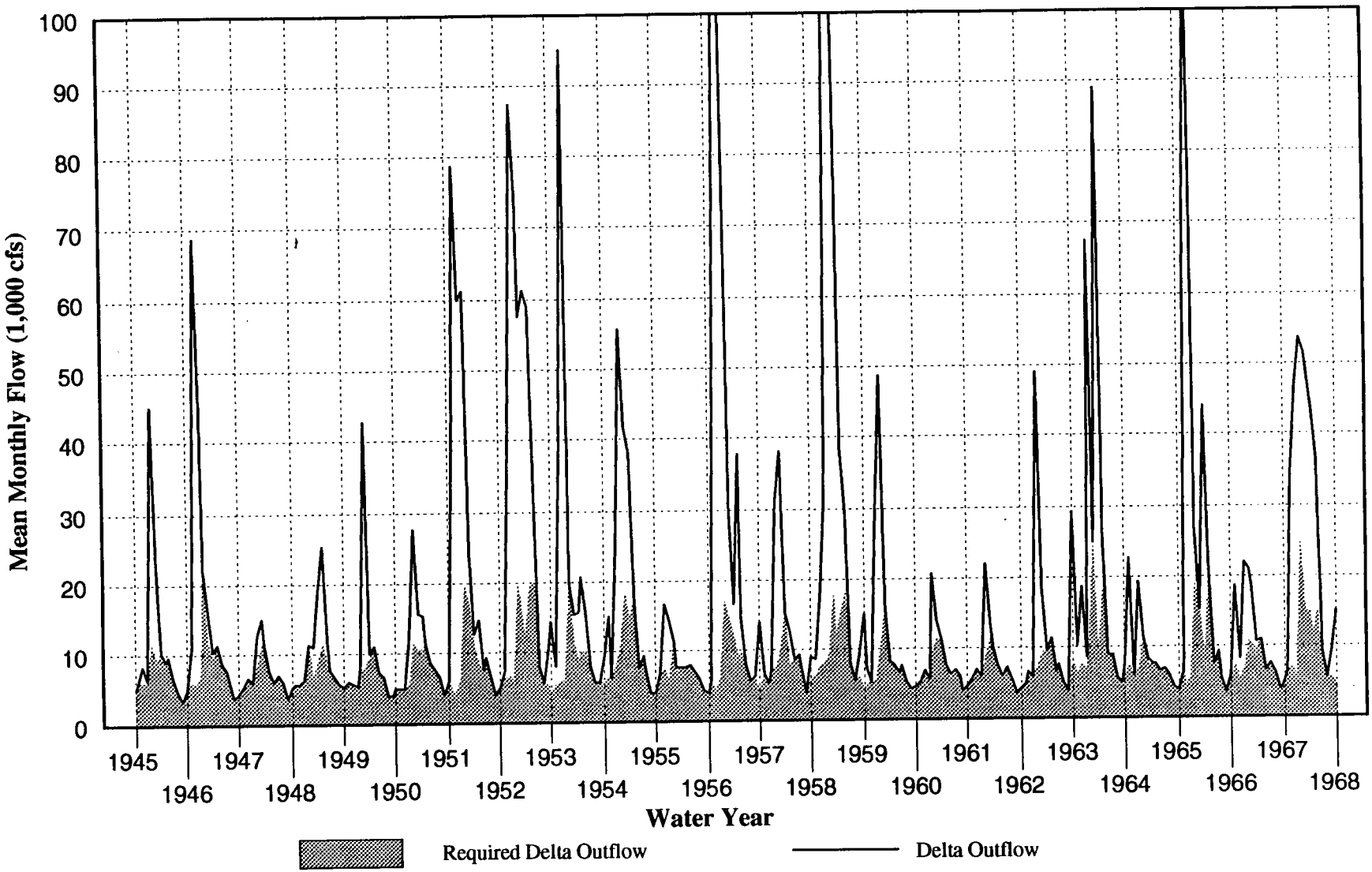

Figure A3-1B.
DeltaSOS-Simulated Mean Monthly Delta Outflow and Required Delta Outflow for 1945-1967 for the No-Project Alternative

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

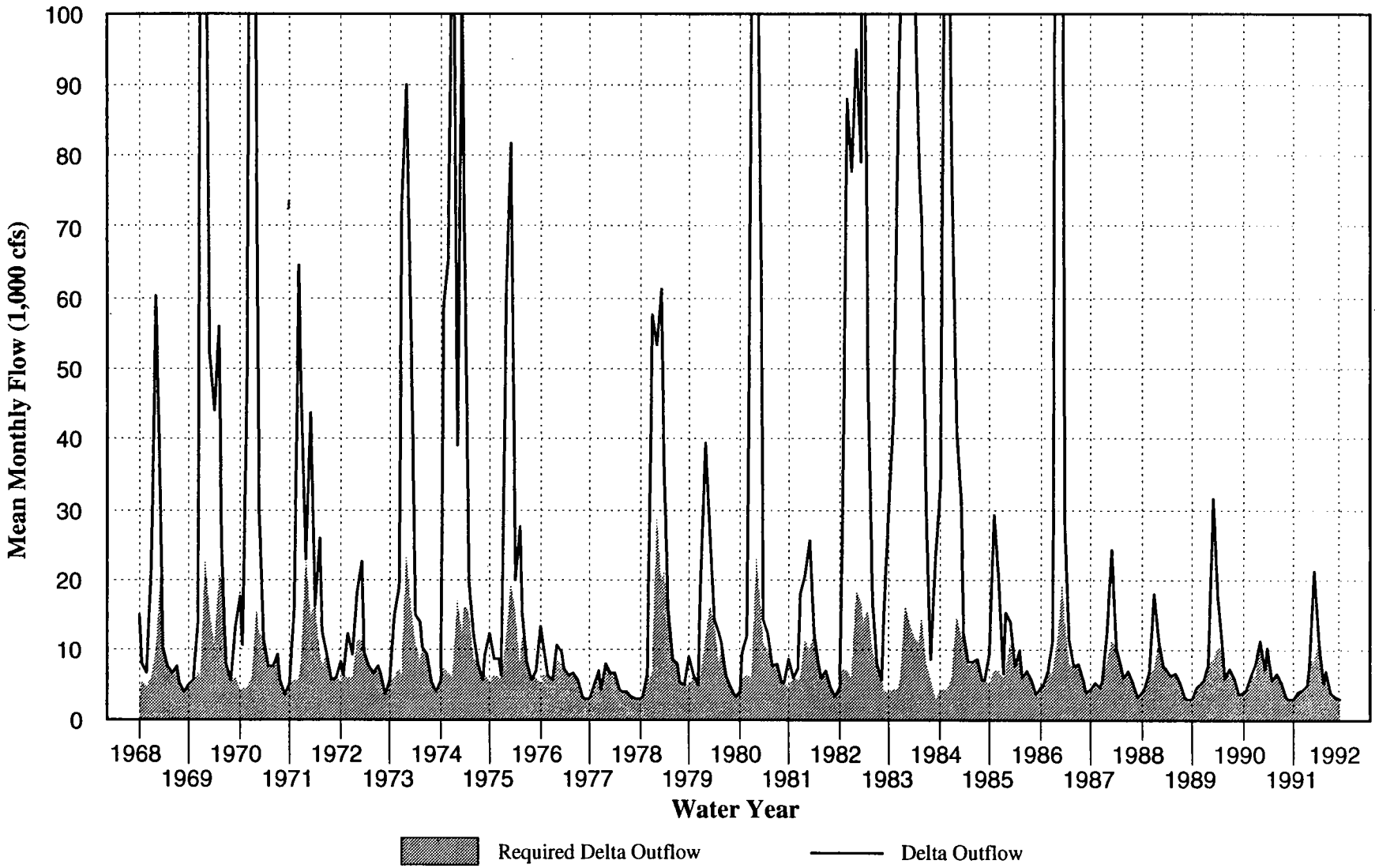

Figure A3-1C.
DeltaSOS-Simulated Mean Monthly Delta Outflow and Required Delta Outflow for 1968-1991 for the No-Project Alternative

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

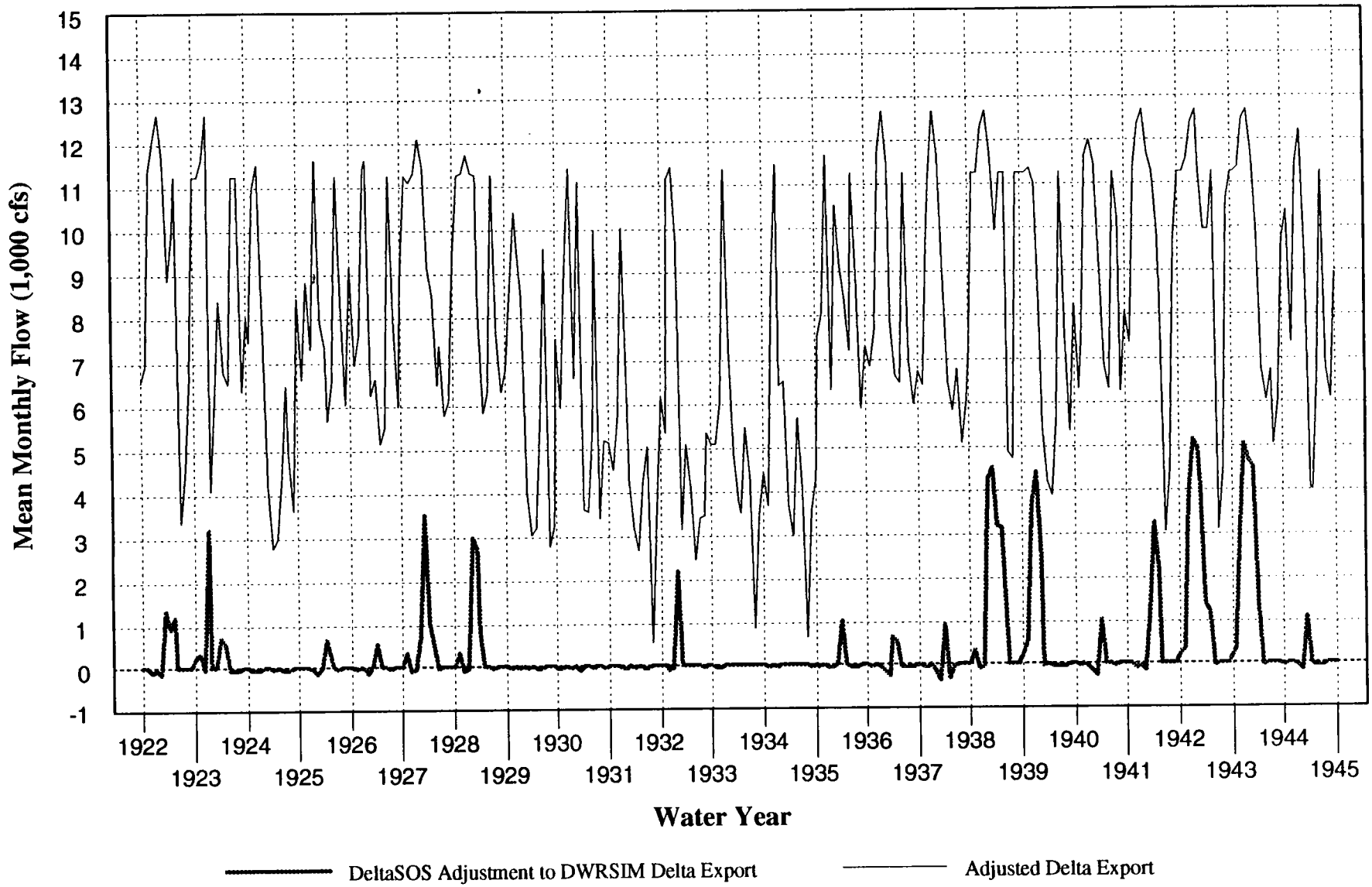

Figure A3-2A.
DeltaSOS-Simulated Mean Monthly Delta Export and Export Adjustment for 1922-1944 for the No-Project Alternative

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

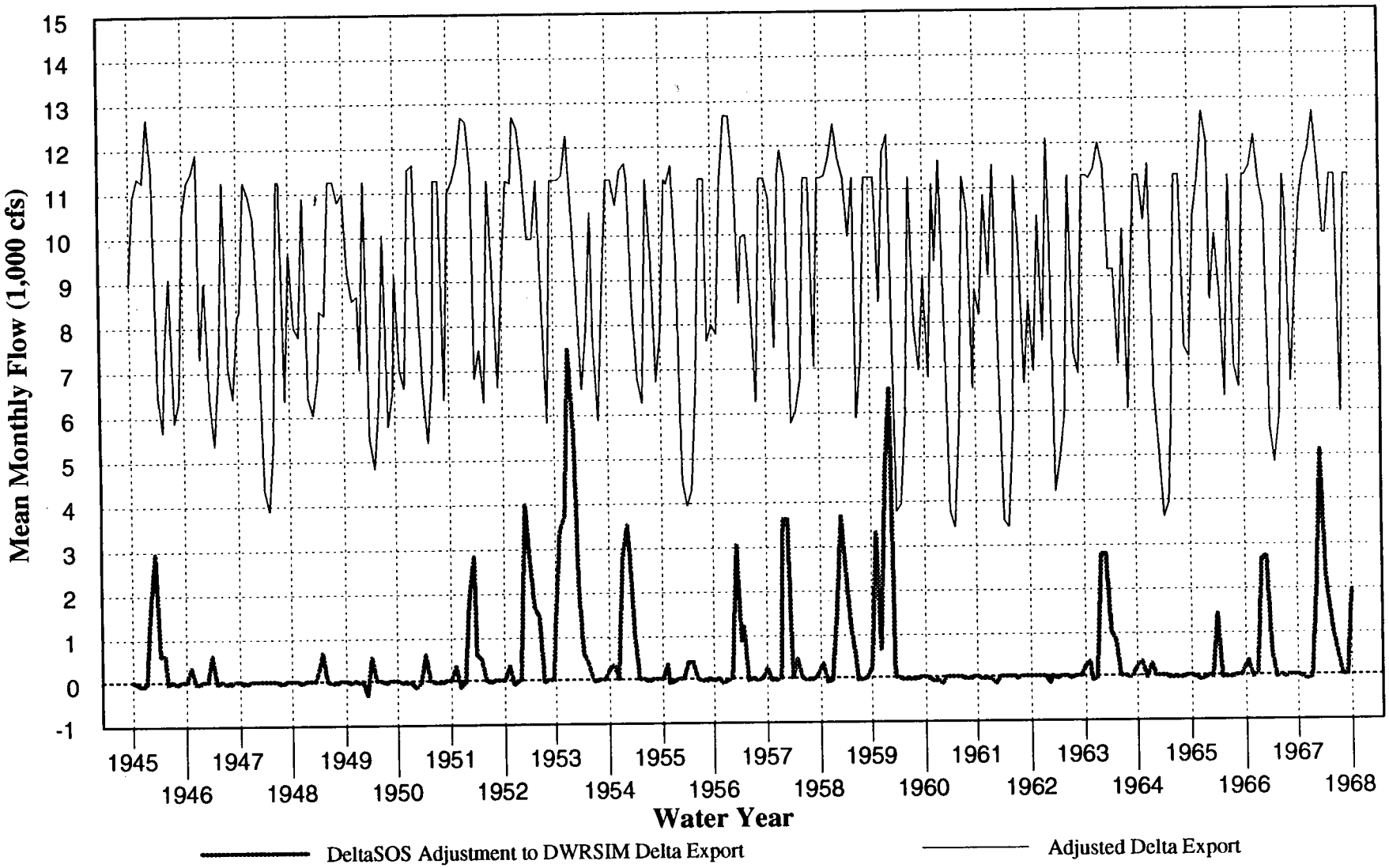

Figure A3-2B.
DeltaSOS-Simulated Mean Monthly Delta Export and Export Adjustment for 1945-1967 for the No-Project Alternative

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

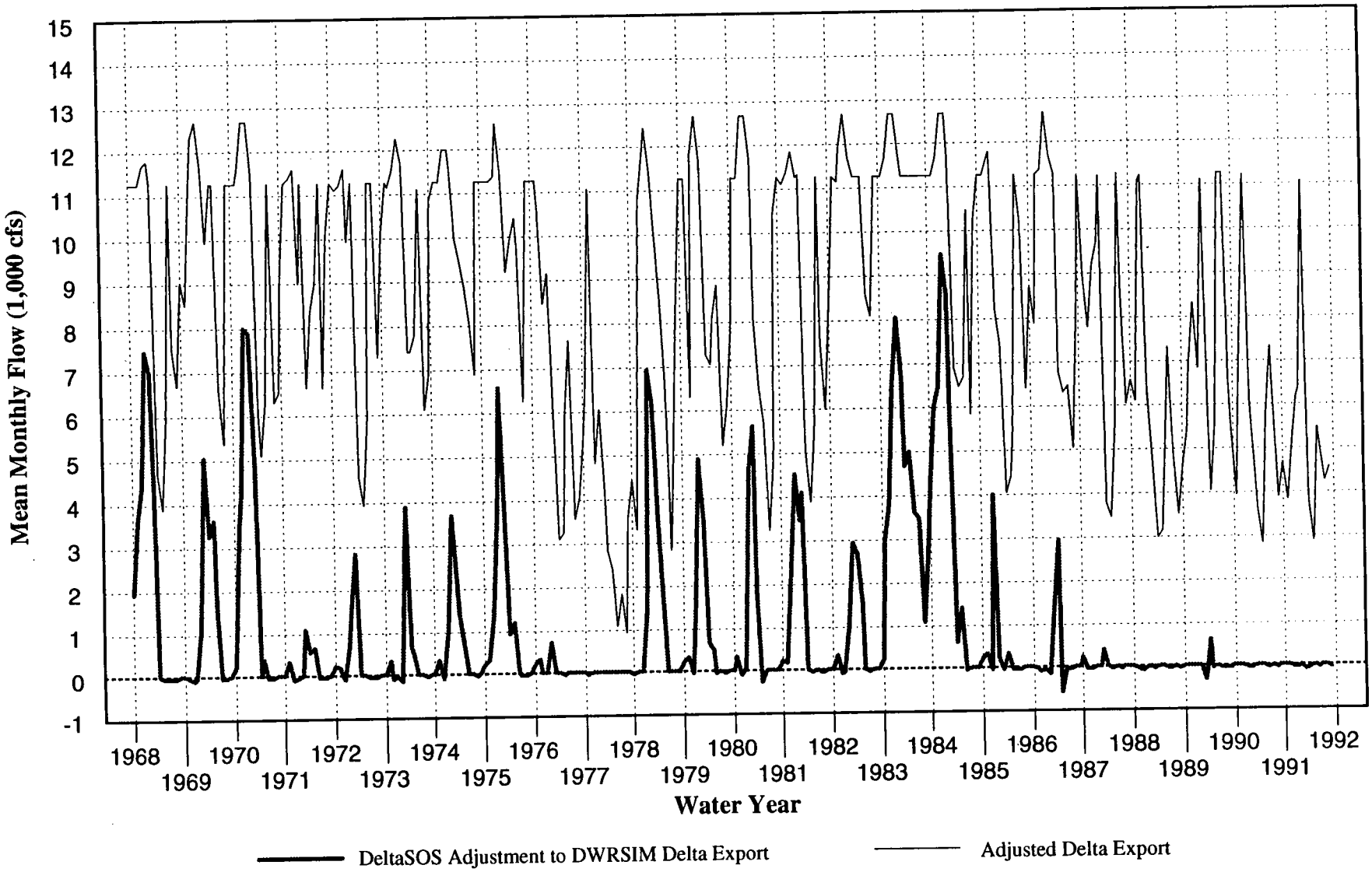

Figure A3-2C.
DeltaSOS-Simulated Mean Monthly Delta Export and Export Adjustment for 1968-1991 for the No-Project Alternative

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

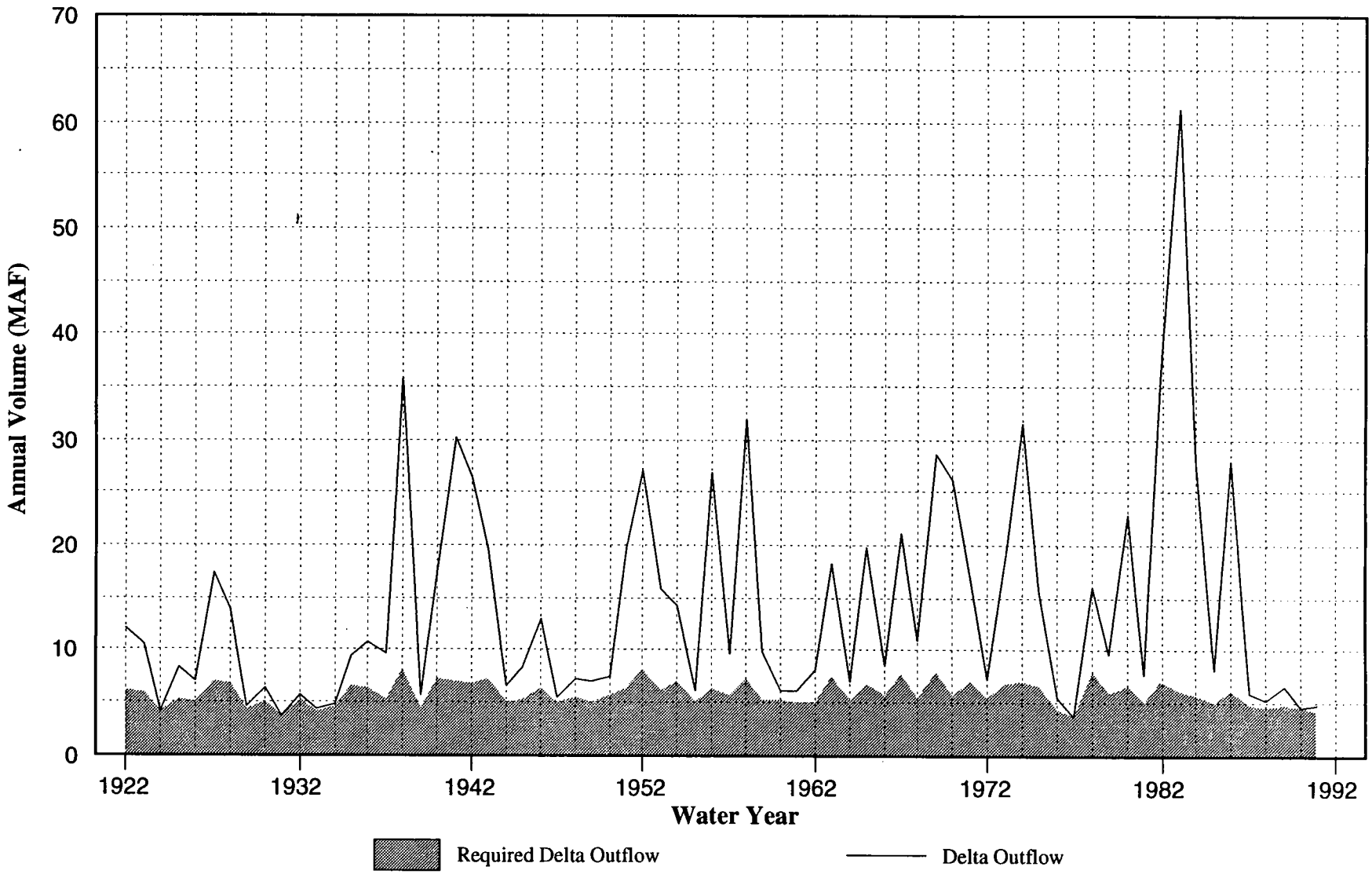

Figure A3-3.
DeltaSOS-Simulated Annual Delta Outflow and Required Delta Outflow for 1922-1991 for the No-Project Alternative

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

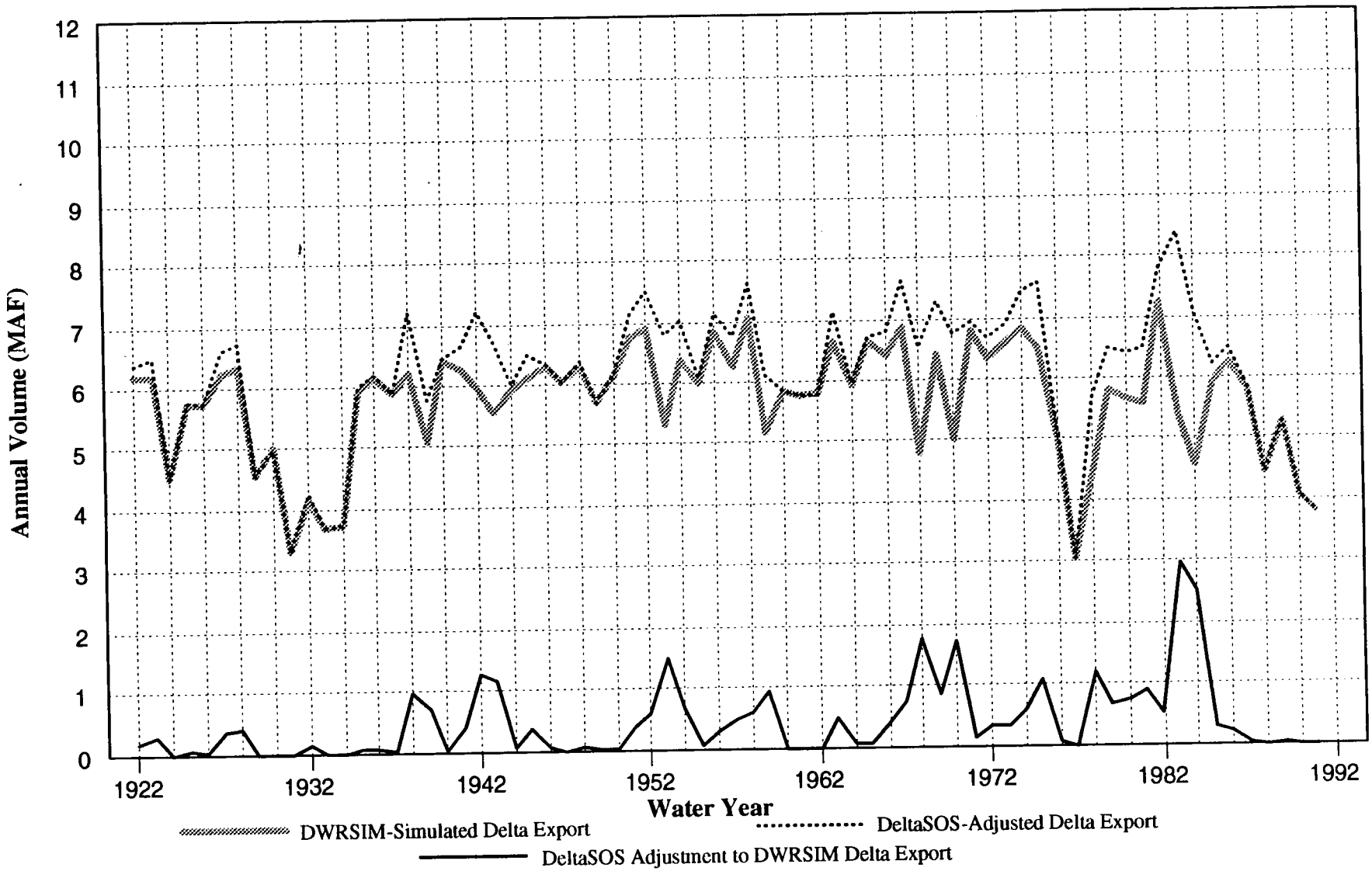

Figure A3-4.
DWRSIM-Simulated and DeltaSOS-Adjusted Annual Delta Export for 1922-1991 for the No-Project Alternative

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

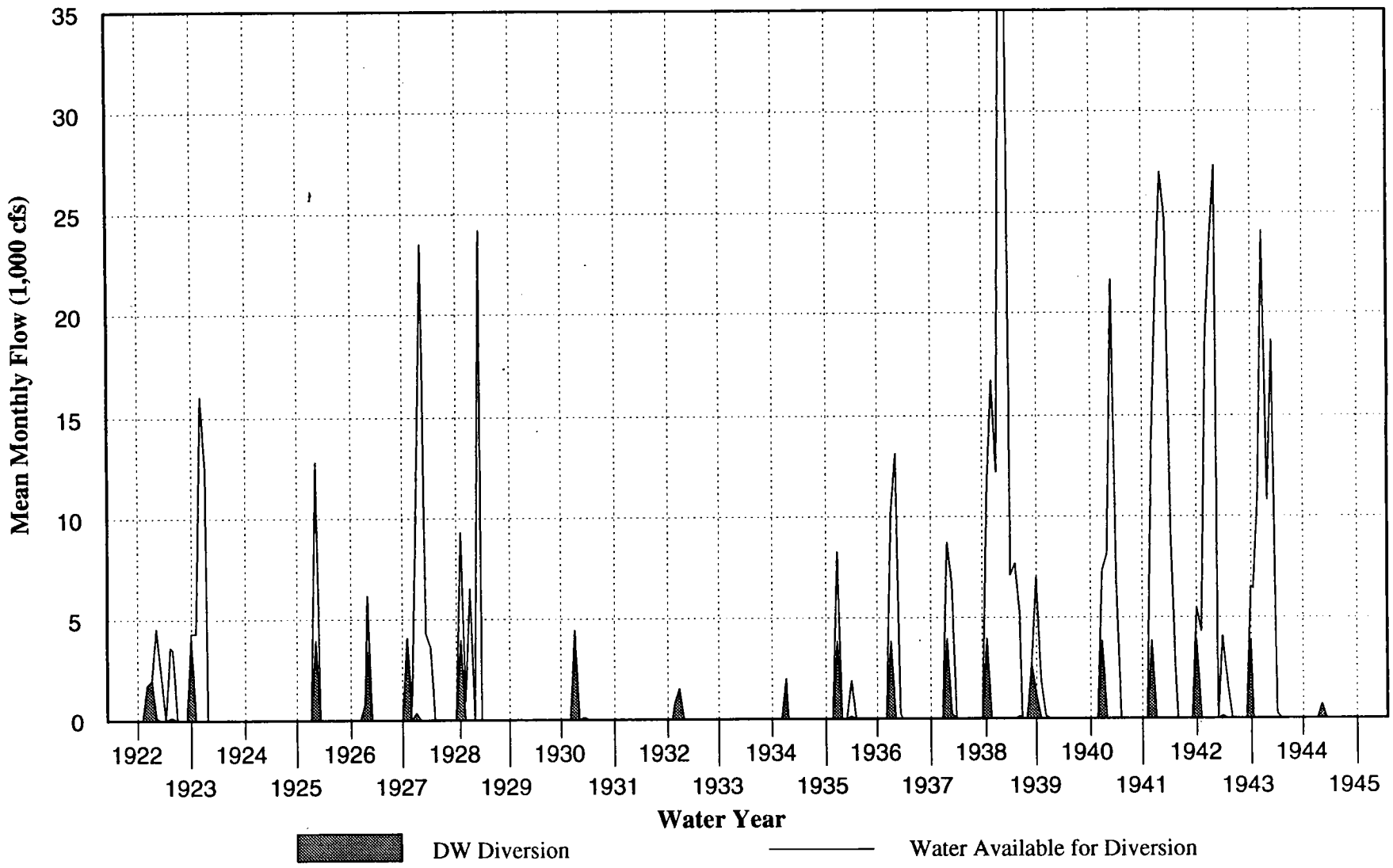

Figure A3-5A.
DeltaSOS-Simulated Mean Monthly Water Available for Diversion and DW Diversion for 1922-1944 for Alternative 1

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

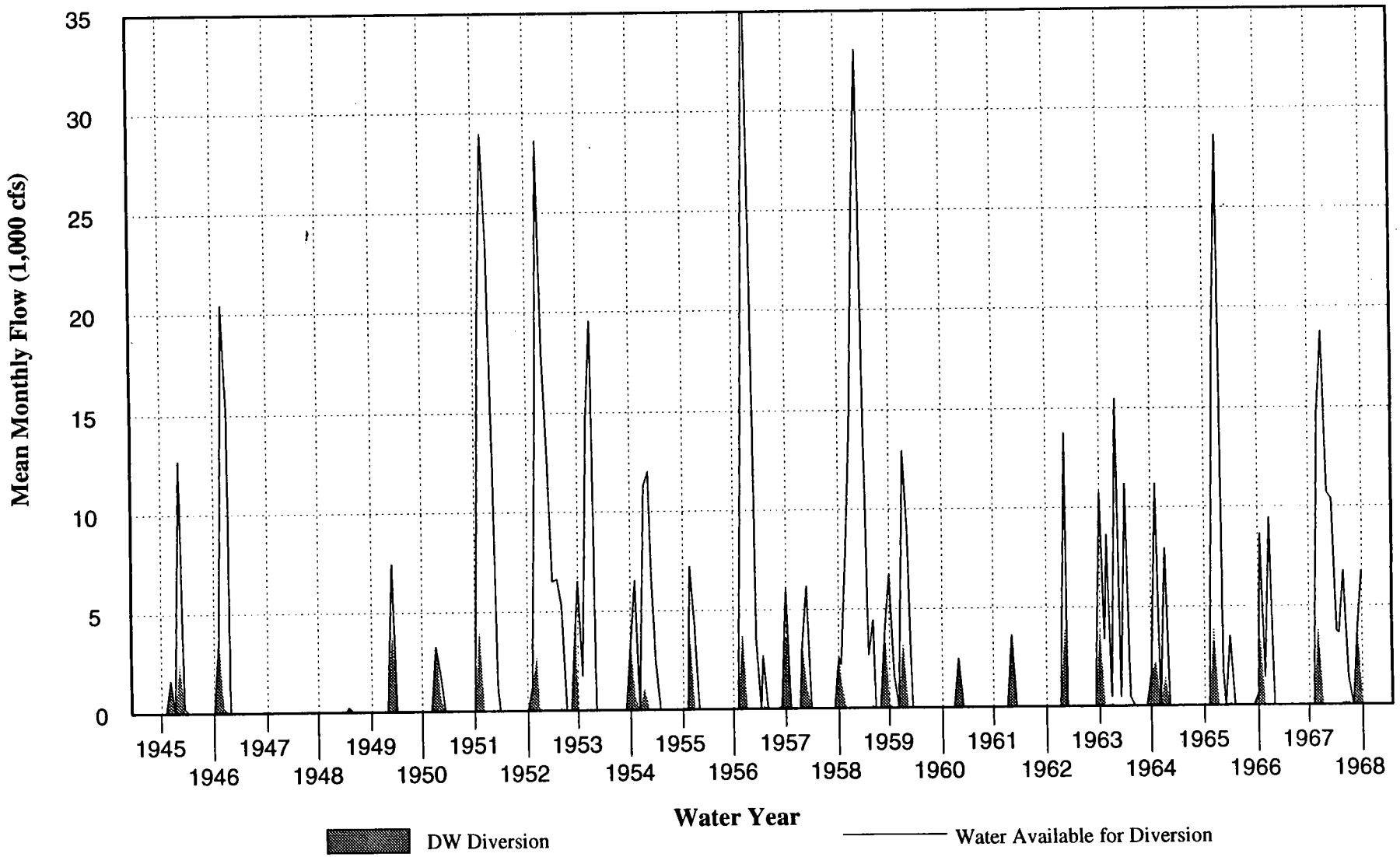

Figure A3-5B.
DeltaSOS-Simulated Mean Monthly Water Available for Diversion and DW Diversion for 1945-1967 for Alternative 1

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

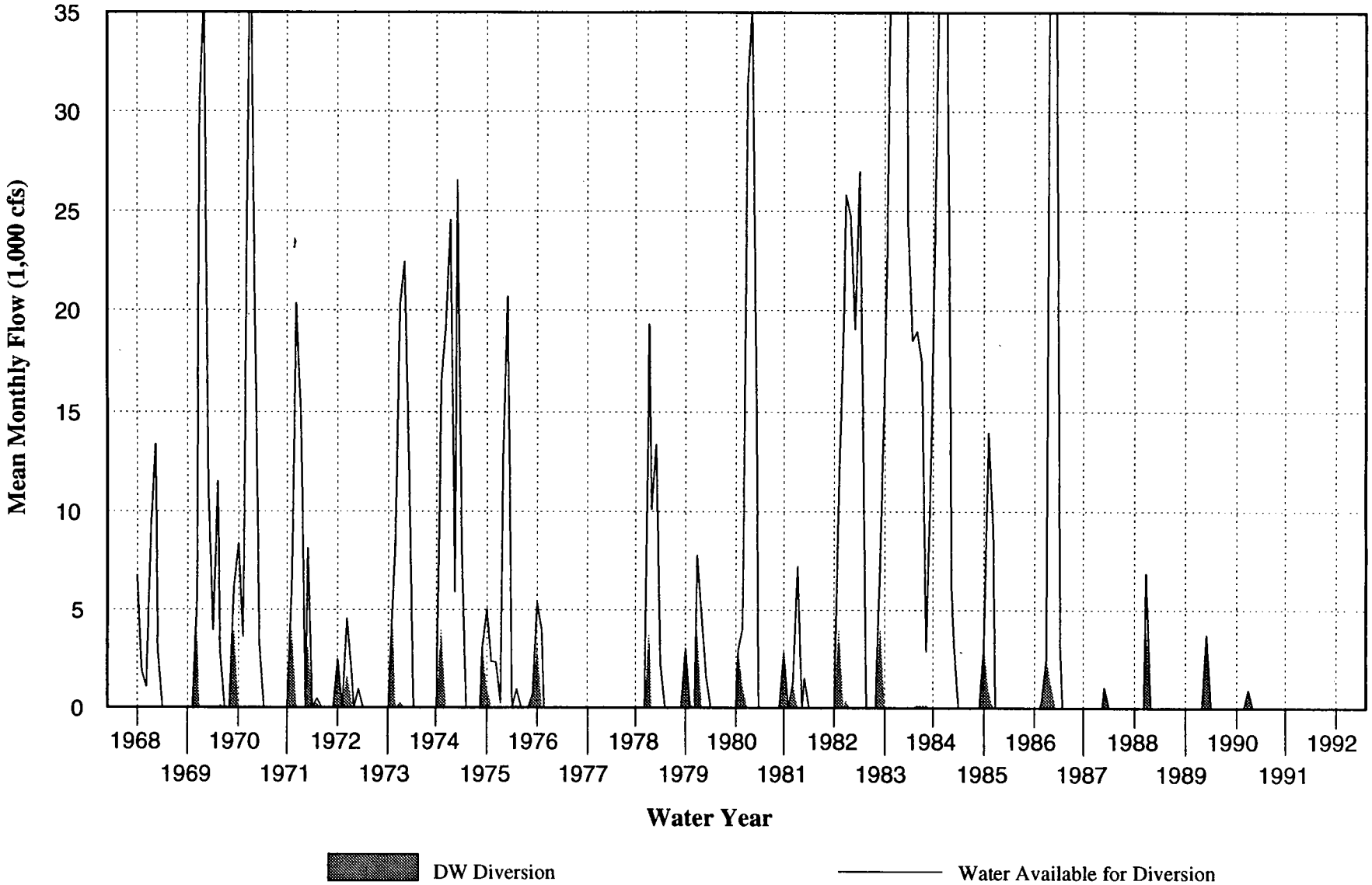

Figure A3-5C.
DeltaSOS-Simulated Mean Monthly Water Available for Diversion and DW Diversion for 1968-1991 for Alternative 1

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

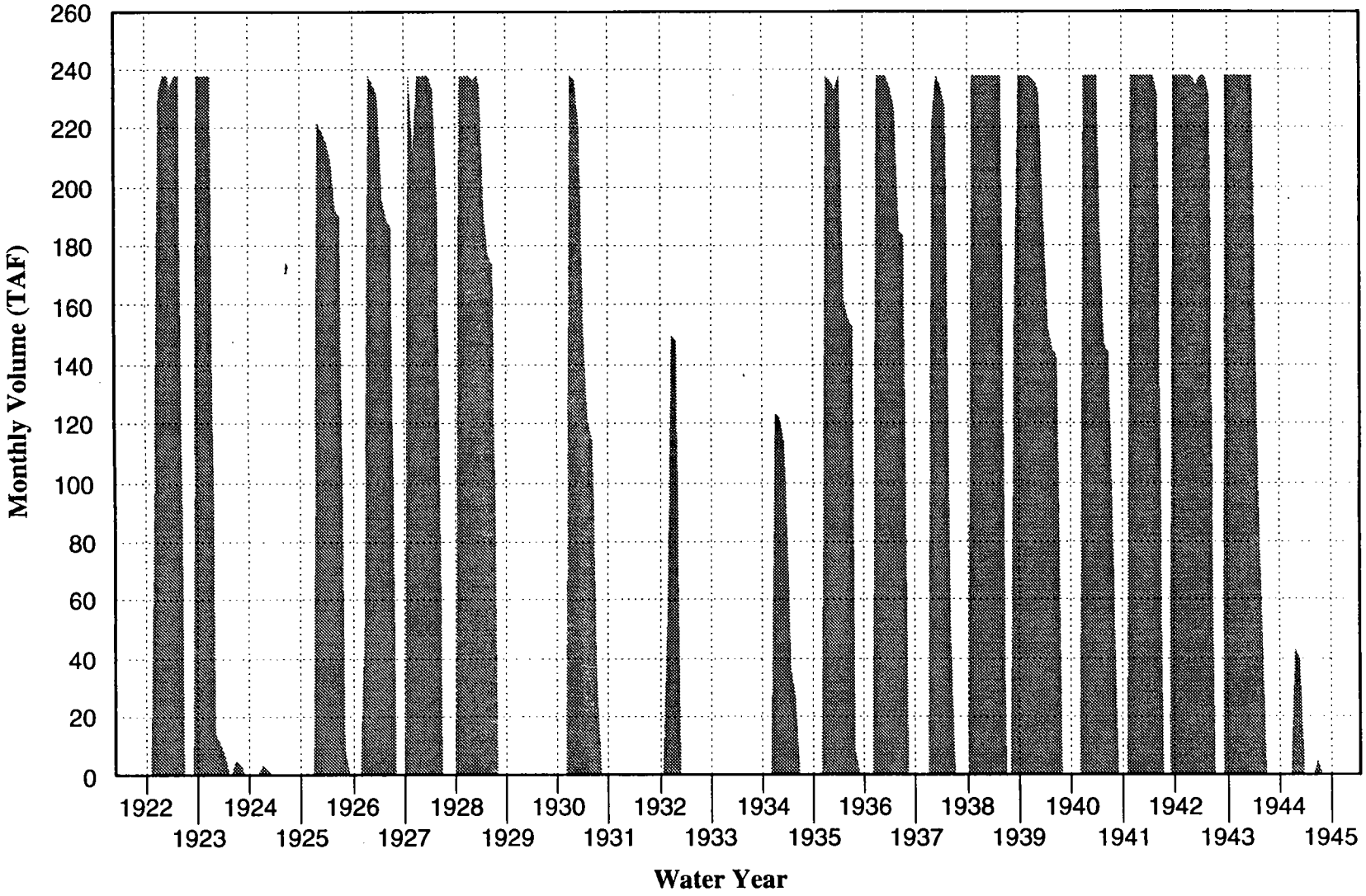

Figure A3-6A.
DeltaSOS-Simulated End-of-Month DW Storage
for 1922-1944 for Alternative 1

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

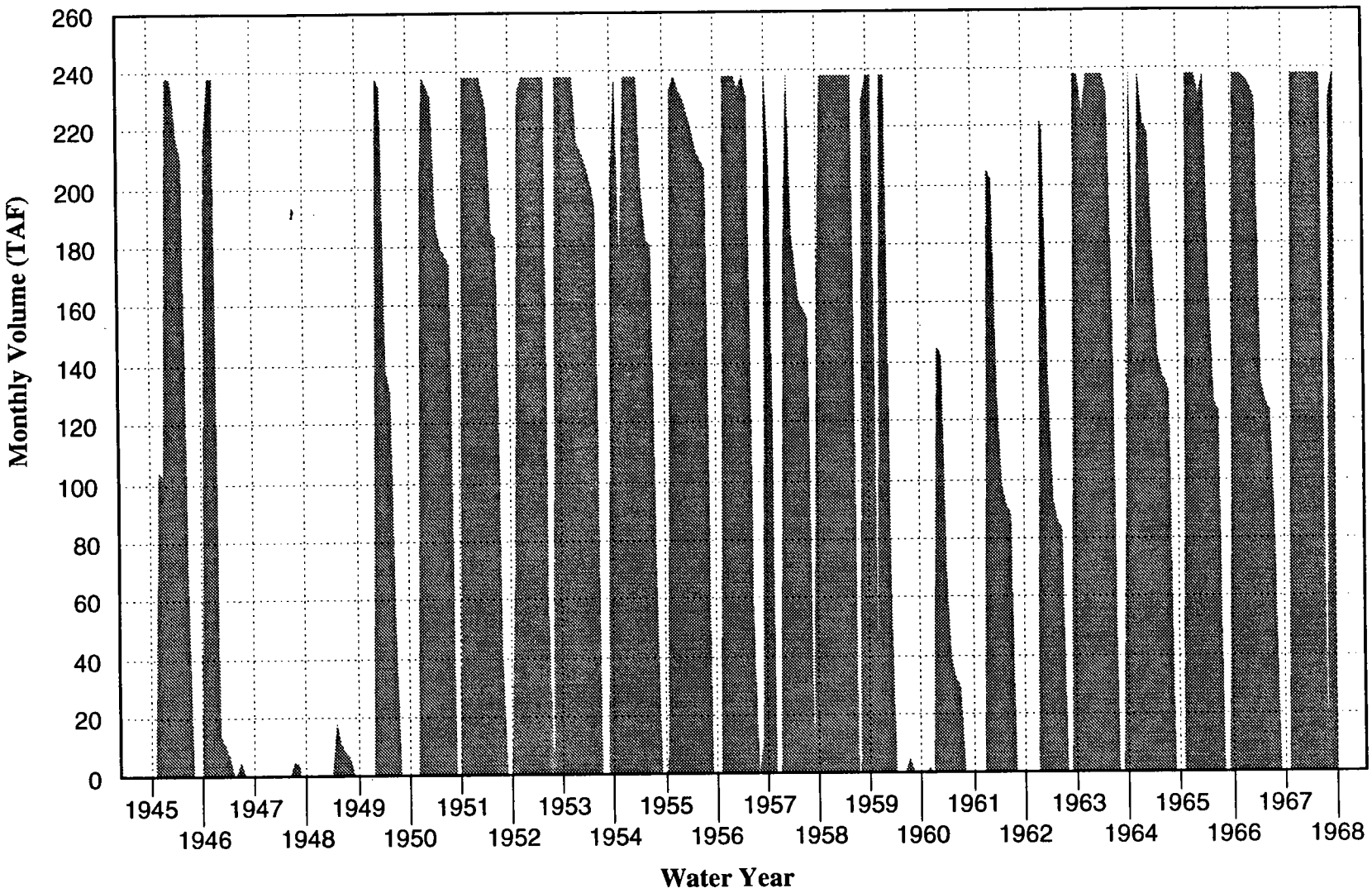

Figure A3-6B.
DeltaSOS-Simulated End-of-Month DW Storage
for 1945-1967 for Alternative 1

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

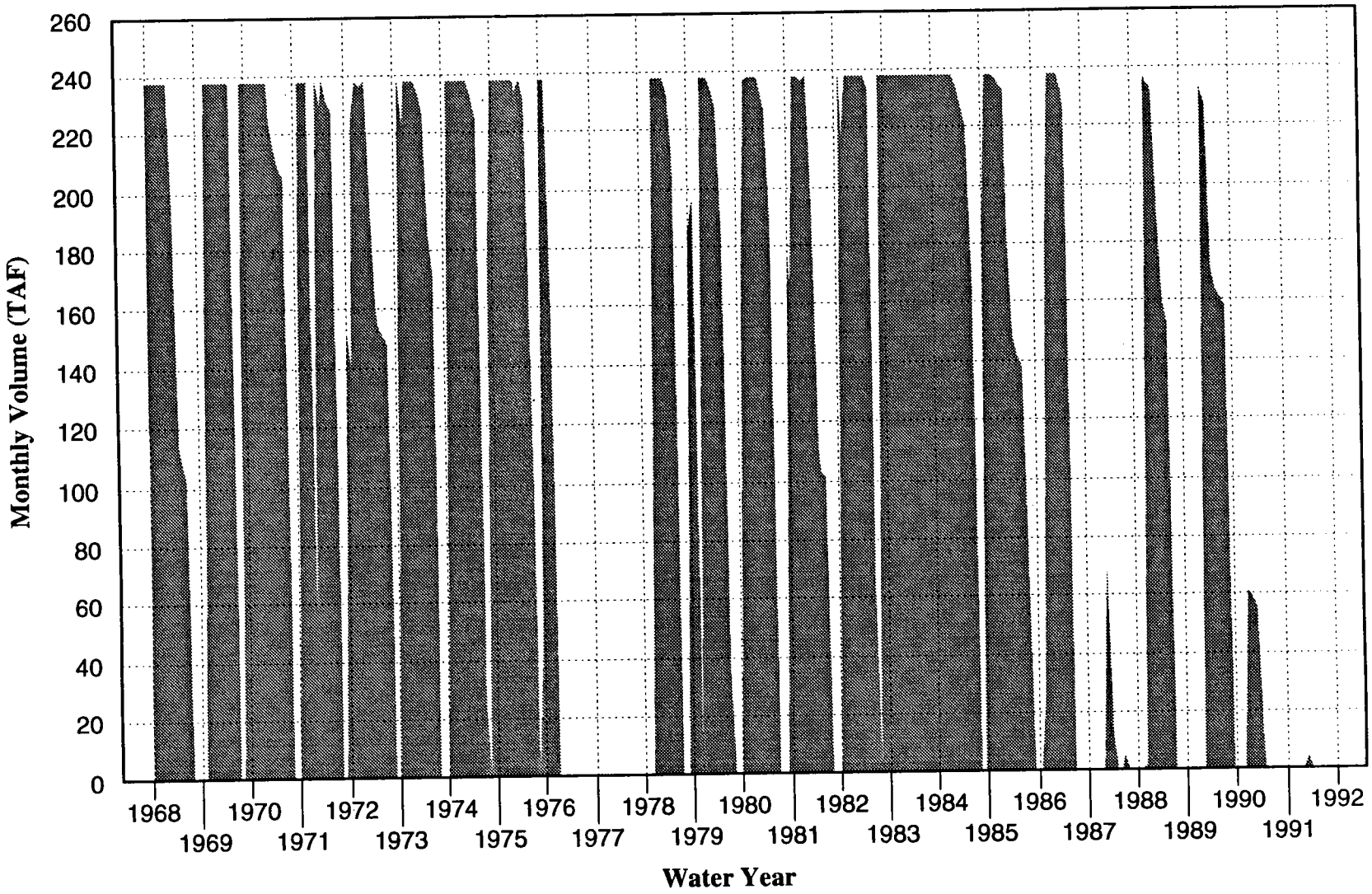

Figure A3-6C.
DeltaSOS-Simulated End-of-Month DW Storage for 1968-1991 for Alternative 1

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

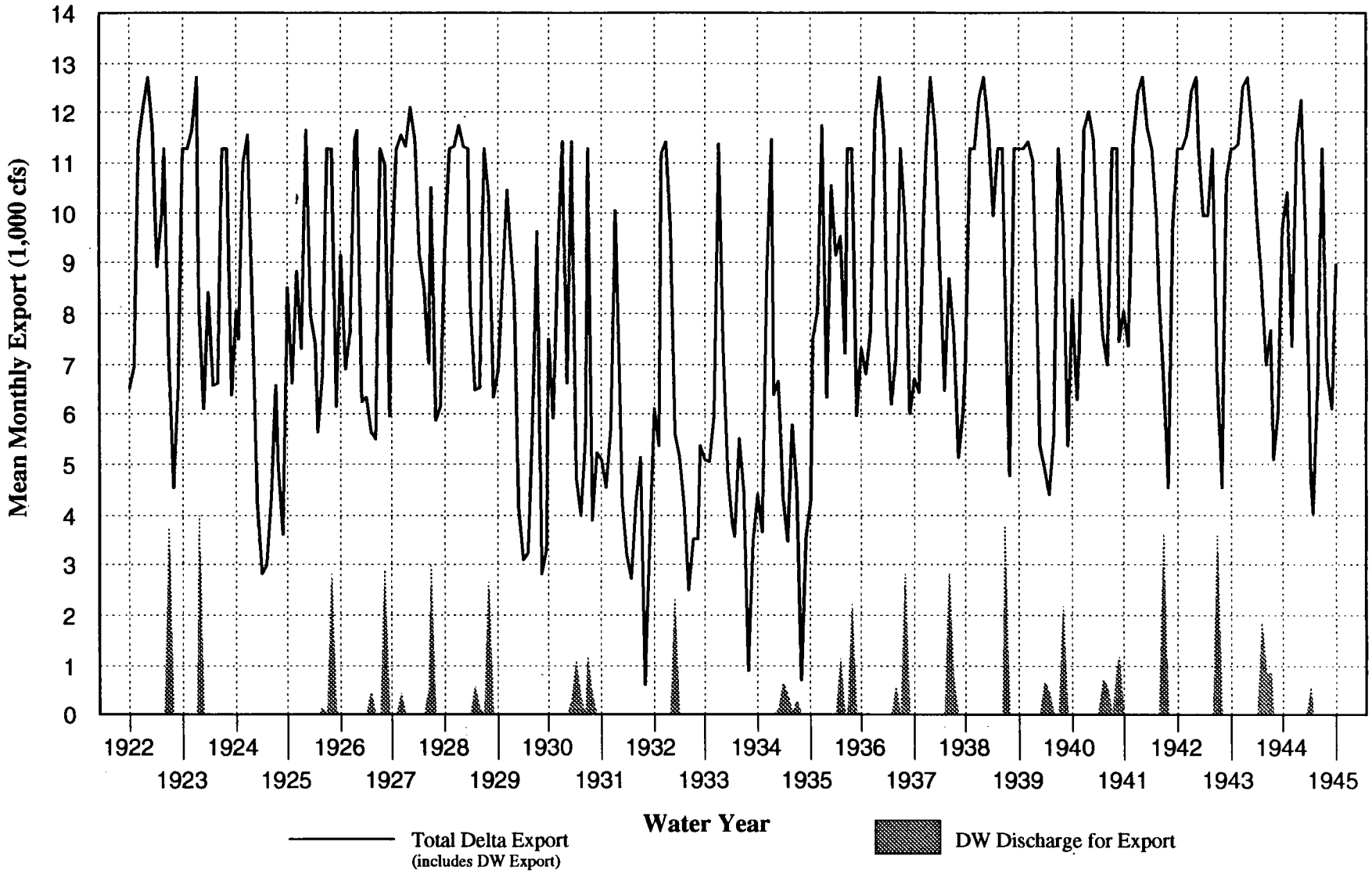

Figure A3-7A.
DeltaSOS-Simulated Mean Monthly Final Total Delta Export and DW Discharge for Export for 1922-1944 for Alternative 1

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

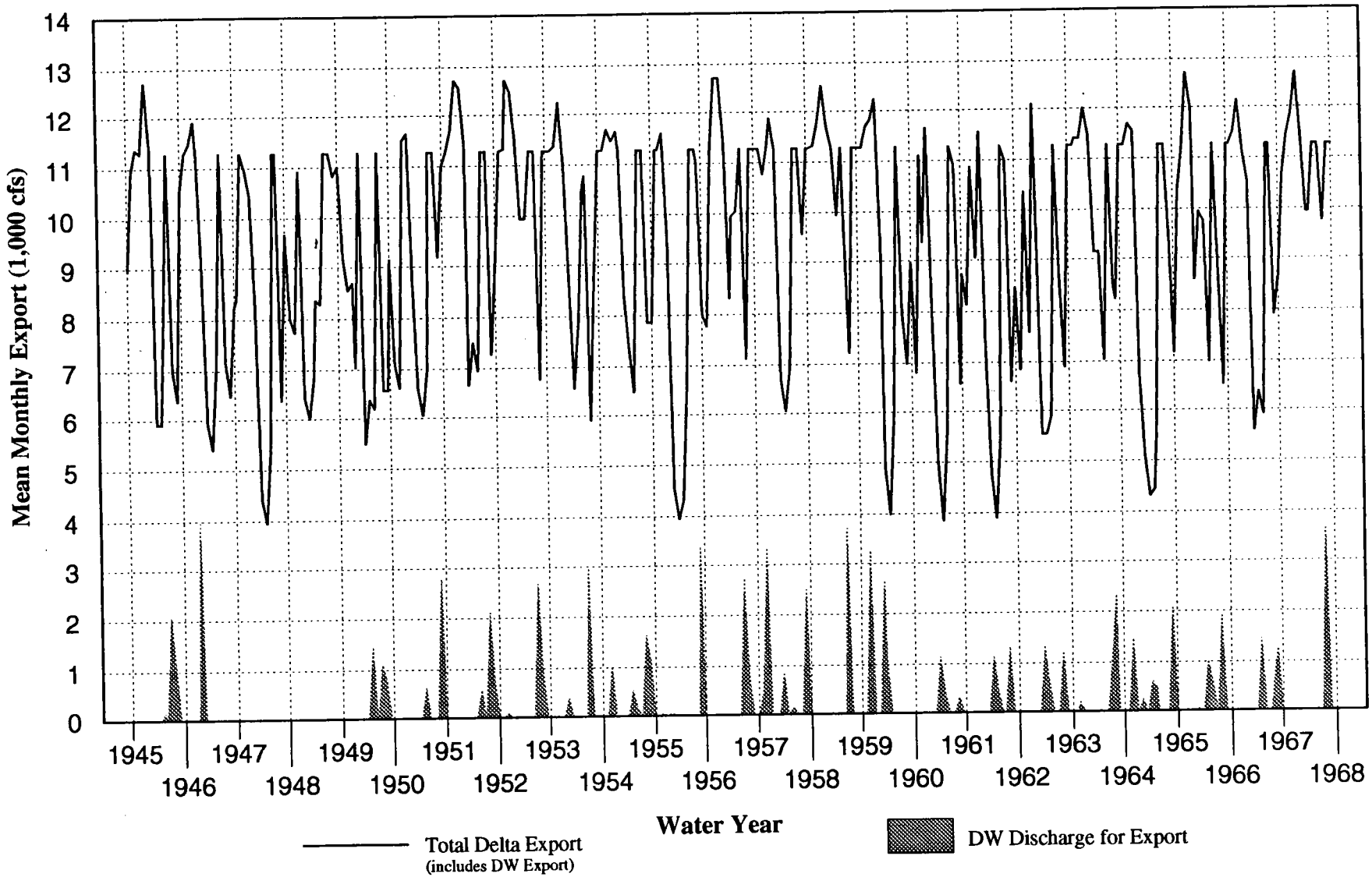

Figure A3-7B.
DeltaSOS-Simulated Mean Monthly Final Total Delta Export and DW Discharge for Export for 1945-1967 for Alternative 1

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

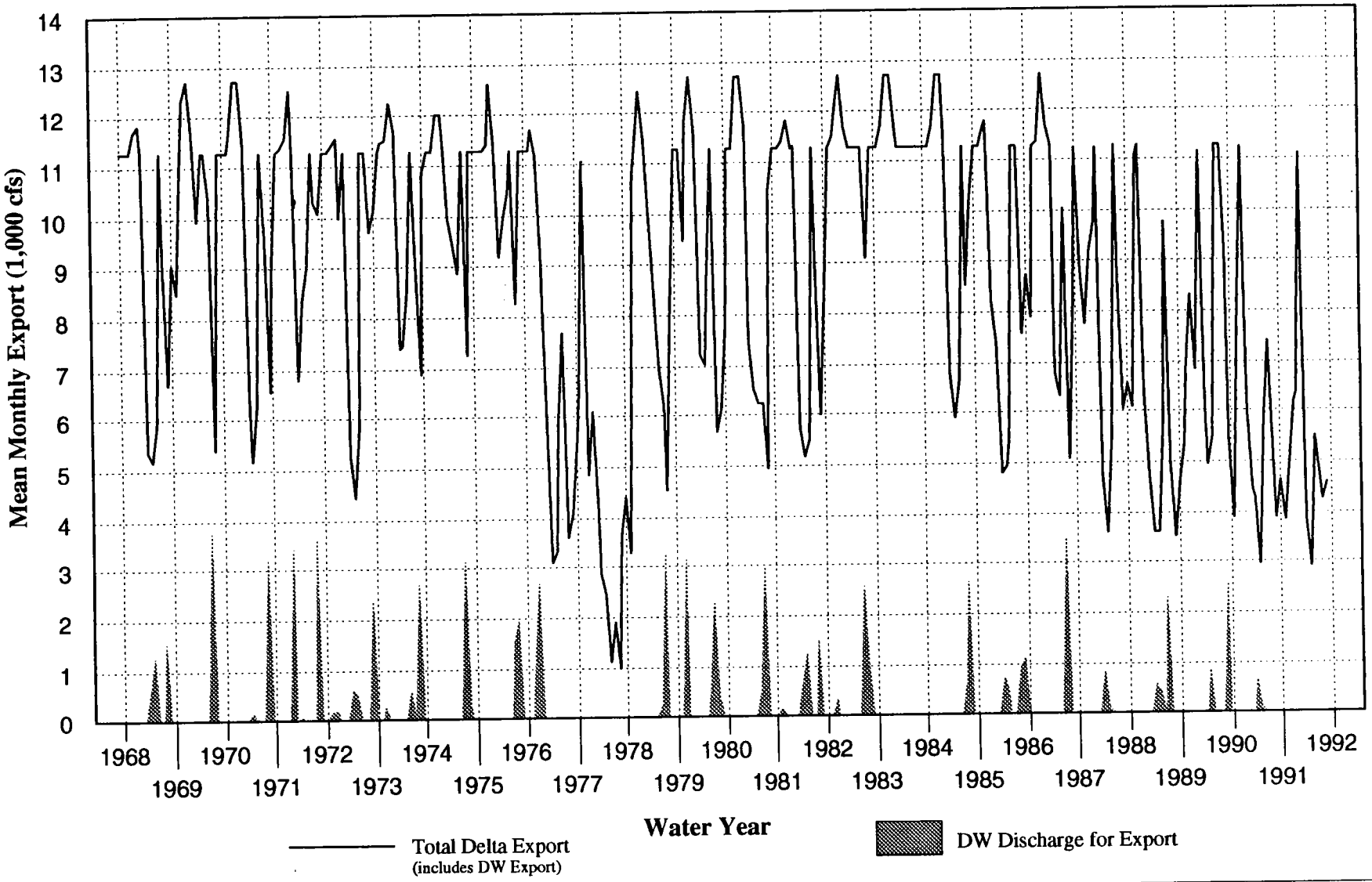

Figure A3-7C.
DeltaSOS-Simulated Mean Monthly Final Total Delta Export and DW Discharge for Export for 1968-1991 for Alternative 1

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

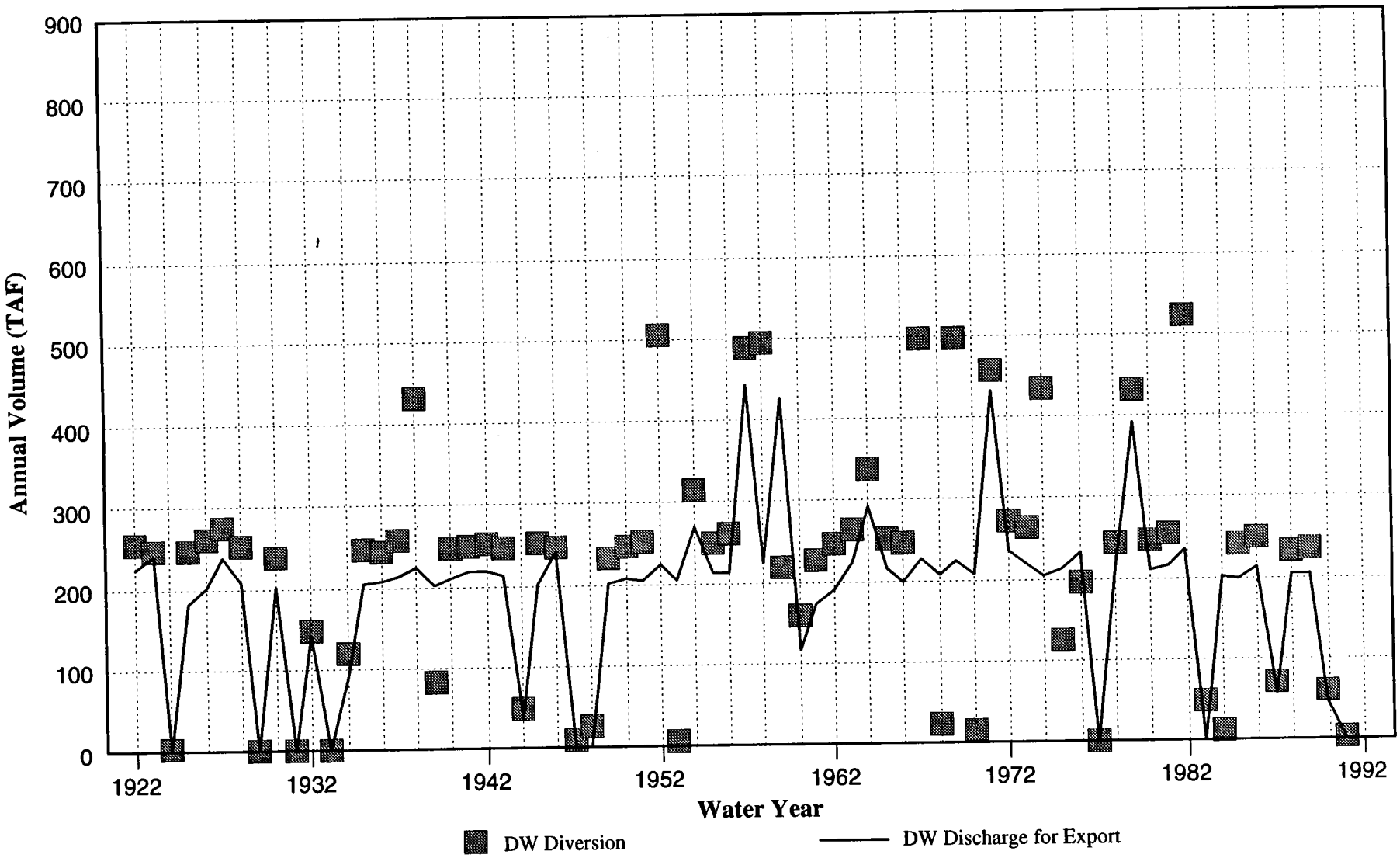

Figure A3-8.
DeltaSOS-Simulated Annual DW Diversion and DW Discharge for Export for 1922-1991 for Alternative 1

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

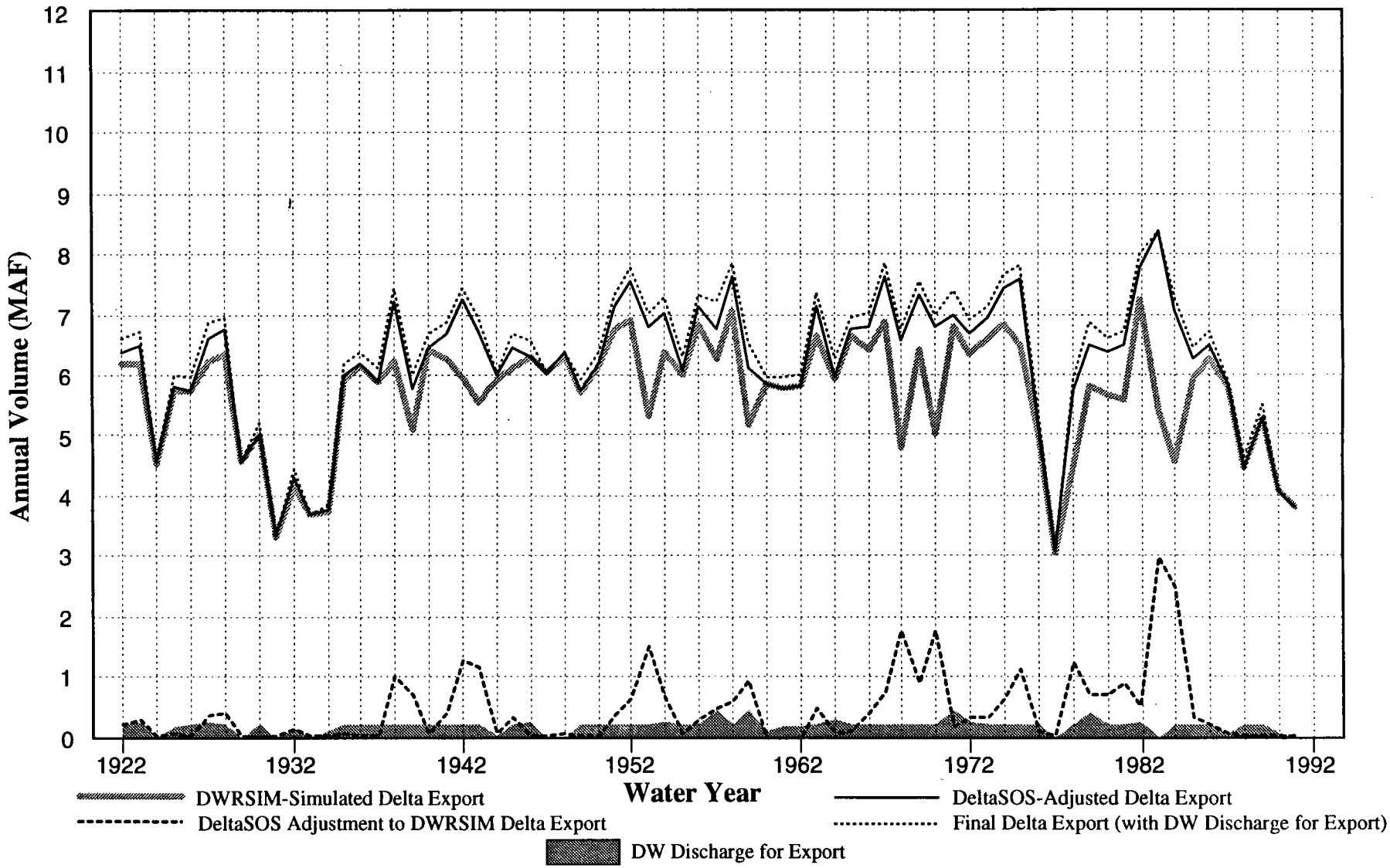

Figure A3-9.
DWRSIM-Simulated, DeltaSOS-Adjusted, and Final (with DW Discharge for Export) Annual Delta Export for 1922-1991 for Alternative 1

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

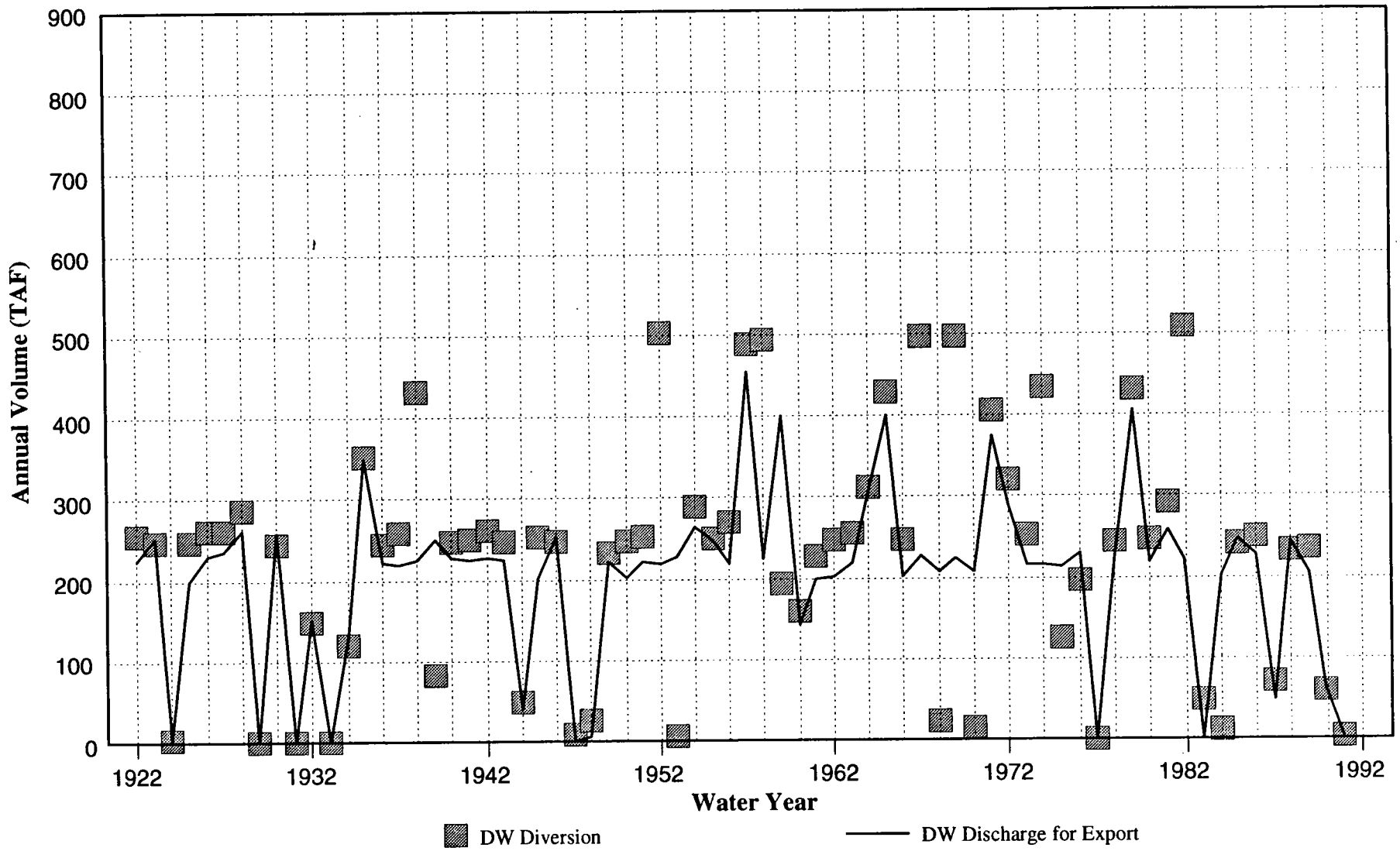

Figure A3-10.
DeltaSOS-Simulated Annual DW Diversion and DW Discharge for Export for 1922-1991 for Alternative 2

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

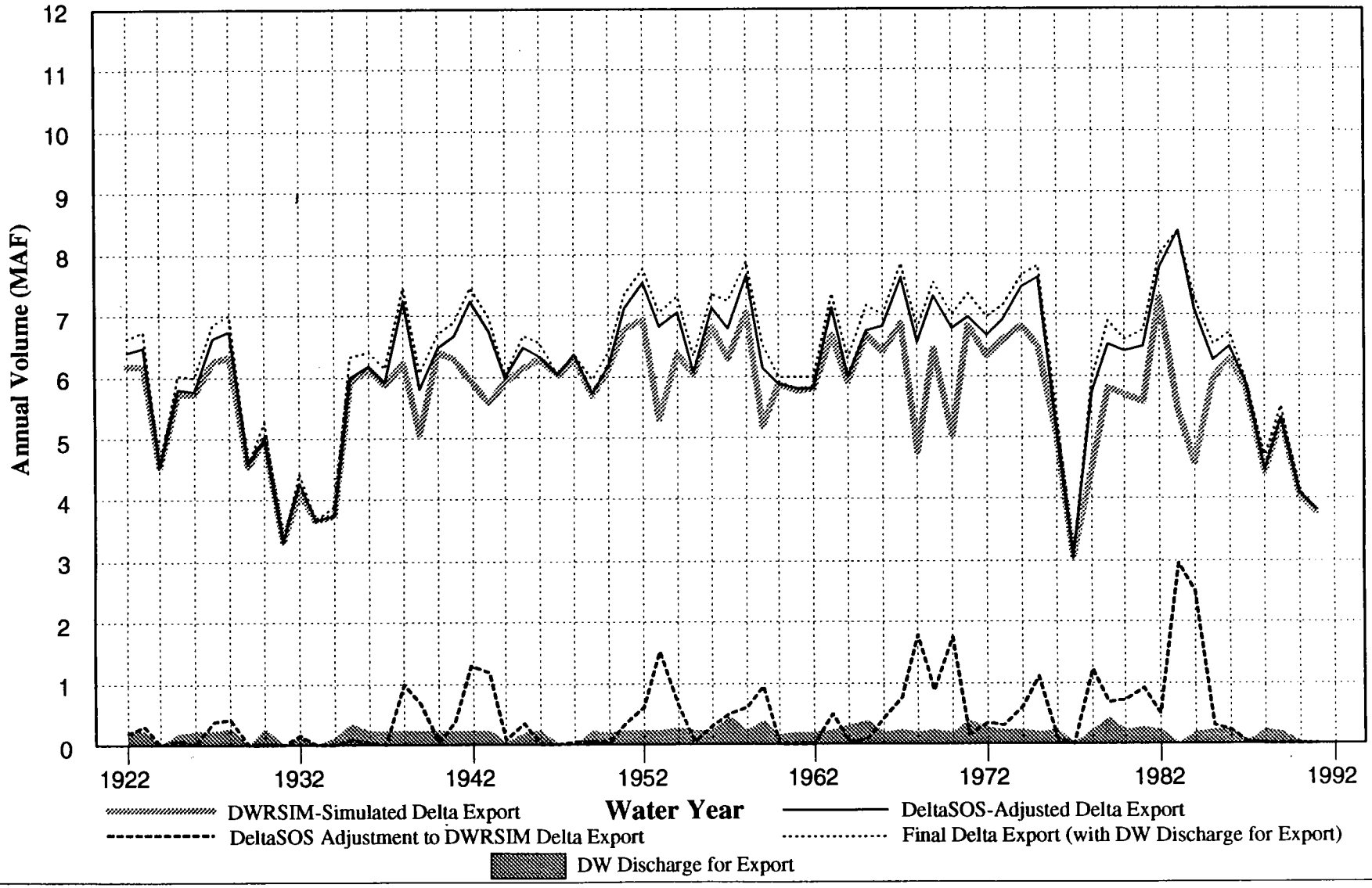

Figure A3-11.
DWRSIM-Simulated, DeltaSOS-Adjusted, and Final (with DW Discharge for Export) Annual Delta Export for 1922-1991 for Alternative 2

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

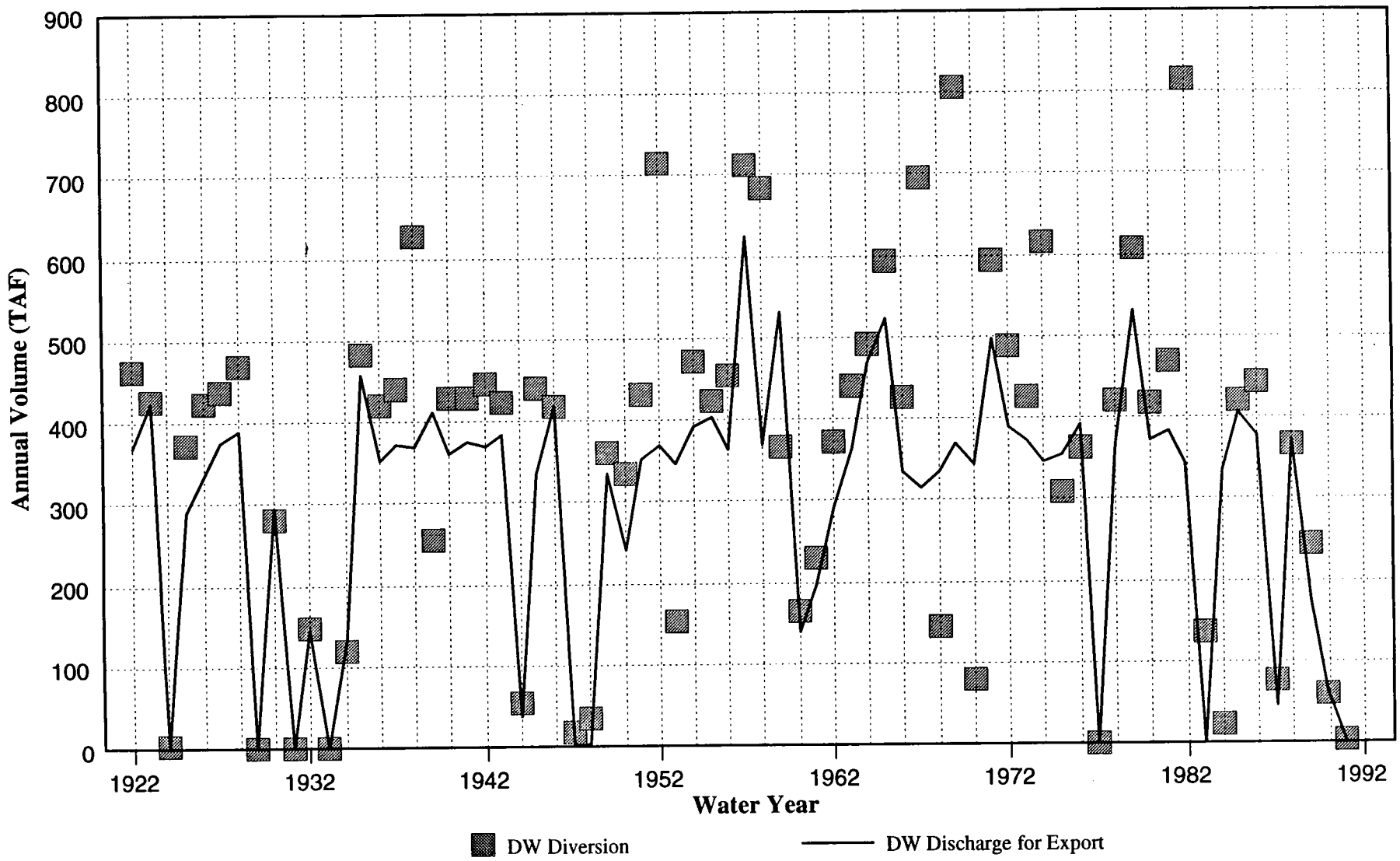

Figure A3-12.
DeltaSOS-Simulated Annual DW Diversion and DW Discharge for Export for 1922-1991 for Alternative 3

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

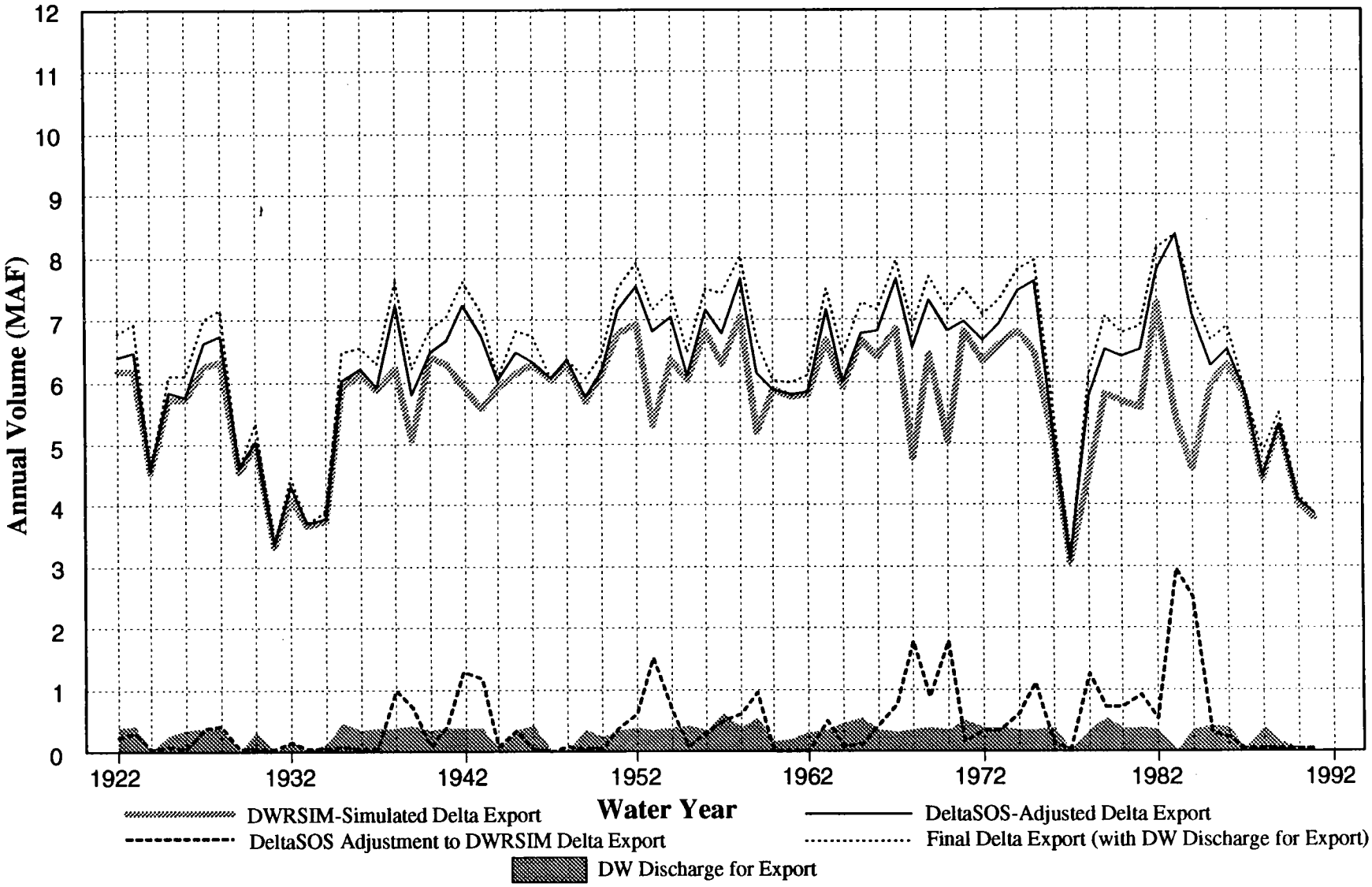

Figure A3-13.
DWRSIM-Simulated, DeltaSOS-Adjusted, and Final (with DW Discharge for Export) Annual Delta Export for 1922-1991 for Alternative 3

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

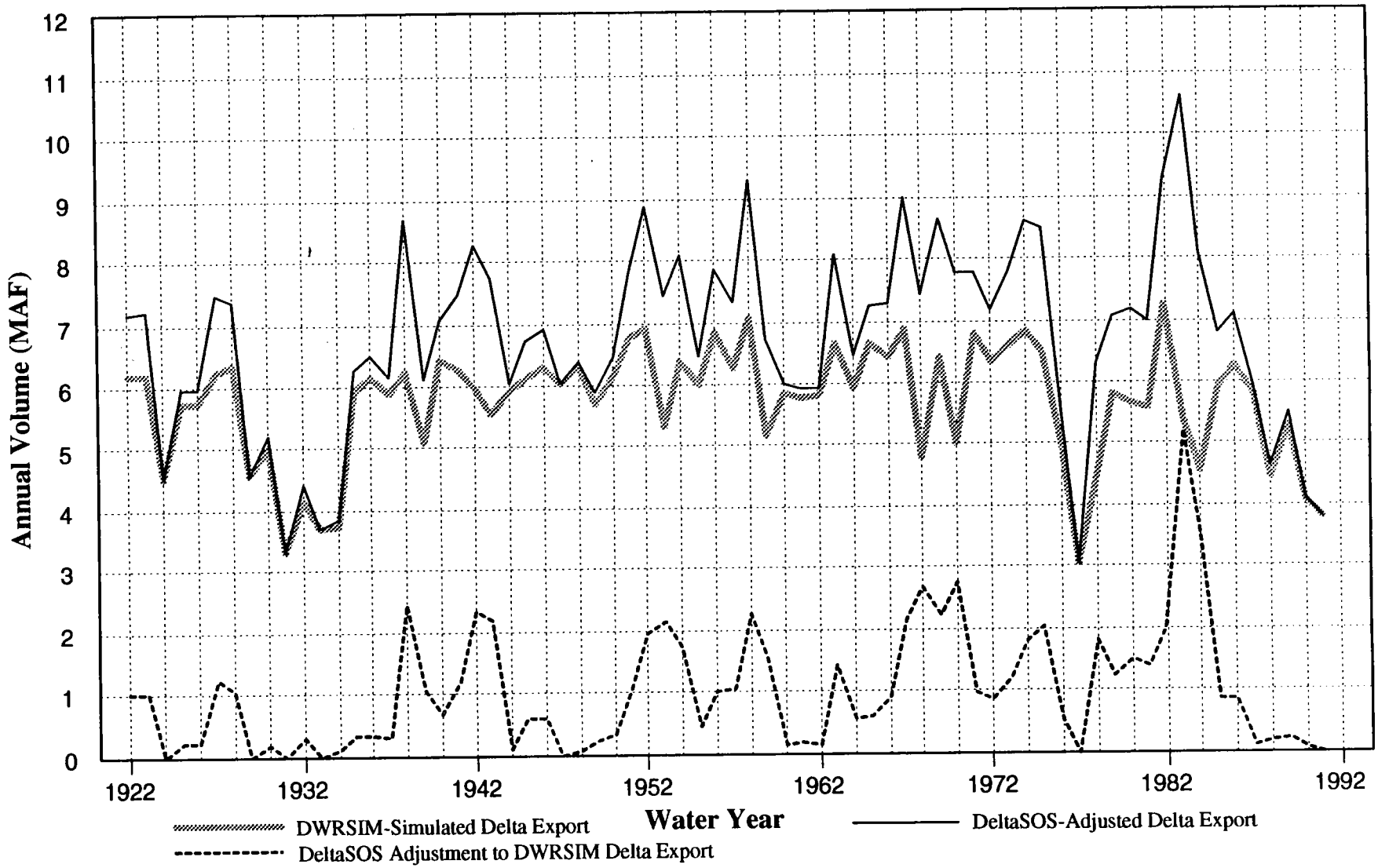

Figure A3-14.
DWRSIM-Simulated, DeltaSOS-Adjusted, and Final (with DW Discharge for Export) Annual Delta Export for 1922-1991 for the No-Project Cumulative Conditions

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

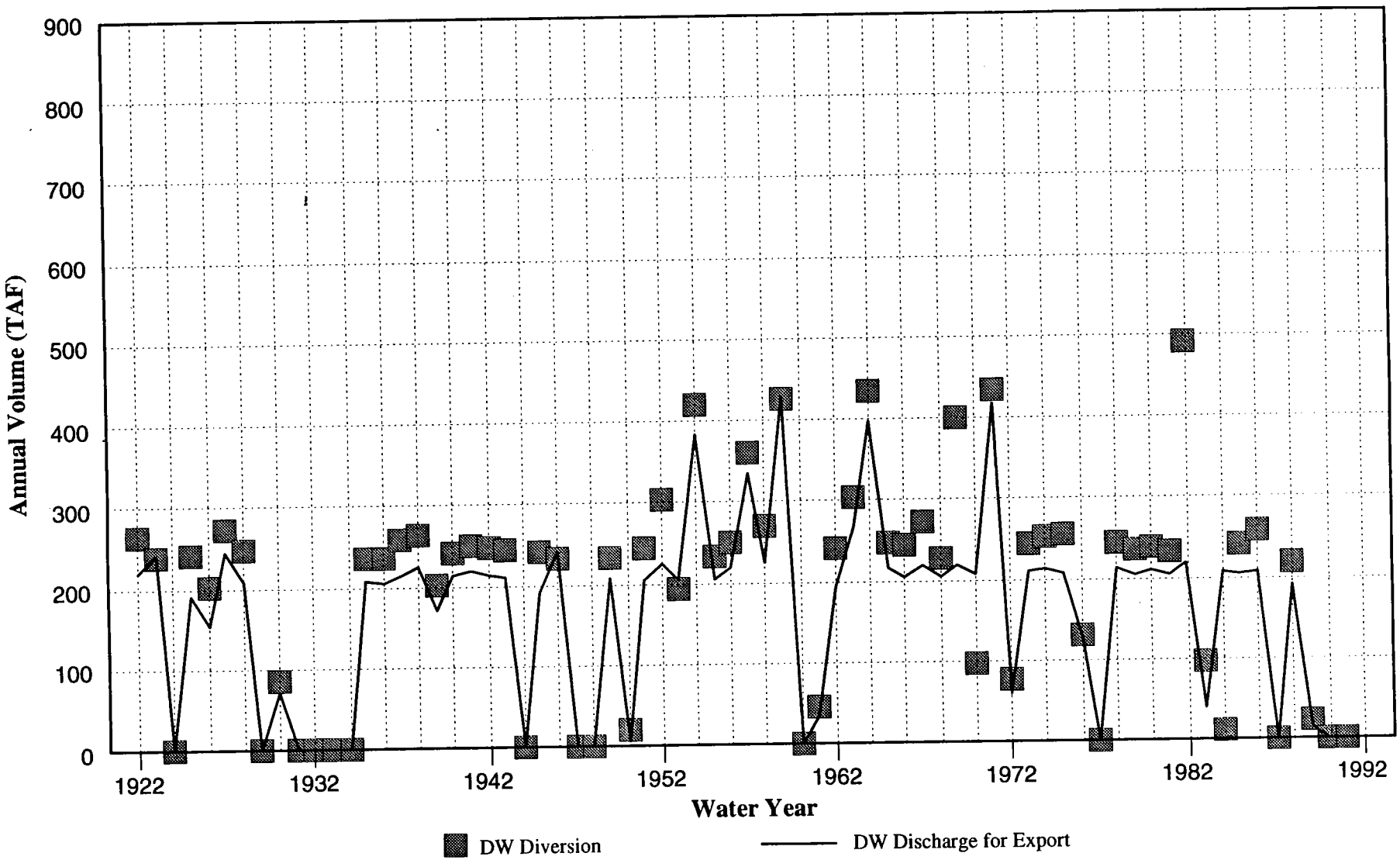

Figure A3-15.
DeltaSOS-Simulated Annual DW Diversion and DW Discharge for Export for 1922-1991 for Alternative 1 Cumulative Conditions

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

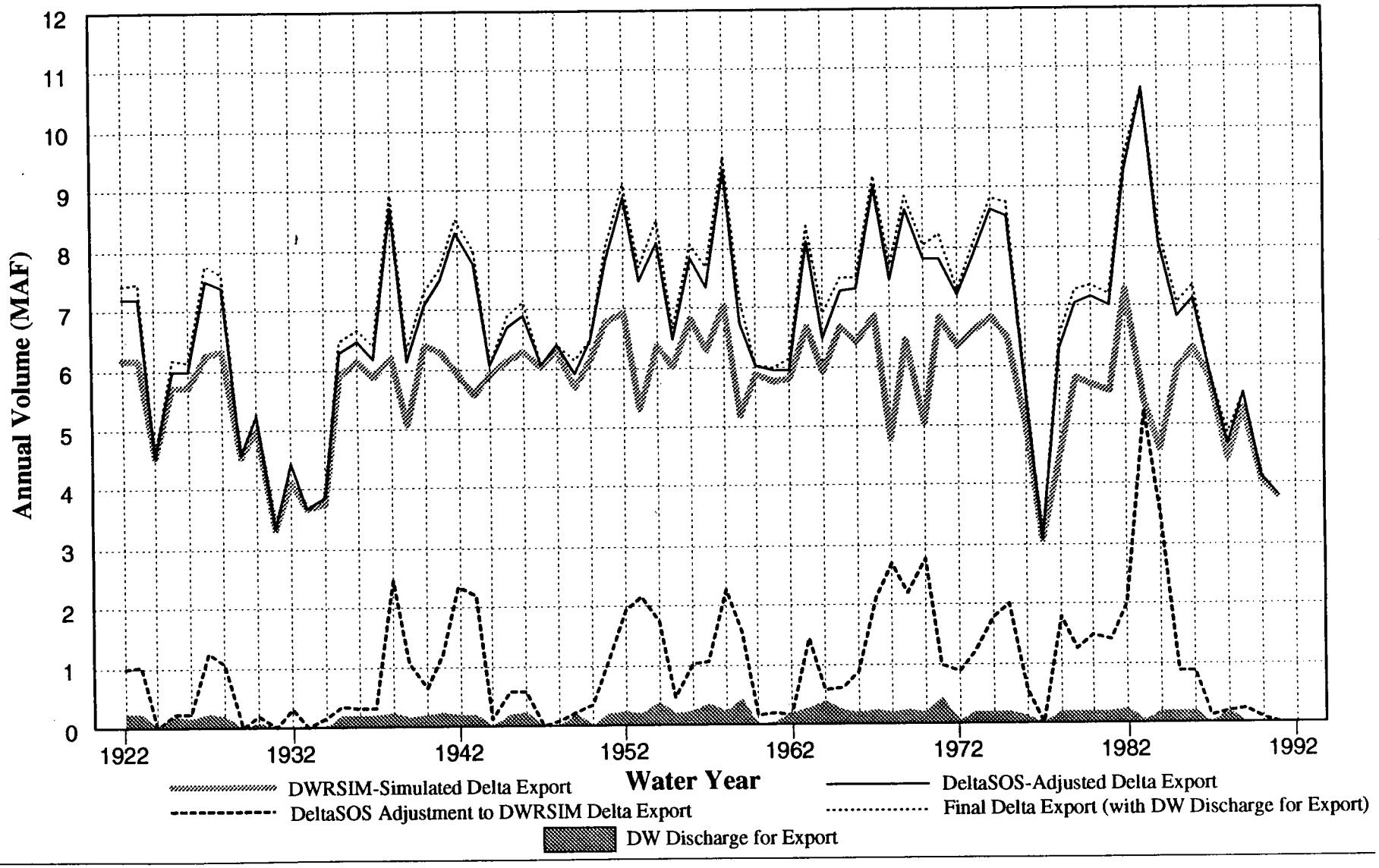

Figure A3-16.
DWRSIM-Simulated, DeltaSOS-Adjusted, and Final (with DW Discharge for Export) Annual Delta Export for 1922-1991 for Alternative 1 Cumulative Conditions

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

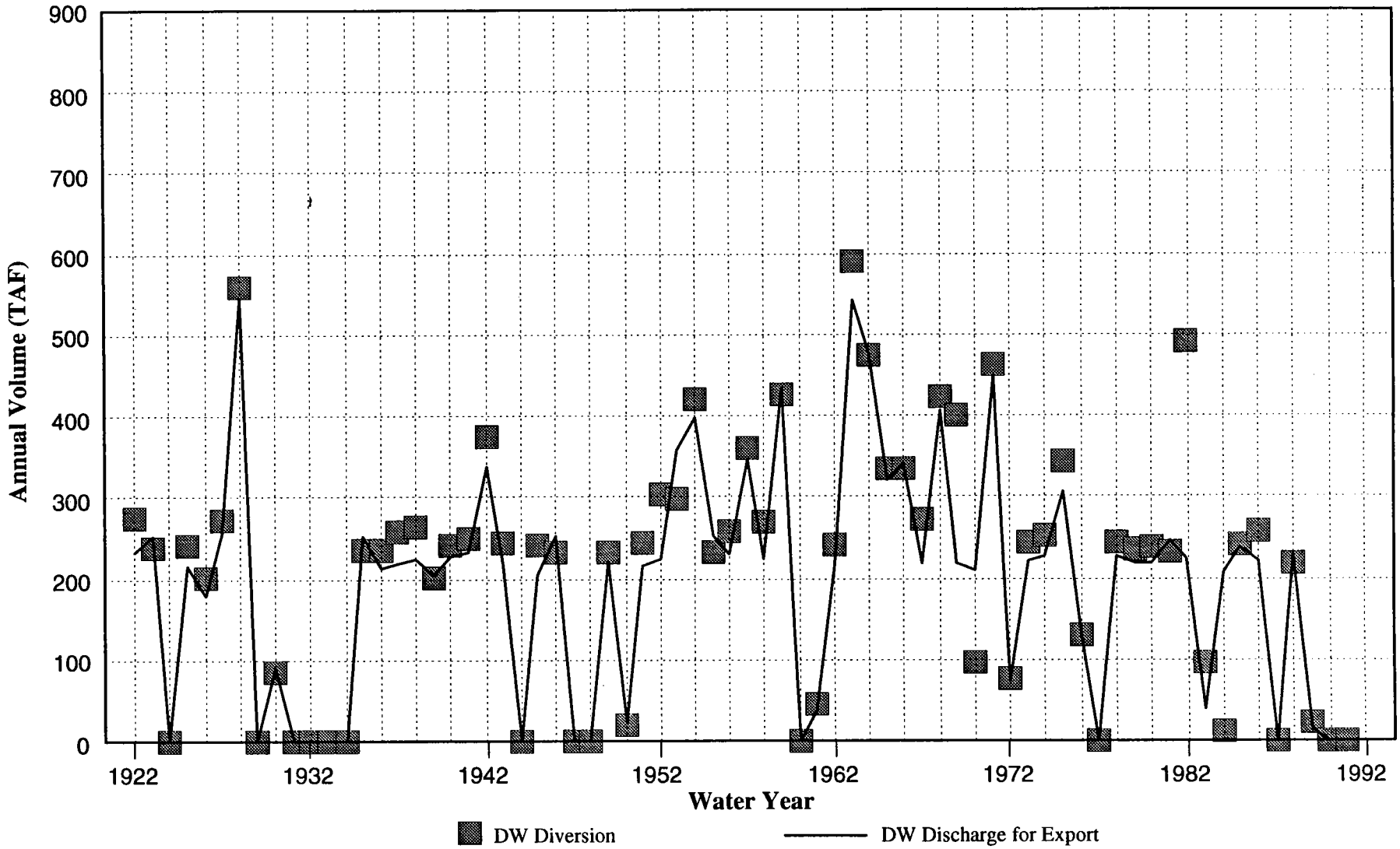

Figure A3-17.
DeltaSOS-Simulated Annual DW Diversion and DW Discharge for Export for 1922-1991 for Alternative 2 Cumulative Conditions

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

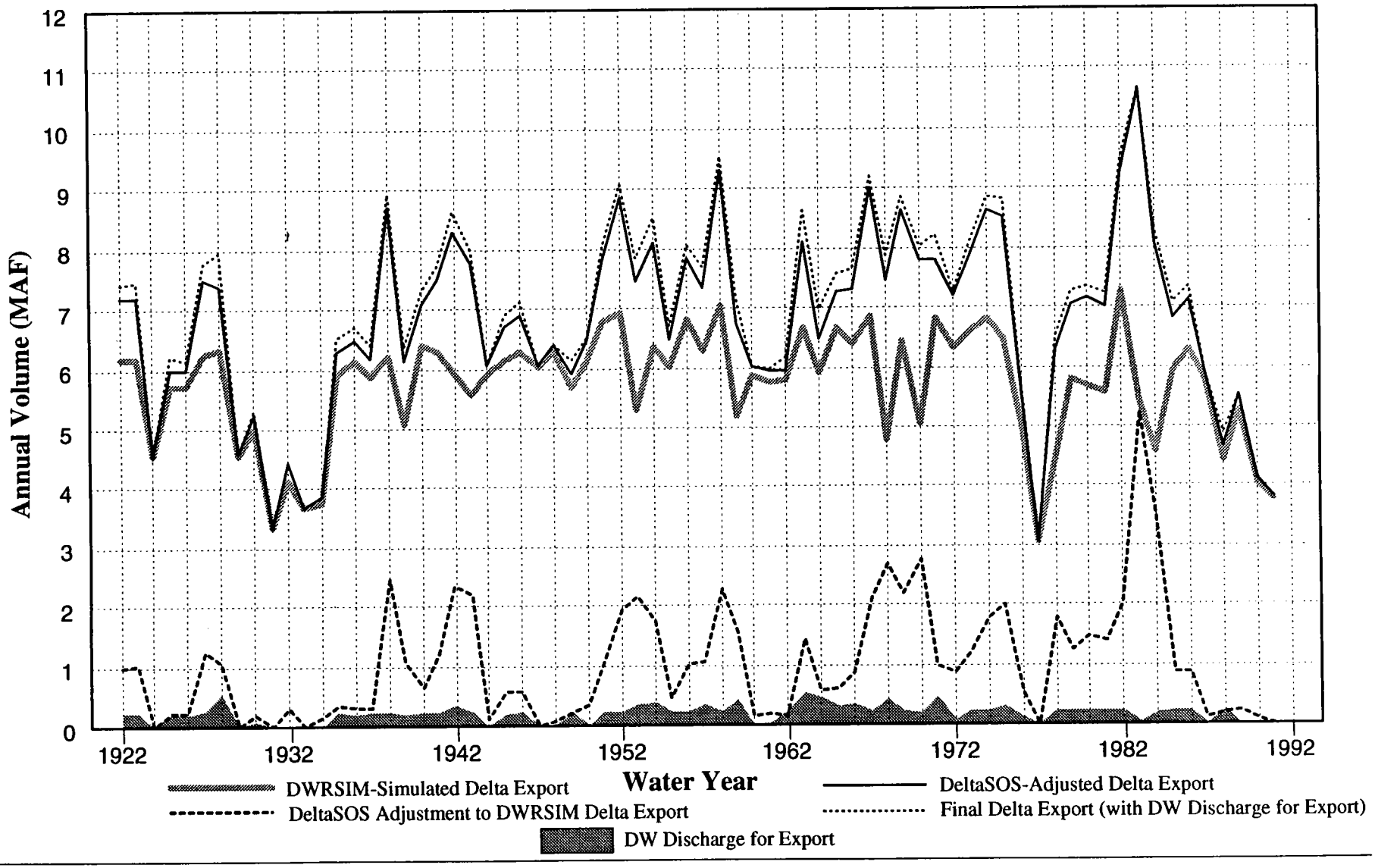

Figure A3-18.
DWRSIM-Simulated, DeltaSOS-Adjusted, and Final (with DW Discharge for Export) Annual Delta Export for 1922-1991 for Alternative 2 Cumulative Conditions

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

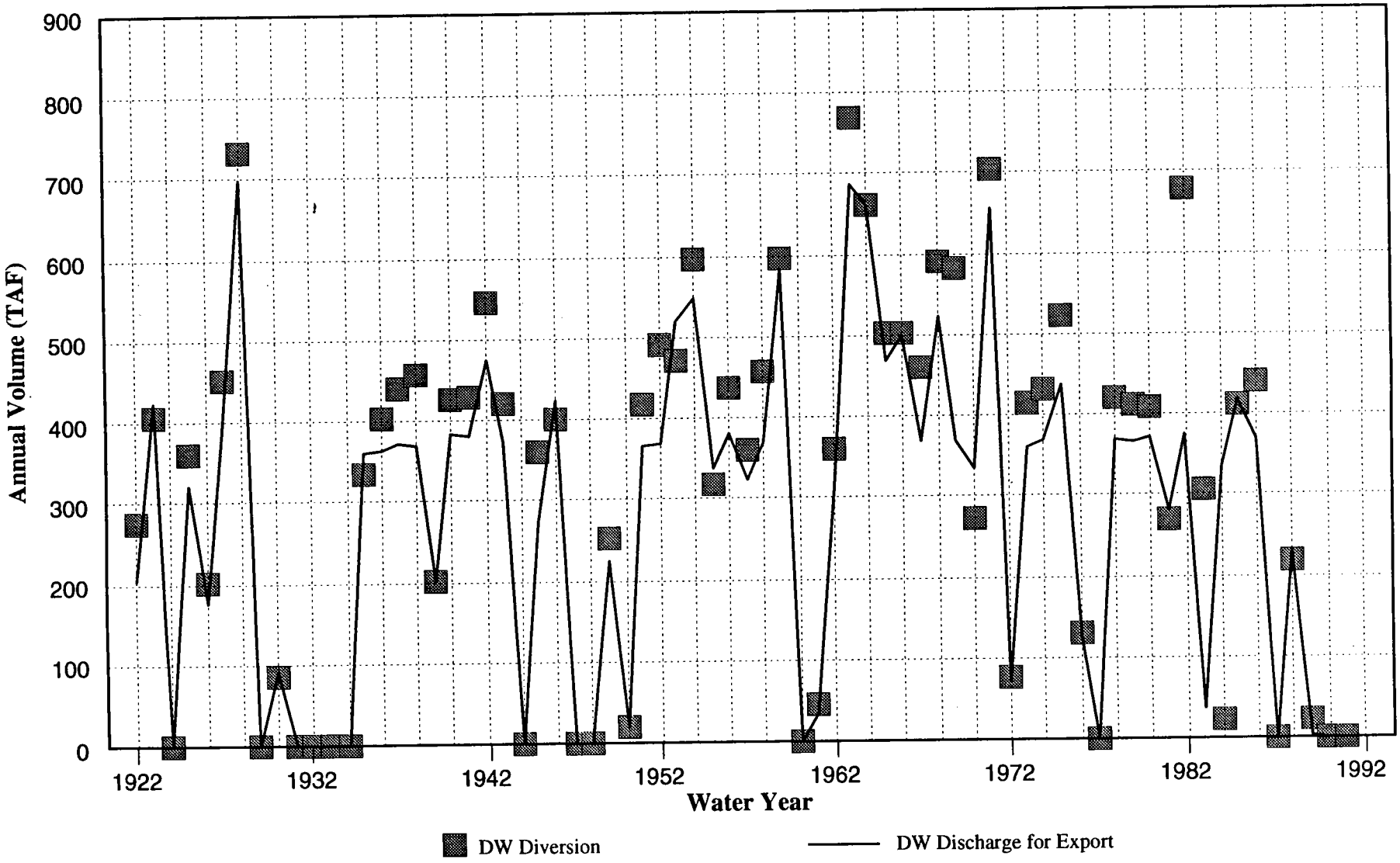

Figure A3-19.
DeltaSOS-Simulated Annual DW Diversion and DW Discharge for Export for 1922-1991 for Alternative 3 Cumulative Conditions

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

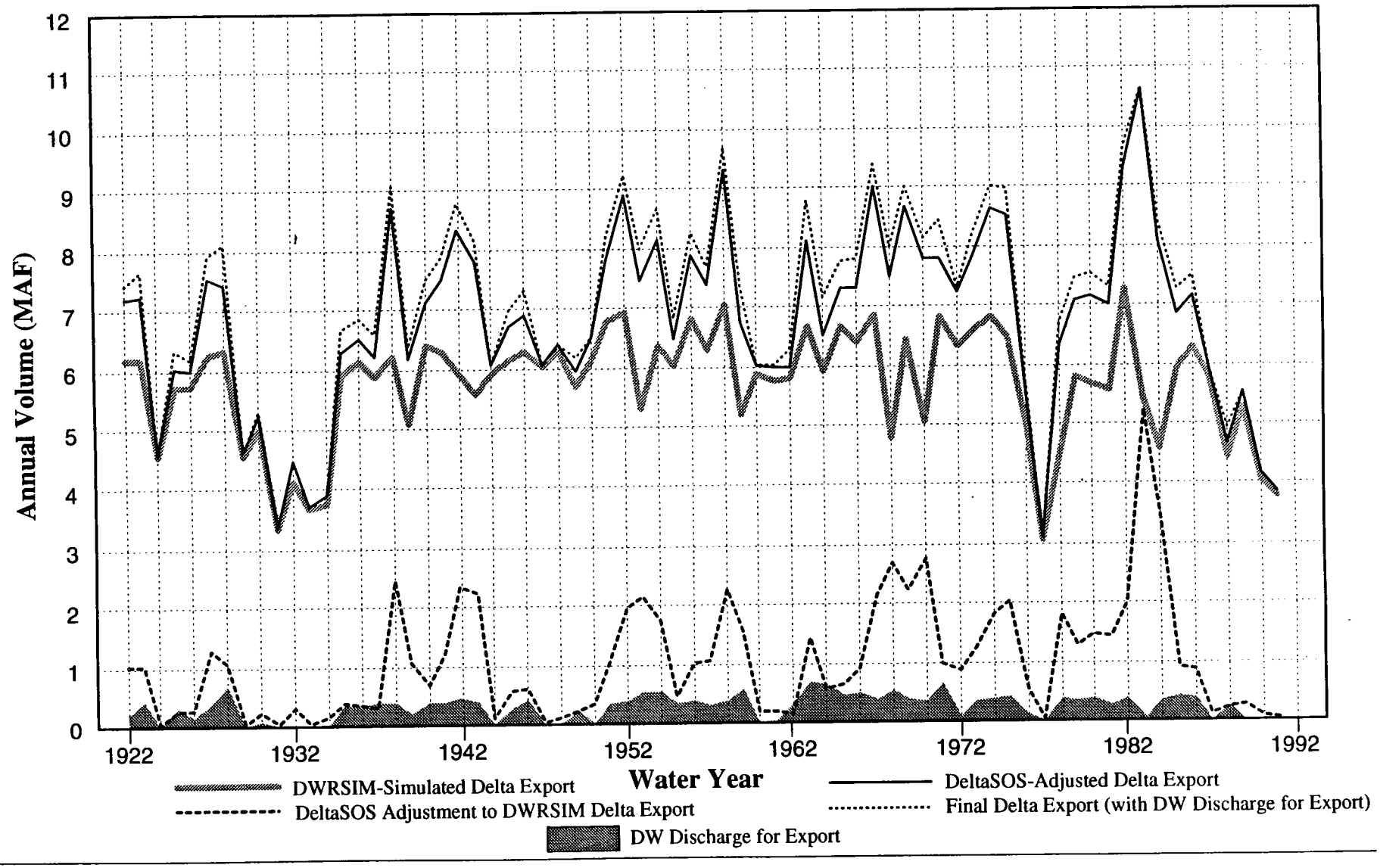

Figure A3-20.
DWRSIM-Simulated, DeltaSOS-Adjusted, and Final (with DW Discharge for Export) Annual Delta Export for 1922-1991 for Alternative 3 Cumulative Conditions

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

Appendix A4. Possible Effects of Daily Delta Conditions on Delta Wetlands Project Operations and Impact Assessments

Appendix A4. Possible Effects of Daily Delta Conditions on Delta Wetlands Project Operations and Impact Assessments

SUMMARY

This appendix evaluates how the averaging period used to simulate Delta conditions may influence estimates of the effects of Delta flows and Delta objectives on operations of the Delta Wetlands (DW) project. Results of daily simulations of Delta conditions, Central Valley Project (CVP) and State Water Project (SWP) operations, compliance with Delta objectives, and DW project operations are presented and comparison is made between these daily values and results of monthly simulations used in the DW project impact assessments.

The Delta Standards and Operations Simulation (DeltaSOS) monthly operations model was modified to simulate Delta conditions with a daily time step based on the historical hydrologic record. Results of the daily model, DailySOS, show the effects of variations in daily hydrologic conditions in the Delta. The differences between the ranges of these daily values and monthly mean values are shown, and examples of averaging-period effects on simulated CVP and SWP operations and on DW project operations are presented. The discussion concludes that impact assessments of the DW project based on monthly models of Delta conditions and CVP and SWP operations provide the basis for a reliable evaluation of major potential impacts of the project on water supply, hydrodynamics, water quality, and fishery resources. It further concludes that DW project operations should be regulated using information on actual daily Delta flow and salinity conditions, DW project operating capacities, CVP and SWP operations, and Delta objectives compliance and available water quality and fishery monitoring information.

INTRODUCTION

The principal impact assessments of the DW project presented in the environmental impact report/environmental impact statement (EIR/EIS) are based on monthly models of hydrologic, water quality, and fishery conditions in the Delta (i.e., models that use monthly average flows with a 1-month time step for simulations). The DW project would be operated, however, in response to short-term changes in hydrologic, water quality, or fishery conditions. DW project operations will be coordinated with daily operations of the CVP and SWP and will comply with all existing and future Delta water quality and fish protection requirements.

Purpose of This Appendix

The purpose of this appendix is to compare likely daily Delta conditions, daily CVP and SWP operations, daily compliance with Delta objectives, and daily DW project operations with monthly simulations of these Delta conditions, compliance with objectives, and operations used in the impact assessments of this EIR/EIS.

The results of the comparison of daily and monthly simulations of Delta conditions and DW operations will allow comparison between potential impacts of likely daily operation and monthly simulation of the DW project, facilitating evaluation of possible bias and uncertainty in the impact assessments. The description of daily Delta conditions, daily CVP and SWP operations, daily compliance with Delta objectives, and daily DW operations can be used to guide the formulation of:

- water right permit terms and conditions,

- mitigation measures that may be necessary for potentially significant water quality or fishery impacts, and
- monitoring programs that may be required for compliance or mitigation.

Daily Simulation Method

To assess the potential effects of short-term changes in Delta conditions on operations of the DW project, the monthly model DeltaSOS was modified to simulate Delta conditions with a daily time step. A description of the daily model (DailySOS) and a comparison between DeltaSOS and DailySOS model results are presented in this appendix. Potential bias (consistently higher or lower simulation results) and uncertainty in the monthly water supply, hydrodynamic, water quality, and fishery impact assessments can be approximated from the differences between the daily and monthly Delta model results.

Organization of This Appendix

This appendix includes sections on the following:

- daily DW project operations,
- daily variations in Delta conditions,
- daily CVP and SWP operations,
- daily compliance with water quality objectives and fishery protection requirements,
- possible daily monitoring and mitigation measures,
- comparison of simulated daily and monthly Delta conditions and DW operations, and
- conclusions.

DAILY DW PROJECT OPERATIONS

DW Diversion Facilities

The DW project and proposed operations are fully described in Appendix 2, "Supplemental Description of the Delta Wetlands Project Alternatives", and are summarized in Chapter 2, "Delta Wetlands Project Alternatives". Under the DW project, two new siphon stations, with 16 siphons each, would be installed on each reservoir island. Each siphon would have a diameter of 36 inches and a maximum flow capacity of about 140 cubic feet per second (cfs). Each siphon station would have a combined capacity of about 2,250 cfs. The diversion rate of DW siphons would not be constant but would be related to the amount of water already stored on the DW reservoir islands. The maximum diversion rate would be achieved when filling of a reservoir island began because the maximum head differential would exist between the channel water elevation and the reservoir water level. As the reservoir islands filled and the hydraulic head difference decreased, the siphon capacity would decline. Booster pumps would be installed in about half the siphons to maintain a diversion capacity of about 1,250 cfs for each siphon station. The booster pumps will allow the islands to be filled to approximately 6 feet above mean sea level.

Fish screens would be installed around the intake end of each existing and new siphon pipe. The screens will be designed and operated to prevent entrainment and impingement of most adult and juvenile fish that are present in the Delta. The proposed design would consist of a barrel-type screen with a maximum approach velocity of less than 0.33 feet per second (fps). The anticipated hydraulic operation of the siphon stations to fill the reservoir islands is further described in Chapter 3B, "Hydrodynamics".

The combined siphon capacity on two reservoir islands (four siphon stations) would be approximately 9,000 cfs, and the average daily maximum diversion rate will be limited to 9,000 cfs. The diversion rate would reach this maximum during the first week of filling and would decline to less than 5,000 cfs as the reservoir islands were filled. The actual daily diversion rate will depend on the reservoir storage and the number of booster pumps that are used at each siphon station, as well as the availability of water for DW diversion.

Conditions Required for DW Diversions

The DW project would divert water to storage under appropriative water rights. The project permits, if granted by the California State Water Resources Control Board (SWRCB), would contain terms and conditions to protect prior riparian and appropriative water right holders and the public trust. All existing and any future Delta water quality objectives would apply to the project. The project permits may require that project operations, including those of the existing SWP and CVP Delta facilities, fully comply with any applicable conditions in biological opinions or allowable "take limits" for threatened or endangered species.

It is expected that the DW project diversions to storage would not be permitted to interfere with the diversion and use of water by other users holding riparian or prior appropriative rights. Although most riparian and senior appropriative water right holders are located upstream of the Delta in the Sacramento River or San Joaquin River basins, a large number of riparian and appropriative water right holders divert water from Delta locations. The CVP and SWP, as well as Contra Costa Water District (CCWD) and several smaller diverters, also hold senior appropriative water rights. The DW project would not interfere with diversions by these prior water right holders.

Actual operation of the DW project would necessarily be conducted on a daily basis. The California Department of Water Resources (DWR) Division of Operations and Maintenance and the U.S. Bureau of Reclamation (Reclamation) Central Valley Operations Coordinating Office (CVOCO) maintain daily water budget estimates for the Delta and designate whether Delta conditions each day are either "in balance" or "in excess" relative to all SWRCB objectives and water right terms and conditions. When the Delta is designated by DWR and CVOCO (with possible review by the CALFED Operations Group) to be "in balance", all Delta inflow is determined to be required to meet Delta objectives and satisfy diversions by CCWD, CVP, SWP, other senior water right holders, and Delta riparian users. No additional water would be available for diversion by the DW project when the Delta is "in balance".

When the DWR Division of Operations and Maintenance and CVOCO determine that the Delta is "in excess", some water could be available to be diverted for storage on the DW project reservoir islands. DWR and CVOCO would estimate the daily quantity of available excess water according to their normal accounting procedures. However, these procedures must be approved by SWRCB, which has the final water allocation authority. Additional rules to govern allowable DW diversions would be provided by SWRCB in terms and conditions in water right permits.

Delta conditions are currently governed by the SWRCB 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (1995 WQCP). One of the 1995 WQCP objectives limits maximum allowable SWP and CVP export diversions to a specified percentage of the total Delta inflows. This specified percentage of total inflow may control the allowable exports and may determine when the Delta is designated by DWR and CVOCO to be "in balance" or "in excess". The Delta inflows would be "in excess" only if the allowable exports, as a specified percentage of Delta inflows, exceeded the SWP and CVP permitted pumping capacity. For example, with a permitted CVP and SWP combined rate of 11,280 cfs and a 35%-of-inflow export limit, Delta inflows would be "in excess" only if they were greater than 32,228 cfs (11,280/0.35).

Diversions under all the DW project alternatives are assumed in the impact analyses to be governed by the 1995 WQCP "percentage of total inflow" (percent inflow) objective for export diversions (see Chapter 3A, "Water Supply and Water Project Operations", and Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives", for additional discussion of this assumption). Therefore, DW diversions would only occur when the amount of allowable diversions (as a percentage of total inflow) was greater than the permitted maximum CVP and SWP pumping capacity.

SWRCB may establish DW requirements for various "buffers" to further protect Delta standards and existing water right holders. A buffer would be a volume of Delta water exceeding the "in excess" threshold but which would not be available for diversion to the DW reservoirs. During major runoff events, considerable "excess" Delta inflow could be available above the specified "buffer" amounts for diversion by the proposed DW project.

DW Discharge Facilities

One discharge pump station would be located on each reservoir island. The pump stations would consist of 32 new pumps (on Webb Tract) or 40 new pumps (on Bacon Island) with 36-inch-diameter pipes discharging

to adjacent Delta channels. An assortment of axial-flow and mixed-flow pumps would be used to accommodate the variety of head conditions during drawdown of the reservoir storage islands. Actual rate of discharge by each pump would vary according to each pool's remaining elevation. The maximum daily average discharge rate would be about 4,000 cfs for Bacon Island and 3,000 cfs for Webb Tract, and the maximum combined daily average discharge rate would be 7,000 cfs. The pump stations are more fully described in Appendix 2 and are summarized in Chapter 2.

Conditions Required for DW Discharges

The DW project could discharge water to Delta channels at any time when DW storage water was available for beneficial uses. Potential beneficial uses for DW storage water include Delta flows to maintain salinity control or estuarine habitat, Delta flows to provide fish transport management, and Delta diversions for water supply needs (1995 WQCP objectives).

Water supply diversions of discharged DW storage water could occur at any existing Delta diversion location, but discharged DW water is most likely to be exported at either the CVP Tracy Pumping Plant or the SWP Banks Pumping Plant. (Use of these facilities to pump and convey water for another party is often called "wheeling".)

Pumping, conveyance, and storage of water in CVP or SWP facilities allows water transfers and exchanges of various kinds. The SWP and CVP routinely wheel water for each other to improve the efficiency of their operations. DW storage water that is exported from the Delta will require pumping and conveyance in CVP or SWP facilities to the designated purchaser of DW storage water (if it is not purchased directly by the CVP or SWP). There may be some opportunity to temporarily bank water or store water transfers from another water district or agency on the DW islands until unused pumping capacity becomes available. Diversions and discharges for this potential transfer "parking" arrangement are not considered here. Delivery of purchased DW water or of water temporarily stored on the DW islands may be subject to further environmental review.

Discharges of DW storage water for export can only be accomplished if there is available pumping capacity at the CVP Tracy or SWP Banks Pumping Plant; available conveyance in the Delta-Mendota Canal (DMC) or the California Aqueduct; and if needed, available pumping capacity at Edmonston pumping plant (to the southern California SWP) or storage in San Luis Reservoir or other storage facilities. Available pumping capacity may be limited by physical capacity or operating restrictions. The two most important existing restrictions are the U.S. Army Corps of Engineers (Corps) permit for operating the SWP Banks Pumping Plant and the SWRCB pumping restrictions for the CVP and SWP specified in the 1995 WQCP. The 1995 WQCP designates the "operations group" to be responsible for recommending changes in daily export pumping rates to provide additional fishery protection. DW operations will likely also be subject to "operation group" recommendations and may be utilized to provide adaptive management of Delta fisheries and water supply. These restrictions are described in Chapter 3A, "Water Supply and Water Project Operations". SWRCB retains final authority for water allocation rules.

The daily unused pumping capacity will fluctuate as Delta conditions change and CVP and SWP operations change correspondingly. The daily rates of DW discharge for export will therefore fluctuate considerably more than the monthly average rates of DW discharge for export. The daily rate of DW discharge for export would be limited by the maximum daily average DW discharge capacity of about 6,000 cfs.

Possible DW Discharges under 1995 WQCP Export Limits

The 1995 WQCP does not specifically describe operating conditions for DW project discharges for export at the SWP or CVP pumping plants. DW discharge operations might be controlled in various ways to be compatible with the1995 WQCP objectives and to protect senior water right holders and the public trust. This EIR/EIS evaluates two alternatives for controlling DW project discharges, as described in Chapter 3A and Appendix A3.

Under Alternative 1, it is assumed that DW discharges are considered to be additional Delta inflow but that SWP and CVP export pumping of any DW discharge water must remain within the specified percentage of total inflow. Opportunities for DW discharges and exports would exist whenever the SWP and CVP pumping is limited by Delta outflow requirements. In this case there may be unused pumping capacity within the specified percent inflow limits.

Under Alternative 2, it is assumed that DW diversions are controlled by the specified percent inflow limits, but that DW discharges for export are not controlled by the percent inflow limits. DW discharges for export pumping would be allowed whenever there was unused permitted capacity at the CVP or SWP pumping plants. Opportunities for DW discharges and exports would exist whenever the SWP and CVP pumping was limited by Delta outflow requirements or whenever the SWP and CVP pumping was limited by the specified percent inflow limits. In this case there may be considerably more days with unused pumping capacity that could be used for exports of DW discharges.

Because Delta inflows may fluctuate considerably within a month, the allowable export pumping as a specified percentage of inflow or as controlled by outflow requirements may change significantly from day to day within a month. The possible effects of these daily variations in Delta inflows on CVP and SWP pumping and on allowable DW project diversions and discharges are described and evaluated in the following sections of this appendix.

DAILY VARIATIONS IN DELTA CONDITIONS

There are three major categories of changes in Delta conditions:

- hydrologic changes associated with inflows, rainfall, and tidal effects;
- water quality changes resulting from inflows, salinity intrusion, temperature variations, and phytoplankton growth; and
- fishery changes resulting from migration, spawning, transport, growth, mortality, and entrainment processes.

Hydrologic changes directly affect the operations of the SWP and CVP Delta facilities (gates and pumps). Water quality changes may influence CVP and SWP operations necessary for compliance with applicable water quality objectives. Fishery variations have generally not influenced CVP or SWP operations, except recently when operations have reponded to endangered species incidental take limits for winter-run chinook salmon and delta smelt.

Because available data describe the patterns of hydrologic variables more accurately than they describe patterns of water quality or fishery conditions, the effects of daily hydrologic variations on CVP and SWP operations will be used to generally evaluate likely effects of daily variations in water quality and fishery conditions.

Daily Hydrologic Variations

The relative magnitudes of short-term fluctuations in flow were evaluated through comparison of daily and monthly average Delta flows. Daily inflow measurements and outflow estimates for water years 1967-1991 were obtained from DWR's DAYFLOW database, which is described in DWR (1986).

Monthly Maximum and Minimum Flows

Figure A4-1 shows the monthly range between minimum and maximum daily values for Sacramento River inflow for each month of water years 1967-1991. Figure A4-2 shows the range between minimum and maximum daily values for San Joaquin River inflow for each month of water years 1967-1991. Figure A4-3 shows the same information for Yolo Bypass inflow to the Delta for 1967-1991. The monthly ranges of QWEST flows calculated from DAYFLOW and monthly ranges for Delta outflow from DAYFLOW are shown in Figures A4-4 and A4-5, respectively, for 1967-1991. A wide shaded line indicates substantial variation within a month, while a thin line indicates small variation within a month.

As shown in Figures A4-1 to A4-5, the daily flows differed substantially during some months but were similar during other months. In months when the maximum and minimum daily values are similar, the monthly mean adequately represents flow conditions for simulation of potential project impacts. In months when the daily maximum and minimum are very different, however, the monthly mean may poorly characterize flow conditions for determining potential project operations and impacts. The maximums and minimums for Delta inflows, QWEST flows, and Delta outflows were generally similar to mean flows during the low-flow period at the end of each water year. During high-flow months, however, the means were often quite different from the maximums and minimums.

Figure A4-6 shows that daily minimum and maximum values of Delta exports are often quite different from the monthly mean. The daily variations in exports

may be caused by hydrologic variations, necessary compliance with objectives, changes in demands, or other operational considerations (e.g., maintenance and electric power rates). Historical Delta exports have increased substantially during the 1967-1991 period, and exports vary substantially by month because of seasonal agricultural demands, export pumping limits, amount of water available for diversions, and available seasonal storage capacity (i.e., San Luis Reservoir).

Relation of Mean Flow and Daily Flow Variability

Figure A4-7 shows the daily Sacramento River inflows for 1967-1991 (25 years) as a function of the mean monthly flow plotted for each month to identify possible seasonal effects in this relationship. Figure A4-8 shows this relationship for San Joaquin River flow at Vernalis. Figure A4-9 shows this relationship for Delta outflow. Daily variation in inflows and outflows was substantial in many months and was generally greater when mean monthly flow was higher.

Although absolute variation in flows increased with mean flow, variation expressed as a percentage of the mean increased only slightly with mean flow. The lines in Figures A4-7 to A4-9 show the mean flows and values 25% above and 25% below the mean. Points between the upper and lower lines indicate days with flows within 25% of the monthly mean flow, and points outside the lines indicate days with flows greater than 25% above or 25% below the monthly mean.

During high-flow months, San Joaquin River inflows (Figure A4-8) were within 25% of the monthly mean flow much more often than Sacramento River inflows (Figure A4-7), presumably because San Joaquin River flows are more completely regulated than Sacramento River flows. San Joaquin River runoff characteristics may also differ from Sacramento River runoff (i.e., snowmelt controlled, less rainfall). Delta outflows (Figure A4-9) were within 25% of the monthly mean much less often than Sacramento or San Joaquin River inflows. All three flows were more often within 25% of the monthly mean during the driest months (July-October) than during the wettest months (December-March).

The hydrologic variations during months with substantial rainfall runoff are therefore expected to cause the largest effects on daily CVP and SWP Delta operations and on allowable daily DW project operations and potential DW project impacts. Summer periods during regulated reservoir releases without rainfall runoff will be more uniform and more easily represented in monthly operations models.

Daily Variations in Water Quality

Temporal variations in salinity were not analyzed, although salinity is largely determined by outflows and tides, with some influence from San Joaquin River inflow and agricultural drainage in the south Delta. Changes in daily average salinity lag slightly behind changes in daily average flow in the Delta, so short-term fluctuations in salinity should be similar to, but less pronounced than, short-term fluctuations in flow. Because salinity intrusion increases with lower Delta outflows, effects of flow fluctuations on salinity will be most important during periods of low Delta outflow. Tidal fluctuations in salinity are not considered in this appendix. The daily variations in measured electrical conductivity (EC) values at several Delta locations are shown as monthly minimum, mean, and maximum values for water years 1968-1991 in Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project" (Figures B2-7 through B2-17).

Daily Variations in Fisheries

Daily records of fish abundance in the Delta are available from the CVP and SWP salvage records and other sampling programs. Unfortunately, the salvage records contain no information about fish eggs and larvae because the eggs and larvae are too small to be screened and counted. The egg and larval surveys conducted by California Department of Fish and Game (DFG) and DWR provide a great deal of information about the temporal and spatial distribution of fish larvae in the Delta, and although sampling is not conducted daily, it is conducted frequently (as often as every other day) during the spawning periods of some species. Short-term variations in fish abundance as indicated by salvage records and egg and larval survey data are described below.

Fish Salvage Records

The salvage records (number of fish each day) of the SWP and CVP Delta pumping facilities provide a measure of the daily variation of fish abundance in the south Delta. However, the variation in salvage records is generally influenced by a number of factors in addition to variation in abundance; influences include the spatial

distribution of the fish, the level of prescreening losses (i.e., predation), and export rate. An estimate of fish density is obtained by dividing the number of fish salvaged by the volume of water exported each day. If fish density is constant, the salvage rate will be proportional to the export rate. This may not be strictly true because the export rate also affects efficiency of the fish screens and possible predation losses.

Estimates of SWP and CVP daily salvage "density" of several species (estimated by dividing the number of fish salvaged by the daily SWP or CVP exported volume) for February-September 1993 are shown in Figure A4-10.

Figure A4-10 shows that each fish species is found in the salvage records at a different time during spring and summer. The salvage records from SWP Banks and CVP Tracy Pumping Plants provide "replicate" daily samples of south Delta fish density. Because the source of water entering these two pumping plants is sometimes different (CVP may sometimes pump predominantly San Joaquin River water), the fish density estimates may also be different. There are also effects from spawning of local populations of fish or from predators in the intake channels or Clifton Court Forebay that may cause differences in the salvage records. However, for many species the period of greatest salvage "density" occurs during several weeks and is similar at the SWP and CVP pumping plants.

Only juvenile and adult fish are salvaged at the SWP Banks and CVP Tracy Pumping Plants. The interpretation of the daily salvage records will be different for each species. Some fish are migrating through the Delta from upstream rearing habitat to estuary or ocean habitats. Some are resident fish that spawn and rear in Delta channels. For some species, periods of migrating juvenile fish can be identified directly from the salvage records. For other species, the daily salvage records may be indicative of the spawning patterns that would have occurred sometime previously in the Delta or upstream in tributary rivers. For species that have eggs or larval life stages in the Delta, the approximate time of spawning can be estimated from the salvage records using length and growth-rate information.

The daily salvage records provide a measure of the daily variation of fish abundance in the south Delta. As fish sampling and monitoring methods improve, it should be possible to obtain accurate recent information about spawning, migration, and juvenile density patterns for several important fish species in the Delta. These monitoring records could be used in adaptive management of Delta facilities, including DW project siphons and discharge pumps, to provide increased fishery protection of target species. Adaptive management may increase fishery protection by limiting diversions or by increasing fish transport flows to reduce the vulnerability of the early life stages to entrainment and allow most of the population to reach suitable estuarine habitat for rearing.

Larval Fish Samples

Larval fish samples are collected every 2-4 days during February-June at a number of sites in the Delta for the egg and larval survey (DFG 1992). Four stations (Stations 930 to 933) sampled in 1992 that are fairly close to Bacon Island and Webb Tract, the two reservoir islands of the DW project, were selected to evaluate short-term variations in larval fish abundance. The stations were sampled about once every four days during February 12-April 4 and every other day during April 4-July 7.

The number of delta smelt larvae collected at these stations was analyzed. Larval smelt data from the four stations were pooled because on most days no delta smelt larvae were collected from individual stations. Delta smelt were collected from at least one of the four stations on only 13 of the 68 days during which the stations were sampled, and no smelt were collected after May. The mean number rather than total number collected was used to estimate abundance because not all four stations were sampled during each sampling date.

The number of delta smelt collected at the four stations was highly variable (Figure A4-11). The results demonstrate that daily estimates of abundance are often very different from the monthly averages, which are influenced by relatively few days with high abundance. This difference may be caused by patchiness in the distribution of delta smelt larvae.

DAILY CVP AND SWP OPERATIONS

The averaging period used to simulate Delta conditions may affect estimates of the effects of Delta flows and Delta objectives on operations of the DW project. When DW project operations are simulated using monthly mean flow values, the simulated project is operated as if objectives were monthly average objectives. It is possible, however, that a month might have several days when minimum flow objectives were satisfied and other

days when flows were above objectives. Therefore, simulations of project operations based on daily flows and daily objectives might be very different from simulated operations based on monthly mean flows and monthly average objectives.

Capacity limitations of the proposed DW siphons or discharge pumps and the SWP and CVP export pumps would affect DW operations. The averaging period used for simulations of operations could bias estimates of the effects of these capacity limitations on CVP and SWP or DW project operations. Daily flows may often exceed CVP and SWP export pumping capacity and the DW diversion capacity, although mean flow for a month might be well below these capacities.

Simulating proposed DW project operations using a daily time-step model rather than a monthly model could result in either higher or lower estimates of diversions by the DW project, depending on the distribution of flows during the month. The following sections describe examples of averaging-period effects on simulated CVP and SWP operations and on DW project operations.

DCC Gate Closure

Reclamation's standard operating procedure is to close the Delta Cross Channel (DCC) gates to protect Mokelumne River levees and prevent scour damage to the DCC gate structure whenever Sacramento River inflow exceeds 25,000 cfs (Reclamation 1992). Reclamation may not immediately change the DCC gate positions, however, because they are manually operated. A horizontal line represents this flow threshold in Figure A4-7 for Sacramento River inflows. Months in which flows were above or below 25,000 cfs on all days would be adequately simulated, with respect to DCC closure, using a monthly time-step model. However, because the relationship of DCC diversion to Sacramento River inflow is slightly nonlinear, estimated total diversion based on daily flows might be different from the mean monthly diversion estimate.

In most months, there were some days with flows above and some days with flows below 25,000 cfs, so the DCC gates would be closed during a portion of the month. Monthly average simulations would probably not give accurate results for DCC flows in these months.

The 1995 WQCP objectives specify that the DCC will remain closed from February 1 to May 20 to reduce the diversion of fish from the Sacramento River into the central Delta. In addition, the DCC may be closed by the "operations group" for up to 45 days during November-January (50% of the time) and for up to 14 days in the period of May 21 to June 15 for the protection of fish. These partial DCC closure periods cannot be accurately represented with a monthly model, but the selected days of gate closure for fish protection cannot be identified with the daily model either. Therefore, the monthly and daily models simulated complete DCC closure from November through May.

Minimum Required Delta Outflow

The 1995 WQCP outflow objectives are a combination of the following:

- specified minimum monthly outflows that depend on water-year type;
- outflow required to satisfy several 14-day average salinity objectives at specified locations for various periods of time depending on water-year type; and
- outflow required to maintain X2, the position of the mean daily 2-parts-per-thousand (2-ppt) salinity gradient, downstream of three control locations for a specified number of days during February-June that depends on the unimpaired runoff (Eight-River Index) of the previous month.

These outflow objectives are discussed in Appendix A2, "DeltaSOS: Delta Standards and Operations Simulation Model".

A monthly average Delta outflow requirement must be estimated from the daily outflow requirements for monthly simulations models. The results of monthly simulation of CVP and SWP Delta operations using monthly estimates of required Delta outflows may be quite different from simulated daily operations if the variations in daily outflow or daily outflow requirements are large.

The results of daily simulations depend on the assumed equation for estimating daily X2. Because the upstream movement of X2 is slow relative to the changing flow during periods of declining outflow, there may be a considerable delay in the need for Delta ouflow to maintain X2 at a specified location if previous periods of higher outflow have moved X2 downstream. The outflow

requirements for maintaining the X2 location estimated with the daily model will be more accurate, because it is difficult to approximate the relationship between previous outflow and outflow requirements for maintaining X2 in the monthly model.

Although the 1995 WQCP objectives allow some averaging of the required salinity and X2 location for compliance purposes, the daily simulations described and evaluated in this appendix assume that the daily requirements specified in the 1995 WQCP must be satisfied each day without averaging. This provides an estimate of CVP and SWP Delta operations and potential DW operations assuming "perfect" daily operations decisions, which is a reasonable approach for evaluating the effects of daily variations in hydrology on Delta operations. DailySOS (the daily version of DeltaSOS, described below) can be used to investigate the possible benefits of allowing the use of various averaging periods for inflows, exports, salinity, and X2 for compliance purposes, but results for different averaging periods were not included in this appendix to support the EIR/EIS impact assessments.

SWP and CVP Export Pumping Capacity and Limits

The 1995 WQCP objectives limit CVP and SWP exports to a specified percentage of total Delta inflow. The 1995 WQCP objectives allow 3-day averaging of inflows (14-day averaging under some "in excess" conditions) and 3-day averaging of exports to be used for compliance purposes. Whenever the inflows change, the export limits will change. Monthly simulations of SWP and CVP Delta operations using monthly average inflows could differ substantially from simulations based on daily inflows. Allowable DW operations simulated with a monthly model may also be substantially different from daily estimates that account for daily variations of inflow and exports.

The 1995 WQCP objectives further limit CVP and SWP exports during the specified San Joaquin River pulse-flow period of April 15 to May 15 (the actual pulse-flow period may be shifted by the "operations group"). Monthly simulations for these two months therefore may not be as accurate as daily simulations.

From mid-March to mid-December, SWP exports are limited by the Corps permit (Section 10 of the Rivers and Harbors Act of 1899) to 6,680 cfs. During mid-December to mid-March, if San Joaquin flow (at Vernalis) exceeds 1,000 cfs, SWP exports are allowed to increase above 6,680 cfs by one-third of San Joaquin River flow. The SWP exports water to the California Aqueduct, which has a maximum conveyance capacity of 10,300 cfs. Therefore, maximum SWP pumping during the period of mid-December to mid-March can exceed the pumping limit for the rest of the year by approximately 3,620 cfs (10,300 cfs - 6,680 cfs = 3,620 cfs). The daily maximum extra SWP pumping constitutes one-third of San Joaquin River flow when the total flow of the river is 10,860 cfs. CVP pumping during this period is limited by the DMC capacity of approximately 4,200 cfs.

The actual amount of water pumped by CVP and SWP export pumps depends on the daily San Joaquin River flows and other applicable objectives (e.g., percent of inflow, Delta outflow). The combined capacity of the CVP and SWP increases from approximately 10,880 cfs to 14,500 cfs as the San Joaquin River flow increases to 10,860 cfs. Estimates of how much San Joaquin River water would be available for increased SWP pumping and how much would be available for possible DW diversions are influenced by the averaging period used to estimate the flows.

In many years, months with mean San Joaquin River flows below the 10,860-cfs threshold that allows maximum SWP pumping have several days with flows exceeding 10,860 cfs (Figure A4-8). Simulations based on monthly mean flows may not accurately estimated SWP pumping capacity, whereas simulations using a daily time step would provide a more accurate estimate of SWP pumping capacity.

If total daily inflow or pumping capacity is limiting CVP and SWP exports, simulations based on monthly mean flows may not provide accurate estimates of CVP and SWP exports, whereas simulations using a daily time step would provide a more accurate estimate of CVP and SWP export pumping.

DAILY COMPLIANCE WITH WATER QUALITY STANDARDS AND FISHERY PROTECTION REQUIREMENTS

All existing and any future Delta water quality objectives or fish and wildlife requirements, as adopted by SWRCB or other regulatory agencies, would apply to the DW project. DW project operations permitted by SWRCB would therefore not be allowed to interfere with the exercise of prior water rights, which may require

meeting applicable Delta water quality objectives or fish and wildlife protection requirements.

In the DW project impact assessments, results of the monthly DeltaSOS simulation model are used as the basis for the impact assessment of hydrologic and water quality effects. The monthly model is most appropriate for monthly average objectives and cannot accurately simulate daily or short-term objectives. The terms and conditions that SWRCB establishes for operation of the DW project, however, will consider the likely daily Delta conditions and CVP and SWP operations, in addition to the general monthly effects identified in the impact assessments.

Compliance with Flow and Salinity Objectives

SWRCB's 1995 WQCP set forth most of the currently applicable Delta flow and salinity objectives. Objectives in the 1995 WQCP are based on daily parameter estimates, longer term averages (monthly averages or averages for a specified period), and running averages (averages for some specified previous period).

The averaging period used for defining objectives may affect operations of Delta water projects necessary for compliance with the objectives. Although the DWR Division of Operations and Maintenance and CVOCO establish the "official" Delta water budget on a daily basis, estimates of allowable export pumping each day may be greatly influenced by the averaging period used for compliance with each objective. Use of long-term and running averages for compliance with objectives may allow the CVP and SWP to divert more water on some days than would be allowed if daily or short-term averages were used for compliance.

Specifying DW project operations criteria as daily or short-term requirements is advantageous because DW operations could more closely track actual Delta conditions. Daily operations criteria would provide Delta protection as needed and allow maximum DW diversions and discharges for various beneficial purposes. Storm-related flows with corresponding abrupt reductions of salinity, for instance, could provide conditions allowing DW diversions if daily objectives were used but might not allow DW operations if salinity objectives were based on monthly or long-term averages.

Compliance with Fish Take Limits

Under the Endangered Species Act, federal resource agencies will identify DW project operations criteria, incidental take limits, and facility design criteria (e.g., for fish screens) for protected fish species. The project permits will require that project operations comply with applicable fish protection measures and allowable take limits. In addition, DW operations relating to SWP or CVP facilities (i.e., export of DW discharges) may require satisfying existing fish protection measures controlling operations of the SWP and CVP facilities.

Because the sampling error of salvage data is large, incidental take limits for entrainment of fish at the CVP and SWP pumps are generally specified in terms of a cumulative total (e.g., for winter-run chinook salmon) or running average (e.g., for delta smelt) for the number of fish salvaged.

Sampling errors are also high for data from sampling programs designed to determine fish abundance and distribution in the Delta (e.g., DFG's egg and larval survey). Operations criteria relying on data from such programs would likely use spatial or temporal averages.

Chapter 3F, "Fishery Resources", recommends several operations criteria for the proposed DW project to avoid or mitigate expected impacts on protected fish species. Generally, suggested operations criteria would restrict DW project diversions and discharges during periods of expected or detected presence of sensitive life stages of fish species. The operations criteria would be defined by specified Delta flow and estuarine habitat conditions.

POSSIBLE DAILY MONITORING AND MITIGATION REQUIREMENTS

Most fish populations have very clumped distributions because fish seek out specific habitat conditions and many species travel in schools. Larval fish abundance often varies temporally as well as spatially because spawning activity may vary markedly from day to day and because fish mature quickly through the larval stage and may be highly mobile. The patchiness of fish populations combined with their tendency to use shallow habitat that is difficult to sample results in very high sampling variability, making it difficult to reliably monitor fish abundance.

The monthly time-step model used to assess potential impacts of the DW project on fish populations is probably sufficiently accurate to identify likely potential impacts. Daily fluctuations in Delta flows that were discussed in previous sections of this appendix presumably affect transport of fish eggs and larvae and flow-related habitat conditions of all stages and may therefore affect fish growth and survival. Although daily simulation of fish transport and entrainment using the daily flow data from DailySOS was not used for the DW impact assessments, short-term fluctuations in real fish abundance data were examined to evaluate the potential effects of these fluctuations on project impacts. Daily monitoring and possible mitigation requirements were investigated.

CVP and SWP Delta Export Take Limits

As noted earlier, incidental take limits for entrainment of fish at the CVP and SWP pumps are currently specified in terms of cumulative number or 14-day running average of the number of fish salvaged because daily salvage estimates based on daily counts are extremely variable. A running average may provide a more reliable estimate of the abundance of fish at risk of entrainment than would be provided by daily estimates. The reduced variability of the running average also results in more predictable and consistent project operations. However, the CVP and SWP have had very little experience with adjusting operations to comply with take limits, so the possible effects of basing take limits on running averages are not fully known.

The 1995 WQCP allows the "operations group" to recommend changes in SWP and CVP export pumping for fish protection to the project operators, based on available fish monitoring information. Until decision-making guidelines are developed for this "operations group", however, possible operational changes to comply with "take limits" can be illustrated with monitoring results and salvage records from recent years.

The 1994 U.S. Fish and Wildlife Service (USFWS) biological opinion for delta smelt (USFWS 1994) specifies that if the 14-day running average of delta smelt salvaged at the SWP and CVP facilities exceeds the allowable monthly value of the delta smelt take limit, "operations shall be modified to restore the 14-day running average". The opinion later states that "if reasonable operation of the CVP/SWP cannot correct numbers of fish taken, the Working Group . . . shall meet to develop alternative actions". Modifications to restore the 14-day running average (i.e., to reduce it to below the take limit) presumably would include reduced pumping. The allowable monthly take limit is determined on the basis of a variety of factors, including the month, water-year type, and previous abundance indices (USFWS 1994).

Although use of a 14-day running average for salvage may have certain advantages, it could also lead to serious problems. For instance, the 14-day running average responds so slowly to rapid increases in salvage caused by an increased abundance (density) of delta smelt that a great deal of entrainment could occur before the 14-day average allowable take limit is reached. The 14-day average also responds slowly to decreases in delta smelt abundance and therefore could lead to unnecessary delays in the resumption of pumping. A 14-day average may neither protect delta smelt nor be an efficient basis for determining allowable pumping.

The possible effects of a take limit strategy based on the 14-day running average can be illustrated with 1993 SWP delta smelt daily salvage records, shown in Figure A4-12. If the 1994 biological opinion "formula" for monthly delta smelt take limits had been in effect in 1993, the 14-day average take limit for May 1993 would have allowed the salvage of 600 delta smelt per day.

In early May, SWP and CVP pumping was reduced during a period of San Joaquin flushing flows to benefit migrating chinook salmon. On May 17, 1993, the SWP increased exports from 1,462 cfs to 6,179 cfs, and daily salvage of delta smelt increased from about 200 per day to nearly 900 per day. Another 5 days passed, however, before the 14-day running average of delta smelt salvage exceeded the take limit of 600 per day. Continued pumping during these days caused entrainment of a large number of delta smelt. Note that a 7-day running average would have tracked the increase in salvage more closely than the 14-day average (Figure A4-12).

DW Project Monitoring for Larval Fish

Real-time monitoring of larval fish abundance at stations near the DW project islands would provide the greatest protection for fish. The DW project is designed to respond quickly to changing conditions and therefore could be operated in response to real-time fluctuations in fish numbers. Daily sampling at several stations may be required. There is some delay between sampling and analysis. Net or siphon sampling may be combined with

an automated fish counting system, such as hydroacoustic technology, to provide a comprehensive monitoring program. Automated sampling techniques might provide a general indication of larval density, but identification of species would require hand processing by qualified technicians. It is likely that sampling techniques will change and improve in the near future.

COMPARISON OF SIMULATED DAILY AND MONTHLY DW PROJECT OPERATIONS

The DeltaSOS monthly planning model (described in Appendix A2, "DeltaSOS: Delta Standards and Operations Simulation Model") was modified to estimate Delta water supply conditions and possible DW project operations using a daily time-step model; the modified daily model is named DailySOS. DailySOS simulation results for the 1967-1991 period were compared with monthly DeltaSOS results (presented in Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives") for the same period to determine the likely differences in proposed DW operations between daily simulations and monthly average simulations. The daily simulations assumed that all objectives required daily compliance, while the monthly simulations assumed that all objectives required monthly average compliance.

Changes in DeltaSOS Calculations and Standards

Appendix A2 describes the concept and basic calculations of the DeltaSOS monthly model. DailySOS uses these same calculations. Hydraulic flow-split calculations are assumed to be the same for daily flows and monthly average flows. The monthly objectives, as specified in DeltaSOS, are assumed to be applicable each day throughout the entire month.

The following changes in DeltaSOS model calculations were needed for representing the 1995 WQCP objectives, estimating SWP and CVP Delta exports, and evaluating possible DW project operations at a daily time step:

- SWP and CVP daily export limits are calculated as a specified monthly fraction of total daily inflows (the February fraction depends on January's unimpaired runoff); the 3-day averaging of inflows and exports was not simulated.

- The required San Joaquin River inflows and daily export limits (minimum of San Joaquin River inflow or the specified fraction of total inflow) for the pulse-flow period (April 15 to May 15) were accurately simulated in the daily model with daily flows. The required San Joaquin River inflows for February-June depend on the San Joaquin River water-year type and the daily X2 (more inflow is required if X2 is downstream of Chipps Island).

- The Corps permitted maximum daily SWP pumping limit was calculated as 6,680 cfs plus 33% of the daily San Joaquin River inflows for the period of December 15 to March 15 (with a maximum SWP pumping capacity of 10,300 cfs).

- X2 was calculated with the daily X2 equation; the daily required X2 positions for the month were calculated at the beginning of each month between February and June. The required number of days for X2 to be downstream of Chipps Island or Roe Island are specified in the 1995 WQCP, and depend on the previous month's runoff (Eight-River Index). The Chipps Island or Roe Island requirements were simulated starting on the first of each month. The Roe Island requirements were only applicable if the simulated X2 position was downstream of Roe Island at the beginning of the month; the 14-day average EC trigger at Roe Island was not simulated.

- The maximum daily DW diversion and maximum daily DW discharge rates were estimated as a function of the DW storage. The diversion rate was assumed to decrease linearly from 9,000 cfs to 3,000 cfs as the stored volume on the reservoir islands increased to maximum reservoir storage capacity. The discharge rate was assumed to decrease linearly from 6,000 cfs to 2,000 cfs as the stored volume decreased.

DailySOS calculations provide a more accurate estimate than monthly DeltaSOS calculations provide of possible Delta operations with specified Delta facilities, water quality objectives (1995 WQCP), and specified inflows (from historical DAYFLOW records). However, the DeltaSOS monthly model results were used as the basis for impact assessments in the EIR/EIS. The following sections of this appendix illustrate and discuss the DailySOS results for three recent example years (1986-

1988) and compare the DeltaSOS monthly model results with the DailySOS daily model results for 1967-1991.

The monthly results that are compared with the DailySOS results for the 1967-1991 period were obtained from the DeltaSOS model using historical Delta inflows. The simulation of the 1995 WQCP objectives, including the estimation of outflow requirements for X2 objectives, followed the methods and assumptions described in Appendix A2, "DeltaSOS: Delta Standards and Operations Simulation Model". These monthly results are different from the simulations of Delta conditions under the No-Project Alternative used in the EIR/EIS impact assessments (Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives"). These comparisons of daily and monthly model results were performed to identify the differences in likely operations of Delta facilities, including the DW project, that may be caused by consideration of daily variations in Delta hydrology and daily compliance with 1995 WQCP objectives.

Table A4-1 compares the annual DeltaSOS and DailySOS results for water years 1967-1991. The models gave somewhat different results for allowable CVP and SWP exports and DW operations for some years. Table A4-2 gives the DeltaSOS monthly results and monthly average of DailySOS daily results for historical inflows for water years 1967-1991. The results given in these tables indicate that while there are differences in the monthly and daily model results, the simulated Delta conditions are generally similar for both models.

Large changes in Delta conditions associated with fluctuating hydrologic inflows are simulated with both models. Export limits are simulated more often with the daily model; simulated maximum allowable CVP and SWP exports are lower with the daily model than with the monthly model. Periods of excess inflows, which would provide water for DW diversions, are simulated more often with the daily model than with the monthly model. Periods of limited CVP and SWP exports, which would allow DW discharge water to be exported, are simulated more often with the daily model than with the monthly model. Results for the three example years are described in the next section to illustrate the reasons for differences in the results from the monthly and daily models

The differences between the daily and monthly simulation results indicate that the DW project, if operated in response to short-term variations in hydrology (or fish abundance), may be used to "even out" or "top off" the CVP and SWP Delta operations. Although the DailySOS simulations described in this appendix assume the DW project to be independent of the CVP and SWP facilities, it may be possible to implement more integrated Delta operations that might include upstream reservoir releases and discharges from DW project reservoir islands for increased Delta outflow. Use of a daily model such as DailySOS would be necessary for studies of integrated operations.

The daily variations in hydrology (and biology) that have been investigated in this appendix should be considered in the terms and conditions for the DW water rights and should be incorporated into the mitigation measures required for potential DW project impacts.

Nevertheless, the monthly DeltaSOS simulation of the No-Project Alternative and the DW project alternatives will generally provide an adequate representation of likely Delta conditions and the potential changes associated with DW project operations. The wide range of future hydrologic conditions are well represented by the monthly average flows simulated with DeltaSOS. The DeltaSOS results and subsequent monthly impact assessments used to evaluate the DW project in this EIR/EIS are a reasonable basis for lead agency decisions and public disclosure of potential environmental effects of DW project implementation.

DailySOS Results for 1986

DailySOS results for three recent years (1986, 1987, and 1988) are presented here to illustrate the calculations of channel flows and adjustments in historical exports and outflow that are required to satisfy the 1995 WQCP objectives. DailySOS will increase San Joaquin River inflow to satisfy 1995 WQCP objectives. DailySOS will reduce exports from historical levels (and increase historical outflow above historical levels) if necessary to satisfy outflow objectives or pumping limit objectives. DailySOS will increase exports above historical levels (and reduce outflow) if additional exports would be allowable under the 1995 WQCP objectives.

Figure A4-13A shows the historical 1986 Sacramento and San Joaquin River inflows and DailySOS adjustments. The DailySOS-simulated DCC and Georgiana Slough diversions to the central Delta (with the DCC closed during November-May), QWEST flow from the central Delta, and Delta exports (including simulated DW exports) are shown for comparison.

There were no adjustments required in Sacramento River inflows because the 1995 WQCP objectives for

Rio Vista are normally satisfied with historical inflows. Although 1986 was classified as a wet year (Eight-River Index of 29,240 thousand acre-feet [TAF]) and extreme flooding occurred in February, the Sacramento River inflows were only moderately high (10,000 cfs to 20,000 cfs) during fall and summer. Monthly average inflows and monthly model results would be adequate for these periods. During February and March, inflows were much higher than necessary to provide required outflow and supply maximum pumping capacity, so monthly model results would be adequate. Daily simulations might produce different results, however, during the periods of moderate storm-event inflows in December and January.

Even with the DCC closed from November to May, there was considerable diversion of Sacramento River water simulated to the central Delta through Georgiana Slough. The QWEST flow represents the balance between the available San Joaquin River, eastside stream, DCC, and Georgiana Slough water and south Delta exports and agricultural diversions (65% of total). Simulated QWEST was negative (more exports than inflows) during some portions of November-January and August-September.

San Joaquin River inflows were about 2,000 cfs during fall and increased to above 10,000 cfs from February through April. The Corps permit for SWP pumping capacity allowed some additional exports during January-March. The 1995 WQCP objectives for San Joaquin River February-June inflows and pulse flows from April 15 to May 15 were satisfied without any additional simulated releases.

The likely source of Delta exports can be determined through comparison of the San Joaquin River inflow with the simulated exports. Because most San Joaquin River inflows are diverted toward Delta exports, the San Joaquin River would have supplied most of the exports from mid-February to mid-June. The remainder of exports come from the Sacramento River through the DCC and Georgiana Slough. When QWEST is negative, some of the Threemile Slough diversions from the Sacramento River move upstream toward the export pumps.

Figure A4-13B shows the DailySOS adjustments to historical exports for 1986 and the DW project diversions and DW discharges for export simulated for Alternative 2 (DW exports limited by permitted capacity but not by the 1995 WQCP criteria for percentage of Delta inflow diverted).

DailySOS-simulated exports were slightly reduced from historical levels so that 1995 WQCP outflow objectives and percent of inflow limits would be met during fall. Simulated exports were increased substantially above historical exports from mid-January through April because DailySOS assumes that all available water is exported, without checking south-of-Delta storage capacity or demands. Exports were curtailed in May in the simulations because 1995 WQCP objectives for X2 were not satisfied with historical outflow. The Roe Island objective was applicable in May because X2 was downstream at the beginning of May and the April Eight-River index of 5,880 TAF required 28 days of X2 compliance in May.

The DailySOS simulation of DW project operations, starting with empty reservoir islands, showed diversions during the early December storm-event, with discharges for export in December and January. DW diversions filled the reservoir islands by early February, with discharges for export in May. Excess inflow was simulated for September, and simulated DW diversions refilled the reservoir islands to 193 TAF by the end of the year.

Figure A4-13C shows the simulated daily X2 requirements and estimated position of X2, along with the historical and adjusted outflow for 1986. DailySOS adjusted historical outflow to satisfy the 1995 WQCP minimum monthly outflow objectives by reducing exports below historical export levels for several periods in 1986.

Required outflow for X2 objectives is only added to the minimum monthly outflow requirements in DailySOS if the daily X2 is upstream of the location for which the X2 objective is specified. The 1995 WQCP X2 objectives would have required export reductions or additional reservoir releases for a few days in February to satisfy the Chipps Island objective and for about 20 days in May to satisfy the Roe Island objective. Because DailySOS reduces exports to a minimum of 1,500 cfs but does not simulate additional reservoir releases to satisfy X2 requirements, an outflow deficit was simulated during most of May, with the simulated X2 moving upstream.

DailySOS reduced the outflow during several periods to allow increased exports and DW diversions. The magnitude of the simulated reductions in outflow was greatest during periods of relatively high outflow, when the 1995 WQCP percent of inflow limits for exports (and simulated DW diversions) allowed the largest change in exports and DW diversions without reducing outflow to less than the 1995 WQCP objectives for minimum outflow.

Comparison of Daily and Monthly Results for 1986

The monthly and daily results for 1986 were generally similar. Both models simulated allowable exports to be much higher than historical exports in 1986. The periods of potential DW diversions, which depend on relatively large Delta inflows, were simulated for December-April with both models. The periods of potential DW discharges for export, which depend on relatively low Delta inflows, were simulated in June and July with the monthly model but were also simulated in May with the daily model because of the simulated export reductions for outflow requirements to satisfy X2 objectives.

Table A4-1 indicates that the annual historical CVP and SWP exports for 1986 totaled 5,286 TAF. The DeltaSOS monthly model results for historical inflows estimated maximum allowable CVP and SWP exports of 7,120 TAF. The DailySOS model results estimated maximum allowable CVP and SWP exports of 6,592 TAF. Both DeltaSOS and DailySOS allowable exports to be higher than actual historical exports, because south-of-Delta demands and storage capacity (San Luis Reservoir) were not included in the simulations. Additional storage and/or delivery facilities may be required to actually export the maximum allowable under the 1995 WQCP objectives.

The DailySOS daily simulated CVP and SWP exports were substantially less than DeltaSOS monthly simulated exports (528 TAF less) because of two major effects:

- For some months of the simulations, more water was allowed to be exported with the monthly average flows and monthly export limits than with the daily inflows and export limits because the daily export limit exceeded the daily pumping capacity during some storm-events, and because the daily export limit was lower than the monthly average limit during periods of relatively low inflow.

- The DeltaSOS monthly estimated outflow requirements and X2 requirements for the February-June period were often less than the DailySOS daily estimated outflow and X2 requirements. The monthly model only reduced historical 1986 exports in October and July without any reduction in May. The daily model required export reductions for outflow in several months, with major reductions required for satisfying X2 objectives in May.

Table A4-1 indicates that the DeltaSOS monthly model results for DW diversions and discharges for export in 1986 were 489 TAF of diversions and 228 TAF of exports, with 238 TAF carryover storage on the reservoir islands at the end of September. The DailySOS model results were somewhat higher, with 551 TAF of diversions, 328 TAF export, and 193 TAF of carryover storage.

The DailySOS daily simulated DW operations were somewhat greater than DeltaSOS monthly simulated DW operations (62 TAF more in diversion and 100 TAF more in export, but 45 TAF less in carryover storage) because of two major effects:

- For some months of the simulations, the monthly average flows and monthly export limits did not allow any water to be diverted onto the DW reservoir islands, while there may have been at least one storm-event period with excess inflow for some days within the month. During other months, the monthly average flows allowed full CVP and SWP exports, while the daily export limits were sometimes below full capacity and allowed some periods of DW discharge and export.

- The DailySOS simulation of DW diversion and DW discharge capacity, which varied with reservoir island storage, allowed periods of higher diversion and discharge rates than were simulated by the monthly model. During months with opportunities for DW project diversions and discharges in sequence (i.e., December and January 1986), the daily diversion and discharge rates allowed more rapid filling and emptying of the DW reservoir islands.

These differences between the daily and monthly simulation results are generally consistent; reduced allowable CVP and SWP exports will allow greater DW diversions and discharges. The daily variations in hydrology that may exceed pumping capacity or require export reductions to satisfy export limits or outflow requirements will at the same time allow periods of DW diversions (whenever the export capacity is exceeded) or allow DW exports (whenever there is unused CVP or SWP export capacity).

DailySOS Results for 1987

Figure A4-14A shows the historical 1987 Sacramento and San Joaquin River inflows and DailySOS adjustments. Water year 1987 was classified as a dry year (Eight-River Index of 18,880 TAF); the Sacramento River inflows were relatively low (10,000 cfs to 15,000 cfs) during the entire year, with a few small storm-events in the January-March period. Monthly model results would perhaps be adequate for simulating Delta conditions during most of 1987. Daily simulations might produce different results, however, during the periods of moderate storm-event inflows.

San Joaquin River inflows were about 4,000 cfs during fall and declined to about 2,000 cfs by the end of the year. The Corps permit for SWP pumping capacity allowed only a small amount of additional exports in the December-March period. The 1995 WQCP objectives for San Joaquin River pulse flow from April 15 to May 15 required about 1,000 cfs of simulated additional releases from tributaries. DailySOS assumes the water will be supplied, and increases the San Joaquin River inflow above the historical inflow.

Figure A4-14B shows the DailySOS adjustments to historical exports for 1987 and the DW project diversions and DW discharges for export simulated for Alternative 2 (DW exports limited by permitted capacity).

DailySOS generally increased exports above the historical levels to the percent of inflow limits or pumping capacity from October through March. Simulated exports were reduced below the levels of historical exports from April through September for so that required outflow would satisfy X2 objectives.

The DailySOS simulation of DW project operations for 1987 started with nearly full reservoir islands, and DailySOS simulated diversions to fill the reservoir islands in October and simulated some DW exports during November and December because the CVP and SWP export limits were slightly less than pumping capacity. A sequence of DW diversions and discharges was simulated during January, February, and March. Delta inflows were limiting for the rest of the year, and DW reservoir islands remained empty in the simulations from April to the end of the year.

Figure A4-14C shows the daily simulated X2 requirements and estimated X2, along with the historical and adjusted outflow for 1987. DailySOS adjusted historical outflow to the 1995 WQCP minimum monthly outflow objectives by increasing exports above the historical export levels in fall and by reducing historical exports for several periods in spring and summer.

The 1995 WQCP X2 objectives would have required export reductions or additional reservoir releases for a few days in March and for most of April and May to satisfy the Chipps Island X2 objective. The Roe Island X2 objective was not applicable in 1987. Because DailySOS reduces exports to a minimum of 1,500 cfs but does not simulate additional reservoir releases to satisfy X2 requirements, an outflow deficit was simulated during most of April and May, with the simulated X2 moving upstream of Chipps Island (kilometer 74).

Comparison of Daily and Monthly Results for 1987

The monthly and daily results for 1987 were generally similar. Both models simulated maximum allowable CVP and SWP exports to be greater than historical exports. Periods of potential DW diversions, which depend on relatively large Delta inflows, were not simulated with the monthly model in 1987. The daily model simulated periods of potential DW diversions in October, and in the December-March period because of the sequence of storm-event inflows. The monthly model simulated DW discharges for export, which depended on carryover storage from the previous year in November-February. The daily model simulated discharges in October-March because of carryover storage and additional diversion opportunities.

Table A4-1 indicates that the annual historical CVP and SWP exports for 1987 totaled 5,047 TAF. The DeltaSOS monthly model results for historical inflows estimated maximum allowable CVP and SWP exports of 5,742 TAF. The DailySOS model results estimated maximum allowable CVP and SWP exports of 5,382 TAF. Both DeltaSOS and DailySOS simulated allowable exports to be higher than historical exports because south-of-Delta demands and storage capacity (San Luis Reservoir) were not included in the simulations. Additional storage or delivery facilities may be required to actually export the maximum allowable under the 1995 WQCP objectives.

The DailySOS daily simulated CVP and SWP exports were substantially less than DeltaSOS monthly simulated exports (360 TAF less) because inflow and export capacity are limiting more often with daily exports than with monthly exports and because exports may be limited more by daily outflow requirements than by the monthly average outflow requirements.

Table A4-1 indicates that the DeltaSOS monthly model results for DW diversions and discharges for export in 1987 were 3 TAF of diversions and 241 TAF of exports, with no carryover storage on the reservoir islands at the end of September. The DailySOS model results were somewhat higher, with 142 TAF of diversions, 324 TAF export, and no carryover storage.

The DailySOS daily simulated DW operations were somewhat greater than DeltaSOS monthly simulated DW operations (139 TAF more of diversions, 83 TAF more of exports) because of short periods of simulated DW diversions during storm-event inflows in fall and winter.

These differences between the daily and monthly simulation results are generally consistent; reduced allowable CVP and SWP exports will allow greater DW diversions and discharges. The daily variations in hydrology that may exceed pumping capacity or require export reductions to satisfy outflow requirements will at the same time allow periods of DW diversions (whenever the export capacity is exceeded) or allow DW exports (whenever there is unused CVP or SWP export capacity).

DailySOS Results for 1988

Figure A4-15A shows the historical 1988 Sacramento and San Joaquin River inflows and DailySOS adjustments. Water year 1988 was classified as a critical year (Eight-River Index of 11,385 TAF); the Sacramento River inflows were relatively low (10,000 cfs to 15,000 cfs) during the entire year, with a few small storm-events in December-January. Monthly average inflows and monthly model results would perhaps be adequate for this year. Daily simulations might produce different results, however, during the periods of moderate storm-event inflows.

San Joaquin River inflows were between about 1,000 cfs and 2,000 cfs during the entire year. The Corps permit for SWP pumping capacity allowed some additional exports only in January. The 1995 WQCP objectives for San Joaquin River pulse flow from April 15 to May 15 required about 1,000 cfs of additional releases from tributaries.

Figure A4-15B shows the DailySOS adjustments to historical exports for 1988 and the DW project diversions and DW discharges for export simulated for Alternative 2 (DW exports limited by permitted capacity).

The historical exports were adjusted slightly to match the percent of inflow limits or pumping capacity from October through January. Simulated exports were reduced from historical exports from February through June to satisfy outflow requirements for X2 objectives. The April and May storm-event inflows did not increase exports; simulated exports were reduced to satisfy the export limits associated with the San Joaquin River pulse flows.

The DailySOS simulation of DW project operations in 1988 started with empty reservoir islands. DW diversions were simulated in early December and January storm events. DW exports were simulated in late December and February. Delta inflows were limiting for the rest of the year, and DW reservoir islands were simulated to remain empty from March to the end of the year.

Figure A4-15C shows the daily simulated X2 requirements and estimated X2, along with the historical and adjusted outflow for 1988. DailySOS increased outflow above the historical levels to meet the 1995 WQCP minimum monthly outflow objectives by reducing exports during October-January and July-September. Outflow was reduced below historical levels during some storm events to provide increased exports. Simulated X2 objectives controlled outflow requirements in February, March, and June. Inflow limits and pulse-flow export limits resulted in increased simulated outflow during April and May.

Comparison of Daily and Monthly Results for 1988

The monthly and daily results for 1988 were generally similar. Both models simulated reduced allowable exports compared with historical exports. Periods of potential DW diversions, which depend on relatively large Delta inflows, were simulated in January with the monthly model. The daily model simulated periods of potential DW diversions in December and January storm events. The monthly model simulated DW discharges for export in February. The daily model simulated discharges in December and February.

Table A4-1 indicates that the annual historical CVP and SWP exports for 1988 totaled 5,611 TAF. The DeltaSOS monthly model results for historical inflows estimated maximum allowable CVP and SWP exports of only 4,646 TAF. The DailySOS model results estimated maximum allowable CVP and SWP exports of 4,233 TAF. Allowable exports simulated by both DeltaSOS and DailySOS were less than actual historical exports because exports were reduced to satisfy 1995 WQCP

objectives for percentage of inflow diverted, San Joaquin River pulse flow, minimum outflow, and X2 position.

The DailySOS daily simulated CVP and SWP exports were again substantially less than DeltaSOS monthly simulated exports (413 TAF less) because daily inflows and export capacity limits on daily exports are greater than monthly inflow limits and because exports may be limited more by daily outflow requirements than by the monthly average outflow requirements.

Table A4-1 indicates that the DeltaSOS monthly model results for DW diversions and discharges for export in 1988 were 234 TAF of diversions and 244 TAF of exports, with no carryover storage on the reservoir islands at the end of September. The DailySOS model results were somewhat higher, with 283 TAF of diversions, 278 TAF of exports, and no carryover storage.

The DailySOS daily simulated DW operations were somewhat greater than DeltaSOS monthly simulated DW operations (49 TAF more of diversions, 34 TAF more of exports) because of short periods of diversions during storm-event inflows in winter.

CONCLUSIONS

This appendix has presented information on daily Delta flow conditions, CVP and SWP operations, fish abundance patterns, and likely DW project operations and has compared daily and monthly conditions and operations. Two major conclusions can be drawn from the information presented above.

- **Impact assessments of the DW project that are based on monthly models of Delta hydrologic, water quality, and fishery conditions and likely CVP and SWP operations provide a good basis for reliable evaluation of major potential impacts on water supply, hydrodynamics, water quality, and fishery resources.**

  DW project impact assessments are based on monthly simulations of the 1922-1991 period, which includes a wide range of likely Delta conditions. Although daily variations in hydrology, water quality, and fishery conditions are expected, monthly average values are representative of the anticipated range of conditions. Simulated average monthly DW operations provide adequate estimates of likely environmental effects of the DW project on Delta conditions.

  Variations in both fish abundance and distribution are relatively unknown and uncertain; monthly average conditions are sufficient for estimates of likely fish conditions for impact assessment.

- **DW project operations should be governed and regulated under SWRCB-adopted water right terms and conditions and possible biological opinion requirements using available daily information on Delta flow and salinity conditions, DW project operating capacities, CVP and SWP operations, and compliance with Delta objectives and available water quality and fishery monitoring information.**

  The magnitude of possible effects of DW project operations will change as daily Delta conditions change. Potential impacts may be minimized through adaptive-management evaluations of the daily effects of DW operations on Delta flows, water quality, or fishery resources.

  Mitigation measures should be designed to reduce the possible daily effects of DW project operations, with appropriate monitoring requirements to allow the effectiveness of daily operational mitigation measures to be evaluated.

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Table A4–1. Comparison of Annual Results from DailySOS and DeltaSOS for Historical Inflows and Exports for 1967–1991

Water Year	Sac Basin Year Type	SJR Basin Year Type	Historical Banks& Tracy Pumping (TAF)	Historical Sac Inflow (TAF)	Historical Yolo Bypass Flow (TAF)	Historical CCWD Pumping (TAF)	Historical Eastside Inflow (TAF)	Historical SJR Basin Inflow (TAF)	Historical Delta Depletion (TAF)	Historical Delta Outflow (TAF)	DailySOS Added SJR Flow (TAF)	DeltaSOS Added SJR Flow (TAF)	DailySOS New SJR Flow (TAF)	DeltaSOS New SJR Flow (TAF)
1967	1	1	1,250	24,233	3,654	71	1,720	5,559	389	33,457	38	24	5,597	5,593
1968	3	4	2,460	13,377	653	96	514	1,423	1,036	12,373	341	376	1,764	1,807
1969	1	1	2,870	23,362	6,270	78	2,387	10,168	424	38,817	13	7	10,180	10,192
1970	1	2	2,064	20,289	8,485	94	1,412	2,996	788	30,237	415	384	3,412	3,385
1971	1	3	2,825	22,811	1,304	75	900	1,778	742	23,151	279	241	2,057	2,022
1972	3	4	3,427	12,470	29	103	362	1,112	1,246	9,145	436	427	1,548	1,546
1973	2	2	3,358	20,758	3,880	92	1,426	2,392	439	24,616	327	249	2,720	2,645
1974	1	1	4,353	30,663	7,554	79	1,548	2,773	688	37,417	321	125	3,094	2,902
1975	1	1	3,898	19,941	949	79	1,123	2,826	854	20,008	348	247	3,174	3,078
1976	5	5	4,815	10,963	14	111	206	1,523	1,225	6,556	149	127	1,672	1,657
1977	5	5	2,075	5,497	1	99	30	416	1,237	2,528	427	420	843	836
1978	2	1	4,342	17,691	2,839	77	1,144	4,490	316	21,411	121	97	4,611	4,595
1979	3	2	4,462	13,034	153	91	1,018	2,625	742	11,535	358	335	2,983	2,965
1980	2	1	4,502	19,248	6,390	87	1,810	5,975	645	28,190	0	0	5,975	6,025
1981	4	4	4,714	11,498	126	107	286	1,763	958	7,895	167	164	1,930	1,930
1982	1	1	4,613	30,150	7,217	75	3,033	5,477	30	41,159	14	7	5,491	5,493
1983	1	1	4,392	34,051	14,936	79	4,549	15,438	(29)	64,531	0	0	15,438	15,464
1984	1	2	3,822	22,437	4,678	97	1,799	6,279	823	30,450	281	242	6,560	6,555
1985	4	4	5,461	12,192	172	112	469	2,119	939	8,438	125	107	2,244	2,229
1986	1	1	5,277	18,112	10,589	110	2,121	5,235	230	30,419	15	0	5,251	5,244
1987	4	5	5,034	10,031	35	131	383	1,810	999	6,094	43	0	1,853	1,813
1988	5	5	5,580	9,653	115	135	142	1,164	965	4,395	78	13	1,241	1,182
1989	4	5	5,957	12,244	44	134	220	1,057	888	6,588	84	60	1,140	1,119
1990	5	5	5,798	9,860	21	135	169	914	1,074	3,957	122	83	1,036	998
1991	5	5	3,180	7,540	75	106	221	655	834	4,371	234	228	889	883
Average			4,021	17,284	3,207	98	1,160	3,519	739	20,310	190	158	3,708	3,686

Note: Negative values shown in parentheses.

Table A4–1. Continued

Water Year	DailySOS Added SJR Flow (TAF)	DeltaSOS Added SJR Flow (TAF)	DailySOS New SJR Flow (TAF)	DeltaSOS New SJR Flow (TAF)	DailySOS Required Delta Outflow (TAF)	DeltaSOS Required Delta Outflow (TAF)	DailySOS Export Limits for Inflow (TAF)	DeltaSOS Export Limits for Inflow (TAF)	DailySOS Reduced Export for Objectives (TAF)	DeltaSOS Reduced Export for Objectives (TAF)	DailySOS Outflow Deficit (TAF)	DeltaSOS Outflow Deficit (TAF)	DailySOS Net Export Change (TAF)	DeltaSOS Net Export Change (TAF)
1967	38	24	5,597	5,593	4,121	5,706	15,785	15,739	3	0	14	0	6,303	6,664
1968	341	376	1,764	1,807	5,704	5,922	7,965	7,945	694	554	594	208	2,911	3,355
1969	13	7	10,180	10,192	3,743	5,432	19,049	19,184	25	0	0	0	5,100	5,023
1970	415	384	3,412	3,385	6,353	5,120	17,711	17,682	601	322	1,589	123	4,103	4,436
1971	279	241	2,057	2,022	5,611	6,325	13,825	13,745	159	0	309	0	4,349	5,049
1972	436	427	1,548	1,546	5,696	4,611	7,498	7,443	810	417	776	0	2,125	2,627
1973	327	249	2,720	2,645	5,460	5,345	14,120	14,064	614	220	695	0	3,366	3,776
1974	321	125	3,094	2,902	5,443	5,407	21,230	20,711	524	0	288	0	3,185	3,781
1975	348	247	3,174	3,078	5,430	6,065	11,840	11,497	100	0	68	0	3,622	4,065
1976	149	127	1,672	1,657	4,075	3,942	7,033	7,035	692	647	220	0	313	424
1977	427	420	843	836	3,458	3,272	3,405	3,393	501	310	713	591	(334)	(118)
1978	121	97	4,611	4,595	4,444	5,082	12,074	11,912	568	250	418	21	1,482	1,920
1979	358	335	2,983	2,965	5,261	4,994	8,626	8,303	522	383	294	21	2,073	2,337
1980	0	0	5,975	6,025	5,485	5,482	16,431	16,081	209	0	393	0	2,865	3,334
1981	167	164	1,930	1,930	5,958	4,445	7,125	6,895	686	231	1,078	6	623	1,449
1982	14	7	5,491	5,493	4,758	5,368	21,086	20,912	84	0	319	0	2,875	3,399
1983	0	0	15,438	15,464	3,814	4,873	30,995	30,937	0	0	0	0	4,329	3,978
1984	281	242	6,560	6,555	6,166	5,832	20,211	20,207	575	393	1,088	0	3,467	3,335
1985	125	107	2,244	2,229	5,092	4,427	8,074	8,068	956	434	616	0	285	788
1986	15	0	5,251	5,244	6,240	5,217	15,973	14,983	701	81	1,148	0	1,070	1,834
1987	43	0	1,853	1,813	5,661	4,600	6,408	6,424	896	657	1,533	16	292	699
1988	78	13	1,241	1,182	5,008	3,802	5,732	5,734	1,587	1,180	995	0	(1,337)	(965)
1989	84	60	1,140	1,119	5,376	4,056	6,658	6,594	1,163	780	1,338	2	(829)	(272)
1990	122	83	1,036	998	4,141	3,927	5,845	5,675	1,328	959	321	0	(1,025)	(594)
1991	234	228	889	883	3,767	3,473	4,378	4,335	646	491	538	122	(301)	(4)
Average	190	158	3,708	3,686	5,051	4,909	12,363	12,220	586	332	614	44	2,037	2,413

Table A4–1. Continued

Water Year	DailySOS CVP & SWP Export (TAF)	DeltaSOS CVP & SWP Export (TAF)	DailySOS Available Flow (TAF)	DeltaSOS Available Flow (TAF)	DailySOS Carryover Delta Storage (TAF)	DeltaSOS Carryover Delta Storage (TAF)	DailySOS Delta Storage Diversion (TAF)	DeltaSOS Delta Storage Diversion (TAF)	DailySOS Delta Storage Export (TAF)	DeltaSOS Delta Storage Export (TAF)	DailySOS Final Total Export (TAF)	DeltaSOS Final Total Export (TAF)	DailySOS Final QWEST Flow (TAF)	DeltaSOS Final QWEST Flow (TAF)	DailySOS Final Delta Outflow (TAF)	DeltaSOS Final Delta Outflow (TAF)
1967	7,552	7,916	6,113	6,548	232	231	482	306	200	24	7,753	7,940	3,898	3,639	26,697	26,359
1968	5,371	5,823	1,234	1,215	0	0	117	11	334	236	5,705	6,059	(561)	(923)	9,370	9,117
1969	7,970	7,898	8,617	9,111	238	238	451	447	173	169	8,142	8,067	8,991	9,031	33,289	33,203
1970	6,167	6,503	5,088	5,641	110	0	127	128	234	223	6,401	6,726	2,323	1,914	26,032	25,656
1971	7,174	7,880	3,942	3,680	238	0	647	269	474	97	7,648	7,977	(800)	(1,119)	18,180	17,692
1972	5,552	6,067	691	671	48	(0)	98	55	273	238	5,825	6,305	(1,348)	(1,799)	6,999	6,624
1973	6,724	7,140	4,608	4,814	72	0	295	282	243	206	6,968	7,346	1,329	886	20,931	20,522
1974	7,537	8,141	7,145	7,312	238	179	486	261	281	55	7,818	8,196	1,851	1,500	33,772	33,323
1975	7,520	7,969	3,510	3,224	238	44	292	256	255	207	7,775	8,176	283	(50)	16,119	15,639
1976	5,128	5,264	1,176	1,148	0	0	6	6	244	244	5,373	5,508	(863)	(1,030)	6,261	6,129
1977	1,740	1,961	0	0	0	0	0	0	0	0	1,740	1,961	78	(158)	2,893	2,681
1978	5,825	6,270	4,090	4,052	173	0	465	419	267	234	6,092	6,504	3,268	2,700	19,508	18,917
1979	6,535	6,807	1,232	823	0	0	371	185	521	343	7,056	7,150	(76)	(270)	9,115	8,900
1980	7,367	7,857	5,510	6,014	106	0	426	359	291	218	7,659	8,074	4,186	3,791	24,924	24,772
1981	5,337	6,171	605	289	0	0	379	234	473	344	5,810	6,515	(923)	(1,717)	6,918	6,075
1982	7,488	8,019	8,900	9,220	238	238	487	285	204	0	7,692	8,019	6,449	5,862	37,822	37,163
1983	8,720	8,377	19,927	20,905	238	238	49	49	0	0	8,720	8,377	17,403	17,536	60,178	60,529
1984	7,289	7,176	7,938	8,400	238	0	264	258	231	236	7,520	7,412	5,058	5,192	26,743	26,853
1985	5,746	6,258	1,441	1,554	0	0	35	6	276	252	6,022	6,510	(304)	(813)	8,143	7,640
1986	6,348	7,120	5,862	6,209	193	0	575	489	349	228	6,696	7,348	4,639	3,777	28,819	27,896
1987	5,326	5,742	217	107	0	0	143	3	332	241	5,658	5,983	(741)	(1,126)	5,684	5,263
1988	4,243	4,646	474	451	0	0	287	234	298	244	4,541	4,890	(820)	(1,225)	5,469	5,058
1989	5,128	5,695	665	440	116	0	511	351	367	236	5,494	5,932	(1,395)	(1,948)	6,931	6,309
1990	4,773	5,218	212	93	0	0	181	93	299	210	5,072	5,428	(1,474)	(1,842)	4,826	4,447
1991	2,879	3,176	86	0	0	0	85	0	83	0	2,962	3,176	(18)	(422)	4,612	4,134
Average	6,058	6,444	3,971	4,077	109	47	290	199	268	179	6,326	6,623	2,017	1,655	18,009	17,636

Table A4–2. Comparison of DailySOS and DeltaSOS Monthly Results for Historical Inflows and Exports

Water Year	Historical Banks& Tracy Pumping (cfs)	Historical Sac Inflow (cfs)	Historical Yolo Bypass Flow (cfs)	Historical CCWD Pumping (cfs)	Historical Eastside Inflow (cfs)	Historical SJR Basin Inflow (cfs)	Historical Estimated Delta Depletion (cfs)	Historical Delta Outflow (cfs)
1968								
Oct	1,693	16,155	22	101	1,326	2,725	1,685	16,749
Nov	1,040	14,593	15	92	430	3,473	1,178	16,202
Dec	595	17,177	41	79	234	3,635	(86)	20,498
Jan	1,077	20,477	899	91	602	2,940	(507)	24,257
Feb	1,768	39,779	6,613	60	2,516	2,617	(2,364)	52,061
Mar	4,435	36,016	2,843	51	1,869	3,093	(979)	40,314
Apr	5,250	14,437	282	130	623	1,435	1,467	9,932
May	5,452	13,316	51	159	384	891	2,294	6,737
Jun	4,484	11,353	27	224	150	592	3,747	3,666
Jul	4,944	12,594	3	224	103	503	4,352	3,684
Aug	4,674	13,003	8	194	138	768	3,785	5,264
Sep	5,417	13,120	27	185	154	938	2,632	6,004
1969								
Oct	6,099	11,629	21	149	139	1,384	1,473	5,453
Nov	4,928	13,603	14	114	203	1,604	(738)	11,120
Dec	3,677	22,935	857	88	751	2,533	(2,371)	25,682
Jan	5,688	55,403	45,312	60	10,995	13,815	(4,827)	123,140
Feb	4,647	71,793	45,185	60	9,957	32,554	(4,146)	159,046
Mar	3,349	49,729	10,688	53	5,439	30,874	101	93,506
Apr	3,139	45,350	1,070	74	4,731	22,117	960	69,375
May	3,162	40,606	698	108	4,011	24,613	2,374	64,564
Jun	2,381	23,123	148	113	1,388	27,887	3,736	46,596
Jul	3,228	14,216	32	154	695	5,803	4,352	13,143
Aug	4,921	18,345	21	176	570	2,325	3,785	12,458
Sep	2,421	21,017	26	140	736	3,255	2,332	20,188
1970								
Oct	1,902	16,694	25	104	1,094	4,462	784	19,484
Nov	994	16,940	21	78	413	4,628	965	19,964
Dec	727	35,252	6,341	94	1,850	2,658	(910)	46,190
Jan	1,067	70,261	98,162	49	9,355	11,116	(5,343)	193,121
Feb	1,866	66,061	32,998	84	4,510	9,191	(515)	111,326
Mar	2,193	44,206	3,004	72	3,780	7,180	(81)	55,986
Apr	4,524	14,620	123	128	656	1,673	1,392	11,027
May	3,845	14,265	47	166	473	2,393	2,406	10,761
Jun	4,800	11,787	33	197	267	2,737	3,612	6,214
Jul	5,016	13,174	16	212	315	1,330	4,352	5,256
Aug	4,394	14,977	23	214	296	1,044	3,785	7,947
Sep	2,928	18,513	43	161	431	1,319	2,632	14,587

Table A4–2. Continued

Water Year	Historical Banks& Tracy Pumping (cfs)	Historical Sac Inflow (cfs)	Historical Yolo Bypass Flow (cfs)	Historical CCWD Pumping (cfs)	Historical Eastside Inflow (cfs)	Historical SJR Basin Inflow (cfs)	Historical Estimated Delta Depletion (cfs)	Historical Delta Outflow (cfs)
1971								
Oct	2,469	15,261	25	116	472	1,466	1,217	13,423
Nov	1,952	22,520	226	78	1,008	1,655	(2,738)	26,117
Dec	1,852	63,971	10,983	63	4,078	5,044	(3,207)	85,369
Jan	1,841	52,323	6,628	63	2,179	5,204	275	64,152
Feb	3,074	31,196	835	65	1,370	4,391	442	34,211
Mar	4,631	30,481	1,269	71	1,766	2,589	(665)	32,069
Apr	4,351	38,270	851	80	1,281	1,961	950	36,983
May	4,452	29,190	589	97	913	1,833	1,570	26,406
Jun	5,627	27,550	184	142	639	2,322	3,709	21,218
Jul	6,344	20,981	14	165	454	1,066	4,352	11,654
Aug	6,520	22,465	5	180	113	892	3,785	12,988
Sep	3,779	24,393	36	128	667	1,096	2,625	19,659
1972								
Oct	3,694	16,071	8	118	978	2,253	1,540	13,957
Nov	2,962	15,853	16	85	318	1,646	1,044	13,743
Dec	2,344	21,758	56	92	937	2,398	(1,252)	23,967
Jan	1,549	20,000	115	66	618	3,117	896	21,339
Feb	3,661	22,117	143	70	897	2,701	160	21,968
Mar	6,588	23,897	96	94	663	1,380	1,276	18,078
Apr	6,196	13,120	6	161	727	1,037	991	7,542
May	6,282	12,848	8	213	378	744	2,344	5,140
Jun	5,121	13,837	17	229	133	587	3,571	2,891
Jul	4,893	15,000	2	181	80	481	4,352	6,211
Aug	6,771	15,658	15	215	112	543	3,785	6,470
Sep	6,817	16,817	7	194	173	1,563	1,978	10,476
1973								
Oct	6,300	16,077	10	112	153	1,992	466	11,919
Nov	3,472	23,203	640	75	281	2,216	(2,912)	25,943
Dec	3,384	27,423	468	67	471	2,502	300	27,133
Jan	2,899	60,132	30,170	63	6,084	4,059	(4,203)	101,685
Feb	1,114	65,257	20,132	64	7,528	7,988	(2,438)	102,165
Mar	1,216	51,642	12,122	66	4,606	7,611	(2,208)	76,907
Apr	3,268	20,670	668	84	1,574	4,203	1,572	22,191
May	6,311	16,416	89	190	1,161	2,937	2,404	11,699
Jun	7,161	14,937	37	194	764	2,576	3,747	7,211
Jul	7,461	15,168	14	233	379	1,082	4,352	4,599
Aug	7,557	16,123	13	217	319	1,067	3,785	5,963
Sep	5,601	17,487	33	167	355	1,471	2,425	11,153

Table A4–2. Continued

Water Year	Historical Banks& Tracy Pumping (cfs)	Historical Sac Inflow (cfs)	Historical Yolo Bypass Flow (cfs)	Historical CCWD Pumping (cfs)	Historical Eastside Inflow (cfs)	Historical SJR Basin Inflow (cfs)	Historical Estimated Delta Depletion (cfs)	Historical Delta Outflow (cfs)
1974								
Oct	5,822	16,723	11	105	471	2,546	(246)	14,071
Nov	4,819	48,037	10,932	84	2,041	2,281	(1,557)	59,945
Dec	3,283	61,632	10,389	56	3,404	3,586	(732)	76,406
Jan	1,917	74,826	51,191	58	5,475	7,781	(1,400)	138,699
Feb	5,397	52,389	6,017	58	1,256	5,094	123	59,178
Mar	6,209	64,681	9,011	66	4,614	4,817	(727)	77,575
Apr	4,125	66,283	37,497	78	3,828	5,850	(291)	109,547
May	7,015	29,177	174	114	1,650	4,106	2,434	25,544
Jun	8,942	24,413	51	188	1,247	3,860	3,499	16,943
Jul	10,493	21,752	24	198	545	1,636	3,901	9,365
Aug	9,281	23,948	12	192	467	1,615	3,785	12,783
Sep	4,940	25,060	61	115	701	2,846	2,632	20,981
1975								
Oct	4,496	20,119	20	98	761	3,497	1,274	18,529
Nov	1,878	22,003	15	71	903	3,891	872	23,991
Dec	2,755	25,645	127	59	788	4,162	(110)	28,017
Jan	5,405	19,432	38	67	303	3,766	579	17,489
Feb	6,634	47,518	3,983	83	2,529	6,212	(3,805)	57,330
Mar	6,005	50,942	9,408	73	5,327	5,685	(1,551)	66,834
Apr	6,207	33,173	1,716	97	2,626	3,957	650	34,519
May	5,471	30,265	286	112	2,290	3,972	2,434	28,796
Jun	4,353	23,710	28	167	1,309	5,708	3,726	22,508
Jul	5,010	18,284	13	175	550	1,718	4,252	11,129
Aug	8,817	19,497	7	171	561	1,681	3,235	9,523
Sep	7,662	20,380	109	137	697	2,652	2,621	13,419
1976								
Oct	7,474	19,174	18	87	912	4,543	186	16,900
Nov	7,949	22,250	13	61	890	3,906	1,128	17,921
Dec	7,778	25,545	40	42	344	3,745	1,901	19,953
Jan	8,158	15,132	37	101	120	3,326	1,010	9,346
Feb	7,628	12,772	34	166	160	2,115	(208)	7,495
Mar	8,207	14,574	51	144	169	1,823	409	7,858
Apr	4,865	12,724	0	172	183	1,293	329	8,833
May	5,280	10,910	40	207	99	939	2,434	4,066
Jun	3,930	10,935	1	222	49	798	3,716	3,915
Jul	3,876	12,077	0	233	55	671	4,352	4,343
Aug	6,624	13,348	4	212	74	1,055	3,135	4,509
Sep	8,140	12,510	4	190	357	1,067	1,937	3,670

Table A4–2. Continued

Water Year	Historical Banks& Tracy Pumping (cfs)	Historical Sac Inflow (cfs)	Historical Yolo Bypass Flow (cfs)	Historical CCWD Pumping (cfs)	Historical Eastside Inflow (cfs)	Historical SJR Basin Inflow (cfs)	Historical Estimated Delta Depletion (cfs)	Historical Delta Outflow (cfs)
1977								
Oct	4,471	8,103	1	135	28	1,274	1,176	3,623
Nov	4,082	7,823	6	162	94	1,136	1,172	3,644
Dec	2,659	7,743	1	125	58	965	1,770	4,213
Jan	6,927	9,802	3	115	51	1,091	(461)	4,365
Feb	4,175	8,003	1	160	40	789	(426)	4,924
Mar	3,688	6,573	4	125	50	524	267	3,070
Apr	1,176	5,961	1	120	25	212	1,820	3,083
May	2,877	7,597	1	110	31	400	1,043	3,999
Jun	557	6,865	1	182	23	118	3,747	2,521
Jul	701	8,248	1	145	67	93	4,352	3,212
Aug	1,388	7,687	1	141	16	124	3,785	2,514
Sep	1,734	6,838	1	123	13	179	2,280	2,791
1978								
Oct	628	4,494	0	135	9	246	1,821	2,075
Nov	2,527	6,687	0	123	34	430	390	4,004
Dec	5,802	11,745	0	110	274	506	(1,945)	8,488
Jan	9,794	45,490	18,701	51	4,430	2,276	(5,159)	66,171
Feb	10,273	44,704	8,618	36	3,065	7,319	(2,764)	56,159
Mar	5,883	55,571	18,368	36	3,174	11,475	(2,874)	85,544
Apr	3,209	38,883	1,378	63	3,451	20,030	(806)	61,276
May	2,968	25,194	21	90	1,912	19,119	2,314	40,874
Jun	7,484	12,660	17	137	706	7,069	3,747	9,086
Jul	7,895	14,300	17	193	189	1,908	4,352	3,974
Aug	8,247	15,968	7	178	745	1,418	3,785	5,927
Sep	7,364	17,933	1	124	999	2,730	2,384	11,793
1979								
Oct	5,023	12,487	1	100	804	3,327	1,863	9,633
Nov	5,484	12,443	3	89	470	3,498	(87)	10,928
Dec	5,963	13,203	7	88	312	2,812	1,504	8,779
Jan	4,038	23,190	425	66	1,943	5,233	(3,835)	30,522
Feb	2,885	32,443	1,662	54	4,441	7,138	(3,597)	46,341
Mar	4,280	29,165	334	67	3,476	8,652	(807)	38,086
Apr	5,794	16,547	30	88	1,535	3,506	1,252	14,485
May	6,088	17,984	31	157	1,500	2,524	2,358	13,435
Jun	6,143	12,207	18	198	935	2,254	3,747	5,326
Jul	9,116	16,413	15	223	463	1,334	3,501	5,384
Aug	10,153	15,677	13	209	481	1,451	3,785	3,475
Sep	9,090	14,567	7	172	537	1,841	2,632	5,058

Table A4–2. Continued

Water Year	Historical Banks& Tracy Pumping (cfs)	Historical Sac Inflow (cfs)	Historical Yolo Bypass Flow (cfs)	Historical CCWD Pumping (cfs)	Historical Eastside Inflow (cfs)	Historical SJR Basin Inflow (cfs)	Historical Estimated Delta Depletion (cfs)	Historical Delta Outflow (cfs)
1980								
Oct	7,578	12,577	9	152	658	2,790	485	7,821
Nov	5,745	15,203	10	112	648	2,320	149	12,176
Dec	5,894	20,319	919	79	591	2,487	(685)	19,029
Jan	6,318	58,635	40,646	59	8,640	13,069	(3,598)	118,212
Feb	6,131	52,576	46,505	54	8,048	18,648	(2,061)	121,653
Mar	4,286	55,339	17,793	54	4,917	25,232	(230)	99,171
Apr	5,269	22,587	56	75	1,781	10,249	640	28,689
May	4,494	15,894	36	136	1,744	9,912	2,044	20,912
Jun	5,796	17,813	29	165	1,430	5,305	3,747	14,870
Jul	6,695	17,726	27	174	715	3,384	3,792	11,191
Aug	9,015	14,916	21	197	344	1,969	3,785	4,253
Sep	7,502	15,887	8	181	520	3,802	2,632	9,902
1981								
Oct	6,529	11,344	7	165	458	4,072	1,818	7,368
Nov	6,338	10,879	11	118	555	3,278	1,596	6,670
Dec	6,687	16,687	17	76	264	2,949	666	12,488
Jan	8,178	18,510	975	86	551	3,251	(3,304)	18,326
Feb	7,162	24,239	717	77	345	2,879	(234)	21,174
Mar	4,755	24,494	260	79	1,357	3,122	(2,069)	26,467
Apr	7,983	17,224	32	106	438	2,532	485	11,653
May	4,267	13,781	21	211	277	1,967	2,425	9,143
Jun	3,793	10,729	18	239	129	1,499	3,747	4,596
Jul	6,808	15,294	17	238	119	1,265	4,353	5,296
Aug	9,112	14,865	13	203	114	1,269	3,785	3,161
Sep	6,625	12,797	4	172	136	1,182	2,632	4,690
1982								
Oct	5,787	9,895	5	143	154	1,386	293	5,218
Nov	4,632	32,909	3,761	85	1,101	1,564	(1,352)	35,971
Dec	5,127	62,349	24,454	40	3,199	1,851	108	86,579
Jan	5,127	64,610	21,287	49	8,326	3,889	(4,771)	97,706
Feb	9,402	59,646	26,362	50	7,895	6,645	(1,673)	92,770
Mar	10,369	62,813	5,265	48	8,210	10,062	(4,156)	80,089
Apr	9,550	76,580	38,218	53	11,595	22,963	(2,450)	142,203
May	5,859	42,358	316	135	4,976	18,654	2,434	57,876
Jun	3,765	26,076	50	171	2,334	7,584	3,594	28,515
Jul	3,860	17,632	30	172	1,185	6,163	4,130	16,849
Aug	7,913	20,629	23	182	650	4,017	3,785	13,438
Sep	5,167	24,917	11	117	709	6,122	549	25,926

Table A4-2. Continued

Water Year	Historical Banks& Tracy Pumping (cfs)	Historical Sac Inflow (cfs)	Historical Yolo Bypass Flow (cfs)	Historical CCWD Pumping (cfs)	Historical Eastside Inflow (cfs)	Historical SJR Basin Inflow (cfs)	Historical Estimated Delta Depletion (cfs)	Historical Delta Outflow (cfs)
1983								
Oct	5,202	19,229	17	83	1,392	8,179	547	22,986
Nov	6,004	31,523	453	69	3,818	6,974	(2,457)	39,152
Dec	8,367	57,735	12,298	61	9,025	16,494	(1,814)	88,937
Jan	10,045	47,513	21,640	40	8,640	19,068	(2,979)	89,755
Feb	10,155	79,039	60,480	91	11,923	31,604	(2,956)	175,757
Mar	5,221	78,290	130,358	150	17,937	40,035	(5,438)	266,688
Apr	3,755	60,500	17,919	59	6,927	36,447	(131)	118,109
May	3,198	62,303	3,519	96	5,438	31,771	1,030	98,707
Jun	4,841	48,380	1,106	170	4,226	26,083	3,747	71,038
Jul	5,035	30,990	50	171	3,150	19,227	4,352	43,860
Aug	7,016	25,039	34	174	1,435	9,035	3,785	24,567
Sep	4,050	24,617	27	154	1,589	11,310	1,839	31,501
1984								
Oct	2,415	21,148	188	82	1,491	13,323	1,362	32,293
Nov	1,686	48,820	5,985	68	5,993	10,876	(4,217)	74,138
Dec	2,088	75,384	51,892	54	9,166	19,126	(2,033)	155,458
Jan	1,674	56,803	16,700	46	4,199	25,729	805	100,906
Feb	5,700	32,372	1,301	67	2,325	10,833	(452)	41,515
Mar	6,856	31,426	1,080	60	2,140	7,502	302	34,929
Apr	7,542	17,933	333	143	1,229	4,285	1,364	14,732
May	5,739	15,406	64	189	856	3,240	2,434	11,204
Jun	5,950	14,990	38	215	626	2,297	3,747	8,038
Jul	9,204	21,632	21	254	504	1,904	4,352	10,252
Aug	9,265	18,784	16	250	586	2,179	3,778	8,272
Sep	5,312	17,693	18	186	739	2,917	2,219	13,650
1985								
Oct	5,456	13,235	20	149	772	4,029	535	11,916
Nov	7,893	26,280	1,489	103	1,184	2,865	(2,130)	25,953
Dec	8,407	32,558	1,131	57	1,269	4,775	203	31,067
Jan	5,756	16,790	48	79	472	4,070	426	15,120
Feb	7,517	18,271	157	97	1,012	3,243	(522)	15,590
Mar	8,487	14,310	5	129	952	2,743	(1,040)	10,432
Apr	7,194	12,495	0	147	891	2,445	1,576	6,913
May	5,997	13,432	0	218	461	2,134	2,434	7,378
Jun	6,300	13,310	0	230	230	1,751	3,546	5,215
Jul	9,209	16,035	0	256	148	2,567	4,352	4,934
Aug	9,884	13,448	0	227	157	2,616	3,785	2,325
Sep	8,545	12,192	0	174	231	1,929	2,422	3,211

Table A4–2. Continued

Water Year	Historical Banks& Tracy Pumping (cfs)	Historical Sac Inflow (cfs)	Historical Yolo Bypass Flow (cfs)	Historical CCWD Pumping (cfs)	Historical Eastside Inflow (cfs)	Historical SJR Basin Inflow (cfs)	Historical Estimated Delta Depletion (cfs)	Historical Delta Outflow (cfs)
1986								
Oct	7,518	9,711	20	185	209	2,072	931	3,378
Nov	7,202	10,418	25	127	309	1,929	(1,539)	6,891
Dec	9,751	16,106	182	107	598	2,205	(197)	9,431
Jan	8,925	19,965	142	145	1,150	2,060	(963)	15,209
Feb	6,002	68,893	115,391	72	14,793	8,744	(7,415)	205,414
Mar	3,141	74,984	58,664	58	9,913	25,035	(3,082)	169,448
Apr	4,612	25,827	1,151	84	3,505	19,590	227	46,572
May	6,080	12,761	43	180	1,962	8,764	2,258	15,911
Jun	5,954	11,820	43	222	1,048	6,233	3,747	9,322
Jul	8,378	16,881	43	230	488	2,894	4,315	7,384
Aug	9,727	15,113	34	224	541	3,183	3,785	5,135
Sep	10,296	18,140	20	194	680	4,181	1,753	10,778
1987								
Oct	7,432	15,445	20	134	852	3,741	1,865	10,628
Nov	6,712	12,680	25	148	737	2,842	1,692	7,732
Dec	7,112	13,110	25	148	565	3,706	1,160	8,987
Jan	6,130	13,171	25	121	484	2,305	(1,085)	10,819
Feb	6,737	17,404	31	109	580	2,136	(3,554)	16,859
Mar	5,468	21,577	219	132	1,110	3,415	(2,194)	22,916
Apr	6,837	11,826	46	184	427	2,867	1,853	6,291
May	5,075	9,996	43	238	378	2,178	2,330	4,951
Jun	4,940	10,067	43	244	325	1,990	3,747	3,496
Jul	8,707	15,142	43	245	316	1,632	4,352	3,829
Aug	9,560	14,439	34	239	337	1,627	3,785	2,851
Sep	8,845	11,625	20	224	250	1,597	2,632	1,790
1988								
Oct	5,726	9,509	20	182	126	1,370	1,328	3,789
Nov	5,307	8,129	25	153	112	1,548	64	4,291
Dec	8,861	15,744	25	125	155	1,278	(1,239)	9,454
Jan	10,289	25,400	1,571	128	335	1,483	(1,222)	19,593
Feb	9,895	12,188	16	128	170	1,389	695	3,045
Mar	8,256	11,348	26	185	265	2,241	897	4,542
Apr	8,364	16,887	46	206	292	2,146	(700)	11,499
May	6,069	10,974	43	194	193	1,781	1,981	4,748
Jun	5,691	10,578	43	209	205	1,711	3,441	3,197
Jul	7,720	14,642	43	247	197	1,357	4,352	3,920
Aug	8,539	13,287	34	255	173	1,557	3,785	2,472
Sep	7,897	11,537	20	223	133	1,452	2,632	2,391

Table A4–2. Continued

Water Year	Historical Banks& Tracy Pumping (cfs)	Historical Sac Inflow (cfs)	Historical Yolo Bypass Flow (cfs)	Historical CCWD Pumping (cfs)	Historical Eastside Inflow (cfs)	Historical SJR Basin Inflow (cfs)	Historical Estimated Delta Depletion (cfs)	Historical Delta Outflow (cfs)
1989								
Oct	5,435	9,314	20	197	58	1,127	1,661	3,226
Nov	5,936	11,356	25	152	84	1,274	(9)	6,660
Dec	7,037	12,388	25	147	102	1,372	(556)	7,259
Jan	10,057	12,825	25	138	131	1,255	407	3,635
Feb	8,065	12,057	16	137	204	1,234	(1,095)	6,405
Mar	10,136	43,374	427	125	1,469	2,023	(1,919)	38,951
Apr	10,302	21,273	46	145	663	1,915	1,643	11,808
May	6,014	13,799	33	205	356	1,949	2,388	7,531
Jun	5,044	13,287	33	228	165	1,583	3,479	6,317
Jul	9,252	18,768	40	264	132	1,284	4,352	6,356
Aug	11,057	18,319	29	262	147	1,169	3,711	4,634
Sep	10,534	16,463	18	219	147	1,353	673	6,555
1990								
Oct	10,351	14,274	17	178	110	1,401	348	4,926
Nov	10,224	14,830	25	154	244	1,404	622	5,503
Dec	10,297	15,397	25	146	142	1,381	2,081	4,422
Jan	10,484	18,910	25	137	179	1,242	(177)	9,913
Feb	10,405	13,804	20	148	285	1,365	(1,894)	6,815
Mar	10,405	12,868	26	153	482	1,760	672	3,906
Apr	9,465	15,271	46	201	340	1,309	1,259	6,041
May	3,175	10,402	33	217	285	1,279	771	7,837
Jun	3,276	10,519	33	215	233	1,116	3,410	4,999
Jul	6,007	13,506	33	238	163	1,009	4,352	4,115
Aug	6,446	13,839	26	230	176	1,033	3,785	4,612
Sep	5,692	10,029	36	226	164	876	2,594	2,594
1991								
Oct	3,364	7,620	15	185	234	993	1,816	3,498
Nov	3,708	7,723	26	149	202	1,115	650	4,558
Dec	5,057	10,818	25	148	65	918	196	6,425
Jan	4,766	8,984	25	146	69	816	969	4,013
Feb	4,384	8,133	16	137	86	758	(2,948)	7,420
Mar	9,652	25,755	893	111	1,225	1,779	(4,737)	24,626
Apr	7,399	10,879	46	100	509	1,168	1,316	3,787
May	2,555	7,332	43	130	471	1,049	2,212	3,998
Jun	1,770	8,930	43	155	269	568	3,716	4,169
Jul	2,401	9,514	43	173	181	594	4,279	3,479
Aug	3,650	9,515	34	167	166	537	3,739	2,696
Sep	4,074	9,948	36	161	192	574	2,632	3,884

Table A4–2. Continued

Water Year	DailySOS Added SJR Flow (cfs)	DeltaSOS Added SJR Flow (cfs)	DailySOS New SJR Flow (cfs)	DeltaSOS New SJR Flow (cfs)	DailySOS Required Delta Outflow (cfs)	DeltaSOS Required Delta Outflow (cfs)	DailySOS Export Limits for Inflow (cfs)	DeltaSOS Direct Export Limits (cfs)	DailySOS Reduced Export for Objectives (cfs)	DeltaSOS Reduced Export for Objectives (cfs)	DailySOS Outflow Deficit (cfs)	DeltaSOS Outflow Deficit (cfs)	DailySOS Net Export Change (cfs)	DeltaSOS Net Export Change (cfs)
1968														
Oct	0	0	2,725	2,730	4,000	4,000	13,148	13,172	0	0	0	0	9,587	9,584
Nov	0	0	3,473	3,479	4,500	4,500	12,033	12,052	0	0	0	0	10,207	10,238
Dec	0	0	3,635	3,641	4,500	4,500	13,706	13,731	0	0	0	0	10,919	10,903
Jan	0	0	2,940	2,946	4,500	5,225	16,197	16,226	0	0	0	0	10,629	10,773
Feb	89	0	2,706	2,715	18,531	11,271	18,864	18,711	64	0	518	0	7,066	9,941
Mar	1	0	3,094	3,099	7,813	24,947	15,338	15,365	135	0	208	0	6,404	6,964
Apr	2,436	2,203	3,871	3,641	19,265	14,236	6,133	5,550	3,065	3,258	6,253	1,027	(3,065)	(3,258)
May	1,759	2,687	2,650	3,580	12,168	7,580	4,863	5,250	3,480	835	2,403	0	(3,238)	(835)
Jun	811	828	1,403	1,420	6,014	8,534	4,656	4,539	2,002	2,492	478	2,421	(1,914)	(2,492)
Jul	397	396	900	900	6,419	6,500	8,840	8,855	2,670	2,608	0	0	(2,658)	(2,608)
Aug	159	130	928	900	3,968	4,000	9,150	9,147	32	0	0	0	1,355	2,731
Sep	12	0	950	940	3,000	3,000	9,263	9,270	66	0	0	0	3,030	3,739
1969														
Oct	208	113	1,593	1,500	4,000	4,000	8,698	8,652	249	0	0	0	1,300	1,657
Nov	0	0	1,604	1,607	4,500	4,500	10,026	10,042	0	0	0	0	4,714	5,106
Dec	0	0	2,533	2,537	4,500	4,500	17,599	17,631	0	0	0	0	7,315	7,628
Jan	0	0	13,815	13,839	4,500	5,092	81,591	81,736	0	0	0	0	7,476	7,002
Feb	0	0	32,554	32,611	7,100	21,409	55,821	55,919	0	0	0	0	9,853	8,045
Mar	0	0	30,874	30,929	7,100	10,250	33,855	33,916	0	0	0	0	9,282	8,345
Apr	0	0	22,117	22,152	7,100	7,580	23,400	23,918	0	0	0	0	8,141	8,136
May	0	0	24,613	24,657	4,000	10,241	23,212	24,518	0	0	0	0	8,118	8,113
Jun	0	0	27,887	27,931	4,000	7,580	18,391	18,421	0	0	0	0	8,850	8,895
Jul	0	0	5,803	5,813	8,329	8,000	13,485	13,509	160	0	0	0	4,525	5,238
Aug	0	0	2,325	2,329	4,000	4,000	13,820	13,844	0	0	0	0	6,205	6,350
Sep	0	0	3,255	3,260	3,000	3,000	16,272	16,298	0	0	0	0	8,859	8,855
1970														
Oct	0	0	4,462	4,470	4,000	4,000	14,478	14,504	0	0	0	0	9,378	9,375
Nov	0	0	4,628	4,635	4,500	4,500	14,301	14,324	0	0	0	0	10,286	10,285
Dec	317	0	2,976	2,663	4,500	4,500	30,172	30,019	0	0	0	0	10,552	10,604
Jan	0	0	11,116	11,136	4,500	4,500	122,782	123,000	0	0	0	0	12,280	11,631
Feb	0	0	9,191	9,207	7,100	13,933	39,466	39,535	0	0	0	0	12,015	10,831
Mar	18	0	7,198	7,192	7,100	10,123	20,366	20,396	0	0	0	0	10,086	9,503
Apr	3,667	3,545	5,340	5,220	25,775	9,868	7,259	6,595	2,580	0	13,524	0	(1,983)	1,022
May	2,763	2,823	5,156	5,220	18,735	7,580	6,435	6,381	1,579	0	7,955	0	(1,080)	2,529
Jun	130	0	2,867	2,741	14,120	10,970	5,234	5,197	3,115	2,808	4,808	2,038	(3,090)	(2,808)
Jul	0	0	1,330	1,333	8,110	8,000	9,643	9,660	2,695	2,532	80	0	(2,695)	(2,532)
Aug	0	0	1,044	1,046	4,000	4,000	10,622	10,640	0	0	0	0	3,999	4,833
Sep	0	0	1,319	1,321	3,000	3,000	13,200	13,221	0	0	0	0	8,352	8,347

Table A4–2. Continued

Water Year	DailySOS Added SJR Flow (cfs)	DeltaSOS Added SJR Flow (cfs)	DailySOS New SJR Flow (cfs)	DeltaSOS New SJR Flow (cfs)	DailySOS Required Delta Outflow (cfs)	DeltaSOS Required Delta Outflow (cfs)	DailySOS Export Limits for Inflow (cfs)	DeltaSOS Direct Export Limits (cfs)	DailySOS Reduced Export for Objectives (cfs)	DeltaSOS Reduced Export for Objectives (cfs)	DailySOS Outflow Deficit (cfs)	DeltaSOS Outflow Deficit (cfs)	DailySOS Net Export Change (cfs)	DeltaSOS Net Export Change (cfs)
1971														
Oct	94	31	1,560	1,500	4,000	4,000	11,257	11,236	0	0	0	0	8,466	8,763
Nov	0	0	1,655	1,658	4,500	4,500	16,516	16,542	0	0	0	0	9,280	9,325
Dec	0	0	5,044	5,053	4,500	4,500	54,649	54,747	0	0	0	0	10,092	9,845
Jan	0	0	5,204	5,213	6,000	4,500	43,116	43,193	0	0	0	0	10,756	10,756
Feb	0	0	4,391	4,399	7,889	21,052	13,227	13,250	102	0	246	0	8,164	9,252
Mar	0	0	2,589	2,594	24,483	13,885	12,637	12,659	1,686	0	4,024	0	865	6,682
Apr	2,025	1,916	3,987	3,880	7,884	20,281	11,482	10,221	68	0	225	0	3,703	4,022
May	1,997	2,044	3,830	3,880	5,626	9,683	8,644	8,520	89	0	223	0	3,552	3,920
Jun	219	0	2,541	2,326	13,240	7,580	10,820	10,761	701	0	409	0	1,813	5,125
Jul	240	0	1,306	1,068	8,000	8,000	14,790	14,661	0	0	0	0	3,238	3,877
Aug	50	7	941	900	4,000	4,000	15,290	15,290	0	0	0	0	4,751	4,748
Sep	1	0	1,096	1,097	3,000	3,000	17,025	17,052	0	0	0	0	7,501	7,494
1972														
Oct	0	0	2,253	2,257	4,000	4,000	12,551	12,574	0	0	0	0	7,564	7,579
Nov	0	0	1,646	1,649	4,500	4,500	11,591	11,610	0	0	0	0	7,762	8,313
Dec	0	0	2,398	2,403	4,500	4,500	16,347	16,377	0	0	0	0	9,038	8,941
Jan	0	0	3,117	3,122	4,500	4,500	15,502	15,530	0	0	0	0	10,360	10,359
Feb	136	0	2,838	2,803	8,624	11,324	10,145	9,390	175	0	101	0	5,681	5,592
Mar	904	898	2,284	2,280	17,794	9,933	9,429	9,443	2,165	0	1,337	0	(1,304)	2,843
Apr	2,683	2,603	3,720	3,641	15,629	9,848	5,262	5,288	3,343	2,833	5,951	0	(3,157)	(2,833)
May	1,850	1,974	2,594	2,720	9,923	7,580	4,699	4,579	3,464	2,630	2,324	0	(3,387)	(2,630)
Jun	816	832	1,403	1,420	11,683	6,845	5,569	5,400	3,586	1,309	3,159	0	(3,011)	(1,309)
Jul	419	418	900	900	6,419	6,500	10,389	10,406	719	149	0	0	(204)	(149)
Aug	357	356	900	900	3,968	4,000	10,845	10,863	0	0	0	0	1,648	2,438
Sep	77	0	1,641	1,566	3,000	3,000	12,114	12,083	0	0	0	0	4,282	4,453
1973														
Oct	2	0	1,994	1,995	4,000	4,000	11,852	11,872	0	0	0	0	4,924	4,969
Nov	0	0	2,216	2,220	4,500	4,500	17,121	17,149	0	0	0	0	7,634	7,802
Dec	0	0	2,502	2,506	4,500	4,500	20,062	20,097	0	0	0	0	7,943	7,916
Jan	0	0	4,059	4,066	6,000	4,500	65,289	65,405	0	0	0	0	9,320	9,318
Feb	0	0	7,988	8,002	7,100	19,995	35,317	35,379	0	0	0	0	12,316	11,584
Mar	0	0	7,611	7,625	7,100	12,499	26,593	26,641	0	0	0	0	10,913	10,482
Apr	2,205	1,010	6,408	5,220	15,761	8,556	8,904	8,124	1,059	0	3,129	0	3,323	4,851
May	2,489	2,278	5,426	5,220	15,381	7,580	7,765	7,206	1,920	0	6,626	0	(1,154)	884
Jun	740	840	3,316	3,420	11,278	7,580	6,668	6,714	3,889	459	1,776	0	(3,734)	(459)
Jul	0	0	1,082	1,084	8,000	8,000	10,818	10,838	3,323	3,191	0	0	(3,323)	(3,191)
Aug	0	0	1,067	1,069	4,000	4,000	11,389	11,410	0	0	0	0	2,023	2,845
Sep	0	0	1,471	1,473	3,000	3,000	12,575	12,595	0	0	0	0	5,679	5,670

Table A4–2. Continued

Water Year	DailySOS Added SJR Flow (cfs)	DeltaSOS Added SJR Flow (cfs)	DailySOS New SJR Flow (cfs)	DeltaSOS New SJR Flow (cfs)	DailySOS Required Delta Outflow (cfs)	DeltaSOS Required Delta Outflow (cfs)	DailySOS Export Limits for Inflow (cfs)	DeltaSOS Direct Export Limits (cfs)	DailySOS Reduced Export for Objectives (cfs)	DeltaSOS Reduced Export for Objectives (cfs)	DailySOS Outflow Deficit (cfs)	DeltaSOS Outflow Deficit (cfs)	DailySOS Net Export Change (cfs)	DeltaSOS Net Export Change (cfs)
1974														
Oct	0	0	2,546	2,551	4,000	4,000	12,838	12,861	0	0	0	0	5,458	5,448
Nov	26	0	2,307	2,285	4,500	4,500	41,156	41,205	0	0	0	0	6,461	6,453
Dec	0	0	3,586	3,593	4,500	4,500	51,358	51,449	0	0	0	0	8,343	8,202
Jan	0	0	7,781	7,795	6,000	4,500	90,528	90,689	0	0	0	0	11,531	10,780
Feb	0	0	5,094	5,102	7,100	13,106	22,665	22,704	0	0	0	0	7,164	7,157
Mar	0	0	4,817	4,826	7,100	10,633	29,093	29,145	0	0	0	0	5,490	5,480
Apr	2,180	161	8,030	6,020	7,100	15,895	32,318	23,770	0	0	0	0	5,737	5,819
May	2,232	1,906	6,338	6,020	5,626	10,030	10,470	10,343	439	0	12	0	2,305	2,922
Jun	387	0	4,247	3,866	27,520	7,580	10,485	10,366	6,582	0	4,281	0	(6,582)	1,410
Jul	500	0	2,137	1,639	9,890	8,000	15,897	15,600	1,673	0	483	0	(1,391)	769
Aug	0	0	1,615	1,618	4,000	4,000	16,927	16,957	0	0	0	0	1,999	1,982
Sep	0	0	2,846	2,850	3,000	3,000	18,634	18,664	0	0	0	0	6,340	6,332
1975														
Oct	10	0	3,507	3,503	4,000	4,000	15,865	15,887	0	0	0	0	6,784	6,776
Nov	0	0	3,891	3,897	4,500	4,500	17,428	17,456	0	0	0	0	9,402	9,399
Dec	0	0	4,162	4,169	4,500	4,500	19,969	20,004	0	0	0	0	8,801	8,829
Jan	0	0	3,766	3,773	6,000	4,500	15,301	15,328	0	0	0	0	6,718	6,711
Feb	0	0	6,212	6,223	7,100	10,703	25,475	21,121	0	0	0	0	6,212	6,055
Mar	0	0	5,685	5,695	9,146	20,210	24,976	25,021	0	0	0	0	5,586	5,684
Apr	2,895	2,057	6,852	6,020	7,268	18,011	12,795	11,484	0	0	0	0	3,655	3,733
May	2,501	2,041	6,472	6,020	10,966	8,642	10,764	10,666	341	0	162	0	3,480	4,470
Jun	237	0	5,945	5,717	21,640	10,602	10,847	10,781	1,314	0	967	0	191	6,421
Jul	136	0	1,855	1,721	8,000	8,000	13,456	13,391	0	0	0	0	3,207	3,332
Aug	0	0	1,681	1,684	4,000	4,000	14,135	14,160	0	0	0	0	2,463	2,447
Sep	0	0	2,652	2,657	3,000	3,000	15,495	15,520	0	0	0	0	3,618	3,606
1976														
Oct	0	0	4,543	4,551	4,000	4,000	16,020	16,049	0	0	0	0	3,806	3,793
Nov	0	0	3,906	3,912	4,500	4,500	17,588	17,617	0	0	0	0	3,331	3,318
Dec	0	0	3,745	3,752	4,500	4,500	19,288	19,322	0	0	0	0	3,815	3,726
Jan	0	0	3,326	3,332	4,500	4,500	12,100	12,121	42	0	0	0	3,014	3,807
Feb	0	0	2,115	2,194	9,386	11,400	6,722	7,041	1,614	4,267	1,603	0	(1,520)	(4,267)
Mar	0	0	1,823	1,826	11,377	8,068	5,816	5,826	3,703	2,395	986	0	(3,703)	(2,395)
Apr	1,134	710	2,427	2,005	7,283	9,967	4,224	3,975	1,503	2,322	279	0	(1,027)	(2,322)
May	976	1,064	1,915	2,005	5,247	4,000	3,733	3,649	2,335	1,640	0	0	(2,335)	(1,640)
Jun	104	101	901	900	6,870	4,000	4,274	4,166	2,100	110	788	0	(2,098)	(110)
Jul	229	228	900	900	3,968	4,000	8,471	8,485	10	0	0	0	453	553
Aug	24	0	1,079	1,057	3,000	3,500	9,428	9,429	26	0	0	0	1,371	1,661
Sep	11	0	1,078	1,068	3,000	3,000	9,067	9,074	158	0	0	0	97	921

Table A4–2. Continued

Water Year	DailySOS Added SJR Flow (cfs)	DeltaSOS Added SJR Flow (cfs)	DailySOS New SJR Flow (cfs)	DeltaSOS New SJR Flow (cfs)	DailySOS Required Delta Outflow (cfs)	DeltaSOS Required Delta Outflow (cfs)	DailySOS Export Limits for Inflow (cfs)	DeltaSOS Direct Export Limits (cfs)	DailySOS Reduced Export for Objectives (cfs)	DeltaSOS Reduced Export for Objectives (cfs)	DailySOS Outflow Deficit (cfs)	DeltaSOS Outflow Deficit (cfs)	DailySOS Net Export Change (cfs)	DeltaSOS Net Export Change (cfs)
1977														
Oct	0	0	1,274	1,276	3,000	3,000	6,114	6,124	249	0	0	0	145	560
Nov	0	0	1,136	1,138	3,500	3,500	5,888	5,898	493	0	0	0	(6)	453
Dec	13	0	977	967	3,500	3,500	5,707	5,709	98	0	0	0	537	1,593
Jan	0	0	1,091	1,093	4,500	4,500	7,115	7,128	1,544	493	0	0	(1,011)	(493)
Feb	173	110	961	900	7,889	7,100	4,053	4,031	2,153	2,182	1,179	948	(2,047)	(2,182)
Mar	376	375	900	900	7,100	7,100	2,634	2,638	1,931	1,695	2,284	2,869	(1,931)	(1,695)
Apr	1,867	1,793	2,079	2,005	7,100	7,100	2,755	2,414	135	0	3,831	3,872	(135)	0
May	1,570	1,605	1,969	2,005	6,800	4,000	2,909	2,990	1,118	779	1,985	0	(1,033)	(779)
Jun	782	782	900	900	4,000	4,000	2,726	2,730	0	0	1,410	1,491	0	0
Jul	807	807	900	900	4,000	4,000	5,991	6,000	54	0	693	547	(17)	0
Aug	776	776	900	900	3,000	3,500	5,593	5,601	312	0	297	78	(129)	0
Sep	721	721	900	900	3,000	3,000	5,039	5,046	222	0	161	0	80	591
1978														
Oct	754	753	1,000	1,000	3,000	3,000	3,577	3,582	0	0	892	353	48	0
Nov	470	470	900	900	3,500	3,500	4,954	4,961	414	0	112	0	310	289
Dec	394	393	900	900	3,500	3,500	8,398	8,412	426	0	211	0	467	2,600
Jan	70	0	2,345	2,280	4,500	6,000	46,128	46,165	69	0	0	0	1,530	1,821
Feb	319	0	7,638	7,331	7,100	7,486	22,408	22,336	127	0	0	0	2,546	2,409
Mar	0	0	11,475	11,495	7,100	17,509	31,006	31,061	0	0	0	0	6,304	5,807
Apr	0	0	20,030	20,062	7,100	13,194	22,238	21,204	0	0	0	0	8,071	8,066
May	0	0	19,119	19,153	5,132	7,580	17,981	16,215	80	0	2	0	7,942	8,307
Jun	4	0	7,074	7,081	17,285	7,580	7,160	7,170	3,999	326	5,550	0	(3,999)	(326)
Jul	0	0	1,908	1,911	8,548	8,000	10,669	10,688	4,318	3,816	178	0	(4,318)	(3,816)
Aug	0	0	1,418	1,421	4,000	4,000	11,790	11,811	0	0	0	0	1,784	2,809
Sep	0	0	2,730	2,735	3,000	3,000	14,081	14,104	0	0	0	0	3,916	3,905
1979														
Oct	0	0	3,327	3,333	4,000	4,000	10,803	10,822	0	0	0	0	5,176	5,790
Nov	0	0	3,498	3,503	4,500	4,500	10,669	10,686	0	0	0	0	4,582	5,194
Dec	0	0	2,812	2,817	4,500	4,500	10,618	10,636	0	0	0	0	4,005	4,662
Jan	0	0	5,233	5,243	4,500	4,500	20,014	20,050	0	0	0	0	8,202	8,564
Feb	0	0	7,138	7,150	9,468	11,398	20,557	16,017	0	0	0	0	8,276	9,810
Mar	0	0	8,652	8,667	9,952	7,436	14,569	14,595	0	0	0	0	7,698	7,412
Apr	2,526	1,708	6,032	5,220	13,749	15,049	8,077	7,283	1,259	499	1,245	0	(7)	(499)
May	2,837	2,692	5,361	5,220	12,511	8,223	7,948	7,530	853	0	1,808	0	476	1,431
Jun	576	1,163	2,830	3,420	10,478	9,776	5,596	5,810	3,716	4,153	1,811	355	(3,707)	(4,153)
Jul	0	0	1,334	1,336	6,658	6,500	11,846	11,867	1,908	1,707	23	0	(1,588)	(1,707)
Aug	0	0	1,451	1,454	4,000	4,000	11,455	11,475	931	0	0	0	(464)	353
Sep	0	0	1,841	1,844	3,000	3,000	11,019	11,036	0	0	0	0	1,763	1,932

Table A4–2. Continued

Water Year	DailySOS Added SJR Flow (cfs)	DeltaSOS Added SJR Flow (cfs)	DailySOS New SJR Flow (cfs)	DeltaSOS New SJR Flow (cfs)	DailySOS Required Delta Outflow (cfs)	DeltaSOS Required Delta Outflow (cfs)	DailySOS Export Limits for Inflow (cfs)	DeltaSOS Direct Export Limits (cfs)	DailySOS Reduced Export for Objectives (cfs)	DeltaSOS Reduced Export for Objectives (cfs)	DailySOS Outflow Deficit (cfs)	DeltaSOS Outflow Deficit (cfs)	DailySOS Net Export Change (cfs)	DeltaSOS Net Export Change (cfs)
1980														
Oct	0	0	2,790	2,795	4,000	4,000	10,423	10,441	0	0	0	0	2,410	2,850
Nov	0	0	2,320	2,324	4,500	4,500	11,818	11,837	0	0	0	0	4,731	5,526
Dec	0	0	2,487	2,491	4,500	4,500	15,806	15,834	0	0	0	0	4,977	5,399
Jan	0	0	13,069	13,092	6,000	5,266	78,644	78,784	0	0	0	0	7,305	6,370
Feb	0	0	18,648	19,348	7,100	22,183	51,171	45,674	0	0	0	0	8,352	6,339
Mar	0	0	25,232	25,277	7,100	12,796	36,148	36,213	0	0	0	0	8,241	7,406
Apr	0	0	10,249	10,266	10,335	7,580	11,511	11,210	446	0	518	0	4,081	5,496
May	0	0	9,912	9,930	24,323	7,580	9,784	9,672	2,136	0	4,156	0	(1,345)	5,170
Jun	0	0	5,305	5,314	8,333	7,580	8,858	8,616	599	0	1,854	0	1,804	2,811
Jul	0	0	3,384	3,390	7,871	8,000	14,204	14,229	0	0	0	0	2,878	3,064
Aug	0	0	1,969	1,973	3,968	4,000	11,213	11,233	286	0	0	0	344	1,132
Sep	0	0	3,802	3,808	3,000	3,000	13,141	13,162	0	0	0	0	3,778	3,766
1981														
Oct	0	0	4,072	4,080	4,000	4,000	10,322	10,341	24	0	0	0	2,826	3,792
Nov	0	0	3,278	3,283	4,500	4,500	9,570	9,585	0	0	0	0	2,158	2,842
Dec	0	0	2,949	2,955	4,500	4,500	12,946	12,969	0	0	0	0	4,175	4,683
Jan	0	0	3,251	3,256	4,500	4,500	15,136	15,163	181	0	0	0	2,122	3,762
Feb	14	0	2,893	2,884	10,257	11,400	12,687	9,880	758	0	1,217	0	2,264	2,706
Mar	6	0	3,128	3,127	12,803	10,351	10,234	10,250	820	0	1,172	0	3,214	5,486
Apr	1,239	1,105	3,772	3,641	22,570	9,020	6,820	5,962	5,188	2,034	8,072	0	(5,021)	(2,034)
May	1,493	1,610	3,459	3,580	15,441	7,580	5,606	5,307	1,827	0	5,124	0	(1,366)	1,033
Jun	19	0	1,518	1,501	8,816	6,428	4,338	4,338	1,842	1,799	2,309	92	(1,842)	(1,799)
Jul	0	0	1,265	1,267	5,000	5,000	10,852	10,871	154	0	0	0	374	509
Aug	0	0	1,269	1,272	3,500	3,500	10,570	10,589	584	0	0	0	(279)	538
Sep	0	0	1,182	1,184	3,000	3,000	9,177	9,192	0	0	0	0	1,715	2,540
1982														
Oct	169	111	1,556	1,500	4,000	4,000	7,547	7,522	517	0	0	0	449	582
Nov	4	0	1,568	1,567	4,500	4,500	25,571	25,609	58	0	0	0	4,257	6,641
Dec	61	0	1,912	1,854	4,500	4,500	59,744	59,811	0	0	0	0	6,088	6,059
Jan	0	0	3,889	3,896	6,000	4,500	63,773	63,886	0	0	0	0	7,037	7,030
Feb	3	0	6,648	6,657	7,100	14,623	35,193	35,254	0	0	0	0	3,672	3,282
Mar	0	0	10,062	10,080	7,100	13,669	30,222	30,276	5	0	0	0	2,007	1,313
Apr	0	0	22,963	23,000	7,100	10,265	40,913	37,679	0	0	0	0	1,730	1,715
May	0	0	18,654	18,687	4,000	10,460	21,041	20,967	0	0	0	0	5,421	5,410
Jun	0	0	7,584	7,596	7,360	7,580	12,615	12,636	192	0	542	0	6,260	7,509
Jul	0	0	6,163	6,174	20,310	8,000	16,257	16,286	624	0	4,751	0	1,323	7,413
Aug	0	0	4,017	4,024	4,000	4,000	16,457	16,487	0	0	0	0	3,367	3,353
Sep	0	0	6,122	6,132	3,000	3,000	20,643	20,676	0	0	0	0	6,113	6,105

Table A4–2. Continued

Water Year	DailySOS Added SJR Flow (cfs)	DeltaSOS Added SJR Flow (cfs)	DailySOS New SJR Flow (cfs)	DeltaSOS New SJR Flow (cfs)	DailySOS Required Delta Outflow (cfs)	DeltaSOS Required Delta Outflow (cfs)	DailySOS Export Limits for Inflow (cfs)	DeltaSOS Direct Export Limits (cfs)	DailySOS Reduced Export for Objectives (cfs)	DeltaSOS Reduced Export for Objectives (cfs)	DailySOS Outflow Deficit (cfs)	DeltaSOS Outflow Deficit (cfs)	DailySOS Net Export Change (cfs)	DeltaSOS Net Export Change (cfs)
1983														
Oct	0	0	8,179	8,194	4,000	4,000	18,731	18,765	0	0	0	0	6,078	6,069
Nov	0	0	6,974	6,986	4,500	4,500	27,800	27,844	0	0	0	0	5,276	5,267
Dec	0	0	16,494	16,523	4,500	4,500	62,109	62,219	0	0	0	0	4,498	3,318
Jan	0	0	19,068	19,102	6,000	4,500	62,959	63,071	0	0	0	0	4,455	2,637
Feb	0	0	31,604	31,659	7,100	15,007	64,066	64,178	0	0	0	0	4,345	2,528
Mar	0	0	40,035	40,107	7,100	8,552	93,317	93,484	0	0	0	0	7,411	6,470
Apr	0	0	36,447	36,505	7,100	7,580	42,560	39,601	0	0	0	0	7,525	7,519
May	0	0	31,771	31,828	4,000	7,844	32,736	33,976	0	0	0	0	8,082	8,076
Jun	0	0	26,083	26,125	4,000	9,397	27,928	27,973	0	0	0	0	6,439	6,431
Jul	0	0	19,227	19,262	8,000	8,000	34,722	34,783	0	0	0	0	6,245	6,236
Aug	0	0	9,035	9,051	4,000	4,000	23,103	23,144	0	0	0	0	4,264	4,251
Sep	0	0	11,310	11,328	3,000	3,000	24,403	24,442	0	0	0	0	7,230	7,224
1984														
Oct	0	0	13,323	13,346	4,000	4,000	23,498	23,540	0	0	0	0	8,865	8,861
Nov	0	0	10,876	10,894	4,500	4,500	46,588	46,663	0	0	0	0	9,594	9,591
Dec	0	0	19,126	19,160	4,500	4,500	101,119	101,299	0	0	0	0	10,777	9,608
Jan	0	0	25,729	25,775	6,000	4,500	67,230	67,350	0	0	0	0	12,826	11,023
Feb	0	0	10,833	11,240	7,100	11,954	16,391	17,006	0	0	0	0	8,067	6,786
Mar	0	0	7,502	7,515	9,177	15,536	14,752	14,778	0	0	0	0	4,957	4,832
Apr	1,708	928	5,993	5,220	21,349	19,623	8,410	7,526	4,059	4,949	6,045	0	(3,410)	(4,949)
May	1,886	1,975	5,126	5,220	12,473	7,580	7,052	6,921	1,829	0	5,009	0	(408)	1,172
Jun	1,076	1,120	3,373	3,420	18,406	9,599	6,866	6,684	3,641	1,582	7,005	0	(3,511)	(1,582)
Jul	0	0	1,904	1,907	7,871	8,000	15,640	15,667	9	0	0	0	1,816	2,060
Aug	0	0	2,179	2,183	3,968	4,000	14,018	14,042	0	0	0	0	2,008	1,998
Sep	0	0	2,917	2,922	3,000	3,000	13,889	13,911	0	0	0	0	5,968	5,959
1985														
Oct	0	0	4,029	4,037	4,000	4,000	11,737	11,758	0	0	0	0	5,578	5,814
Nov	0	0	2,865	2,870	4,500	4,500	20,682	20,715	0	0	0	0	3,350	3,374
Dec	0	0	4,775	4,783	4,500	4,500	25,827	25,873	0	0	0	0	3,427	3,271
Jan	0	0	4,070	4,078	6,000	4,500	13,898	13,922	0	0	0	0	6,389	6,459
Feb	0	0	3,243	3,248	11,046	10,885	7,939	7,953	1,601	0	2,025	0	(736)	422
Mar	0	0	2,743	2,747	22,071	10,306	6,303	6,314	5,765	2,188	6,703	0	(5,763)	(2,188)
Apr	1,262	1,192	3,707	3,641	11,467	8,842	5,280	5,207	3,700	1,999	1,369	0	(3,696)	(1,999)
May	801	582	2,935	2,720	4,239	7,993	4,923	4,694	1,244	1,314	62	0	(1,156)	(1,314)
Jun	8	0	1,759	1,754	5,192	6,454	5,355	5,361	1,685	1,397	71	0	(1,531)	(1,397)
Jul	0	0	2,567	2,572	5,000	5,000	12,188	12,210	303	0	0	0	12	144
Aug	0	0	2,616	2,621	3,500	3,500	10,544	10,563	1,205	299	0	0	(1,115)	(299)
Sep	0	0	1,929	1,932	3,000	3,000	9,329	9,344	367	0	0	0	(28)	785

Table A4–2. Continued

Water Year	DailySOS Added SJR Flow (cfs)	DeltaSOS Added SJR Flow (cfs)	DailySOS New SJR Flow (cfs)	DeltaSOS New SJR Flow (cfs)	DailySOS Required Delta Outflow (cfs)	DeltaSOS Required Delta Outflow (cfs)	DailySOS Export Limits for Inflow (cfs)	DeltaSOS Direct Export Limits (cfs)	DailySOS Reduced Export for Objectives (cfs)	DeltaSOS Reduced Export for Objectives (cfs)	DailySOS Outflow Deficit (cfs)	DeltaSOS Outflow Deficit (cfs)	DailySOS Net Export Change (cfs)	DeltaSOS Net Export Change (cfs)
1986														
Oct	0	0	2,072	2,076	4,000	4,000	7,808	7,822	1,545	915	0	0	(1,202)	(915)
Nov	0	0	1,929	1,932	4,500	4,500	8,242	8,256	891	0	0	0	(322)	360
Dec	0	0	2,205	2,209	4,500	4,500	12,409	12,431	1,243	0	0	0	(910)	1,487
Jan	0	0	2,060	2,063	6,000	6,000	15,156	15,183	84	0	0	0	2,122	2,620
Feb	257	0	9,000	8,759	7,100	11,400	87,119	72,864	0	0	0	0	6,985	6,688
Mar	0	0	25,035	25,080	7,100	17,290	59,009	59,114	0	0	0	0	9,491	8,554
Apr	0	0	19,590	19,621	7,100	8,732	19,206	17,554	0	0	0	0	6,665	6,660
May	0	0	8,764	8,779	24,835	7,580	9,027	8,250	3,564	0	7,802	0	(3,128)	2,160
Jun	0	0	6,233	6,243	23,441	7,580	6,701	6,711	3,529	0	11,256	0	(3,455)	747
Jul	0	0	2,894	2,899	8,000	8,000	13,199	13,222	757	422	0	0	(538)	(422)
Aug	0	0	3,183	3,189	4,000	4,000	12,266	12,288	24	0	0	0	1,076	1,536
Sep	0	0	4,181	4,187	3,000	3,000	14,964	14,988	3	0	0	0	984	968
1987														
Oct	0	0	3,741	3,748	4,000	4,000	13,038	13,061	0	0	0	0	3,552	3,835
Nov	0	0	2,842	2,846	4,500	4,500	10,584	10,601	0	0	0	0	3,220	3,878
Dec	0	0	3,706	3,713	4,500	4,500	11,314	11,334	0	0	0	0	3,708	4,209
Jan	0	0	2,305	2,309	4,500	4,500	10,390	10,409	0	0	0	0	3,620	4,268
Feb	0	0	2,136	2,140	10,257	11,400	9,068	9,084	971	0	2,411	0	999	2,335
Mar	0	0	3,415	3,421	9,952	11,400	9,213	9,229	954	0	1,531	0	2,489	3,752
Apr	281	0	3,148	2,872	10,783	10,317	4,103	4,311	3,027	3,759	2,953	0	(3,020)	(3,759)
May	434	0	2,611	2,182	19,200	7,580	3,707	3,601	3,521	2,750	10,700	0	(3,498)	(2,750)
Jun	0	0	1,990	1,993	14,773	6,651	4,349	4,356	3,356	2,948	7,852	269	(3,356)	(2,948)
Jul	0	0	1,632	1,635	5,000	5,000	11,136	11,156	1,093	962	0	0	(1,093)	(962)
Aug	0	0	1,627	1,630	3,500	3,500	10,684	10,703	732	0	0	0	(589)	228
Sep	0	0	1,597	1,599	3,000	3,000	8,770	8,784	1,212	482	0	0	(1,184)	(482)
1988														
Oct	0	0	1,370	1,372	4,000	4,000	7,166	7,179	577	90	0	0	(239)	(90)
Nov	0	0	1,548	1,551	4,500	4,500	6,380	6,391	1,011	873	0	0	(709)	(873)
Dec	0	0	1,278	1,280	4,500	4,500	11,181	11,200	626	0	0	0	881	2,222
Jan	0	0	1,483	1,486	4,500	6,000	18,713	18,746	19	0	0	0	988	1,063
Feb	0	0	1,389	1,441	11,672	11,400	4,817	4,998	5,701	7,786	4,193	0	(5,701)	(7,786)
Mar	0	0	2,241	2,245	21,319	7,100	4,858	4,867	6,301	3,404	10,586	0	(6,301)	(3,404)
Apr	669	0	2,814	2,150	11,643	7,100	4,834	4,783	4,283	3,596	1,518	0	(4,283)	(3,596)
May	624	221	2,405	2,005	4,121	4,000	3,785	3,678	2,521	2,402	0	0	(2,393)	(2,402)
Jun	0	0	1,711	1,714	6,897	4,000	4,518	4,396	3,410	1,305	221	0	(3,410)	(1,305)
Jul	0	0	1,357	1,359	3,968	4,000	10,555	10,574	548	0	0	0	30	146
Aug	0	0	1,557	1,560	3,000	3,500	9,784	9,800	594	137	0	0	(469)	(137)
Sep	0	0	1,452	1,455	3,000	3,000	8,542	8,557	744	0	0	0	(584)	138

Table A4–2. Continued

Water Year	DailySOS Added SJR Flow (cfs)	DeltaSOS Added SJR Flow (cfs)	DailySOS New SJR Flow (cfs)	DeltaSOS New SJR Flow (cfs)	DailySOS Required Delta Outflow (cfs)	DeltaSOS Required Delta Outflow (cfs)	DailySOS Export Limits for Inflow (cfs)	DeltaSOS Direct Export Limits (cfs)	DailySOS Reduced Export for Objectives (cfs)	DeltaSOS Reduced Export for Objectives (cfs)	DailySOS Outflow Deficit (cfs)	DeltaSOS Outflow Deficit (cfs)	DailySOS Net Export Change (cfs)	DeltaSOS Net Export Change (cfs)
1989														
Oct	0	0	1,127	1,129	3,000	3,000	6,837	6,849	323	0	0	0	193	516
Nov	0	0	1,274	1,276	3,500	3,500	8,280	8,294	345	0	0	0	519	2,348
Dec	0	0	1,372	1,374	3,500	3,500	9,026	9,042	393	0	0	0	721	1,993
Jan	0	0	1,255	1,257	6,000	4,500	9,254	9,270	2,796	805	0	0	(2,594)	(805)
Feb	0	0	1,234	1,236	11,836	11,400	6,080	6,091	3,291	6,079	3,829	33	(3,272)	(6,079)
Mar	0	0	2,023	2,027	9,952	7,100	16,553	16,582	533	0	760	0	24	1,071
Apr	797	517	2,713	2,435	7,100	8,263	6,760	5,856	4,088	4,463	0	0	(3,923)	(4,463)
May	593	483	2,542	2,435	8,877	8,431	4,828	4,490	2,494	1,536	3,239	0	(2,041)	(1,536)
Jun	0	0	1,583	1,586	23,960	6,120	5,274	5,283	3,287	59	14,383	0	(3,287)	(59)
Jul	0	0	1,284	1,286	5,000	5,000	13,145	13,169	468	0	0	0	458	1,570
Aug	0	0	1,169	1,171	3,500	3,500	12,782	12,804	693	0	0	0	(502)	205
Sep	0	0	1,353	1,355	3,000	3,000	11,687	11,708	598	0	0	0	(55)	728
1990														
Oct	0	0	1,401	1,403	4,000	4,000	10,272	10,290	1,319	79	0	0	(1,098)	(79)
Nov	0	0	1,404	1,313	4,500	4,500	10,727	10,029	646	0	0	0	(274)	457
Dec	0	0	1,381	1,383	4,500	4,500	11,014	11,034	636	0	0	0	(351)	719
Jan	0	0	1,242	1,204	4,500	4,500	13,231	12,827	609	0	0	0	(88)	1,114
Feb	0	0	1,365	1,514	7,889	11,400	6,963	6,007	3,896	5,630	586	0	(3,896)	(5,630)
Mar	0	0	1,760	1,706	11,377	7,100	5,298	5,136	5,826	4,951	3,510	0	(5,826)	(4,951)
Apr	1,088	650	2,397	2,005	10,683	10,683	4,586	4,549	6,072	5,249	6	0	(6,072)	(5,249)
May	881	724	2,161	2,005	5,479	4,000	4,136	3,592	743	0	58	0	(134)	411
Jun	0	0	1,116	1,118	5,805	4,000	4,165	4,173	1,178	0	1,167	0	(752)	806
Jul	0	0	1,009	1,011	4,000	4,000	9,563	9,579	327	0	0	0	193	339
Aug	2	0	1,034	1,001	3,000	3,500	9,799	9,499	7	0	0	0	1,672	1,737
Sep	51	0	927	907	3,000	3,000	7,252	7,472	785	0	0	0	(381)	475
1991														
Oct	49	7	1,042	1,000	3,000	3,000	5,793	5,765	249	0	0	0	488	1,016
Nov	0	0	1,115	1,115	3,500	3,500	5,892	5,892	238	0	0	0	617	803
Dec	7	0	925	918	3,500	3,500	7,692	7,686	74	0	0	0	1,698	2,268
Jan	93	84	909	900	4,500	4,500	6,492	6,485	621	0	0	0	(472)	463
Feb	152	142	909	900	7,889	7,100	4,115	4,111	1,786	2,384	2,018	634	(1,778)	(2,384)
Mar	19	0	1,797	1,779	7,100	7,100	10,385	10,379	1,123	0	0	0	(702)	727
Apr	1,226	1,267	2,394	2,435	7,100	10,438	4,469	4,004	3,785	5,399	556	1,383	(3,785)	(5,399)
May	1,021	956	2,070	2,005	8,118	4,000	3,266	3,061	1,039	0	3,063	0	(998)	184
Jun	332	332	900	900	7,817	4,000	3,550	3,550	435	0	3,144	0	(435)	873
Jul	306	306	900	900	4,000	4,000	6,915	6,915	521	367	148	0	(296)	(367)
Aug	363	363	900	900	3,000	3,500	6,900	6,900	622	0	0	0	(244)	112
Sep	326	326	900	900	3,000	3,000	7,200	7,199	232	0	0	0	909	1,638

Table A4–2. Continued

Water Year	DailySOS CVP & SWP Export (cfs)	DeltaSOS CVP & SWP Export (cfs)	DailySOS Available Flow (cfs)	DeltaSOS Available Flow (cfs)	DailySOS Delta Storage (TAF)	DeltaSOS Delta Storage (TAF)	DailySOS Delta Storage Diversion (cfs)	DeltaSOS Delta Storage Diversion (cfs)	DailySOS Delta Storage Export (cfs)	DeltaSOS Delta Storage Export (cfs)	DailySOS Final Total Export (cfs)	DeltaSOS Final Total Export (cfs)	DailySOS Final QWEST Flow (cfs)	DeltaSOS Final QWEST Flow (cfs)	DailySOS Final Delta Outflow (cfs)	DeltaSOS Final Delta Outflow (cfs)
1968																
Oct	11,280	11,280	1,868	1,892	238	238	155	53	0	0	11,280	11,280	(1,093)	(769)	6,997	7,451
Nov	11,248	11,280	752	772	238	238	58	25	32	0	11,280	11,280	(5,177)	(4,957)	5,925	6,307
Dec	11,514	11,499	2,192	2,232	238	238	13	13	0	0	11,514	11,499	(4,296)	(4,875)	9,545	8,681
Jan	11,706	11,852	4,486	4,374	238	238	15	15	0	0	11,706	11,852	(4,092)	(3,878)	13,628	14,095
Feb	8,834	11,776	6,933	6,935	232	238	1,576	30	1,642	0	10,476	11,776	2,695	305	43,444	41,957
Mar	10,839	11,407	4,254	3,958	214	238	129	49	381	0	11,220	11,407	575	(606)	33,854	32,433
Apr	2,184	2,000	0	0	24	(0)	0	0	3,117	3,924	5,301	5,924	1,925	2,057	13,048	13,210
May	2,214	4,627	0	0	0	0	0	0	369	0	2,583	4,627	519	(2,064)	10,036	7,580
Jun	2,571	2,000	0	0	0	0	0	0	0	0	2,571	2,000	1,608	2,117	5,649	6,113
Jul	2,286	2,345	0	0	0	0	0	0	0	0	2,286	2,345	1,794	1,823	6,419	6,500
Aug	6,030	7,414	0	0	0	0	0	0	0	0	6,030	7,414	(1,143)	(1,608)	3,968	4,000
Sep	8,447	9,165	0	0	0	0	0	0	0	0	8,447	9,165	(2,621)	(2,866)	3,000	3,000
1969																
Oct	7,399	7,767	0	0	0	0	0	0	0	0	7,399	7,767	(867)	(1,085)	4,143	4,000
Nov	9,643	10,042	0	0	0	0	0	0	0	0	9,643	10,042	(4,504)	(5,841)	6,394	4,607
Dec	10,992	11,311	6,111	6,319	209	238	3,407	3,871	0	0	10,992	11,311	(5,524)	(8,070)	14,938	11,523
Jan	13,164	12,700	35,893	38,865	238	238	486	15	0	0	13,164	12,700	23,080	23,850	116,656	117,761
Feb	14,500	12,700	41,296	43,219	238	238	31	31	0	0	14,500	12,700	41,776	43,258	149,067	150,572
Mar	12,632	11,700	21,224	22,216	238	238	49	49	0	0	12,632	11,700	31,449	32,164	83,968	84,700
Apr	11,280	11,280	12,120	12,638	238	238	76	76	0	0	11,280	11,280	22,035	21,903	60,928	60,777
May	11,280	11,280	11,932	13,238	238	238	99	99	0	0	11,280	11,280	22,171	22,240	56,127	56,279
Jun	11,231	11,280	7,160	7,141	235	238	110	118	49	0	11,280	11,280	22,946	24,658	37,425	37,317
Jul	7,753	8,472	237	0	67	57	70	0	2,662	2,808	10,415	11,280	2,715	2,165	8,496	8,000
Aug	11,126	11,280	2,055	2,564	177	208	2,055	2,564	154	0	11,280	11,280	(4,785)	(4,909)	4,178	4,357
Sep	11,280	11,280	4,992	5,018	238	238	1,110	593	0	0	11,280	11,280	(1,262)	(445)	10,197	11,201
1970																
Oct	11,280	11,280	3,198	3,224	238	238	53	53	0	0	11,280	11,280	1,241	1,104	10,043	9,840
Nov	11,280	11,280	3,021	3,044	238	238	25	25	0	0	11,280	11,280	(3,605)	(3,511)	9,641	9,816
Dec	11,279	11,333	10,523	13,820	238	238	13	13	0	0	11,279	11,333	(401)	(1,193)	35,603	34,689
Jan	13,347	12,700	36,474	36,602	238	238	15	15	0	0	13,347	12,700	21,504	21,588	180,841	181,011
Feb	13,881	12,700	21,220	26,306	238	238	31	31	0	0	13,881	12,700	10,331	11,275	99,304	100,311
Mar	12,279	11,700	8,087	8,696	229	238	41	49	140	0	12,419	11,700	5,777	5,963	45,932	46,069
Apr	2,542	5,554	0	0	14	159	0	0	3,539	1,254	6,081	6,808	1,907	(1,256)	13,060	9,868
May	2,765	6,381	0	0	0	133	0	0	212	319	2,977	6,701	1,489	(2,198)	11,902	8,229
Jun	1,711	2,000	0	0	0	(0)	0	0	0	2,120	1,711	4,120	4,996	4,613	9,373	8,932
Jul	2,321	2,493	0	0	0	0	0	0	0	0	2,321	2,493	2,992	2,910	8,030	8,000
Aug	8,393	9,234	9	0	0	0	9	0	0	0	8,393	9,234	(2,511)	(2,807)	4,000	4,000
Sep	11,280	11,280	1,920	1,941	110	116	1,920	1,941	0	0	11,280	11,280	(5,171)	(4,718)	4,340	5,064

Table A4–2. Continued

Water Year	DailySOS CVP & SWP Export (cfs)	DeltaSOS CVP & SWP Export (cfs)	DailySOS Available Flow (cfs)	DeltaSOS Available Flow (cfs)	DailySOS Delta Storage (TAF)	DeltaSOS Delta Storage (TAF)	DailySOS Delta Storage Diversion (cfs)	DeltaSOS Delta Storage Diversion (cfs)	DailySOS Delta Storage Export (cfs)	DeltaSOS Delta Storage Export (cfs)	DailySOS Final Total Export (cfs)	DeltaSOS Final Total Export (cfs)	DailySOS Final QWEST Flow (cfs)	DeltaSOS Final QWEST Flow (cfs)	DailySOS Final Delta Outflow (cfs)	DeltaSOS Final Delta Outflow (cfs)
1971																
Oct	10,935	11,236	224	0	99	110	224	0	345	44	11,280	11,280	(2,890)	(2,968)	4,724	4,655
Nov	11,232	11,280	5,268	5,262	238	238	2,412	2,184	48	0	11,280	11,280	(5,203)	(6,720)	14,413	12,030
Dec	11,944	11,700	24,130	23,472	238	238	13	13	0	0	11,944	11,700	9,117	8,459	75,242	74,253
Jan	12,597	12,600	17,790	18,318	238	238	15	15	0	0	12,597	12,600	2,775	3,303	53,396	54,357
Feb	11,238	12,332	1,750	919	208	238	17	31	523	0	11,761	12,332	(590)	(1,646)	26,053	25,093
Mar	5,496	11,321	2,819	1,338	140	238	1,532	49	2,593	0	8,089	11,321	2,950	(2,134)	29,745	24,410
Apr	8,054	8,380	3,295	1,841	228	238	1,683	76	133	0	8,187	8,380	(930)	45	31,648	32,549
May	8,004	8,380	272	140	209	238	272	99	470	0	8,474	8,380	(1,647)	(2,063)	22,642	22,143
Jun	7,439	10,761	0	0	53	200	0	0	2,514	519	9,953	11,280	(836)	(5,606)	19,474	16,107
Jul	9,582	10,232	494	0	0	128	494	0	1,237	1,048	10,818	11,280	(2,888)	(2,787)	8,000	8,000
Aug	11,272	11,280	3,632	4,010	200	238	3,358	1,910	0	0	11,272	11,280	(8,133)	(5,109)	4,939	7,224
Sep	11,280	11,280	5,745	5,772	238	238	724	87	0	0	11,280	11,280	(4,994)	(1,354)	11,460	12,828
1972																
Oct	11,258	11,280	1,293	1,294	236	238	48	53	22	0	11,280	11,280	(1,742)	(1,631)	6,336	6,515
Nov	10,724	11,280	628	330	238	238	609	25	556	0	11,280	11,280	(6,898)	(6,746)	5,360	5,618
Dec	11,381	11,288	4,966	5,088	238	238	13	13	0	0	11,381	11,288	(3,376)	(4,313)	14,895	13,439
Jan	11,909	11,910	3,594	3,619	238	238	15	15	0	0	11,909	11,910	(5,066)	(4,319)	10,979	12,160
Feb	9,342	9,390	115	0	154	97	69	0	1,493	2,415	10,834	11,805	(1,935)	(1,683)	16,242	17,227
Mar	5,284	9,443	0	0	0	0	0	0	2,465	1,535	7,749	10,978	170	(3,891)	19,455	15,494
Apr	3,039	3,373	0	0	0	0	0	0	0	0	3,039	3,373	892	150	10,749	9,848
May	2,895	3,664	0	0	0	0	0	0	0	0	2,895	3,664	(451)	(1,525)	8,587	7,580
Jun	2,111	3,820	0	0	0	0	0	0	0	0	2,111	3,820	2,951	1,132	8,731	6,845
Jul	4,689	4,753	0	0	0	0	0	0	0	0	4,689	4,753	111	137	6,419	6,500
Aug	8,419	9,221	0	0	0	0	0	0	0	0	8,419	9,221	(3,021)	(3,289)	3,968	4,000
Sep	11,098	11,280	872	803	48	48	872	803	0	0	11,098	11,280	(4,011)	(3,879)	4,443	4,721
1973																
Oct	11,223	11,280	616	592	79	81	616	592	57	0	11,280	11,280	(2,645)	(2,849)	5,804	5,520
Nov	11,106	11,280	5,944	5,869	238	238	2,866	2,665	174	0	11,280	11,280	(5,488)	(6,981)	15,193	12,940
Dec	11,327	11,306	7,917	8,791	238	238	13	13	0	0	11,327	11,306	(3,923)	(3,531)	19,135	19,789
Jan	12,219	12,222	24,220	25,720	238	238	15	15	0	0	12,219	12,222	10,063	10,705	92,365	93,682
Feb	13,430	12,700	21,795	22,679	238	238	31	31	0	0	13,430	12,700	13,746	14,879	89,842	91,359
Mar	12,128	11,700	14,465	14,941	238	238	49	49	0	0	12,128	11,700	9,650	8,767	66,019	64,635
Apr	6,591	8,124	228	0	108	234	15	0	2,124	0	8,715	8,124	1,957	486	18,904	17,485
May	5,157	7,206	0	0	0	227	0	0	1,686	0	6,842	7,206	567	(1,523)	12,913	10,844
Jun	3,427	6,714	0	0	0	191	0	0	0	492	3,427	7,206	4,495	1,143	11,014	7,615
Jul	4,138	4,283	0	0	0	3	0	0	0	2,923	4,138	7,206	1,562	1,504	8,000	8,000
Aug	9,580	10,415	0	0	0	0	0	0	0	0	9,580	10,415	(3,321)	(3,624)	4,000	4,000
Sep	11,280	11,280	1,293	1,315	72	78	1,293	1,315	0	0	11,280	11,280	(4,608)	(4,270)	4,206	4,754

Table A4–2. Continued

Water Year	DailySOS CVP & SWP Export (cfs)	DeltaSOS CVP & SWP Export (cfs)	DailySOS Available Flow (cfs)	DeltaSOS Available Flow (cfs)	DailySOS Delta Storage (TAF)	DeltaSOS Delta Storage (TAF)	DailySOS Delta Storage Diversion (cfs)	DeltaSOS Delta Storage Diversion (cfs)	DailySOS Delta Storage Export (cfs)	DeltaSOS Delta Storage Export (cfs)	DailySOS Final Total Export (cfs)	DeltaSOS Final Total Export (cfs)	DailySOS Final QWEST Flow (cfs)	DeltaSOS Final QWEST Flow (cfs)	DailySOS Final Delta Outflow (cfs)	DeltaSOS Final Delta Outflow (cfs)
1974																
Oct	11,280	11,280	1,558	1,581	164	172	1,558	1,581	0	0	11,280	11,280	(2,123)	(2,854)	7,044	5,946
Nov	11,280	11,280	13,402	15,485	238	238	1,261	1,131	0	0	11,280	11,280	431	(645)	52,211	50,818
Dec	11,625	11,491	20,362	20,694	238	238	13	13	0	0	11,625	11,491	5,349	5,681	68,029	68,615
Jan	13,448	12,700	27,289	28,106	238	238	15	15	0	0	13,448	12,700	12,275	13,092	127,168	128,279
Feb	12,561	12,564	10,004	10,140	238	238	31	31	0	0	12,561	12,564	1,880	1,754	52,007	51,952
Mar	11,699	11,700	17,341	17,445	238	238	49	49	0	0	11,699	11,700	8,223	8,063	72,110	72,018
Apr	9,861	9,950	13,779	13,820	236	238	35	76	0	0	9,861	9,950	10,289	9,438	103,826	102,847
May	9,320	9,950	489	393	212	238	137	99	419	0	9,740	9,950	(399)	(869)	23,162	22,786
Jun	2,360	10,366	0	0	(0)	177	0	0	3,447	914	5,808	11,280	7,709	1,825	23,593	15,412
Jul	9,102	11,280	1,367	641	28	208	1,354	641	801	0	9,903	11,280	(2,702)	(3,473)	9,479	8,000
Aug	11,280	11,280	5,640	5,677	238	238	3,525	603	0	0	11,280	11,280	(7,216)	(2,368)	7,319	11,092
Sep	11,280	11,280	7,354	7,384	238	238	87	87	0	0	11,280	11,280	(2,994)	(4,756)	14,579	15,320
1975																
Oct	11,280	11,280	4,585	4,607	238	238	53	53	0	0	11,280	11,280	527	650	11,683	11,892
Nov	11,280	11,280	6,148	6,176	238	238	25	25	0	0	11,280	11,280	(3,147)	(3,144)	14,552	14,591
Dec	11,555	11,589	8,392	8,416	238	238	13	13	0	0	11,555	11,589	(2,144)	(2,695)	19,183	18,393
Jan	12,123	12,125	3,173	3,203	238	238	15	15	0	0	12,123	12,125	(4,810)	(4,334)	10,771	11,537
Feb	12,846	12,700	12,251	8,421	238	238	64	31	34	0	12,879	12,700	5,794	4,465	51,077	49,090
Mar	11,592	11,700	13,350	13,321	238	238	49	49	0	0	11,592	11,700	8,443	8,075	61,272	60,960
Apr	9,861	9,950	2,934	1,534	236	238	35	76	0	0	9,861	9,950	1,717	1,266	30,880	30,322
May	8,950	9,950	851	716	210	238	470	99	787	0	9,737	9,950	293	(235)	24,906	24,463
Jun	4,544	10,781	0	0	0	201	0	0	3,412	499	7,956	11,280	6,906	3,071	22,386	16,052
Jul	8,217	8,351	0	0	0	13	0	0	0	2,929	8,217	11,280	(747)	(801)	8,000	8,000
Aug	11,280	11,280	2,365	2,880	139	183	2,365	2,880	0	0	11,280	11,280	(5,235)	(5,449)	4,755	4,728
Sep	11,280	11,280	4,215	4,240	238	238	1,759	1,008	0	0	11,280	11,280	(2,900)	(1,693)	8,067	9,541
1976																
Oct	11,280	11,280	4,740	4,769	238	238	53	53	0	0	11,280	11,280	2,204	1,820	13,031	12,462
Nov	11,280	11,280	6,308	6,337	238	238	25	25	0	0	11,280	11,280	(3,274)	(3,121)	14,553	14,815
Dec	11,593	11,518	7,695	7,805	238	238	13	13	0	0	11,593	11,518	(4,354)	(3,651)	16,104	17,172
Jan	11,172	11,980	779	142	204	238	8	15	551	0	11,723	11,980	(5,316)	(5,524)	6,339	6,502
Feb	6,108	3,647	0	0	3	6	0	0	3,463	4,000	9,571	7,647	(960)	1,180	9,040	11,400
Mar	4,504	5,826	0	0	0	0	0	0	43	52	4,546	5,879	254	(1,672)	11,633	9,446
Apr	3,838	2,551	0	0	0	0	0	0	0	0	3,838	2,551	179	622	9,911	9,967
May	2,945	3,649	0	0	0	0	0	0	0	0	2,945	3,649	(868)	(1,970)	6,462	5,393
Jun	1,832	3,827	0	0	0	0	0	0	0	0	1,832	3,827	2,330	284	6,082	4,000
Jul	4,329	4,436	0	0	0	0	0	0	0	0	4,329	4,436	(312)	(325)	3,968	4,000
Aug	7,995	8,297	0	0	0	0	0	0	0	0	7,995	8,297	(2,376)	(2,285)	3,198	3,500
Sep	8,237	9,074	0	0	0	0	0	0	0	0	8,237	9,074	(1,831)	(2,455)	3,599	3,071

Table A4–2. Continued

Water Year	DailySOS CVP & SWP Export (cfs)	DeltaSOS CVP & SWP Export (cfs)	DailySOS Available Flow (cfs)	DeltaSOS Available Flow (cfs)	DailySOS Delta Storage (TAF)	DeltaSOS Delta Storage (TAF)	DailySOS Delta Storage Diversion (cfs)	DeltaSOS Delta Storage Diversion (cfs)	DailySOS Delta Storage Export (cfs)	DeltaSOS Delta Storage Export (cfs)	DailySOS Final Total Export (cfs)	DeltaSOS Final Total Export (cfs)	DailySOS Final QWEST Flow (cfs)	DeltaSOS Final QWEST Flow (cfs)	DailySOS Final Delta Outflow (cfs)	DeltaSOS Final Delta Outflow (cfs)
1977																
Oct	4,617	5,039	0	0	0	0	0	0	0	0	4,617	5,039	273	59	3,468	3,000
Nov	4,076	4,541	0	0	0	0	0	0	0	0	4,076	4,541	(1,464)	(1,820)	3,638	3,500
Dec	3,196	4,257	0	0	0	0	0	0	0	0	3,196	4,257	(1,161)	(1,739)	3,654	3,500
Jan	5,916	6,447	0	0	0	0	0	0	0	0	5,916	6,447	(2,037)	(2,872)	5,391	4,500
Feb	2,128	2,000	0	0	0	0	0	0	0	0	2,128	2,000	1,179	575	6,995	6,152
Mar	1,757	2,000	0	0	0	0	0	0	0	0	1,757	2,000	780	7	5,074	4,231
Apr	1,040	1,177	0	0	0	0	0	0	0	0	1,040	1,177	74	(163)	3,269	3,228
May	1,844	2,104	0	0	0	0	0	0	0	0	1,844	2,104	155	(758)	5,092	4,000
Jun	557	558	0	0	0	0	0	0	0	0	557	558	1,105	1,081	2,590	2,509
Jul	684	702	0	0	0	0	0	0	0	0	684	702	1,375	1,472	3,307	3,453
Aug	1,259	1,390	0	0	0	0	0	0	0	0	1,259	1,390	862	1,294	2,703	3,422
Sep	1,813	2,328	0	0	0	0	0	0	0	0	1,813	2,328	156	236	2,839	3,000
1978																
Oct	675	629	0	0	0	0	0	0	0	0	675	629	(148)	206	2,108	2,647
Nov	2,837	2,821	0	0	0	0	0	0	0	0	2,837	2,821	(560)	(879)	3,789	3,500
Dec	6,269	8,412	773	0	37	0	773	0	159	0	6,427	8,412	(2,341)	(5,091)	7,298	3,923
Jan	11,324	11,632	18,796	20,575	238	238	3,513	3,871	237	0	11,560	11,632	2,507	1,704	61,183	60,583
Feb	12,820	12,700	9,589	9,636	238	238	207	31	179	0	12,998	12,700	6,316	5,918	53,429	52,858
Mar	12,187	11,700	17,972	19,361	238	238	51	49	0	0	12,187	11,700	13,069	12,828	79,262	78,858
Apr	11,280	11,280	10,958	9,924	238	238	76	76	0	0	11,280	11,280	18,906	18,076	53,180	51,937
May	10,910	11,280	6,783	4,935	222	238	86	99	246	0	11,156	11,280	12,935	12,624	32,906	32,671
Jun	3,485	7,170	0	0	0	(0)	0	0	3,614	3,882	7,099	11,052	8,250	4,502	13,154	9,359
Jul	3,577	4,092	0	0	0	0	0	0	0	0	3,577	4,092	2,545	2,121	8,370	8,000
Aug	10,031	11,071	203	0	12	0	203	0	0	0	10,031	11,071	(3,206)	(3,505)	4,000	4,000
Sep	11,280	11,280	2,801	2,824	173	168	2,801	2,824	0	0	11,280	11,280	(4,028)	(3,690)	5,100	5,644
1979																
Oct	10,199	10,822	306	0	122	137	306	0	1,081	458	11,280	11,280	(1,300)	(1,280)	4,142	4,315
Nov	10,066	10,686	167	0	59	100	167	0	1,214	594	11,280	11,280	(3,468)	(4,440)	6,167	4,980
Dec	9,968	10,636	7	0	2	55	7	0	912	722	10,880	11,359	(5,008)	(5,313)	4,746	4,690
Jan	12,241	12,610	7,662	7,440	215	238	3,501	2,998	34	0	12,275	12,610	(1,919)	(2,811)	18,833	17,484
Feb	11,161	12,700	9,396	3,317	238	238	1,636	31	1,186	0	12,347	12,700	6,627	5,811	36,452	35,437
Mar	11,978	11,700	2,591	2,895	238	238	232	49	183	0	12,161	11,700	5,416	5,271	30,230	29,827
Apr	5,787	5,303	0	0	89	(0)	0	0	2,426	3,924	8,212	9,227	1,742	2,210	14,542	15,049
May	6,564	7,530	0	0	0	0	0	0	1,364	0	7,928	7,530	(663)	(1,586)	13,019	12,153
Jun	2,436	2,000	0	0	0	0	0	0	0	0	2,436	2,000	4,502	4,870	9,102	9,420
Jul	7,528	7,425	244	0	0	0	244	0	211	0	7,738	7,425	(829)	(915)	6,806	6,500
Aug	9,689	10,524	0	0	0	0	0	0	0	0	9,689	10,524	(3,012)	(3,301)	4,000	4,000
Sep	10,853	11,036	67	0	0	0	67	0	32	0	10,885	11,036	(3,353)	(3,003)	3,253	3,859

Table A4–2. Continued

Water Year	DailySOS CVP & SWP Export (cfs)	DeltaSOS CVP & SWP Export (cfs)	DailySOS Available Flow (cfs)	DeltaSOS Available Flow (cfs)	DailySOS Delta Storage (TAF)	DeltaSOS Delta Storage (TAF)	DailySOS Delta Storage Diversion (cfs)	DeltaSOS Delta Storage Diversion (cfs)	DailySOS Delta Storage Export (cfs)	DeltaSOS Delta Storage Export (cfs)	DailySOS Final Total Export (cfs)	DeltaSOS Final Total Export (cfs)	DailySOS Final QWEST Flow (cfs)	DeltaSOS Final QWEST Flow (cfs)	DailySOS Final Delta Outflow (cfs)	DeltaSOS Final Delta Outflow (cfs)
1980																
Oct	9,988	10,441	175	0	8	0	175	0	41	0	10,029	10,441	(771)	(1,288)	5,226	4,548
Nov	10,476	11,280	1,066	557	62	33	1,066	557	135	0	10,612	11,280	(5,623)	(6,336)	6,366	5,475
Dec	10,870	11,304	3,984	4,530	148	238	1,791	3,345	383	0	11,254	11,304	(5,397)	(7,825)	12,241	9,676
Jan	13,624	12,700	33,654	34,926	238	238	1,477	15	0	0	13,624	12,700	18,119	19,911	109,445	111,200
Feb	14,483	12,700	25,423	32,974	238	238	30	30	0	0	14,483	12,700	21,871	25,794	113,295	121,343
Mar	12,528	11,700	23,621	24,513	238	238	50	49	0	0	12,528	11,700	26,434	26,969	90,952	91,507
Apr	9,349	10,773	1,077	437	190	238	33	76	756	0	10,105	10,773	6,293	4,476	24,627	22,643
May	3,149	9,672	0	0	0	232	0	0	3,001	0	6,150	9,672	10,480	3,762	22,318	15,720
Jun	7,600	8,616	64	0	4	66	64	0	0	2,664	7,600	11,280	4,462	3,478	13,071	12,049
Jul	9,573	9,771	520	0	0	(0)	520	0	517	949	10,090	10,720	(636)	(449)	7,871	8,000
Aug	9,359	10,163	0	0	0	0	0	0	0	0	9,359	10,163	(2,501)	(2,762)	3,968	4,000
Sep	11,280	11,280	1,861	1,882	106	112	1,861	1,882	0	0	11,280	11,280	(3,262)	(2,817)	4,288	4,995
1981																
Oct	9,355	10,332	374	0	29	50	374	0	1,564	948	10,919	11,280	(768)	(836)	4,159	4,000
Nov	8,496	9,190	0	0	0	0	0	0	486	823	8,983	10,012	(3,172)	(3,469)	4,500	4,500
Dec	10,862	11,382	1,777	1,587	99	98	1,666	1,587	47	0	10,909	11,382	(6,490)	(7,025)	6,626	6,089
Jan	10,300	11,955	4,552	3,208	143	238	1,673	2,298	945	0	11,245	11,955	(2,467)	(6,375)	14,545	9,883
Feb	9,425	9,880	2,065	0	142	128	1,288	0	1,263	1,951	10,688	11,832	(3,069)	(2,509)	17,646	18,133
Mar	7,969	10,250	1,281	0	101	53	1,281	0	1,905	1,162	9,873	11,412	924	(1,201)	22,046	19,387
Apr	2,962	5,962	0	0	0	0	0	0	1,646	823	4,608	6,785	3,074	(587)	16,724	12,777
May	2,900	5,307	0	0	0	0	0	0	0	0	2,900	5,307	618	(1,789)	10,569	8,220
Jun	1,951	2,000	0	0	0	0	0	0	0	0	1,951	2,000	2,868	2,758	6,507	6,336
Jul	7,183	7,330	0	0	0	0	0	0	0	0	7,183	7,330	(1,550)	(1,589)	5,000	5,000
Aug	8,833	9,666	0	0	0	0	0	0	0	0	8,833	9,666	(2,922)	(3,217)	3,500	3,500
Sep	8,340	9,176	0	0	0	0	0	0	0	0	8,340	9,176	(2,373)	(2,662)	3,000	3,000
1982																
Oct	6,236	6,379	0	0	0	0	0	0	0	0	6,236	6,379	166	(81)	4,759	4,000
Nov	8,889	11,280	8,500	11,668	201	238	3,391	4,000	0	0	8,889	11,280	(3,185)	(7,332)	28,310	23,904
Dec	11,215	11,195	18,459	18,819	238	238	615	13	0	0	11,215	11,195	2,844	3,806	79,855	81,253
Jan	12,163	12,166	28,193	27,914	238	238	15	15	0	0	12,163	12,166	13,178	12,899	90,670	90,454
Feb	13,074	12,700	19,762	22,554	238	238	31	31	0	0	13,074	12,700	11,866	11,549	89,090	88,671
Mar	12,376	11,700	17,846	18,576	238	238	49	49	0	0	12,376	11,700	18,353	18,169	78,106	77,597
Apr	11,280	11,280	29,165	26,399	238	238	76	76	0	0	11,280	11,280	36,677	35,020	140,448	138,103
May	11,280	11,280	9,761	9,687	238	238	99	99	0	0	11,280	11,280	17,373	17,532	52,416	52,736
Jun	10,025	11,280	1,523	1,356	185	238	67	118	839	0	10,864	11,280	3,924	524	22,256	20,832
Jul	5,183	11,280	45	1,446	23	238	45	130	2,544	0	7,727	11,280	7,232	1,007	15,559	9,316
Aug	11,280	11,280	5,105	5,207	238	238	3,605	115	0	0	11,280	11,280	(4,135)	(106)	6,526	10,865
Sep	11,280	11,280	9,363	9,396	238	238	87	87	0	0	11,280	11,280	2,745	4,300	19,751	19,088

Table A4–2. Continued

Water Year	DailySOS CVP & SWP Export (cfs)	DeltaSOS CVP & SWP Export (cfs)	DailySOS Available Flow (cfs)	DeltaSOS Available Flow (cfs)	DailySOS Delta Storage (TAF)	DeltaSOS Delta Storage (TAF)	DailySOS Delta Storage Diversion (cfs)	DeltaSOS Delta Storage Diversion (cfs)	DailySOS Delta Storage Export (cfs)	DeltaSOS Delta Storage Export (cfs)	DailySOS Final Total Export (cfs)	DeltaSOS Final Total Export (cfs)	DailySOS Final QWEST Flow (cfs)	DeltaSOS Final QWEST Flow (cfs)	DailySOS Final Delta Outflow (cfs)	DeltaSOS Final Delta Outflow (cfs)
1983																
Oct	11,280	11,280	7,451	7,485	238	238	53	53	0	0	11,280	11,280	6,090	5,930	16,845	16,595
Nov	11,280	11,280	15,833	16,564	238	238	25	25	0	0	11,280	11,280	6,294	5,236	33,839	32,293
Dec	12,865	11,700	36,709	38,332	238	238	13	13	0	0	12,865	11,700	22,808	23,319	84,405	84,774
Jan	14,500	12,700	34,120	40,509	238	238	15	15	0	0	14,500	12,700	22,705	25,495	85,300	88,871
Feb	14,500	12,700	49,500	51,478	238	238	31	31	0	0	14,500	12,700	43,109	45,278	171,404	174,013
Mar	12,632	11,700	69,352	76,371	238	238	49	49	0	0	12,632	11,700	60,891	61,323	259,302	259,815
Apr	11,280	11,280	31,280	28,321	238	238	76	76	0	0	11,280	11,280	41,525	41,433	110,559	110,539
May	11,280	11,280	21,456	22,696	238	238	99	99	0	0	11,280	11,280	34,830	34,186	90,586	89,714
Jun	11,280	11,280	16,648	16,693	238	238	118	118	0	0	11,280	11,280	24,007	23,990	64,550	64,587
Jul	11,280	11,280	23,442	23,503	238	238	130	130	0	0	11,280	11,280	13,754	13,354	37,563	37,774
Aug	11,280	11,280	11,823	11,864	238	238	115	115	0	0	11,280	11,280	5,014	1,468	20,248	21,148
Sep	11,280	11,280	13,123	13,162	238	238	87	87	0	0	11,280	11,280	7,821	10,048	24,209	24,508
1984																
Oct	11,280	11,280	12,218	12,260	238	238	53	53	0	0	11,280	11,280	9,705	11,394	23,364	23,519
Nov	11,280	11,280	26,510	28,194	238	238	25	25	0	0	11,280	11,280	16,084	13,168	64,507	60,354
Dec	12,865	11,700	43,372	44,550	238	238	13	13	0	0	12,865	11,700	28,359	29,537	144,647	146,076
Jan	14,500	12,700	38,434	41,227	238	238	15	15	0	0	14,500	12,700	23,765	26,213	88,080	91,048
Feb	13,767	12,700	2,624	4,306	238	238	30	30	0	0	13,767	12,700	4,997	6,506	33,442	35,957
Mar	11,813	11,700	2,939	3,078	238	238	50	49	0	0	11,813	11,700	2,843	2,815	29,995	29,932
Apr	4,132	2,604	140	0	65	(0)	8	0	2,836	3,924	6,968	6,528	3,908	5,349	18,184	19,623
May	5,331	6,921	0	0	0	0	0	0	989	0	6,321	6,921	374	(1,377)	11,672	10,074
Jun	2,439	4,378	0	0	0	0	0	0	0	0	2,439	4,378	5,069	3,076	11,619	9,599
Jul	11,019	11,280	636	412	35	25	636	412	0	0	11,019	11,280	(3,329)	(3,284)	7,878	8,000
Aug	11,273	11,280	2,270	2,762	167	188	2,270	2,762	7	0	11,280	11,280	(5,229)	(5,185)	4,053	4,406
Sep	11,280	11,280	2,609	2,631	238	238	1,279	926	0	0	11,280	11,280	(2,601)	(2,044)	6,429	7,099
1985																
Oct	11,034	11,280	659	478	222	238	36	53	246	0	11,280	11,280	(134)	(636)	6,292	5,651
Nov	11,243	11,280	8,701	9,435	238	238	334	25	37	0	11,280	11,280	(1,660)	(2,589)	22,257	20,769
Dec	11,835	11,693	12,722	14,180	238	238	13	13	0	0	11,835	11,693	(608)	(366)	27,605	27,955
Jan	12,145	12,226	1,639	1,697	238	238	11	15	0	0	12,145	12,226	(4,595)	(4,114)	8,735	9,555
Feb	6,781	7,953	154	0	68	14	154	0	3,189	3,999	9,970	11,952	1,136	(120)	16,196	14,858
Mar	2,724	6,314	0	0	0	(0)	0	0	1,077	182	3,801	6,496	4,654	703	16,269	12,175
Apr	3,498	5,207	0	0	0	0	0	0	0	0	3,498	5,207	1,564	(120)	10,659	9,054
May	4,842	4,694	0	0	0	0	0	0	0	0	4,842	4,694	(1,028)	(896)	8,594	8,776
Jun	4,769	4,913	0	0	0	0	0	0	0	0	4,769	4,913	1,407	1,131	6,815	6,454
Jul	9,221	9,370	0	0	0	0	0	0	0	0	9,221	9,370	(2,049)	(2,109)	5,000	5,000
Aug	8,769	9,602	0	0	0	0	0	0	0	0	8,769	9,602	(1,913)	(2,203)	3,500	3,500
Sep	8,517	9,344	34	0	0	0	34	0	24	0	8,541	9,344	(1,823)	(2,183)	3,230	3,064

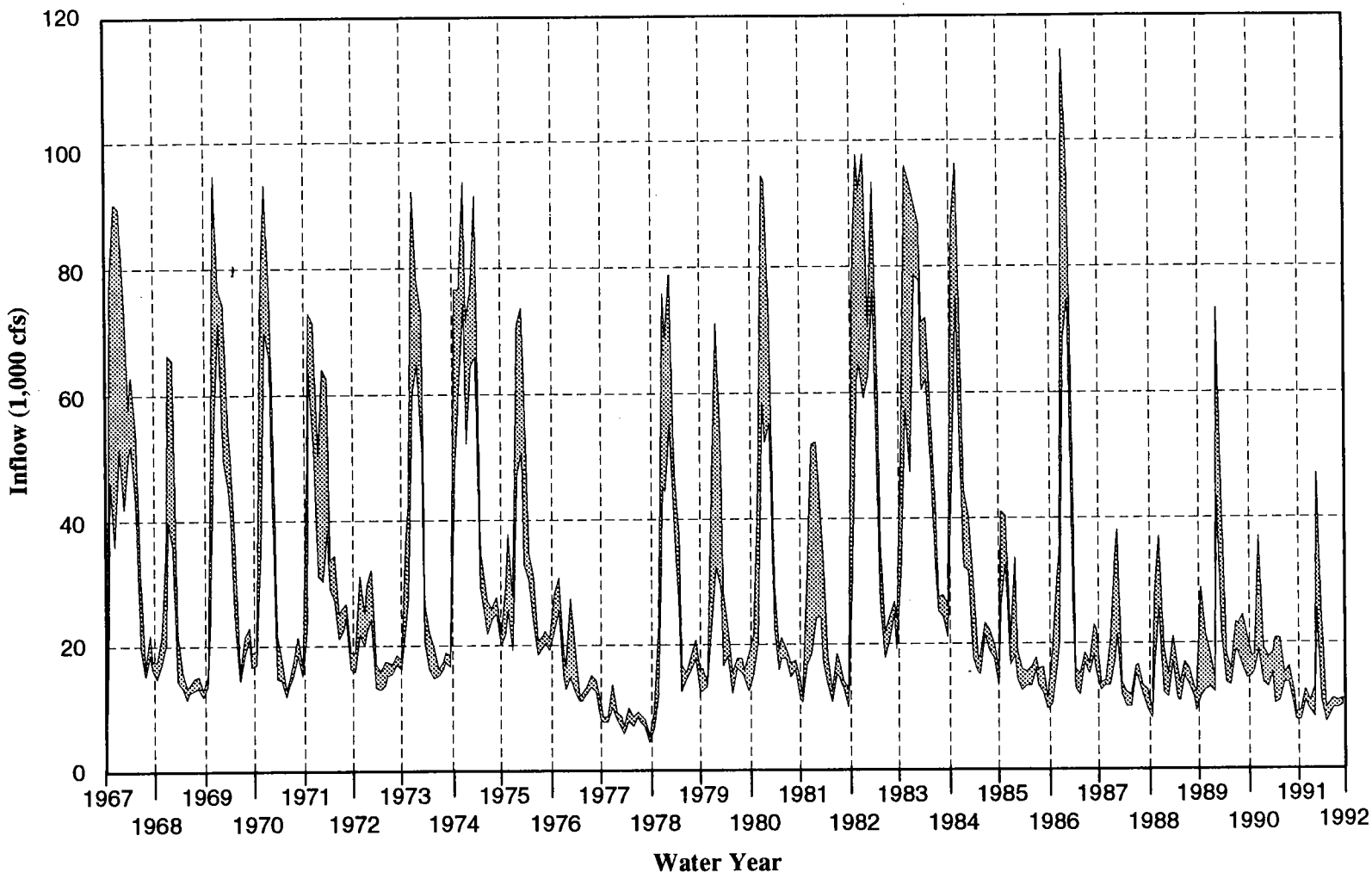
Table A4–2. Continued

Water Year	DailySOS CVP & SWP Export (cfs)	DeltaSOS CVP & SWP Export (cfs)	DailySOS Available Flow (cfs)	DeltaSOS Available Flow (cfs)	DailySOS Delta Storage (TAF)	DeltaSOS Delta Storage (TAF)	DailySOS Delta Storage Diversion (cfs)	DeltaSOS Delta Storage Diversion (cfs)	DailySOS Delta Storage Export (cfs)	DeltaSOS Delta Storage Export (cfs)	DailySOS Final Total Export (cfs)	DeltaSOS Final Total Export (cfs)	DailySOS Final QWEST Flow (cfs)	DeltaSOS Final QWEST Flow (cfs)	DailySOS Final Delta Outflow (cfs)	DeltaSOS Final Delta Outflow (cfs)
1986																
Oct	6,316	6,616	0	0	0	0	0	0	0	0	6,316	6,616	299	119	4,571	4,000
Nov	6,880	7,574	121	0	7	0	121	0	0	0	6,880	7,574	(1,291)	(3,233)	7,081	4,500
Dec	8,841	11,256	2,542	1,176	37	72	2,161	1,176	1,655	0	10,496	11,256	(4,904)	(6,568)	8,159	6,435
Jan	11,047	11,561	3,871	3,622	187	238	2,770	2,709	321	0	11,368	11,561	(6,342)	(6,458)	10,332	10,456
Feb	12,986	12,700	37,340	40,386	238	238	946	31	0	0	12,986	12,700	25,153	25,355	201,254	201,374
Mar	12,632	11,700	41,693	47,414	238	238	49	49	0	0	12,632	11,700	35,933	35,954	159,013	158,808
Apr	11,277	11,280	7,928	6,274	238	238	73	76	0	0	11,277	11,280	16,097	15,517	38,462	37,636
May	2,951	8,250	0	0	17	232	0	0	3,499	0	6,450	8,250	9,065	3,795	18,200	13,002
Jun	2,500	6,711	0	0	0	0	0	0	263	3,780	2,763	10,491	8,357	4,117	12,745	8,439
Jul	7,840	7,971	0	0	0	0	0	0	0	0	7,840	7,971	281	226	8,000	8,000
Aug	10,803	11,280	119	480	1	30	119	480	54	0	10,857	11,280	(2,619)	(2,915)	4,000	4,000
Sep	11,280	11,280	3,684	3,708	193	238	3,313	3,591	0	0	11,280	11,280	(3,040)	(3,219)	6,506	6,351
1987																
Oct	10,983	11,280	1,996	1,781	218	238	767	53	297	0	11,280	11,280	(1,272)	(478)	6,299	7,215
Nov	9,932	10,601	0	0	137	196	0	0	1,348	679	11,280	11,280	(4,744)	(4,939)	4,500	4,622
Dec	10,820	11,334	184	0	135	184	184	0	206	177	11,026	11,511	(4,736)	(4,891)	5,074	5,071
Jan	9,750	10,409	318	0	71	108	318	0	1,340	1,233	11,091	11,642	(3,751)	(4,703)	6,895	5,678
Feb	7,736	9,084	575	0	2	0	575	0	1,792	1,909	9,527	10,992	83	(2,619)	15,309	11,630
Mar	7,957	9,229	530	0	0	0	530	0	526	0	8,484	9,229	1,386	(617)	19,970	17,357
Apr	3,817	3,089	0	0	0	0	0	0	0	0	3,817	3,089	908	1,737	9,362	10,317
May	1,577	2,334	0	0	0	0	0	0	0	0	1,577	2,334	1,846	909	8,509	7,580
Jun	1,583	2,000	0	0	0	0	0	0	0	0	1,583	2,000	3,677	3,194	6,921	6,382
Jul	7,614	7,760	0	0	0	0	0	0	0	0	7,614	7,760	(1,448)	(1,506)	5,000	5,000
Aug	8,972	9,805	0	0	0	0	0	0	0	0	8,972	9,805	(2,640)	(2,934)	3,500	3,500
Sep	7,661	8,378	0	0	0	0	0	0	0	0	7,661	8,378	(1,602)	(1,847)	3,000	3,000
1988																
Oct	5,487	5,647	0	0	0	0	0	0	0	0	5,487	5,647	(184)	126	4,018	4,000
Nov	4,598	4,443	0	0	0	0	0	0	0	0	4,598	4,443	(793)	(1,153)	4,988	4,500
Dec	9,742	11,098	1,359	103	33	6	1,359	103	816	0	10,558	11,098	(5,766)	(6,848)	7,193	5,640
Jan	11,278	11,370	6,510	7,375	238	238	3,402	3,783	48	0	11,326	11,370	(7,713)	(7,997)	15,217	15,105
Feb	4,194	2,481	0	0	20	6	0	0	3,760	4,000	7,954	6,481	(375)	1,672	8,770	11,400
Mar	1,955	4,867	0	0	0	0	0	0	317	52	2,272	4,919	2,571	(367)	10,915	8,046
Apr	4,081	4,783	0	0	0	0	0	0	0	0	4,081	4,783	2,028	26	15,833	13,170
May	3,676	3,678	0	0	0	0	0	0	0	0	3,676	3,678	(348)	(563)	7,201	7,116
Jun	2,281	4,396	0	0	0	0	0	0	0	0	2,281	4,396	2,984	846	6,676	4,472
Jul	7,749	7,879	0	0	0	0	0	0	0	0	7,749	7,879	(2,131)	(2,154)	3,968	4,000
Aug	8,070	8,417	0	0	0	0	0	0	0	0	8,070	8,417	(2,348)	(2,130)	3,000	3,500
Sep	7,312	8,048	0	0	0	0	0	0	0	0	7,312	8,048	(1,540)	(1,795)	3,000	3,000

Table A4–2. Continued

Water Year	DailySOS CVP & SWP Export (cfs)	DeltaSOS CVP & SWP Export (cfs)	DailySOS Available Flow (cfs)	DeltaSOS Available Flow (cfs)	DailySOS Delta Storage (TAF)	DeltaSOS Delta Storage (TAF)	DailySOS Delta Storage Diversion (cfs)	DeltaSOS Delta Storage Diversion (cfs)	DailySOS Delta Storage Export (cfs)	DeltaSOS Delta Storage Export (cfs)	DailySOS Final Total Export (cfs)	DeltaSOS Final Total Export (cfs)	DailySOS Final QWEST Flow (cfs)	DeltaSOS Final QWEST Flow (cfs)	DailySOS Final Delta Outflow (cfs)	DeltaSOS Final Delta Outflow (cfs)
1989																
Oct	5,628	5,961	0	0	0	0	0	0	0	0	5,628	5,961	(727)	(593)	3,023	3,000
Nov	6,454	8,294	712	0	36	0	712	0	105	0	6,559	8,294	(3,235)	(4,895)	5,418	3,578
Dec	7,758	9,042	300	0	13	0	300	0	666	0	8,424	9,042	(3,552)	(5,332)	6,216	4,082
Jan	7,463	9,270	70	0	0	0	70	0	277	0	7,739	9,270	(3,646)	(5,029)	6,174	5,047
Feb	4,792	2,000	0	0	0	0	0	0	0	0	4,792	2,000	41	2,054	9,701	11,367
Mar	10,160	11,225	6,108	5,357	228	238	3,745	3,871	0	0	10,160	11,225	(2,242)	(4,655)	35,256	32,359
Apr	6,379	5,856	381	0	188	(0)	176	0	773	3,924	7,152	9,780	(1,201)	(543)	15,605	16,304
May	3,973	4,490	0	0	56	0	0	0	2,045	0	6,019	4,490	(360)	(999)	9,632	8,988
Jun	1,756	4,994	0	0	0	0	0	0	904	0	2,661	4,994	4,223	790	9,673	6,120
Jul	9,710	10,838	976	0	57	0	976	0	0	0	9,710	10,838	(4,106)	(4,159)	5,000	5,000
Aug	10,554	11,280	1,547	1,524	100	94	1,547	1,524	726	0	11,280	11,280	(5,343)	(5,489)	3,649	3,793
Sep	10,480	11,280	948	428	116	114	948	428	590	0	11,069	11,280	(3,003)	(3,477)	5,686	5,083
1990																
Oct	9,253	10,290	415	0	36	50	415	0	1,670	990	10,923	11,280	(1,649)	(2,658)	5,599	4,326
Nov	9,951	10,016	164	0	8	0	164	0	625	813	10,576	10,829	(5,913)	(6,138)	5,601	4,500
Dec	9,946	11,034	251	0	3	0	251	0	327	0	10,273	11,034	(7,002)	(7,099)	4,500	4,845
Jan	10,396	11,277	2,693	1,550	91	95	2,171	1,550	720	0	11,115	11,277	(7,511)	(7,696)	7,845	7,294
Feb	6,510	5,910	0	0	0	(0)	0	0	1,619	1,685	8,129	7,595	(750)	(868)	10,734	11,400
Mar	4,579	5,136	0	0	0	0	0	0	0	0	4,579	5,136	40	(744)	9,806	8,664
Apr	3,393	4,549	0	0	0	0	0	0	0	0	3,393	4,549	465	(845)	12,164	11,205
May	3,040	3,592	0	0	0	0	0	0	0	0	3,040	3,592	484	(401)	8,032	7,082
Jun	2,525	4,089	0	0	0	0	0	0	0	0	2,525	4,089	2,074	468	5,820	4,000
Jul	6,200	6,357	0	0	0	0	0	0	0	0	6,200	6,357	(1,296)	(1,343)	4,000	4,000
Aug	8,119	7,986	0	0	0	0	0	0	0	0	8,119	7,986	(2,710)	(2,195)	3,000	3,500
Sep	5,311	6,367	0	0	0	0	0	0	0	0	5,311	6,367	(694)	(1,056)	3,000	3,000
1991																
Oct	3,852	4,380	0	0	0	0	0	0	0	0	3,852	4,380	174	149	3,000	3,000
Nov	4,325	4,512	0	0	0	0	0	0	0	0	4,325	4,512	(1,284)	(1,730)	3,929	3,500
Dec	6,755	7,325	0	0	0	0	0	0	0	0	6,755	7,325	(3,415)	(4,448)	4,706	3,500
Jan	4,294	5,229	0	0	0	0	0	0	0	0	4,294	5,229	(1,723)	(2,127)	4,500	4,500
Feb	2,606	2,000	0	0	0	0	0	0	0	0	2,606	2,000	2,397	722	9,222	6,466
Mar	8,951	10,379	1,434	0	70	0	1,406	0	241	0	9,191	10,379	218	(2,357)	23,995	20,100
Apr	3,614	2,000	0	0	0	0	0	0	1,143	0	4,757	2,000	(165)	1,267	7,623	9,055
May	1,558	2,740	0	0	0	0	0	0	0	0	1,558	2,740	723	(490)	5,055	4,000
Jun	1,335	2,643	0	0	0	0	0	0	0	0	1,335	2,643	2,085	1,215	4,673	4,000
Jul	2,106	2,034	0	0	0	0	0	0	0	0	2,106	2,034	1,130	1,268	3,852	4,000
Aug	3,406	3,762	0	0	0	0	0	0	0	0	3,406	3,762	105	314	3,000	3,500
Sep	4,983	5,712	0	0	0	0	0	0	0	0	4,983	5,712	(546)	(793)	3,000	3,000

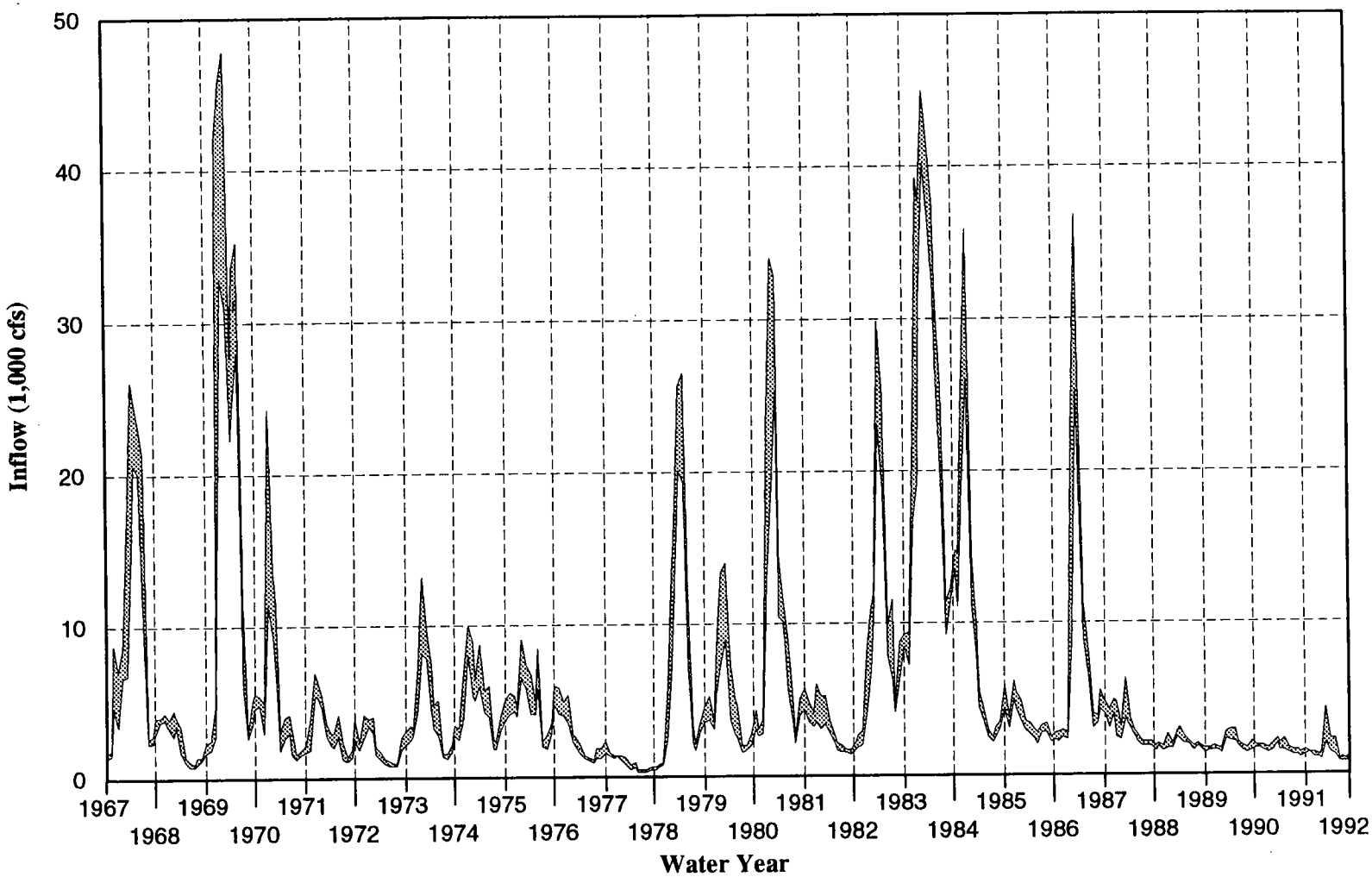
Note: Negative values shown in parentheses.



Source: DWR Central District DAYFLOW records.

Figure A4-1.
Monthly Range of Daily Sacramento River Flow at Freeport for 1967-1991

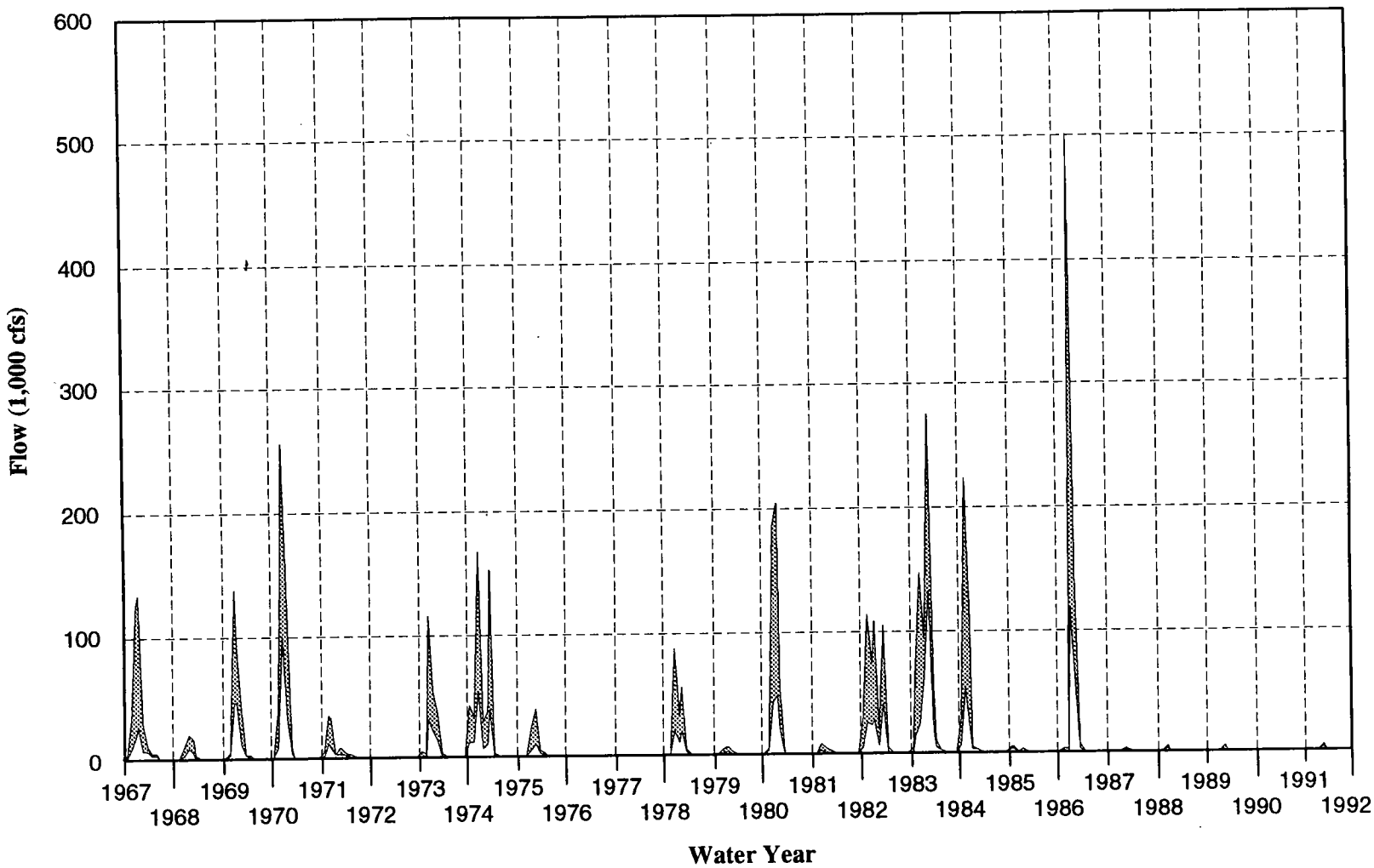
DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



Source: DWR Central District DAYFLOW records.

Figure A4-2.
Monthly Range of Daily San Joaquin River Flow at Vernalis for 1967-1991

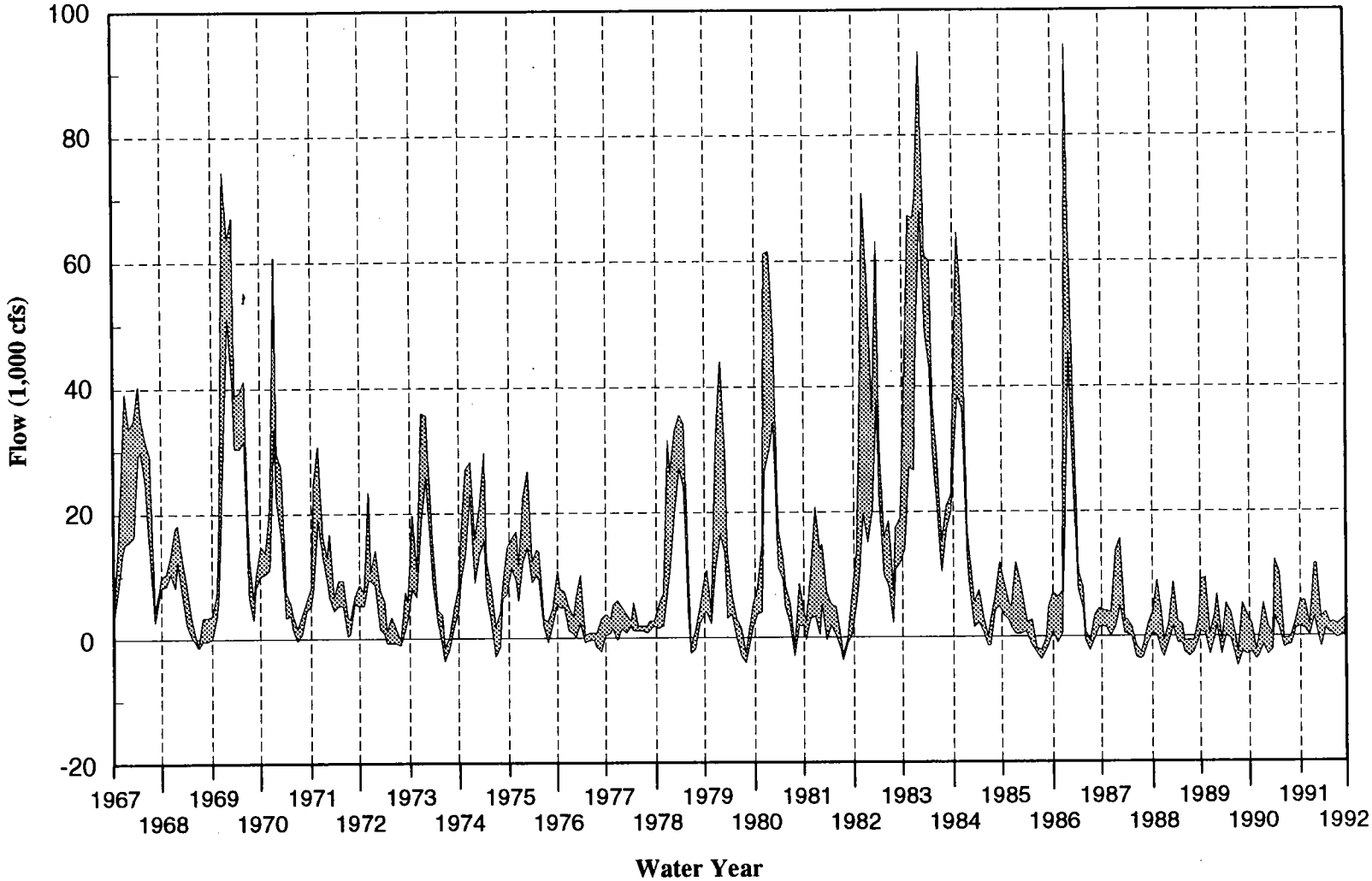
DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



Source: DWR Central District DAYFLOW records.

Figure A4-3.
Monthly Range of Daily Yolo Bypass Flows for 1967-1991

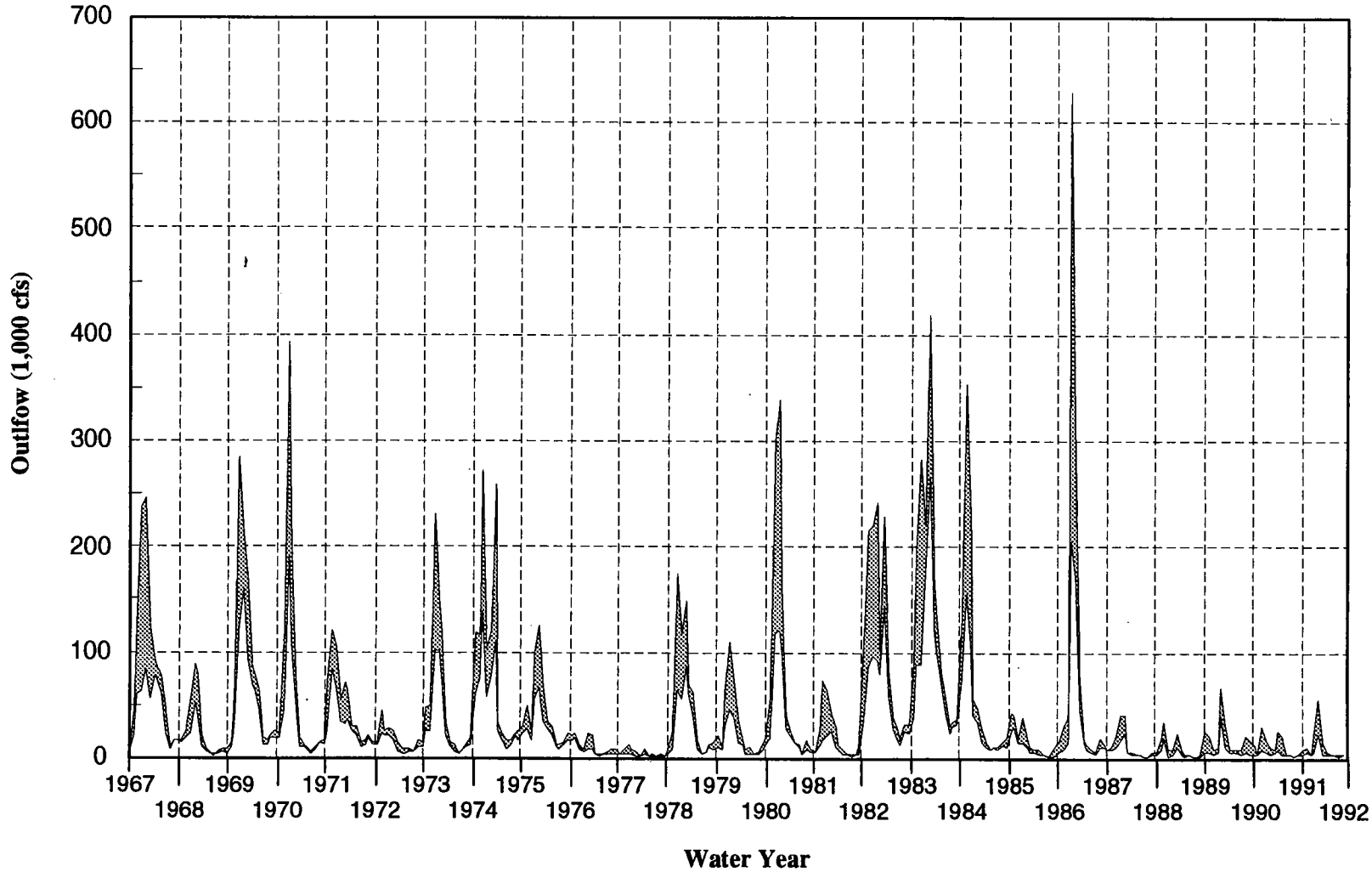
DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



Source: DWR Central District DAYFLOW records.

Figure A4-4.
Monthly Range of Daily QWEST Flows
for 1967-1991

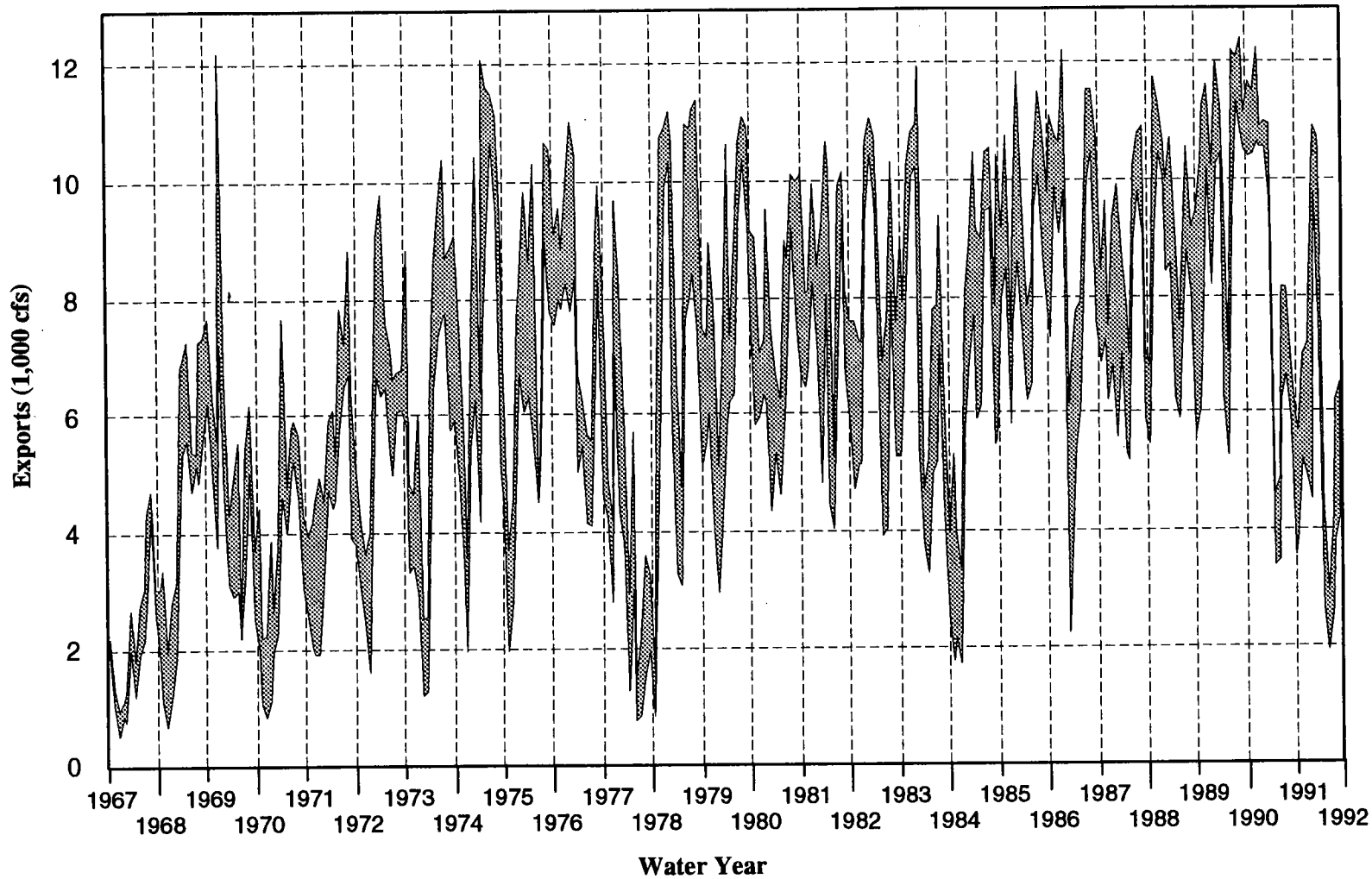
DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



Source: DWR Central District DAYFLOW records.

Figure A4-5.
Monthly Range of Daily Delta Outflow
for 1967-1991

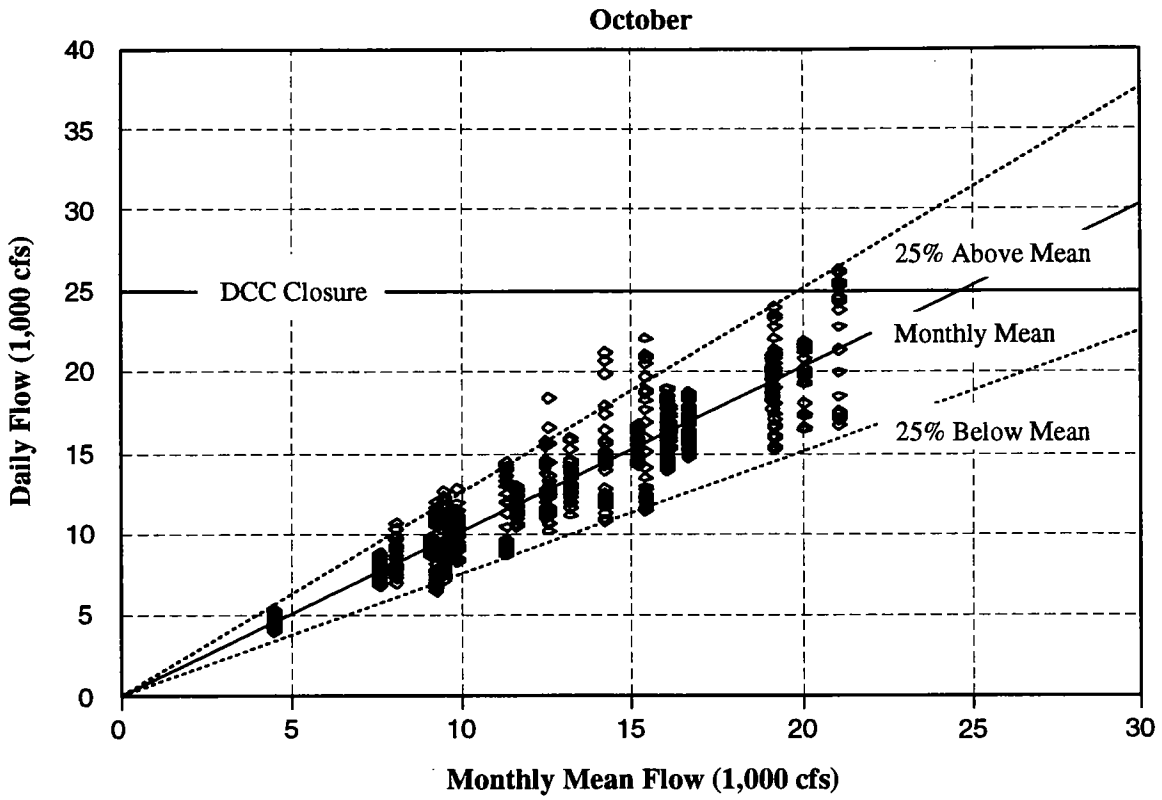
DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



Source: DWR Central District DAYFLOW records.

Figure A4-6.
Monthly Range of Daily Total Delta Exports for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



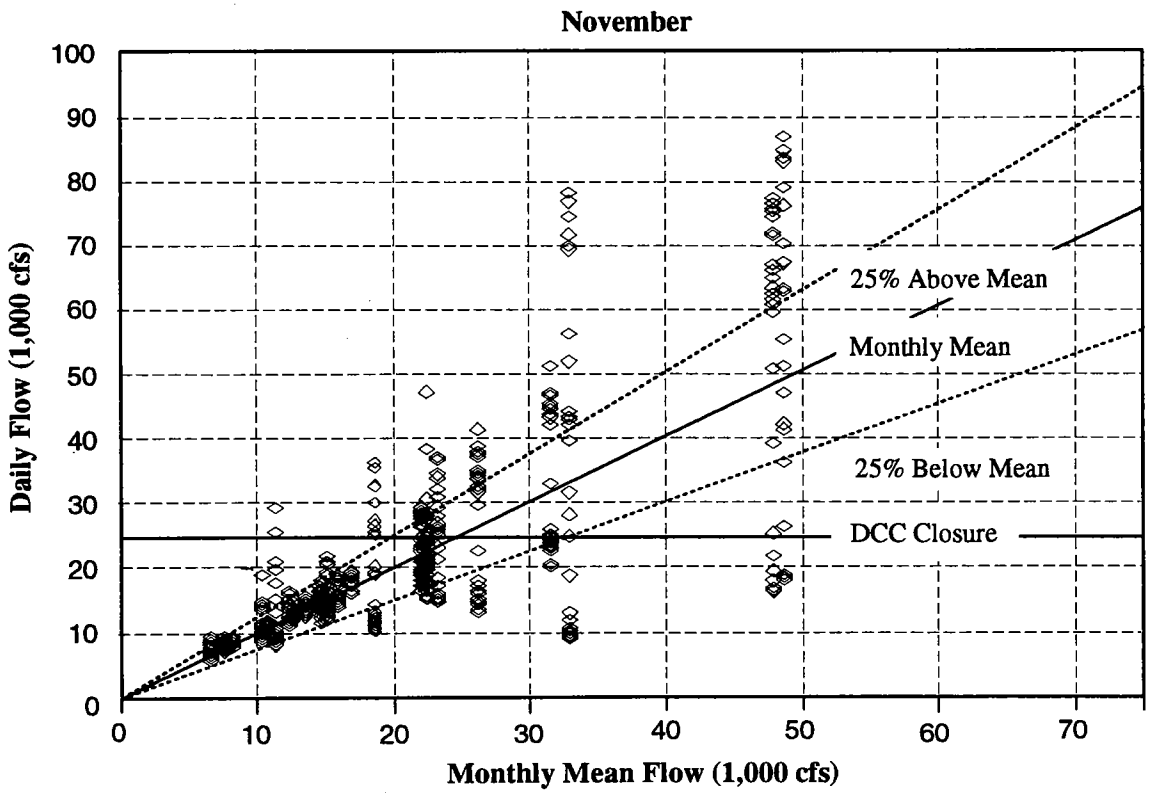
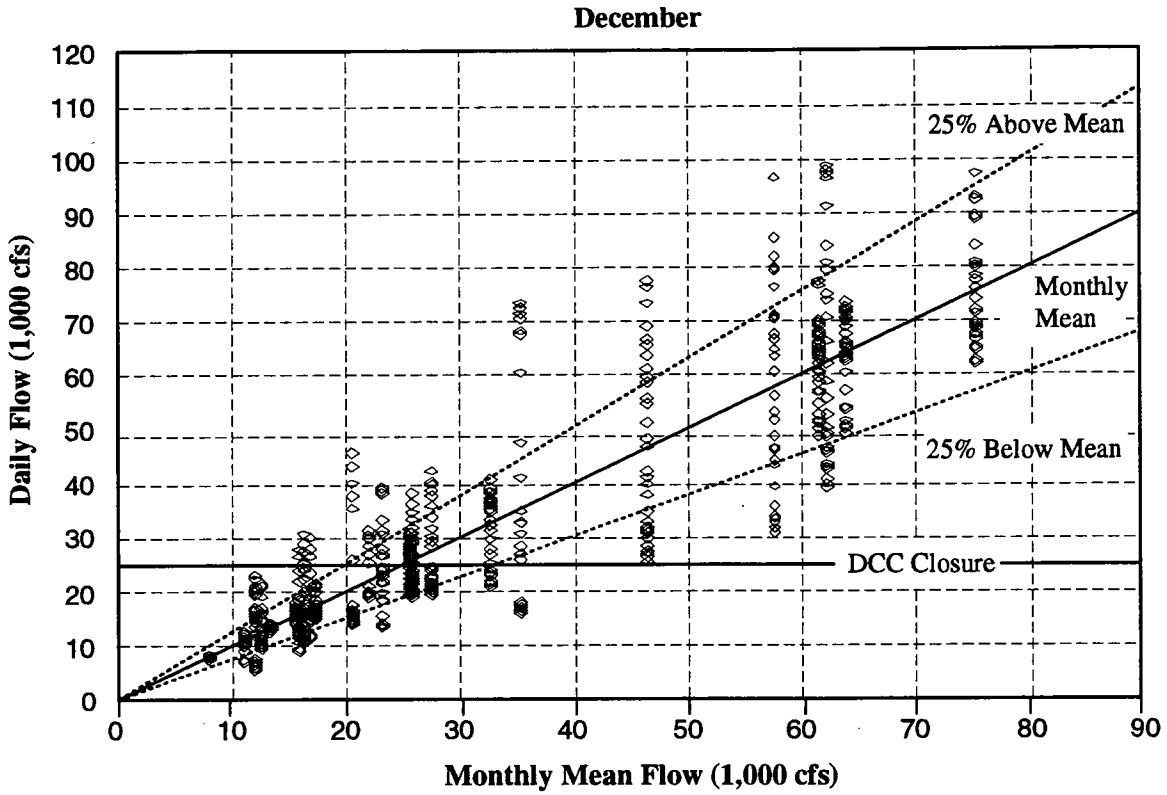


Figure A4-7.
Daily versus Monthly Mean Sacramento River Inflow at Freeport

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



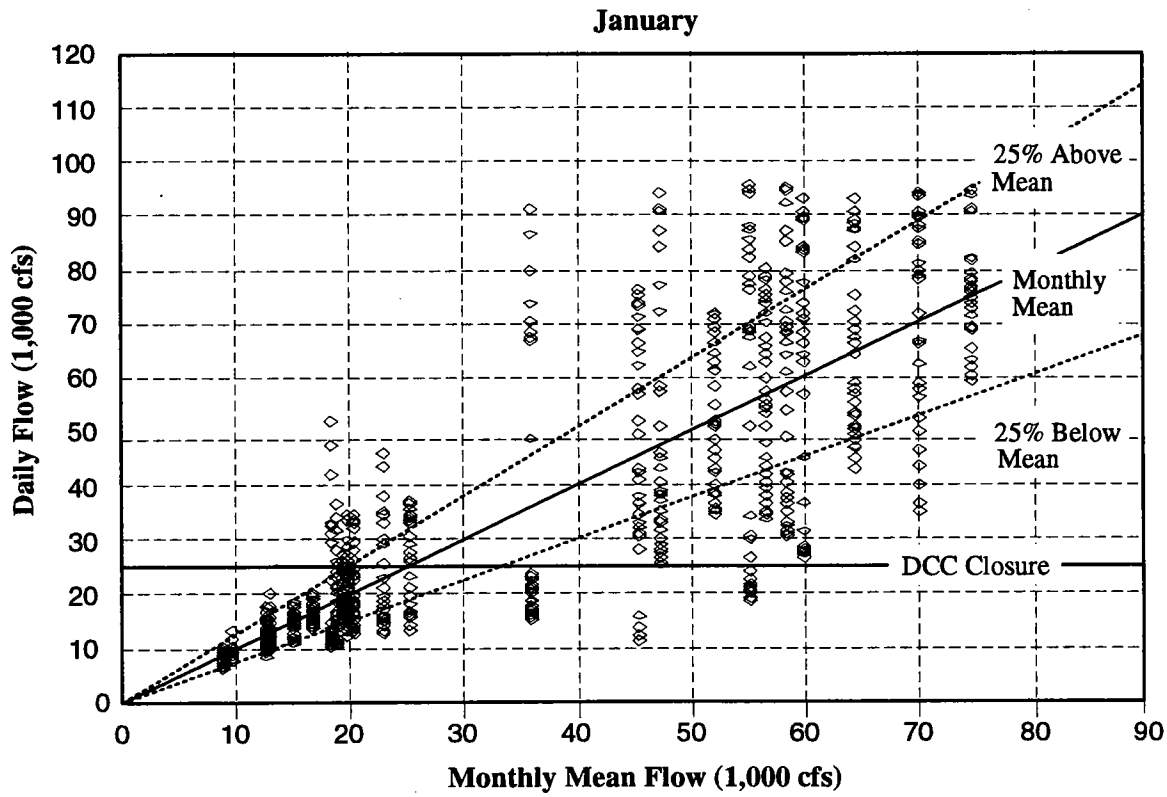


Figure A4-7.
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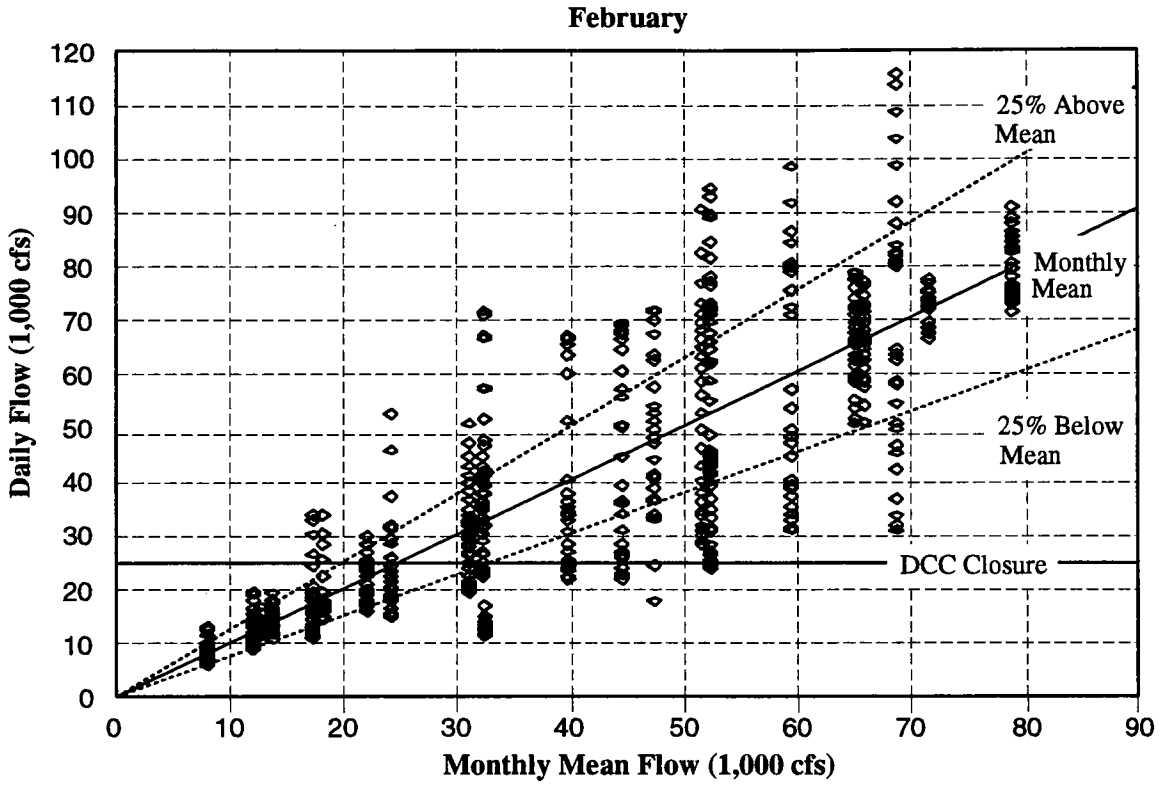


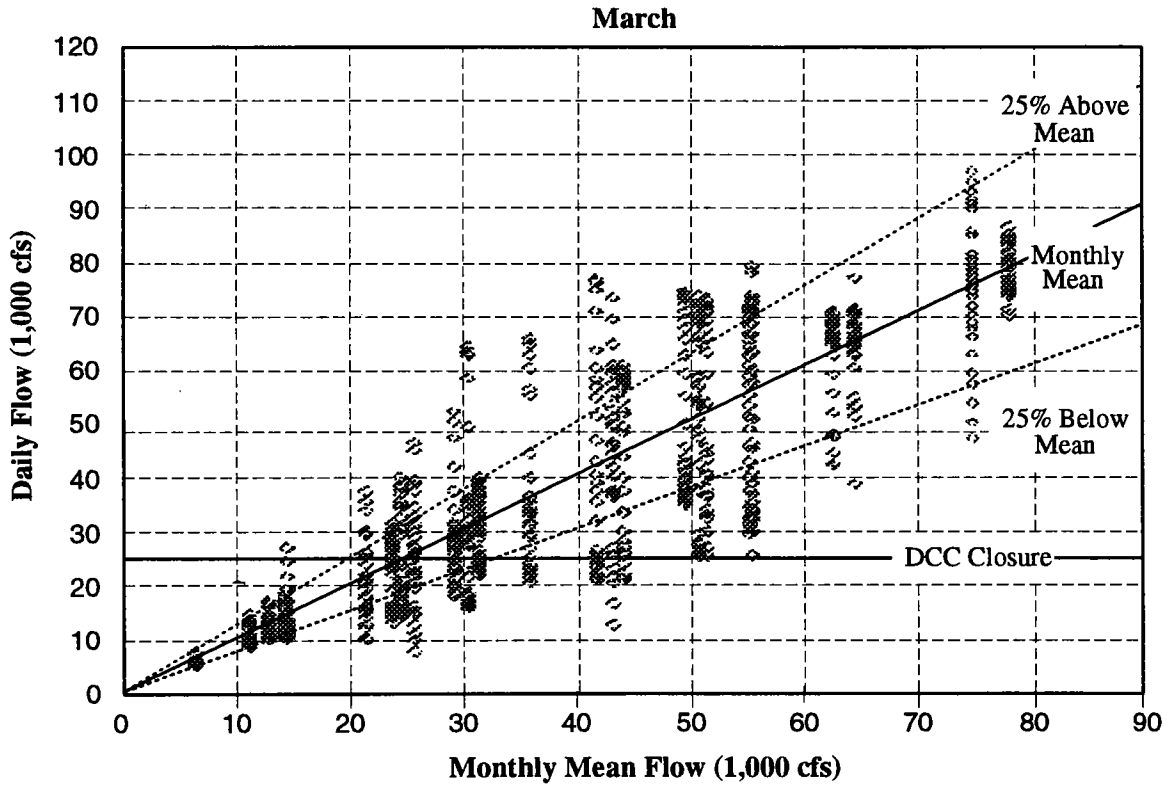
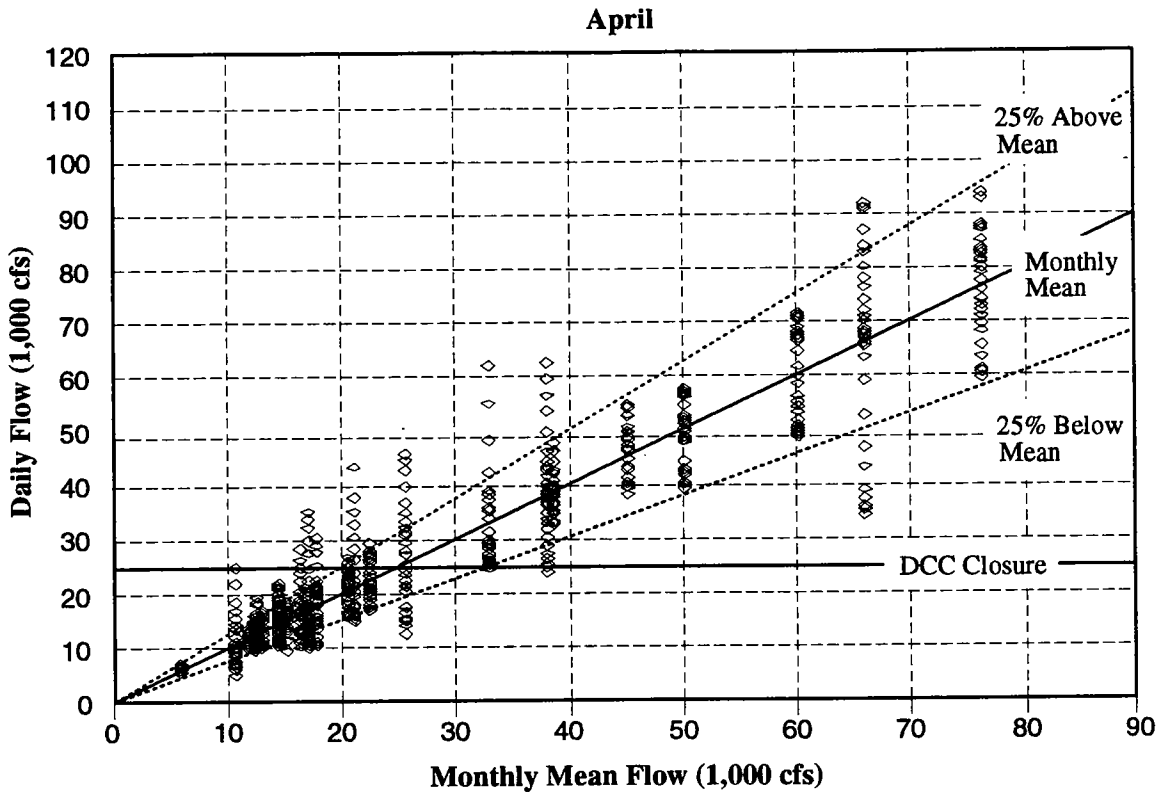


Figure A4-7.
Continued

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



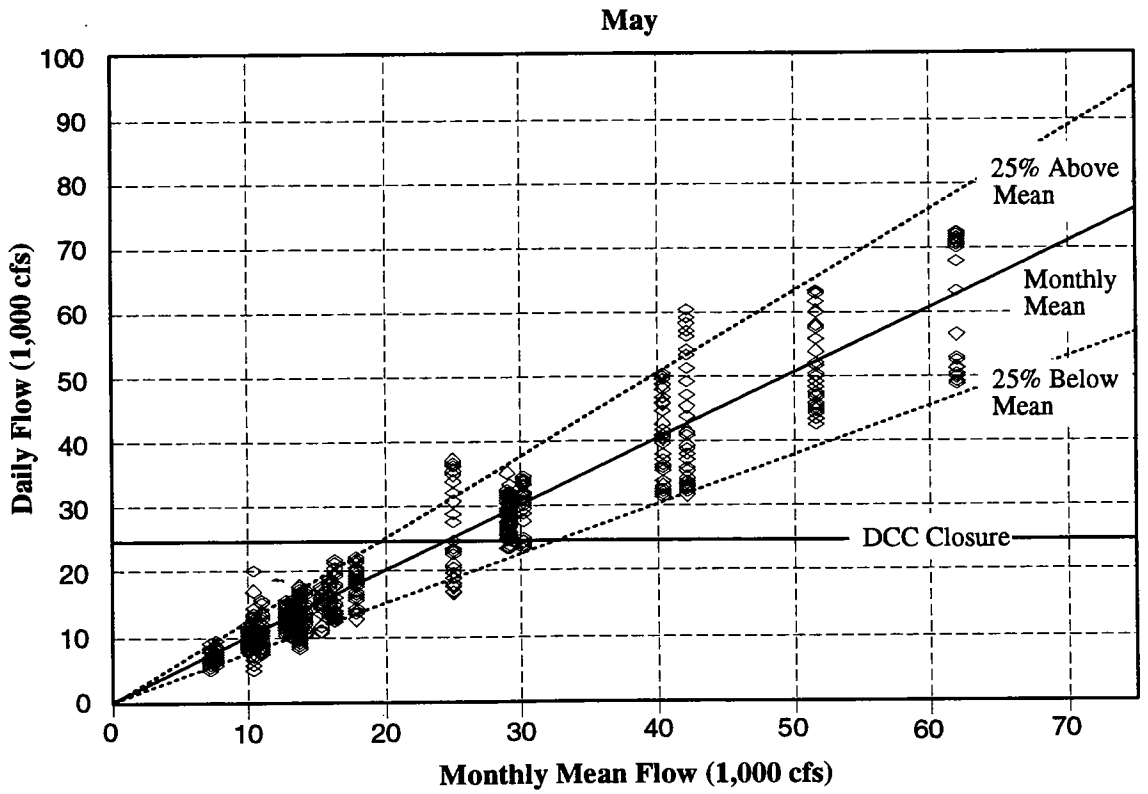
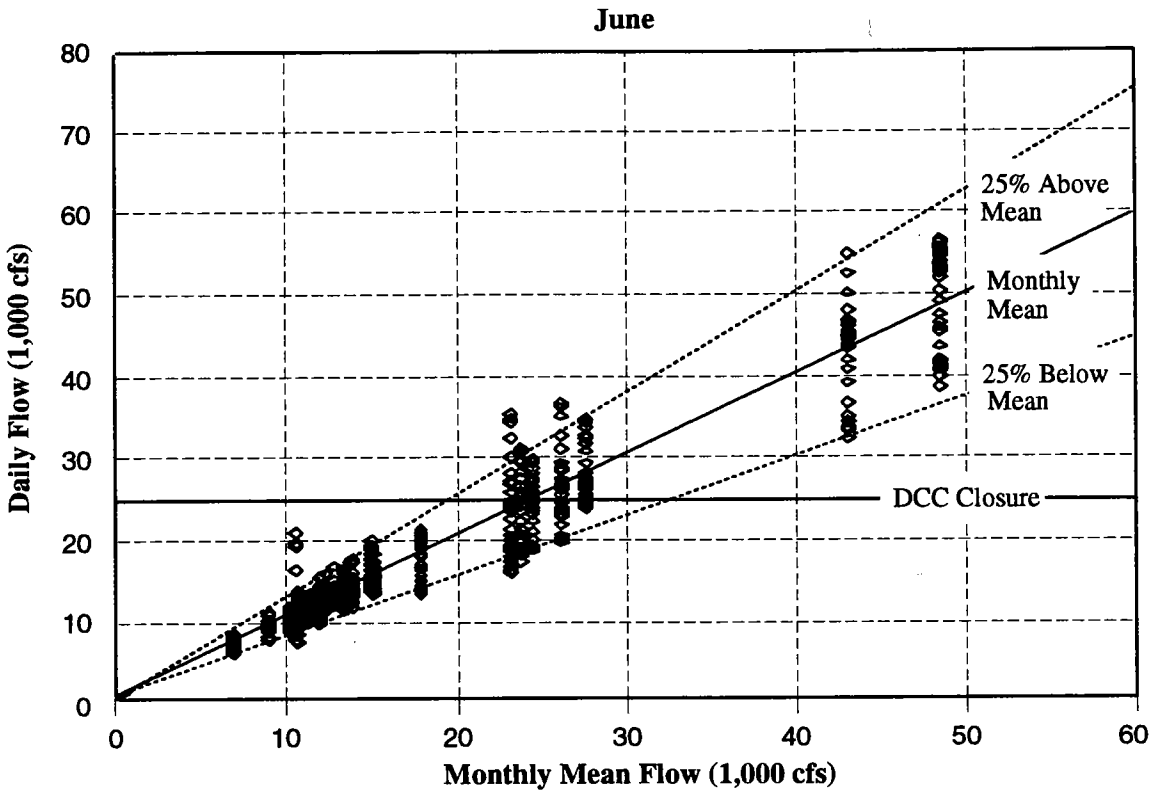


Figure A4-7.
Continued

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



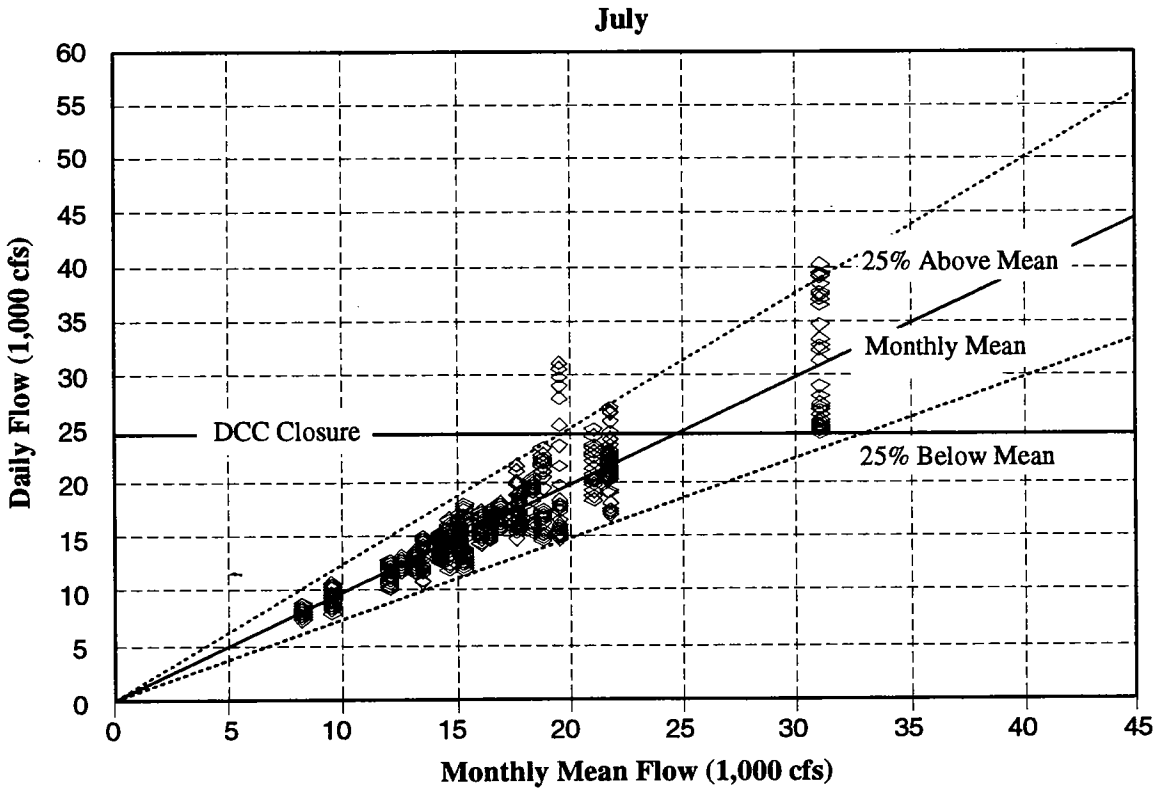


Figure A4-7.
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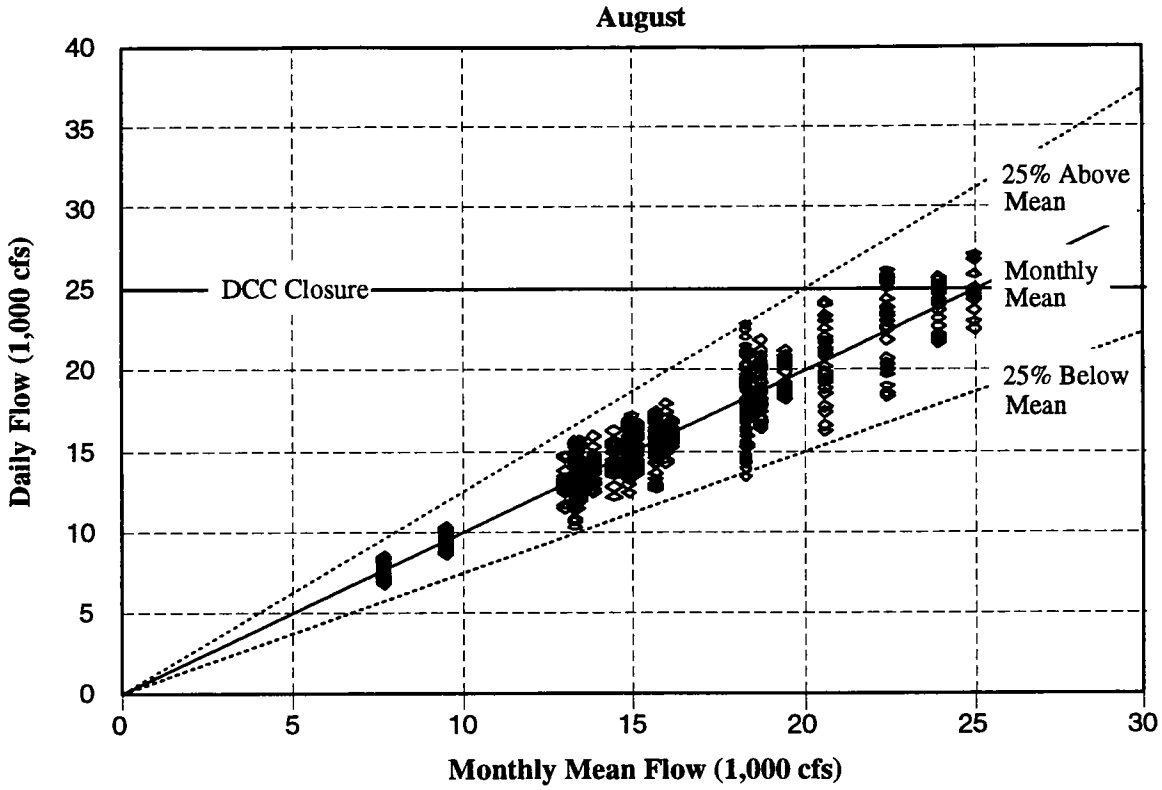
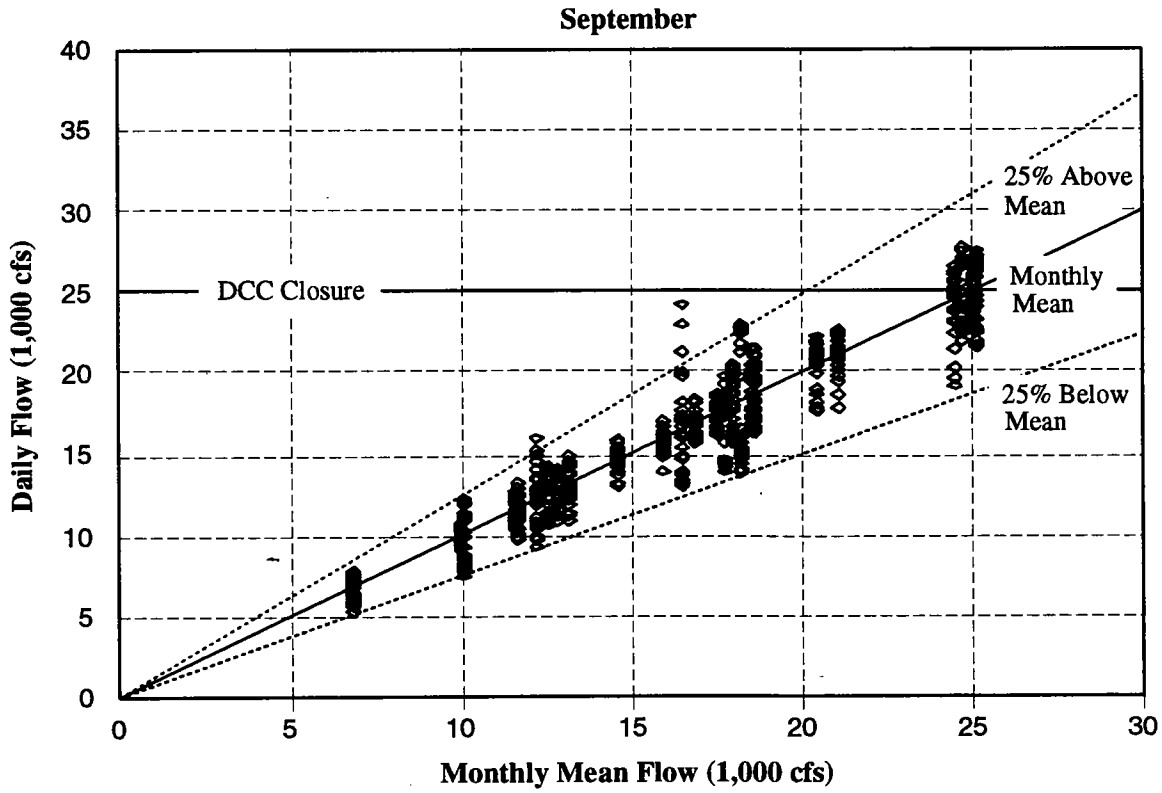
DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates





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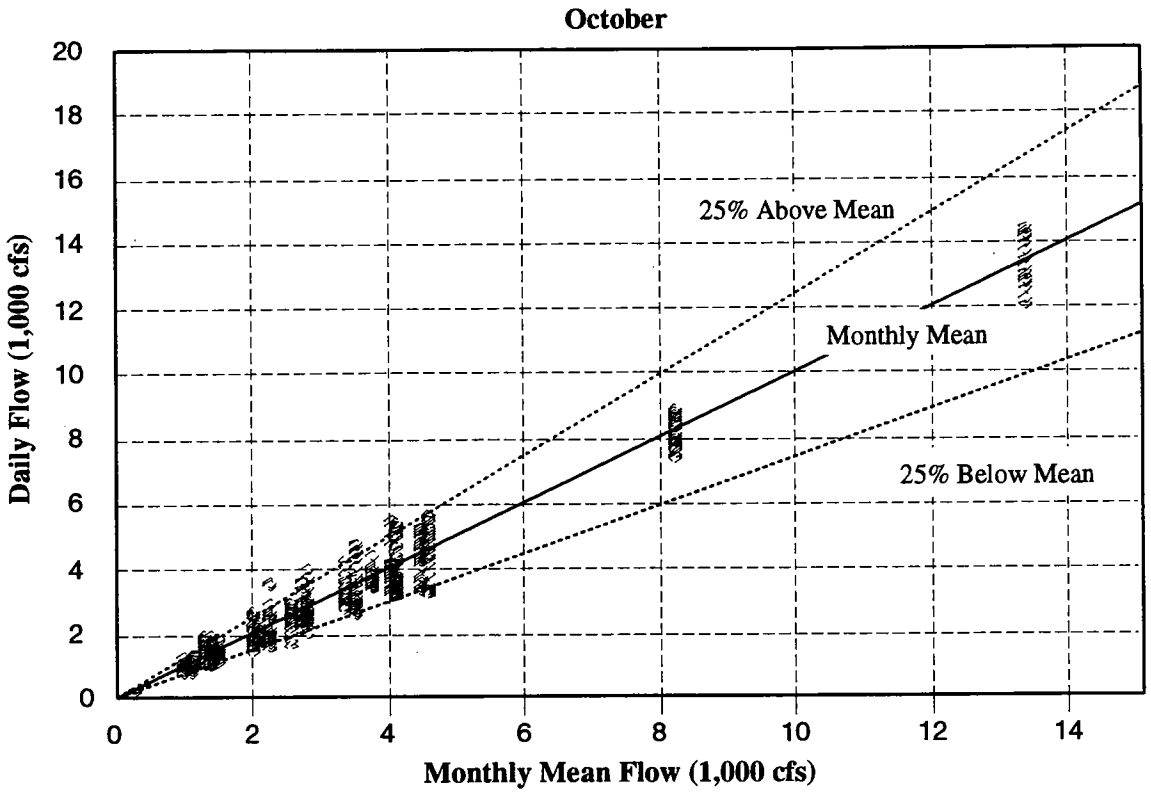


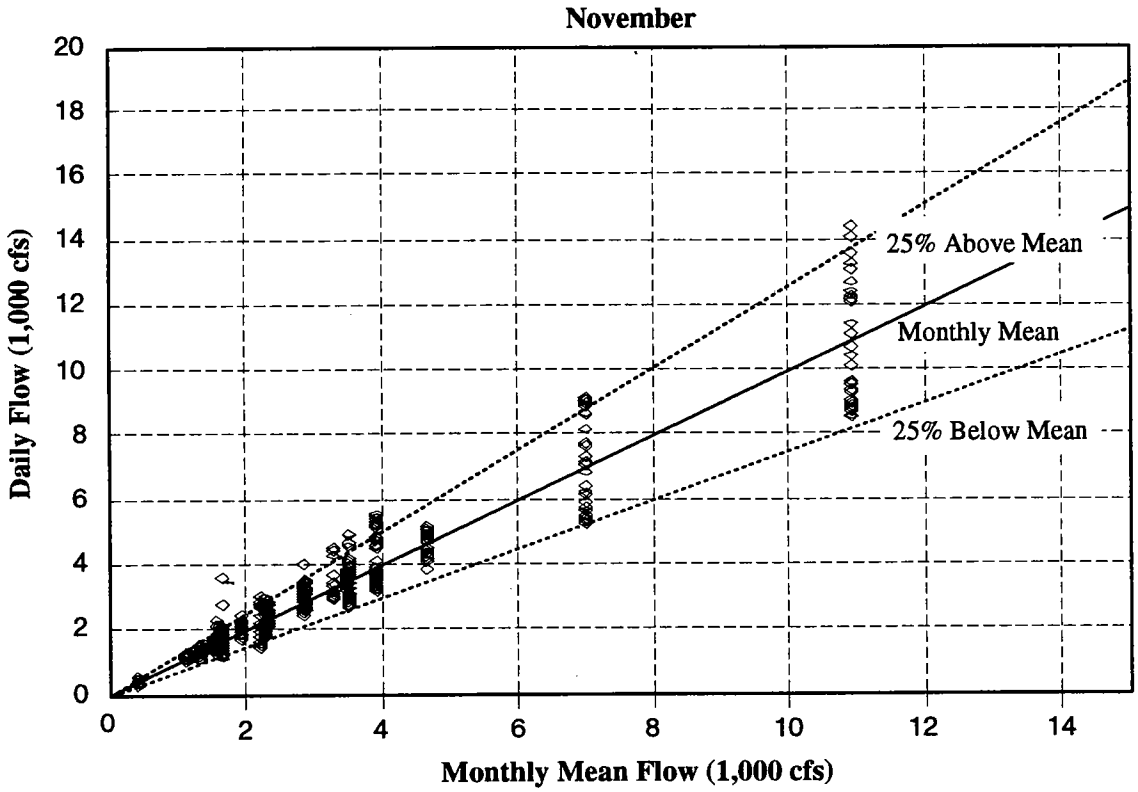
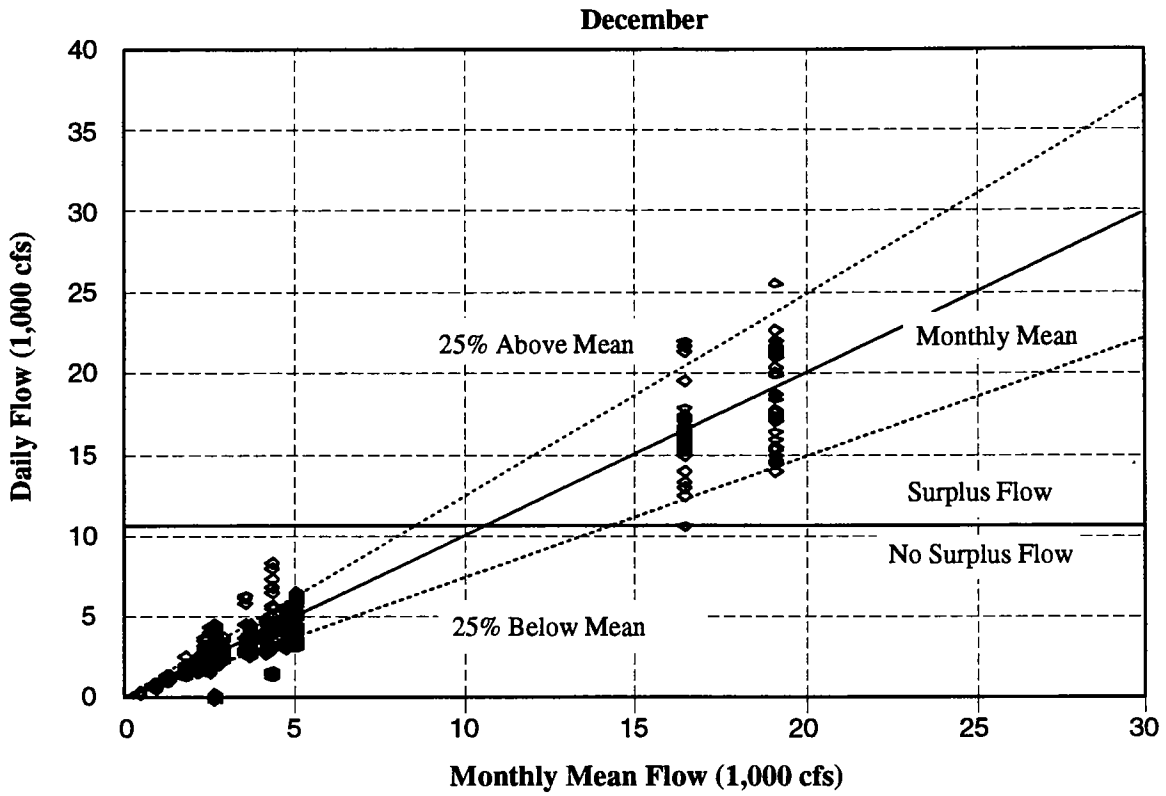
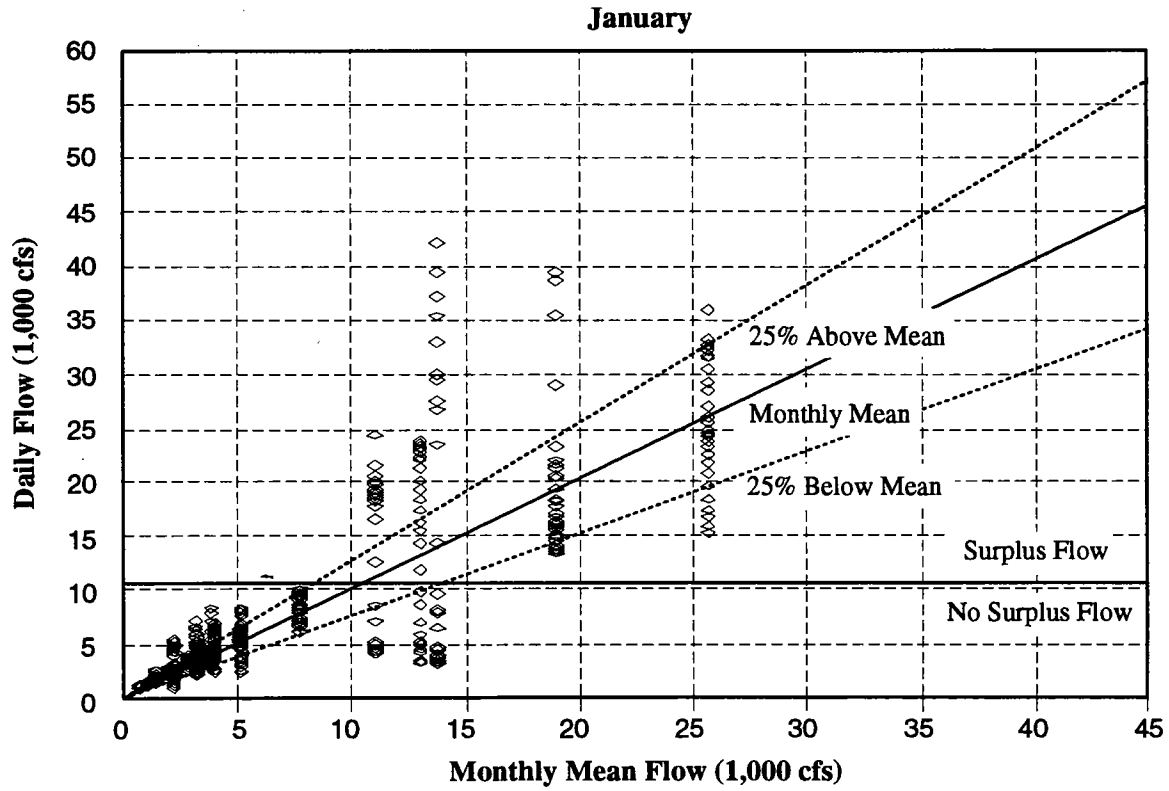


Figure A4-8.
Daily versus Monthly Mean San Joaquin River Inflow at Vernalis

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates





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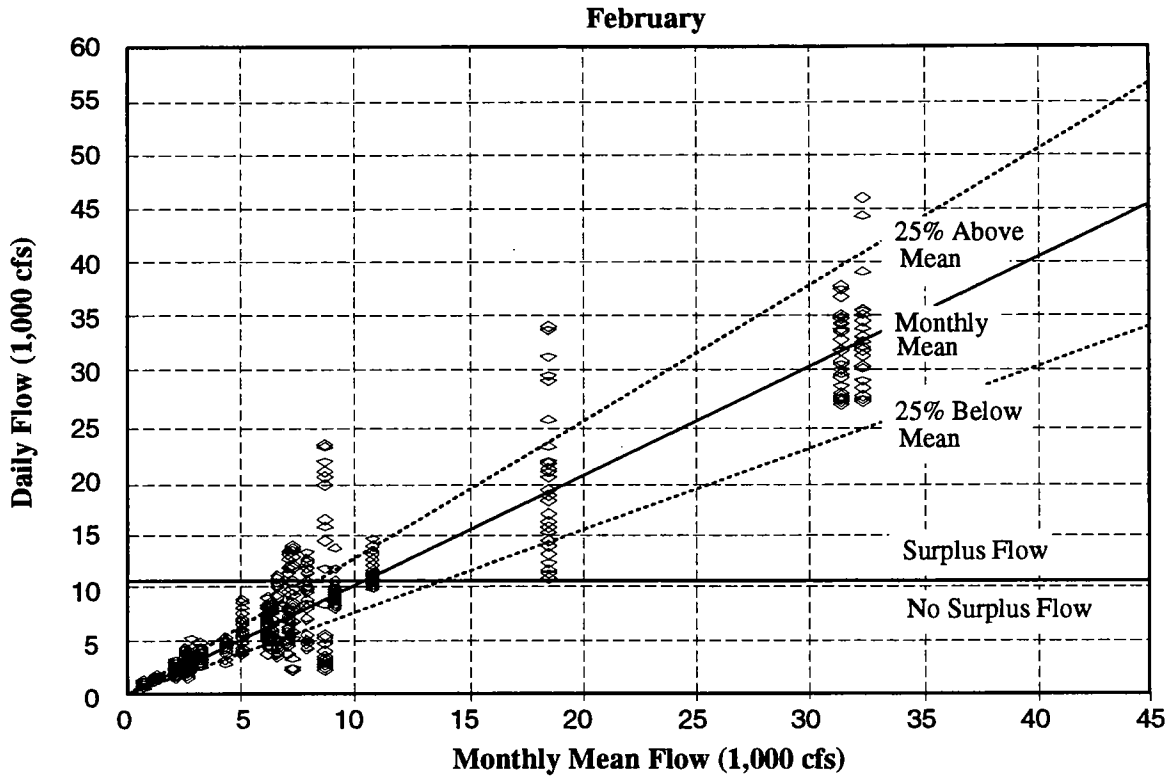

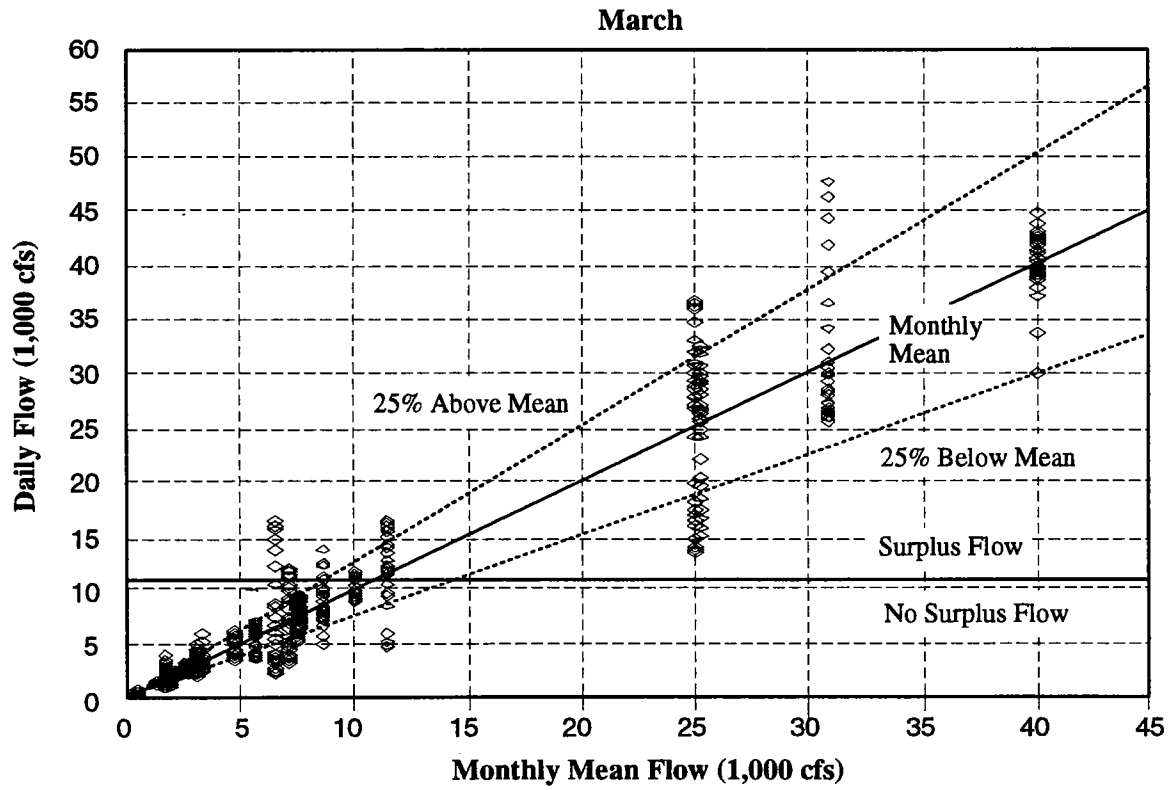

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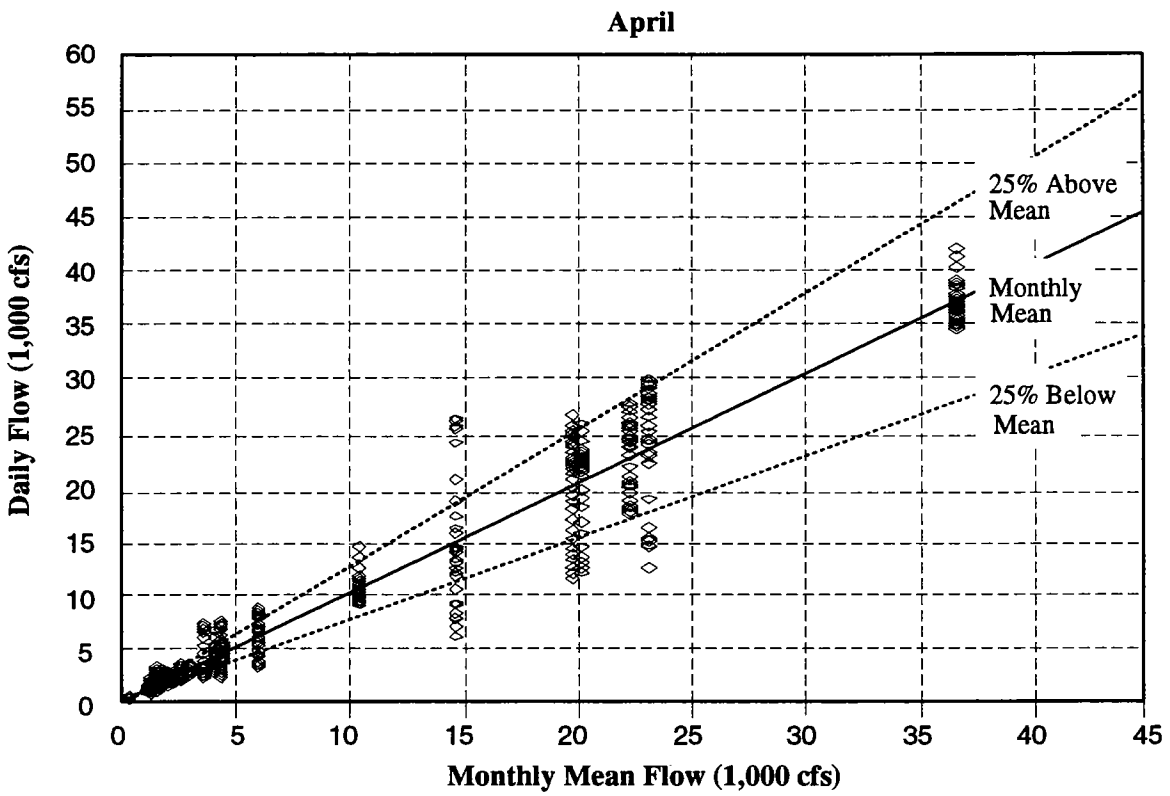

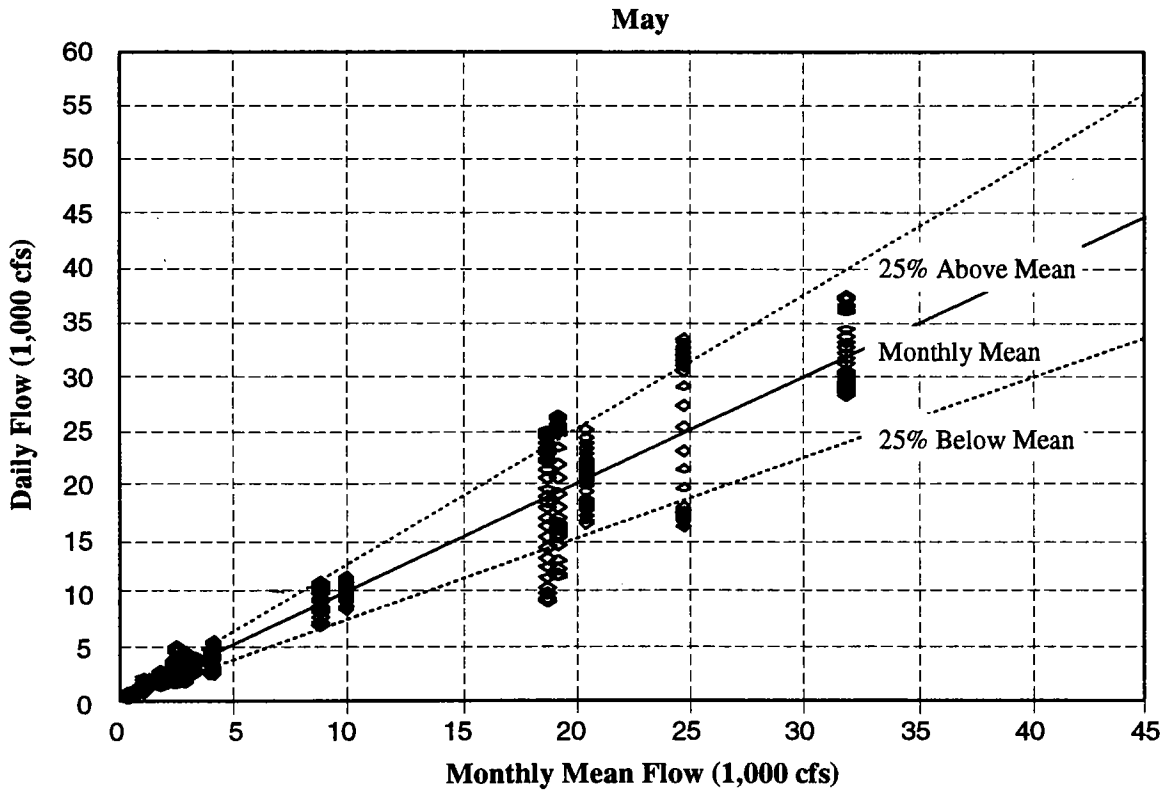

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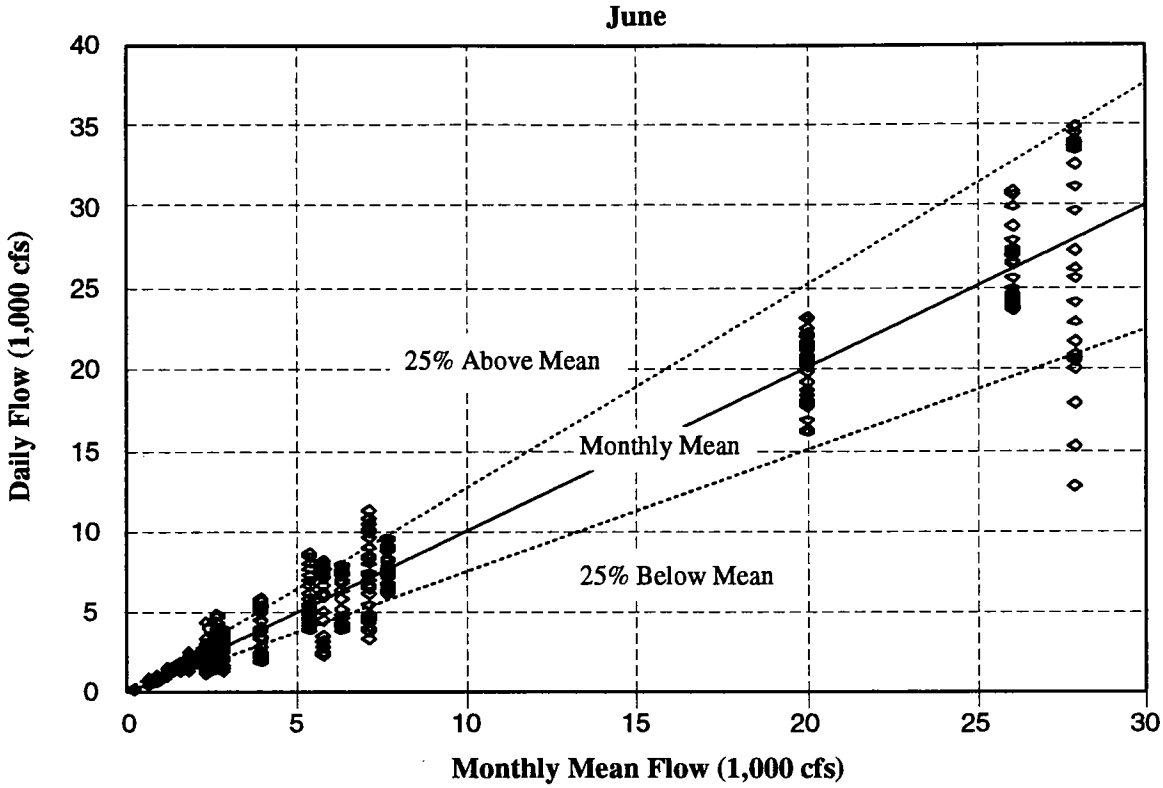

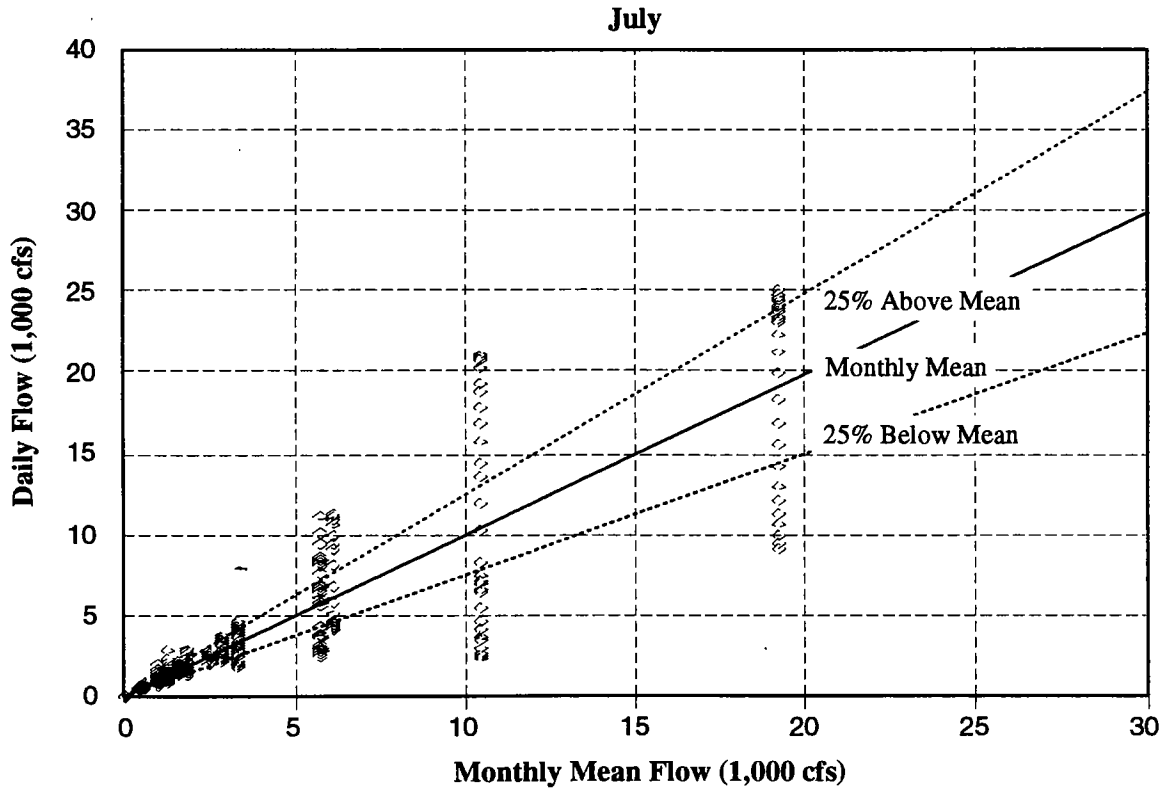

Figure A4-8.
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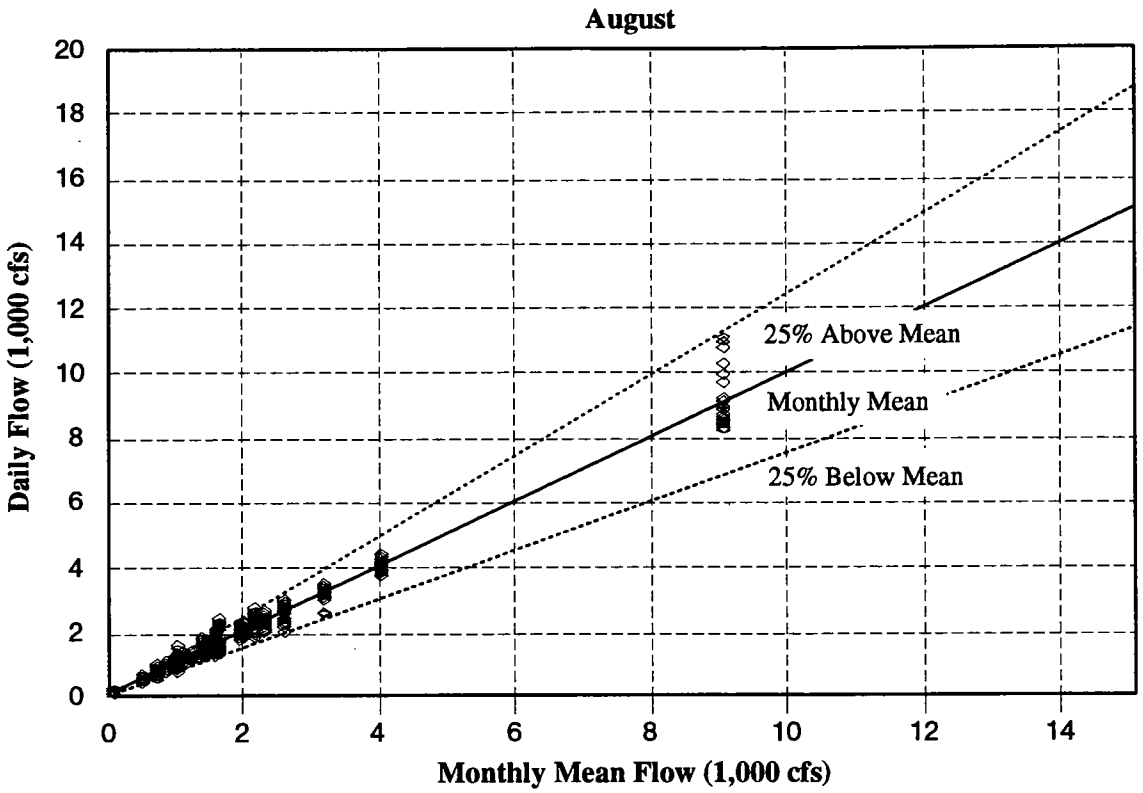
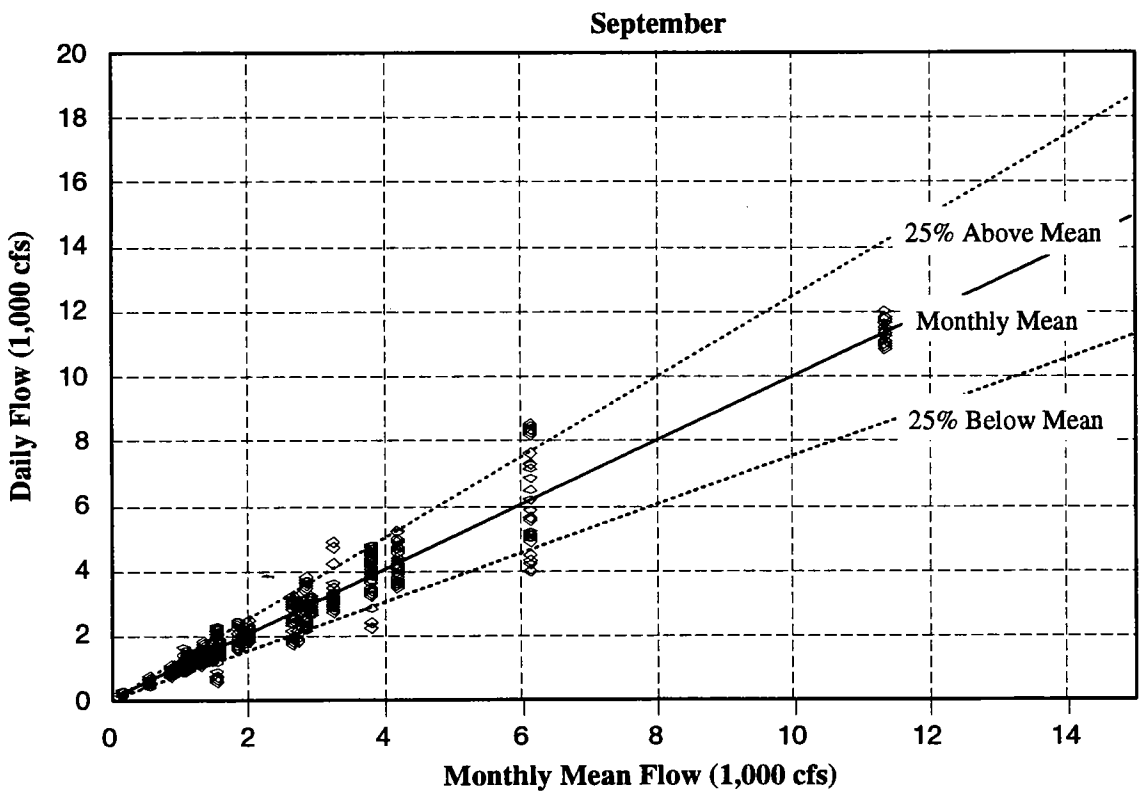
DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates





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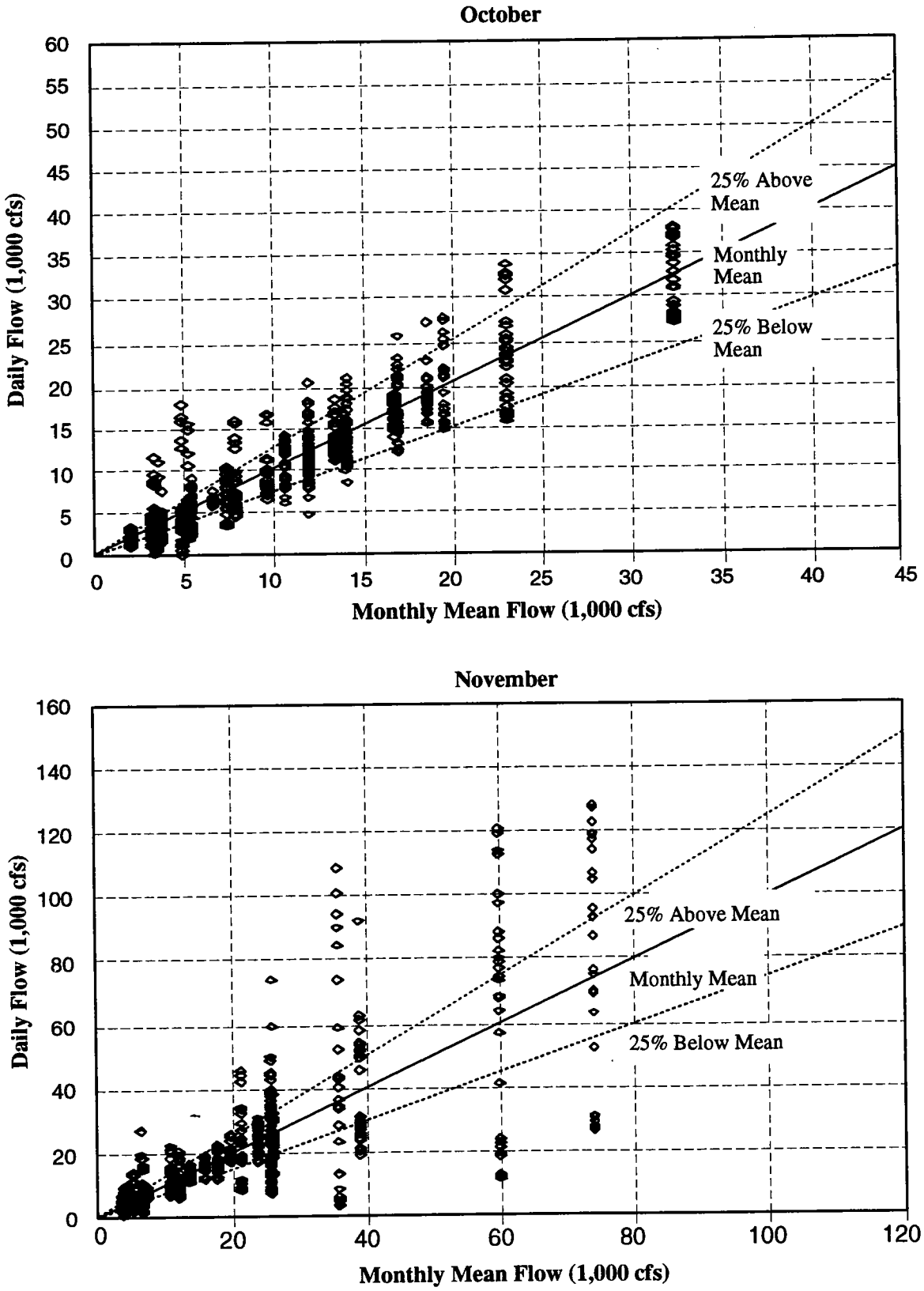
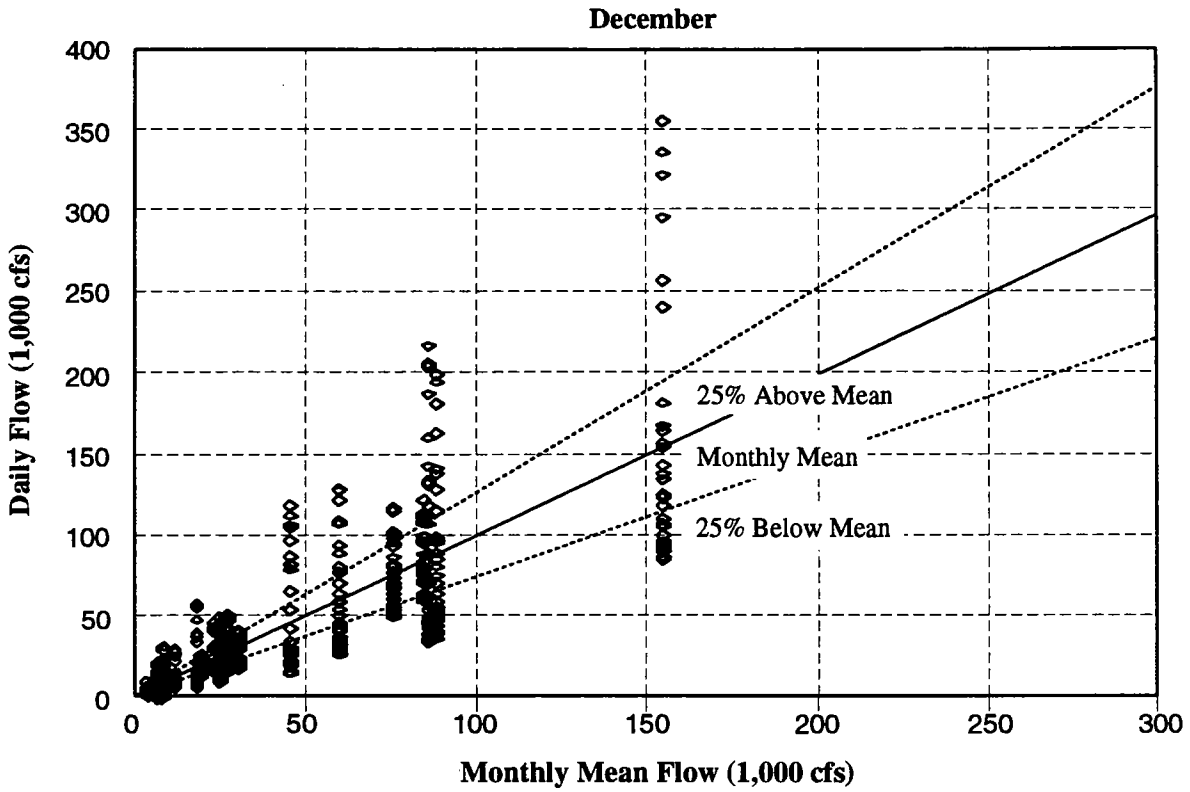
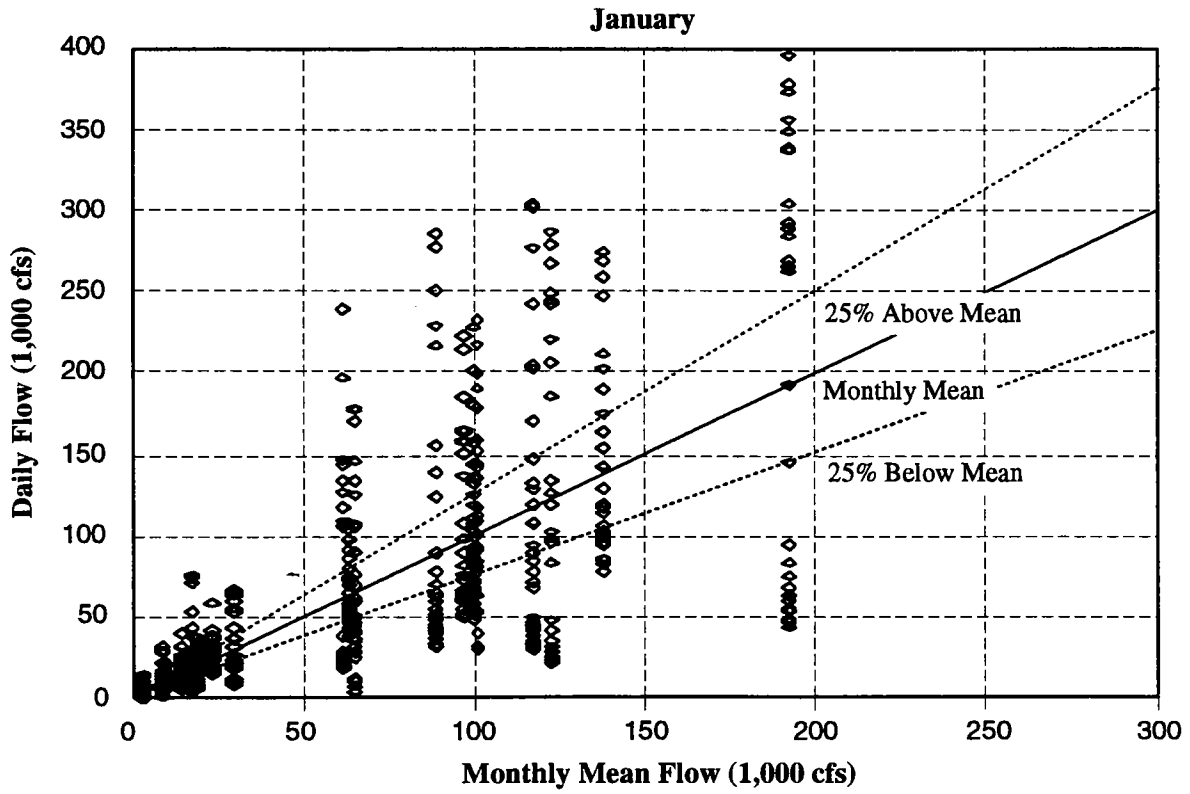


Figure A4-9.
Daily versus Mean Monthly Delta Outflow

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates





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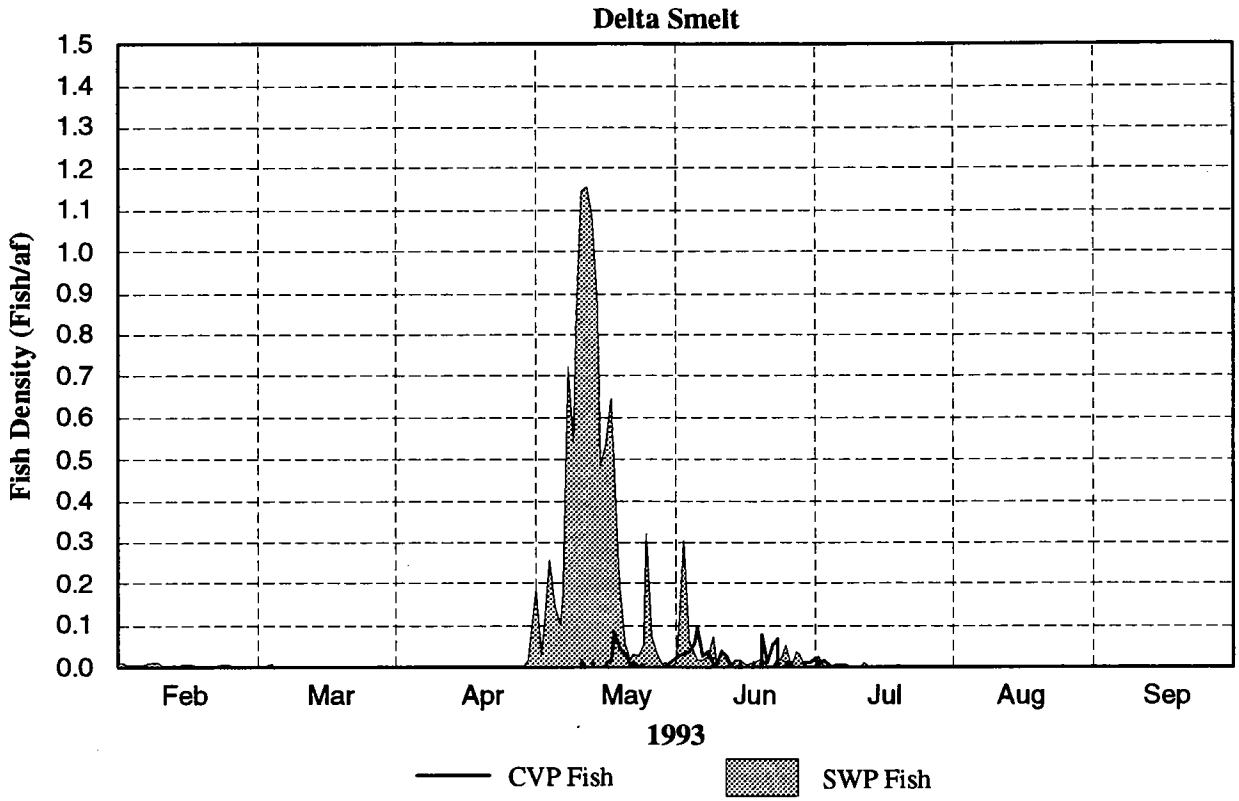

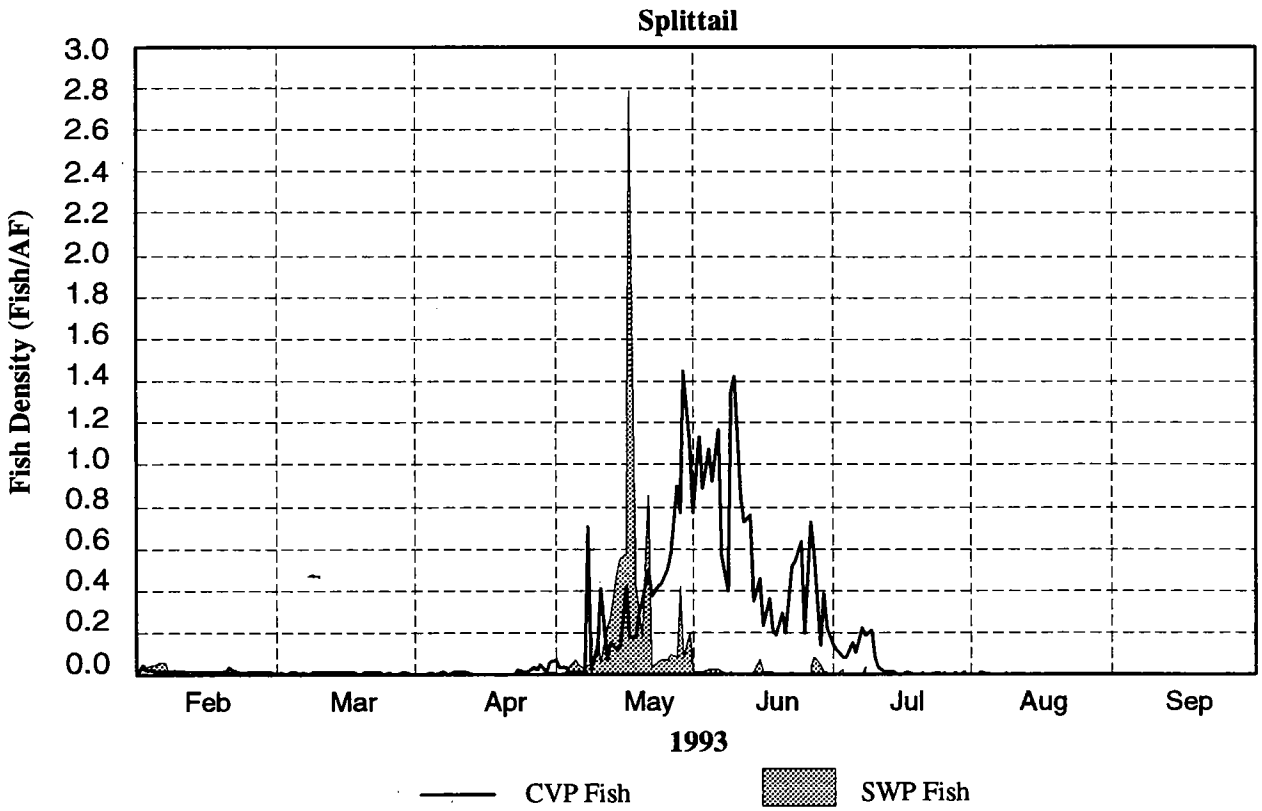

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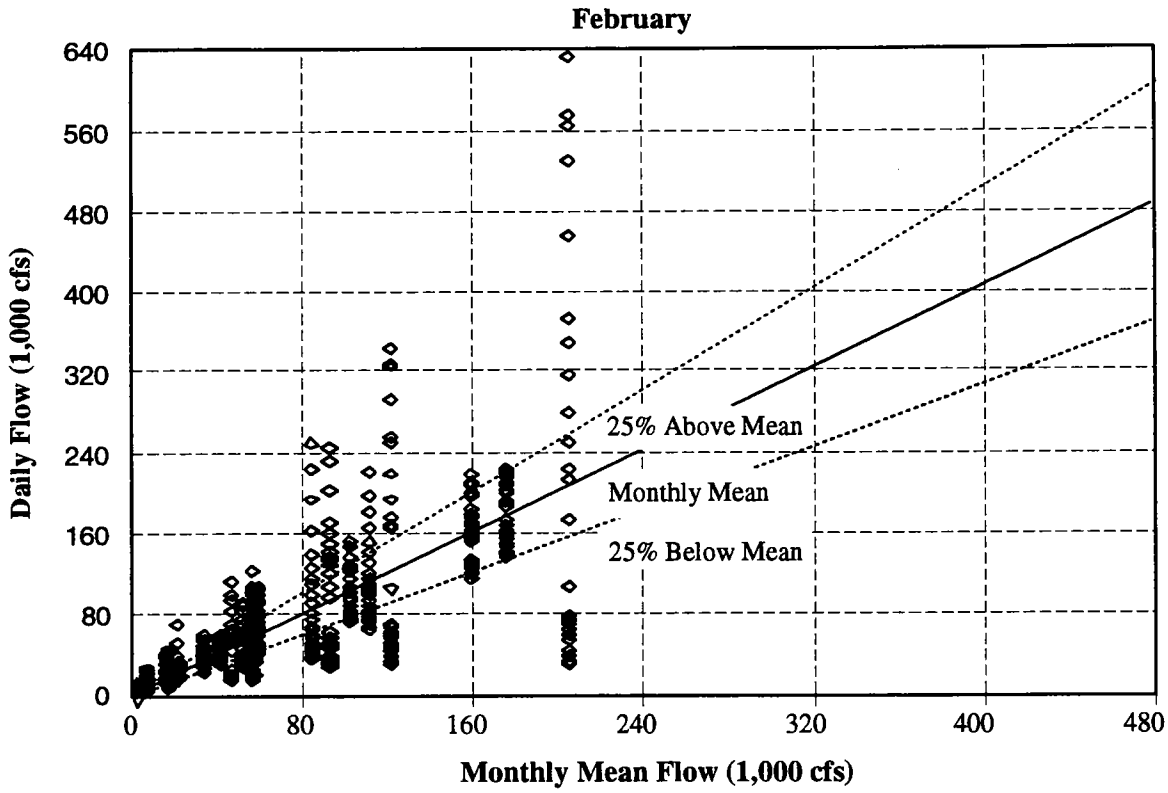

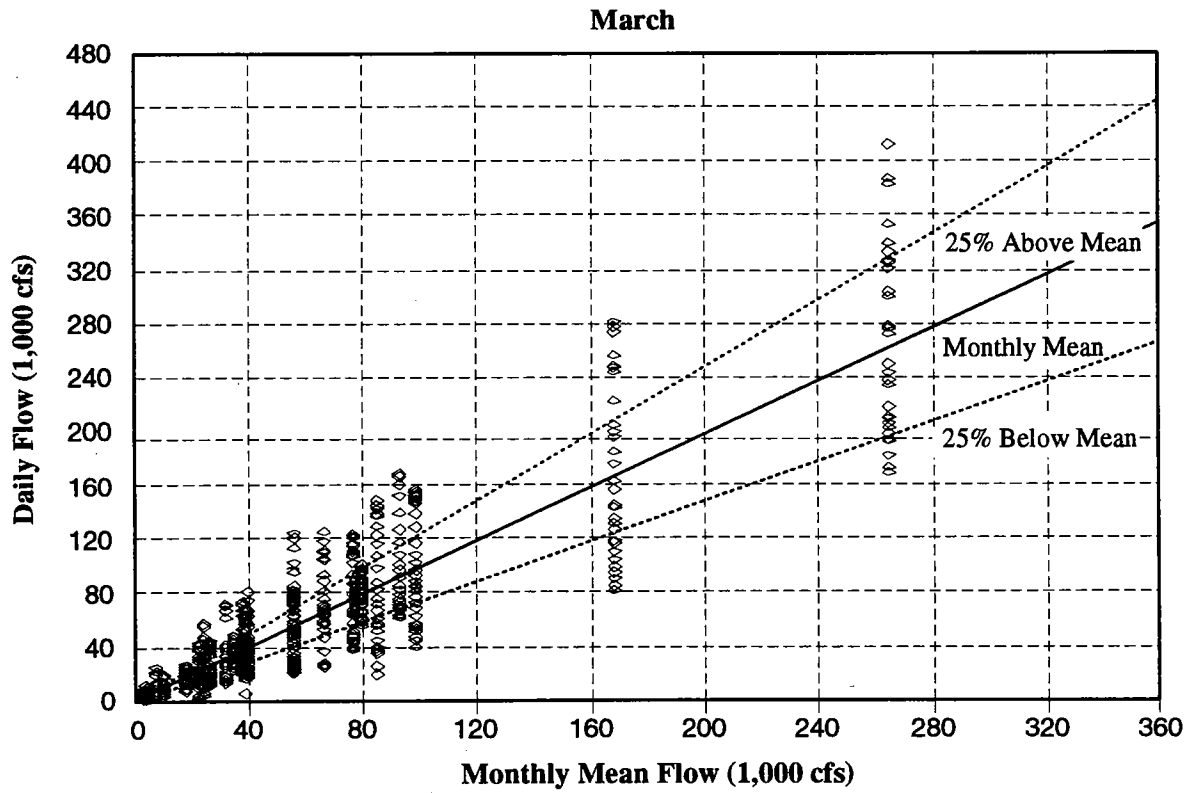

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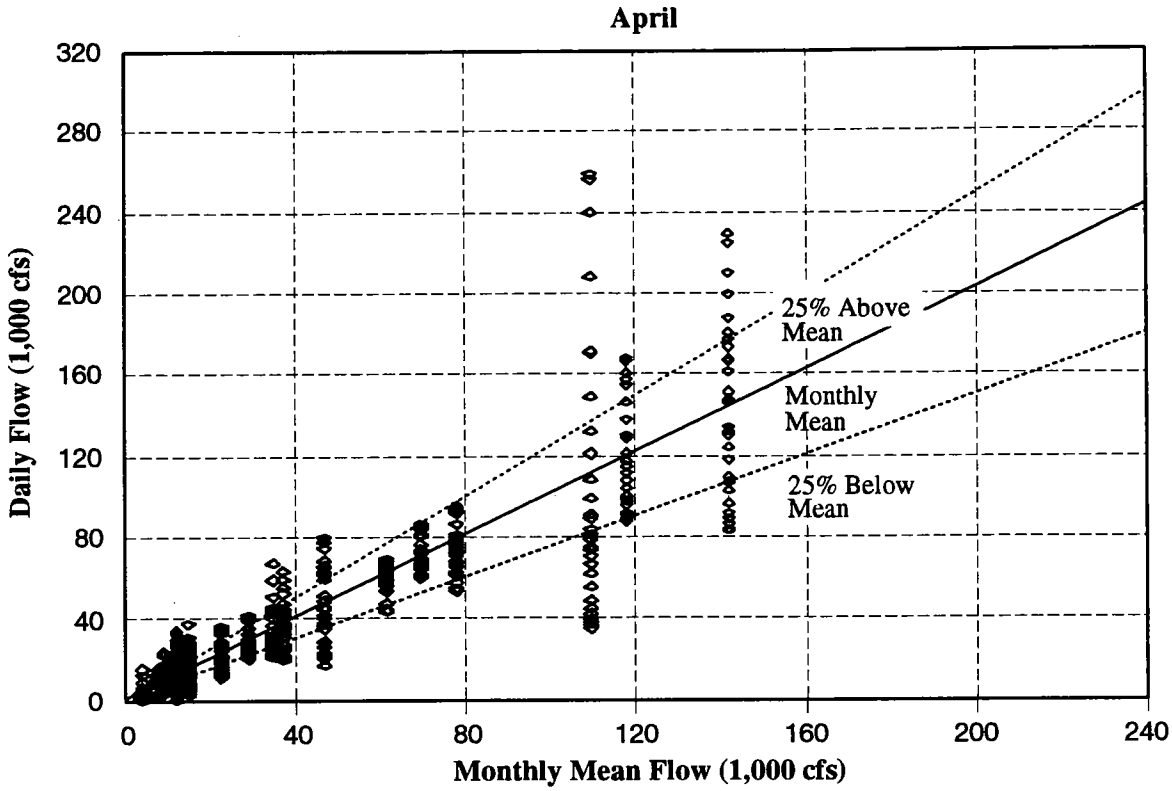

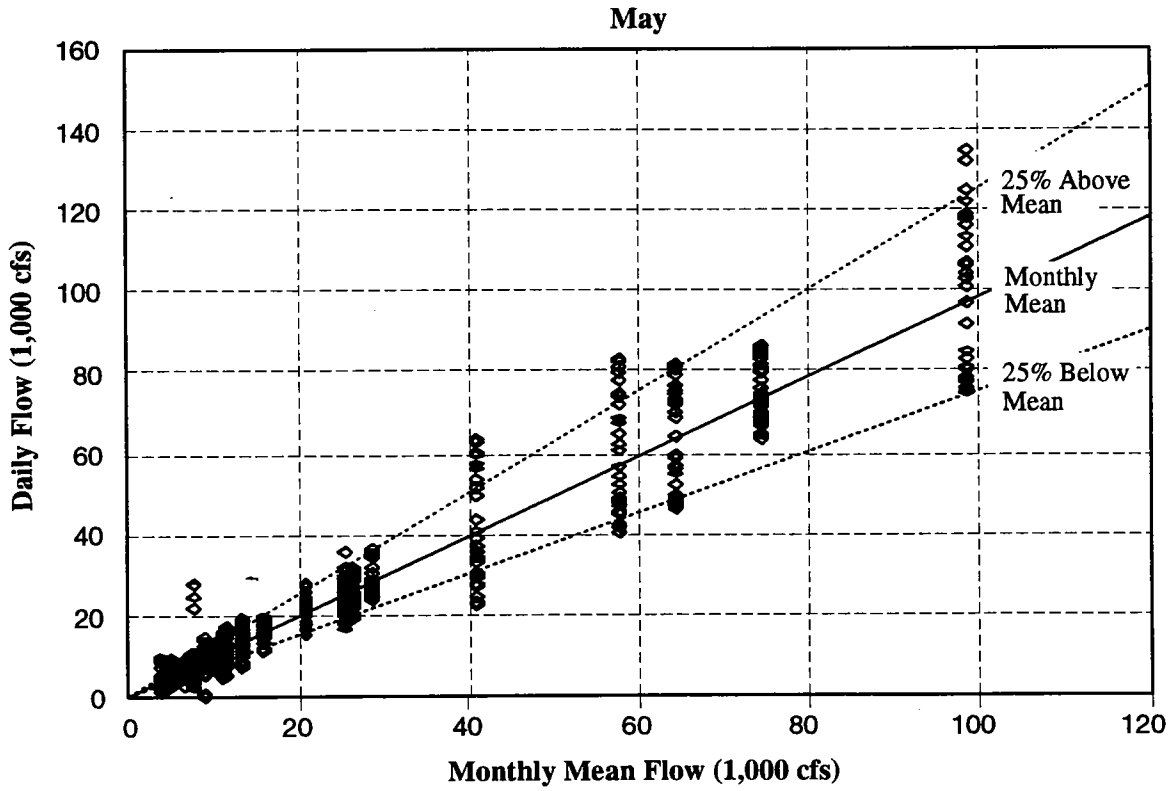

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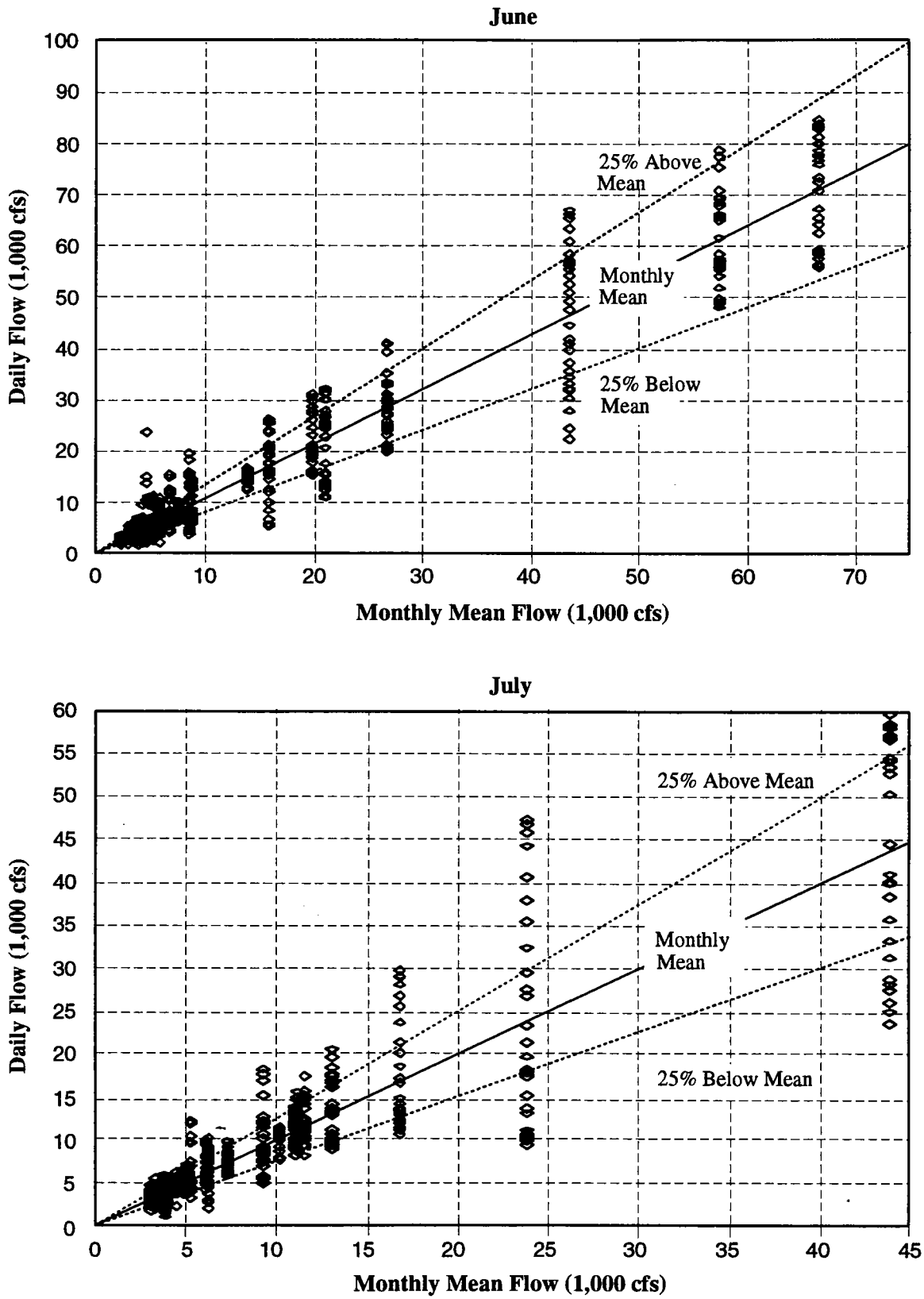

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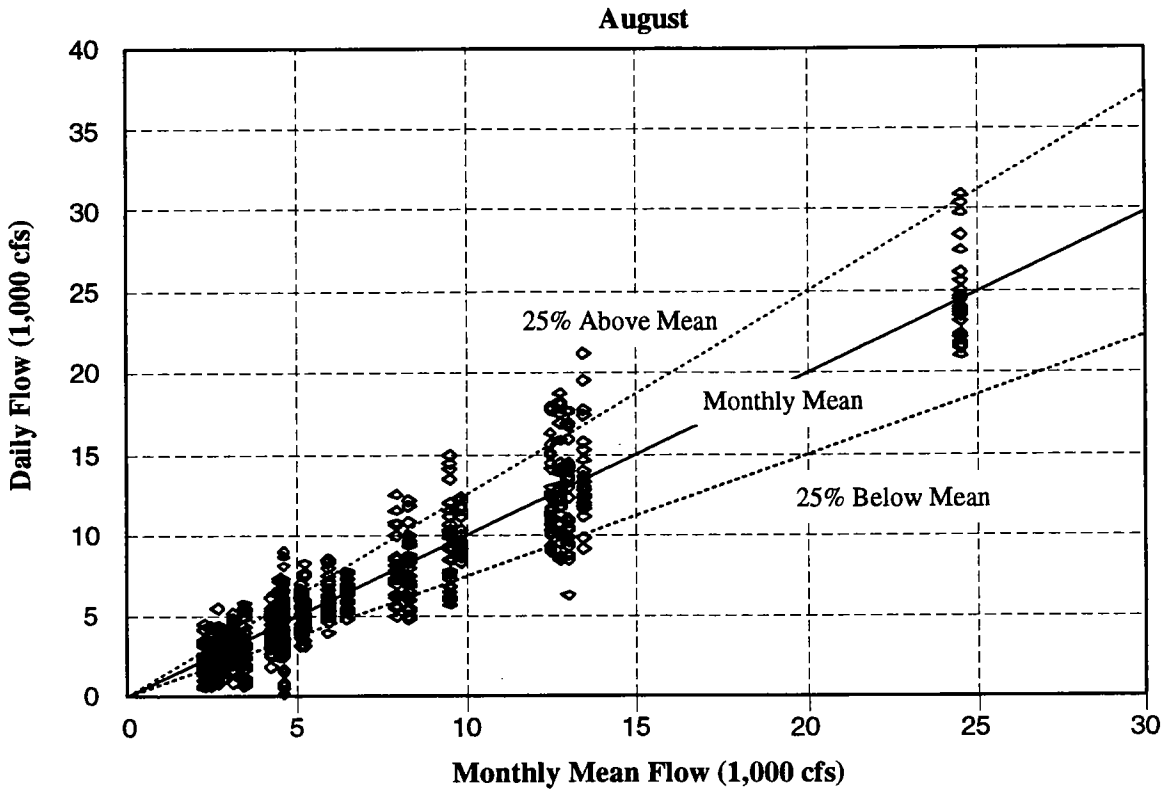

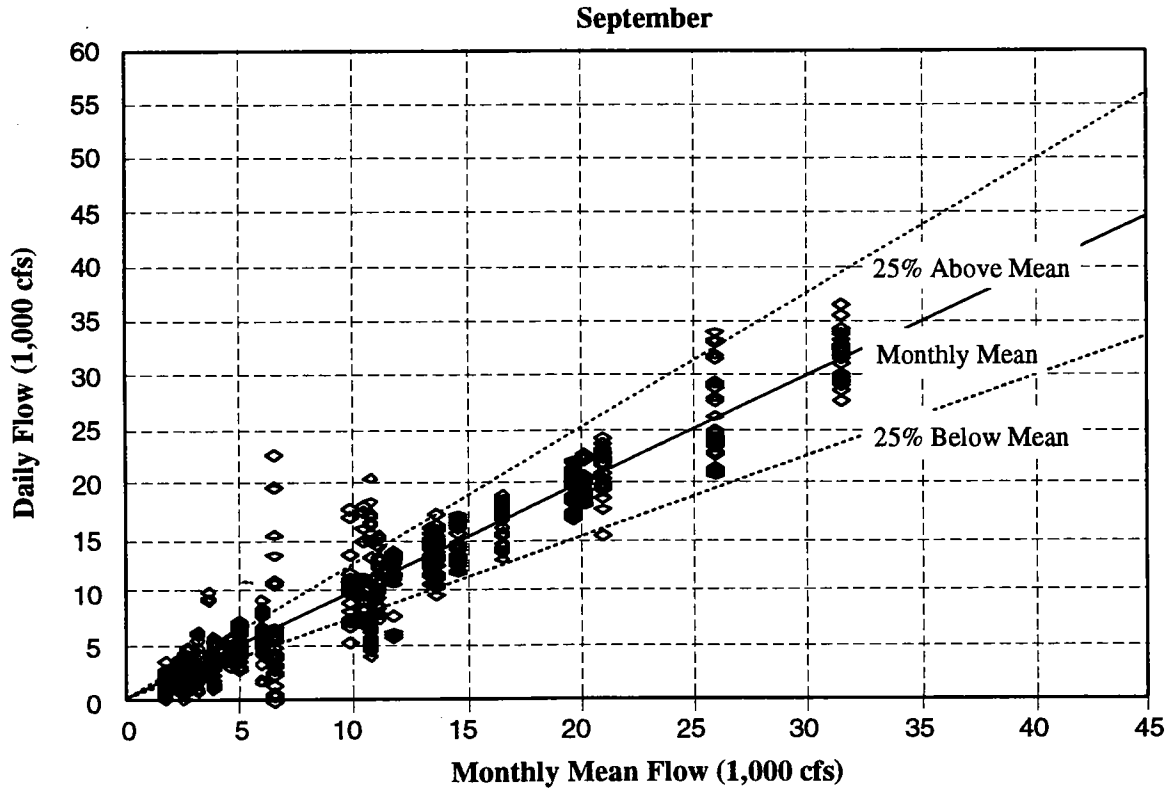

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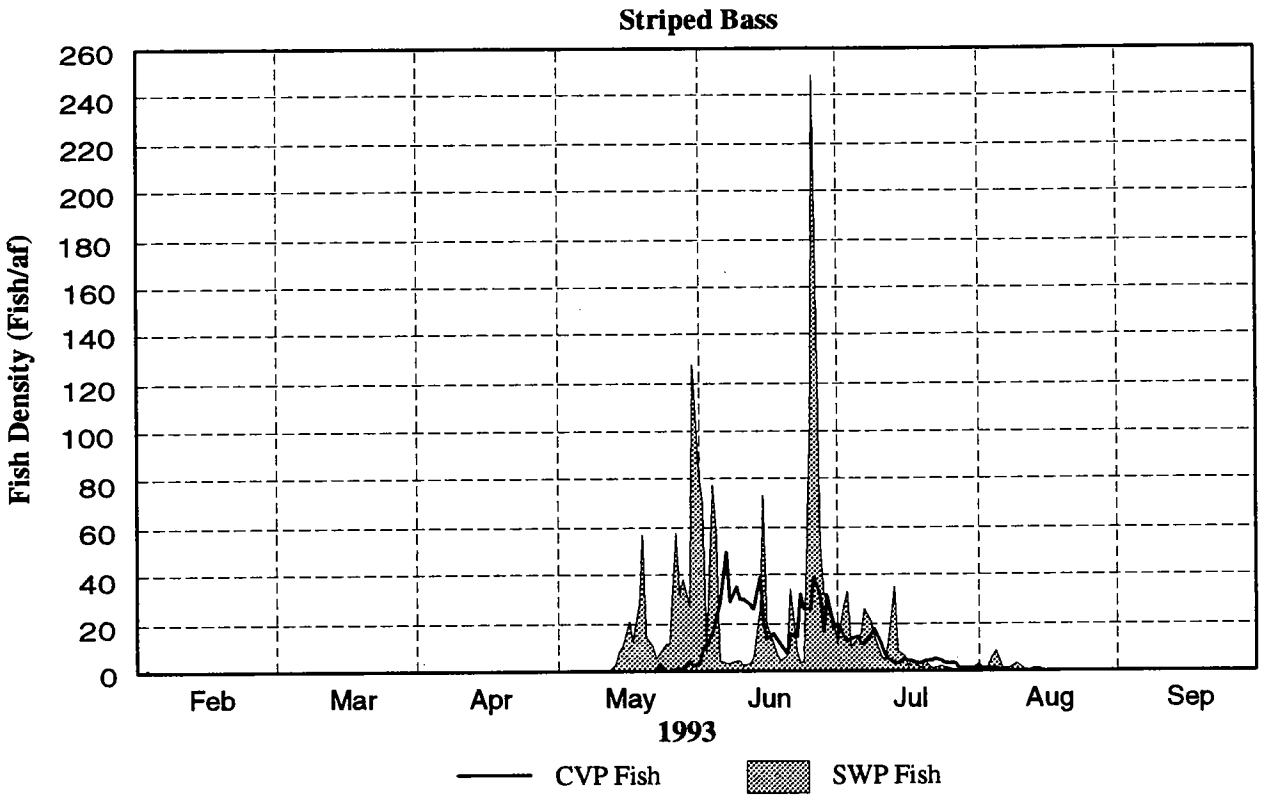


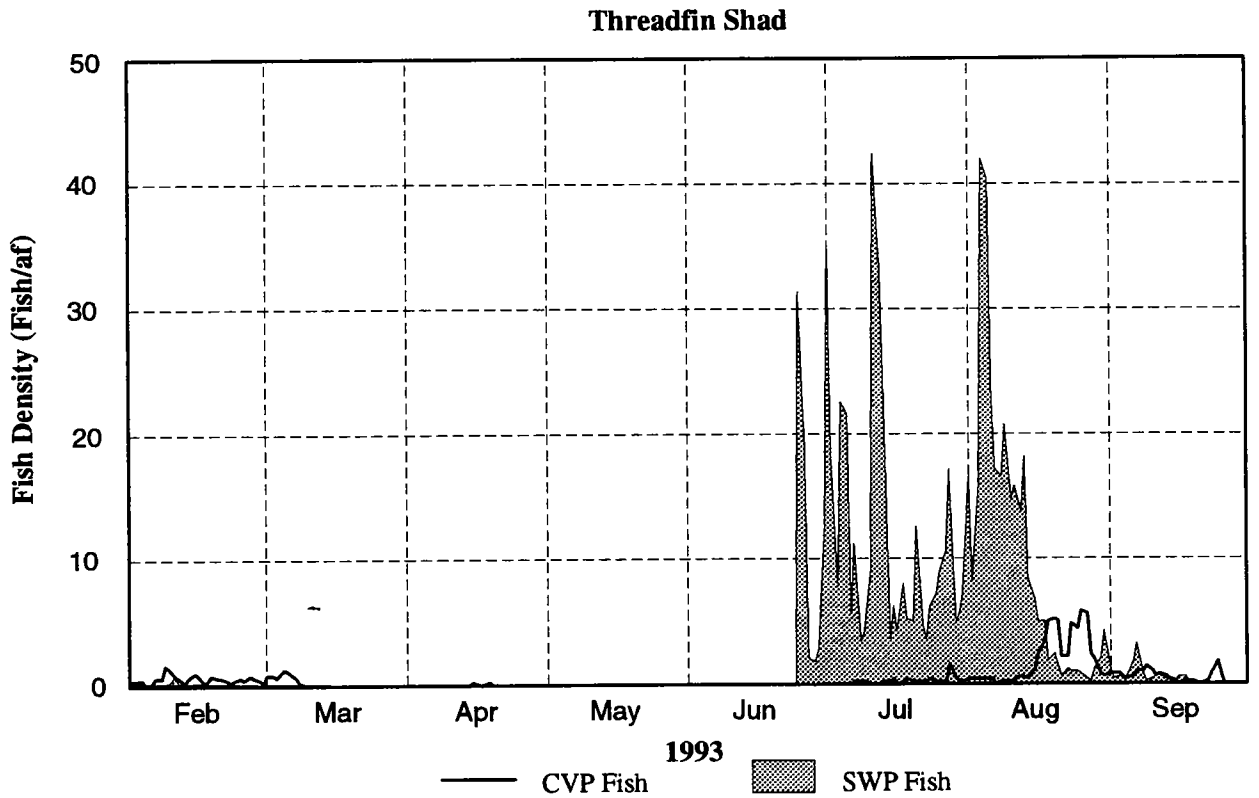
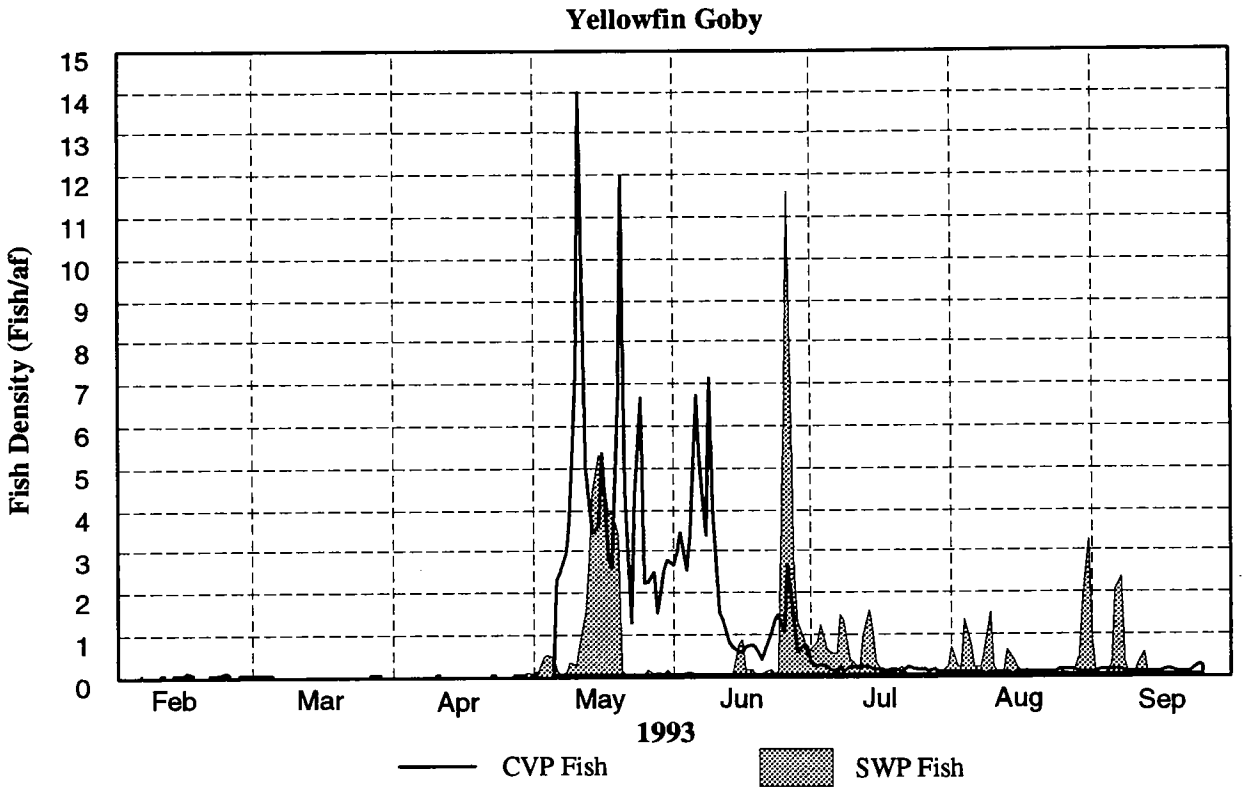
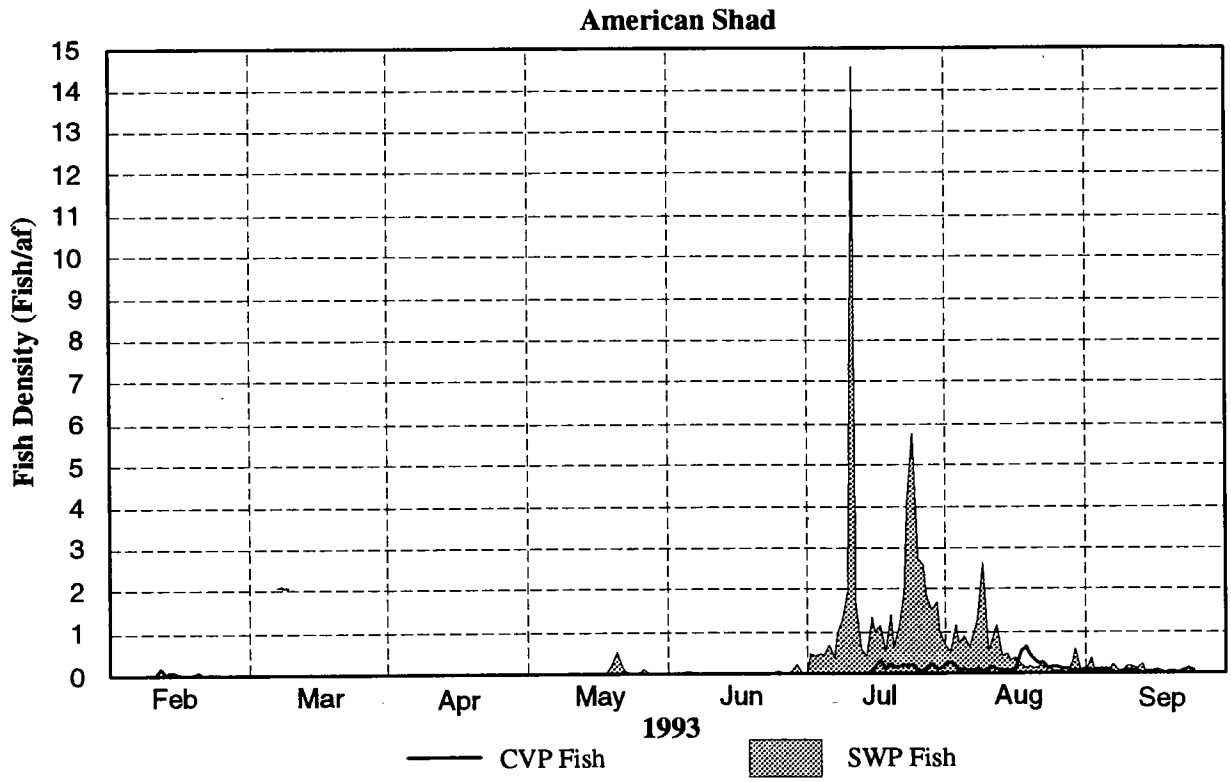


Figure A4-10.
Daily Estimates of Fish Density Obtained from SWP Banks and CVP Tracy Salvage Records for February-September 1993

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates





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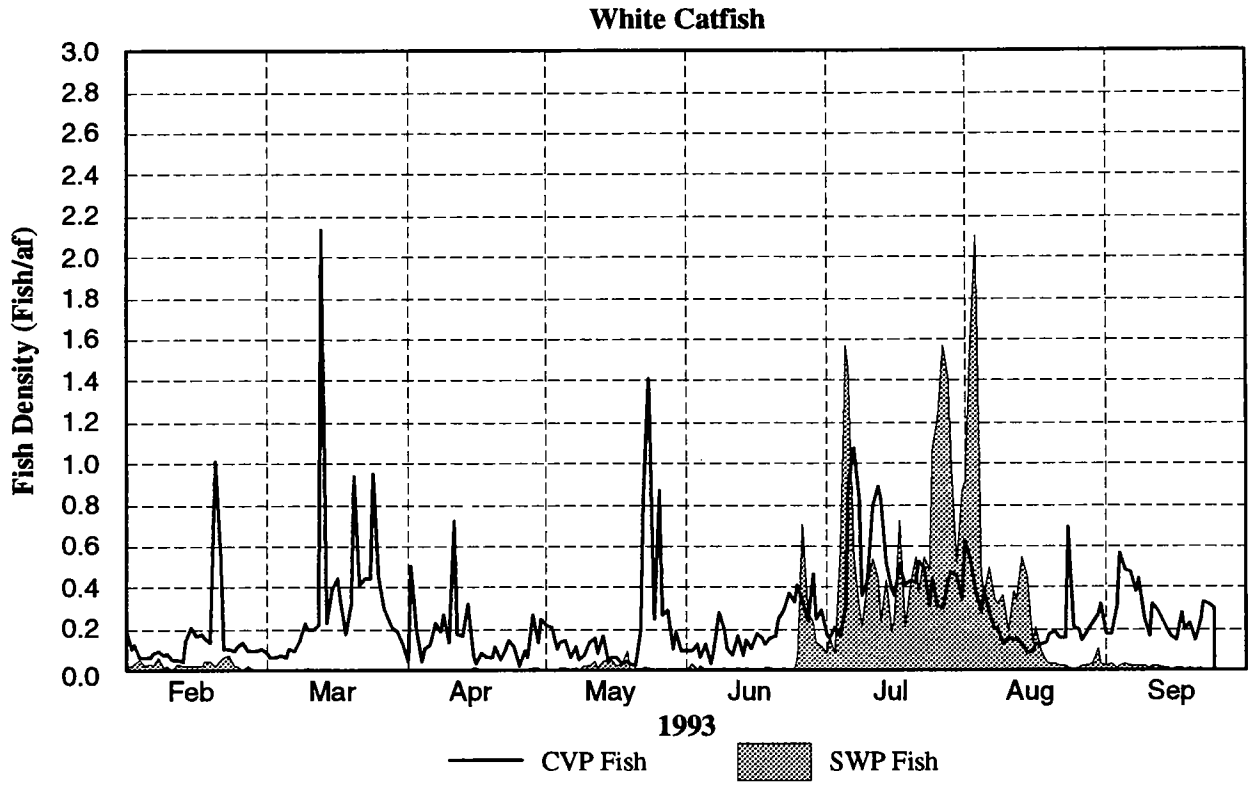
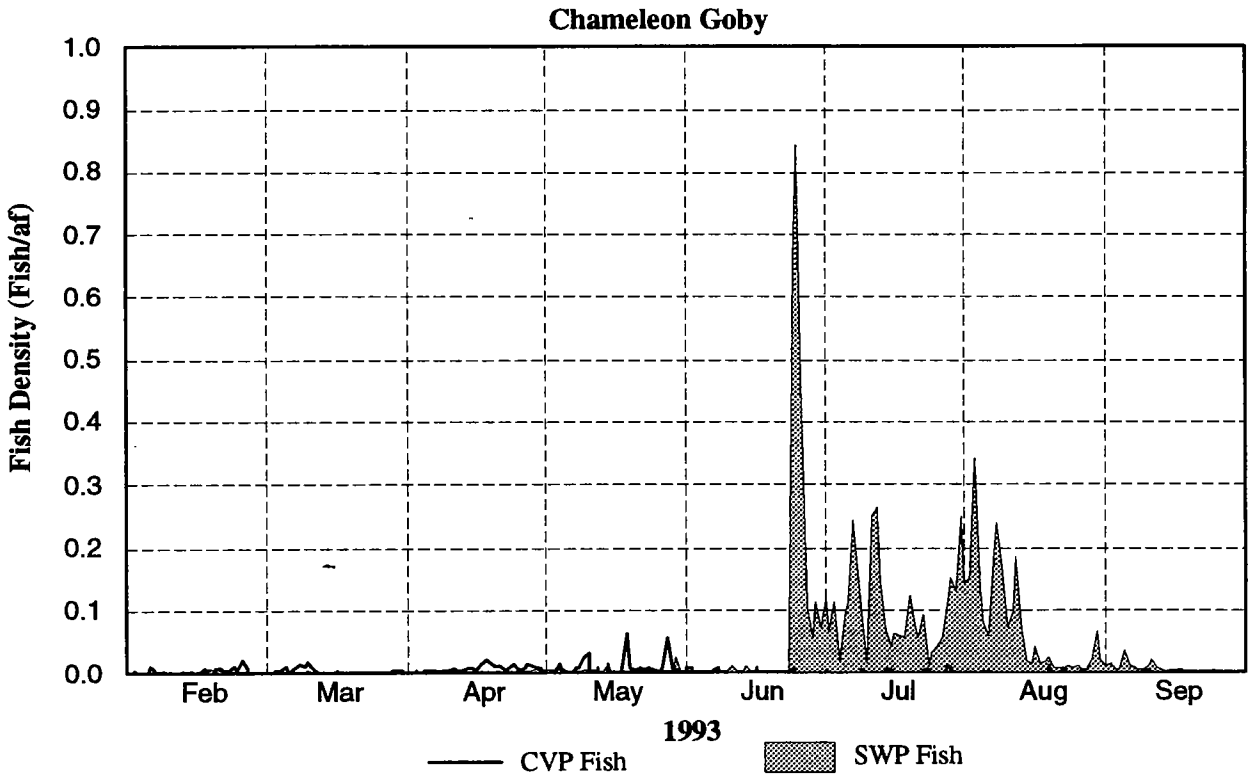
DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates





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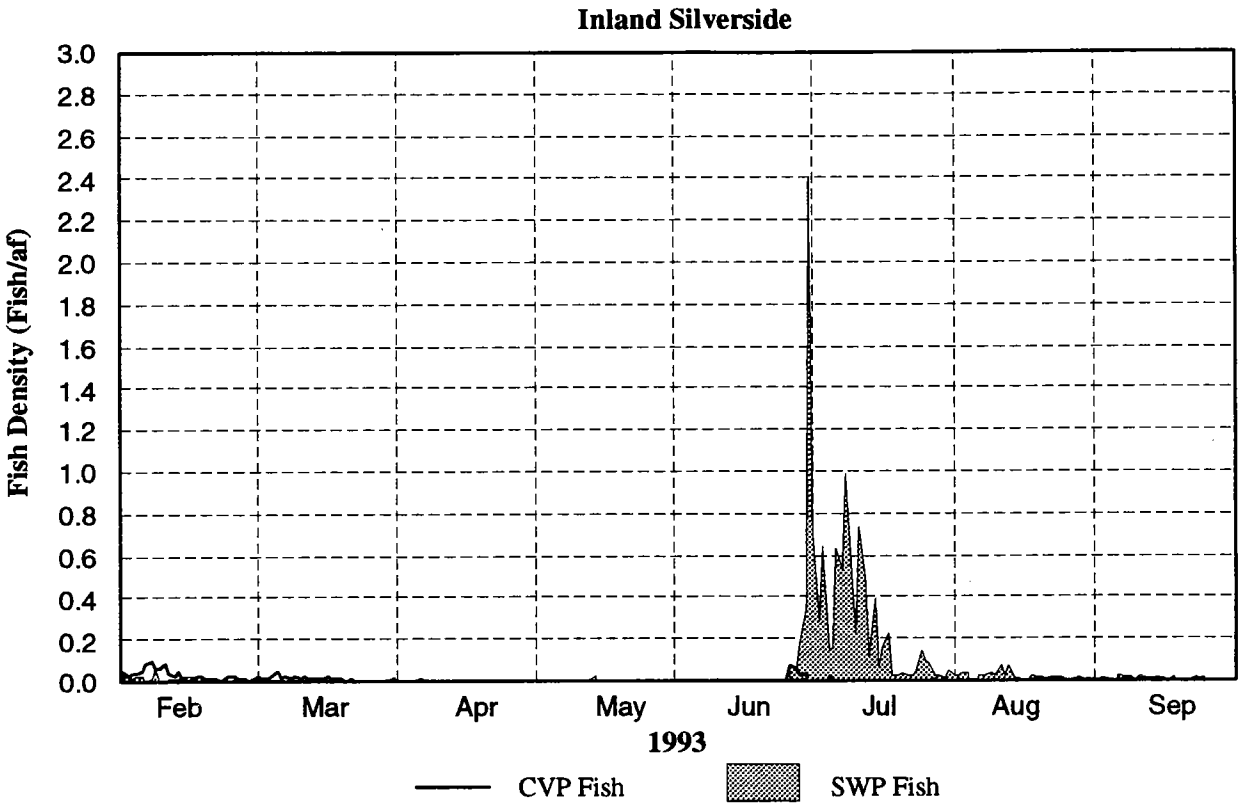

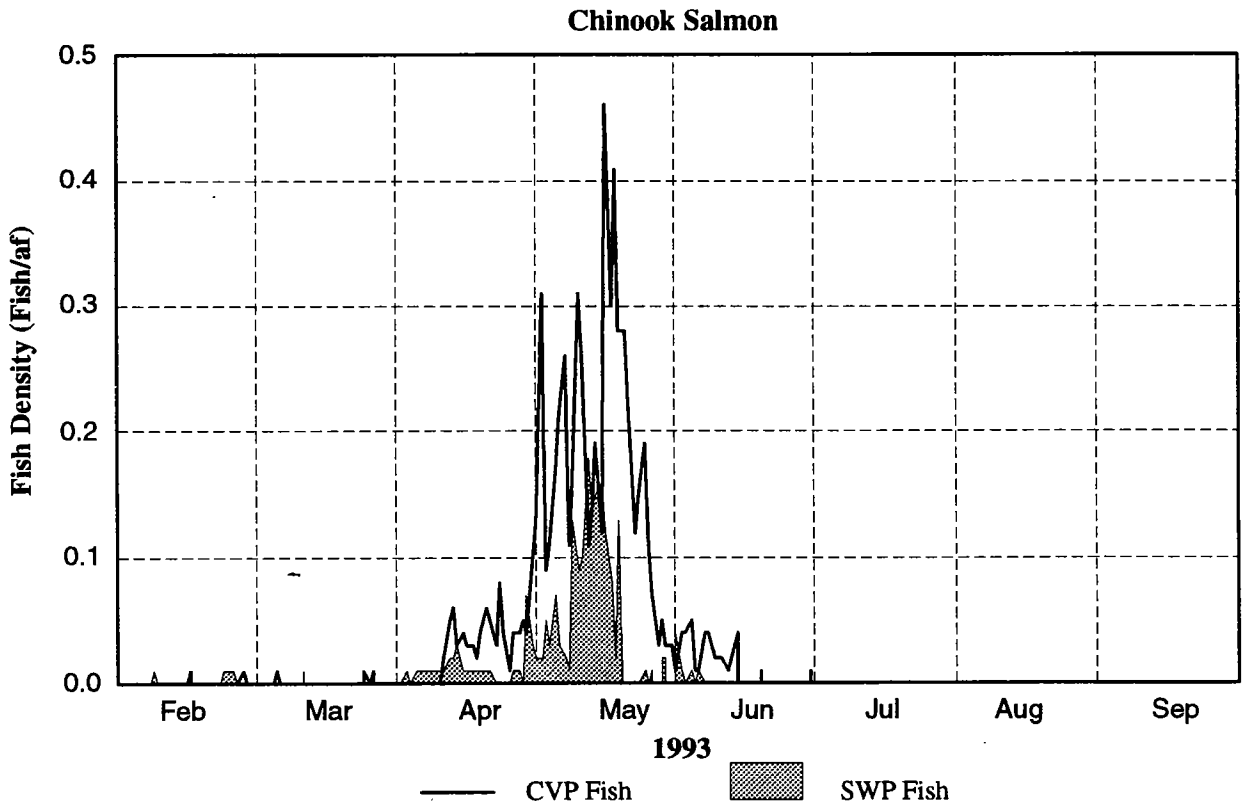

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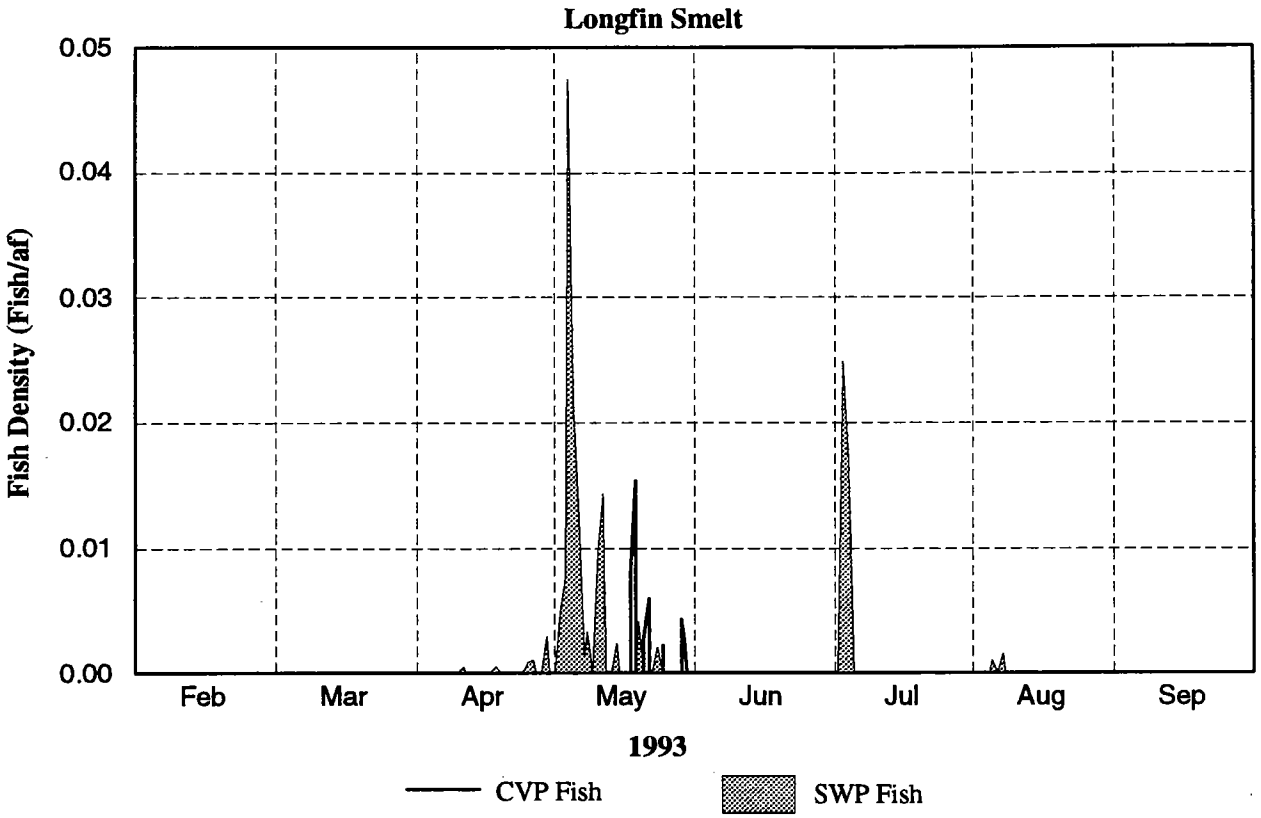

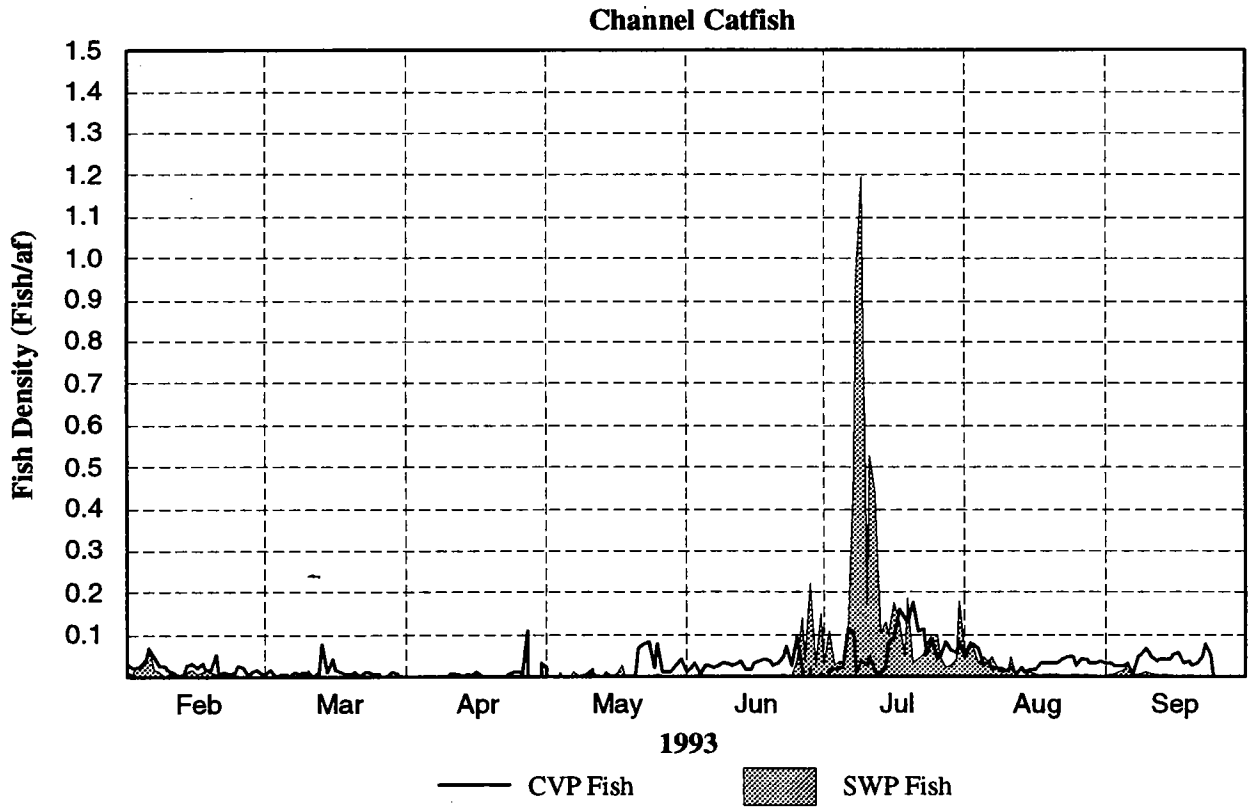

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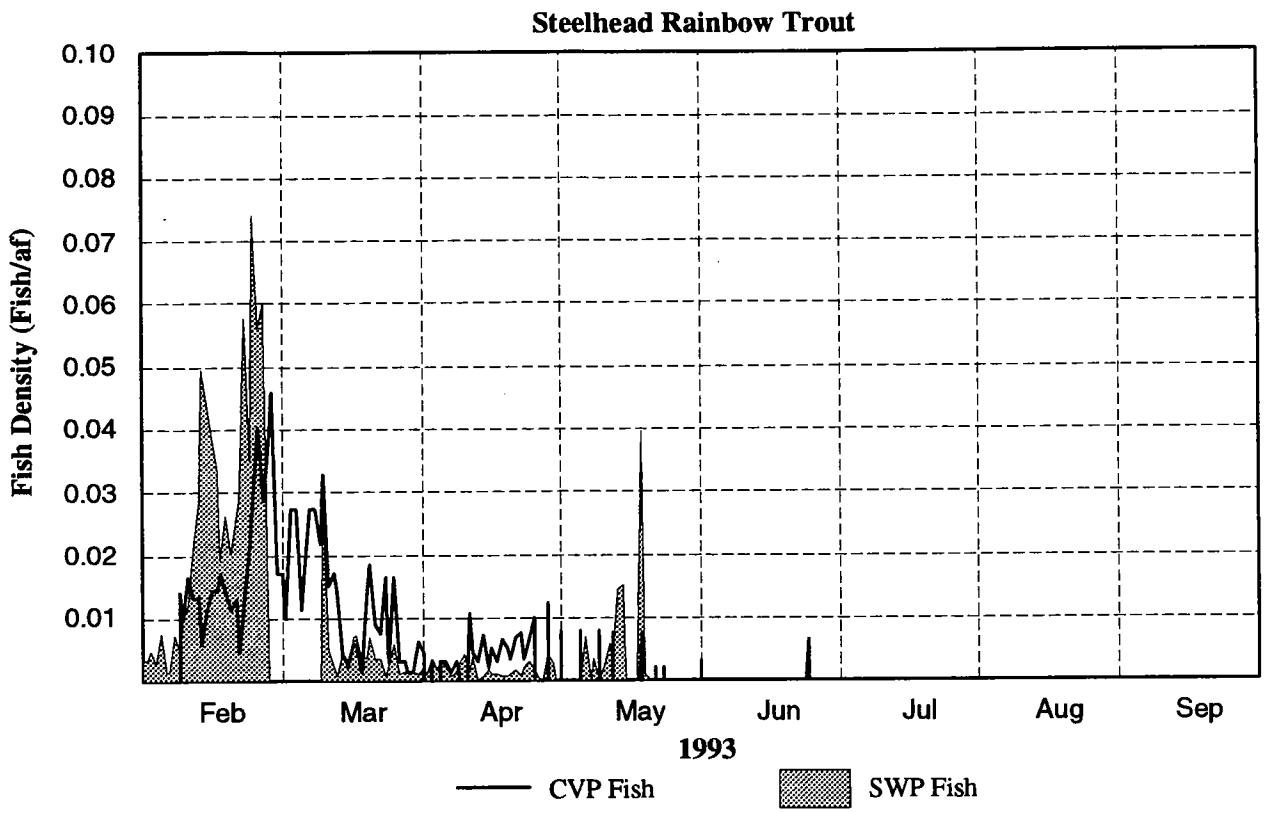

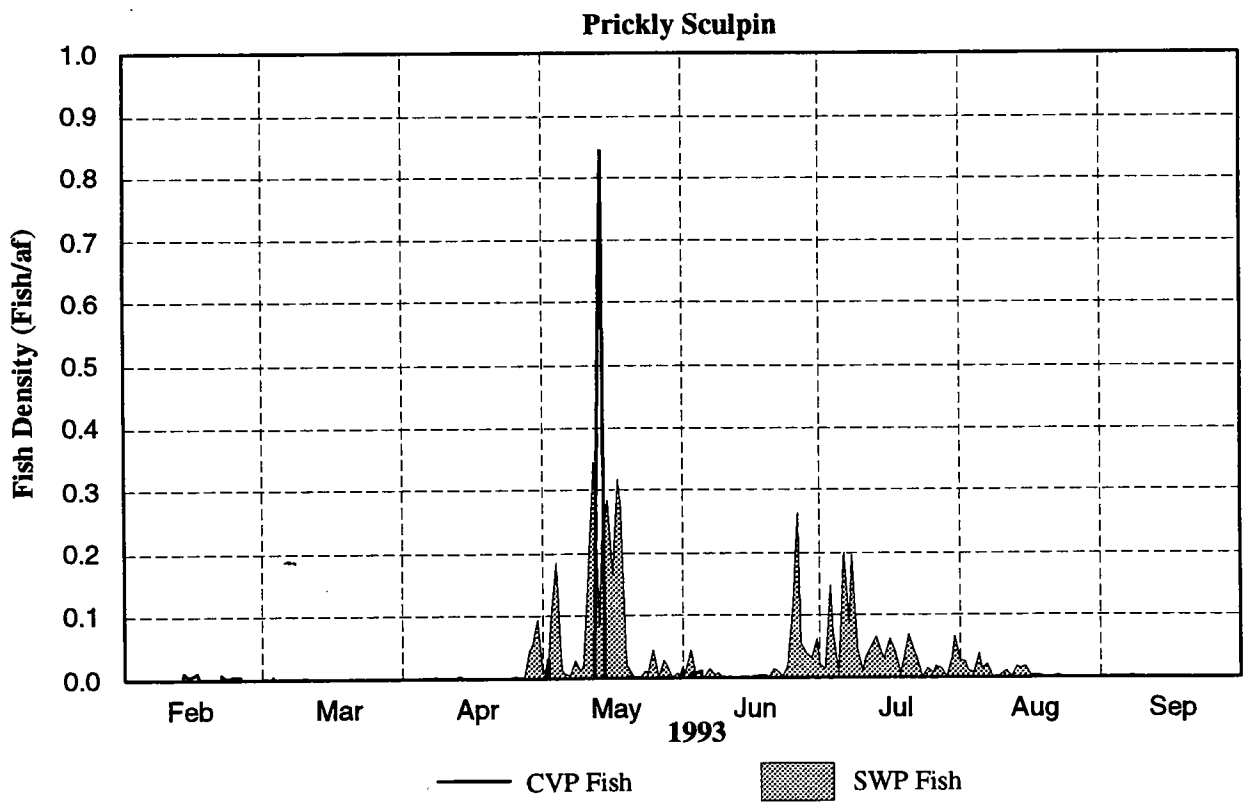

Figure A4-10.
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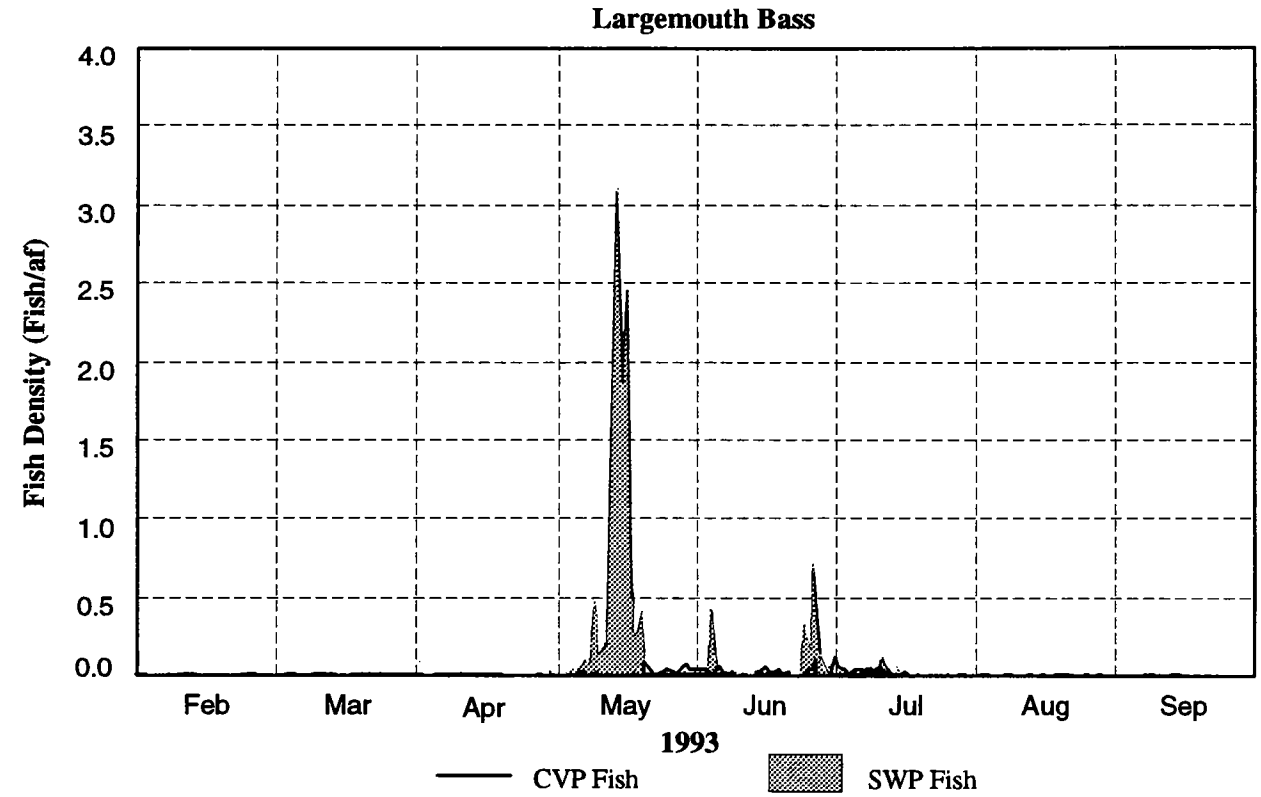
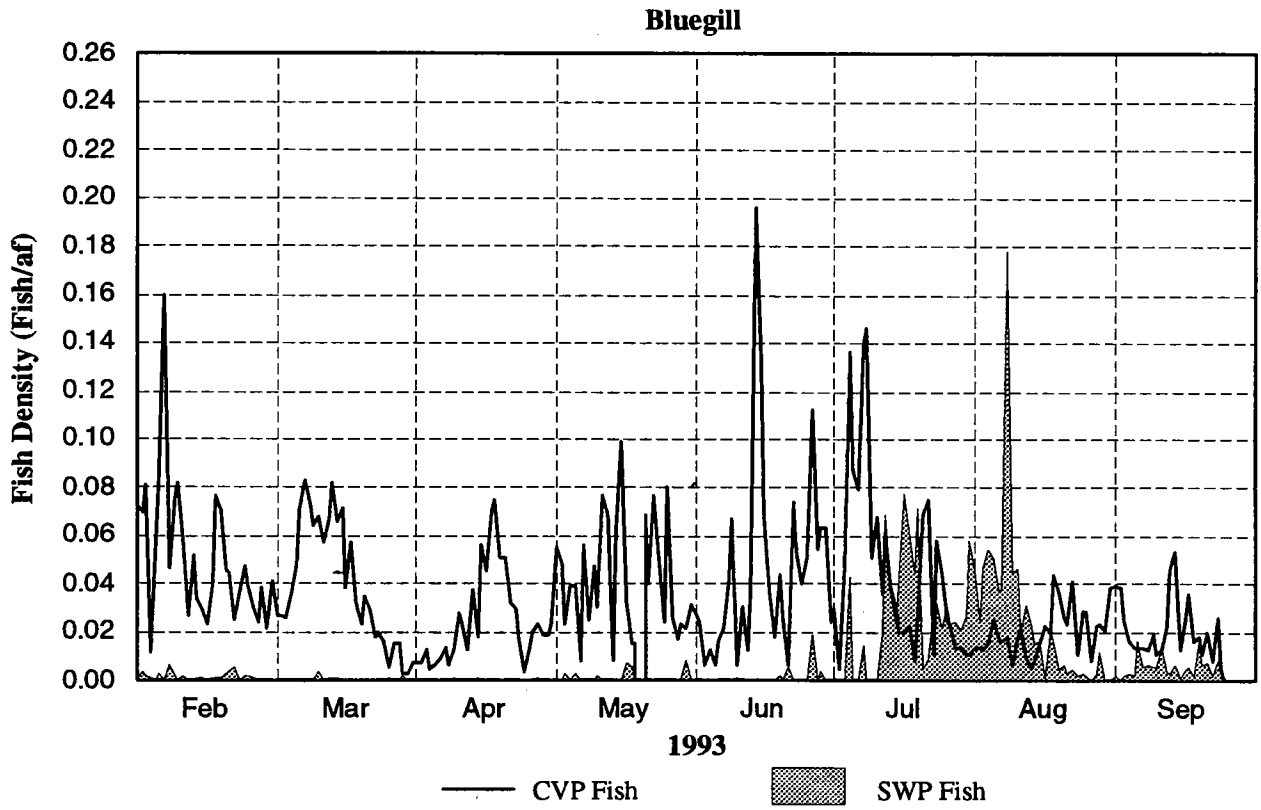
DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates





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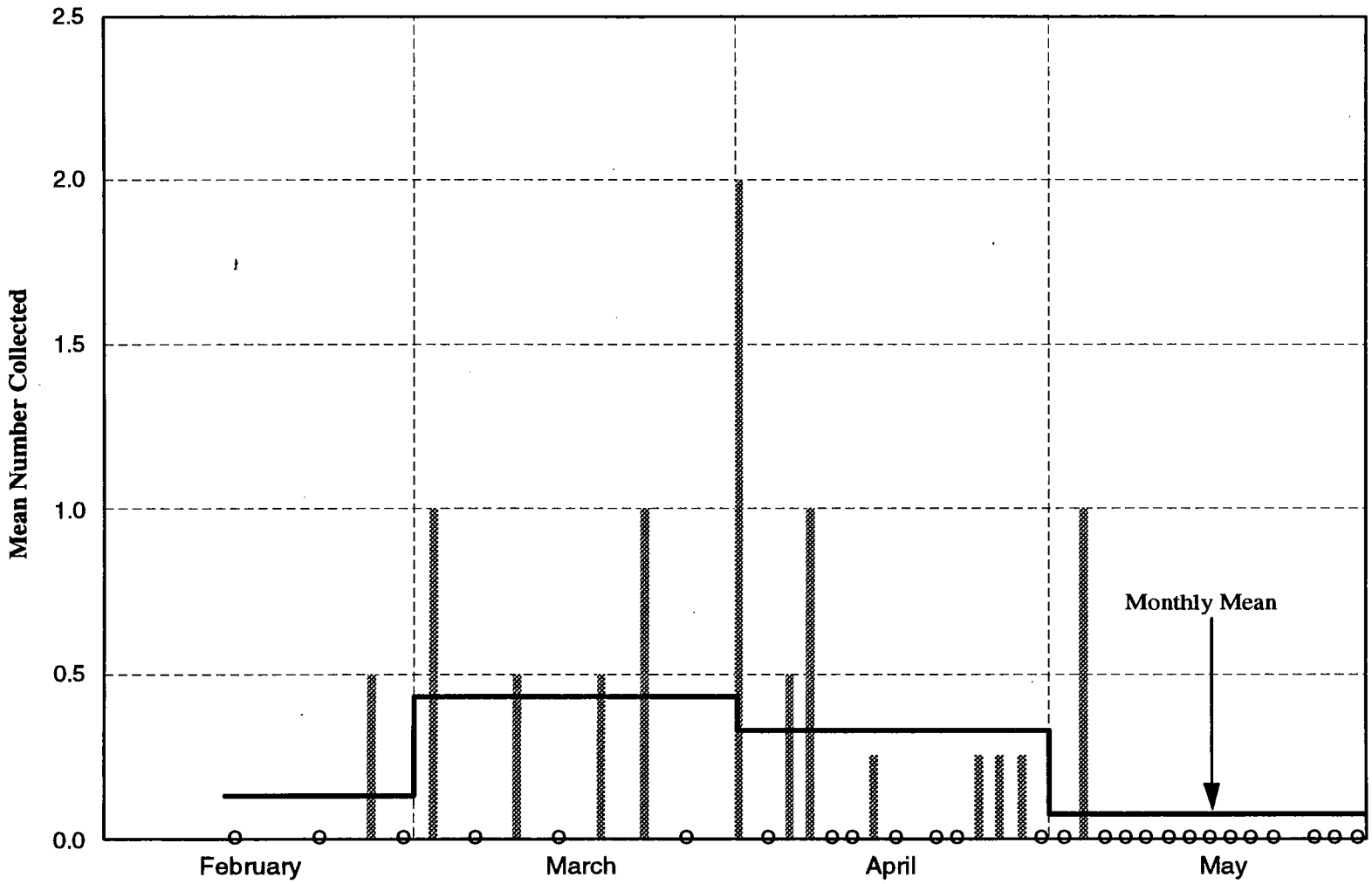


Note: The o's represent sampling days on which no delta smelt larvae were caught.

Figure A4-11.
Delta Smelt Larvae at Four Sites near the DW Project Islands for February-May 1992

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

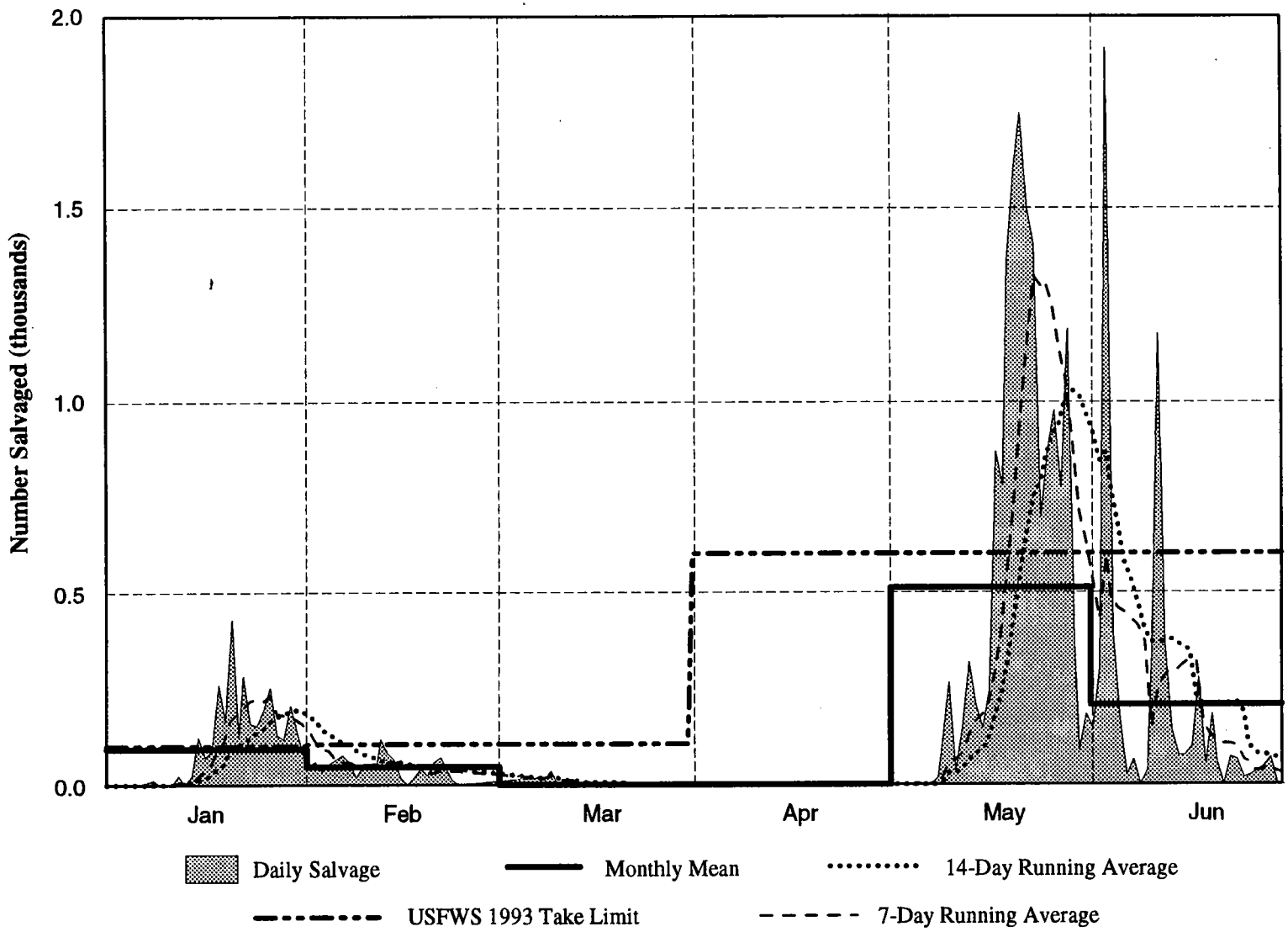
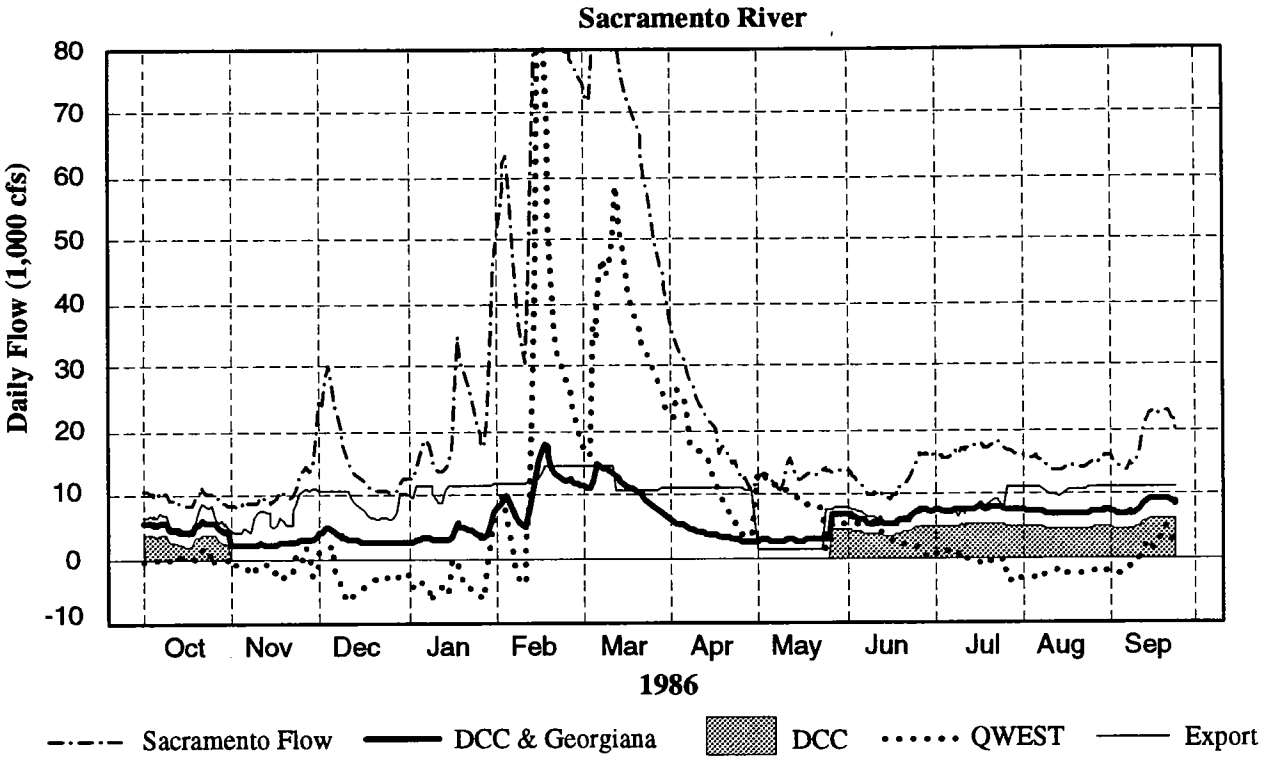


Figure A4-12.
Delta Smelt Salvaged at SWP Banks and CVP Tracy Pumping Plants during January-June 1993

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



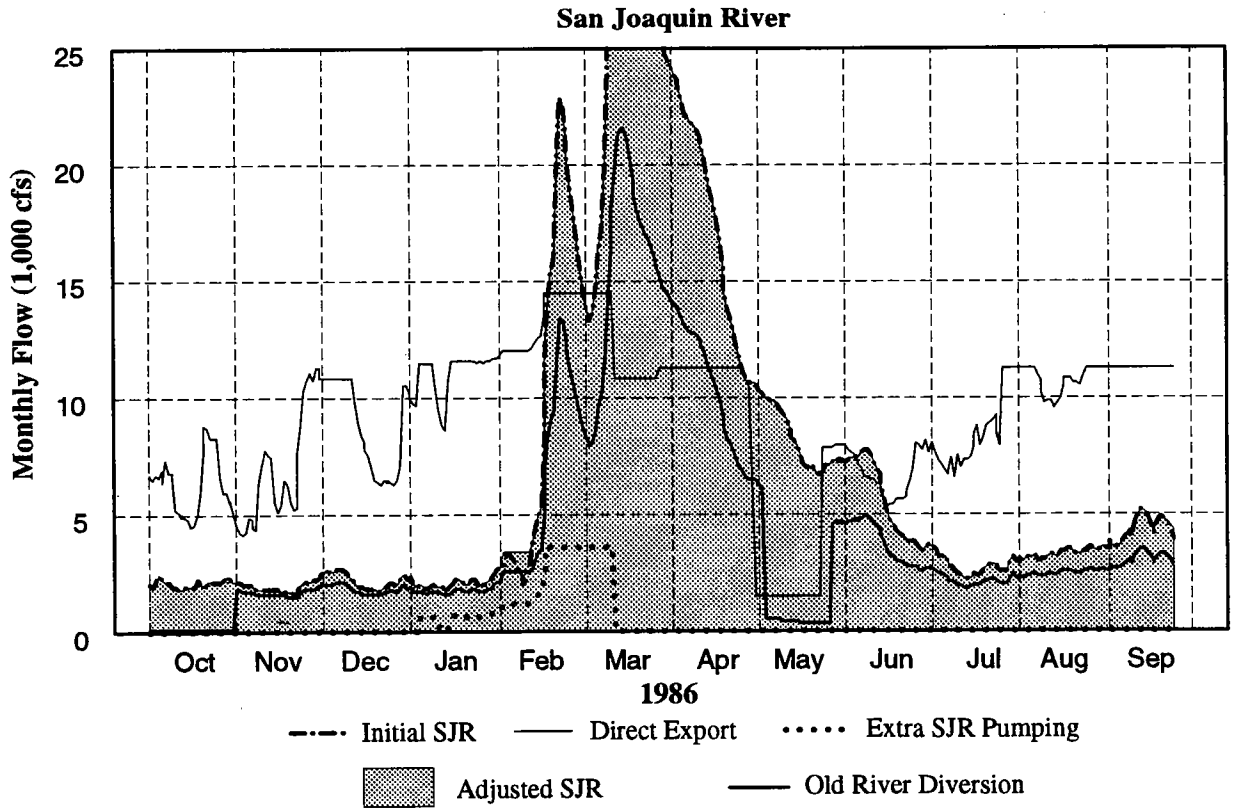
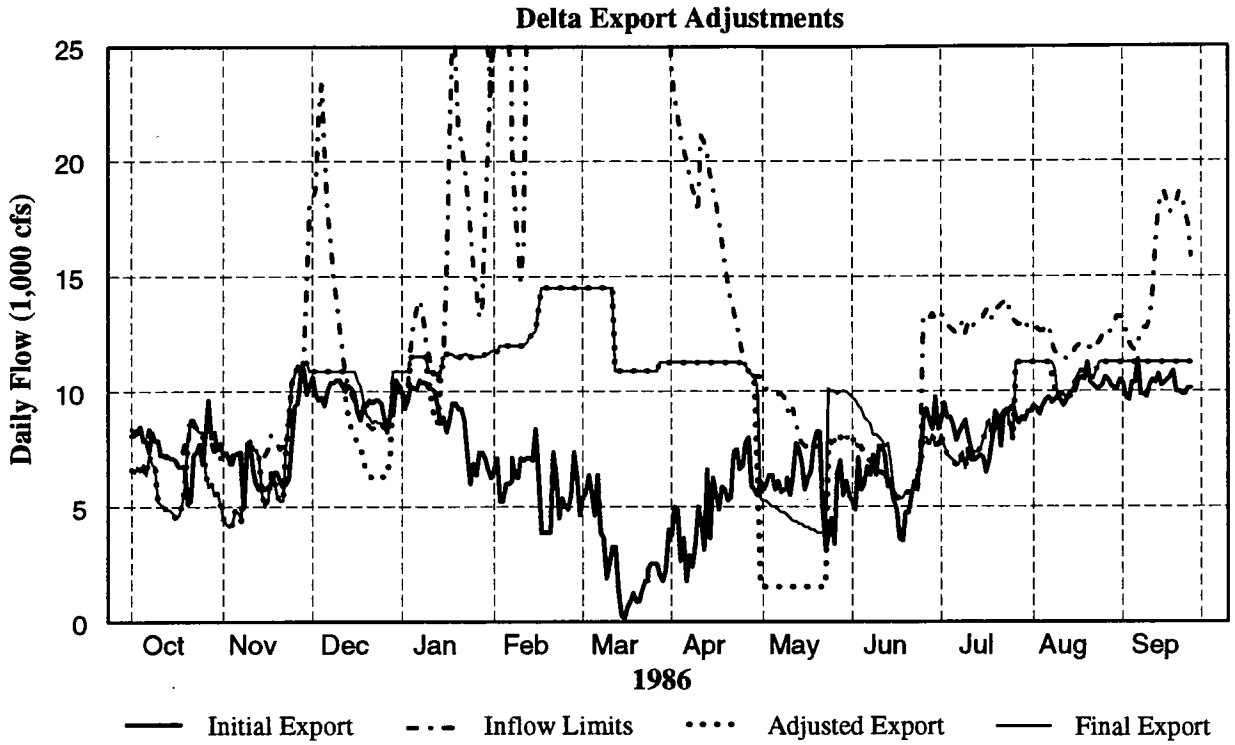


Figure A4-13A.
DailySOS Estimates of Sacramento and San Joaquin River Adjustments and Diversions with 1995 WQCP Objectives for 1986 Historical Inflows

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



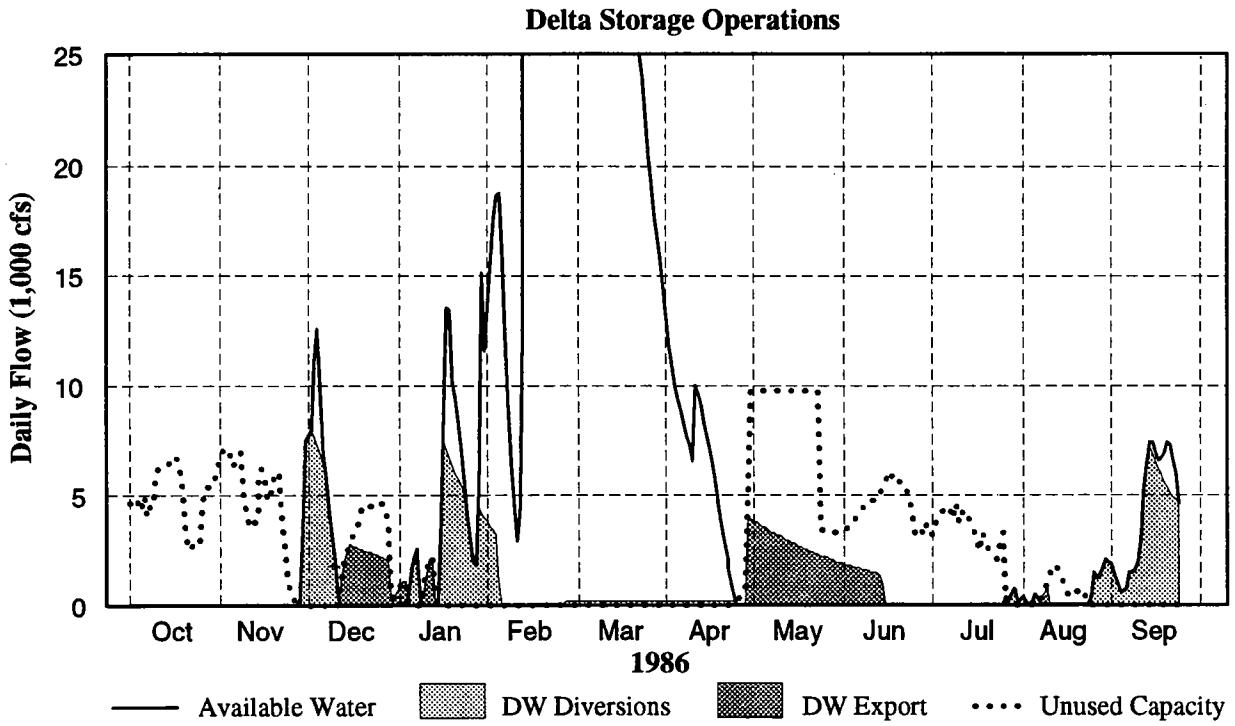


Figure A4-13B.
DailySOS Estimates of Adjustments to Historical CVP and SWP Delta Exports and DW Diversions and Exports with 1995 WQCP Objectives for 1986 Historical Inflows

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

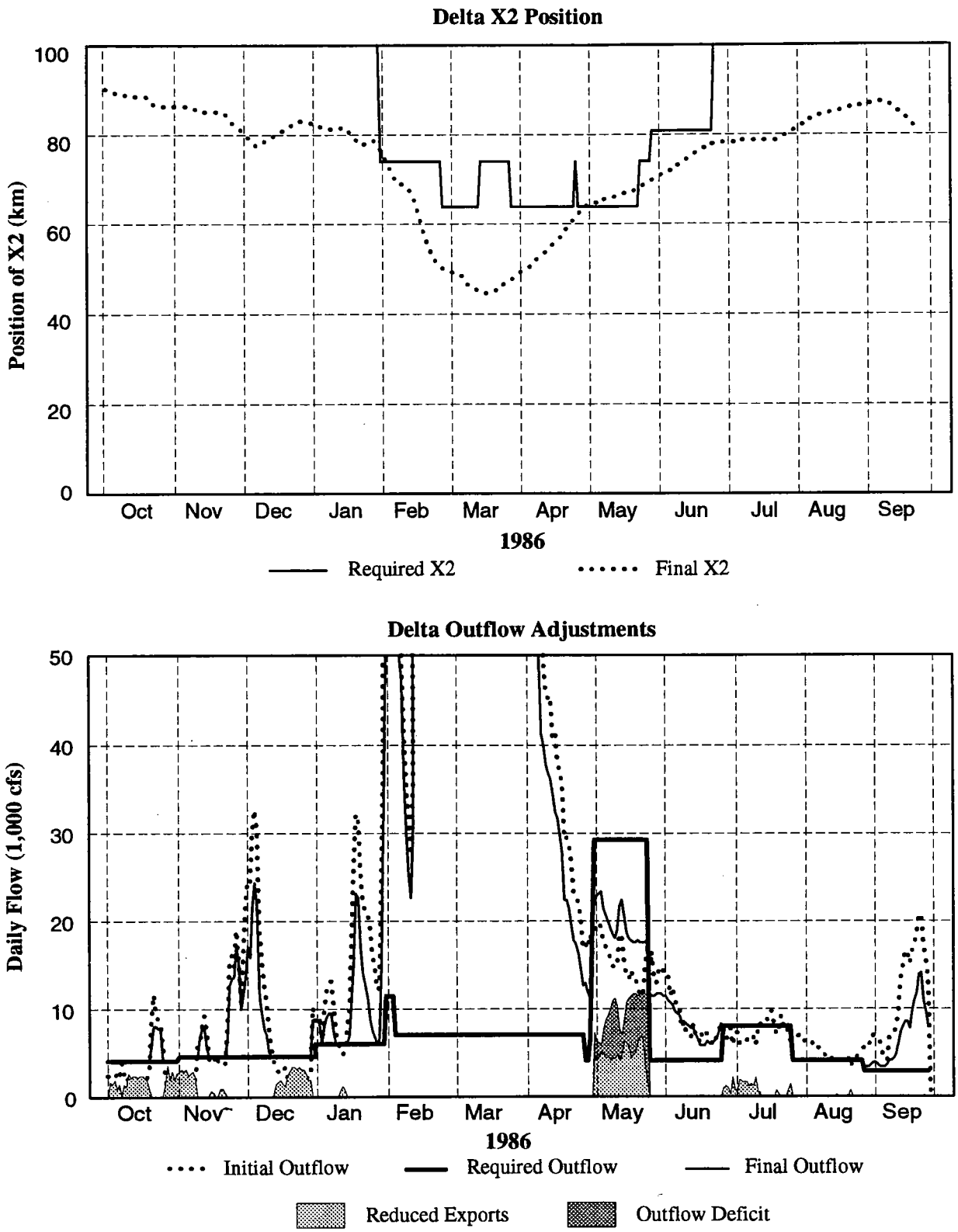


Figure A4-13C.
DailySOS Estimates of Required and Resulting X2 Location and Adjustments to Historical Outflow with 1995 WQCP Objectives for 1986 Historical Inflows

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

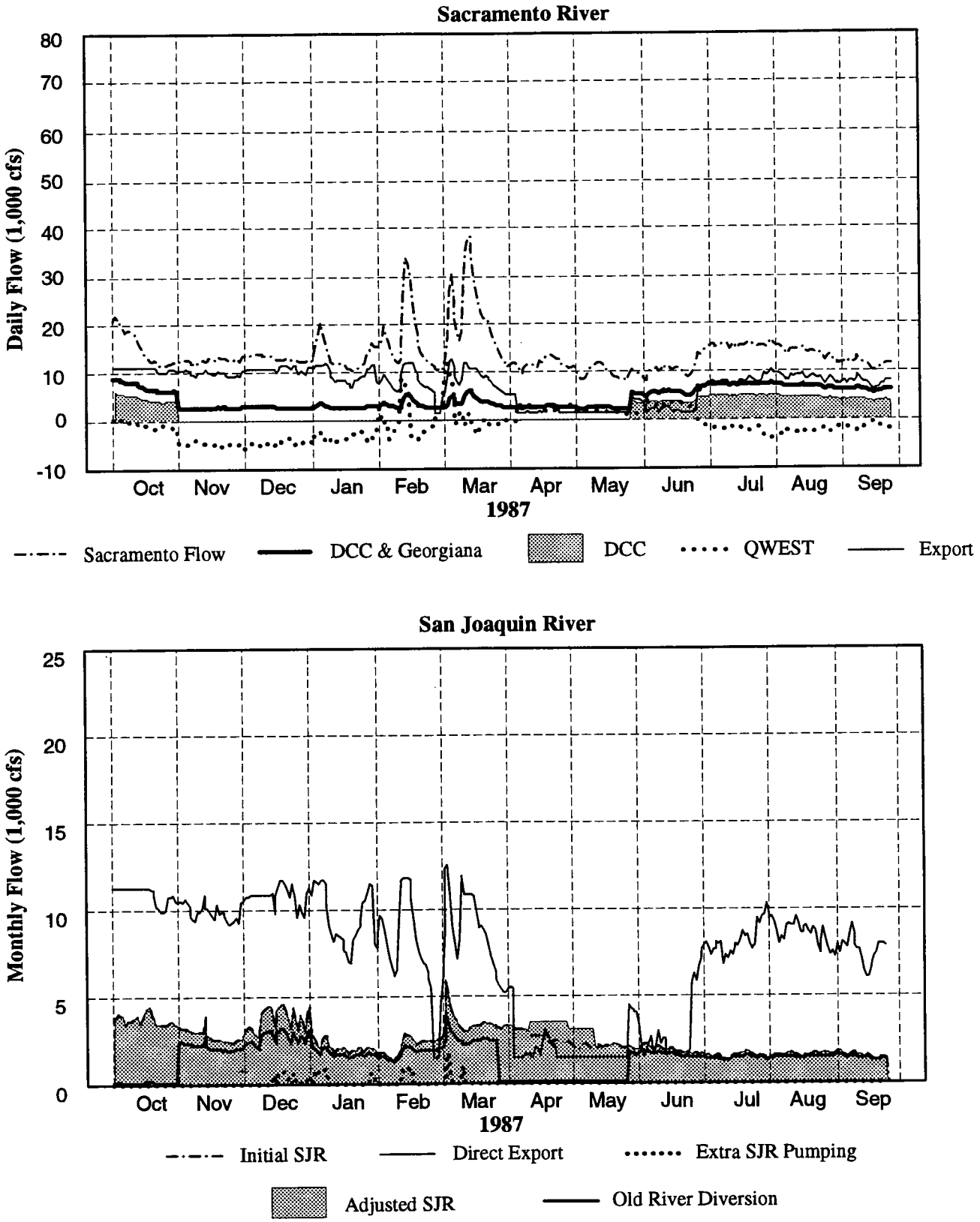
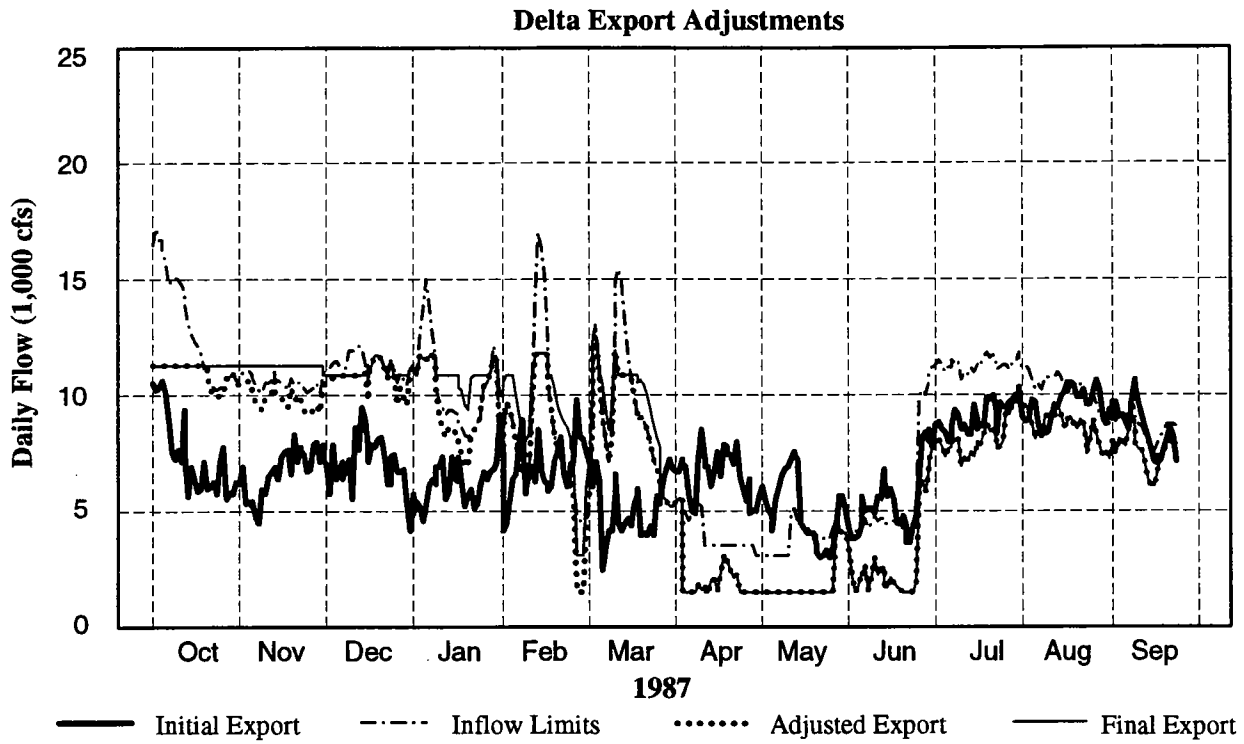


Figure A4-14A.
DailySOS Estimates of Sacramento and San Joaquin River Adjustments and Diversions with 1995 WQCP Objectives for 1987 Historical Inflows

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



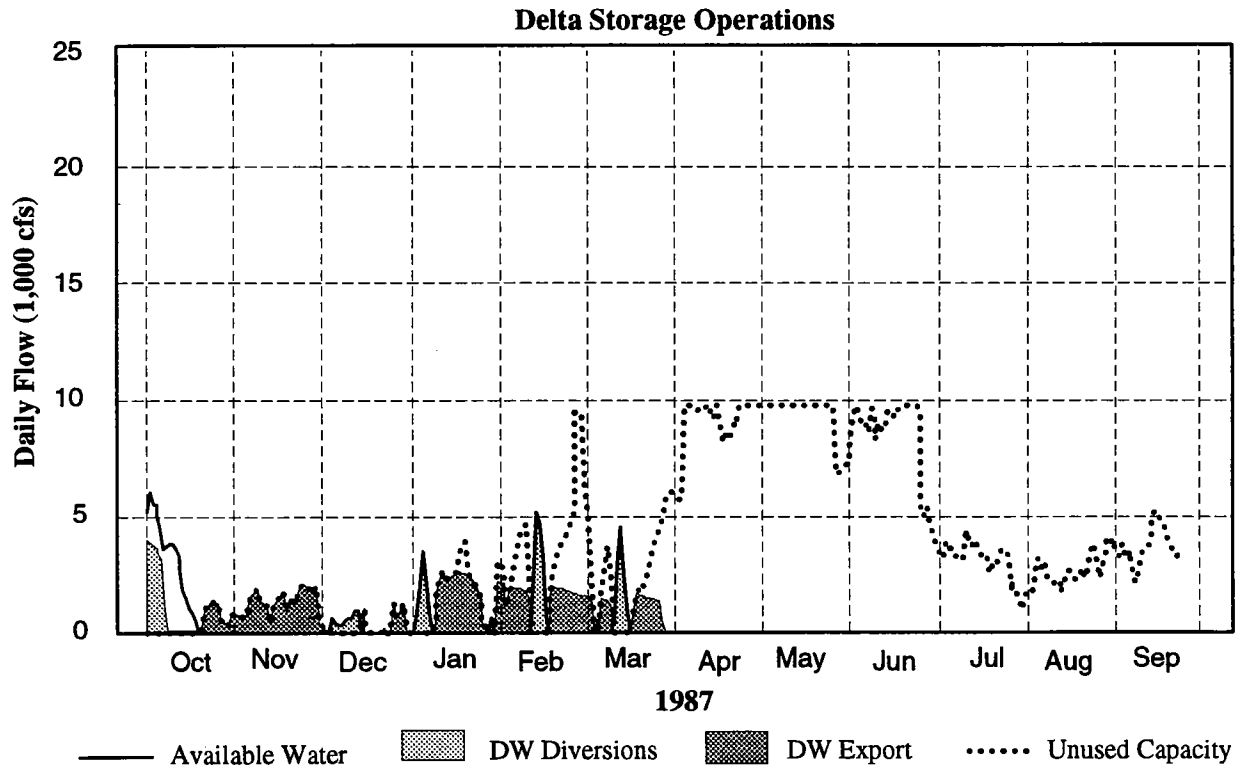


Figure A4-14B.
DailySOS Estimates of Adjustments to Historical CVP and SWP Delta Exports and DW Diversions and Exports with 1995 WQCP Objectives for 1987 Historical Inflows

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

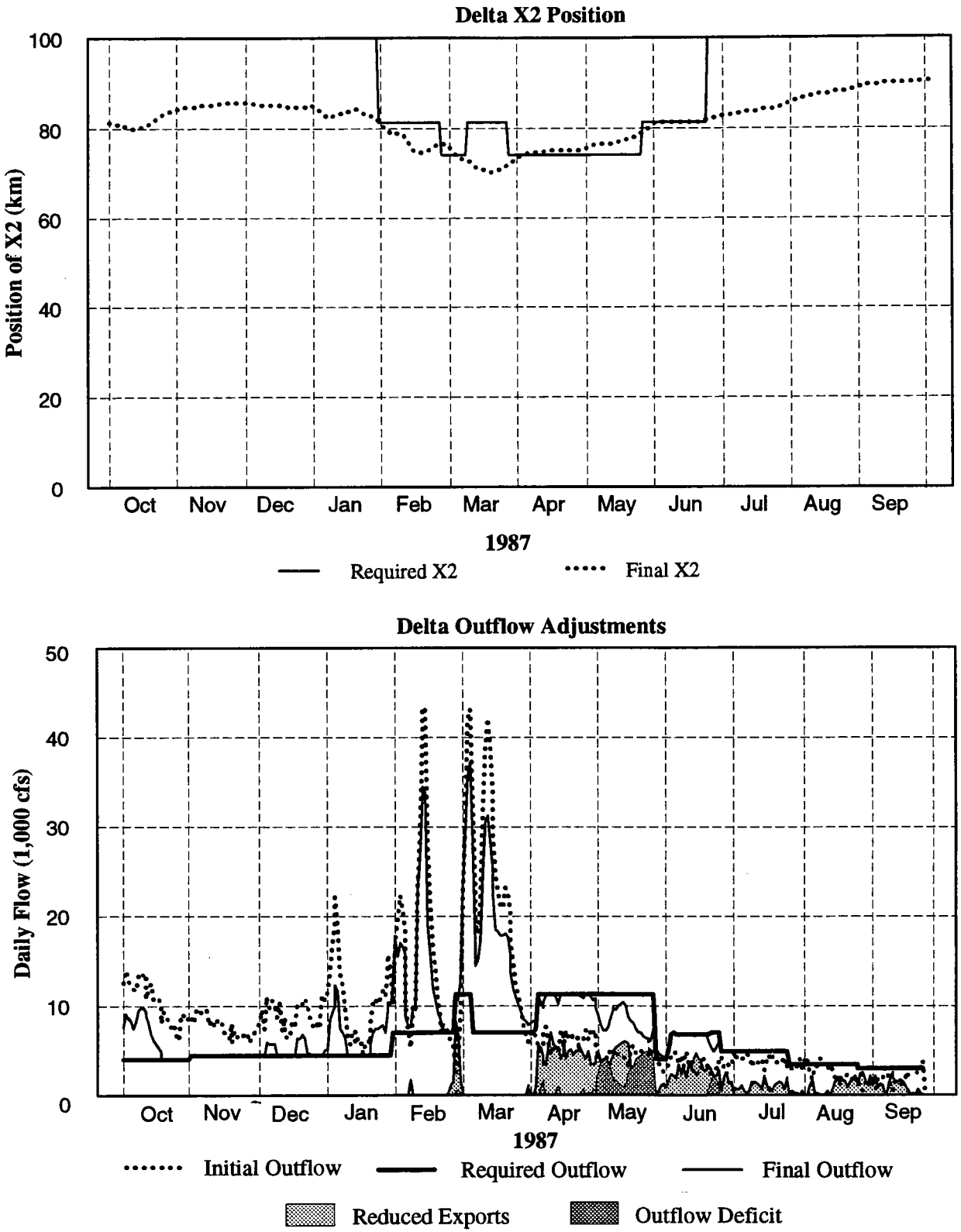
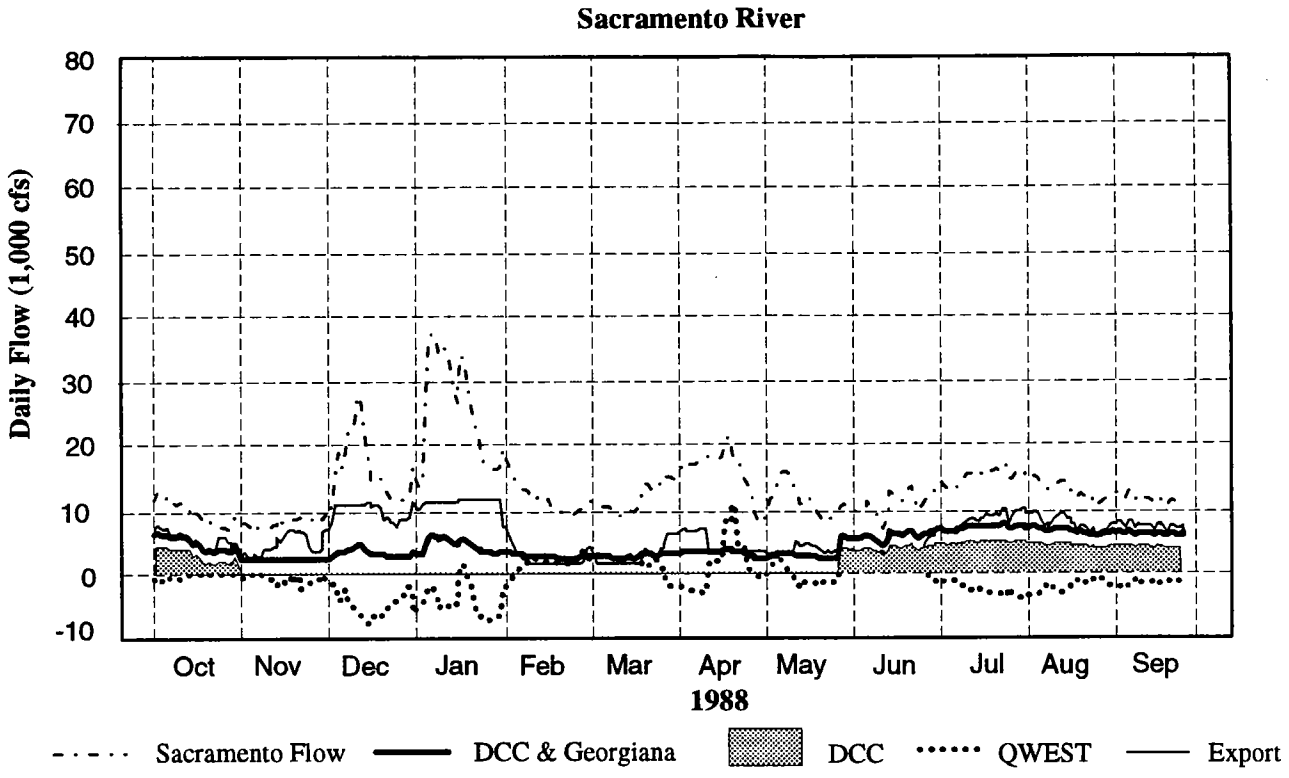


Figure A4-14C.
DailySOS Estimates of Required and Resulting X2 Location and Adjustments to Historical Outflow with 1995 WQCP Objectives for 1987 Historical Inflows

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



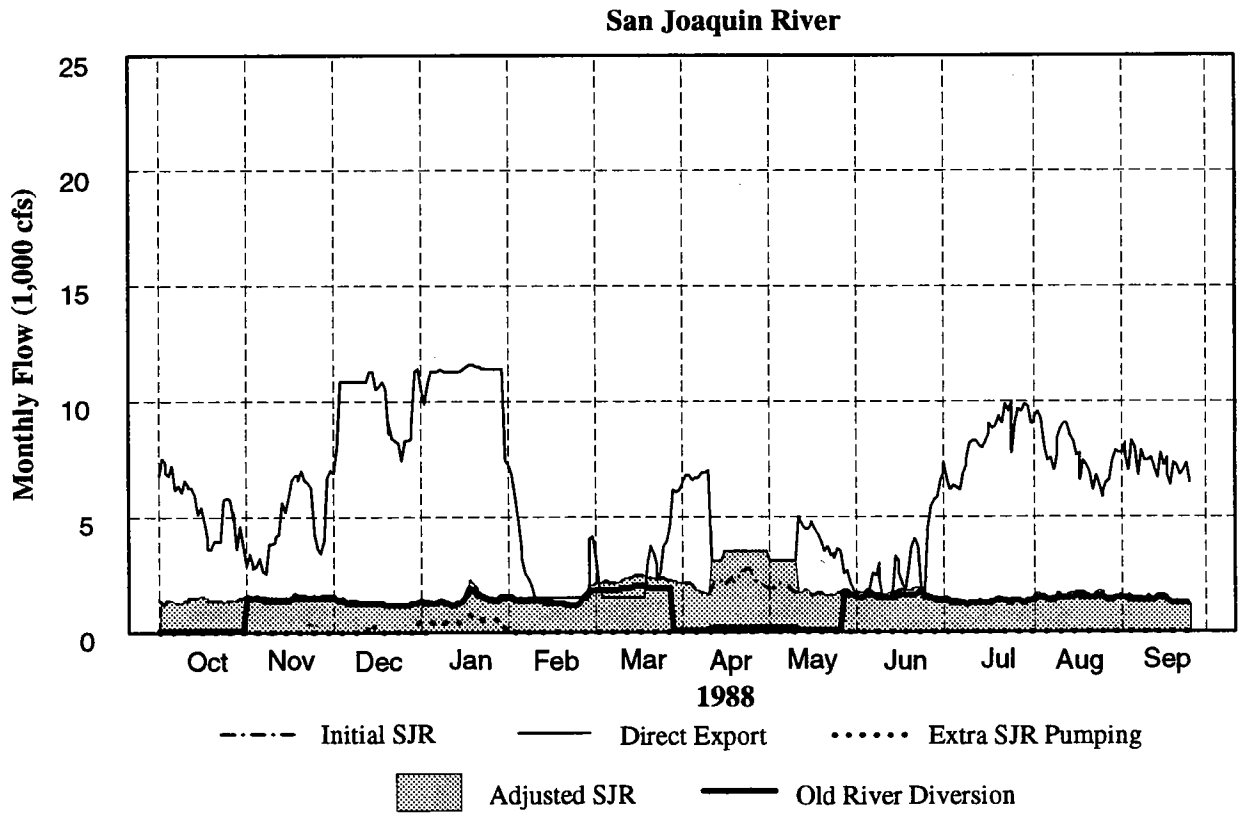
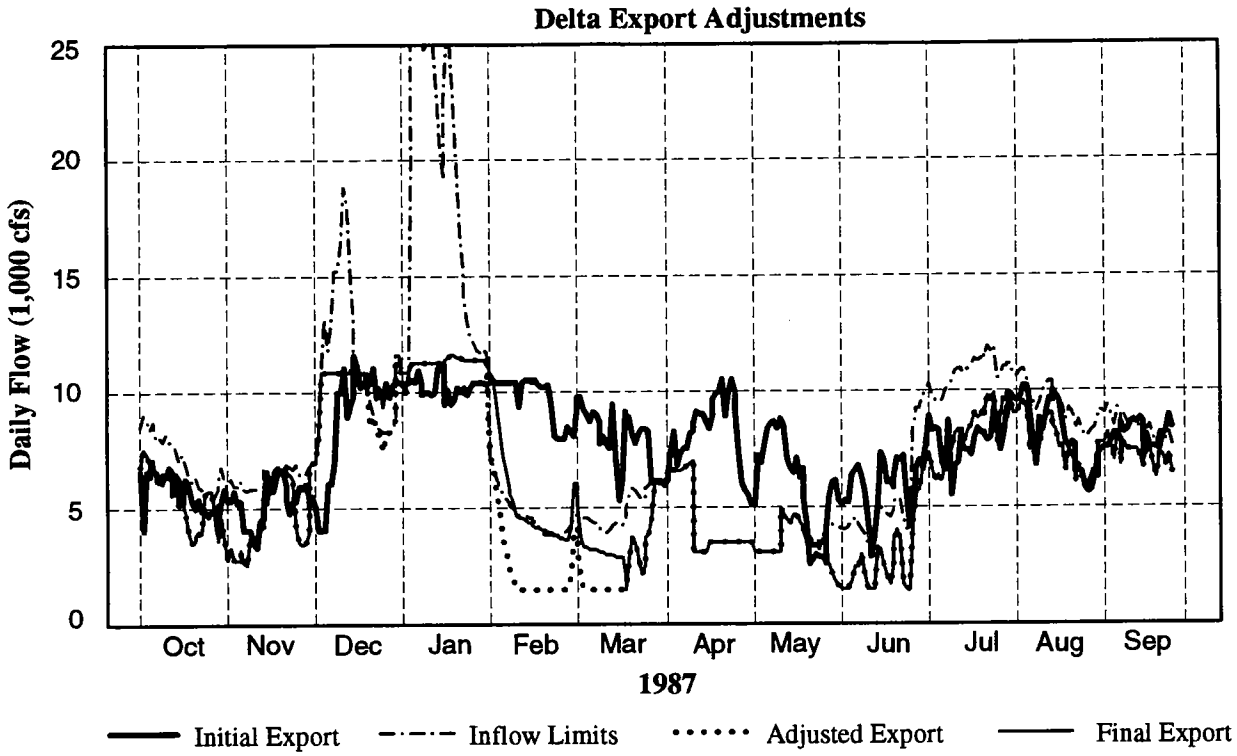


Figure A4-15A.
DailySOS Estimates of Sacramento and San Joaquin River Adjustments and Diversions with 1995 WQCP Objectives for 1988 Historical Inflows

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



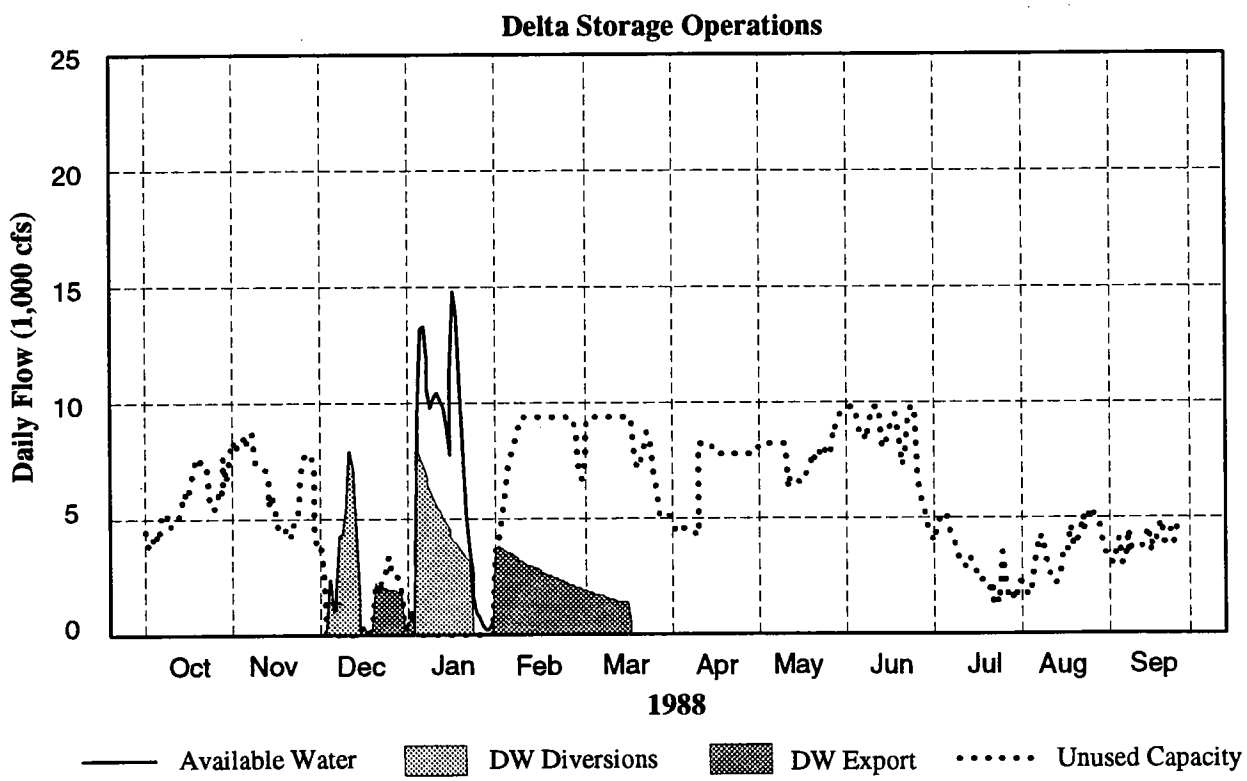
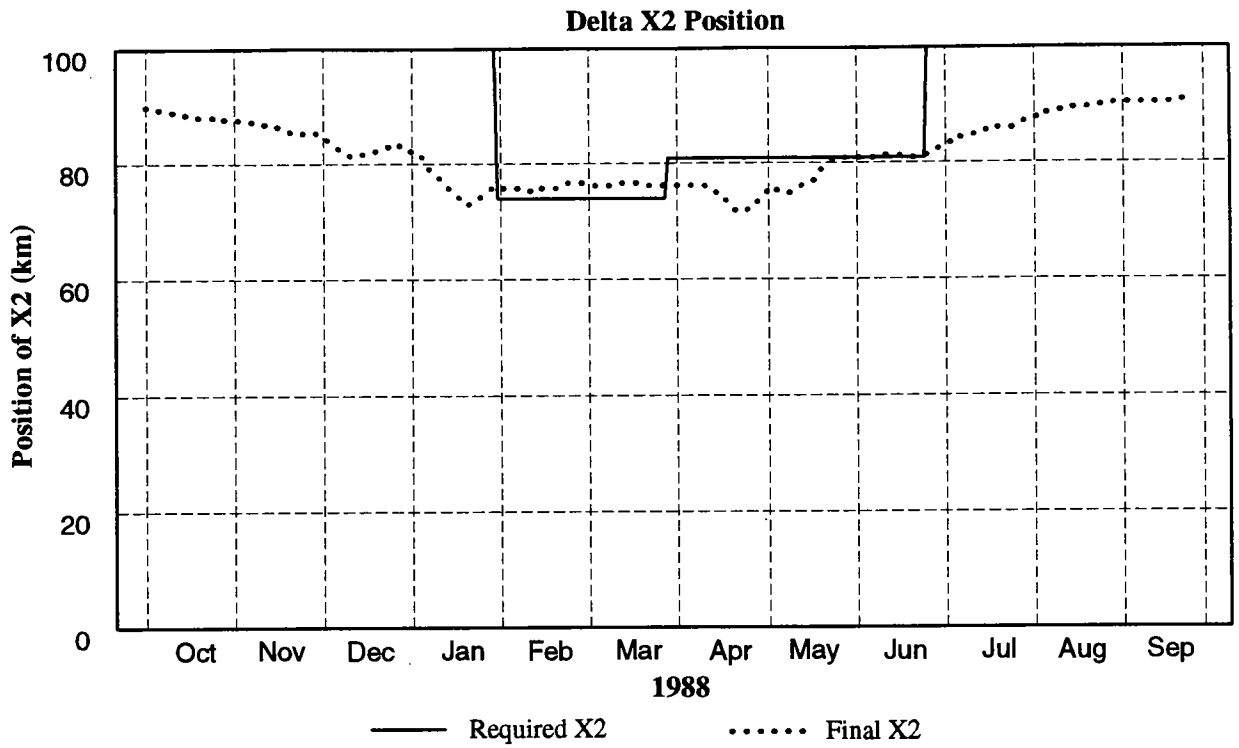


Figure A4-15B.
DailySOS Estimates of Adjustments to Historical CVP and SWP Delta Exports and DW Diversions and Exports with 1995 WQCP Objectives for 1988 Historical Inflows

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



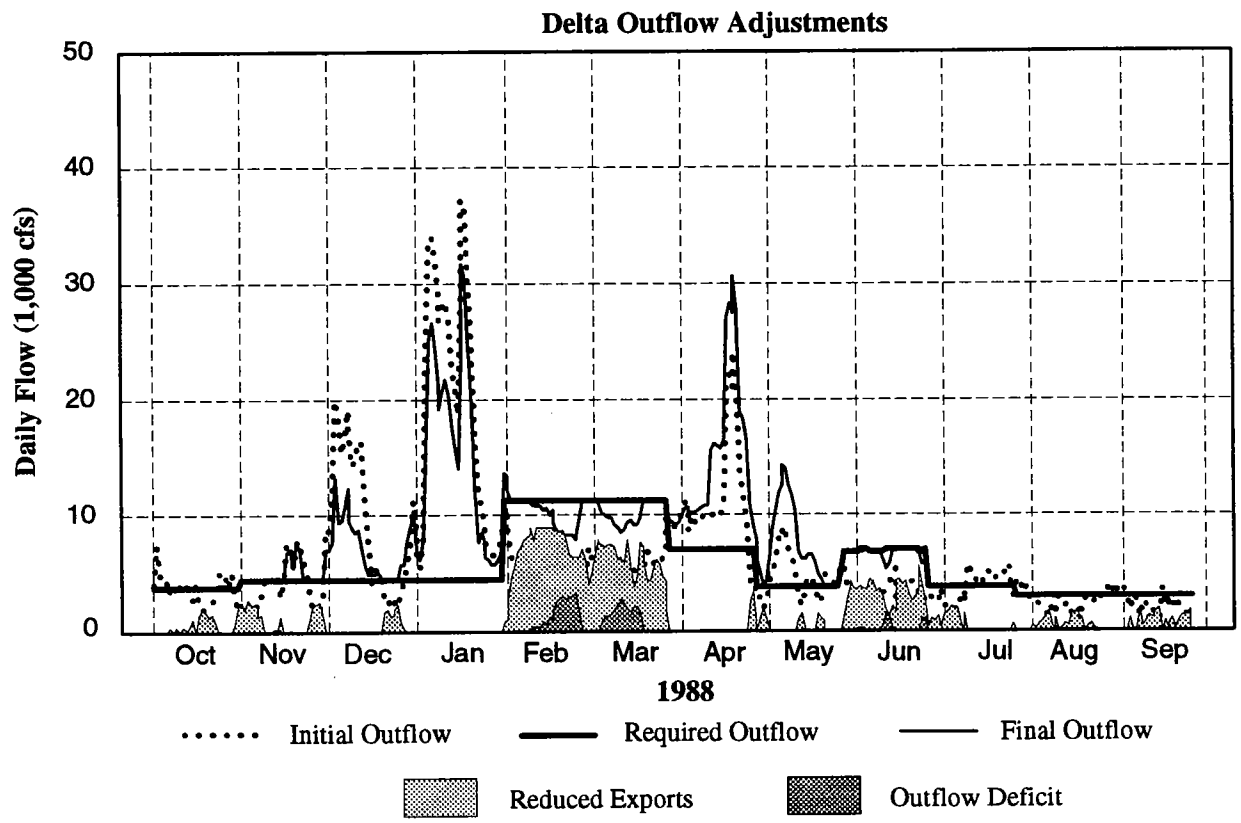


Figure A4-15C.
DailySOS Estimates of Required and Resulting X2 Location and Adjustments to Historical Outflow with 1995 WQCP Objectives for 1988 Historical Inflows

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

Appendix B1. Hydrodynamic Modeling Methods and Results for the Delta Wetlands Project

Appendix B1. Hydrodynamic Modeling Methods and Results for the Delta Wetlands Project

SUMMARY

This appendix describes the methods and results of modeling Delta hydrodynamic impacts of the Delta Wetlands (DW) project using the hydrodynamic module of the Resource Management Associates (RMA) Delta model. The RMA Delta model was used to estimate net Delta channel flows and inflow source contributions over a wide range of monthly Delta inflows, exports, and outflows to determine hydrodynamic changes that could be caused by diversions to and discharges from the DW project islands under DW project operations.

The appendix describes model calibration performed using tidal stage data and provides simulation results showing Delta tidal hydraulic patterns; relationships between inflows, exports, and assumed Delta channel gate operations; divisions of flow between several important Delta channels; and inflow source contributions at export and outflow locations. These hydrodynamic relationships were incorporated into the Delta Standards and Operations Simulation (DeltaSOS) and Delta Drainage Water Quality (DeltaDWQ) assessment models for impact assessment of the DW project alternatives.

The discussion describes the relationship between DW project operations and several hydrodynamic variables and identifies those variables that could be affected by DW project operations: Delta and local net channel flows and inflow source contributions. Results of simulations to determine effects of DW operations on net channel flows and source contributions are presented for each DW project alternative and the No-Project Alternative.

INTRODUCTION

Background

Analysis of Delta water resource impacts of the DW project is based on hydrodynamic modeling performed by RMA using its link-node hydrodynamic model of the Delta. RMA performed the modeling under the direction of the lead agencies and provided results to Jones & Stokes Associates (JSA) for use in conducting impact analyses for hydrodynamics, water quality, and fisheries, which are discussed in Chapters 3B, 3C, and 3F, respectively, of this environmental impact report/environmental impact statement (EIR/EIS). The RMA Delta model, developed jointly with California Department of Water Resources (DWR), represents the hydrodynamic responses of the Delta to different hydrologic and operational conditions.

Previous hydrodynamic modeling performed by RMA was used by JSA in preparing the 1990 draft EIR/EIS on the DW project. That previous modeling focused on 5 study years (1964, 1972, 1975, 1976, and 1978), representing each of the hydrologic year types classified under D-1485 criteria. A detailed description of the RMA model and its use for the 1990 draft EIR/EIS is provided in Smith and Durbin (1989) and summarized in this appendix.

For preparation of this revised draft EIR/EIS on the DW project, RMA performed new hydrodynamic modeling of Delta conditions based on monthly average historical Delta hydrology for the 25-year period of water years 1967-1991. Appendix A1, "Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project", describes the historical hydrologic inputs for the RMA model.

Purpose of This Appendix

The general goal of the hydrodynamic modeling described in this appendix was to simulate Delta net channel flows and inflow source contributions over a wide range of historical monthly Delta inflows, exports,

and outflows to determine hydrodynamic changes that would be caused by additional diversions to and discharges from the DW project islands.

Following are the major sections of this appendix and the purpose of each:

- "RMA Delta Hydrodynamic Model Formulation" describes the hydrodynamic modeling methodology used by RMA.
- "RMA Delta Model Tidal Flow Calibration" discusses the calibration of the RMA Delta hydraulic simulations with available Delta tide gage records.
- "Simulated Delta Tidal Hydraulic Patterns" describes typical Delta tidal hydrodynamics, which are the computational basis for simulating and evaluating hydrodynamic effects of the DW project.
- "Simulations of Monthly Average Net Delta Channel Flows Using Historical Delta Inflows and Exports" presents results of simulations of historical Delta net channel flows.
- "Variables for Measuring Hydrodynamic Effects of DW Operations" defines the hydrodynamic relationships used by JSA to describe hydrodynamic effects of the DW project.
- "Maximum Hydrodynamic Effects on Local Channel Flows, Velocities, and Stages" and "Simulated Effects of DW Operations on Delta Channel Flows and Source Contributions" present detailed results of the hydrodynamic impact assessment of the DW project alternatives.

RMA DELTA HYDRODYNAMIC MODEL FORMULATION

The RMA Delta model represents the Delta as a network of nodes (volume elements) and links (channels). Nodes are discrete volume units characterized by surface area, depth, side slope, and volume as a function of water depth (stage). A node generally represents half the volume of the channels to which it is connected, so the channel volume is represented in the two nodes connected to the channel. The channels (links) connecting the nodes are each characterized by length, cross-sectional area, hydraulic radius (related to depth), and friction factor (Manning's "n" value) as a function of water depth. Water is modeled to flow from one node to another through one or more links representing the significant channels between nodes. The RMA Delta model is formulated with approximately 375 nodes and 465 links (Figure B1-1).

The RMA Delta model combines a link-node hydrodynamic module and a mass-balance water quality module. The hydrodynamic module is a branched one-dimensional formulation, which simulates average flow and velocity in each channel (model link) and average stage (water surface elevation) at each volume element (model node). Tidal flows simulated with the hydrodynamic module are used to estimate net channel flows and tidal mixing between model nodes, both of which are used to simulate mixed concentrations of water quality variables at model nodes in the mass-balance water quality module. The water quality module is described in Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project".

The RMA hydrodynamic module operates on a 1.5-minute time step and estimates stages, flows, and velocities in the Delta channels for a repeating average tide. The primary inputs to the RMA hydrodynamic model are Delta inflows, exports, Delta channel diversions and drainage discharges, and the repeating average tidal boundary conditions at the downstream end of Suisun Bay near Benicia. Delta agricultural diversions and drainage discharges are treated as sinks or sources at appropriate nodes.

Time Step of Inputs and Calculations

Impact assessments of DW operations are based on DWRSIM simulations of monthly average SWP and CVP reservoir operations and Delta exports, which are used in the DeltaSOS assessment model. The RMA simulations of monthly average flows were used to provide an accurate characterization of hydrodynamic conditions (tidal and net channel flows) for a full range of possible Delta inflows and exports.

The RMA model was used to simulate 1967-1991 historical Delta conditions using monthly average inflows and exports. All historical hydrologic data and simulations use water years (October-September). The range of hydrologic conditions that occurred during this 25-year period is similar to the full range of conditions represented by the 1922-1991 hydrologic record. The historical Delta inflows and exports for 1967-1991 are similar to those that would be expected under the No-Project Alternative because most of the existing SWP and CVP facilities and reservoirs and diversion facilities on Delta

tributaries were operational during this period (conditions for the No-Project Alternative differ from historical conditions because the No-Project Alternative would operate under 1995 WQCP requirements and export demands).

Monthly Delta inflows and exports and estimates of agricultural diversions and drainage were derived from DAYFLOW, as described in Appendix A1. Daily variations in river inflows, Delta exports, or Delta Cross Channel (DCC) gate operations for flood control or fishery management are not simulated in monthly simulations. Although hydrologic conditions can be specified and used in the RMA model at a daily time step, monthly simulations are considered adequate for impact assessment of the DW project because year-to-year and seasonal changes in Delta hydrology and potential DW operations are adequately represented by monthly simulations (see Appendix A4, "Possible Effects of Daily Delta Conditions on Delta Wetlands Project Operations and Impact Assessments").

The tidal boundary condition used in the RMA model is the 19-year average tidal pattern measured at Benicia, typically used in Delta hydrodynamic studies. Long-term average tide data were used in place of actual tide data for all RMA simulations of operations of the DW project alternatives (Smith and Durbin 1989). An extreme tide was used for simulating maximum DW diversions and maximum DW discharge conditions (see "Maximum Hydrodynamic Effects on Local Channel Flows, Velocities, and Stages", below). Although averaging tide measurements smooths the differences between extreme tides throughout the year, it is justified because the hydrologic inputs are monthly averages. The hydrodynamic model repeats this average tide for each set of monthly inputs. Because the tidal cycle is 25 hours long, net channel flows are averages for the 25-hour tidal period in units of cubic feet per second (cfs). Figure B1-2 illustrates typical variations in tidal fluctuations at Antioch during a half lunar cycle of 14 days.

The RMA model calculations of tidal hydraulics were made at a 1.5-minute time step (tidal hydraulics simulated for the average Benicia tide are described in a later section of this appendix). Hydrodynamic results are summarized as average ebb tide flows, average flood tide flows, and net (positive or negative) channel flows for each set of hydrologic inputs (net flow = ebb tide flow - flood tide flow). The sign convention of the RMA link-node model is based on the assumption that positive flow is from a lower number node to a higher number node. Most node numbers increase from upstream to downstream so that positive channel flows correspond to river flow and ebb tide flow. Flood tide flows for these nodes are negative. Positive and negative flows are added and the result is divided by the approximately 25-hour tidal period to give the average net channel flow for each model link. Because the hydrologic inputs to the RMA model for the DW impact assessment were monthly averages, the model outputs for net channel flows are also monthly averages.

Hydrologic Inputs

The RMA hydrodynamic model inputs are specified in a hydrologic input file with monthly values for water years 1967 to 1991 for each required input variable. Values for river inflows, Delta exports, and combined DW project diversions and discharges were obtained from DeltaSOS model results for each DW project simulation case. The RMA input file spreadsheet disaggregates the total DW project diversions and discharges into monthly average flows for each of the four DW project islands. Agricultural diversions and drainage flow estimates for Delta uplands and Delta lowlands, as well as channel evaporation estimates, were obtained from results of simulations using the DeltaDWQ model (described in Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model").

The RMA Delta model allocates Delta inflows, exports, agricultural diversions and drainage flows, and proposed DW project diversions and discharges to the appropriate model nodes. The total drainage and diversion volume for the Delta is allocated among the Delta islands in proportion to each island's acreage as a percentage of total Delta acreage. The total drainage and diversion volume for an individual island is also allocated between the nodes surrounding the island in proportion to the relative sizes of siphons and pumps at each node. RMA has further divided the drainage and diversion fractions to correspond to Delta uplands and lowlands. DeltaDWQ produces separate estimates for water budget terms for these two regions of the Delta (see Figure C4-12 in Appendix C4).

Simulated Delta Facilities

The simulation results produced by the RMA Delta model depend on assumed Delta channel configurations and geometry, the DCC gate operation pattern, and the tidal operation pattern of the Clifton Court intake and the Suisun Marsh salinity control gate.

The analysis described in this appendix used existing channel geometry without any of DWR's proposed modifications in north Delta or south Delta channels. Existing

CCWD, CVP, and SWP pumping capacities, as simulated by the DeltaSOS model (described in Appendix A2), were assumed in the RMA model.

The RMA input file specified the operation of the various Delta channel control gates. Monthly operation (open or closed) of the DCC, the Suisun Marsh salinity control gate, and the temporary barrier at the head of Old River were specified. The partial barriers that are being installed and operated by DWR in the south Delta were not simulated.

RMA DELTA MODEL TIDAL FLOW CALIBRATION

Hydrodynamic calibration of the RMA model has been previously demonstrated for selected years (Smith and Durbin 1989). Direct hydrodynamic calibration of the RMA model with channel flows and velocities has not been possible because flows and velocities have not been measured routinely in the Delta channels (some stations are now operational). Calibration is therefore based on the match between observed and simulated water surface fluctuations at several tidal stage recording stations located throughout the Delta.

Conservation of mass requires that flow past a location depends directly on tidal phase and amplitude. Therefore, agreement between measured and computed stage is a good indication that the model is properly simulating the tidal movement of water in Delta channels. As the figures described below demonstrate, the Delta channel tidal stage patterns simulated by the RMA hydrodynamic model generally match tidal stage data.

The following are example comparisons of observed and simulated stage at important Delta locations. Two methods are used to compare simulated and observed tidal stage: time-series plots of tidal stage and scatter plots of observed and simulated stage. Inaccurate gage datums caused by levee subsidence may result in observed stage being consistently high; thus, simulated stage may be consistently lower than observed stage. Errors in modeled tidal phase or the magnitude of tidal fluctuations will cause the difference between the observed and simulated stage to fluctuate.

Figure B1-2 shows observed and simulated stage for the San Joaquin River at Antioch for the period of July 6-19, 1979. Average Delta hydrology during this periods was as follows: Sacramento River inflow of about 16,000 cfs, San Joaquin and eastside stream inflow of about 1,700 cfs, Delta exports of about 9,300 cfs, channel depletion of about 4,400 cfs, and Delta outflow of about 4,000 cfs. Both the time-series and scatter plots indicate agreement between simulated and observed stage at Antioch. The time-series plot shows that the model correctly accounts for the 2.5-hour tidal lag between the Benicia tidal boundary and Antioch, thus correctly representing conveyance factors and friction terms in the channels over that distance. The correspondence of simulated and observed stage at Antioch suggests that the tidal flow split between the Sacramento River and San Joaquin River channels is accurately simulated by the RMA model.

Figure B1-3 shows observed and simulated stage for the Sacramento River at Walnut Grove for the period of July 6-19, 1979. Both the time-series and scatter plots indicate agreement between simulated and observed stage at Walnut Grove. The time-series plot shows that the model correctly accounts for the 4-hour tidal lag between the Benicia tidal boundary and Walnut Grove. Simulated low tides are several inches lower than measured low tides, but the simulated magnitudes and timing of the tides are very close to those observed. The stage correspondence at Walnut Grove suggests that tidal flows in the Sacramento River, and therefore in the DCC and Georgiana Slough, are accurately simulated by the RMA model.

Figure B1-4 shows observed and simulated stage for Old River at Rock Slough for the period of July 6-19, 1979. Both the time-series and scatter plots indicate close agreement between simulated and observed stage at Rock Slough. The time-series plot shows that the model correctly accounts for the 4.5-hour tidal lag between the Benicia tidal boundary and Rock Slough. Low tides are lower than measured by a few inches, but the simulated magnitudes and timing of the tides are very close to the observed stage. The stage correspondence at Rock Slough suggests that tidal flows in Old River near two of the islands for the proposed DW project, Holland Tract and Bacon Island, are accurately simulated by the RMA model.

Tidal stage calibrations at several other Delta locations are shown in Smith and Durbin (1989). The tidal calibration results suggest that the RMA Delta model can be used with confidence to simulate the possible effects of the proposed DW project on Delta channel stage, velocity, and flow. Appendix B2 presents further confirmation of the RMA model calibration by comparing observed and simulated salinity (electrical conductivity [EC]) patterns for 1968-1991. Simulation of the historical EC data provides indirect evidence that the hydrodynamic simulations are accurate because the tidal flows govern the upstream mixing of EC from the downstream boundary.

The U.S. Geological Survey (USGS) and DWR have installed ultrasonic velocity meters (UVMs) in the Sacramento River at Freeport, Montezuma Slough at the Suisun Marsh salinity control gate, Old River at Bacon Island, and Middle River at Bacon Island and plan to install more of these velocity and flow measuring devices. Obtaining tidal flow measurements in Delta channels will provide an opportunity to adjust hydraulic model coefficients and further increase the hydrodynamic model accuracy.

SIMULATED DELTA TIDAL HYDRAULIC PATTERNS

The RMA Delta model computes hydrodynamic effects based on simulations of tidal flows in Delta channels induced by the average tide at the downstream Delta boundary and based on the inflows and exports specified at model boundary nodes. Because the same average tide is used for all specified inflows and exports, Delta tidal flows induced by the average tide, without any inflows or exports, can be described once for all hydraulic simulations. The purposes of this section are to:

- document typical Delta tidal hydraulics, which are the computational basis for simulating and evaluating hydrodynamic effects of the DW project;
- demonstrate the influence of tidal flows on transport and mixing exchange in the Delta channels, which govern the movement of salt and other water quality variables and may govern the movement and survival of various fish life stages in the Delta; and
- describe the averaging of the tidal flows to calculate the tidally averaged net channel flows and tidal mixing flows (part of tidal flow involved in mixing), which are used in the RMA Delta water quality mass-balance model computations.

Channel Geometry

Hydraulic simulations require accurate geometry data for the Delta channels. Surface area is important in determining the upstream tidal flow for a given change in stage at a node. Cross-sectional areas and lengths of channels (with corresponding friction factor) determine divisions of flow when tidal flows can move into more than one channel. Volume determines the change in stage corresponding to a tidal inflow or outflow at a node. Table B1-1 summarizes these important hydraulic geometry data for major Delta channel segments.

As the flood tide flow moves into Delta channels, stage increases and water is stored in the channels. This dynamic storage in a channel reduces the total flow in an upstream direction and attenuates the flood tide wave. The amount of storage is a function of the channel surface area and the change in stage. As the tide reverses to ebb, the temporary channel storage empties and creates the ebb tide flow out of the Delta.

Typical tidal hydrodynamic simulations do not include the effects of the spring-neap tidal cycle on the mean tidal stage of the Delta. There is a daily variation in the average tidal stage over the spring-neap cycle, with a variation of approximately 1 foot within the 28-day lunar cycle; the mean stage during spring tides (one large and one small tidal fluctuation) tends to be higher, and the mean stage during neap tides (two moderate tidal fluctuations) tends to be lower. This variation in mean stage produces a component of Delta outflow (positive or negative) due to this tidal filling and emptying cycle of the Delta that is not included in the RMA simulations that used long-term typical tidal fluctuations at Benicia.

Simulated Tidal Hydraulics

Table B1-2 presents simulated tidal flows, tidal velocities, channel cross-sectional area, and tidal excursions for selected Delta channel locations. The average flood tide flow is typically calculated from the tidal simulation results as the 12.5-hour average of all flood tide flows during the tidal cycle. The actual tidal cycle may contain two periods of flood tide flow corresponding to the two periods of rising water surface elevations (stages) between low tide and high tide. An equivalent flow moves in the opposite direction during the ebb flow portions of the tidal cycle. The magnitude of the simulated tidal flow determines the strength of simulated tidal effects in a Delta channel.

Average flood tide velocity is the average simulated velocity during the 12.5 hours of simulated floodflows in a channel. The average channel cross-sectional area can be approximated as the average flow divided by the average simulated velocity. The channel area of some channels may increase considerably between low tide and high tide.

Tidal excursion is the average distance that a passive object would move between high tide (upstream) and low tide (downstream). The daily tidal excursion is the range

of the cumulative tidal movement, calculated from the simulated average tidal velocities as the estimated position of imaginary objects (particles) released at the beginning of the tidal cycle and followed as they move upstream on flood tide flows and then downstream on ebb tide flows. During tidal flows there is a considerable "spreading" of water in Delta channels because water in the central portion of the channel has a greater velocity than water near the sides and bottom. This tidal spreading is what causes tidal mixing of salt and other materials released into Delta channels.

Tidal Hydraulics in Suisun Bay

Figure B1-5 shows the simulated tidal hydraulics in Suisun Bay. The average tide at Benicia at the west end of Suisun Bay begins with the high-high tide of 3.0 feet (mean sea level [msl] datum); the low-low tide of -2.8 feet occurs at about hour 8. The low-high tide of 2.2 feet occurs at hour 14; the high-low tide of -0.2 feet occurs at hour 19. The RMA model therefore simulates average tide in Suisun Bay with a 5.8-foot range over the tidal cycle. The change in tidal stage controls the movement of water into and out of Suisun Bay and the Delta.

The simulated tidal stages at Chipps Island at the east end of Suisun Bay are very similar to those for the boundary tide specified at Benicia, except that the low-low tide stage at Chipps Island is only -2.1 feet, not as low as at Benicia. The tidal stage pattern for Chipps Island lags behind the Benicia pattern by about 1-1.5 hours.

The change in tidal velocity lags behind the change in tidal stage. This is because the tidal change in the slope of the water surface elevation drives the tidal velocity and flow in the estuary channels. At Benicia, for example, the simulated stage is decreasing from high tide during the first 7.5 hours of the tidal cycle. The simulated velocity and flow at Benicia are in the upstream (negative) direction for the first 2.5 hours, and then are in the downstream direction with a peak downstream flow at hour 6.5, about 1 hour before low tide. The peak flood tide flow and velocity (upstream direction) occurs at hour 13.5, approximately 1 hour before the high tide simulated at hour 14.5. Therefore, high tides are generally associated with maximum upstream flow and velocity, while low tides are associated with maximum downstream flow and velocity, but peak flows precede the high and low tides. The delay between peak flows and peak stages varies with location within the estuary.

Simulated tidal velocities at Benicia and Chipps Island are similar, with a lag of about 1 hour between these two locations. The peak tidal velocities are about 3 feet per second (fps), with an average velocity of about 1.8 fps. Although the pattern of tidal velocities depends on the specified tide, these tidal velocities provide a general indication of the magnitude of the tidal exchange within Suisun Bay.

Simulated tidal flows at Benicia are quite large, with a peak ebb tide flow of about 575,000 cfs (positive downstream flow) and a peak flood tide flow of about 500,000 cfs (negative upstream flow). The average simulated flood tide flow at Benicia is 322,000 cfs (Table B1-2). Because this flood tide flow occurs during one-half of the day, the conversion factor between average flood tide flow (cfs) and daily flow volume (acre-feet/day) is about 1. Therefore, the volume of water moving upstream into Suisun Bay from the Benicia boundary during the flood tide periods of one tidal cycle is approximately 322,000 acre-feet (af). This daily flood tide volume is about 73% of the mean tide volume of Suisun Bay shown in Table B1-1 (443,000 af at mean sea level). A similar amount of water moves from Suisun Bay into San Pablo Bay during the ebb tide periods. These simulated results indicate very high exchange rates for water in Suisun Bay.

Simulated tidal flows at Chipps Island are considerably less than at Benicia, with a peak ebb flow of about 320,000 cfs and a peak flood tide flow of 310,000 cfs. The average flood tide flow is about 203,000 cfs. The reduction in flood tide flow at Chipps Island is caused by the temporary storage of water in Suisun Bay. The surface area of Suisun Bay is approximately 25,000 acres, and about 100,000 af can be temporarily stored within a tidal range of 4 feet. In addition, a large tidal flow (approximately 20,000 cfs flood tide flow) moves into the Suisun Marsh channels.

Tidal Hydraulics in the Sacramento River

Based on specified model channel geometry (Table B1-1), the Sacramento River from Chipps Island to Sacramento is estimated to have a water volume of about 280,000 af. The Sacramento River upstream of Chipps Island encompasses about 13,000 surface acres of water with a mean depth of 21.5 feet. Simulated tidal hydraulics at four locations along the Sacramento River in the Delta are shown in Figure B1-6.

Simulated tidal stage at Collinsville has a slightly reduced range compared with tidal stage at Benicia, with a high tide of 2.8 feet and a low tide of -2.0 feet. The tidal range at Rio Vista is about the same as at Collinsville. The tidal range is reduced at Walnut Grove and Courtland, with a high tide of 2.5 feet and a low tide of -1.0 foot (Figure B1-6). The tidal lag between Benicia

and Collinsville is about 2 hours, between Collinsville and Rio Vista is about 1 hour, between Rio Vista and Walnut Grove is another hour, and between Walnut Grove and Courtland is somewhat less than an hour. Therefore, the total simulated tidal lag from Benicia to Courtland is approximately 5 hours.

The simulated typical tidal hydraulic patterns at Walnut Grove (Figure B1-6) can be compared with the 14-day period of tidal stage measurements and simulation results shown in Figure B1-3. The simulated stage at Walnut Grove for the long-term average typical tide varied from -1.0 foot to 2.5 feet msl. The measured tide for the 14-day period in July 1979 varied from about 0.0 to about 3.5 feet. The measured tide fluctuations were well matched by simulated stages during the July 1979 period because the Sacramento river flow of approximately 16,000 cfs raised the average stage by about 1 foot. The simulations producing the typical tidal hydraulic results shown in Figure B1-6 assumed no river inflows, so the average stage was determined by the average tidal stage used as input at the Benicia boundary. A tidal range of about 3.5 feet at Walnut Grove was simulated both for the historical 1979 period and for the typical tidal simulation.

The magnitude of the flood tide flow decreases in the upstream direction as the flood wave is attenuated through storage in the Sacramento River and connecting Delta channels. Table B1-2 lists simulated average flood tide flows for Sacramento River and Delta channels. The average flood tide flow at Collinsville is about 100,000 cfs at an average flood tide velocity of 1.3 fps. At Rio Vista, the average flood tide flow is 46,000 cfs at an average velocity of 0.8 fps. A large portion of flood tide flow (29,000 cfs) moves up Cache Slough and the Sacramento Ship Channel, and a smaller portion continues up the Sacramento River. At Walnut Grove, average flood tide flow is 6,500 cfs at an average velocity of 0.8 fps.

Tidal Hydraulics in the San Joaquin River

Figure B1-7 shows simulated tidal hydraulics at four locations on the San Joaquin River. The San Joaquin River joins the Sacramento River near Collinsville. Because the San Joaquin River has more side channels than the Sacramento River, its tidal flow patterns are more complex. The San Joaquin River between Vernalis and the mouth near Collinsville has a total surface area of approximately 11,300 acres and volume of about 240,000 af.

Simulated tidal stage at Antioch has a range of about 4.5 feet, with a high tide of 2.7 feet and a low tide of about -1.8 feet. Tidal stage decreases only slightly as far upstream as Fourteenmile Slough near Stockton. Tidal lag, however, increases upstream on the San Joaquin River. Tidal lag between Benicia and Antioch is about 2 hours; tidal lag is another hour at Jersey Point; and at Fourteenmile Slough, the tidal lag from Benicia is about 5 hours. Tidal lag from Benicia to the head of Old River is approximately 7 hours (Figure B1-7).

Table B1-2 lists simulated average flood tide flows for the San Joaquin River and connecting channels. Simulated average flood tide flow at Antioch is 95,000 cfs at an average velocity of 1.6 fps. Upstream at Jersey Point, the average flood tide flow is 86,000 cfs at an average velocity of 1.4 fps. Approximately half the San Joaquin River flood tide flow enters the Franks Tract area through Dutch Slough and False River. The average flood tide flows in Dutch Slough and False River are about 4,800 cfs and 39,000 cfs, respectively. A small flood tide flow (3,000 cfs) reenters the San Joaquin River through the mouth of Old River.

At the mouth of the Mokelumne River, simulated average flood tide flow in the San Joaquin River is about 57,000 cfs at an average velocity of 0.9 fps. A portion of the tidal flow moves into the Mokelumne River channels through the Mokelumne River mouth and Potato Slough.

The average flood tide flow above the mouth of Middle River mouth and Columbia Cut is about 12,600 cfs, and above Turner Cut and Fourteenmile Slough the average flood tide flow is reduced to about 4,000 cfs. At the head of Old River near Mossdale, the average flood tide flow is reduced to about 1,000 cfs.

Tidal Hydraulics in Old River

Figure B1-8 shows the simulated tidal hydraulics at three Old River locations. Old River and connecting channels, including Franks Tract and Big Break, have a total surface area of about 10,000 acres and a volume of about 115,000 af. Flood tide flow actually enters Old River through Franks Tract from Dutch Slough and False River. Flood tide flow at the mouth of Old River moves from Franks Tract to the San Joaquin River.

The simulated tidal stage is similar at the three Old River locations. At Holland Tract, tidal range is about 3.8 feet, with a high tide of 2.6 feet and a low tide of -1.2 feet. At Coney Island, opposite the Clifton Court entrance gates, high tide is 2.6 feet and low tide is -0.9 feet, for a tidal range of 3.5 feet. The tidal lag from Benicia is about 4 hours at Holland Tract and increases to about 7 hours at Coney Island.

Table B1-2 lists simulated average flood tide flows in Old River. Simulated average flood tide flow in Old River at Rock Slough is about 9,300 cfs at an average velocity of 0.8 fps. At Woodward Canal, just north of Victoria Canal and Clifton Court, the average flood tide flow is about 7,700 cfs at an average velocity of 1.1 fps. At Coney Island, opposite the entrance to Clifton Court and north of Grant Line Canal, the average flood tide flow is about 5,700 cfs at an average velocity of 1.2 fps. Some of this flood tide flow joins Old River from Victoria Canal and Middle River.

Tidal Hydraulics in Middle River

Figure B1-9 shows simulated tidal hydraulics at four locations on Middle River. Middle River, including Turner and Columbia Cuts, Mildred Island, and Victoria Canal, has a surface area of about 4,000 acres and a volume of about 62,000 af. Flood tide flow from the San Joaquin River enters Middle River at the mouth and through Turner Cut. Flood tide flow reenters the San Joaquin River from Middle River through Columbia Cut.

The simulated tidal range in Middle River channels is quite uniform, with a high tide of about 2.6 feet and a low tide of -1.2 feet at the mouth and -0.8 feet at the head of Middle River. The tidal lag between Benicia and the mouth of Middle River is about 4 hours. The tidal lag increases to about 5 hours at Victoria Canal and about 7 hours at the head of Middle River.

Table B1-2 lists simulated average flood tide flows in Middle River. Simulated average flood tide flow entering the mouth of Middle River from the San Joaquin River is about 18,000 cfs at an average velocity of 0.5 fps. Upstream of Columbia Cut, average flood tide flow is about 14,700 cfs. At Victoria Canal, average flood tide flow is 4,300 cfs at an average velocity of 1.0 fps. Most of the flood tide flow (3,400 cfs) enters Victoria Canal, and a flow of only about 900 cfs continues upstream in Middle River.

Tidal Hydraulics in the South Delta

Simulated tidal hydraulics in the south Delta are of particular interest because fluctuations in tidal stage are important for agricultural diversions, and tidal flows provide flushing of agricultural drainage water. Simulated tidal hydraulics at four south Delta locations are shown in Figure B1-10.

Three inflows to the south Delta channels are the Old River near Byron, Middle River at Victoria Canal, and the head of Old River near Mossdale. High tide is about 2.6 feet in Old and Middle Rivers and about 2.2 feet at Mossdale. Low tide is about -1.0 feet in Old and Middle Rivers and about -0.3 feet at Mossdale. The tidal lag from Benicia to the south Delta varies from about 5 hours to 7 hours.

Because the south Delta is near the southern boundary of the estuary, tidal flows are relatively small. The average flood tide flow in Middle River upstream (south) of Victoria Canal is only 900 cfs at an average velocity of 0.5 fps. The average flood tide flow is less than 50 cfs at the head of Middle River. The average flood tide flow in the Grant Line Canal (which includes the Fabian and Bell Canal) is about 3,500 cfs at the west end near Coney Island and decreases to about 2,700 cfs at the east end of Fabian Tract. The average flood tide flow in Old River near the CVP Tracy Pumping Plant is about 1,200 cfs at an average velocity of 0.5 fps. This flood tide flow in Old River is reduced to about 150 cfs near the town of Tracy. The average flood tide flow at the head of Old River is about 1,100 cfs at an average velocity of 1.0 fps, moving upstream from Grant Line Canal toward the San Joaquin River.

Various channel barriers have been installed in south Delta channels for maintenance of fisheries and water quality. A barrier at the head of Old River has been used periodically. Several tidal barriers and gates have been proposed and are being evaluated by DWR. None of these channel barriers were included in these basic tidal simulations of south Delta channels. The barrier at the head of Old River was included in simulations of the DW project alternatives and the No-Project Alternative.

Tidal Hydraulics in the Mokelumne River

In the north Delta, the Mokelumne River channels include the DCC, Georgiana Slough, North and South Forks of the Mokelumne River, Potato Slough, Little Potato Slough, White Slough, and several smaller channels between the Sacramento River and the San Joaquin River. The surface area of these channels is approximately 3,800 acres and volume is about 52,000 af. Tidal flood tide flows enter the Mokelumne River channels from the Sacramento River through the DCC (when simulated to be open) and Georgiana Slough. Flood tide flows also enter the Mokelumne River channels from the San Joaquin River through the Mokelumne River mouth and through Potato, Disappointment, and Fourteenmile Sloughs. Flood tide flows reenter the San Joaquin River from Potato Slough through Little Potato Slough around Venice Island.

Figure B1-11 shows the simulated tidal hydraulics in the Mokelumne River channels. The stage levels on the

Sacramento River at Walnut Grove (near the DCC and Georgiana Slough) and the San Joaquin River at the mouth of the Mokelumne River are almost identical. This similarity indicates that tidal flows enter the Mokelumne River channels from both the Sacramento and San Joaquin Rivers at the same time.

Simulated average flood tide flow from the Sacramento River into Georgiana Slough is about 950 cfs at an average velocity of 0.3 fps. The average flood tide flow from the Sacramento River into the DCC is about 2,000 cfs at an average velocity of 0.4 fps. Average flood tide flow from the San Joaquin River into the Mokelumne River mouth is about 8,100 cfs at an average velocity of 0.5 fps, and the average flood tide flow from the San Joaquin River into Potato Slough is about 9,300 cfs at an average velocity of 0.7 fps.

Tidal Hydraulics in Suisun Marsh

Figure B1-12 shows the simulated tidal hydraulics in the Suisun Marsh channels. The Suisun Marsh salinity control gate was open in the tidal simulation. Simulated tide stage at Grizzly Bay (south of Suisun Marsh) is about 1 hour ahead of the stage at Collinsville. Flood tide flow enters Suisun Marsh from Grizzly Bay and exits from Montezuma Slough into the Sacramento River at Collinsville. Ebb tide flow enters Suisun Marsh from the Sacramento River and empties from Suisun Marsh into Grizzly Bay.

Simulated average flood tide flow into Montezuma Slough from Grizzly Bay is about 13,700 cfs at an average velocity of 0.6 fps. Average flood tide flow into Suisun Slough from Grizzly Bay is about 7,800 cfs at an average velocity of 0.4 fps. Average flood tide flow at the Suisun Marsh salinity control gate on Montezuma Slough is about 4,700 cfs at an average velocity of 1.0 fps.

Tidal Hydraulics in Threemile Slough

Threemile Slough connects the Sacramento River at Emmaton with the San Joaquin River upstream of Jersey Point. Figure B1-13 shows the simulated tidal hydraulics for Threemile Slough. Tidal stage at the Sacramento River end of Threemile Slough is about an hour ahead of the tide at the San Joaquin River end. Ebb flow through Threemile Slough is from the San Joaquin River to the Sacramento River and flood tide flow is from the Sacramento River to the San Joaquin River.

Simulated average flood tide flow in Threemile Slough from the Sacramento River to the San Joaquin River is about 18,400 cfs at an average velocity of 1.4 fps.

Tidal Hydraulics in Steamboat and Sutter Sloughs

Steamboat and Sutter Sloughs, along with Cache and Miner Sloughs and the Sacramento Deep Water Ship Channel, have a surface area of about 4,250 acres and a volume of about 86,000 af. Simulated average flood tide flow from the Sacramento River into Cache Slough is about 28,800 cfs at an average velocity of 1.1 fps. Average flood tide flow at the mouth of Steamboat Slough is 4,700 cfs at an average velocity of 0.9 fps. At the upstream end of Steamboat Slough, the average flood tide flow into the Sacramento River is about 1,500 cfs. At the upstream end of Sutter Slough, average flood tide flow into the Sacramento River is about 1,900 cfs.

Summary Map of Tidal Flows

Simulated average flood tide flows throughout the Delta are summarized in Figure B1-14. Arrows indicate the direction of the flood tide flow. The RMA model uses the average tidal boundary pattern at Benicia as the basis for simulating monthly average Delta channel flows. Tidally averaged net channel flows caused by inflows and exports should be understood to be superimposed on the tidal flows shown on this "tidal map" of the Delta. In many cases, the tidal flows are much larger than the net channel flows. These fluctuating tidal flows are relatively constant from day to day, independent of the net channel flows.

Because the times of peak tidal flows are delayed as the tide progresses upstream, tidal flows in the south and north Delta are out of phase with the Benicia boundary condition. Nevertheless, these tidal flows occur during the tidal cycle and provide tidal exchange mixing that, along with Delta outflow, governs salinity intrusion, tidal flushing flows that may affect water quality, and tidal currents that may influence fish movement.

Simulation of Tidal Gate Operations in the Delta

Several tidal gates are operating in the Delta and several others are proposed. The most important Delta tidal gates are the gate at the entrance to Clifton Court Forebay and the Suisun Marsh salinity control gate. Operating tidal gates are also simulated on Tom Paine Slough in the south Delta and on Sandmound Slough at

Rock Slough. Gates on the DCC and at the head of Old River were also simulated, but they were either open or closed during an entire month and do not operate as tidal gates.

Clifton Court Forebay

Inflow to Clifton Court Forebay is controlled by a gated weir that allows inflow during high tide and prevents outflow during ebb tides. The gate is represented in the RMA Delta model by a channel that approximates the head loss through the control structure. Clifton Court inflow is computed based on channel hydraulic characteristics and the simulated head difference between Old River and Clifton Court and the assumption that there is a constant outflow to the Banks Pumping Plant. The gate is assumed to be open for several hours near high tides to approximate the current operating schedule.

Suisun Marsh Salinity Control Gate

The RMA Delta model includes tidal gates to control flow in Montezuma Slough. Almost all flood tide flow is blocked by the gates, producing a net ebb flow from the Sacramento River into Suisun Marsh. The magnitude of the net ebb flow depends on the Sacramento River flow. This tidal gate creates a net inflow of Sacramento River water into the Suisun Marsh channels for salinity control.

SIMULATIONS OF MONTHLY AVERAGE NET DELTA CHANNEL FLOWS USING HISTORICAL DELTA INFLOWS AND EXPORTS

To describe basic Delta channel flow patterns, historical monthly average Delta channel flows were simulated with the RMA model based on historical inflows and exports for water years 1967-1991. Net flows in Delta channels are governed by channel geometry and tidal hydrodynamics, in combination with Delta inflows, exports, diversions, and agricultural drainage.

Movements of water through the Delta are described based on channel flow divisions ("flow splits") and tracking of each inflow ("source tracking") simulated by the RMA model. Flow splits represent the relative proportions of flow simulated to enter two or more Delta channels at channel junctions. Source tracking was performed by numerically marking the water from a particular source (i.e., Sacramento River) and following the marked water through the Delta. Source tracking is used to indicate the percentage of water from a given source (Sacramento and San Joaquin Rivers, eastside streams, Yolo Bypass, San Francisco Bay, and Delta island drainage) that is simulated at each model node at the end of each month. The results from the RMA simulations of channel flow splits were incorporated in the DeltaSOS assessment model.

The purpose of this description of simulated historical Delta channel flows is to:

- describe the simulated relationships between inflows, exports, and assumed Delta gate operations and channel flows;
- describe the simulated divisions of flow (flow splits) between several important Delta channels; and
- provide a foundation for describing simulated changes in Delta channel flows resulting from proposed DW project operations.

Historical Monthly Average Inflows and Exports

For purposes of impact assessments, river inflows and Delta exports are the most important simulation terms; rainfall and estimated agricultural diversions and drainage are assumed to remain unchanged from the historical values (except for diversions to and drainage from DW islands under proposed project operations).

The RMA Delta model requires inputs specifying inflows for the Sacramento River, Yolo Bypass, eastside streams (Mokelumne, Cosumnes, and Calaveras Rivers), and the San Joaquin River. Inflows to the Delta represented by rainfall and agricultural drainage are specified as components of monthly net Delta channel depletion (or gain) estimates.

The RMA Delta model requires specification of exports at SWP North Bay Aqueduct, SWP Banks Pumping Plant, CVP Tracy Pumping Plant, and diversions at Contra Costa Water District (CCWD) Rock Slough intake. Agricultural diversions are estimated as a component of net Delta channel depletions with an assumed irrigation efficiency of 70% (DWR 1994). The RMA model estimates diversions to each of the agricultural siphons and pumps in the Delta at each model node based on the proportional acreage of Delta islands adjacent to the model nodes.

Model input values for historical Delta inflows and exports for water years 1967-1991 were obtained from

DWR's DAYFLOW database. The historical island flooding events and subsequent pumping discharges to empty the flooded islands that are reported as "exports" were not simulated, however.

Table B1-3 gives the monthly historical Delta inflows and exports that were used in the simulation of historical Delta channel flows with the RMA Delta model for water years 1968-1991. The only deviations from actual historical DAYFLOW estimates of channel flow are the removal of the island flooding events and some differences in the simulated DCC closure rules. The RMA model input specifies the DCC status for each month, as a function of Sacramento River inflow and Delta outflow, while actual historical DCC closure was governed by daily flows and other operational considerations.

Sacramento River and Yolo Bypass Flows

Figure B1-15 shows the historical monthly average Sacramento River flow at Sacramento and Yolo Bypass flow for water years 1967-1991. The average combined flow during this period was 28,400 cfs, average flow in the Sacramento River was 23,950 cfs, and average Yolo Bypass flow was about 4,450 cfs. Figure B1-16 shows, however, that the maximum channel flow capacity of the Sacramento River is about 80,000 cfs; flows greater than this capacity are diverted into Yolo Bypass upstream of the City of Sacramento. The maximum monthly average Yolo Bypass flow during 1967-1991 was approximately 130,000 cfs. Flows of less than about 40,000 cfs remain in the Sacramento River channel. When Sacramento River flows are between 40,000 cfs and 80,000 cfs, some water begins to be diverted into the Yolo Bypass.

Minimum monthly average Sacramento River flows of about 10,000 cfs have occurred during late summer of most years, with flows of less than 10,000 cfs persisting for several months in 1977 and 1991 (Figure B1-15). Such low-flow periods are the most critical for maintaining salinity control in the Delta.

Sacramento River and Yolo Bypass flows consist of uncontrolled runoff downstream of reservoirs and reservoir spills or releases. A large proportion of the Sacramento River and Yolo Bypass flow during periods of high runoff cannot be controlled by upstream reservoirs.

All releases and spills from upstream Sacramento Valley SWP and CVP reservoirs enter the Delta through the Sacramento River and Yolo Bypass. These Delta inflows may change directly with alternative operations of the CVP and SWP systems and with various possible operations of the proposed DW project. Because Yolo Bypass flows become substantial only during relatively rare events when Sacramento River flows are greater than about 40,000 cfs, the Sacramento River inflow is the inflow most directly changed by upstream CVP and SWP reservoir operations.

San Joaquin and Eastside Stream Flows

Historical 1967-1991 monthly average inflows for the San Joaquin River at Vernalis and eastside streams (Mokelumne, Cosumnes, and Calaveras Rivers) are shown in Figures B1-17 and B1-18, respectively. The average flow in the San Joaquin River for 1967-1991 was 4,875 cfs, and the combined average flow in the eastside streams for 1967-1991 was about 1,600 cfs.

Most runoff occurs during winter storms and spring snowmelt, with maximum San Joaquin River flows exceeding 20,000 cfs and combined flows of the eastside streams exceeding 10,000 cfs. Historical minimum flows on the San Joaquin River have been less than 1,000 cfs, although releases from New Melones Reservoir (part of the CVP system completed in 1979 and first filled in 1983) have been used to maintain San Joaquin River flows above 1,000 cfs in recent years. Periods of high flow in the San Joaquin River correspond with high flows in the other eastside streams and in the Sacramento River.

Delta CVP and SWP Exports and CCWD Rock Slough Diversions

Figure B1-19 shows the historical monthly average Delta CVP and SWP exports and CCWD diversions for water years 1967-1991 obtained from DWR's DAYFLOW database. Exports were limited in the first part of the period because the SWP facilities were not completed. Banks Pumping Plant began operating in 1968, San Luis Reservoir was completed in 1967 and filled in 1969, and Edmonston Pumping Plant was completed in 1973. Delta exports increased throughout the historical period, except when limited by drought conditions in 1976-1977 and 1988-1991 and during extremely wet periods, such as 1983 and 1986. Historical CCWD exports are relatively small and have averaged about 135 cfs.

CVP demands for Delta exports are dominated by agricultural uses with large seasonal fluctuation. CVP export pumping has become more uniform because the CVP portion of San Luis Reservoir is filled before the irrigation season, and its releases are used to help supply the CVP demands. CVP exports are often limited by the capacity of the Tracy Pumping Plant (4,600 cfs) or the pumping capacity at O'Neil Forebay (4,200 cfs).

SWP exports at Banks Pumping Plant increased significantly during the historical period of water years 1967-1991. Although exports have been limited by the Banks Pumping Plant capacity, an additional four pumps became operational in 1992, increasing pumping capacity from 6,800 cfs to about 10,300 cfs during periods of high San Joaquin River inflows (see Appendix A1).

Delta Rainfall, Evapotranspiration, and Channel Depletion

Rainfall and evapotranspiration (ET) are significant terms in the historical water budget of the Delta. Rainfall and pan evaporation can be measured but soil moisture retention and release cannot. Therefore, a soil moisture accounting procedure is used to estimate the monthly average net channel depletion in the Delta. The RMA Delta model requires that agricultural drainage and diversions be separately estimated as components of net Delta channel depletion.

Figure B1-20 shows the monthly pattern of measured rainfall, average monthly evaporation pan data, and Delta channel depletion estimated with the DeltaDWQ model (see Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model"), a soil moisture accounting for the 1967-1991 historical period. With a total Delta area of 678,200 acres, average monthly values representing rainfall and potential ET are quite large. Average long-term Delta channel depletion was estimated to be 1,175 cfs.

Estimated (DAYFLOW) irrigation diversions from the Delta are quite large in July and August and correspond to a Delta channel depletion flow of about 5,000 cfs. These unmeasured Delta diversions can have a substantial effect on the Delta outflow during summer. Channel depletion estimates are a major source of potential error in Delta hydrodynamic simulations.

Delta Outflow

Delta outflow is an important Delta flow that can be estimated as the difference between Delta inflows and the combination of Delta exports and net channel depletion. Figure B1-21 shows Delta outflow calculated from historical inflows, exports, and estimated net channel depletion. The average estimated Delta outflow for 1967-1991 was about 28,000 cfs, and the maximum monthly average outflow was about 260,000 cfs. Minimum monthly average Delta outflow has been less than 10,000 cfs during summer in almost all years, with considerably lower Delta outflow persisting for several months during several of the years (1976-1977 and 1987-1991).

Figure B1-22 shows the cumulative distribution of monthly average estimated Delta outflow for 1967-1991. Estimated monthly average Delta outflow was less than 10,000 cfs in approximately 45% of the months for 1967-1991 historical conditions. Delta outflow was less than 12,000 cfs about 50% of the time, so 12,000 cfs is the median monthly average Delta outflow for 1967-1991. Delta outflow was less than 40,000 cfs about 80% of the time and less than 80,000 cfs about 90% of the time.

Upstream reservoir operations and Delta exports cannot greatly modify high Delta outflow events, as discussed above. Reservoir operations and Delta export limits can more easily affect lower Delta outflows.

Delta Channel Pathways

Seven major pathways convey water through the Delta. As illustrated in Figure B1-23, these pathways represent groups of Delta channels to reflect the general movement of water from Delta inflow to Delta outflow and Delta exports. The primary Delta channels are the Sacramento and San Joaquin Rivers. Numerous other channels play an important role in the hydrodynamics of the Delta.

Pathway 1 is the Sacramento River channel between the Sacramento River inflow at Sacramento and Delta outflow at Chipps Island. A relatively small portion of Sacramento River flow is diverted into Suisun Marsh through Montezuma Slough downstream of Collinsville.

Pathway 2 is the natural diversion from the Sacramento River into Steamboat and Sutter Sloughs. This pathway returns to the Sacramento River at Rio Vista through Steamboat, Miner, and Cache Sloughs. Yolo Bypass flow joins this pathway and enters the Sacramento River at Rio Vista.

Pathway 3 encompasses the Mokelumne River channels that connect the DCC and Georgiana Slough, carrying Sacramento River diversions, with the San Joaquin River in the central Delta. The combined flow of the Mokelumne River and the Sacramento River diversions through the DCC and Georgiana Slough enters the San Joaquin River channel through five separate channels (Mokelumne River mouth and Potato, Little Connection, Disappointment, and Fourteenmile Sloughs).

Pathway 4 consists of the San Joaquin River channel between the San Joaquin River inflow at Vernalis and the mouth of the Mokelumne River in the central Delta. Inflow from the Calaveras River joins this pathway downstream of Stockton.

Pathway 5 consists of Old River and Grant Line Canal between the head of Old River on the San Joaquin River at Mossdale and the Tracy and Banks Pumping Plants for Delta exports. A major portion of the San Joaquin River flow is diverted into Old River along this pathway unless a barrier is installed at the head of Old River. Very little flow is diverted from Old River into Middle River at the head of Middle River.

Pathway 6 is the combination of Old and Middle Rivers between the Delta export locations and the mouth of Old and Middle Rivers on the San Joaquin River in the central Delta. Rock Slough, which connects Old River with the CCWD diversion location, is located on this pathway.

During high San Joaquin River inflows, water moves down Old River past the Delta export pumps and then down Old River and Victoria Canal to Middle River and into the central Delta. During periods when Delta exports exceed flows diverted from the San Joaquin River into Old River, water moves upstream in Pathway 6 from the central Delta to the Delta export pumps at Tracy and Banks Pumping Plants. Thus, Pathway 6 transports water in both directions, with the direction of flow depending on the relative magnitudes of Delta exports and Old River diversions from the San Joaquin River.

Pathway 7 is the lower San Joaquin River channel between the mouth of Old River and the confluence with the Sacramento River downstream of Antioch. This pathway includes Fishermans Cut, False River, and Dutch Slough, which connect Franks Tract to the west with the San Joaquin River. The net flow through these San Joaquin River channels is referred to as QWEST. Threemile Slough is considered a part of this pathway because under normal flow conditions a substantial flow from the Sacramento River moves to the San Joaquin River through Threemile Slough.

Delta outflow past Chipps Island flows through Suisun Bay to Benicia and toward San Pablo and San Francisco Bays. Salinity intrusion from tidal exchange mixing can transport a significant quantity of salt from Suisun Bay into the Sacramento and lower San Joaquin River pathways during periods of low Delta outflow.

The following sections describe RMA model simulations of channel flows and flow splits along these transport pathways, based on historical Delta inflows and exports. The results are given in Table B1-4 for 1968-1991 for selected channel locations.

Historical Simulations

Assumed Operation of Delta Gates for Historical Simulations

Currently operating Delta gates include the DCC, the Suisun Marsh salinity control gate, and temporary barriers in south Delta channels. For the monthly historical simulation, the DCC gates were simulated in a general way that reflects the basic DCC operations to limit diversions of fish and provide flood control. If the monthly average Sacramento River flow was greater than 25,000 cfs, the DCC gates were assumed to be closed for flood control purposes. During January-April, if Delta outflow was estimated to be greater than 12,000 cfs, the DCC gates were assumed to be closed to limit diversion of fish from the Sacramento River into the central Delta. The actual historical gate operations might have changed on a daily basis. Other gates and barriers were not simulated.

Sacramento River Channel Flows

Sacramento River diversions into Steamboat and Sutter Sloughs, the DCC, and Georgiana Slough are determined by channel geometry and tidal hydraulics. With a uniform simulated tidal cycle, the average monthly flow diversions are governed by stage differentials and conveyance capacities of the diversion channels.

Figure B1-24 shows the historical monthly average Sacramento River inflows at Sacramento (as previously shown in Figure B1-15) and simulated combined diversions to Steamboat and Sutter Sloughs and diversions to the DCC and Georgiana Slough for water years 1967-1991. The diversion channel flows are governed primarily by Sacramento River inflow and operation of the DCC gates. Delta exports, Mokelumne River or Yolo Bypass inflows, and other Delta conditions do not have a substantial effect on these Sacramento River diversions, according to the RMA model results.

Steamboat and Sutter Slough Diversions. Figure B1-25 shows the simulated combined diversions into Steamboat and Sutter Sloughs as a function of Sacramento River inflow and DCC gate operation. The combined diversions into Steamboat and Sutter Sloughs are shown as diversion flow (cfs) and as a percentage of the Sacramento River inflow.

When the DCC gates are open, the combined Steamboat and Sutter Slough flow is a major portion of the Sacramento River inflow, with approximately 2,000 cfs (20%) diverted at a Sacramento River inflow of 10,000

cfs and about 7,500 (30%) diverted at a Sacramento River inflow of 25,000 cfs.

When the DCC gates are closed, the combined Steamboat and Sutter Slough flow is an even greater portion of the Sacramento River inflow, ranging from 10,000 cfs (33%) at a Sacramento River inflow of 30,000 cfs to about 30,000 cfs (39%) at a Sacramento River inflow of 80,000 cfs.

These simulated Delta channel flows based on historical inflows indicate that a considerable portion (20%-40%) of the Sacramento River inflow is diverted into Steamboat and Sutter Sloughs and returned to the Sacramento River channel at Rio Vista.

Delta Cross Channel and Georgiana Slough Diversions. Figure B1-26 shows the simulated combined diversions into the DCC and Georgiana Slough as a function of Sacramento River inflow and DCC gate operation. The combined diversions into the DCC and Georgiana Slough are shown as diversion flow (cfs) and as a percentage of the Sacramento River inflow.

When the DCC gates are open, the combined DCC and Georgiana Slough flow is a major portion of the Sacramento River inflow, with approximately 5,500 cfs (55%) diverted at a Sacramento River inflow of 10,000 cfs and about 10,000 cfs (40%) diverted at a Sacramento River inflow of 25,000 cfs. The proportion diverted decreases with increasing Sacramento River flow because of the respective channel configurations of the river and the DCC.

When the DCC gates are closed, the Georgiana Slough diversion flow constitutes a smaller portion of the Sacramento River inflow, ranging from about 4,000 cfs (20%) at a Sacramento River inflow of 20,000 cfs to about 12,000 cfs (15%) at a Sacramento River inflow of 80,000 cfs. The DCC gates were not closed in the simulations at Delta outflows of less than 12,000 cfs.

Comparing the simulated flow into Georgiana Slough with the Sacramento River flow downstream of the DCC (at the head of Georgiana Slough) indicates a consistent hydraulic relationship between flow in the two channels, with about 25% of the Sacramento River flow below the DCC entering Georgiana Slough. The RMA model results indicate that the proportion diverted to Georgiana Slough corresponds to 15%-20% of the Sacramento River inflow at Sacramento (i.e., above the Sutter and Steamboat Slough diversions) (Figure B1-26).

These simulated Delta channel flows indicate that a considerable portion (15%-60%) of the Sacramento River inflow is diverted into the DCC and Georgiana Slough and is conveyed into the central Delta. The simulated channel flows indicate that the DCC flow is greater than the Georgiana Slough flow when the DCC is open (Figure B1-26). Closing the DCC increases the Georgiana Slough flow but reduces the total diversions from the Sacramento River to the Mokelumne River by about half.

Threemile Slough Diversions. The RMA model simulates flows entering Threemile Slough from the Sacramento River as generally increasing with Sacramento River flow at Emmaton, which includes Yolo Bypass inflows. Flows in Threemile Slough are influenced, however, by the average hydraulic gradient (difference in water surface elevation) in the slough between the Sacramento River and the San Joaquin River. The hydraulic gradient can be correlated with the ratio of QWEST flow to Sacramento River flow. QWEST flow is estimated as the simulated flow in the San Joaquin River at Antioch minus the Threemile Slough flow. QWEST therefore represents the San Joaquin River outflow from the central Delta, as is calculated in DAYFLOW. A portion of the QWEST flow moves through False River and Dutch Slough, as well as the San Joaquin River channel.

As simulated by the RMA model, Threemile Slough flow can be as much as 40% of Sacramento River flow whenever central Delta outflow (QWEST) is negative (reversed) and equal to half the Sacramento River flow (Figure B1-27). When central Delta outflow (QWEST) is zero, simulated Threemile Slough flows are about 20% of Sacramento River flow. When central Delta outflow is about 75% of Sacramento River flow, simulated Threemile Slough flows are zero. When central Delta outflow is equal to Sacramento River flow (i.e., ratio of 1:1), the net flow direction in Threemile Slough reverses and conveys about 10% of the central Delta outflow to the Sacramento River.

These simulated historical Delta channel flows indicate that a considerable portion of Sacramento River flow is diverted through Threemile Slough to the San Joaquin River (Figure B1-27). The proportion of the Sacramento River flow diverted into Threemile Slough is greatest when the ratio of central Delta outflow (QWEST) to Sacramento River flow is negative (i.e., San Joaquin River flows are reversed into the central Delta). The diverted Threemile Slough flow is usually greater than the reversed central Delta flow (as a fraction of Sacramento River flow); therefore, the simulated flows at Antioch (which are the sum of QWEST and Threemile Slough flows) were almost always positive (see "Flows through Franks Tract and Connecting Channels", below).

Montezuma Slough Diversions. For the simulations based on historical inflows and exports, the Suisun Marsh salinity control gate was assumed to be open. Simulated net channel flows diverted through Montezuma Slough into Suisun Marsh are about 2% of Delta outflow for moderate and high Delta outflows (Figure B1-28). At a Delta outflow of 10,000 cfs, however, the Montezuma Slough net flow is simulated to be zero. When Delta outflow is less than 10,000 cfs, a small upstream net flow transports water from Suisun Marsh into the Sacramento River channel near Collinsville.

The salinity control gate on Montezuma Slough began operation in 1989. Approximately 2,200 cfs plus 0.5% of Delta outflow enters Suisun Marsh through Montezuma Slough when the tidal gates are operated to be open on ebb tide and closed on flood tide. Delta outflow past Chipps Island is reduced by about 2,000 cfs during periods of low Delta outflow when the tidal gates are operating.

San Joaquin River Channel Flows

The San Joaquin River channel divides into several channels through the Delta. Near Mossdale, the San Joaquin River branches into Old River and then branches again into Middle River. Under conditions without Delta exports, San Joaquin River inflow moves down all three channels toward the central Delta, where the Middle and Old River channels rejoin the San Joaquin River. Franks Tract (now permanently flooded), located near the mouth of Old River, connects with the lower San Joaquin River channel through False River, Fishermans Cut, and Dutch Slough. The San Joaquin River joins the Sacramento River through Broad Slough near Collinsville, although a substantial portion of the San Joaquin River flow moves through New York and Middle Sloughs to the Sacramento River near Pittsburg.

Old River and Middle River Diversions. Some San Joaquin River inflow at Vernalis is diverted into the head of Old River near Mossdale. Figure B1-29 shows the monthly average historical San Joaquin River flows and simulated flows downstream of the head of Old River for water years 1967-1991. These simulated channel flows do not include the effects of temporary barriers at the head of Old River that have been installed during fall in some years to increase flows past Stockton.

Figure B1-30 shows the simulated flow split at the head of Old River. The relationship between flows at the head of Old River and San Joaquin River inflow when above 2,000 cfs is governed by San Joaquin River inflow only (i.e., both are straight-line relationships above 2,000 cfs in Figure B1-30). During periods of low San Joaquin River inflows, most San Joaquin River inflow is diverted into the Old River channel near Mossdale. The simulated channel flows indicate slight reverse net flows in the San Joaquin River channel upstream of Stockton (i.e., 100-200 cfs) as indicated by the negative values of San Joaquin River flow at Stockton. Stagnant conditions are simulated whenever the San Joaquin River inflow is less than about 2,000 cfs. During periods of higher San Joaquin River flow, about 40% remains in the San Joaquin River channel and flows past Stockton.

Flows through Franks Tract and Connecting Channels. Water from the central Delta flows out of the Delta through the San Joaquin River and through Franks Tract and connecting channels (False River and Dutch Slough). Central Delta water includes inflows from the San Joaquin River and eastside streams, as well as Sacramento River flow diverted through the DCC and Georgiana Slough.

Figure B1-31 shows the simulated central Delta outflow (QWEST) and the simulated San Joaquin River flow at Antioch. The flow through False River and Dutch Slough is a significant portion of the total central Delta outflow. False River is the major channel, although Dutch Slough flow is also important because of its effects on salt transport. The flow at Antioch includes central Delta outflow and Threemile Slough flow from the Sacramento River.

Figure B1-32 shows the flow split of central Delta outflow between the main San Joaquin River channel and the Franks Tract channels. False River carries a nearly constant fraction of about 40% of the central Delta outflow (QWEST), and Dutch Slough carries about 5%. About 55% of the total central Delta outflow remains in the main channel of the San Joaquin River.

Old and Middle River Channel Flows

As simulated by the RMA model, Old and Middle River channel flows move downstream during periods of high San Joaquin River inflow, but during periods of low San Joaquin River inflow, Old and Middle River flows are often reversed and move from the central Delta toward the Delta export locations at the Banks and Tracy Pumping Plants. Hydraulic relationships govern channel flows in Old and Middle Rivers regardless of the direction of flow.

During periods when Delta exports exceed the San Joaquin River diversion into Old River, central Delta water moves through Old and Middle River channels toward the export pumps. Central Delta water may the enter Old and Middle River channels at their mouths or

flow through Turner, Empire, and Columbia Cuts, which connect the upper San Joaquin River with Middle River, or flow through Franks Tract channels, which connect Old River with the lower San Joaquin River. Most Middle River flow moves through Victoria Canal to Old River near the CVP and SWP pumping plants.

The total flow between the central Delta and the Delta export locations is equal to the total exports plus south Delta channel depletions (estimated as 65% of total Delta channel depletions) unmet by the head of Old River diversion from the San Joaquin River near Mossdale. The unmet export term can be negative when San Joaquin River diversions into Old River exceed the export pumping demand. When the barrier on Old River is closed, none of the exports can be met with head of Old River diversions.

Figure B1-33 shows the simulated combined channel flows in Old and Middle Rivers for water years 1967-1991. Head of Old River diversions from the San Joaquin River can sometimes meet export pumping demand and provide excess flow to the central Delta in Old and Middle Rivers. More often, total Delta exports (shown as a negative flow in Figure B1-33) are greater than the head of Old River diversions from the San Joaquin River, and a negative net flow in Old and Middle Rivers toward the export locations is required to meet Delta export pumping demands.

Several Delta channels connect Middle and Old River channels. Victoria Canal carries almost all Middle River flow southwestward to Old River near Coney Island and the Clifton Court entrance gates. Woodward Canal, Santa Fe Cut, and Connection Slough connect the Middle and Old River channels. These connecting channels shift flows between the Middle and Old River channels. However, the total flow between the central Delta and the export locations is the amount of exports and channel depletions unmet by head of Old River diversions (Figure B1-33).

Figure B1-34 shows the simulated flow split of unmet Delta exports between Old and Middle River channels at Bacon Island for water years 1967-1991. The simulation location is north of Santa Fe Cut and Woodward Canal, which redistributes flows between Old and Middle Rivers, and corresponds to the tidal flow measurement stations installed by USGS (in 1987). The simulated channel flows indicate that Old River conveys about 60% of the net flow and Middle River conveys about 40% of the net flow. The USGS measurements indicate, however, that Old River conveys 45% and Middle River conveys 55% of the total net flow. This difference has not been resolved. Both USGS measurements and RMA simulations indicate that the tidal flows are about the same for the Old and Middle River channels (Table B1-2). The only difference between the USGS measurements and the RMA simulations is the net flow split for the two channels. This division of flow remains consistent whether the flow is downstream during high San Joaquin inflows or upstream to supply unmet Delta export pumping.

Mokelumne River Channel Flows

Mokelumne River channels are located in the northeast portion of the Delta. The inflow from the Mokelumne and Cosumnes Rivers (the major proportion of eastside streamflow) combines with DCC and Georgiana Slough flows. The North and South Forks of the Mokelumne River channel split just downstream of the DCC and rejoin just upstream of Georgiana Slough at the northwest corner of Bouldin Island. The mouth of the Mokelumne River at the San Joaquin River carries most of the Mokelumne River outflow. Little Potato Slough connects the South Fork of the Mokelumne River with Potato and Little Connection Sloughs, which join the San Joaquin River channel at Venice Island. Disappointment and Fourteenmile Sloughs also connect with the San Joaquin River farther upstream.

Figure B1-35 shows the simulated monthly average Mokelumne River outflows for historical Delta inflows and exports for water years 1967-1991. Mokelumne River outflow is the sum of flow in the North and South Forks of the Mokelumne River and in Georgiana Slough. Most Mokelumne River outflow originates from DCC and Georgiana Slough diversions from the Sacramento River. During periods of high runoff, the eastside streams contribute substantial inflow. During high Sacramento River flow, the DCC gates are normally closed.

Although DCC and Georgiana Slough diversions from the Sacramento River are not changed substantially by Delta exports, the distribution of flows in the Mokelumne River channels that connect with the San Joaquin River depend on the unmet export flows. Figure B1-36 illustrates simulated relationships between unmet export flows and proportions of Mokelumne River outflow in the connecting channels. Channel flow relationships shift during periods of excess San Joaquin River inflow to the Delta (i.e., San Joaquin inflow greater than export pumping). During normal periods with positive unmet exports (i.e., central Delta water flowing toward the Delta export pumps), the Mokelumne River channel carries about 65% of the total Mokelumne River outflow (Figure B1-36).

Little Connection Slough carries a greater fraction of the Mokelumne River outflow as the magnitude of the

unmet export pumping increases. Little Connection Slough conveys water southward from the east end of Bouldin Island toward the mouth of Middle River in the central Delta. When unmet export values are low, Little Connection Slough carries about 15% of the Mokelumne River outflow toward the Delta export pumps. When unmet export values are high, Little Connection Slough carries about 25% of the Mokelumne River outflow.

In contrast to the pattern for Little Connection Slough, Potato Slough carries a smaller fraction of the Mokelumne River outflow as the magnitude of the unmet export pumping increases. Potato Slough conveys water westward along the south edge of Bouldin Island toward the mouth of Old River in the central Delta. About 15% of the Mokelumne River outflow flows through Potato Slough at low unmet exports values, but this fraction is reduced to less than 5% at high unmet export values. Flow is shifted from Potato Slough to Little Connection Slough as the unmet export amount increases.

Disappointment Slough carries between 5% and 10% of the Mokelumne River outflow. Fourteenmile Slough carries a small fraction of the Mokelumne River outflow when unmet export values are high.

Little Connection Slough acts as a side channel for the San Joaquin River and its flows can reverse during high San Joaquin River flows (Figure B1-36). At high San Joaquin River inflows, water moves from the San Joaquin River upstream into Fourteenmile Slough and back out through Disappointment Slough. Similarly, San Joaquin River water can move into Little Connection Slough and back out through Potato Slough. During most conditions, however, these channels transport a fraction of the Mokelumne River outflow to the San Joaquin River in the central Delta.

Source Tracking of Historical Delta Inflows

The RMA Delta model was used to track water from each inflow source as it moved through the Delta. An inflow source can be identified at any model node. The RMA model used a series of "numerical dye" tracers to track the contribution of each Delta water source. A constant inflow concentration of the tracer (i.e., 1,000 parts per million [ppm]) was specified at the source to be tracked, and the concentrations at the end of each month at other Delta locations indicate the relative contribution of the water from that source.

Delta inflow water sources consist of the Sacramento River, San Joaquin River, eastside streams, Yolo Bypass, Delta agricultural drainage, salinity intrusion from the Benicia boundary, and DW project island discharges. Net rainfall (minus evaporation) was not tracked but was represented by small "missing" fractions in the sum of the other source contributions. The results of the RMA source tracking simulations were incorporated in the DeltaDWQ assessment model (Appendix C4, "Delta-DWQ: Delta Drainage Water Quality Model").

The purpose of describing the source of water at important Delta locations is to:

- provide a description of how water from each inflow moves through the Delta,
- describe a general method for simulating the movement of salts and passive fish life stages through the Delta channels, and
- demonstrate how DW project releases into Delta channels may replace other sources of water at the Delta export or outflow locations.

Selected Locations for Describing Source Tracking

Five Delta locations were selected for describing the tracking of Delta water sources: Chipps Island, Antioch, the CCWD Rock Slough intake, SWP Banks Pumping Plant, and CVP Tracy Pumping Plant. The monthly contributions from inflow sources at each of these locations were simulated by the RMA model based on the (DAYFLOW) historical Delta inflow and export record for 1967-1991. The reasons these locations were selected are discussed below.

Water at Chipps Island represents the combined Delta outflow from all possible water sources, and source contributions of Chipps Island represent the mixture of water flowing into Suisun Bay. Sacramento River and Yolo Bypass inflow will usually dominate source contributions at Chipps Island. Contributions from other sources, including salinity intrusion from Benicia, can be important at Chipps Island, however.

Water at Antioch represents combined San Joaquin River outflow from the central Delta and includes some portion of Sacramento River diversions through the DCC, Georgiana Slough, and Threemile Slough. Eastside streams and San Joaquin River inflows contribute directly to source contributions at Antioch. Delta agricultural drainage may contribute a substantial percentage of the water at Antioch. Salinity intrusion from Benicia can be important at Antioch during periods of low Delta outflow. The water supply intake for the City of Antioch is located here.

The three major Delta export/diversion locations are generally in the southwest portion of the Delta but may have slightly different source contribution patterns because of their different locations and intake configurations. The CCWD intake is at the end of Rock Slough, which connects to Old River south of Holland Tract. The SWP Banks Pumping Plant draws water from Clifton Court, which connects to Old River near Coney Island with a tidal gate that is usually open during high tides. The CVP Tracy Pumping Plant connects to Old River just south of the entrance to Clifton Court. Each of these locations was therefore considered separately in the RMA Delta model source tracking simulation.

Table B1-5 gives the simulated monthly average source contributions from the Benicia boundary (representing salinity intrusion), the Sacramento River, Yolo Bypass, the San Joaquin River, the eastside streams, and Delta agricultural drainage at the CCWD diversion and SWP and CVP export locations for historical inflows and exports (presented in Table B1-3) for water years 1968-1991. Hydrologic variation accounts for the majority of fluctuations in these simulated source contributions. The patterns of source water contribution at each location depends on the relative source flows and the Delta channel configuration, as described in the next sections.

Source Tracking Simulation Results

The RMA simulations of historical source contributions indicated that some of the source contributions were different at the CCWD intake and SWP and CVP export locations (Table B1-5). For example, the seawater intrusion effects were simulated by the RMA Delta model to be slightly higher at the CCWD intake. San Joaquin River source contributions were simulated to be generally higher at the CVP location. Agricultural drainage effects were often simulated to be higher at the CCWD intake. However, the basic patterns of source contributions at the three locations were similar.

The following example calculations from the simulations of historical conditions and Alternative 1 are described to illustrate the simulated source contributions (see Table B1-5). During August 1968, the simulated historical south Delta diversions totaled 7,559 cfs, consisting of 194 cfs of CCWD diversions, 775 cfs of SWP pumping, 3,909 cfs of CVP pumping, and 2,682 cfs of agricultural diversions (assuming that these represent 65% of total Delta agricultural diversions with an irrigation efficiency of 70%). During the same month the simulated water from south Delta sources totaled 1,994 cfs, consisting of 707 cfs of San Joaquin River inflow, 138 cfs of eastside stream inflow, and 1,149 cfs of agricultural drainage (30% of diversions). The average export source contribution calculations assumed that the south Delta sources are fully mixed by tidal flows and that each diversion will have the same source contributions.

Because the simulated source rates are less than the diversion rates, additional water from the Sacramento River (5,565 cfs) would be required to satisfy the diversions. The source contribution is calculated as the source flow divided by the total diversion flow. The agricultural drainage of 1,149 cfs would contribute 15.2% of the total diversion flow. The San Joaquin River flow of 707 cfs would contribute 9.4% of the total diversion flow. The estimated Benicia contribution (salinity intrusion) was about 0.5%, with an effective outflow of about 5,500 cfs. The remainder of the water would come from eastside streams (2.0%) and Sacramento River inflow (73.6%).

Chipps Island

Figure B1-37 shows simulated monthly average contributions of the Sacramento River, Yolo Bypass, San Joaquin River, eastside streams, agricultural drainage, and salinity intrusion from Benicia at Chipps Island for water years 1967-1991. Separate panels in the figure show percentages of water from the different inflow sources at Chipps Island. All percentages shown for a single month sum to 100% of the water at Chipps Island.

As expected, the Sacramento River is the dominant water source most of the time at Chipps Island. Yolo Bypass, San Joaquin River, and eastside streams contribute episodically during periods of high inflows. Agricultural drainage contributes seasonally at Chipps Island, but the drainage is usually less than 2% of the Delta outflow. Seawater intrusion from Benicia is a significant source of water at Chipps Island during periods of low Delta outflow. Even small Benicia water source contributions can have a very large effect on the simulated salt concentrations (see Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project").

RMA model results for the historical 1967-1991 Delta inflows and exports suggest that the average contribution at Chipps Island from the Sacramento River was 71.6%, Yolo Bypass contributed about 4.1%, the San Joaquin River contributed an average of 3.8%, eastside streams contributed about 2.1%, agricultural drainage contributed 1.3%, and water from the Benicia boundary contributed 16.1%. A small percentage of rainfall (1.1%) was not tracked with the RMA model.

Antioch

Figure B1-38 shows the simulated monthly average contributions from the seven tracked sources at Antioch. The Sacramento River is the dominant source of water at Antioch, even though Antioch is located along the lower San Joaquin River. Sacramento River water diverted through the DCC, Georgiana Slough, and Threemile Slough provides the Sacramento River source contribution at Antioch. The Sacramento River is the dominant source contribution most of the time. The episodic contributions from the San Joaquin River and eastside streams are proportionally larger at Antioch than at Chipps Island.

Yolo Bypass and seawater intrusion from Benicia have smaller contributions at Antioch than at Chipps Island. Contributions from agricultural drainage are larger at Antioch than at Chipps Island because most of the agricultural drainage at Antioch is from the Delta lowlands (as described in Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model").

For the historical Delta inflows and exports for 1967-1991, the average contribution at Antioch from the Sacramento River was 78.2%, Yolo Bypass contributed about 2.0%, the San Joaquin River contributed an average of 8.1%, eastside streams contributed about 5.0%, agricultural drainage contributed 2.3%, and water from the Benicia boundary contributed 4.1% (calculated from the salinity simulations). The Yolo Bypass contribution at Antioch was less than at Chipps Island. The reduced Benicia boundary contribution allowed the other inflow sources to contribute higher percentages at Antioch than at Chipps Island.

CCWD Rock Slough Intake

Figure B1-39 shows the simulated monthly average contributions of the tracked Delta inflow sources at the CCWD Rock Slough intake. The Sacramento River is the dominant source most of the time, often supplying 80%-90% of CCWD exports. During periods of high San Joaquin River inflow, a large portion of the CCWD exports are contributed by the combination of flows from the San Joaquin River and eastside streams. The Sacramento River contribution is reduced during high Sacramento River inflows because the DCC is closed. Agricultural drainage contributions are moderately high (10%) during the irrigation season each year and can be extremely high (40%-50%) during winter drainage periods as a result of excess rainfall and salt leaching practices.

Table B1-5 shows the monthly source contributions at CCWD Rock Slough intake for 1968-1991. For the historical Delta inflows and exports for 1967-1991, the simulated average contribution at the CCWD intake from the Sacramento River was 62.3%, Yolo Bypass contributed 0%, the San Joaquin River contributed an average of 21.3%, eastside streams contributed about 5.6%, agricultural drainage contributed about 10.1%, and water from the Benicia boundary contributed 0.2%.

SWP Banks Pumping Plant

Figure B1-40 shows the simulated monthly average contributions of the Delta inflow sources at the SWP Banks Pumping Plant. The Sacramento River contributed most of the water for SWP exports most of the time, but the episodic contributions from the San Joaquin River and eastside streams are greater than for CCWD diversions. Agricultural drainage is not as large a source of SWP exports as it is of CCWD diversions, contributing about 5% during the irrigation season and about 15% during wet winter periods. Yolo Bypass contributions are very small because when Yolo Bypass flows are high (during wet periods), San Joaquin and Sacramento inflows are high also and there is no pathway for Yolo Bypass water to move toward the exports. The average simulated contribution from the Benicia boundary is only about 0.1%.

Table B1-5 shows the monthly source contributions at SWP Banks Pumping Plant for 1968-1991. For the historical Delta inflows and exports for 1967-1991, the simulated average contribution to the SWP Banks Pumping Plant from the Sacramento River was about 54.9%, Yolo Bypass contributed 0%, the San Joaquin River contributed an average of 35.0%, eastside streams contributed about 5.4%, agricultural drainage contributed about 4.2%, and water from the Benicia boundary contributed 0.1%.

CVP Tracy Pumping Plant

Figure B1-41 shows the simulated monthly average contributions of the Delta inflow sources at the CVP Tracy Pumping Plant. Because of the direct connection between the San Joaquin River and the CVP pumps at Tracy, Old River diversions supply most of the CVP exports when San Joaquin inflows are sufficient. During many months, however, San Joaquin River inflow is limited, and the Sacramento River contributes 60%-80% of the CVP Tracy Pumping Plant exports. The eastside streams contribute less to CVP exports than to SWP exports because the eastside streams enter the central Delta and eastside stream water is transported down

Middle River and Old River to the export locations. The agricultural drainage contribution is similar, but is slightly higher for CVP exports than for SWP exports.

Table B1-5 shows the monthly source contributions at CVP Tracy Pumping Plant for 1968-1991. For the historical Delta inflows and exports for 1967-1991, the simulated average contribution to the CVP exports at Tracy from the Sacramento River was about 39.0%, Yolo Bypass contributed 0%, the San Joaquin River contributed an average of 52.0%, eastside streams contributed about 2.7%, agricultural drainage contributed about 5.9%, and water from the Benicia boundary contributed 0.1%.

VARIABLES FOR MEASURING HYDRODYNAMIC EFFECTS OF DW OPERATIONS

Assessment of the Delta hydrodynamic impacts of DW project operations was accomplished by considering hydrodynamic variables in the Delta and selecting those that could possibly be changed or influenced by DW operations. These selected "impact variables" were then described and analyzed with the RMA Delta model to determine whether significant changes from conditions under the simulated No-Project Alternative would likely occur with any proposed DW operations.

The Delta hydrodynamic variables considered in the selection of impact variables included a wide range of possible hydrologic and tidal effects, some of which were determined from RMA model simulation results to be outside the influence of DW project operations. The evaluation of possible impact variables recognized that the basic hydrologic conditions in the Sacramento and San Joaquin River basins and tidal fluctuations from San Francisco Bay are beyond the control of any proposed DW operation.

Possible Hydrodynamic Impact Variables

The following general types of Delta hydrodynamic variables might be affected by proposed DW operations and these were selected as the response variables:

- Delta tidal hydraulics that result from changes in tidal prism volume caused by flooding or diking of tidal wetlands, changes in channel geometry, or changes in the operation of tidal gates or major siphons;
- Delta inflows that result from changes in upstream reservoir operations or water transfers to the DW islands;
- Delta exports that result from changes in pumping limitations (physical or regulatory), export demands, Delta inflows, Delta water quality standards, or required minimum Delta outflows;
- Delta outflows that result from changes in requirements for minimum outflows, Delta inflows, Delta exports, or net in-Delta diversions;
- Delta channel net flows, including QWEST flows, that respond to changes in Delta inflows, diversions, and exports; modified operations of Delta facilities (the DCC, Clifton Court Forebay, and Suisun Marsh salinity control gate); and modified channel conveyance capacities that might be affected by dredging, widening, clearing, cutting of new Delta channels, or installation of barriers or by different hydraulic gradients (water surface slope); and
- Delta source contributions that respond to changes in DW diversions and discharges.

These selected impact variables are summarized in Table B1-6, with the method of analysis and assessment and the Delta locations selected to represent possible hydrodynamic effects of DW operations. Possible effects of DW operations on each response variable are briefly described below.

Delta Tidal Hydraulics

The DW project might change Delta tidal hydraulics in local channels adjacent to proposed DW siphons or discharge pumps. These possible effects were evaluated with RMA Delta model simulations of tidal flow, velocity, and stage with typical Delta inflow and Delta export conditions that would allow maximum DW diversions or discharges. Simulations of tidal hydraulics during periods of maximum diversion and discharge were analyzed for Delta channels surrounding each DW island (Bacon Island, Bouldin Island, Holland Tract, and Webb Tract). Results of these simulations are discussed later in this appendix.

Delta Inflow

The DW project might affect Delta inflow through changes in the upstream storage and release patterns of

reservoirs operated by the CVP, the SWP, or other water agencies that might transfer water to and/or from the DW islands. DW project operations could not cause changes in long-term average Delta inflow but might influence the monthly pattern of inflow released from upstream reservoir storage. For purposes of this EIR/EIS, however, potential changes in Delta inflow conditions have not been simulated. Appendix A1, "Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project", describes the assumed Delta inflows that were simulated by DWRSIM for the selected No-Project Alternative conditions.

Potential operations of the DW project depend directly on Sacramento and San Joaquin River inflows. Figure B1-42 shows simulated monthly inflows for the Sacramento and San Joaquin Rivers for the No-Project Alternative for water years 1967-1991. Historical inflows are shown as a reference baseline for understanding the No-Project Alternative conditions.

Delta Export

The DW project would change Delta export by providing an additional source of water. Possible effects of an additional water source on Delta exports have been analyzed for unspecified water supply destinations with the DeltaSOS model, as described in Appendix A3. The effects of these possible export changes on Delta channel flows were simulated with the RMA Delta model and are described in this appendix. Figure B1-42 shows monthly combined SWP and CVP exports for water years 1967-1991 for the No-Project Alternative, with the historical export conditions shown as a reference baseline. Differences between values for the No-Project Alternative and historical conditions are explained below under "Simulation Results for the No-Project Alternative" in the section "Simulated Effects of DW Operations on Delta Channel Flows and Source Contributions".

Delta Outflow

The DW project would change Delta outflow by diverting water for seasonal storage during periods of excess Delta inflows, or by discharging some or all of the stored water for increased Delta outflow to potentially benefit fish and estuarine habitat conditions later in the year during periods of lower Delta outflow. Possible effects on Delta outflows have been analyzed for a variety of assumed DW project operations with the DeltaSOS model, as described in Appendix A3. The effects of these outflow changes on Delta channel flows were simulated with the RMA Delta model and are described in this appendix. Figure B1-43 shows simulated monthly Delta outflow at Chipps Island for the No-Project Alternative for water years 1967-1991, with historical outflow conditions shown for reference. Differences between values for the No-Project Alternative and historical conditions are explained below under "Simulation Results for the No-Project Alternative".

Delta Channel Net Flow

The DW project would change flows in some Delta channels because diversions to and discharges from the DW islands would be modified from No-Project Alternative agricultural operations. Changes in diversion and discharge from no-project conditions include:

- reduced agricultural diversions,
- increased riparian or appropriative diversions for waterfowl habitat flooding,
- diversion of excess Delta inflow for seasonal storage, and
- discharge of seasonal storage to increase Delta export and/or increase Delta outflow.

DW operations would also modify hydraulic gradients in some Delta channels. During the diversion period, lowered stage levels at the DW siphons may cause tidal flows in several central Delta channels to shift slightly. During the discharge period, increased stage at the DW discharge locations may cause tidal flows in Old and Middle Rivers and their connecting canals to shift slightly. The effects of DW diversions and discharges on Delta channel flows were simulated with the RMA Delta model and are described in this appendix. Potential channel scour effects of DW project operations are discussed in Chapter 3D, "Flood Control".

Figure B1-43 shows monthly diversions from the Sacramento River through the DCC and Georgiana Slough to the central Delta for the No-Project Alternative and for historical conditions. Figure B1-43 also shows central Delta outflow (QWEST flow) downstream of the Mokelumne River for the No-Project Alternative and for historical conditions. Simulated DCC and Georgiana Slough flows depend on Sacramento River inflow and are not substantially affected by exports, whereas the central Delta outflow (QWEST flow) is reduced by exports.

Figure B1-44 shows Delta channel flows at three locations that have been selected to describe the overall effects of the DW project operations on Delta hydrodynamics:

- San Joaquin River flow at Antioch includes net Delta outflow from the central Delta, along with Threemile Slough flow from the Sacramento River. This flow is almost the same as the flow that will be measured by the USGS UVM stations at Jersey Point and Dutch Slough (Antioch flow also includes Dutch Slough flow).

- Threemile Slough flow represents flow between the Sacramento River near Emmaton and the San Joaquin River near Bradford Island, upstream of Jersey Point and False River. Threemile Slough flows are influenced by Sacramento River flow and San Joaquin River flows from the central Delta (QWEST flow). Closure of the DCC increases Threemile Slough flow because Sacramento River flows are increased and QWEST flows are reduced (see Figure B1-27).

- Old River flow at Bacon Island indicates flow in Old River past Bacon Island and Holland Tract. Negative flows indicate that net flow is moving toward the Delta exports pumps. The Old River channel carries approximately half the total net flow toward the export pumps. The remainder flows in Middle River on the east side of Bacon and Victoria Islands. Because flows in Old and Middle Rivers are about the same, Old River flow is assumed to also represent Middle River flow. Most periods of historical positive flows in Old River (i.e., downstream and northward) are reduced or eliminated in the No-Project Alternative simulations because of greater simulated exports.

The sum of Old River and Middle River channel flows, if positive, is the excess San Joaquin River diversions to the head of Old River flowing past the export pumps toward the central Delta. The sum of these channel flows, if negative, is the net flow from the central Delta to the export pumps. Because the DW project islands are in the central Delta, DW operations would directly affect one or more of these selected channel flows. DW diversions would reduce Antioch flows, increase Threemile Slough flows, and increase reverse flows in the lower Old and Middle River channels. DW discharges for export would increase Old and Middle River flows toward the export pumps.

Delta Source Contributions

The DW project might change the pattern of source contributions of water at Delta exports or in Delta outflow by diverting water that would otherwise have been transported to other locations, specifically to the Delta export pumps and Delta outflow. During the discharge period, the DW seasonal storage facilities would supply a new source of water that might replace other inflow sources to Delta exports or Delta outflow. Historical source contributions were simulated using the water quality module of the RMA Delta model as described in Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project". The possible effects of DW operations on simulated Delta source contributions are described in this appendix, however, because these source contributions are determined by hydrodynamic processes. These source contribution changes were incorporated into the DeltaDWQ assessment model (Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model").

MAXIMUM HYDRODYNAMIC EFFECTS ON LOCAL CHANNEL FLOWS, VELOCITIES, AND STAGES

Direct effects of DW project operations during filling and discharge operations would be greatest in Delta channels surrounding the DW project islands. Effects of the maximum possible proposed diversion rates and discharge rates on tidal hydraulics in Delta channels surrounding the DW project islands were simulated with the RMA Delta hydrodynamic model. These conditions would occur at the beginning of diversions or discharge periods; average hydrodynamic effects during the entire diversion or discharge period would be smaller because the diversion and discharge rates decline as the DW reservoir islands are filled or emptied.

For the tidal simulations of maximum DW filling operations, Delta inflows and exports were specified to produce maximum expected flows and velocities in Delta channels during a high inflow period. The proposed DW diversion rate would be limited to a daily maximum of 9,000 cfs for all alternatives evaluated; this rate would decrease as the reservoir islands are filled and head differential decreases.

For the tidal simulations of maximum DW discharge operations, Delta inflows were specified to produce maximum expected flows and velocities in Delta channels during a typical DW discharge period. Exports were set at 5,000 cfs to allow an additional export of 6,000 cfs of water discharged from the DW project. Table B1-7 lists the assumed Delta flows and exports for simulations of maximum DW diversion effects and Table B1-8 lists the assumed and simulated Delta channel flows for maximum DW discharge effects.

Hydrodynamics during Maximum DW Diversions

Simulated Hydrodynamic Changes

Hydrodynamic changes caused by maximum DW project diversions would not persist throughout an entire diversion period of several weeks. After the first few days of diversions, hydrodynamic effects would decrease as siphoning rates decreased during filling in response to decreasing head differential.

Simulated net Delta channel flows under maximum flow conditions specified for a typical diversion period, but without the DW project, are shown in Figure B1-45. The simulated Sacramento River inflow was 80,000 cfs to provide the maximum possible Georgiana Slough flow (of about 12,000 cfs) to the central Delta (with the DCC closed). San Joaquin River inflow was 5,000 cfs and eastside stream inflow was 1,000 cfs. Channel depletion was assumed to be 0 cfs. CCWD diversions were set at 150 cfs, North Bay Aqueduct pumping at 50 cfs, CVP pumping at approximately 4,200 cfs (winter maximum), and SWP pumping at approximately 8,345 cfs (Table B1-7). The SWP pumping was estimated as 6,680 cfs plus one third of the San Joaquin River inflow, as specified in the SWP's U.S. Army Corps of Engineers (Corps) permit.

The 1995 WQCP would allow a maximum of 35% of the Delta inflows (30,100 cfs for these river inflows) to be exported during February-June and a maximum of 65% to be exported during July-January. The maximum DW diversions of 9,000 cfs is assumed to be included in the specified percentage for exports. The maximum DW diversions with maximum SWP and CVP exports (of approximately 12,900 cfs) could occur with a combined river inflow of about 61,000 cfs during those months under the 35% inflow criterion. Maximum DW diversions could occur with a combined river inflow of about 32,000 cfs during months with an inflow criterion of 65%, assuming that outflow and channel depletion would be satisfied with the 11,200 cfs (35% of inflow) reserved for these purposes.

The maximum DW diversions would occur at four siphon stations with capacities of 2,250 cfs each. Two stations are on Bacon Island, one on Middle River and one on Old River. The other two are on Webb Tract, one on the San Joaquin River and the other on False River adjacent to Franks Tract. Proposed DW project filling would cause greatest hydrodynamic changes in Delta channels adjacent to the DW project islands in the central Delta. The simulated effects of proposed project diversions adjacent to each DW island are described below.

Table B1-7 lists the net flows in each major Delta channel simulated for the typical diversion period, with and without the maximum DW diversions of 9,000 cfs (4,500 cfs to Bacon Island and 4,500 cfs to Webb Tract). Figure B1-45 shows the directions of these net flows in the major Delta channels without DW diversions. The Sacramento River provides the largest Delta inflow, and diversions from the Sacramento River to the San Joaquin River and south toward Delta export pumps are of interest for evaluating effects on fisheries (see Chapter 3F, "Fishery Resources").

An extreme tidal stage record for Benicia was used in these simulations to approximate maximum tidal flows. The total Delta inflows were 86,000 cfs, and the total Delta exports were 12,745 cfs, so the net outflow at Benicia was 73,255 cfs.

The simulated Georgiana Slough diversion flow was about 12,220 cfs without the DW diversions and increased by only 45 cfs with the maximum DW diversions (0.5% change). The simulated DCC flow was 0 cfs because the DCC would be closed at this high Sacramento River inflow rate (80,000 cfs). Flow at the mouth of the Mokelumne River was 8,785 cfs, and the remainder of the Georgiana Slough flow (and Mokelumne River inflow of 700 cfs) entered the San Joaquin River channel through Potato, Little Connection, and Disappointment Sloughs.

The San Joaquin River inflow at Vernalis was 5,000 cfs and the simulated diversion at the head of Old River was about 3,369 cfs, so the simulated San Joaquin River flow past Stockton was 1,630 cfs. Some of the San Joaquin River flow entered Empire (Turner) and Columbia Cuts and the mouth of Middle River and moved toward the export pumps and Bacon Island DW diversions. Middle River flow at Columbia Cut increased from about 4,888 cfs to 7,197 cfs (2,309-cfs increase) with maximum DW diversions of 2,250 cfs from Middle River onto Bacon Island. Empire Cut flow increased from 951 cfs to about 1,169 cfs (218-cfs increase) with the maximum DW diversions. Flows in Middle River south of the Bacon Island diversion were not significantly changed.

The flow from the mouth of Old River into Franks Tract increased from about 5,687 cfs to 6,978 cfs (1,290-cfs increase) with maximum DW diversions. Flows in Old River south of the Bacon Island diversion were not significantly changed.

Webb Tract maximum diversions of 4,500 cfs were supplied from the San Joaquin River channel opposite the Mokelumne River mouth and from False River and Franks Tract. The maximum DW diversions of 9,000 cfs were supplied by reduced outflow from the central Delta. San Joaquin River flow north of Webb Tract was reduced by 6,014 cfs, from about 3,324 cfs to -2,690 cfs (reversed upstream flow), with the maximum DW diversions. False River flow from Franks Tract was reduced by 2,834 cfs, from about 2,278 cfs to -556 cfs. Dutch Slough flow was reduced by 323 cfs, from 432 cfs to 110 cfs, by the maximum DW diversions.

The reduced central Delta outflow caused flow changes in Threemile Slough, in the San Joaquin River at Antioch, and at Chipps Island and Montezuma Slough. Threemile Slough flows from the Sacramento River increased by 2,879 cfs, from about 15,015 cfs to 17,894 cfs, with the maximum DW diversions. Antioch flow was reduced by 6,077 cfs, from 20,541 cfs to 14,465 cfs, with maximum DW diversions. The increased Georgiana Slough and Threemile Slough diversions to the San Joaquin River and the reduced San Joaquin River flows at Antioch (45 + 2,879 + 6,077 = 9,001 cfs) account for the water supply for maximum DW diversions.

Delta outflow past Chipps Island was reduced by about 8,780 cfs, from 70,357 cfs to about 61,577 cfs, with maximum DW diversions. Montezuma Slough net flow (with the tidal gate operating) was reduced by about 218 cfs, from 2,896 cfs to about 2,678 cfs, with maximum DW diversions. The changes in these Delta outflows were about equal to the maximum DW diversion of 9,000 cfs.

The changes in the hourly flow and velocity patterns in several major Delta channels are shown below to fully disclose the effects of maximum DW diversions on Delta hydrodynamics. The major change in flows were simulated to occur in the San Joaquin River channel between Antioch and the mouth of Old River. However, because the San Joaquin River channel cross-sectional area is large, the changes in flow and velocity were quite small (as a fraction of tidal flows and velocities).

A relatively large increase in flow (2,894 cfs) was simulated to occur in Threemile Slough with maximum DW diversions. The simulated tidal hydraulics for Threemile Slough are shown in Figure B1-46. Simulated tidal flows from the Sacramento River to the San Joaquin River ranged from about 60,000 cfs to -25,000 cfs. Velocities ranged from about 4 ft/sec to about -2 ft/sec. The channel cross-sectional area for Threemile Slough is therefore approximately 13,500 ft^2 (54,000/4 = 13,500).

A relatively large reduction in flow was simulated to occur in False River with maximum DW diversions. However, the tidal flows were quite large, ranging from about 50,000 cfs to -50,000 cfs, and the velocities ranged from about 2.5 ft/sec to -2.5 ft/sec, with a conveyance area of about 20,000 ft^2.

Relatively large increases in flow were simulated to occur in Old and Middle River channels. For example, Figure B1-47 shows the simulated tidal flows and velocities in Middle River between Columbia Cut and Bacon Island. The tidal flow ranged from 15,000 cfs to about -25,000 cfs. The tidal velocity ranged from 0.8 ft/sec to -1.2 ft/sec. The conveyance area of the Middle River channel is therefore about 20,000 ft^2. The net flow direction in Middle River was toward the Delta export pumps. Maximum DW diversions increased the net flow by about 2,309 cfs, but the change in the tidal flow and velocity was relatively small (10%).

Summary of Hydrodynamic Effects during Maximum DW Diversions

The hydrodynamic simulation results for maximum DW siphoning rates indicate that maximum channel flows and velocities would be within the range of conditions normally encountered during tidal fluctuations in the Delta channels surrounding the DW project islands. Because the maximum DW diversions would occur when Delta inflows and exports are relatively high and because DW diversions would occur at four separate siphon stations located on two islands, the incremental changes in tidal stages, flows, and velocities would be relatively small. Table B1-7 and Figures B1-46 and B1-47 indicate that maximum DW diversions are not expected to change the tidal hydraulics in the Delta channels.

Hydrodynamics during Maximum DW Discharges

Simulated Hydrodynamic Changes

Hydrodynamics in the channels surrounding the project islands were simulated with maximum DW discharges to estimate maximum expected changes during DW project discharge operations for all project alternatives. Figure B1-48 shows simulated net Delta channel flows for the hydrodynamic simulations during maximum DW discharges, but without the DW project.

CVP and SWP exports were set at 2,500 cfs each to allow maximum DW discharges of 6,000 cfs to be exported in the RMA simulations of the No-Project

Alternative (Table B1-8). For simulation of maximum DW discharge effects, pumping at CVP Tracy Pumping Plant was increased to 4,600 cfs (capacity) and at SWP Banks Pumping Plant was increased to 6,400 cfs. CCWD diversions were 150 cfs and North Bay Aqueduct pumping was 50 cfs.

Table B1-8 lists the net flows in each major Delta channel simulated for the typical discharge period, with and without the maximum DW discharges of 6,000 cfs (4,000 cfs from Bacon Island and 2,000 cfs from Webb Tract). Figure B1-48 shows the direction of these net flows in the major Delta channels without DW discharges. The Sacramento River provides the largest Delta inflow (20,000 cfs), and diversions from the Sacramento River to the San Joaquin River and south toward Delta export pumps are of interest for assessment of impacts on fisheries (see Chapter 3F, "Fishery Resources"). Delta channel depletion was assumed to be 3,000 cfs. San Joaquin River inflow was 1,000 cfs. The DCC was simulated to be open during the maximum DW discharge period.

Measured tidal stage values at Benicia for a representative day with a large tidal fluctuation were used in these simulations. The total Delta inflows were 21,250 cfs, and the total Delta exports (without DW exports) were 5,200 cfs, with 3,000 cfs of Delta channel depletion, so the expected base Delta outflow was about 13,050 cfs. However, the simulated Benicia outflow was 12,220 cfs (830 cfs less than expected) and the simulated Delta outflow past Chipps Island and in Montezuma Slough was 12,480 cfs (570 cfs less than expected). This simply means that there was an increase in water elevations during the tidal cycle upstream of Chipps Island that reduced the net outflow by 570 cfs. In addition, tidal stages between Chipps Island and Benicia increased during this particular tidal cycle, reducing the outflow at Benicia by 830 cfs. Over a longer time period, the effects of the tidal hydraulics on net channel flows would be reduced.

The simulated Georgiana Slough diversion flow was about 2,836 cfs without the DW discharges and did not change with maximum DW discharges for export. The simulated DCC flow was 5,810 cfs and also did not change with maximum DW discharges. Flow at the mouth of the Mokelumne River was 5,408 cfs, and the remainder of the simulated DCC and Georgiana Slough flow entered the San Joaquin River channel through Potato, Little Connection, and Disappointment Sloughs.

Threemile Slough flow was about 1,592 cfs and did not change substantially with maximum DW discharges. Because DW discharges were simulated for export, very little change in Delta channels located "downstream" of Bacon and Webb Tract was caused by maximum DW discharges.

The San Joaquin River inflow at Vernalis was 1,000 cfs and the simulated diversion at the head of Old River was about 813 cfs, so the simulated San Joaquin River flow past Stockton was 187 cfs (3%). Diversions at the head of Old River increased to 1,089 cfs with maximum DW discharges, indicating a slight reverse flow of -89 cfs in the San Joaquin River at Stockton. The increased export pumping of 6,000 cfs caused about 276 cfs to be drawn from the San Joaquin River at the head of Old River. San Joaquin River flow downstream of the mouth of Old River was not changed by maximum DW discharges.

Maximum DW discharges of 2,000 cfs from Webb Tract (into False River and Franks Tract) and 4,000 cfs from Bacon Island (into Santa Fe Cut) would change flows in Old and Middle River channels. Middle River flow at Victoria Canal (south of Bacon Island discharge pumps) increased from about 1,701 cfs to 3,605 cfs (1,904-cfs increase) with maximum DW discharges. Middle River flows north of Bacon Island were increased by about 474 cfs from maximum DW discharges from Webb Tract.

Flow near the mouth of Old River into Franks Tract was reduced from about 3,270 cfs to 2,486 cfs (about a 785-cfs reduction) with maximum DW discharges. This flow moves down the San Joaquin and Middle River channels to the export pumps. Reverse flows in Old River south of Woodward Canal were increased from about 3,230 cfs to about 7,049 cfs (3,819-cfs increase) by maximum DW discharges for export.

The changes in the tidal flow and velocity patterns in several major Delta channels are shown below to fully disclose the effects of maximum DW discharges on Delta hydrodynamics. The major change in flows were simulated to occur in the Old and Middle River channels between Webb Tract or Bacon Island and the SWP Banks and CVP Tracy export pumps.

Because the Bacon Island discharge pumps would be located along Santa Fe Cut, the simulated tidal flows and velocities at both ends of Santa Fe Cut were substantially increased. Tidal flows without DW discharges ranged from 2,000 cfs to -1,000 cfs, with a net flow of 424 cfs from Middle River to Old River. Simulated tidal velocities ranged from 0.5 ft/sec to -0.5 ft/sec without DW discharges. The maximum DW discharges of 4,000 cfs from Bacon Island increased the flow at both ends of Santa Fe Cut by about 2,000 cfs. Maximum DW discharges increased the tidal velocities by about 0.5 ft/sec at both ends of Santa Fe Cut.

Figure B1-49 shows the simulated tidal flows and velocities in Middle River south of Bacon Island at Victoria Canal. Tidal flows ranged from 4,000 cfs to about -8,000 cfs without maximum DW discharges. The tidal velocities ranged from about 1 ft/sec to -1.8 ft/sec without maximum DW discharges. The maximum DW discharges were simulated to increase flows toward the export pumps by between 1,000 cfs and about 4,000 cfs and to increase velocities by between 0.2 ft/sec and about 0.8 ft/sec, depending on the tidal hydraulics.

Figure B1-50 shows the simulated tidal flows and velocities in Old River south of Woodward Canal. The simulated tidal flows ranged from about 8,000 cfs to -14,000 cfs without maximum DW discharges. The tidal velocities ranged from about 1 ft/sec to -1.8 ft/sec without maximum DW discharges. The maximum DW discharges were simulated to increase flows toward the export pumps by between 1,000 cfs and about 4,000 cfs and to increase velocities by between 0.2 ft/sec and about 0.8 ft/sec, depending on the tidal hydraulics.

Simulated Stage Changes during Maximum DW Diversions and Discharges

Table B1-9 lists simulated channel stages during periods of maximum DW diversions and discharges. The results indicate that stages would not be substantially changed by DW operations. The minimum and maximum stages would be lowered in some channels by as much as 0.25 foot (3 inches). However, because these south Delta channels normally experience tidal fluctuations of more than 5 feet, this is not considered a substantial change (5%) for these south Delta channels. These simulations did not include DWR's proposed south Delta project barriers. These tidal gates are designed to help control minimum tidal stages in south Delta channels and may also reduce the potential effects of DW operations on channel stages.

Measured Tidal Hydraulics in the Old and Middle River Channels

Figure B1-51 shows the tidal stage measurements from the USGS UVM station on Old and Middle River on each side of Bacon Island for half the lunar cycle for October 17-30, 1987. The tidal stage varied in approximately the same way at these two locations, indicating a nearly flat water surface gradient between these stations. The difference between the Middle River stage and the Old River stage was usually less than 0.1 foot. The variation is produced by the tidal hydraulics in this portion of the Delta; Middle River stage is slightly higher during falling tides.

The largest tidal range was observed on October 26, when the low tide was -1.0 foot msl and the high tide was about 3.25 feet msl (spring tide). The smallest tidal range was observed on October 19, when the low tide was about -0.25 foot and the high tide about 2.5 feet (neap tide). However, these daily variations in tidal fluctuations are moderate, with an average tidal range that is similar to the RMA-simulated tidal range of -1.0 foot to 2.5 feet msl for the long-term average tidal boundary at Benicia (Figure B1-9).

The 25-hour moving average tidal stage is also shown in Figure B1-51. The average stage varied from about 0.75 foot to about 1.25 feet (maximum during the spring tide period). This demonstrates the variations in average Delta stage caused by tidal variations in the lunar cycle, which may produce a fluctuating tidal component of daily average Delta outflow.

Figure B1-52 shows the measured tidal flows in Old and Middle Rivers during the period of October 17-30, 1987. The channel flows were quite similar at these two locations, with nearly identical flows in each channel. The highest flows correspond to the largest change in tidal stage, rather than the highest or lowest tides. The flows in both Old River and Middle River fluctuated between about -15,000 cfs (flood tide toward the export pumps) to about 12,000 cfs (ebb tide toward the bay). The 25-hour moving average flow was approximately 2,500 cfs in each channel, indicating a net combined channel flow of about 5,000 cfs moving toward the export locations. SWP and CVP exports averaged 5,100 cfs during this period. CVP export pumping is nearly constant from Old River. Because the SWP exports are diverted from Old River into Clifton Court Forebay on high tides, the effects on the tidal flows are not uniform.

These measured peak tidal flows of about 10,000 cfs (adjusted for 0 net flow) are larger than the peak tidal flows simulated with the RMA hydrodynamic model for Middle River at Bacon Island without DW discharges (Figure B1-49) and are about the same as the simulated peak Old River tidal flows (Figure B1-50) (adjusted for zero net flow). Therefore, these simulated typical tidal hydraulics during maximum DW discharge are confirmed to be representative of actual measured tidal flow conditions during October 17-30, 1987. The effects of the maximum DW discharges on Old and Middle River channel flows are moderate and within the range of normal fluctuations of tidal hydraulics in this portion of the Delta.

Summary of Hydrodynamic Effects during Maximum Discharges

The RMA hydrodynamic model results for maximum anticipated DW discharge rates indicate that maximum possible channel flows and velocities are within the range of conditions normally encountered during tidal fluctuations in the Delta channels surrounding the DW project islands. The comparison with measured tidal flows in Old and Middle Rivers confirms that DW discharges will not change the range of normal tidal flows. DW discharges will not change the maximum Delta export pumping and therefore will not change the maximum net reverse flows in Old and Middle Rivers. DW discharges will change the source of the water but not the maximum flows in Old and Middle Rivers.

SIMULATED EFFECTS OF DW OPERATIONS ON DELTA CHANNEL FLOWS AND SOURCE CONTRIBUTIONS

The channel flows and source contributions simulated with the RMA Delta hydrodynamic model for historical monthly average inflows and exports for water years 1967-1991 were summarized with "channel split" and "source contribution" equations that were incorporated into the DeltaSOS and DeltaDWQ assessment models. This allowed hydrodynamic impact assessment of the DW alternatives to be performed for the 70-year period of water years 1922-1991 using DeltaSOS without the RMA Delta hydrodynamic model being used for the entire 70-year period for each alternative. In addition, water quality and fishery assessment methods relied on the DeltaSOS simulations of channel flows and source contributions, which were derived from the RMA Delta hydrodynamic simulations of channel flows using the 1967-1991 historical inflows and exports.

The No-Project Alternative was the basis of comparison for the impact assessments for the EIR/EIS. Monthly average Delta channel net flows for each of the DW alternatives, including the No-Project Alternative, were simulated with the DeltaSOS model. The results of these simulations are described below for each of the impact assessment variables identified in Table B1-6.

Simulation Results for the No-Project Alternative

Table B1-10 presents the assumed monthly Delta inflows and simulated monthly exports and channel flows at selected locations for the No-Project Alternative for water years 1968-1991. These No-Project Alternative conditions can be compared with the historical conditions presented in detail above under "Simulations of Monthly Average Net Delta Channel Flows Using Historical Delta Inflows and Exports" to provide a reference baseline. The simulated No-Project Alternative conditions are considerably different from the historical conditions because the simulations for the No-Project Alternative were performed based on existing demands for SWP and CVP exports, which are higher than historical demands, and on Delta objectives and requirements that differ from the standards that historically governed Delta operations (see Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives" for an explanation of the modeling assumptions).

Simulated No-Project Alternative Delta exports are generally higher than simulated historical Delta exports because of the assumed increase in export demands above historical levels (Figure B1-42). Simulated Delta outflows are less for the No-Project Alternative than for historical conditions, although the assumed minimum Delta outflows required to satisfy 1995 WQCP objectives and carriage-water requirements result in simulated outflow that is higher than historical outflow for some months of some years. Average annual Delta inflows are about the same for historical conditions and the No-Project Alternative, although the monthly pattern of simulated inflows is shifted slightly to satisfy increased export demands and minimum outflow requirements in the No-Project Alternative simulations.

The differences between the simulated DCC and Georgiana Slough diversions under the No-Project Alternative and historical conditions are related to Sacramento River flow and DCC closure criteria being different (see Chapter 3A, "Water Supply and Water Project Operations"). Differences in central Delta outflows (QWEST flows) are related to changes in DCC and Georgiana Slough diversions and increased Delta exports (Figure B1-43).

Simulated Delta Channel Flows for the No-Project Alternative

As discussed above under "Possible Hydrodynamic Impact Variables", three Delta channel locations were selected for analysis of Delta hydrodynamic effects of DW project operations. DW project operations would most directly modify channel flows in the San Joaquin River downstream of the DW project islands (e.g., Antioch), in Threemile Slough, and in Old and Middle Rivers between the DW islands and the Delta export

pumps. (Old River is used as the selected location because flow in the two channels is nearly equivalent.)

Simulated flows for the No-Project Alternative in the San Joaquin River at Antioch are generally less than the simulated historical conditions by several thousand cfs most of the time (Figure B1-44). Lower San Joaquin River net flows in the No-Project Alternative simulation are primarily the result of exports being increased in comparison with historical conditions, although some changes in Sacramento River inflows and diversions through the DCC, Georgiana Slough, and Threemile Slough also modify net flows past Antioch.

Flows in Threemile Slough were considerably higher in the No-Project Alternative simulations than under simulated historical conditions because for the No-Project Alternative, 1995 WQCP criteria for DCC closure were simulated for November-May and simulated exports were usually higher (Figure B1-44). Because more water is required for the increased Delta exports and DCC closure is simulated for the fall and spring months, flows simulated for Threemile Slough are larger under the No-Project Alternative than under historical conditions (Tables B1-4 and Table B1-10).

Table B1-11 presents selected channel flows simulated for the No-Project Alternative for comparison of operations of the DW alternatives.

Simulated flows in Old River (and Middle River) were higher in the upstream (negative) flow direction toward the Delta export pumps for the No-Project Alternative simulation than under historical conditions (Figure B1-44). Periods of downstream flows in Old and Middle Rivers caused by San Joaquin River inflows in excess of total Delta export pumping were simulated to occur in wet years for the No-Project Alternative (e.g., 1983).

Simulated Source Contributions for the No-Project Alternative

Simulated source contributions from each Delta inflow to the CCWD Rock Slough intake and Delta export locations (SWP Banks and CVP Tracy Pumping Plants) were previously shown in Figures B1-39 to B1-41 for the historical inflows and exports for water years 1967-1991. The historical patterns of source contributions were discussed under "Source Tracking of Historical Delta Inflows".

Impact assessment of effects of the DW alternatives on export water quality, presented in Chapter 3C, "Water Quality", depends on the simulated monthly average source contributions for south Delta exports (representative of CCWD diversions and SWP and CVP exports) and monthly water quality estimates for each inflow source. The DW alternatives are compared with the No-Project Alternative for impact assessment purposes. Table B1-12 presents the monthly source contributions from each Delta inflow for these combined Delta exports (including CCWD diversions), as estimated from DeltaSOS simulations of Delta exports, for the No-Project Alternative.

Simulated DW discharges for export increased both the source and diversion flow totals, and reduced the contributions from other sources during DW discharges for export. For example, for August 1968 the DW discharge for Alternative 1 (1,623 cfs) was simulated to contribute 12.2% of the south Delta exports and to reduce the agricultural drainage contribution from 6.4% (estimated for the No-Project Alternative) to 5.5% (Table B1-12). The San Joaquin River contribution was reduced from 8.5% to 7.5% with the DW discharge. The Sacramento River contribution was reduced from 81.6% to 71.8%. DW discharges would therefore reduce the percentage contributions from other sources. The corresponding change in water quality would depend on the water quality estimates for this particular month for all sources, including DW discharges.

Simulated DW diversions increased the total south Delta diversion flow and changed the simulated contributions from other sources. For example, for December 1969 the DW diversion (3,892 cfs) for Alternative 1 was simulated to change the agricultural drainage contribution from 13.2% (estimated for the No-Project Alternative) to 9.5% (Table B1-12). The DW diversions reduced the San Joaquin River contribution in south Delta exports from 14.5% to 10.8%. The eastside stream contribution was reduced from 5.4% to 4.2%. The Sacramento River contribution was increased from 66.8% to 75.1%. The contribution from the Benicia boundary was increased from 0.1% to 0.3%. These shifts in source contributions during DW diversions are controlled by the increased total diversions and the limited supply from agricultural drainage, eastside streams, and the San Joaquin River. The Sacramento River contributions increase to supply the increased total diversions, and tidal mixing from Benicia increases because of reduced outflow.

The average source contributions for south Delta exports have been used for water quality impact assessment of the DW alternatives, which is presented in Chapter 3C. The simulated average source contribution effects of the DW alternatives are considered appropriate for the monthly average impact assessments used throughout this EIR/EIS. Although variations in these percentages for monthly average simulated source

contributions are expected because of daily variations in flows and tidal mixing characteristics, these variations cannot be accurately estimated with monthly model results. Therefore, simulated changes in average monthly source contributions in representative south Delta exports are described in this chapter and used in Chapter 3C for water quality impact assessment.

The patterns of simulated source contributions for the No-Project Alternative are generally similar to those for the historical source contributions shown in Table B1-5 because the source contributions are related to the hydrologic inflows, which were approximately the same for the historical and No-Project Alternative conditions for many months. However, because exports under the simulated No-Project Alternative are often higher than historical exports, the simulated San Joaquin River, eastside stream, and agricultural drainage source contribution percentages are often lower for the No-Project Alternative than for the historical conditions. The Sacramento River contributions are generally higher in the No-Project Alternative simulations because Sacramento River water supplies most of the increased exports under the No-Project Alternative.

Simulation Results for Alternative 1

Under Alternative 1, water would be diverted for storage on Bacon Island and Webb Tract and a habitat management plan (HMP), with limited conjunctive water storage, would be implemented on Bouldin Island and Holland Tract. Chapter 2, "Delta Wetlands Project Alternatives", provides a complete description of Alternative 1.

Alternative 1 Operations

In DeltaSOS simulations of this alternative, the maximum storage volume of the two reservoir islands is approximately 238 thousand acre-feet (TAF). Maximum storage may increase slightly over the life of the project because of subsidence on the reservoir islands. Incidental storage on the habitat islands during certain seasons would be approximately 9 TAF. As simulated in DeltaSOS, the maximum monthly average DW diversion rate to the reservoir islands is 4,000 cfs, and the maximum monthly average DW discharge rate from the reservoir islands is 4,000 cfs. The maximum diversion rate is assumed to be 9,000 cfs, and the maximum discharge rate is assumed to be 6,000 cfs.

Under this alternative, DW diversions are treated consistently with the 1995 WQCP objectives for Delta exports at the SWP and CVP pumping plants. That is, DW diversions are considered to be the same as SWP and CVP exports in complying with the WQCP objectives, although DW's new water rights for diversions have a lower priority than the senior SWP and CVP water rights. As simulated in DeltaSOS, DW diversions to storage would occur only when the volume of allowable water for export (i.e., the lesser of the amount specified by the export limits and the amount of available water) is greater than the permitted pumping rate of the export pumps. This would occur when two conditions are met: 1) when all Delta outflow requirements are met and the export limit is exceeded and 2) when water that is allowable for export is not being exported by the SWP and CVP pumps. For purposes of modeling Alternative 1, the second condition is assumed to occur only when water that is allowable for export exceeds the permitted pumping rate.

For DeltaSOS simulations of Alternative 1, it is assumed that discharges of water from the DW islands would be exported in any month when unused capacity within the permitted pumping rate exists at the SWP and CVP pumps, and strict interpretation of the export limits (percentage of total Delta inflow) specified in the 1995 WQCP does not prevent use of that capacity. Such unused capacity could exist when the amount of available water (i.e., total inflow less Delta outflow requirements) is less than the amount specified by the export limits. Under this alternative, DW discharges would be treated as additions to total Delta inflow. Export of DW discharges thus would be limited to the lesser of the permitted export pumping capacity and the amount calculated under the "percent inflow" export limit, based on the adjusted inflow amount (including DW discharges).

Under Alternative 1, DW has two choices regarding allocation of discharges. If DW chooses to discharge at the maximum DW discharge rate, some of the releases must be used to increase Delta outflow while the balance is exported, according to the specified "percent inflow" criterion. Alternatively, DW could choose to limit discharges so that no allocation to Delta outflow is needed. The DeltaSOS simulations of Alternative 1 assumed that DW discharges were limited to allowable exports, with none allocated to Delta outflow.

DW monthly operations were simulated with DeltaSOS as reported in Appendix A3. The 70-year average annual DW operations were simulated to be 222 TAF/yr of diversions, with 188 TAF/yr of discharge for export. DW diversions would normally occur during one of the fall or winter months, and DW discharges would generally occur in July and August.

Simulated Channel Flows for Alternative 1

Table B1-11 presents the changes in the selected channel flows simulated for Alternative 1 compared with the channel flows simulated for the No-Project Alternative. As presented in detail above under "Simulations of Monthly Average Net Delta Channel Flows Using Historical Delta Inflows and Exports", the Delta channel flows simulated with the RMA Delta hydrodynamic model can be summarized with relatively simple channel flow-split relationships that depend on Delta inflows and exports.

The effects of DW project diversions and discharges on export pumping can be summarized according to these general channel flow relationships. DW diversions would reduce Delta outflow and QWEST flow (outflow from the central Delta) by the same amount as the DW diversion because DCC and Georgiana Slough flows are not changed by increased exports or DW diversions. The hydraulic relationship between Threemile Slough flow and QWEST flow indicates that Threemile Slough flow would increase by about 31% of the reduction in QWEST. Antioch flow would therefore decrease by 69% of the QWEST reduction. If the DW diversions are specified, these corresponding changes in Delta channel flows can be easily calculated.

DW discharges for export pumping would only change Delta channel flows in Old and Middle Rivers. Because the Old and Middle River channels near Bacon Island have approximately equal tidal and net flows, the change in flow in each channel would equal approximately half the DW discharge rate. If the DW discharges are from Bacon Island, only the channel flows from Bacon Island to the export pumps would change. If the DW discharges are from Webb Tract, about half the DW discharge would move directly down the Old River channel and the other half would flow toward Middle River (via the San Joaquin River or Connection Slough). Delta outflow and QWEST flows would not be changed by DW discharges for Delta export.

Simulated Source Contributions for Alternative 1

The simulated percent source contributions for Alternative 1 are shown in Table B1-12. As described in detail above under "Source Tracking of Historical Delta Inflows", the source contribution from DW discharges would be approximately equal to the DW discharges divided by the total south Delta diversions (exports and agricultural diversions). Because the total simulated exports are increased by the amount of the simulated DW discharges, the percent source contribution from all other sources will decrease during periods with DW discharges.

The maximum source contribution from DW discharges will occur with a large DW discharge (4,000 cfs monthly maximum) during a month with limited SWP and CVP pumping. The maximum simulated DW source contribution for Alternative 1 was approximately 35%. The RMA source tracking for historical inflows and exports demonstrated that there may be differences in the source contributions between the export locations. However, the average monthly contribution from DW discharges is expected to be similar to these simulated monthly values. The possible water quality impacts of these changes in source contributions at the export locations are described in the impact assessment in Chapter 3C, "Water Quality".

Simulation Results for Alternative 2

Alternative 2 would have the same physical arrangement and operating capacities as Alternative 1. Chapter 2 provides a complete description of Alternative 2.

Alternative 2 Operations

The diversion-period modeling assumptions for this alternative are the same as for Alternative 1. In DeltaSOS simulations of Alternative 2, it is assumed that releases of water from the DW islands would be exported by the SWP and CVP pumps when unused capacity within the permitted pumping rate exists at the SWP and CVP pumps. DW discharges would be allowed to be exported in any month when such capacity exists and would not be subject to strict interpretation of the export limits (percentage of total Delta inflow). Under this alternative, it is assumed that export of DW discharges is limited by the 1995 WQCP Delta outflow requirements and the permitted combined pumping rate of the export pumps but is not subject to strict interpretation of the 1995 WQCP "percent inflow" export limit. Because the 1995 WQCP limits exports to an amount equal to the San Joaquin River inflow during the April-May pulse-flow period, DeltaSOS does not allow DW discharges to be exported during the pulse-flow period.

Alternative 2 monthly operations were simulated with DeltaSOS as reported in Appendix A3. The 70-year average annual DW operations were simulated to be 225 TAF/yr of diversions, and 202 TAF/yr of discharge for export. DW diversions would normally occur during one

of the fall or winter months, and DW discharges would generally occur in February or March or in summer (June or July). The February and March discharges were simulated to occur in years when inflows were not high enough to allow full SWP and CVP export pumping.

Simulated Channel Flows for Alternative 2

Table B1-11 presents the changes in the selected channel flows for Alternative 2 compared with the No-Project Alternative channel flows. DW diversions and discharges were simulated to occur during only one or two months each year, so that most of the time there is no simulated change in Delta channel flows. The simulated average monthly change in outflow and QWEST during DW diversions for Alternative 2 was 292 cfs. The simulated average monthly change in Old and Middle River flow during DW discharge for Alternative 2 was 295 cfs.

Simulated Source Contributions for Alternative 2

The simulated source contributions for Alternative 2 are shown in Table B1-12. The DW percentage source contributions for Alternative 2 are slightly higher than for Alternative 1 because the allowable DW exports are greater (limited by permitted pumping rate rather than percent inflow limits). The possible water quality impacts of these changes in source contributions at the export locations are described in the impact assessment in Chapter 3C.

Simulation Results for Alternative 3

Under Alternative 3, water would be diverted for storage in reservoirs on all four DW project islands. A habitat reserve would be created on Bouldin Island north of State Route 12. Chapter 2 provides a complete description of Alternative 3.

Alternative 3 Operations

In DeltaSOS simulations of this alternative, DW initial storage volume is assumed to be approximately 406 TAF; this volume may increase slightly over the life of the project. Incidental storage in the habitat management area would be minimal. The maximum monthly DW diversion rate to the four islands is simulated to be 6,000 cfs, which would allow almost the entire DW storage volume to be filled in a single month; the initial daily average maximum is assumed to be 9,000 cfs. The maximum monthly average DW discharge rate is 6,000 cfs for simulation purposes (maximum discharge rate of 12,000 cfs).

The diversion-period modeling assumptions for this alternative are the same as for Alternatives 1 and 2. The discharge-period modeling assumptions for this alternative are the same as for Alternative 2 (permitted export pumping rate limits).

Alternative 3 monthly operations were simulated with DeltaSOS as reported in Appendix A3. The 70-year average annual DW operations were simulated to be 356 TAF/yr of diversions, with 302 TAF/yr of discharge for export. DW diversions would normally occur during one of the fall or winter months, and DW discharges would generally occur in February or March or in summer (June, July, and August). The February and March discharges are simulated to occur in years when inflows are not high enough to allow full SWP and CVP export pumping. Discharges are usually limited by the export pumping capacity, and more than one month is required to empty the DW storage.

Simulated Channel Flows for Alternative 3

Table B1-11 presents the changes in the selected channel flows for Alternative 3 compared with the No-Project Alternative channel flows. DW diversions and discharges were simulated to occur during only one or two months each year, so that most of the time there was no simulated change in Delta channel flows. The simulated average monthly change in outflow and QWEST during DW diversions for Alternative 3 was 457 cfs. The simulated average monthly change in Old and Middle River flow during DW discharge for Alternative 3 was 452 cfs.

Simulated Source Contributions for Alternative 3

The simulated source contributions for Alternative 3 are shown in Table B1-12. The DW source contributions for Alternative 3 are about the same as for Alternative 2 because the allowable DW exports are the same in most months. Alternative 3 requires more months of discharges, however, to empty the DW storage in many years. The possible water quality impacts of these changes in source contributions at the export locations are described in the impact assessment in Chapter 3C.

CITATIONS

California. Department of Water Resources. 1993. Sacramento-San Joaquin Delta atlas. Sacramento, CA.

_____. 1994. Mathematical models for estimating Delta island diversions and drainage flows. Division of Planning, Delta Modeling Section. Sacramento, CA.

Smith, D. J., and T. J. Durbin. 1989. Mathematical model evaluation of the proposed Delta Wetlands project on the hydrodynamic and water quality response of Suisun Bay and the Sacramento-San Joaquin River Delta System. (RMA 8808.) Resource Management Associates, Inc. Lafayette, CA.

Table B1-1. Specified Channel Geometry in the RMA Delta Model

Channel Location	Surface Area (acres)	Channel Volume (acre-feet)	Mean Depth (feet)
San Joaquin River: Vernalis to Old River Split	513	2,781	5.4
San Joaquin River: Mossdale to Mokelumne	3,586	82,935	23.1
Lower San Joaquin River: Mokelumne River to Broad Slough	7,190	153,041	21.3
Old River: Mossdale to Tracy and Grant Line Canal	932	8,974	9.6
Old River: Clifton Court to Rock Slough	1,106	17,033	15.4
Old River: Rock Slough to San Joaquin River	1,147	21,695	18.9
Old River: Paradise Cut and Tom Paine Slough	272	1,331	4.9
Clifton Court Forebay	2,109	31,635	15.0
Indian and Rock Sloughs	363	3,000	8.3
Franks Tract and Big Break	6,265	64,141	10.2
Middle River and Victoria Canal	4,111	62,178	15.1
Mokelumne River: Georgiana, White, Potato, and Little Potato Sloughs	3,838	52,039	13.6
Sutter, Steamboat, and Miner Sloughs: Sacramento Ship Channel and Cache Slough	4,249	85,951	20.2
American River to Delta Cross Channel	2,037	33,586	16.5
Sacramento River: Delta Cross Channel to Rio Vista	1,495	29,761	19.9
Sacramento River: Rio Vista to Chipps Island	9,581	217,671	22.7
Delta (upstream of Chipps Island)	48,794	857,206	17.6
Suisun Bay	24,570	442,682	18.0
Suisun Marsh	2,530	68,161	26.9
Total Delta, Suisun Bay, and Suisun Marsh	75,894	1,368,050	18.2

Table B1–2. Tidal Flows, Velocities, and Excursions at Selected Delta Locations Simulated with the RMA Delta Hydrodynamic Model for Mean Tide Conditions (5.67–Foot Tidal Range at Benicia)

Delta Channel Location	RMA Channel Number	Average Flood Tide Flow[a] (cfs)	Average Flood Tide Velocity[a] (ft/sec)	Average Channel Area[b] (ft^2)	Tidal Excursion[c] Range (miles)
Benicia	441	321,919	1.8	176,925	12.13
Suisun Bay	440	133,880	1.7	77,184	11.49
Roe Island (Port Chicago)	439	126,995	1.4	90,252	9.25
Honker Bay	438	121,364	1.2	100,714	7.90
Chipps Island	437	203,222	1.8	111,626	11.80
Pittsburg	436	145,695	1.4	105,460	8.88
Sac. R. at Collinsville	435	100,258	1.3	76,762	8.16
Sac. R. at Rio Vista	430	45,772	0.8	57,548	4.84
Sac. R. at Walnut Grove	421	6,511	0.8	8,469	4.95
Sac. R. at Sacramento	410	623	0.1	10,255	0.36
Mouth of Suisun Slough	458	7,777	0.4	21,137	2.19
Mouth of Montezuma Slough	465	13,707	0.6	21,293	4.05
Suisun Marsh salinity control gate	461	4,740	1.0	4,573	6.30
Threemile Slough	309	18,371	1.4	13,505	8.46
SJR at Antioch	51	95,332	1.6	61,305	10.18
SJR at Jersey Point	49	86,076	1.4	59,514	9.24
SJR at Mokelumne R.	45	57,192	0.9	62,464	5.76
SJR at Columbia Cut	37	12,580	0.6	22,771	3.43
SJR at 14–Mile Slough	23	4,072	0.2	17,760	1.44
SJR below Head of Old River	8	944	0.7	1,274	4.53
SJR at Vernalis	1	63	0.1	1,184	0.34
Dutch Slough	274	4,851	1.1	4,231	6.81
False River	279	39,275	2.0	20,125	13.15
Fisherman's Cut	280	2,347	0.4	5,544	2.85
Mouth of Old River	124	2,918	0.1	20,296	0.64
Old River at Rock Slough	106	9,276	0.8	11,149	5.27
Old River at Woodward Canal	92	7,739	1.1	7,308	6.58
Old River at SWP Clifton Court	83	5,693	1.2	4,853	7.20
Old River at CVP Tracy	80	1,205	0.5	2,382	3.01
Head of Old River	54	1,061	1.0	1,099	5.96
Grant Line Canal	210	3,494	0.7	4,949	4.42
Middle River at Columbia Cut	159	14,731	0.7	19,759	4.72
Middle River at Victoria Canal	135	4,282	1.0	4,193	6.24
Head of Middle River	125	35	0.2	139	1.67
Mouth of Mokelumne River	349	8,098	0.5	14,925	3.70
Mouth of Cache Slough	398	28,823	1.1	25,375	6.54
Head of Georgiana Slough	366	942	0.3	3,667	1.62
Delta Cross Channel	365	2,025	0.4	4,978	2.17
Head of Steamboat Slough	383	1,474	0.9	1,662	5.25
Head of Sutter Slough	379	1,942	0.8	2,573	4.48

Notes: [a] Average during 12.5–hour period of flood tide flows and velocities
[b] Channel area equals average flood flow divided by average flood velocity (A = Q/V)
[c] Excursion is the distance between the position of a "floating object" at high tide and at low tide.

Table B1–3. Monthly Historical Delta Inflows (cfs) and Exports (cfs) for 1968–1991

Water Year	Sac. R. at Freeport	Yolo Bypass	SJR at Vernalis	Eastside Streams	DCC & Georgiana	CCWD Intake	CVP Pumps	SWP Pumps	Total Exports	Channel Depletion	QWEST	Threemile Slough	SJR at Antioch	Island Breaks	Total Outflow
1968															
OCT	16,184	22	2,730	1,328	6,836	102	1,589	107	1,798	1,688	8,000	(422)	7,578	0	16,779
NOV	14,617	15	3,479	431	6,376	92	965	77	1,134	1,180	8,385	(768)	7,616	0	16,228
DEC	17,208	41	3,641	234	7,136	79	429	167	676	(86)	10,392	(890)	9,501	0	20,535
JAN	20,514	900	2,946	603	5,354	91	640	438	1,170	(508)	8,062	1,224	9,286	0	24,300
FEB	41,272	6,861	2,715	2,611	7,648	60	1,724	47	1,897	(2,453)	12,670	5,525	18,195	0	54,015
MAR	36,080	2,848	3,099	1,872	5,869	51	3,288	1,155	4,495	(981)	6,983	5,496	12,478	0	40,386
APR	14,460	283	1,438	624	6,330	130	3,777	1,481	5,388	1,469	2,049	1,215	3,264	0	9,948
MAY	13,340	51	893	384	6,002	159	4,173	1,291	5,621	2,298	164	1,516	1,681	0	6,749
JUN	11,371	27	592	150	5,425	224	4,207	287	4,716	3,753	(988)	1,464	476	0	3,672
JUL	12,616	3	504	104	5,790	224	4,746	209	5,177	4,359	(1,613)	1,820	207	0	3,690
AUG	13,026	8	770	138	5,910	194	3,909	775	4,877	3,792	(524)	1,583	1,059	0	5,273
SEP	13,141	27	940	154	5,944	186	3,603	1,825	5,612	2,636	(288)	1,599	1,312	0	6,014
1969															
OCT	11,650	21	1,387	139	5,507	150	3,792	2,319	6,260	1,475	(185)	1,390	1,205	0	5,462
NOV	13,625	14	1,607	203	6,086	114	2,301	2,634	5,051	(740)	3,326	749	4,075	0	11,138
DEC	22,976	858	2,537	752	5,855	88	1,107	2,575	3,772	(2,376)	6,917	2,128	9,044	0	25,728
JAN	55,502	45,392	13,839	11,015	8,212	60	2,888	2,808	5,759	(4,835)	28,984	12,610	41,594	1,466	123,359
FEB	71,919	45,264	32,611	9,975	10,396	60	3,003	1,650	4,715	(4,153)	51,084	8,964	60,048	(119)	159,325
MAR	49,818	10,707	30,929	5,448	7,456	53	2,210	1,145	3,409	101	40,640	(398)	40,241	(280)	93,672
APR	45,423	1,071	22,152	4,739	6,872	74	1,889	1,255	3,218	962	30,200	(304)	29,896	(280)	69,486
MAY	40,679	699	24,657	4,018	6,241	109	2,191	978	3,276	2,378	30,374	(1,471)	28,903	(280)	64,679
JUN	23,161	148	27,931	1,390	6,761	113	1,893	494	2,498	3,742	31,433	(6,154)	25,280	(280)	46,671
JUL	14,241	32	5,813	696	6,267	154	2,707	527	3,388	4,359	6,684	(481)	6,203	(130)	13,166
AUG	18,378	21	2,329	571	7,478	177	4,374	559	5,107	3,792	2,886	1,399	4,285	(80)	12,480
SEP	21,050	26	3,260	737	8,261	140	2,247	179	2,565	2,336	8,222	265	8,487	(46)	20,220
1970															
OCT	16,723	25	4,470	1,096	6,994	105	1,632	274	2,010	785	10,039	(914)	9,125	0	19,518
NOV	16,967	21	4,635	413	7,065	78	367	629	1,074	967	10,411	(1,001)	9,411	0	19,996
DEC	35,314	6,352	2,663	1,853	6,702	94	0	727	823	(912)	10,989	4,688	15,676	0	46,272
JAN	70,386	98,337	11,136	9,372	10,192	49	413	653	1,118	(5,352)	33,060	26,521	59,582	0	193,465
FEB	66,176	33,056	9,207	4,518	9,632	84	1,483	386	1,953	(516)	21,740	13,898	35,638	0	111,521
MAR	44,285	3,009	7,192	3,787	7,600	72	1,760	436	2,269	(81)	16,363	4,062	20,425	0	56,085
APR	14,643	123	1,675	657	6,384	128	3,650	881	4,660	1,394	3,150	871	4,022	0	11,045
MAY	14,290	48	2,397	474	6,281	166	3,568	286	4,019	2,410	3,567	609	4,176	0	10,780
JUN	11,806	33	2,741	267	5,552	197	4,237	573	5,005	3,618	1,204	865	2,069	0	6,224
JUL	13,198	16	1,333	315	5,961	212	4,455	571	5,237	4,359	(462)	1,561	1,099	0	5,266
AUG	15,004	23	1,046	297	6,490	215	3,565	838	4,616	3,792	752	1,513	2,264	0	7,962
SEP	18,543	43	1,321	432	7,526	161	2,285	650	3,094	2,636	4,473	1,006	5,478	0	14,610

Table B1-3. Continued

Water Year	Sac. R. at Freeport	Yolo Bypass	SJR at Vernalis	Eastside Streams	DCC & Georgiana	CCWD Intake	CVP Pumps	SWP Pumps	Total Exports	Channel Depletion	QWEST	Threemile Slough	SJR at Antioch	Island Breaks	Total Outflow
1971															
OCT	15,288	25	1,469	473	6,573	116	2,049	425	2,589	1,219	5,134	349	5,482	0	13,447
NOV	22,556	226	1,658	1,010	5,119	78	471	1,482	2,034	(2,743)	7,535	1,884	9,420	0	26,159
DEC	64,085	11,002	5,053	4,086	9,354	63	8	1,846	1,918	(3,213)	18,663	9,518	28,181	0	85,521
JAN	52,416	6,639	5,213	2,182	7,802	64	24	1,820	1,908	276	13,110	7,708	20,818	0	64,266
FEB	31,251	836	4,399	1,372	6,643	65	2,316	762	3,145	443	8,982	3,042	12,024	0	34,271
MAR	30,535	1,272	2,594	1,769	6,400	71	3,811	828	4,710	(666)	6,486	3,871	10,357	0	32,126
APR	38,332	852	1,964	1,283	6,173	80	3,344	1,015	4,438	951	4,365	6,185	10,550	0	37,043
MAY	29,242	590	1,836	914	7,870	97	3,616	845	4,557	1,572	5,041	3,398	8,439	0	26,453
JUN	27,594	185	2,326	640	10,179	142	4,447	1,191	5,777	3,715	4,952	2,299	7,251	0	21,252
JUL	21,018	14	1,068	455	8,252	165	4,571	1,786	6,521	4,359	420	2,559	2,979	0	11,675
AUG	22,505	5	893	113	8,688	180	4,380	2,154	6,713	3,792	517	2,801	3,317	0	13,011
SEP	24,433	36	1,097	668	9,252	128	2,784	1,004	3,913	2,630	5,395	1,676	7,071	0	19,691
1972															
OCT	16,100	8	2,257	980	6,811	118	2,863	839	3,819	1,543	5,225	430	5,655	0	13,982
NOV	15,879	16	1,649	318	6,746	85	2,325	641	3,052	1,045	4,982	500	5,482	0	13,765
DEC	21,797	57	2,403	939	7,623	92	1,946	401	2,440	(1,255)	9,340	450	9,790	0	24,010
JAN	20,036	115	3,122	619	7,546	66	1,036	516	1,618	897	9,086	31	9,117	0	21,377
FEB	22,947	148	2,803	931	8,892	70	3,259	408	3,871	166	8,647	577	9,224	0	22,793
MAR	23,939	96	1,382	664	6,976	94	3,911	2,689	6,694	1,278	1,498	3,386	4,884	0	18,110
APR	13,141	6	1,038	728	5,944	161	3,533	2,674	6,366	993	698	1,383	2,081	0	7,554
MAY	12,871	8	746	379	5,865	214	4,073	2,223	6,507	2,348	(1,043)	1,802	758	0	5,149
JUN	13,859	17	588	133	6,154	229	3,324	1,807	5,359	3,577	(3,574)	2,678	(896)	2,765	2,896
JUL	15,027	2	482	81	6,497	181	4,235	669	5,083	4,359	(785)	1,955	1,170	(73)	6,222
AUG	15,686	15	544	112	6,690	215	4,398	2,386	6,998	3,792	(1,202)	2,227	1,025	(915)	6,482
SEP	16,844	7	1,566	173	7,029	194	3,943	2,886	7,022	1,982	1,364	1,722	3,086	(906)	10,492
1973															
OCT	16,106	10	1,995	153	6,813	112	3,374	2,938	6,423	467	2,800	1,245	4,045	(566)	11,940
NOV	23,241	641	2,220	281	6,442	75	0	3,476	3,553	(2,916)	7,524	1,847	9,370	(238)	25,985
DEC	27,471	469	2,506	472	7,135	67	0	3,389	3,458	300	6,480	2,759	9,240	(20)	27,181
JAN	60,239	30,223	4,066	6,095	8,842	63	1,474	1,428	2,967	(4,210)	18,772	13,195	31,968	0	101,866
FEB	65,371	20,167	8,002	7,541	9,525	64	632	483	1,180	(2,442)	25,475	9,726	35,202	0	102,344
MAR	51,734	12,144	7,625	4,614	7,711	67	642	575	1,284	(2,212)	20,103	6,813	26,917	0	77,044
APR	20,703	669	4,210	1,576	7,513	84	2,477	797	3,357	1,574	8,919	332	9,251	0	22,227
MAY	16,445	89	2,942	1,163	6,389	190	4,485	1,839	6,512	2,408	2,417	1,446	3,863	0	11,719
JUN	14,961	37	2,580	765	5,344	194	4,598	2,576	7,367	3,753	(1,117)	2,351	1,234	0	7,223
JUL	15,195	14	1,084	380	5,096	233	4,649	2,827	7,707	4,359	(3,980)	3,309	(671)	0	4,607
AUG	16,151	13	1,069	320	6,826	218	4,497	3,075	7,788	3,792	(2,038)	2,561	524	0	5,973
SEP	17,515	33	1,473	356	7,225	168	3,812	1,800	5,777	2,429	1,698	1,708	3,406	0	11,171

Table B1–3. Continued

Water Year	Sac. R. at Freeport	Yolo Bypass	SJR at Vernalis	Eastside Streams	DCC & Georgiana	CCWD Intake	CVP Pumps	SWP Pumps	Total Exports	Channel Depletion	QWEST	Threemile Slough	SJR at Antioch	Island Breaks	Total Outflow
1974															
OCT	16,752	11	2,551	472	7,002	105	3,348	2,484	5,937	(247)	4,248	942	5,191	0	14,096
NOV	48,114	10,950	2,285	2,044	8,663	84	2,998	1,828	4,911	(1,560)	9,095	8,862	17,957	0	60,041
DEC	61,742	10,408	3,593	3,411	9,042	56	1,553	1,734	3,344	(734)	13,178	10,472	23,650	0	76,542
JAN	74,959	51,283	7,795	5,485	10,800	58	1,237	682	1,978	(1,402)	23,014	19,498	42,512	0	138,946
FEB	52,481	6,028	5,102	1,258	7,810	58	3,480	1,926	5,464	123	8,626	8,979	17,606	0	59,282
MAR	64,796	9,027	4,826	4,622	9,448	66	4,245	1,976	6,286	(728)	13,084	10,792	23,876	0	77,713
APR	66,390	37,558	5,859	3,834	9,660	78	2,568	1,564	4,209	(291)	15,334	16,949	32,283	0	109,723
MAY	29,229	174	4,114	1,653	9,954	115	4,387	2,640	7,143	2,438	6,994	2,165	9,159	0	25,590
JUN	24,453	51	3,866	1,249	9,258	188	4,403	4,555	9,144	3,504	2,951	2,390	5,341	0	16,970
JUL	21,790	24	1,639	546	7,960	198	4,506	6,008	10,710	3,908	(3,105)	3,924	819	0	9,381
AUG	23,991	12	1,618	468	8,453	193	4,528	4,772	9,490	3,792	(1,417)	3,798	2,381	0	12,806
SEP	25,100	61	2,850	703	9,448	115	3,326	1,624	5,063	2,636	6,224	1,533	7,757	0	21,015
1975															
OCT	20,155	20	3,503	763	7,999	98	3,446	1,060	4,603	1,276	6,833	609	7,442	0	18,562
NOV	22,039	15	3,897	904	8,551	71	0	1,881	1,952	873	10,832	(303)	10,530	0	24,030
DEC	25,691	127	4,169	789	7,071	59	10	2,749	2,819	(110)	9,281	1,441	10,722	0	28,067
JAN	19,467	38	3,773	304	7,797	67	2,692	2,722	5,482	581	6,016	795	6,810	0	17,520
FEB	47,601	3,990	6,223	2,533	7,605	83	4,196	2,449	6,728	(3,811)	12,110	6,582	18,692	0	57,430
MAR	51,033	9,425	5,695	5,336	8,332	73	3,766	2,250	6,089	(1,554)	14,284	7,650	21,934	0	66,953
APR	33,227	1,719	3,963	2,630	8,978	97	4,220	1,997	6,314	651	8,834	3,197	12,031	0	34,574
MAY	30,318	286	3,979	2,294	10,977	112	3,956	1,526	5,592	2,438	10,073	1,252	11,324	0	28,847
JUN	23,748	28	5,717	1,311	9,052	167	4,003	360	4,527	3,732	9,126	343	9,469	0	22,544
JUL	18,316	13	1,721	551	7,460	175	4,620	400	5,194	4,259	1,771	1,706	3,477	0	11,149
AUG	19,531	7	1,684	562	7,816	171	4,498	4,337	9,004	3,241	(1,049)	2,835	1,786	0	9,540
SEP	20,413	109	2,657	699	8,074	137	3,643	4,033	7,811	2,626	1,912	2,119	4,031	0	13,440
1976															
OCT	19,208	18	4,551	913	7,722	87	3,610	3,878	7,574	186	5,491	933	6,424	0	16,930
NOV	22,286	13	3,912	892	8,623	61	3,839	4,123	8,023	1,130	4,670	1,633	6,302	0	17,949
DEC	25,591	40	3,752	344	9,592	42	3,888	3,904	7,834	1,904	4,616	2,149	6,765	0	19,989
JAN	15,159	37	3,332	120	6,535	102	4,062	4,111	8,274	1,011	1,056	1,606	2,662	0	9,362
FEB	13,252	35	2,194	166	6,051	166	4,593	3,049	8,086	(216)	465	1,532	1,998	0	7,777
MAR	14,600	51	1,826	170	6,372	144	4,571	3,651	8,366	410	(265)	1,963	1,698	0	7,872
APR	12,745	0	1,295	183	5,828	173	4,406	468	5,046	330	2,045	938	2,983	0	8,847
MAY	10,929	40	941	99	5,296	208	4,548	744	5,497	2,438	(746)	1,396	650	0	4,073
JUN	10,952	1	799	49	5,302	222	3,741	198	4,158	3,722	(427)	1,218	791	0	3,921
JUL	12,099	0	672	55	5,639	233	3,465	421	4,117	4,359	(584)	1,416	832	0	4,350
AUG	13,372	4	1,057	74	6,012	212	4,572	2,066	6,848	3,141	(1,747)	2,055	307	0	4,517
SEP	12,530	4	1,068	357	5,765	191	4,546	3,608	8,344	1,940	(2,415)	2,194	(221)	0	3,676

Table B1–3. Continued

Water Year	Sac. R. at Freeport	Yolo Bypass	SJR at Vernalis	Eastside Streams	DCC & Georgiana	CCWD Intake	CVP Pumps	SWP Pumps	Total Exports	Channel Depletion	QWEST	Threemile Slough	SJR at Antioch	Island Breaks	Total Outflow
1977															
OCT	8,117	1	1,276	28	4,472	135	3,176	1,304	4,614	1,178	396	648	1,044	0	3,630
NOV	7,836	6	1,138	94	4,389	162	2,522	1,566	4,250	1,174	608	538	1,146	0	3,650
DEC	7,757	1	967	58	4,366	125	1,572	1,092	2,789	1,774	1,450	229	1,678	0	4,220
JAN	9,819	3	1,093	51	4,971	115	3,636	3,302	7,055	(462)	(640)	1,341	701	0	4,373
FEB	8,017	1	790	40	4,443	161	2,254	1,928	4,343	(427)	1,208	472	1,680	0	4,933
MAR	6,585	4	525	50	4,023	125	2,032	1,663	3,820	268	604	387	991	0	3,075
APR	5,971	1	212	25	3,843	120	1,004	175	1,297	1,823	1,597	(110)	1,487	0	3,088
MAY	7,610	1	400	31	4,324	110	1,660	1,223	2,992	1,045	1,084	360	1,444	0	4,006
JUN	6,876	1	118	23	4,032	182	311	249	740	3,753	994	131	1,124	0	2,525
JUL	8,263	1	93	67	4,441	145	354	351	847	4,359	920	343	1,264	0	3,218
AUG	7,700	1	124	16	4,350	141	1,096	296	1,532	3,792	494	400	894	0	2,518
SEP	6,849	1	179	13	4,100	123	1,643	95	1,859	2,284	845	239	1,084	103	2,796
1978															
OCT	4,502	0	247	9	3,413	136	489	140	764	1,824	1,627	(359)	1,269	91	2,078
NOV	6,698	0	430	34	4,056	123	1,640	891	2,655	391	1,505	119	1,624	107	4,011
DEC	11,766	0	507	275	5,541	111	2,172	3,638	5,923	(1,949)	1,596	1,049	2,645	70	8,503
JAN	45,571	18,734	2,280	4,438	7,639	51	3,878	5,932	9,863	(5,168)	7,813	10,908	18,722	40	66,289
FEB	44,782	8,633	7,331	3,070	8,928	36	4,072	6,218	10,327	(2,769)	10,802	7,043	17,844	0	56,257
MAR	55,670	18,401	11,495	3,180	9,099	36	3,992	1,901	5,929	(2,880)	19,717	8,997	28,714	0	85,696
APR	38,946	1,380	20,062	3,456	6,010	63	2,745	469	3,277	(807)	26,777	(362)	26,415	0	61,375
MAY	25,238	21	19,153	1,915	7,584	90	2,070	904	3,063	2,318	24,083	(3,533)	20,549	0	40,947
JUN	12,680	17	7,081	708	5,809	137	4,140	3,356	7,633	3,753	3,525	276	3,801	0	9,100
JUL	14,325	17	1,911	189	6,291	193	4,513	3,398	8,102	4,359	(2,544)	2,390	(154)	0	3,982
AUG	15,996	7	1,421	747	6,781	179	4,174	4,090	8,440	3,792	(1,957)	2,510	553	0	5,938
SEP	17,962	1	2,735	1,001	7,356	124	3,787	3,590	7,499	2,387	2,040	1,670	3,710	0	11,812
1979															
OCT	12,509	1	3,333	805	5,754	101	2,957	2,076	5,133	1,866	3,547	347	3,894	0	9,650
NOV	12,463	3	3,503	471	5,688	89	3,211	2,282	5,581	(87)	4,137	282	4,419	0	10,946
DEC	13,227	7	2,817	313	5,969	88	3,184	2,790	6,062	1,507	2,058	946	3,004	0	8,795
JAN	23,232	426	5,243	1,946	5,309	66	2,704	1,340	4,111	(3,842)	10,884	1,067	11,951	0	30,577
FEB	32,500	1,665	7,150	4,449	5,153	54	1,229	1,661	2,944	(3,603)	16,150	1,873	18,023	0	46,422
MAR	29,216	334	8,667	3,482	4,761	68	1,990	2,298	4,355	(809)	13,081	1,693	14,774	0	38,154
APR	16,573	30	3,512	1,537	4,495	88	3,187	2,615	5,891	1,254	2,839	1,833	4,671	0	14,508
MAY	18,016	31	2,528	1,502	7,372	158	2,996	3,105	6,256	2,362	3,611	1,200	4,811	0	13,459
JUN	12,226	18	2,257	936	5,676	198	2,992	3,163	6,351	3,753	79	1,271	1,349	0	5,335
JUL	16,442	15	1,336	464	6,911	223	4,557	4,577	9,356	3,508	(2,925)	2,900	(24)	0	5,394
AUG	15,705	13	1,454	482	6,695	210	4,566	5,606	10,380	3,792	(4,215)	3,164	(1,051)	0	3,482
SEP	14,590	7	1,844	538	6,368	172	4,389	4,717	9,277	2,636	(2,240)	2,436	195	0	5,067

Table B1–3. Continued

Water Year	Sac. R. at Freeport	Yolo Bypass	SJR at Vernalis	Eastside Streams	DCC & Georgiana	CCWD Intake	CVP Pumps	SWP Pumps	Total Exports	Channel Depletion	QWEST	Threemile Slough	SJR at Antioch	Island Breaks	Total Outflow
1980															
OCT	12,600	9	2,795	660	5,786	152	3,917	3,676	7,744	485	1,181	1,175	2,356	0	7,834
NOV	15,228	10	2,324	649	6,555	112	1,032	4,722	5,866	149	3,565	883	4,448	0	12,195
DEC	20,356	921	2,491	592	6,476	79	0	5,903	5,984	(687)	4,022	2,197	6,219	0	19,063
JAN	58,740	40,718	13,092	8,655	8,643	59	0	6,330	6,389	(3,605)	26,345	12,928	39,273	0	118,422
FEB	54,549	48,251	19,348	8,350	8,115	54	2,758	3,383	6,417	(2,139)	30,786	12,357	43,143	0	126,220
MAR	55,437	17,825	25,277	4,926	8,204	54	3,242	1,053	4,348	(231)	34,209	4,372	38,581	0	99,348
APR	22,623	56	10,266	1,784	4,575	75	3,843	1,432	5,352	641	10,856	761	11,618	0	28,735
MAY	15,922	36	9,930	1,748	3,589	137	2,920	1,584	4,639	2,048	9,297	(155)	9,142	0	20,949
JUN	17,842	29	5,314	1,432	6,315	165	2,868	2,938	5,971	3,753	4,651	1,000	5,651	0	14,893
JUL	17,757	27	3,390	716	7,297	174	4,577	2,132	6,881	3,798	2,052	1,558	3,610	0	11,211
AUG	14,943	21	1,973	344	6,472	197	4,549	4,484	9,228	3,792	(2,905)	2,636	(269)	0	4,261
SEP	15,912	8	3,808	521	6,756	181	3,514	4,001	7,695	2,636	1,676	1,437	3,112	0	9,918
1981															
OCT	11,364	7	4,080	458	5,097	165	3,573	2,969	6,705	1,822	1,746	797	2,543	0	7,381
NOV	10,896	11	3,283	556	3,363	118	3,858	2,491	6,467	1,599	(304)	1,738	1,433	0	6,681
DEC	16,717	17	2,955	264	6,992	76	3,795	2,905	6,775	667	3,002	1,272	4,274	0	12,511
JAN	18,543	977	3,256	552	5,628	86	4,091	4,100	8,279	(3,310)	3,309	2,360	5,668	0	18,358
FEB	24,282	718	2,884	346	4,060	78	3,662	3,512	7,252	(234)	190	4,771	4,960	0	21,212
MAR	24,537	260	3,127	1,360	4,094	79	1,945	2,817	4,843	(2,073)	5,086	3,304	8,390	0	26,515
APR	17,252	32	2,536	439	4,807	107	3,689	4,308	8,103	486	(636)	3,039	2,403	0	11,671
MAY	13,805	21	1,970	278	5,414	212	3,142	1,134	4,486	2,429	1,598	1,300	2,897	0	9,159
JUN	10,746	18	1,501	130	5,242	239	3,463	338	4,039	3,753	395	932	1,327	0	4,603
JUL	15,321	17	1,267	120	6,583	238	4,359	2,465	7,058	4,361	(1,923)	2,359	436	0	5,306
AUG	14,891	13	1,272	114	6,457	203	4,117	5,013	9,332	3,792	(3,954)	2,951	(1,003)	0	3,166
SEP	12,818	4	1,184	136	5,849	173	3,319	3,318	6,808	2,636	(1,353)	1,872	519	0	4,698
1982															
OCT	9,913	5	1,389	154	4,998	143	2,115	3,683	5,941	293	410	988	1,398	0	5,227
NOV	32,962	3,767	1,567	1,103	6,512	86	1,438	3,202	4,725	(1,354)	5,337	5,374	10,710	0	36,029
DEC	62,460	24,497	1,854	3,205	9,138	40	786	4,350	5,176	108	8,951	15,118	24,069	0	86,733
JAN	64,725	21,325	3,896	8,341	9,439	49	1,807	3,326	5,185	(4,779)	19,597	11,820	31,417	0	97,880
FEB	59,751	26,409	6,657	7,909	8,777	50	3,795	5,622	9,469	(1,676)	14,964	13,255	28,219	0	92,932
MAR	62,925	5,275	10,080	8,224	9,200	48	4,130	6,255	10,436	(4,164)	19,774	7,679	27,454	0	80,231
APR	76,703	38,279	23,000	11,614	11,032	53	3,458	6,108	9,619	(2,454)	37,622	12,387	50,009	0	142,431
MAY	42,433	316	18,687	4,985	6,474	135	2,989	2,881	6,004	2,438	22,557	1,211	23,767	0	57,979
JUN	26,118	50	7,596	2,337	6,177	171	2,940	831	3,942	3,600	9,829	1,344	11,173	0	28,561
JUL	17,664	31	6,174	1,187	7,269	172	2,916	953	4,039	4,137	7,902	(290)	7,612	0	16,879
AUG	20,666	23	4,024	652	8,149	183	4,357	3,572	8,110	3,792	2,250	1,969	4,218	0	13,462
SEP	24,957	11	6,132	711	9,406	117	2,069	3,108	5,292	550	10,598	262	10,861	0	25,968

Table B1–3. Continued

Water Year	Sac. R. at Freeport	Yolo Bypass	SJR at Vernalis	Eastside Streams	DCC & Georgiana	CCWD Intake	CVP Pumps	SWP Pumps	Total Exports	Channel Depletion	QWEST	Threemile Slough	SJR at Antioch	Island Breaks	Total Outflow
1983															
OCT	19,263	17	8,194	1,394	7,738	83	2,243	2,969	5,294	548	11,676	(996)	10,680	0	23,026
NOV	31,574	454	6,986	3,824	7,627	69	3,342	2,669	6,082	(2,461)	13,954	1,428	15,382	0	39,215
DEC	57,838	12,319	16,523	9,041	8,523	61	3,144	5,238	8,443	(1,817)	26,825	5,965	32,790	0	89,096
JAN	47,597	21,679	19,102	8,655	7,161	40	3,871	6,189	10,103	(2,984)	26,755	6,164	32,919	0	89,915
FEB	79,178	60,586	31,659	11,944	11,361	91	3,954	6,218	10,263	(2,961)	46,626	15,249	61,874	0	176,064
MAR	78,430	130,590	40,107	17,969	11,262	150	3,941	1,287	5,381	(5,448)	67,498	24,873	92,371	0	267,163
APR	60,597	17,948	36,505	6,938	8,890	59	3,668	93	3,820	(131)	48,598	963	49,561	0	118,299
MAY	62,414	3,525	31,828	5,448	9,132	96	2,828	376	3,299	1,032	42,436	(149)	42,288	0	98,883
JUN	48,458	1,108	26,125	4,232	7,275	170	2,980	1,871	5,018	3,753	30,175	157	30,332	0	71,152
JUL	31,045	50	19,262	3,156	6,606	172	3,978	1,067	5,216	4,359	20,974	(1,120)	19,854	0	43,938
AUG	25,083	34	9,051	1,438	9,443	174	4,274	2,756	7,203	3,792	10,264	205	10,469	0	24,610
SEP	24,656	27	11,328	1,592	9,318	154	3,350	708	4,210	1,842	16,830	(1,789)	15,041	0	31,552
1984															
OCT	21,186	189	13,346	1,494	8,301	82	2,085	335	2,501	1,364	19,754	(3,195)	16,559	0	32,350
NOV	48,898	5,995	10,894	6,002	9,299	68	956	731	1,757	(4,224)	27,184	2,302	29,487	0	74,257
DEC	75,518	51,985	19,160	9,182	10,874	54	1,607	483	2,146	(2,036)	38,394	15,040	53,433	0	155,735
JAN	56,904	16,729	25,775	4,206	8,399	46	1,375	302	1,723	806	36,133	3,757	39,889	0	101,085
FEB	33,588	1,350	11,240	2,412	5,327	68	3,817	1,890	5,984	(469)	13,300	2,714	16,014	0	43,074
MAR	31,482	1,082	7,515	2,144	5,018	61	4,291	2,577	6,929	303	7,551	3,978	11,528	0	34,991
APR	17,962	333	4,292	1,231	4,376	143	3,967	3,587	7,697	1,366	1,314	2,716	4,029	0	14,755
MAY	15,434	64	3,245	858	5,493	190	2,995	2,756	5,939	2,438	2,072	1,519	3,591	0	11,223
JUN	15,014	38	2,300	627	6,493	215	2,990	2,972	6,175	3,753	805	1,503	2,309	0	8,051
JUL	21,671	21	1,907	505	8,443	254	4,684	4,539	9,474	4,359	(1,452)	3,247	1,794	0	10,271
AUG	18,817	16	2,183	587	7,607	250	4,386	4,898	9,532	3,785	(1,614)	2,865	1,250	0	8,287
SEP	17,722	18	2,922	740	7,286	186	3,123	2,199	5,507	2,223	3,996	1,038	5,034	0	13,672
1985															
OCT	13,259	20	4,037	774	5,979	150	3,620	1,846	5,615	536	4,825	152	4,977	0	11,937
NOV	26,322	1,492	2,870	1,186	5,858	103	3,900	4,005	8,009	(2,134)	3,292	4,152	7,444	0	25,995
DEC	32,616	1,133	4,783	1,271	5,168	57	3,963	4,459	8,479	203	2,612	5,752	8,364	0	31,122
JAN	16,820	49	4,078	473	3,068	79	3,865	1,900	5,846	426	1,495	2,686	4,182	0	15,147
FEB	18,303	157	3,248	1,014	3,265	97	4,046	3,484	7,628	(523)	239	3,451	3,690	0	15,617
MAR	14,335	5	2,747	953	4,521	129	3,956	4,546	8,631	(1,042)	268	2,235	2,503	0	10,451
APR	12,515	0	2,449	892	5,760	148	3,906	3,301	7,354	1,579	721	1,239	1,961	0	6,924
MAY	13,456	0	2,138	462	5,563	219	2,996	3,013	6,226	2,438	352	1,566	1,918	0	7,392
JUN	13,331	0	1,754	231	5,380	231	3,005	3,307	6,540	3,552	(1,485)	2,085	600	0	5,224
JUL	16,064	0	2,572	148	6,801	257	4,581	4,648	9,482	4,359	(2,796)	2,747	(49)	0	4,942
AUG	13,472	0	2,621	157	6,041	228	4,384	5,520	10,129	3,792	(3,775)	2,661	(1,113)	0	2,329
SEP	12,212	0	1,932	232	5,671	175	4,103	4,458	8,733	2,426	(2,475)	2,132	(343)	0	3,216

Table B1–3. Continued

Water Year	Sac. R. at Freeport	Yolo Bypass	SJR at Vernalis	Eastside Streams	DCC & Georgiana	CCWD Intake	CVP Pumps	SWP Pumps	Total Exports	Channel Depletion	QWEST	Threemile Slough	SJR at Antioch	Island Breaks	Total Outflow
1986															
OCT	9,728	20	2,076	210	4,575	185	3,934	3,599	7,717	932	(1,463)	1,590	127	0	3,384
NOV	10,434	25	1,932	310	4,705	127	3,725	3,488	7,341	(1,542)	609	1,223	1,832	0	6,902
DEC	16,135	182	2,209	599	5,835	107	3,878	5,890	9,876	(198)	(1,105)	2,765	1,660	0	9,447
JAN	20,000	143	2,063	1,152	5,445	145	3,888	5,052	9,086	(965)	201	3,374	3,575	0	15,236
FEB	69,013	115,593	8,759	14,819	10,009	72	3,947	2,062	6,085	(7,428)	28,577	31,726	60,302	3,754	205,774
MAR	75,117	58,769	25,080	9,930	10,821	58	2,439	706	3,205	(3,088)	45,604	14,345	59,949	(970)	169,749
APR	25,868	1,153	19,621	3,510	4,271	84	2,787	1,832	4,704	228	23,976	(2,213)	21,763	(1,425)	46,647
MAY	12,784	43	8,779	1,965	3,573	181	3,003	3,087	6,271	2,262	7,477	(320)	7,158	(901)	15,939
JUN	11,839	43	6,243	1,050	5,562	223	2,997	2,968	6,186	3,753	4,331	(105)	4,226	(101)	9,337
JUL	16,911	43	2,899	489	7,049	230	4,458	3,937	8,622	4,322	(995)	2,338	1,343	0	7,397
AUG	15,140	34	3,189	542	6,530	224	4,393	5,354	9,968	3,792	(2,173)	2,444	271	0	5,144
SEP	18,169	20	4,187	681	6,234	195	4,017	6,298	10,507	1,756	(545)	2,818	2,272	0	10,795
1987															
OCT	15,473	20	3,748	853	5,383	134	4,007	3,439	7,579	1,868	1,191	1,849	3,039	0	10,647
NOV	12,700	25	2,846	738	5,815	148	3,699	3,024	6,871	1,694	1,427	1,050	2,476	0	7,744
DEC	13,133	25	3,713	566	5,253	148	4,018	3,107	7,273	1,162	1,504	1,285	2,789	0	9,003
JAN	13,194	25	2,309	485	2,585	121	4,011	2,129	6,262	(1,087)	(177)	2,563	2,386	0	10,838
FEB	17,434	31	2,140	581	3,333	109	4,037	2,710	6,857	(3,560)	1,511	2,986	4,498	0	16,889
MAR	21,616	220	3,421	1,112	4,241	133	2,383	3,093	5,610	(2,198)	4,593	2,749	7,342	0	22,957
APR	11,845	46	2,872	427	5,249	184	4,346	2,504	7,033	1,856	308	1,325	1,634	0	6,301
MAY	10,014	43	2,182	379	4,423	239	3,003	2,083	5,322	2,335	143	1,117	1,260	0	4,960
JUN	10,084	43	1,993	326	5,048	244	3,003	1,947	5,192	3,753	(264)	1,034	770	0	3,501
JUL	15,169	43	1,635	316	6,538	246	4,443	4,282	8,968	4,359	(3,312)	2,771	(541)	0	3,836
AUG	14,464	34	1,630	337	6,332	240	4,573	5,007	9,817	3,792	(3,983)	2,895	(1,088)	0	2,856
SEP	11,644	20	1,599	250	5,505	225	4,291	4,571	9,084	2,636	(3,443)	2,332	(1,111)	0	1,793
1988															
OCT	9,526	20	1,372	127	4,190	182	4,005	1,733	5,919	1,330	(1,090)	1,493	403	0	3,796
NOV	8,143	25	1,551	113	4,230	153	3,937	1,379	5,470	64	383	783	1,166	0	4,299
DEC	15,772	25	1,280	154	6,715	125	4,040	4,834	9,001	(1,241)	(45)	2,174	2,129	0	9,472
JAN	25,445	1,574	1,486	336	5,303	128	4,070	6,236	10,435	(1,224)	(2,516)	5,845	3,329	0	19,627
FEB	12,645	17	1,441	176	5,873	133	4,252	6,015	10,399	721	(368)	1,634	1,266	0	3,159
MAR	11,368	26	2,245	265	5,424	185	4,090	4,181	8,456	899	(1,106)	1,664	558	0	4,550
APR	16,917	46	2,150	293	7,050	206	4,090	4,290	8,585	(701)	1,362	1,898	3,260	0	11,519
MAY	10,993	43	1,784	193	4,326	194	2,976	3,105	6,274	1,984	(1,260)	1,820	560	0	4,755
JUN	10,597	43	1,714	206	4,887	209	2,998	2,705	5,910	3,447	(1,345)	1,542	197	0	3,203
JUL	14,668	43	1,359	197	6,391	247	4,487	3,250	7,981	4,360	(2,867)	2,552	(315)	0	3,927
AUG	13,310	34	1,560	173	5,993	255	4,539	4,017	8,809	3,792	(3,547)	2,572	(975)	0	2,476
SEP	11,557	20	1,455	133	5,480	223	4,600	3,312	8,133	2,637	(2,780)	2,113	(667)	0	2,395

Table B1–3. Continued

Water Year	Sac. R. at Freeport	Yolo Bypass	SJR at Vernalis	Eastside Streams	DCC & Georgiana	CCWD Intake	CVP Pumps	SWP Pumps	Total Exports	Channel Depletion	QWEST	Threemile Slough	SJR at Antioch	Island Breaks	Total Outflow
1989															
OCT	9,330	20	1,129	57	4,827	197	3,553	1,892	5,642	1,664	(708)	1,164	456	0	3,232
NOV	11,376	25	1,276	83	5,426	152	3,608	2,338	6,099	(9)	695	1,159	1,854	0	6,672
DEC	12,410	25	1,374	102	5,730	147	4,173	2,875	7,197	(557)	372	1,459	1,831	0	7,272
JAN	12,847	25	1,257	131	5,858	138	4,190	5,884	10,213	408	(3,231)	2,591	(639)	0	3,641
FEB	12,078	16	1,236	204	5,626	137	4,104	3,975	8,216	(1,097)	(437)	1,686	1,249	0	6,416
MAR	43,450	428	[1] 2,027	1,472	7,407	125	4,119	6,036	10,279	(1,922)	1,876	7,917	9,793	0	39,019
APR	21,310	46	1,918	664	5,907	145	3,994	6,326	10,464	1,646	(3,044)	4,402	1,358	0	11,829
MAY	13,823	33	1,952	356	5,386	205	3,004	3,023	6,231	2,392	(89)	1,838	1,749	0	7,544
JUN	13,310	33	1,586	165	5,314	228	3,001	2,054	5,281	3,485	(481)	1,795	1,315	0	6,328
JUL	18,801	40	1,286	132	7,602	264	4,747	4,523	9,532	4,360	(3,345)	3,371	26	0	6,368
AUG	18,351	29	1,171	147	7,471	262	4,712	6,365	11,338	3,719	(4,967)	3,835	(1,132)	0	4,642
SEP	16,492	18	1,355	147	6,926	219	4,430	6,124	10,772	674	(2,782)	3,028	246	0	6,566
1990															
OCT	14,299	17	1,403	111	6,283	178	4,224	6,146	10,547	349	(2,976)	2,750	(226)	0	4,935
NOV	13,866	23	1,313	228	6,017	144	3,894	5,665	9,703	582	(2,523)	2,560	36	0	5,145
DEC	15,424	25	1,383	142	6,613	146	4,120	6,195	10,461	2,085	(3,676)	3,052	(624)	0	4,430
JAN	18,332	24	1,204	174	5,500	133	4,011	6,152	10,296	(172)	(3,307)	3,992	685	0	9,610
FEB	15,310	22	1,514	316	6,804	164	4,542	6,998	11,704	(2,101)	(1,705)	2,611	906	0	7,558
MAR	12,475	25	1,706	467	5,681	148	3,983	6,105	10,235	651	(2,804)	2,400	(404)	0	3,787
APR	15,808	48	1,355	351	6,775	208	4,402	5,396	10,006	1,303	(2,372)	2,749	377	0	6,253
MAY	10,420	33	1,281	285	5,039	217	2,775	407	3,398	772	2,707	362	3,069	0	7,851
JUN	10,537	33	1,118	233	5,181	215	2,992	293	3,498	3,416	814	791	1,605	0	5,008
JUL	13,530	33	1,011	163	6,058	238	3,667	2,353	6,257	4,360	(1,857)	2,051	194	0	4,122
AUG	13,416	25	1,001	171	5,957	223	2,940	3,311	6,472	3,669	(1,729)	2,046	318	0	4,471
SEP	10,381	37	907	170	5,206	234	3,307	2,587	6,126	2,685	(1,590)	1,537	(52)	0	2,685
1991															
OCT	7,620	15	993	234	4,323	185	1,107	2,258	3,549	1,816	821	403	1,224	0	3,498
NOV	7,723	26	1,115	201	4,353	149	1,588	2,121	3,858	650	1,390	313	1,703	0	4,558
DEC	10,818	25	918	64	5,260	148	2,277	2,780	5,205	196	910	991	1,901	0	6,245
JAN	8,984	25	816	68	4,722	146	1,883	2,883	4,912	969	66	910	976	0	4,013
FEB	8,133	16	758	87	4,473	137	2,606	1,778	4,521	(2,948)	2,712	174	2,886	0	7,420
MAR	25,755	893	1,779	1,226	5,184	111	3,722	5,929	9,763	(4,737)	1,504	4,743	6,247	0	24,626
APR	10,879	46	1,168	510	4,747	100	2,882	4,518	7,499	1,316	(1,930)	1,944	14	0	3,787
MAY	7,332	43	1,049	471	3,515	130	1,277	1,281	2,686	2,212	912	478	1,390	0	3,998
JUN	8,930	43	568	269	3,935	155	894	878	1,925	3,716	431	811	1,242	0	4,169
JUL	9,514	43	594	181	4,878	173	1,633	770	2,574	4,279	297	738	1,035	0	3,479
AUG	9,515	34	537	166	4,878	167	1,659	1,993	3,817	3,739	(666)	1,066	400	0	2,696
SEP	9,948	36	574	192	5,005	161	1,852	2,224	4,235	2,632	(174)	1,048	874	0	3,884

Note: Negative values shown in parentheses.

Table B1–4. RMA Delta Model Simulated Historical Channel Flows (cfs) and Exports (cfs) for 1968–1991

Water Year	Steamboat & Sutter	RMA DCC & Georgiana	Sac R. at Rio Vista	RMA Threemile Slough	Total Outflow	Montezuma Slough	Head of Old R.	SJR below Old R.	RMA QWEST	False River	Dutch Slough	SJR at Antioch	Old R. & Middle R.	RMA Channel Depletion	Total Exports
1968															
OCT	4,154	7,123	8,714	(613)	17,210	120	1,855	813	8,519	2,607	360	7,906	(100)	1,360	1,798
NOV	3,564	6,763	7,684	(1,048)	16,788	111	2,242	1,215	9,113	2,790	380	8,065	1,071	642	1,134
DEC	4,531	7,578	9,581	(1,054)	20,220	180	2,315	1,326	10,627	3,188	441	9,573	1,653	195	676
JAN	6,708	3,759	17,770	2,110	24,273	262	1,977	1,007	6,495	2,146	313	8,605	996	(497)	1,170
FEB	14,095	6,499	40,475	5,997	51,664	798	1,844	853	11,172	3,351	552	17,169	435	(2,031)	1,897
MAR	12,618	5,971	33,078	5,559	39,884	566	2,197	918	6,805	2,181	372	12,364	(2,150)	(449)	4,495
APR	3,439	6,963	7,594	775	10,789	(6)	1,232	198	3,214	1,162	164	3,989	(4,114)	883	5,388
MAY	3,010	6,730	6,172	1,054	7,353	(74)	791	(30)	1,217	628	84	2,271	(5,029)	1,956	5,621
JUN	2,248	6,064	4,051	1,142	3,237	(156)	514	(118)	(753)	123	9	389	(4,857)	4,521	4,716
JUL	2,593	6,557	4,581	1,451	3,202	(156)	456	(184)	(1,308)	(35)	(8)	143	(5,526)	5,185	5,177
AUG	2,780	6,657	5,211	1,176	5,213	(117)	650	(67)	62	332	42	1,238	(4,848)	4,127	4,877
SEP	2,873	6,708	5,720	1,166	6,179	(97)	832	(17)	501	443	59	1,667	(5,114)	2,693	5,612
1969															
OCT	2,451	6,191	5,172	956	5,885	(103)	1,214	121	734	510	65	1,690	(5,113)	1,148	6,260
NOV	3,134	6,762	6,774	542	10,115	(19)	1,332	274	3,334	1,206	164	3,876	(3,676)	242	5,051
DEC	6,620	9,205	15,390	298	26,155	298	1,897	776	10,723	3,119	446	11,021	(1,260)	(2,910)	3,772
JAN	20,568	8,718	93,606	13,825	125,212	2,253	8,330	5,723	31,538	8,711	1,525	45,363	3,609	(5,467)	5,759
FEB	27,723	10,906	107,248	11,494	158,589	2,888	19,035	13,721	51,298	13,993	2,350	62,792	15,033	(3,695)	4,715
MAR	18,298	7,682	52,750	(229)	93,168	1,621	18,000	12,925	40,427	11,188	1,704	40,198	14,593	453	3,409
APR	16,452	7,085	39,207	(346)	69,494	1,146	12,983	9,151	30,308	8,459	1,265	29,962	9,735	857	3,218
MAY	12,834	12,951	27,934	(5,050)	65,055	1,059	14,347	10,172	37,156	10,139	1,474	32,106	10,811	1,988	3,276
JUN	6,866	8,140	13,980	(6,786)	46,214	690	16,180	11,554	32,290	8,986	1,262	25,504	12,954	4,264	2,498
JUL	3,272	6,619	6,197	(644)	12,771	31	3,435	2,159	6,630	2,096	283	5,986	(749)	5,185	3,388
AUG	4,783	8,146	9,091	1,089	12,381	26	1,714	431	3,348	1,187	173	4,437	(4,019)	4,127	5,107
SEP	5,925	8,711	11,707	59	20,288	182	2,158	987	8,621	2,612	373	8,680	(737)	2,393	2,565
1970															
OCT	4,387	7,256	9,292	(1,042)	19,614	167	2,769	1,675	10,336	3,094	429	9,294	725	747	2,010
NOV	4,454	7,433	9,390	(1,237)	20,425	183	2,826	1,795	11,042	3,297	456	9,805	1,724	554	1,074
DEC	12,335	5,837	35,866	5,332	45,637	679	1,808	881	9,753	3,009	490	15,085	1,119	(389)	823
JAN	26,917	11,051	159,245	32,972	193,891	3,509	6,703	4,668	34,571	9,794	2,074	67,543	6,720	(5,983)	1,118
FEB	25,155	10,244	88,996	15,516	111,090	1,980	5,472	3,736	22,096	6,342	1,175	37,612	3,620	(63)	1,953
MAR	15,939	7,076	40,166	4,466	55,841	878	4,305	2,887	15,681	4,546	723	20,147	2,082	323	2,269
APR	3,523	6,974	7,586	468	11,769	13	1,353	305	4,196	1,427	198	4,664	(3,286)	983	4,660
MAY	3,379	6,880	6,947	208	11,420	5	1,714	544	4,510	1,527	207	4,718	(2,508)	2,026	4,019
JUN	2,419	6,095	4,499	592	5,779	(106)	1,939	610	1,340	686	86	1,932	(3,720)	4,387	5,005
JUL	2,808	6,657	5,078	1,230	4,792	(125)	1,039	62	(216)	252	31	1,014	(5,011)	5,185	5,237
AUG	3,478	7,231	6,630	1,127	7,903	(63)	830	28	1,333	665	93	2,460	(4,386)	4,127	4,616
SEP	4,920	8,166	9,677	676	14,755	73	983	211	5,121	1,676	240	5,797	(2,477)	2,693	3,094

Table B1–4. Continued

Water Year	Steamboat & Sutter	RMA DCC & Georgiana	Sac R. at Rio Vista	RMA Threemile Slough	Total Outflow	Montezuma Slough	Head of Old R.	SJR below Old R.	RMA QWEST	False River	Dutch Slough	SJR at Antioch	Old R. & Middle R.	RMA Channel Depletion	Total Exports
1971															
OCT	3,760	7,135	7,935	15	13,826	53	1,104	323	5,909	1,906	263	5,924	(1,542)	926	2,589
NOV	6,522	9,057	13,864	116	24,027	257	1,255	461	10,135	2,995	428	10,251	(598)	(709)	2,034
DEC	24,178	9,934	66,407	9,691	86,850	1,501	3,149	2,089	20,388	5,770	986	30,079	2,148	(4,796)	1,918
JAN	19,258	8,294	50,864	7,622	64,957	1,060	3,172	2,055	14,090	4,149	706	21,712	1,403	(363)	1,908
FEB	10,778	5,242	26,736	3,810	34,334	457	2,783	1,616	7,602	2,418	383	11,412	(358)	568	3,145
MAR	10,471	5,172	26,636	4,634	31,525	403	1,924	669	4,892	1,672	282	9,526	(2,698)	(29)	4,710
APR	13,500	6,306	32,654	6,129	37,234	514	1,531	411	4,605	1,606	293	10,734	(2,941)	864	4,438
MAY	8,704	10,792	18,634	1,859	26,622	307	1,412	320	8,015	2,390	366	9,874	(3,346)	1,654	4,557
JUN	9,247	4,783	21,964	5,173	21,548	209	1,734	402	(363)	278	78	4,810	(4,633)	3,745	5,777
JUL	5,714	9,041	10,518	2,230	11,232	4	916	(77)	782	472	83	3,012	(6,460)	5,185	6,521
AUG	6,266	9,564	11,780	2,384	12,955	38	821	(115)	1,235	591	104	3,619	(6,524)	4,127	6,713
SEP	7,037	9,833	13,893	1,396	19,831	174	868	103	5,980	1,869	282	7,376	(3,444)	2,686	3,913
1972															
OCT	4,077	7,290	8,493	138	14,420	65	1,668	534	5,947	1,900	265	6,085	(2,263)	1,216	3,819
NOV	3,972	7,354	8,369	129	14,248	62	1,261	371	5,887	1,896	264	6,016	(1,816)	586	3,052
DEC	6,262	8,849	13,068	(30)	23,086	238	1,738	704	9,995	2,965	422	9,965	(562)	(400)	2,440
JAN	6,535	3,700	16,391	2,026	22,103	219	2,076	1,044	5,718	1,942	285	7,744	494	188	1,618
FEB	7,312	4,004	18,173	3,074	21,789	213	1,943	760	3,626	1,364	213	6,700	(1,779)	420	3,871
MAR	7,958	4,309	19,500	4,771	18,625	152	1,244	108	(854)	140	53	3,917	(5,484)	898	6,694
APR	2,970	6,587	6,251	1,061	7,497	(71)	966	8	1,267	635	87	2,328	(5,451)	1,224	6,366
MAY	2,818	6,616	5,649	1,373	5,406	(112)	727	(116)	(203)	244	31	1,170	(6,015)	2,343	6,507
JUN	3,036	6,966	5,677	1,444	5,204	(116)	539	(141)	(414)	196	27	1,030	(5,440)	4,345	5,359
JUL	3,406	7,362	6,186	1,582	5,659	(107)	436	(187)	(456)	182	27	1,126	(5,495)	5,185	5,083
AUG	3,677	7,628	6,908	2,039	5,518	(109)	586	(228)	(1,331)	(69)	(2)	708	(7,008)	4,127	6,998
SEP	4,230	7,891	8,406	1,570	9,686	(27)	1,347	119	1,316	637	97	2,886	(5,877)	2,039	7,022
1973															
OCT	4,007	7,607	8,340	1,048	11,260	3	1,640	341	2,933	1,081	156	3,981	(4,782)	615	6,423
NOV	6,698	9,453	14,744	588	24,061	257	1,678	608	9,285	2,756	398	9,873	(1,589)	(1,336)	3,553
DEC	9,289	4,739	23,532	3,836	28,709	349	1,825	730	5,165	1,760	279	9,001	(1,327)	(1,288)	3,458
JAN	22,542	9,442	82,288	14,345	102,289	1,809	2,684	1,570	19,944	5,673	1,042	34,289	654	(4,842)	2,967
FEB	24,794	10,072	75,986	10,587	101,805	1,800	4,786	3,292	25,799	7,218	1,236	36,386	4,026	(1,986)	1,180
MAR	18,990	8,161	56,183	7,021	76,548	1,292	4,563	3,128	20,347	5,791	952	27,368	3,670	(1,678)	1,284
APR	6,798	3,777	17,436	2,231	23,225	240	2,685	1,513	5,805	1,938	290	8,036	(676)	926	3,357
MAY	4,185	7,469	8,527	817	12,296	23	2,125	680	3,805	1,302	185	4,622	(4,576)	2,126	6,512
JUN	3,456	7,165	6,550	1,432	6,799	(85)	1,943	441	310	369	55	1,742	(6,105)	4,521	7,367
JUL	3,467	7,413	6,317	2,140	4,139	(137)	978	(125)	(2,109)	(283)	(32)	31	(7,521)	5,185	7,707
AUG	3,865	7,713	7,285	2,125	5,916	(101)	994	(112)	(1,309)	(72)	0	816	(7,390)	4,127	7,788
SEP	4,496	7,989	8,876	1,320	11,301	4	1,218	137	2,465	949	140	3,785	(4,877)	2,486	5,777

Table B1–4. Continued

Water Year	Steamboat & Sutter	RMA DCC & Georgiana	Sac R. at Rio Vista	RMA Threemile Slough	Total Outflow	Montezuma Slough	Head of Old R.	SJR below Old R.	RMA QWEST	False River	Dutch Slough	SJR at Antioch	Old R. & Middle R.	RMA Channel Depletion	Total Exports
1974															
OCT	4,292	7,661	8,968	727	13,398	46	1,950	598	4,438	1,485	212	5,165	(3,969)	441	5,937
NOV	17,446	7,736	51,390	9,909	58,821	941	1,773	537	7,418	2,362	462	17,327	(2,997)	(539)	4,911
DEC	23,181	9,629	63,127	10,577	78,029	1,324	2,437	1,245	14,877	4,322	777	25,454	(434)	(2,320)	3,344
JAN	28,999	11,509	115,263	22,745	139,505	2,526	4,680	3,193	24,219	6,945	1,401	46,964	3,123	(2,039)	1,978
FEB	19,279	8,340	50,082	9,006	59,143	945	3,221	1,882	9,065	2,798	519	18,071	(2,227)	413	5,464
MAR	24,507	10,044	63,794	11,233	77,091	1,304	3,118	1,704	13,303	3,880	728	24,536	(3,075)	(140)	6,286
APR	25,229	10,328	93,545	18,993	109,193	1,940	3,589	2,266	15,661	4,641	965	34,654	(573)	296	4,209
MAY	8,739	10,623	18,424	1,692	26,785	310	2,763	1,260	8,385	2,464	378	10,077	(4,519)	1,689	7,143
JUN	7,026	9,805	13,706	2,115	17,202	122	2,681	1,003	3,546	1,178	190	5,661	(6,974)	3,616	9,144
JUL	5,985	9,366	11,105	3,291	8,926	(39)	1,516	(85)	(2,118)	(336)	(20)	1,173	(9,925)	4,735	10,710
AUG	6,779	9,953	12,882	3,062	12,739	35	1,456	(26)	(83)	210	58	2,979	(8,656)	4,127	9,490
SEP	7,264	9,991	14,426	1,273	21,145	199	2,036	686	6,763	2,075	312	8,036	(3,444)	2,693	5,063
1975															
OCT	5,644	8,495	11,433	328	18,981	156	2,387	1,072	7,566	2,316	333	7,894	(2,297)	950	4,603
NOV	6,356	8,871	13,026	(478)	24,382	263	2,490	1,396	11,364	3,347	477	10,886	504	515	1,952
DEC	7,564	9,960	15,766	(16)	27,729	329	2,661	1,508	11,951	3,478	505	11,935	(159)	192	2,819
JAN	6,317	3,691	15,701	3,005	17,757	134	2,550	1,222	2,060	943	150	5,065	(2,919)	379	5,482
FEB	17,211	7,620	44,811	6,803	56,709	897	3,903	2,445	11,866	3,481	588	18,669	(2,150)	(3,336)	6,728
MAR	18,674	8,093	52,629	8,187	66,398	1,090	3,566	2,167	13,763	3,984	695	21,950	(2,256)	(1,021)	6,089
APR	11,527	5,550	29,268	5,052	34,763	466	2,692	1,271	5,509	1,820	313	10,561	(3,591)	705	6,314
MAY	9,115	10,740	19,410	1,310	29,693	367	2,637	1,223	10,319	2,987	451	11,629	(3,175)	1,857	5,592
JUN	6,823	9,354	13,275	214	22,492	225	3,431	2,091	9,273	2,751	400	9,487	(1,735)	4,109	4,527
JUL	4,703	8,172	8,713	1,400	10,718	(6)	1,312	185	2,070	840	125	3,470	(4,700)	5,085	5,194
AUG	5,214	8,648	9,886	2,453	9,465	(30)	1,488	32	(369)	155	40	2,084	(8,044)	3,577	9,004
SEP	5,621	8,772	11,009	1,776	13,582	50	2,033	497	2,616	964	151	4,392	(6,164)	2,682	7,811
1976															
OCT	5,282	8,245	10,838	742	16,624	110	3,005	1,541	5,797	1,825	267	6,539	(4,573)	498	7,574
NOV	6,384	9,180	12,936	1,311	18,485	147	2,720	1,172	5,558	1,742	263	6,869	(5,356)	621	8,023
DEC	7,464	10,236	15,232	1,664	21,362	204	2,643	1,095	6,139	1,890	291	7,803	(5,247)	541	7,834
JAN	3,650	7,350	7,687	1,126	9,870	(23)	2,442	876	2,188	875	126	3,314	(5,825)	564	8,274
FEB	2,821	6,605	6,064	1,180	6,801	(84)	1,774	337	743	497	68	1,923	(5,957)	533	8,086
MAR	3,425	7,239	7,184	1,583	7,517	(70)	1,607	181	348	378	57	1,931	(6,763)	841	8,366
APR	2,824	6,504	5,995	650	8,335	(54)	1,100	154	2,358	948	127	3,008	(3,937)	949	5,046
MAY	2,220	5,960	4,457	947	4,609	(128)	818	(14)	190	370	41	1,137	(4,884)	2,163	5,497
JUN	2,130	5,899	3,780	912	3,476	(151)	634	(30)	(243)	268	26	669	(4,180)	4,490	4,158
JUL	2,443	6,331	4,288	1,076	3,860	(144)	523	(83)	(357)	230	24	719	(4,391)	5,185	4,117
AUG	2,895	6,867	5,534	1,611	4,428	(131)	955	(58)	(1,054)	19	2	557	(6,364)	3,477	6,848
SEP	2,687	6,555	5,440	1,767	3,801	(144)	1,069	(95)	(1,607)	(140)	(18)	160	(7,463)	1,998	8,344

Table B1–4. Continued

Water Year	Steamboat & Sutter	RMA DCC & Georgiana	Sac R. at Rio Vista	RMA Threemile Slough	Total Outflow	Montezuma Slough	Head of Old R.	SJR below Old R.	RMA QWEST	False River	Dutch Slough	SJR at Antioch	Old R. & Middle R.	RMA Channel Depletion	Total Exports
1977															
OCT	1,526	4,747	3,132	397	3,974	(141)	1,066	169	860	582	62	1,257	(3,586)	910	4,614
NOV	1,477	4,580	3,076	294	4,211	(136)	961	156	1,145	662	72	1,439	(3,250)	640	4,250
DEC	1,479	4,478	3,134	(82)	5,518	(110)	784	174	2,390	1,009	118	2,308	(1,967)	487	2,789
JAN	1,919	5,568	4,151	1,099	3,639	(147)	1,075	18	(518)	178	15	581	(5,920)	269	7,055
FEB	1,508	4,694	3,182	406	4,056	(139)	733	54	879	588	63	1,285	(3,526)	454	4,343
MAR	1,205	3,996	2,446	363	2,854	(163)	527	(4)	422	483	45	785	(3,241)	556	3,820
APR	1,103	3,590	2,012	(127)	3,625	(148)	158	(31)	1,641	834	87	1,514	(1,284)	1,482	1,297
MAY	1,419	4,490	2,756	243	3,780	(145)	358	(44)	1,051	647	67	1,294	(2,791)	1,436	2,992
JUN	1,209	3,988	1,717	73	2,423	(172)	14	(89)	764	595	55	837	(1,361)	4,181	740
JUL	1,468	4,640	2,143	213	2,728	(167)	(15)	(123)	655	554	54	868	(1,748)	5,185	847
AUG	1,366	4,436	2,100	273	2,467	(171)	58	(120)	427	492	45	700	(2,145)	4,127	1,532
SEP	1,239	4,054	2,156	134	3,037	(160)	150	(81)	918	628	62	1,052	(2,038)	2,341	1,859
1978															
OCT	813	2,727	1,366	(166)	2,614	(168)	171	8	1,273	755	73	1,107	(740)	1,496	764
NOV	1,246	3,995	2,576	48	4,105	(138)	414	14	1,533	788	85	1,581	(2,196)	390	2,655
DEC	2,505	6,143	6,005	760	8,107	(58)	645	(58)	2,066	844	107	2,826	(4,899)	(1,535)	5,923
JAN	16,353	7,416	58,407	11,569	66,690	1,100	2,040	461	8,217	2,474	500	19,786	(6,718)	(5,799)	9,863
FEB	16,078	7,246	46,781	8,249	55,718	878	4,590	2,829	8,913	2,681	490	17,162	(5,279)	(2,312)	10,327
MAR	20,618	8,761	65,928	9,954	85,057	1,464	6,916	4,669	19,107	5,471	946	29,061	1,440	(2,345)	5,929
APR	13,839	6,167	34,223	(338)	60,752	974	11,796	8,267	26,533	7,466	1,107	26,195	8,602	(108)	3,277
MAY	7,626	8,749	16,185	(4,287)	42,103	610	11,235	7,850	25,951	7,246	1,025	21,664	8,043	1,442	3,063
JUN	2,788	6,226	5,444	(54)	9,544	(32)	4,258	2,638	4,143	1,404	188	4,089	(3,922)	3,791	7,633
JUL	3,152	7,171	5,698	1,974	3,569	(148)	1,562	123	(2,064)	(267)	(33)	(90)	(7,359)	5,185	8,102
AUG	3,830	7,583	7,255	2,120	5,886	(102)	1,274	(40)	(1,309)	(80)	(1)	811	(7,801)	4,127	8,440
SEP	4,708	7,985	9,305	1,362	11,927	17	2,067	550	2,662	987	148	4,024	(5,787)	2,445	7,499
1979															
OCT	2,790	6,185	5,905	41	10,095	(20)	2,305	959	4,216	1,451	194	4,257	(3,020)	1,539	5,133
NOV	2,785	6,234	6,115	42	10,509	(12)	2,431	1,070	4,392	1,497	201	4,434	(3,138)	328	5,581
DEC	3,009	6,585	6,522	458	9,905	(23)	2,097	718	3,389	1,221	166	3,847	(3,946)	404	6,062
JAN	7,699	4,079	20,459	1,798	29,978	373	3,294	2,085	9,470	2,867	416	11,268	(155)	(3,365)	4,111
FEB	11,236	5,330	29,654	1,849	45,821	682	4,349	2,922	16,135	4,620	690	17,984	2,026	(3,145)	2,944
MAR	10,006	4,860	24,762	1,700	37,636	522	5,210	3,465	12,876	3,786	566	14,576	978	(277)	4,355
APR	5,265	3,340	13,098	2,398	15,207	83	2,441	1,070	2,127	944	145	4,525	(3,431)	793	5,891
MAY	4,880	7,643	9,908	1,013	14,103	60	1,887	506	4,231	1,411	204	5,244	(4,574)	1,982	6,256
JUN	2,564	6,187	4,803	1,016	4,994	(121)	1,711	351	250	372	46	1,266	(5,302)	4,435	6,351
JUL	3,957	7,823	7,400	2,526	4,864	(122)	1,253	(114)	(2,477)	(398)	(43)	49	(8,736)	4,334	9,356
AUG	3,684	7,634	6,920	2,710	3,440	(150)	1,389	(120)	(3,421)	(654)	(78)	(711)	(9,591)	4,127	10,380
SEP	3,366	7,201	6,656	2,001	5,225	(115)	1,617	101	(1,389)	(97)	(6)	612	(8,009)	2,693	9,277

Table B1–4. Continued

Water Year	Steamboat & Sutter	RMA DCC & Georgiana	Sac R. at Rio Vista	RMA Threemile Slough	Total Outflow	Montezuma Slough	Head of Old R.	SJR below Old R.	RMA QWEST	False River	Dutch Slough	SJR at Antioch	Old R. & Middle R.	RMA Channel Depletion	Total Exports
1980															
OCT	2,799	6,380	6,057	880	7,724	(66)	2,145	635	1,681	750	102	2,561	(5,564)	622	7,744
NOV	3,729	7,167	7,949	614	11,968	17	1,813	510	4,021	1,377	194	4,635	(4,016)	359	5,866
DEC	5,679	8,651	12,848	1,044	19,266	163	1,924	603	6,397	1,978	290	7,441	(3,829)	(940)	5,984
JAN	21,934	9,193	91,354	14,499	118,796	2,130	7,878	5,378	27,393	7,643	1,366	41,892	2,291	(4,238)	6,389
FEB	19,415	8,319	91,394	13,598	121,471	2,177	11,052	7,695	30,059	8,413	1,476	43,657	5,215	(1,717)	6,417
MAR	20,602	8,581	64,618	4,722	98,901	1,739	14,784	10,489	34,292	9,553	1,517	39,014	10,446	216	4,348
APR	7,543	3,951	18,625	1,055	29,034	353	6,161	4,108	10,414	3,154	459	11,469	839	703	5,352
MAY	4,201	6,578	8,939	(1,838)	21,478	203	5,886	3,929	12,571	3,676	507	10,733	1,078	1,777	4,639
JUN	4,680	7,695	9,102	231	15,138	79	3,255	1,869	6,089	1,911	271	6,320	(3,286)	3,888	5,971
JUL	4,516	7,967	8,500	1,287	10,709	(7)	2,355	827	2,270	889	132	3,557	(5,263)	4,625	6,881
AUG	3,418	7,359	6,444	2,184	4,251	(134)	1,667	122	(2,137)	(297)	(34)	47	(8,168)	4,127	9,228
SEP	3,888	7,457	7,719	1,066	10,053	(20)	2,612	1,068	2,379	925	133	3,445	(5,429)	2,693	7,695
1981															
OCT	2,406	5,891	5,072	284	7,826	(65)	2,720	1,293	2,779	1,062	139	3,063	(4,106)	1,494	6,705
NOV	2,284	5,720	4,933	333	7,440	(72)	2,340	906	2,519	995	128	2,852	(4,184)	901	6,467
DEC	4,262	7,718	8,906	868	12,858	35	2,202	752	3,950	1,350	194	4,818	(4,566)	294	6,775
JAN	4,971	8,152	12,015	1,169	17,469	127	2,450	927	5,411	1,691	244	6,580	(5,288)	(2,488)	8,279
FEB	8,082	4,350	20,588	4,684	20,824	195	2,175	706	242	438	97	4,926	(5,019)	158	7,252
MAR	8,182	4,320	20,870	3,268	25,895	294	2,221	957	5,012	1,697	264	8,280	(2,270)	(1,484)	4,843
APR	4,460	7,905	9,221	1,423	11,625	11	2,027	508	2,420	925	140	3,843	(6,041)	683	8,103
MAY	3,191	6,799	6,584	439	10,034	(21)	1,482	376	3,487	1,251	169	3,926	(3,112)	1,808	4,486
JUN	2,116	5,768	3,874	592	4,662	(128)	1,114	194	844	561	65	1,436	(3,470)	4,027	4,039
JUL	3,501	7,493	6,364	1,948	4,822	(123)	1,075	(40)	(1,472)	(104)	(9)	476	(6,773)	5,185	7,058
AUG	3,370	7,449	6,291	2,453	3,125	(156)	1,213	(127)	(3,107)	(556)	(69)	(654)	(8,726)	4,127	9,332
SEP	2,754	6,647	5,435	1,423	4,859	(123)	1,059	0	(534)	159	20	889	(6,098)	2,693	6,808
1982															
OCT	1,969	5,507	4,260	718	5,005	(120)	1,221	161	757	530	63	1,475	(4,673)	543	5,941
NOV	11,399	5,553	31,067	6,180	34,406	460	1,290	277	3,330	1,271	240	9,510	(3,416)	119	4,725
DEC	23,487	9,788	77,525	15,985	88,167	1,528	1,518	387	10,632	3,234	692	26,617	(3,362)	(1,480)	5,176
JAN	24,477	10,039	77,476	12,666	98,412	1,734	2,697	1,412	20,868	5,820	1,045	33,534	(1,443)	(5,411)	5,185
FEB	22,362	9,362	77,119	14,340	92,459	1,613	4,180	2,523	15,328	4,388	858	29,668	(5,007)	(1,221)	9,469
MAR	23,699	9,735	59,443	7,892	79,618	1,354	6,187	4,034	20,134	5,560	942	28,026	(3,525)	(3,627)	10,436
APR	29,810	11,606	103,837	14,828	141,639	2,573	13,550	9,516	37,790	10,330	1,820	52,618	4,291	(1,753)	9,619
MAY	13,437	13,525	28,907	(2,743)	59,304	946	10,985	7,631	30,428	8,271	1,218	27,685	4,903	1,492	6,004
JUN	7,698	9,666	15,498	(567)	28,916	351	4,480	2,936	13,461	3,849	557	12,894	30	3,711	3,942
JUL	4,563	7,588	8,696	(400)	16,416	104	3,652	2,299	7,783	2,386	334	7,383	(1,189)	4,963	4,039
AUG	5,657	8,827	10,698	1,641	13,437	47	2,716	1,122	2,796	1,011	157	4,437	(6,015)	4,127	8,110
SEP	7,308	9,801	14,915	149	25,618	287	3,746	2,343	10,725	3,138	458	10,874	(1,617)	940	5,292

Table B1–4. Continued

Water Year	Steamboat & Sutter	RMA DCC & Georgiana	Sac R. at Rio Vista	RMA Threemile Slough	Total Outflow	Montezuma Slough	Head of Old R.	SJR below Old R.	RMA QWEST	False River	Dutch Slough	SJR at Antioch	Old R. & Middle R.	RMA Channel Depletion	Total Exports
1983															
OCT	5,398	7,898	11,207	(1,047)	22,974	234	4,942	3,234	11,779	3,443	487	10,732	(383)	648	5,294
NOV	10,891	5,238	27,045	2,901	37,812	526	4,292	2,744	10,740	3,185	489	13,641	(1,539)	(1,162)	6,082
DEC	21,555	8,962	62,083	5,961	90,482	1,572	9,867	6,788	28,361	7,793	1,260	34,322	2,079	(3,402)	8,443
JAN	17,301	7,518	62,748	6,388	90,525	1,573	11,367	7,879	27,731	7,649	1,238	34,119	1,973	(3,618)	10,103
FEB	30,932	11,971	128,427	19,671	175,471	3,186	18,502	13,255	47,018	12,817	2,318	66,689	8,768	(2,505)	10,263
MAR	30,516	12,170	198,181	38,249	266,543	4,946	23,315	16,988	68,302	18,477	3,596	106,551	18,981	(4,909)	5,381
APR	22,844	9,214	69,252	1,373	117,884	2,117	21,169	15,332	48,645	13,361	2,080	50,018	17,368	411	3,820
MAY	20,698	19,790	45,894	(5,835)	99,031	1,733	18,487	13,302	53,164	14,247	2,135	47,329	15,136	1,060	3,299
JUN	17,647	7,519	41,262	(108)	72,289	1,201	15,167	10,770	31,072	8,653	1,298	30,964	9,774	3,016	5,018
JUL	10,589	4,993	24,656	(234)	43,582	636	11,219	7,810	18,989	5,440	792	18,755	5,177	5,185	5,216
AUG	7,276	9,667	14,300	84	24,685	268	5,381	3,488	10,438	3,034	444	10,522	(2,423)	4,127	7,203
SEP	7,276	9,274	14,896	(1,740)	31,635	404	6,707	4,527	16,771	4,764	679	15,031	2,274	1,899	4,210
1984															
OCT	6,177	8,113	12,987	(3,119)	32,760	426	7,886	5,411	19,791	5,612	787	16,672	5,266	1,037	2,501
NOV	17,830	7,681	47,711	3,645	71,985	1,200	6,528	4,485	24,229	6,792	1,056	27,874	5,202	(2,153)	1,757
DEC	29,280	11,494	116,958	18,154	157,197	2,859	11,328	7,975	40,195	11,108	1,997	58,349	9,889	(3,621)	2,146
JAN	21,234	8,777	64,836	3,931	101,812	1,797	15,049	10,723	36,980	10,311	1,625	40,911	13,345	123	1,723
FEB	11,249	5,352	28,426	2,531	41,377	594	6,504	4,352	12,943	3,809	580	15,474	833	(34)	5,984
MAR	10,857	5,264	27,156	3,862	34,834	467	4,590	2,924	7,690	2,408	386	11,552	(2,342)	561	6,929
APR	5,765	3,526	14,513	3,144	15,254	85	2,857	1,393	761	565	98	3,905	(4,852)	1,115	7,697
MAY	3,801	7,199	7,778	530	11,877	15	2,257	850	4,136	1,403	195	4,666	(3,859)	2,075	5,939
JUN	3,478	7,172	6,597	1,193	7,639	(68)	1,728	376	1,102	592	84	2,295	(5,100)	4,521	6,175
JUL	5,931	9,293	10,915	2,908	9,778	(23)	1,615	58	(1,066)	(43)	17	1,842	(8,633)	5,185	9,474
AUG	4,908	8,450	9,223	2,470	8,241	(54)	1,803	192	(922)	7	18	1,548	(8,290)	4,120	9,532
SEP	4,630	7,885	9,231	736	13,787	53	2,091	721	4,593	1,523	218	5,329	(3,676)	2,280	5,507
1985															
OCT	3,066	6,420	6,685	(74)	11,875	14	2,683	1,337	5,202	1,708	233	5,128	(2,898)	643	5,615
NOV	7,727	10,277	17,625	2,082	24,293	262	2,225	680	6,647	2,004	312	8,729	(5,613)	(513)	8,009
DEC	11,247	5,493	28,604	5,365	32,636	425	3,157	1,677	4,020	1,407	251	9,385	(5,013)	(1,385)	8,479
JAN	5,343	3,381	13,545	2,456	15,837	96	2,707	1,380	2,288	993	151	4,744	(3,010)	(213)	5,846
FEB	5,872	3,580	14,883	3,379	15,173	84	2,373	876	293	440	82	3,672	(5,138)	(69)	7,628
MAR	3,390	6,888	7,583	1,054	9,934	(22)	2,162	605	2,350	900	129	3,404	(6,234)	(510)	8,631
APR	2,783	6,298	6,005	835	7,754	(66)	1,939	492	1,775	776	106	2,610	(5,380)	928	7,354
MAY	3,052	6,721	6,184	879	7,928	(62)	1,651	348	1,782	779	104	2,661	(4,766)	2,158	6,226
JUN	2,869	6,758	5,347	1,395	4,771	(125)	1,403	162	(518)	163	21	877	(5,748)	4,320	6,540
JUL	3,765	7,758	6,823	2,328	4,443	(130)	2,000	337	(2,309)	(344)	(38)	19	(8,255)	5,185	9,482
AUG	2,888	6,952	5,356	2,191	2,284	(174)	2,070	364	(3,012)	(526)	(69)	(821)	(8,644)	4,127	10,129
SEP	2,562	6,460	5,072	1,692	3,369	(152)	1,651	165	(1,664)	(152)	(22)	28	(7,387)	2,483	8,733

Table B1–4. Continued

Water Year	Steamboat & Sutter	RMA DCC & Georgiana	Sac R. at Rio Vista	RMA Threemile Slough	Total Outflow	Montezuma Slough	Head of Old R.	SJR below Old R.	RMA QWEST	False River	Dutch Slough	SJR at Antioch	Old R. & Middle R.	RMA Channel Depletion	Total Exports
1986															
OCT	1,904	5,482	4,052	1,051	3,574	(148)	1,731	314	(462)	192	17	589	(5,952)	808	7,717
NOV	2,121	5,695	4,707	908	5,262	(115)	1,652	293	539	455	54	1,447	(5,600)	52	7,341
DEC	4,010	7,566	9,150	1,690	10,738	(5)	1,937	341	1,571	665	100	3,261	(7,544)	(1,529)	9,876
JAN	5,547	8,506	12,059	1,686	15,842	96	1,819	306	3,767	1,235	188	5,453	(6,824)	(1,602)	9,086
FEB	26,245	10,972	175,436	38,298	208,706	3,774	5,411	3,619	33,192	9,371	2,125	71,490	652	(6,965)	6,085
MAR	29,125	11,427	123,142	18,572	168,171	3,057	14,710	10,469	45,001	12,395	2,220	63,573	12,016	(2,552)	3,205
APR	8,825	4,227	22,722	(1,720)	45,132	667	11,556	8,063	22,415	6,360	913	20,695	6,882	649	4,704
MAY	3,076	5,663	6,772	(1,327)	15,983	94	5,256	3,431	9,238	2,777	377	7,911	(1,085)	1,668	6,271
JUN	2,551	5,823	5,021	(313)	9,594	(31)	3,751	2,302	4,624	1,550	204	4,311	(2,913)	3,776	6,186
JUL	4,125	7,870	7,617	1,982	6,946	(81)	2,151	520	(604)	110	25	1,378	(7,252)	5,148	8,622
AUG	3,506	7,355	6,654	2,033	5,096	(118)	2,365	636	(1,499)	(130)	(10)	534	(8,192)	4,127	9,968
SEP	4,784	8,170	9,530	1,824	10,875	(3)	2,899	1,197	1,378	625	102	3,202	(7,762)	1,814	10,507
1987															
OCT	3,794	7,229	7,845	816	11,102	0	2,601	1,078	3,283	1,167	166	4,099	(5,136)	1,541	7,579
NOV	2,837	6,364	6,082	645	8,516	(51)	2,128	677	2,448	960	129	3,093	(4,787)	996	6,871
DEC	2,990	6,511	6,527	499	9,787	(26)	2,594	1,117	3,263	1,178	161	3,762	(4,605)	359	7,273
JAN	3,004	6,565	6,597	592	9,649	(28)	1,832	492	3,040	1,118	151	3,632	(4,336)	90	6,262
FEB	4,542	7,773	10,490	705	16,257	103	1,790	471	5,732	1,780	251	6,437	(4,400)	(3,025)	6,857
MAR	7,083	3,939	18,336	2,997	22,379	225	2,398	1,086	4,029	1,433	220	7,026	(2,769)	(1,664)	5,610
APR	2,552	6,139	5,516	687	7,338	(74)	2,150	695	1,849	807	107	2,536	(4,825)	1,043	7,033
MAY	2,000	5,459	4,027	470	5,341	(114)	1,639	408	1,352	691	82	1,822	(3,863)	2,212	5,322
JUN	1,913	5,474	3,368	808	3,058	(159)	1,494	302	(249)	266	24	559	(4,337)	4,521	5,192
JUL	3,445	7,450	6,281	2,370	3,353	(152)	1,417	(14)	(2,858)	(489)	(60)	(488)	(8,332)	5,185	8,968
AUG	3,235	7,251	6,082	2,437	2,808	(163)	1,475	(31)	(3,215)	(588)	(73)	(778)	(8,915)	4,127	9,817
SEP	2,370	6,288	4,637	1,890	1,964	(180)	1,450	24	(2,632)	(412)	(58)	(742)	(7,929)	2,693	9,084
1988															
OCT	1,856	5,378	3,905	763	4,210	(136)	1,190	136	325	416	45	1,088	(4,738)	998	5,919
NOV	1,537	4,750	3,299	491	4,004	(140)	1,315	234	704	533	57	1,195	(4,075)	342	5,470
DEC	3,850	7,608	8,344	1,824	8,886	(42)	1,321	5	522	401	62	2,346	(7,431)	(696)	9,001
JAN	8,477	4,569	22,970	6,164	20,340	186	1,531	31	(2,650)	(385)	(9)	3,514	(8,402)	(2,002)	10,435
FEB	2,734	6,693	5,821	2,117	3,423	(150)	1,475	(32)	(2,391)	(362)	(45)	(274)	(8,864)	552	10,399
MAR	2,369	6,103	5,084	1,273	4,724	(126)	1,862	358	(339)	211	26	934	(6,534)	822	8,456
APR	4,300	7,899	8,771	1,743	9,810	(24)	1,799	292	1,062	558	88	2,805	(6,782)	1,128	8,585
MAY	2,261	5,944	4,663	866	5,245	(116)	1,444	230	613	479	57	1,479	(4,958)	1,712	6,274
JUN	2,061	5,764	3,811	1,036	3,147	(157)	1,354	185	(611)	159	12	425	(5,087)	3,791	5,910
JUL	3,265	7,299	5,931	2,142	3,444	(151)	1,183	(56)	(2,417)	(362)	(45)	(275)	(7,577)	5,185	7,981
AUG	2,838	6,884	5,295	2,109	2,428	(171)	1,382	(8)	(2,808)	(465)	(61)	(699)	(7,985)	4,127	8,809
SEP	2,343	6,256	4,581	1,665	2,566	(168)	1,311	19	(1,974)	(228)	(34)	(309)	(7,118)	2,693	8,133

Table B1–4. Continued

Water Year	Steamboat & Sutter	RMA DCC & Georgiana	Sac R. at Rio Vista	RMA Threemile Slough	Total Outflow	Montezuma Slough	Head of Old R.	SJR below Old R.	RMA QWEST	False River	Dutch Slough	SJR at Antioch	Old R. & Middle R.	RMA Channel Depletion	Total Exports
1989															
OCT	1,785	5,317	3,655	808	3,614	(148)	997	68	(17)	328	32	791	(4,711)	1,393	5,642
NOV	2,381	6,090	5,190	847	6,291	(95)	1,156	118	1,102	611	78	1,949	(4,867)	348	6,099
DEC	2,694	6,492	5,868	1,160	6,540	(89)	1,283	100	663	477	63	1,823	(5,808)	156	7,197
JAN	2,790	6,762	6,110	2,065	4,110	(137)	1,342	(79)	(1,998)	(262)	(31)	67	(8,715)	(47)	10,213
FEB	2,569	6,390	5,682	1,442	5,294	(114)	1,226	7	(383)	187	26	1,059	(6,855)	23	8,216
MAR	15,506	7,089	36,841	8,420	37,353	518	1,831	201	522	460	155	8,942	(8,252)	(432)	10,279
APR	6,971	4,016	17,152	5,336	12,791	38	1,760	140	(4,342)	(815)	(78)	994	(8,676)	995	10,464
MAY	3,164	6,873	6,412	995	7,970	(61)	1,537	277	1,595	727	99	2,590	(4,914)	2,222	6,231
JUN	2,866	6,724	5,364	1,105	5,711	(107)	1,231	162	407	421	55	1,512	(4,686)	4,426	5,281
JUL	4,804	8,617	8,742	2,942	5,883	(101)	1,208	(155)	(2,788)	(489)	(49)	154	(9,085)	5,185	9,532
AUG	4,670	8,545	8,706	3,326	4,644	(125)	1,249	(259)	(4,005)	(825)	(94)	(679)	(10,612)	4,008	11,338
SEP	4,094	7,939	8,336	2,579	6,417	(90)	1,416	(97)	(1,900)	(250)	(19)	679	(9,306)	901	10,772
1990															
OCT	3,285	7,270	6,851	2,317	4,621	(126)	1,443	(63)	(2,216)	(323)	(35)	101	(9,052)	730	10,547
NOV	3,156	7,053	6,703	2,020	5,302	(113)	1,355	(44)	(1,395)	(97)	(6)	625	(8,279)	426	9,703
DEC	3,699	7,601	7,675	2,362	5,950	(100)	1,430	(64)	(1,716)	(194)	(15)	646	(8,990)	589	10,461
JAN	4,826	8,421	9,908	2,516	9,423	(30)	1,310	(106)	(492)	116	35	2,024	(8,869)	(13)	10,296
FEB	3,652	7,524	7,915	2,519	5,916	(100)	1,573	(58)	(2,004)	(291)	(26)	515	(9,894)	(465)	11,704
MAR	2,703	6,540	5,808	1,947	3,917	(141)	1,631	72	(1,875)	(222)	(26)	72	(8,533)	602	10,235
APR	3,854	7,651	7,893	2,309	6,472	(90)	1,363	(69)	(1,394)	(108)	(3)	915	(8,643)	1,258	10,006
MAY	2,147	5,559	4,618	80	7,660	(68)	1,003	225	3,064	1,162	147	3,144	(2,375)	1,070	3,398
JUN	2,095	5,661	3,953	459	5,231	(117)	824	104	1,330	693	82	1,789	(3,149)	3,512	3,498
JUL	2,887	6,878	5,205	1,667	3,642	(147)	854	(75)	(1,494)	(97)	(13)	173	(6,190)	5,185	6,257
AUG	2,894	6,841	5,435	1,594	4,296	(134)	879	(65)	(1,079)	13	1	515	(6,184)	4,127	6,472
SEP	2,025	5,740	3,943	1,188	2,918	(162)	830	(46)	(984)	57	0	204	(5,578)	2,674	6,126
1991															
OCT	1,435	4,417	2,883	193	4,167	(137)	806	130	1,307	711	78	1,500	(2,795)	1,246	3,549
NOV	1,463	4,482	3,039	199	4,444	(131)	918	162	1,417	739	82	1,616	(2,949)	807	3,858
DEC	2,221	5,865	4,860	669	6,263	(95)	862	55	1,403	701	88	2,072	(4,264)	348	5,205
JAN	1,729	5,134	3,741	567	4,550	(129)	776	38	817	559	63	1,384	(4,061)	458	4,912
FEB	1,535	4,744	3,277	452	4,090	(138)	721	36	813	568	61	1,265	(3,734)	373	4,521
MAR	8,608	4,576	22,478	5,544	21,439	208	1,671	158	(1,059)	36	47	4,485	(7,692)	(1,642)	9,763
APR	2,239	5,874	4,844	1,241	4,392	(132)	1,141	13	(429)	190	22	812	(6,363)	932	7,499
MAY	1,401	4,207	2,738	(60)	4,701	(127)	777	160	1,995	902	101	1,935	(2,102)	1,712	2,686
JUN	1,712	4,929	3,287	39	5,373	(114)	405	30	2,126	931	109	2,165	(1,897)	2,737	1,925
JUL	1,751	5,225	2,860	552	2,944	(162)	401	(38)	154	394	38	706	(3,020)	5,157	2,574
AUG	1,773	5,300	3,122	777	2,716	(166)	439	(83)	(348)	250	20	429	(3,998)	3,999	3,817
SEP	1,930	5,487	3,757	725	4,046	(140)	512	(62)	330	425	46	1,055	(4,083)	2,693	4,235

Note: Negative values shown in parentheses.

Table B1–5. Simulated Historical Percentage Source Contributions at the CCWD Diversion and SWP and CVP Export Locations

	CCWD Pump #1 (RMA Node No. 206)						SWP Pump (RMA Node No. 193)						CVP Pump (RMA Node No. 181)					
Water Year	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary
1968																		
OCT	53.9	15.8	0.0	21.3	9.0	0.00	11.4	81.4	0.0	3.9	3.3	0.00	3.3	92.2	0.0	1.2	3.3	0.00
NOV	7.7	85.1	0.0	3.8	3.5	0.00	0.2	99.3	0.0	0.1	0.4	0.00	0.0	98.8	0.0	0.0	1.2	0.00
DEC	0.5	97.7	0.0	0.2	0.1	0.00	0.0	99.3	0.0	0.0	0.0	0.00	0.0	99.4	0.0	0.0	0.0	0.00
JAN	1.1	79.8	0.0	0.2	17.6	0.00	0.0	95.3	0.0	0.0	4.4	0.00	0.0	88.2	0.0	0.0	11.4	0.00
FEB	2.2	50.3	0.0	1.7	43.7	0.00	0.0	87.3	0.0	0.0	11.4	0.00	0.0	82.4	0.0	0.0	17.1	0.00
MAR	37.3	20.9	0.0	28.4	12.9	0.00	22.5	39.7	0.0	25.5	11.9	0.00	10.2	70.1	0.0	11.5	8.0	0.00
APR	84.4	2.6	0.1	11.5	1.3	0.00	70.8	11.5	0.1	16.0	1.6	0.00	52.5	34.3	0.0	11.7	1.4	0.00
MAY	91.0	0.3	0.1	3.9	4.7	0.00	90.3	2.6	0.1	6.2	0.8	0.00	79.6	12.6	0.1	5.6	2.2	0.00
JUN	90.0	0.1	0.2	1.1	8.6	0.11	91.8	0.4	0.1	2.0	5.7	0.06	89.4	1.7	0.1	1.7	6.9	0.07
JUL	88.4	0.0	0.1	0.3	10.4	0.70	92.0	0.1	0.1	0.5	6.9	0.44	91.1	0.3	0.1	0.4	7.6	0.48
AUG	89.9	0.0	0.1	0.4	9.1	0.56	92.2	0.6	0.0	0.6	6.1	0.41	87.3	4.3	0.0	0.6	7.3	0.38
SEP	92.9	0.0	0.0	0.8	6.0	0.28	93.1	1.6	0.0	1.2	3.8	0.19	81.5	12.1	0.0	1.1	5.2	0.17
1969																		
OCT	96.1	0.0	0.0	1.2	2.6	0.15	93.4	3.3	0.0	1.8	1.5	0.10	71.0	25.5	0.0	1.3	2.1	0.07
NOV	95.6	0.3	0.0	2.7	0.3	0.03	85.0	10.0	0.0	3.0	0.9	0.02	49.5	47.4	0.0	1.7	0.5	0.01
DEC	49.7	9.7	0.0	5.4	31.6	0.00	24.5	48.4	0.0	2.6	22.0	0.00	5.3	63.1	0.0	0.6	29.7	0.00
JAN	0.1	39.0	0.0	0.2	58.4	0.00	0.0	94.1	0.0	0.0	5.6	0.00	0.0	83.0	0.0	0.0	16.5	0.00
FEB	0.0	69.8	0.0	0.0	29.3	0.00	0.0	97.9	0.0	0.0	1.9	0.00	0.0	91.1	0.0	0.0	8.8	0.00
MAR	0.0	99.6	0.0	0.0	0.4	0.00	0.0	99.9	0.0	0.0	0.1	0.00	0.0	99.8	0.0	0.0	0.2	0.00
APR	0.0	98.9	0.0	0.0	1.1	0.00	0.0	100.0	0.0	0.0	0.0	0.00	0.0	99.5	0.0	0.0	0.5	0.00
MAY	0.0	92.1	0.0	0.0	7.9	0.00	0.0	99.7	0.0	0.0	0.3	0.00	0.0	97.2	0.0	0.0	2.8	0.00
JUN	0.0	88.0	0.0	0.0	12.0	0.00	0.0	99.2	0.0	0.0	0.8	0.00	0.0	95.9	0.0	0.0	4.1	0.00
JUL	20.9	58.4	0.0	5.3	15.5	0.00	2.6	86.9	0.0	1.3	9.2	0.00	0.6	91.8	0.0	0.3	7.2	0.00
AUG	82.2	4.0	0.0	4.3	9.4	0.00	72.1	14.8	0.0	6.2	6.9	0.00	55.1	32.7	0.0	4.7	7.6	0.00
SEP	65.1	14.7	0.0	9.8	10.4	0.00	38.8	49.2	0.0	5.1	7.0	0.00	14.5	77.5	0.0	2.1	5.9	0.00
1970																		
OCT	20.0	70.2	0.0	4.7	5.2	0.00	0.1	99.6	0.0	0.0	0.3	0.00	0.0	99.1	0.0	0.0	0.9	0.00
NOV	0.5	97.8	0.0	0.2	1.5	0.00	0.0	99.8	0.0	0.0	0.2	0.00	0.0	98.7	0.0	0.0	1.3	0.00
DEC	0.9	83.5	0.0	0.5	12.5	0.00	0.0	94.5	0.0	0.0	4.6	0.00	0.0	90.6	0.0	0.0	6.4	0.00
JAN	0.0	38.2	0.0	0.1	59.5	0.00	0.0	88.4	0.0	0.0	10.7	0.00	0.0	64.0	0.0	0.0	35.1	0.00
FEB	0.0	94.9	0.0	0.0	5.0	0.00	0.0	99.2	0.0	0.0	0.8	0.00	0.0	98.6	0.0	0.0	1.4	0.00
MAR	0.1	97.4	0.0	0.2	2.3	0.00	0.0	99.7	0.0	0.0	0.3	0.00	0.0	99.5	0.0	0.0	0.5	0.00
APR	72.6	10.6	0.0	15.6	1.3	0.00	54.5	25.0	0.0	19.8	0.6	0.00	39.5	45.9	0.0	13.7	0.9	0.00
MAY	80.5	5.2	0.0	9.2	5.1	0.00	65.2	21.5	0.0	12.1	1.1	0.00	43.2	46.3	0.0	7.6	2.8	0.00
JUN	85.8	1.9	0.0	3.0	9.3	0.00	75.9	12.9	0.0	4.3	6.8	0.00	53.9	35.6	0.0	2.9	7.6	0.00
JUL	87.7	0.2	0.0	1.5	10.6	0.08	88.2	2.1	0.0	2.2	7.3	0.05	79.5	9.9	0.0	2.0	8.5	0.05
AUG	89.6	0.0	0.0	1.8	8.5	0.06	89.4	1.6	0.0	2.6	6.3	0.05	80.8	9.2	0.0	2.3	7.6	0.04
SEP	88.4	0.1	0.0	4.2	7.3	0.01	82.4	6.7	0.0	4.6	6.2	0.01	63.8	25.1	0.0	3.7	7.4	0.01

Table B1–5. Continued

Water Year	CCWD Pump #1 (RMA Node No. 206)						SWP Pump (RMA Node No. 193)						CVP Pump (RMA Node No. 181)					
	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary
1971																		
OCT	87.1	1.5	0.0	7.5	4.0	0.00	71.2	18.0	0.0	7.0	3.8	0.00	45.9	45.8	0.0	4.7	3.6	0.00
NOV	63.8	8.4	0.0	10.7	13.8	0.00	24.8	60.2	0.0	4.0	8.8	0.00	7.0	71.1	0.0	1.1	19.0	0.00
DEC	0.5	30.7	0.0	0.2	66.0	0.00	0.0	80.0	0.0	0.0	19.3	0.00	1.0	54.1	0.0	0.2	40.3	0.00
JAN	0.4	82.7	0.0	0.5	16.0	0.00	0.0	97.2	0.0	0.0	2.7	0.00	0.0	92.3	0.0	0.0	7.5	0.00
FEB	11.9	64.9	0.0	14.8	8.0	0.00	0.8	94.2	0.0	2.1	2.8	0.00	0.2	98.6	0.0	0.5	0.7	0.00
MAR	51.6	20.0	0.0	24.4	3.9	0.00	34.4	36.2	0.0	24.5	4.8	0.00	20.2	61.7	0.0	14.4	3.7	0.00
APR	70.6	7.3	0.0	20.3	1.8	0.00	52.9	21.5	0.0	24.2	1.3	0.00	34.3	48.9	0.0	15.6	1.2	0.00
MAY	79.7	2.8	0.0	12.5	5.1	0.00	68.1	13.4	0.0	17.6	0.9	0.00	49.4	35.9	0.0	12.5	2.3	0.00
JUN	87.7	0.6	0.1	2.5	9.0	0.00	82.5	7.6	0.1	5.5	4.3	0.00	61.7	28.6	0.1	4.1	5.6	0.00
JUL	87.6	0.0	0.0	1.8	10.6	0.00	90.3	0.9	0.0	3.0	5.8	0.00	83.3	6.5	0.0	2.9	7.3	0.00
AUG	91.5	0.0	0.0	0.3	8.1	0.00	94.2	0.7	0.0	0.6	4.4	0.00	87.2	6.2	0.0	0.7	5.9	0.00
SEP	88.3	0.0	0.0	4.7	6.9	0.00	86.5	3.3	0.0	5.7	4.5	0.00	72.3	17.0	0.0	4.9	5.9	0.00
1972																		
OCT	80.0	2.3	0.0	13.5	4.2	0.00	64.8	17.5	0.0	14.6	3.2	0.00	37.5	50.8	0.0	8.7	3.1	0.00
NOV	80.2	5.6	0.0	12.7	1.5	0.00	59.7	24.6	0.0	14.4	1.2	0.00	37.0	53.1	0.0	8.7	1.2	0.00
DEC	61.8	15.2	0.0	11.6	8.4	0.00	32.1	54.7	0.0	6.5	4.2	0.00	11.2	79.0	0.0	2.3	6.2	0.00
JAN	32.3	50.0	0.0	8.5	7.6	0.00	0.2	98.7	0.0	0.0	1.1	0.00	0.0	98.8	0.0	0.0	1.2	0.00
FEB	53.3	29.7	0.0	14.0	2.6	0.00	32.2	52.3	0.0	12.0	3.0	0.00	17.4	74.1	0.0	6.5	1.8	0.00
MAR	89.1	2.2	0.1	6.9	1.6	0.00	81.0	8.4	0.1	10.0	0.5	0.00	60.5	31.0	0.1	7.5	0.9	0.00
APR	90.6	0.4	0.0	6.7	2.3	0.00	84.8	3.9	0.0	10.7	0.5	0.00	68.0	21.8	0.0	8.6	1.6	0.00
MAY	92.6	0.1	0.0	2.8	4.5	0.04	92.5	1.1	0.0	4.7	1.6	0.03	83.5	8.4	0.0	5.0	3.0	0.02
JUN	91.1	0.0	0.0	0.7	8.0	0.14	93.0	0.3	0.0	1.2	5.4	0.09	89.6	2.3	0.0	1.3	6.7	0.09
JUL	88.8	0.0	0.0	0.1	10.9	0.20	93.1	0.0	0.0	0.2	6.5	0.14	92.2	0.2	0.0	0.2	7.2	0.14
AUG	91.3	0.0	0.0	0.2	8.2	0.31	94.4	0.2	0.0	0.3	4.9	0.21	91.4	2.0	0.0	0.3	6.1	0.20
SEP	94.8	0.0	0.0	1.0	4.1	0.08	93.2	2.8	0.0	1.5	2.4	0.06	71.0	24.4	0.0	1.1	3.4	0.04
1973																		
OCT	97.2	0.3	0.0	1.8	0.8	0.01	88.6	8.3	0.0	2.2	0.9	0.01	55.0	42.8	0.0	1.4	0.8	0.01
NOV	70.8	7.4	0.0	3.3	15.5	0.00	32.0	51.9	0.0	1.4	12.5	0.00	20.6	58.1	0.0	0.5	16.9	0.00
DEC	59.3	14.6	0.0	3.6	20.2	0.00	21.0	60.5	0.0	1.5	15.8	0.00	8.7	65.3	0.0	0.3	22.6	0.00
JAN	5.8	14.7	0.0	2.0	74.0	0.00	0.1	82.6	0.0	0.0	16.4	0.00	0.0	68.5	0.0	0.0	30.7	0.00
FEB	0.1	69.7	0.0	0.1	29.2	0.00	0.0	94.9	0.0	0.0	4.7	0.00	0.0	81.4	0.0	0.0	18.3	0.00
MAR	0.0	72.8	0.0	0.1	26.4	0.00	0.0	95.6	0.0	0.0	4.2	0.00	0.0	82.7	0.0	0.0	17.0	0.00
APR	11.1	60.0	0.0	20.7	7.7	0.00	1.5	86.9	0.0	6.8	4.6	0.00	0.4	96.4	0.0	1.6	1.5	0.00
MAY	74.9	6.7	0.0	13.6	4.8	0.00	60.2	19.9	0.0	18.3	1.6	0.00	38.7	46.8	0.0	11.7	2.8	0.00
JUN	85.6	0.8	0.0	4.5	9.0	0.01	79.6	6.9	0.0	7.7	5.8	0.00	57.9	29.7	0.0	5.6	6.8	0.00
JUL	88.3	0.2	0.1	1.4	9.8	0.22	90.6	0.9	0.1	2.3	6.1	0.15	82.8	7.1	0.1	2.3	7.6	0.14
AUG	90.2	0.1	0.0	1.2	8.1	0.36	92.0	0.9	0.0	2.0	4.8	0.25	82.5	8.9	0.0	1.9	6.4	0.22
SEP	91.8	0.0	0.0	2.7	5.5	0.06	89.8	3.0	0.0	3.8	3.5	0.04	71.2	21.2	0.0	3.0	4.6	0.03

Table B1–5. Continued

Water Year	CCWD Pump #1 (RMA Node No. 206)						SWP Pump (RMA Node No. 193)						CVP Pump (RMA Node No. 181)					
	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary
1974																		
OCT	91.2	2.0	0.0	6.0	0.7	0.01	75.9	15.8	0.0	7.0	1.2	0.00	41.2	54.4	0.0	3.8	0.7	0.00
NOV	63.0	9.6	0.1	18.7	6.9	0.00	48.5	24.2	0.0	20.6	5.0	0.00	25.2	57.1	0.0	10.9	5.7	0.00
DEC	25.4	13.7	0.0	22.3	36.0	0.00	6.9	68.2	0.0	5.7	18.0	0.00	1.4	78.4	0.0	1.1	18.5	0.00
JAN	0.2	66.3	0.0	0.2	32.0	0.00	0.0	95.3	0.0	0.0	4.3	0.00	0.0	86.4	0.0	0.0	13.3	0.00
FEB	35.2	39.8	0.0	21.1	3.6	0.00	18.8	60.5	0.0	16.9	3.5	0.00	5.0	89.3	0.0	4.4	1.2	0.00
MAR	27.8	28.0	0.0	40.1	4.0	0.00	17.5	42.5	0.0	35.5	4.6	0.00	6.7	76.8	0.0	13.7	2.7	0.00
APR	17.4	39.3	0.0	39.3	4.0	0.00	4.1	81.5	0.0	11.6	2.8	0.00	0.7	96.2	0.0	2.0	1.1	0.00
MAY	64.8	12.9	0.0	18.1	4.3	0.00	48.9	29.4	0.0	20.8	0.9	0.00	24.4	63.4	0.0	10.4	1.8	0.00
JUN	81.5	3.2	0.0	7.9	7.4	0.00	69.9	14.4	0.0	12.0	3.7	0.00	39.1	49.5	0.0	6.7	4.7	0.00
JUL	89.5	0.1	0.1	1.5	8.9	0.01	91.4	1.4	0.0	2.8	4.4	0.01	73.5	17.7	0.0	2.6	6.2	0.00
AUG	90.7	0.0	0.0	1.5	7.7	0.01	91.9	1.5	0.0	2.7	3.9	0.00	74.3	17.9	0.0	2.3	5.5	0.00
SEP	83.4	1.7	0.0	7.0	7.8	0.00	71.6	14.4	0.0	9.0	5.0	0.00	41.7	47.7	0.0	5.3	5.3	0.00
1975																		
OCT	68.6	16.7	0.0	11.4	3.3	0.00	49.5	38.0	0.0	10.7	1.8	0.00	23.1	70.3	0.0	5.0	1.6	0.00
NOV	33.6	56.2	0.0	8.2	2.0	0.00	0.1	99.6	0.0	0.0	0.3	0.00	11.1	85.0	0.0	2.4	1.5	0.00
DEC	29.7	56.8	0.0	10.9	0.6	0.00	1.3	97.6	0.0	0.5	0.1	0.00	0.7	97.4	0.0	0.2	0.2	0.00
JAN	71.5	22.1	0.0	5.9	0.2	0.00	47.1	47.3	0.0	5.1	0.3	0.00	13.3	85.0	0.0	1.5	0.1	0.00
FEB	18.3	34.3	0.0	14.6	30.8	0.00	12.3	52.8	0.0	11.6	21.5	0.00	1.8	81.8	0.0	1.8	14.0	0.00
MAR	13.0	33.8	0.0	38.7	13.8	0.00	7.5	51.0	0.0	30.1	10.8	0.00	1.5	85.7	0.0	6.1	6.4	0.00
APR	44.9	19.7	0.1	34.4	0.9	0.00	29.2	36.0	0.0	33.7	1.0	0.00	13.8	69.7	0.0	15.9	0.5	0.00
MAY	50.1	17.2	0.0	27.2	5.5	0.00	35.5	34.7	0.0	28.7	1.1	0.00	17.5	66.1	0.0	14.1	2.3	0.00
JUN	39.2	32.5	0.0	17.3	11.0	0.00	24.2	52.0	0.0	16.7	7.1	0.00	9.3	78.6	0.0	6.1	6.0	0.00
JUL	84.3	1.3	0.0	3.6	10.8	0.00	80.7	6.4	0.0	5.9	7.0	0.00	69.8	17.3	0.0	4.8	8.2	0.00
AUG	90.1	0.2	0.0	2.3	7.5	0.01	90.2	2.2	0.0	3.8	3.8	0.00	71.1	20.6	0.0	3.0	5.2	0.00
SEP	88.7	0.4	0.0	4.6	6.3	0.00	80.8	7.9	0.0	7.8	3.5	0.00	49.1	41.8	0.0	4.7	4.4	0.00
1976																		
OCT	73.4	15.5	0.0	10.8	0.4	0.00	53.3	35.1	0.0	11.2	0.4	0.00	17.7	78.4	0.0	3.7	0.1	0.00
NOV	79.9	9.4	0.0	9.5	1.1	0.00	62.3	26.3	0.0	11.2	0.2	0.00	26.6	68.2	0.0	4.8	0.4	0.00
DEC	86.8	7.6	0.0	4.7	0.8	0.00	69.8	25.1	0.0	4.9	0.2	0.00	31.3	66.2	0.0	2.2	0.3	0.00
JAN	93.5	4.2	0.0	1.7	0.7	0.00	78.6	19.3	0.0	1.9	0.2	0.00	39.7	59.0	0.0	1.0	0.4	0.00
FEB	97.1	1.0	0.0	1.6	0.3	0.01	88.2	9.7	0.0	2.1	0.1	0.00	59.7	38.7	0.0	1.4	0.2	0.00
MAR	96.9	0.3	0.0	1.4	1.4	0.03	92.3	5.4	0.0	2.0	0.2	0.02	65.7	32.0	0.0	1.5	0.8	0.01
APR	95.9	0.5	0.0	2.2	1.4	0.01	90.5	6.3	0.0	2.8	0.4	0.01	72.8	23.9	0.0	2.3	1.0	0.01
MAY	94.7	0.1	0.0	0.8	4.3	0.05	95.2	2.2	0.0	1.4	1.1	0.03	84.8	11.5	0.0	1.2	2.4	-0.03
JUN	90.8	0.0	0.0	0.2	8.7	0.24	92.6	0.8	0.0	0.4	6.0	0.13	87.8	4.2	0.0	0.3	7.5	0.14
JUL	89.0	0.0	0.0	0.0	10.4	0.52	91.8	0.2	0.0	0.1	7.6	0.36	89.7	1.2	0.0	0.1	8.7	0.36
AUG	91.7	0.0	0.0	0.1	7.5	0.79	93.5	1.1	0.0	0.2	4.7	0.54	83.5	9.8	0.0	0.1	6.0	0.48
SEP	92.8	0.0	0.0	1.6	4.6	1.09	92.9	1.3	0.0	2.7	2.4	0.71	78.7	14.7	0.0	2.3	3.6	0.60

Table B1–5. Continued

Water Year	CCWD Pump #1 (RMA Node No. 206)						SWP Pump (RMA Node No. 193)						CVP Pump (RMA Node No. 181)					
	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary
1977																		
OCT	95.8	0.0	0.0	1.3	2.2	0.69	91.1	4.8	0.0	2.3	1.4	0.44	68.9	27.3	0.0	1.7	1.8	0.33
NOV	97.3	0.2	0.0	1.0	1.1	0.44	90.4	7.1	0.0	1.4	0.8	0.28	65.8	31.8	0.0	1.0	1.2	0.20
DEC	96.7	0.9	0.0	1.6	0.6	0.22	83.5	14.0	0.0	1.8	0.6	0.16	57.2	40.8	0.0	1.2	0.7	0.11
JAN	97.8	0.1	0.0	0.6	0.1	0.38	94.0	3.9	0.0	0.9	0.1	0.23	71.3	27.0	0.0	0.7	0.1	0.18
FEB	98.4	0.2	0.0	0.6	0.1	0.39	92.7	5.7	0.0	0.9	0.1	0.25	71.2	27.6	0.0	0.7	0.1	0.19
MAR	98.4	0.2	0.0	0.7	0.1	0.55	93.9	4.7	0.0	0.9	0.1	0.32	77.3	21.6	0.0	0.7	0.0	0.26
APR	94.5	0.2	0.0	0.8	3.9	0.53	95.4	2.5	0.0	1.1	0.6	0.35	91.8	4.8	0.0	1.0	1.9	0.34
MAY	95.3	0.1	0.0	0.3	3.9	0.48	96.2	2.2	0.0	0.4	0.8	0.31	88.0	8.9	0.0	0.4	2.4	0.28
JUN	89.6	0.0	0.0	0.2	9.7	0.55	91.1	0.1	0.0	0.3	8.2	0.34	88.3	0.1	0.0	0.3	11.0	0.33
JUL	85.1	0.0	0.0	0.0	14.1	0.81	87.4	0.0	0.0	0.1	12.0	0.53	84.8	0.0	0.0	0.1	14.6	0.52
AUG	86.5	0.0	0.0	0.0	12.4	1.16	89.1	0.0	0.0	0.0	10.2	0.75	87.9	0.0	0.0	0.0	11.4	0.76
SEP	90.2	0.0	0.0	0.0	8.6	1.28	91.9	0.0	0.0	0.0	7.3	0.88	91.2	0.1	0.0	0.0	7.9	0.86
1978																		
OCT	92.2	0.0	0.0	0.0	6.7	1.15	89.0	2.3	0.0	0.0	7.9	0.77	84.3	5.0	0.0	0.0	10.0	0.72
NOV	97.2	0.0	0.0	0.1	1.6	0.89	91.9	4.9	0.0	0.1	2.3	0.62	77.9	19.2	0.0	0.1	2.2	0.53
DEC	81.2	0.0	0.0	2.4	13.5	0.20	81.7	2.7	0.0	3.2	9.6	0.14	58.6	18.2	0.0	2.3	18.3	0.10
JAN	26.7	1.7	0.1	19.2	49.4	0.00	29.0	9.0	0.1	34.0	25.1	0.00	11.7	42.1	0.0	13.8	30.6	0.00
FEB	26.2	23.5	0.0	21.5	27.3	0.00	17.7	48.4	0.0	20.7	12.2	0.00	2.2	85.9	0.0	2.6	9.0	0.00
MAR	1.3	50.9	0.0	1.7	44.5	0.00	0.0	96.6	0.0	0.0	3.3	0.00	0.0	93.2	0.0	0.0	6.7	0.00
APR	0.0	95.9	0.0	0.0	4.1	0.00	0.0	99.6	0.0	0.0	0.4	0.00	0.0	99.2	0.0	0.0	0.8	0.00
MAY	0.0	95.5	0.0	0.0	4.4	0.00	0.0	99.8	0.0	0.0	0.2	0.00	0.0	98.5	0.0	0.0	1.5	0.00
JUN	48.6	34.1	0.0	7.2	10.1	0.00	32.1	56.3	0.0	6.8	4.8	0.00	7.0	87.4	0.0	1.5	4.2	0.00
JUL	84.8	3.2	0.0	1.2	10.6	0.12	86.9	5.3	0.0	1.5	6.2	0.08	70.0	21.2	0.0	1.2	7.5	0.06
AUG	87.4	0.9	0.0	2.5	8.9	0.33	88.4	2.3	0.0	4.2	4.9	0.22	73.3	16.3	0.0	3.7	6.5	0.18
SEP	85.6	0.8	0.0	7.3	6.3	0.04	75.7	9.3	0.0	11.7	3.3	0.03	46.0	42.8	0.0	7.1	4.1	0.02
1979																		
OCT	73.7	9.6	0.0	11.9	4.8	0.01	55.0	29.5	0.0	12.8	2.7	0.00	23.9	67.7	0.0	5.6	2.8	0.00
NOV	74.6	14.6	0.0	9.8	0.6	0.00	53.2	36.2	0.0	9.4	0.6	0.00	21.7	73.9	0.0	3.8	0.3	0.00
DEC	87.1	7.1	0.0	5.7	0.1	0.00	68.6	25.3	0.0	6.0	0.1	0.00	33.1	64.0	0.0	2.9	0.0	0.00
JAN	29.9	14.3	0.0	4.6	47.2	0.00	5.7	74.0	0.0	0.7	18.0	0.00	0.9	81.1	0.0	0.1	17.0	0.00
FEB	0.5	47.2	0.0	0.2	50.2	0.00	0.0	92.8	0.0	0.0	6.9	0.00	0.0	79.3	0.0	0.0	20.2	0.00
MAR	0.3	82.4	0.0	1.4	15.7	0.00	0.0	98.9	0.0	0.0	1.1	0.00	0.0	97.9	0.0	0.0	2.1	0.00
APR	47.2	24.8	0.0	26.4	1.5	0.00	29.7	43.3	0.0	25.5	1.4	0.00	11.9	77.3	0.0	10.1	0.6	0.00
MAY	74.1	4.6	0.0	16.4	4.9	0.00	59.4	17.0	0.0	22.5	1.1	0.00	33.3	51.1	0.0	12.6	3.0	0.00
JUN	83.9	0.7	0.0	6.4	9.0	0.01	76.0	7.4	0.0	10.6	6.0	0.00	51.0	34.4	0.0	7.1	7.5	0.00
JUL	89.4	0.1	0.0	1.8	8.4	0.31	90.9	1.2	0.0	2.9	4.8	0.21	77.2	13.1	0.0	3.0	6.5	0.18
AUG	88.9	0.1	0.0	1.3	8.4	1.35	91.1	1.1	0.0	2.4	4.5	0.90	75.1	15.5	0.0	2.4	6.2	0.73
SEP	90.7	0.0	0.0	2.2	6.1	1.00	90.0	2.1	0.0	4.1	3.2	0.63	66.6	25.7	0.0	3.0	4.2	0.46

Table B1–5. Continued

Water Year	CCWD Pump #1 (RMA Node No. 206)						SWP Pump (RMA Node No. 193)						CVP Pump (RMA Node No. 181)					
	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary
1980																		
OCT	90.8	1.5	0.0	6.6	1.0	0.21	76.8	12.9	0.0	9.3	0.9	0.12	42.8	51.3	0.0	5.2	0.7	0.07
NOV	87.2	3.8	0.0	8.6	0.1	0.02	61.1	29.3	0.0	9.1	0.1	0.01	17.4	79.7	0.0	2.6	0.1	0.00
DEC	74.8	5.5	0.0	8.0	9.9	0.00	44.0	40.1	0.0	6.7	7.8	0.00	10.0	76.2	0.0	1.5	9.6	0.00
JAN	0.6	40.7	0.0	0.5	55.9	0.00	0.0	92.0	0.0	0.0	7.7	0.00	3.7	72.6	0.0	0.6	17.6	0.00
FEB	0.0	76.6	0.0	0.1	22.5	0.00	0.0	98.3	0.0	0.0	1.6	0.00	0.0	94.5	0.0	0.0	5.3	0.00
MAR	0.0	98.6	0.0	0.0	1.4	0.00	0.0	99.8	0.0	0.0	0.2	0.00	0.0	99.8	0.0	0.0	0.2	0.00
APR	0.2	98.6	0.0	1.0	0.3	0.00	0.0	100.0	0.0	0.0	0.0	0.00	0.0	100.0	0.0	0.0	0.0	0.00
MAY	0.3	90.8	0.0	1.1	7.7	0.00	0.0	99.4	0.0	0.0	0.6	0.00	0.0	97.9	0.0	0.0	2.1	0.00
JUN	49.8	25.4	0.0	15.1	9.7	0.00	32.2	47.7	0.0	14.7	5.4	0.00	7.6	83.6	0.0	3.5	5.4	0.00
JUL	81.5	3.2	0.0	5.2	10.1	0.00	71.5	14.2	0.0	7.7	6.6	0.00	47.0	40.9	0.0	5.0	7.1	0.00
AUG	89.5	0.3	0.0	1.5	8.5	0.09	89.9	2.8	0.0	2.5	4.8	0.06	68.9	23.1	0.0	1.9	6.0	0.05
SEP	85.6	4.0	0.0	4.2	6.2	0.03	71.7	18.9	0.0	5.4	4.0	0.02	33.3	59.9	0.0	2.5	4.3	0.01
1981																		
OCT	79.1	11.6	0.0	5.6	3.6	0.01	60.1	31.7	0.0	5.9	2.2	0.00	25.0	70.2	0.0	2.5	2.3	0.00
NOV	82.4	8.5	0.0	6.9	2.2	0.01	64.8	26.2	0.0	7.9	1.1	0.00	33.7	60.9	0.0	4.1	1.3	0.00
DEC	89.2	5.4	0.0	4.6	0.1	0.00	72.6	21.5	0.0	5.0	0.2	0.00	38.4	58.5	0.0	2.6	0.1	0.00
JAN	63.2	6.1	0.0	5.0	23.1	0.00	56.5	20.9	0.0	6.4	13.7	0.00	24.2	56.4	0.0	2.7	15.2	0.00
FEB	88.3	3.6	0.4	2.8	4.3	0.00	72.3	18.4	0.3	3.4	5.1	0.00	37.1	57.5	0.1	1.8	3.3	0.00
MAR	50.3	17.6	0.1	12.8	18.1	0.00	30.5	44.0	0.1	10.0	14.6	0.00	7.4	77.2	0.0	2.4	12.5	0.00
APR	90.7	1.9	0.0	6.3	1.0	0.00	77.2	13.1	0.0	8.2	1.4	0.00	42.6	52.0	0.0	4.5	0.8	0.00
MAY	89.8	2.2	0.0	4.6	3.5	0.00	77.7	15.5	0.0	5.8	1.0	0.00	52.3	41.3	0.0	3.8	2.6	0.00
JUN	90.1	0.5	0.0	1.4	7.9	0.01	85.9	6.1	0.0	2.5	5.5	0.00	72.2	18.9	0.0	1.9	7.1	0.00
JUL	89.8	0.0	0.0	0.3	9.6	0.25	92.0	1.1	0.0	0.4	6.2	0.17	82.1	9.6	0.0	0.4	7.7	0.15
AUG	89.7	0.0	0.0	0.2	8.7	1.36	92.9	1.1	0.0	0.3	4.8	0.92	78.8	13.5	0.0	0.3	6.6	0.77
SEP	92.3	0.0	0.0	0.6	6.2	0.97	92.8	2.0	0.0	0.9	3.6	0.63	75.3	18.4	0.0	0.7	5.1	0.51
1982																		
OCT	97.1	0.0	0.0	1.6	0.9	0.46	90.3	6.2	0.0	2.0	1.2	0.28	53.6	44.2	0.0	1.2	0.9	0.17
NOV	88.8	1.3	0.2	7.1	0.9	0.07	72.7	15.6	0.1	9.1	0.8	0.05	32.1	61.8	0.1	4.0	0.9	0.02
DEC	46.3	5.4	0.1	28.4	18.6	0.00	30.8	28.0	0.0	28.1	12.2	0.00	8.4	64.1	0.0	7.6	19.3	0.00
JAN	7.1	8.6	0.0	26.7	54.2	0.00	3.5	47.8	0.0	16.2	30.1	0.00	0.6	62.8	0.0	2.7	32.9	0.00
FEB	15.7	24.1	0.0	45.3	14.2	0.00	9.5	42.0	0.0	40.8	7.1	0.00	1.4	86.7	0.0	6.0	5.7	0.00
MAR	4.4	30.3	0.0	29.9	33.5	0.00	2.0	63.3	0.0	20.6	13.0	0.00	0.2	86.4	0.0	1.8	11.2	0.00
APR	0.0	74.7	0.0	0.2	24.6	0.00	0.0	98.6	0.0	0.0	1.4	0.00	0.0	95.6	0.0	0.0	4.4	0.00
MAY	0.0	95.1	0.0	0.0	4.9	0.00	0.0	99.8	0.0	0.0	0.2	0.00	0.0	98.8	0.0	0.0	1.2	0.00
JUN	6.8	66.9	0.0	13.6	12.7	0.00	0.0	97.2	0.0	0.1	2.7	0.00	0.0	95.8	0.0	0.0	4.2	0.00
JUL	28.8	42.6	0.0	14.7	13.9	0.00	10.7	70.4	0.0	9.5	9.4	0.00	2.2	89.2	0.0	1.9	6.7	0.00
AUG	81.9	4.7	0.0	4.6	8.8	0.00	70.2	17.9	0.0	6.4	5.5	0.00	39.3	51.3	0.0	3.6	5.8	0.00
SEP	44.0	44.0	0.0	8.6	3.4	0.00	17.4	77.3	0.0	3.9	1.3	0.00	2.8	95.3	0.0	0.6	1.2	0.00

Table B1–5. Continued

Water Year	CCWD Pump #1 (RMA Node No. 206)						SWP Pump (RMA Node No. 193)						CVP Pump (RMA Node No. 181)					
	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary
1983																		
OCT	24.6	63.0	0.0	10.6	1.9	0.00	3.0	95.7	0.0	1.1	0.3	0.00	0.3	99.1	0.0	0.1	0.4	0.00
NOV	10.4	49.1	0.0	24.8	13.2	0.00	4.2	74.9	0.0	12.1	7.3	0.00	0.6	91.9	0.0	1.7	5.3	0.00
DEC	0.1	49.2	0.0	0.6	48.1	0.00	0.0	96.7	0.0	0.0	3.1	0.00	0.0	90.3	0.0	0.0	9.5	0.00
JAN	0.0	44.2	0.0	0.4	53.2	0.00	0.0	97.0	0.0	0.0	2.8	0.00	0.0	91.1	0.0	0.0	8.6	0.00
FEB	0.0	76.5	0.0	0.0	22.8	0.00	0.0	98.6	0.0	0.0	1.3	0.00	0.0	94.8	0.0	0.0	5.1	0.00
MAR	0.0	71.5	0.0	0.0	27.6	0.00	0.0	97.8	0.0	0.0	1.9	0.00	0.0	90.6	0.0	0.0	9.2	0.00
APR	0.0	99.2	0.0	0.0	0.8	0.00	0.0	99.8	0.0	0.0	0.1	0.00	0.0	99.8	0.0	0.0	0.2	0.00
MAY	0.0	98.1	0.0	0.0	1.9	0.00	0.0	99.9	0.0	0.0	0.1	0.00	0.0	99.4	0.0	0.0	0.6	0.00
JUN	0.0	89.9	0.0	0.0	10.1	0.00	0.0	99.5	0.0	0.0	0.5	0.00	0.0	97.0	0.0	0.0	3.0	0.00
JUL	0.0	84.1	0.0	0.0	15.9	0.00	0.0	98.8	0.0	0.0	1.2	0.00	0.0	96.6	0.0	0.0	3.4	0.00
AUG	26.2	51.2	0.0	12.3	10.2	0.00	12.1	73.7	0.0	8.4	5.8	0.00	1.6	93.6	0.0	1.1	3.8	0.00
SEP	0.1	92.3	0.0	0.1	7.4	0.00	0.0	99.4	0.0	0.0	0.6	0.00	0.0	98.4	0.0	0.0	1.6	0.00
1984																		
OCT	0.0	96.0	0.0	0.0	4.0	0.00	0.0	99.8	0.0	0.0	0.2	0.00	0.0	98.9	0.0	0.0	1.1	0.00
NOV	0.0	68.7	0.0	0.0	29.1	0.00	0.0	96.1	0.0	0.0	3.2	0.00	0.0	80.3	0.0	0.0	19.0	0.00
DEC	0.0	64.6	0.0	0.0	34.1	0.00	0.0	96.3	0.0	0.0	3.1	0.00	0.0	85.1	0.0	0.0	14.6	0.00
JAN	0.0	98.5	0.0	0.0	1.5	0.00	0.0	99.8	0.0	0.0	0.2	0.00	0.0	99.7	0.0	0.0	0.3	0.00
FEB	0.2	91.2	0.0	1.0	7.6	0.00	0.0	99.4	0.0	0.0	0.6	0.00	0.0	99.3	0.0	0.0	0.7	0.00
MAR	18.7	58.9	0.0	21.9	0.5	0.00	8.7	75.5	0.0	15.4	0.4	0.00	1.2	96.5	0.0	2.2	0.1	0.00
APR	63.8	16.9	0.2	17.4	1.7	0.00	45.3	35.7	0.1	18.5	0.4	0.00	19.0	72.3	0.1	7.7	0.9	0.00
MAY	74.7	8.5	0.0	12.1	4.7	0.00	57.1	26.9	0.0	14.7	1.4	0.00	26.5	63.5	0.0	6.8	3.2	0.00
JUN	86.3	0.9	0.0	4.2	8.7	0.00	78.7	8.5	0.0	6.6	6.2	0.00	52.5	35.6	0.0	4.4	7.6	0.00
JUL	89.7	0.1	0.0	1.5	8.6	0.02	90.3	1.8	0.0	2.7	5.2	0.01	72.5	18.6	0.0	2.2	6.7	0.01
AUG	90.7	0.0	0.0	2.0	7.2	0.03	88.9	2.4	0.0	4.0	4.6	0.02	65.3	25.9	0.0	2.9	5.8	0.01
SEP	83.3	3.0	0.0	8.0	5.7	0.00	68.3	17.3	0.0	10.1	4.3	0.00	36.5	53.5	0.0	5.4	4.6	0.00
1985																		
OCT	67.4	19.5	0.0	11.9	1.3	0.00	47.2	40.6	0.0	11.2	1.0	0.00	19.4	75.3	0.0	4.6	0.7	0.00
NOV	77.1	4.9	0.0	10.7	5.6	0.00	63.8	17.3	0.0	14.3	3.0	0.00	32.6	54.9	0.0	7.3	4.1	0.00
DEC	55.4	15.0	0.1	11.9	16.5	0.00	41.5	34.1	0.0	13.4	10.0	0.00	12.5	74.8	0.0	4.0	8.2	0.00
JAN	59.3	21.2	0.1	11.0	8.0	0.00	39.1	43.0	0.1	9.8	7.7	0.00	16.2	74.9	0.0	4.0	4.6	0.00
FEB	74.7	8.8	0.1	11.3	5.0	0.00	57.3	24.1	0.1	13.2	5.2	0.00	29.0	60.6	0.0	6.7	3.6	0.00
MAR	80.5	3.0	0.0	9.6	6.7	0.00	66.5	14.2	0.0	13.1	6.1	0.00	34.9	52.4	0.0	6.9	5.7	0.00
APR	87.5	2.2	0.0	9.1	1.1	0.00	73.0	13.1	0.0	12.9	1.0	0.00	43.7	47.8	0.0	7.7	0.9	0.00
MAY	89.8	0.9	0.0	5.0	4.3	0.01	80.4	10.4	0.0	7.8	1.4	0.01	50.5	41.2	0.0	4.9	3.3	0.00
JUN	90.4	0.1	0.0	1.4	8.0	0.07	88.3	3.9	0.0	2.3	5.5	0.04	66.0	25.0	0.0	1.7	7.2	0.03
JUL	89.8	0.0	0.0	0.4	9.3	0.47	89.8	3.0	0.0	0.6	6.1	0.32	65.5	26.6	0.0	0.5	7.2	0.23
AUG	89.2	0.1	0.0	0.4	8.5	1.94	88.8	3.8	0.0	0.7	5.4	1.28	60.5	31.9	0.0	0.4	6.3	0.87
SEP	90.8	0.1	0.0	1.0	5.9	2.25	90.0	3.5	0.0	1.7	3.4	1.41	64.2	29.3	0.0	1.2	4.3	1.01

Table B1–5. Continued

Water Year	CCWD Pump #1 (RMA Node No. 206)						SWP Pump (RMA Node No. 193)						CVP Pump (RMA Node No. 181)					
	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary
1986																		
OCT	94.6	0.3	0.0	1.9	1.7	1.57	87.8	7.2	0.0	2.6	1.3	0.97	56.9	39.4	0.0	1.7	1.4	0.63
NOV	92.5	0.5	0.0	3.1	1.4	0.76	84.5	8.7	0.0	4.1	0.6	0.45	53.4	41.4	0.0	2.6	1.0	0.29
DEC	80.2	0.6	0.0	4.0	13.8	0.11	75.5	7.9	0.0	6.4	8.9	0.06	40.2	44.2	0.0	3.4	11.3	0.03
JAN	77.1	0.9	0.0	8.1	12.9	0.01	67.8	7.9	0.0	12.7	10.5	0.00	38.1	41.8	0.0	7.2	12.2	0.00
FEB	5.6	5.7	0.0	3.3	82.0	0.00	0.2	86.5	0.0	0.1	12.4	0.00	0.0	79.3	0.0	0.0	20.2	0.00
MAR	0.0	75.8	0.0	0.0	23.5	0.00	0.0	98.1	0.0	0.0	1.6	0.00	0.0	92.0	0.0	0.0	7.8	0.00
APR	0.0	99.9	0.0	0.0	0.1	0.00	0.0	100.0	0.0	0.0	0.0	0.00	0.0	99.9	0.0	0.0	0.1	0.00
MAY	7.7	71.5	0.0	16.6	4.2	0.00	1.0	93.9	0.0	4.4	0.7	0.00	0.1	97.6	0.0	0.5	1.8	0.00
JUN	43.6	34.3	0.0	13.4	8.7	0.00	23.8	59.9	0.0	11.2	5.1	0.00	4.4	88.7	0.0	2.1	4.8	0.00
JUL	85.9	1.7	0.0	2.8	9.5	0.02	82.0	7.6	0.0	4.1	6.2	0.01	56.8	33.0	0.0	2.9	7.2	0.01
AUG	88.5	0.8	0.1	2.4	8.1	0.14	83.2	7.5	0.0	4.0	5.2	0.09	52.1	39.4	0.0	2.5	5.9	0.06
SEP	88.1	3.7	0.0	4.6	3.6	0.04	74.6	17.2	0.0	6.5	1.8	0.02	32.3	62.6	0.0	2.8	2.3	0.01
1987																		
OCT	80.9	7.2	0.0	8.3	3.6	0.00	64.8	23.0	0.0	10.4	1.8	0.00	32.0	60.8	0.0	5.1	2.1	0.00
NOV	85.3	4.4	0.0	8.2	2.1	0.00	69.7	18.5	0.0	10.7	1.1	0.00	38.4	54.3	0.0	5.9	1.5	0.00
DEC	82.2	9.5	0.0	7.9	0.1	0.00	63.2	27.5	0.0	8.9	0.2	0.00	29.7	65.9	0.0	4.2	0.1	0.00
JAN	87.0	3.8	0.0	6.5	1.3	0.00	72.9	17.3	0.0	8.1	0.3	0.00	45.1	47.9	0.0	5.0	1.0	0.00
FEB	63.0	3.9	0.0	6.2	24.9	0.00	56.0	15.0	0.0	7.9	19.1	0.00	30.6	42.4	0.0	4.3	21.3	0.00
MAR	51.2	14.7	0.0	11.8	20.8	0.00	32.7	37.4	0.0	10.3	18.2	0.00	7.5	76.1	0.0	2.4	13.5	0.00
APR	84.6	4.4	0.0	7.8	3.0	0.00	68.5	18.6	0.0	9.6	3.0	0.00	40.8	51.2	0.0	5.7	2.2	0.00
MAY	88.7	2.0	0.0	4.8	4.5	0.02	77.2	14.5	0.0	6.1	2.1	0.01	48.9	43.4	0.0	3.9	3.8	0.01
JUN	88.0	0.5	0.1	2.4	8.8	0.18	82.6	6.9	0.0	3.5	6.8	0.10	60.5	28.7	0.0	2.5	8.2	0.07
JUL	87.6	0.1	0.1	1.0	9.8	1.54	89.8	1.4	0.1	1.6	6.1	1.05	74.5	15.6	0.1	1.4	7.6	0.87
AUG	88.0	0.0	0.1	0.9	8.2	2.85	90.0	1.4	0.1	1.8	4.9	1.94	72.5	18.1	0.1	1.5	6.3	1.56
SEP	89.3	0.0	0.1	1.0	5.9	3.92	90.1	2.0	0.1	1.9	3.5	2.63	69.3	22.7	0.1	1.4	4.6	2.02
1988																		
OCT	94.4	0.0	0.0	1.4	2.3	2.01	91.6	3.3	0.0	2.2	1.6	1.31	70.8	24.5	0.0	1.7	2.0	1.00
NOV	96.2	0.2	0.0	1.6	0.5	1.00	89.4	6.4	0.0	2.2	0.9	0.64	65.0	31.9	0.0	1.6	0.6	0.46
DEC	90.0	0.1	0.0	1.2	6.8	0.29	89.5	3.3	0.0	1.9	3.6	0.17	62.5	28.4	0.0	1.3	6.3	0.12
JAN	79.8	0.0	1.8	1.5	15.3	0.08	80.7	3.2	1.6	2.4	10.7	0.05	50.2	31.7	1.0	1.5	14.5	0.03
FEB	95.2	0.0	1.7	1.2	1.4	0.07	92.1	2.3	1.3	2.2	1.8	0.04	65.1	30.5	0.9	1.6	1.6	0.03
MAR	95.5	0.2	0.6	2.3	1.2	0.23	88.4	6.3	0.4	3.3	1.3	0.14	55.6	40.7	0.3	2.1	1.2	0.09
APR	95.4	0.3	0.1	2.4	1.7	0.08	89.1	6.8	0.1	3.4	0.5	0.05	58.1	38.3	0.1	2.2	1.3	0.03
MAY	94.1	0.4	0.1	1.9	3.5	0.05	88.7	7.8	0.0	2.7	0.8	0.03	59.1	36.5	0.0	1.8	2.6	0.02
JUN	90.8	0.1	0.1	1.1	7.6	0.26	88.5	4.6	0.1	1.7	4.9	0.16	66.2	25.8	0.0	1.3	6.6	0.12
JUL	88.6	0.0	0.1	0.4	9.6	1.33	91.1	1.1	0.1	0.8	6.1	0.91	79.8	11.0	0.1	0.7	7.7	0.80
AUG	88.7	0.0	0.1	0.4	8.1	2.86	90.7	1.5	0.1	0.8	5.2	1.90	74.6	16.7	0.1	0.6	6.5	1.56
SEP	90.4	0.0	0.1	0.5	5.9	3.34	91.6	1.8	0.1	0.9	3.6	2.18	74.0	18.9	0.1	0.7	4.7	1.76

Table B1–5. Continued

Water Year	CCWD Pump #1 (RMA Node No. 206)						SWP Pump (RMA Node No. 193)						CVP Pump (RMA Node No. 181)					
	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary	Sac. R.	SJR	Yolo Bypass	Eastside Streams	Ag. Drains	Benicia Boundary
1989																		
OCT	94.4	0.0	0.0	0.5	3.2	2.00	92.8	2.8	0.0	0.8	2.3	1.34	74.4	20.9	0.0	0.6	3.0	1.07
NOV	97.6	0.0	0.0	0.8	0.4	0.71	93.3	3.9	0.0	1.1	0.8	0.47	69.3	28.5	0.0	0.9	0.6	0.34
DEC	96.7	0.1	0.0	1.0	0.9	0.23	93.0	3.9	0.0	1.4	0.4	0.15	68.9	28.2	0.0	1.0	0.8	0.11
JAN	95.6	0.0	0.1	0.8	2.7	0.47	93.4	2.2	0.1	1.3	2.5	0.30	67.7	27.8	0.1	1.0	3.1	0.21
FEB	95.2	0.0	0.1	1.5	2.7	0.44	91.4	2.6	0.1	2.3	3.2	0.27	68.2	26.7	0.0	1.7	3.2	0.20
MAR	86.3	0.2	0.1	8.1	5.2	0.05	77.1	4.6	0.1	13.5	4.6	0.03	47.1	39.7	0.0	8.2	4.9	0.02
APR	95.0	0.1	0.3	3.4	1.2	0.02	88.4	3.8	0.3	6.8	0.7	0.01	56.2	38.4	0.2	4.3	0.9	0.01
MAY	90.8	0.3	0.0	4.3	4.6	0.00	84.0	7.0	0.0	7.3	1.6	0.00	55.6	36.0	0.0	4.8	3.5	0.00
JUN	90.4	0.1	0.0	1.1	8.4	0.02	88.1	3.8	0.0	2.0	6.1	0.01	70.1	20.6	0.0	1.5	7.7	0.01
JUL	90.6	0.0	0.1	0.2	8.9	0.28	93.3	0.8	0.0	0.4	5.3	0.19	82.4	9.9	0.0	0.4	7.1	0.17
AUG	91.6	0.0	0.1	0.2	7.2	0.98	94.2	0.7	0.1	0.5	3.9	0.65	81.9	11.3	0.0	0.4	5.9	0.55
SEP	97.1	0.0	0.1	0.7	1.6	0.67	96.0	1.6	0.0	1.2	0.7	0.41	72.8	24.7	0.0	0.9	1.3	0.31
1990																		
OCT	97.7	0.0	0.1	0.6	1.0	0.67	96.3	1.9	0.0	1.0	0.3	0.41	70.3	27.8	0.0	0.8	0.8	0.30
NOV	97.8	0.0	0.1	1.3	0.2	0.61	95.0	2.2	0.0	2.3	0.1	0.37	68.5	29.4	0.0	1.6	0.2	0.26
DEC	97.9	0.0	0.1	0.8	0.7	0.52	96.1	2.0	0.1	1.4	0.2	0.31	69.7	28.5	0.0	1.1	0.5	0.22
JAN	96.7	0.0	0.0	1.0	1.3	0.17	94.2	1.9	0.0	1.7	1.4	0.10	69.9	26.4	0.0	1.3	1.7	0.07
FEB	93.7	0.0	0.1	1.6	4.0	0.15	90.5	1.8	0.1	2.7	4.4	0.09	63.2	29.8	0.0	1.9	4.7	0.07
MAR	96.2	0.0	0.1	2.5	0.6	0.42	91.8	2.6	0.1	4.4	0.7	0.26	60.4	35.9	0.0	2.9	0.5	0.17
APR	95.7	0.0	0.1	1.8	1.9	0.45	94.1	1.8	0.1	3.3	0.4	0.28	71.6	23.9	0.0	2.8	1.4	0.21
MAY	93.5	0.1	0.0	4.6	1.7	0.11	86.0	7.5	0.0	5.6	0.8	0.10	64.4	29.5	0.0	4.3	1.7	0.07
JUN	89.8	0.1	0.0	2.7	7.3	0.04	88.0	3.4	0.0	4.3	4.2	0.03	77.4	13.0	0.0	3.6	5.9	0.03
JUL	89.3	0.0	0.0	0.6	9.7	0.38	91.5	0.8	0.0	0.9	6.5	0.25	84.3	6.5	0.0	0.8	8.1	0.23
AUG	90.3	0.0	0.0	0.6	8.4	0.69	91.8	1.2	0.0	0.9	5.6	0.48	80.7	10.6	0.0	0.8	7.5	0.42
SEP	92.3	0.0	0.0	0.8	5.8	1.04	92.4	1.5	0.0	1.3	4.0	0.69	80.3	12.4	0.0	1.1	5.5	0.60
1991																		
OCT	93.5	0.0	0.0	2.4	3.4	0.69	85.4	8.6	0.0	2.7	2.9	0.46	54.9	38.7	0.0	1.7	4.4	0.30
NOV	94.1	0.1	0.0	3.5	2.0	0.40	85.1	8.9	0.0	4.1	1.6	0.25	55.2	39.6	0.0	2.7	2.3	0.16
DEC	97.4	0.2	0.0	1.6	0.2	0.20	91.1	5.7	0.0	2.3	0.4	0.13	66.2	31.4	0.0	1.7	0.3	0.09
JAN	98.5	0.1	0.0	1.0	0.1	0.15	92.5	5.8	0.0	1.4	0.2	0.09	66.4	32.4	0.0	1.0	0.1	0.07
FEB	98.0	0.1	0.0	1.1	0.1	0.20	93.1	4.7	0.0	1.5	0.1	0.12	74.0	24.2	0.0	1.2	0.1	0.10
MAR	78.0	0.2	0.6	6.6	12.9	0.09	72.1	5.1	0.4	11.3	9.6	0.06	41.8	38.7	0.3	6.6	11.7	0.03
APR	92.3	0.1	0.6	4.9	1.9	0.03	85.6	3.8	0.4	8.1	1.7	0.02	59.7	32.4	0.3	5.7	1.7	0.01
MAY	87.2	0.2	0.2	7.0	5.1	0.05	77.8	10.1	0.2	9.8	1.9	0.02	55.7	32.5	0.2	7.0	4.5	0.02
JUN	86.3	0.3	0.1	6.2	7.1	0.06	81.2	4.1	0.1	9.4	5.3	0.03	73.1	10.6	0.1	8.4	7.8	0.03
JUL	86.0	0.0	0.1	1.7	12.0	0.20	87.9	0.3	0.0	2.8	8.8	0.11	86.1	0.7	0.0	2.7	10.3	0.11
AUG	88.0	0.0	0.1	0.9	10.2	0.80	90.4	0.5	0.1	1.3	7.2	0.52	86.5	2.6	0.0	1.3	9.0	0.49
SEP	90.7	0.0	0.0	1.3	7.1	0.88	91.3	1.3	0.0	1.8	5.0	0.59	82.8	8.0	0.0	1.7	6.9	0.53

Table B1-6. Impact Variables Selected for Assessment of DW Project Operation Effects on Delta Hydrodynamics

Impact Variable	Method of Analysis and Assessment	Locations for Assessment	EIR/EIS Chapter
Tidal Hydraulics	RMA model for maximum diversion and discharge	Channels adjacent to DW islands	3B
Delta export	70-year simulation of export using DeltaSOS	CCWD Rock Slough SWP Banks CVP Tracy	3A
Delta outflow	70-year simulation of outflow using DeltaSOS	Chipps Island	3C and 3F
Delta channel flow	70-year simulations using DeltaSOS	San Joaquin River at Antioch Threemile Slough Old River at Bacon Island (represents Middle River at Bacon Island)	3B

Table B1–7. Summary of Typical Net Delta Channel Flows during Periods of Maximum DW Diversion of 9,000 cfs (4,500 cfs to Bacon Island and 4,500 cfs to Webb Tract)

		Diversion Conditions					
Delta Channel Location	RMA Model Number	Base Flow (cfs)	Flow with Diversions (cfs)	Changed Flow (cfs)	Base Velocity (ft/sec)	Velocity with Diversions (ft/sec)	Changed Velocity (ft/sec)
CVP Tracy pumping		4,199	4,199	(0)	1.07	1.07	0.00
SWP Banks pumping		8,344	8,345	0	1.00	1.00	0.00
CCWD pumping		150	149	(0)	0.14	0.14	0.00
North Bay Aqueduct	406	(50)	(50)	0	(0.05)	(0.05)	(0.00)
Eastside streams		1,000	1,000	0			
Channel depletion		0	0	0			
Sacramento R. at Freeport		79,999	80,000	0	3.21	3.21	0.00
SJR Vernalis	1	5,000	4,999	(0)	2.03	2.03	0.00
SJR at head of Old River	8	1,630	1,638	8	1.10	1.12	0.02
SJR above Turner Cut	25	1,961	1,975	14	0.10	0.10	0.00
SJR above Columbia Cut	31	1,010	806	(204)	0.04	0.04	(0.01)
SJR above mouth of Middle River	37	2,009	1,718	(291)	0.09	0.08	(0.01)
SJR below Mokelumne	45	3,324	(2,690)	(6,014)	0.07	(0.03)	(0.10)
SJR at Jersey Point	49	20,109	14,354	(5,755)	(0.44)	(0.33)	0.11
SJR at Antioch	50	20,541	14,465	(6,077)	0.39	0.30	(0.10)
Head of Old River	54	3,369	3,361	(8)	2.43	2.45	0.02
Old River south of Tracy	80	339	326	(13)	0.16	0.16	(0.00)
Old River north of Clifton Court	83	(7,434)	(7,449)	(15)	(1.55)	(1.56)	(0.02)
Old River at Woodward Canal	92	(6,106)	(6,118)	(12)	(0.80)	(0.81)	(0.01)
Old River at Rock Slough	106	(4,980)	(4,925)	55	(0.41)	(0.41)	0.00
Mouth of Old River	124	(5,687)	(6,978)	(1,290)	0.28	0.35	0.07
Middle River at Victoria Canal	135	(3,069)	(3,065)	4	(0.71)	(0.72)	(0.01)
Middle River at Columbia Cut	159	(4,888)	(7,197)	(2,309)	(0.23)	(0.35)	(0.12)
Empire–Turner Cut	175	951	1,169	218	0.18	0.22	0.05
Grant Line Canal	213	2,999	3,006	(7)	(0.68)	(0.69)	(0.01)
Mouth of Rock Slough	244	575	566	(10)	0.18	0.19	0.00
Connection Slough	248	2,025	2,232	207	0.29	0.33	0.03
E. Santa Fe Cut	258	701	750	49	0.15	0.17	0.02
W. Santa Fe Cut	259	701	749	48	(0.18)	(0.20)	(0.02)
Dutch Slough	274	432	110	(323)	0.13	0.05	(0.07)
False River	279	2,278	(556)	(2,834)	(0.16)	(0.02)	0.15
Fishermans Cut	280	508	294	(214)	0.11	0.07	(0.03)
Threemile Slough	309	15,015	17,894	2,879	0.97	1.18	0.21
Little Connection	319	2,463	2,773	310	(0.23)	(0.26)	(0.03)
White Slough	322	(870)	(919)	(49)	(0.09)	(0.10)	(0.01)
Little Potato	324	4,157	4,222	64	0.80	0.82	0.02
Potato	327	825	530	(294)	0.05	0.03	(0.02)
Mokelumne Mouth	349	8,782	8,763	(19)	(0.61)	(0.62)	(0.01)
DCC	365	0	0	0	0.00	0.00	0.00
Georgiana Slough	366	12,220	12,265	45	(2.47)	(2.49)	(0.01)
Cache Creek at Yolo Bypass	404	(50)	(50)	(0)	(0.00)	(0.00)	(0.00)
Sacramento R. at Rio Vista	430	67,729	67,684	(45)	1.14	1.15	0.00
Sacramento R. at Collinsville	435	52,403	49,454	(2,949)	0.78	0.74	(0.04)
Chipps Island	437	70,357	61,577	(8,780)	0.69	0.61	(0.08)
Roe Island	439	37,582	33,570	(4,012)	0.47	0.43	(0.04)
Benicia	441	73,252	64,255	(8,997)	0.47	0.42	(0.05)
Montezuma Slough	461	2,896	2,678	(218)	0.65	0.61	(0.04)

Notes: This table presents results for the analysis of the maximum diversion rate typical only of the first several days of filling an empty reservoir under maximum tidal conditions. Negative values shown in parentheses.

Table B1–8. Summary of Typical Net Delta Channel Flows during Periods of Maximum DW Discharge of 6,000 cfs (4,000 cfs from Bacon Island and 2,000 cfs from Webb Tract)

		Discharge Conditions					
Delta Channel Location	RMA Model Number	Base Flow (cfs)	Flow with Discharges (cfs)	Changed Flow (cfs)	Base Velocity (ft/sec)	Velocity with Discharges (ft/sec)	Changed Velocity (ft/sec)
CVP Tracy pumping		2,500	4,600	2,100	1.07	2.11	1.04
SWP Banks pumping		2,502	6,402	3,900	1.00	2.84	1.83
CCWD pumping		150	150	0	0.14	0.14	0.00
North Bay Aqueduct	406	(50)	(50)	(0)	(0.05)	(0.05)	0.00
Eastside streams		250	250	0			
Channel depletion		3,000	3,000	0			
Sacramento R. at Freeport		19,998	19,998	(0)	1.49	1.49	(0.00)
SJR at Vernalis	1	999	999	0	0.77	0.80	0.03
SJR at head of Old River	8	1	(275)	(276)	0.01	(0.22)	(0.23)
SJR above Turner Cut	25	(85)	(355)	(270)	(0.00)	(0.02)	(0.02)
SJR above Columbia Cut	31	(587)	(904)	(317)	(0.02)	(0.03)	(0.01)
SJR above mouth of Middle River	37	635	449	(186)	0.03	0.02	(0.01)
SJR below Mokelumne	45	1,414	1,422	8	0.04	0.04	(0.00)
SJR at Jersey Point	49	3,896	3,961	65	(0.13)	(0.13)	(0.00)
SJR at Antioch	50	3,981	4,052	71	0.12	0.13	0.00
Head of Old River	54	813	1,089	276	0.78	1.05	0.27
Old River south of Tracy	80	(38)	(7)	31	0.00	0.01	0.01
Old River north of Clifton Court	83	(3,833)	(8,484)	(4,651)	(0.78)	(1.79)	(1.02)
Old River at Woodward Canal	92	(3,230)	(7,049)	(3,819)	(0.41)	(0.93)	(0.53)
Old River at Rock Slough	106	(2,814)	(4,174)	(1,359)	(0.22)	(0.34)	(0.12)
Mouth of Old River	124	(3,270)	(2,486)	785	0.16	0.12	(0.04)
Middle River at Victoria Canal	135	(1,701)	(3,605)	(1,904)	(0.38)	(0.86)	(0.48)
Middle River at Columbia Cut	159	(2,917)	(3,390)	(474)	(0.13)	(0.16)	(0.03)
Empire–Turner Cut	175	441	488	47	0.07	0.09	0.01
Grant Line Canal	213	421	678	257	(0.13)	(0.18)	(0.06)
Mouth of Rock Slough	244	454	630	176	0.15	0.21	0.06
Connection Slough	248	1,153	1,526	373	0.16	0.22	0.06
E. Santa Fe Cut	258	435	(1,521)	(1,956)	0.08	(0.43)	(0.51)
W. Santa Fe Cut	259	433	2,478	2,044	(0.10)	(0.75)	(0.66)
Dutch Slough	274	122	128	6	0.06	0.06	0.00
False River	279	1,026	1,071	45	(0.10)	(0.10)	0.00
Fishermans Cut	280	61	45	(17)	0.03	0.03	(0.00)
Threemile Slough	309	1,592	1,579	12	(0.02)	(0.02)	(0.00)
Little Connection	319	1,842	1,945	(102)	(0.17)	(0.18)	(0.01)
White Slough	322	(739)	(751)	(12)	(0.08)	(0.08)	(0.00)
Little Potato	324	3,060	3,079	19	0.59	0.60	0.00
Potato	327	470	378	(92)	0.03	0.02	(0.00)
Mokelumne Mouth	349	5,408	5,403	5	(0.38)	(0.38)	0.00
DCC	365	5,810	5,806	3	(1.19)	(1.19)	0.00
Georgiana Slough	366	2,836	2,837	(1)	(0.78)	(0.78)	0.00
Cache Creek at Yolo Bypass	404	(268)	(268)	0	(0.02)	(0.02)	0.00
Sac. R. at Rio Vista	430	10,266	10,268	2	0.19	0.19	0.00
Sac. R. at Collinsville	435	8,413	8,426	13	0.17	0.17	0.00
Chipps Island	437	12,433	12,515	82	0.18	0.18	0.00
Roe Island	439	10,764	10,794	30	0.19	0.19	(0.00)
Benicia	441	12,220	12,292	72	0.14	0.14	0.00
Montezuma Slough	461	47	48	1	0.10	0.10	(0.00)

Notes: This table presents results for the analysis of the maximum diversion rate typical only of the first several days of filling an empty reservoir under maximum tidal conditions. Negative values shown in parentheses.

Table B1–9. Simulated Stage Differences during Periods of Maximum DW Diversion (9,000 cfs) and Maximum DW Discharge (6,000 cfs) at Selected Nodes of the RMA Delta Hydrodynamic Model

		Simulated Stage Differences with Maximum DW Diversion (ft)									Simulated Stage Differences with Maximum DW Discharge (ft)								
Channel Location	RMA Model Node	Base Mean Stage	Diversion Mean Stage	Change	Base Min Stage	Diversion Min Stage	Change	Base Max Stage	Diversion Max Stage	Change	Base Mean Stage	Discharge Mean Stage	Change	Base Min Stage	Discharge Min Stage	Change	Base Max Stage	Discharge Max Stage	Change
SJR at Vernalis	1	7.07	7.05	−0.02	6.98	6.97	−0.01	7.21	7.18	−0.03	1.62	1.36	−0.25	0.99	0.88	−0.11	2.69	2.28	−0.40
Head of Old River	8	2.41	2.31	−0.09	1.84	1.77	−0.07	3.32	3.18	−0.13	0.66	0.33	−0.33	−0.52	−0.72	−0.20	2.19	1.67	−0.52
SJR at Stockton	15	0.96	0.81	−0.14	−0.73	−0.89	−0.16	3.06	2.92	−0.14	0.58	0.54	−0.04	−1.44	−1.50	−0.06	2.89	2.89	−0.00
SJR at Turner Cut	26	0.73	0.57	−0.15	−1.30	−1.48	−0.19	2.95	2.82	−0.14	0.54	0.53	−0.00	−1.68	−1.69	−0.00	2.87	2.89	0.02
SJR at Columbia Cut	31	0.72	0.57	−0.15	−1.22	−1.40	−0.17	2.87	2.74	−0.13	0.54	0.53	−0.00	−1.59	−1.59	−0.00	2.82	2.83	0.01
SJR at mouth of Middle River	35	0.72	0.57	−0.15	−1.14	−1.34	−0.20	2.76	2.64	−0.12	0.54	0.53	−0.00	−1.54	−1.54	−0.01	2.78	2.79	0.01
Mouth of Old River	38	0.72	0.57	−0.15	−1.12	−1.31	−0.19	2.70	2.56	−0.14	0.54	0.53	−0.00	−1.51	−1.52	−0.00	2.74	2.75	0.01
Mokelumne River mouth	40	0.72	0.57	−0.15	−1.10	−1.29	−0.19	2.69	2.55	−0.14	0.54	0.54	−0.00	−1.49	−1.49	−0.00	2.71	2.73	0.01
False River mouth	44	0.65	0.56	−0.09	−1.44	−1.55	−0.11	2.77	2.70	−0.06	0.46	0.46	−0.00	−1.91	−1.91	−0.00	2.75	2.75	−0.00
Head of Middle River	52	0.98	0.85	−0.14	−0.09	−0.20	−0.11	2.46	2.30	−0.15	0.38	−0.06	−0.44	−1.37	−1.63	−0.27	2.38	1.76	−0.62
Old River at Tracy	65	0.21	0.05	−0.16	−1.26	−1.40	−0.14	2.10	1.91	−0.19	0.19	−0.29	−0.48	−1.68	−1.96	−0.27	2.40	1.77	−0.63
Old River at DMC	70	−0.03	−0.20	−0.18	−1.78	−1.98	−0.20	1.95	1.77	−0.18	0.14	−0.36	−0.50	−1.92	−2.23	−0.31	2.34	1.66	−0.67
Clifton Court gates	73	0.06	−0.11	−0.17	−1.72	−1.91	−0.19	1.97	1.80	−0.17	0.19	−0.23	−0.42	−1.89	−2.14	−0.25	2.41	1.83	−0.59
Old River at Victoria	82	0.49	0.32	−0.17	−1.45	−1.65	−0.21	2.52	2.35	−0.17	0.42	0.31	−0.11	−1.67	−1.82	−0.15	2.68	2.58	−0.10
Old River at Rock Slough	93	0.65	0.49	−0.17	−1.31	−1.50	−0.18	2.79	2.64	−0.15	0.50	0.48	−0.02	−1.65	−1.68	−0.03	2.77	2.77	0.00
Mouth of Old River	103	0.71	0.56	−0.15	−1.13	−1.33	−0.20	2.70	2.55	−0.15	0.53	0.53	−0.00	−1.53	−1.53	−0.00	2.73	2.75	0.01
Mouth of Middle River	108	0.37	0.21	−0.16	−1.46	−1.63	−0.17	2.35	2.17	−0.18	0.24	0.02	−0.22	−1.84	−1.99	−0.14	2.59	2.29	−0.30
Middle River at Victoria Canal	113	0.32	0.15	−0.17	−1.54	−1.71	−0.18	2.33	2.17	−0.16	0.31	0.09	−0.22	−1.79	−1.93	−0.14	2.54	2.28	−0.26
Mouth of Columbia	133	0.72	0.56	−0.16	−1.21	−1.38	−0.17	2.84	2.71	−0.13	0.54	0.53	−0.00	−1.57	−1.58	−0.00	2.81	2.82	0.01
Turner Cut	142	0.71	0.56	−0.16	−1.33	−1.52	−0.19	2.97	2.83	−0.14	0.53	0.53	−0.00	−1.72	−1.73	−0.01	2.90	2.92	0.02
Tom Paine Slough	160	2.04	1.88	−0.16	2.04	1.88	−0.16	2.04	1.88	−0.16	0.45	−0.09	−0.53	0.03	−0.59	−0.61	0.91	0.41	−0.49
Grant Line Canal	175	0.16	−0.00	−0.17	−1.36	−1.52	−0.16	2.07	1.89	−0.18	0.20	−0.28	−0.48	−1.74	−2.01	−0.27	2.35	1.74	−0.61
Victoria Canal	185	0.18	0.01	−0.17	−1.69	−1.88	−0.19	2.13	1.96	−0.18	0.25	−0.08	−0.33	−1.89	−2.10	−0.21	2.52	2.09	−0.43
Connection Slough	208	0.69	0.53	−0.16	−1.21	−1.38	−0.17	2.79	2.66	−0.13	0.52	0.52	−0.01	−1.56	−1.57	−0.01	2.77	2.78	0.01
Dutch Slough	222	0.70	0.56	−0.14	−1.19	−1.35	−0.17	2.62	2.51	−0.11	0.53	0.53	−0.00	−1.57	−1.58	−0.00	2.61	2.62	0.01
False River	226	0.68	0.57	−0.12	−1.20	−1.35	−0.16	2.63	2.53	−0.10	0.50	0.50	−0.00	−1.64	−1.64	−0.00	2.60	2.60	0.00
Franks Tract	232	0.71	0.56	−0.15	−1.15	−1.34	−0.19	2.69	2.55	−0.14	0.53	0.53	−0.00	−1.54	−1.54	−0.00	2.73	2.74	0.01
S. Mokelumne River	268	0.85	0.71	−0.14	−1.06	−1.23	−0.17	2.93	2.80	−0.13	0.61	0.61	−0.00	−1.53	−1.53	−0.00	2.85	2.86	0.01
N. Mokelumne River	285	0.91	0.76	−0.14	−0.97	−1.14	−0.17	2.92	2.79	−0.13	0.73	0.73	−0.00	−1.32	−1.32	−0.00	2.88	2.89	0.01
Georgiana Slough	295	2.25	2.15	−0.10	0.92	0.82	−0.11	3.78	3.68	−0.10	0.72	0.72	−0.00	−1.30	−1.30	−0.00	2.87	2.88	0.01
Sacramento R. at DCC	342	7.88	7.86	−0.02	7.48	7.46	−0.02	8.39	8.38	−0.02	1.30	1.30	−0.00	−0.39	−0.39	−0.00	3.31	3.31	0.00
Sacramento R. at Threemile Slough	352	0.84	0.78	−0.06	−1.41	−1.49	−0.08	3.22	3.20	−0.01	0.46	0.46	0.00	−2.14	−2.15	−0.00	2.97	2.96	−0.01
Sacramento R. at Benicia	361	−0.11	−0.11	0.00	−3.69	−3.69	0.00	2.81	2.81	0.00	0.03	0.03	0.00	−3.74	−3.74	0.00	3.14	3.14	0.00

Table B1-10. Simulated Monthly Delta Channel Flows (cfs) and Exports (cfs) under the No-Project Alternative for 1968-1991

Water Year	Sac. R. at Freeport	Yolo Bypass	SJR at Vernalis	Eastside Streams	Channel Depletion	Total Exports	DCC & Georgiana	Sac. R. at Rio Vista	Threemile Slough	Head of Old R.	Final QWEST	SJR at Antioch	Old R. & Middle R.	Total Outflow
1968														
OCT	23,545	98	3,342	716	1,372	11,280	9,390	13,910	2,910	167	1,062	3,972	(11,876)	14,835
NOV	17,983	34	2,072	218	854	11,280	3,499	14,304	5,287	1,756	(6,229)	(942)	(10,048)	7,990
DEC	16,174	33	2,460	342	854	11,298	3,273	12,721	4,822	1,986	(5,923)	(1,102)	(9,799)	6,712
JAN	28,229	1,025	2,483	553	(985)	11,699	4,818	24,682	6,796	2,000	(3,326)	3,470	(9,427)	21,455
FEB	61,379	6,050	2,866	1,747	(286)	11,826	9,526	57,974	12,763	2,219	2,396	15,160	(9,595)	60,399
MAR	34,432	2,618	2,280	1,285	88	11,268	5,653	31,375	8,005	1,881	(2,206)	5,799	(9,521)	29,160
APR	12,159	134	3,669	622	1,483	4,666	2,773	9,150	1,718	183	1,324	3,042	(5,186)	10,325
MAY	10,609	211	3,580	439	2,354	3,869	2,578	7,653	1,734	179	161	1,895	(4,852)	7,579
JUN	14,457	303	1,827	336	3,878	5,923	7,019	6,771	1,435	1,606	457	1,892	(6,149)	6,841
JUL	21,061	455	1,675	342	4,211	11,280	8,773	11,690	3,834	1,510	(3,538)	296	(11,765)	7,731
AUG	13,673	504	1,021	309	2,373	7,537	6,787	6,797	1,992	1,055	(1,301)	691	(7,769)	5,259
SEP	11,372	303	1,091	269	1,928	6,685	6,046	5,147	1,449	1,109	(796)	653	(6,611)	4,158
1969														
OCT	13,932	146	1,527	114	1,274	9,074	6,864	6,895	2,112	76	(1,611)	501	(9,721)	5,157
NOV	12,473	101	2,213	319	703	8,545	2,812	9,586	3,438	1,841	(3,841)	(403)	(7,168)	5,675
DEC	22,663	488	1,823	732	382	11,190	4,093	18,963	5,967	1,604	(4,936)	1,032	(9,884)	13,989
JAN	72,606	38,886	4,380	8,799	(4,644)	12,325	11,224	101,429	18,951	3,058	14,975	33,926	(7,531)	116,869
FEB	67,092	44,061	18,427	9,543	(3,527)	12,700	10,385	101,649	14,969	10,853	27,845	42,814	(539)	129,847
MAR	43,846	9,091	8,065	3,236	511	11,700	6,966	45,844	8,764	5,058	6,135	14,899	(6,945)	51,928
APR	43,157	739	8,111	3,479	1,214	9,950	6,868	36,725	6,176	406	7,609	13,785	(10,140)	44,212
MAY	44,408	325	21,183	3,724	2,321	11,280	7,045	37,107	2,713	12,441	18,944	21,657	13	55,819
JUN	24,948	387	14,091	1,193	3,861	11,280	9,735	14,634	(20)	8,392	10,949	10,929	(4,713)	25,197
JUL	12,587	455	5,701	358	4,211	6,577	6,450	5,539	388	3,775	2,884	3,271	(4,797)	8,002
AUG	11,644	439	1,989	309	2,943	5,359	6,140	5,208	955	1,706	828	1,782	(5,168)	5,741
SEP	23,339	319	2,814	303	1,861	11,280	9,339	13,854	3,323	2,190	(298)	3,025	(10,099)	13,370
1970														
OCT	21,825	114	7,649	634	1,047	11,280	8,964	12,713	1,374	382	5,072	6,446	(11,530)	17,681
NOV	18,756	50	4,023	185	854	11,280	3,596	14,996	4,816	2,863	(4,214)	603	(8,942)	10,697
DEC	51,679	6,099	4,136	911	106	11,583	8,093	49,658	11,155	2,925	1,343	12,498	(8,846)	50,991
JAN	91,517	92,816	11,305	9,969	(4,384)	12,700	14,157	171,272	31,946	6,838	25,459	57,405	(4,230)	197,170
FEB	56,215	29,422	7,638	2,773	(106)	12,700	8,759	76,905	15,910	4,826	6,436	22,346	(7,935)	83,351
MAR	33,273	2,879	3,420	2,814	495	11,461	5,495	30,533	7,166	2,530	(153)	7,012	(9,228)	30,331
APR	13,131	101	5,343	655	1,550	5,991	2,894	9,950	1,761	267	1,784	3,544	(6,454)	11,579
MAY	10,290	472	5,220	618	2,484	5,086	2,538	7,603	1,702	261	224	1,926	(6,039)	7,579
JUN	14,734	504	2,297	370	3,777	6,267	7,099	7,195	1,438	1,891	763	2,201	(6,168)	7,580
JUL	22,569	537	1,721	342	4,211	11,280	9,149	12,905	3,985	1,540	(3,116)	868	(11,736)	9,367
AUG	12,891	472	1,674	309	2,943	6,324	6,546	6,081	1,432	1,510	(46)	1,386	(6,330)	5,741
SEP	10,674	319	1,294	269	1,894	6,526	5,799	4,721	1,307	1,256	(659)	648	(6,292)	3,872

Table B1-10. Continued

Water Year	Sac. R. at Freeport	Yolo Bypass	SJR at Vernalis	Eastside Streams	Channel Depletion	Total Exports	DCC & Georgiana	Sac. R. at Rio Vista	Threemile Slough	Head of Old R.	Final QWEST	SJR at Antioch	Old R. & Middle R.	Total Outflow
1971														
OCT	13,625	98	1,737	114	1,242	9,055	6,772	6,640	2,003	87	(1,453)	550	(9,679)	5,063
NOV	22,080	908	2,676	1,042	(37)	11,280	4,018	18,979	5,585	2,111	(3,703)	1,882	(9,337)	15,280
DEC	59,077	8,636	2,794	3,773	(1,716)	11,355	9,183	58,959	12,062	2,178	5,365	17,428	(8,635)	64,496
JAN	47,425	6,001	2,114	1,415	(562)	11,578	7,477	46,089	10,846	1,782	(327)	10,519	(9,692)	45,818
FEB	28,709	450	2,281	864	398	9,028	4,882	24,178	6,063	1,881	(1,363)	4,700	(7,409)	22,775
MAR	50,628	1,431	2,280	1,236	430	11,268	7,940	44,011	10,319	1,881	(190)	10,129	(9,658)	43,778
APR	19,323	118	3,988	992	1,382	6,650	3,668	15,428	3,286	199	989	4,276	(7,113)	16,279
MAY	31,190	358	3,933	862	1,931	8,380	5,213	25,852	5,978	197	153	6,131	(9,176)	25,812
JUN	22,755	235	2,281	521	3,794	9,027	9,195	12,847	2,925	1,881	222	3,147	(8,945)	12,690
JUL	22,883	309	1,724	342	4,211	11,280	9,226	12,913	3,961	1,541	(3,036)	926	(11,734)	9,456
AUG	13,337	325	1,690	309	2,943	6,639	6,685	6,242	1,520	1,520	(206)	1,313	(6,634)	5,741
SEP	16,509	252	1,247	269	1,911	10,062	7,595	8,689	2,796	1,223	(2,458)	338	(9,867)	6,040
1972														
OCT	18,767	98	2,000	260	1,356	11,280	8,191	10,335	3,012	100	(1,924)	1,088	(11,936)	8,275
NOV	16,451	34	1,901	269	871	11,116	3,307	12,960	5,023	1,652	(6,388)	(1,365)	(9,995)	6,485
DEC	21,067	211	1,911	1,057	415	11,205	3,889	17,286	5,522	1,658	(4,763)	759	(9,858)	12,481
JAN	18,239	49	2,086	390	(204)	11,568	3,531	14,808	5,191	1,765	(5,550)	(358)	(9,843)	9,279
FEB	25,328	54	2,281	828	200	9,972	4,437	20,895	5,704	1,881	(2,659)	3,045	(8,274)	18,216
MAR	32,274	81	2,280	472	1,113	11,268	5,359	26,717	7,475	1,881	(3,979)	3,496	(9,931)	22,627
APR	11,474	118	3,669	790	1,550	4,580	2,687	8,518	1,532	183	1,448	2,980	(5,127)	9,811
MAY	10,598	358	2,763	602	2,598	3,924	2,577	7,730	1,768	138	109	1,877	(5,045)	7,579
JUN	14,216	387	1,812	353	3,777	5,869	6,948	6,710	1,405	1,597	509	1,913	(6,064)	6,841
JUL	20,984	634	1,674	358	4,211	11,280	8,754	11,811	3,863	1,510	(3,542)	321	(11,766)	7,848
AUG	19,341	748	989	309	2,943	11,280	8,338	11,015	3,788	1,030	(3,895)	(106)	(11,765)	6,826
SEP	10,516	420	1,787	235	1,609	7,294	5,741	4,793	1,381	1,581	(841)	540	(6,620)	3,791
1973														
OCT	14,964	163	1,508	98	786	10,115	7,165	7,765	2,459	75	(2,069)	390	(10,568)	5,618
NOV	22,305	723	2,560	538	(490)	11,280	4,047	19,104	5,707	2,044	(4,000)	1,707	(9,223)	15,153
DEC	27,226	651	1,831	439	(203)	11,191	4,686	23,242	6,749	1,609	(4,249)	2,501	(9,646)	19,014
JAN	46,559	26,119	1,979	4,147	(5,246)	11,533	7,353	66,637	13,893	1,700	5,235	19,128	(7,856)	72,396
FEB	71,663	17,016	4,197	6,464	(3,005)	12,265	11,080	78,350	14,714	2,958	11,326	26,041	(8,208)	89,977
MAR	45,792	10,734	6,685	4,001	(221)	11,700	7,243	49,338	9,535	4,308	6,274	15,809	(7,402)	55,634
APR	16,912	504	5,343	1,260	1,483	7,420	3,365	13,680	2,727	267	1,474	4,201	(7,856)	15,006
MAY	17,833	146	5,279	960	2,435	7,443	3,480	13,890	3,090	264	473	3,563	(8,374)	14,120
JUN	19,410	286	3,420	420	3,878	7,787	8,356	10,371	2,318	2,530	318	2,636	(7,089)	10,301
JUL	22,533	439	1,691	342	4,211	11,110	9,140	12,779	3,915	1,520	(2,985)	929	(11,585)	9,373
AUG	12,298	455	1,628	325	2,943	6,123	6,357	5,661	1,340	1,480	(64)	1,275	(6,158)	5,302
SEP	11,305	303	1,262	269	1,861	6,867	6,023	5,120	1,440	1,234	(786)	653	(6,642)	4,147

Table B1–10. Continued

Water Year	Sac. R. at Freeport	Yolo Bypass	SJR at Vernalis	Eastside Streams	Channel Depletion	Total Exports	DCC & Georgiana	Sac. R. at Rio Vista	Threemile Slough	Head of Old R.	Final QWEST	SJR at Antioch	Old R. & Middle R.	Total Outflow
1974														
OCT	14,977	49	1,500	1,106	900	10,863	7,169	7,632	2,383	75	(1,927)	456	(11,362)	5,615
NOV	57,052	9,445	2,459	1,697	131	11,280	8,883	57,582	12,956	1,986	1,491	14,446	(9,530)	59,059
DEC	60,493	9,482	2,441	3,269	(935)	11,295	9,394	60,815	12,838	1,975	4,272	17,109	(9,091)	65,180
JAN	78,775	49,164	3,390	5,123	(1,473)	11,999	12,172	116,135	24,088	2,514	9,523	33,610	(9,017)	125,805
FEB	42,016	5,096	3,422	864	326	12,009	6,706	40,324	9,817	2,531	(1,332)	8,486	(9,711)	38,960
MAR	97,768	8,847	3,423	4,147	(432)	11,462	15,142	91,581	17,766	2,532	11,431	29,197	(8,856)	103,056
APR	36,823	34,552	6,195	2,168	760	9,950	5,981	65,204	14,012	310	3,790	17,802	(10,054)	68,918
MAY	24,439	276	6,105	992	2,240	9,437	4,322	19,833	4,528	305	306	4,833	(10,248)	19,915
JUN	21,148	286	3,422	471	3,727	8,864	8,795	11,707	2,378	2,531	1,120	3,498	(8,105)	12,455
JUL	17,717	472	1,717	407	3,935	8,065	7,917	9,288	2,445	1,537	(892)	1,552	(8,413)	8,002
AUG	13,531	325	1,769	309	2,943	6,912	6,744	6,376	1,593	1,570	(341)	1,252	(6,857)	5,741
SEP	20,973	202	1,336	269	1,928	11,280	8,751	11,942	3,549	1,285	(2,441)	1,108	(11,030)	9,308
1975														
OCT	22,708	16	2,010	325	1,112	11,280	9,183	13,263	3,311	101	(699)	2,612	(11,838)	12,453
NOV	17,806	34	2,729	454	888	11,280	3,477	14,141	4,983	2,141	(5,380)	(398)	(9,677)	8,672
DEC	17,880	163	2,267	651	740	11,265	3,486	14,372	5,070	1,873	(5,487)	(417)	(9,833)	8,811
JAN	16,032	49	1,564	325	(107)	11,396	3,255	12,853	4,972	1,438	(6,303)	(1,332)	(10,036)	6,560
FEB	61,624	2,917	5,246	2,593	(1,402)	12,611	9,563	55,329	11,143	3,529	5,599	16,742	(8,625)	61,068
MAR	74,091	9,303	3,420	5,302	(1,148)	11,461	11,451	72,230	13,904	2,530	9,359	23,263	(8,571)	81,704
APR	21,535	1,109	6,195	1,546	1,147	9,203	3,948	18,409	3,780	310	1,631	5,411	(9,462)	19,925
MAY	32,215	228	6,105	1,578	2,289	9,950	5,351	26,519	5,750	305	1,377	7,127	(10,780)	27,667
JUN	24,875	387	3,422	1,143	3,861	10,439	9,717	14,579	3,069	2,531	1,052	4,121	(9,734)	15,246
JUL	19,683	569	1,747	374	4,130	9,669	8,426	10,794	3,180	1,556	(2,118)	1,062	(10,076)	8,263
AUG	12,690	325	1,792	276	2,764	6,240	6,483	5,841	1,306	1,584	176	1,483	(6,099)	5,741
SEP	18,106	168	1,850	269	1,928	11,280	8,019	9,773	3,111	1,621	(2,659)	453	(10,695)	6,921
1976														
OCT	22,960	114	2,000	569	835	11,280	9,245	13,620	3,245	100	(222)	3,022	(11,728)	13,314
NOV	20,504	0	2,796	252	938	11,280	3,817	16,452	5,467	2,180	(5,208)	260	(9,659)	11,151
DEC	15,624	65	2,186	195	984	10,586	3,204	12,239	4,666	1,825	(5,785)	(1,119)	(9,300)	6,355
JAN	13,398	16	1,007	114	72	8,477	2,927	10,469	3,881	1,045	(4,596)	(716)	(7,582)	5,865
FEB	19,051	18	1,088	252	452	9,184	3,633	15,323	5,016	1,107	(4,607)	408	(8,361)	10,670
MAR	15,023	179	1,740	309	1,272	6,038	3,130	11,754	3,330	1,552	(1,883)	1,447	(5,192)	9,744
APR	9,755	118	2,005	403	1,545	3,072	2,470	7,017	1,444	100	612	2,056	(3,769)	7,475
MAY	10,224	81	2,013	374	2,819	3,267	2,529	7,071	1,781	101	(423)	1,358	(4,534)	6,366
JUN	14,636	101	1,775	336	3,805	5,896	7,071	6,715	1,389	1,574	563	1,952	(6,094)	6,897
JUL	16,465	98	997	342	4,205	7,623	7,583	7,929	2,399	1,037	(1,759)	641	(8,592)	5,750
AUG	8,227	423	900	260	2,513	3,547	4,796	3,226	614	959	440	1,054	(3,867)	3,415
SEP	7,675	218	900	252	1,636	4,042	4,489	2,995	643	959	177	820	(4,017)	3,008

Table B1–10. Continued

Water Year	Sac. R. at Freeport	Yolo Bypass	SJR at Vernalis	Eastside Streams	Channel Depletion	Total Exports	DCC & Georgiana	Sac. R. at Rio Vista	Threemile Slough	Head of Old R.	Final QWEST	SJR at Antioch	Old R. & Middle R.	Total Outflow
1977														
OCT	8,134	49	1,558	163	1,237	5,434	4,752	3,122	730	78	(6)	724	(6,092)	2,992
NOV	11,087	17	1,549	67	883	6,432	2,638	8,245	2,845	1,429	(2,946)	(101)	(5,551)	5,211
DEC	18,098	33	1,091	98	899	11,058	3,514	14,393	5,585	1,109	(7,117)	(1,531)	(10,486)	7,186
JAN	8,254	49	1,029	98	(62)	4,844	2,276	6,042	1,892	1,062	(1,543)	349	(3,901)	4,505
FEB	13,432	36	1,310	72	538	6,067	2,932	10,402	3,135	1,267	(2,265)	870	(5,177)	8,083
MAR	10,289	114	1,562	179	852	4,198	2,538	7,652	1,994	1,437	(670)	1,324	(3,299)	6,897
APR	8,892	235	2,027	403	1,656	2,825	2,359	6,354	1,259	101	709	1,968	(3,565)	6,897
MAY	6,120	667	2,022	228	1,897	2,395	1,994	4,319	889	101	376	1,265	(3,293)	4,505
JUN	6,807	202	1,790	319	3,792	1,076	4,067	1,994	(283)	1,583	2,385	2,103	(1,260)	4,000
JUL	8,808	195	973	325	4,158	1,818	5,057	2,906	204	1,018	1,511	1,715	(2,787)	4,001
AUG	6,218	98	911	293	2,890	941	3,717	1,877	(135)	968	1,827	1,692	(1,403)	3,415
SEP	7,128	50	1,045	235	1,591	3,580	3,833	2,947	618	1,074	220	838	(3,421)	3,008
1978														
OCT	7,130	49	1,633	146	1,311	4,414	3,898	2,953	635	82	170	805	(5,098)	2,992
NOV	6,109	151	1,360	151	714	3,326	1,992	4,089	1,104	1,302	(481)	623	(2,504)	3,537
DEC	15,370	732	1,418	455	153	10,813	3,173	12,891	4,899	1,341	(6,044)	(1,145)	(9,710)	6,832
JAN	44,069	14,361	2,880	3,220	(4,986)	11,830	6,997	52,679	10,912	2,227	4,365	15,277	(7,752)	57,543
FEB	50,420	6,896	4,668	2,197	(1,777)	12,420	7,910	49,850	10,571	3,215	3,348	13,919	(8,657)	53,376
MAR	47,850	16,816	3,580	2,732	(1,766)	11,489	7,538	57,569	12,351	2,619	3,411	15,762	(8,262)	61,156
APR	37,669	1,042	6,195	2,588	559	9,950	6,098	32,473	6,173	310	4,458	10,631	(9,974)	36,875
MAY	19,632	49	6,105	976	2,207	8,527	3,707	15,423	3,405	305	606	4,011	(9,284)	15,808
JUN	14,216	134	4,591	605	3,878	6,613	6,948	6,432	644	3,173	2,730	3,374	(5,272)	8,774
JUL	12,930	325	1,766	342	4,211	2,839	6,558	5,644	445	1,568	2,779	3,224	(3,266)	8,002
AUG	10,740	130	1,877	309	2,943	4,473	5,823	4,312	602	1,637	1,285	1,887	(4,351)	5,302
SEP	13,677	101	1,558	218	1,844	8,219	6,788	6,529	1,872	1,435	(1,118)	755	(7,786)	5,227
1979														
OCT	18,420	49	3,367	163	1,404	11,280	8,101	10,017	2,578	168	(776)	1,803	(11,887)	9,101
NOV	15,857	67	2,612	168	720	11,280	3,233	12,511	4,771	2,074	(5,918)	(1,147)	(9,677)	6,521
DEC	10,622	16	1,642	130	951	6,330	2,580	7,821	2,682	1,489	(2,741)	(59)	(5,366)	4,984
JAN	25,053	732	2,935	1,415	(2,140)	11,849	4,401	21,919	5,682	2,259	(1,827)	3,855	(8,855)	20,305
FEB	40,292	630	5,623	3,475	(2,375)	12,700	6,464	35,052	6,822	3,733	4,303	11,125	(8,120)	39,592
MAR	30,623	195	4,506	2,700	170	11,646	5,137	25,638	5,824	3,127	488	6,311	(8,687)	26,109
APR	16,639	50	5,343	958	1,248	7,240	3,331	13,046	2,580	267	1,471	4,051	(7,582)	14,392
MAY	15,506	65	5,279	1,057	2,272	7,039	3,190	11,813	2,506	264	790	3,296	(7,904)	12,376
JUN	20,505	67	3,420	437	3,878	8,099	8,634	10,969	2,463	2,530	301	2,764	(7,401)	10,882
JUL	17,624	195	1,682	342	4,162	8,865	7,893	8,886	2,687	1,515	(1,965)	723	(9,326)	6,505
AUG	11,156	49	1,621	309	2,943	5,186	5,971	4,498	903	1,476	464	1,367	(5,226)	4,668
SEP	9,951	50	1,437	269	1,928	6,118	5,527	3,992	1,057	1,354	(403)	654	(5,799)	3,397

Table B1–10. Continued

Water Year	Sac. R. at Freeport	Yolo Bypass	SJR at Vernalis	Eastside Streams	Channel Depletion	Total Exports	DCC & Georgiana	Sac. R. at Rio Vista	Threemile Slough	Head of Old R.	Final QWEST	SJR at Antioch	Old R. & Middle R.	Total Outflow
1980														
OCT	10,574	49	2,256	98	933	7,829	5,762	4,628	1,246	113	(533)	713	(8,303)	4,001
NOV	18,058	67	3,447	303	804	11,280	3,509	14,415	4,842	2,545	(4,727)	115	(9,239)	9,608
DEC	19,749	1,057	2,321	472	8	11,275	3,721	17,083	5,521	1,905	(4,910)	611	(9,518)	12,171
JAN	69,421	31,519	9,413	7,286	(2,627)	12,700	10,739	90,858	16,064	5,795	16,324	32,388	(5,975)	107,445
FEB	69,057	43,736	17,275	6,914	(3,527)	12,700	10,683	102,991	16,373	10,195	24,362	40,735	(1,198)	127,706
MAR	35,876	15,125	21,300	3,676	283	11,700	5,851	45,080	4,603	12,509	18,844	23,447	597	63,895
APR	16,641	50	6,195	992	1,214	8,064	3,331	13,056	2,556	310	1,555	4,111	(7,794)	14,490
MAY	13,874	390	6,105	764	2,142	6,516	2,987	10,742	1,963	305	1,727	3,690	(7,288)	12,255
JUN	12,244	403	4,184	555	3,844	5,682	6,339	5,347	426	2,951	2,617	3,043	(4,550)	7,579
JUL	12,732	309	2,163	358	4,016	3,233	6,496	5,541	395	1,811	2,863	3,257	(3,339)	8,002
AUG	10,987	228	1,932	309	2,943	4,873	5,911	4,568	742	1,671	1,028	1,771	(4,717)	5,302
SEP	14,383	50	3,371	269	1,928	10,445	6,997	6,954	2,036	2,503	(1,325)	711	(8,977)	5,436
1981														
OCT	17,237	49	4,023	455	1,388	11,280	7,790	9,149	2,173	201	(128)	2,045	(11,848)	8,882
NOV	14,220	34	3,656	403	938	11,130	3,030	10,990	4,077	2,661	(4,834)	(757)	(9,027)	6,062
DEC	16,221	98	3,051	244	821	11,399	3,279	12,835	4,717	2,324	(5,504)	(787)	(9,548)	7,249
JAN	25,220	455	2,876	667	(790)	11,829	4,423	21,449	6,088	2,225	(3,470)	2,617	(9,409)	18,058
FEB	28,023	576	3,225	342	200	11,258	4,791	23,758	6,520	2,422	(3,133)	3,387	(9,020)	20,605
MAR	32,372	146	2,704	1,496	(286)	11,340	5,373	27,217	6,871	2,127	(1,680)	5,191	(9,197)	25,565
APR	14,636	50	3,669	437	1,432	5,027	3,081	11,247	2,271	183	1,120	3,390	(5,526)	12,223
MAY	10,824	65	3,580	390	2,370	3,873	2,605	7,691	1,754	179	125	1,879	(4,862)	7,579
JUN	13,587	67	1,820	336	3,878	5,534	6,761	5,924	1,199	1,602	582	1,780	(5,764)	6,118
JUL	20,715	163	1,680	342	4,211	11,280	8,686	11,139	3,731	1,513	(3,620)	111	(11,762)	7,098
AUG	14,156	65	1,132	309	2,943	7,550	6,931	6,554	1,976	1,140	(1,429)	547	(7,926)	4,831
SEP	10,095	50	1,141	269	1,793	6,006	5,582	4,115	1,098	1,146	(443)	655	(5,841)	3,492
1982														
OCT	12,785	16	1,500	81	949	8,382	6,513	6,051	1,775	75	(1,163)	612	(8,901)	4,793
NOV	32,339	3,311	1,631	1,008	199	11,280	5,368	30,232	8,171	1,482	(3,585)	4,586	(10,061)	26,627
DEC	71,377	23,306	1,628	2,618	(415)	11,157	11,036	83,750	18,191	1,480	4,250	22,441	(9,656)	88,042
JAN	53,073	20,801	3,306	8,490	(4,303)	11,971	8,297	66,653	12,153	2,467	10,798	22,951	(7,904)	77,881
FEB	70,537	22,183	5,999	8,265	(664)	12,700	10,908	81,978	15,098	3,936	12,801	27,899	(8,601)	94,845
MAR	62,008	5,172	12,944	8,018	(2,758)	11,700	9,620	58,249	7,130	7,749	20,576	27,706	(2,946)	79,101
APR	78,803	36,502	23,396	12,806	172	11,280	12,176	103,086	12,473	13,728	36,876	49,350	2,269	139,945
MAY	35,743	374	19,251	5,042	2,207	11,280	5,832	29,733	1,543	11,326	17,191	18,734	(1,057)	46,703
JUN	22,539	67	7,492	2,235	3,777	11,280	9,141	12,520	1,398	4,746	4,852	6,250	(8,326)	16,995
JUL	15,018	146	4,614	1,334	4,211	8,588	7,181	6,931	1,148	3,185	1,492	2,640	(7,398)	8,002
AUG	13,802	49	2,508	846	2,943	8,123	6,826	6,290	1,527	2,014	(194)	1,333	(7,624)	5,801
SEP	23,119	17	5,180	588	1,272	11,280	9,285	13,533	2,314	3,493	2,682	4,996	(8,560)	16,088

Table B1–10. Continued

Water Year	Sac. R. at Freeport	Yolo Bypass	SJR at Vernalis	Eastside Streams	Channel Depletion	Total Exports	DCC & Georgiana	Sac. R. at Rio Vista	Threemile Slough	Head of Old R.	Final QWEST	SJR at Antioch	Old R. & Middle R.	Total Outflow
1983														
OCT	29,962	98	12,173	1,285	884	11,280	5,049	24,790	3,761	7,319	6,438	10,199	(4,528)	31,140
NOV	40,150	1,647	8,422	4,302	(726)	11,280	6,444	35,534	5,721	5,253	8,177	13,898	(5,920)	43,784
DEC	58,262	10,620	18,514	9,921	(740)	11,700	9,062	60,005	5,798	10,903	26,133	31,931	(646)	86,212
JAN	57,238	20,882	21,391	10,165	(4,514)	12,700	8,910	70,338	6,813	12,562	30,579	37,392	1,546	101,369
FEB	82,605	58,627	35,143	14,045	(3,401)	12,700	12,765	129,317	14,049	20,705	51,361	65,409	9,262	181,018
MAR	87,187	113,503	42,741	19,923	(4,482)	11,700	13,478	188,332	22,824	25,321	67,257	90,080	15,315	256,037
APR	64,475	15,360	30,300	7,126	122	11,280	9,991	69,814	5,008	17,802	35,947	40,956	6,363	105,749
MAY	56,196	3,253	27,493	5,025	2,061	11,280	8,756	50,178	2,785	16,135	28,435	31,220	3,811	78,406
JUN	51,139	958	30,126	4,134	3,844	11,280	8,015	43,121	1,209	17,698	28,215	29,424	4,599	70,952
JUL	23,363	49	18,015	2,927	4,211	11,280	9,345	13,014	(1,968)	10,617	15,959	13,991	(2,658)	28,552
AUG	15,542	49	6,171	1,382	2,910	11,280	7,328	7,535	1,327	4,030	1,372	2,698	(8,752)	8,616
SEP	24,376	34	10,520	1,328	1,575	11,280	9,595	14,422	580	6,404	8,875	9,455	(5,770)	23,139
1984														
OCT	27,488	33	16,954	1,496	1,274	11,280	4,720	22,482	1,841	10,012	10,848	12,689	(1,992)	33,203
NOV	64,593	5,395	11,669	6,974	148	11,280	10,008	59,943	8,617	7,039	17,092	25,709	(4,483)	77,020
DEC	85,103	46,595	19,380	11,580	(1,895)	11,700	13,153	119,018	17,245	11,400	33,500	50,745	313	152,708
JAN	45,529	15,011	23,241	4,847	(155)	12,700	7,205	53,373	5,367	13,638	22,573	27,941	879	75,962
FEB	38,969	918	10,761	3,187	(124)	12,700	6,279	33,639	5,490	6,537	7,505	12,994	(6,217)	41,156
MAR	33,026	537	6,953	2,667	592	11,700	5,461	27,954	5,608	4,454	2,897	8,506	(7,582)	30,792
APR	14,102	118	5,343	1,378	1,466	6,881	3,015	10,839	1,965	267	1,792	3,757	(7,172)	12,484
MAY	12,536	81	5,220	960	2,451	6,484	2,820	9,184	2,307	261	(529)	1,778	(6,888)	8,411
JUN	15,378	67	2,819	773	3,861	6,663	7,282	7,197	1,232	2,193	1,421	2,653	(6,296)	8,232
JUL	21,356	81	1,768	667	4,211	10,505	8,847	11,537	3,401	1,569	(2,271)	1,130	(10,931)	8,845
AUG	12,137	49	1,960	716	2,926	5,857	6,304	5,150	924	1,688	883	1,807	(5,677)	5,741
SEP	15,062	50	2,221	723	1,911	10,243	7,193	7,441	2,240	1,846	(1,612)	628	(9,426)	5,638
1985														
OCT	17,217	1,382	2,765	634	965	11,280	7,785	10,573	2,758	138	(937)	1,821	(11,742)	9,539
NOV	34,863	1,059	3,636	941	(221)	11,280	5,712	30,266	7,378	2,650	(1,031)	6,347	(8,725)	29,257
DEC	26,254	33	4,576	1,106	122	11,658	4,558	21,698	5,573	3,165	(1,642)	3,931	(8,687)	20,044
JAN	14,297	146	3,332	374	(399)	11,797	3,039	11,504	4,221	2,481	(4,913)	(692)	(9,277)	6,630
FEB	19,640	198	2,692	1,008	(106)	8,238	3,708	16,157	4,037	2,120	(865)	3,173	(6,179)	15,303
MAR	17,774	16	2,349	1,025	(465)	7,407	3,473	14,433	3,476	1,921	(357)	3,119	(5,399)	14,123
APR	9,809	50	3,641	790	1,466	4,018	2,477	7,016	1,324	182	994	2,318	(4,532)	7,863
MAY	13,703	81	2,763	504	2,402	4,417	2,965	10,218	2,371	138	34	2,405	(5,460)	10,012
JUN	13,422	67	1,813	353	3,777	5,479	6,711	5,834	1,153	1,597	661	1,814	(5,674)	6,118
JUL	20,916	49	1,667	342	4,211	11,280	8,737	11,175	3,728	1,505	(3,582)	146	(11,770)	7,172
AUG	17,852	49	1,137	309	2,943	10,259	7,953	9,212	3,123	1,143	(3,111)	11	(10,631)	5,807
SEP	10,656	50	1,313	235	1,793	6,439	5,792	4,466	1,207	1,269	(528)	678	(6,151)	3,758

Table B1–10. Continued

Water Year	Sac. R. at Freeport	Yolo Bypass	SJR at Vernalis	Eastside Streams	Channel Depletion	Total Exports	DCC & Georgiana	Sac. R. at Rio Vista	Threemile Slough	Head of Old R.	Final QWEST	SJR at Antioch	Old R. & Middle R.	Total Outflow
1986														
OCT	12,678	33	2,000	130	1,225	8,727	6,479	5,926	1,735	100	(1,128)	607	(9,331)	4,675
NOV	10,779	218	2,473	353	535	7,911	2,599	8,264	2,872	1,994	(3,016)	(145)	(6,314)	5,194
DEC	15,273	667	2,248	569	203	11,262	3,161	12,729	4,710	1,862	(5,561)	(851)	(9,627)	7,147
JAN	18,731	33	1,491	1,073	(1,408)	11,372	3,593	15,523	5,004	1,390	(4,421)	583	(9,539)	11,243
FEB	108,473	89,634	10,998	17,700	(5,886)	12,700	16,843	182,736	31,138	6,668	36,564	67,702	(3,781)	219,888
MAR	67,672	55,263	24,532	11,986	(1,587)	11,700	10,473	112,858	14,956	14,392	36,224	51,180	3,228	149,241
APR	19,089	1,143	17,338	3,260	1,130	11,280	3,638	16,311	7	10,230	12,112	12,118	(1,612)	28,310
MAY	11,015	179	7,523	1,838	2,175	6,810	2,629	8,021	758	376	3,546	4,305	(7,524)	11,350
JUN	12,412	67	4,538	1,042	3,878	6,321	6,394	5,116	299	3,144	2,851	3,150	(5,009)	7,579
JUL	16,305	49	2,080	520	4,195	6,446	7,539	7,766	1,605	1,761	655	2,260	(6,674)	8,002
AUG	11,377	49	2,062	585	2,943	5,051	6,048	4,642	645	1,750	1,393	2,039	(4,816)	5,741
SEP	10,851	50	2,613	521	1,659	8,075	5,863	4,624	1,210	2,075	(421)	789	(6,928)	4,037
1987														
OCT	10,589	49	5,921	748	1,388	11,250	5,768	4,523	1,032	296	71	1,103	(11,723)	4,455
NOV	12,099	34	2,922	571	955	8,934	2,765	9,129	3,219	2,251	(3,480)	(261)	(7,248)	5,554
DEC	9,414	81	3,463	455	886	7,784	2,426	6,847	2,273	2,554	(2,161)	113	(5,729)	4,598
JAN	12,797	114	1,679	358	(139)	9,199	2,852	10,093	3,713	1,513	(4,340)	(627)	(7,752)	5,767
FEB	19,140	216	1,663	666	(520)	9,758	3,645	15,841	4,805	1,503	(3,550)	1,256	(8,151)	12,344
MAR	31,898	374	2,005	943	(204)	11,221	5,309	27,014	7,216	1,716	(2,931)	4,285	(9,522)	24,104
APR	13,323	134	2,435	319	1,617	3,800	2,918	10,135	2,206	122	500	2,706	(4,435)	10,473
MAY	11,414	81	2,005	325	2,516	3,455	2,679	8,187	2,020	100	(356)	1,664	(4,581)	7,579
JUN	13,589	67	1,835	319	3,878	5,534	6,761	5,925	1,199	1,611	580	1,780	(5,754)	6,118
JUL	21,212	49	1,428	325	4,211	11,280	8,811	11,397	3,836	1,348	(3,764)	72	(11,927)	7,212
AUG	16,093	49	1,010	293	2,943	8,755	7,481	7,925	2,544	1,047	(2,222)	322	(9,223)	5,409
SEP	10,204	50	1,204	269	1,928	6,020	5,624	4,148	1,105	1,192	(440)	665	(5,863)	3,515
1988														
OCT	10,336	33	1,480	163	1,209	6,588	5,674	4,393	1,109	74	(271)	838	(7,212)	4,001
NOV	9,844	67	1,559	336	770	6,113	2,481	7,238	2,446	1,435	(2,421)	25	(5,169)	4,740
DEC	15,966	439	1,378	732	317	11,114	3,247	13,079	4,963	1,314	(6,108)	(1,145)	(10,072)	6,939
JAN	25,075	1,236	1,078	488	(1,440)	11,236	4,404	22,267	6,585	1,099	(4,450)	2,135	(9,682)	17,960
FEB	17,056	90	900	180	326	6,370	3,383	13,681	3,894	959	(2,249)	1,645	(5,645)	11,400
MAR	11,941	65	1,359	130	869	4,723	2,745	9,043	2,469	1,301	(1,152)	1,317	(3,868)	7,804
APR	9,123	84	2,005	420	1,242	2,965	2,389	6,508	1,230	100	916	2,146	(3,472)	7,300
MAY	9,509	65	2,005	358	2,052	3,114	2,438	6,623	1,519	100	78	1,598	(4,055)	6,496
JUN	14,268	50	1,840	319	3,533	5,766	6,964	6,471	1,264	1,614	779	2,044	(5,846)	6,897
JUL	15,721	49	1,212	325	4,185	7,320	7,378	7,345	2,162	1,198	(1,436)	726	(8,107)	5,491
AUG	10,209	49	1,004	293	2,916	4,886	5,626	3,903	972	1,042	(197)	775	(5,348)	3,415
SEP	7,239	50	1,114	269	1,903	3,497	3,866	2,947	608	1,126	251	859	(3,396)	3,008

Table B1–10. Continued

Water Year	Sac. R. at Freeport	Yolo Bypass	SJR at Vernalis	Eastside Streams	Channel Depletion	Total Exports	DCC & Georgiana	Sac. R. at Rio Vista	Threemile Slough	Head of Old R.	Final QWEST	SJR at Antioch	Old R. & Middle R.	Total Outflow
1989														
OCT	7,130	49	1,826	163	1,333	4,629	3,893	2,953	634	91	172	807	(5,285)	2,992
NOV	9,396	50	1,235	303	750	5,403	2,424	6,835	2,255	1,214	(2,112)	143	(4,672)	4,648
DEC	11,596	163	1,082	472	674	6,929	2,702	8,888	3,092	1,102	(3,256)	(164)	(6,241)	5,565
JAN	12,906	65	937	163	(155)	8,317	2,866	10,144	3,735	989	(4,371)	(637)	(7,387)	5,788
FEB	13,896	90	917	288	76	6,836	2,989	10,978	3,435	973	(2,794)	641	(5,997)	8,176
MAR	39,162	455	1,472	1,480	(82)	11,130	6,306	33,332	8,371	1,378	(1,918)	6,453	(9,819)	31,422
APR	22,181	202	2,435	756	1,623	6,052	4,031	17,946	4,186	122	(8)	4,178	(6,690)	17,776
MAY	14,571	65	2,435	472	2,521	4,049	3,073	10,932	2,678	122	(412)	2,265	(5,156)	10,268
JUN	13,397	67	1,896	353	3,815	5,500	6,703	5,807	1,137	1,649	692	1,829	(5,658)	6,117
JUL	21,621	49	1,049	342	4,198	11,280	8,913	11,707	3,988	1,077	(4,016)	(28)	(12,193)	7,272
AUG	19,234	49	1,018	309	2,865	11,280	8,311	10,256	3,595	1,053	(3,842)	(247)	(11,711)	6,127
SEP	10,466	17	900	252	1,042	6,500	5,722	4,500	1,230	959	(578)	652	(6,222)	3,818
1990														
OCT	9,151	0	1,456	114	1,036	5,470	4,908	3,984	891	73	121	1,012	(6,026)	4,001
NOV	8,058	34	1,114	202	794	3,927	2,251	5,643	1,647	1,126	(1,059)	588	(3,301)	4,504
DEC	14,230	33	1,018	65	943	7,842	3,031	10,996	3,969	1,053	(4,486)	(517)	(7,311)	6,416
JAN	17,203	260	1,026	293	(456)	11,219	3,401	14,176	5,286	1,059	(6,323)	(1,037)	(10,098)	7,898
FEB	15,179	756	1,007	414	(222)	6,075	3,149	12,842	3,452	1,045	(1,463)	1,989	(5,044)	11,400
MAR	11,050	33	1,311	374	792	4,469	2,634	8,251	2,194	1,268	(862)	1,332	(3,715)	7,310
APR	12,816	286	2,005	538	1,579	3,621	2,855	9,852	2,122	100	556	2,679	(4,331)	10,251
MAY	10,420	33	1,281	285	5,039	217	2,222	2,775	407	3,398	772	2,707	362	3,069
JUN	10,537	33	1,118	233	5,181	215	7,054	2,992	293	3,498	3,416	814	791	1,605
JUL	13,530	33	1,011	163	6,058	238	7,463	3,667	2,353	6,257	4,360	(1,857)	2,051	194
AUG	13,416	25	1,001	171	5,957	223	5,672	2,940	3,311	6,472	3,669	(1,729)	2,046	318
SEP	10,381	37	907	170	5,206	234	4,138	3,307	2,587	6,126	2,685	(1,590)	1,537	(52)
1991														
OCT	7,620	15	993	234	4,323	185	3,887	1,107	2,258	3,549	1,816	821	403	1,224
NOV	7,723	26	1,115	201	4,353	149	2,206	1,588	2,121	3,858	650	1,390	313	1,703
DEC	10,818	25	918	64	5,260	148	2,413	2,277	2,780	5,205	196	910	991	1,901
JAN	8,984	25	816	68	4,722	146	2,563	1,883	2,883	4,912	969	66	910	976
FEB	8,133	16	758	87	4,473	137	2,984	2,606	1,778	4,521	(2,948)	2,712	174	2,886
MAR	25,755	893	1,779	1,226	5,184	111	4,861	3,722	5,929	9,763	(4,737)	1,504	4,743	6,247
APR	10,879	46	1,168	510	4,747	100	3,010	2,882	4,518	7,499	1,316	(1,930)	1,944	14
MAY	7,332	43	1,049	471	3,515	130	2,242	1,277	1,281	2,686	2,212	912	478	1,390
JUN	8,930	43	568	269	3,935	155	6,809	894	878	1,925	3,716	431	811	1,242
JUL	9,514	43	594	181	4,878	173	6,387	1,633	770	2,574	4,279	297	738	1,035
AUG	9,515	34	537	166	4,878	167	5,340	1,659	1,993	3,817	3,739	(666)	1,066	400
SEP	9,948	36	574	192	5,005	161	4,816	1,852	2,224	4,235	2,632	(174)	1,048	874

Note: Negative values shown in parentheses.

Table B1-11. Simulated No-Project Channel Flows (cfs) and Changes in Flows (cfs) Resulting from Operations of the DW Project Alternatives for 1968-1991

Water Year	No-Project Alternative Flows				Alternative 1 Changes in Flows				Alternative 2 Changes in Flows				Alternative 3 Changes in Flows			
	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.
1968																
OCT	14,835	2,910	3972	(11,876)	(180)	56	(123)	0	(180)	56	(123)	0	(1,949)	611	(1,338)	0
NOV	7,990	5,287	-942	(10,048)	(37)	12	(25)	0	(37)	12	(25)	0	(20)	6	(14)	0
DEC	6,712	4,822	-1102	(9,799)	(34)	11	(23)	0	(34)	11	(23)	0	(11)	4	(8)	0
JAN	21,455	6,796	3470	(9,427)	0	(0)	0	0	0	(0)	0	0	(11)	4	(8)	0
FEB	60,399	12,763	15160	(9,595)	(7)	2	(5)	0	(7)	2	(5)	0	(19)	6	(13)	0
MAR	29,160	8,005	5799	(9,521)	25	(8)	17	0	25	(8)	17	0	(42)	13	(29)	0
APR	10,325	1,718	3042	(5,186)	0	0	0	(687)	0	0	0	(464)	0	(0)	0	(464)
MAY	7,579	1,734	1895	(4,852)	0	0	0	(1,305)	0	0	0	(940)	0	0	0	(940)
JUN	6,841	1,435	1892	(6,149)	69	(22)	47	0	69	(22)	47	0	131	(41)	90	0
JUL	7,731	3,834	296	(11,765)	(7)	2	(5)	0	(7)	2	(5)	0	(7)	2	(5)	0
AUG	5,259	1,992	691	(7,769)	0	0	(0)	(1,623)	0	0	(0)	(2,204)	0	(0)	0	(3,743)
SEP	4,158	1,449	653	(6,611)	0	0	0	(25)	0	0	0	(25)	0	0	0	(774)
1969																
OCT	5,157	2,112	501	(9,721)	0	0	0	10	0	0	0	10	0	0	0	(41)
NOV	5,675	3,438	-403	(7,168)	0	(0)	0	12	0	(0)	0	12	0	(0)	0	(30)
DEC	13,989	5,967	1032	(9,884)	(3,892)	1,220	(2,672)	0	(3,892)	1,220	(2,672)	0	(5,504)	1,725	(3,779)	0
JAN	116,869	18,951	33926	(7,531)	0	(0)	0	0	0	(0)	0	0	(1,095)	343	(752)	0
FEB	129,847	14,969	42814	(539)	(7)	2	(5)	0	(7)	2	(5)	0	(20)	6	(14)	0
MAR	51,928	8,764	14899	(6,945)	25	(8)	17	0	25	(8)	17	0	(42)	13	(29)	0
APR	44,212	6,176	13785	(10,140)	(25)	8	(17)	0	(25)	8	(17)	0	(77)	24	(53)	0
MAY	55,819	2,713	21657	13	(39)	12	(27)	0	(39)	12	(27)	0	(97)	31	(67)	0
JUN	25,197	(20)	10929	(4,713)	(49)	15	(33)	0	(49)	15	(33)	0	(104)	33	(71)	0
JUL	8,002	388	3271	(4,797)	0	0	0	(3,819)	0	0	0	(3,819)	0	0	0	(4,703)
AUG	5,741	955	1782	(5,168)	0	0	0	(60)	0	0	0	(60)	0	0	0	(1,674)
SEP	13,370	3,323	3025	(10,099)	(3,974)	1,246	(2,729)	0	(3,974)	1,246	(2,729)	0	(5,931)	1,859	(4,072)	0
1970																
OCT	17,681	1,374	6446	(11,530)	(63)	20	(43)	0	(63)	20	(43)	0	(861)	270	(591)	0
NOV	10,697	4,816	603	(8,942)	(37)	12	(25)	0	(37)	12	(25)	0	(20)	6	(14)	0
DEC	50,991	11,155	12498	(8,846)	(34)	11	(23)	0	(34)	11	(23)	0	(11)	4	(8)	0
JAN	197,170	31,946	57405	(4,230)	0	(0)	0	0	0	(0)	0	0	(11)	4	(8)	0
FEB	83,351	15,910	22346	(7,935)	(7)	2	(5)	0	(7)	2	(5)	0	(20)	6	(14)	0
MAR	30,331	7,166	7012	(9,228)	25	(8)	17	0	25	(8)	17	0	(42)	13	(29)	0
APR	11,579	1,761	3544	(6,454)	0	0	0	(207)	0	0	0	(591)	0	0	(0)	(591)
MAY	7,579	1,702	1926	(6,039)	0	0	(0)	(112)	0	0	(0)	(724)	7	(2)	5	(724)
JUN	7,580	1,438	2201	(6,168)	69	(22)	47	0	69	(22)	47	0	131	(41)	90	0
JUL	9,367	3,985	868	(11,736)	(9)	3	(6)	0	(9)	3	(6)	0	(9)	3	(6)	0
AUG	5,741	1,432	1386	(6,330)	0	0	(0)	(3,282)	0	0	(0)	(2,300)	0	(0)	0	(4,684)
SEP	3,872	1,307	648	(6,292)	0	0	0	(25)	0	0	0	(25)	0	(0)	0	(69)

Table B1–11. Continued

Water Year	No-Project Alternative Flows				Alternative 1 Changes in Flows				Alternative 2 Changes in Flows				Alternative 3 Changes in Flows			
	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.
1971																
OCT	5,063	2,003	550	(9,679)	0	(0)	0	10	0	(0)	0	10	0	(0)	0	(41)
NOV	15,280	5,585	1882	(9,337)	(4,011)	1,257	(2,754)	0	(4,011)	1,257	(2,754)	0	(5,970)	1,871	(4,099)	0
DEC	64,496	12,062	17428	(8,635)	(34)	11	(23)	0	(34)	11	(23)	0	(808)	253	(555)	0
JAN	45,818	10,846	10519	(9,692)	0	(0)	0	0	0	(0)	0	0	(11)	4	(8)	0
FEB	22,775	6,063	4700	(7,409)	0	0	0	(3,493)	0	0	0	(2,605)	0	(0)	0	(2,605)
MAR	43,778	10,319	10129	(9,658)	(3,137)	983	(2,154)	0	(2,335)	732	(1,603)	0	(2,413)	756	(1,657)	0
APR	16,279	3,286	4276	(7,113)	0	0	0	(131)	0	0	0	(103)	0	0	(0)	(103)
MAY	25,812	5,978	6131	(9,176)	(190)	59	(130)	0	(163)	51	(112)	0	(271)	85	(186)	0
JUN	12,690	2,925	3147	(8,945)	69	(22)	47	0	69	(22)	47	0	131	(41)	90	0
JUL	9,456	3,961	926	(11,734)	(7)	2	(5)	0	(7)	2	(5)	0	(7)	2	(5)	0
AUG	5,741	1,520	1313	(6,634)	0	0	(0)	(3,657)	0	0	(0)	(3,657)	0	0	0	(4,641)
SEP	6,040	2,796	338	(9,867)	0	0	0	(25)	0	0	0	(25)	0	(0)	0	(1,218)
1972																
OCT	8,275	3,012	1088	(11,936)	(2,461)	771	(1,690)	0	(2,461)	771	(1,690)	0	(2,411)	755	(1,655)	0
NOV	6,485	5,023	−1365	(9,995)	0	0	0	(164)	0	0	0	(164)	0	0	0	(164)
DEC	12,481	5,522	759	(9,858)	(1,648)	517	(1,132)	(215)	(1,648)	517	(1,132)	(75)	(4,212)	1,320	(2,892)	(75)
JAN	9,279	5,191	−358	(9,843)	(215)	67	(147)	0	(75)	24	(52)	0	(86)	27	(59)	0
FEB	18,216	5,704	3045	(8,274)	23	(7)	16	0	23	(7)	16	(1,661)	40	(13)	27	(1,661)
MAR	22,627	7,475	3496	(9,931)	(3)	1	(2)	0	(947)	297	(650)	0	(964)	302	(662)	0
APR	9,811	1,532	2980	(5,127)	0	0	0	(676)	0	0	0	(457)	0	0	(0)	(457)
MAY	7,579	1,768	1877	(5,045)	0	0	(0)	(540)	0	0	(0)	(372)	0	0	0	(372)
JUN	6,841	1,405	1913	(6,064)	69	(22)	47	0	69	(22)	47	0	131	(41)	90	0
JUL	7,848	3,863	321	(11,766)	(8)	3	(5)	0	(8)	3	(5)	0	(8)	3	(5)	0
AUG	6,826	3,788	−106	(11,765)	(6)	2	(4)	0	(6)	2	(4)	0	(6)	2	(4)	0
SEP	3,791	1,381	540	(6,620)	0	0	0	(2,424)	0	0	0	(2,186)	0	0	0	(3,986)
1973																
OCT	5,618	2,459	390	(10,568)	0	0	0	10	0	0	0	10	0	0	0	(465)
NOV	15,153	5,707	1707	(9,223)	(4,011)	1,257	(2,754)	0	(4,011)	1,257	(2,754)	0	(5,672)	1,777	(3,894)	0
DEC	19,014	6,749	2501	(9,646)	(34)	11	(23)	(254)	(34)	11	(23)	(89)	(1,096)	344	(753)	(89)
JAN	72,396	13,893	19128	(7,856)	(253)	79	(174)	0	(89)	28	(61)	0	(100)	31	(69)	0
FEB	89,977	14,714	26041	(8,208)	(7)	2	(5)	0	(7)	2	(5)	0	(20)	6	(14)	0
MAR	55,634	9,535	15809	(7,402)	25	(8)	17	0	25	(8)	17	0	(42)	13	(29)	0
APR	15,006	2,727	4201	(7,856)	51	(16)	35	0	51	(16)	35	0	74	(23)	51	0
MAY	14,120	3,090	3563	(8,374)	60	(19)	41	0	60	(19)	41	0	101	(32)	69	0
JUN	10,301	2,318	2636	(7,089)	0	(0)	0	(656)	0	(0)	0	(3,493)	0	(0)	0	(3,493)
JUL	9,373	3,915	929	(11,585)	0	0	0	(170)	0	0	0	(170)	0	0	0	(170)
AUG	5,302	1,340	1275	(6,158)	0	0	(0)	(2,739)	0	0	(0)	(60)	0	(0)	0	(2,382)
SEP	4,147	1,440	653	(6,642)	0	0	0	(25)	0	0	0	(25)	0	0	0	(69)

Table B1–11. Continued

Water Year	No–Project Alternative Flows				Alternative 1 Changes in Flows				Alternative 2 Changes in Flows				Alternative 3 Changes in Flows			
	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.
1974																
OCT	5,615	2,383	456	(11,362)	0	0	0	10	0	0	0	10	0	0	0	(41)
NOV	59,059	12,956	14446	(9,530)	(4,011)	1,257	(2,754)	0	(4,011)	1,257	(2,754)	0	(5,970)	1,871	(4,099)	0
DEC	65,180	12,838	17109	(9,091)	(34)	11	(23)	0	(34)	11	(23)	0	(808)	253	(555)	0
JAN	125,805	24,088	33610	(9,017)	0	(0)	0	0	0	(0)	0	0	(11)	4	(8)	0
FEB	38,960	9,817	8486	(9,711)	(7)	2	(5)	0	(7)	2	(5)	0	(20)	6	(14)	0
MAR	103,056	17,766	29197	(8,856)	25	(8)	17	0	25	(8)	17	0	(42)	13	(29)	0
APR	68,918	14,012	17802	(10,054)	(25)	8	(17)	0	(25)	8	(17)	0	(77)	24	(53)	0
MAY	19,915	4,528	4833	(10,248)	60	(19)	41	0	60	(19)	41	0	101	(32)	69	0
JUN	12,455	2,378	3498	(8,105)	69	(22)	47	0	69	(22)	47	(2,416)	131	(41)	90	(2,416)
JUL	8,002	2,445	1552	(8,413)	0	0	0	(3,215)	0	0	0	(1,268)	0	0	(0)	(3,215)
AUG	5,741	1,593	1252	(6,857)	0	0	(0)	(335)	0	0	(0)	(60)	0	0	0	(399)
SEP	9,308	3,549	1108	(11,030)	(2,975)	932	(2,043)	0	(2,975)	932	(2,043)	0	(2,975)	932	(2,043)	0
1975																
OCT	12,453	3,311	2612	(11,838)	(1,030)	323	(707)	0	(1,030)	323	(707)	0	(3,722)	1,166	(2,556)	0
NOV	8,672	4,983	−398	(9,677)	(37)	12	(25)	0	(37)	12	(25)	0	(20)	6	(14)	0
DEC	8,811	5,070	−417	(9,833)	(34)	11	(23)	0	(34)	11	(23)	0	(11)	4	(8)	0
JAN	6,560	4,972	−1332	(10,036)	0	(0)	0	0	0	(0)	0	0	(11)	4	(8)	0
FEB	61,068	11,143	16742	(8,625)	(7)	2	(5)	0	(7)	2	(5)	0	(20)	6	(14)	0
MAR	81,704	13,904	23263	(8,571)	25	(8)	17	0	25	(8)	17	0	(42)	13	(29)	0
APR	19,925	3,780	5411	(9,462)	51	(16)	35	0	51	(16)	35	0	74	(23)	51	0
MAY	27,667	5,750	7127	(10,780)	(112)	35	(77)	0	(112)	35	(77)	0	(244)	76	(167)	0
JUN	15,246	3,069	4121	(9,734)	69	(22)	47	0	69	(22)	47	(841)	131	(41)	90	(841)
JUL	8,263	3,180	1062	(10,076)	0	0	0	(1,611)	0	0	0	(1,611)	0	0	(0)	(1,611)
AUG	5,741	1,306	1483	(6,099)	0	0	0	(2,039)	0	0	0	(1,225)	0	(0)	0	(3,725)
SEP	6,921	3,111	453	(10,695)	(709)	222	(487)	0	(709)	222	(487)	0	(709)	222	(487)	0
1976																
OCT	13,314	3,245	3022	(11,728)	(3,223)	1,010	(2,213)	0	(3,223)	1,010	(2,213)	0	(5,347)	1,676	(3,671)	0
NOV	11,151	5,467	260	(9,659)	(37)	12	(25)	0	(37)	12	(25)	0	(607)	190	(417)	0
DEC	6,355	4,666	−1119	(9,300)	0	0	0	(1,114)	0	0	0	(694)	0	0	0	(666)
JAN	5,865	3,881	−716	(7,582)	0	0	0	(2,722)	0	0	0	(2,735)	0	0	0	(2,735)
FEB	10,670	5,016	408	(8,361)	23	(7)	16	0	23	(7)	16	(406)	40	(13)	27	(2,055)
MAR	9,744	3,330	1447	(5,192)	73	(23)	50	0	73	(23)	50	0	55	(17)	38	(1,104)
APR	7,475	1,444	2056	(3,769)	0	0	0	(51)	0	0	0	(51)	0	0	0	(74)
MAY	6,366	1,781	1358	(4,534)	0	0	0	(60)	0	0	0	(60)	0	0	0	(101)
JUN	6,897	1,389	1952	(6,094)	68	(21)	47	(1)	68	(21)	47	(1)	131	(41)	90	(1)
JUL	5,750	2,399	641	(8,592)	0	0	0	(78)	0	0	0	(78)	0	0	(0)	(150)
AUG	3,415	614	1054	(3,867)	0	0	0	(60)	0	0	0	(60)	0	0	0	(116)
SEP	3,008	643	820	(4,017)	0	0	0	(25)	0	0	0	(25)	0	0	0	(69)

Table B1–11. Continued

Water Year	No–Project Alternative Flows				Alternative 1 Changes in Flows				Alternative 2 Changes in Flows				Alternative 3 Changes in Flows			
	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.
1977																
OCT	2,992	730	724	(6,092)	0	0	0	10	0	0	0	10	0	0	0	(41)
NOV	5,211	2,845	−101	(5,551)	0	0	0	12	0	0	0	12	0	0	(0)	(30)
DEC	7,186	5,585	−1531	(10,486)	0	0	0	21	0	0	0	21	0	0	0	(7)
JAN	4,505	1,892	349	(3,901)	0	0	0	(15)	0	0	0	(15)	0	0	0	(18)
FEB	8,083	3,135	870	(5,177)	0	0	0	(23)	0	0	0	(23)	0	0	(0)	(41)
MAR	6,897	1,994	1324	(3,299)	21	(7)	14	(52)	21	(7)	14	(52)	3	(1)	2	(52)
APR	6,897	1,259	1968	(3,565)	0	0	0	(51)	0	0	0	(51)	0	0	(0)	(74)
MAY	4,505	889	1265	(3,293)	0	0	(0)	(60)	0	0	(0)	(60)	0	0	0	(101)
JUN	4,000	(283)	2103	(1,260)	0	0	0	(69)	0	0	0	(69)	0	0	0	(131)
JUL	4,001	204	1715	(2,787)	0	(0)	0	(78)	0	(0)	0	(78)	0	(0)	0	(150)
AUG	3,415	(135)	1692	(1,403)	0	0	(0)	(60)	0	0	(0)	(60)	0	0	0	(116)
SEP	3,008	618	838	(3,421)	0	0	0	(25)	0	0	0	(25)	0	0	0	(69)
1978																
OCT	2,992	635	805	(5,098)	0	(0)	0	10	0	(0)	0	10	0	(0)	0	(41)
NOV	3,537	1,104	623	(2,504)	0	0	0	12	0	0	0	12	0	0	0	(30)
DEC	6,832	4,899	−1145	(9,710)	0	0	0	21	0	0	0	21	0	0	0	(15)
JAN	57,543	10,912	15277	(7,752)	(3,856)	1,208	(2,648)	0	(3,856)	1,208	(2,648)	0	(5,982)	1,875	(4,107)	0
FEB	53,376	10,571	13919	(8,657)	(7)	2	(5)	0	(7)	2	(5)	0	(687)	215	(472)	0
MAR	61,156	12,351	15762	(8,262)	25	(8)	17	0	25	(8)	17	0	(42)	13	(29)	0
APR	36,875	6,173	10631	(9,974)	(25)	8	(17)	0	(25)	8	(17)	0	(77)	24	(53)	0
MAY	15,849	3,392	4039	(9,284)	60	(19)	41	0	60	(19)	41	(67)	101	(32)	69	(67)
JUN	8,774	644	3374	(5,272)	0	(0)	0	(314)	0	(0)	0	(3,780)	0	(0)	0	(4,667)
JUL	8,002	445	3224	(3,266)	0	0	0	(3,369)	0	0	0	(78)	0	0	0	(1,610)
AUG	5,302	602	1887	(4,351)	0	0	0	(60)	0	0	0	(60)	0	0	0	(116)
SEP	5,227	1,872	755	(7,786)	0	0	0	(25)	0	0	0	(25)	0	(0)	0	(69)
1979																
OCT	9,101	2,578	1803	(11,887)	(3,029)	949	(2,080)	0	(3,029)	949	(2,080)	0	(2,979)	934	(2,045)	0
NOV	6,521	4,771	−1147	(9,677)	(205)	64	(141)	0	(205)	64	(141)	0	(205)	64	(141)	0
DEC	4,984	2,682	−59	(5,366)	0	0	0	(3,148)	0	0	0	(3,148)	0	0	0	(3,187)
JAN	20,305	5,682	3855	(8,855)	(3,856)	1,208	(2,648)	0	(3,856)	1,208	(2,648)	0	(5,982)	1,875	(4,107)	0
FEB	39,592	6,822	11125	(8,120)	(7)	2	(5)	0	(7)	2	(5)	0	(687)	215	(472)	0
MAR	26,109	5,824	6311	(8,687)	25	(8)	17	0	25	(8)	17	0	(42)	13	(29)	0
APR	14,392	2,580	4051	(7,582)	51	(16)	35	0	51	(16)	35	0	74	(23)	51	0
MAY	12,376	2,506	3296	(7,904)	60	(19)	41	0	60	(19)	41	0	101	(32)	69	0
JUN	10,882	2,463	2764	(7,401)	0	0	0	(657)	0	0	0	(3,181)	0	0	0	(3,181)
JUL	6,505	2,687	723	(9,326)	0	(0)	(0)	(2,415)	0	(0)	(0)	(521)	0	0	0	(2,415)
AUG	4,668	903	1367	(5,226)	0	0	(0)	(493)	0	0	(0)	(60)	0	0	0	(438)
SEP	3,397	1,057	654	(5,799)	0	0	0	(25)	0	0	0	(25)	0	(0)	0	(69)

Table B1–11. Continued

Water Year	No–Project Alternative Flows				Alternative 1 Changes in Flows				Alternative 2 Changes in Flows				Alternative 3 Changes in Flows			
	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.
1980																
OCT	4,001	1,246	713	(8,303)	0	0	0	10	0	0	0	10	0	0	0	(41)
NOV	9,608	4,842	115	(9,239)	(2,951)	925	(2,026)	0	(2,951)	925	(2,026)	0	(2,908)	912	(1,997)	0
DEC	12,171	5,521	611	(9,518)	(1,061)	332	(728)	(16)	(1,061)	332	(728)	(5)	(3,770)	1,182	(2,589)	(5)
JAN	107,445	16,064	32388	(5,975)	(15)	5	(11)	0	(5)	2	(4)	0	(17)	5	(12)	0
FEB	127,706	16,373	40735	(1,198)	(7)	2	(5)	0	(7)	2	(5)	0	(19)	6	(13)	0
MAR	63,895	4,603	23447	597	25	(8)	17	0	25	(8)	17	0	(42)	13	(29)	0
APR	15,045	2,382	4493	(7,794)	51	(16)	35	0	51	(16)	35	(556)	74	(23)	51	(556)
MAY	12,255	1,963	3690	(7,288)	60	(19)	41	0	60	(19)	41	(1,548)	101	(32)	69	(1,548)
JUN	7,579	426	3043	(4,550)	0	0	0	(583)	0	0	0	(1,618)	0	0	0	(4,207)
JUL	8,002	395	3257	(3,339)	0	0	0	(3,035)	0	0	0	(78)	0	0	0	(150)
AUG	5,302	742	1771	(4,717)	0	0	0	(60)	0	0	0	(60)	0	0	0	(116)
SEP	5,436	2,036	711	(8,977)	0	0	0	(25)	0	0	0	(25)	0	0	0	(69)
1981																
OCT	8,882	2,173	2045	(11,848)	(2,876)	901	(1,975)	0	(2,876)	901	(1,975)	0	(2,826)	886	(1,940)	0
NOV	6,062	4,077	−757	(9,027)	0	0	0	(150)	0	0	0	(150)	0	0	0	(150)
DEC	7,249	4,717	−787	(9,548)	(1,219)	382	(837)	0	(1,219)	382	(837)	0	(1,336)	419	(917)	0
JAN	18,058	6,088	2617	(9,409)	0	(0)	0	0	0	(0)	0	0	(2,588)	811	(1,777)	0
FEB	20,605	6,520	3387	(9,020)	23	(7)	16	0	23	(7)	16	(686)	41	(13)	28	(686)
MAR	25,565	6,871	5191	(9,197)	(3)	1	(2)	0	(623)	195	(428)	0	(717)	225	(492)	0
APR	12,223	2,271	3390	(5,526)	0	0	0	(726)	0	0	0	(490)	0	(0)	0	(490)
MAY	7,579	1,754	1879	(4,862)	0	0	0	(1,310)	0	0	0	(940)	0	0	0	(940)
JUN	6,118	1,199	1780	(5,764)	69	(22)	47	0	69	(22)	47	0	131	(41)	90	0
JUL	7,098	3,731	111	(11,762)	(8)	3	(5)	0	(8)	3	(5)	0	(8)	3	(5)	0
AUG	4,831	1,976	547	(7,926)	0	0	0	(1,582)	0	0	0	(2,181)	0	0	0	(3,730)
SEP	3,492	1,098	655	(5,841)	0	0	0	(25)	0	0	0	(25)	0	0	0	(764)
1982																
OCT	4,793	1,775	612	(8,901)	0	0	0	10	0	0	0	10	0	0	0	(41)
NOV	26,627	8,171	4586	(10,061)	(4,011)	1,257	(2,754)	0	(4,011)	1,257	(2,754)	0	(5,970)	1,871	(4,099)	0
DEC	88,042	18,191	22441	(9,656)	(34)	11	(23)	(352)	(34)	11	(23)	(123)	(808)	253	(555)	(123)
JAN	77,881	12,153	22951	(7,904)	(352)	110	(242)	0	(123)	39	(85)	0	(135)	42	(92)	0
FEB	94,845	15,098	27899	(8,601)	(7)	2	(5)	0	(7)	2	(5)	0	(20)	6	(14)	0
MAR	79,101	7,130	27706	(2,946)	25	(8)	17	0	25	(8)	17	0	(42)	13	(29)	0
APR	139,945	12,473	49350	2,269	(25)	8	(17)	0	(25)	8	(17)	0	(77)	24	(53)	0
MAY	46,703	1,543	18734	(1,057)	(39)	12	(27)	0	(39)	12	(27)	0	(97)	31	(67)	0
JUN	16,995	1,398	6250	(8,326)	32	(10)	22	0	32	(10)	22	0	95	(30)	65	0
JUL	8,002	1,148	2640	(7,398)	0	0	0	(2,692)	0	0	0	(2,692)	0	0	0	(2,692)
AUG	5,801	1,527	1333	(7,624)	0	0	(0)	(993)	0	0	(0)	(993)	0	0	0	(3,157)
SEP	16,088	2,314	4996	(8,560)	(3,974)	1,246	(2,729)	0	(3,974)	1,246	(2,729)	0	(5,931)	1,859	(4,072)	0

Table B1–11. Continued

Water Year	No–Project Alternative Flows				Alternative 1 Changes in Flows				Alternative 2 Changes in Flows				Alternative 3 Changes in Flows			
	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.
1983																
OCT	31,140	3,761	10199	(4,528)	(63)	20	(43)	0	(63)	20	(43)	0	(695)	218	(477)	0
NOV	43,784	5,721	13898	(5,920)	(37)	12	(25)	0	(37)	12	(25)	0	(20)	6	(14)	0
DEC	86,212	5,798	31931	(646)	(34)	11	(23)	0	(34)	11	(23)	0	(11)	4	(8)	0
JAN	101,369	6,813	37392	1,546	0	(0)	0	0	0	(0)	0	0	(11)	4	(8)	0
FEB	181,018	14,049	65409	9,262	(7)	2	(5)	0	(7)	2	(5)	0	(20)	6	(14)	0
MAR	256,037	22,824	90080	15,315	25	(8)	17	0	25	(8)	17	0	(42)	13	(29)	0
APR	105,749	5,008	40956	6,363	(25)	8	(17)	0	(25)	8	(17)	0	(77)	24	(53)	0
MAY	78,406	2,785	31220	3,811	(39)	12	(27)	0	(39)	12	(27)	0	(97)	31	(67)	0
JUN	70,952	1,209	29424	4,599	(49)	15	(33)	0	(49)	15	(33)	0	(104)	33	(71)	0
JUL	28,552	(1,968)	13991	(2,658)	(52)	16	(36)	0	(52)	16	(36)	0	(110)	35	(76)	0
AUG	8,616	1,327	2698	(8,752)	(55)	17	(38)	0	(55)	17	(38)	0	(115)	36	(79)	0
SEP	23,139	580	9455	(5,770)	(62)	19	(43)	0	(62)	19	(43)	0	(106)	33	(73)	0
1984																
OCT	33,203	1,841	12689	(1,992)	(63)	20	(43)	0	(63)	20	(43)	0	(65)	20	(45)	0
NOV	77,020	8,617	25709	(4,483)	(37)	12	(25)	0	(37)	12	(25)	0	(20)	6	(14)	0
DEC	152,708	17,245	50745	313	(34)	11	(23)	0	(34)	11	(23)	0	(11)	4	(8)	0
JAN	75,962	5,367	27941	879	0	(0)	0	0	0	(0)	0	0	(11)	4	(8)	0
FEB	41,156	5,490	12994	(6,217)	(7)	2	(5)	0	(7)	2	(5)	0	(19)	6	(13)	0
MAR	30,792	5,608	8506	(7,582)	25	(8)	17	0	25	(8)	17	0	(42)	13	(29)	0
APR	12,623	1,922	3852	(7,172)	51	(16)	35	0	51	(16)	35	(139)	74	(23)	51	(139)
MAY	8,946	2,139	2146	(6,888)	60	(19)	41	0	60	(19)	41	(536)	101	(32)	69	(536)
JUN	8,232	1,232	2653	(6,296)	69	(22)	47	0	69	(22)	47	0	131	(41)	90	0
JUL	8,845	3,401	1130	(10,931)	0	0	0	(775)	0	0	0	(775)	0	0	0	(775)
AUG	5,741	924	1807	(5,677)	0	0	(0)	(2,702)	0	0	(0)	(2,032)	0	(0)	0	(4,360)
SEP	5,638	2,240	628	(9,426)	0	0	0	(25)	0	0	0	(25)	0	0	0	(69)
1985																
OCT	9,539	2,758	1821	(11,742)	(3,028)	949	(2,079)	0	(3,028)	949	(2,079)	0	(2,978)	933	(2,045)	0
NOV	29,257	7,378	6347	(8,725)	(917)	287	(630)	0	(917)	287	(630)	0	(3,724)	1,167	(2,557)	0
DEC	20,044	5,573	3931	(8,687)	(34)	11	(23)	0	(34)	11	(23)	0	(11)	4	(8)	0
JAN	6,630	4,221	−692	(9,277)	15	(5)	10	0	15	(5)	10	(183)	18	(6)	12	(183)
FEB	15,303	4,037	3173	(6,179)	23	(7)	16	0	23	(7)	16	(3,530)	41	(13)	28	(3,530)
MAR	14,123	3,476	3119	(5,399)	73	(23)	50	0	73	(23)	50	(408)	55	(17)	38	(3,050)
APR	7,863	1,324	2318	(4,532)	0	0	0	(819)	0	0	0	(51)	0	0	(0)	(74)
MAY	10,012	2,371	2405	(5,460)	0	0	(0)	(517)	0	0	(0)	(60)	0	0	0	(101)
JUN	6,118	1,153	1814	(5,674)	69	(22)	47	0	69	(22)	47	0	131	(41)	90	0
JUL	7,172	3,728	146	(11,770)	(8)	3	(5)	0	(8)	3	(5)	0	(8)	3	(5)	0
AUG	5,807	3,123	11	(10,631)	0	0	0	(1,021)	0	0	0	(60)	0	(0)	0	(116)
SEP	3,758	1,207	678	(6,151)	0	0	0	(1,150)	0	0	0	(25)	0	(0)	0	(69)

Table B1–11. Continued

Water Year	No–Project Alternative Flows				Alternative 1 Changes in Flows				Alternative 2 Changes in Flows				Alternative 3 Changes in Flows			
	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.
1986																
OCT	4,675	1,735	607	(9,331)	0	(0)	0	10	0	(0)	0	10	0	(0)	0	(41)
NOV	5,194	2,872	−145	(6,314)	0	0	0	12	0	0	0	12	0	0	0	(30)
DEC	7,147	4,710	(851)	(9,627)	(405)	127	(278)	0	(405)	127	(278)	0	(405)	127	(278)	0
JAN	11,243	5,004	583	(9,539)	(2,477)	776	(1,700)	0	(2,477)	776	(1,700)	0	(2,473)	775	(1,698)	0
FEB	219,888	31,138	67,702	(3,781)	(1,126)	353	(773)	0	(1,126)	353	(773)	0	(4,140)	1,297	(2,842)	0
MAR	149,241	14,956	51,180	3,228	25	(8)	17	0	25	(8)	17	0	(42)	13	(29)	0
APR	28,310	7	12,118	(1,612)	(25)	8	(17)	0	(25)	8	(17)	0	(77)	24	(53)	0
MAY	11,350	758	4,305	(7,524)	60	(19)	41	0	60	(19)	41	(3,771)	101	(32)	69	(3,000)
JUN	7,579	299	3,150	(5,009)	69	(22)	47	0	69	(22)	47	0	131	(41)	90	(3,283)
JUL	8,002	1,605	2,260	(6,674)	0	0	0	(3,606)	0	0	0	(78)	0	0	0	(150)
AUG	5,741	645	2,039	(4,816)	0	0	0	(60)	0	0	0	(60)	0	(0)	0	(116)
SEP	4,037	1,210	789	(6,928)	0	0	0	(25)	0	0	0	(25)	0	0	0	(69)
1987																
OCT	4,455	1,032	1,103	(11,723)	(10)	3	(7)	0	(10)	3	(7)	0	41	(13)	28	0
NOV	5,554	3,219	(261)	(7,248)	0	0	0	12	0	0	0	12	0	0	0	(30)
DEC	4,598	2,273	113	(5,729)	0	0	(0)	21	0	0	(0)	21	0	0	0	(15)
JAN	5,767	3,713	(627)	(7,752)	0	0	0	(15)	0	0	0	(15)	0	0	0	(18)
FEB	12,344	4,805	1,256	(8,151)	23	(7)	16	0	23	(7)	16	0	41	(13)	28	0
MAR	24,104	7,216	4,285	(9,522)	(1,033)	324	(709)	0	(1,033)	324	(709)	0	(1,051)	329	(721)	0
APR	10,473	2,206	2,706	(4,435)	0	0	0	(917)	0	0	0	(614)	0	0	0	(614)
MAY	7,579	2,020	1,664	(4,581)	0	0	(0)	(156)	0	0	(0)	(326)	0	0	0	(326)
JUN	6,118	1,199	1,780	(5,754)	69	(22)	47	0	69	(22)	47	0	131	(41)	90	0
JUL	7,212	3,836	72	(11,927)	(7)	2	(5)	0	(7)	2	(5)	0	(7)	2	(5)	0
AUG	5,409	2,544	322	(9,223)	0	0	0	(60)	0	0	0	(60)	0	0	0	(116)
SEP	3,515	1,105	665	(5,863)	0	0	0	(25)	0	0	0	(25)	0	(0)	0	(69)
1988																
OCT	4,001	1,109	838	(7,212)	0	(0)	0	10	0	(0)	0	10	0	0	0	(41)
NOV	4,740	2,446	25	(5,169)	0	0	0	12	0	0	0	12	0	0	0	(30)
DEC	6,939	4,963	(1,145)	(10,072)	(62)	19	(42)	0	(62)	19	(42)	0	(62)	19	(42)	0
JAN	17,960	6,585	2,135	(9,682)	(3,830)	1,200	(2,630)	(26)	(3,830)	1,200	(2,630)	(26)	(5,982)	1,875	(4,107)	(44)
FEB	11,400	3,894	1,645	(5,645)	14	(4)	9	(9)	14	(4)	9	(4,009)	31	(10)	21	(4,510)
MAR	7,804	2,469	1,317	(3,868)	73	(23)	50	(0)	73	(23)	50	(27)	55	(17)	38	(1,640)
APR	7,300	1,230	2,146	(3,472)	0	0	0	(638)	0	0	0	(51)	0	0	0	(74)
MAY	6,496	1,519	1,598	(4,055)	0	0	(0)	(485)	0	0	(0)	(60)	0	0	0	(101)
JUN	6,897	1,264	2,044	(5,846)	68	(21)	47	(1)	68	(21)	47	(1)	130	(41)	89	(1)
JUL	5,491	2,162	726	(8,107)	0	0	0	(2,437)	0	0	0	(78)	0	0	(0)	(150)
AUG	3,415	972	775	(5,348)	0	0	0	(60)	0	0	0	(60)	0	0	0	(116)
SEP	3,008	608	859	(3,396)	0	0	0	(25)	0	0	0	(25)	0	0	0	(69)

Table B1–11. Continued

Water Year	No–Project Alternative Flows				Alternative 1 Changes in Flows				Alternative 2 Changes in Flows				Alternative 3 Changes in Flows			
	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.	Outflow	Threemile Slough	SJR at Antioch	Old R. & Middle R.
1989																
OCT	2,992	634	807	(5,285)	0	(0)	0	10	0	(0)	0	10	0	(0)	0	(41)
NOV	4,648	2,255	143	(4,672)	0	0	0	12	0	0	0	12	0	0	0	(30)
DEC	5,565	3,092	(164)	(6,241)	0	0	0	21	0	0	0	21	0	0	0	(15)
JAN	5,788	3,735	(637)	(7,387)	0	0	0	(15)	0	0	0	(15)	0	0	0	(18)
FEB	8,176	3,435	641	(5,997)	23	(7)	16	0	23	(7)	16	0	41	(13)	28	0
MAR	31,422	8,371	6,453	(9,819)	(3,696)	1,158	(2,537)	0	(3,696)	1,158	(2,537)	0	(3,714)	1,164	(2,550)	0
APR	17,776	4,186	4,178	(6,690)	51	(16)	35	0	51	(16)	35	0	74	(23)	51	0
MAY	10,268	2,678	2,265	(5,156)	0	0	0	(887)	0	0	0	(598)	0	0	0	(598)
JUN	6,117	1,137	1,829	(5,658)	69	(22)	47	0	69	(22)	47	0	131	(41)	90	0
JUL	7,272	3,988	(28)	(12,193)	(8)	3	(5)	0	(8)	3	(5)	0	(8)	3	(5)	0
AUG	6,127	3,595	(247)	(11,711)	(7)	2	(5)	0	(7)	2	(5)	0	(7)	2	(5)	0
SEP	3,818	1,230	652	(6,222)	0	0	0	(2,587)	0	0	0	(2,886)	0	0	0	(2,466)
1990																
OCT	4,001	891	1,012	(6,026)	0	(0)	0	10	0	(0)	0	10	0	(0)	0	(41)
NOV	4,504	1,647	588	(3,301)	0	0	0	12	0	0	0	12	0	0	0	(30)
DEC	6,416	3,969	(517)	(7,311)	0	0	0	21	0	0	0	21	0	0	0	(15)
JAN	7,898	5,286	(1,037)	(10,098)	(975)	306	(669)	0	(975)	306	(669)	0	(972)	305	(667)	0
FEB	11,400	3,452	1,989	(5,044)	23	(7)	16	0	23	(7)	16	(1,065)	41	(13)	28	(1,035)
MAR	7,310	2,194	1,332	(3,715)	73	(23)	50	0	73	(23)	50	0	55	(17)	38	0
APR	10,251	2,122	2,679	(4,331)	0	0	0	(709)	0	0	0	(51)	0	0	(0)	(74)
MAY	5,910	1,040	1,709	(3,426)	0	0	0	(164)	0	0	0	(60)	0	0	0	(101)
JUN	6,897	1,376	1,955	(6,053)	68	(21)	47	(1)	68	(21)	47	(1)	131	(41)	90	(1)
JUL	5,584	2,258	686	(8,281)	0	0	0	(78)	0	0	0	(78)	0	0	(0)	(150)
AUG	3,447	1,006	759	(5,441)	0	(0)	0	(60)	0	(0)	0	(60)	0	(0)	0	(116)
SEP	3,008	618	849	(3,713)	0	0	0	(25)	0	0	0	(25)	0	0	0	(69)
1991																
OCT	2,992	637	801	(5,320)	0	(0)	0	10	0	(0)	0	10	0	(0)	0	(41)
NOV	4,187	1,550	537	(3,151)	0	(0)	0	12	0	(0)	0	12	0	0	(0)	(30)
DEC	4,532	2,237	113	(4,461)	0	0	(0)	21	0	0	(0)	21	0	0	0	(15)
JAN	5,025	2,769	(152)	(5,372)	0	0	0	(15)	0	0	0	(15)	0	0	0	(18)
FEB	8,258	3,326	779	(5,649)	0	0	(0)	(23)	0	0	(0)	(23)	0	0	(0)	(41)
MAR	21,327	6,766	3,450	(9,803)	9	(3)	6	0	9	(3)	6	0	(9)	3	(6)	0
APR	11,259	2,296	2,959	(4,425)	0	0	0	(51)	0	0	0	(51)	0	0	0	(74)
MAY	5,362	1,150	1,421	(3,841)	0	0	(0)	(60)	0	0	(0)	(60)	0	0	0	(101)
JUN	7,037	1,106	2,216	(5,449)	0	(0)	0	(69)	0	(0)	0	(69)	47	(15)	32	(85)
JUL	4,215	1,288	907	(5,991)	0	(0)	(0)	(78)	0	(0)	(0)	(78)	0	0	(0)	(150)
AUG	3,415	743	961	(4,639)	0	0	0	(60)	0	0	0	(60)	0	0	0	(116)
SEP	3,008	656	820	(4,428)	0	0	0	(25)	0	0	0	(25)	0	(0)	0	(69)

Note: Negative values shown in parentheses.

Table B1–12. Simulated Historical Percentage Source Contributions to Total Combined SWP and CVP Delta Exports and CCWD Diversions from Selected Delta Locations under the No–Project Alternative and the DW Project Alternatives

	DW Project				Agricultural Drains				SJR Inflow				Eastside Streams				Sacramento Inflow				Benicia Boundary			
Water Year	No–Proj.	Alt. 1	Alt. 2	Alt. 3	No–Proj.	Alt. 1	Alt. 2	Alt. 3	No–Proj.	Alt. 1	Alt. 2	Alt. 3	No–Proj.	Alt. 1	Alt. 2	Alt. 3	No–Proj.	Alt. 1	Alt. 2	Alt. 3	No–Proj.	Alt. 1	Alt. 2	Alt. 3
1968																								
OCT	0.0	0.0	0.0	0.0	1.3	1.2	1.2	1.1	24.8	24.4	24.4	21.3	4.3	4.2	4.2	3.9	69.6	70.1	70.1	73.7	0.0	0.0	0.0	0.1
NOV	0.0	0.1	0.1	0.1	0.3	0.3	0.3	0.3	16.1	16.0	16.0	16.0	1.5	1.5	1.5	1.5	81.9	81.9	81.9	81.9	0.2	0.2	0.2	0.2
DEC	0.0	0.2	0.2	0.2	0.0	0.0	0.0	0.0	19.3	19.3	19.3	19.2	2.3	2.3	2.3	2.3	77.9	77.8	77.8	77.8	0.4	0.4	0.4	0.4
JAN	0.0	0.3	0.3	0.3	3.4	3.3	3.3	3.3	18.9	18.8	18.8	18.8	3.7	3.7	3.7	3.7	74.0	73.9	73.9	74.0	0.0	0.0	0.0	0.0
FEB	0.0	0.5	0.5	0.5	8.9	8.5	8.5	8.5	21.6	21.5	21.5	21.5	11.1	11.1	11.1	11.1	58.3	58.4	58.4	58.5	0.0	0.0	0.0	0.0
MAR	0.0	0.3	0.3	0.3	3.9	3.7	3.7	3.7	18.1	17.9	17.9	17.8	9.0	9.0	9.0	9.0	69.0	69.0	69.0	69.2	0.0	0.0	0.0	0.0
APR	0.0	12.1	8.5	8.1	0.3	0.3	0.3	0.3	68.2	59.4	61.9	61.9	3.1	3.8	3.6	3.6	28.3	24.3	25.5	26.0	0.1	0.1	0.1	0.1
MAY	0.0	19.6	14.8	14.1	4.5	3.5	3.8	3.8	64.1	50.8	53.9	53.9	2.5	3.0	2.9	2.9	28.6	22.8	24.4	25.1	0.3	0.3	0.3	0.3
JUN	0.0	0.1	0.1	0.1	8.1	7.9	7.9	7.9	17.6	17.8	17.8	17.8	2.9	2.9	2.9	2.9	71.0	70.9	70.9	70.9	0.4	0.4	0.4	0.4
JUL	0.0	0.0	0.0	0.0	5.9	5.8	5.8	5.7	9.8	9.8	9.8	9.8	2.0	2.0	2.0	2.0	81.9	82.1	82.1	82.2	0.3	0.3	0.3	0.3
AUG	0.0	12.2	16.0	24.2	6.4	5.5	5.2	4.7	8.5	7.5	7.1	6.4	2.6	2.3	2.2	2.0	81.6	71.8	68.7	62.0	0.8	0.8	0.8	0.8
SEP	0.0	0.0	0.0	7.1	4.5	4.4	4.4	4.1	11.5	11.5	11.5	10.6	2.7	2.7	2.7	2.6	79.9	80.0	80.0	74.3	1.4	1.4	1.4	1.4
1969																								
OCT	0.0	0.0	0.0	0.0	1.1	1.1	1.1	1.1	14.1	14.1	14.1	14.0	1.0	1.0	1.0	1.0	82.6	82.6	82.6	82.7	1.2	1.2	1.2	1.2
NOV	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	22.8	22.8	22.8	22.7	2.7	2.7	2.7	2.7	73.4	73.3	73.3	73.5	1.0	1.0	1.0	1.0
DEC	0.0	0.2	0.2	0.2	13.2	9.5	9.5	8.5	14.5	10.8	10.8	9.7	5.4	4.2	4.2	3.9	66.8	75.1	75.1	77.3	0.1	0.3	0.3	0.4
JAN	0.0	0.4	0.4	0.4	16.6	16.0	16.0	16.0	23.7	23.8	23.8	23.8	39.0	39.1	39.1	39.1	20.7	20.7	20.7	20.7	0.0	0.0	0.0	0.0
FEB	0.0	0.2	0.2	0.2	5.8	5.6	5.6	5.6	55.0	55.0	55.0	55.0	12.3	12.3	12.3	12.3	26.9	26.9	26.9	26.9	0.0	0.0	0.0	0.0
MAR	0.0	0.2	0.2	0.2	0.4	0.3	0.3	0.3	61.5	61.0	61.0	60.8	8.7	8.8	8.8	8.8	29.4	29.6	29.6	29.8	0.0	0.0	0.0	0.0
APR	0.0	0.4	0.4	0.4	0.2	0.2	0.2	0.2	62.8	62.6	62.6	62.6	9.0	9.1	9.1	9.1	27.9	27.7	27.7	27.7	0.0	0.0	0.0	0.0
MAY	0.0	0.0	0.0	0.0	0.9	0.9	0.9	0.9	75.7	75.6	75.6	75.6	2.4	2.4	2.4	2.4	21.1	21.1	21.1	21.1	0.0	0.0	0.0	0.0
JUN	0.0	0.0	0.0	0.0	4.3	4.2	4.2	4.2	78.5	78.6	78.6	78.6	0.9	0.9	0.9	0.9	16.2	16.2	16.2	16.2	0.0	0.0	0.0	0.0
JUL	0.0	22.6	22.6	26.1	8.6	6.2	6.2	5.8	47.9	35.6	35.6	33.6	1.6	1.5	1.5	1.5	41.7	33.9	33.9	32.8	0.2	0.2	0.2	0.2
AUG	0.0	0.0	0.0	14.0	8.1	7.9	7.9	6.6	20.8	20.9	20.9	17.6	2.8	2.8	2.8	2.4	67.7	67.8	67.8	58.7	0.6	0.6	0.6	0.6
SEP	0.0	0.0	0.0	0.0	2.6	1.9	1.9	1.7	19.6	15.0	15.0	13.4	1.8	1.5	1.5	1.4	75.9	81.4	81.4	83.1	0.1	0.2	0.2	0.4
1970																								
OCT	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	59.1	58.7	58.7	54.7	1.9	1.9	1.9	2.0	38.7	39.1	39.1	43.0	0.0	0.0	0.0	0.0
NOV	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	31.4	31.2	31.2	31.2	1.0	1.0	1.0	1.0	67.4	67.4	67.4	67.5	0.1	0.1	0.1	0.1
DEC	0.0	0.2	0.2	0.2	2.2	2.1	2.1	2.1	31.7	31.6	31.6	31.6	5.0	5.0	5.0	5.0	61.1	61.1	61.1	61.1	0.0	0.0	0.0	0.0
JAN	0.0	0.2	0.2	0.2	12.0	11.5	11.5	11.5	40.7	40.8	40.8	40.8	21.8	21.9	21.9	21.9	25.5	25.6	25.6	25.6	0.0	0.0	0.0	0.0
FEB	0.0	0.3	0.3	0.3	1.9	1.8	1.8	1.8	53.7	53.4	53.4	53.3	8.7	8.8	8.8	8.8	35.7	35.8	35.8	35.9	0.0	0.0	0.0	0.0
MAR	0.0	0.3	0.3	0.3	0.9	0.8	0.8	0.8	26.6	26.4	26.4	26.3	17.1	17.1	17.1	17.0	55.4	55.4	55.4	55.6	0.0	0.0	0.0	0.0
APR	0.0	3.1	8.4	8.0	0.6	0.6	0.6	0.6	76.7	74.0	69.8	69.8	1.5	1.8	2.1	2.1	21.1	20.5	19.0	19.3	0.0	0.0	0.0	0.0
MAY	0.0	1.0	9.5	9.0	3.8	3.7	3.4	3.4	74.7	73.2	66.8	66.8	1.7	1.8	2.3	2.3	19.7	20.0	17.8	18.3	0.3	0.3	0.3	0.3
JUN	0.0	0.1	0.1	0.1	7.6	7.4	7.4	7.4	21.6	21.8	21.8	21.8	2.9	3.0	3.0	3.0	67.6	67.4	67.4	67.5	0.3	0.3	0.3	0.3
JUL	0.0	0.0	0.0	0.0	5.9	5.8	5.8	5.7	10.1	10.1	10.1	10.0	2.0	2.0	2.0	2.0	81.9	82.0	82.0	82.1	0.2	0.2	0.2	0.2
AUG	0.0	23.8	17.8	30.6	7.3	5.3	5.7	4.8	15.8	11.8	12.8	10.6	2.7	2.1	2.3	1.9	73.7	56.4	60.8	51.5	0.6	0.6	0.6	0.6
SEP	0.0	0.0	0.0	0.0	4.6	4.5	4.5	4.5	13.9	13.9	13.9	13.8	2.7	2.7	2.7	2.7	77.4	77.5	77.5	77.6	1.4	1.4	1.4	1.4

Table B1–12. Continued

Water Year	DW Project				Agricultural Drains				SJR Inflow				Eastside Streams				Sacramento Inflow				Benicia Boundary			
	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3
1971																								
OCT	0.0	0.0	0.0	0.0	0.7	0.7	0.7	0.7	16.4	16.4	16.4	16.3	1.0	1.0	1.0	1.0	80.7	80.7	80.7	80.8	1.3	1.3	1.3	1.3
NOV	0.0	0.1	0.1	0.1	3.1	2.2	2.2	2.0	21.0	15.6	15.6	13.8	7.0	5.6	5.6	5.0	68.9	76.3	76.3	78.7	0.1	0.2	0.2	0.4
DEC	0.0	0.3	0.3	0.3	21.2	20.4	20.4	19.0	21.9	21.8	21.8	20.3	24.8	24.8	24.8	23.6	32.1	32.8	32.8	36.7	0.0	0.0	0.0	0.0
JAN	0.0	0.2	0.2	0.2	3.3	3.2	3.2	3.1	16.3	16.2	16.2	16.1	9.9	9.9	9.9	9.9	70.5	70.6	70.6	70.6	0.0	0.0	0.0	0.0
FEB	0.0	25.7	20.5	20.4	0.0	0.0	0.0	0.0	22.5	16.2	17.4	17.4	7.1	5.6	5.9	5.9	70.4	52.5	56.2	56.3	0.0	0.0	0.0	0.0
MAR	0.0	0.2	0.2	0.2	2.2	1.6	1.7	1.7	18.1	14.0	14.9	14.8	8.7	7.1	7.5	7.4	71.1	77.0	75.7	75.8	0.0	0.0	0.0	0.0
APR	0.0	1.8	1.4	1.1	0.4	0.4	0.4	0.4	52.2	51.1	51.3	51.3	6.1	6.1	6.1	6.1	41.3	40.6	40.8	41.1	0.0	0.0	0.0	0.0
MAY	0.0	0.2	0.2	0.2	1.9	1.8	1.9	1.8	37.9	36.9	37.0	36.4	5.3	5.3	5.3	5.3	54.9	55.8	55.7	56.3	0.0	0.0	0.0	0.0
JUN	0.0	0.1	0.1	0.1	5.0	4.9	4.9	4.9	17.5	17.6	17.6	17.6	3.6	3.6	3.6	3.6	73.9	73.9	73.9	73.9	0.0	0.0	0.0	0.0
JUL	0.0	0.0	0.0	0.0	5.9	5.8	5.8	5.7	10.1	10.1	10.1	10.0	2.0	2.0	2.0	2.0	81.9	82.1	82.1	82.1	0.1	0.1	0.1	0.1
AUG	0.0	25.2	25.2	29.7	7.0	5.0	5.0	4.7	15.4	11.3	11.3	10.5	2.6	2.0	2.0	1.9	74.4	55.8	55.8	52.6	0.6	0.6	0.6	0.6
SEP	0.0	0.0	0.0	8.4	3.2	3.2	3.2	2.9	9.4	9.4	9.4	8.6	2.0	2.0	2.0	1.9	84.7	84.7	84.7	77.7	0.7	0.7	0.7	0.7
1972																								
OCT	0.0	0.0	0.0	0.0	1.0	0.8	0.8	0.8	15.0	12.4	12.4	12.4	1.8	1.5	1.5	1.5	81.8	84.4	84.4	84.4	0.3	0.8	0.8	0.8
NOV	0.0	1.5	1.5	1.2	0.2	0.2	0.2	0.2	15.0	14.8	14.8	14.8	2.0	1.9	1.9	1.9	82.3	81.0	81.0	81.3	0.5	0.6	0.6	0.6
DEC	0.0	1.7	0.7	0.6	2.1	1.7	1.8	1.5	15.2	13.0	13.1	11.0	7.7	6.8	6.9	5.9	75.0	76.6	77.3	80.7	0.1	0.1	0.1	0.3
JAN	0.0	0.2	0.2	0.2	1.2	1.1	1.1	1.1	16.1	15.7	15.9	15.8	2.7	2.7	2.7	2.7	79.9	80.2	79.9	79.9	0.1	0.2	0.1	0.2
FEB	0.0	0.4	13.3	13.3	0.5	0.5	0.4	0.4	20.4	20.3	17.4	17.4	6.4	6.3	5.7	5.7	72.7	72.5	63.2	63.2	0.0	0.0	0.0	0.0
MAR	0.0	0.3	0.3	0.3	0.4	0.4	0.4	0.4	17.7	17.5	16.2	16.2	3.3	3.2	3.1	3.1	78.6	78.5	80.1	80.1	0.0	0.0	0.0	0.0
APR	0.0	11.4	8.0	7.6	2.0	1.8	1.9	1.9	64.4	56.7	58.9	58.9	4.4	5.0	4.9	4.9	29.1	25.0	26.3	26.7	0.1	0.1	0.1	0.1
MAY	0.0	8.2	5.6	4.9	5.7	5.1	5.3	5.3	45.7	41.6	42.8	42.8	5.4	5.4	5.4	5.4	42.9	39.4	40.6	41.3	0.3	0.3	0.3	0.3
JUN	0.0	0.1	0.1	0.1	7.9	7.7	7.7	7.7	17.8	18.0	18.0	18.0	3.1	3.1	3.1	3.1	70.8	70.7	70.7	70.7	0.4	0.4	0.4	0.4
JUL	0.0	0.0	0.0	0.0	5.9	5.8	5.8	5.7	9.8	9.8	9.8	9.8	2.1	2.1	2.1	2.1	81.9	82.0	82.0	82.1	0.3	0.3	0.3	0.3
AUG	0.0	0.0	0.0	0.0	4.8	4.6	4.6	4.6	6.1	6.1	6.1	6.1	2.0	2.0	2.0	2.0	86.7	86.8	86.8	86.8	0.4	0.4	0.4	0.4
SEP	0.0	20.2	18.5	29.1	3.0	2.3	2.4	2.0	18.6	14.6	14.9	12.8	2.2	1.8	1.8	1.6	74.9	59.8	61.1	53.1	1.4	1.4	1.4	1.4
1973																								
OCT	0.0	0.0	0.0	3.9	0.2	0.2	0.2	0.2	13.0	13.0	13.0	12.5	0.8	0.8	0.8	0.8	84.9	84.9	84.9	81.6	1.1	1.1	1.1	1.1
NOV	0.0	0.1	0.1	0.1	5.8	4.2	4.2	3.7	20.1	14.9	14.9	13.4	3.6	2.9	2.9	2.7	70.4	77.8	77.8	79.8	0.1	0.2	0.2	0.3
DEC	0.0	2.2	0.9	0.8	7.2	6.7	6.8	6.2	14.5	14.2	14.4	13.1	3.2	3.2	3.2	3.0	75.0	73.7	74.7	76.8	0.0	0.0	0.0	0.0
JAN	0.0	0.5	0.5	0.5	21.1	19.8	20.1	20.1	15.3	14.9	15.1	15.1	29.5	28.9	29.2	29.2	34.1	35.9	35.1	35.2	0.0	0.0	0.0	0.0
FEB	0.0	0.4	0.4	0.4	8.5	8.1	8.1	8.1	30.5	30.4	30.4	30.3	34.5	34.4	34.4	34.4	26.5	26.6	26.6	26.8	0.0	0.0	0.0	0.0
MAR	0.0	0.3	0.3	0.3	8.5	8.2	8.2	8.2	50.3	50.3	50.3	50.3	14.8	14.8	14.8	14.8	26.4	26.4	26.4	26.4	0.0	0.0	0.0	0.0
APR	0.0	0.6	0.6	0.6	0.3	0.3	0.3	0.3	63.1	62.9	62.9	62.9	4.9	5.0	5.0	5.0	31.7	31.3	31.3	31.3	0.0	0.0	0.0	0.0
MAY	0.0	0.2	0.2	0.2	3.0	3.0	3.0	3.0	54.3	54.3	54.3	54.3	4.4	4.4	4.4	4.4	38.3	38.2	38.2	38.2	0.0	0.0	0.0	0.0
JUN	0.0	4.5	21.5	21.1	6.7	6.2	5.0	5.0	27.5	26.2	21.1	21.1	2.6	2.5	2.2	2.2	63.1	60.5	50.2	50.6	0.1	0.1	0.1	0.1
JUL	0.0	0.6	0.6	0.1	6.0	5.8	5.8	5.8	10.0	10.0	10.0	10.0	2.0	2.0	2.0	2.0	81.9	81.6	81.6	82.0	0.1	0.1	0.1	0.1
AUG	0.0	20.9	0.0	18.2	7.4	5.6	7.2	5.8	15.7	12.2	15.7	12.6	2.9	2.3	2.9	2.4	73.4	58.2	73.5	60.3	0.7	0.7	0.7	0.7
SEP	0.0	0.0	0.0	0.0	4.1	4.0	4.0	3.9	13.2	13.3	13.3	13.2	2.7	2.7	2.7	2.7	78.7	78.8	78.8	78.9	1.3	1.3	1.3	1.3

Table B1–12. Continued

Water Year	DW Project				Agricultural Drains				SJR Inflow				Eastside Streams				Sacramento Inflow				Benicia Boundary			
	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3
1974																								
OCT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.2	12.2	12.2	12.1	8.6	8.6	8.6	8.6	78.1	78.1	78.1	78.2	1.1	1.1	1.1	1.1
NOV	0.0	0.1	0.1	0.1	3.0	2.2	2.2	1.9	19.3	14.3	14.3	12.7	11.6	9.2	9.2	8.3	66.0	74.2	74.2	77.0	0.0	0.0	0.0	0.0
DEC	0.0	0.2	0.2	0.2	11.3	10.8	10.8	10.1	19.2	19.1	19.1	17.9	22.5	22.4	22.4	21.3	47.0	47.4	47.4	50.5	0.0	0.0	0.0	0.0
JAN	0.0	0.3	0.3	0.3	9.6	9.2	9.2	9.2	25.2	25.0	25.0	25.0	30.4	30.3	30.3	30.3	34.8	35.1	35.1	35.2	0.0	0.0	0.0	0.0
FEB	0.0	0.3	0.3	0.3	0.4	0.4	0.4	0.4	25.4	25.3	25.3	25.2	5.1	5.1	5.1	5.1	69.0	68.9	68.9	69.0	0.0	0.0	0.0	0.0
MAR	0.0	0.3	0.3	0.3	2.6	2.5	2.5	2.4	26.6	26.5	26.5	26.3	25.3	25.1	25.1	25.1	45.5	45.7	45.7	45.8	0.0	0.0	0.0	0.0
APR	0.0	0.5	0.5	0.5	1.5	1.4	1.4	1.4	55.4	54.9	54.9	54.5	8.3	8.3	8.3	8.4	34.8	34.9	34.9	35.3	0.0	0.0	0.0	0.0
MAY	0.0	0.1	0.1	0.1	1.5	1.5	1.5	1.5	53.2	53.2	53.2	53.2	3.9	3.9	3.9	3.9	41.3	41.2	41.2	41.2	0.0	0.0	0.0	0.0
JUN	0.0	0.1	15.9	15.9	4.9	4.8	3.9	3.9	26.8	27.0	22.3	22.3	2.9	2.9	2.6	2.6	65.4	65.3	55.3	55.3	0.0	0.0	0.0	0.0
JUL	0.0	19.9	8.6	19.5	7.0	5.4	6.2	5.4	13.1	10.3	11.9	10.3	2.9	2.4	2.7	2.4	76.8	61.7	70.4	62.2	0.2	0.2	0.2	0.2
AUG	0.0	2.4	0.0	2.5	6.8	6.5	6.7	6.4	15.7	15.3	15.7	15.2	2.5	2.5	2.5	2.5	74.3	72.7	74.5	72.8	0.6	0.6	0.6	0.6
SEP	0.0	0.0	0.0	0.0	2.9	2.3	2.3	2.3	9.1	7.5	7.5	7.4	1.8	1.5	1.5	1.5	85.8	88.0	88.0	88.1	0.2	0.6	0.6	0.6
1975																								
OCT	0.0	0.0	0.0	0.0	0.6	0.5	0.5	0.5	15.3	14.1	14.1	11.6	2.3	2.1	2.1	1.8	81.7	83.1	83.1	85.8	0.0	0.1	0.1	0.3
NOV	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	21.3	21.2	21.2	21.2	3.0	3.0	3.0	3.0	75.4	75.4	75.4	75.4	0.2	0.2	0.2	0.2
DEC	0.0	0.2	0.2	0.2	0.0	0.0	0.0	0.0	17.9	17.8	17.8	17.8	4.6	4.6	4.6	4.6	77.4	77.3	77.3	77.3	0.2	0.2	0.2	0.2
JAN	0.0	0.2	0.2	0.2	0.1	0.1	0.1	0.1	12.2	12.1	12.1	12.1	2.4	2.4	2.4	2.4	84.8	84.6	84.6	84.7	0.4	0.4	0.4	0.4
FEB	0.0	0.5	0.5	0.5	12.7	12.1	12.1	12.1	37.1	36.9	36.9	36.9	12.0	12.0	12.0	12.0	38.2	38.5	38.5	38.6	0.0	0.0	0.0	0.0
MAR	0.0	0.3	0.3	0.3	6.2	5.9	5.9	5.9	26.6	26.4	26.4	26.3	32.3	32.2	32.2	32.1	34.9	35.2	35.2	35.4	0.0	0.0	0.0	0.0
APR	0.0	0.5	0.5	0.5	0.0	0.0	0.0	0.0	59.9	59.7	59.7	59.7	5.6	5.6	5.6	5.6	34.6	34.2	34.2	34.2	0.0	0.0	0.0	0.0
MAY	0.0	0.1	0.1	0.1	1.8	1.8	1.8	1.7	50.0	49.2	49.2	48.4	6.4	6.4	6.4	6.4	41.8	42.5	42.5	43.3	0.0	0.0	0.0	0.0
JUN	0.0	0.1	5.4	5.4	4.9	4.8	4.5	4.5	22.8	23.0	21.6	21.6	6.3	6.3	6.1	6.1	65.9	65.8	62.3	62.3	0.0	0.0	0.0	0.0
JUL	0.0	9.6	9.6	9.1	6.5	5.7	5.7	5.7	11.5	10.3	10.3	10.3	2.4	2.2	2.2	2.2	79.4	72.0	72.0	72.5	0.2	0.2	0.2	0.2
AUG	0.0	16.7	10.6	26.7	6.5	5.2	5.6	4.5	17.9	14.7	15.9	12.7	2.5	2.1	2.2	1.9	72.6	60.7	65.2	53.6	0.6	0.6	0.6	0.6
SEP	0.0	0.0	0.0	0.0	2.9	2.7	2.7	2.7	12.7	12.0	12.0	12.0	1.8	1.7	1.7	1.7	82.1	82.9	82.9	83.0	0.5	0.6	0.6	0.6
1976																								
OCT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.7	12.2	12.2	10.6	4.1	3.3	3.3	3.0	80.2	84.3	84.3	86.0	0.1	0.2	0.2	0.4
NOV	0.0	0.1	0.1	0.1	0.3	0.3	0.3	0.2	21.7	21.6	21.6	20.5	1.7	1.6	1.6	1.6	76.3	76.3	76.3	77.4	0.1	0.1	0.1	0.1
DEC	0.0	8.9	5.8	5.3	0.2	0.2	0.2	0.2	18.2	16.4	17.0	17.1	1.4	1.3	1.4	1.4	79.8	72.7	75.2	75.6	0.4	0.4	0.4	0.5
JAN	0.0	22.8	22.8	22.8	0.3	0.2	0.2	0.2	10.4	7.9	7.9	7.9	1.2	0.9	0.9	0.9	87.5	67.6	67.5	67.5	0.7	0.7	0.7	0.7
FEB	0.0	0.4	4.3	17.5	0.1	0.1	0.1	0.1	10.5	10.4	10.0	8.6	2.4	2.4	2.3	2.0	86.8	86.5	83.1	71.7	0.2	0.2	0.2	0.2
MAR	0.0	0.5	0.5	13.4	0.9	0.9	0.9	0.8	24.1	24.0	24.0	20.5	3.5	3.5	3.5	3.1	71.3	71.0	71.0	62.0	0.1	0.1	0.1	0.1
APR	0.0	1.3	1.3	1.3	1.8	1.8	1.8	1.8	51.3	50.4	50.4	50.0	4.9	5.0	5.0	5.0	41.6	41.3	41.3	41.6	0.3	0.3	0.3	0.3
MAY	0.0	0.3	0.3	0.3	5.8	5.7	5.7	5.6	39.2	38.7	38.7	38.3	4.6	4.6	4.6	4.5	49.9	50.3	50.3	50.7	0.5	0.5	0.5	0.5
JUN	0.0	0.1	0.1	0.1	8.1	7.9	7.9	7.9	17.3	17.4	17.4	17.4	2.9	3.0	3.0	3.0	71.3	71.2	71.2	71.2	0.5	0.5	0.5	0.5
JUL	0.0	0.0	0.0	0.0	7.8	7.6	7.6	7.5	7.6	7.7	7.7	7.6	2.7	2.7	2.7	2.7	81.2	81.4	81.4	81.5	0.7	0.7	0.7	0.7
AUG	0.0	0.0	0.0	0.0	9.2	8.9	8.9	8.8	13.1	13.1	13.1	13.0	3.6	3.6	3.6	3.6	72.5	72.7	72.7	72.9	1.7	1.7	1.7	1.7
SEP	0.0	0.0	0.0	0.0	4.7	4.6	4.6	4.6	15.1	15.0	15.0	14.9	3.9	3.9	3.9	3.9	73.9	74.0	74.0	74.2	2.4	2.4	2.4	2.4

Table B1–12. Continued

Water Year	DW Project				Agricultural Drains				SJR Inflow				Eastside Streams				Sacramento Inflow				Benicia Boundary			
	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3
1977																								
OCT	0.0	0.0	0.0	0.0	1.1	1.1	1.1	1.1	23.6	23.6	23.6	23.4	2.0	2.0	2.0	2.0	70.5	70.6	70.6	70.8	2.8	2.8	2.8	2.8
NOV	0.0	0.1	0.1	0.1	0.5	0.5	0.5	0.5	20.6	20.6	20.6	20.5	0.8	0.8	0.8	0.8	76.3	76.2	76.2	76.3	1.9	1.9	1.9	1.9
DEC	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	8.7	8.7	8.7	8.7	0.8	0.8	0.8	0.8	89.5	89.4	89.4	89.4	0.9	0.9	0.9	0.9
JAN	0.0	0.6	0.6	0.6	0.0	0.0	0.0	0.0	18.6	18.3	18.3	18.3	1.6	1.5	1.5	1.5	78.6	78.3	78.3	78.3	1.3	1.3	1.3	1.3
FEB	0.0	0.6	0.6	0.6	0.0	0.0	0.0	0.0	18.9	18.8	18.8	18.7	0.9	0.9	0.9	0.9	79.6	79.2	79.2	79.3	0.5	0.5	0.5	0.5
MAR	0.0	0.7	0.7	0.7	0.0	0.0	0.0	0.0	32.0	31.3	31.3	31.3	2.6	2.6	2.6	2.6	64.9	64.9	64.9	64.9	0.5	0.5	0.5	0.5
APR	0.0	1.3	1.3	1.3	3.8	3.8	3.8	3.7	51.0	49.9	49.9	49.6	4.9	4.9	4.9	4.9	39.8	39.7	39.7	40.0	0.5	0.5	0.5	0.5
MAY	0.0	0.4	0.4	0.4	4.4	4.3	4.3	4.3	56.3	55.1	55.1	54.5	2.6	2.7	2.7	2.7	35.5	36.3	36.3	37.0	1.1	1.1	1.1	1.1
JUN	0.0	0.2	0.2	0.2	16.3	15.9	15.9	15.7	38.8	38.9	38.9	38.3	4.4	4.4	4.4	4.4	38.9	39.1	39.1	40.0	1.6	1.6	1.6	1.6
JUL	0.0	0.0	0.0	0.0	15.4	15.0	15.0	14.8	14.7	14.8	14.8	14.6	4.6	4.6	4.6	4.5	63.6	63.8	63.8	64.2	1.8	1.8	1.8	1.8
AUG	0.0	0.0	0.0	0.0	16.9	16.5	16.5	16.3	20.0	20.1	20.1	19.8	5.5	5.6	5.6	5.5	55.4	55.6	55.6	56.2	2.2	2.2	2.2	2.2
SEP	0.0	0.0	0.0	0.0	6.2	6.0	6.0	6.0	18.1	18.1	18.1	18.0	3.6	3.6	3.6	3.6	69.4	69.5	69.5	69.8	2.7	2.7	2.7	2.7
1978																								
OCT	0.0	0.0	0.0	0.0	3.3	3.2	3.2	3.2	27.2	27.2	27.2	27.0	1.9	1.9	1.9	1.9	64.6	64.7	64.7	65.0	3.0	3.0	3.0	3.0
NOV	0.0	0.2	0.2	0.2	0.0	0.0	0.0	0.0	34.8	34.7	34.7	34.3	2.6	2.6	2.6	2.6	59.8	59.7	59.7	60.1	2.8	2.8	2.8	2.8
DEC	0.0	0.3	0.3	0.3	7.2	7.0	7.0	6.9	11.6	11.6	11.6	11.6	3.6	3.6	3.6	3.6	76.3	76.3	76.3	76.3	1.3	1.3	1.3	1.3
JAN	0.0	0.4	0.4	0.4	24.3	17.6	17.6	15.5	21.6	16.3	16.3	14.4	20.4	16.6	16.6	15.0	33.7	49.1	49.1	54.7	0.0	0.0	0.0	0.0
FEB	0.0	0.4	0.4	0.4	9.4	9.0	9.0	8.5	33.4	33.2	33.2	31.5	11.0	11.0	11.0	10.7	46.2	46.4	46.4	48.9	0.0	0.0	0.0	0.0
MAR	0.0	0.4	0.4	0.4	11.4	10.9	10.9	10.9	27.8	27.6	27.6	27.5	16.3	16.2	16.2	16.2	44.5	44.8	44.8	45.0	0.0	0.0	0.0	0.0
APR	0.0	0.5	0.5	0.5	3.2	3.0	3.0	3.0	55.4	55.0	55.0	54.6	9.9	9.9	9.9	10.0	31.5	31.6	31.6	32.0	0.0	0.0	0.0	0.0
MAY	0.0	0.2	0.9	0.9	1.2	1.2	1.2	1.2	60.1	60.0	59.5	59.5	3.5	3.6	3.6	3.6	35.2	35.2	34.9	34.9	0.0	0.0	0.0	0.0
JUN	0.0	2.2	25.0	28.8	6.3	6.0	4.4	4.1	44.1	43.0	31.6	29.6	3.3	3.3	3.0	2.9	46.1	45.4	35.9	34.4	0.1	0.1	0.1	0.1
JUL	0.0	29.7	0.0	15.7	13.2	8.7	12.8	10.5	22.8	15.6	22.9	18.8	3.7	2.8	3.7	3.2	60.1	43.0	60.3	51.6	0.2	0.2	0.2	0.2
AUG	0.0	0.0	0.0	0.0	9.0	8.8	8.8	8.7	21.9	22.0	22.0	21.8	3.0	3.0	3.0	3.0	65.3	65.5	65.5	65.7	0.7	0.7	0.7	0.7
SEP	0.0	0.0	0.0	0.0	3.4	3.4	3.4	3.3	14.2	14.2	14.2	14.1	1.9	1.9	1.9	1.9	79.6	79.7	79.7	79.7	0.9	0.9	0.9	0.9
1979																								
OCT	0.0	0.0	0.0	0.0	1.5	1.2	1.2	1.2	24.7	19.8	19.8	19.8	1.0	0.8	0.8	0.8	72.5	77.4	77.4	77.4	0.3	0.8	0.8	0.8
NOV	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	20.5	20.1	20.1	20.1	1.1	1.1	1.1	1.1	77.9	78.0	78.0	78.0	0.5	0.7	0.7	0.7
DEC	0.0	30.4	30.4	30.3	0.0	0.0	0.0	0.0	22.8	15.3	15.3	15.2	1.5	1.1	1.1	1.1	74.8	52.2	52.2	52.3	0.9	1.0	1.0	1.0
JAN	0.0	0.4	0.4	0.3	14.2	10.3	10.3	9.1	22.1	16.6	16.6	14.7	8.9	7.3	7.3	6.6	54.8	65.4	65.4	69.3	0.0	0.0	0.0	0.1
FEB	0.0	0.5	0.5	0.5	12.0	11.5	11.5	10.9	39.5	39.3	39.3	37.3	15.2	15.2	15.2	15.0	33.3	33.5	33.5	36.4	0.0	0.0	0.0	0.0
MAR	0.0	0.3	0.3	0.3	3.1	3.0	3.0	3.0	34.5	34.3	34.3	34.1	14.2	14.1	14.1	14.1	48.2	48.3	48.3	48.5	0.0	0.0	0.0	0.0
APR	0.0	0.6	0.6	0.6	0.0	0.0	0.0	0.0	65.3	65.1	65.1	65.1	3.6	3.6	3.6	3.6	31.0	30.6	30.6	30.6	0.0	0.0	0.0	0.0
MAY	0.0	0.2	0.2	0.2	2.8	2.8	2.8	2.8	57.9	57.8	57.8	57.8	4.6	4.6	4.6	4.6	34.7	34.6	34.6	34.6	0.0	0.0	0.0	0.0
JUN	0.0	4.4	19.6	19.2	6.4	5.9	4.9	4.9	26.9	25.6	21.2	21.2	2.7	2.6	2.3	2.3	63.9	61.3	52.0	52.4	0.1	0.1	0.1	0.1
JUL	0.0	15.2	3.3	14.7	6.1	5.0	5.7	5.0	12.3	10.4	11.9	10.4	2.4	2.1	2.3	2.1	78.8	67.0	76.4	67.5	0.4	0.4	0.4	0.4
AUG	0.0	4.5	0.0	3.4	8.3	7.6	8.0	7.7	17.3	16.5	17.4	16.6	3.0	2.9	3.0	2.9	70.5	67.5	70.6	68.4	1.0	1.0	1.0	1.0
SEP	0.0	0.0	0.0	0.0	4.9	4.7	4.7	4.7	16.2	16.2	16.2	16.1	2.8	2.8	2.8	2.8	74.4	74.5	74.5	74.6	1.8	1.8	1.8	1.8

Table B1–12. Continued

Water Year	DW Project				Agricultural Drains				SJR Inflow				Eastside Streams				Sacramento Inflow				Benicia Boundary			
	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3
1980																								
OCT	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	25.0	25.0	25.0	24.8	0.9	0.9	0.9	0.9	72.0	72.0	72.0	72.2	1.9	1.9	1.9	1.9
NOV	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	27.1	21.5	21.5	21.5	1.8	1.6	1.6	1.6	70.6	75.8	75.8	75.8	0.5	1.0	1.0	1.0
DEC	0.0	0.3	0.2	0.2	4.9	4.3	4.3	3.5	18.3	16.7	16.7	13.7	3.3	3.1	3.1	2.6	73.4	75.4	75.5	79.5	0.1	0.2	0.2	0.4
JAN	0.0	0.3	0.3	0.3	11.2	10.8	10.8	10.8	43.6	43.7	43.7	43.7	19.3	19.3	19.3	19.3	25.8	25.9	25.9	25.9	0.0	0.0	0.0	0.0
FEB	0.0	0.2	0.2	0.2	3.7	3.5	3.5	3.5	61.3	61.3	61.3	61.3	8.7	8.7	8.7	8.7	26.3	26.3	26.3	26.3	0.0	0.0	0.0	0.0
MAR	0.0	0.1	0.1	0.1	0.6	0.6	0.6	0.6	76.2	76.1	76.1	76.1	2.2	2.3	2.3	2.3	21.0	21.0	21.0	21.0	0.0	0.0	0.0	0.0
APR	0.0	0.6	7.2	7.2	0.0	0.0	0.0	0.0	73.2	73.0	68.0	68.0	2.4	2.5	3.0	3.0	24.4	23.9	21.8	21.8	0.0	0.0	0.0	0.0
MAY	0.0	0.2	16.9	16.9	2.5	2.5	2.1	2.1	72.9	72.8	60.4	60.4	1.9	1.9	2.8	2.8	22.6	22.5	17.8	17.8	0.0	0.0	0.0	0.0
JUN	0.0	4.8	13.2	28.5	7.2	6.6	5.9	4.7	44.2	41.7	37.4	29.7	3.3	3.3	3.2	2.9	45.0	43.4	40.0	33.9	0.2	0.2	0.2	0.2
JUL	0.0	27.3	0.0	0.0	11.7	7.9	11.4	11.2	28.2	19.8	28.3	28.0	3.6	2.8	3.6	3.5	56.3	41.8	56.5	56.9	0.3	0.3	0.3	0.3
AUG	0.0	0.0	0.0	0.0	8.6	8.3	8.3	8.3	21.5	21.5	21.5	21.4	2.9	2.9	2.9	2.9	66.3	66.5	66.5	66.7	0.7	0.7	0.7	0.7
SEP	0.0	0.0	0.0	0.0	3.1	3.1	3.1	3.1	24.6	24.6	24.6	24.6	1.6	1.6	1.6	1.6	69.8	69.8	69.8	69.9	0.9	0.9	0.9	0.9
1981																								
OCT	0.0	0.0	0.0	0.0	1.5	1.2	1.2	1.2	29.6	24.0	24.0	24.0	2.5	2.2	2.2	2.2	66.1	71.9	71.9	71.9	0.3	0.8	0.8	0.8
NOV	0.0	1.3	1.3	1.0	0.7	0.7	0.7	0.7	28.3	27.9	27.9	27.9	2.4	2.4	2.4	2.4	68.1	67.1	67.1	67.4	0.6	0.8	0.8	0.7
DEC	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	23.8	21.5	21.5	21.2	1.6	1.5	1.5	1.4	74.2	76.2	76.2	76.4	0.5	0.7	0.7	0.8
JAN	0.0	0.4	0.4	0.4	10.6	10.2	10.2	8.4	21.7	21.5	21.5	17.7	4.2	4.2	4.2	3.7	63.5	63.6	63.6	69.8	0.0	0.0	0.0	0.0
FEB	0.0	0.3	5.4	5.4	1.4	1.3	1.2	1.2	25.5	25.5	24.0	24.0	2.2	2.2	2.1	2.1	70.9	70.8	67.3	67.3	0.0	0.0	0.0	0.0
MAR	0.0	0.4	0.4	0.4	8.1	7.7	7.3	7.2	21.3	21.1	20.0	19.9	10.0	9.9	9.6	9.5	60.7	61.0	62.8	63.0	0.0	0.0	0.0	0.0
APR	0.0	12.1	8.5	8.1	0.0	0.0	0.0	0.0	64.3	56.1	58.5	58.5	2.4	2.8	2.7	2.7	33.3	28.9	30.3	30.7	0.0	0.0	0.0	0.0
MAY	0.0	20.1	15.1	14.4	3.8	3.0	3.2	3.2	66.2	52.0	55.3	55.3	2.1	2.7	2.6	2.6	27.6	21.9	23.5	24.2	0.2	0.2	0.2	0.2
JUN	0.0	0.1	0.1	0.1	7.6	7.4	7.4	7.4	19.3	19.4	19.4	19.4	3.1	3.1	3.1	3.1	69.5	69.4	69.4	69.4	0.5	0.5	0.5	0.5
JUL	0.0	0.0	0.0	0.0	5.9	5.8	5.8	5.7	9.8	9.8	9.8	9.8	2.0	2.0	2.0	2.0	81.8	81.9	81.9	82.0	0.5	0.5	0.5	0.5
AUG	0.0	11.8	15.7	24.1	6.4	5.5	5.2	4.7	9.4	8.3	7.9	7.1	2.6	2.3	2.2	2.0	80.6	71.2	68.0	61.3	1.0	1.0	1.0	1.0
SEP	0.0	0.0	0.0	7.5	4.9	4.8	4.8	4.4	13.0	13.0	13.0	11.9	2.9	2.9	2.9	2.7	77.4	77.5	77.5	71.7	1.8	1.8	1.8	1.8
1982																								
OCT	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	15.7	15.6	15.6	15.5	0.8	0.8	0.8	0.8	81.9	82.0	82.0	82.1	1.5	1.5	1.5	1.5
NOV	0.0	0.1	0.1	0.1	0.2	0.1	0.1	0.1	12.8	9.5	9.5	8.4	7.5	5.8	5.8	5.2	79.5	84.5	84.5	86.2	0.0	0.0	0.0	0.0
DEC	0.0	3.0	1.2	1.1	8.0	7.4	7.6	7.1	13.0	12.5	12.8	11.9	19.8	19.3	19.6	18.5	59.2	57.8	58.9	61.4	0.0	0.0	0.0	0.0
JAN	0.0	0.4	0.4	0.4	17.9	17.3	17.3	17.3	19.6	19.6	19.6	19.6	43.7	43.8	43.8	43.8	18.8	18.8	18.8	18.8	0.0	0.0	0.0	0.0
FEB	0.0	0.3	0.3	0.3	4.8	4.6	4.6	4.6	35.6	35.5	35.5	35.5	32.9	32.9	32.9	32.9	26.7	26.6	26.6	26.6	0.0	0.0	0.0	0.0
MAR	0.0	0.2	0.2	0.2	8.2	7.9	7.9	7.9	49.9	49.9	49.9	49.9	15.3	15.3	15.3	15.3	26.6	26.6	26.6	26.6	0.0	0.0	0.0	0.0
APR	0.0	0.1	0.1	0.1	2.8	2.7	2.7	2.7	56.1	56.1	56.1	56.1	12.8	12.9	12.9	12.9	28.2	28.2	28.2	28.2	0.0	0.0	0.0	0.0
MAY	0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.5	70.9	70.9	70.9	70.9	4.4	4.4	4.4	4.4	24.3	24.2	24.2	24.2	0.0	0.0	0.0	0.0
JUN	0.0	0.0	0.0	0.0	4.1	4.0	4.0	4.0	48.3	48.3	48.3	48.3	7.4	7.4	7.4	7.4	40.2	40.2	40.2	40.2	0.0	0.0	0.0	0.0
JUL	0.0	15.5	15.5	15.0	7.0	5.6	5.6	5.6	33.1	27.5	27.5	27.5	6.7	6.1	6.1	6.1	53.0	45.1	45.1	45.5	0.2	0.2	0.2	0.2
AUG	0.0	7.0	7.0	19.6	6.1	5.5	5.5	4.7	19.9	18.4	18.4	15.6	5.8	5.5	5.5	4.8	67.6	63.0	63.0	54.6	0.6	0.6	0.6	0.6
SEP	0.0	0.0	0.0	0.0	0.5	0.4	0.4	0.3	39.5	29.5	29.5	26.2	2.8	2.5	2.5	2.3	57.1	67.5	67.5	70.9	0.0	0.1	0.1	0.2

Table B1–12. Continued

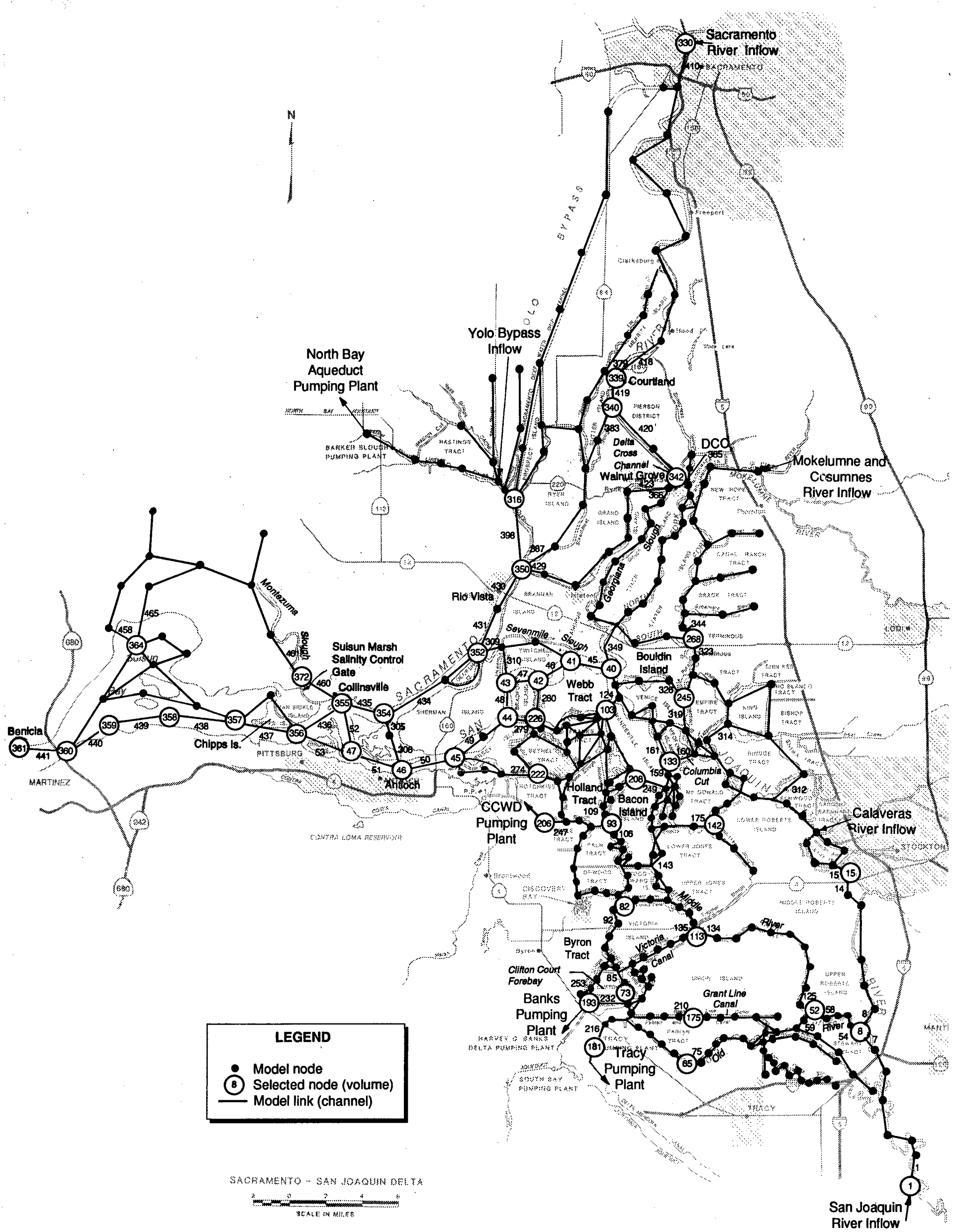
Water Year	DW Project				Agricultural Drains				SJR Inflow				Eastside Streams				Sacramento Inflow				Benicia Boundary			
	No–Proj.	Alt. 1	Alt. 2	Alt. 3	No–Proj.	Alt. 1	Alt. 2	Alt. 3	No–Proj.	Alt. 1	Alt. 2	Alt. 3	No–Proj.	Alt. 1	Alt. 2	Alt. 3	No–Proj.	Alt. 1	Alt. 2	Alt. 3	No–Proj.	Alt. 1	Alt. 2	Alt. 3
1983																								
OCT	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	81.2	81.2	81.2	81.2	0.9	0.9	0.9	0.9	17.7	17.7	17.7	17.7	0.0	0.0	0.0	0.0
NOV	0.0	0.1	0.1	0.1	4.5	4.3	4.3	4.3	56.2	56.3	56.3	56.3	12.0	12.0	12.0	12.0	27.3	27.3	27.3	27.3	0.0	0.0	0.0	0.0
DEC	0.0	0.1	0.1	0.1	5.9	5.6	5.6	5.6	54.3	54.4	54.4	54.4	12.8	12.8	12.8	12.8	27.0	27.1	27.1	27.1	0.0	0.0	0.0	0.0
JAN	0.0	0.1	0.1	0.1	5.6	5.4	5.4	5.4	56.7	56.8	56.8	56.8	11.1	11.1	11.1	11.1	26.6	26.6	26.6	26.6	0.0	0.0	0.0	0.0
FEB	0.0	0.1	0.1	0.1	2.5	2.4	2.4	2.4	62.3	62.3	62.3	62.3	8.5	8.5	8.5	8.5	26.7	26.7	26.7	26.7	0.0	0.0	0.0	0.0
MAR	0.0	0.1	0.1	0.1	3.8	3.7	3.7	3.7	58.5	58.5	58.5	58.5	10.6	10.6	10.6	10.6	27.1	27.1	27.1	27.1	0.0	0.0	0.0	0.0
APR	0.0	0.1	0.1	0.1	0.3	0.2	0.2	0.2	72.6	72.5	72.5	72.5	3.7	3.7	3.7	3.7	23.4	23.4	23.4	23.4	0.0	0.0	0.0	0.0
MAY	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	75.9	75.9	75.9	75.9	2.4	2.4	2.4	2.4	21.5	21.5	21.5	21.5	0.0	0.0	0.0	0.0
JUN	0.0	0.0	0.0	0.0	1.2	1.2	1.2	1.2	77.9	77.9	77.9	77.9	1.6	1.6	1.6	1.6	19.3	19.3	19.3	19.3	0.0	0.0	0.0	0.0
JUL	0.0	0.0	0.0	0.0	4.1	4.0	4.0	4.0	73.4	73.5	73.5	73.5	2.4	2.4	2.4	2.4	20.0	20.0	20.0	20.0	0.0	0.0	0.0	0.0
AUG	0.0	0.0	0.0	0.0	4.8	4.6	4.6	4.6	38.3	38.2	38.2	37.9	5.5	5.5	5.5	5.5	51.3	51.5	51.5	51.9	0.2	0.2	0.2	0.2
SEP	0.0	0.0	0.0	0.0	1.9	1.8	1.8	1.8	75.6	75.2	75.2	74.7	1.7	1.7	1.7	1.8	20.8	21.2	21.2	21.7	0.0	0.0	0.0	0.0
1984																								
OCT	0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.5	82.2	82.2	82.2	82.2	0.7	0.7	0.7	0.7	16.6	16.6	16.6	16.6	0.0	0.0	0.0	0.0
NOV	0.0	0.1	0.1	0.1	5.0	4.9	4.9	4.9	52.8	52.8	52.8	52.8	14.5	14.5	14.5	14.5	27.7	27.7	27.7	27.7	0.0	0.0	0.0	0.0
DEC	0.0	0.1	0.1	0.1	5.7	5.5	5.5	5.5	52.3	52.4	52.4	52.4	14.5	14.5	14.5	14.5	27.4	27.5	27.5	27.5	0.0	0.0	0.0	0.0
JAN	0.0	0.1	0.1	0.1	0.6	0.6	0.6	0.6	73.9	73.9	73.9	73.9	3.1	3.1	3.1	3.1	22.4	22.4	22.4	22.4	0.0	0.0	0.0	0.0
FEB	0.0	0.2	0.2	0.2	1.6	1.5	1.5	1.5	68.0	67.9	67.9	67.9	5.5	5.5	5.5	5.5	24.9	24.9	24.9	24.9	0.0	0.0	0.0	0.0
MAR	0.0	0.3	0.3	0.2	0.0	0.0	0.0	0.0	53.0	52.6	52.6	52.4	9.3	9.3	9.3	9.3	37.7	37.8	37.8	38.0	0.0	0.0	0.0	0.0
APR	0.0	0.7	2.5	2.5	1.0	1.0	1.0	1.0	67.3	67.1	65.8	65.8	4.9	4.9	5.1	5.1	26.8	26.4	25.6	25.6	0.0	0.0	0.0	0.0
MAY	0.0	0.2	7.0	7.0	3.4	3.4	3.2	3.2	65.3	65.2	60.7	60.7	3.7	3.7	4.0	4.0	27.5	27.4	25.0	25.0	0.1	0.1	0.1	0.1
JUN	0.0	0.1	0.1	0.1	7.5	7.3	7.3	7.3	25.2	25.4	25.4	25.4	5.5	5.6	5.6	5.6	61.6	61.5	61.5	61.5	0.2	0.2	0.2	0.2
JUL	0.0	4.3	4.3	3.9	6.3	5.8	5.8	5.8	10.9	10.4	10.4	10.4	4.0	3.9	3.9	3.9	78.7	75.4	75.4	75.9	0.2	0.2	0.2	0.2
AUG	0.0	21.0	16.5	29.8	7.6	5.7	6.1	5.0	19.4	15.1	16.0	13.2	6.2	5.1	5.3	4.6	66.2	52.5	55.5	46.8	0.6	0.6	0.6	0.6
SEP	0.0	0.0	0.0	0.0	2.6	2.6	2.6	2.5	16.9	17.0	17.0	16.9	5.0	5.0	5.0	5.0	74.7	74.7	74.7	74.8	0.8	0.8	0.8	0.8
1985																								
OCT	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	21.5	17.0	17.0	17.0	4.2	3.5	3.5	3.5	73.9	78.7	78.7	78.7	0.3	0.6	0.6	0.6
NOV	0.0	0.1	0.1	0.1	2.6	2.3	2.3	1.9	28.5	26.4	26.4	21.5	5.6	5.4	5.4	4.7	63.3	65.8	65.8	71.8	0.0	0.0	0.0	0.0
DEC	0.0	0.2	0.2	0.2	7.3	7.0	7.0	7.0	34.9	34.7	34.7	34.7	5.7	5.7	5.7	5.7	52.1	52.4	52.4	52.4	0.0	0.0	0.0	0.0
JAN	0.0	0.2	1.6	1.6	2.7	2.5	2.5	2.5	25.2	25.0	24.7	24.7	2.3	2.3	2.2	2.2	69.5	69.5	68.6	68.6	0.4	0.4	0.4	0.4
FEB	0.0	0.4	27.3	27.3	2.9	2.8	2.0	2.0	29.0	28.9	20.4	20.4	8.2	8.2	6.6	6.6	59.8	59.6	43.8	43.8	0.0	0.0	0.0	0.0
MAR	0.0	0.4	4.9	26.5	6.3	6.0	5.7	4.3	28.2	28.0	26.6	20.0	9.4	9.4	9.1	7.5	56.1	56.1	53.6	41.7	0.0	0.0	0.0	0.0
APR	0.0	15.2	1.0	1.0	0.5	0.4	0.5	0.5	73.3	62.0	72.5	72.5	3.3	4.7	3.4	3.4	22.7	17.5	22.3	22.3	0.2	0.2	0.2	0.2
MAY	0.0	7.4	0.3	0.3	4.6	4.2	4.6	4.5	43.3	39.7	42.8	42.5	4.6	4.5	4.5	4.5	47.4	44.1	47.7	48.1	0.1	0.1	0.1	0.1
JUN	0.0	0.1	0.1	0.1	8.2	8.0	8.0	8.0	18.7	18.9	18.9	18.9	3.2	3.2	3.2	3.2	69.5	69.3	69.3	69.4	0.5	0.5	0.5	0.5
JUL	0.0	0.0	0.0	0.0	5.9	5.8	5.8	5.7	9.7	9.8	9.8	9.7	2.0	2.0	2.0	2.0	81.9	82.0	82.0	82.1	0.4	0.4	0.4	0.4
AUG	0.0	6.4	0.0	0.0	5.1	4.7	5.0	5.0	7.6	7.1	7.6	7.6	2.1	2.0	2.1	2.1	84.5	79.2	84.6	84.7	0.7	0.7	0.7	0.7
SEP	0.0	11.3	0.0	0.0	4.3	3.7	4.2	4.1	14.5	12.8	14.5	14.4	2.4	2.2	2.4	2.4	77.3	68.6	77.4	77.5	1.5	1.5	1.5	1.5

Table B1–12. Continued

Water Year	DW Project No-Proj.	DW Project Alt. 1	DW Project Alt. 2	DW Project Alt. 3	Agricultural Drains No-Proj.	Agricultural Drains Alt. 1	Agricultural Drains Alt. 2	Agricultural Drains Alt. 3	SJR Inflow No-Proj.	SJR Inflow Alt. 1	SJR Inflow Alt. 2	SJR Inflow Alt. 3	Eastside Streams No-Proj.	Eastside Streams Alt. 1	Eastside Streams Alt. 2	Eastside Streams Alt. 3	Sacramento Inflow No-Proj.	Sacramento Inflow Alt. 1	Sacramento Inflow Alt. 2	Sacramento Inflow Alt. 3	Benicia Boundary No-Proj.	Benicia Boundary Alt. 1	Benicia Boundary Alt. 2	Benicia Boundary Alt. 3
1986																								
OCT	0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.5	19.7	19.7	19.7	19.6	1.1	1.1	1.1	1.1	77.2	77.2	77.2	77.3	1.5	1.5	1.5	1.5
NOV	0.0	0.2	0.2	0.2	0.5	0.5	0.5	0.5	27.5	27.5	27.5	27.3	3.0	3.0	3.0	3.0	67.7	67.5	67.5	67.7	1.3	1.3	1.3	1.3
DEC	0.0	0.2	0.2	0.2	8.0	7.4	7.4	7.4	17.7	17.1	17.1	17.0	4.0	3.9	3.9	3.9	69.6	70.6	70.6	70.7	0.7	0.8	0.8	0.8
JAN	0.0	0.3	0.3	0.3	8.4	6.6	6.6	6.6	11.7	9.6	9.6	9.6	8.1	6.8	6.8	6.8	71.7	76.4	76.4	76.4	0.1	0.3	0.3	0.3
FEB	0.0	0.3	0.3	0.3	9.6	9.3	9.3	9.3	30.4	30.4	30.4	30.4	36.0	36.0	36.0	36.0	24.1	24.1	24.1	24.1	0.0	0.0	0.0	0.0
MAR	0.0	0.1	0.1	0.1	3.7	3.6	3.6	3.6	57.7	57.7	57.7	57.7	11.2	11.2	11.2	11.2	27.4	27.4	27.4	27.4	0.0	0.0	0.0	0.0
APR	0.0	0.2	0.2	0.2	0.0	0.0	0.0	0.0	75.8	75.6	75.6	75.6	2.5	2.5	2.5	2.5	21.7	21.7	21.7	21.7	0.0	0.0	0.0	0.0
MAY	0.0	0.2	28.0	23.6	1.7	1.7	1.2	1.3	70.8	70.7	50.7	53.8	4.1	4.1	6.0	5.9	23.4	23.3	14.1	15.4	0.0	0.0	0.0	0.0
JUN	0.0	0.1	0.1	23.4	6.5	6.4	6.4	4.7	45.1	45.4	45.4	33.3	5.7	5.7	5.7	5.3	42.4	42.2	42.2	33.1	0.3	0.2	0.2	0.2
JUL	0.0	23.6	0.0	0.0	8.6	6.3	8.4	8.3	17.8	13.3	17.8	17.7	4.0	3.2	4.0	3.9	69.4	53.4	69.6	69.8	0.3	0.3	0.3	0.3
AUG	0.0	0.0	0.0	0.0	8.4	8.2	8.2	8.1	22.4	22.5	22.5	22.3	5.3	5.3	5.3	5.3	63.3	63.4	63.4	63.6	0.6	0.6	0.6	0.6
SEP	0.0	0.0	0.0	0.0	2.4	2.3	2.3	2.3	25.4	25.4	25.4	25.3	4.0	4.0	4.0	4.0	66.8	66.9	66.9	67.1	1.3	1.3	1.3	1.3
1987																								
OCT	0.0	0.0	0.0	0.0	1.5	1.5	1.5	1.5	43.5	43.5	43.5	43.5	3.2	3.2	3.2	3.2	50.3	50.4	50.4	50.4	1.5	1.5	1.5	1.5
NOV	0.0	0.1	0.1	0.1	1.0	1.0	1.0	1.0	27.6	27.6	27.6	27.5	4.2	4.2	4.2	4.1	66.0	66.0	66.0	66.1	1.2	1.2	1.2	1.1
DEC	0.0	0.2	0.2	0.2	0.0	0.0	0.0	0.0	39.3	39.2	39.2	39.0	3.2	3.2	3.2	3.2	56.1	56.0	56.0	56.2	1.3	1.3	1.3	1.3
JAN	0.0	0.4	0.4	0.4	0.5	0.5	0.5	0.5	16.2	16.1	16.1	16.1	3.1	3.1	3.1	3.1	79.1	78.8	78.8	78.8	1.0	1.0	1.0	1.0
FEB	0.0	0.7	0.7	0.7	15.0	14.4	14.4	14.4	15.2	15.1	15.1	15.1	5.6	5.6	5.6	5.6	64.1	64.1	64.1	64.1	0.1	0.1	0.1	0.1
MAR	0.0	0.4	0.4	0.4	8.9	7.8	7.8	7.8	15.9	14.5	14.5	14.5	6.9	6.4	6.4	6.4	68.3	71.0	71.0	71.0	0.0	0.0	0.0	0.0
APR	0.0	18.0	12.8	12.3	1.0	0.8	0.8	0.8	53.8	43.6	46.4	46.4	3.2	3.3	3.3	3.3	42.0	34.3	36.6	37.1	0.1	0.1	0.1	0.1
MAY	0.0	2.2	5.4	4.6	5.8	5.6	5.4	5.4	37.2	36.1	34.9	34.9	3.9	3.9	3.8	3.8	52.8	52.0	50.3	51.0	0.3	0.3	0.3	0.3
JUN	0.0	0.1	0.1	0.1	8.4	8.2	8.2	8.2	18.4	18.6	18.6	18.6	2.8	2.9	2.9	2.9	69.8	69.7	69.7	69.7	0.5	0.5	0.5	0.5
JUL	0.0	0.0	0.0	0.0	5.9	5.8	5.8	5.7	8.3	8.4	8.4	8.3	1.9	1.9	1.9	1.9	83.4	83.5	83.5	83.6	0.4	0.4	0.4	0.4
AUG	0.0	0.0	0.0	0.0	5.8	5.6	5.6	5.6	7.6	7.6	7.6	7.6	2.2	2.2	2.2	2.2	83.6	83.7	83.7	83.8	0.8	0.8	0.8	0.8
SEP	0.0	0.0	0.0	0.0	4.9	4.8	4.8	4.8	13.7	13.7	13.7	13.7	2.9	2.9	2.9	2.9	76.8	76.9	76.9	77.0	1.7	1.7	1.7	1.7
1988																								
OCT	0.0	0.0	0.0	0.0	1.1	1.1	1.1	1.1	18.7	18.6	18.6	18.5	1.8	1.8	1.8	1.8	76.6	76.6	76.6	76.7	1.8	1.8	1.8	1.8
NOV	0.0	0.2	0.2	0.2	0.0	0.0	0.0	0.0	22.3	22.2	22.2	22.1	4.0	4.0	4.0	4.0	72.1	72.0	72.0	72.1	1.6	1.6	1.6	1.6
DEC	0.0	0.2	0.2	0.2	3.8	3.6	3.6	3.6	11.0	10.9	10.9	10.9	5.7	5.7	5.7	5.7	78.7	78.7	78.7	78.7	0.8	0.9	0.9	0.9
JAN	0.0	0.4	0.4	0.5	10.1	7.2	7.2	6.3	8.5	6.3	6.3	5.6	3.9	3.0	3.0	2.6	77.5	83.0	83.0	84.9	0.0	0.1	0.1	0.1
FEB	0.0	0.6	36.7	39.4	0.0	0.0	0.0	0.0	12.5	12.4	7.7	7.3	2.4	2.4	1.6	1.5	85.0	84.6	54.0	51.7	0.0	0.1	0.1	0.1
MAR	0.0	0.6	1.1	22.7	0.7	0.7	0.7	0.5	24.6	24.4	24.2	18.4	1.9	1.9	1.9	1.6	72.5	72.2	71.9	56.6	0.2	0.2	0.2	0.2
APR	0.0	15.3	1.4	1.3	2.6	2.2	2.6	2.5	52.3	43.9	51.2	50.9	5.1	5.2	5.1	5.1	39.7	33.0	39.4	39.7	0.3	0.3	0.3	0.3
MAY	0.0	9.5	0.4	0.4	4.5	4.0	4.5	4.4	43.9	39.2	43.2	42.7	4.5	4.4	4.5	4.5	46.6	42.4	47.1	47.5	0.5	0.5	0.5	0.5
JUN	0.0	0.1	0.1	0.1	7.1	6.9	6.9	6.9	19.3	19.5	19.5	19.5	2.9	2.9	2.9	2.9	70.2	70.1	70.1	70.1	0.5	0.5	0.5	0.5
JUL	0.0	16.4	0.0	0.0	8.0	6.5	7.8	7.7	9.5	7.9	9.6	9.5	2.5	2.2	2.5	2.5	79.2	66.3	79.3	79.5	0.8	0.8	0.8	0.8
AUG	0.0	0.0	0.0	0.0	8.6	8.3	8.3	8.3	11.1	11.2	11.2	11.1	3.2	3.2	3.2	3.2	75.4	75.6	75.6	75.8	1.7	1.7	1.7	1.7
SEP	0.0	0.0	0.0	0.0	7.2	7.0	7.0	7.0	18.6	18.7	18.7	18.6	4.0	4.0	4.0	4.0	67.8	67.9	67.9	68.1	2.4	2.4	2.4	2.4

Table B1–12. Continued

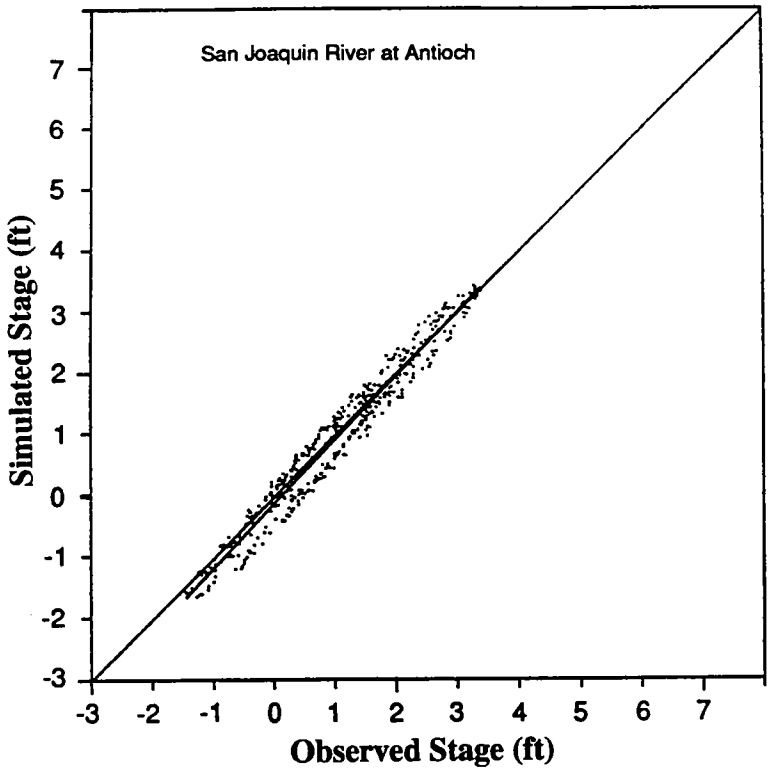
Water Year	DW Project				Agricultural Drains				SJR Inflow				Eastside Streams				Sacramento Inflow				Benicia Boundary			
	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3	No-Proj.	Alt. 1	Alt. 2	Alt. 3
1989																								
OCT	0.0	0.0	0.0	0.0	2.9	2.8	2.8	2.8	29.9	29.9	29.9	29.6	2.0	2.0	2.0	2.0	62.5	62.5	62.5	62.8	2.8	2.8	2.8	2.8
NOV	0.0	0.2	0.2	0.2	0.0	0.0	0.0	0.0	19.9	19.9	19.9	19.7	4.2	4.2	4.2	4.2	73.8	73.6	73.6	73.8	2.1	2.1	2.1	2.1
DEC	0.0	0.3	0.3	0.3	0.5	0.5	0.5	0.5	13.8	13.7	13.7	13.7	5.7	5.6	5.6	5.6	78.7	78.4	78.4	78.5	1.4	1.4	1.4	1.4
JAN	0.0	0.3	0.3	0.3	2.8	2.6	2.6	2.6	10.0	9.9	9.9	9.9	1.7	1.7	1.7	1.7	84.4	84.4	84.4	84.4	1.1	1.1	1.1	1.1
FEB	0.0	0.6	0.6	0.6	3.0	2.8	2.8	2.8	11.9	11.8	11.8	11.8	3.6	3.6	3.6	3.6	81.1	80.7	80.7	80.7	0.5	0.5	0.5	0.5
MAR	0.0	0.2	0.2	0.2	3.9	2.8	2.8	2.8	11.8	8.8	8.8	8.8	11.5	8.9	8.9	8.9	72.8	79.3	79.3	79.3	0.0	0.0	0.0	0.0
APR	0.0	0.8	0.8	0.8	0.5	0.5	0.5	0.5	34.8	34.6	34.6	34.6	7.4	7.4	7.4	7.4	57.3	56.7	56.7	56.7	0.0	0.0	0.0	0.0
MAY	0.0	13.2	9.0	8.4	5.2	4.4	4.6	4.6	40.3	34.6	36.3	36.3	4.8	4.6	4.7	4.7	49.7	43.2	45.3	46.0	0.1	0.1	0.1	0.1
JUN	0.0	0.1	0.1	0.1	8.3	8.1	8.1	8.1	19.3	19.5	19.5	19.5	3.1	3.2	3.2	3.2	68.8	68.7	68.7	68.7	0.5	0.5	0.5	0.5
JUL	0.0	0.0	0.0	0.0	5.9	5.8	5.8	5.7	6.1	6.1	6.1	6.1	2.1	2.1	2.1	2.1	85.4	85.6	85.6	85.7	0.4	0.4	0.4	0.4
AUG	0.0	0.0	0.0	0.0	4.7	4.5	4.5	4.5	6.4	6.4	6.4	6.3	2.0	2.0	2.0	2.0	86.4	86.5	86.5	86.6	0.6	0.6	0.6	0.6
SEP	0.0	25.4	27.5	24.1	0.8	0.6	0.6	0.6	11.6	8.5	8.2	8.6	3.1	2.4	2.3	2.4	83.1	61.8	60.0	63.0	1.4	1.4	1.4	1.4
1990																								
OCT	0.0	0.0	0.0	0.0	0.6	0.6	0.6	0.6	22.5	22.4	22.4	22.2	1.5	1.5	1.5	1.5	73.7	73.8	73.8	74.0	1.7	1.7	1.7	1.7
NOV	0.0	0.2	0.2	0.2	0.0	0.0	0.0	0.0	24.4	24.3	24.3	24.1	3.6	3.6	3.6	3.6	70.4	70.2	70.2	70.5	1.6	1.6	1.6	1.6
DEC	0.0	0.2	0.2	0.2	0.3	0.3	0.3	0.3	11.3	11.3	11.3	11.2	0.7	0.7	0.7	0.7	86.7	86.5	86.5	86.6	1.0	1.0	1.0	1.0
JAN	0.0	0.3	0.3	0.3	1.2	1.1	1.1	1.1	8.1	7.5	7.5	7.5	2.4	2.2	2.2	2.2	87.8	88.4	88.4	88.4	0.5	0.6	0.6	0.6
FEB	0.0	0.7	14.2	13.9	6.5	6.1	5.2	5.2	14.7	14.6	12.5	12.5	5.6	5.6	4.9	4.9	73.2	72.9	63.1	63.4	0.1	0.1	0.1	0.1
MAR	0.0	0.7	0.7	0.7	0.0	0.0	0.0	0.0	25.3	25.0	25.0	25.0	5.8	5.7	5.7	5.7	68.6	68.3	68.3	68.3	0.3	0.3	0.3	0.3
APR	0.0	14.2	1.1	1.1	2.3	1.9	2.2	2.2	43.0	36.6	42.2	41.9	6.7	6.5	6.7	6.7	47.9	40.7	47.7	47.9	0.1	0.1	0.1	0.1
MAY	0.0	3.3	0.4	0.4	2.5	2.4	2.5	2.5	53.0	50.5	52.0	51.4	3.9	4.0	4.0	4.0	40.0	39.3	40.6	41.2	0.5	0.5	0.5	0.5
JUN	0.0	0.1	0.1	0.1	6.4	6.3	6.3	6.3	17.3	17.4	17.4	17.4	3.5	3.5	3.5	3.5	72.4	72.3	72.3	72.3	0.5	0.5	0.5	0.5
JUL	0.0	0.0	0.0	0.0	8.0	7.8	7.8	7.7	7.9	7.9	7.9	7.8	2.6	2.6	2.6	2.6	80.8	81.0	81.0	81.1	0.8	0.8	0.8	0.7
AUG	0.0	0.0	0.0	0.0	8.5	8.3	8.3	8.2	10.6	10.7	10.7	10.6	3.2	3.2	3.2	3.1	76.1	76.3	76.3	76.4	1.7	1.7	1.7	1.7
SEP	0.0	0.0	0.0	0.0	6.7	6.5	6.5	6.5	18.4	18.5	18.5	18.3	3.7	3.7	3.7	3.7	68.8	68.8	68.8	69.1	2.4	2.4	2.4	2.4
1991																								
OCT	0.0	0.0	0.0	0.0	2.4	2.3	2.3	2.3	31.0	31.0	31.0	30.7	1.6	1.6	1.6	1.6	62.2	62.3	62.3	62.6	2.8	2.8	2.8	2.8
NOV	0.0	0.2	0.2	0.2	1.4	1.4	1.4	1.4	27.0	26.9	26.9	26.7	1.9	1.9	1.9	1.9	67.4	67.2	67.2	67.5	2.3	2.3	2.3	2.3
DEC	0.0	0.3	0.3	0.3	0.0	0.0	0.0	0.0	19.1	19.0	19.0	18.9	2.2	2.2	2.2	2.2	76.8	76.6	76.6	76.7	1.9	1.9	1.9	1.9
JAN	0.0	0.4	0.4	0.4	0.0	0.0	0.0	0.0	12.8	12.7	12.7	12.7	0.9	0.9	0.9	0.9	84.7	84.5	84.5	84.5	1.5	1.5	1.5	1.5
FEB	0.0	0.7	0.7	0.7	0.0	0.0	0.0	0.0	14.0	13.9	13.9	13.8	3.3	3.2	3.2	3.2	82.2	81.7	81.7	81.7	0.6	0.6	0.6	0.6
MAR	0.0	0.5	0.5	0.5	8.4	7.9	7.9	7.9	9.3	9.2	9.2	9.2	11.4	11.3	11.3	11.3	70.9	71.0	71.0	71.0	0.0	0.0	0.0	0.0
APR	0.0	1.1	1.1	1.1	0.6	0.6	0.6	0.6	53.9	52.9	52.9	52.6	5.6	5.7	5.7	5.7	39.8	39.7	39.7	40.0	0.0	0.0	0.0	0.0
MAY	0.0	0.4	0.4	0.4	4.8	4.7	4.7	4.7	46.4	45.6	45.6	45.1	6.7	6.7	6.7	6.7	41.5	42.0	42.0	42.5	0.7	0.7	0.7	0.7
JUN	0.0	0.1	0.1	0.1	5.5	5.3	5.3	5.3	19.9	19.9	19.9	19.8	3.9	3.9	3.9	3.9	70.2	70.3	70.3	70.4	0.5	0.5	0.5	0.5
JUL	0.0	0.0	0.0	0.0	10.0	9.7	9.7	9.6	9.6	9.7	9.7	9.6	3.0	3.0	3.0	3.0	76.2	76.4	76.4	76.6	1.2	1.2	1.2	1.2
AUG	0.0	0.0	0.0	0.0	9.2	8.9	8.9	8.9	11.7	11.7	11.7	11.6	3.3	3.3	3.3	3.3	73.9	74.1	74.1	74.3	1.9	1.9	1.9	1.9
SEP	0.0	0.0	0.0	0.0	6.0	5.9	5.9	5.8	16.0	16.0	16.0	15.9	3.2	3.2	3.2	3.2	72.2	72.3	72.3	72.5	2.5	2.5	2.5	2.5

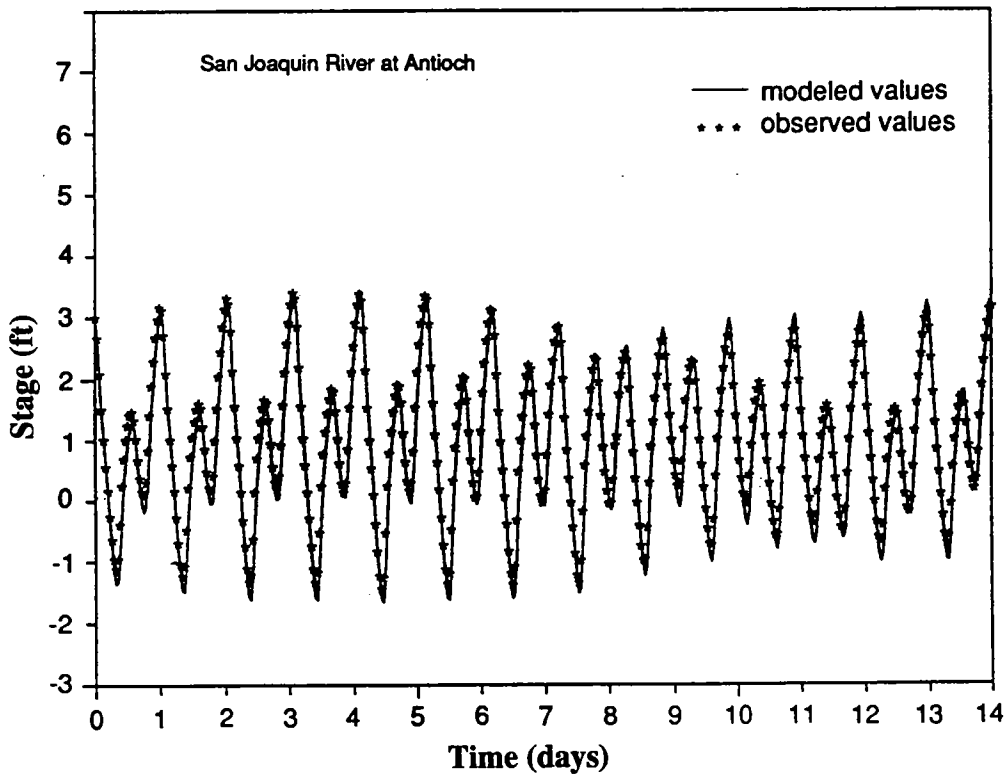


Source: Adapted from California Department of Water Resources 1993.

Figure B1-1.
RMA Delta Model Link-Node Representation of Major Delta Channels

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

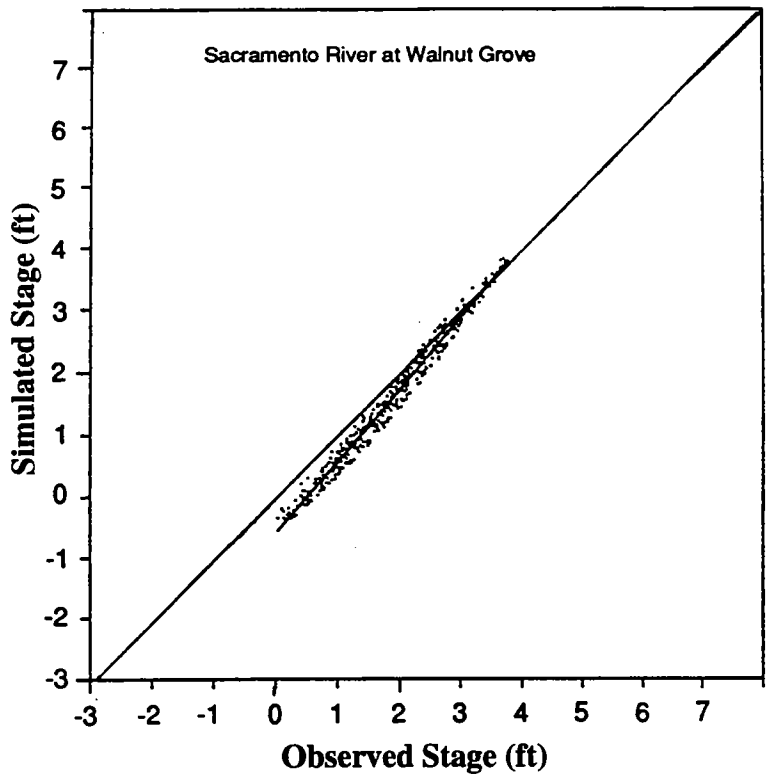


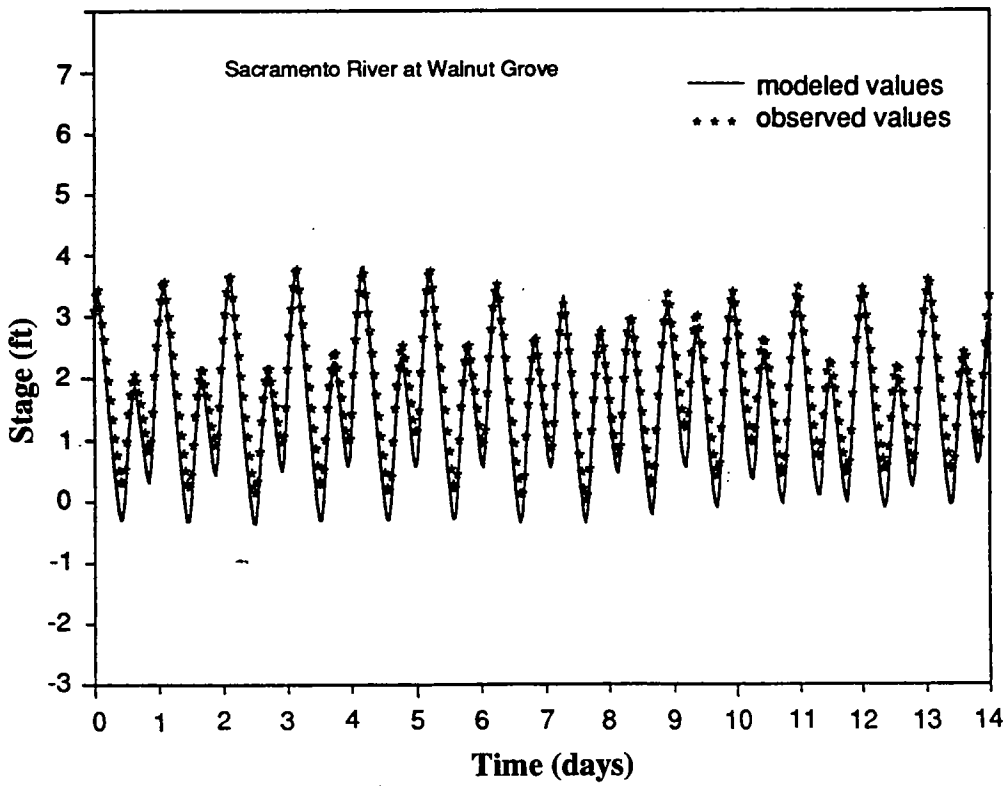


Source: Smith and Durbin 1989.

Figure B1-2.
Comparison of Observed and Simulated Stage on the San Joaquin River at Antioch during July 6-19, 1979

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

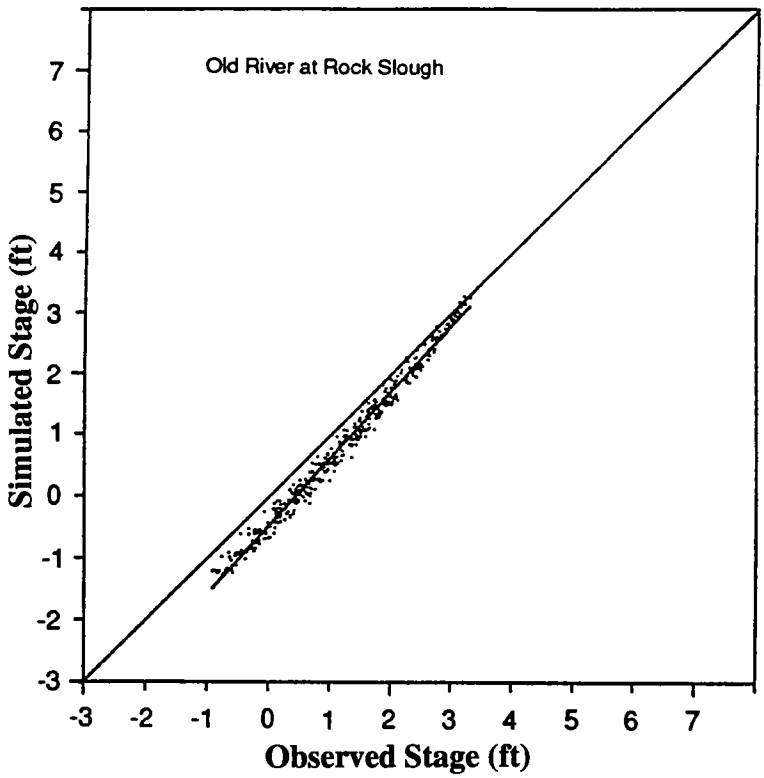


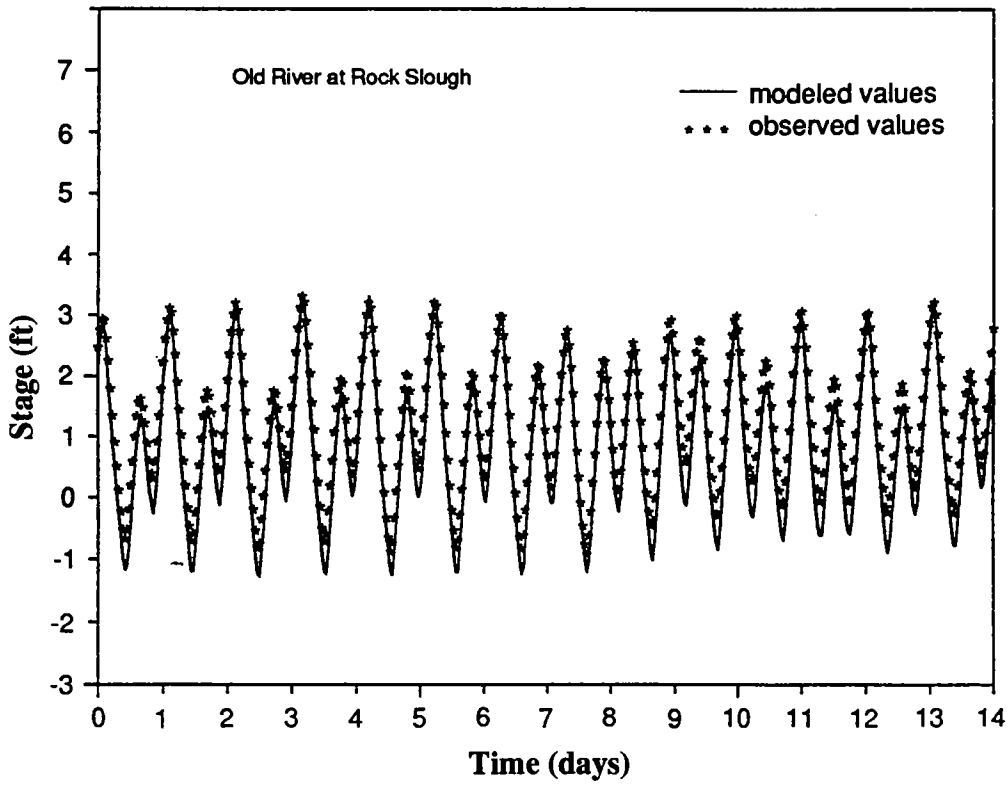


Source: Smith and Durbin 1989.

Figure B1-3.
Comparison of Observed and Simulated Stage on the Sacramento River at Walnut Grove during July 6-19, 1979

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates





Source: Smith and Durbin 1989.

Figure B1-4.
Comparison of Observed and Simulated Stage on Old River at Rock Slough during July 6-19, 1979

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Prepared by: Jones & Stokes Associates

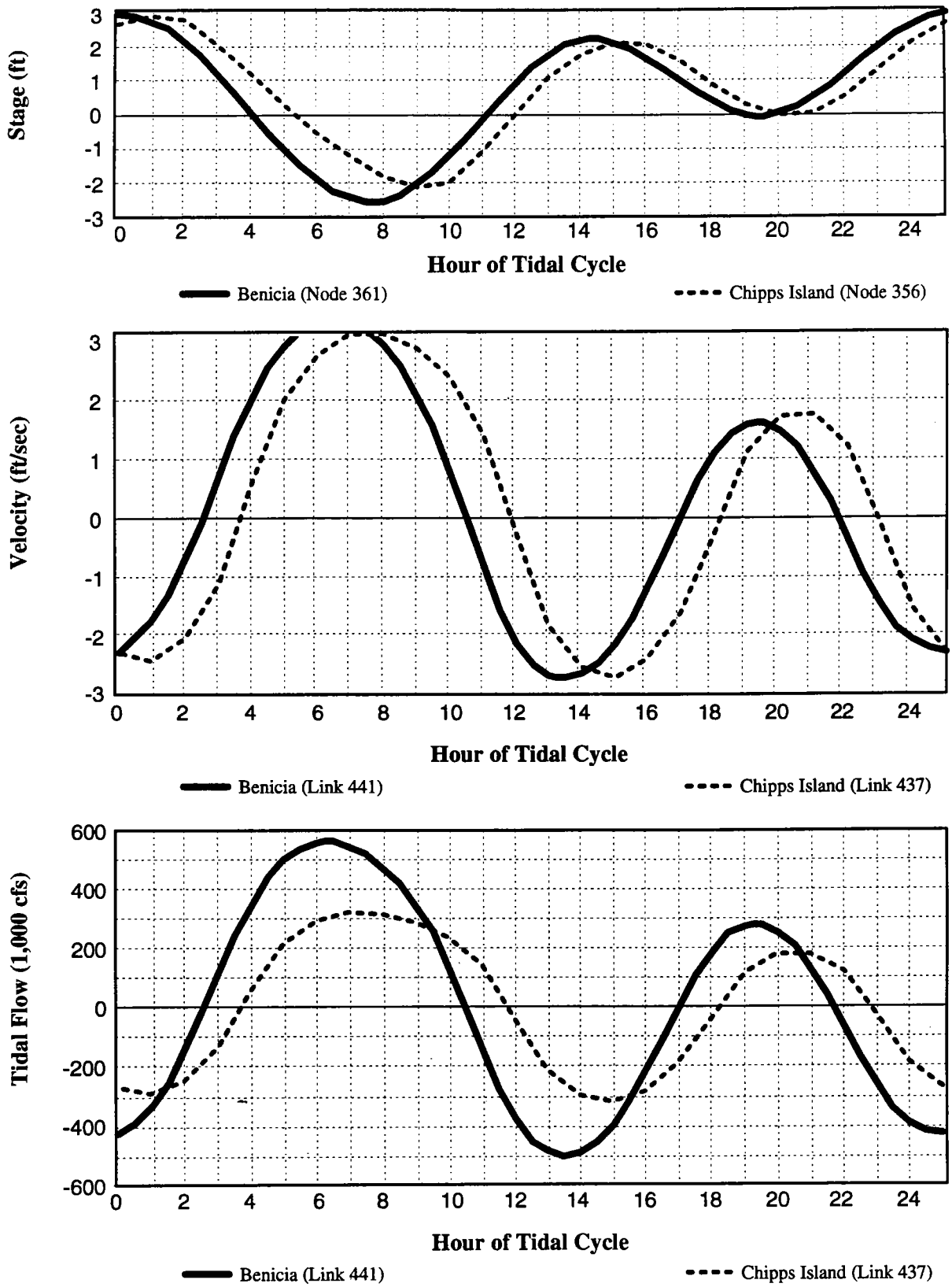


Figure B1-5.
Simulated Tidal Hydraulics in Suisun Bay

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

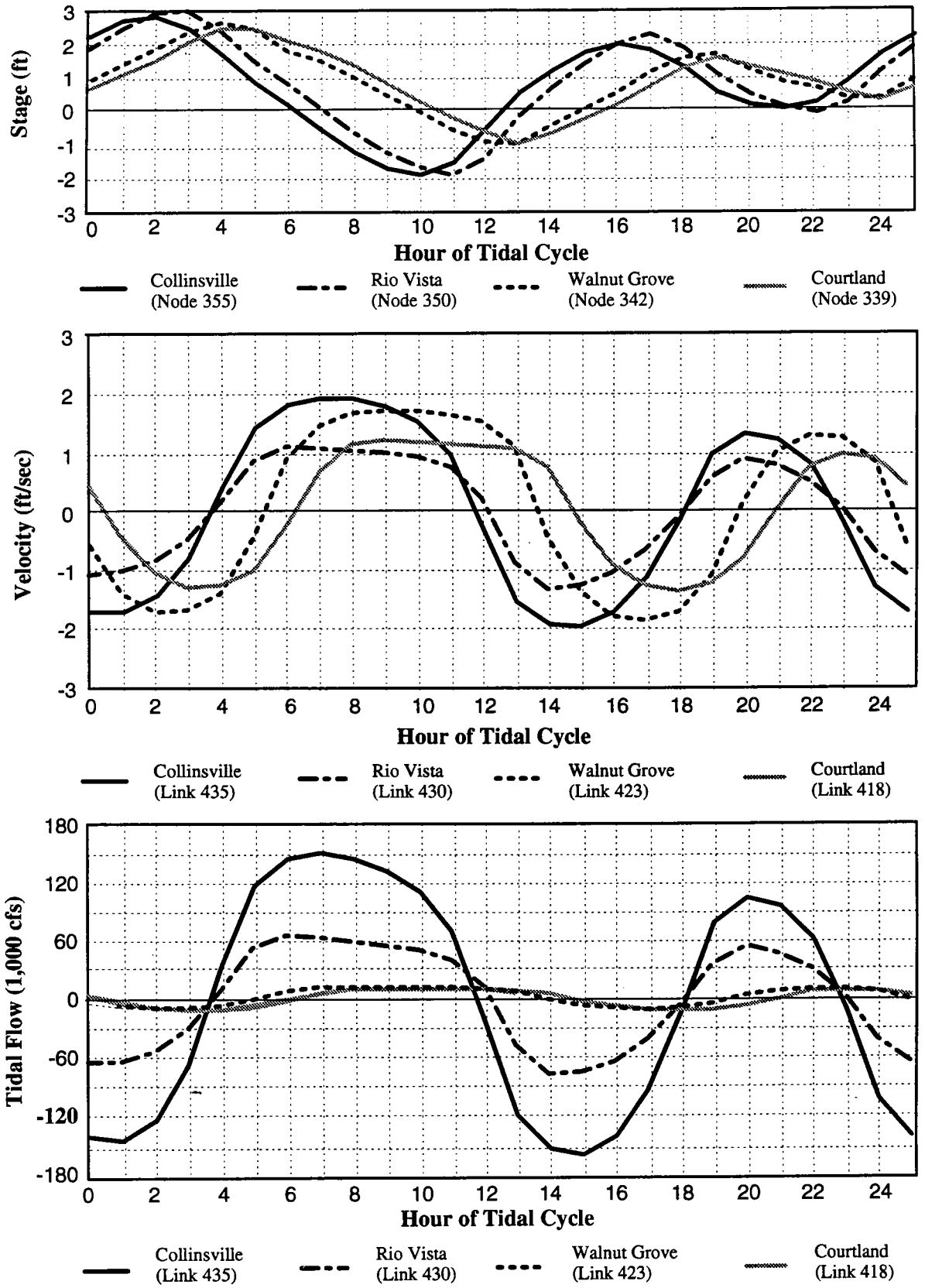


Figure B1-6.
Simulated Tidal Hydraulics in the Sacramento River

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

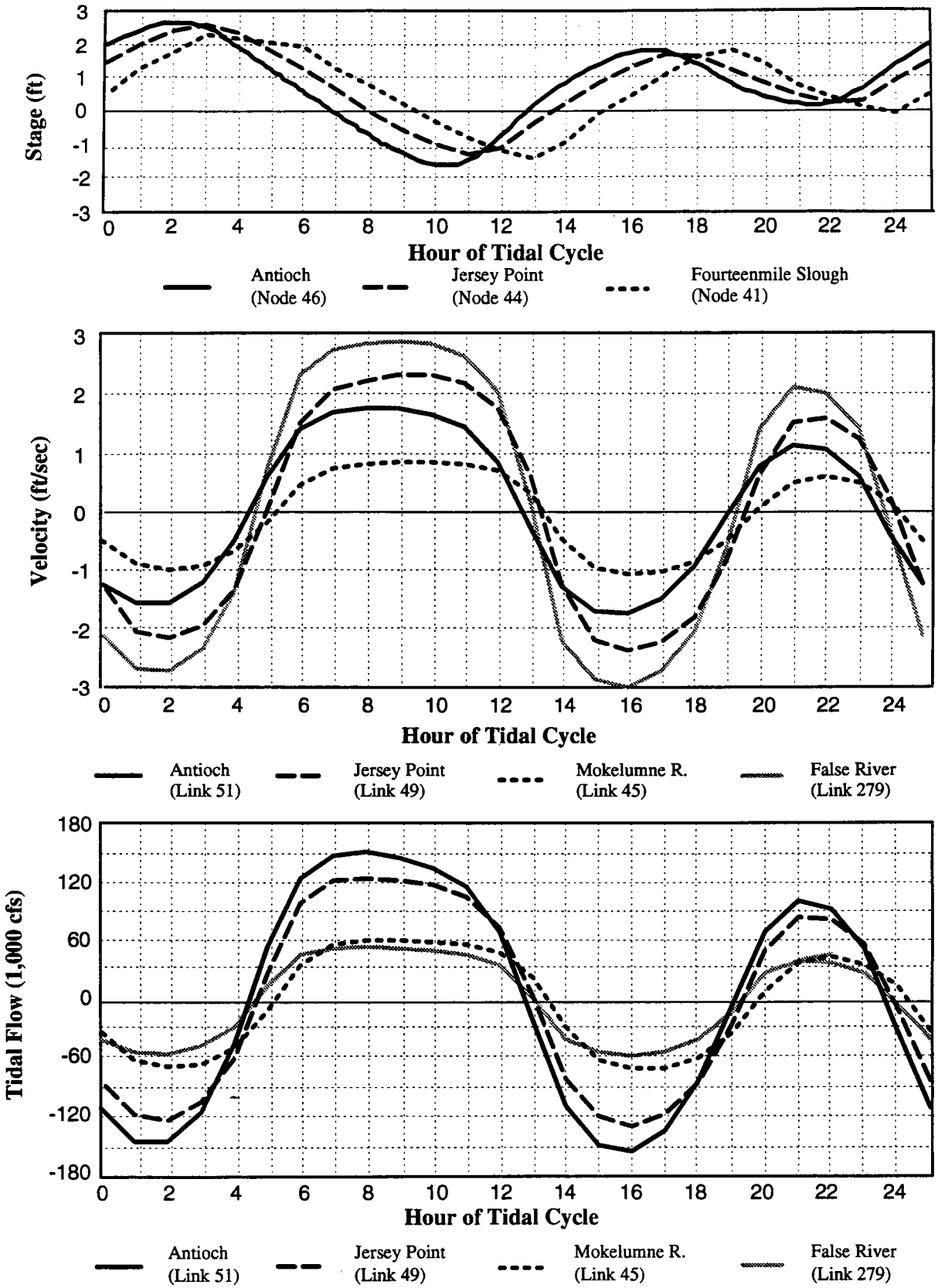


Figure B1-7.
Simulated Tidal Hydraulics in the San Joaquin River

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

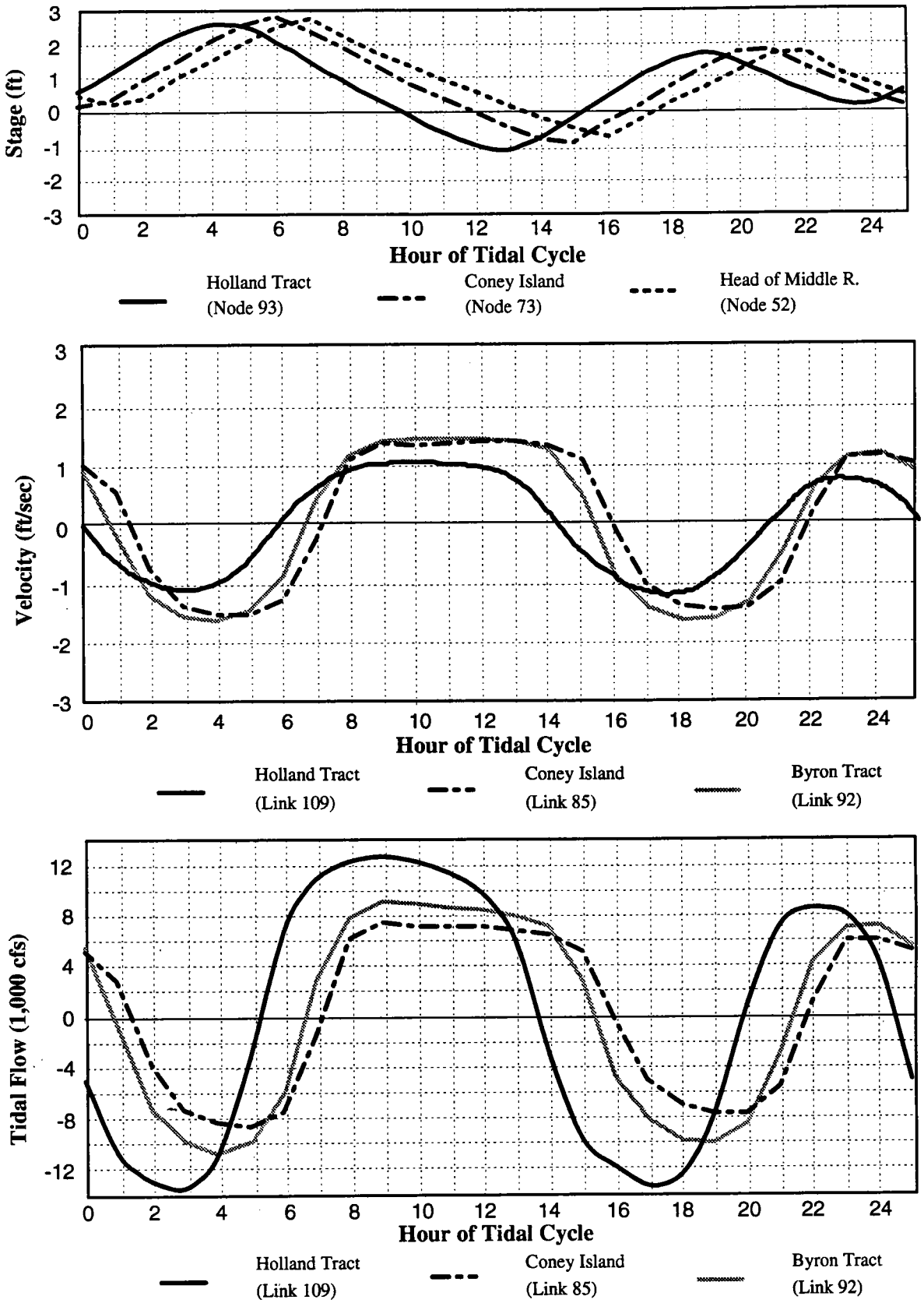


Figure B1-8.
Simulated Tidal Hydraulics in Old River

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

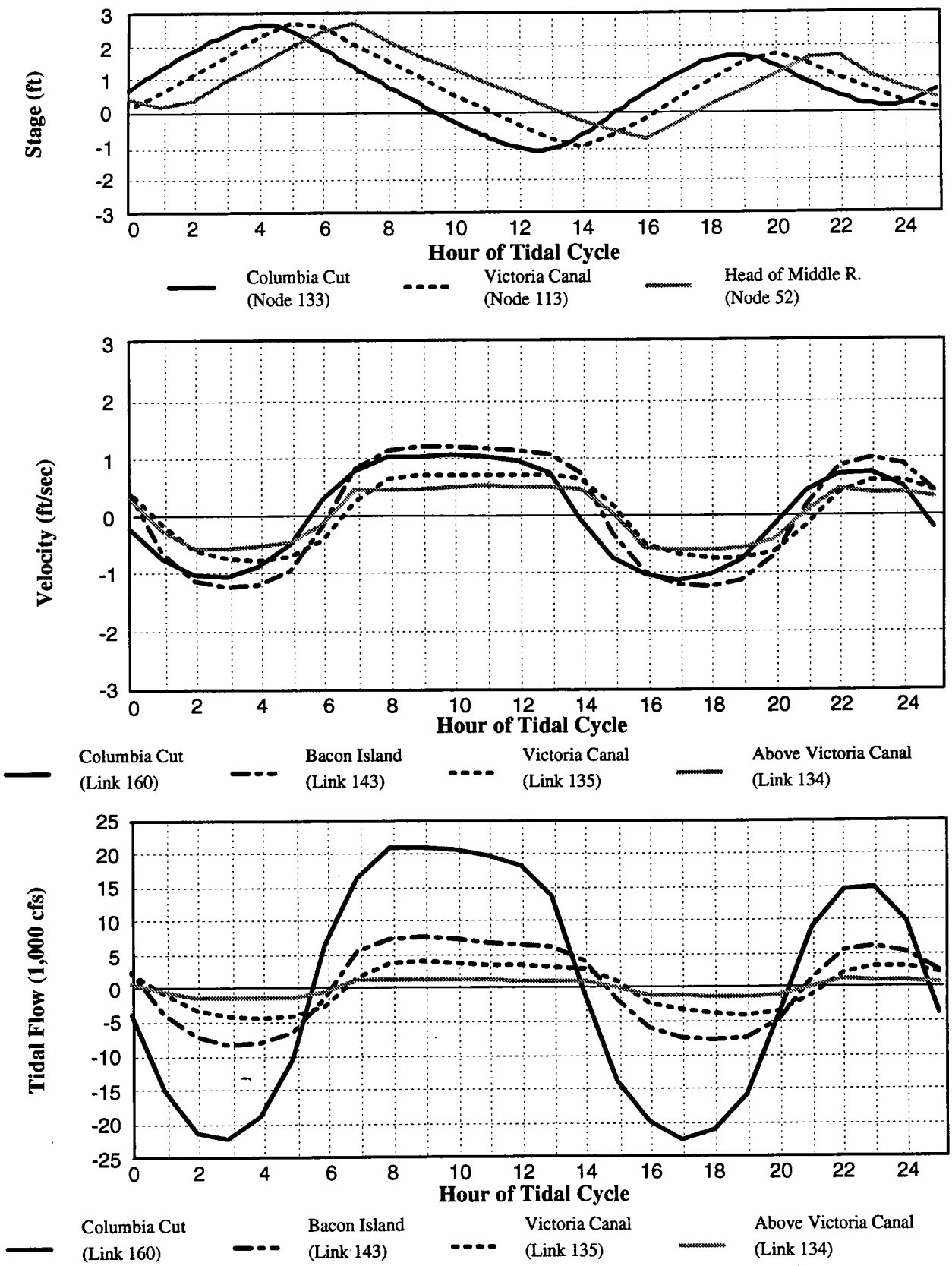


Figure B1-9.
Simulated Tidal Hydraulics in Middle River

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

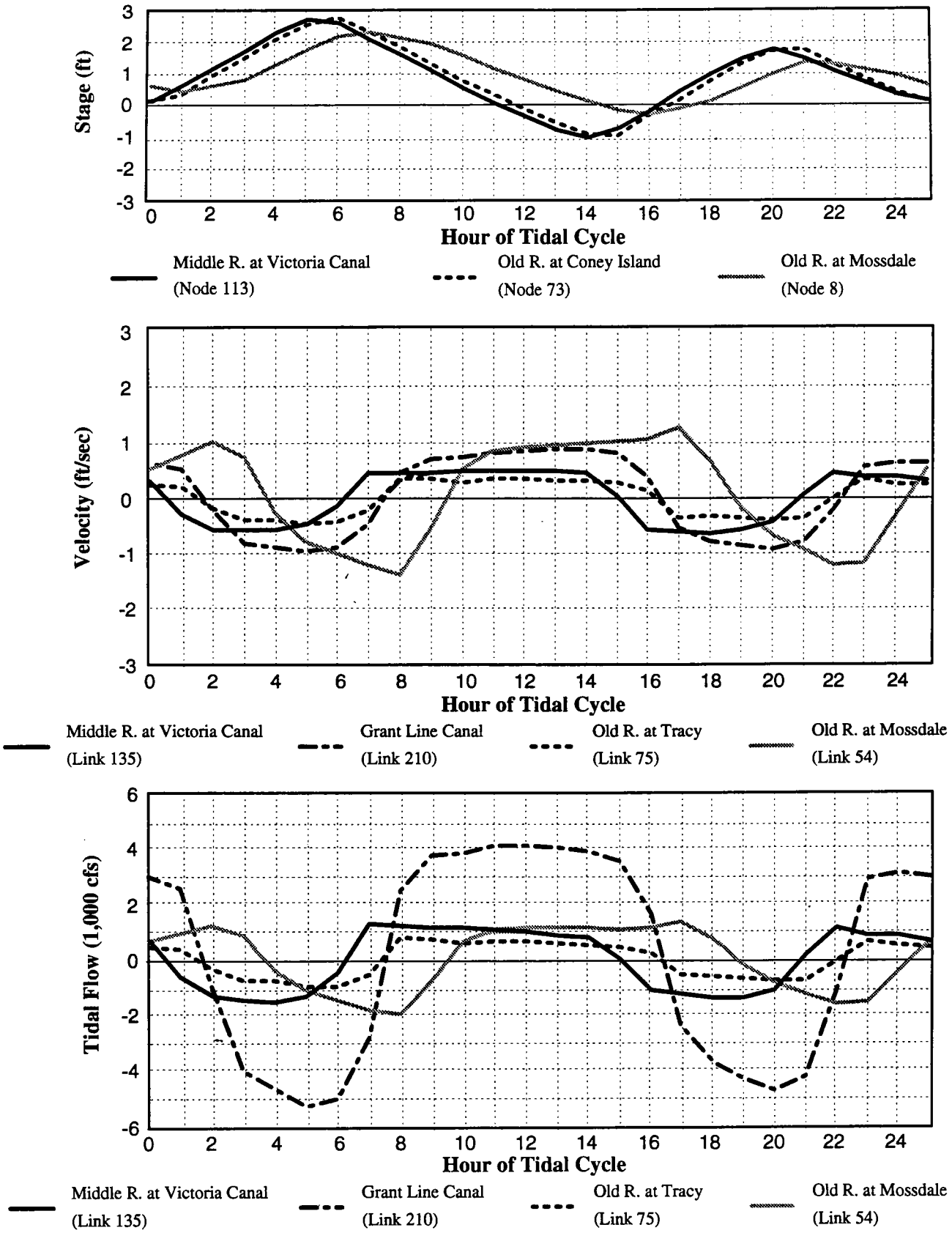


Figure B1-10.
Simulated Tidal Hydraulics in the South Delta

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

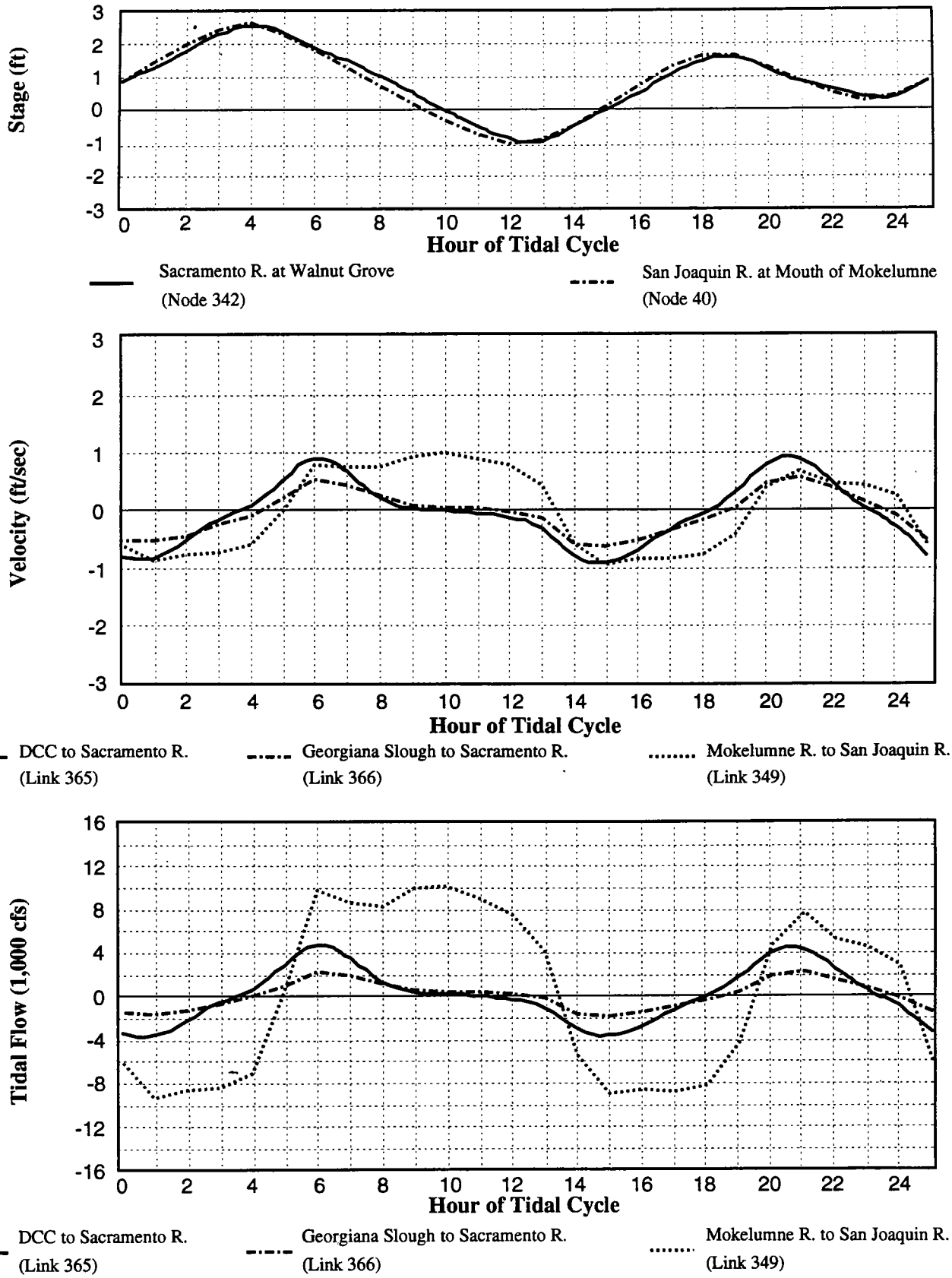


Figure B1-11.
Simulated Tidal Hydraulics in Mokelumne River Channels

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

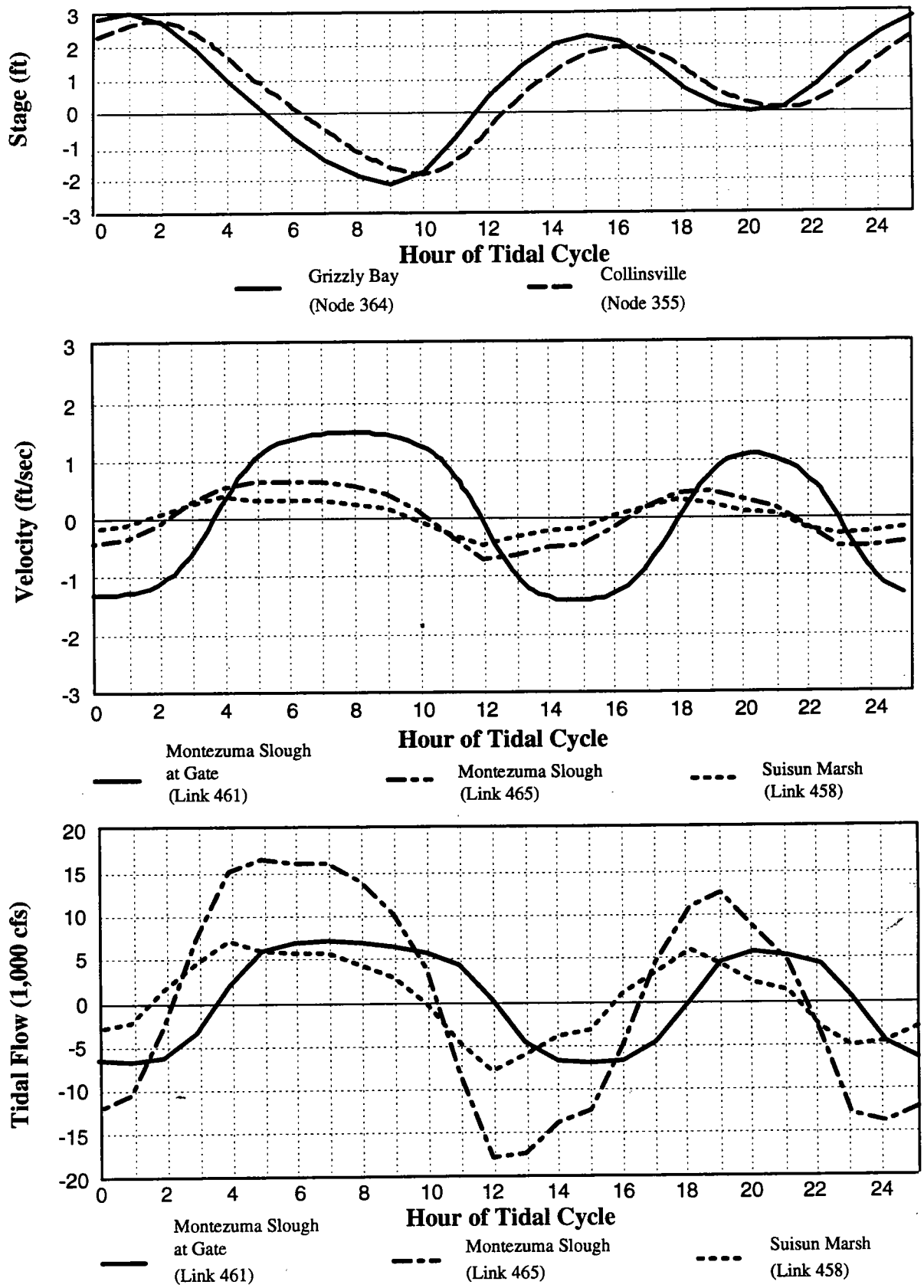


Figure B1-12.
Simulated Tidal Hydraulics in Suisun Marsh

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

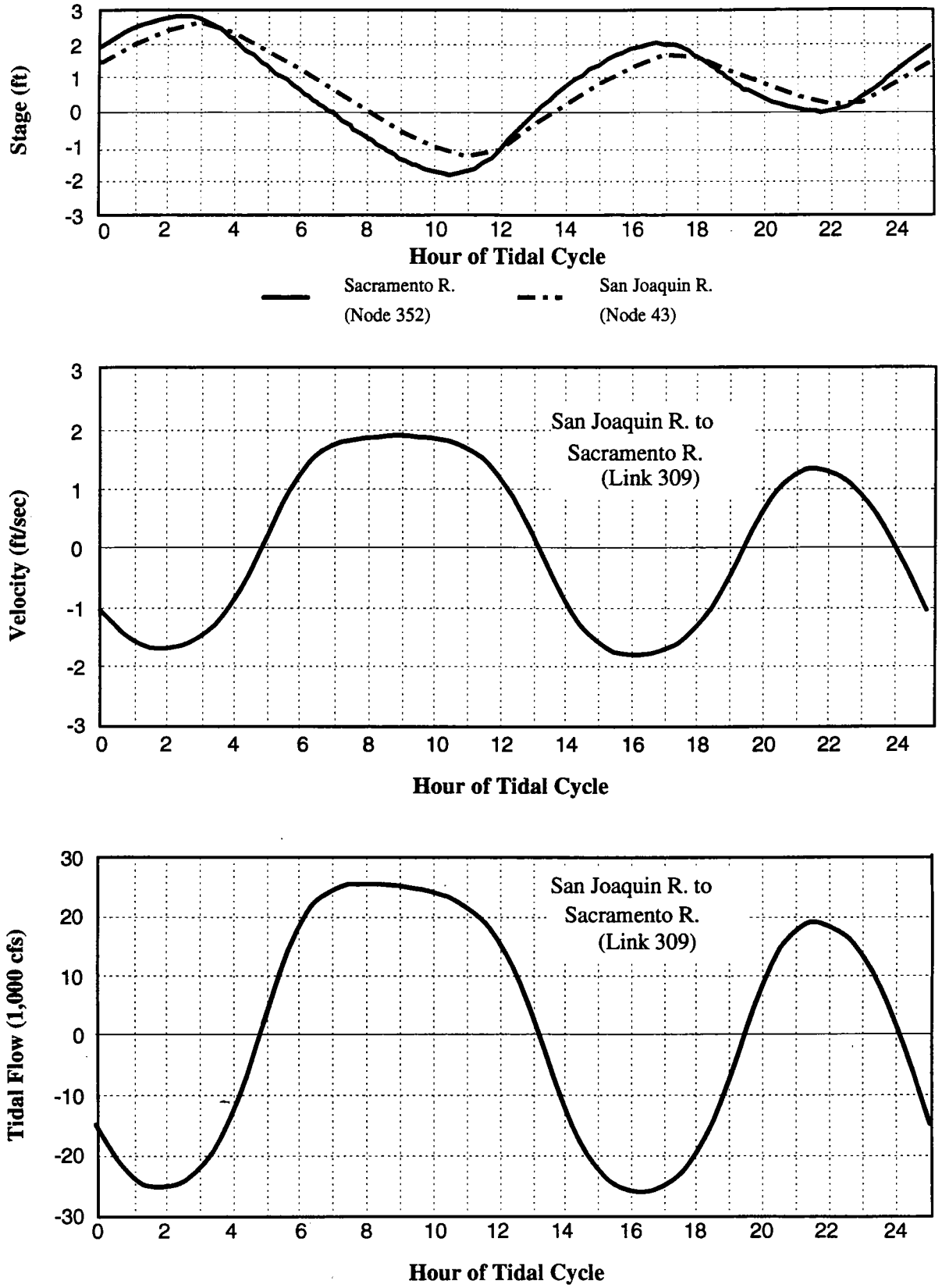
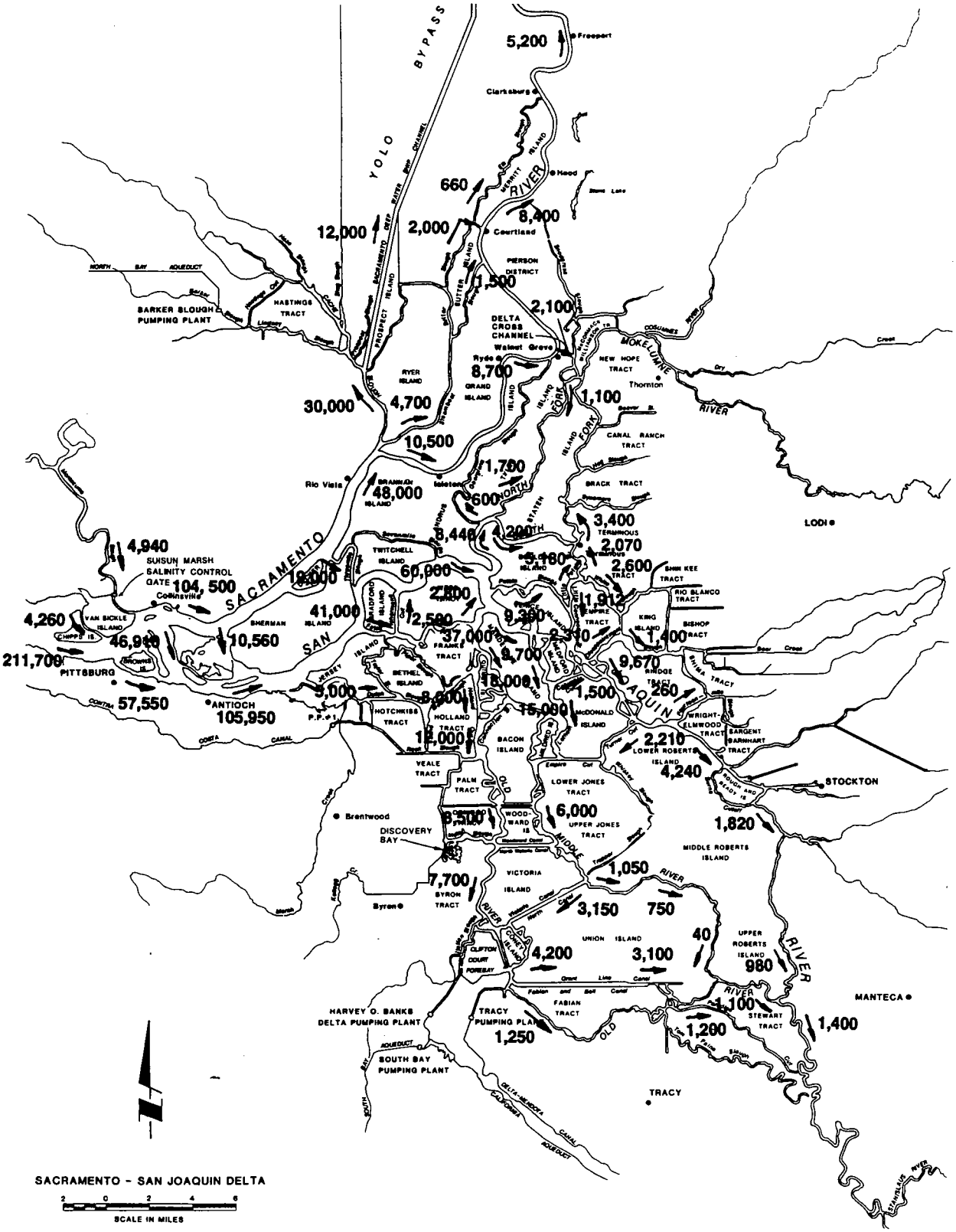


Figure B1-13.
Simulated Tidal Hydraulics in Threemile Slough

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



Source: Adapted from California Department of Water Resources 1993.

Figure B1-14.
Average Flood Tide Flows (cfs) Simulated by the RMA Delta Model

DELTA WETLANDS
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Prepared by: Jones & Stokes Associates

Figure B1-15.
Historical Monthly Average Sacramento River and Yolo Bypass Flows for 1967-1991

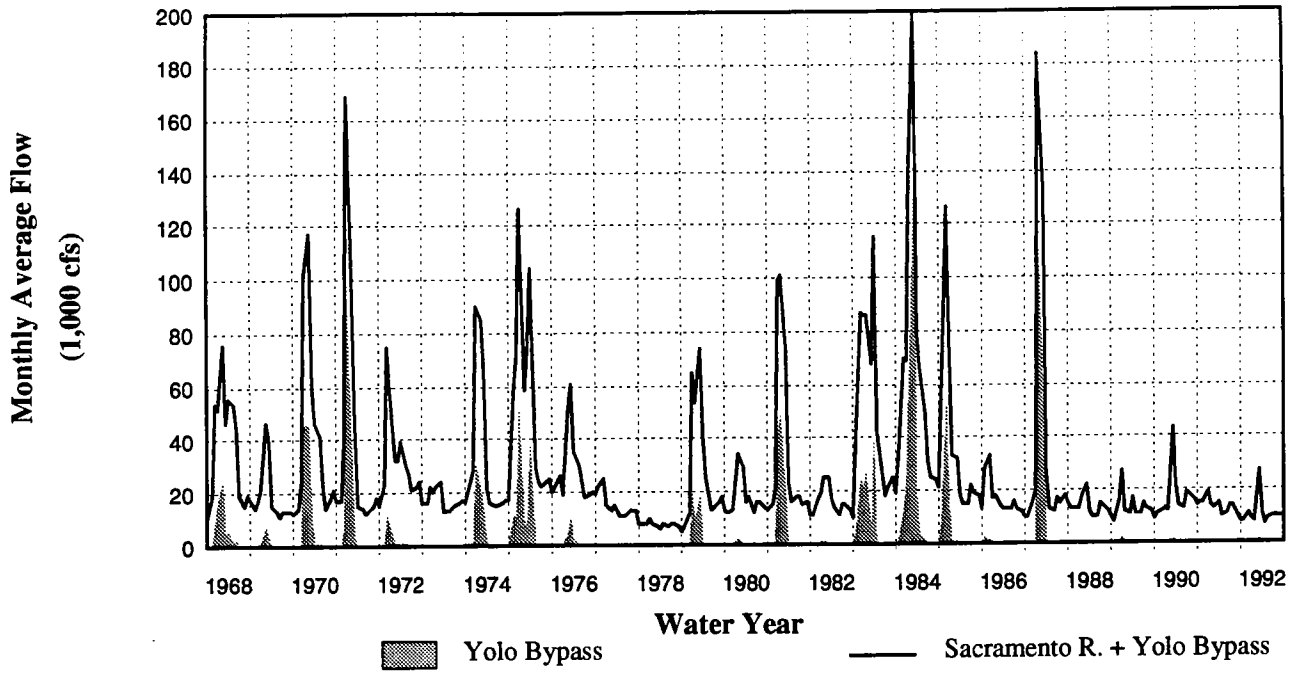


Figure B1-16.
Relationship between Historical Sacramento River and Yolo Bypass Flows for 1967-1991

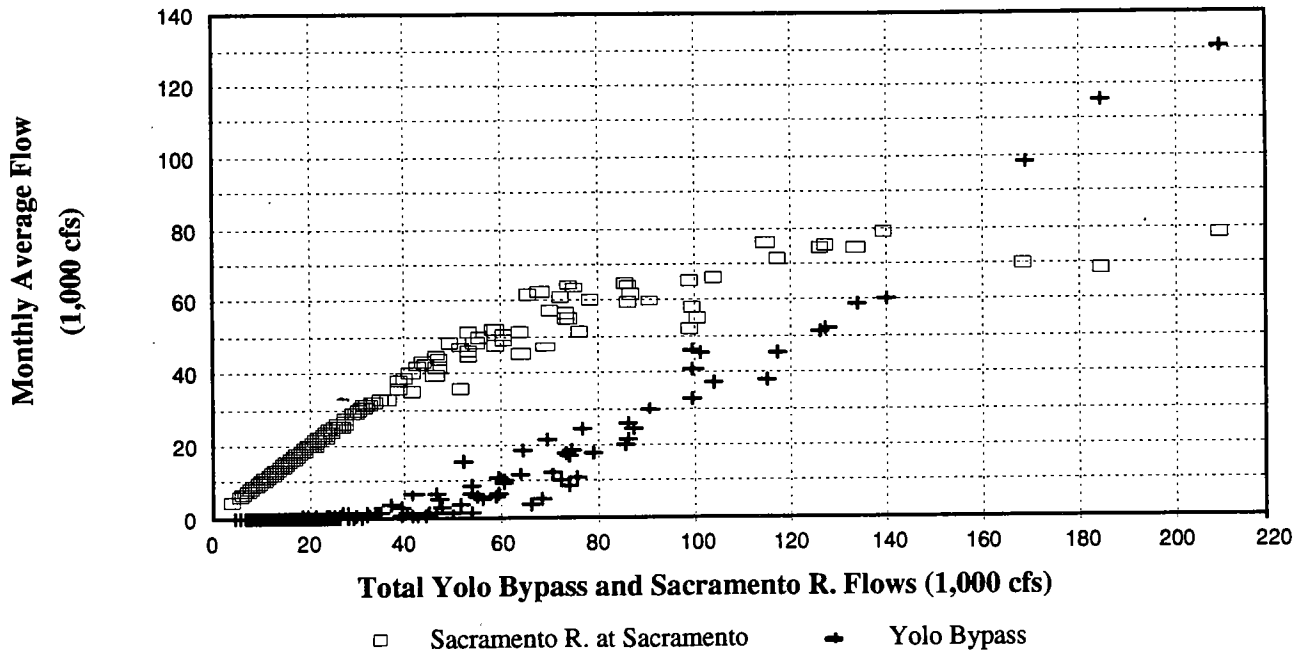


Figure B1-17.
Historical Monthly Average San Joaquin River Flow
at Vernalis for 1967-1991

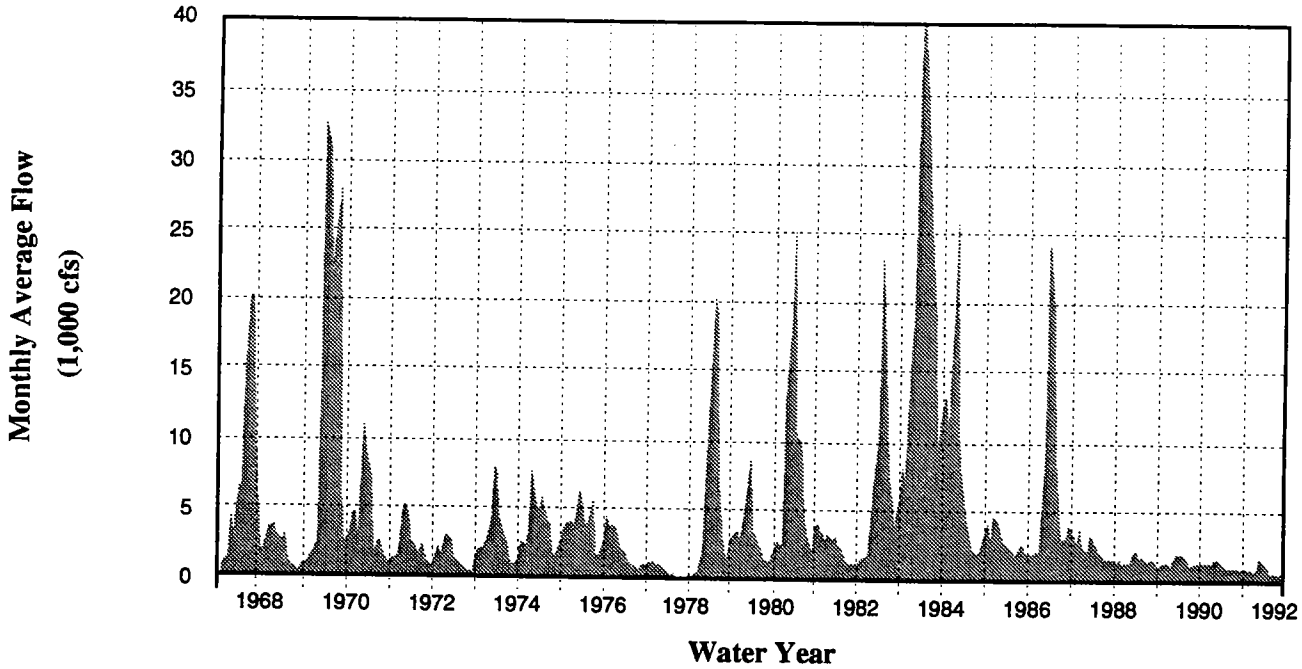


Figure B1-18.
Historical Monthly Average Eastside Stream Flow
for 1967-1991

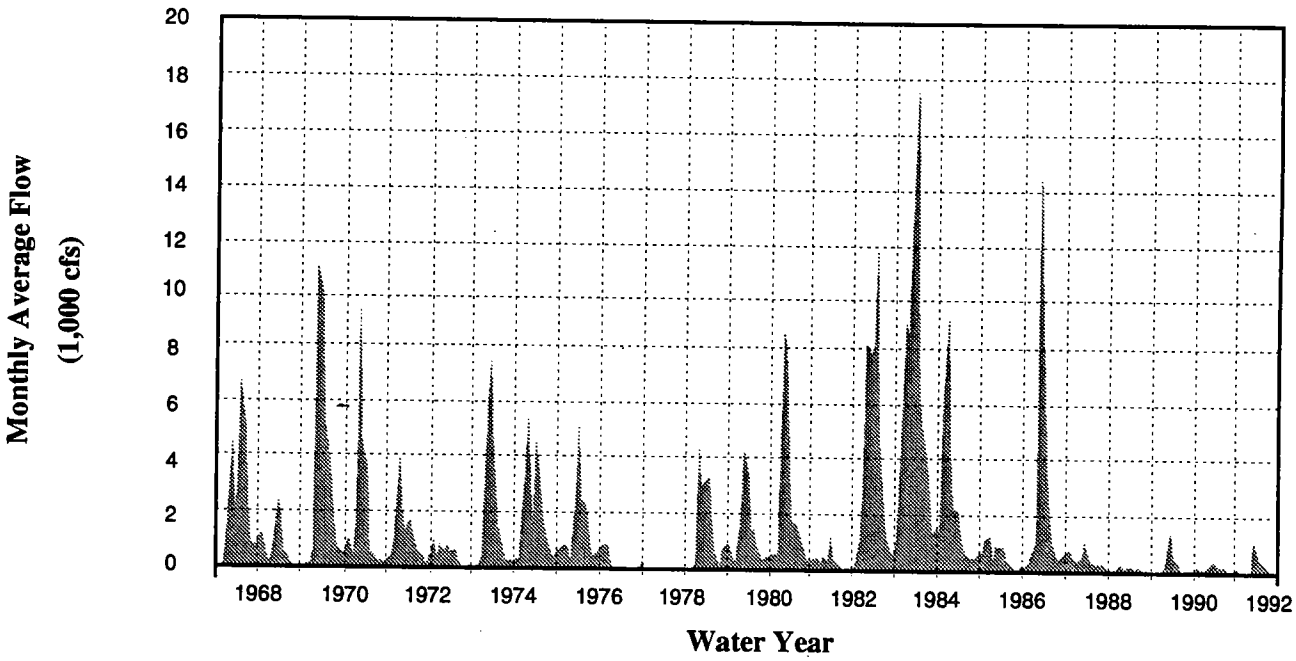


Figure B1-19.
Historical Monthly Average Delta CVP and SWP Exports and CCWD Diversions for 1967-1991

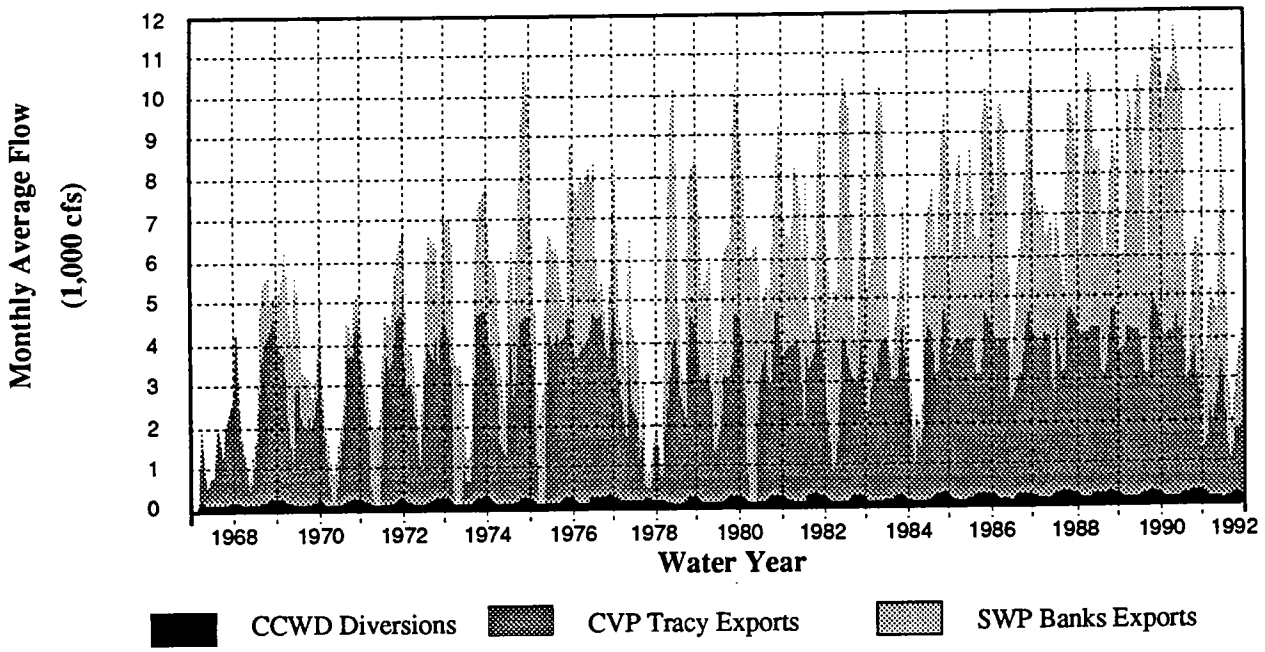


Figure B1-20.
Estimated Historical Monthly Average Delta Channel Depletions for 1967-1991

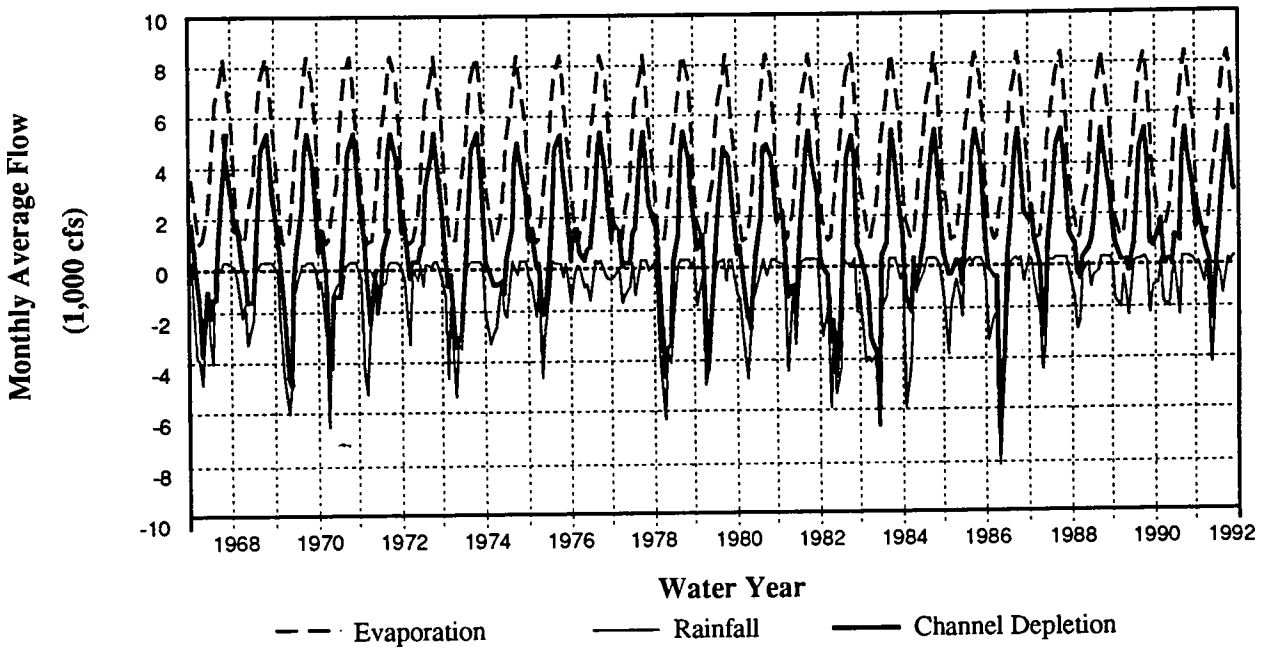


Figure B1-21.
Estimated Historical Monthly Average Delta Outflow
for 1967-1991

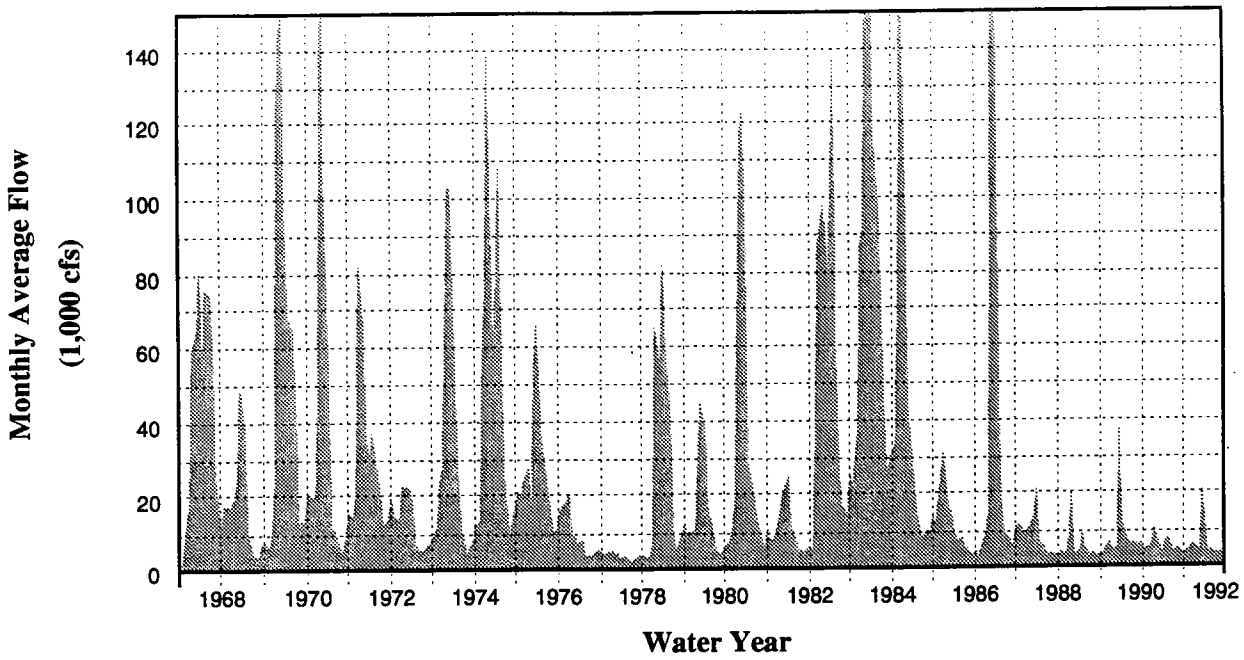
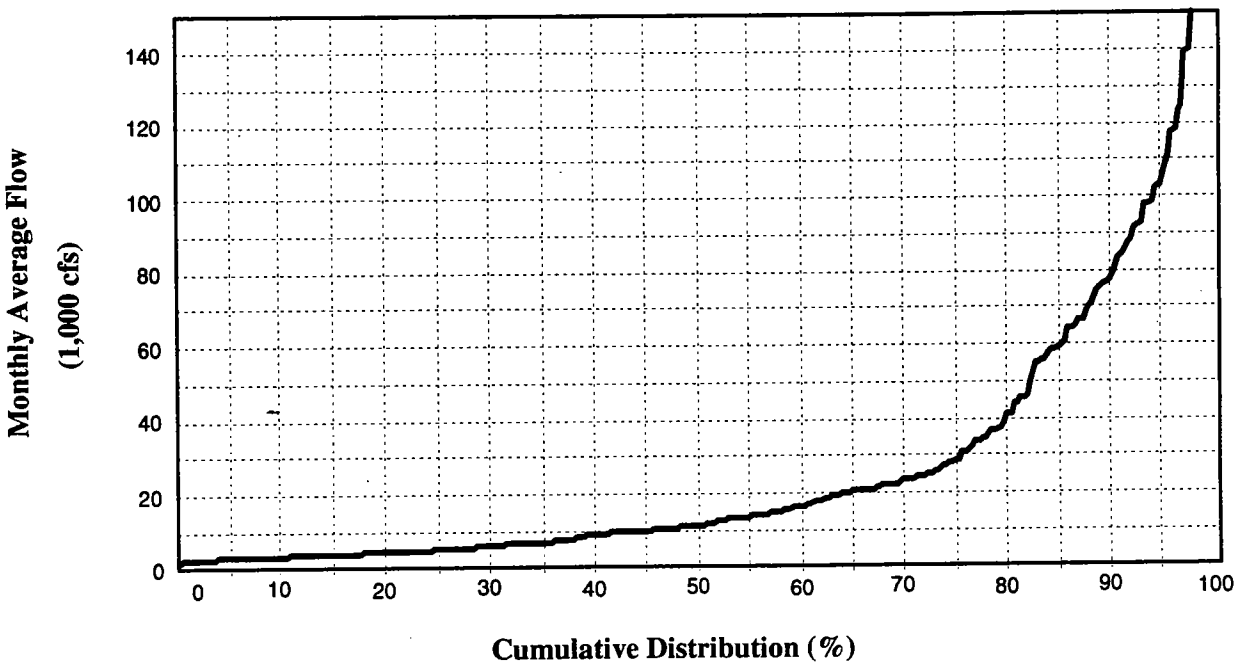
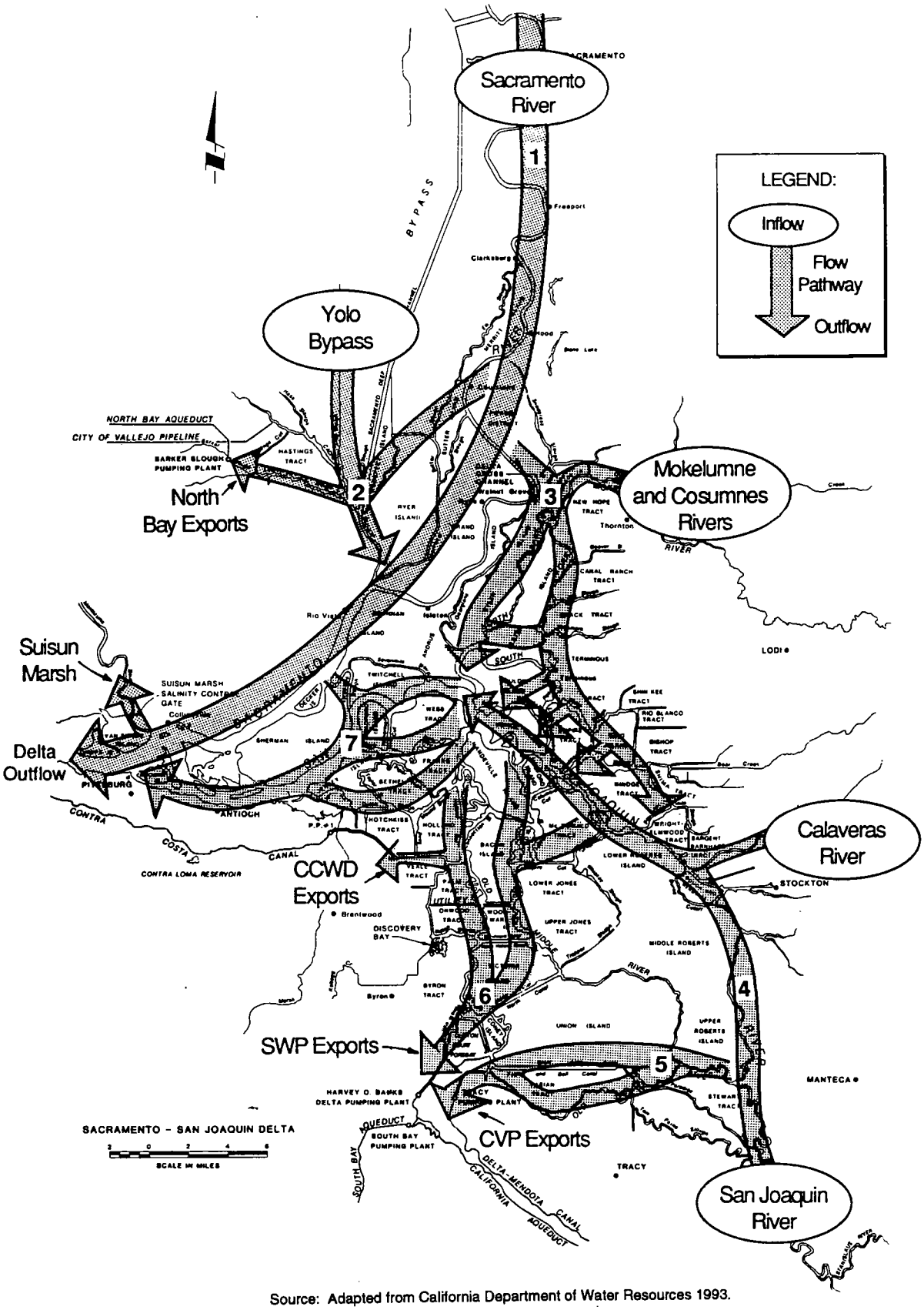


Figure B1-22.
Cumulative Distribution of Estimated Delta Outflow
for 1967-1991





Source: Adapted from California Department of Water Resources 1993.

Figure B1-23.
Major Delta Flow Pathways

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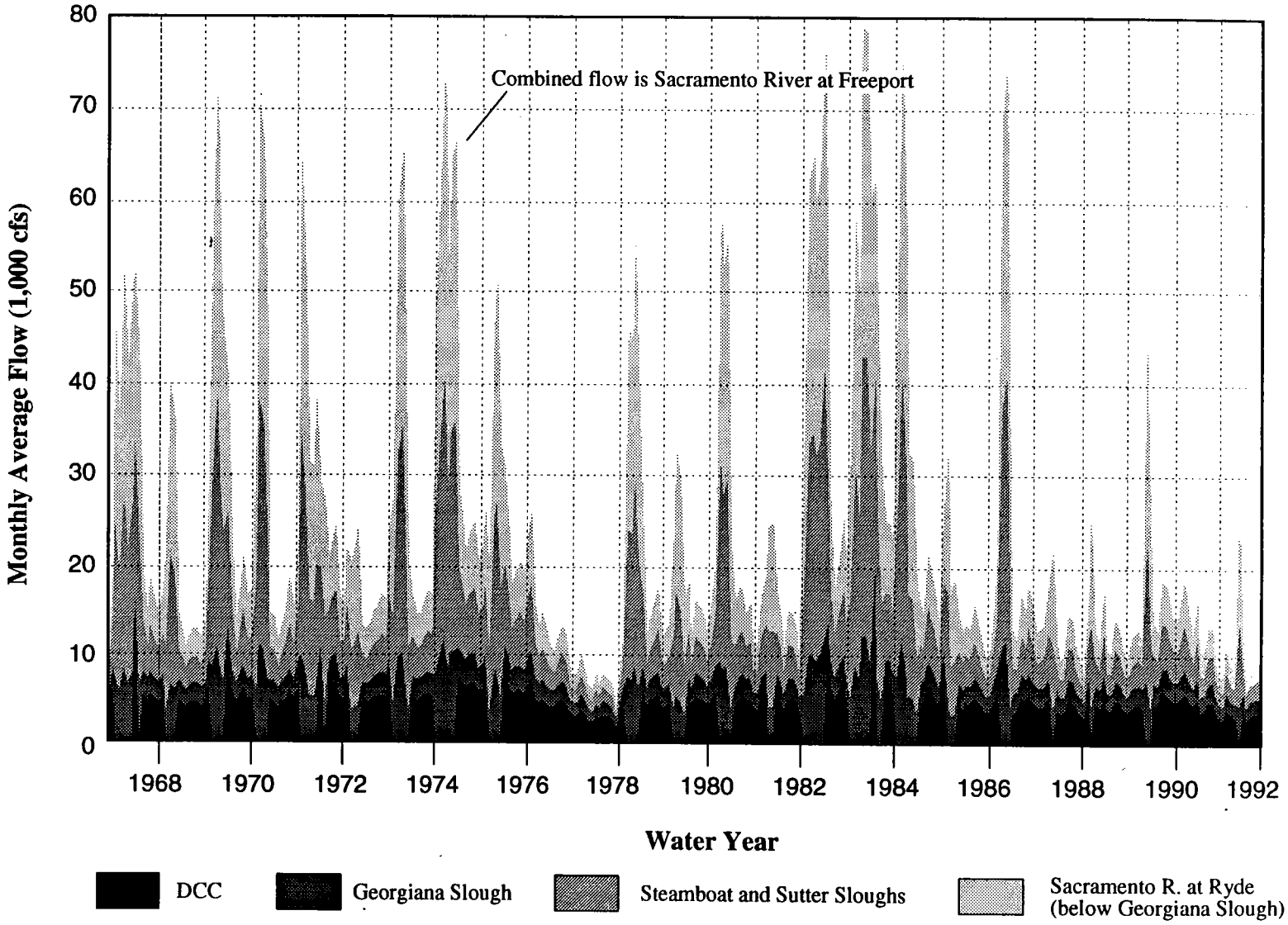

Figure B1-24.
Monthly Average Historical Sacramento River Flow and Simulated Diversions to Steamboat and Sutter Sloughs, the DCC, and Georgiana Slough for 1967-1991

DELTA WETLANDS
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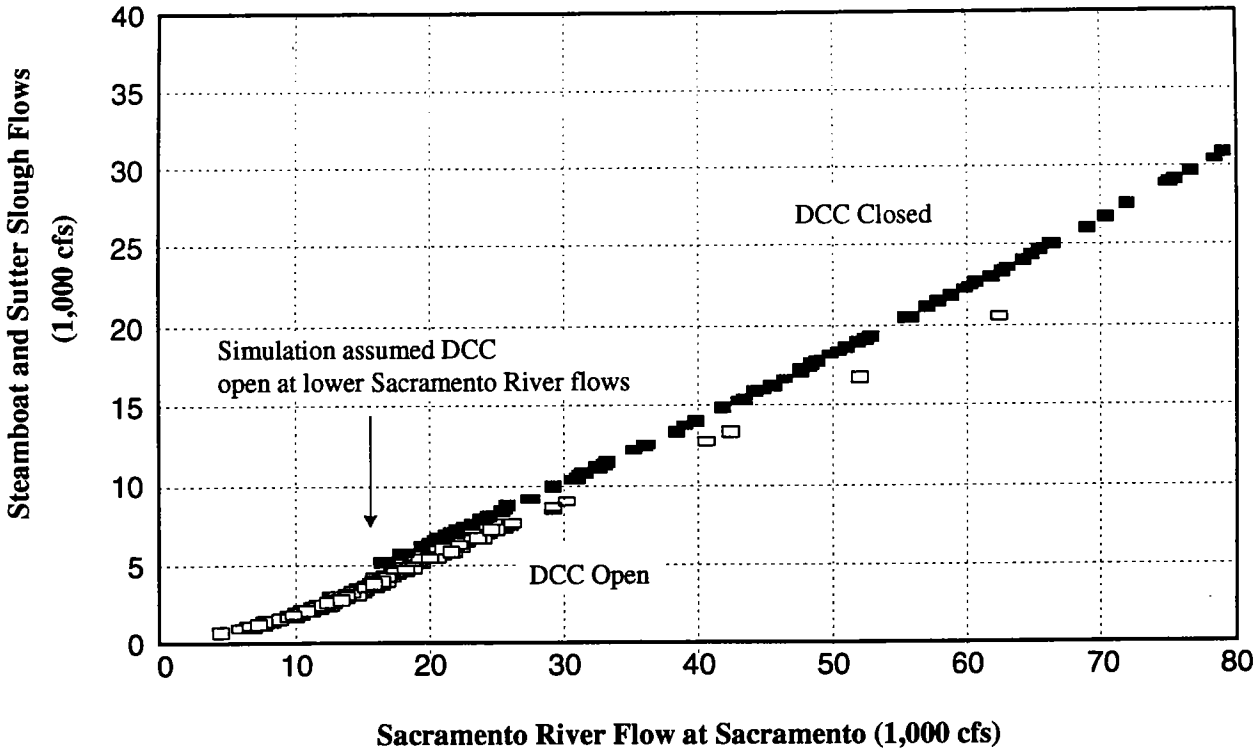
Prepared by: Jones & Stokes Associates



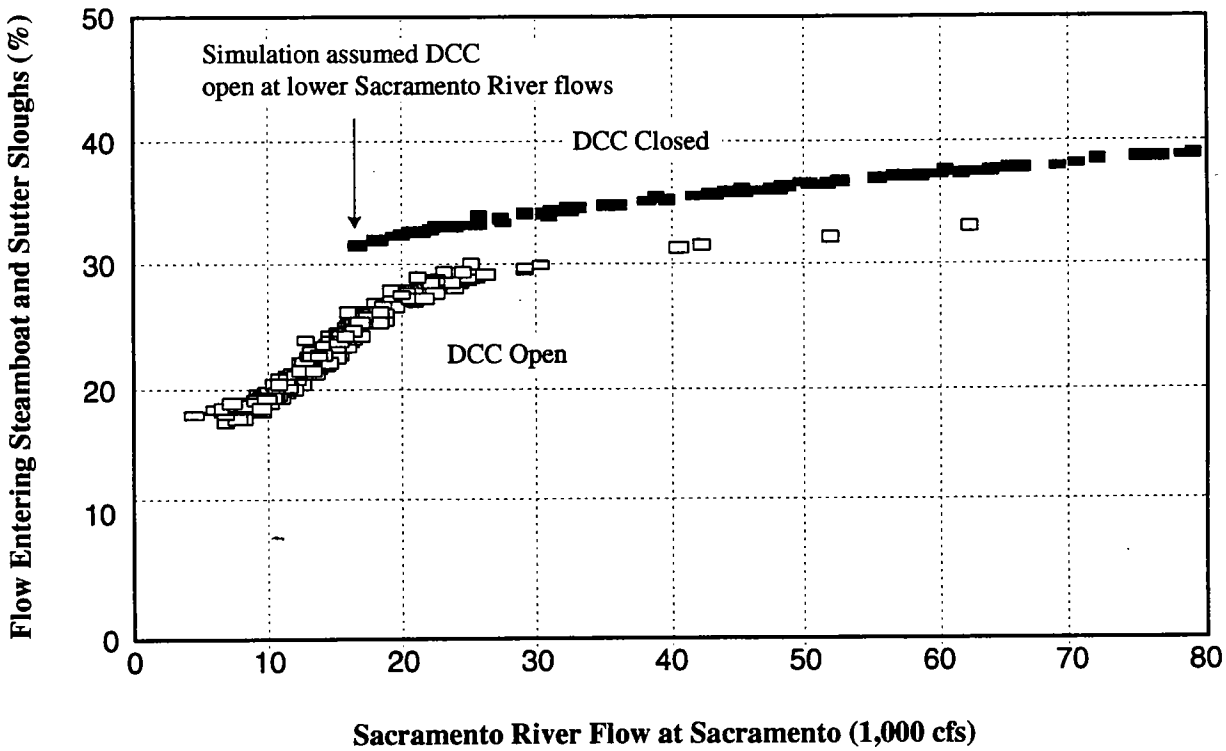


Figure B1-25.
Simulated Relationship between Monthly Average Steamboat and Sutter Slough Diversions and Sacramento River Inflow for 1967-1991

DELTA WETLANDS
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Prepared by: Jones & Stokes Associates

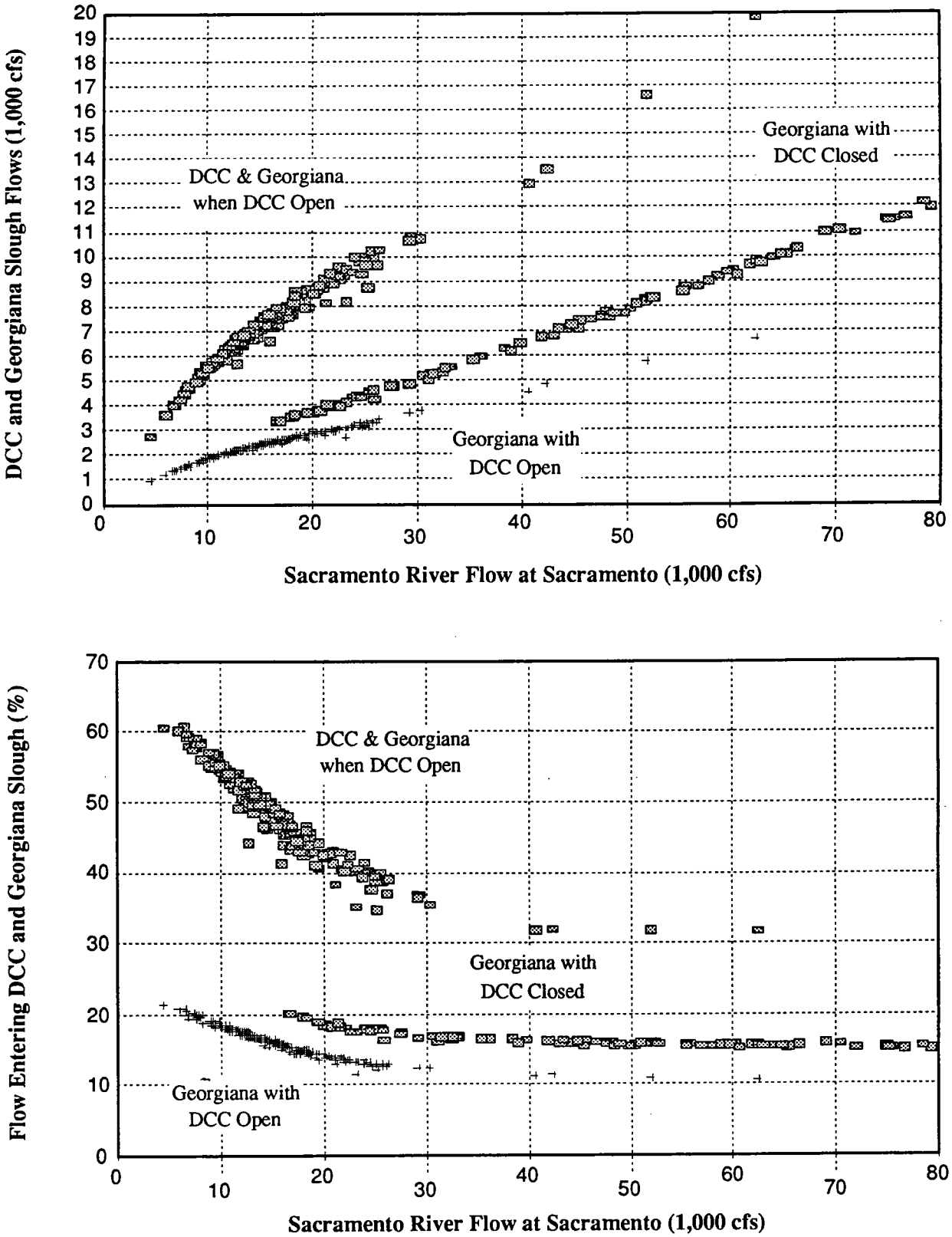


Figure B1-26.
Simulated Relationship between Monthly Average DCC and Georgiana Slough Diversions and Sacramento River Inflow for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

Figure B1-27.
Simulated Relationship between Monthly Average Threemile Slough and Sacramento and San Joaquin River Flows for 1967-1991

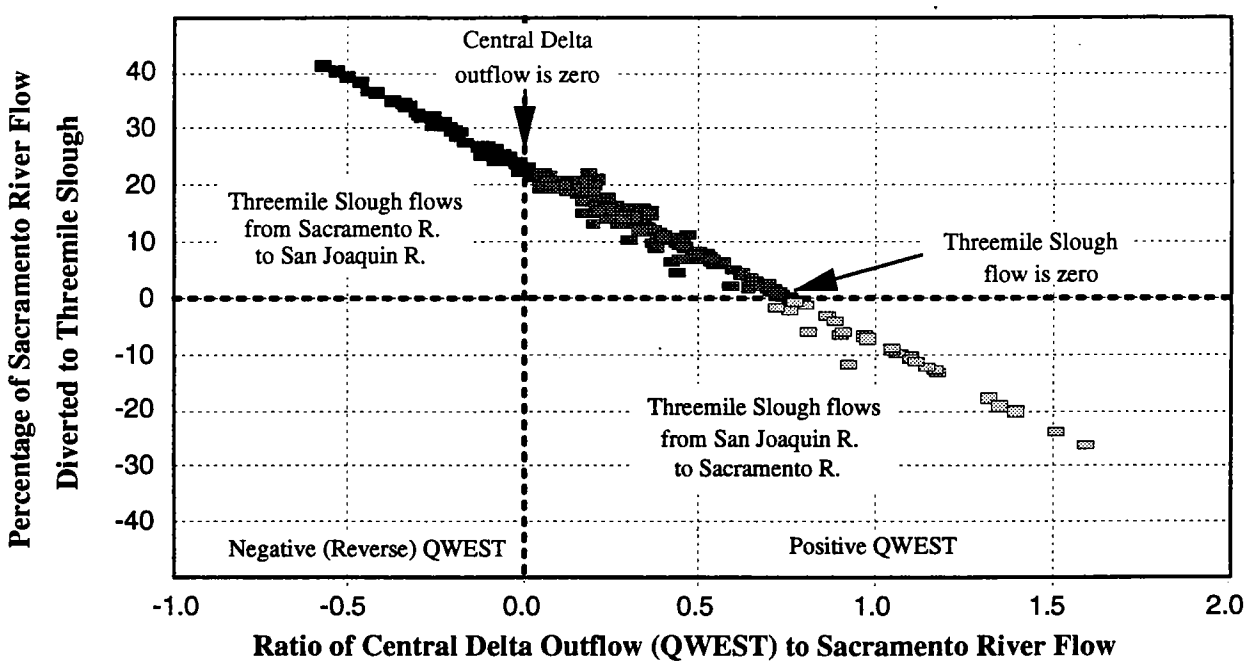
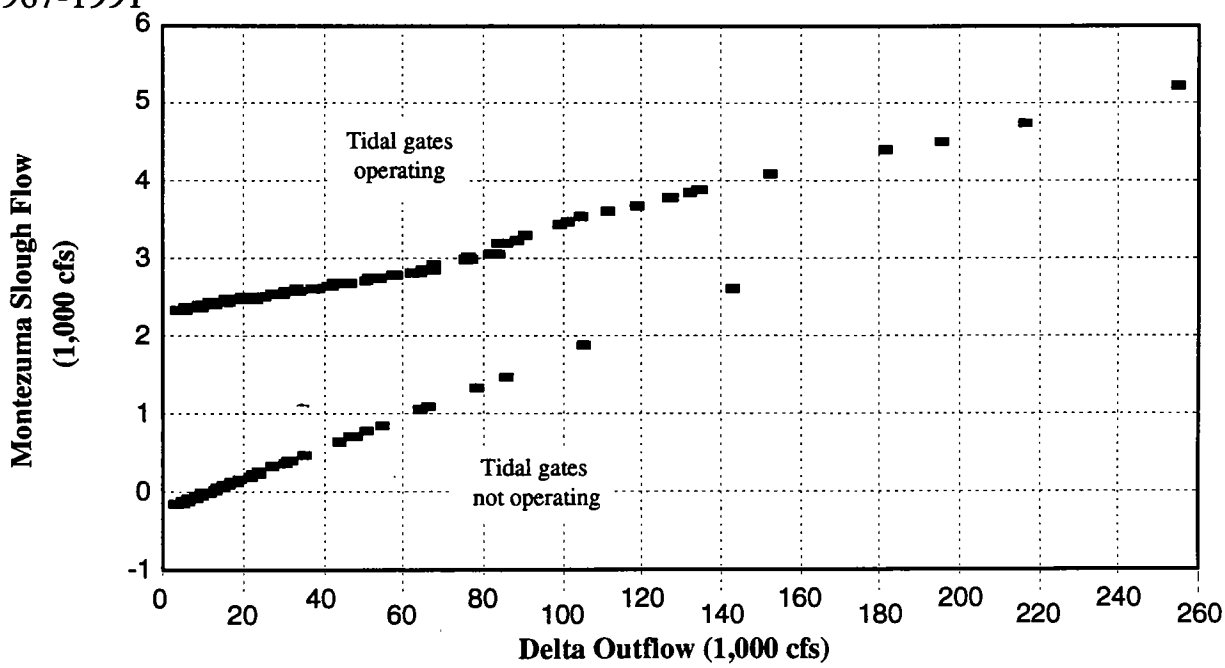


Figure B1-28.
Simulated Relationship between Monthly Average Montezuma Slough Flow and Delta Outflow for 1967-1991



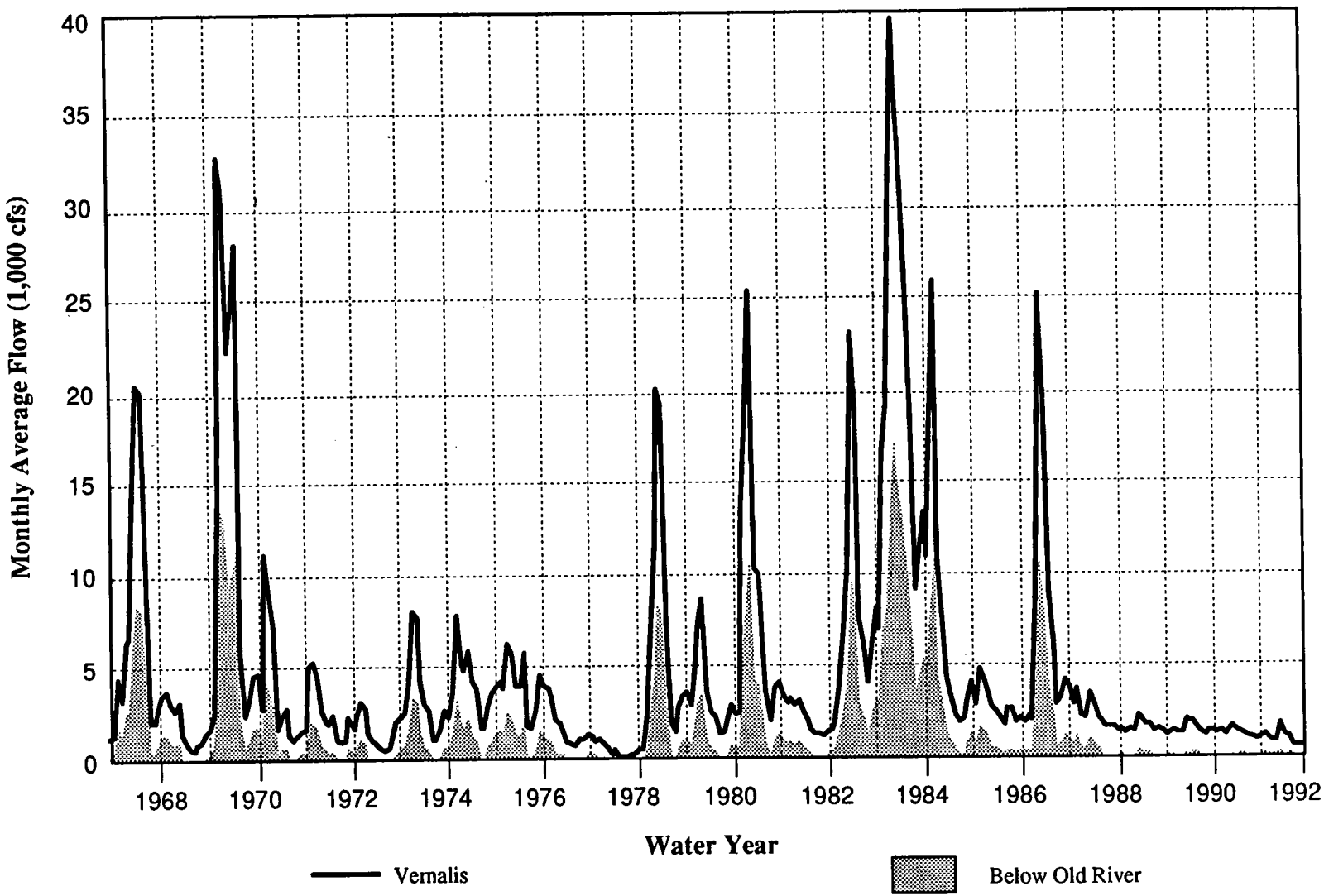


Figure B1-29.
Monthly Average Historical San Joaquin River Flow at Vernalis and Simulated Flow Downstream of the Head of Old River for 1967-1991

DELTA WETLANDS
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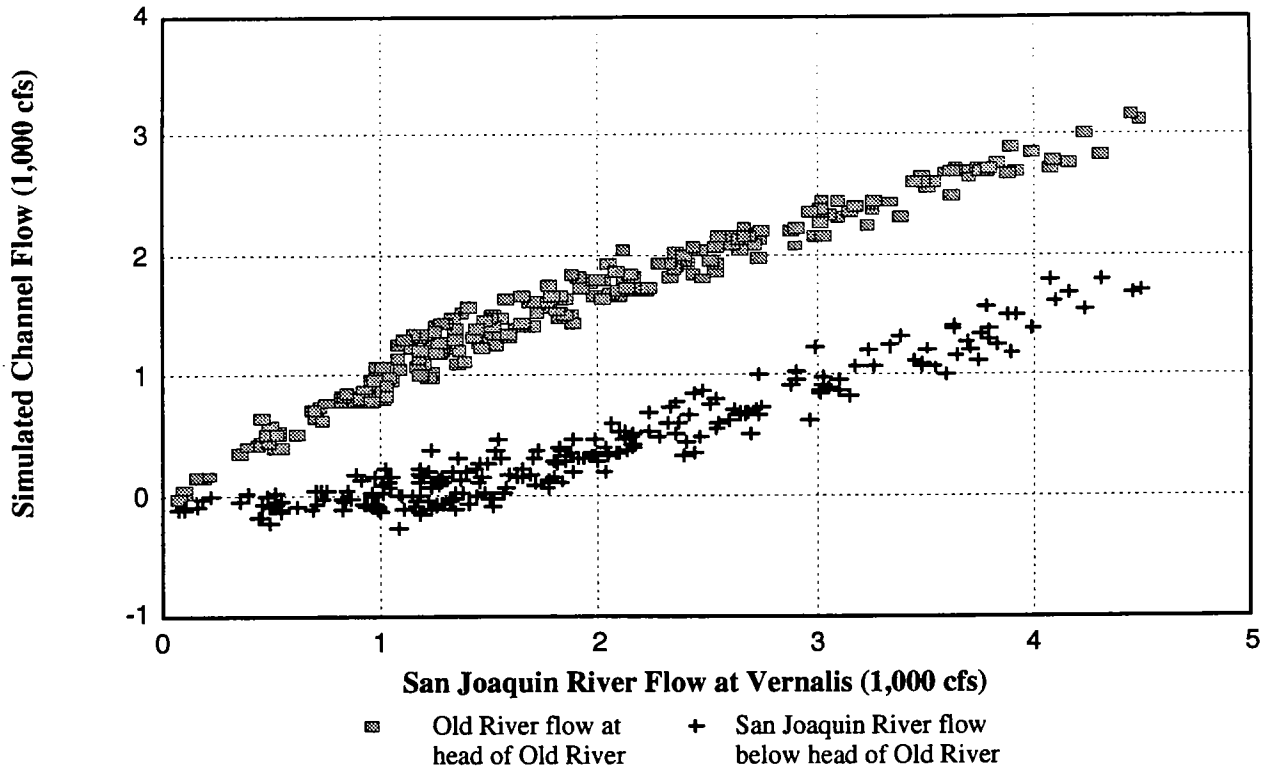
Prepared by: Jones & Stokes Associates



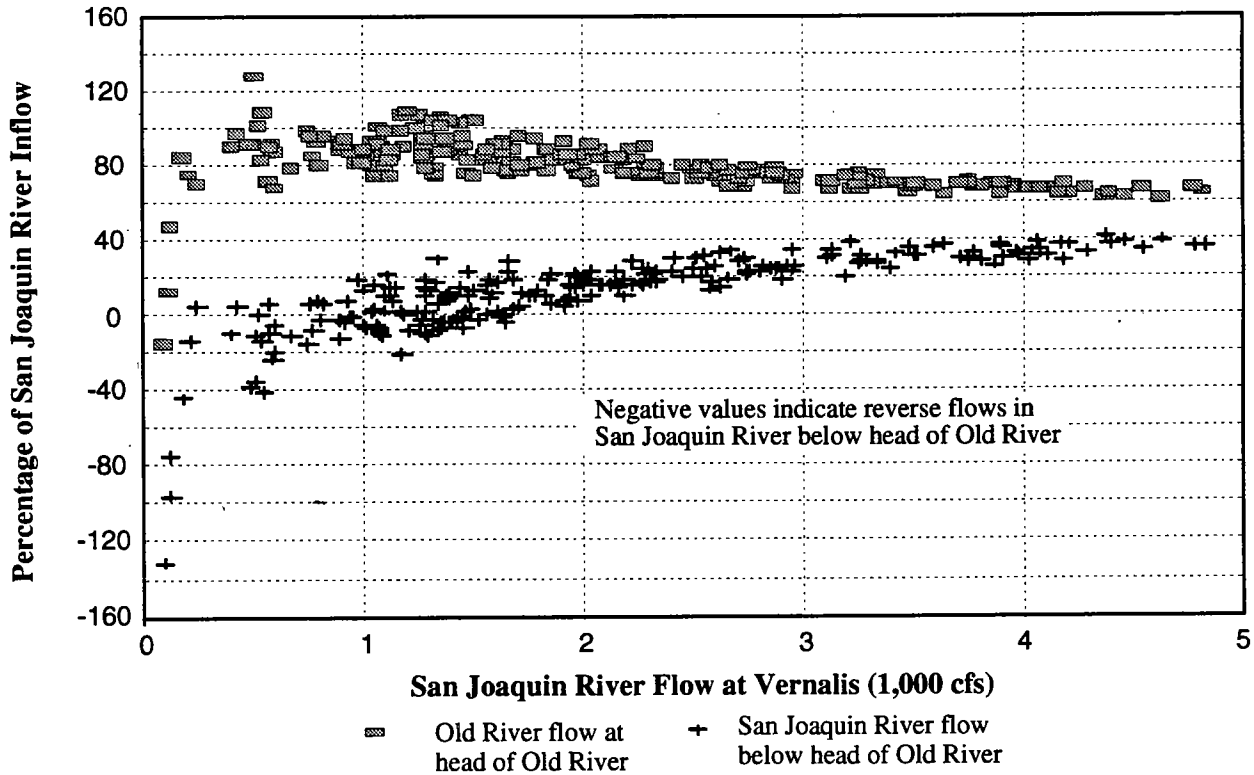


Figure B1-30.
Simulated Relationship between Monthly Average Head of Old River and San Joaquin River Flows for 1967-1991

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Prepared by: Jones & Stokes Associates

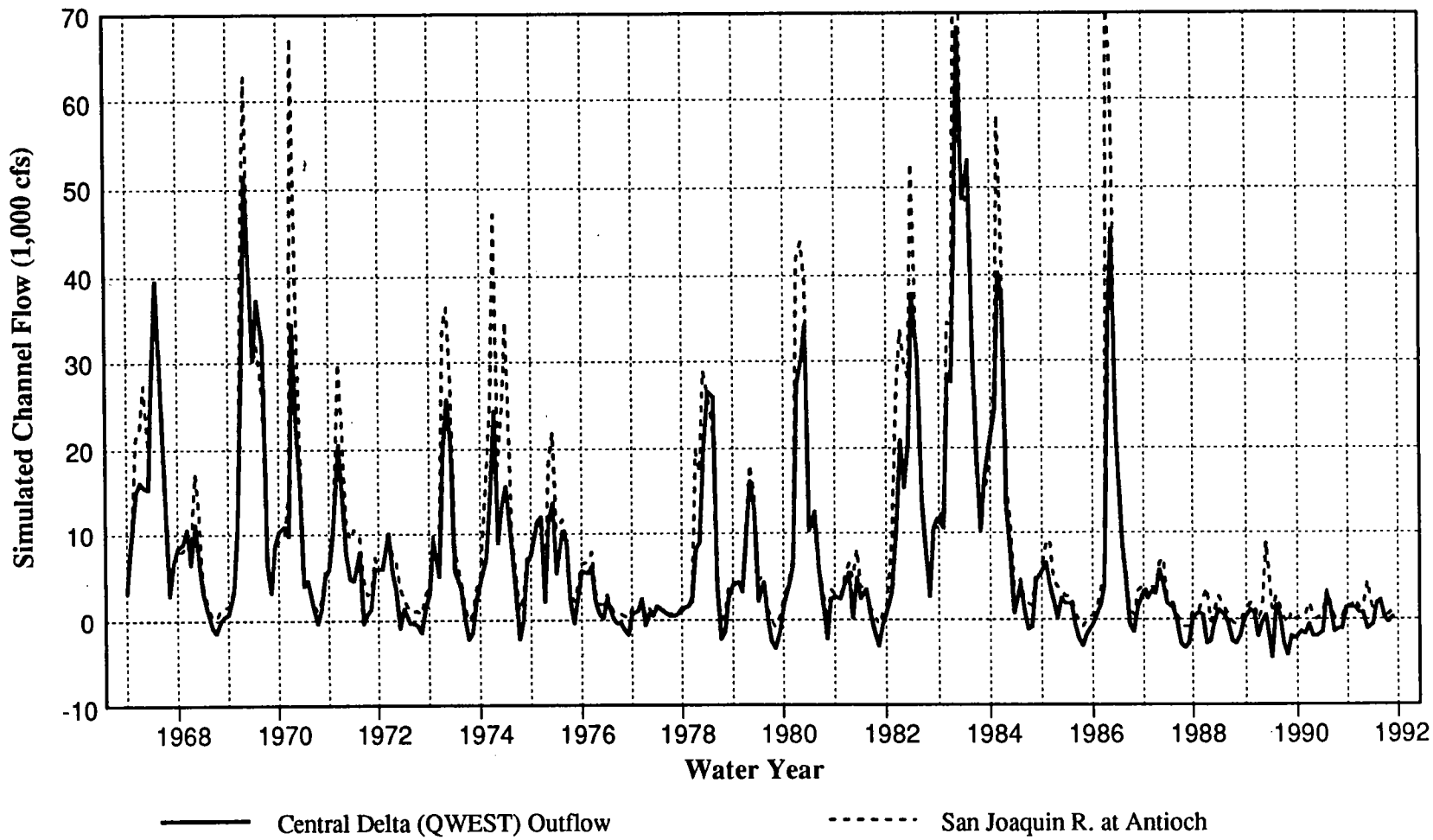


Figure B1-31.
Simulated Historical Monthly Average Central Delta (QWEST) Flow and San Joaquin River Flow at Antioch for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

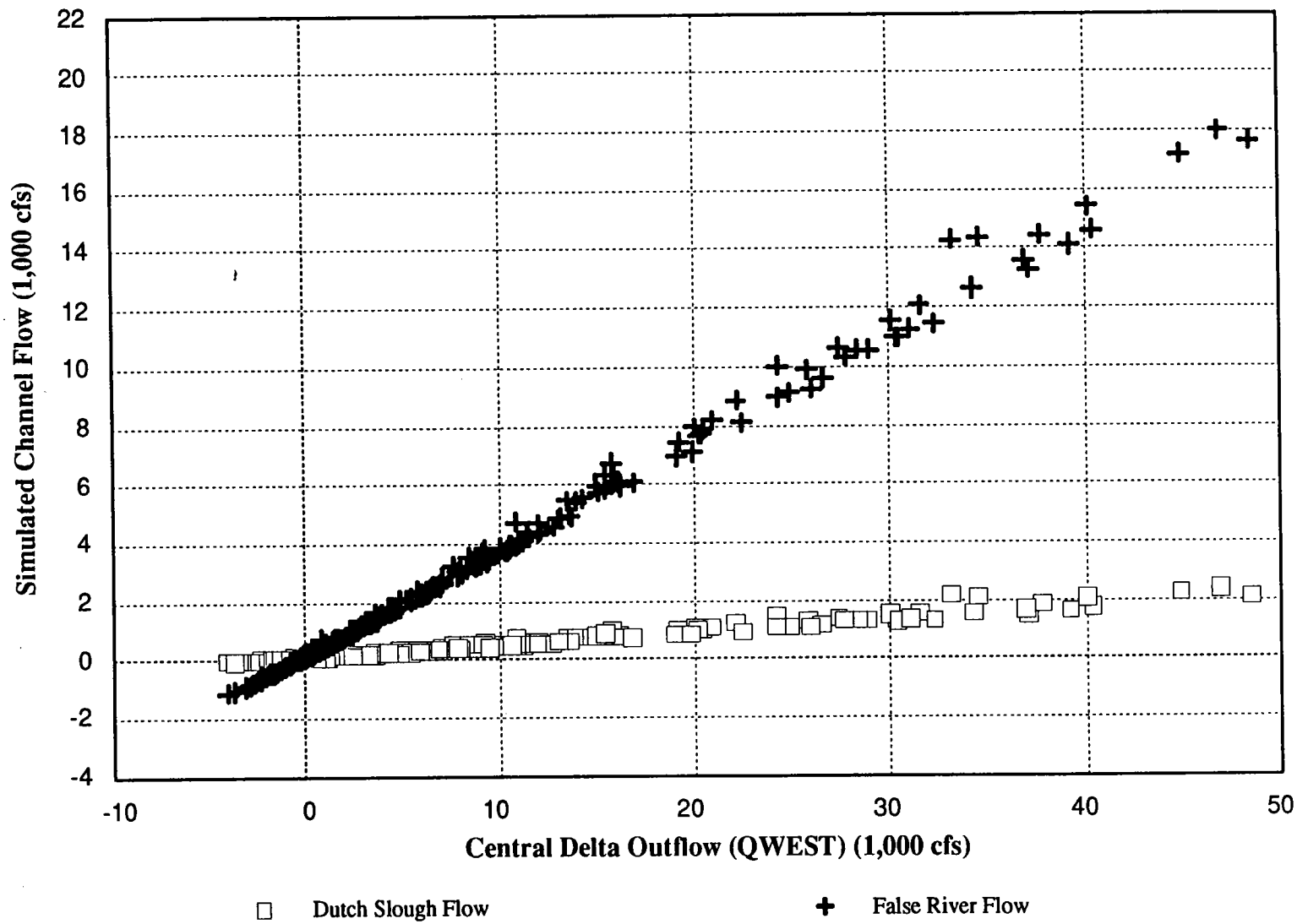


Figure B1-32.
Simulated Relationship between Monthly Dutch Slough and False River Flows and Central Delta Outflow (QWEST) for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

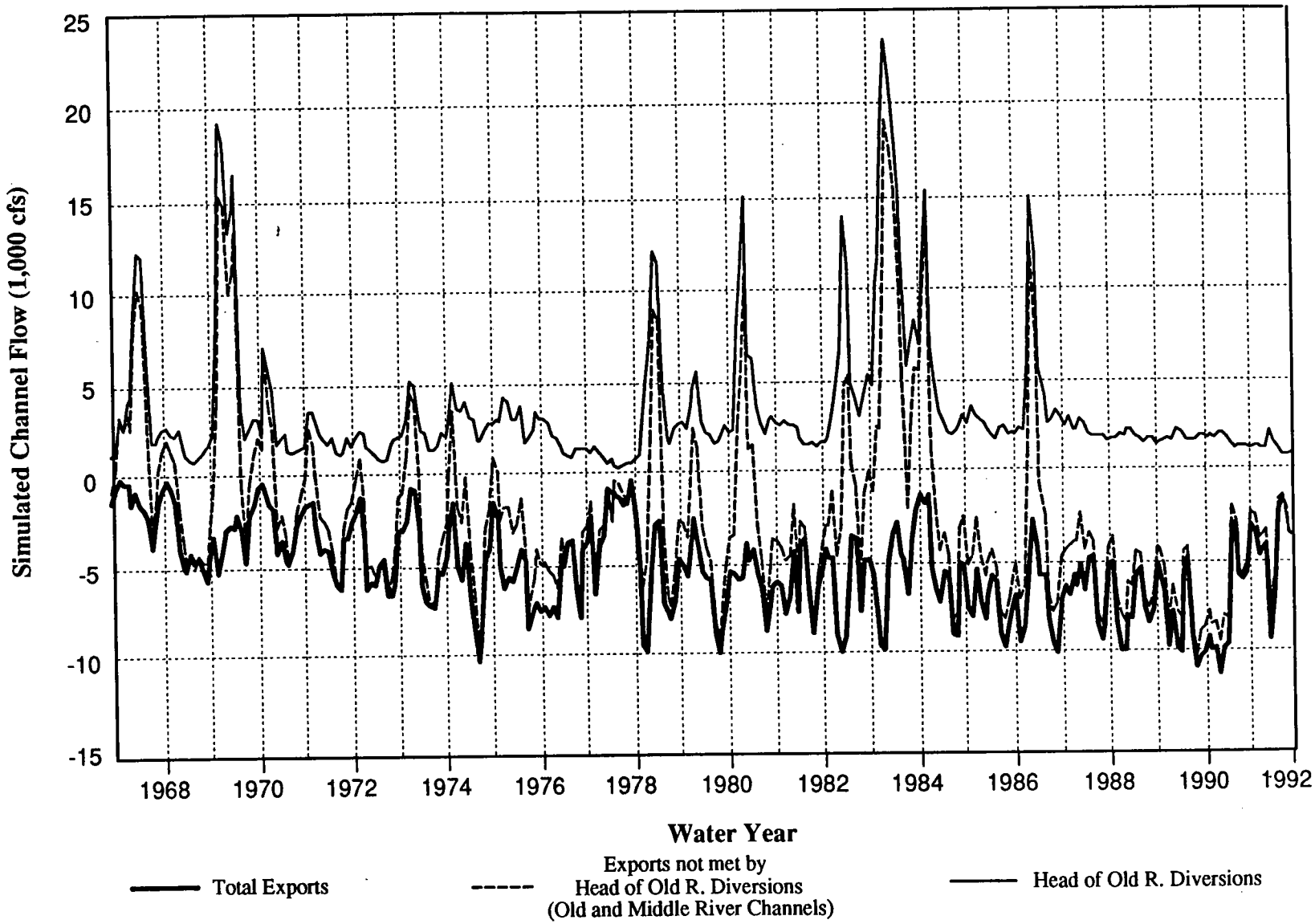


Figure B1-33.
Simulated Historical Monthly Average Channel Flows Supplying Exports for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

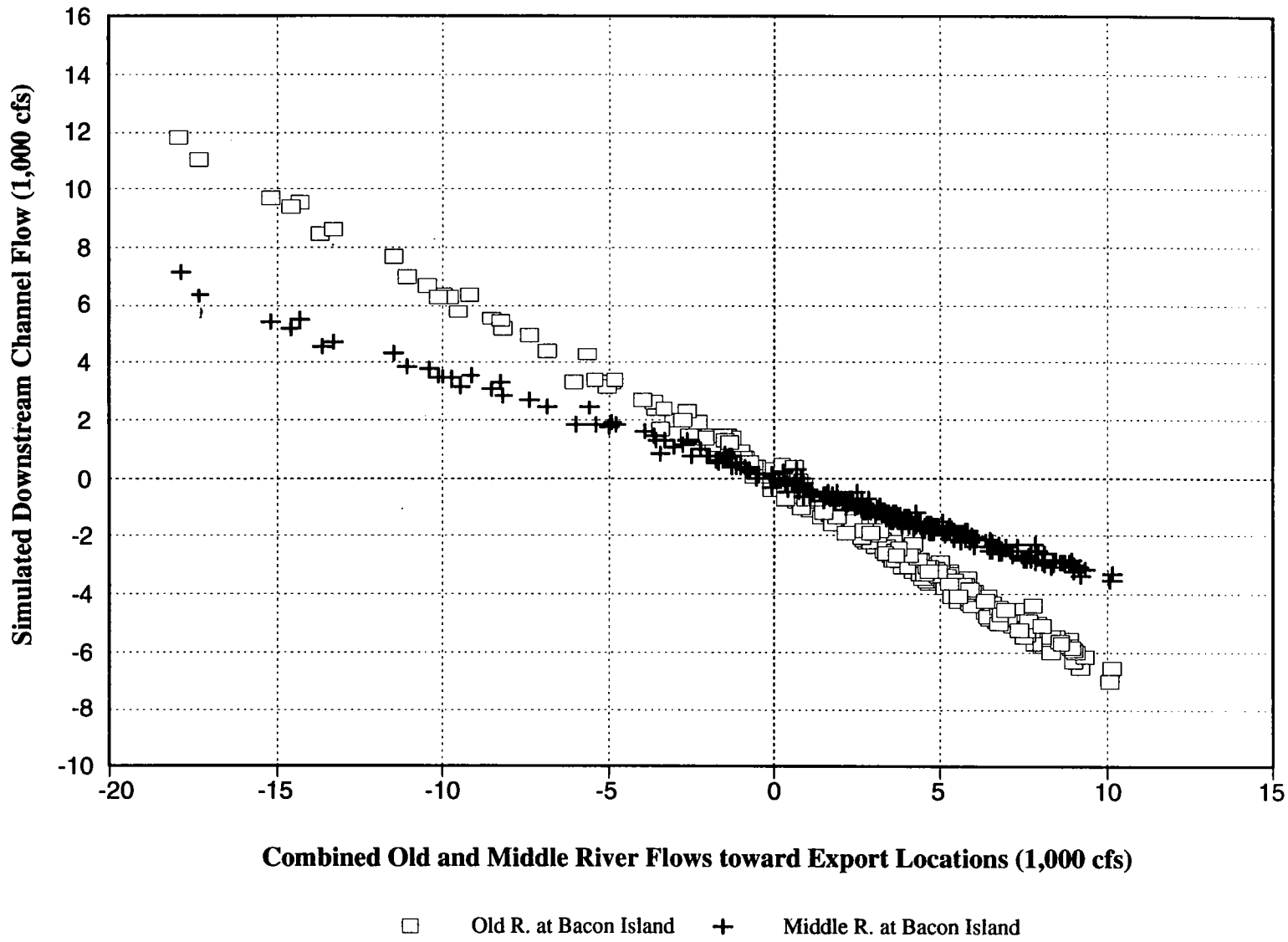


Figure B1-34.
Simulated Relationship between Old and Middle River Flows for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

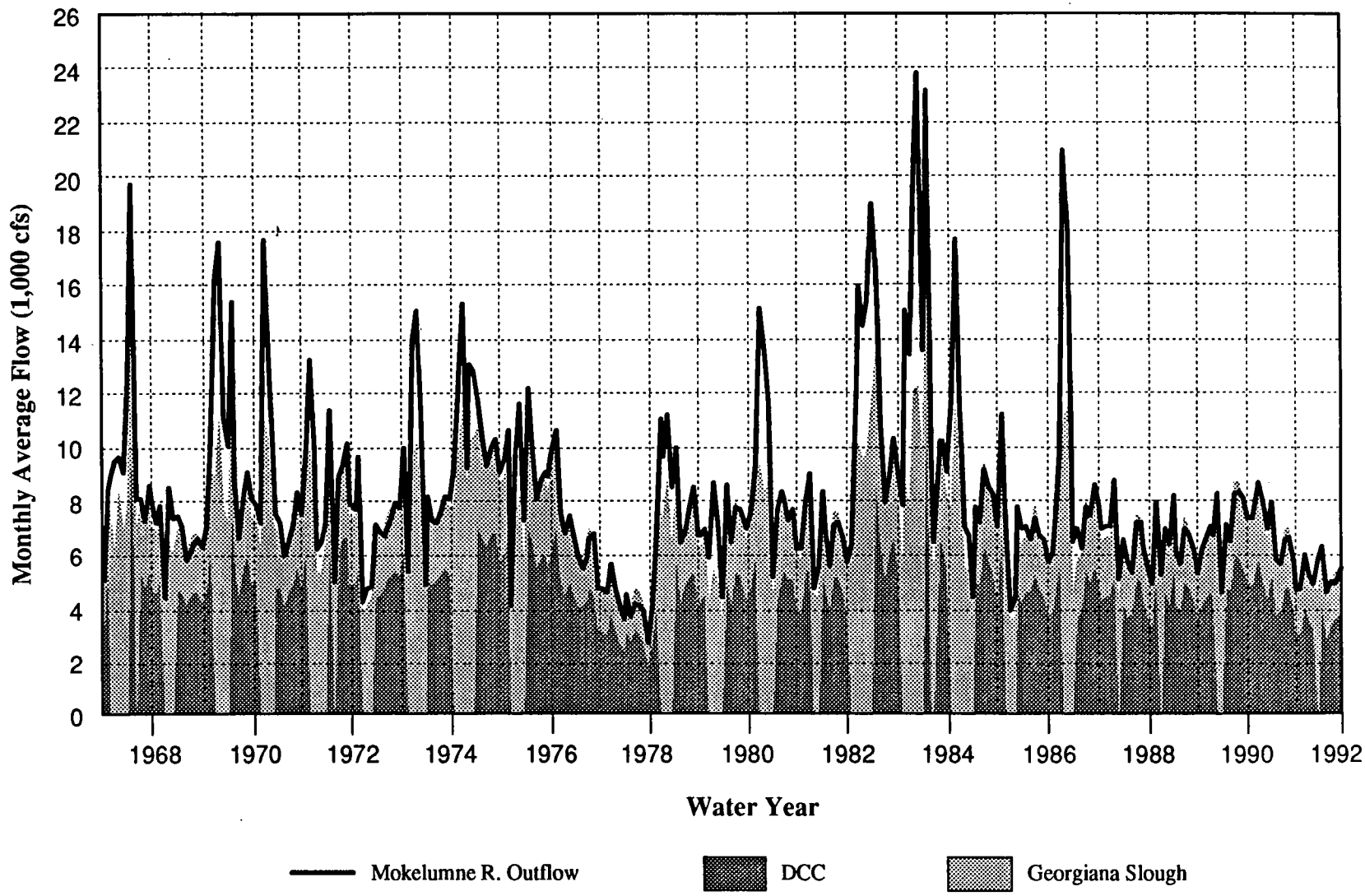


Figure B1-35.
Simulated Historical Monthly Average Mokelumne River Outflow (Including DCC and Georgiana Slough Flows) for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

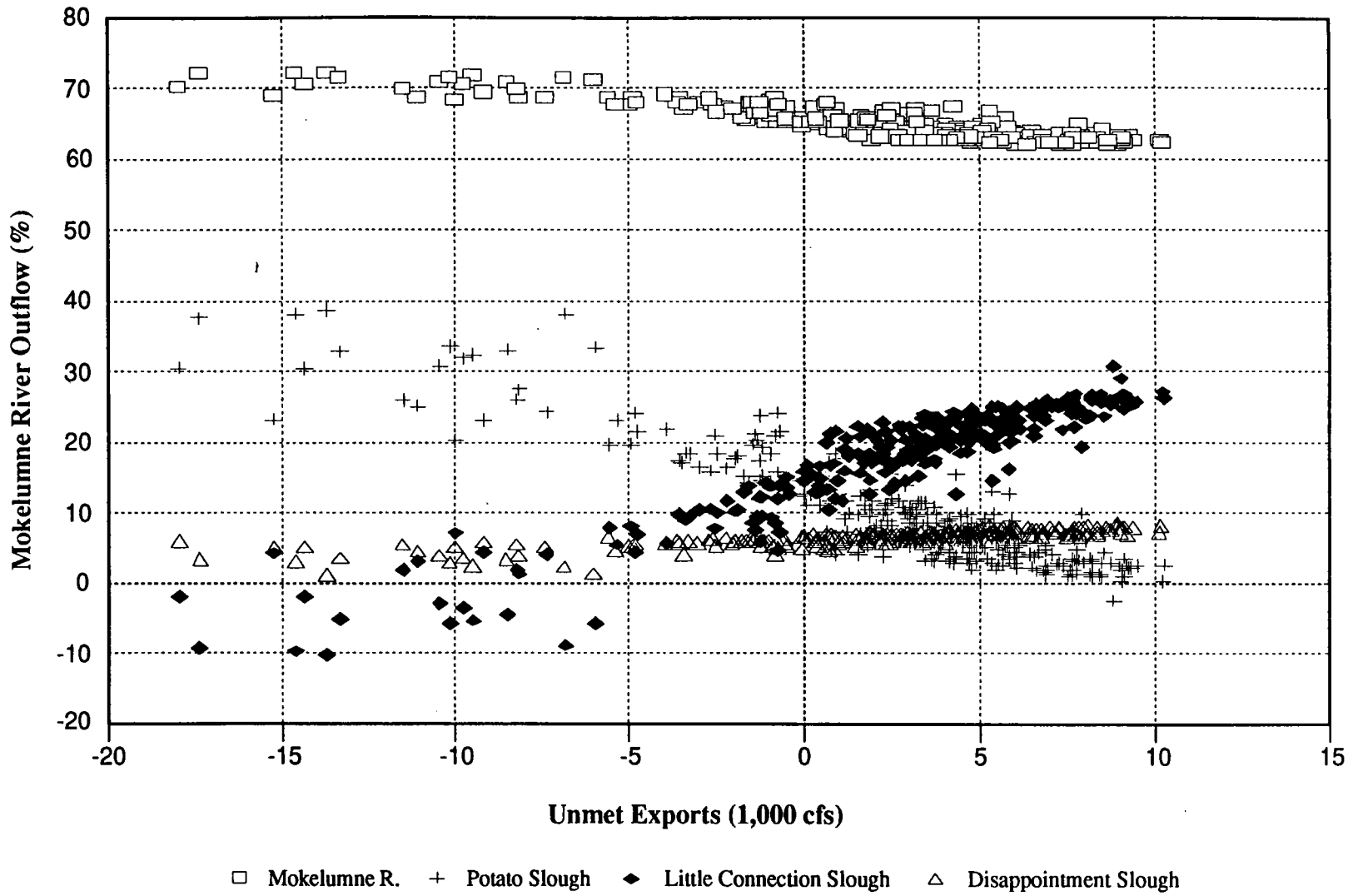


Figure B1-36.
Simulated Relationship between Monthly Average Mokelumne River Channel Flows and Unmet Delta Exports for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

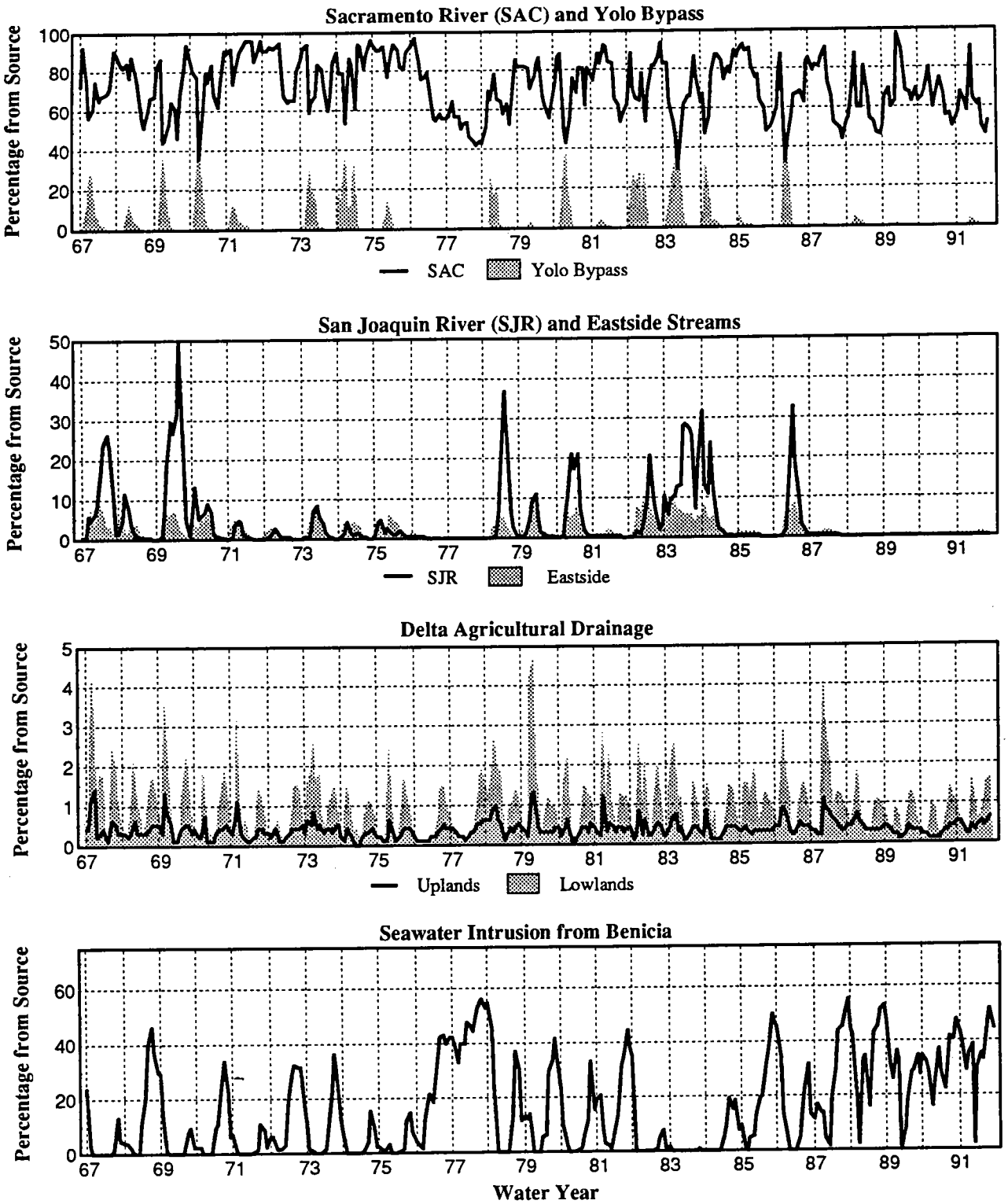


Figure B1-37.
Simulated Historical Monthly Average Contributions of Delta Inflow Sources, Agricultural Drainage, and Seawater Intrusion at Chipps Island for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

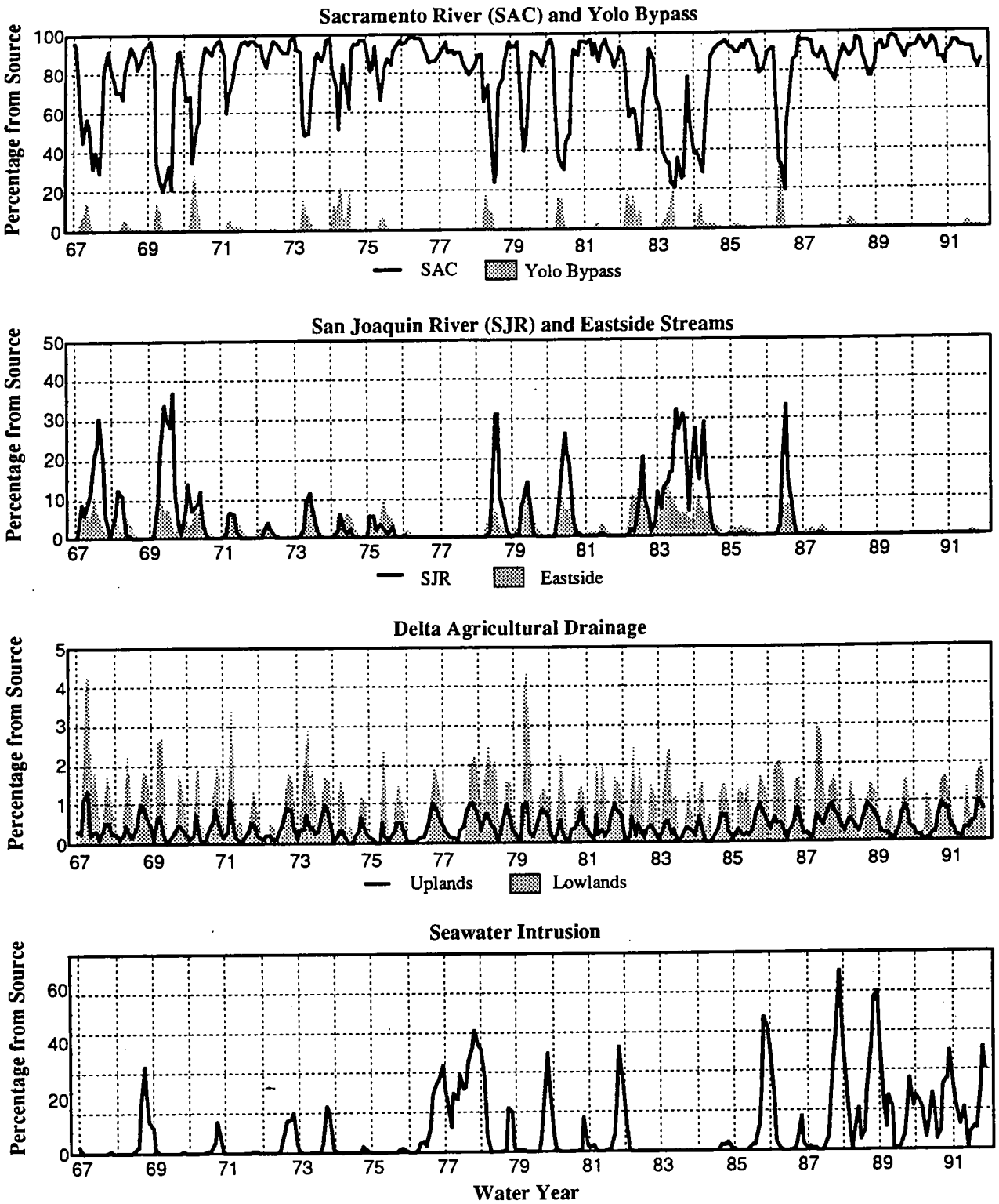


Figure B1-38.
Simulated Historical Monthly Average Contributions of Delta Inflow Sources, Agricultural Drainage, and Seawater Intrusion at Antioch for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

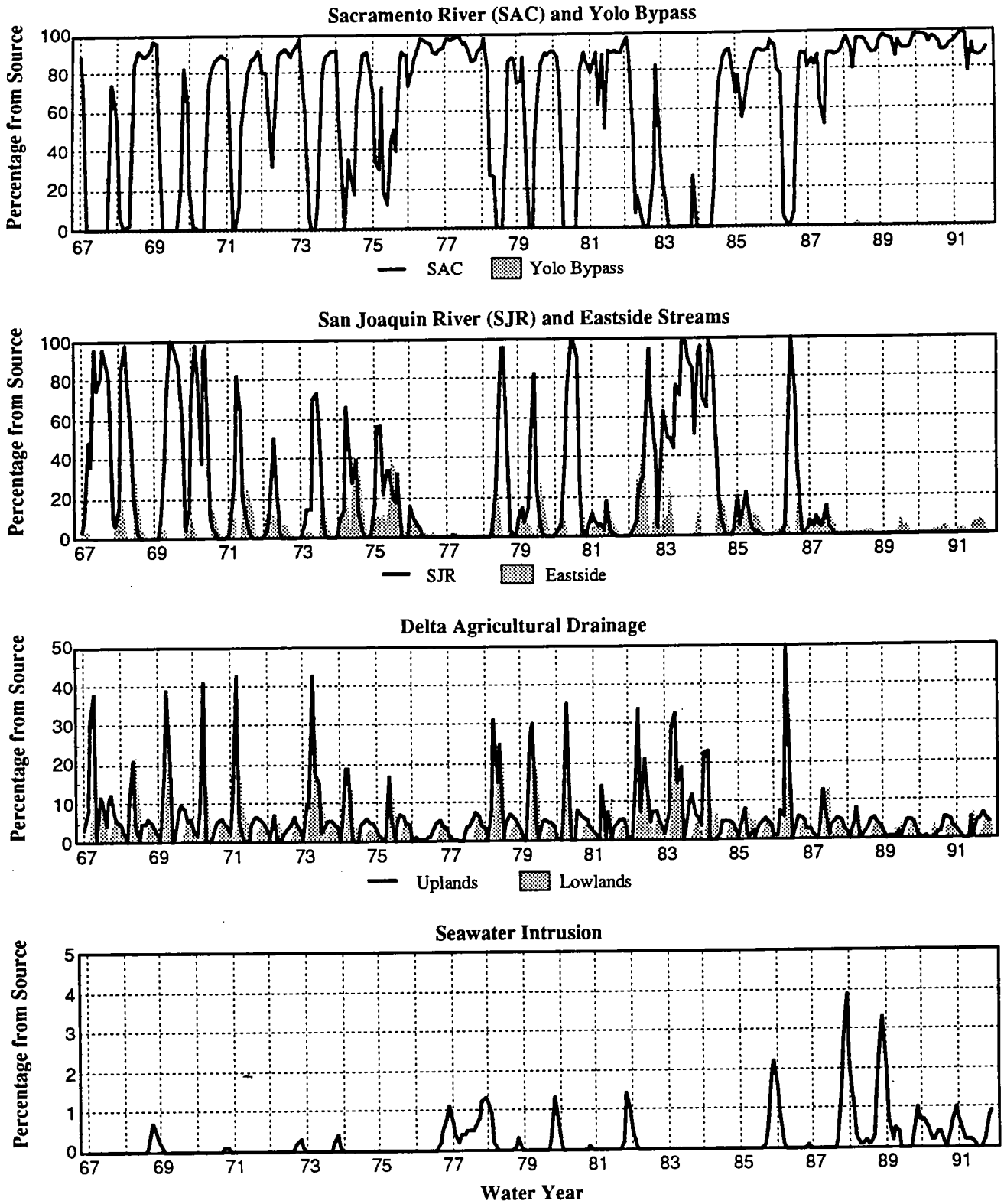


Figure B1-39.
Simulated Historical Monthly Average Contributions of Delta Inflow Sources, Agricultural Drainage, and Seawater Intrusion at CCWD Rock Slough Intake for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

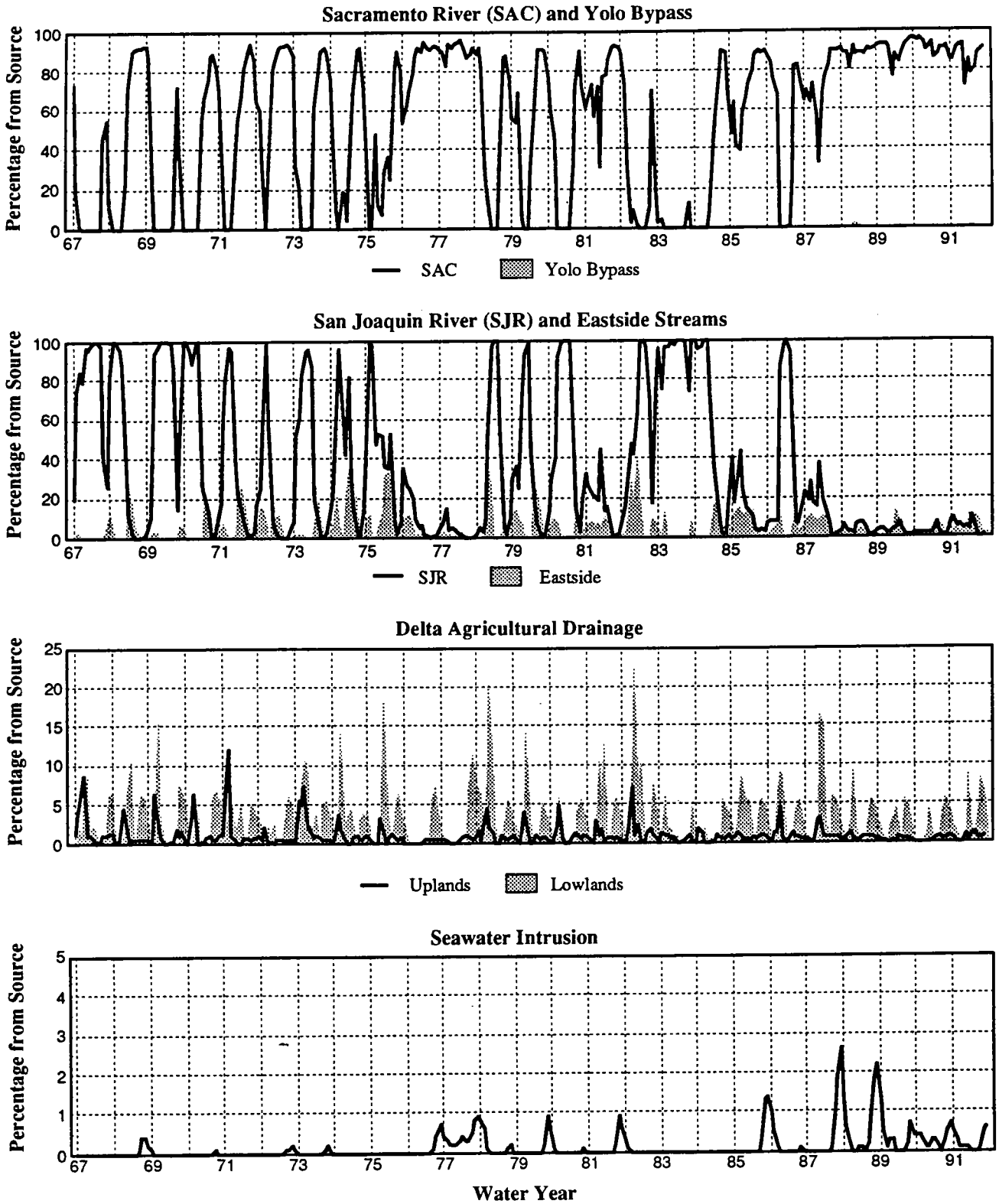


Figure B1-40.
Simulated Historical Monthly Average Contributions of Delta Inflow Sources, Agricultural Drainage, and Seawater Intrusion at SWP Banks Pumping Plant for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

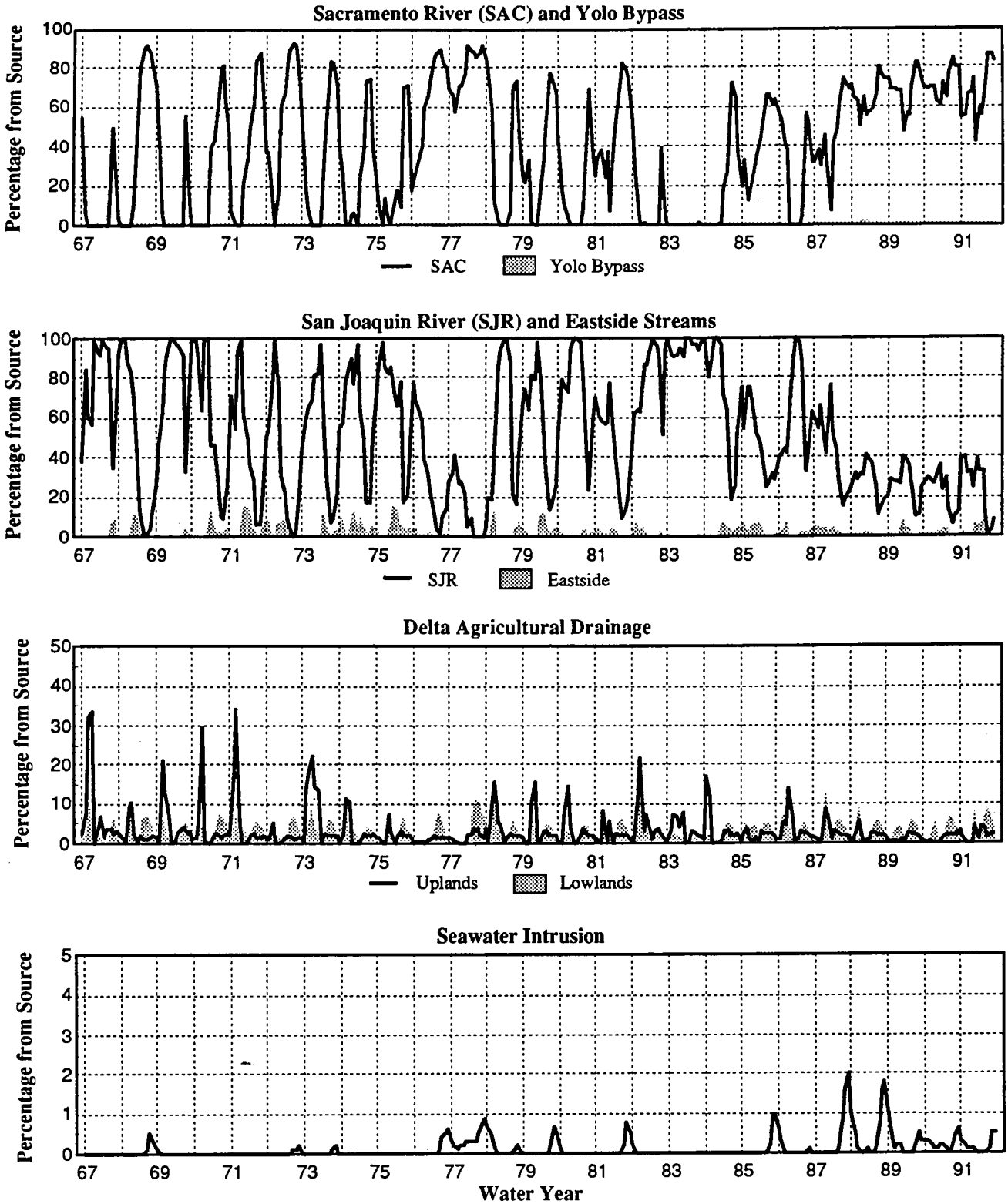


Figure B1-41.
Simulated Historical Monthly Average Contributions of Delta Inflow Sources, Agricultural Drainage, and Seawater Intrusion at CVP Tracy Pumping Plant for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

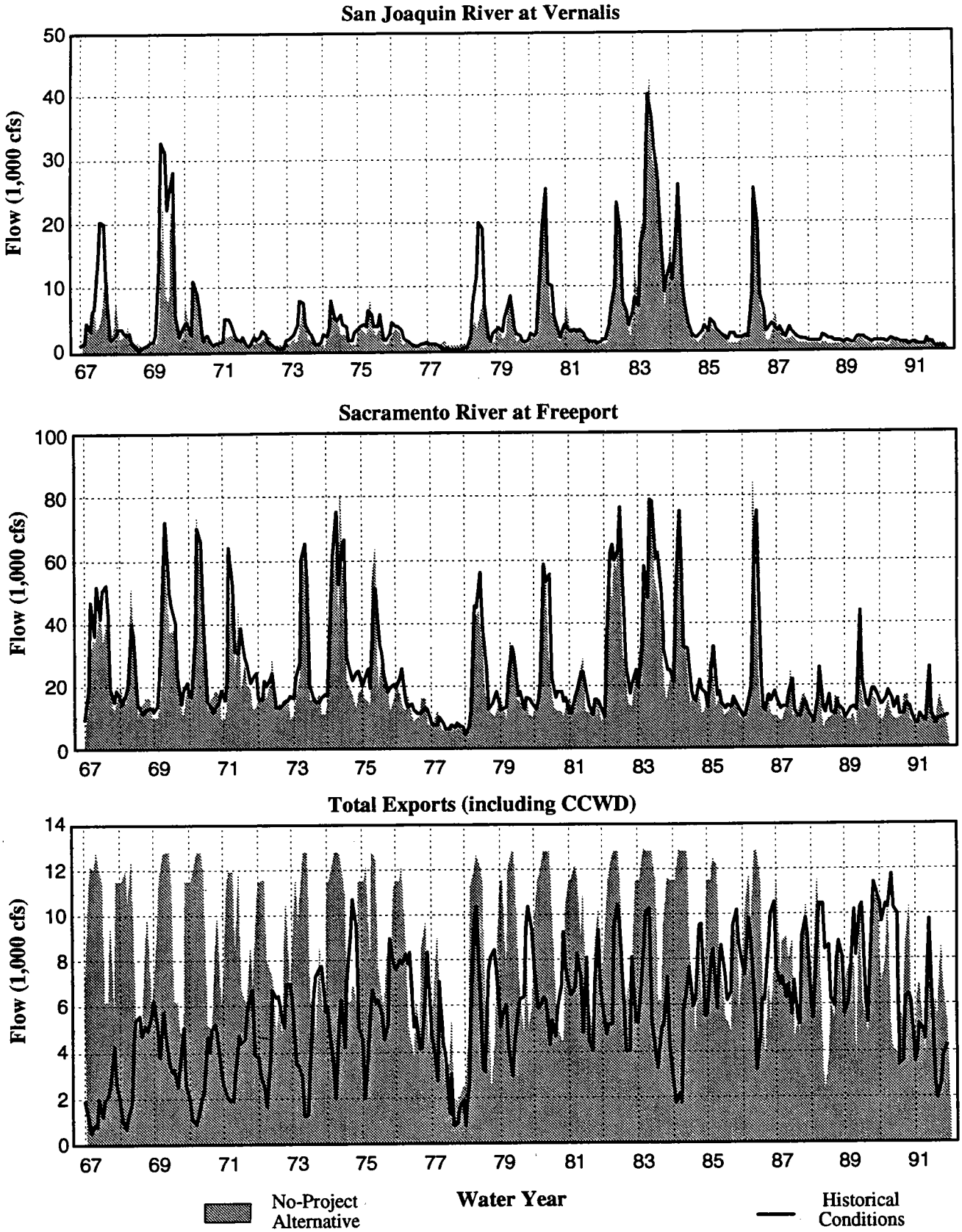


Figure B1-42.
Simulated Monthly Average San Joaquin and Sacramento River Flows and Exports for the No-Project Alternative and Historical Conditions for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

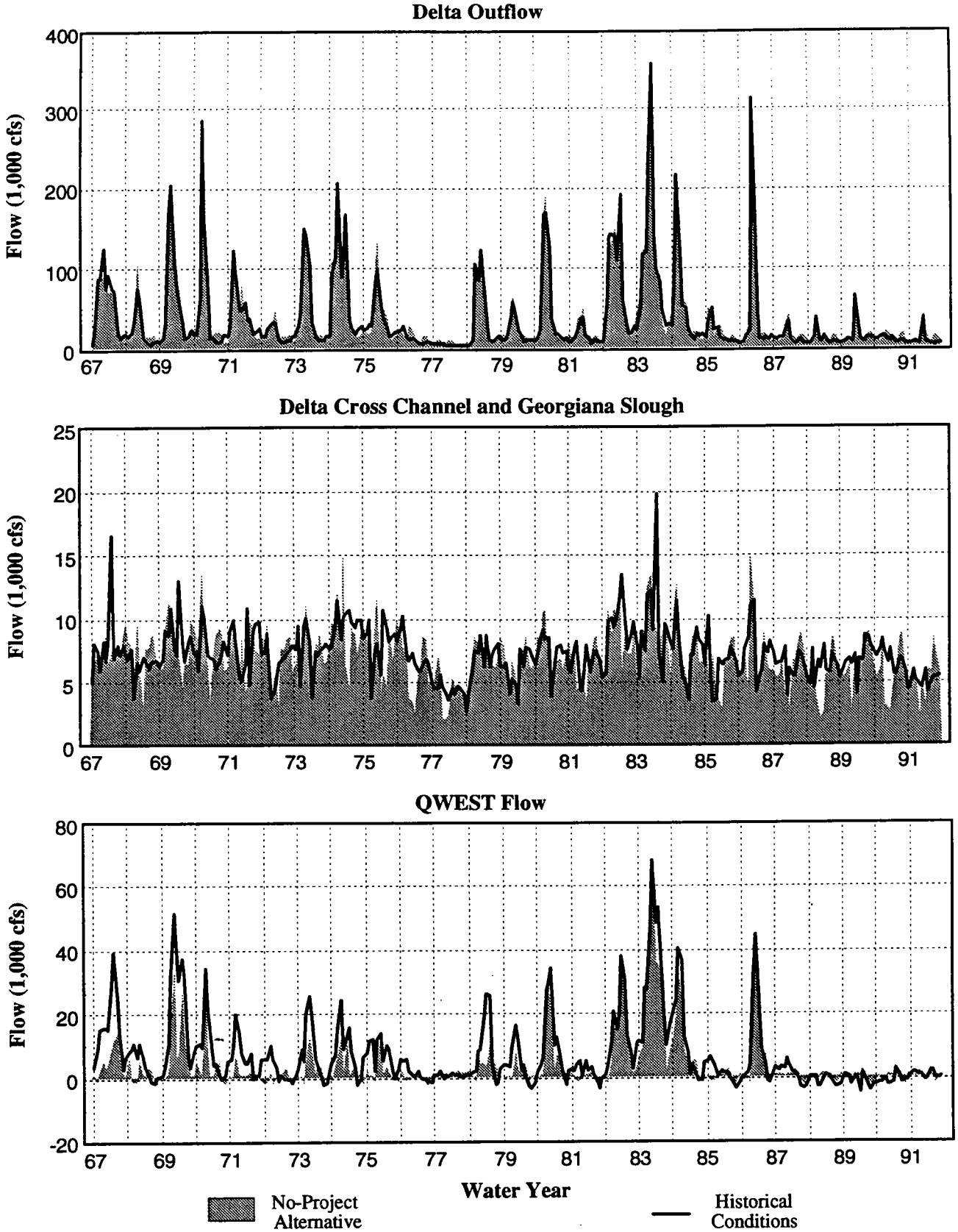


Figure B1-43.
Simulated Monthly Average Delta Outflow, DCC and Georgiana Slough Flow, and QWEST Flow for the No-Project Alternative and Historical Conditions for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

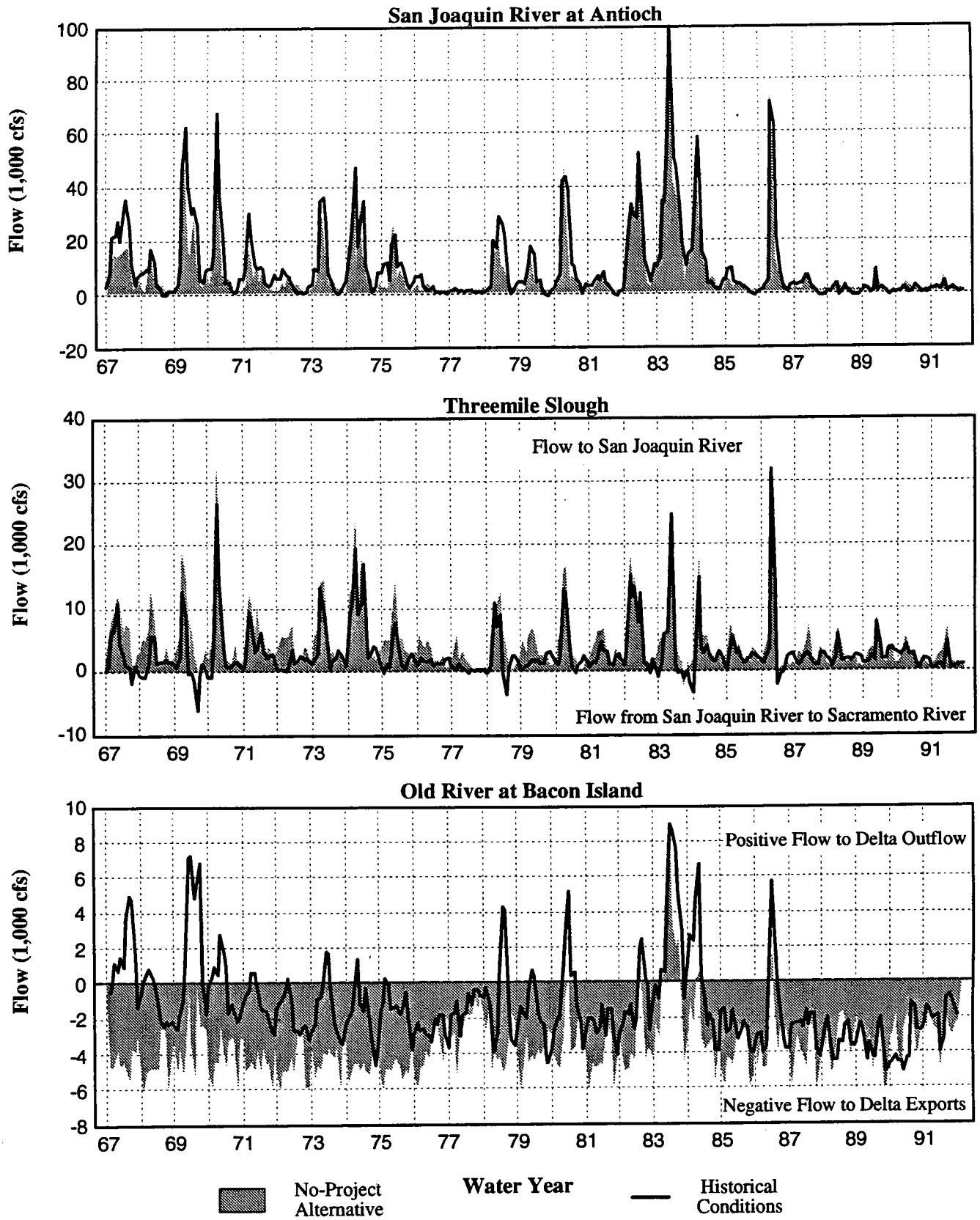
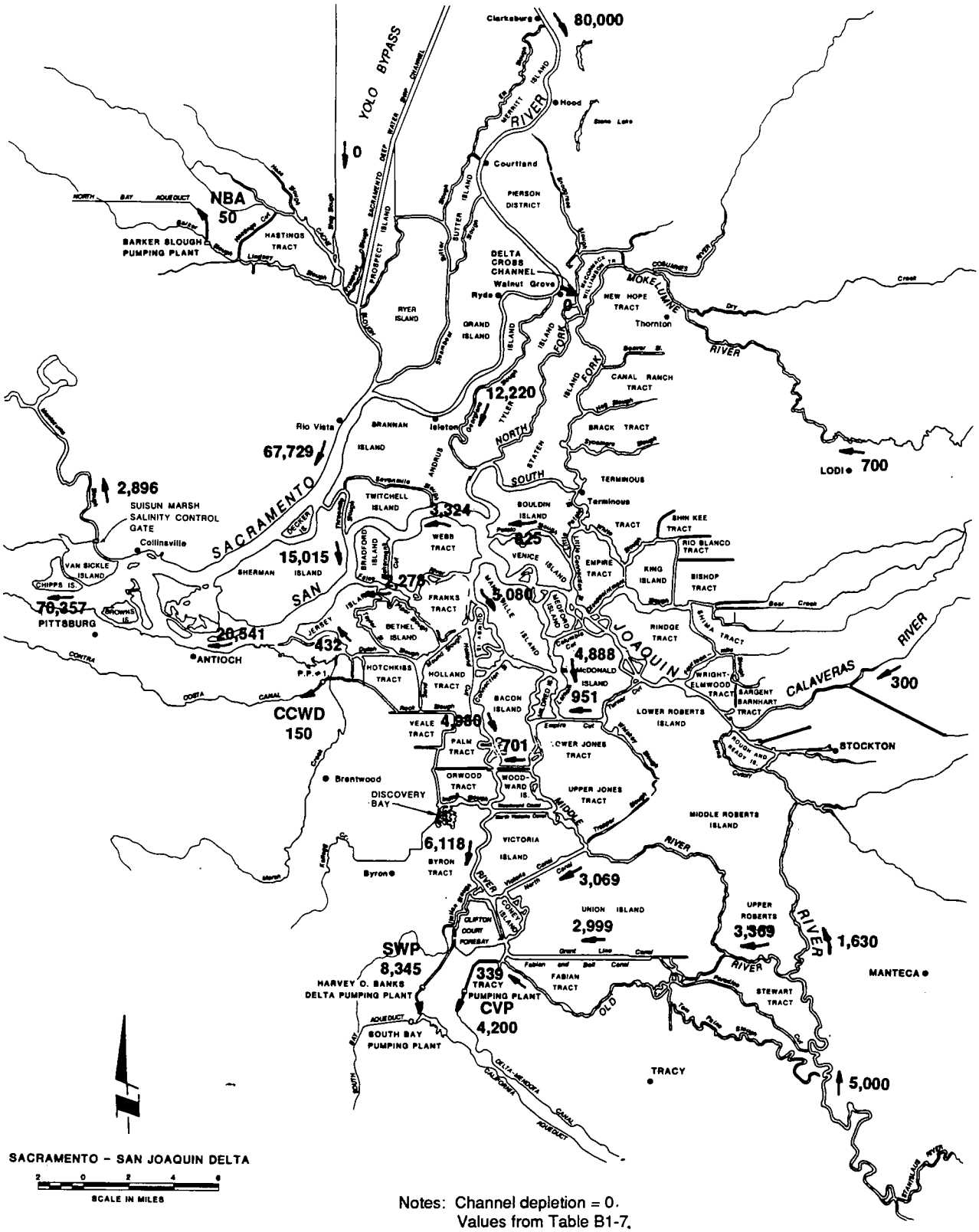


Figure B1-44.
Simulated Monthly Average San Joaquin River, Threemile Slough, and Old River Flows for the No-Project Alternative and Simulated Historical Conditions for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



Notes: Channel depletion = 0.
Values from Table B1-7.

Map source: Adapted from California Department of Water Resources 1993.

Figure B1-45.
Delta Flow Patterns (cfs) under Typical Delta Conditions for Maximum DW Diversions (9,000 cfs) but without the DW Project

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

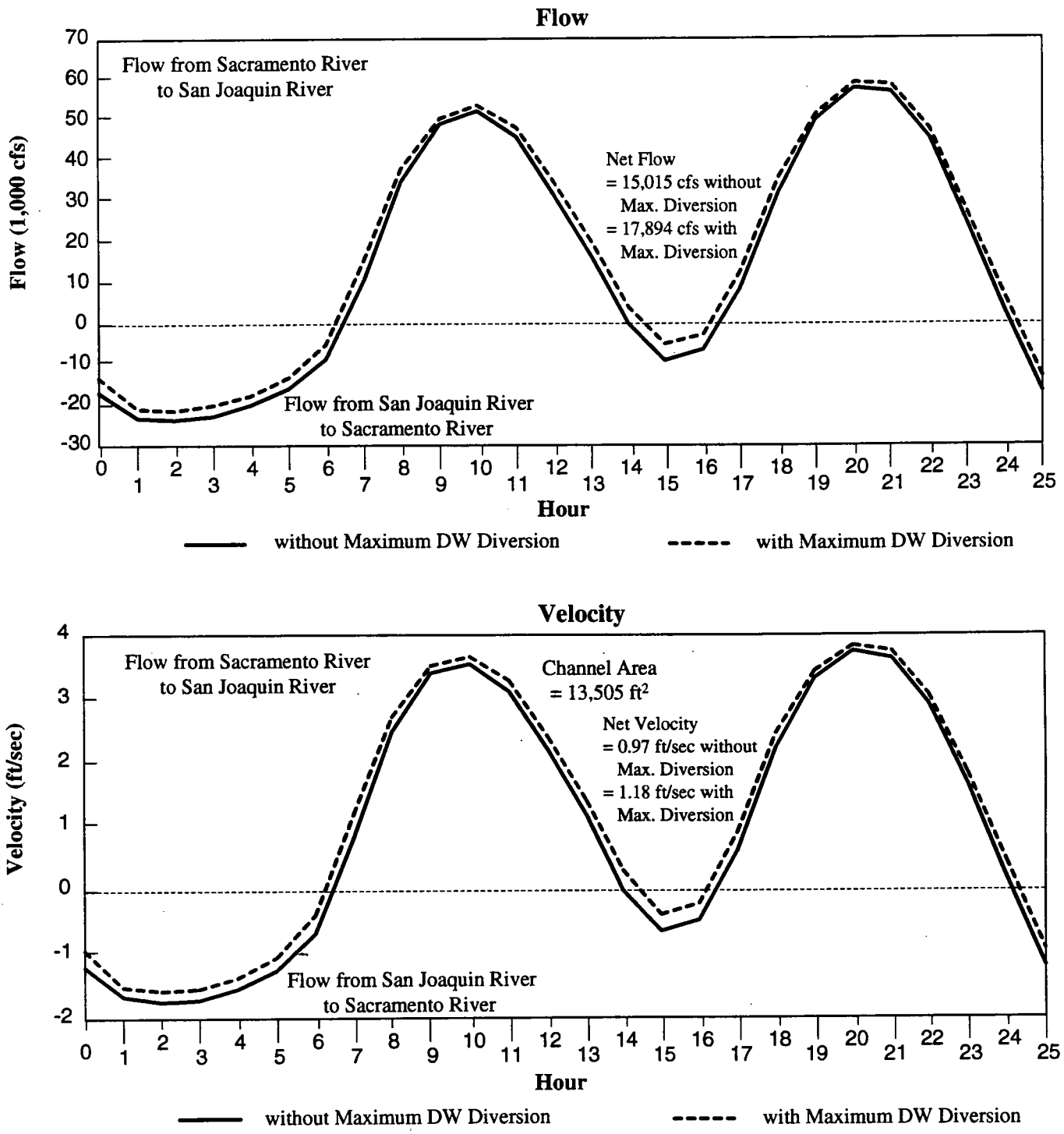


Figure B1-46.
Simulated Tidal Flow and Velocity in Threemile Slough with and without Maximum DW Diversion of 9,000 cfs

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

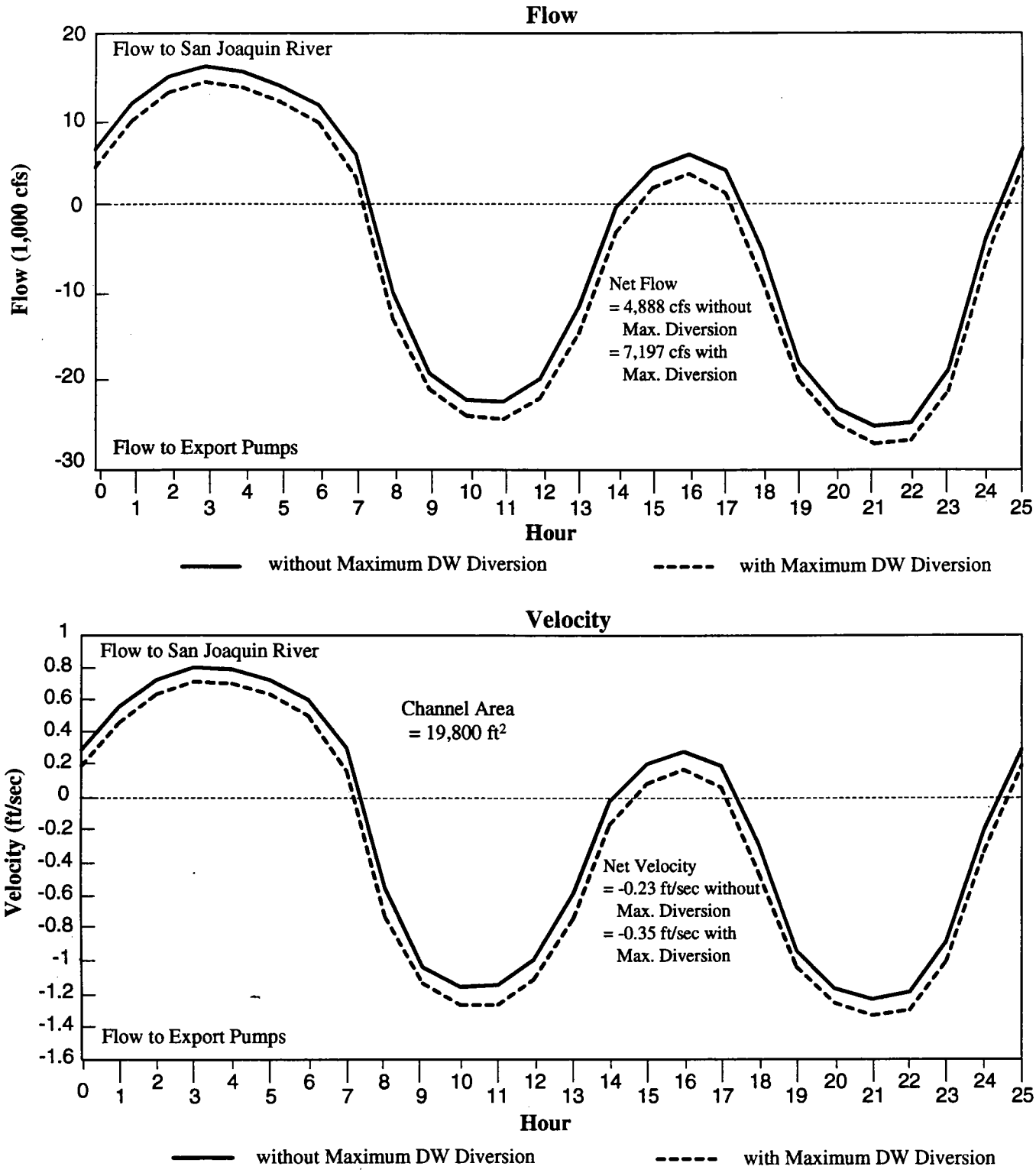
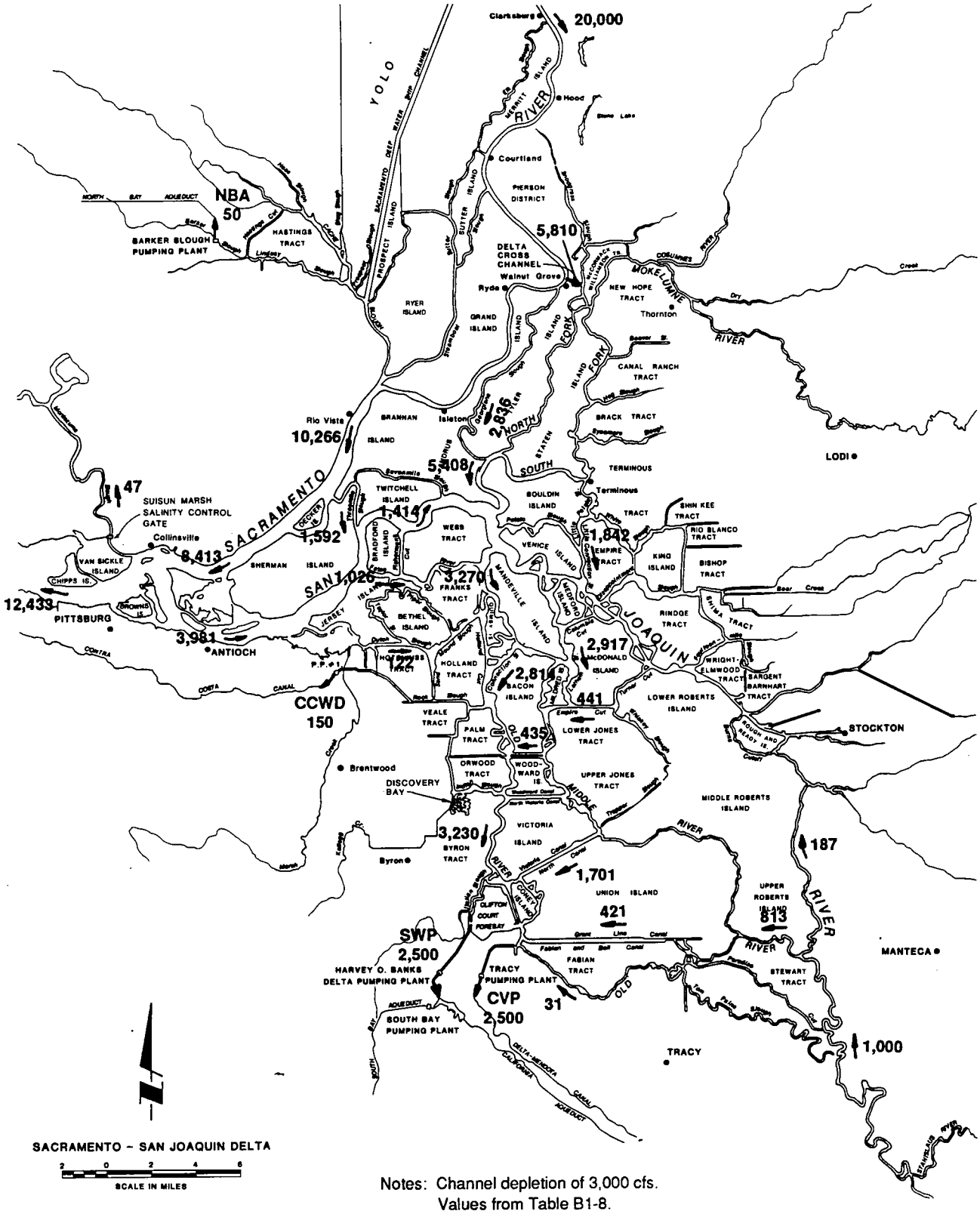


Figure B1-47.
Simulated Tidal Flow and Velocity in Middle River at Columbia Cut with and without Maximum DW Diversion of 9,000 cfs

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

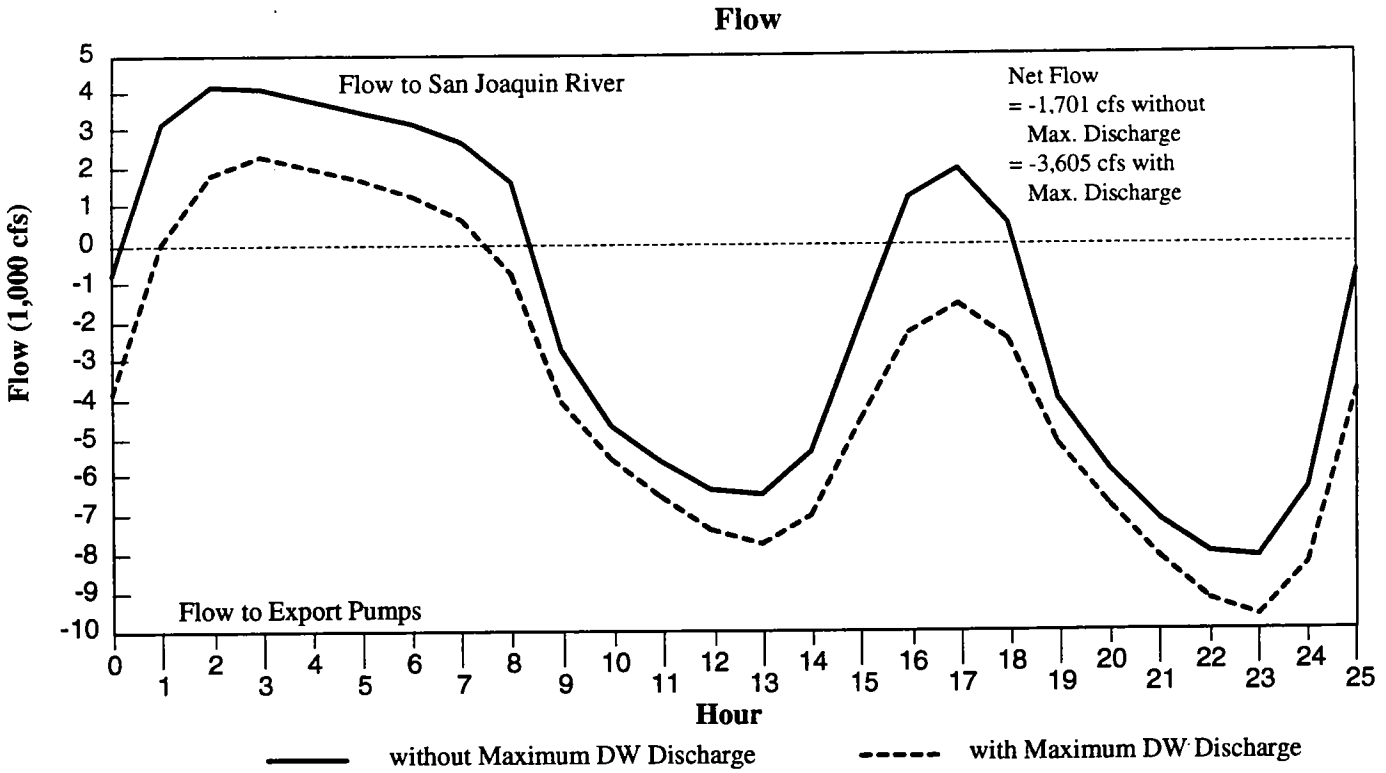


Notes: Channel depletion of 3,000 cfs.
Values from Table B1-8.

Map source: Adapted from California Department of Water Resources 1993.

Figure B1-48.
Delta Flow Patterns (cfs) under Typical Delta Conditions for Maximum DW Discharges (6,000 cfs) but without the DW Project

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



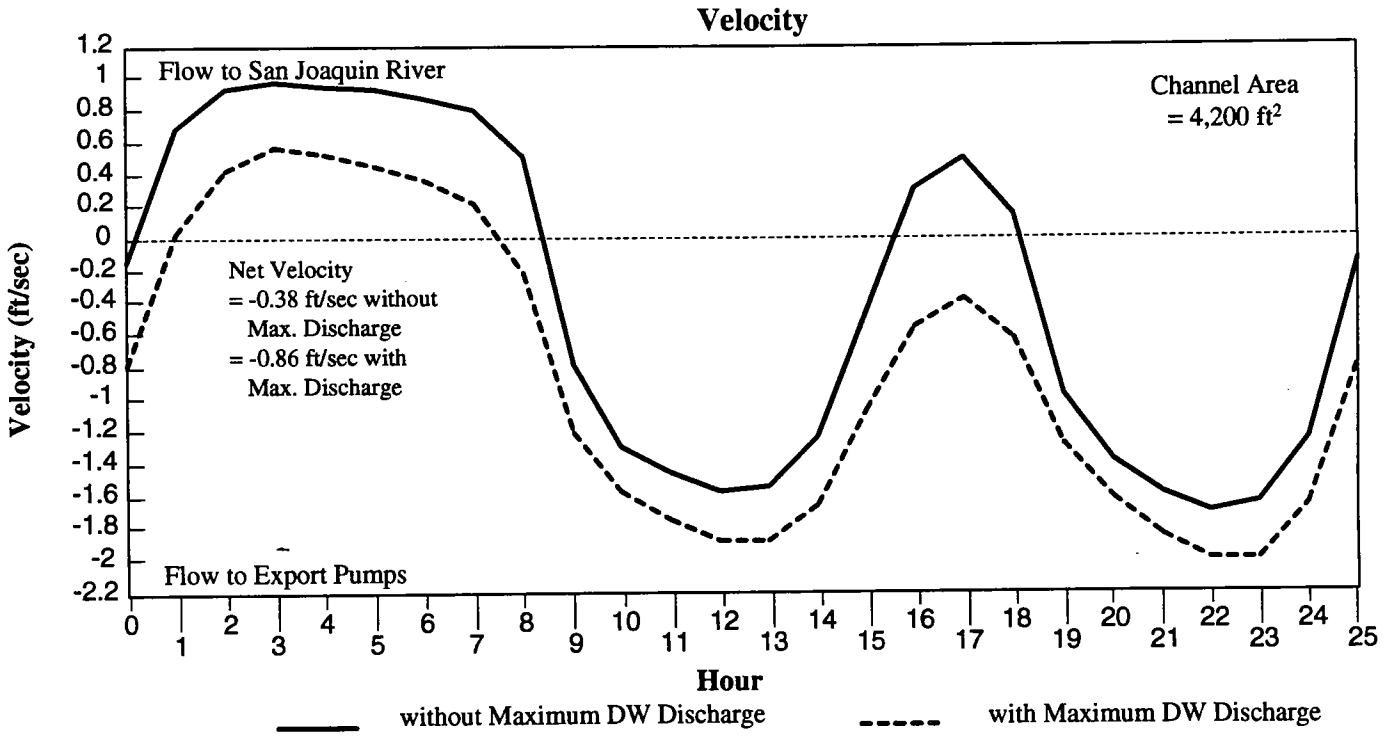
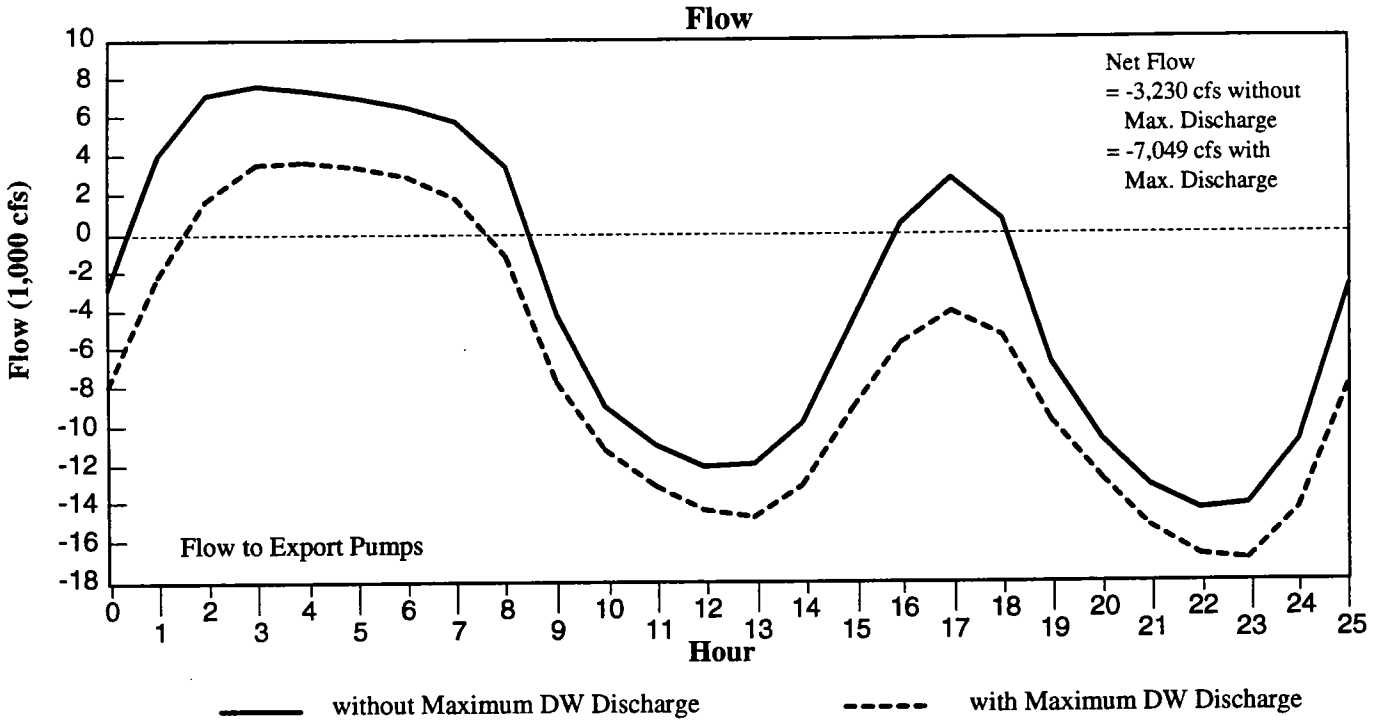


Figure B1-49.
Simulated Tidal Flow and Velocity in Middle River at Woodward Canal with and without Maximum DW Discharge of 6,000 cfs

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



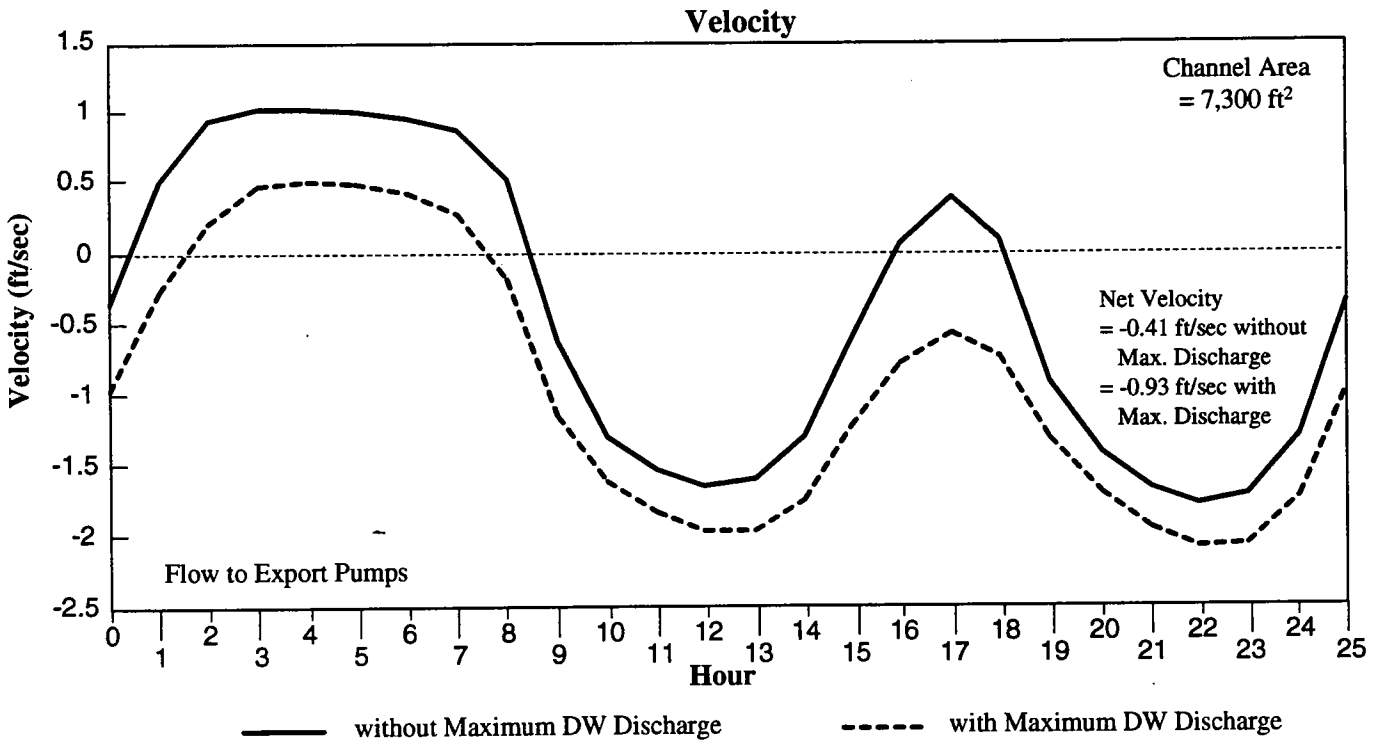


Figure B1-50.
Simulated Tidal Flow and Velocity in
Old River South of Woodward Canal
with and without Maximum DW Discharge of 6,000 cfs

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

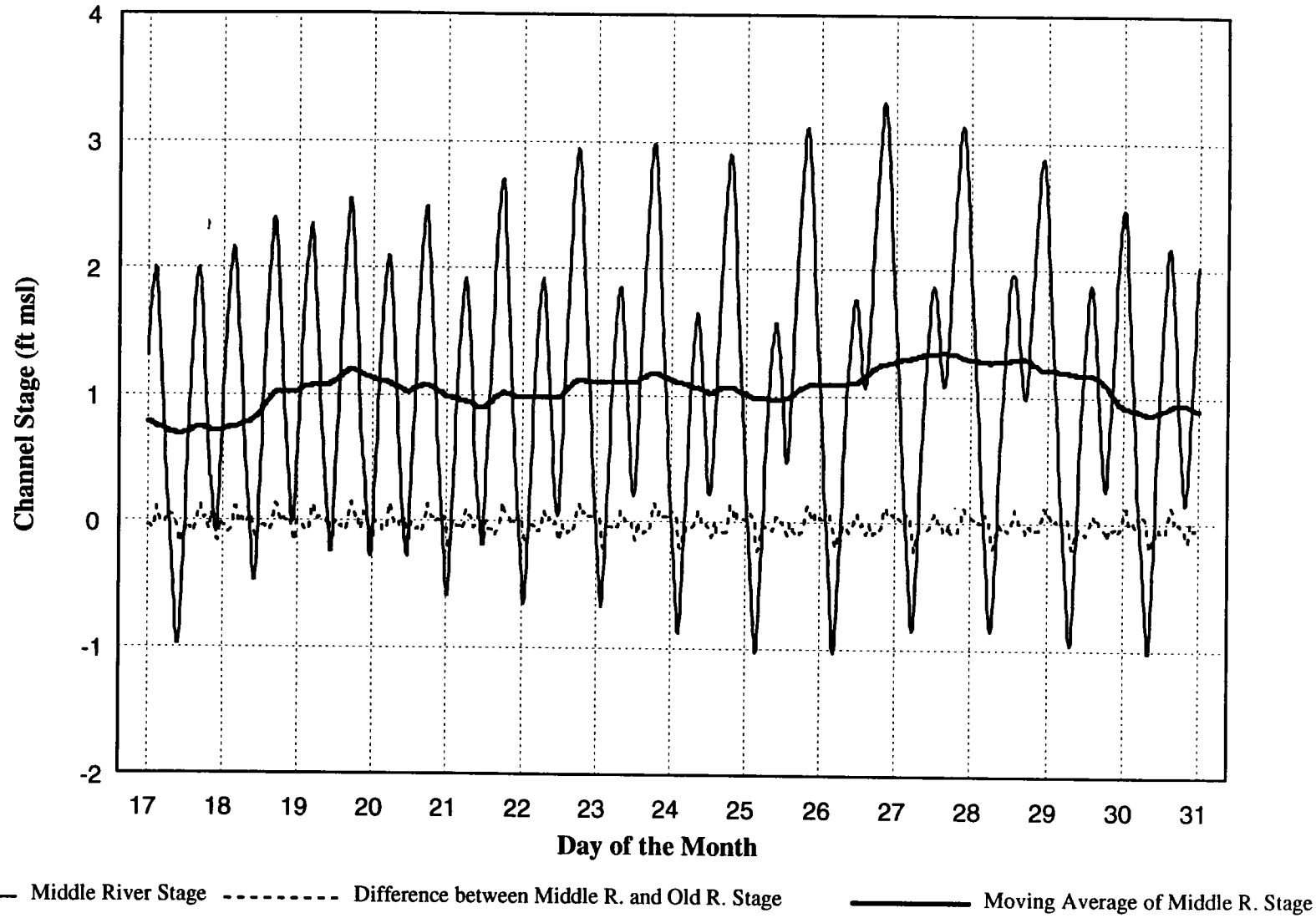


Figure B1-51.
Measured Tidal Stage (15-minute and 25-hour moving average) in Middle River at USGS Ultrasonic Velocity Meter Stations near Bacon Island during October 17-30, 1987

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

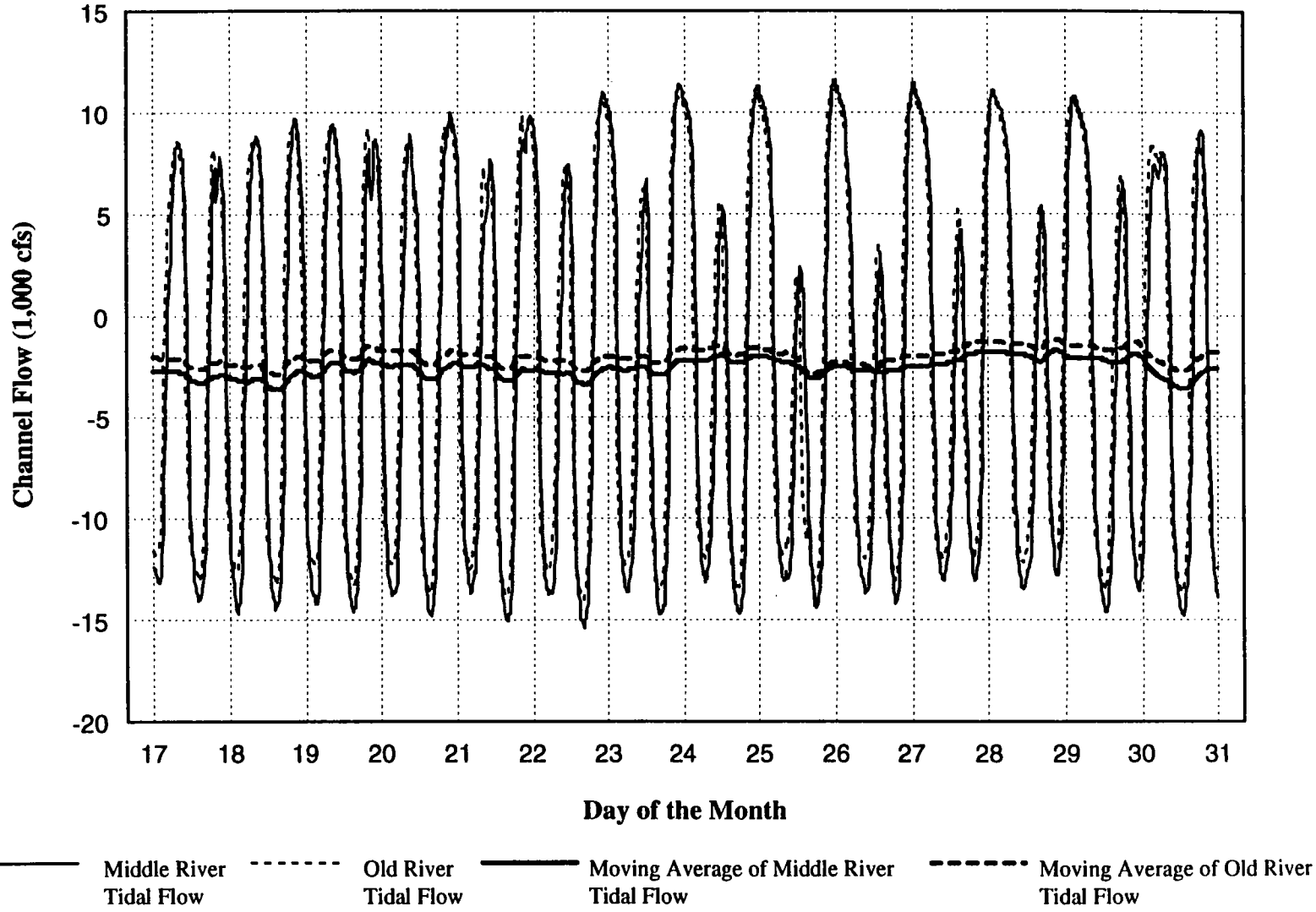


Figure B1-52.
Measured Tidal Flow (15-minute and 25-hour moving average) in Old River and Middle River at USGS UVM Stations near Bacon Island, October 17-30, 1987

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

Appendix B2. Salt Transport Modeling for the Delta Wetlands Project

Appendix B2. Salt Transport Modeling Methods and Results for the Delta Wetlands Project

SUMMARY

This appendix describes the methods and results of modeling the effects of the Delta Wetlands (DW) project on Delta salt transport and contributions of inflow sources to salinity in Delta outflow and exports based on the mass-balance water quality module of the Resource Management Associates (RMA) Delta model. The RMA Delta model results were used to estimate mixed concentrations of water quality constituents at selected Delta locations for each DW alternative and the No-Project Alternative.

The appendix describes net inflow and outflow inputs to the model, estimation of tidal mixing exchange, and calculation of inflow concentrations of water quality constituents. RMA model reliability is confirmed through comparison of simulations of historical monthly electrical conductivity (EC) values with EC data from several Delta locations, and the general accuracy of the model is discussed. The RMA Delta model results were incorporated into the Delta Drainage Water Quality (DeltaDWQ) impact assessment model. Results of DeltaDWQ simulations to determine effects of DW operations on concentrations of water quality constituents at key Delta locations are presented for each DW project alternative and the No-Project Alternative.

Background

Appendix B1, "Hydrodynamic Modeling Methods and Results for the Delta Wetlands Project", describes hydrodynamic modeling of the DW project performed by RMA using its link-node hydrodynamic model of the Delta. As described in this appendix, RMA also performed salt transport modeling under contract to DW and provided modeling results to Jones & Stokes Associates (JSA) for use in the impact analysis for water quality performed for this environmental impact report/environmental impact statement (EIR/EIS).

Previous salt transport modeling performed by RMA was used by JSA in preparing the 1990 draft EIR/EIS on the DW project. That modeling focused on five study years (1964, 1972, 1975, 1976, and 1978), representing each of the five hydrologic year types classified under the criteria of California State Water Resources Control Board's (SWRCB's) Water Right Decision 1485 (D-1485). A detailed description of the RMA model and its use for the 1990 draft EIR/EIS is provided in Smith and Durbin (1989). The major features of the RMA salt transport model are described in this appendix.

For preparation of this revised draft EIR/EIS on the DW project, RMA performed new modeling of historical Delta conditions based on historical inflows and exports for water years 1968-1991. The 1968-1991 period was selected because of the availability of historical EC data for confirmation of model results and because almost all major Central Valley Project (CVP) and State Water Project (SWP) facilities were operational during this period.

As described in Appendix B1, some of the simulated Delta channel flows may have been slightly different from the historical flows because of differences in Delta Cross Channel (DCC) gate openings and operations of the barrier at the head of Old River and uncertainty in estimated channel depletion values (Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model"). Also, the historical island flooding events were not included in the RMA model simulation of historical Delta EC patterns. Nevertheless, the comparison of historical EC data with the RMA model simulations of historical EC values provides the basis for determining the adequacy of these simulations for impact assessment purposes. The simulated response of EC at selected locations to changes in Delta outflow is particularly important for water quality impact assessment of the DW project.

Purpose of This Appendix

The general goal of the salt transport modeling described in this appendix was to simulate salt transport in the Delta over a wide range of monthly inflows, exports, and outflows to determine likely changes that would be caused by additional diversions to and discharges from the DW project islands. Following are the major sections of this appendix and the purpose of each:

- "Formulation of the RMA Delta Water Quality Module" describes the salt transport modeling methodology used by RMA.
- "Modifications of the RMA Model for Simulation of Historical Delta Conditions" describes modifications made to the RMA Delta model for simulations of historical Delta conditions, including using monthly average input data for long-term simulations, performing inflow source tracking, adding simulations of EC and chloride ion (Cl^-) concentration, and using flow regressions to determine inflow concentrations.
- "Confirmation of Historical Monthly Salinity Simulations" provides confirmation of model simulations by comparing historical EC data with water quality module results of EC predicted using historical Delta flows and exports for the 1968-1991 period. The relationships between effective Delta outflow and both measured and simulated EC are described.
- "Impact Assessment Results for the DW Project Alternatives" presents results of the salt transport simulations for the DW project alternatives in comparison with results for the No-Project Alternative.

FORMULATION OF THE RMA DELTA WATER QUALITY MODULE

The RMA Delta model consists of a link-node hydrodynamic module and a mass-balance water quality module. The model represents the Delta as a network of links (channels) and nodes (volume elements). The link-node module, a branched one-dimensional formulation, simulates average velocity and flow in each specified channel cross section (model link) during the specified tidal cycle and average stage (elevation above or below mean sea level) for each volume element (model node) (Appendix B1). The mass-balance module of the RMA Delta model was formulated and used to simulate Delta salt transport and estimate average mixed concentrations of water quality constituents in each volume element.

Water quality module simulations are based on results of the hydrodynamic module simulations. The Delta channel tidal flows simulated with the hydrodynamic module are used to estimate daily tidal mixing (mixing of water caused by fluctuating tidal flows) and net daily flows between volume elements (model nodes). Mixed concentrations of water quality constituents are simulated in the water quality module based on these hydrodynamic module results.

Mass Balance with Net Flows and Tidal Mixing

The RMA water quality module estimates the mass balance for each water quality constituent to calculate a daily mixed concentration for each of the volume elements (model nodes), based on the net flows between nodes calculated in the hydrodynamic module and on tidal mixing between volume elements. Tidal mixing is estimated based on tidal flows in the channels (links) connecting volume elements (nodes). As described in Appendix B1, monthly average inflows and exports are used to simulate flows in Delta channels.

The hydrodynamic module tracks water moving into and out of a volume element (node). The water quality module computes mass balances of water quality constituents in each node by combining flow rates with appropriate concentrations for the water quality constituents. Figure B2-1 illustrates the mass-balance terms for a typical model node. Water quality concentrations are simulated using a daily time step within the month, but end-of-month values are reported as the most appropriate results from simulations of monthly average flows.

Inflows and Outflows

Because the RMA water quality module uses net daily flows, the volume of each element can be considered as a constant representing mean water elevation conditions.

For a constant water volume, the sum of all inflows must equal the sum of all outflows. Inflows include net flows from other volume elements, river inflows at upstream boundaries, agricultural drainage, and rainfall onto the water surface. Outflows include net flows to other

volume elements or across the downstream boundary, agricultural diversions (or Delta export), and evaporation from the water surface. Tidal mixing exchanges are also included in the water budget but they represent equal flows moving in both directions (i.e., no net change in flow). (Tidal mixing exchange flows are explained in the next section.)

For the change in concentration of a water quality constituent within a volume element (node) to be calculated, inflowing concentrations must be combined with water flow rates. The outflowing concentration is assumed to be the average mixed concentration of the volume element for the previous time step. Average mixed concentrations of surrounding volume elements for the previous time step are used for net inflows from other volume elements and tidal exchange flows between adjacent volume elements. Rainfall is assumed to have a concentration of zero. The agricultural drainage concentration must be estimated separately, as described below under "Agricultural Drainage Salt".

Tidal Mixing Exchange

Tidal mixing exchange flow is the portion of tidal flow that causes mixing of concentrations between adjacent model segments. Tidal mixing exchange flows must be estimated from tidal flow characteristics and geometry for each connecting channel (model link). Tidal mixing exchange flow is a two-way flow between model elements that is related to the dispersion coefficient as follows:

$$\text{TME (cfs)} = \text{area (ft}^2\text{)} \times \text{D (ft}^2\text{/sec)/(2 x length [ft])}$$

where:

TME = tidal mixing exchange flow, in units of cubic feet per second (cfs);

area = cross section of the connecting channel (link), in units of square feet (ft^2);

D = dispersion coefficient as normally used in one-dimensional mixing studies, in square feet per second (ft^2/sec); and

length = length of the connecting channel.

In the RMA water quality module, the dispersion coefficient is assumed to be proportional to the average tidal velocity for each link. The module has an additional term for circulation induced by the longitudinal salinity gradient. The term for circulation induced by the salinity gradient is small compared with the tidal velocity term in most parts of the Delta.

Measured values of the dispersion coefficient generally range between 200 ft^2/sec and 2,000 ft^2/sec (Fischer et al. 1979). Following is the equation used to estimate the dispersion coefficient in the RMA water quality module:

$$\text{D (ft}^2\text{/sec)} = \text{(C x tidal flow parameter)} + \text{(K x salt gradient)}$$

where:

C and K are empirical coefficients used in the RMA dispersion formulation that are estimated during calibration (Smith and Durbin 1989).

Tidal flow parameter is estimated from average tidal velocity to be

$$(|\bar{u}| + \sigma_u)/R^{0.43}$$

where:

$|\bar{u}|$ = tidal average absolute velocity (ft/sec);

σ_u = standard deviation of tidal velocity (ft/sec); and

R = hydraulic radius (ft), equal to channel cross-sectional area divided by channel perimeter.

Salt gradient = measure of the longitudinal change in salinity, in units of parts per million per foot (ppm/ft).

Dispersion coefficients estimated in the RMA water quality module range from about 300 ft^2/sec to 900 ft^2/sec.

As indicated above, in the RMA water quality module, the dispersion coefficient is multiplied by the cross-sectional area of a channel to yield the tidal mixing exchange flow. Because both $|\bar{u}|$ and σ_u have a linear correlation to tidal velocity, tidal mixing exchange flow is proportional to tidal flow. The exchange flow is generally 1%-5% of tidal flow. Figure B1-14 (in Appendix B1) shows the magnitude of average flood tide flows in Delta channels, indicating the relative strength of the tidal mixing exchange in these channels. Channels with high tidal flows will have greater simulated tidal mixing exchanges between volume elements.

The assumption that tidal mixing exchanges are largely controlled by tidal flows and do not depend strongly on the salt gradient itself allows the model to be used for water quality constituents other than salt. Tidal mixing exchange occurs between volume elements in the RMA model regardless of the magnitude of the salt gradient.

Downstream Boundary for Tidal Salt Exchange

A net outflow of water and a large tidal mixing exchange are simulated at the downstream boundary of the RMA Delta model (node 361) near Benecia. A tidal exchange formula (Fischer et al. 1979) is used to estimate the downstream concentrations of San Pablo Bay water quality constituents for use in the tidal exchange term. A mass balance of the downstream node is estimated from the ebb and flood tidal flows and freshwater outflow. The concentration of the flood tide flow represents a mixture of the ebb flow and a specified constant downstream (San Pablo Bay) concentration. The ebb flow is assumed to have a concentration proportional to that of the downstream node concentration. The boundary condition is calibrated through adjustment of the proportional coefficient.

In the RMA water quality module, San Pablo Bay EC is assumed to be constant at 31,700 microseimens per centimeter (μS/cm), or 31.7 milliseimens per centimeter (mS/cm) (containing total dissolved solids [TDS] at a concentration of 22,000 milligrams per liter [mg/l] and Cl^- at 11,600 mg/l). Flood tide flows are assumed to be a 1:1 mixture of the previous ebb flow (outflow) and San Pablo Bay water. The model represents a characteristic relationship between outflow and the EC value at the downstream node (node 361) as an exponential decrease in EC with increasing Delta outflow (called a negative exponential relationship). However, the maximum simulated boundary EC is 31.7 mS/cm for an outflow of 0 cfs.

Figure B2-2 compares the results of the downstream salt boundary formulation simulated by the RMA water quality module with historical Delta flows and historical monthly average EC data from Benicia. At the lowest historical monthly average Delta outflow of about 2,000 cfs, the module simulated an EC value of about 26,000 μS/cm (26 mS/cm) for Benicia (node 360). With Delta outflow of 20,000 cfs, the simulated EC value at Benicia is about 11,000 μS/cm (11 mS/cm). At Delta outflow of 40,000 cfs, the simulated EC value at Benicia is approximately 5,000 μS/cm (5 mS/cm).

Historical EC measurements from Benicia are presented as monthly averages of the daily means. The measured historical Benicia EC data and the RMA simulation results for node 360 have similar relationships to Delta outflow (Figure B2-2). The basic pattern observed and simulated at Benicia is an exponential increase in EC with decreasing flow. The match is most important at relatively low Delta outflows (less than 20,000 cfs), when salinity intrusion is greatest and EC is highest.

Figure B2-2 also shows the relationship between Delta outflow and simulated EC values at Pittsburg (node 356), just upstream of Chipps Island. This simulated relationship is quite similar to that between Delta outflow and historical mean monthly EC values at Pittsburg. The RMA model's simulation of tidal mixing exchange at the downstream boundary and in Suisun Bay between Benicia and Pittsburg has been calibrated to provide a good match with the general pattern of historical monthly EC data as summarized by the relationships between Delta outflow and EC values at these locations. Additional comparisons of simulation results with measured EC data are described below under "Confirmation of Historical Monthly Salinity Simulations".

The historical monthly average EC data from Benicia and Pittsburg appear more scattered than the simulated values on the graph of the relationship between Delta outflow and EC. Some of this scatter can be explained by the concept of effective outflow, which incorporates the sequence of previous Delta outflows. Effective outflow is defined as the steady outflow that would produce the salinity gradient location observed in the historical EC data. The salinity gradient location in Suisun Bay is governed by the balance between Delta outflow and tidal mixing of salinity from San Pablo Bay. During periods of steady outflow, the mean salinity gradient becomes stationary at a location that depends on Delta outflow. However, an increase or decrease in outflow will not immediately change the location of the salinity gradient; its movement can be described in terms of effective outflow, which depends on antecedent conditions.

Contra Costa Water District (CCWD) has suggested a method for estimating the effective Delta outflow to describe salinity intrusion effects in the Delta (Denton 1993a). The method involves using a relatively simple "routing" equation to calculate the equivalent steady outflow for each month, based on the previous month's effective outflow and this month's estimated average outflow. If this adjustment is made to the historical monthly average Delta outflow estimates and the historical monthly average EC data are plotted against effective outflow rather than historical outflow, these data from Benicia and Pittsburg more closely follow the expected negative

exponential relationship with outflow, as shown in Figure B2-3. The suggested method for adjusting outflows to obtain the effective Delta outflows is described below under "Relationships between Electrical Conductivity Data and Effective Delta Outflow".

Upstream Inflow Concentrations

Inflow concentrations of water quality constituents must be specified for each upstream inflow to the RMA model: Sacramento River and Yolo Bypass, eastside streams, and San Joaquin River.

Historical EC measurements are available for inflows from the Sacramento and San Joaquin Rivers. Future inflow sequences may differ from historical sequences, however, because of changed operation of upstream reservoirs and changed upstream diversions. For planning studies based on future sequences of simulated inflows, historical EC sequences cannot be used. Instead, the historical EC data are related to flows using flow regressions, and the flow regressions are used to estimate the corresponding EC values from the simulated inflows. Flow regressions for Sacramento and San Joaquin River inflow EC values are described below under "Flow Regressions for Inflow Concentrations".

Agricultural Drainage Salt

In the Delta, EC values in agricultural drainage water vary seasonally and depend on the water and salt management practices on each island. The EC values of the agricultural diversions from the Delta channels to the islands depend on seasonal salinity intrusion and EC values in inflowing rivers. Agricultural islands do not represent large net sources of salt, although the islands may receive some residual salt from fertilizers and dissolution of soil minerals. EC values in drainage water are related primarily to the seasonal buildup of salt in agricultural fields resulting from evapotranspiration (ET); this salt is subsequently removed from the soils by rainfall or water applied for salt leaching in winter.

The RMA model tracks the water and salt budget for each Delta island, assigning diversions and drainage flows to the appropriate model nodes. The monthly volume estimates for applied and drained water for the lowland and upland portions of the Delta are obtained from the DeltaDWQ model described in Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model", and are included in the input file for the RMA Delta model. The increased salt concentrations in drainage water caused by ET are simulated with the RMA water quality module.

Irrigated Delta lowlands encompass about 340,000 acres, and irrigated Delta uplands encompass about 140,000 acres. Agricultural diversions and drainage flows can be quite large during the irrigation season. Only rough estimates of the actual drainage and diversion flows are available. Therefore, possible inaccuracies in these specified flows may have a relatively large effect on simulations of Delta outflow volumes and corresponding salinity intrusion events during low-flow periods.

For example, 1 inch of drainage or diversion volume from 480,000 acres is equivalent to a flow of about 675 cfs for a month. Because it is likely that the available estimate of net channel depletion in the Delta is only moderately accurate (±0.5 inch per month), the resulting estimates of Delta outflow may easily be 500 cfs higher or lower than actual Delta outflow.

An additional uncertainty in the simulation of Delta agricultural drainage effects results from the magnitude of seasonal buildup and discharge of soil salinity from irrigation, ET, rainfall, and leaching practices being unknown (see Appendix C2, "Analysis of Delta Agricultural Drainage Water Quality Data"). The RMA model represents an accurate salt budget for each Delta island, but the seasonal patterns of drainage volume and drainage EC values are only approximate average conditions for the Delta.

MODIFICATIONS OF THE RMA MODEL FOR SIMULATION OF HISTORICAL DELTA CONDITIONS

Several modifications to the RMA Delta model were made for the simulations of historical Delta conditions:

- JSA developed input data for long-term (25-year) RMA simulations based on 1967-1991 monthly average Delta inflows and exports.
- The RMA model tracked each of the river inflows, Delta agricultural drainage, and seawater intrusion from the downstream model boundary throughout the Delta to calculate source water contributions.
- The RMA model tracked Cl^- concentration and EC along with TDS, the traditional modeled variable for salinity. JSA used flow regressions

to estimate EC and concentrations of Cl^- in each river inflow.

- The RMA model calculated salt balances for each DW island and each Delta agricultural island to estimate drainage concentrations.

The following sections describe these modifications for long-term monthly average historical simulations.

Long-Term Simulations

For the current EIR/EIS analysis, results of long-term RMA model simulations were used to estimate Delta levels of EC and concentrations of Cl^- and bromide ion (Br^-). Values for other water quality constituents were estimated using a combination of direct simulation performed by the water quality module and flow weighting of source concentrations based on source tracking simulated by the water quality module. Monthly average inflows were used to simulate monthly average net flows in Delta channels using the RMA hydrodynamic model (Appendix B1). Inflow water quality is held constant during the month. The water quality constituents were simulated with daily time steps within the month, but only the end-of-month values are reported.

The long-term simulations allow the Delta water quality patterns to be compared under a wide range of Delta flow conditions. Seasonal effects and long-term effects from drought sequences are simulated within the 25-year period.

Source Tracking with Modeled Dye

The RMA model was used to track Delta inflows, seawater intrusion, DW discharges, and Delta agricultural drainage from their sources to various Delta locations. Based on the source tracking analysis, other Delta water quality constituents could be evaluated if their inflow concentrations are known.

Source tracking was accomplished through simulation of movements of conservative (nondecaying) dye tracer having a constant inflow concentration at each inflow location. Concentrations of the dye simulated at other locations in the Delta reflect the proportional contribution of water at that location from the inflow source being tracked. The RMA model produced end-of-month modeled dye concentrations corresponding to average monthly net flow patterns.

Seawater intrusion volume tracking was performed using a seawater salt simulation that tracked only salt moving upstream from the downstream boundary. Salt tracking was used because water source tracking from the downstream boundary involves small flow percentages. The seawater source contribution was estimated by dividing the simulated seawater salt concentration by the salt concentration for seawater from San Pablo Bay (11,600 mg Cl^- per liter of seawater).

Each DW island discharge was tracked to the selected destinations with modeled dye simulations. Although individual DW island discharges were tracked, only the aggregate contribution from DW project discharges is reported.

All Delta agricultural discharges were dyed and tracked with another modeled dye simulation. More dye simulations could be used to track discharges from other selected locations. Although the source tracking was performed with the RMA water quality module, the simulation results are described in Appendix B1, "Hydrodynamic Modeling Methods and Results for the Delta Wetlands Project", because these results are primarily used to identify the effects of hydraulic flow transport from each source of water. The seawater intrusion effects are described in this appendix.

Addition of Electrical Conductivity and Chloride Variables

TDS is the salinity variable that has been traditionally used in the RMA water quality module, although relatively few measurements of TDS are available for the Delta. In contrast, several EC monitoring stations throughout the Delta provide continuous EC records. For model calibration purposes, modeling EC directly is a more reliable approach than modeling TDS and estimating EC values with a regression equation. Therefore, the RMA model was modified to include direct EC modeling.

The RMA water quality module was also modified to simulate Cl^- concentrations directly to allow accurate estimates of Br^- concentrations; Br^- in seawater and in the Delta is present at a constant bromide-to-chloride (Br^-/Cl-) ratio of about 0.0035. In addition, the Cl^-/EC ratios vary between the Sacramento River, the San Joaquin River, and San Pablo Bay (seawater). When both Cl^- and EC are modeled, the simulated Cl^-/EC ratio at various Delta locations can be used to estimate the proportional contributions of water from these three

sources. Measured Cl^- and EC values can then be used to confirm the modeled mixtures from these sources.

Flow Regressions for Inflow Concentrations

The RMA Delta model was used to simulate conditions based on historical monthly inflows and exports. A method was needed to estimate the inflow salinity (expressed as TDS and Cl^- concentrations and EC) for each river inflow. Flow regressions were used to estimate monthly average EC values; ratios between other variables of interest and EC were used to estimate inflow concentrations for the other variables at each inflow location.

Figure B2-4 shows the monthly average EC data for the Sacramento River at Greene's Landing for the 25-year historical period (1967-1991) used in the RMA historical simulations. These measurements were collected by various agencies and aggregated in a single computerized database by CCWD (Leib pers. comm.).

Measured mean monthly Sacramento EC values ranged only from about 100 μS/cm to 260 μS/cm. A definite flow dilution pattern is evident, as shown in the relationship between EC and flow in Figure B2-4, although there is considerable scatter in the data.

To estimate monthly average Sacramento River EC as a function of average monthly flow, JSA empirically fit the following equation to the monthly average EC data set:

$$\text{Sacramento River EC } (\mu\text{S/cm}) = 5{,}000 \cdot \text{flow (cfs)}^{-0.35}$$

This equation represents the approximate relationship between Sacramento River inflow and EC, especially for flows of less than 25,000 cfs, those most likely to correspond to low Delta outflow and high salinity intrusion. The equation's flow exponent of -0.35 corresponds to a dilution effect with increasing flow. For example, as flow doubles from 12,000 cfs to 24,000 cfs, EC decreases from 180 μS/cm to about 130 μS/cm (Figure B2-4).

In the RMA simulations, Yolo Bypass EC was assumed to be the same as Sacramento River EC for each month. A similar flow regression equation for EC was estimated for the eastside streams, although field data are limited. The eastside streams had an average simulated EC value of about 105 μS/cm.

Figure B2-5 shows the monthly average EC data for the San Joaquin River at Vernalis for 1968-1991. The EC values fluctuate over a much greater range, from about 150 μS/cm at high flows to more than 1,500 μS/cm at low flows in 1977. Although high flows produce a strong dilution effect that is adequately represented by a flow regression equation, considerable data scatter at low flows cannot be explained by a simple flow dilution relationship. Nevertheless, the following equation is used to estimate San Joaquin River EC as a function of average monthly flow:

$$\text{San Joaquin River EC } (\mu\text{S/cm}) = 25{,}000 \cdot \text{flow (cfs)}^{-0.5}$$

The simulations of historical salinity conditions performed with the RMA model used these flow regression equations to estimate the EC of river inflows. Use of these regression equations introduces potential errors in simulated EC values at Delta locations where river inflows have strong influences. For example, in the winters of 1988, 1989, and 1990, the San Joaquin River EC values estimated using the flow regression equation were less than 800 μS/cm; the actual values were considerably higher (Figure B2-5). Because the estimated inflows will be the same for each DW alternative analyzed, potential errors in the regression estimates of inflow EC will not change the impact assessments.

Estimating inflow EC values as a function of river flow provides the most appropriate method for estimating inflow EC for Delta planning studies and impact assessments of project alternatives when the simulated inflows are expected to be different from historical inflows because of the operations of reservoirs and other upstream facilities and changes in Delta export demands.

Agricultural Diversions and Drainage Salt Balance

Agricultural drainage is generally considered to have a large effect on salinity (TDS, EC, and Cl^-) in the central and southern Delta near the CCWD diversion and CVP and SWP export pumping locations. For accurate simulation of probable effects of agricultural drainage on salinity, the water and salt balances for the Delta agricultural area must be specified properly.

The RMA Delta model was modified to account for water and salt mass balances on each Delta island. Estimates of diversions, storage (as soil moisture or leaching water), ET, rainfall, and discharge of water for each Delta

island or tract are used to estimate salt concentrations in Delta-wide agricultural discharges.

Water budget terms for the Delta uplands and lowlands were separately obtained from DeltaDWQ model simulations (Appendix C4). Concentrations in the monthly diversions were calculated from the appropriate model nodes supplying water to each Delta island. Island water budgets were assumed to be proportional to land area. The monthly water balance terms, specified as inches per month in the input file, were converted to flows at appropriate model nodes. An individual island may divert from and discharge to several different nodes. Nodes may supply diversion water or receive drainage from several different islands.

Relationships between islands and model nodes were obtained from data developed by the California Department of Water Resources (DWR) for its Delta simulation model (DWRDSM), which has a similar mass-balance accounting for agricultural drainage. The major uncertainty in this formulation is not the spatial relationships between islands and model nodes, but the unknown water balance and corresponding salt budget terms for each island. Seepage, applied water, and subsequent drainage volumes are thought to differ substantially between Delta islands depending on soils, major crops, and agricultural practices (DWR 1995).

Discharge concentrations also depend on the effectiveness of drainage water in removing accumulated salt from Delta island soils. Winter leaching practices and rainfall drainage are very effective in removing accumulated salts from the soils. Drainage of unused applied irrigation water in the summer is much less effective in removing salts because this water generally remains in irrigation and drainage canals.

The RMA model simulates the lag between application and removal of salts using an assumed soil-water mixing volume for each island. Because a certain amount of water is retained in the soil according to this relationship, the buildup of soil salt concentration resulting from loss of soil moisture through ET is delayed. Improved formulations that more accurately represent actual agricultural salt budgets in the Delta may be developed (DWR 1995). Nevertheless, the RMA Delta model can be used to account for the general features of the seasonal salt budget in the Delta.

CONFIRMATION OF HISTORICAL MONTHLY SALINITY SIMULATIONS

RMA calibrated the Delta water quality module for the previous modeling used in the 1990 draft EIR/EIS using daily simulations for selected years with significant seawater intrusion events (Smith and Durbin 1989). The only calibration parameters for the salinity (TDS or EC) simulations are the tidal mixing exchange coefficients. RMA adjusted these coefficients using a combination of iterative manual adjustments and automatic adjustments using a "calibration program".

This section compares end-of-month average EC values simulated with the RMA model for historical inflows and exports with historical monthly average EC data to confirm the salinity calibration of the RMA Delta salt transport model. The observed and simulated relationships between effective Delta outflow and EC at selected Delta locations are compared. The differences between end-of-month simulated EC values and monthly average EC data indicate the model errors (uncertainties) that should be considered during impact assessment using simulations of operations of the DW project alternatives and the No-Project Alternative. Because the model uncertainties will be similar for simulations of the No-Project Alternative and the DW alternatives, the model uncertainties will not affect the model estimates of water quality impacts.

Available Electrical Conductivity Data

Daily minimum, average, and maximum EC data recorded at several Delta monitoring stations during 1968-1991 were obtained from CCWD, which had aggregated various agencies' measurements into a single database (Leib pers. comm.). These daily data were summarized as monthly means of the daily minimum, average, and maximum values for comparison with simulated end-of-month EC values.

Numerous EC monitoring stations in the Delta are used in the Interagency Ecological Program for the Sacramento-San Joaquin Estuary. Figure B2-6 shows the locations of the following stations (with monitoring station ID number, indicating river name and kilometer upstream, plus the Interagency Ecological Program [IEP] station code); data from these stations were selected for comparison with the RMA EC simulations:

- Benicia (RSAC056),
- Port Chicago (RSAC063),
- Chipps Island (Mallard Island) (RSAC075),
- Collinsville (RSAC084),
- Emmaton (RSAC092),
- Rio Vista (RSAC101),
- Pittsburg (RSAC077),
- Antioch (RSAN007),
- Jersey Point (RSAN018),
- Old River at Holland Tract (ROLD014), and
- Old River at Tracy Pumping Plant (CHDMC004).

The significance of each monitoring location to this analysis is described below under "Comparison of Simulation Results with Historical Data".

Relationships between Electrical Conductivity Data and Effective Delta Outflow

Because the salinity gradient location in Suisun Bay is governed by the balance between Delta outflow and tidal mixing of salinity from San Pablo Bay, the observed EC at a fixed station is a function of the effective Delta outflow. During periods of steady outflow, the observed daily average EC value will remain relatively constant (with a large tidal fluctuation). The expected mean EC value at a fixed location in an idealized one-dimensional estuary is a negative exponential function of outflow:

$$EC = a \cdot \exp(-\text{outflow} \cdot b)$$

However, the observed EC at a location is not immediately changed by an increase or decrease in Delta outflow. During periods of increasing outflow, the EC will be decreasing but will be higher than expected with calculations based on a steady Delta outflow. During periods of decreasing outflow the EC will be increasing but will be lower than expected with calculations based on a steady Delta outflow. This dynamic change in the observed EC can be approximated as described below with use of a calculated effective (lagged) outflow, which depends on antecedent conditions.

CCWD has suggested a method for estimating the effective Delta outflow for describing salinity intrusion effects in the Delta (Denton 1993a). Once the historical monthly average Delta outflow estimates are adjusted based on this calculation, the historical monthly average EC data from each Delta location more closely follow the expected negative exponential relationship with the effective outflow (as shown in Figure B2-3).

The suggested method for adjusting outflows to obtain the effective Delta outflow is a relatively simple "routing" equation to calculate the equivalent steady outflow for each month, based on the previous month's effective outflow and this month's average Delta outflow. The rate of change in effective outflow is assumed to be proportional to the effective outflow times the change in outflow. Because the impact assessment simulations use monthly average flows, an exponential estimate of the monthly change in the effective Delta outflow is used:

$$\text{Change in effective outflow} = (\text{outflow} - \text{effective outflow}) \cdot (1 - \exp[-\text{effective outflow}/R])$$

where R is an estimated "response" factor that is approximately 5,000 cfs for monthly average flows.

For example, if the effective Delta outflow is 5,000 cfs, then the response of effective outflow to a change in outflow will be 63% (1 - exp[-5,000/5,000]). If the monthly average outflow increases from 5,000 cfs to 10,000 cfs, the effective outflow will increase to 8,160 cfs (5,000 cfs + 0.63 · 5,000 cfs). If the effective outflow is 20,000 cfs, then the response of effective outflow to a change in outflow will be 98% (1 - exp [-20,000/5,000]). Therefore, the relative adjustments for effective outflow will be greatest during periods of low Delta outflow.

The historical EC data and RMA model simulations of historical EC values are described below relative to the effective monthly average Delta outflow calculated as shown from the historical Delta outflow sequence.

Comparison of Simulation Results with Historical Data

Figures B2-7 to B2-17 compare simulated end-of-month EC values at selected RMA model nodes with monthly averages of measured EC data from nearby monitoring stations. The figures show the time series of monthly values for 1968-1991 and the relationship between EC at the selected locations and the effective monthly average Delta outflow at Chipps Island. Differences between the monthly means of measured daily maximums and minimums characterize the typical daily fluctuations in EC values caused by tidal excursion of the salinity gradient back and forth at the monitoring stations. The RMA water quality module cannot simulate daily variations in EC values caused by tidal movement of the salinity gradient. Mean monthly EC data should corres-

pond, however, with simulated EC values for the historical Delta inflows and exports.

Table B2-1 gives a summary of historical EC data at these locations and the RMA simulation results for EC values near these locations. The table also shows the average difference between each set of simulated and measured values (bias) and shows the average standard deviation of the differences between the RMA simulation results and the mean monthly measured EC. The standard deviation provides a general measure of the average error between the RMA simulation results and the mean monthly measured EC.

Suisun Bay Region

Seawater intrusion from the downstream boundary has the greatest effect on salinity in the Suisun Bay portion of the Delta. The Suisun Bay region encompasses the estuarine "entrapment zone", an important aquatic habitat region associated with high levels of biological productivity (Arthur and Ball 1980). The entrapment zone as defined by Arthur and Ball (1980) is the salinity (EC) range of 5-15 mS/cm, corresponding to 3,330-10,000 ppm (3.3-10 parts per thousand [ppt]) of TDS, assuming a constant ratio of about 1.5 mS/cm EC to 1 ppt TDS. The upstream boundary of the entrapment zone can also be identified as the location of the 2-ppt bottom salinity, or "X2" (measured in kilometers upstream of the Golden Gate Bridge).

Benicia. Historical monthly average EC values for Benicia varied widely, from less than 1 mS/cm at high Delta outflows to approximately 30 mS/cm at low Delta outflows (Figure B2-7) with an average EC of 15.8 mS/cm. Simulated EC values at RMA model node 360 were similar to the observed values for most months.

The general response of EC at Benicia to effective Delta outflow is easily detected in the monthly data and was well represented by the RMA model formulation. The simulated EC range of 5-15 mS/cm at Benicia, characterizing the upstream and downstream extent of the entrapment zone, corresponds with Delta outflows ranging from about 13,000 cfs to about 40,000 cfs. The monthly average observed EC data are more scattered than the simulated EC values but follow a similar relationship with effective monthly average Delta outflow.

Table B2-1 shows that for Benicia, the mean measured EC for the 1968-1991 period was 15,792 μS/cm. The mean of the RMA simulation of historical EC at Benicia (node 360) was 14,604 μS/cm. The RMA-simulated EC was lower than the measured EC by an average of 1,188 μS/cm. The standard deviation from mean monthly EC measured at Benicia was 3,050 μS/cm (19% of mean measured EC).

Port Chicago. Figure B2-8 shows the observed and simulated EC values for Port Chicago for 1968-1991. Port Chicago is opposite Roe Island and is the downstream monitoring location for the 1995 WQCP estuarine salinity objectives. Historical EC data for Port Chicago averaged 10 mS/cm. The Port Chicago EC was approximately 5 mS/cm at an outflow of about 15,000 cfs and approximately 15 mS/cm at an outflow of about 5,000 cfs. The monthly average observed EC data are more scattered than the simulated EC values but follow a similar relationship with effective monthly average Delta outflow. Table B2-1 indicates that the mean RMA-simulated EC for Port Chicago was 417 μS/cm lower than the measured EC, with a standard deviation of 2,337 μS/cm (23% of mean measured EC).

Chipps Island. Figure B2-9 shows the observed and simulated EC values for Chipps Island for 1968-1991. Chipps Island is usually considered to be the primary station for estimating Delta outflow because it is located downstream of the confluence of the Sacramento and San Joaquin Rivers.

Chipps Island is opposite one of the 1995 WQCP estuarine salinity habitat monitoring locations (Mallard Island) and is therefore an important EC measurement location; however, historical EC data from Chipps Island are only available beginning with 1981. The RMA-simulated EC (node 357) was slightly higher than the measured data, indicating that the measured station is slightly "upstream" of the model node location. Use of the RMA salinity curve to estimate the effective outflow corresponding to various EC values indicates that the Chipps Island station will be within the entrapment zone (5-15 mS/cm) for effective outflows of about 3,500 cfs to 7,500 cfs. X2 (3 mS/cm) would be located downstream of Chipps Island for effective Delta outflows of greater than about 12,000 cfs. Statistics for the Chipps Island station in Table B2-1 indicate that the RMA-simulated EC was 808 μS/cm greater than measured EC, with a standard deviation of 2,471 μS/cm (40% of mean measured EC).

Pittsburg. Figure B2-10 shows the observed and simulated EC values for the Pittsburg station, located upstream of Chipps Island.

The relationship between effective outflow and Pittsburg EC was similar for the measured EC and the RMA-simulated EC. The maximum historical monthly average EC was about 15 mS/cm. The Pittsburg station would therefore remain within the entrapment zone for effective

outflows of less than 7,000 cfs, but would be upstream of the entrapment zone at higher outflows. The X2 position would be downstream of the Pittsburg station for effective outflows of greater than about 9,000 cfs.

Table B2-1 indicates that the mean observed EC at Pittsburg for the 1968-1991 period was 4,061 μS/cm, and the mean of the RMA simulation (node 356) was 3,309 μS/cm (752 μS/cm less than observed). The standard deviation was 1,777 μS/cm (44% of mean measured EC). The relationship between effective outflow and EC at Pittsburg was accurately simulated by the RMA model, and simulated incremental effects of changes in outflow on Pittsburg EC values are reliable.

Sacramento River Electrical Conductivity Monitoring Stations

Because most Delta outflow is from the Sacramento River channel, data from these stations are presented first, followed by EC data from stations located along the San Joaquin River.

Collinsville. Figure B2-11 shows the observed and simulated values for the Collinsville EC monitoring station. The Collinsville station is on the Sacramento River, just upstream of the mouth of the San Joaquin River. Montezuma Slough is located near Collinsville, so measurements from this station indicate the salinity of inflows from the Sacramento River to Suisun Marsh. The observed range in mean monthly EC at Collinsville is from less than 1 mS/cm at Delta outflows of greater than 12,000 cfs to greater than 10 mS/cm at Delta outflows of about 3,000 cfs.

Table B2-1 indicates that the observed average EC at Collinsville for the 1968-1991 period was 2,542 μS/cm. The RMA model (node 355) average for the historical simulation was 2,421 μS/cm. The RMA-simulated EC was lower than the measured EC by an average of 121 μS/cm. However, there was considerable scatter in the monthly data, so the standard deviation between the RMA simulations and observed values was 1,190 μS/cm (47% of measured EC).

Figure B2-11 indicates that Collinsville EC is strongly controlled by effective Delta outflow when outflow is less than about 10,000 cfs. Although there are other factors influencing the Collinsville EC data, the effects of outflow are well modeled by the RMA model. For impact assessment purposes, where the incremental effects of modified outflow on Collinsville EC are to be determined, the RMA results for Collinsville are reliable.

Emmaton. Figure B2-12 shows the observed and simulated EC values for Emmaton. Emmaton serves as a monitoring location for agricultural water quality under the 1995 WQCP Delta objectives. Table B2-1 shows that the mean measured EC at Emmaton was 810 μS/cm. The mean RMA-simulated EC was 532 μS/cm, 278 μS/cm less than the measured EC, with a standard deviation of 585 μS/cm (72% of mean measured EC). The EC data from Emmaton show a marked reduction in the extent of salinity intrusion in comparison with the Collinsville EC data. Only during a few periods of low flow in 1977 did the entrapment zone, as defined by the EC range of 5-15 mS/cm (Arthur and Ball 1980), extend up the Sacramento River as far as Emmaton. The entrapment zone has rarely been observed this far upstream. The X2 position (3 mS/cm) would be downstream of Emmaton for effective Delta outflow greater than about 3,000 cfs.

Emmaton is located on the Sacramento River downstream of its junction with Threemile Slough. Emmaton EC data indicate salinity intrusion up the Sacramento River channel and are representative of Sacramento River water entering Threemile Slough and flowing to the lower San Joaquin River, upstream of Jersey Point. Because of large tidal flows in Threemile Slough, there is considerable exchange of San Joaquin River water from upstream of Jersey Point that may influence Emmaton EC.

Rio Vista. Historical monthly EC data from Rio Vista are compared with simulated EC patterns for the 1968-1991 period in Figure B2-13. Elevated salinity at Rio Vista was limited to extreme conditions during 1977.

The historical EC data indicate that seawater intrusion on the Sacramento River was generally not observed at Rio Vista between 1968 and 1991. Therefore, EC conditions at Walnut Grove, near the DCC and Georgiana Slough, can be considered to be about the same as Sacramento River inflow conditions.

San Joaquin River and South Delta Monitoring Stations

Antioch. Figure B2-14 shows the observed and simulated EC values for the Antioch monitoring location. Because the Antioch station is farther upriver than the Collinsville station, EC is consistently lower at Antioch than at Collinsville (Figure B2-11) for the same effective Delta outflow. The scatter in measured and simulated EC values is caused by variations in factors other than effective Delta outflow that influence Antioch EC values.

Antioch and other central and southern Delta locations may be more affected by the variable quality of San Joaquin River inflow and agricultural drainage in the Delta than are locations in the western Delta. Both of these salinity effects are included in the RMA model, but there are differences between simulated and measured EC values for these terms.

As defined by the 5- to 15-mS/cm range in EC values, the entrapment zone extends upstream to Antioch only during periods of Delta outflow less than about 4,000 cfs. The simulated seawater intrusion at Antioch in some summers was greater than measured (Figure B2-14).

Some of the differences between the RMA simulations of historical conditions and the observed EC values during periods of elevated EC measurements may be caused by the uncertainty of estimates of Delta outflow used in the RMA simulations.

Table B2-1 indicates that the average observed EC at Antioch for 1968-1991 was 1,809 μS/cm and the RMA-simulated EC (node 46) was 1,509 μS/cm (average of 300 μS/cm less than observed). The standard deviation of the difference between RMA-simulated and measured EC was 1,123 μS/cm (62% of mean measured EC).

Figure B2-14 indicates that Antioch EC is strongly controlled by effective Delta outflow when outflow is less than about 7,500 cfs. Although there are other factors influencing the Antioch EC data, the effects of effective Delta outflow are well modeled by the RMA model. For impact assessment purposes, where the incremental effects of modified outflow on Antioch EC are to be determined, the RMA results for Antioch are reliable.

Jersey Point. The Jersey Point EC station is another important location for monitoring Delta agricultural water quality standards under the 1995 WQCP objectives. Figure B2-15 shows historical and simulated EC values for Jersey Point. Although the entrapment zone does not extend upstream to Jersey Point, salinity intrusion (EC value greater than about 0.5 mS/cm) has been observed at this station when Delta outflow was less than 7,500 cfs.

Table B2-1 indicates that the average measured EC at Jersey Point for the 1968-1991 period was 694 μS/cm. The RMA-simulated historical EC at Jersey Point (node 44) averaged 547 μS/cm (140 μS/cm less than measured). The standard deviation was 564 μS/cm (81% of mean measured EC). Figure B2-15 shows that most of the deviation in simulated and measured EC values occur during periods of low effective Delta outflow.

Figure B2-15 indicates that Jersey Point EC is strongly controlled by effective Delta outflow when outflow is less than about 7,500 cfs. Although there are other factors influencing Jersey Point EC, the effects of outflow are well modeled by the RMA model. For impact assessment purposes, where the incremental effects of modified outflow on Jersey Point EC are to be determined, the RMA results for Jersey Point are reliable.

The simulated salinity intrusion at Jersey Point was greater than measured EC data indicated for low outflow conditions. For purposes of impact assessment for the DW project, however, the simulated EC patterns at Jersey Point are sufficiently accurate to represent the general influence of salinity intrusion from Benicia as a function of effective Delta outflow.

Old River at the CCWD Diversion Location. Figure B2-16 shows historical EC data and EC values simulated by the RMA model for CCWD diversions at Rock Slough. Salinity intrusion events occur during periods of low Delta outflows.

Table B2-1 indicates that the average CCWD EC for the 1968-1991 period was 500 μS/cm. The RMA simulation of historical CCWD EC was 292 μS/cm, considerably lower than measured data. The RMA model appears to underestimate the salinity intrusion effects during periods of low effective Delta outflow. The standard deviation was 210 μS/cm (42% of mean measured EC).

Figure B2-16 suggests that there is a minimum EC at CCWD's Rock Slough diversion location that is a function of the effective Delta outflow, as observed for the other Delta stations. However, there are many more months with elevated EC values that do not appear to be directly controlled by the effective outflow. San Joaquin River inflow EC and Delta agricultural discharges are two possible influences at this location, in addition to salinity intrusion effects.

Measured EC at Holland Tract, located on Old River just downstream of the mouth of Rock Slough, are shown for comparison with CCWD EC data. The average Holland Tract EC was 419 μS/cm for the 1968-1991 period (81 μS/cm less than the average CCWD EC). Differences between these two locations can be attributed to local effects of agricultural discharges and tidal gate leakage between Sand Mound Slough and Rock Slough. During the 1976-1977 drought, when a temporary CCWD intake was established in Middle River, the CCWD measurements were less than the Holland Tract measurements.

Old River at Tracy Pumping Plant. Figure B2-17 shows measured monthly EC data and simulated EC values for the CVP Tracy Pumping Plant. Salinity intrusion (EC value greater than 0.5 mS/cm) at the CVP Tracy Pumping Plant was relatively infrequent and of moderate magnitude during the historical period compared with salinity intrusion at Jersey Point. CVP export EC values, however, are substantially affected by the variable quality of San Joaquin River inflow and agricultural drainage in the Delta (Figure B2-5).

Table B2-1 indicates that the average EC at CVP Tracy Pumping Plant for the 1968-1991 period was 497 μS/cm. The mean RMA simulation of historical CVP Tracy Pumping Plant EC was 369 μS/cm, considerably lower than measured data. The RMA model appears to underestimate the salinity intrusion effects during periods of low effective Delta outflow. The standard deviation was 150 μS/cm (30% of mean measured EC).

The uncertain effects of agricultural drainage on export EC will not influence the impact assessment results because the simulated effects of San Joaquin River inflow EC and agricultural drainage EC on export EC will be the same for each DW alternative; the impact assessment of effects of DW project operations on likely export EC values will be reliable.

Summary of Relationships between Simulated Electrical Conductivity at Selected Delta Channel Locations and Effective Delta Outflow

The previous section presented the RMA simulations of Delta EC for historical inflow and export conditions. The dominant controlling factor at each channel location was effective Delta outflow. Figure B2-18 shows the resulting negative exponential relationship between effective Delta outflow and EC at several of the EC monitoring stations.

Table B2-1 gives the coefficient values that were estimated for the negative exponential relationship for each EC measurement station. These equations are similar to the RMA simulation results as well as the historical measurements for 1968-1991. A constant of 150 μS/cm is assumed as the Sacramento River inflow EC. These equations can be used to estimate the effects of a change in outflow on EC at these locations. Because effective Delta outflow is a lagged moving average of monthly outflow values, a change in outflow caused by DW project operations may have a slight effect on EC values for more than one month.

These effective outflow equations summarize the historical EC measurements and the RMA simulation results. They are used for impact assessment in the same way that the hydraulic channel flow split equations were used to summarize the RMA hydrodynamic model results and to estimate the effects of DW operations on Delta channel flows. These summary relationships between EC and effective Delta outflow can be used to estimate EC under each DW project alternative for the entire 70-year hydrologic record (water years 1922-1991).

For example, Table B2-1 indicates that monthly average EC values (μS/cm) for Port Chicago (kilometer 63) can be reliably estimated from effective Delta outflow (cfs) as follows:

$$\text{Port Chicago EC} = 150 + 32{,}000 \cdot \exp(-0.00010 \cdot \text{effective outflow})$$

Similarly, EC values (μS/cm) for Chipps Island (kilometer 75) or Pittsburg (kilometer 77) can be reliably estimated from effective Delta outflow (cfs) as follows:

$$\text{Pittsburg EC} = 150 + 30{,}000 \cdot \exp(-0.00025 \cdot \text{effective outflow})$$

The negative exponent for Pittsburg is larger than for Port Chicago, so the effects of increasing effective outflow are stronger, and the salinity intrusion effects for a particular effective Delta outflow are reduced at Pittsburg compared with effects at Port Chicago. The EC at Collinsville (kilometer 84) can be reliably estimated as follows:

$$\text{Collinsville EC} = 150 + 25{,}000 \cdot \exp(-0.00030 \cdot \text{effective outflow})$$

Antioch (kilometer 89) EC can be estimated as follows:

$$\text{Antioch EC} = 150 + 20{,}000 \cdot \exp(-0.00035 \cdot \text{effective outflow})$$

Emmaton (kilometer 92) and Jersey Point (kilometer 100) EC have similar equations with approximately the same negative exponent, but because Emmaton is slightly downstream of Jersey Point, the effects of salinity intrusion are stronger at Emmaton during periods of low effective outflow:

$$\text{Emmaton EC} = 150 + 10{,}000 \cdot \exp(-.00040 \cdot \text{effective outflow})$$

$$\text{Jersey EC} = 150 + 8{,}000 \cdot \exp(-0.00040 \cdot \text{effective outflow})$$

Rio Vista (kilometer 101) has a larger negative exponent, with greatly reduced magnitude of salinity intrusion episodes:

$$\text{Rio Vista} = 150 + 15{,}000 \cdot \exp(-0.00080 \cdot \text{effective outflow})$$

Summary of Simulated Electrical Conductivity Values and Chloride Concentrations in Delta Exports

Delta export EC values are more strongly influenced than EC values at western Delta locations by San Joaquin River EC and by agricultural drainage flows and EC values. However, DW project effects on salinity at the export locations are calculated as the change from conditions under the No-Project Alternative. Because these influences from San Joaquin River EC and agricultural drainage EC would be the same under DW project operations and operations under the No-Project Alternative, impacts of the DW project on export salinity will be estimated from changes in effective Delta outflow.

The RMA simulation results for EC at Delta export locations (SWP and CVP pumping plants and CCWD diversion intake) varied slightly because of differences in estimated seawater intrusion and the varying contributions of San Joaquin River inflow and agricultural drainage at each location. However, the source contribution simulations, described in Appendix B1, "Hydrodynamic Modeling Methods and Results for the Delta Wetlands Project", indicated that the effects of DW project operations on source contributions at these export/diversion locations could be reliably estimated as a single representative value for the three locations using monthly inflows and exports, along with simulated DW project operations. The differences between the three locations were generally not large relative to the month-to-month differences caused by hydrologic variations in the inflow sources, periods of low effective outflow, and variations in agricultural drainage effects.

Cl^- concentrations at the Delta export locations are included as 1995 WQCP objectives. Elevated Cl^- concentrations at the export locations are largely dominated by seawater intrusion sources, although there is some Cl^- concentration in Sacramento and San Joaquin River inflows (see Appendix C1, "Analysis of Delta Inflow and Export Water Quality"). A background Cl^- concentration of 15 mg/l is assumed for impact assessment purposes. The ratio of Cl^- (mg/l) to EC (μS/cm) in seawater is approximately 1/3. The predicted seawater intrusion concentration for export Cl^- is therefore one third of the predicted export EC value.

The historical EC and Cl^- measurements for the CCWD intake and EC for the CVP Tracy Pumping Plant suggest that the increased EC (μS/cm) and Cl^- concentration (mg/l) during periods of low Delta outflow can be reliably estimated as follows:

$$\text{Export EC} = 150 + 5{,}000 \cdot \exp(-0.00050 \cdot \text{effective outflow})$$

$$\text{Export } Cl^- = 15 + 1{,}667 \cdot \exp(-0.00050 \cdot \text{effective outflow})$$

The effects of DW discharges on Delta export water quality are calculated in the DeltaDWQ assessment model (described in Appendix C4) from the estimated DW discharge EC and the estimated source contribution from DW discharges (reducing the source contributions from other sources as described in Appendix B1). The slightly different Delta export EC and Cl^- concentration values obtained from the DeltaDWQ impact assessment model are reported in Chapter 3C for water quality impact assessment. However, the salinity intrusion effects resulting from hydrodynamic changes in Delta flows are accurately estimated with the equations given in this section.

Model uncertainties in monthly San Joaquin River EC values or monthly flow and EC values of Delta agricultural drainage discharges do not reduce the accuracy of the impact assessment results because the same estimates of San Joaquin River EC and agricultural drainage flow and EC values are used for each of the DW project alternatives.

IMPACT ASSESSMENT RESULTS FOR THE DW PROJECT ALTERNATIVES

General Approach

The water quality and fishery impact assessments (Chapters 3C and 3F, respectively) are based on simulations of Delta conditions under the 1995 WQCP objectives using Delta inflows, Delta exports, and DW project operations estimated with the Delta Standards and Operations Simulation model (DeltaSOS) based on DWRSIM results, as described in Appendices A1, "Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project", and A3, "DeltaSOS Simulations of the

Delta Wetlands Project Alternatives". Simulations of Delta hydrodynamics for historical conditions and operations of the DW project alternatives are described in Appendix B1, "Hydrodynamic Modeling Methods and Results for the Delta Wetlands Project".

The 1995 WQCP represents current Delta water quality objectives; therefore, estimates of inflows, exports, and outflows simulated for historical hydrologic conditions under the 1995 WQCP objectives differ from estimated historical values, which correspond to Delta conditions prior to establishment of current outflow requirements and export restrictions. Because the simulated Delta inflows, exports, and outflows associated with each DW alternative are different from historical inflows and exports, simulated seawater intrusion and salinity conditions for each DW project alternative are different from the observed EC patterns.

To provide the most appropriate comparison for determining DW project impacts, simulations of salinity for the DW project alternatives are referenced to simulations for the No-Project Alternative. The No-Project Alternative represents likely future operations on the DW islands (intensified agricultural use), without the DW project, under the 1995 WQCP objectives and with estimated export demands.

The following discussions summarize the results of simulations using the DeltaDWQ impact assessment model for EC at three selected locations and export Cl^- concentrations for the No-Project Alternative and the DW project alternatives. Simulated EC patterns are used as impact assessment response variables because they are regulated by water quality standards (such as those in the 1995 WQCP) or are directly related to potential water quality and fishery variables. Export Cl^- concentration, which is controlled by the 1995 WQCP objectives, can be estimated from salinity intrusion and source contributions and is directly proportional to concentration of Br^-, an important variable for drinking water quality. EC patterns may influence the movement of larvae and juvenile stages of several important fish species and the distribution of estuarine species.

The selected locations are defined as follows:

- Chipps Island is the Delta outflow location, where Sacramento and San Joaquin River flows have combined and mixed.
- Emmaton is an important location for monitoring the effects of salinity intrusion on agricultural diversions upstream along the Sacramento River channel. Emmaton is a salinity control point for the 1995 WQCP objectives.
- Jersey Point is the point of San Joaquin River outflow from the central Delta, where agricultural drainage and diversion flows from the Sacramento River have mixed with San Joaquin River flow. Jersey Point is a salinity control point for the 1995 WQCP objectives
- Delta export salinity is simulated as representative of the CCWD Rock Slough intake, SWP Banks Pumping Plant, and CVP Tracy Pumping Plant locations.

Simulation Results for the No-Project Alternative

Table B2-2 presents monthly simulated EC values for the four selected Delta locations for the 1968-1991 period for the No-Project Alternative. Monthly average Cl^- concentrations are also given for the representative Delta export location. The impact assessment for each DW alternative will be based on the calculated changes from these No-Project Alternative values. The No-Project Alternative values are sometimes considerably different from the measured historical values because the simulated Delta outflow sequence is very different from the historical Delta outflow for many months.

Because the measured historical EC values were accurately estimated from the effective Delta outflow relationships as described in the previous section, these estimates of EC and Cl^- for the No-Project Alternative are also considered to be a reliable basis for impact assessment for each DW project alternative.

Table B2-3 summarizes the changes shown in Table B2-2. The monthly changes are separated into EC increases (with percent increase) and EC decreases (with percent decrease). For example, the upper lefthand box of Table B2-3 indicates that DW Alternative 1 at Chipps Island changed the average EC value for the No-Project Alternative of 5,148 μS/cm to 5,279 μS/cm. There were 138 months (out of 300) with a positive change in EC. The average increase in EC was 356 μS/cm and the maximum increase was 3,804 μS/cm. The simulated increases in EC raised the EC values for the No-Project Alternative by an average of 12.9%, with a maximum change of 95.8%. There were 162 months with reduced EC values. The average reduction in EC was 11.6 μS/cm with a maximum reduction of 99.6 μS/cm. The percentage change for the reductions averaged 0.3%. The maxi-

mum percentage change was 1.6%. Table B2-3 allows the monthly results to be summarized as months with increased salinity (potential impacts) and months with reduced salinity (potential benefits). All simulated changes in salinity are directly related to simulated changes in effective outflow that are the result of reduced agricultural diversions from the DW project islands, increased diversions for habitat islands, diversions for storage on the reservoir islands, or releases from the habitat islands. The largest changes in salinity are caused by storage diversions during months with moderate outflows.

Simulated Electrical Conductivity at Chipps Island

Figure B2-19 shows simulated patterns of monthly EC at Chipps Island for 1968-1991 for the No-Project Alternative. During periods of high Delta inflow, salinity at Chipps Island is flushed and becomes similar to river inflow salinity. During periods of low Delta inflow, outflow is often directly controlled by 1995 WQCP minimum Delta outflow requirements. The simulated average 1922-1991 EC value for the No-Project Alternative at Chipps Island was 5,148 μS/cm (Table B2-3).

Simulated Electrical Conductivity at Emmaton

Figure B2-19 shows simulated patterns of monthly EC at Emmaton for 1968-1991 for the No-Project Alternative. EC is elevated less frequently at Emmaton than at Chipps Island because Emmaton is approximately 17 kilometers upstream, and much lower effective outflow will be required for seawater intrusion to reach Emmaton. During periods of low effective Delta outflow, the EC at Emmaton will remain considerably lower than EC at Chipps Island.

Simulated maximum EC values at Emmaton were generally lower than historical values at Emmaton because effective Delta outflows simulated for the No-Project Alternative were generally greater than historical outflows during periods of low historical Delta outflow that produced elevated Emmaton EC values. The average simulated EC at Emmaton for the 1922-1991 period was 1,050 μS/cm for the No-Project Alternative (Table B2-3).

Simulated Electrical Conductivity at Jersey Point

Figure B2-19 shows simulated patterns of EC at Jersey Point for 1968-1991 for the No-Project Alternative. Simulated EC values for the No-Project Alternative were generally lower than those for historical conditions at Jersey Point because the simulated outflows for the No-Project Alternative during low-flow periods were greater than historical outflows.

Seawater intrusion has much less effect at Jersey Point than at Chipps Island. Seawater intrusion was stronger during summers of a few years for the simulated No-Project Alternative because simulated Delta outflows were less than historical outflows. However, in most water years, simulated EC values for the No-Project Alternative were lower than simulated values for historical conditions during several months at the end of these water years. For such years, assumed Delta outflow values for the No-Project Alternative as simulated by DeltaSOS were greater than historical Delta outflows. The simulated average EC value for Jersey Point for 1922-1991 was 690 μS/cm for the No-Project Alternative (Table B2-3).

Simulated Chloride Concentrations in Representative Delta Exports

Figure B2-20 shows the simulated pattern of monthly average Cl^- in representative Delta exports for the 1968-1991 period for the No-Project Alternative. As described in the previous section, seawater intrusion effects in the exports are similar to those observed at Jersey Point, but the Cl^- concentrations in the exports are reduced to about one third of those at Jersey Point by dilution in the Sacramento River diversions moving toward the export pumping plants (Denton 1993b).

Because Cl^- concentration (mg/l) is approximately one third of EC (μS/cm) in seawater, the resulting Cl^- concentration estimates for representative Delta exports were about 10% of the Jersey Point EC values. Historical Cl^- data for the CCWD intake indicate additional influences of San Joaquin River inflow, agricultural drainage, or temporary failure of the tidal gate on Sand Mound Slough. Because these other influences will not change with the DW project, these influences on Delta export Cl^- concentrations will not change the impact assessment results.

The average of simulated Cl^- concentrations in representative Delta exports for the 1922-1991 period for the No-Project Alternative was 75 mg/l. The 1995 WQCP objectives include a Cl^- concentration of less than 250 mg/l at all export locations, with some periods of 150 mg/l required during some water-year types. These export Cl^- concentrations are simulated indirectly in the DWRSIM model, using "carriage water" estimates (see "Carriage Water Calculations" in Appendix A2, "Delta-

SOS: Delta Standards and Operations Simulation Model"). The simulated Cl^- concentrations, calculated using the "negative exponential" estimates of historical EC and Cl^- data, were somewhat higher than 250 mg/l during some periods of low effective Delta outflow. Actual operations would, of course, protect CCWD exports, as required by the 1995 WQCP.

Simulation Results for Alternative 1

Alternative 1 involves potential year-round diversion and storage of surplus water on Bacon Island and Webb Tract (reservoir islands). Bouldin Island and Holland Tract (habitat islands) would be managed primarily as wildlife habitat.

Under Alternative 1, DW diversions could occur in any month with surplus flows. In DeltaSOS modeling, it is assumed that discharges of water from the DW project islands would be exported in any month when unused capacity within the permitted pumping rate exists at the SWP and CVP pumps and the 1995 WQCP "percent inflow" export limits do not prevent use of that capacity. Such unused capacity would exist when the amount of available water (i.e., total inflow less Delta channel depletion and Delta outflow requirements) is less than the amount specified by the export limits.

Water would be diverted to the reservoir islands (238-TAF water storage capacity) at a maximum average monthly diversion rate of 4,000 cfs, which would fill the two reservoir islands in one month. The maximum initial daily average diversion rate would be 9,000 cfs during several days when siphoning of water onto empty reservoirs begins; at this time, the maximum head differential would exist between island bottoms and channel water surfaces. The maximum initial daily average discharge rate would be 6,000 cfs, but the maximum monthly average discharge rate is assumed to be 4,000 cfs, allowing the two reservoir islands to empty in one month.

Chapter 2 presents a more complete description of DW project facilities and operations. Appendix A3 presents monthly average approximations of DW project operations under Alternative 1.

Table B2-2 gives monthly simulated changes in EC and Cl^- values for Alternative 1 compared with EC and Cl^- simulated for the No-Project Alternative. Mean EC and Cl^- values for Alternative 1 and the No-Project Alternative were very similar. Simulated effects of DW project operations on EC values were fairly small during the diversion periods because the DW diversions generally were simulated to occur during months with high flows, corresponding to low EC values. However, some simulated DW diversions occurred in months with relatively low outflow requirements, so the potential change in EC and Cl^- was greater. Because DW discharge for export would not change Delta outflow, DW discharges would not affect EC values unless the DW discharge EC was different from the No-Project Alternative export EC.

Simulated Electrical Conductivity at Chipps Island and Emmaton

Figure B2-21 shows simulated EC values for Chipps Island and Emmaton for Alternative 1 and the changes from the No-Project Alternative conditions. Table B2-2 indicates that average EC at Chipps Island was 5,279 μS/cm for Alternative 1, about 131 μS/cm higher than for the No-Project Alternative. Average EC at Emmaton for Alternative 1 was 1,076 μS/cm, about 26 μS/cm higher than for the No-Project Alternative.

Simulated Electrical Conductivity at Jersey Point and Chloride Concentrations in Delta Exports

Figure B2-22 shows simulated EC values for Jersey Point for Alternative 1 and the changes from the No-Project Alternative. Table B2-2 indicates that average EC at Jersey Point was 705 μS/cm for Alternative 1, only about 15 μS/cm higher than for the No-Project Alternative.

Average Cl^- concentration in representative Delta exports for Alternative 1 was 77 mg/l, about 2 mg/l higher than for the No-Project Alternative.

Simulation Results for Alternative 2

Alternative 2 represents DW operations with two reservoir islands (Bacon Island and Webb Tract) and two habitat islands (Bouldin Island and Holland Tract). Chapter 2 provides a more complete description of Alternative 2.

Under Alternative 2, DW diversions could occur in any month with surplus flows, as under Alternative 1. In DeltaSOS modeling, it is assumed that discharges from the DW project islands would be exported in any month when unused capacity within the permitted pumping rate

exists at the SWP and CVP pumps. Under this alternative, export of DW discharges would be allowed in any month when such capacity exists and would not be constrained by the 1995 WQCP "percent inflow" export limits. Export of DW discharges would be limited by Delta outflow requirements and the permitted combined pumping rate of the export pumps but would not be subject to the "percent inflow" export limit.

The maximum monthly average diversion rate to reservoir island storage would be 4,000 cfs (maximum initial daily average diversion rate of 9,000 cfs). The maximum monthly average discharge rate is assumed to be 4,000 cfs (maximum initial daily average discharge rate of 6,000 cfs).

Table B2-2 gives monthly simulated changes in EC and Cl^- for Alternative 2 compared with EC and Cl^- simulated for the No-Project Alternative. DW project operation effects on EC values were quite small during the simulated diversion periods because DW diversions generally would occur during months with high flows, corresponding to low EC values. Because DW discharge for export would not change Delta outflow, DW discharges would not affect EC values unless the DW discharge EC was different from No-Project Alternative export EC.

Simulated Electrical Conductivity at Chipps Island and Emmaton

Figure B2-23 shows simulated EC values for Chipps Island and Emmaton for Alternative 2 and the changes from the No-Project Alternative conditions. Table B2-3 indicates that average EC at Chipps Island was 5,279 μS/cm for Alternative 2, about 131 μS/cm higher than for the No-Project Alternative. Average EC at Emmaton for Alternative 2 was 1,076 μS/cm, about 26 μS/cm higher than for the No-Project Alternative.

Simulated Electrical Conductivity at Jersey Point and Chloride Concentrations in Delta Exports

Figure B2-24 shows simulated EC values for Jersey Point for Alternative 2 and the changes from the No-Project Alternative. Table B2-3 indicates that average EC at Jersey Point was 705 μS/cm for Alternative 2, only about 15 μS/cm higher than for the No-Project Alternative.

Average Cl^- concentration in representative Delta exports for Alternative 2 was 77 mg/l, about 2 mg/l higher than for the No-Project Alternative.

Simulation Results for Alternative 3

Alternative 3 involves storage of water on Bacon Island, Webb Tract, Bouldin Island, and Holland Tract, with secondary uses for wildlife habitat and recreation. The portion of Bouldin Island north of SR 12 would be managed as a wildlife habitat area and would not be used for water storage. Diversions to the reservoir islands (406-TAF capacity) would be allowed during any month with available surplus flows. The diversion and discharge operations for Alternative 3 would be the same as for Alternative 2, but the assumed diversion and discharge rates are higher. The maximum average monthly diversion rate would be about 7,000 cfs, which would fill the four reservoir islands in one month (maximum initial daily average diversion rate of 9,000 cfs). The maximum monthly discharge rate is assumed to be 4,000 cfs (maximum initial daily average discharge rate of 8,000 cfs). Chapter 2 provides a more complete description of Alternative 3.

Table B2-2 gives monthly simulated changes in EC and Cl^- values for Alternative 3 compared with EC and Cl^- simulated for the No-Project Alternative. Effects of Alternative 3 on EC values were quite small during simulated diversion periods because the DW diversions generally were simulated to occur during months with high flows, corresponding to low EC values. Because DW discharge for export would not change Delta outflow, DW discharges would not affect EC values.

Simulated Electrical Conductivity at Chipps Island and Emmaton

Figure B2-25 shows simulated EC values for Chipps Island and Emmaton for Alternative 3 and the changes from the No-Project Alternative. Table B2-3 indicates that average EC at Chipps Island was 5,324 μS/cm for Alternative 3, about 177 μS/cm higher than for the No-Project Alternative. Average EC at Emmaton for Alternative 3 was 1,082 μS/cm, about 31 μS/cm higher than for the No-Project Alternative.

Simulated Electrical Conductivity at Jersey Point and Chloride Concentrations in Delta Exports

Figure B2-26 shows simulated EC values at Jersey Point for Alternative 3 and the changes from the No-Project Alternative. Table B2-3 indicates that average EC at Jersey Point was 709 μS/cm for Alternative 3, about 19 μS/cm higher than for the No-Project Alterna-

tive. Average Cl^- concentration in Delta exports for Alternative 3 was 77 mg/l, about 26 mg/l higher than for the No-Project Alternative.

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Table B2–1. Summary of EC Measurements and RMA Model Simulation Results

	Station											
	Benicia	Port Chicago	Chipps Island[1]	Pittsburg	Collinsville	Rio Vista	Antioch	Emmaton	Jersey Point	CCWD Rock Slough	CVP Tracy Pumping Plant	CCWD Chloride (mg/l)
Kilometer upstream	56	63	75	77	84	101	89	92	100			
Measured mean EC (1968–1991)	15,792	9,957	6,241	4,061	2,542	249	1,809	810	694	500	497	88
	Summary of RMA Results (μS/cm)											
RMA mean model EC (1968–1991)	14,604	9,540	7,049	3,309	2,421	191	1,509	532	547	292	369	45
Difference	−1,188	−417	808	−752	−121	−59	−300	−278	−140	−208	−128	−43
Standard deviation	3,050	2,337	2,471	1,777	1,190	95	1,123	585	564	210	150	59
CV[2] of differences	0.19	0.23	0.39	0.44	0.47	0.38	0.62	0.72	0.81	0.42	0.30	0.67
	Coefficient Values for the Negative Exponential Equation Relating EC and Effective Outflow: EC = a+b*exp(Outflow*c)											
a	150	150	150	150	150	150	150	150	150	150	150	15
b	33,000	32,000	30,000	30,000	25,000	15,000	20,000	10,000	8,000	5,000	5,000	1,667
c	−0.00006	−0.00010	−0.00025	−0.00025	−0.00030	−0.00080	−0.00035	−0.00040	−0.00040	−0.00050	−0.00050	−0.00050
	Effective Outflow (cfs) Corresponding to Specified EC Values											
X2 (3 mS/cm)	60,000	25,000	10,000	9,000	7,500	2,000	5,500	3,000	2,500			
"Entrapment zone" (5mS/cm)	40,000	18,000	7,500	7,000	5,500	1,400	4,000	2,000	1,000			
(15mS/cm)	15,000	7,000	3,500	3,000	2,000	--	1,000	--	--			
Outflow model mean EC	17,006	10,783	−5,484	4,216	2,779	338	1,803	805	674	361	361	85
Difference	1,259	866	−548	69	257	87	4	2	−11	−138	−131	−3
Standard deviation	3,368	2,827	2,202	1,798	1,302	260	981	626	425	280	264	80
CV[2] of differences	0.21	0.28	0.35	0.44	0.51	1.00	0.54	0.77	0.61	0.56	0.53	0.91

Notes: [1] Data for 1976–1991.
[2] Coefficient of variation = standard deviation/measured mean of difference.

Table B2–2. Monthly Simulated Effective Outflow (cfs), EC (μS/cm), and Export Chloride (mg/l) for the No–Project Alternative and Changes Resulting from Operations of the DW Alternatives for 1968–1991

	No–Project Alternative					Alternative 1 Changes					Alternative 2 Changes					Alternative 3 Changes				
Water Year	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-
1968																				
OCT	13,816	1,257	175	165	17	(1,693)	583	33	20	2	(1,693)	583	33	20	2	(2,918)	1,188	82	49	6
NOV	8,358	4,482	533	380	41	(35)	39	7	4	0	(35)	39	7	4	0	(57)	62	11	7	1
DEC	7,021	6,200	897	598	65	(32)	49	12	7	1	(32)	49	12	7	1	(16)	25	6	4	0
JAN	17,910	548	153	152	15	(31)	3	0	0	0	(31)	3	0	0	0	(24)	2	0	0	0
FEB	59,217	150	150	150	15	(15)	0	0	0	0	(15)	0	0	0	0	(25)	0	0	0	0
MAR	29,161	174	150	150	15	25	(0)	(0)	(0)	(0)	25	(0)	(0)	(0)	(0)	(42)	0	0	0	0
APR	10,380	2,762	289	234	24	(0)	0	0	0	0	(0)	0	0	0	0	0	(0)	(0)	(0)	(0)
MAY	7,930	4,970	624	434	47	(0)	0	0	0	0	(0)	0	0	0	0	0	(0)	(0)	(0)	(0)
JUN	7,064	6,136	881	589	64	55	(82)	(20)	(12)	(1)	55	(82)	(20)	(12)	(1)	104	(154)	(37)	(22)	(2)
JUL	7,569	5,426	718	491	53	10	(13)	(3)	(2)	(0)	10	(13)	(3)	(2)	(0)	23	(30)	(6)	(4)	(0)
AUG	5,767	8,427	1,548	989	108	1	(2)	(1)	(0)	(0)	1	(2)	(1)	(0)	(0)	3	(6)	(2)	(1)	(0)
SEP	4,666	11,051	2,575	1,605	177	0	(1)	(0)	(0)	(0)	0	(1)	(0)	(0)	(0)	1	(2)	(1)	(0)	(0)
1969																				
OCT	4,964	10,269	2,240	1,404	154	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(1)	(0)	(0)	(0)
NOV	5,411	9,197	1,821	1,152	126	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
DEC	11,083	2,342	248	209	22	(2,573)	1,978	257	154	17	(2,573)	1,978	257	154	17	(3,639)	3,252	507	304	34
JAN	105,340	150	150	150	15	(8,228)	0	0	0	0	(8,228)	0	0	0	0	(14,013)	0	0	0	0
FEB	129,847	150	150	150	15	(7)	0	0	0	0	(7)	0	0	0	0	(20)	0	0	0	0
MAR	51,928	150	150	150	15	25	(0)	(0)	(0)	(0)	25	(0)	(0)	(0)	(0)	(42)	0	0	0	0
APR	44,212	151	150	150	15	(25)	0	0	0	0	(25)	0	0	0	0	(77)	0	0	0	0
MAY	55,817	150	150	150	15	(39)	0	0	0	0	(39)	0	0	0	0	(97)	0	0	0	0
JUN	25,197	214	150	150	15	(49)	1	0	0	0	(49)	1	0	0	0	(104)	2	0	0	0
JUL	8,113	4,754	583	410	44	1	(1)	(0)	(0)	(0)	1	(1)	(0)	(0)	(0)	2	(2)	(0)	(0)	(0)
AUG	6,209	7,562	1,271	823	90	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
SEP	11,302	2,225	238	203	21	(2,826)	2,131	273	164	18	(2,826)	2,131	273	164	18	(4,218)	3,881	636	382	42
1970																				
OCT	17,016	647	155	153	15	(1,076)	153	4	2	0	(1,076)	153	4	2	0	(2,557)	445	13	8	1
NOV	10,907	2,440	257	214	22	(29)	17	2	1	0	(29)	17	2	1	0	(21)	12	1	1	0
DEC	46,466	150	150	150	15	(60)	0	0	0	0	(60)	0	0	0	0	(31)	0	0	0	0
JAN	197,156	150	150	150	15	(0)	0	0	0	0	(0)	0	0	0	0	(11)	0	0	0	0
FEB	83,351	150	150	150	15	(7)	0	0	0	0	(7)	0	0	0	0	(20)	0	0	0	0
MAR	30,331	168	150	150	15	25	(0)	(0)	(0)	(0)	25	(0)	(0)	(0)	(0)	(42)	0	0	0	0
APR	11,623	2,065	225	195	20	(0)	0	0	0	0	(0)	0	0	0	0	0	(0)	(0)	(0)	(0)
MAY	7,975	4,917	614	428	46	(0)	0	0	0	0	(0)	0	0	0	0	6	(8)	(1)	(1)	(0)
JUN	7,660	5,307	693	476	51	55	(70)	(15)	(9)	(1)	55	(70)	(15)	(9)	(1)	106	(135)	(28)	(17)	(2)
JUL	8,998	3,841	428	317	34	9	(8)	(1)	(1)	(0)	9	(8)	(1)	(1)	(0)	23	(21)	(3)	(2)	(0)
AUG	6,280	7,432	1,232	799	87	1	(1)	(0)	(0)	(0)	1	(1)	(0)	(0)	(0)	1	(2)	(1)	(0)	(0)
SEP	4,558	11,350	2,710	1,686	186	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(1)	(0)	(0)	(0)

Table B2–2. Continued

Water Year	No–Project Alternative Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Alternative 1 Changes Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Alternative 2 Changes Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Alternative 3 Changes Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-
1971																				
OCT	4,860	10,535	2,351	1,471	162	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
NOV	11,338	2,206	236	202	21	(2,494)	1,779	214	128	14	(2,494)	1,779	214	128	14	(3,711)	3,144	466	279	31
DEC	58,991	150	150	150	15	(4,014)	0	0	0	0	(4,014)	0	0	0	0	(7,499)	0	0	0	0
JAN	45,818	150	150	150	15	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	(11)	0	0	0	0
FEB	22,777	268	150	150	15	(0)	0	0	0	0	(0)	0	0	0	0	0	(0)	(0)	(0)	(0)
MAR	43,558	151	150	150	15	(3,104)	1	0	0	0	(2,310)	1	0	0	0	(2,387)	1	0	0	0
APR	16,283	747	157	154	15	3	(0)	(0)	(0)	(0)	2	(0)	(0)	(0)	(0)	2	(0)	(0)	(0)	(0)
MAY	25,445	210	150	150	15	(182)	3	0	0	0	(156)	2	0	0	0	(261)	4	0	0	0
JUN	12,768	1,588	192	175	18	70	(25)	(1)	(1)	(0)	70	(25)	(1)	(1)	(0)	133	(47)	(3)	(2)	(0)
JUL	9,714	3,236	344	267	28	(5)	4	0	0	0	(5)	4	0	0	0	(3)	2	0	0	0
AUG	6,310	7,377	1,216	789	86	(0)	0	0	0	0	(0)	0	0	0	0	(0)	0	0	0	0
SEP	6,117	7,735	1,324	855	93	(0)	0	0	0	0	(0)	0	0	0	0	(0)	0	0	0	0
1972																				
OCT	7,640	5,333	698	479	52	(1,737)	2,818	758	455	51	(1,737)	2,818	758	455	51	(1,701)	2,747	735	441	49
NOV	6,736	6,648	1,012	667	72	(429)	736	206	124	14	(429)	736	206	124	14	(417)	714	200	120	13
DEC	10,987	2,395	253	212	22	(1,437)	970	108	65	7	(1,437)	970	108	65	7	(3,270)	2,839	425	255	28
JAN	9,468	3,431	370	282	30	(332)	284	40	24	3	(214)	180	25	15	2	(591)	523	76	45	5
FEB	16,899	662	155	153	15	(125)	16	0	0	0	(72)	9	0	0	0	(232)	31	1	0	0
MAR	22,432	278	150	150	15	(12)	0	0	0	0	(919)	33	0	0	0	(948)	34	0	0	0
APR	9,953	3,057	322	253	26	0	(0)	(0)	(0)	(0)	16	(12)	(1)	(1)	(0)	17	(12)	(1)	(1)	(0)
MAY	7,903	5,003	631	438	47	0	(0)	(0)	(0)	(0)	1	(1)	(0)	(0)	(0)	1	(1)	(0)	(0)	(0)
JUN	7,060	6,142	883	590	64	55	(82)	(20)	(12)	(1)	55	(82)	(20)	(12)	(1)	104	(154)	(37)	(22)	(2)
JUL	7,656	5,312	694	476	51	9	(12)	(3)	(2)	(0)	9	(12)	(3)	(2)	(0)	23	(29)	(6)	(4)	(0)
AUG	7,006	6,224	903	602	65	(3)	5	1	1	0	(3)	5	1	1	0	(1)	1	0	0	0
SEP	4,583	11,280	2,678	1,667	184	(0)	1	0	0	0	(0)	1	0	0	0	(0)	0	0	0	0
1973																				
OCT	5,204	9,679	2,003	1,262	139	(0)	0	0	0	0	(0)	0	0	0	0	(0)	0	0	0	0
NOV	11,639	2,057	224	195	20	(2,595)	1,741	197	118	13	(2,595)	1,741	197	118	13	(3,669)	2,865	390	234	26
DEC	18,295	511	153	152	15	(943)	96	2	1	0	(943)	96	2	1	0	(2,397)	296	6	4	0
JAN	71,002	150	150	150	15	(564)	0	0	0	0	(404)	0	0	0	0	(1,053)	0	0	0	0
FEB	89,977	150	150	150	15	(7)	0	0	0	0	(7)	0	0	0	0	(20)	0	0	0	0
MAR	55,634	150	150	150	15	25	(0)	(0)	(0)	(0)	25	(0)	(0)	(0)	(0)	(42)	0	0	0	0
APR	15,007	972	164	158	16	50	(10)	(0)	(0)	(0)	50	(10)	(0)	(0)	(0)	74	(15)	(1)	(0)	(0)
MAY	14,164	1,165	171	163	16	59	(15)	(1)	(0)	(0)	59	(15)	(1)	(0)	(0)	99	(25)	(1)	(1)	(0)
JUN	10,528	2,668	279	228	24	1	(0)	(0)	(0)	(0)	1	(0)	(0)	(0)	(0)	1	(1)	(0)	(0)	(0)
JUL	9,514	3,394	365	279	29	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
AUG	5,930	8,097	1,439	923	101	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
SEP	4,692	10,981	2,544	1,587	175	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)

Table B2–2. Continued

Water Year	No–Project Alternative					Alternative 1 Changes					Alternative 2 Changes					Alternative 3 Changes				
	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-
1974																				
OCT	5,254	9,561	1,958	1,235	136	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
NOV	40,244	151	150	150	15	(2,609)	1	0	0	0	(2,609)	1	0	0	0	(3,882)	2	0	0	0
DEC	65,172	150	150	150	15	(41)	0	0	0	0	(41)	0	0	0	0	(819)	0	0	0	0
JAN	125,805	150	150	150	15	0	0	0	0	0	0	0	0	0	0	(11)	0	0	0	0
FEB	38,960	152	150	150	15	(7)	0	0	0	0	(7)	0	0	0	0	(20)	0	0	0	0
MAR	103,030	150	150	150	15	24	(0)	0	0	0	24	(0)	0	0	0	(42)	0	0	0	0
APR	68,918	150	150	150	15	(25)	0	0	0	0	(25)	0	0	0	0	(77)	0	0	0	0
MAY	19,915	391	151	151	15	60	(4)	(0)	(0)	(0)	60	(4)	(0)	(0)	(0)	101	(6)	(0)	(0)	(0)
JUN	12,594	1,652	196	178	18	67	(25)	(2)	(1)	(0)	67	(25)	(2)	(1)	(0)	128	(47)	(3)	(2)	(0)
JUL	8,372	4,466	530	378	40	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	1	(1)	(0)	(0)	(0)
AUG	6,234	7,516	1,257	814	89	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
SEP	8,425	4,410	520	372	40	(2,120)	2,977	699	419	47	(2,120)	2,977	699	419	47	(2,120)	2,977	699	419	47
1975																				
OCT	11,706	2,026	222	193	20	(1,733)	1,017	99	59	7	(1,733)	1,017	99	59	7	(3,663)	2,810	376	226	25
NOV	8,964	3,872	433	320	34	(147)	139	22	13	1	(147)	139	22	13	1	(434)	426	68	41	5
DEC	8,836	3,993	451	331	35	(53)	51	8	5	1	(53)	51	8	5	1	(86)	83	13	8	1
JAN	6,949	6,311	925	615	67	(5)	8	2	1	0	(5)	8	2	1	0	(18)	27	7	4	0
FEB	47,585	150	150	150	15	(20)	0	0	0	0	(20)	0	0	0	0	(67)	0	0	0	0
MAR	81,701	150	150	150	15	25	(0)	0	0	0	25	(0)	0	0	0	(42)	0	0	0	0
APR	19,925	390	151	151	15	50	(3)	(0)	(0)	(0)	50	(3)	(0)	(0)	(0)	74	(4)	(0)	(0)	(0)
MAY	27,523	186	150	150	15	(108)	1	0	0	0	(108)	1	0	0	0	(236)	2	0	0	0
JUN	15,295	915	162	157	16	69	(13)	(0)	(0)	(0)	69	(13)	(0)	(0)	(0)	132	(25)	(1)	(0)	(0)
JUL	8,593	4,234	490	354	38	(1)	1	0	0	0	(1)	1	0	0	0	(3)	3	0	0	0
AUG	6,252	7,482	1,247	808	88	(0)	0	0	0	0	(0)	0	0	0	0	(0)	0	0	0	0
SEP	6,730	6,658	1,014	669	73	(506)	878	249	149	17	(506)	878	249	149	17	(506)	878	249	149	17
1976																				
OCT	11,600	2,076	226	195	20	(2,623)	1,784	205	123	14	(2,623)	1,784	205	123	14	(4,135)	3,489	523	314	35
NOV	11,195	2,281	243	206	21	(436)	245	23	14	2	(436)	245	23	14	2	(1,343)	850	89	53	6
DEC	6,871	6,432	955	633	69	(4)	6	1	1	0	(4)	6	1	1	0	(28)	45	11	7	1
JAN	6,120	7,730	1,322	853	93	(1)	1	0	0	0	(1)	1	0	0	0	(6)	11	3	2	0
FEB	9,332	3,545	385	291	31	16	(13)	(2)	(1)	(0)	16	(13)	(2)	(1)	(0)	25	(21)	(3)	(2)	(0)
MAR	9,680	3,262	348	269	28	65	(50)	(6)	(4)	(0)	65	(50)	(6)	(4)	(0)	51	(39)	(5)	(3)	(0)
APR	7,793	5,138	658	455	49	5	(6)	(1)	(1)	(0)	5	(6)	(1)	(1)	(0)	4	(5)	(1)	(1)	(0)
MAY	6,666	6,761	1,042	685	74	1	(1)	(0)	(0)	(0)	1	(1)	(0)	(0)	(0)	1	(1)	(0)	(0)	(0)
JUN	6,836	6,486	969	642	70	50	(79)	(20)	(12)	(1)	50	(79)	(20)	(12)	(1)	96	(151)	(39)	(23)	(3)
JUL	6,027	7,907	1,378	887	97	10	(19)	(6)	(4)	(0)	10	(19)	(6)	(4)	(0)	19	(36)	(11)	(7)	(1)
AUG	4,197	12,406	3,215	1,989	219	1	(4)	(2)	(1)	(0)	1	(4)	(2)	(1)	(0)	3	(8)	(4)	(2)	(0)
SEP	3,522	14,661	4,447	2,728	302	0	(2)	(1)	(1)	(0)	0	(2)	(1)	(1)	(0)	1	(3)	(2)	(1)	(0)

Table B2–2. Continued

Water Year	No–Project Alternative Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Alternative 1 Changes Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Alternative 2 Changes Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Alternative 3 Changes Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-
1977	16	(24)	(6)	(4)	(0)		2	(3)	(1)	(1)	(0)									
OCT	3,254	15,666	5,063	3,098	343	0	(1)	(1)	(0)	(0)	0	(1)	(1)	(0)	(0)	0	(2)	(1)	(1)	(0)
NOV	4,190	12,428	3,227	1,996	220	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(1)	(0)	(0)	(0)
DEC	5,890	8,177	1,465	939	103	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
JAN	4,931	10,351	2,274	1,424	157	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
FEB	6,908	6,374	941	624	68	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
MAR	6,900	6,387	944	626	68	16	(24)	(6)	(4)	(0)	16	(24)	(6)	(4)	(0)	2	(3)	(1)	(1)	(0)
APR	6,898	6,390	945	627	68	4	(6)	(2)	(1)	(0)	4	(6)	(2)	(1)	(0)	1	(1)	(0)	(0)	(0)
MAY	5,107	9,912	2,095	1,317	145	1	(1)	(1)	(0)	(0)	1	(1)	(1)	(0)	(0)	0	(0)	(0)	(0)	(0)
JUN	4,399	11,804	2,922	1,813	200	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
JUL	4,166	12,502	3,264	2,018	223	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
AUG	3,741	13,886	4,000	2,460	272	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
SEP	3,355	15,279	4,821	2,953	326	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
1978	25	(0)	(0)	(0)	(0)		(42)	0	0	0	0									
OCT	3,178	15,965	5,254	3,213	355	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
NOV	3,347	15,310	4,841	2,964	328	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
DEC	5,047	10,060	2,154	1,352	149	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
JAN	38,413	152	150	150	15	(2,451)	2	0	0	0	(2,451)	2	0	0	0	(3,802)	4	0	0	0
FEB	53,369	150	150	150	15	(13)	0	0	0	0	(13)	0	0	0	0	(698)	0	0	0	0
MAR	61,156	150	150	150	15	25	(0)	(0)	(0)	(0)	25	(0)	(0)	(0)	(0)	(42)	0	0	0	0
APR	36,875	153	150	150	15	(25)	0	0	0	0	(25)	0	0	0	0	(77)	0	0	0	0
MAY	15,862	814	159	155	16	60	(10)	(0)	(0)	(0)	60	(10)	(0)	(0)	(0)	101	(17)	(0)	(0)	(0)
JUN	9,071	3,774	418	311	33	(1)	1	0	0	0	(1)	1	0	0	0	(2)	2	0	0	0
JUL	8,176	4,683	569	402	43	(0)	0	0	0	0	(0)	0	0	0	0	(0)	0	0	0	0
AUG	5,862	8,233	1,483	950	104	(0)	0	0	0	0	(0)	0	0	0	0	(0)	0	0	0	0
SEP	5,424	9,170	1,810	1,146	126	(0)	0	0	0	0	(0)	0	0	0	0	(0)	0	0	0	0
1979	25	(0)	(0)	(0)	(0)		(40)	1	0	0	0									
OCT	7,858	5,058	642	445	48	(2,005)	3,195	848	509	57	(2,005)	3,195	848	509	57	(1,972)	3,127	826	496	55
NOV	6,799	6,546	985	651	71	(626)	1,084	307	184	20	(626)	1,084	307	184	20	(615)	1,063	301	180	20
DEC	5,450	9,111	1,789	1,133	124	(120)	273	101	61	7	(120)	273	101	61	7	(118)	267	99	60	7
JAN	15,311	912	162	157	16	(2,691)	731	34	20	2	(2,691)	731	34	20	2	(4,082)	1,352	79	48	5
FEB	38,456	152	150	150	15	(1,032)	1	0	0	0	(1,032)	1	0	0	0	(2,481)	2	0	0	0
MAR	26,115	201	150	150	15	25	(0)	(0)	(0)	(0)	25	(0)	(0)	(0)	(0)	(40)	1	0	0	0
APR	14,455	1,093	168	161	16	50	(12)	(0)	(0)	(0)	50	(12)	(0)	(0)	(0)	74	(17)	(1)	(0)	(0)
MAY	12,491	1,691	198	179	18	59	(22)	(1)	(1)	(0)	59	(22)	(1)	(1)	(0)	98	(37)	(2)	(1)	(0)
JUN	11,014	2,379	251	211	22	3	(2)	(0)	(0)	(0)	3	(2)	(0)	(0)	(0)	5	(3)	(0)	(0)	(0)
JUL	7,003	6,227	904	602	65	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
AUG	5,243	9,585	1,967	1,240	136	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
SEP	4,044	12,885	3,460	2,136	236	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)

Table B2–2. Continued

Water Year	No–Project Alternative Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Alternative 1 Changes Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Alternative 2 Changes Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Alternative 3 Changes Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-
1980																				
OCT	4,020	12,961	3,499	2,160	238	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
NOV	7,107	6,071	865	579	63	(1,630)	2,979	901	541	60	(1,630)	2,979	901	541	60	(1,607)	2,927	882	529	59
DEC	10,949	2,416	255	213	22	(1,722)	1,220	143	86	10	(1,722)	1,220	143	86	10	(3,513)	3,188	502	301	33
JAN	96,644	150	150	150	15	(4,727)	0	0	0	0	(4,719)	0	0	0	0	(11,816)	0	0	0	0
FEB	127,706	150	150	150	15	(7)	0	0	0	0	(7)	0	0	0	0	(19)	0	0	0	0
MAR	63,895	150	150	150	15	25	(0)	(0)	(0)	(0)	25	(0)	(0)	(0)	(0)	(42)	0	0	0	0
APR	15,046	964	164	158	16	50	(10)	(0)	(0)	(0)	50	(10)	(0)	(0)	(0)	74	(15)	(0)	(0)	(0)
MAY	12,392	1,730	201	181	18	58	(23)	(1)	(1)	(0)	58	(23)	(1)	(1)	(0)	98	(38)	(2)	(1)	(0)
JUN	7,983	4,907	612	427	46	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
JUL	7,998	4,889	608	425	46	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
AUG	5,847	8,265	1,494	956	105	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
SEP	5,564	8,860	1,698	1,079	118	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
1981																				
OCT	7,791	5,140	658	455	49	(1,931)	3,097	826	496	55	(1,931)	3,097	826	496	55	(1,897)	3,028	804	482	54
NOV	6,426	7,171	1,156	754	82	(426)	790	239	143	16	(426)	790	239	143	16	(416)	769	232	139	15
DEC	7,022	6,199	897	598	65	(1,001)	1,719	485	291	32	(1,001)	1,719	485	291	32	(1,079)	1,873	534	320	36
JAN	15,348	905	162	157	16	(901)	191	7	4	0	(901)	191	7	4	0	(2,781)	758	35	21	2
FEB	20,361	365	151	151	15	(76)	4	0	0	0	(76)	4	0	0	0	(369)	21	0	0	0
MAR	25,477	210	150	150	15	(6)	0	0	0	0	(615)	10	0	0	0	(718)	12	0	0	0
APR	12,304	1,765	203	182	19	0	(0)	(0)	(0)	(0)	6	(3)	(0)	(0)	(0)	7	(3)	(0)	(0)	(0)
MAY	7,982	4,908	612	427	46	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
JUN	6,495	7,050	1,122	733	80	55	(94)	(26)	(16)	(2)	55	(94)	(26)	(16)	(2)	105	(178)	(50)	(30)	(3)
JUL	6,934	6,334	930	618	67	11	(17)	(4)	(3)	(0)	11	(17)	(4)	(3)	(0)	26	(39)	(10)	(6)	(1)
AUG	5,356	9,323	1,867	1,180	129	2	(4)	(1)	(1)	(0)	2	(4)	(1)	(1)	(0)	4	(8)	(3)	(2)	(0)
SEP	4,131	12,612	3,319	2,052	226	0	(1)	(1)	(0)	(0)	0	(1)	(1)	(0)	(0)	1	(2)	(1)	(1)	(0)
1982																				
OCT	4,503	11,504	2,781	1,729	190	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(1)	(1)	(0)	(0)
NOV	17,638	576	154	152	15	(2,381)	346	8	5	1	(2,381)	346	8	5	1	(3,543)	607	18	11	1
DEC	85,974	150	150	150	15	(1,407)	0	0	0	0	(1,407)	0	0	0	0	(3,104)	0	0	0	0
JAN	77,881	150	150	150	15	(352)	0	0	0	0	(123)	0	0	0	0	(135)	0	0	0	0
FEB	94,845	150	150	150	15	(7)	0	0	0	0	(7)	0	0	0	0	(20)	0	0	0	0
MAR	79,101	150	150	150	15	25	(0)	0	(0)	0	25	(0)	0	(0)	0	(42)	0	0	0	0
APR	139,945	150	150	150	15	(25)	0	0	0	0	(25)	0	0	0	0	(77)	0	0	0	0
MAY	46,703	150	150	150	15	(39)	0	0	0	0	(39)	0	0	0	0	(97)	0	0	0	0
JUN	16,998	650	155	153	15	32	(4)	(0)	(0)	(0)	32	(4)	(0)	(0)	(0)	95	(12)	(0)	(0)	(0)
JUL	8,302	4,542	544	386	41	(1)	1	0	0	0	(1)	1	0	0	0	(3)	3	0	0	0
AUG	6,276	7,438	1,234	800	87	(0)	0	0	0	0	(0)	0	0	0	0	(0)	0	0	0	0
SEP	13,292	1,412	182	169	17	(2,842)	1,306	102	61	7	(2,842)	1,306	102	61	7	(4,241)	2,381	238	143	16

Table B2–2. Continued

Water Year	No–Project Alternative					Alternative 1 Changes					Alternative 2 Changes					Alternative 3 Changes				
	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-
1983																				
OCT	29,889	170	150	150	15	(1,363)	8	0	0	0	(1,363)	8	0	0	0	(2,945)	22	0	0	0
NOV	43,749	151	150	150	15	(52)	0	0	0	0	(52)	0	0	0	0	(62)	0	0	0	0
DEC	86,205	150	150	150	15	(34)	0	0	0	0	(34)	0	0	0	0	(11)	0	0	0	0
JAN	101,369	150	150	150	15	0	(0)	0	0	0	0	(0)	0	0	0	(11)	0	0	0	0
FEB	181,018	150	150	150	15	(7)	0	0	0	0	(7)	0	0	0	0	(20)	0	0	0	0
MAR	256,037	150	150	150	15	25	0	0	0	0	25	0	0	0	0	(42)	0	0	0	0
APR	105,749	150	150	150	15	(25)	0	0	0	0	(25)	0	0	0	0	(77)	0	0	0	0
MAY	78,406	150	150	150	15	(39)	0	0	0	0	(39)	0	0	0	0	(97)	0	0	0	0
JUN	70,952	150	150	150	15	(49)	0	0	0	0	(49)	0	0	0	0	(104)	0	0	0	0
JUL	28,552	178	150	150	15	(52)	0	0	0	0	(52)	0	0	0	0	(110)	1	0	0	0
AUG	8,682	4,144	476	345	37	(54)	55	9	5	1	(54)	55	9	5	1	(114)	115	19	11	1
SEP	20,592	353	151	151	15	(89)	5	0	0	0	(89)	5	0	0	0	(166)	9	0	0	0
1984																				
OCT	32,998	159	150	150	15	(67)	0	0	0	0	(67)	0	0	0	0	(74)	0	0	0	0
NOV	76,960	150	150	150	15	(38)	0	0	0	0	(38)	0	0	0	0	(21)	0	0	0	0
DEC	152,708	150	150	150	15	(34)	0	0	0	0	(34)	0	0	0	0	(11)	0	0	0	0
JAN	75,962	150	150	150	15	0	(0)	0	0	0	0	(0)	0	0	0	(11)	0	0	0	0
FEB	41,156	151	150	150	15	(7)	0	0	0	0	(7)	0	0	0	0	(19)	0	0	0	0
MAR	30,795	166	150	150	15	25	(0)	(0)	(0)	(0)	25	(0)	(0)	(0)	(0)	(42)	0	0	0	0
APR	12,661	1,627	195	177	18	50	(18)	(1)	(1)	(0)	50	(18)	(1)	(1)	(0)	74	(27)	(2)	(1)	(0)
MAY	9,241	3,623	396	298	31	57	(49)	(7)	(4)	(0)	57	(49)	(7)	(4)	(0)	95	(81)	(11)	(7)	(1)
JUN	8,391	4,446	527	376	40	65	(70)	(12)	(7)	(1)	65	(70)	(12)	(7)	(1)	123	(130)	(22)	(13)	(1)
JUL	8,760	4,067	463	338	36	13	(13)	(2)	(1)	(0)	13	(13)	(2)	(1)	(0)	24	(24)	(4)	(2)	(0)
AUG	6,265	7,460	1,240	804	88	1	(2)	(0)	(0)	(0)	1	(2)	(0)	(0)	(0)	2	(3)	(1)	(1)	(0)
SEP	5,817	8,325	1,514	968	106	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(1)	(0)	(0)	(0)
1985																				
OCT	8,376	4,462	529	378	40	(2,082)	2,945	695	417	46	(2,082)	2,945	695	417	46	(2,047)	2,882	677	406	45
NOV	25,347	212	150	150	15	(3,268)	78	0	0	0	(3,268)	78	0	0	0	(5,230)	167	1	1	0
DEC	20,077	381	151	151	15	(43)	2	0	0	0	(43)	2	0	0	0	(43)	3	0	0	0
JAN	6,873	6,429	955	633	69	16	(25)	(6)	(4)	(0)	16	(25)	(6)	(4)	(0)	19	(30)	(8)	(5)	(1)
FEB	13,170	1,451	185	171	17	28	(9)	(0)	(0)	(0)	28	(9)	(0)	(0)	(0)	44	(14)	(1)	(0)	(0)
MAR	14,054	1,193	172	163	16	70	(18)	(1)	(0)	(0)	70	(18)	(1)	(0)	(0)	55	(14)	(1)	(0)	(0)
APR	8,235	4,616	557	394	42	(1)	1	0	0	0	(1)	1	0	0	0	(1)	1	0	0	0
MAY	9,670	3,270	349	269	28	(0)	0	0	0	0	(0)	0	0	0	0	(0)	0	0	0	0
JUN	6,631	6,819	1,058	695	76	59	(98)	(26)	(16)	(2)	59	(98)	(26)	(16)	(2)	112	(185)	(50)	(30)	(3)
JUL	7,028	6,189	894	597	65	11	(17)	(4)	(3)	(0)	11	(17)	(4)	(3)	(0)	26	(40)	(10)	(6)	(1)
AUG	6,106	7,754	1,330	858	94	2	(4)	(1)	(1)	(0)	2	(4)	(1)	(1)	(0)	5	(9)	(3)	(2)	(0)
SEP	4,450	11,654	2,851	1,771	195	0	(1)	(0)	(0)	(0)	0	(1)	(0)	(0)	(0)	1	(2)	(1)	(1)	(0)

Table B2–2. Continued

Water Year	No–Project Alternative					Alternative 1 Changes					Alternative 2 Changes					Alternative 3 Changes				
	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-
1986																				
OCT	4,583	11,280	2,678	1,667	184	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(1)	(0)	(0)	(0)
NOV	4,950	10,305	2,255	1,413	155	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
DEC	6,330	7,341	1,205	783	85	(254)	472	143	86	10	(254)	472	143	86	10	(254)	472	143	86	10
JAN	9,858	3,127	331	259	27	(1,890)	1,798	284	171	19	(1,890)	1,798	284	171	19	(1,887)	1,795	284	170	19
FEB	190,644	150	150	150	15	(14,711)	0	0	0	0	(14,711)	0	0	0	0	(17,093)	0	0	0	0
MAR	149,241	150	150	150	15	25	0	0	0	0	25	0	0	0	0	(42)	0	0	0	0
APR	28,310	180	150	150	15	(25)	0	0	0	0	(25)	0	0	0	0	(77)	1	0	0	0
MAY	11,409	2,170	233	200	21	60	(30)	(2)	(1)	(0)	60	(30)	(2)	(1)	(0)	101	(51)	(4)	(2)	(0)
JUN	7,970	4,922	615	429	46	63	(75)	(15)	(9)	(1)	63	(75)	(15)	(9)	(1)	120	(142)	(27)	(16)	(2)
JUL	7,996	4,892	609	425	46	13	(15)	(3)	(2)	(0)	13	(15)	(3)	(2)	(0)	24	(28)	(5)	(3)	(0)
AUG	6,197	7,585	1,278	827	90	1	(3)	(1)	(0)	(0)	1	(3)	(1)	(0)	(0)	3	(5)	(1)	(1)	(0)
SEP	4,662	11,061	2,580	1,608	177	0	(1)	(0)	(0)	(0)	0	(1)	(0)	(0)	(0)	0	(1)	(1)	(0)	(0)
1987																				
OCT	4,537	11,409	2,737	1,702	187	(6)	16	8	5	1	(6)	16	8	5	1	25	(70)	(32)	(19)	(2)
NOV	5,144	9,824	2,060	1,296	142	(3)	7	3	2	0	(3)	7	3	2	0	12	(29)	(11)	(7)	(1)
DEC	4,793	10,710	2,426	1,516	167	(1)	2	1	1	0	(1)	2	1	1	0	4	(10)	(4)	(3)	(0)
JAN	5,394	9,238	1,836	1,161	127	(0)	1	0	0	0	(0)	1	0	0	0	2	(4)	(1)	(1)	(0)
FEB	9,980	3,037	320	252	26	15	(11)	(1)	(1)	(0)	15	(11)	(1)	(1)	(0)	29	(21)	(2)	(1)	(0)
MAR	22,185	287	150	150	15	(885)	34	0	0	0	(885)	34	0	0	0	(894)	34	0	0	0
APR	10,612	2,616	274	224	23	14	(9)	(1)	(1)	(0)	14	(9)	(1)	(1)	(0)	14	(9)	(1)	(1)	(0)
MAY	7,942	4,956	621	433	46	1	(1)	(0)	(0)	(0)	1	(1)	(0)	(0)	(0)	1	(1)	(0)	(0)	(0)
JUN	6,490	7,059	1,124	734	80	55	(94)	(26)	(16)	(2)	55	(94)	(26)	(16)	(2)	105	(178)	(50)	(30)	(3)
JUL	7,015	6,209	899	600	65	12	(18)	(4)	(3)	(0)	12	(18)	(4)	(3)	(0)	27	(41)	(10)	(6)	(1)
AUG	5,804	8,352	1,523	974	107	2	(4)	(1)	(1)	(0)	2	(4)	(1)	(1)	(0)	4	(9)	(3)	(2)	(0)
SEP	4,232	12,300	3,163	1,958	216	0	(1)	(1)	(0)	(0)	0	(1)	(1)	(0)	(0)	1	(2)	(1)	(1)	(0)
1988																				
OCT	4,100	12,708	3,368	2,081	230	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(1)	(0)	(0)	(0)
NOV	4,458	11,632	2,841	1,764	194	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
DEC	5,922	8,114	1,444	927	101	(36)	73	24	14	2	(36)	73	24	14	2	(36)	73	24	14	2
JAN	14,277	1,136	170	162	16	(2,688)	945	56	34	4	(2,688)	945	56	34	4	(4,177)	1,816	140	84	9
FEB	11,566	2,092	227	196	20	(135)	67	5	3	0	(135)	67	5	3	0	(311)	157	13	8	1
MAR	8,176	4,683	569	402	43	62	(70)	(13)	(8)	(1)	62	(70)	(13)	(8)	(1)	40	(46)	(8)	(5)	(1)
APR	7,471	5,557	747	508	55	10	(13)	(3)	(2)	(0)	10	(13)	(3)	(2)	(0)	6	(9)	(2)	(1)	(0)
MAY	6,715	6,682	1,021	672	73	2	(3)	(1)	(0)	(0)	2	(3)	(1)	(0)	(0)	1	(2)	(1)	(0)	(0)
JUN	6,849	6,465	964	638	69	51	(80)	(20)	(12)	(1)	51	(80)	(20)	(12)	(1)	97	(151)	(38)	(23)	(3)
JUL	5,836	8,286	1,501	961	105	9	(19)	(6)	(4)	(0)	9	(19)	(6)	(4)	(0)	17	(35)	(12)	(7)	(1)
AUG	4,169	12,495	3,260	2,016	222	1	(5)	(2)	(1)	(0)	1	(5)	(2)	(1)	(0)	3	(9)	(4)	(3)	(0)
SEP	3,512	14,696	4,468	2,741	303	0	(2)	(1)	(1)	(0)	0	(2)	(1)	(1)	(0)	1	(3)	(2)	(1)	(0)

Table B2–2. Continued

Water Year	No–Project Alternative					Alternative 1 Changes					Alternative 2 Changes					Alternative 3 Changes				
	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-	Effective Outflow	Chipps EC	Emmaton EC	Jersey EC	Export Cl^-
1989																				
OCT	3,250	15,682	5,074	3,104	343	0	(1)	(1)	(0)	(0)	0	(1)	(1)	(0)	(0)	0	(2)	(1)	(1)	(0)
NOV	3,918	13,293	3,675	2,265	250	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(1)	(0)	(0)	(0)
DEC	4,813	10,658	2,404	1,502	165	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
JAN	5,416	9,188	1,817	1,150	126	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
FEB	7,241	5,876	819	551	60	16	(22)	(5)	(3)	(0)	16	(22)	(5)	(3)	(0)	27	(39)	(9)	(5)	(1)
MAR	25,740	206	150	150	15	(2,809)	57	0	0	0	(2,809)	57	0	0	0	(2,808)	57	0	0	0
APR	17,822	556	153	152	15	56	(6)	(0)	(0)	(0)	56	(6)	(0)	(0)	(0)	80	(8)	(0)	(0)	(0)
MAY	10,482	2,697	282	229	24	(1)	1	0	0	0	(1)	1	0	0	0	(1)	1	0	0	0
JUN	6,654	6,782	1,048	689	75	61	(100)	(27)	(16)	(2)	61	(100)	(27)	(16)	(2)	115	(188)	(50)	(30)	(3)
JUL	7,109	6,069	865	579	63	12	(18)	(4)	(3)	(0)	12	(18)	(4)	(3)	(0)	28	(41)	(10)	(6)	(1)
AUG	6,364	7,281	1,188	773	84	(3)	5	2	1	0	(3)	5	2	1	0	(0)	0	0	0	0
SEP	4,531	11,425	2,744	1,707	188	(0)	1	1	0	0	(0)	1	1	0	0	(0)	0	0	0	0
1990																				
OCT	4,215	12,352	3,188	1,973	218	(0)	0	0	0	0	(0)	0	0	0	0	(0)	0	0	0	0
NOV	4,380	11,860	2,948	1,829	202	(0)	0	0	0	0	(0)	0	0	0	0	(0)	0	0	0	0
DEC	5,568	8,850	1,695	1,077	118	(0)	0	0	0	0	(0)	0	0	0	0	(0)	0	0	0	0
JAN	7,133	6,033	856	574	62	(655)	1,047	274	164	18	(655)	1,047	274	164	18	(653)	1,043	273	164	18
FEB	10,376	2,765	290	234	24	(306)	208	23	14	2	(306)	208	23	14	2	(291)	198	22	13	1
MAR	7,695	5,262	683	470	51	47	(60)	(12)	(7)	(1)	47	(60)	(12)	(7)	(1)	32	(41)	(9)	(5)	(1)
APR	9,703	3,245	345	267	28	15	(12)	(1)	(1)	(0)	15	(12)	(1)	(1)	(0)	10	(8)	(1)	(1)	(0)
MAY	6,455	7,120	1,142	745	81	1	(1)	(0)	(0)	(0)	1	(1)	(0)	(0)	(0)	0	(1)	(0)	(0)	(0)
JUN	6,775	6,583	995	657	71	50	(79)	(21)	(12)	(1)	50	(79)	(21)	(12)	(1)	95	(151)	(39)	(23)	(3)
JUL	5,891	8,175	1,464	939	103	10	(19)	(6)	(4)	(0)	10	(19)	(6)	(4)	(0)	18	(36)	(12)	(7)	(1)
AUG	4,199	12,400	3,212	1,987	219	2	(5)	(2)	(1)	(0)	2	(5)	(2)	(1)	(0)	3	(9)	(4)	(3)	(0)
SEP	3,522	14,659	4,446	2,728	301	0	(2)	(1)	(1)	(0)	0	(2)	(1)	(1)	(0)	1	(3)	(2)	(1)	(0)
1991																				
OCT	3,254	15,665	5,062	3,097	343	0	(1)	(1)	(0)	(0)	0	(1)	(1)	(0)	(0)	0	(2)	(1)	(1)	(0)
NOV	3,700	14,027	4,080	2,508	277	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(1)	(1)	(0)	(0)
DEC	4,135	12,598	3,312	2,047	226	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
JAN	4,636	11,133	2,612	1,627	179	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
FEB	6,825	6,504	974	644	70	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)
MAR	17,624	577	154	152	15	7	(1)	(0)	(0)	(0)	7	(1)	(0)	(0)	(0)	(6)	1	0	0	0
APR	11,447	2,151	232	199	20	(0)	0	0	0	0	(0)	0	0	0	0	0	(0)	(0)	(0)	(0)
MAY	5,979	8,001	1,408	905	99	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	(0)	0	0	0	0
JUN	6,717	6,678	1,020	672	73	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	33	(53)	(14)	(8)	(1)
JUL	4,868	10,514	2,342	1,465	161	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	4	(11)	(5)	(3)	(0)
AUG	3,964	13,143	3,595	2,217	245	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	1	(4)	(2)	(1)	(0)
SEP	3,441	14,958	4,625	2,835	313	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)	(0)	0	(2)	(1)	(1)	(0)

Note: Negative values shown in parentheses.

Table B2–3. Summary of DeltaDWQ–Simulated Changes in EC (μS/cm) and Export Chloride (mg/l) from the No–Project Alternative Resulting from DW Project Alternatives for 1967–1991

Alternative 1

Chipps Island EC (μS/cm)

No–Project Average	5,148
Alt. 1 Average	5,279
Alt. 1 Average Change	131

Changes in EC

	x>0	%	x<=0	%
Months (#)	138		162	
Maximum	3,804	95.8	0.0	0.0
Average	356	12.9	−11.6	−0.3
Minimum	0.0	0.0	−99.6	−1.6

Alternative 2

Chipps Island EC (μS/cm)

No–Project Average	5,148
Alt. 2 Average	5,279
Alt. 2 Average Change	131

Changes in EC

	x>0	%	x<=0	%
Months (#)	138		162	
Maximum	3,804	95.8	0.0	0.0
Average	356	13.0	−11.7	−0.3
Minimum	0.0	0.0	−99.6	−1.6

Alternative 3

Chipps Island EC (μS/cm)

No–Project Average	5,148
Alt. 3 Average	5,324
Alt. 3 Average Change	177

Changes in EC

	x>0	%	x<=0	%
Months (#)	146		154	
Maximum	3,881	174	0.0	0.0
Average	465	20.3	−22.0	−0.5
Minimum	0.0	0.0	−188	−3.0

Alternative 1

Emmaton EC (μS/cm)

No–Project Average	1,050
Alt. 1 Average	1,076
Alt. 1 Average Change	26

Changes in EC

	x>0	%	x<=0	%
Months (#)	124		176	
Maximum	901	198	0.0	0.0
Average	79.4	16.5	−2.3	−0.3
Minimum	0.0	0.0	−26.8	−2.6

Alternative 2

Emmaton EC (μS/cm)

No–Project Average	1,050
Alt. 2 Average	1,076
Alt. 2 Average Change	26

Changes in EC

	x>0	%	x<=0	%
Months (#)	123		177	
Maximum	901	198	0.0	0.0
Average	80.0	16.6	−2.3	−0.3
Minimum	0.0	0.0	−26.8	−2.6

Alternative 3

Emmaton EC (μS/cm)

No–Project Average	1,050
Alt. 3 Average	1,082
Alt. 3 Average Change	31

Changes in EC

	x>0	%	x<=0	%
Months (#)	128		172	
Maximum	882	267	0.0	0.0
Average	98.7	25.6	−4.5	−0.5
Minimum	0.0	0.0	−50.2	−4.8

Alternative 1

Jersey EC (μS/cm)

No–Project Average	690
Alt. 1 Average	705
Alt. 1 Average Change	15

Changes in EC

	x>0	%	x<=0	%
Months (#)	124		176	
Maximum	541	162	0.0	0.0
Average	47.7	13.0	−1.4	−0.3
Minimum	0.0	0.0	−16.1	−2.3

Alternative 2

Jersey EC (μS/cm)

No–Project Average	690
Alt. 2 Average	705
Alt. 2 Average Change	15

Changes in EC

	x>0	%	x<=0	%
Months (#)	124		176	
Maximum	541	162	0.0	0.0
Average	47.6	13.0	−1.4	−0.3
Minimum	0.0	0.0	−16.1	−2.3

Alternative 3

Jersey EC (μS/cm)

No–Project Average	690
Alt. 3 Average	709
Alt. 3 Average Change	19

Changes in EC

	x>0	%	x<=0	%
Months (#)	127		173	
Maximum	529	188	0.0	0.0
Average	59.7	19.4	−2.7	−0.5
Minimum	0.0	0.0	−30.1	−4.4

Alternative 1

Export Chloride (mg/l)

No–Project Average	75
Alt. 1 Average	77
Alt. 1 Average Change	2

Changes in EC

	x>0	%	x<=0	%
Months (#)	125		175	
Maximum	60.1	170	0.0	0.0
Average	5.3	13.6	−0.2	−0.3
Minimum	0.0	0.0	−1.8	−2.4

Alternative 2

Export Chloride (mg/l)

No–Project Average	75
Alt. 2 Average	77
Alt. 2 Average Change	2

Changes in EC

	x>0	%	x<=0	%
Months (#)	124		176	
Maximum	60.1	170	0.0	0.0
Average	5.3	13.7	−0.2	−0.3
Minimum	0.0	0.0	−1.8	−2.4

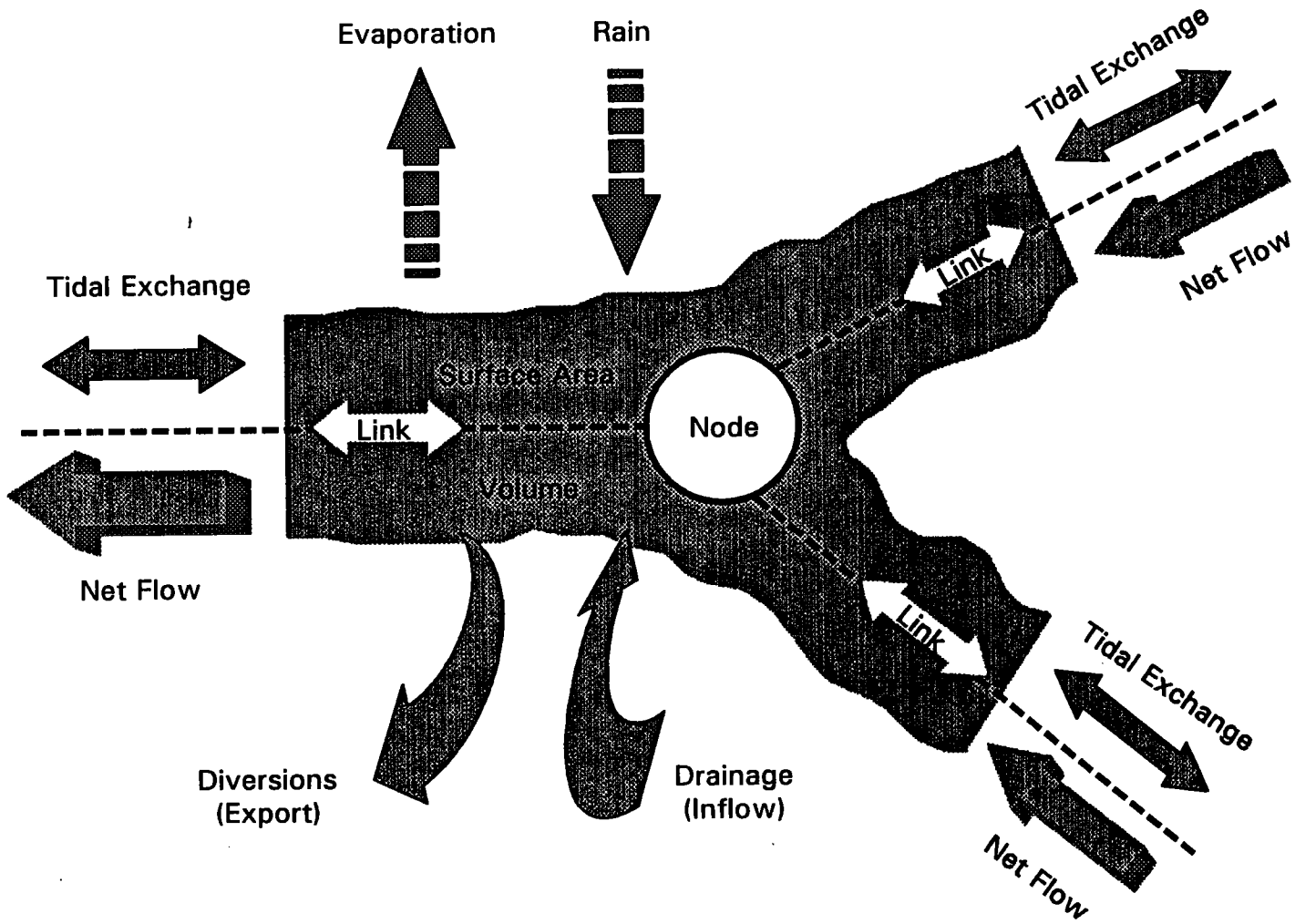
Alternative 3

Export Chloride (mg/l)

No–Project Average	75
Alt. 3 Average	77
Alt. 3 Average Change	2

Changes in EC

	x>0	%	x<=0	%
Months (#)	126		174	
Maximum	58.8	203	0.0	0.0
Average	6.7	20.8	−0.3	−0.5
Minimum	0.0	0.0	−3.3	−4.5



Note: Water quality mass balance will track flow·concentration terms.

Figure B2-1.
Diagram of Mass-Balance Terms for the RMA Delta Model

DELTA WETLANDS
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Prepared by: Jones & Stokes Associates

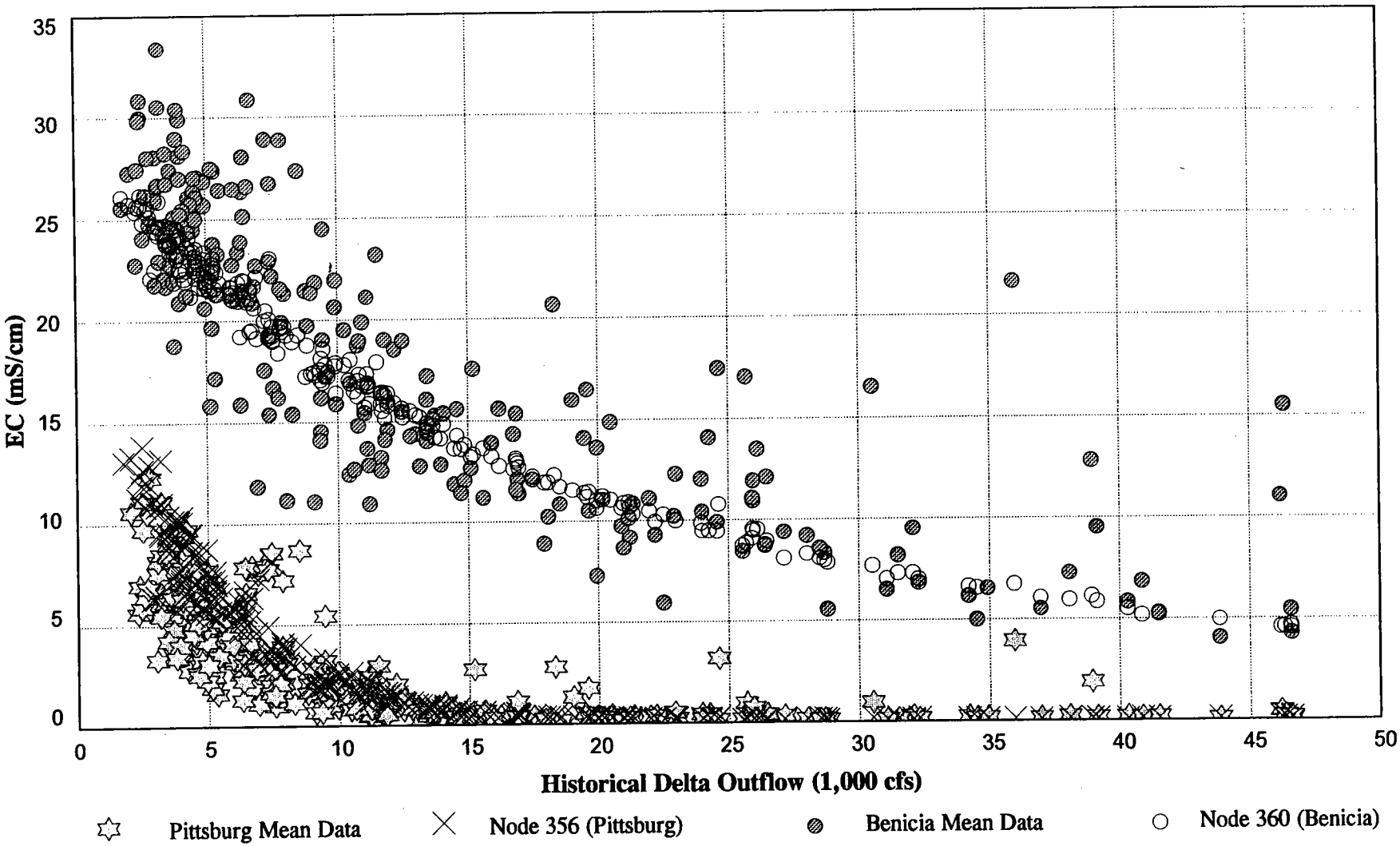


Figure B2-2.
Relationship between Simulated End-of-Month and Measured Mean Monthly EC and Historical Delta Outflow at Pittsburg and Benicia for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

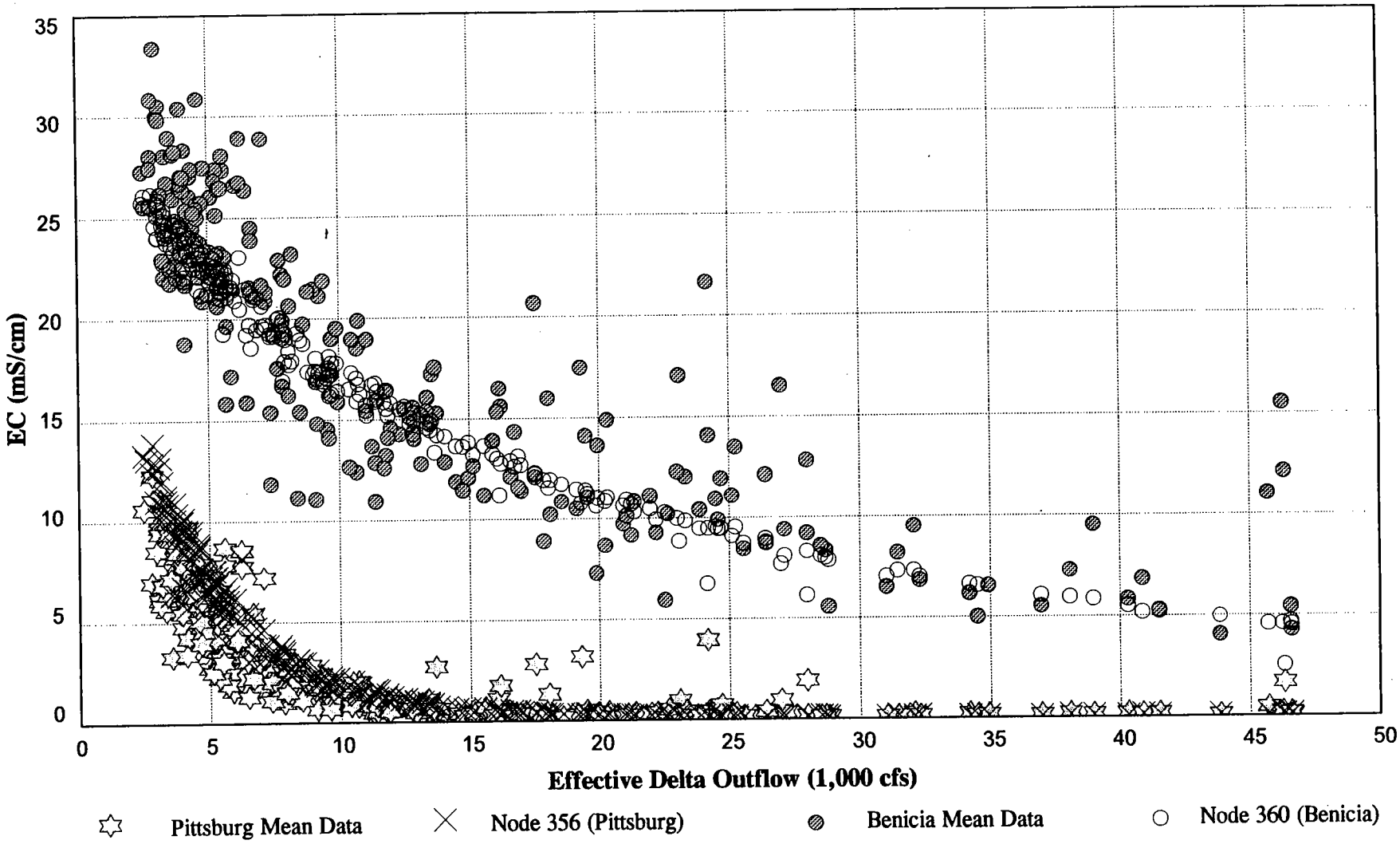
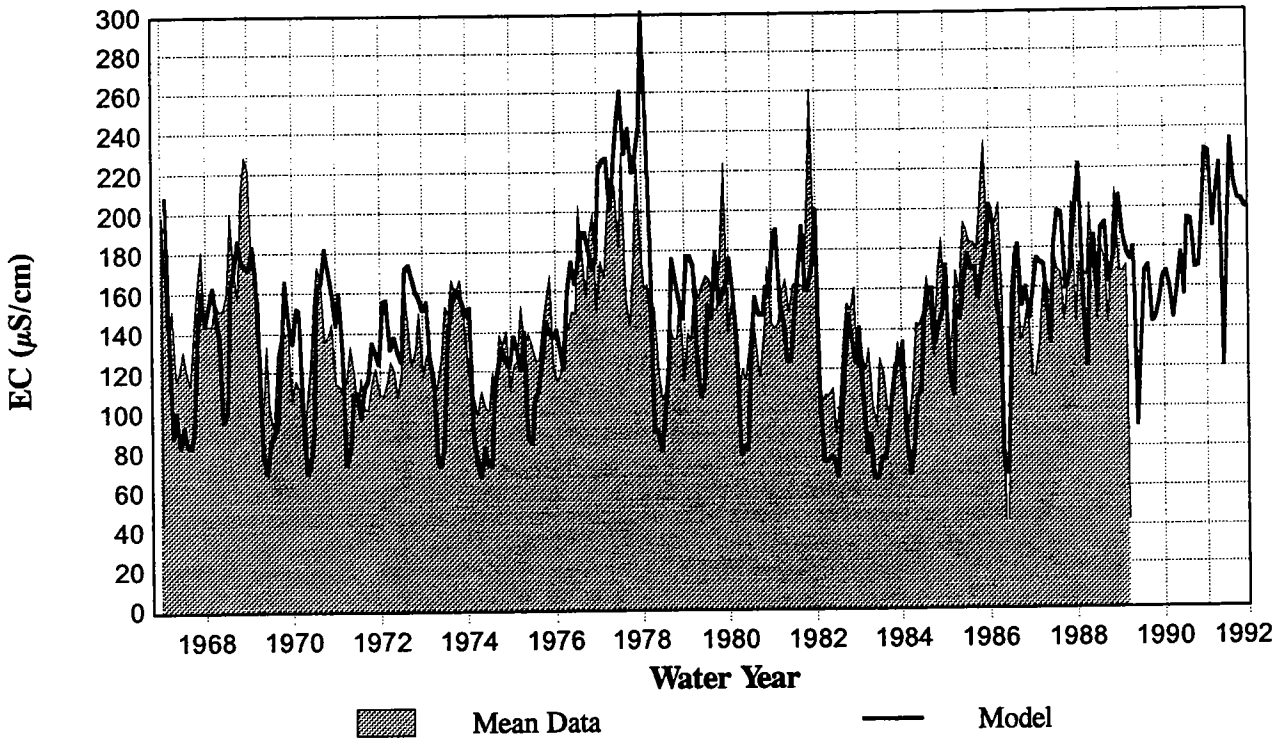


Figure B2-3.
Relationship between Simulated End-of-Month and Measured Mean Monthly EC and Effective Delta Outflow at Pittsburg and Benicia for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



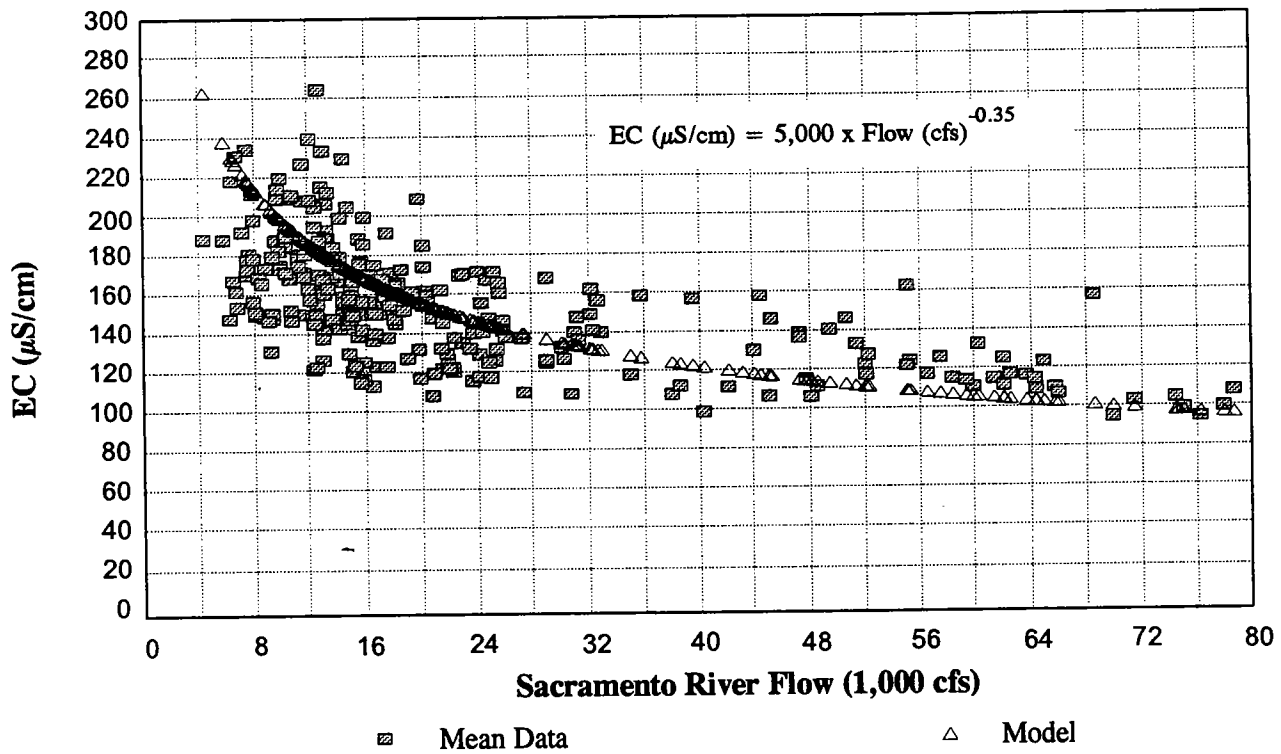
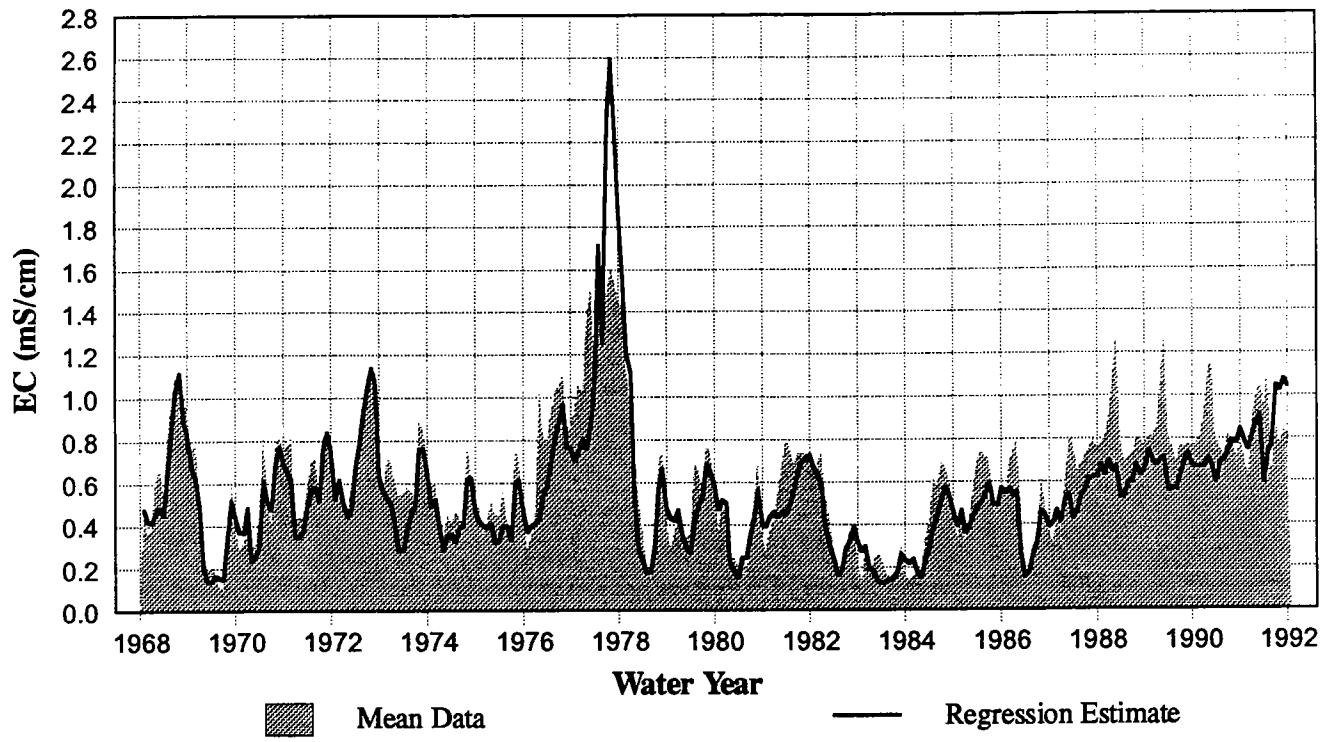


Figure B2-4.
Relationship between Simulated End-of-Month and Measured Mean Monthly EC at Greene's Landing and Sacramento River Flow for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



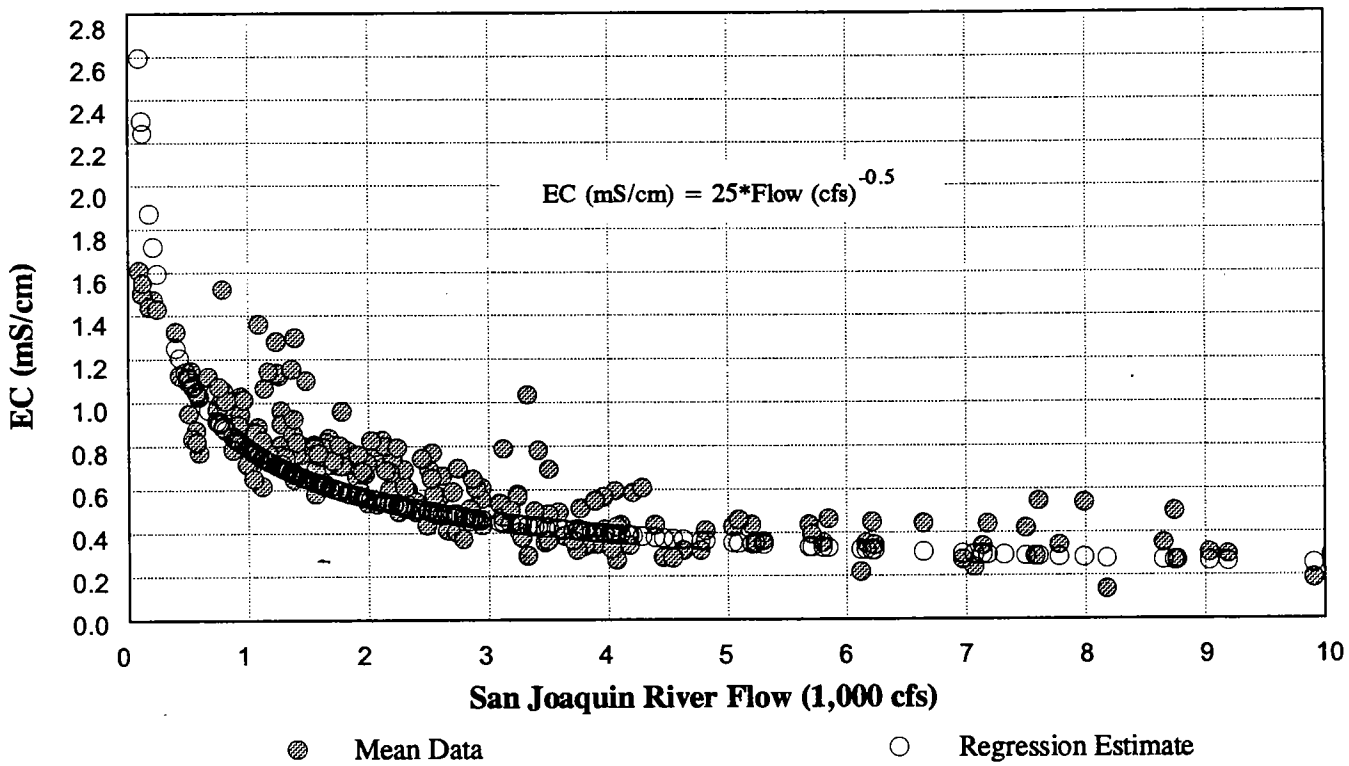
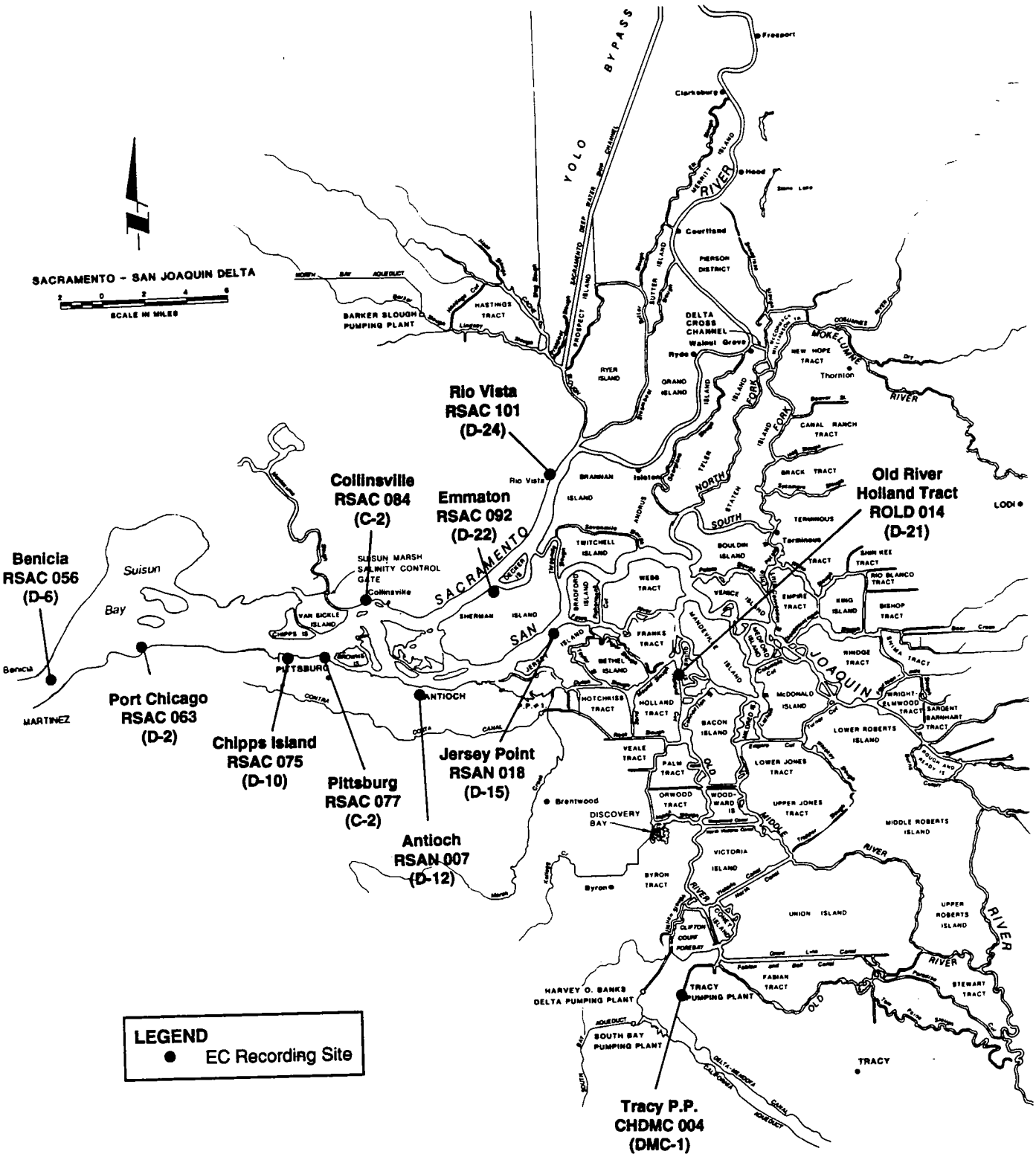


Figure B2-5.
Relationship between Simulated End-of-Month and Measured Mean Monthly EC at Vernalis and San Joaquin River Flow for 1968-1991

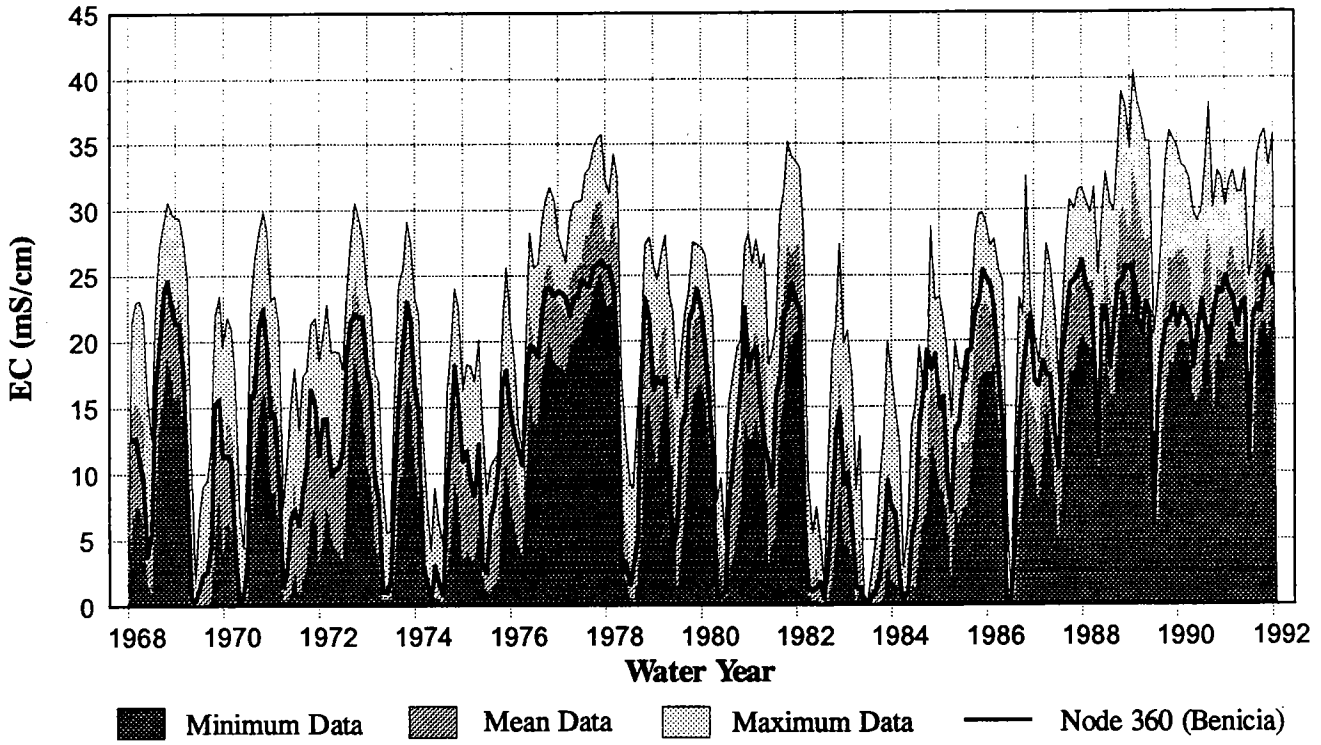
DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



Source: Adapted from California Department of Water Resources 1993.

Figure B2-6.
Map of Selected Delta EC Monitoring Locations

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



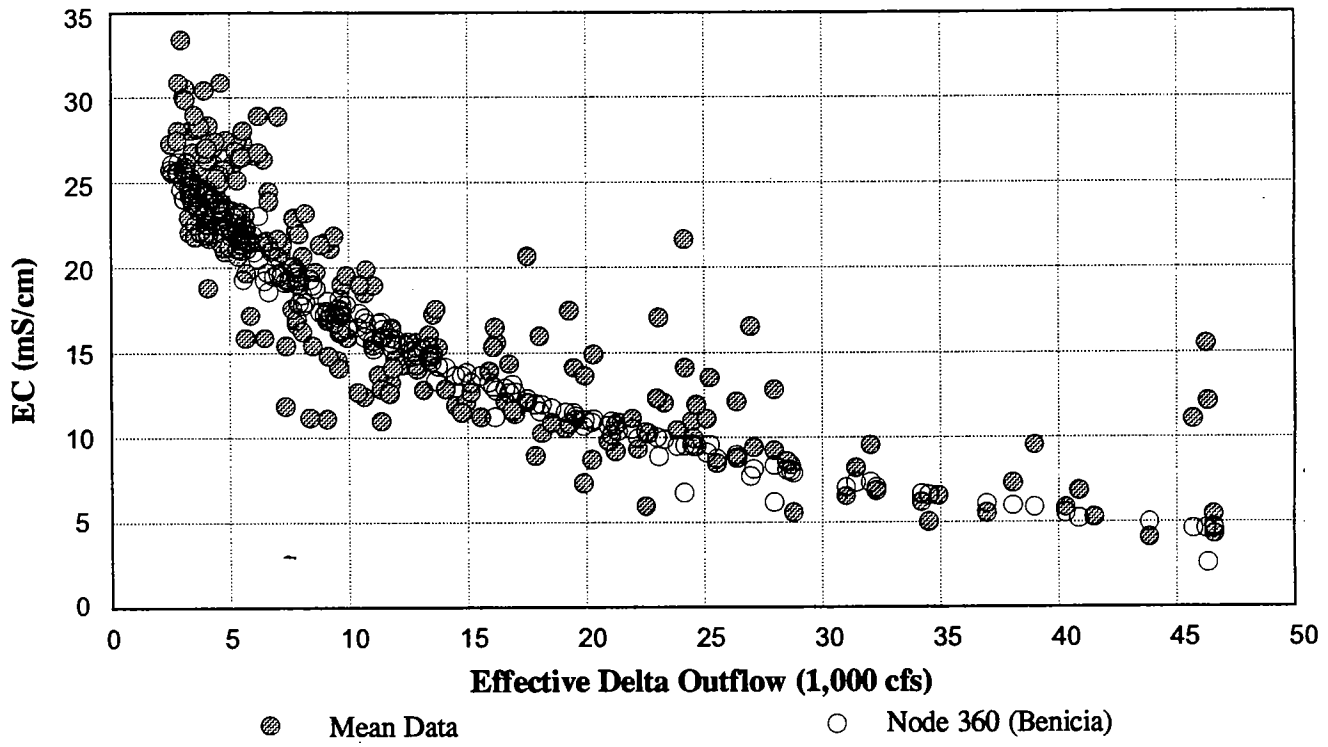
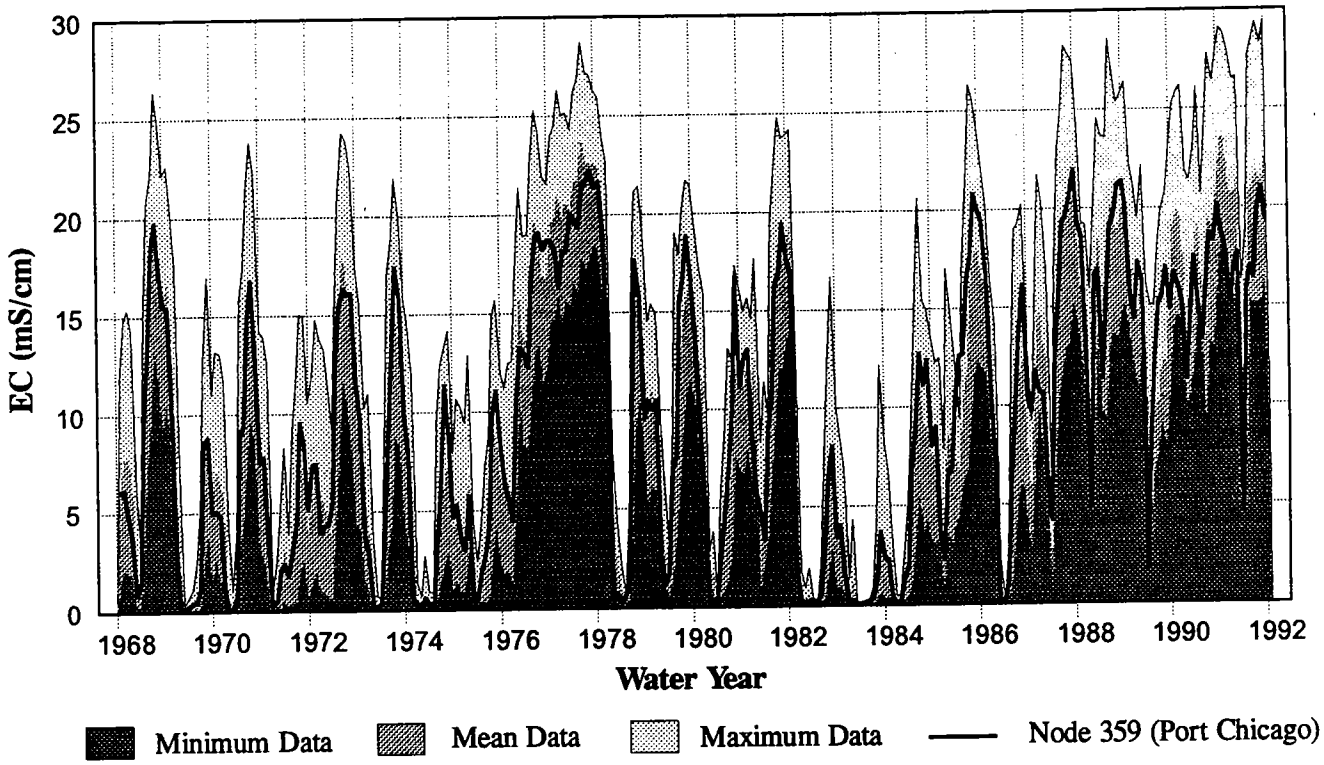


Figure B2-7.
Comparison of Simulated End-of-Month and Measured Mean Monthly EC at Benicia for Historical Delta Inflows and Exports for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



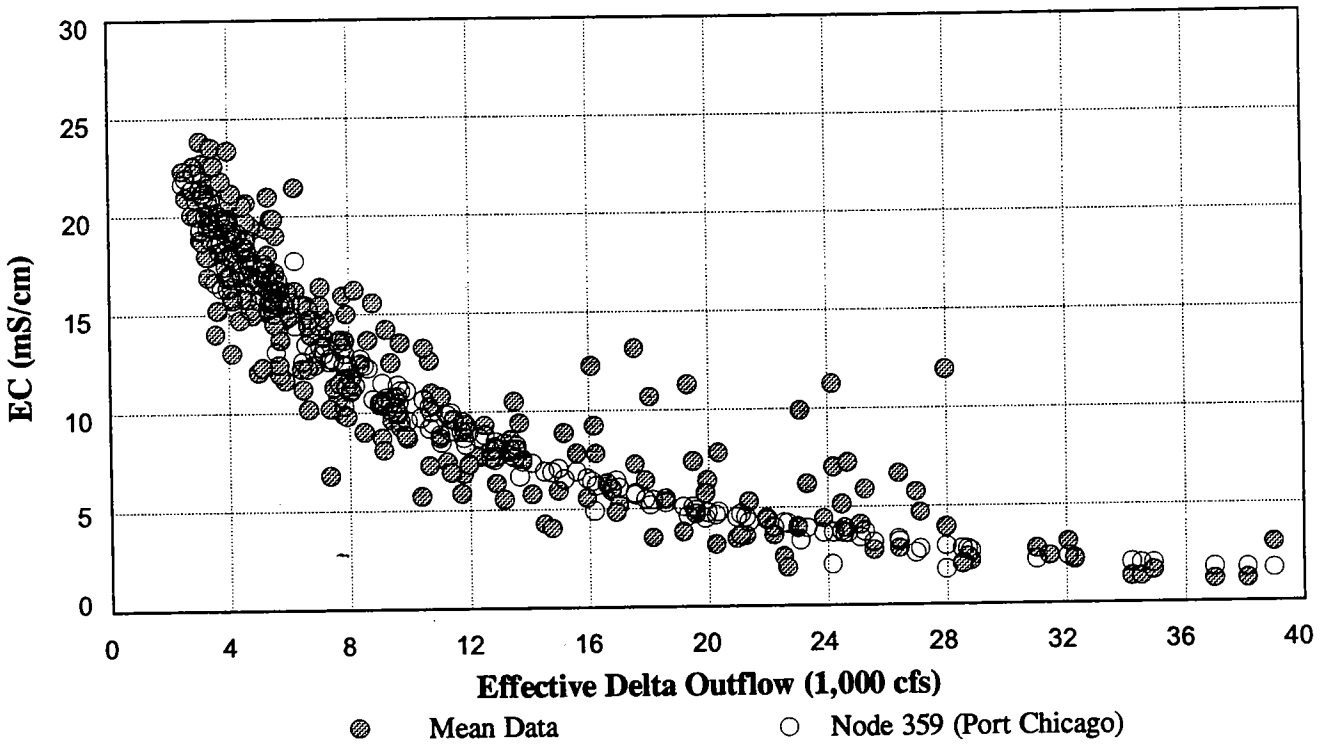
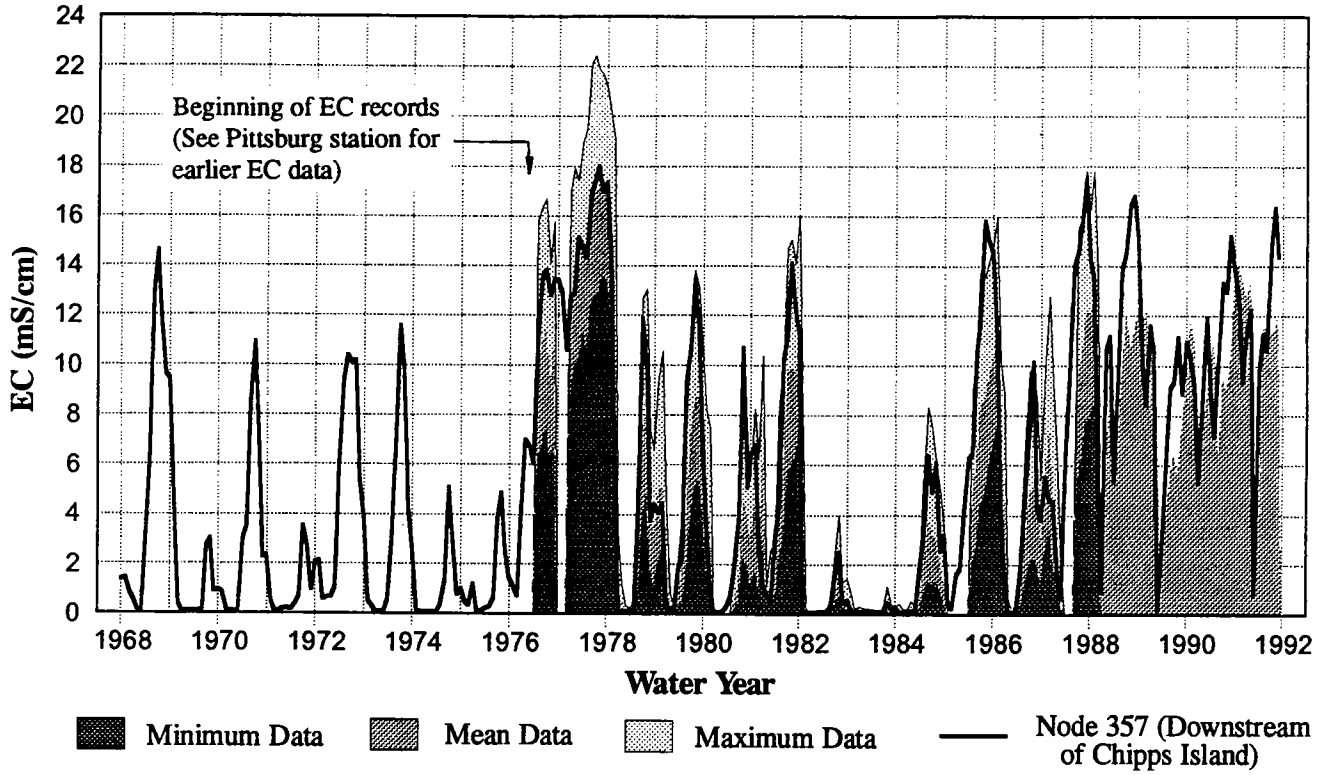


Figure B2-8.
Comparison of Simulated End-of-Month and Measured Mean Monthly EC at Port Chicago for Historical Delta Inflows and Exports for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



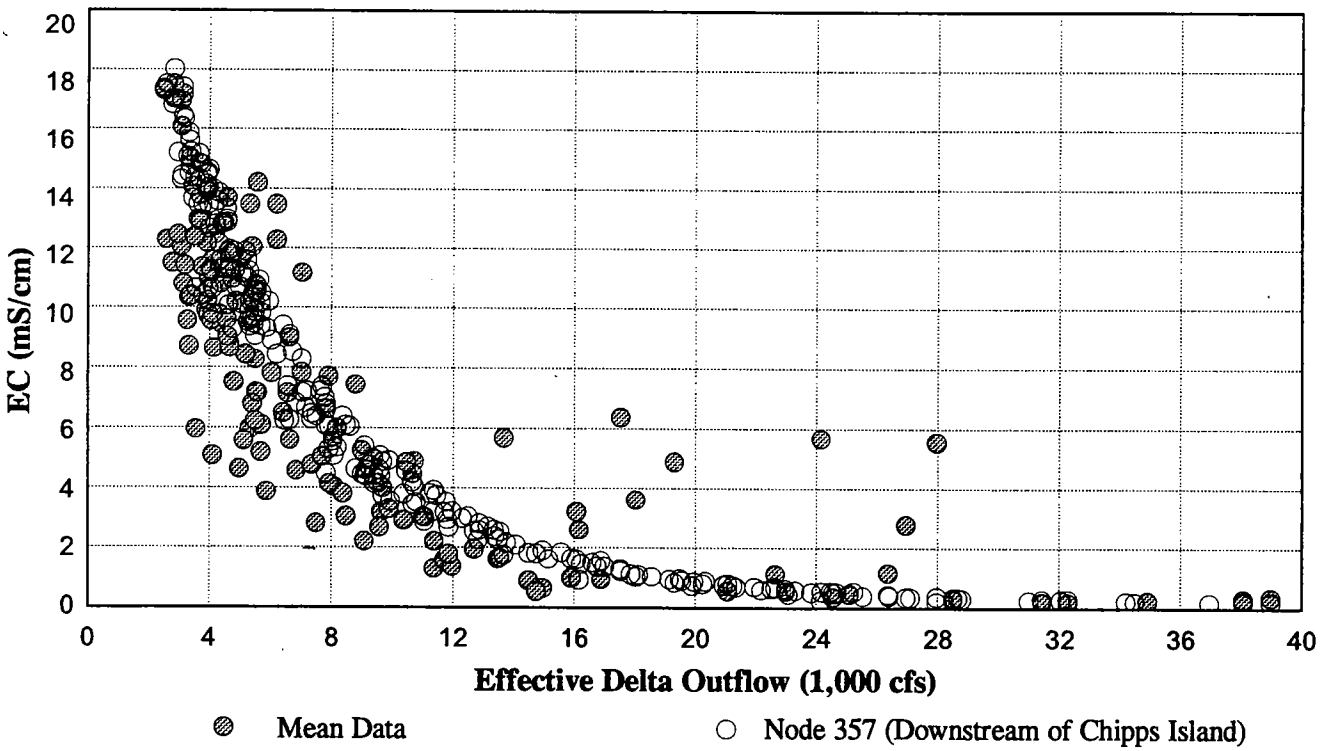
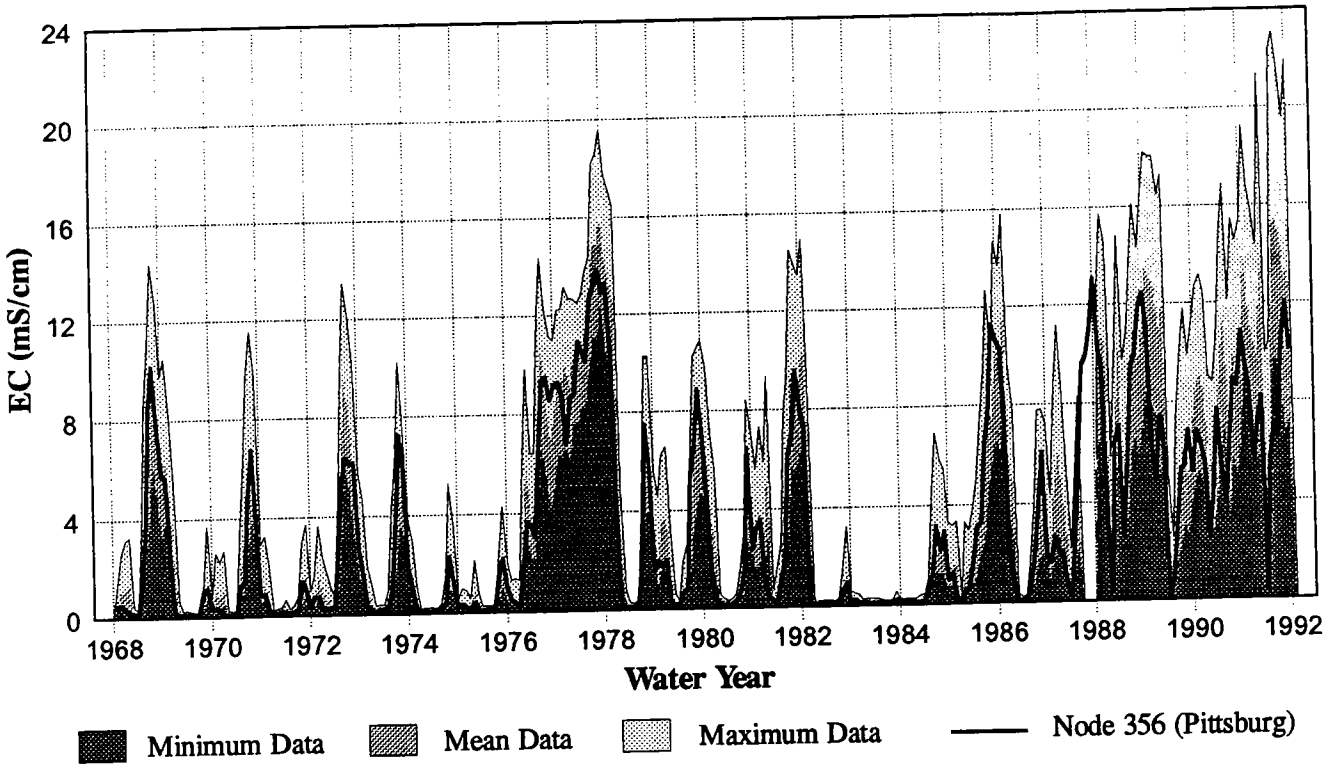


Figure B2-9.
Comparison of Simulated End-of Month and Measured Mean Monthly EC at Chipps Island for Historical Delta Inflows and Exports for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



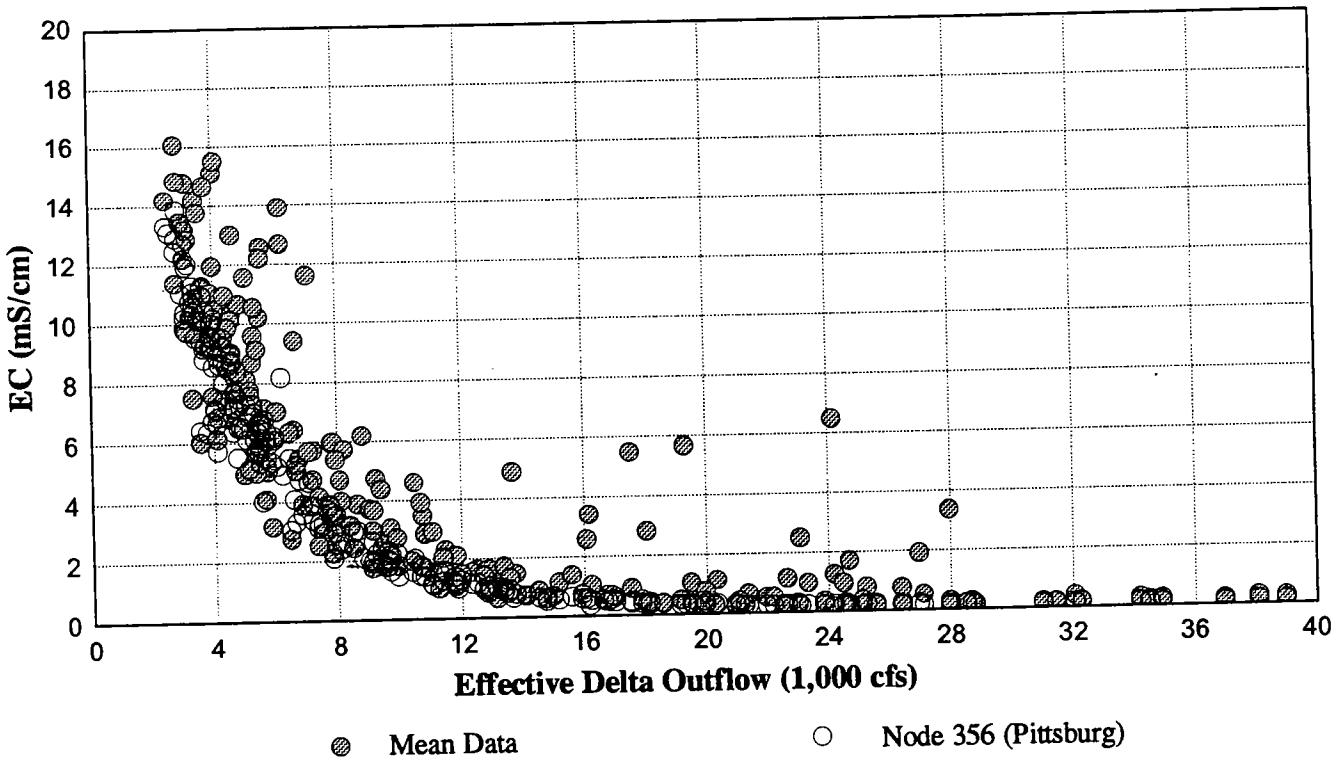
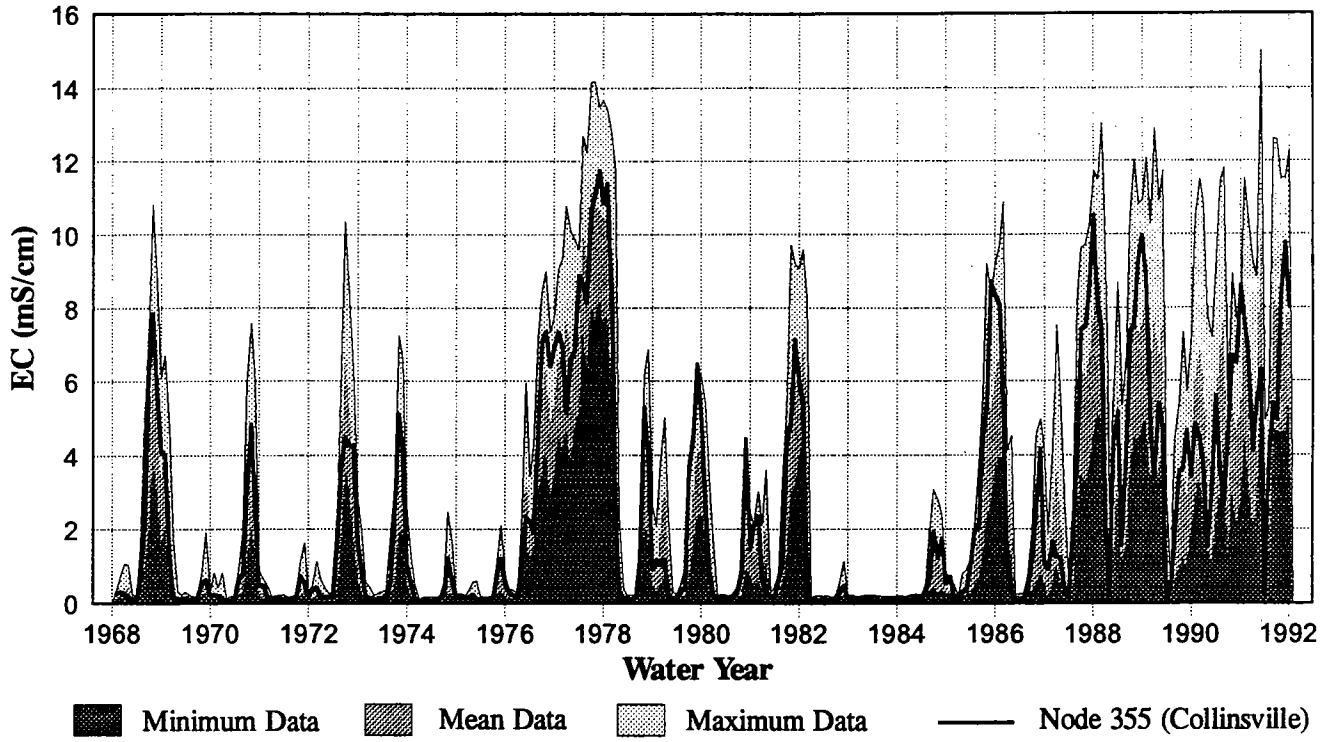


Figure B2-10.
Comparison of Simulated End-of-Month and Measured Mean Monthly EC at Pittsburg for Historical Delta Inflows and Exports for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



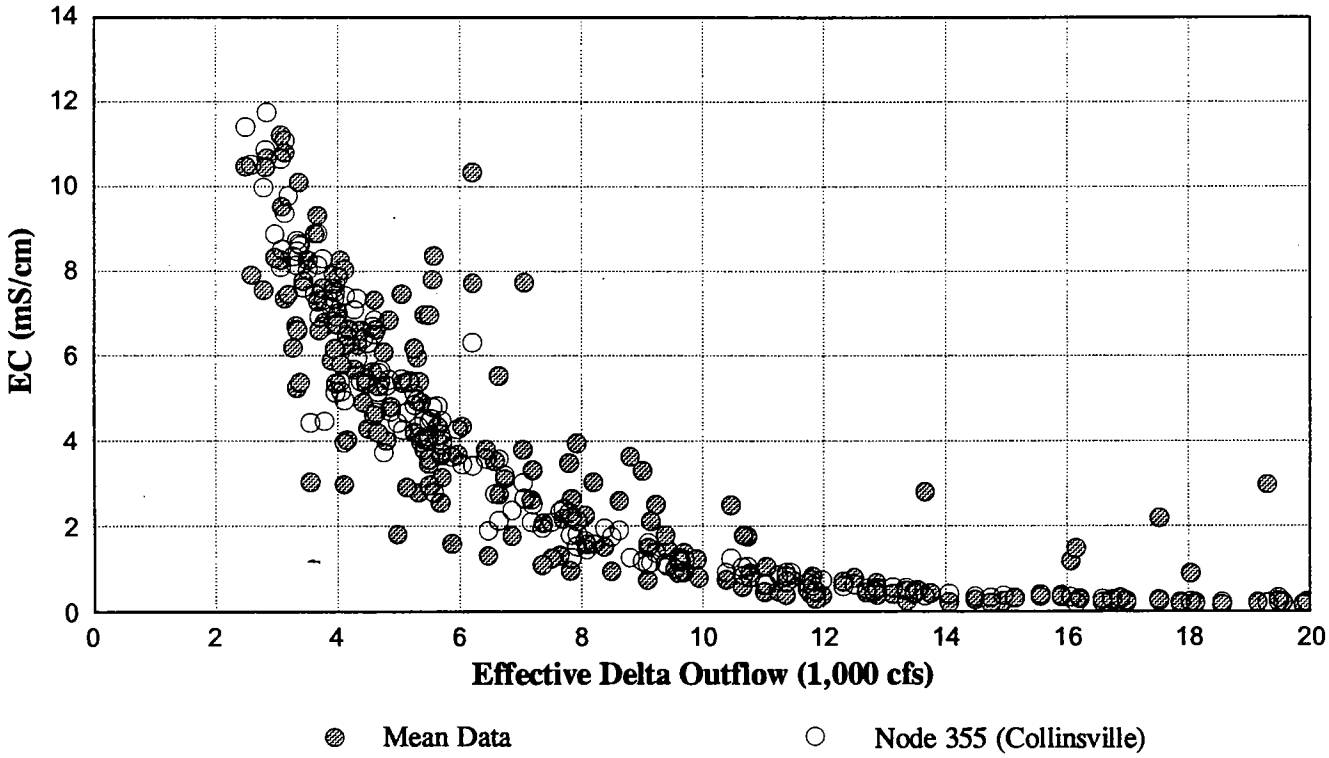
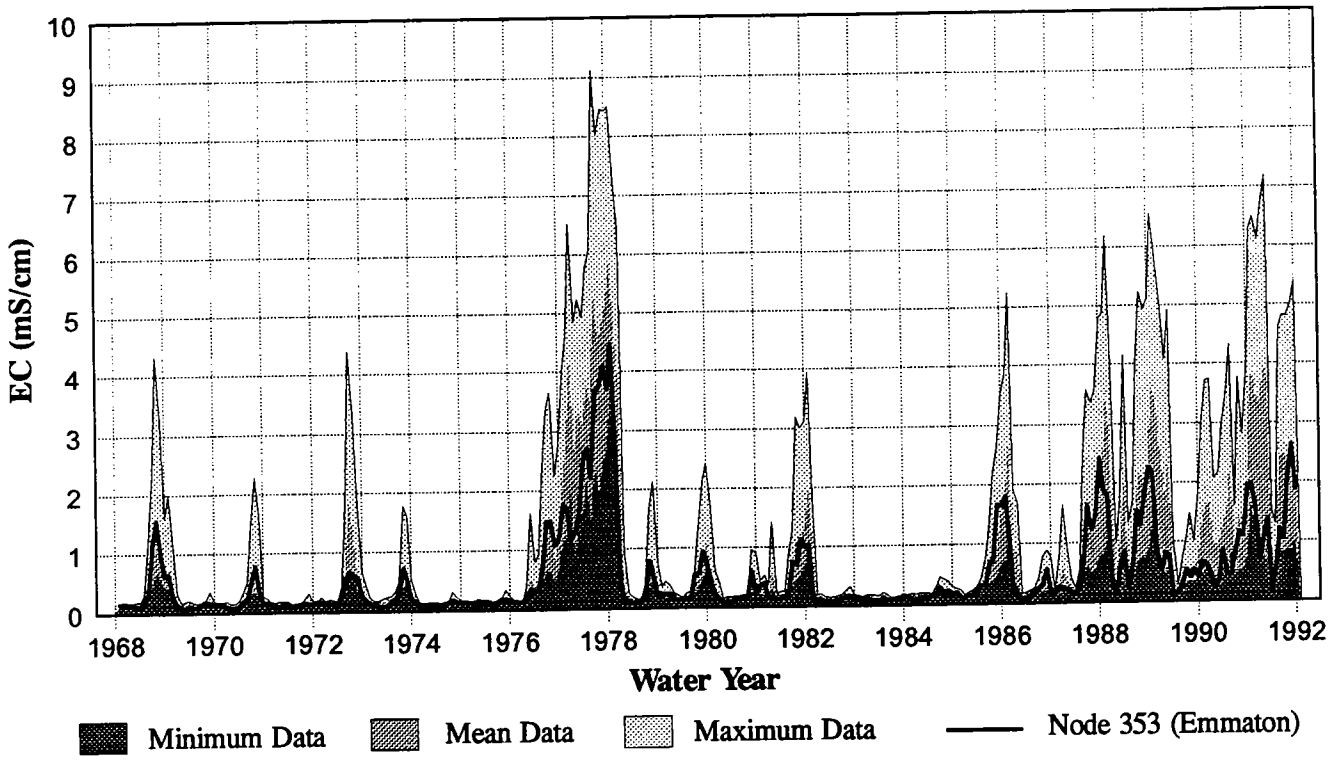


Figure B2-11.
Comparison of Simulated End-of-Month and Measured Mean Monthly EC at Collinsville for Historical Delta Inflows and Exports for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



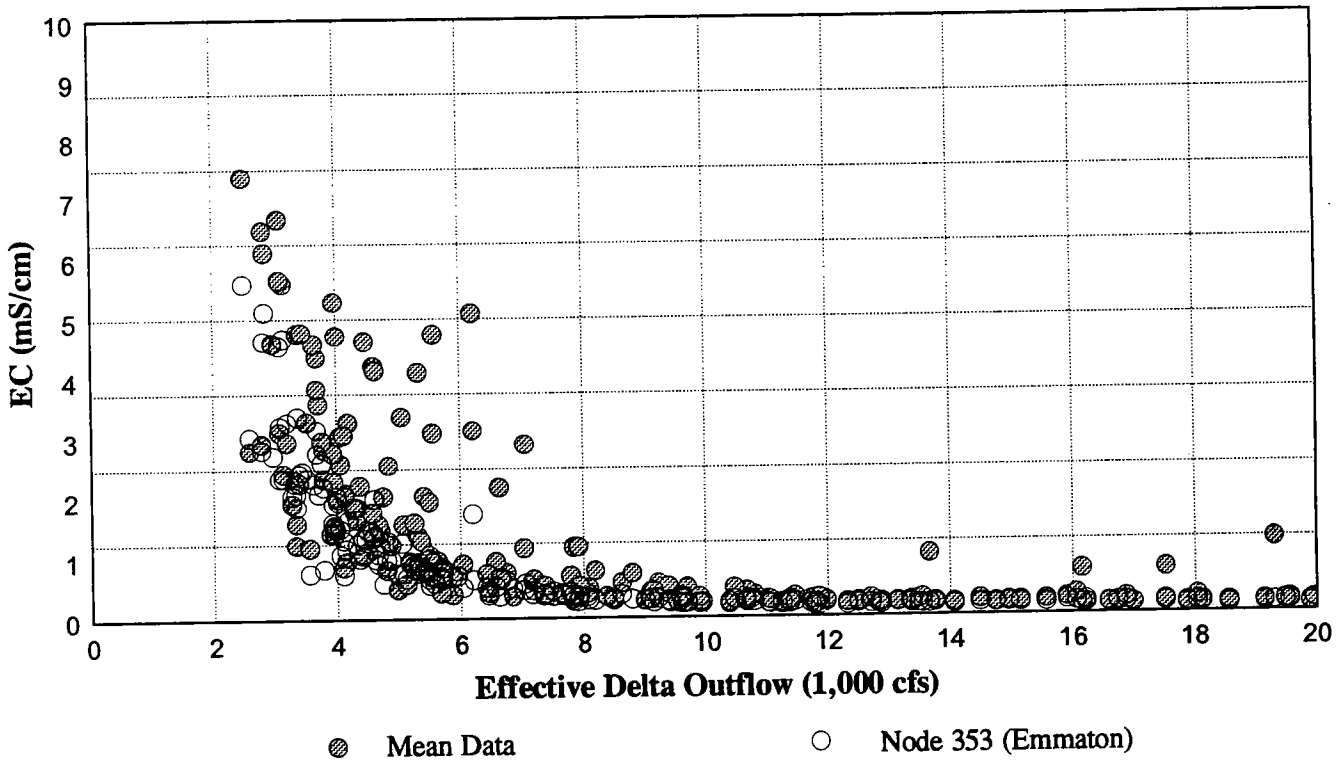
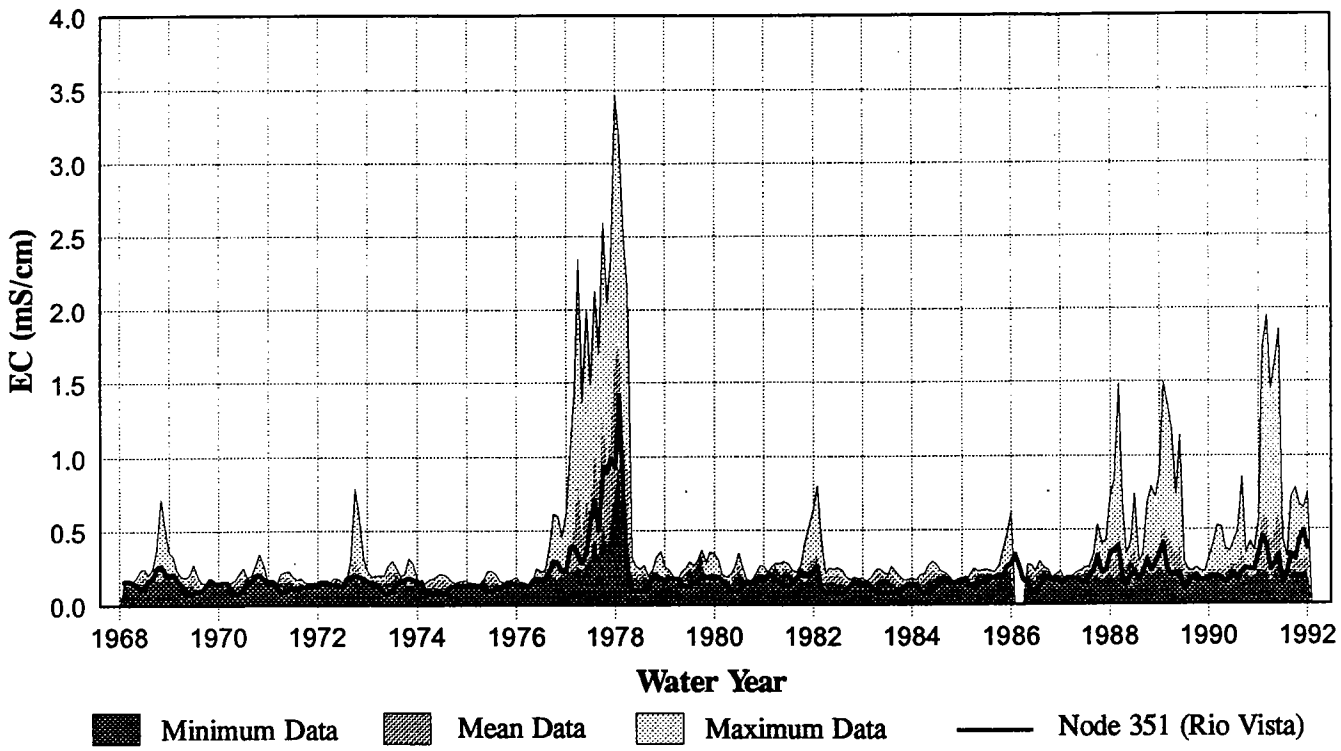


Figure B2-12.
Comparison of Simulated End-of-Month and Measured Mean Monthly EC at Emmaton for Historical Delta Inflows and Exports for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



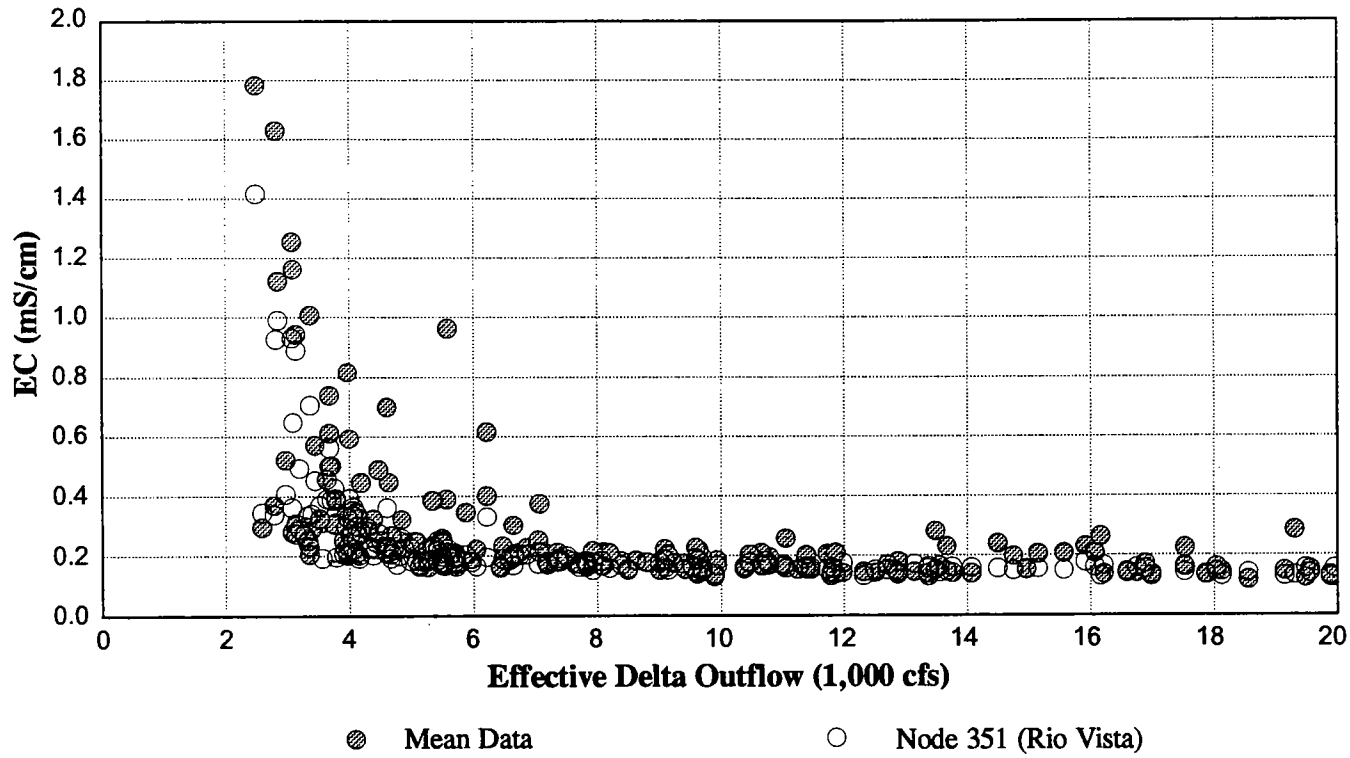
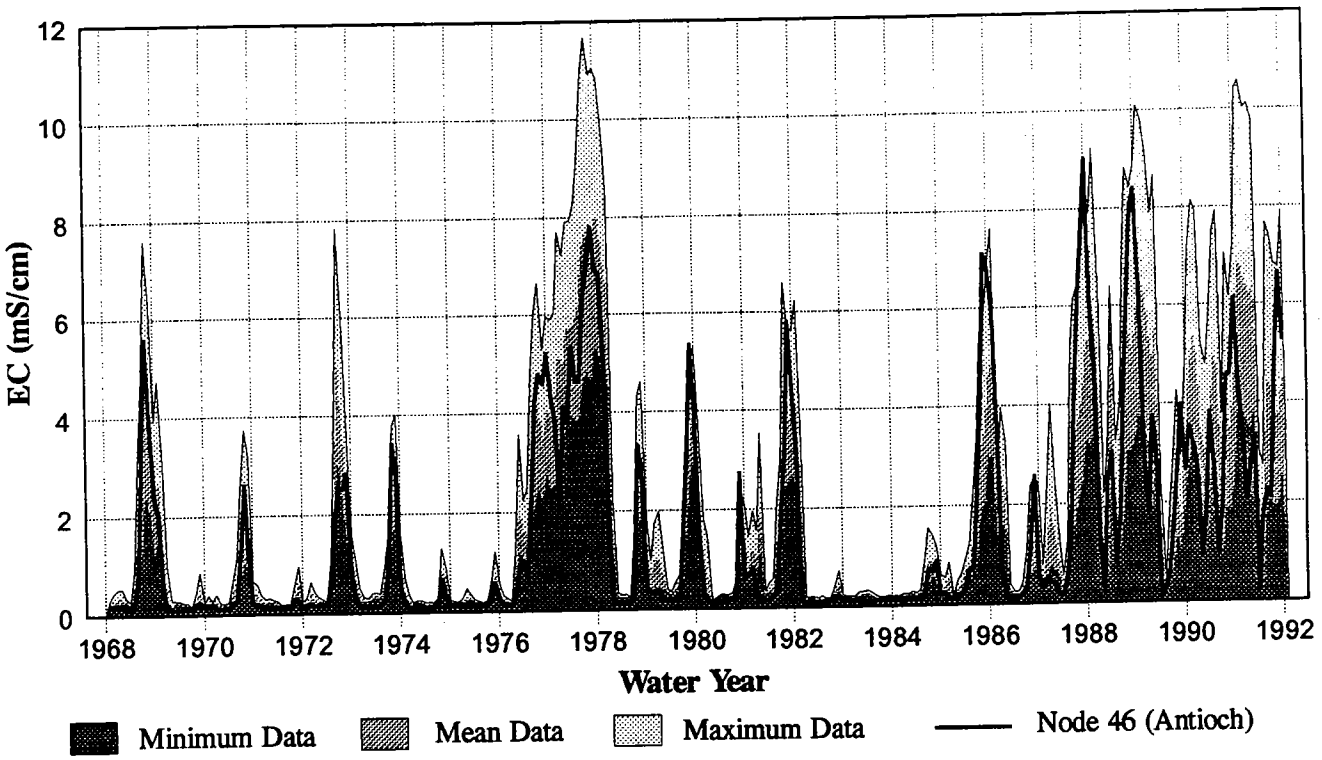


Figure B2-13.
Comparison of Simulated End-of-Month and Measured Mean Monthly EC at Rio Vista for Historical Delta Inflows and Exports for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



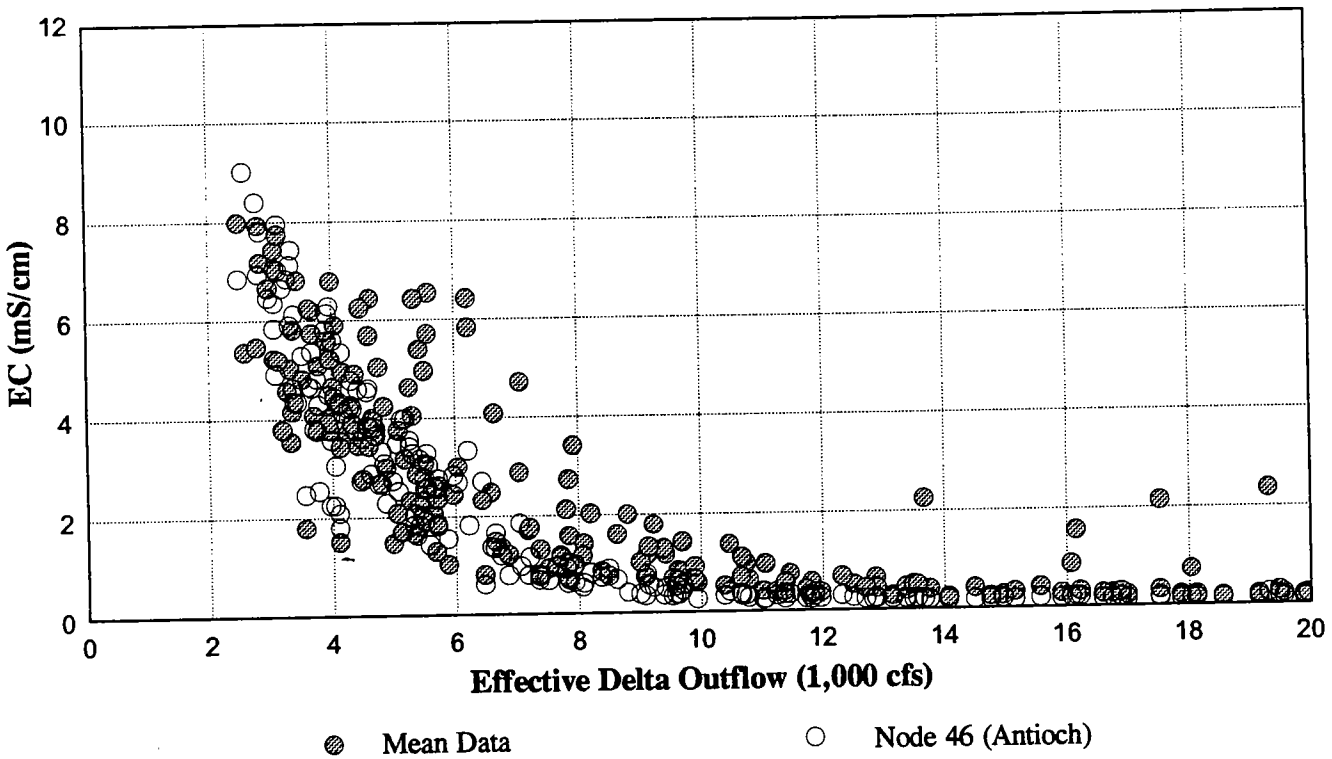
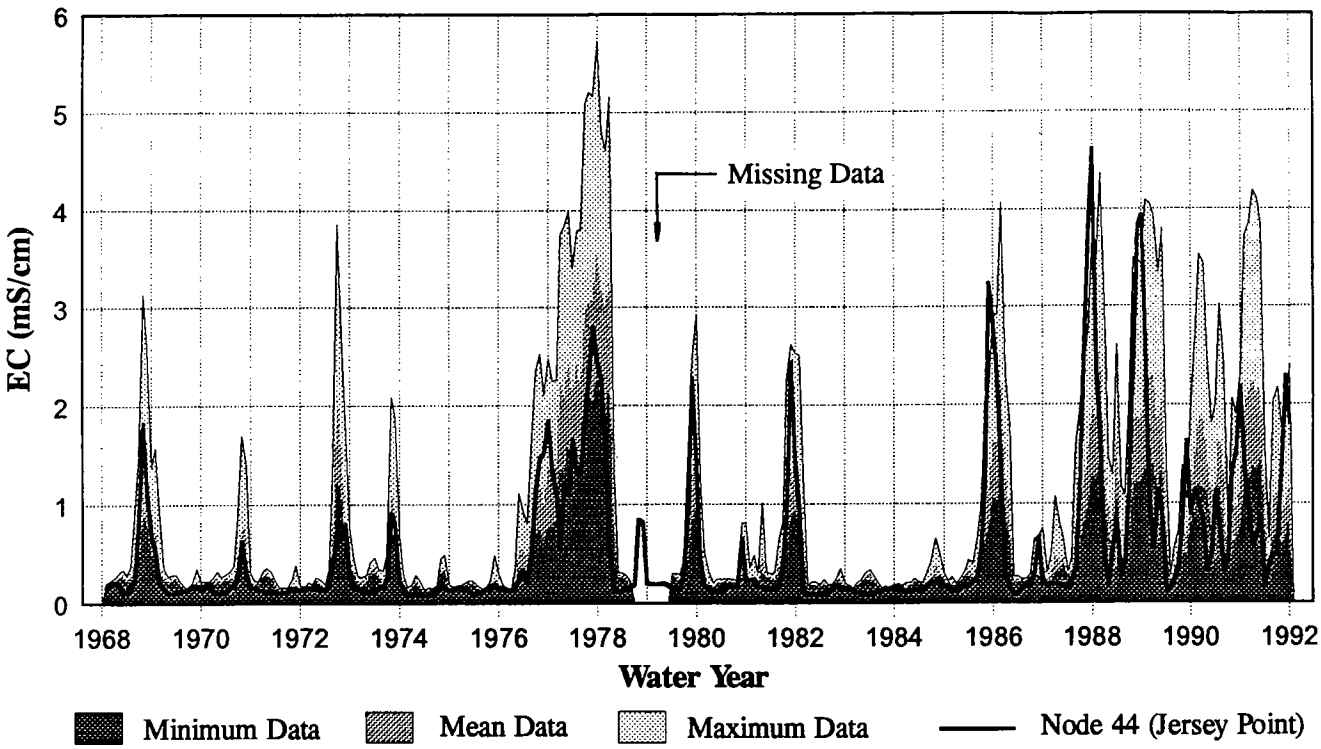


Figure B2-14.
Comparison of Simulated End-of-Month and Measured Mean Monthly EC at Antioch for Historical Delta Inflows and Exports for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



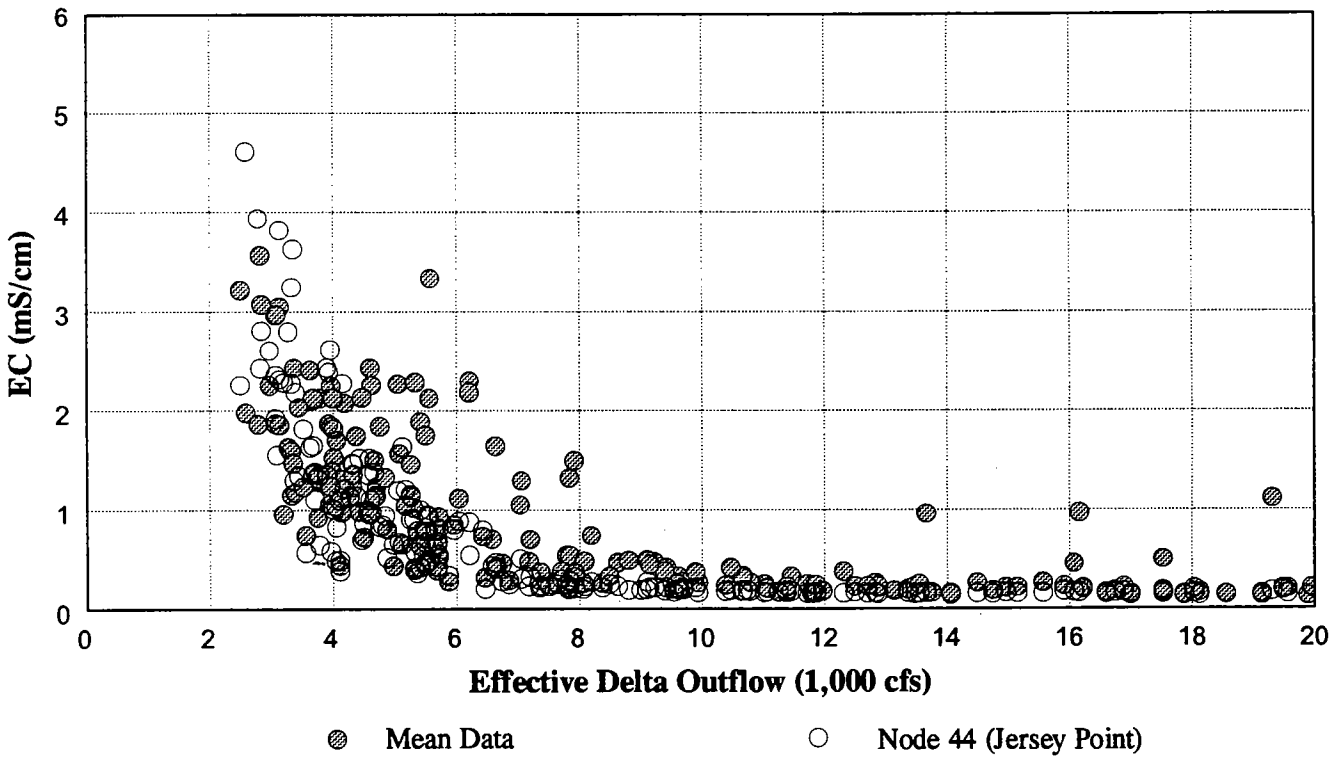
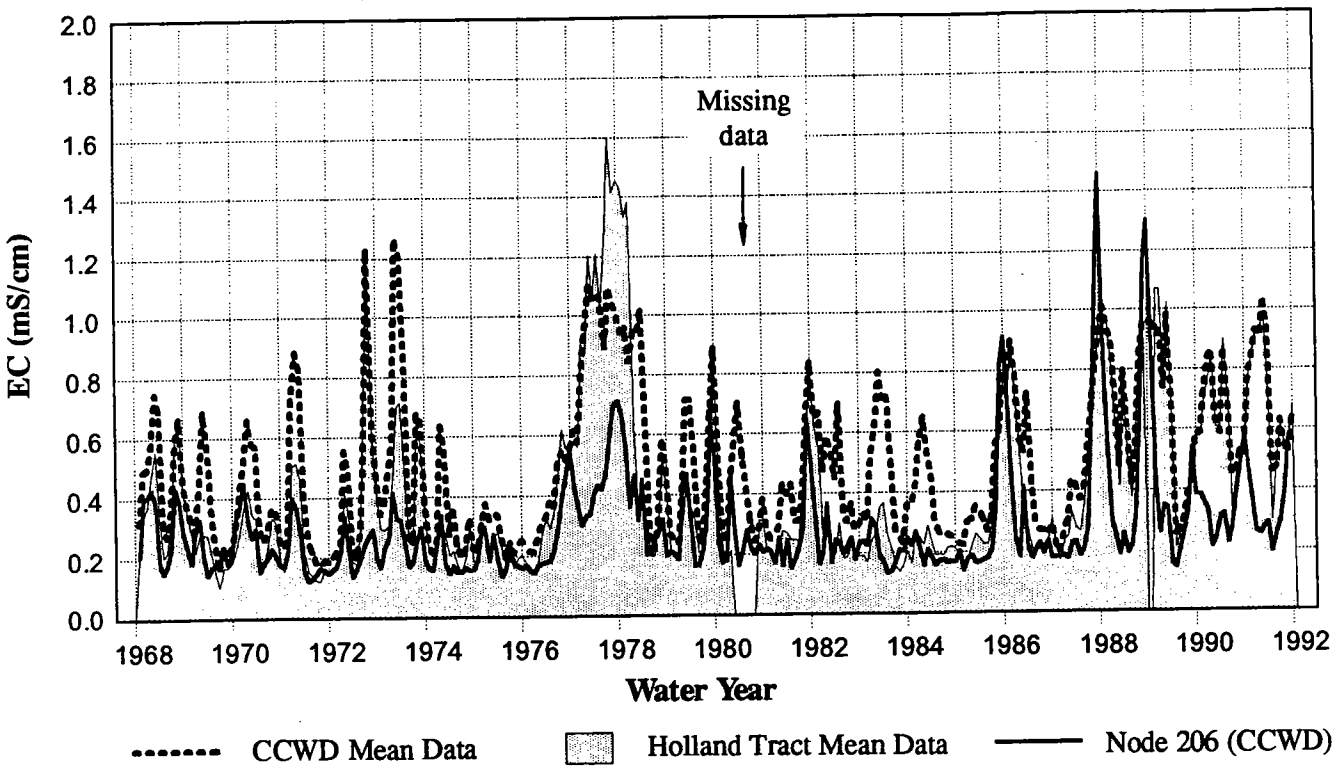


Figure B2-15.
Comparison of Simulated End-of-Month and Measured Mean Monthly EC at Jersey Point for Historical Delta Inflows and Exports for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



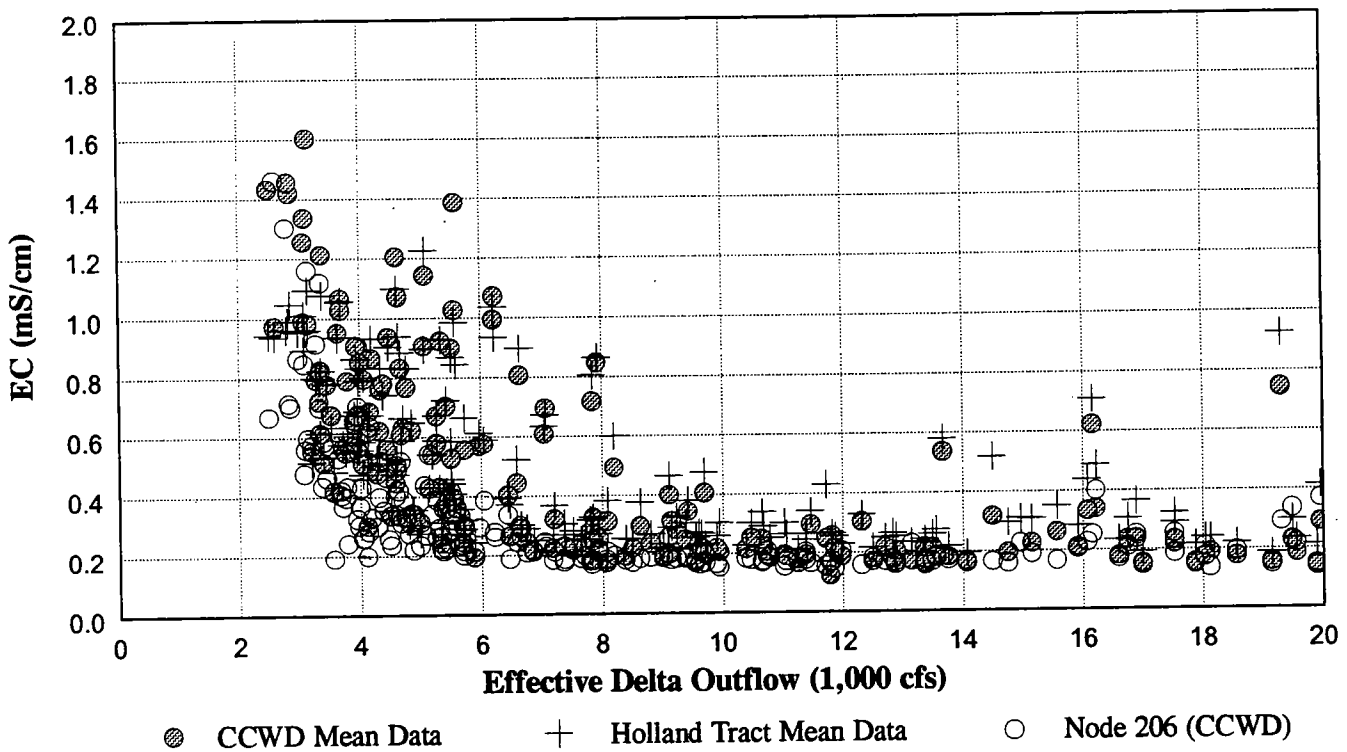
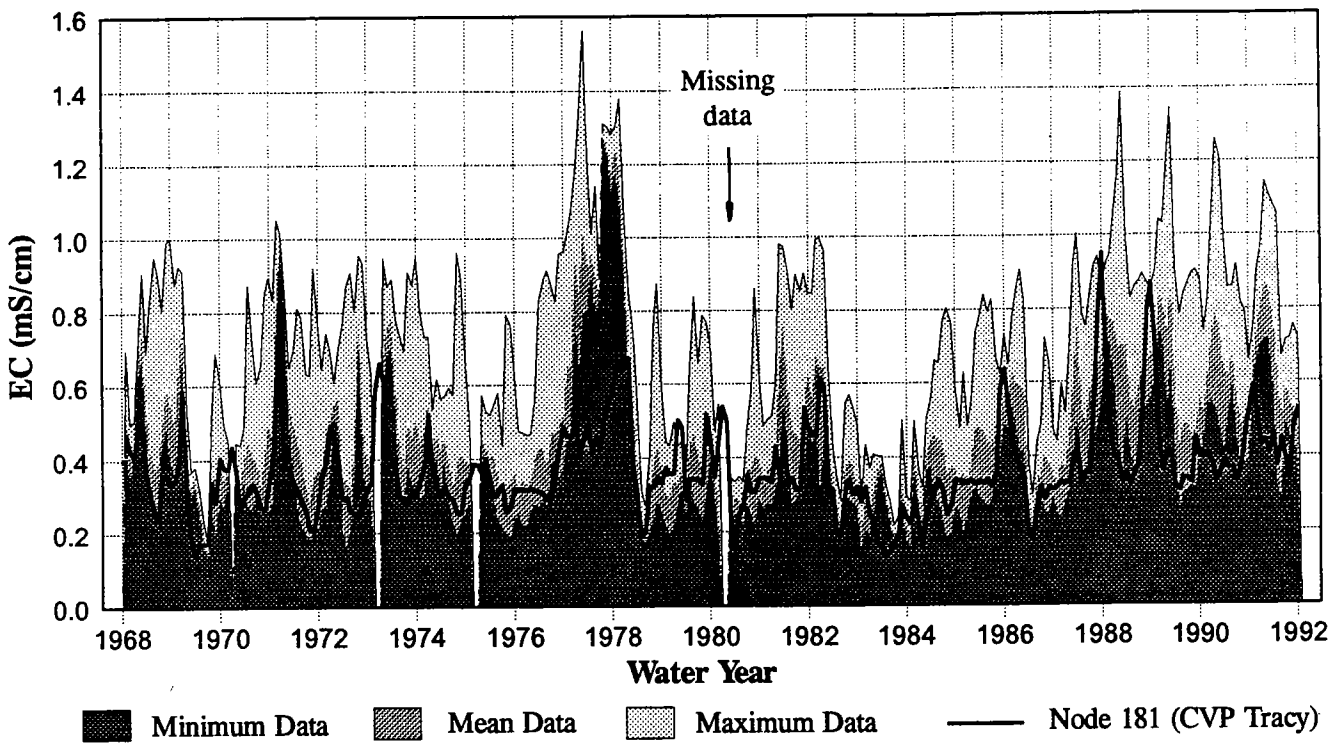


Figure B2-16.
Comparison of Simulated End-of-Month and Measured Mean Monthly EC at Holland Tract and CCWD Canal for Historical Delta Inflows and Exports for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



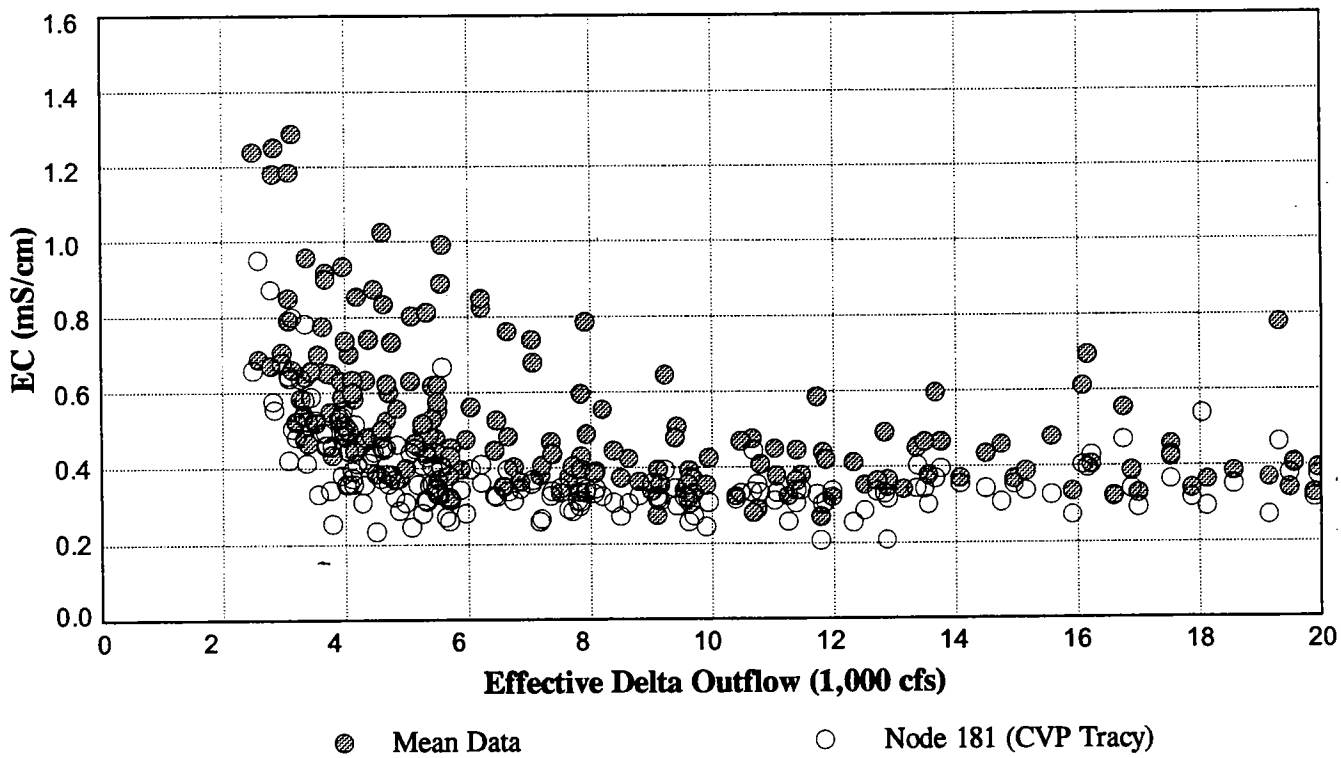


Figure B2-17.
Comparison of Simulated End-of-Month and Measured Mean Monthly EC at the CVP Tracy Pumping Plant for Historical Delta Inflows and Exports for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

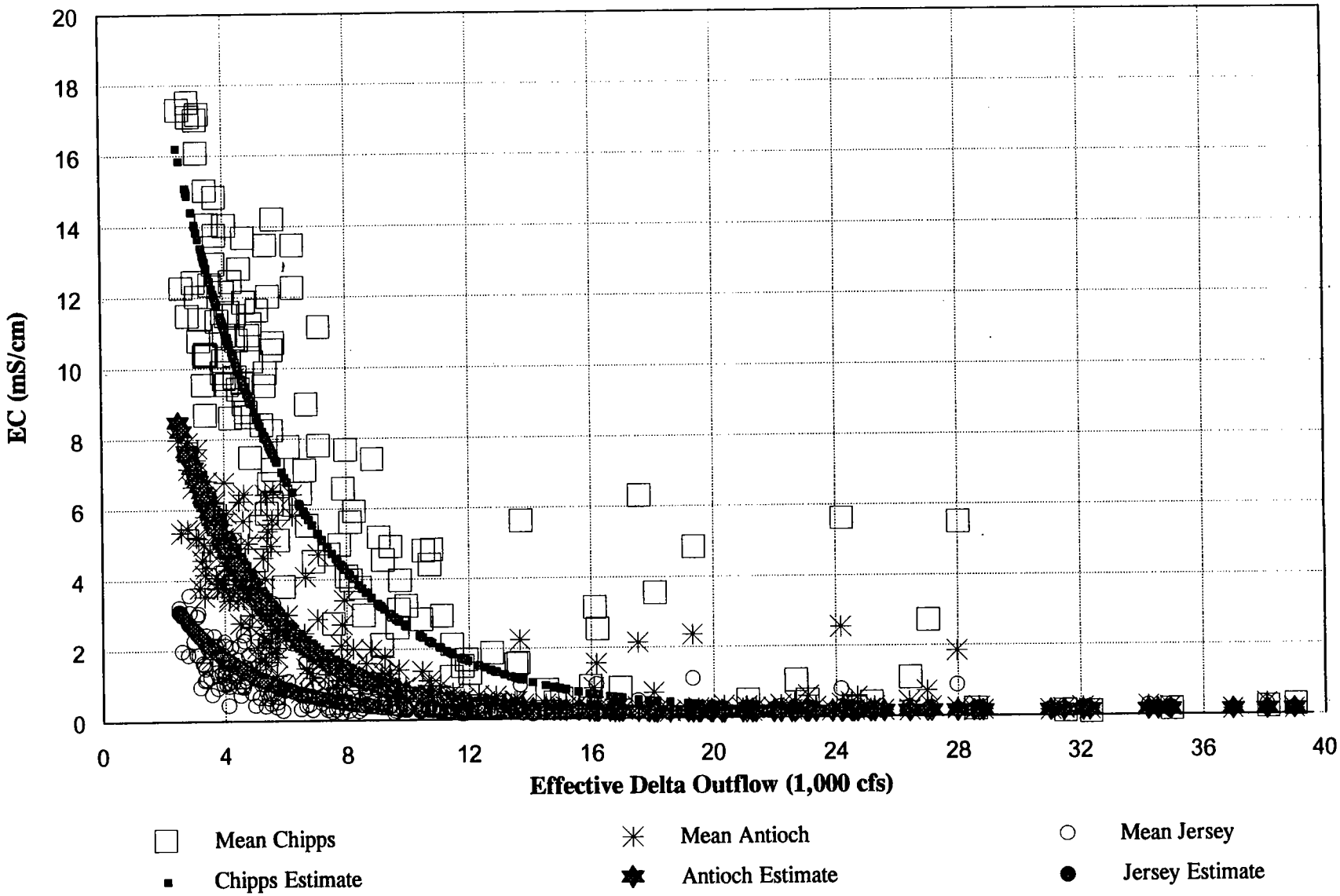


Figure B2-18.
Relationship between Simulated End-of-Month and Measured Mean Monthly EC at Selected Delta Channel Locations for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

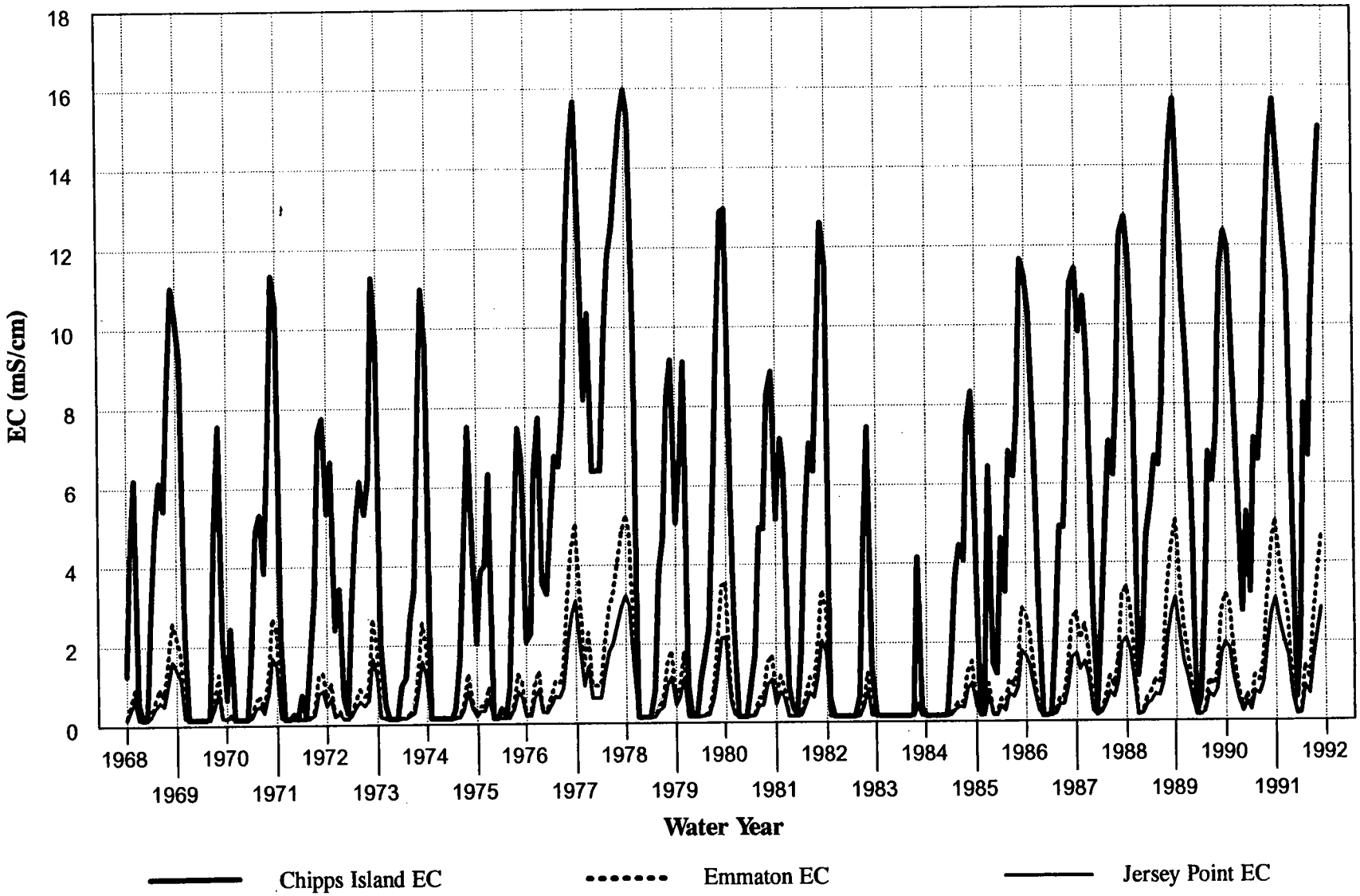


Figure B2-19.
Simulated Patterns of Monthly EC at Selected Delta Channel Locations under the No-Project Alternative for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

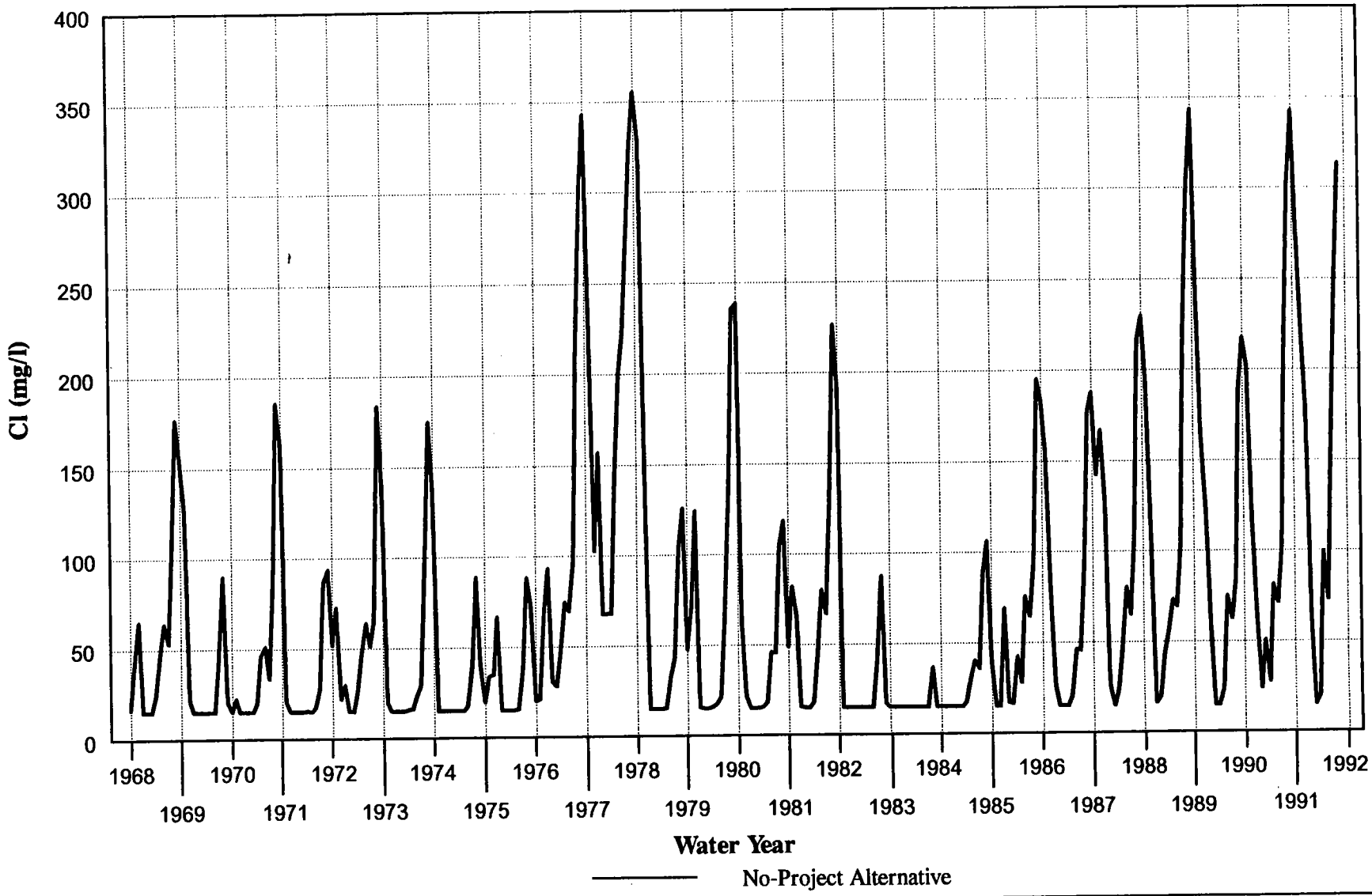


Figure B2-20.
Simulated Patterns of Export Chloride
under the No-Project Alternative for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

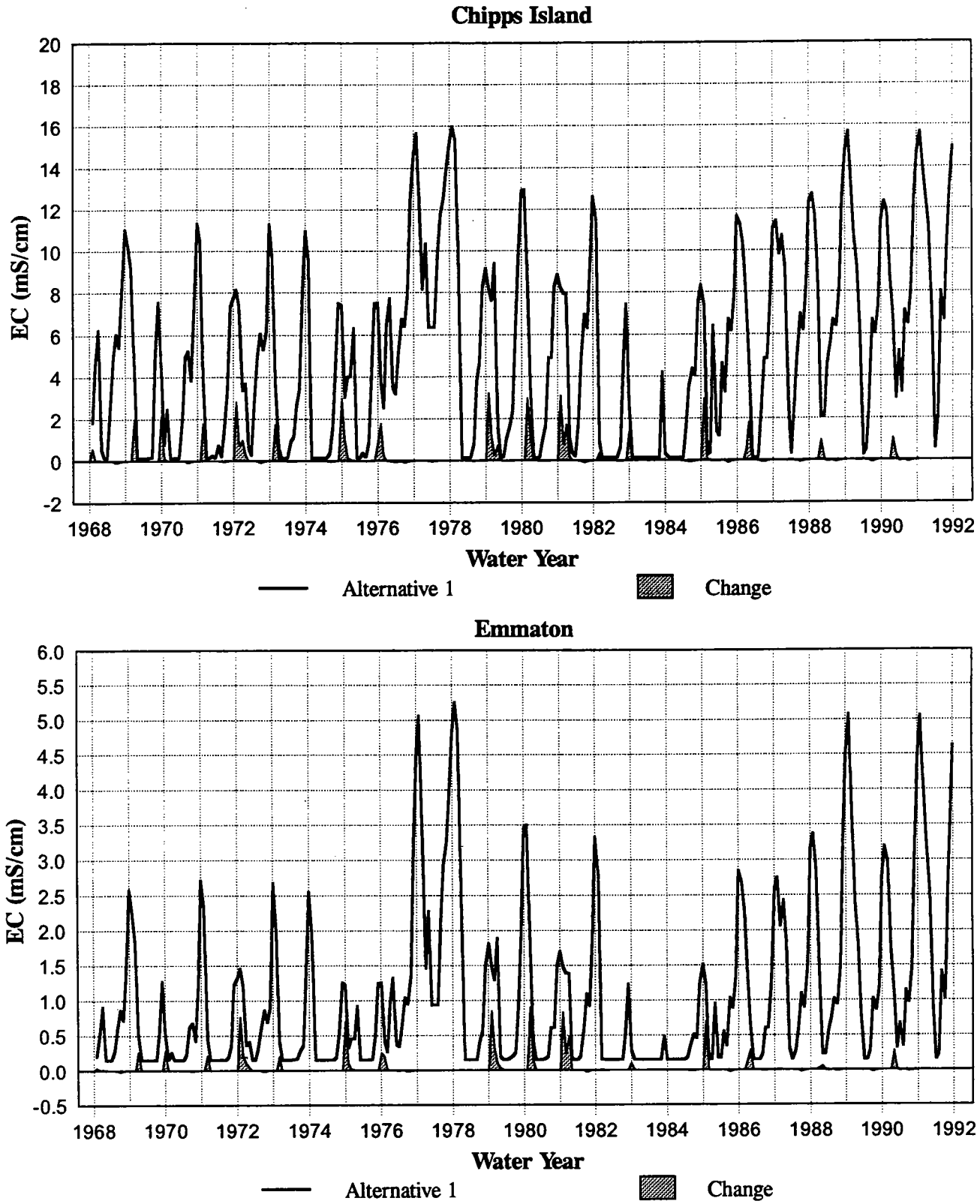


Figure B2-21.
Simulated End-of-Month Values and Predicted Changes for EC under Alternative 1 Operations at Chipps Island and Emmaton for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

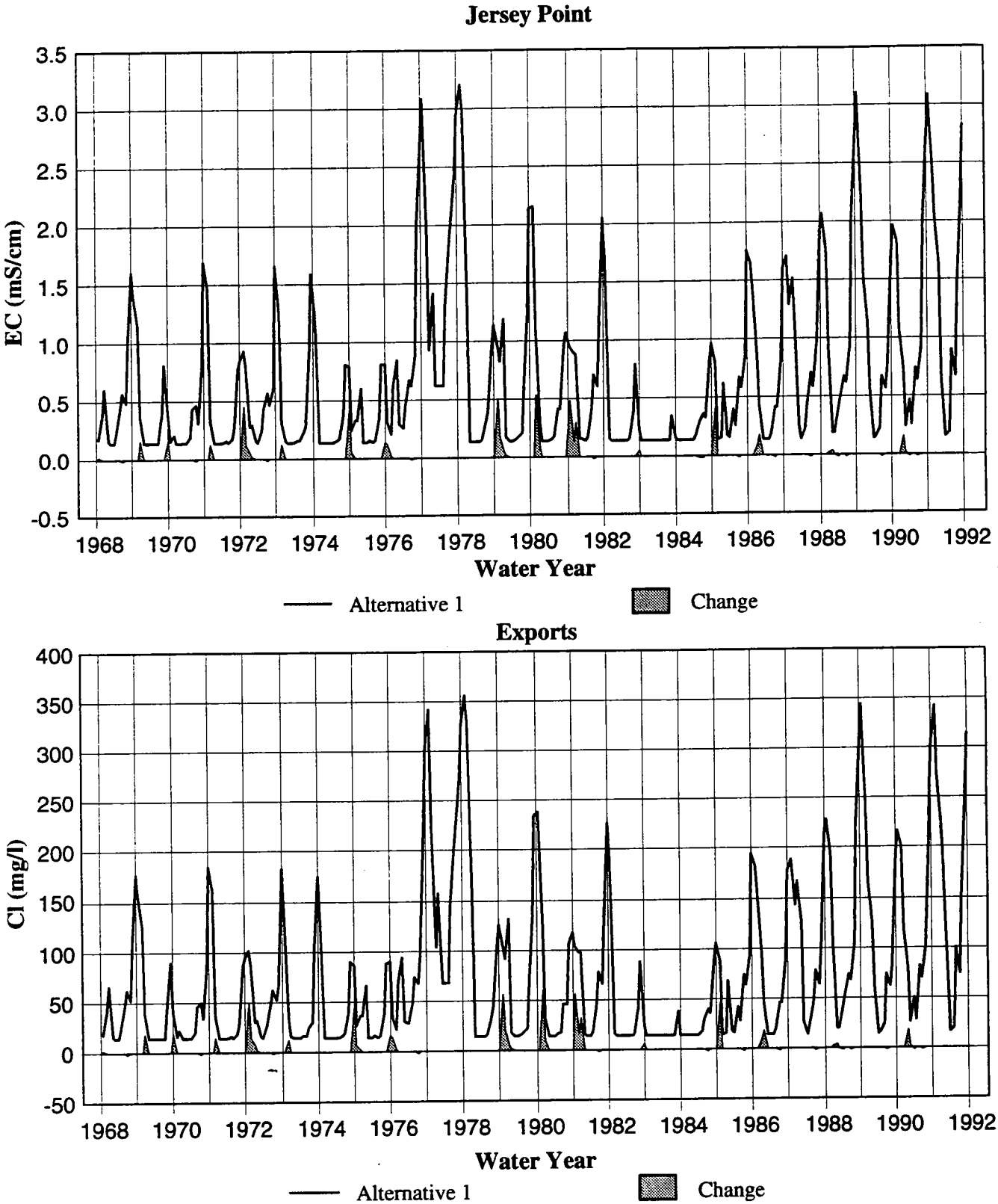


Figure B2-22.
Simulated End-of-Month Values and Predicted Changes under Alternative 1 Operations for Jersey Point EC and Export Chloride for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

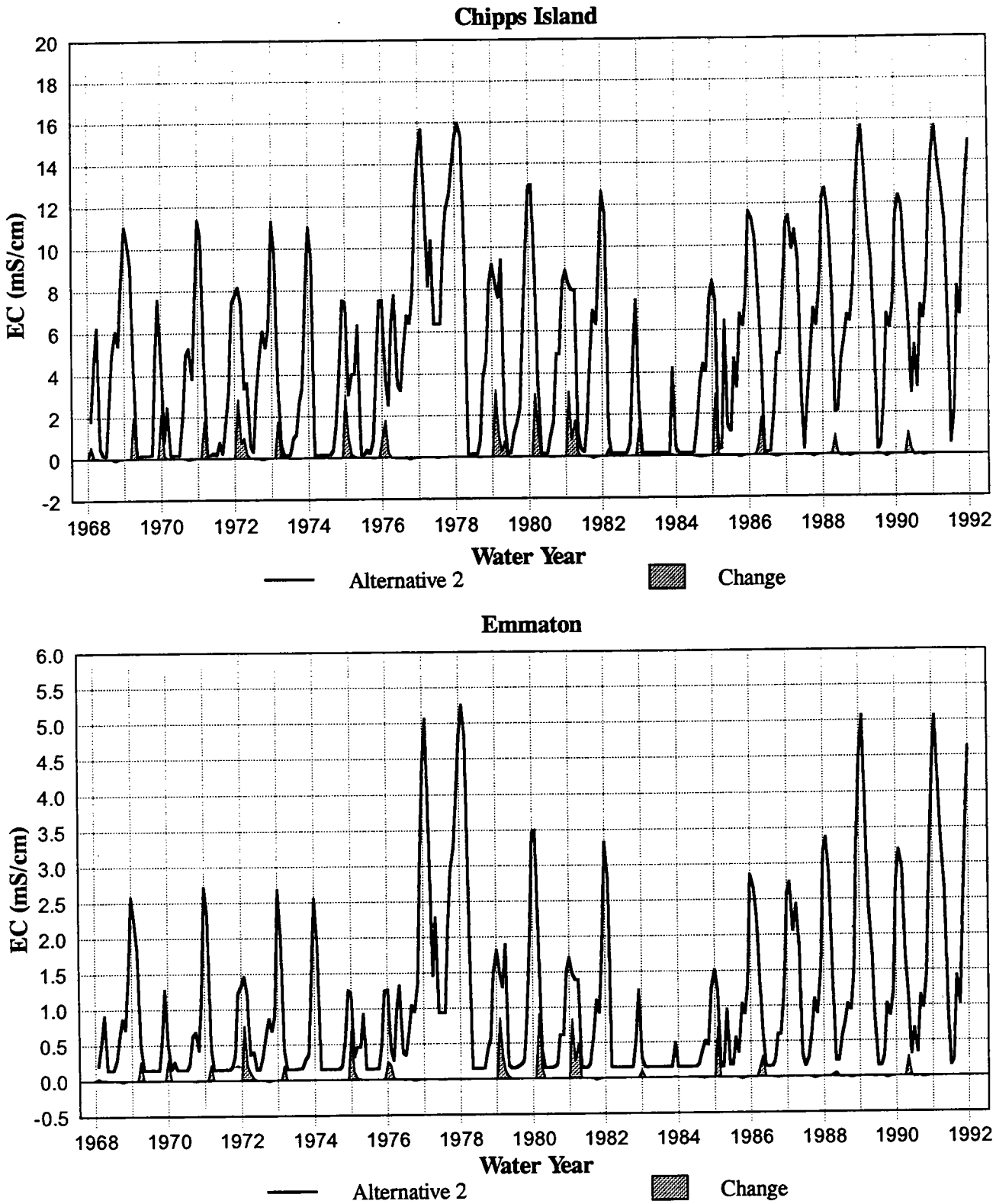


Figure B2-23.
Simulated End-of-Month Values and Predicted Changes for EC under Alternative 2 Operations at Chipps Island and Emmaton for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

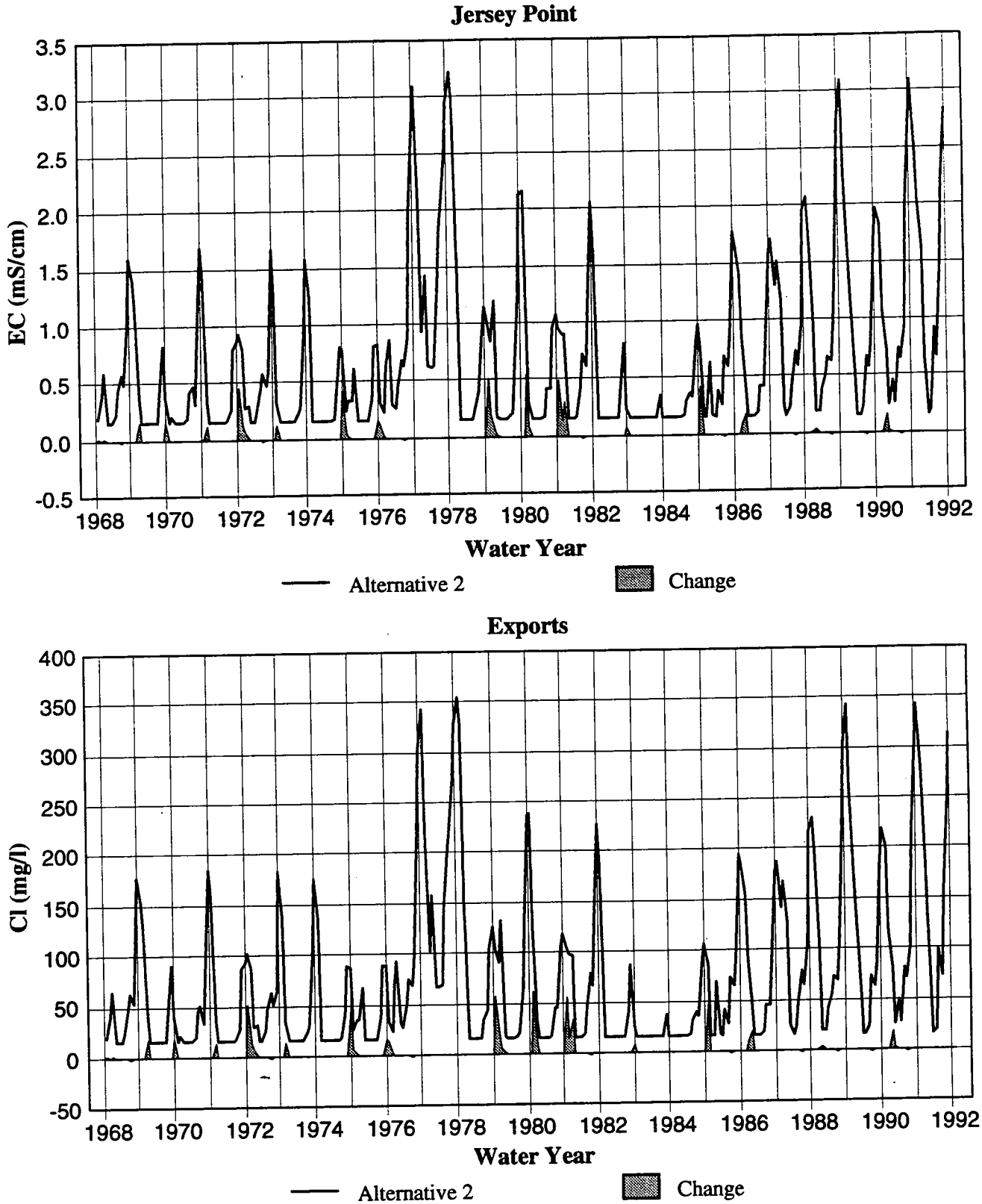
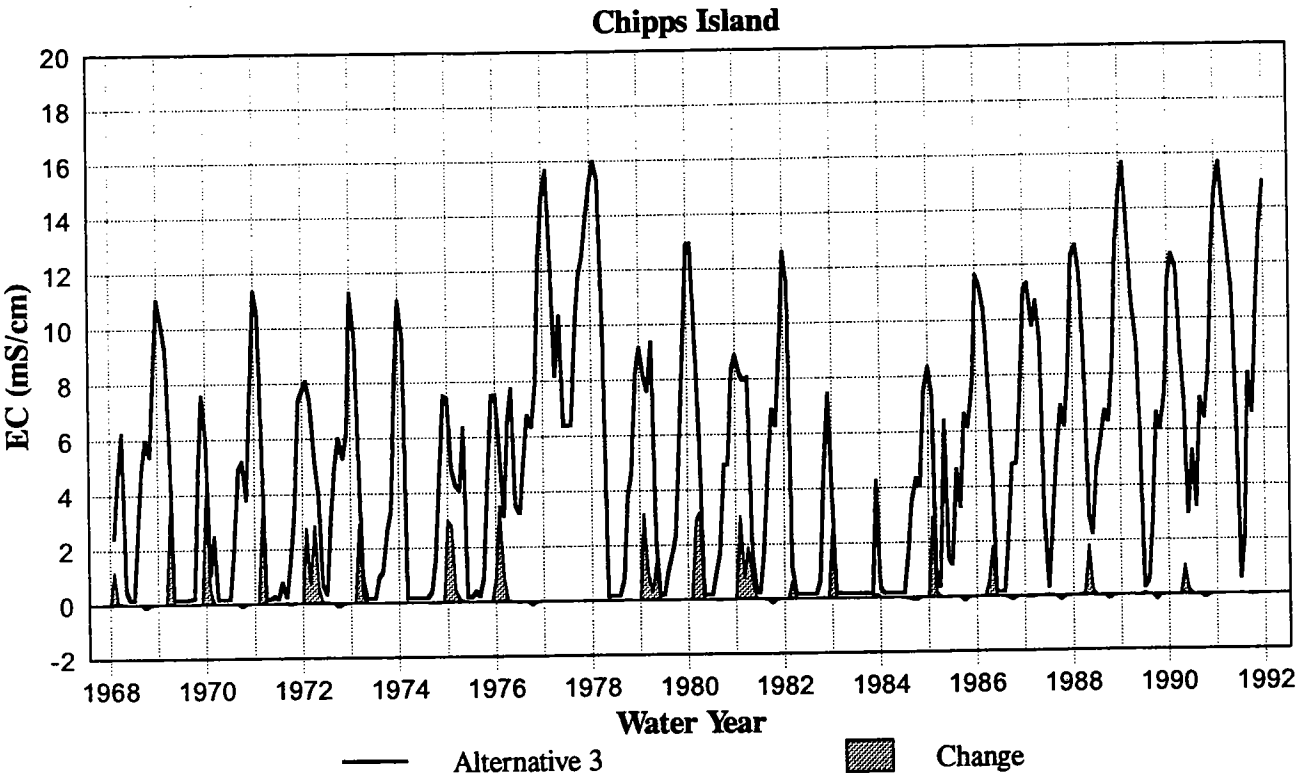


Figure B2-24.
Simulated End-of-Month Values and Predicted Changes under Alternative 2 Operations for Jersey Point EC and Export Chloride 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



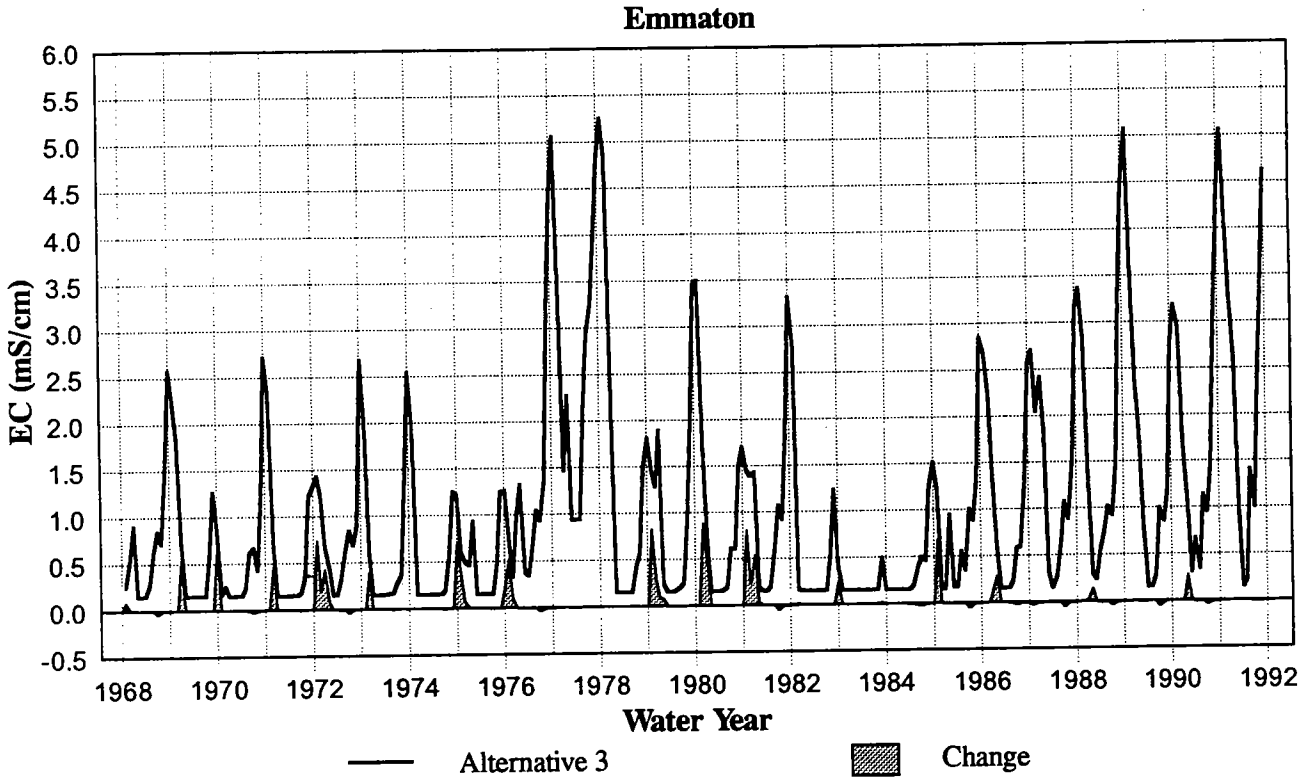


Figure B2-25.
Simulated End-of-Month Values and Predicted Changes for EC under Alternative 3 Operations at Chipps Island and Emmaton for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

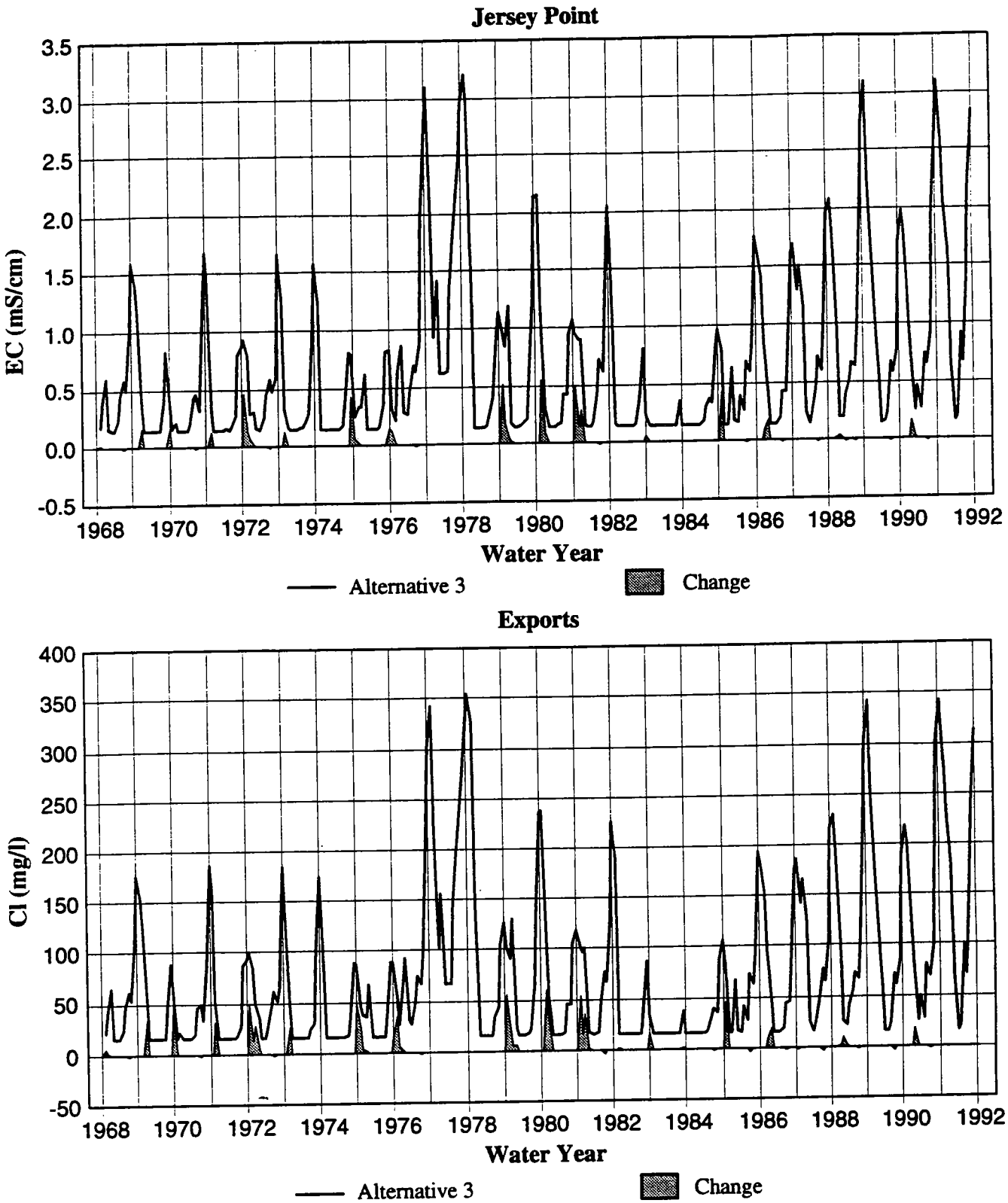


Figure B2-26.
Simulated End-of-Month Values and Predicted Changes under Alternative 3 Operations for Jersey Point EC and Export Chloride for 1968-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

Appendix C1. Analysis of Delta Inflow and Export Water Quality Data

Appendix C1. Analysis of Delta Inflow and Export Water Quality Data

SUMMARY

This appendix presents a review and summary of available water quality data related to salinity, dissolved organic carbon (DOC) and trihalomethane formation potential (THMFP) in Delta inflows (Sacramento and San Joaquin Rivers) and Delta exports. The general water quality characteristics of the Delta inflows and Delta exports are described, and basic relationships between several related variables are identified. A primary purpose of this appendix is to document observed changes in constituent concentrations as water is transported from Delta inflows to Delta export locations. This change in water quality can be attributed to effects of Delta channel processes and Delta agricultural drainage. This information provides the basis for impact assessment of the DW project.

This appendix also presents the conceptual mass-balance framework for identifying Delta sources of water quality constituents by comparison of constituent concentrations in the Delta inflows and the Delta exports. This mass-balance framework, which is the basis for water quality impact assessment for the Delta Wetlands (DW) project, is formulated as a monthly water quality model of Delta island drainage that is described in Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model".

INTRODUCTION

The primary issue of concern about the DW project with regard to municipal water supplies from the Delta is the potential effect of DW project operations on salinity and concentrations of water quality constituents that are precursors of trihalomethane (THM). THM, which is considered a human health risk, is a disinfection by-product (DBP) formed during the chlorination of water. DOC is considered to be the major organic precursor of DBP, including THM, in treated drinking water.

This appendix provides a conceptual foundation for calculating DW project contributions to salinity and DOC concentrations and THMFP in water that could be exported from the Delta and subsequently treated for municipal use. "Delta exports" refers to exports at the Central Valley Project (CVP) Tracy Pumping Plant to the Delta-Mendota Canal (DMC), the State Water Project (SWP) Banks Pumping Plant, and the SWP North Bay Aqueduct and diversions at the Contra Costa Water District (CCWD) Rock Slough intake.

Delta water quality patterns can be identified most reliably if several measured variables are analyzed concurrently. Conclusions are more reliable if several related parameters exhibit similar patterns of variation; in contrast, conclusions are more doubtful if related parameters exhibit different or conflicting patterns. This appendix presents information on several variables used to analyze Delta water quality patterns.

Following are the sections of this appendix:

- "Available Delta Inflow and Delta Export Data" describes the water quality data collection programs for the Delta and the types of data collected by each.
- "Delta Sources of Water Quality Constituents" provides an overview of sources of water quality constituents between Sacramento River inflows and Delta export locations.
- "Conceptual Framework for Estimating Constituent Contributions from Delta Sources" describes a mass-balance method for approximating net contributions of constituents from Delta sources for a month.
- "Water Quality Changes between Delta Inflow and Delta Export Locations" documents observed differences between water constituents

in inflows and exports that may be attributable to Delta sources.

- "Water Quality Characteristics of Delta Inflows" describes patterns of fluctuations in constituent concentrations of inflows, which account for some of the observed variability in Delta export water quality constituents.

- "Water Quality Characteristics of Delta Exports" details water quality characteristics at CCWD's Rock Slough intake, the SWP Banks Pumping Plant, and the CVP exports to the DMC near Tracy Pumping Plant and identifies the dominant influences of water sources on water quality at these locations.

- "Conclusions" relates the information presented in this appendix to other water quality analyses of the DW environmental impact report/environmental impact statement (EIR/EIS).

AVAILABLE DELTA INFLOW AND DELTA EXPORT DATA

A great amount of water quality data is collected in the Delta each year. The Interagency Ecological Program (IEP) coordinates much of the data collection, as required by the California State Water Resources Control Board (SWRCB) as conditions under various water right decisions and Bay-Delta water quality control plans.

The U.S. Bureau of Reclamation (Reclamation), California Department of Water Resources (DWR), and the U.S. Geological Survey (USGS) operate a network of continuous electrical conductivity (EC) monitoring stations primarily to provide information for operating the Delta (SWP and CVP) in compliance with applicable flow and salinity standards. These EC data have been summarized as monthly averages for the period 1968-1991 and are described in Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project".

DWR's Central District organizes daily records of Delta inflows, Delta exports, and estimated Delta outflows in a database called DAYFLOW, which is used to summarize historical Delta flows. Average monthly Delta inflows, exports, and outflows can be calculated from the daily values and used to represent the monthly water budget for the Delta. The relationship between Delta outflow and salinity intrusion can be characterized with the DAYFLOW values and the EC data from various stations.

DWR's Central District has collected samples monthly (twice monthly during spring and summer) since the early 1970s to compile data on minerals, nutrients, and plankton as part of the Delta sampling required by SWRCB in Water Right Decision 1379 (D-1379) in 1971 and Decision 1485 (D-1485) in 1978. These data, reported and analyzed in a series of annual reports, are primarily used to describe the general patterns of Delta water quality related to biological habitat conditions.

The Interagency Delta Health Aspects Monitoring Program was initiated in 1982 to study the quality of Delta water supplies used for human consumption. The same program is now being administered by DWR's Division of Local Assistance as the Municipal Water Quality Investigations (MWQI) program. MWQI sampling consists of monthly measurements of salinity, DOC, THMFP, and related water quality variables at Delta inflow and export locations and at several channel locations in the Delta. These data are used primarily to describe the Delta water quality variables important for municipal water supply evaluations (DWR 1989, 1993).

Salinity has been the dominant water quality variable of concern for municipal and agricultural water supplies in the Delta. However, the objectives specified in the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (1995 WQCP) adequately protect Delta water supplies from salinity intrusion effects during periods of reduced Delta outflow. Therefore, agricultural drainage effects on salinity and DOC concentrations are the major remaining water quality issues of concern for municipal water supplies.

Because the primary issue of concern about the DW project with regard to municipal water supplies from the Delta is a possible increase in DOC, the MWQI data, which include measurements of DOC, THMFP, and related variables, are therefore the most relevant source of Delta water quality information for the DW water quality impact assessment.

The MWQI data have been used by DWR and others to describe increases in DBP precursors that have been observed between Sacramento River inflow and Delta export locations. As is typical of field measurements, the monthly grab-sample MWQI data exhibit considerable scatter from month to month and vary between locations sampled in the same month that would be expected to have similar concentrations.

DELTA SOURCES OF WATER QUALITY CONSTITUENTS

Concentrations of many water quality constituents are often higher in Delta exports than in Sacramento River inflows, which are generally the major source of Delta water. Possible sources of water quality constituents in the Delta are seawater intrusion, inflows from the San Joaquin River and eastside streams, biological production in Delta channels, and agricultural drainage from Delta islands:

- **Seawater intrusion**. Seawater intrusion has been rather extensive during the 1987-1991 period of MWQI sampling, and seawater salts may have caused significant increases in some of the mineral concentrations in export water. Increased bromide (Br^-) concentrations caused by seawater intrusion may contribute to higher THMFP values at the export locations.

- **San Joaquin River and eastside stream inflows**. San Joaquin River concentrations of DOC, Br^-, and related constituents are routinely measured, but the portion of San Joaquin River inflow that is mixed into Delta exports varies. The possible influence of San Joaquin River inflows on export water quality can be estimated through comparison of the magnitude of San Joaquin River inflow with total export pumping. Based on this comparison, a considerable portion of observed increases in export concentrations above Sacramento River concentrations may be attributed to San Joaquin River inflows.

- **Biological production in Delta channels**. Erosion or leaching from channels and biological production of aquatic plants and other decaying materials may add to concentrations of water quality constituents in the Delta. This possible source is difficult to measure directly because it is distributed throughout Delta channels.

- **Agricultural drainage**. The magnitude of the contribution of water quality constituents from agricultural drainage sources can be estimated from the product of the drainage volume and measured drainage concentration. The available data on Delta agricultural drainage water quality are reviewed in Appendix C2, "Analysis of Delta Agricultural Drainage Water Quality Data". Direct measurements of Delta drainage volumes are not currently available. Data on drainage concentrations are being collected as part of the MWQI program, and USGS and DWR have initiated a demonstration project to measure agricultural water budget terms on several Delta islands (DWR 1994).

The change in constituent concentration between the Sacramento River and Delta export locations can be used to estimate the magnitude of the net contribution from Delta sources. It is not possible, however, to determine from concentration data alone the relative contributions from different sources of increased concentrations observed at the export locations. Additional measurements of the individual sources are required to determine their relative contributions. The following section describes a method for estimating the contributions of water quality constituents from different sources within the Delta.

CONCEPTUAL FRAMEWORK FOR ESTIMATING CONSTITUENT CONTRIBUTIONS FROM DELTA SOURCES

The net contribution of a selected water quality constituent from Delta sources, including agricultural drains, can be estimated from the differences between Delta inflow and Delta export concentrations observed in the DWR MWQI data. Because Sacramento River inflows are generally the largest source of Delta water and have the lowest concentration of DOC and related constituents, the Sacramento River concentrations are used as the basis for determining Delta source contributions. The relationship between observed concentrations in the export water and net source contributions from within the Delta can be developed from available data based on the following mass-balance assumptions:

- The Sacramento River concentrations observed during a month are typical of the monthly average inflow concentrations.

- The Delta export concentrations observed during a month are typical of the monthly average export concentrations.

- Contributions from all Delta sources during a particular month are transported during the same month to Delta exports or Delta outflow.

- It is possible to estimate fractions of contributions from all Delta sources that are mixed with Sacramento River water and transported to the export locations.

- The remaining contributions from all Delta sources are mixed with Sacramento River water transported to Delta outflow past Chipps Island.

A simple mass-balance mixing model can be used to approximate the net contributions of constituents from Delta sources for each month. Delta export measurements are used as a "sample" of southern Delta water quality after some fraction of constituent contributions from Delta sources is mixed with Sacramento River inflow. The net contribution from Delta sources can be estimated from the observed increase in concentration in the exports (above the assumed inflow concentration), the Delta export pumping volume, and the assumed fraction of the Delta source contribution transported to the Delta export locations:

Delta source contribution rate (kg/month) for a 30-day month = export pumping rate (cubic feet per second [cfs]) · concentration change (mg/l) ÷ source fraction · 86,400 sec/day · 0.000001 kg/mg · 28.32 liter/ft^3 · 30 days/month

= export pumping rate (cfs) · concentration change (mg/l) ÷ source fraction · 73.4

For example, if an increase of 1 milligram per liter (mg/l) above the Sacramento River concentration was observed in a monthly average export flow of 5,000 cfs, and if the assumed fraction of export water from the Delta source was 50%, the net contribution from the Delta source would be calculated as follows:

Delta source contribution rate (kg/month) = 5,000 cfs · 1 mg/l ÷ 0.50 · 73.4 = 734,000 kg/month = 734 metric tons/month

If this net contribution occurred uniformly from some known area of the Delta, the average uniform contribution per unit area (g/m^2/month) could be estimated as follows:

Areal contribution rate (g/m^2/month) = mass contribution rate (kg/month) ÷ 4,047 m^2/acre ÷ source area (acres) · 1,000 g/kg = mass contribution rate (kg/month) ÷ source area (acres) ÷ 4.047

For the example given above, with an assumed source area equal to the Delta lowlands (396,000 acres), the average areal contribution rate would be calculated as follows:

Areal contribution rate = 734,000 kg/month ÷ 396,000 acres ÷ 4.047 = 0.458 g/m^2/month

To estimate the monthly areal contribution rate (g/m^2/month) from Delta sources for other observed changes in constituent concentration, export pumping rates, assumed fraction from Delta sources in the export pumping flow, or other source areas, appropriate values can be substituted in these equations. Higher calculated net contributions from Delta sources in Delta exports will result with higher rates of export pumping, higher observed concentration increases between Sacramento River inflows and exports, or higher fractions of Delta sources in Delta exports. Greater areal contribution rates will be estimated for smaller assumed contributing areas.

Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model", describes a systematic framework for estimating these net contributions from Delta sources based on observed concentration changes, Delta inflows, and export pumping rates.

WATER QUALITY CHANGES BETWEEN DELTA INFLOW AND DELTA EXPORT LOCATIONS

Patterns of changes in constituent concentrations between Sacramento River inflow (the selected inflow for estimating water quality changes within the Delta) and Delta export locations for several variables measured in the 1982-1991 DWR MWQI data are shown and described in this section. San Joaquin River inflow is treated as a contributing source within the Delta.

The DWR MWQI data collection program has changed somewhat each year. During 1982, preliminary measurements were collected from the SWP Banks Pumping Plant and the San Joaquin River at Vernalis. The THMFP assay was tested and standardized. Sampling from the Sacramento River and other Delta export locations began in 1983. DOC measurements were added in 1987. Br^- and ultraviolet absorbance (UVA) measurements were added in 1990. The use of UVA data is explained below.

The number of samples collected at each station each year has also changed. At Banks Pumping Plant, for example, five samples were collected in water year 1982, nine samples were collected in water year 1983, and 11 or 12 (monthly) samples were collected in water years 1984-1989. During water years 1990 and 1991, weekly and biweekly sampling was conducted during portions of the year, with a total of 26 samples collected in 1990 and 22 collected in 1991.

To standardize the data analysis, Jones & Stokes Associates (JSA) selected a data set of monthly values for the entire 10-year (1982-1991) period by using the first grab sample collected in each calendar month and eliminating any additional samples collected that month. Samples are often, but not always, collected on about the same day at each of the sampling stations. Table C1-1 gives a summary of the available data. The statistics of the monthly samples were not substantially different from those of the entire data set. The following sections describe the data for electrical conductivity (EC), chloride (Cl^-), Br^-, DOC, THM precursors and THMFP, and turbidity.

Delta Electrical Conductivity Values

Figure C1-1 shows EC measurements for the DWR MWQI samples from Sacramento and San Joaquin River inflows and from three export locations (SWP Banks Pumping Plant; the Central Valley Project [CVP] Delta Mendota Canal [DMC] near the Tracy Pumping Plant; and Rock Slough near Old River, the source of water for the Contra Costa Water District [CCWD] intake).

The EC values for the Sacramento River are generally in the range of 100-200 microsiemens per centimeter (μS/cm), although two measurements in the 1986 flood period were below 100 μS/cm, and several values have been above 200 μS/cm. Figure B2-4 in Appendix B2 indicates that Sacramento River EC measurements generally decrease with higher flows, exhibiting a typical flow-dilution relationship that can be approximated with the following equation:

$$\text{Sacramento River EC } (\mu\text{S/cm}) = 5{,}000 \cdot \text{flow (cfs)}^{-0.35}$$

This equation indicates that for Sacramento River flows of less than 10,000 cfs, the corresponding EC values would be greater than 200 μS/cm. For Sacramento River flows greater than 50,000 cfs, the corresponding EC values estimated from this equation would be less than 100 μS/cm.

The EC values for the San Joaquin River are usually much higher than Sacramento River EC values, fluctuating between 150 μS/cm and 1,300 μS/cm. Figure B2-5 in Appendix B2 indicates that San Joaquin River EC measurements also generally decrease with flow, exhibiting a flow-dilution relationship that can be approximated with the following equation:

$$\text{San Joaquin River EC } (\mu\text{S/cm}) = 25{,}000 \cdot \text{Flow (cfs)}^{-0.5}$$

Several San Joaquin River EC values observed during winter in recent years (1988-1991) have been above 1,000 μS/cm and are as much as 500 μS/cm higher than the EC values estimated with the flow-dilution equation. These elevated EC values suggest that an additional load of salt drainage may have been released into the San Joaquin River during these drought years. Measurements when available are superior to flow-regression estimates of inflow water quality; flow regressions must be used for planning and assessment studies.

Observed EC values at the three export locations have fluctuated between about 200 μS/cm and 1,000 μS/cm. During months when low EC values were measured, corresponding to periods of high Delta outflow, the export locations each had similar EC values. During months when high EC values were measured, EC values at Rock Slough (CCWD) were generally the highest because effects of salinity intrusion are usually strongest at Rock Slough. Local agricultural drainage may also have different effects at each export location.

The DWR MWQI EC data clearly indicate that EC (representing dissolved salts) usually increases between Sacramento River inflow and the export locations. The net source of elevated EC may differ, however, for each month and each export location. DWR MWQI EC data alone are not sufficient to determine the relative monthly contributions from the San Joaquin River, salinity intrusion, and Delta agricultural drainage.

Figure C1-2 shows the monthly DWR MWQI grab samples from the DMC, compared with the monthly range of mean daily EC values recorded at the continuous EC monitor located in the DMC. This figure indicates that the monthly DWR MWQI grab samples may not always be representative of the actual monthly mean value, as measured by the continuous EC monitor at the same location. Therefore, monthly grab samples from other locations may not represent actual monthly average EC values or monthly average concentrations of other measured variables.

Delta Chloride Data

Figure C1-3 shows DWR MWQI data on Cl^- concentrations for water years 1982-1991 for the two Delta inflow and three Delta export locations. Cl^- concentration patterns are similar but not identical to the EC patterns because each major water source has a different Cl^-/EC ratio value. Figure C1-4 show the Cl^-/EC ratios for each of the monthly DWR MWQI samples. These two figures will be described together.

Sacramento River Cl^- concentrations were usually less than 10 mg/l (Figure C1-3), and the Cl^-/EC value (mg/l:μS/cm) in this inflow averaged about 0.05 (Figure C1-4). Some of the scatter in the Sacramento Cl^-/EC values was caused by the low Cl^- concentrations, which are normally reported as whole numbers.

San Joaquin River Cl^- concentrations fluctuated between about 20 mg/l and 180 mg/l (Figure C1-3) and Cl^-/EC ratio values increased from about 0.08 at low EC values to about 0.15 at high EC values (Figure C1-4). The variability in the Cl^-/EC values of this inflow may be explained by the fact that it is a mixture of San Joaquin River water and Stanislaus River water (from New Melones Reservoir). MWQI samples from the San Joaquin River at Maze, above the confluence with the Stanislaus River, can be estimated to have a constant Cl^-/EC value of 0.15, and by inference, Stanislaus River inflow can be estimated to have a Cl^-/EC value of approximately 0.06. Nevertheless, the Cl^-/EC value of 0.08 to 0.15 for the San Joaquin River inflow is distinct from the lower Cl^-/EC value of about 0.05 for the Sacramento River. The Cl^-/EC value of 1% seawater mixed with 99% Sacramento River water is 0.30 (pure seawater has a Cl^-/EC value of about 0.35) (CRC 1989).

Agricultural drainage is derived from rainfall (without minerals) and applied water that has partially evaporated; the salinity (EC and Cl^- concentration) of drainage water is usually greater than the salinity of the applied water, but the Cl-/EC ratio remains constant (see Appendix C2, "Analysis of Delta Agricultural Drainage Water Quality Data", for additional discussion). The agricultural drainage salinity is "recycled" salinity from the applied water. There are therefore only three basic sources of Delta salinity: seawater, San Joaquin River water, and Sacramento River water. The Cl^-/EC ratio of agricultural drainage will reflect the Cl^-/EC ratio of the applied water source (or combination of sources). The only source for water in the Delta with a Cl^-/EC ratio value higher than 0.15 is seawater intrusion, and agricultural drainage may also have a Cl^-/EC value above 0.15 if the applied water included substantial seawater intrusion. For a Sacramento River sample with an EC value of 200 μS/cm, the Cl^- concentration would be about 10 mg/l (Cl^-/EC value of 0.05).

The following example illustrates how the Cl^-/EC value changes with the mixture of source water. A sample of San Joaquin River water with an EC of 1,000 μS/cm will have a Cl^- concentration of 150 mg/l (Cl^-/EC value of 0.15). A sample of Mallard Island water (assumed to be seawater diluted with Sacramento River water) with an EC of 1,000 μS/cm will have a Cl^- concentration of about 300 mg/l (Cl^-/EC value of 0.3). If these two water samples are mixed together in various combinations, the EC of the mixture will remain 1,000 μS/cm, but the Cl^- concentration will increase as more Mallard Island water is added to the San Joaquin River water. For a 50/50 mixture, the Cl- concentration will be 225 mg/l ([0.5 · 150] + [0.5 · 300] = 225) and the Cl^-/EC value will be 0.225.

The contributions from the three salinity sources can be estimated through the use of three equations to calculate the fractions of the volume of water contributed from each source , the EC value, and the Cl^- concentration of three-way mixtures. For example, if a mixture of these three water sources (with the EC values given above) had an EC of 600 μS/cm, it could be concluded that the Sacramento River water is contributing 50% of the volume, because the other two each had an EC of 1,000 μS/cm ([0.5 · 200] + [0.5 · 1,000] = 600). The mixture could have a Cl^- concentration of between 80 mg/l (with no Mallard Island water in the mixture) and 155 mg/l (with no San Joaquin River water in the mixture). The measured Cl^- concentration could be used to estimate the mixture of Mallard Island and San Joaquin River water in this example mixture.

Measurements of Cl^- concentrations from the export locations fluctuated between 15 mg/l and about 300 mg/l (Figure C1-3). The Cl^- concentrations in CCWD diversions from Rock Slough were the highest because of the stronger influence of seawater intrusion or local agricultural drainage.

Cl^-/EC values for the export locations were greater than 0.15 (San Joaquin ratio) during periods with the highest Cl^- concentrations (Figure C1-4). These high Cl^-/EC values suggest that the dominant source of Cl^- during these periods is seawater intrusion. CCWD water diverted at Rock Slough usually has a higher Cl^-/EC value than the other export locations, suggesting a slightly higher seawater contribution.

The DWR MWQI data indicate that Delta and San Joaquin River contributions of Cl^- are significant. The relative magnitude of the potential influence by Delta sources on increased Cl^- at the export locations cannot be directly determined, however, from Cl^- concentrations alone. The San Joaquin River, agricultural drainage water, and seawater intrusion water have approximately the same Cl^- concentration. In contrast, the Cl^-/EC values for export water provide more information about the sources of increased Cl^- and can be used to estimate the most likely source of increased Cl^-.

Delta Bromide Data

Figure C1-5 shows DWR MWQI Br^-/Cl^- values, based on Br^- measurements that began in January 1990. Because of drought conditions with relatively high salinity intrusion effects and higher concentrations from San Joaquin River inflows, Br^- concentrations at the export locations have been quite high since measurement began. The Br^-/Cl^- value for concentrations measured from San Joaquin River samples (0.003 to 0.0045) are similar to the Br^-/Cl^- value of about 0.0035 for seawater. Br^-/Cl^- values for Sacramento River inflow were scattered (0.001 to 0.0045) because of low concentrations of Cl^- and Br^- but sometimes were substantially lower (0.0015) than seawater or San Joaquin River water. Although Br^- is more difficult to measure than Cl^-, these DWR MWQI data suggest that Br^- concentrations may be adequately estimated from Cl^- measurements if a Br^-/Cl^- value of about 0.0035 is assumed for all sources for impact assessment purposes.

Delta Dissolved Organic Carbon Data

Figure C1-6 shows DWR MWQI measurements of DOC that were initiated in 1987. DOC is considered to be the major organic precursor of DBP, including THMs. DOC is therefore one of the most important water quality variables for assessment of potential formation of DBP in treated drinking water from the Delta.

DOC concentrations in Sacramento River inflow are generally the lowest measured in the Delta, with concentrations of about 2.0 mg/l often observed (Figure C1-6). American River samples have even lower DOC concentrations (DWR 1989). Sacramento River DOC concentrations are sometimes higher than 2.0 mg/l, with several DOC values above 3.0 mg/l. Daily measurements taken during 1993 have confirmed that Sacramento River DOC concentrations can be elevated above 2.0 mg/l as the result of sources of DOC material in surface runoff (Agee pers. comm.).

DOC concentrations in the San Joaquin River were usually higher than Sacramento River DOC concentrations, with DOC values generally between 3.0 mg/l and 6.0 mg/l. The San Joaquin River is considered a major source of DOC relative to the Sacramento River, which has comparatively low DOC concentrations. Most of the DOC concentrations at the export locations were in the range of 3.0 mg/l to 5.0 mg/l. The DWR MWQI data clearly show that DOC is contributed by Delta sources or San Joaquin River inflow. The relative influences of the various possible sources cannot be easily identified from these data alone.

Delta Trihalomethane Precursor Data

Trihalomethane Formation Potential and Types of Trihalomethane Molecules

To provide a comparative measure of THM precursors in Delta water, the DWR MWQI program developed an assay for determining THMFP, an index of the maximum possible THM concentrations that could be produced by maximum chlorination of Delta water. The assay is performed by spiking a water sample with an initial 120-mg/l concentration of chlorine (Cl_2), holding the sample for 7 days (168 hours) at 25°C, then measuring the THM species with standard U.S. Environmental Protection Agency (EPA) procedures (gas chromatograph purge and trap, EPA method 502.2).

The gas chromatograph method determines concentrations of four types of THM molecules separately (Table C1-2). Each type of THM molecule resembles methane (CH_4), except that three of the four hydrogen atoms are replaced with a halogen (chlorine or bromine). The four types of THM molecules are chloroform ($CHCl_3$), dichlorobromomethane ($CHCl_2Br$), dibromochloromethane ($CHClBr_2$), and bromoform ($CHBr_3$).

Each of these THM molecules has a different weight because of the difference between the molecular weight of chlorine (35.45) and bromine (79.9). Chloroform has a molecular weight of 119.36, whereas bromoform has a molecular weight of 252.71. The chemical properties of the four types of THM molecules are summarized in Table C1-2.

Total THM concentration (by weight) is the basis for current EPA drinking water standards. The greater weight of total THM resulting from increased bromine incorporation, however, complicates comparison of THM precursors from two water samples with different bromine content. One method to normalize the total THM concentrations is to use molar concentrations. This is the standard chemistry method and essentially counts the number (in moles) of THM molecules per liter of water.

A slightly different technique, having equivalent results, is to measure only the carbon weight of each THM molecule because each molecule has one carbon atom. The carbon fractions of the four types of THM molecules are listed in Table C1-2. The carbon-fraction concentrations of the four types of THM molecules are added together to calculate the carbon equivalent of the

total THM concentration, called the C-THM concentration. The DWR MWQI program uses the term "total formation potential carbon" (TFPC) for the same variable.

Dividing the C-THM concentration by the initial DOC concentration in a water sample provides a direct estimate of the fraction of the initial DOC concentration in a water sample that was converted to THM molecules during the THMFP assay, an advantage over using the molar THM concentration. The ratio C-THM/DOC is called the THM yield.

Delta C-THM Data

Figure C1-7 shows the 1982-1991 DWR MWQI calculated C-THM concentrations. Sacramento River concentrations of C-THM were usually below 30 μg/l; however, about a third of the concentrations were above 30 μg/l. Most export concentrations of C-THM were between about 30 μg/l and 90 μg/l, generally higher than Sacramento River concentrations. San Joaquin River C-THM concentrations were higher than Sacramento River concentrations but were not distinctly higher than export concentrations. Because the C-THM concentrations for Sacramento River inflow fluctuated and because the San Joaquin River C-THM concentrations were similar to those measured at the export locations, it is quite difficult to directly estimate the monthly contributions of C-THM from Delta sources.

Figure C1-8 shows the ratios of C-THM to DOC for the two inflow and three export locations. With allowances made for a certain amount of scatter in both measurements, these ratios for "THM yield" from DOC range from about 0.01 to 0.02, indicating that approximately 1%-2% of DOC became THM molecules during the THMFP assay in most samples. This yield relationship suggests that DOC measurements can be used to estimate the C-THM concentration of the THMFP assay. This relatively constant C-THM/DOC value might be used with more frequent DOC measurements to minimize the need for using the comparatively expensive and time-consuming THMFP assay procedure (see Appendix C3, "Water Quality Experiments on Potential Sources of Dissolved Organics and Trihalomethane Precursors for the Delta Wetlands Project", for more discussion of this topic).

Delta Ultraviolet Absorbance Data

UVA (254-nm wavelength) was added to the DWR MWQI program as a measurement variable in 1990. UVA is measured with a spectrophotometer and reported in units of 1/cm.

UVA, a physical measurement used in the study of humic acids and THM precursors, has been found to be linearly related to DOC concentration (see Appendix C2, "Analysis of Delta Agricultural Drainage Water Quality Data"). UVA may be a direct measure of the humic and fulvic acid portion of total DOC in a water sample. The ratio of UVA to DOC would therefore be expected to increase with a higher proportion of humic substances. A greater yield of THM molecules would also be expected from samples with higher UVA/DOC values because the humic substances are thought to be the "active" THM precursor.

Figure C1-9 indicates that most Delta inflow and export samples have UVA(1/cm)/ DOC(mg/l) ratios of between 0.02 and 0.04, with an average of about 0.03. The Sacramento and San Joaquin River UVA/DOC values tend to be slightly lower than the UVA/DOC values for the exports.

Appendix C2 describes the ratio of UVA to DOC from Delta agricultural drainage water. The UVA measurement holds great promise as a monitoring variable if additional data confirm a consistent UVA/DOC value for each water source. Because UVA is a relatively simple physical measurement, frequent (daily) data could be inexpensively collected from Delta inflows and exports and from other locations where DOC concentrations are of possible concern.

Delta Turbidity Data

Figure C1-10 shows the DWR MWQI monthly turbidity data collected since 1983 (reported in nephelometric turbidity units [NTU]). Turbidity is a measure of particulate materials that may originate from erosion and surface runoff during storm events, or from channel scour and resuspension of settled materials (inorganic and organic) within the Delta. These data illustrate that turbidity values of the Sacramento River inflow are sometimes higher than turbidity at Delta export locations.

WATER QUALITY CHARACTERISTICS OF DELTA INFLOWS

A portion of the observed variability in Delta export water quality measurements shown in the previous section is caused by variability in the inflowing water concentrations. This section will identify the relation-

ships between related mineral and organic constituents in Sacramento and San Joaquin River inflows and in seawater intrusion measured at Mallard Island (near Chipps Island).

The previous section of this appendix presented the changes in monthly constituent concentrations observed between Sacramento River inflow and Delta export locations. This section, however, presents the patterns of concentration fluctuations in the Delta inflows from the Sacramento and San Joaquin Rivers and at Mallard Island.

The flow-dilution equations for each river inflow (presented above under "Delta Electrical Conductivity Values") indicate how EC values are expected to vary as a function of river flow. Graphing concentrations of other water quality constituents against the corresponding EC measurements for the same samples illustrates a characteristic signature or "waterprint" for the water quality in each inflow, as described below.

Sacramento River Water Quality Characteristics

Figure C1-11 shows the concentrations of several mineral constituents as measured in the 1982-1991 DWR MWQI samples from the Sacramento River at Greene's Landing. The range of EC values was quite limited for the Sacramento River, with EC values usually between 110 μS/cm and 220 μS/cm. Potassium (K^+) concentrations were reported to the nearest 0.1 mg/l, while the concentrations of other variables were reported only to the nearest mg/l.

Each of the mineral concentrations increased linearly with EC. The Cl^- concentrations were approximately 3%-5% of the EC value, giving a Cl^-/EC value of less than 0.05. The K^+ concentrations were about 1% of the EC value, giving a K^+/EC value of 0.01. Calcium (Ca^{2+}), sodium (Na^+), and sulfate (SO_4^{2-}) each had approximately the same concentration, with concentrations equal to between 5% and 7% of the EC value. Concentrations of magnesium (Mg^{2+}) and Cl^- were about the same (3%-5% of EC). The Sacramento River mineral water quality can be characterized with EC measurements and these observed ratios.

Figure C1-12 shows the organic variables, DOC and C-THM, as measured in the 1982-1991 DWR MWQI samples from the Sacramento River. These constituents did not increase with EC values in Sacramento River inflow, as the mineral concentrations did. Therefore, fluctuations in these organic variables were apparently attributable to causes other than flow dilution. Measurements of DOC are therefore required; estimates based on flow or EC monitoring will not be reliable for Sacramento River concentrations of DOC.

San Joaquin River Water Quality Characteristics

Concentrations of several mineral constituents measured in the 1982-1991 DWR MWQI samples from the San Joaquin River at Vernalis are shown in Figure C1-13. The range of San Joaquin River EC values (i.e., 100-1,300 μS/cm or 0.1-1.3 mS/cm as shown in the figure) is quite large compared with the range of Sacramento River EC values. Concentrations of these minerals increased linearly with EC.

At an EC of 1,000 μS/cm (i.e., 1.0 mS/cm), the K^+ concentration was less than 5 mg/l, indicating a very low K^+/EC value of less than .005 in San Joaquin River water. Mg^{2+} concentration was about 25 mg/l at an EC of 1,000 μS/cm, for a Mg^{2+}/EC value of 0.025. Ca^{2+} concentration was about 50 mg/l at an EC of 1,000 μS/cm, for a Ca^{2+}/EC ratio of 0.05.

Na^+, Cl^-, and SO_4^{2-} had approximately the same concentrations, and each exhibited an increasing ratio with EC as the EC value increased. Higher Cl^-/EC ratios at higher EC values were previously attributed to variable mixing of Stanislaus River and San Joaquin River water. At an EC value of 500 μS/cm, each of the three constituents had a ratio with EC of about 0.10. However, at an EC value of 1,000 μS/cm, the Na^+/EC value increased to 0.12, the Cl^-/EC value increased to 0.15, and the SO_4^{2-} value increased to about 0.17.

Figure C1-14 shows the organic variables, DOC and C-THM, as measured in the 1982-1991 DWR MWQI samples from the San Joaquin River. The range of DOC and C-THM concentrations was greater for the San Joaquin River than for the Sacramento River. Concentrations of DOC and C-THM did not increase with EC values. Because the range of unexplained fluctuation is quite large, monthly samples may not reliably reveal patterns for organic parameters in the San Joaquin River. Estimates of DOC based on flow or EC monitoring will not be reliable for San Joaquin River concentrations of DOC.

Mallard Island Water Quality Characteristics

Mallard Island, located near Chipps Island, is the Delta outflow station sampled in the DWR MWQI program. Figure C1-15 shows the mineral concentrations at this station plotted against EC values. The mineral concentrations clearly increased linearly with EC, and mineral/EC values were similar to those of seawater (CRC 1989). Cl^- had the greatest concentration, and the Cl^-/EC value was about 0.30 at an EC of 10,000 μS/cm. The Na^+ concentration was about 1,800 mg/l at an EC of 10,000 μS/cm, so the Na^+/EC ratio was 0.18. SO_4^{2-} had the next highest concentration, and the ratio of SO_4^{2-} to EC was about 0.05. The ratio of Mg^{2+} to EC was about 0.025. Ca^+ and K^+ concentrations were relatively low, and their ratios to EC were less than 0.01.

Figure C1-16 show the organic variables, DOC and C-THM. in the Mallard Island samples. The lowest EC values at Mallard Island indicate that the sample was dominated by Sacramento and San Joaquin River water, whereas the highest EC values indicate that the sample was dominated by seawater. DOC concentrations were generally quite low, between 2.0 mg/l and 3.0 mg/l, for the entire range of EC values and similar to Sacramento River DOC concentrations, suggesting that seawater intrusion was not a significant source of DOC.

This review of the DWR MWQI data demonstrates that river inflows and seawater intrusion as Delta sources have distinctive mineral characteristics, as summarized by Cl^-/EC ratios. These mineral characteristics may be used to identify the sources of water samples from Delta exports. This source identification technique is important for estimating expected changes in export concentrations of water quality constituents because the DW project operations are expected to change the source contributions of water at the export locations.

WATER QUALITY CHARACTERISTICS OF DELTA EXPORTS

The differences between the observed export concentrations of water quality constituents and the inflow concentrations provides a means to estimate the magnitude of contributions from other Delta sources (channel processes and agricultural drainage). Inflow water quality changes with flow, and the mixture of water at each export location changes with inflows and export pumping each month. Therefore, estimates of source tracking and mixed export concentrations must be calculated for each month. This methodology will be demonstrated as part of the Delta island drainage water quality monthly model DeltaDWQ in Appendix C4 and used for DW project water quality impact assessment.

Water Quality Characteristics of CCWD Diversions at Rock Slough

Figure C1-17 shows mineral concentrations from the 1982-1991 DWR MWQI data for CCWD diversions at Rock Slough. Comparison of this figure with Figures C1-11, C1-13, and C1-15, showing concentrations for the three major Delta water sources (Sacramento and San Joaquin Rivers and Mallard Island), indicates that the dominant source of elevated salinity (i.e., EC above 400 μS/cm or 0.4 mS/cm) was seawater intrusion. Because the Cl^-/EC value was above 0.15, most Cl^- in Rock Slough could not have originated from the San Joaquin River. In addition, Na^+ concentrations were much lower than Cl^- concentrations, which is characteristic of seawater (Figure C1-15). For lower EC values (lower than 400 μS/cm), the mixture of source water in Rock Slough is not as easily detected from the mineral graph.

Figure C1-18 shows the organic parameters, DOC and C-THM, measurements for Rock Slough water samples. Because none of the Delta water sources exhibited any pattern in DOC or C-THM with increasing EC, no reason exists to expect a pattern in DOC or C-THM at the export locations. One way to estimate the change caused by in-Delta processes is to calculate increases in DOC and C-THM between Sacramento and San Joaquin River inflows and Rock Slough for each monthly sample. Increases will depend on the mixture of source water and the measured DOC and C-THM in the sources and exports that month. This will provide an estimate of the contributions from agricultural drainage and channel processes.

Water Quality Characteristics of SWP Banks Pumping Plant Exports

Figure C1-19 shows the mineral concentrations from the 1982-1991 DWR MWQI data for the SWP Banks Pumping Plant. The range of EC observed for Banks Pumping Plant was smaller than that observed for Rock Slough, with EC values between 200 μS/cm and 900 μS/cm. Comparison of this figure with Figures C1-11, C1-13, and C1-15, showing concentrations for the three major Delta water sources, indicates that the dominant source of the elevated salinity (EC above 400 μS/cm) was seawater intrusion. Because the Cl^-/EC value exceeds 0.15 for EC greater than 400 μS/cm, most Cl^- in

these samples could not have originated from the San Joaquin River, which has a maximum Cl^-/EC value of 0.15. In addition, Na^+ concentrations are much lower than Cl^- concentrations, which is characteristic of seawater (Figure C1-15).

For lower EC values (lower than 400 μS/cm), the mixture of source water at Banks Pumping Plant is not easily detected from the mineral graph. The influence of San Joaquin River inflow is evident in some samples with nearly equal concentrations of Cl^-, Na^+, and SO_4^{2-}, with each about 10% of the EC value.

Figure C1-20 shows the organic variables, DOC and C-THM, measured at Banks Pumping Plant. Because none of the Delta water sources exhibited a pattern in DOC or C-THM with increasing EC, no pattern exists in DOC or C-THM at Banks Pumping Plant. One way to estimate the change caused by in-Delta processes is to calculate increases in DOC and C-THM between Sacramento and San Joaquin River inflows and Rock Slough for each monthly sample. Increases will depend on the mixture of source water and the measured DOC and C-THM in the sources and exports that month. This will provide an estimate of the contributions from agricultural drainage and channel processes

Water Quality Characteristics of CVP Tracy Pumping Plant Exports

Figure C1-21 shows the mineral concentrations from the 1982-1991 DWR MWQI data for the DMC near the CVP Tracy Pumping Plant. The range of EC observed for the DMC was about the same as that observed the SWP Banks Pumping Plant, with EC values between 200 μS/cm and 900 μS/cm. Comparison of this figure with Figures C1-11, C1-13, and C1-15 showing the three major Delta water sources, indicates that the dominant source of the elevated salinity (EC above 400 μS/cm) can be identified as a combination of seawater intrusion and San Joaquin River inflow. Whenever the Cl^-/EC value is above 0.15, most Cl^- in a sample could not have originated from the San Joaquin River, which has a maximum Cl^-/EC value of 0.15. In addition, Na^+ concentrations are often much lower than Cl^- concentrations, which is characteristic of seawater (Figure C1-15).

Several samples from the DMC have elevated EC values but nearly equal Cl^- and Na^+ concentrations at about 10% of the EC value. These water samples were apparently dominated by San Joaquin River inflows (Figure C1-13).

For lower EC values (less than 400 μS/cm), the mixture of source water at the DMC is not easily detected from the mineral graph. The influence of San Joaquin River inflow is evident in some samples with nearly equal concentrations of Cl^-, Na^+, and SO_4^{2-}, with each about 10% of the EC value. The comparison of San Joaquin inflow EC value with the DMC export EC value may provide an estimate of the dilution that has occurred with Sacramento River water.

Figure C1-22 shows the organic parameters, DOC and C-THM, measured in the DMC samples. One way to estimate the change caused by in-Delta processes is to calculate increases in DOC and C-THM between Sacramento and San Joaquin River inflows and Rock Slough for each monthly sample. Increases will depend on the mixture of source water and the measured DOC and C-THM in the sources and exports that month. This will provide an estimate of the contributions from agricultural drainage and channel processes.

CONCLUSIONS

The DWR MWQI measurements for minerals, DOC, THMFP, and associated water quality constituents provide the best available characterization of these constituents in Delta inflows and Delta exports. The observed differences between the inflow and export values are related to the mixture of water from different sources (river inflows and salinity intrusion) at the export locations. However, the source contributions at each export location change with Delta inflows and exports, making it difficult to estimate from these water quality measurements the magnitude of the contribution of DOC resulting from Delta channel processes and agricultural drainage.

Mineral characteristics of each river inflow and seawater intrusion are generally distinct and could be used to estimate the likely contributions of water from different sources at the export locations. The estimates of changes in source contributions that would result from DW project operations could then be used to estimate changes in DOC concentrations at the exports. However, because DOC concentrations in the river inflows cannot be reliably estimated from flow or EC monitoring data, inflow measurements are required for accurate prediction of export DOC concentrations.

The concepts of inflow source contributions and Delta source loads from channels or agricultural drainage were introduced in this appendix to explain the observed differences between inflow concentrations and export concentrations. Possible Delta source loads will be further explored in Appendix C2, "Analysis of Delta

Agricultural Drainage Water Quality Data", and Appendix C3, "Water Quality Experiments on Potential Sources of Dissolved Organics and Trihalomethane Precursors for the Delta Wetlands Project". Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model", presents results from a monthly Delta agricultural drainage water quality model that combines calculations of Delta inflow source contributions and agricultural drainage to estimate Delta export water quality for minerals (EC, Br^-) and organics (DOC). These estimated export concentrations are then used to estimate likely THM concentrations in treated drinking water exported from the Delta. These results are presented in Appendix C5, "Modeling Trihalomethane Concentrations at a Typical Water Treatment Plant Using Delta Export Water".

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Personal Communication

Agee, Bruce. Program manager. Water Quality Assessment, Division of Local Assistance, California Department of Water Resources. Sacramento, CA. May 1993 - computer disk file.

Table C1-1. Mean Values for DWR MWQI 1982-1991 Data

	Sacramento River at Greene's Landing		San Joaquin River at Vernalis		Rock Slough (CCWD Intake)		Banks Pumping Plant (SWP Export)		Delta Mendota Canal (CVP Export)		Mallard Island
	All Data n=112	Selected Monthly Data n=88	All Data n=130	Selected Monthly Data n=96	All Data n=125	Selected Monthly Data n=96	All Data n=138	Selected Monthly Data n=105	All Data n=127	Selected Monthly Data n=97	All Data n=101
EC (μS/cm)	167.0	164.0	683.0	645.0	554.0	518.0	483.0	454.0	537.0	507.0	9,018
Turbidity (NTU)	12.0	12.0	20.5	18.8	9.1	9.9	11.0	11.7	14.0	14.5	19.0
DOC (mg/l)	2.3	2.3	3.7	3.6	3.1	3.1	3.6	3.5	3.6	3.6	2.6
C-THM (μg/l)	31.5	32.1	49.4	49.0	48.5	48.0	55.8	54.1	52.4	50.9	49.6
UVA (cm^{-1})	0.052	0.043	0.085	0.074	0.1	0.1	0.12	0.12	0.112	--	0.085
Na^+ (mg/l)	10.8	10.6	82.5	79.0	68.5	62.9	56.6	52.8	61.6	58.1	1,570
Cl^- (mg/l)	7.2	7.1	92.1	85.8	109.6	100.3	82.5	74.6	84.5	77.1	2,852
Ca^{2+} (mg/l)	12.1	12.5	39.8	38.7	17.5	17.2	20.1	19.6	24.1	25.7	74
Mg^{2+} (mg/l)	7.1	7.1	22.0	21.2	17.2	16.7	15.6	15.4	17.4	17.3	207
K^+ (mg/l)	1.5	1.5	3.3	3.2	4.0	3.8	3.8	3.8	3.6	3.6	56
SO_4^{2-} (mg/l)	10.1	10.0	114.0	112.5	32.2	32.6	36.0	35.9	48.6	52.3	398
Br^- (mg/l)	0.02	0.02	0.44	0.43	0.54	0.52	0.39	0.39	0.38	0.37	12.5
Ratios (calculated for selected data only)											
Cl^-/EC		0.04		0.12		0.16		0.15		0.14	0.30
UVA/DOC		0.02		0.023		0.031		0.031		0.029	0.033
Br^-/Cl^-		0.0032		0.0033		0.0035		0.0034		0.0034	0.0038
C-THM/DOC		0.013		0.014		0.016		0.015		0.015	0.020

n = number of samples; some parameters were not measured in each sample.

-- = no measurements.

Table C1-2. Characteristics of Trihalomethane Molecules

THM Molecule Name	Chemical Symbol	Molecular Weight	Percent H	Percent C	Percent Cl	Percent Br
Chloroform	$CHCl_3$	119.36	0.84	10.06	89.10	0.00
Dichlorobromomethane	$CHCl_2Br$	163.81	0.61	7.33	43.28	48.78
Dibromochloromethane	$CHClBr_2$	208.26	0.48	5.76	17.02	76.74
Bromoform	$CHBr_3$	252.71	0.40	4.75	0.00	94.85

Molecular weight:

C = 12.01
H = 1.0
Cl = 35.45
Br = 79.90

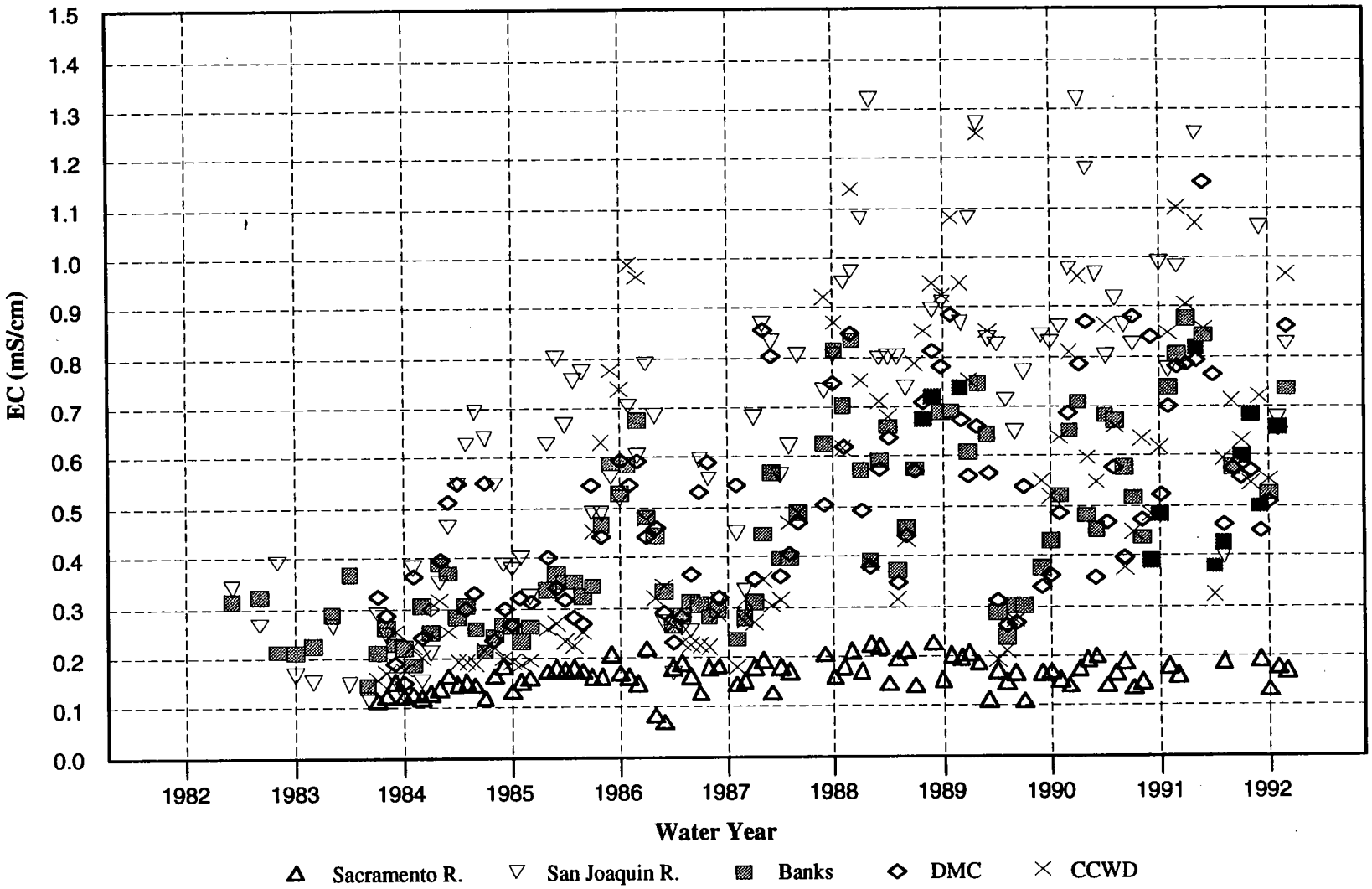

Figure C1-1.
EC Values of 1982-1991 MWQI Monthly Samples
from the Sacramento and San Joaquin Rivers and Delta Exports

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

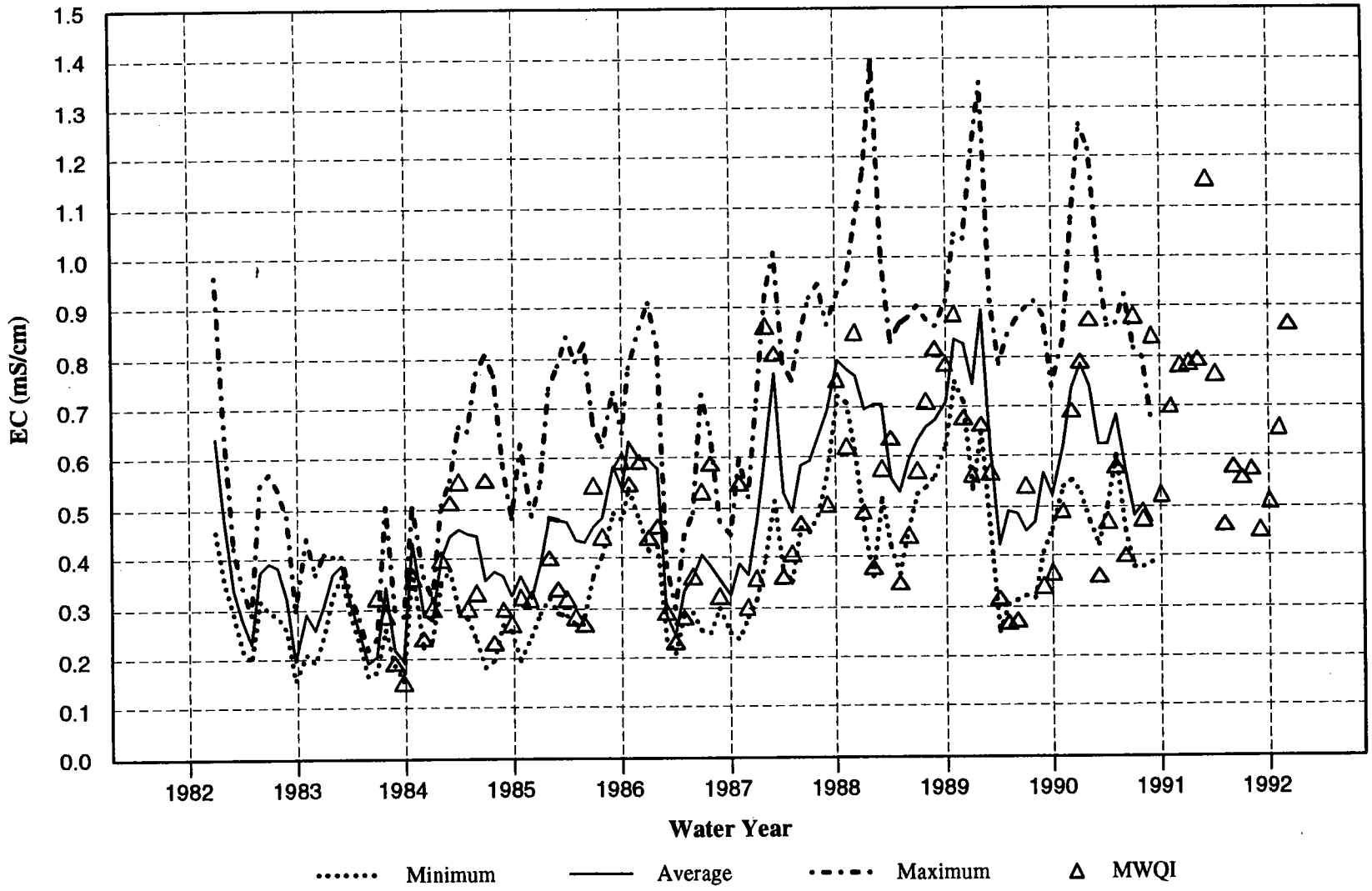

Figure C1-2.
Comparison of 1982-1991 MWQI Sample EC Values with Monthly Range of Daily Mean EC Values from Continuous Monitoring at the DMC

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

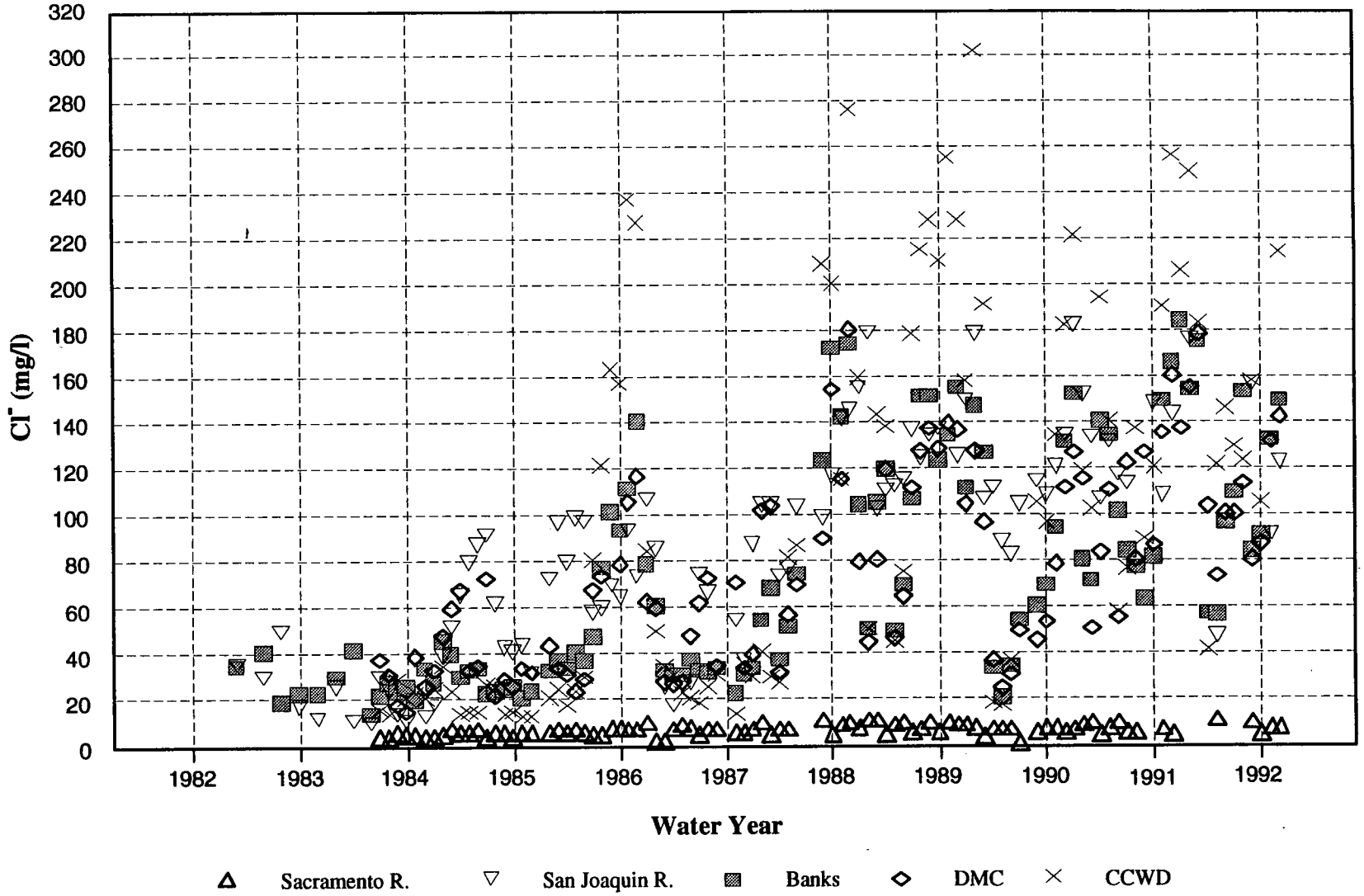

Figure C1-3.
Chloride Concentrations of 1982-1991 MWQI Monthly Samples from the Sacramento and San Joaquin Rivers and Delta Export Locations

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

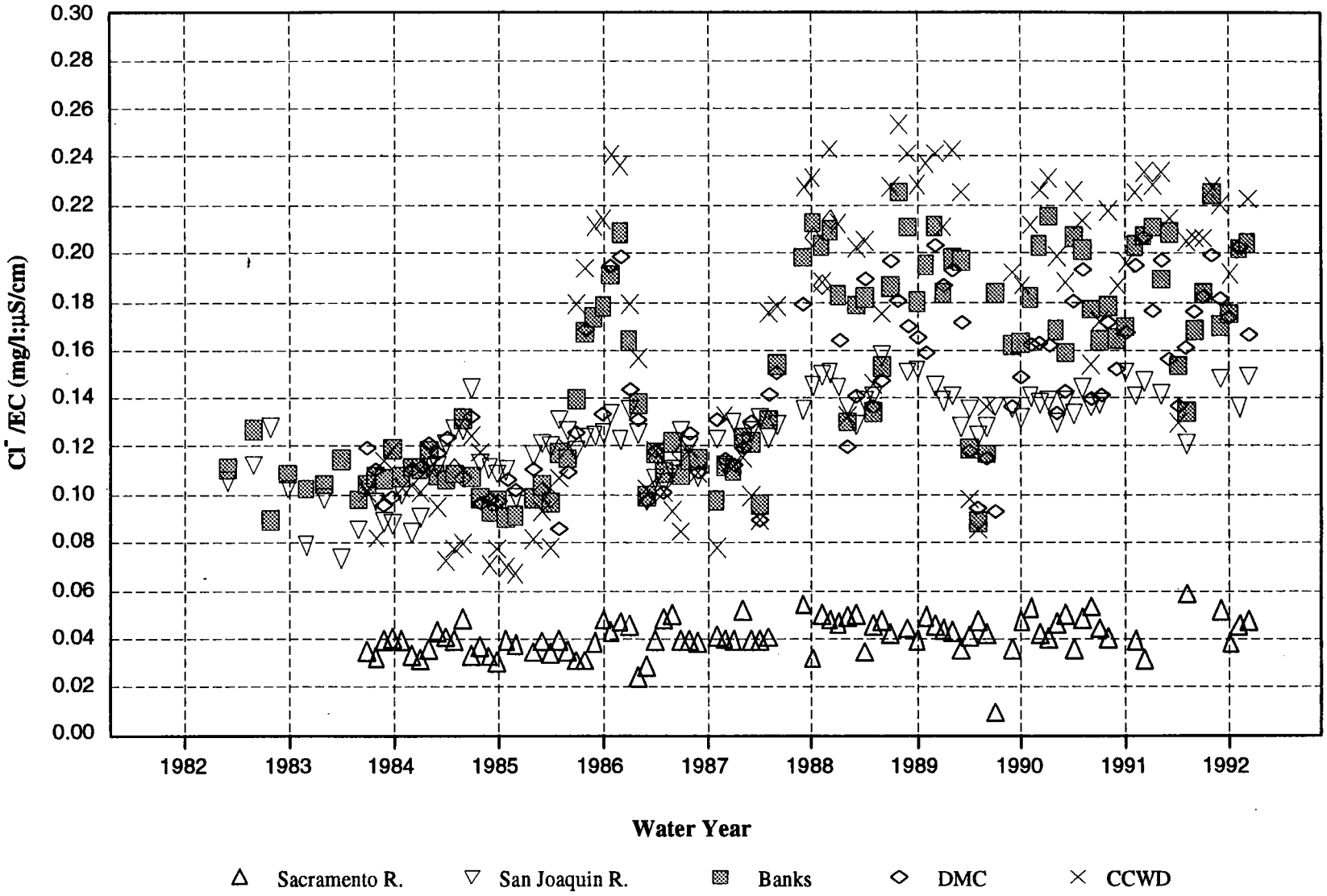

Figure C1-4.
Chloride-to-EC Ratios for 1982-1991 MWQI Monthly Samples from the Sacramento and San Joaquin Rivers and Delta Export Locations

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

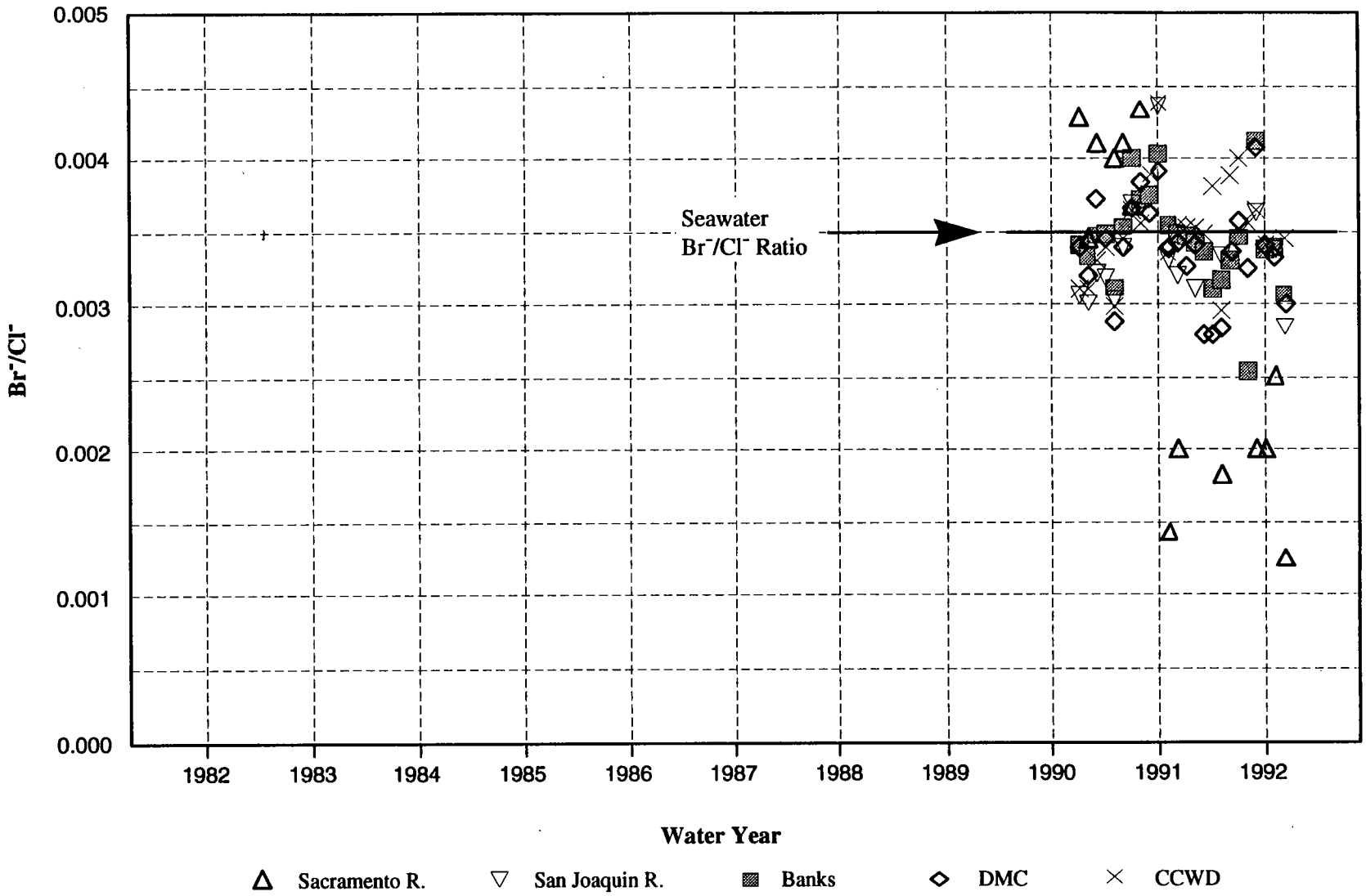

Figure C1-5.
Bromide-to-Chloride Ratios for 1982-1991 MWQI Monthly Samples from the Sacramento and San Joaquin Rivers and Delta Export Locations

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

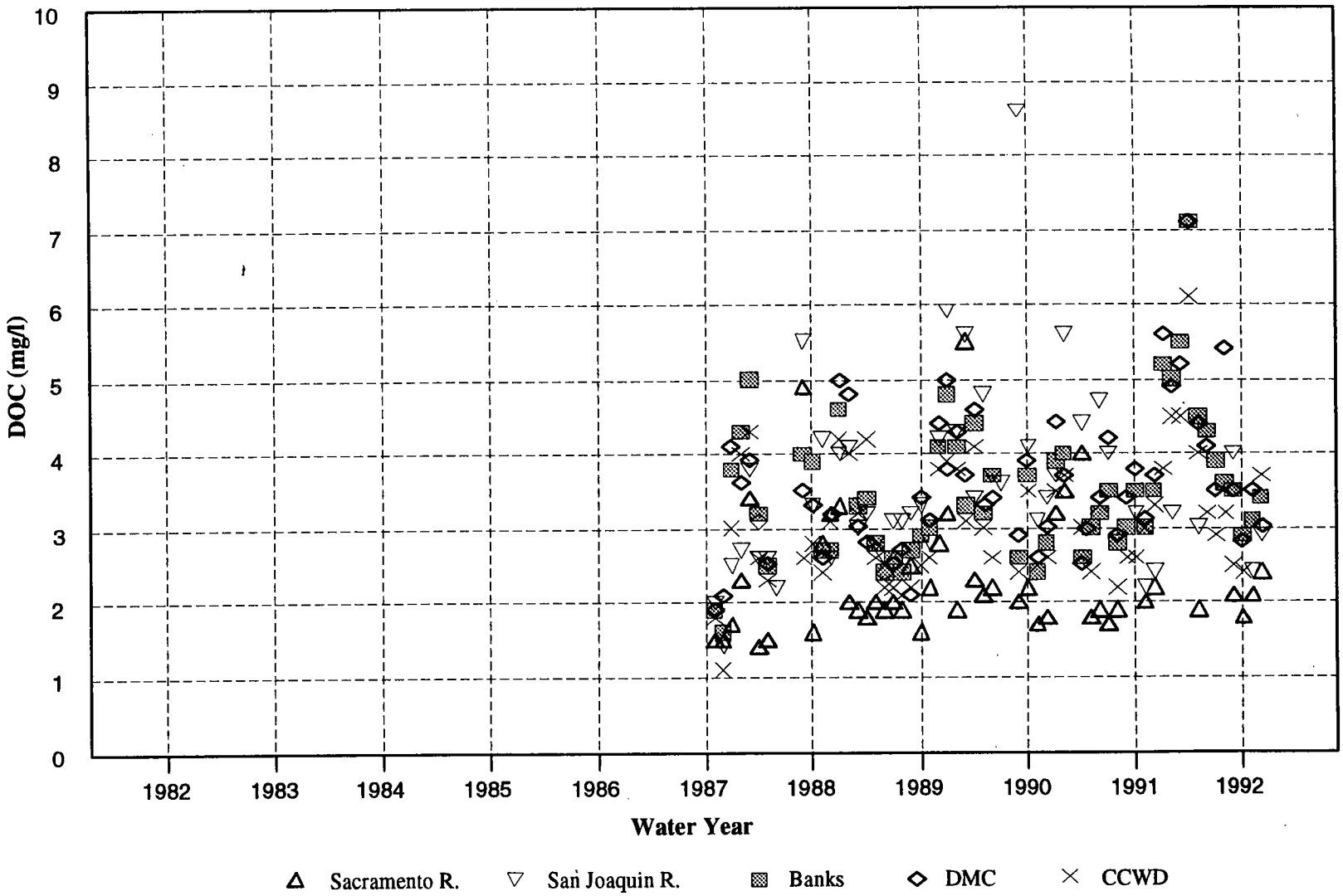

Figure C1-6.
DOC Concentrations of 1982-1991 MWQI Monthly Samples
from the Sacramento and San Joaquin Rivers and Delta Export Locations

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

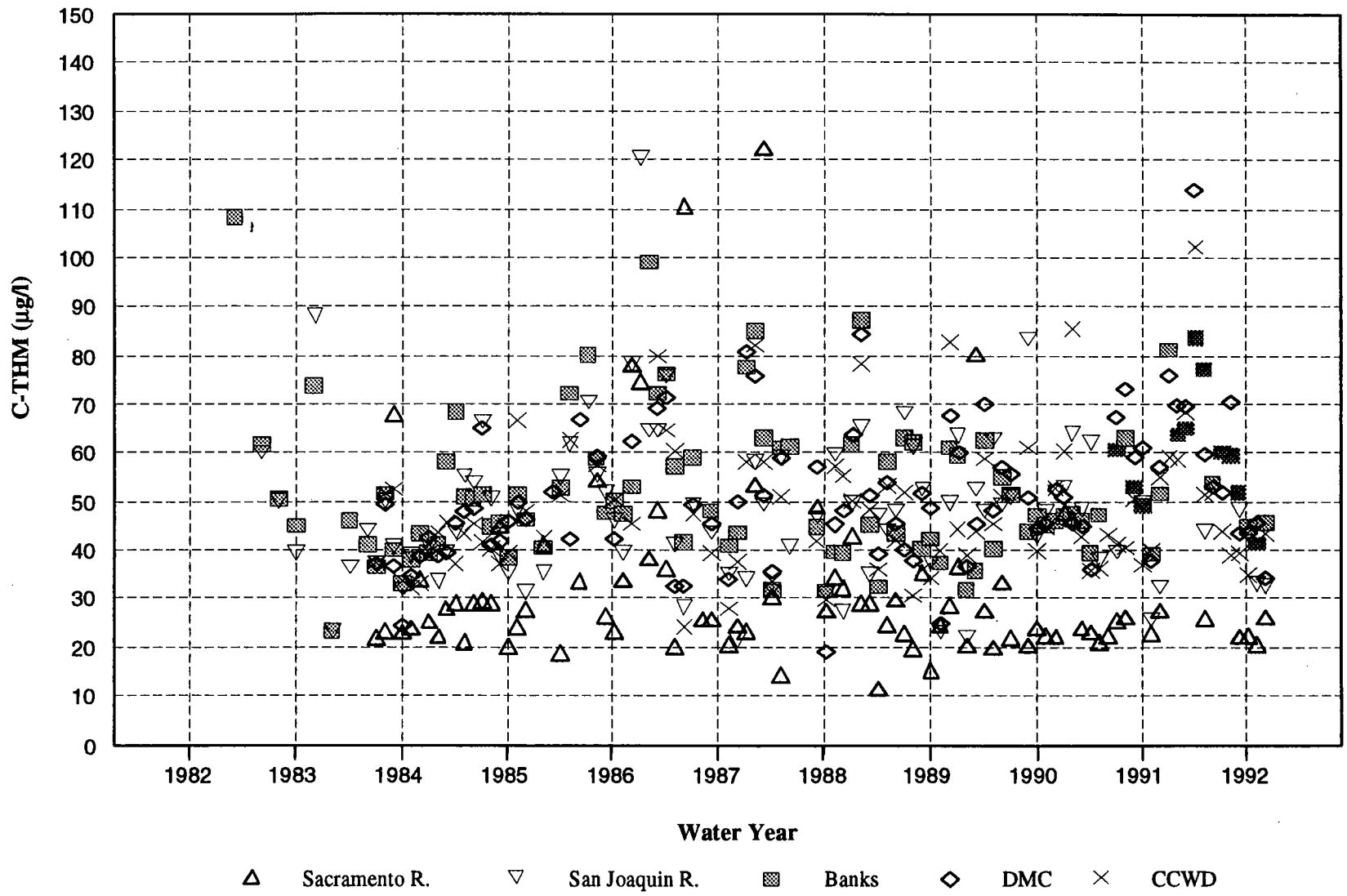

Figure C1-7.
C-THM Concentrations Calculated from 1982-1991 MWQI Monthly Samples from the Sacramento and San Joaquin Rivers and Delta Export Locations

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

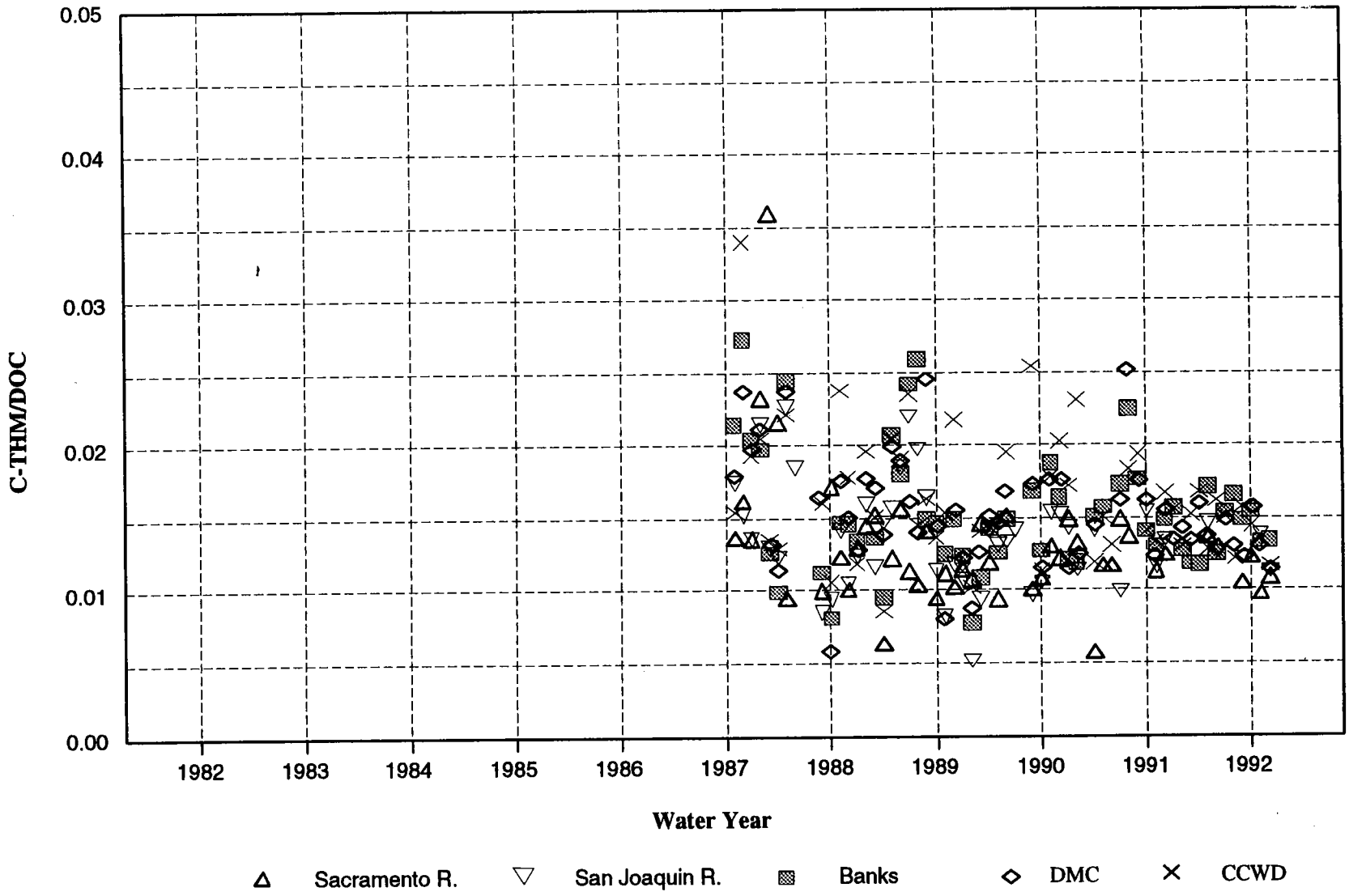

Figure C1-8.
C-THM-to-DOC Ratios Calculated for 1982-1991 MWQI Monthly Samples from the Sacramento and San Joaquin Rivers and Delta Export Locations

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

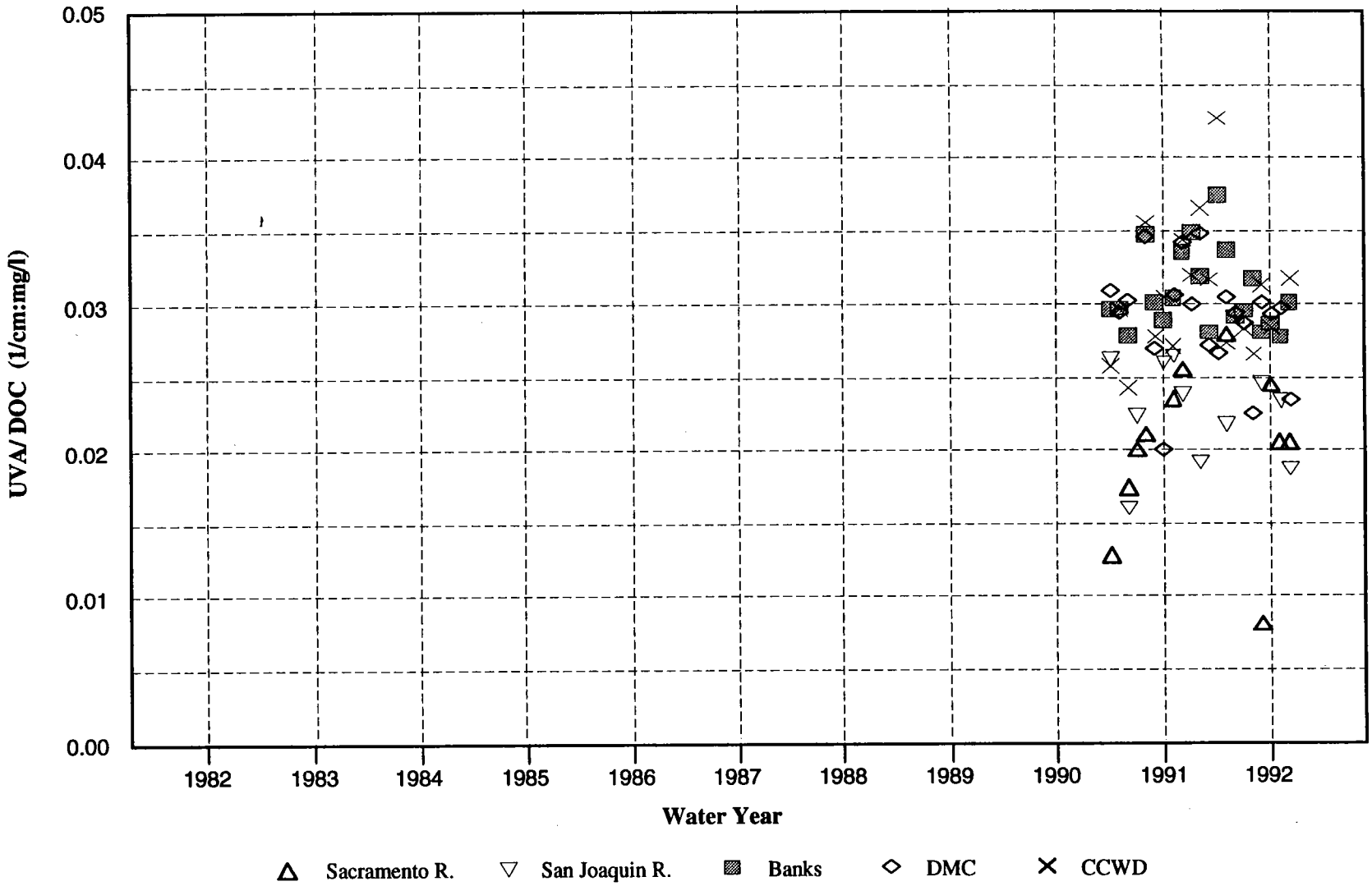

Figure C1-9.
UVA-to-DOC Ratios of 1982-1991 MWQI Monthly Samples
from the Sacramento and San Joaquin Rivers and Delta Export Locations

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

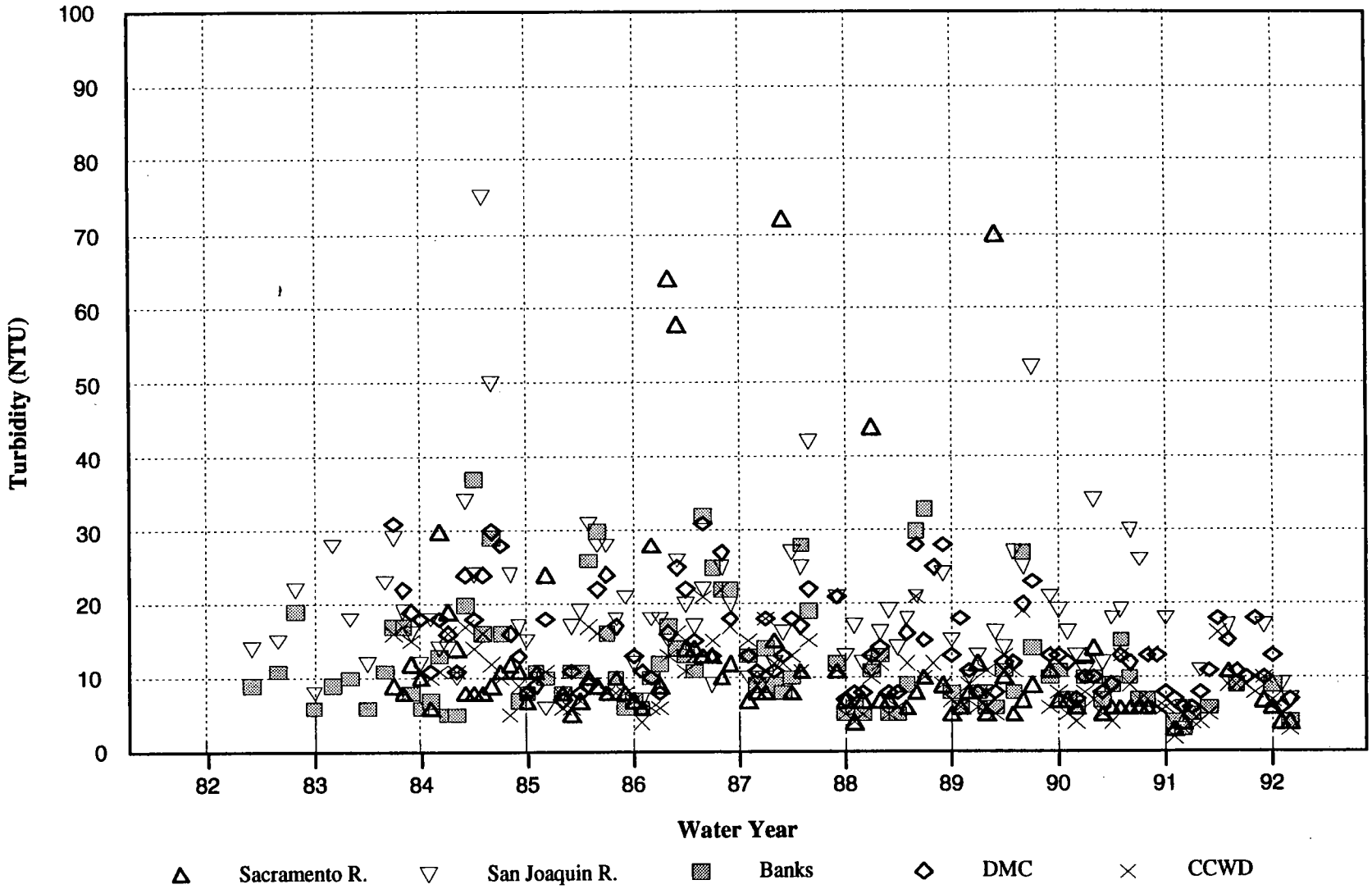

Figure C1-10.
Turbidity Values of 1982-1991 MWQI Monthly Samples from the Sacramento and San Joaquin Rivers and Delta Export Locations

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

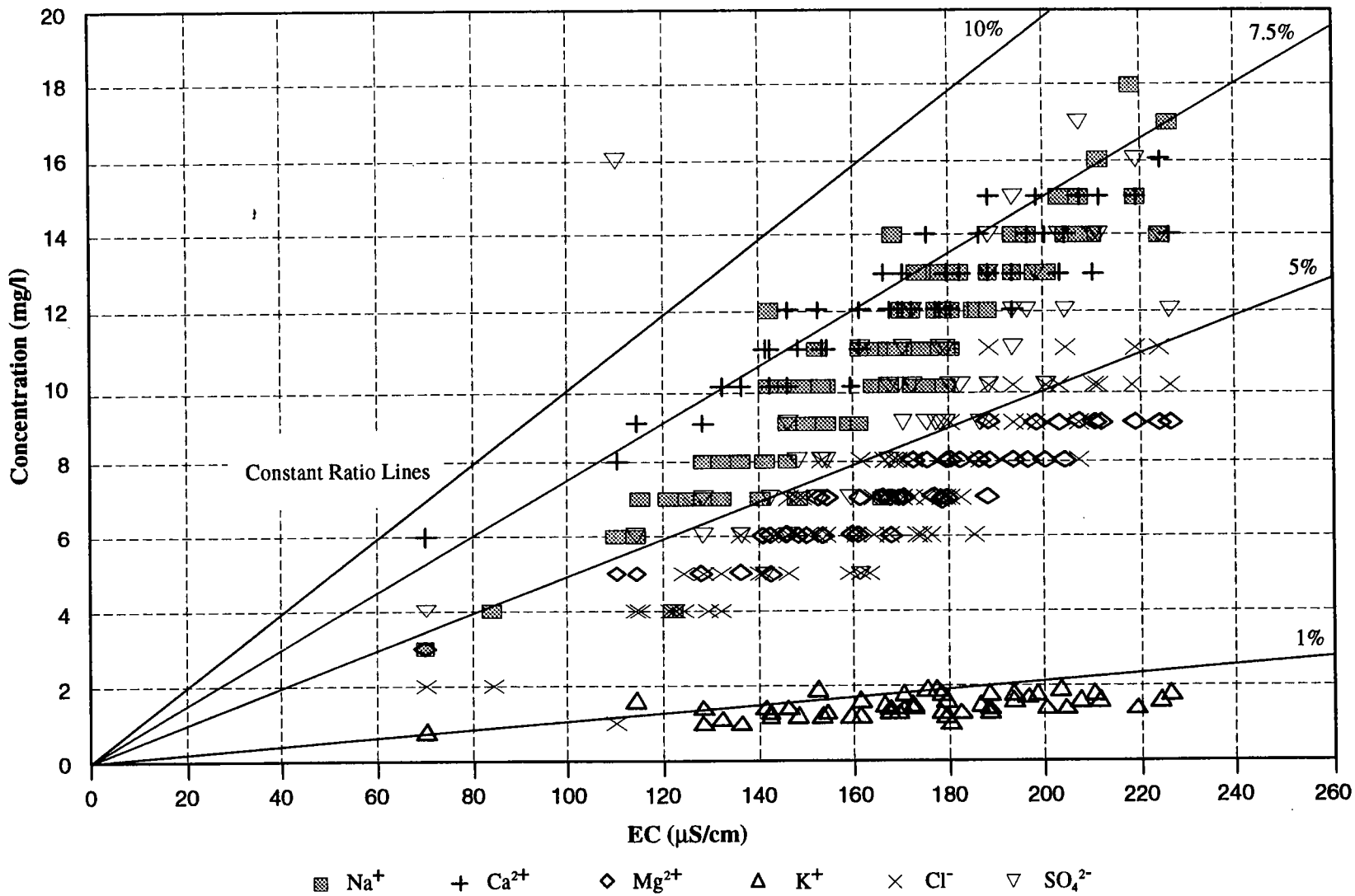

Figure C1-11.
Mineral Concentrations of 1982-1991 MWQI
Monthly Samples from the Sacramento River at Greene's Landing

DELTA WETLANDS
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Prepared by: Jones & Stokes Associates

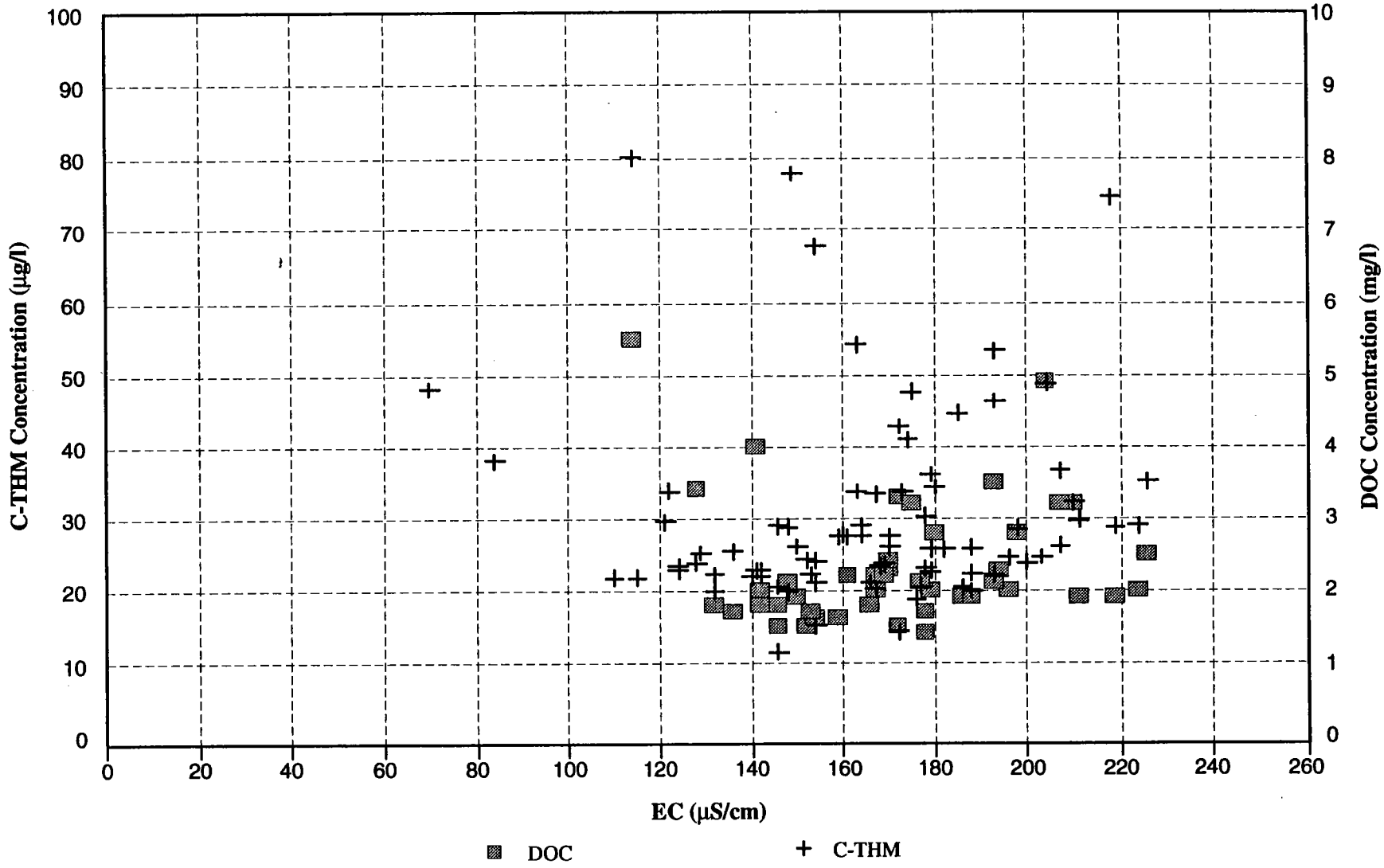

Figure C1-12.
DOC and C-THM Concentrations of 1982-1991 MWQI
Monthly Samples from the Sacramento River at Greene's Landing

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

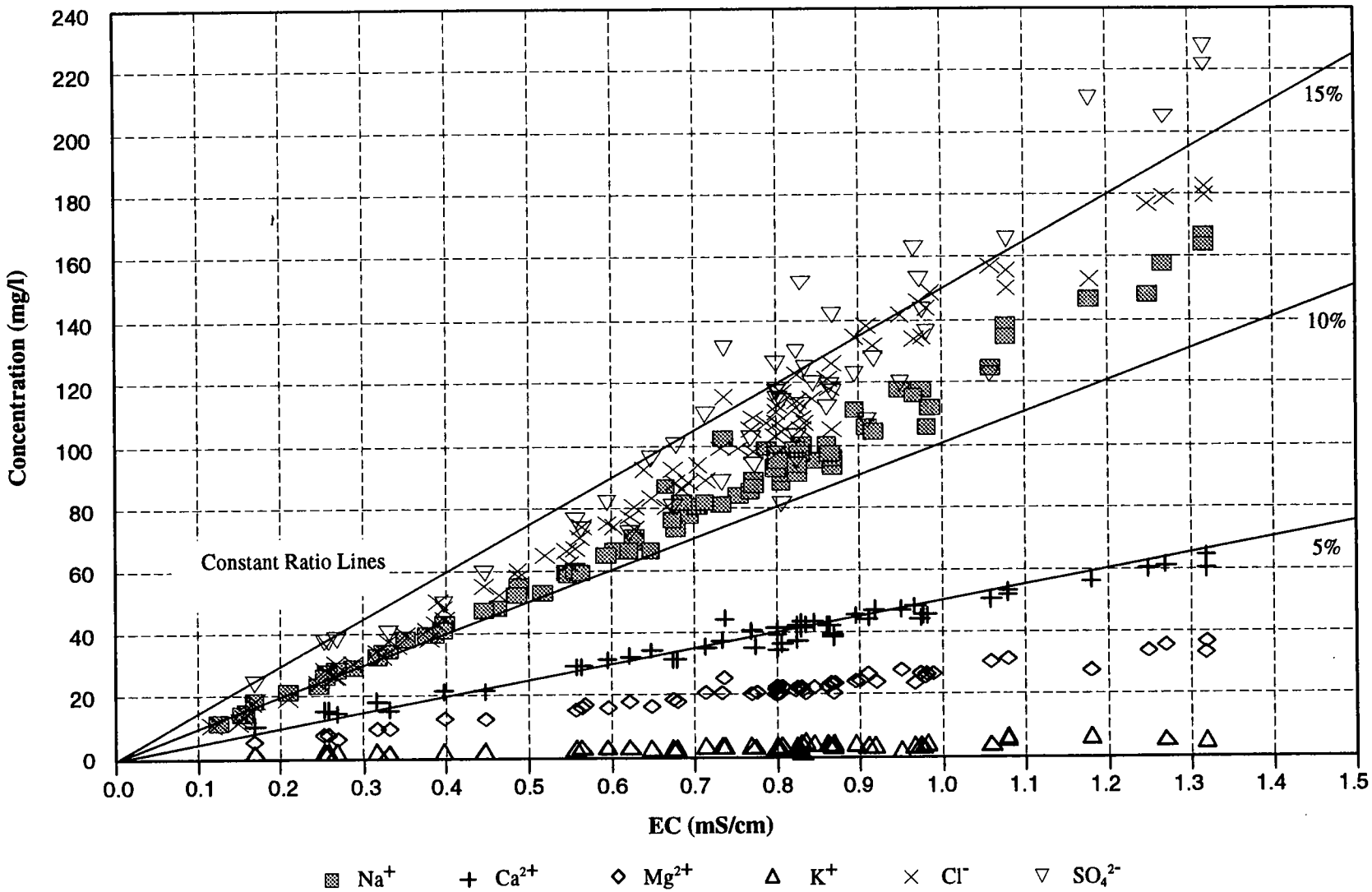

Figure C1-13.
Mineral Concentrations of 1982-1991 MWQI
Monthly Samples from the San Joaquin River at Vernalis

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

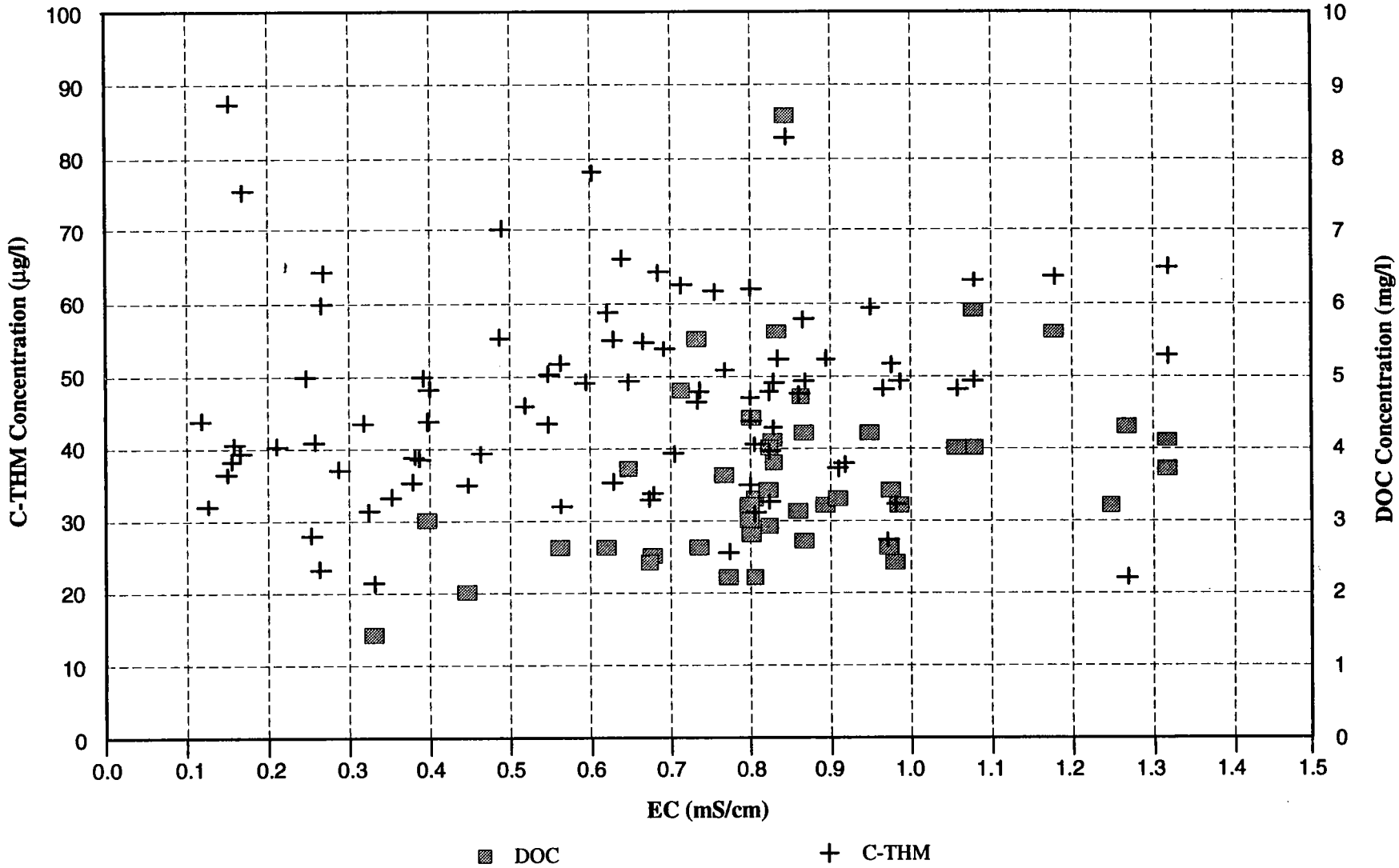

Figure C1-14.
DOC and C-THM Concentrations of 1982-1991 MWQI Monthly Samples from the San Joaquin River at Vernalis

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

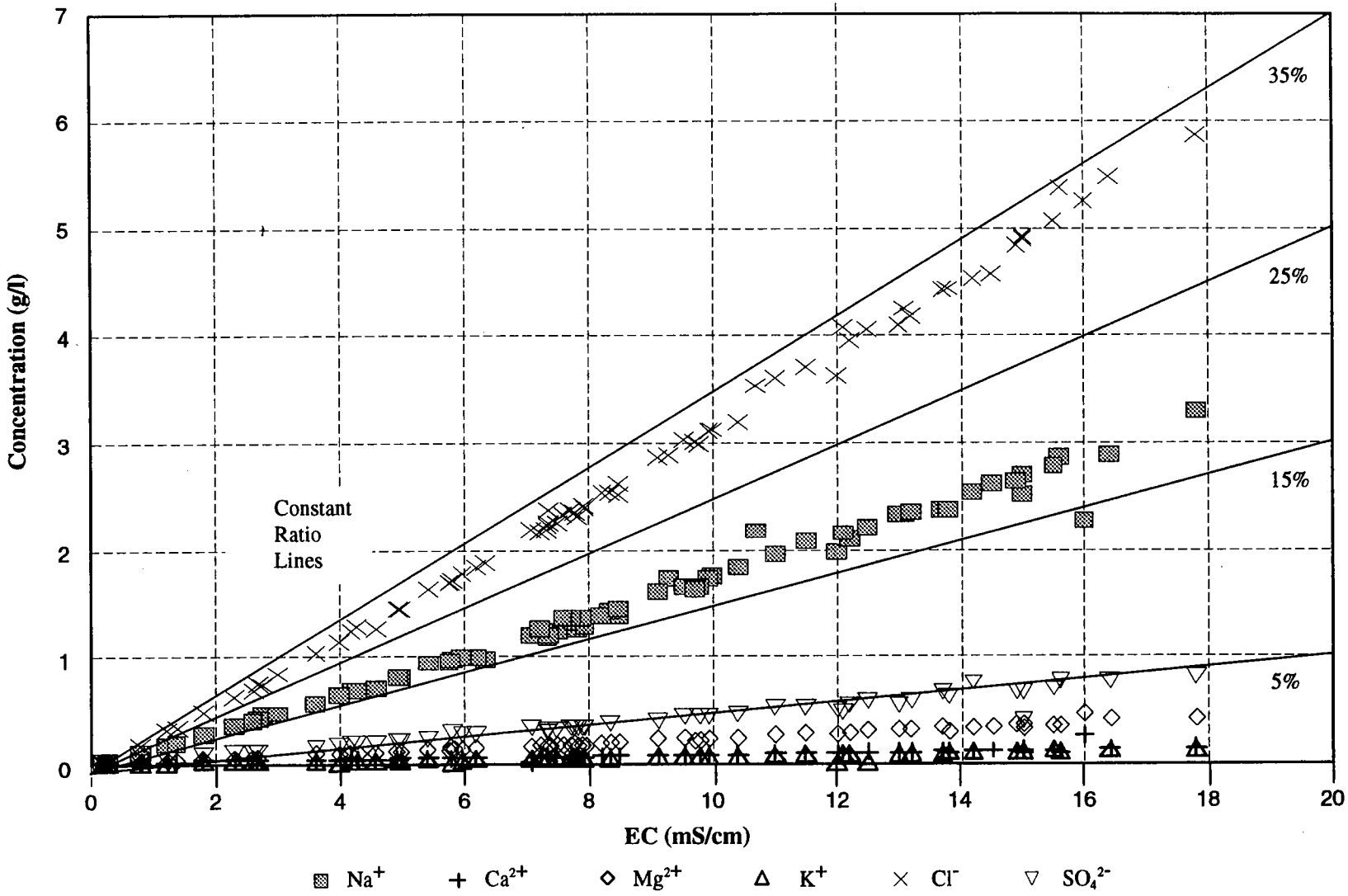

Figure C1-15.
Mineral Concentrations of 1982-1991 MWQI
Monthly Samples from Mallard Island (Chipps Island)

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

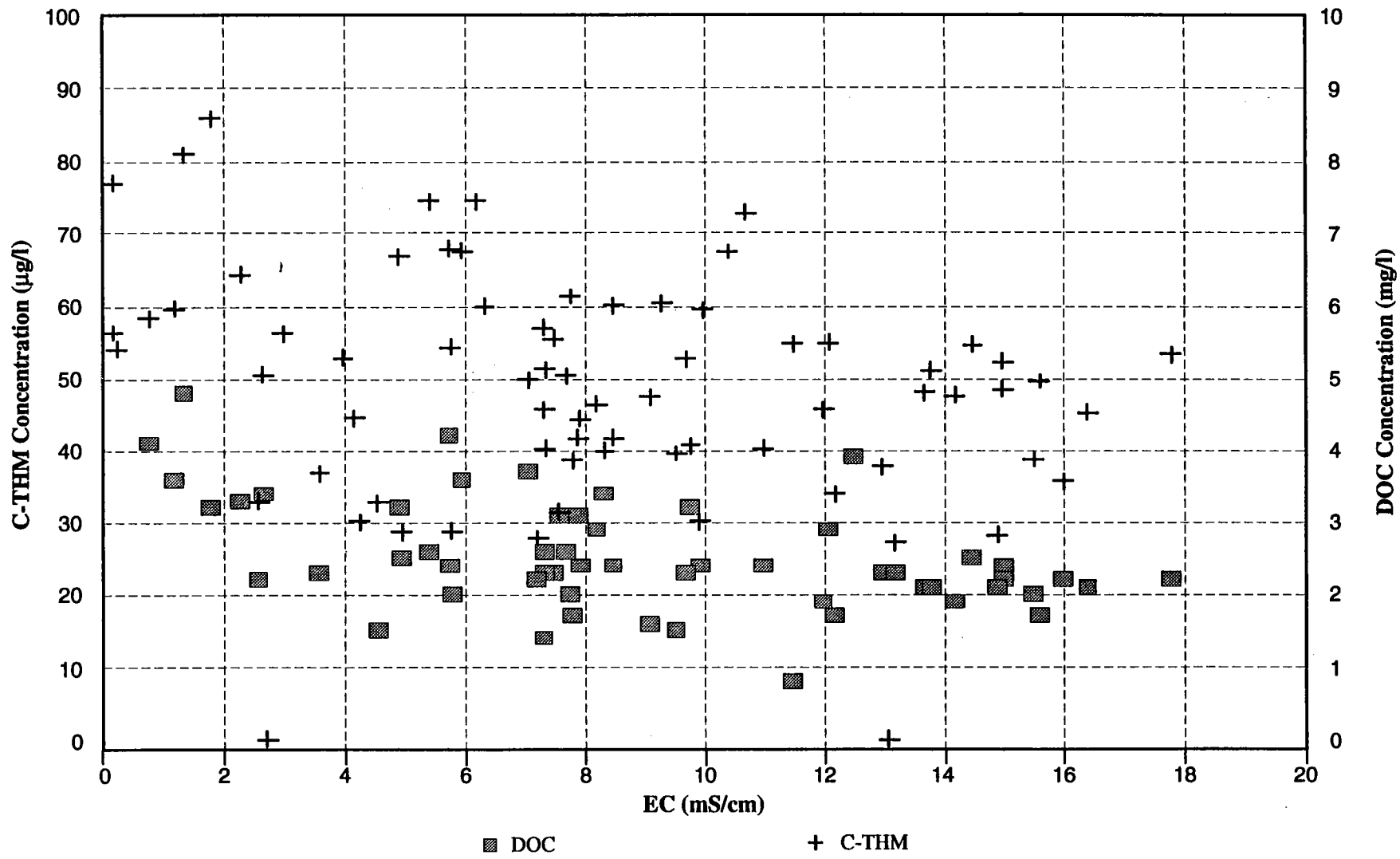

Figure C1-16.
DOC and C-THM Concentrations of 1982-1991 MWQI Monthly Samples from Mallard Island (Chipps Island)

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

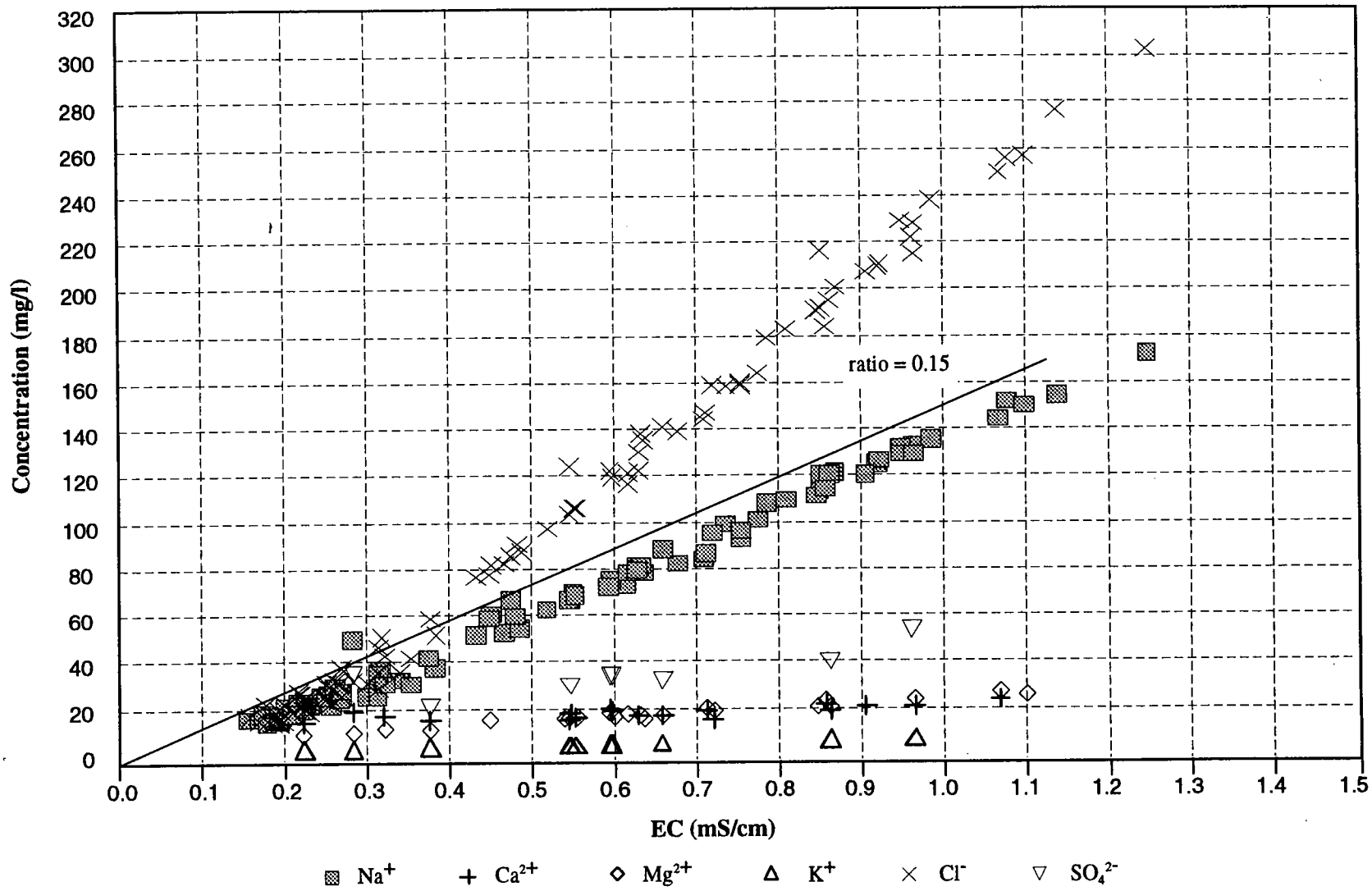

Figure C1-17.
Mineral Concentrations of 1982-1991 MWQI
Monthly Samples from Rock Slough (CCWD Delta Diversions)

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

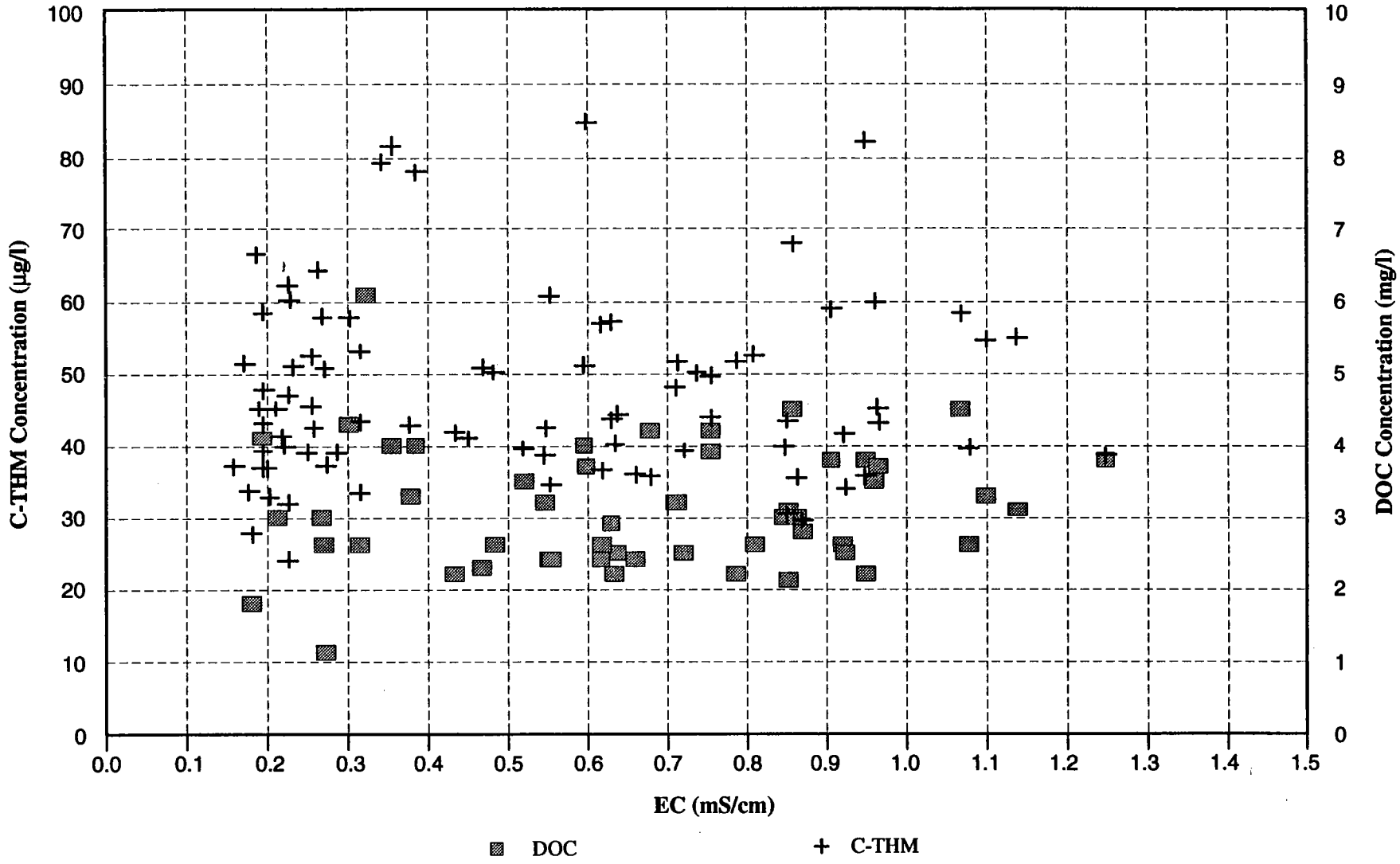

Figure C1-18.
DOC and C-THM Concentrations of 1982-1991 MWQI
Monthly Samples from Rock Slough (CCWD Delta Diversions)

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

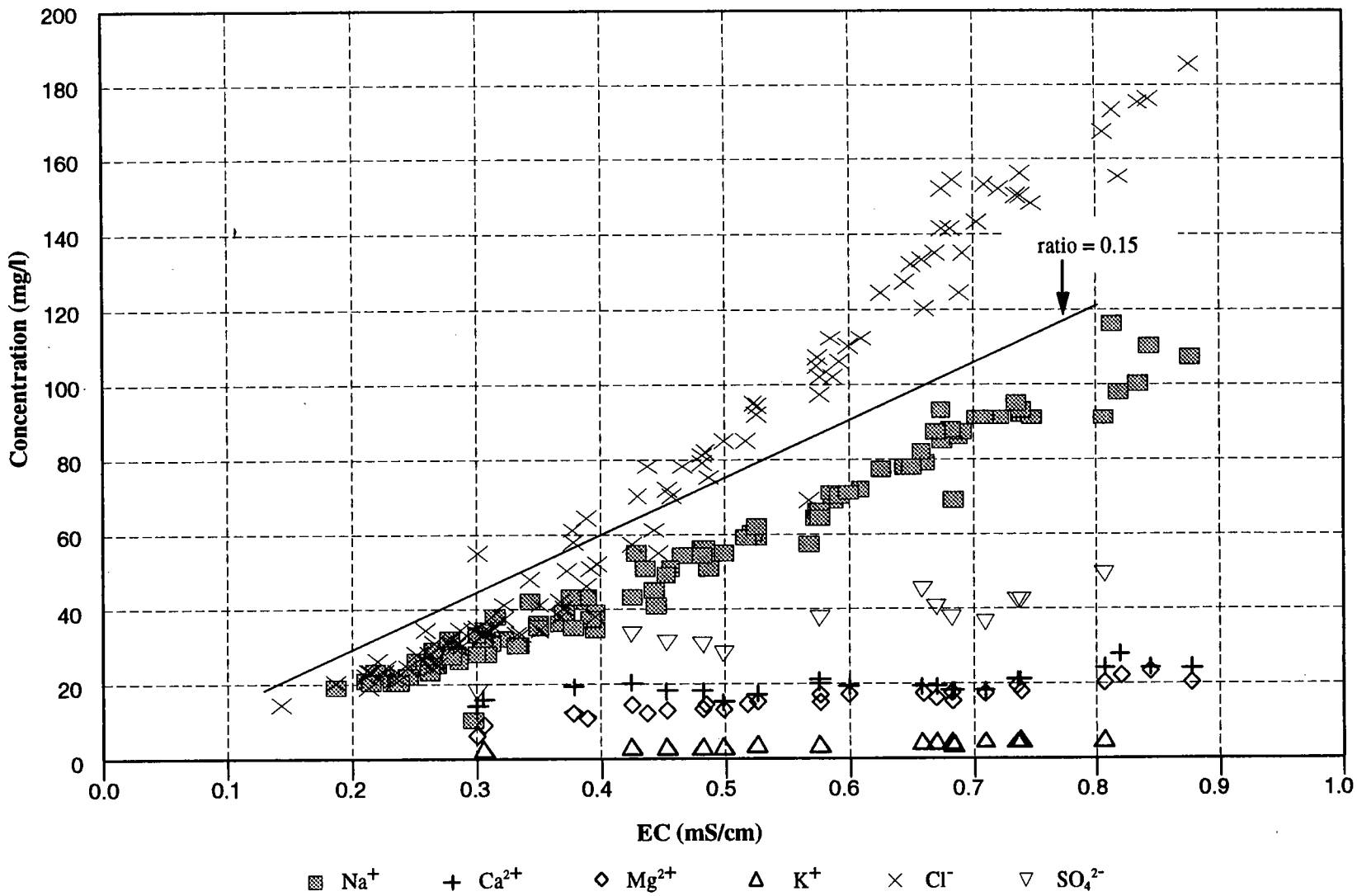

Figure C1-19.
Mineral Concentrations of 1982-1991 MWQI
Monthly Samples from Banks Pumping Plant (SWP Delta Exports)

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

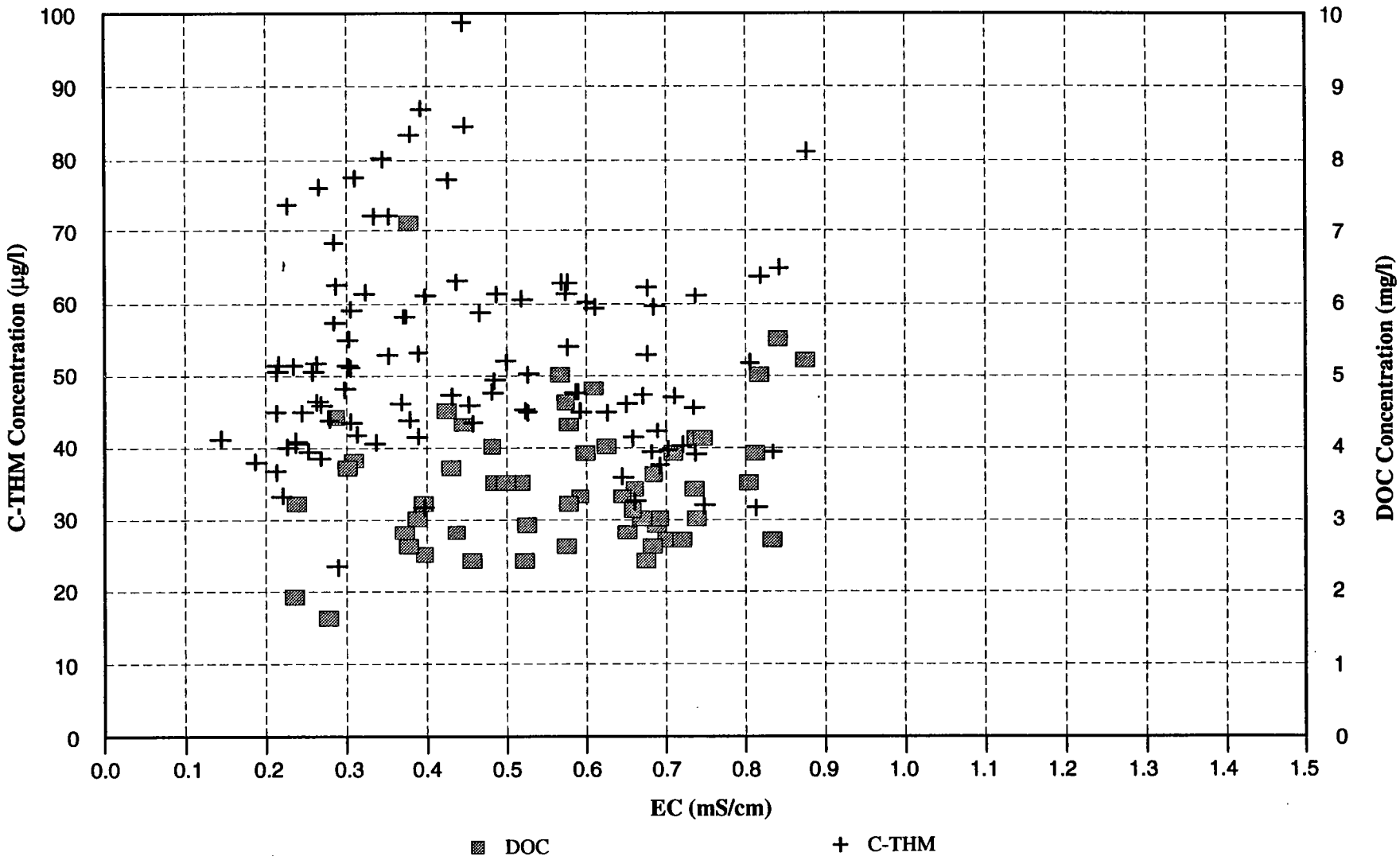

Figure C1-20.
DOC and C-THM Concentrations of 1982-1991 MWQI
Monthly Samples from Banks Pumping Plant (SWP Delta Exports)

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

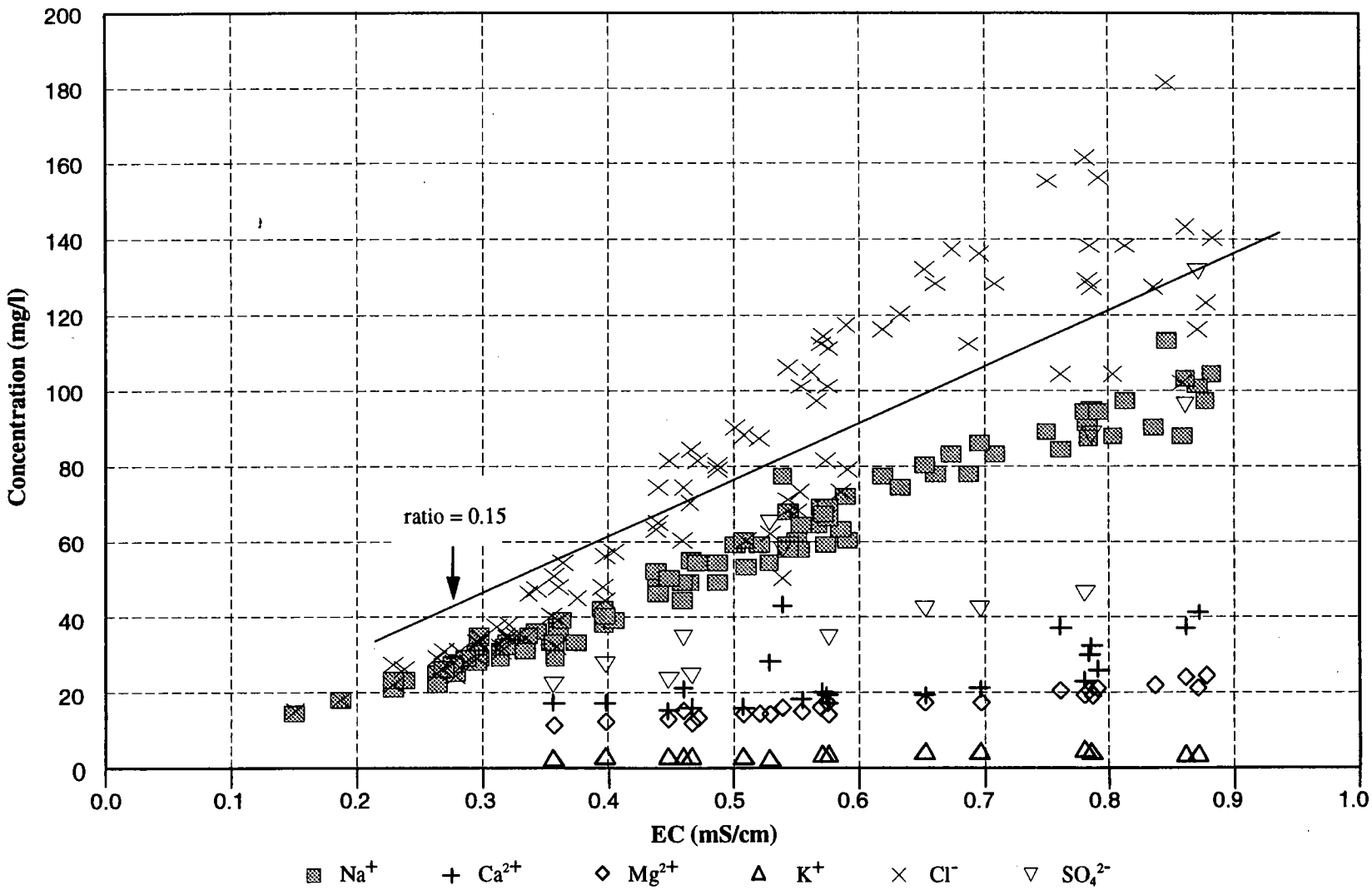

Figure C1-21.
Mineral Concentrations of 1982-1991 MWQI
Monthly Samples from Delta Mendota Canal (CVP Tracy Exports)

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

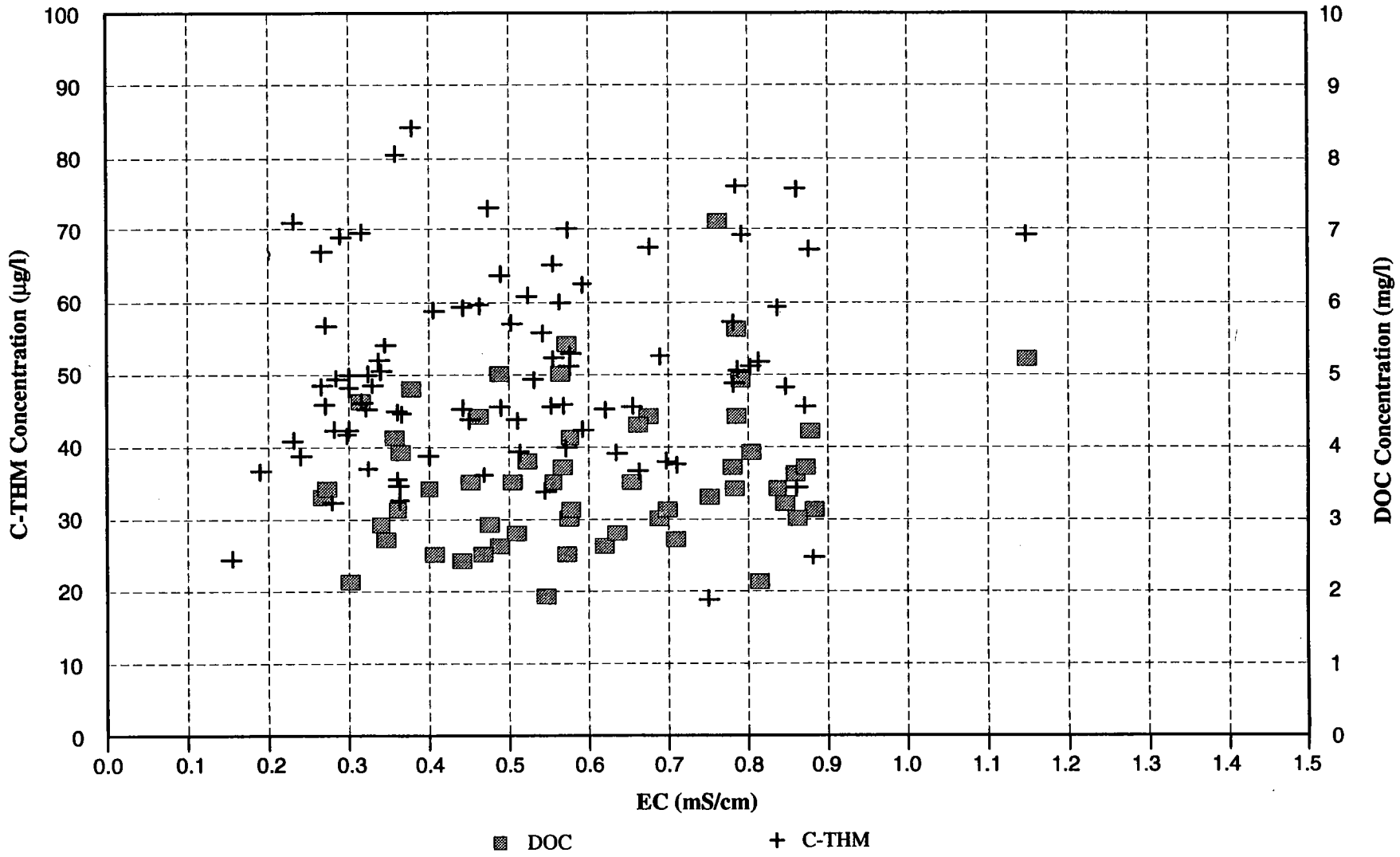

Figure C1-22.
DOC and C-THM Concentrations of 1982-1991 MWQI
Monthly Samples from Delta Mendota Canal (CVP Tracy Exports)

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

Appendix C2. Analysis of Delta Agricultural Drainage Water Quality Data

Appendix C2. Analysis of Delta Agricultural Drainage Water Quality Data

SUMMARY

This appendix presents an analysis of available data on Delta agricultural drainage to provide background information for the analysis of potential effects of Delta Wetlands (DW) project discharges on Delta water quality. The relationships between agricultural drainage and other water budget terms are described and data from Delta island drainage measurements, including measurements from the DW islands, are assessed. The appendix shows the relationships between dissolved organic carbon (DOC) and other water quality variables, and identifies correlations between measurements of different variables that can be used to estimate trihalomethane formation potential (THMFP) of DW discharges.

INTRODUCTION

This appendix presents an analysis of available data on Delta agricultural drainage water quality. These data will be used to assess impacts of the DW project on Delta water quality. A potential water quality impact of primary concern is the project's contribution to the formation of trihalomethane (THM) in municipal water supplies from the Delta. The constituent of particular interest in water discharged from the DW project islands is DOC, which is the major organic precursor of THM.

This appendix reviews and summarizes available data on Delta agricultural drainage water quality, including measurements from drainage pumps on the four DW project islands, Bouldin and Bacon Islands and Webb and Holland Tracts. Also evaluated are water quality data from the California Department of Water Resources (DWR) 1955 Delta Drainage Study and the DWR Municipal Water Quality Investigations (MWQI) program for water years1986-1991 (DWR 1994).

Delta drainage is only one component of the complete water budget for Delta agricultural lands. Understanding the water budget terms is important for interpreting data on salt and DOC in agricultural drainage. This appendix first discusses the water budget for Delta islands in agricultural production and then describes the 1955 data on drainage salinity and estimated total dissolved solids (TDS) and the 1986-1991 data on drainage electrical conductivity (EC), DOC, THMFP, and other water quality variables.

DELTA AGRICULTURAL WATER BUDGET

General Water Budget Terms

Figure C2-1 shows a conceptual diagram of the generalized water budget for Delta agricultural islands. The equations at the bottom of the figure summarize the soil water balance, soil salt (EC) balance, and soil DOC balance terms. These terms are described in the following sections. The water budget terms include evapotranspiration (ET), rainfall, soil moisture storage, seepage from Delta channels, leaching to shallow groundwater, irrigation water, water applied for salt leaching, and pumped drainage water. Shallow groundwater underlying agricultural land may contribute water to soil moisture as seepage from Delta channels, or may receive water as leachate from excess soil moisture.

Identifying the magnitude of these water budget terms, even on a monthly average basis averaged across the Delta islands, is uncertain. The most commonly measured terms are rainfall (at weather stations) and drainage volume (calculated using electrical power consumption and efficiency tests at specific drainage pumps). Crop ET terms are often estimated from pan evaporation data, meteorological conditions, or assigned assumed values for each crop type.

Few measurements of water application rates are available. Water applied for irrigation or salt leaching is obtained from numerous siphons around island margins;

flows through the siphons vary with the tidal cycle. Soil moisture storage can be estimated from soil moisture probes (e.g., neutron probes) used for special studies at specific locations, but such data are not routinely available. Seepage from shallow groundwater and drainage to shallow groundwater are virtually impossible to measure and are often estimated as the difference between other water budget terms.

A reasonably accurate water budget could be estimated from the combination of rainfall, assumed ET, and drainage volumes. Unfortunately, drainage volumes are not routinely measured in the Delta. DWR roughly estimates consumptive use of channel water from the rainfall and assumed ET values, adjusted by assumed patterns of maximum and minimum soil moisture storage on the islands. DWR used this technique in the monthly consumptive use model that is applied to the Delta lowland and upland areas (DWR 1979). The results are used as inputs for the DWRSIM model (see Appendix A1, "Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project").

The difference between the water demand needed to supply ET and the available water from soil moisture is the minimum irrigation amount required to supply the assumed crop ET. The DWR consumptive use model does not estimate excess water applied during the irrigation season, nor does it estimate the water applied for salt leaching in winter; these terms must be specified as model assumptions.

An irrigation efficiency coefficient can be specified to represent the drainage volume associated with irrigation water. A common estimate of irrigation efficiency is 70%. For each inch of irrigation water applied, 0.7 inch supplies the ET demand, while 0.3 inch leaches to the shallow groundwater or flows into drainage canals to be pumped back to Delta channels.

Delta Water Budget Terms from 1955 DWR Studies

DWR investigated Delta water budget terms in a series of five studies conducted during 1954-1955 to determine the basic hydrology and water quality characteristics of the Delta (DWR 1956). Because there has not been a more recent intensive measurement program for Delta water use, the results from this series of studies will be summarized as the best available estimates of Delta agricultural water use patterns.

Water year 1955 was a dry year according to the four-river Sacramento Basin Index. Historical monthly average Delta outflow estimates (from DWR's DAYFLOW database) for water year 1955 are as follows:

October 1954	8,900 cfs
November 1954	17,800 cfs
December 1954	27,400 cfs
January 1955	30,200 cfs
February 1955	18,100 cfs
March 1955	13,900 cfs
April 1955	13,000 cfs
May 1955	19,000 cfs
June 1955	7,000 cfs
July 1955	2,300 cfs
August 1955	3,100 cfs
September 1955	6,000 cfs
Annual average	13,800 cfs

Report No. 4, "Quantity and Quality of Waters Applied to and Drained from the Delta Lowlands", provided estimates of monthly Delta water budget terms for 24 groups of Delta islands and tracts, occupying 469,000 acres in the Delta lowlands. Delta channels occupied 42,000 acres, drainage channels and ponds occupied 7,000 acres, and drained land occupied the remaining 419,000 acres. During 1955, approximately 374,000 acres were in agricultural use and, of these, about 292,000 acres were irrigated.

The four DW project islands were located in four different study units for the DWR (1956) study: Bacon Island in unit 22, Bouldin Island in unit 18, Holland Tract in unit 16, and Webb Tract in unit 15 (Figure C2-2).

DWR (1956) estimated drainage data for each month from May 1954 to October 1955 from power consumption and pump efficiency tests. This effort remains the most comprehensive drainage study attempted by DWR. Irrigation volumes were measured, however, on only a few fields (3,369 acres total) for each month between May and October of 1954. Neither preseason irrigation used to increase soil moisture nor water applied for salt leaching in winter was measured.

The other water budget terms for the 1955 DWR study were rainfall measurements and estimated monthly ET values for each crop. A balanced water budget should have resulted, but the sum of the rainfall and applied water terms (measured inflows) was substantially less (40% less) than the sum of the ET and drainage volumes (total outflows). The combination of seepage and unmeasured applied water (unmeasured inflows) was a major water budget term, which can be estimated as the difference between the other terms.

Table C2-1 shows the estimated annual (water year 1955) Delta lowlands water budget terms for each study

unit in the DWR investigation (DWR 1956). Values for the water budget terms have been converted to inches of water for the entire area of each study unit so that the water budgets for each study unit can be compared. The average estimated water budget terms for the entire Delta lowlands drained area (419,000 acres) for water year 1955 were:

- Outflows: 20.1 inches of drainage water and 33.2 inches of assumed ET and
- Inflows: 14.2 inches of rain and 18.8 inches of applied irrigation water in the April-October period.

An imbalance in the water budget occurred because a total of 53.3 inches of water losses were estimated but only 33.0 inches of rainfall and applied water were estimated. This required that 20.3 inches of unmeasured seepage, preseason irrigation, or leaching water be assumed to balance the water budget.

The amount of estimated drainage varied dramatically between the study units (Table C2-1). The highest annual drainage was 74.4 inches from study unit 22, and the lowest annual drainage was 1.7 inches from study unit 2. Some variation in drainage estimates was caused by differing percentages of units under irrigation, and some was the result of differing crops, soils, and irrigation practices.

Table C2-1 indicates that water budgets for some study units were reasonably well balanced (i.e., values of "missing water" were near zero). Two units (2 and 27) had greater inflows than estimated losses. Many of the study units, however, had much higher drainage volumes than estimated inflows of water, suggesting that unmeasured water was applied during irrigation or supplied as seepage from Delta channels. Estimates of missing water ranged from less than 5 inches for some study units to more than 75 inches for study unit 22 (which included Bacon Island).

Figure C2-3 shows estimates of monthly irrigation depths for the four study units containing the DW project islands. The water was applied predominantly from June through September. Irrigation estimates were quite uniform for the four study units, differing only because of crop acreage. Cumulative estimates of applied water ranged from 16.7 inches for study unit 22 containing Bacon Island to 22.9 inches for study unit 18 containing Bouldin Island.

Figure C2-4 shows the corresponding measured monthly drainage depths for the four study units containing the DW project islands. Drainage occurred predominantly during winter (from excess rainfall and leaching practices) and the irrigation season. Measured cumulative drainage depths differed widely among the four study units, ranging from 15.8 inches for study unit 16 containing Holland Tract to 74.4 inches for study unit 22 containing Bacon Island.

DW Project Island Drainage Records from 1986 to 1992

Jones & Stokes Associates (JSA) obtained monthly pumping records from the four DW islands for the 1986-1992 period. Monthly pumping records from Bouldin Island are available beginning in 1986, Bacon Island pumping records begin in 1988, and Webb and Holland Tract records start in 1990. These data are summarized as inches of drainage in Table C2-2 and are compared with the estimates for the 1955 DWR study units. Inches of drainage are calculated from the drainage volume (in acre-feet [af]) and area (in acres) as follows:

$$\text{Inches of drainage} = \text{drainage volume (af)} \cdot 12 \text{ inches/foot} \div \text{total area (acres)}$$

The estimated monthly drainage depths for the DW islands were quite variable between islands as well as between months. Monthly pumping estimates have varied from less than 1 inch to more than 10 inches. Annual estimates for individual islands have varied from 11 inches to more than 75 inches. Drainage volumes have generally followed a double-peak pattern, with high pumping in winter because of excess rainfall and salt leaching practices and high summer pumping in response to excess irrigation.

Estimated pumping on Bacon Island during the irrigation season is extremely high, averaging more than 6 inches per month for 5 months each year (Table C2-2). High summer pumping is apparently caused by the water management required for the types of row crops grown on Bacon Island. Pumping for Bouldin Island in 1990 and for Webb and Holland Tracts in 1990 and 1991 was lower than normal because of reduced agricultural use during levee rehabilitation and participation in the DWR emergency water bank program. Variations in irrigation practices, leaching practices, and seepage account for major differences between islands.

The annual pumping estimates shown at the bottom of Table C2-2 indicate that drainage volumes have been relatively uniform on each DW project island. This uniformity indicates that the pattern of irrigation and leaching practices may be generally identified for each Delta agricultural island with this type of monthly

pumping monitoring. Additional pumping during winters of wet years is expected, as shown for Bouldin Island in 1986, but only dry year records were available for the other three islands.

DELTA AGRICULTURAL SALT BUDGET

Salt budget terms are directly associated with the water budget terms, as shown in Figure C2-1, and each of the water budget terms has an associated salt concentration (or EC value). Salt is normally measured as TDS or EC.

Soil Salt

Soil salt is the salt associated with the soil moisture water storage term. Rainfall and ET are assumed to have salt concentrations of zero, so soil moisture salt concentrations are diluted by rain but are increased as soil moisture is lost to ET. The combination of applied water (irrigation or seepage) and ET water loss are therefore the basic mechanisms for soil salt buildup.

Applied water adds to the soil salt storage in proportion to the channel water salt concentration. Seepage from channels to shallow groundwater adds to the soil salt storage in proportion to the shallow groundwater salt concentration. Seawater intrusion or upstream sources contribute indirectly to the salt budget by increasing the salt concentration of water in Delta channels and shallow groundwater.

For soil salt to maintain a long-term balance, drainage water must carry away all the salt brought into islands in applied or seepage water. The amount of salt in applied irrigation water or seepage water left behind in the soil as the water is lost to ET must be drained away from the soil moisture salt storage term sometime during the year.

Soil salt concentrations can be measured in saturated soil sample extracts or with EC probes placed in the soil column. Soil moisture salt measurements are not routinely available, however, for the Delta agricultural islands. The salt concentration of applied water can easily be estimated from Delta channel EC measurements. Seepage salt concentrations from shallow groundwater are more difficult to estimate. The applied and seepage water volumes are not measured directly, however, so the applied salt load is difficult to calculate.

If 2 feet of applied water are needed to supply ET and the applied water has an average TDS concentration of 200 milligrams per liter (mg/l), the applied salt load is calculated as follows:

$$\text{Applied salt (tons/acre)} = 2\ \text{af} \cdot 200\ \text{mg/l} \cdot 0.00136 = 0.544\ \text{tons/acre}$$

where 0.00136 is the appropriate conversion between these units.

If more applied water is necessary to supply ET or if the applied water has a higher average salt concentration, a greater load of salt is delivered and must be drained away to maintain a salt balance.

An excess salt load may remain in the soil column until rainfall or leaching water is applied during winter if it is not drained away during the irrigation period. Soil salt may accumulate for several months and then be removed by leaching practices.

The Delta corn salt tolerance experiments (Hoffman et al. 1983) demonstrated that soil salt concentrations depend on the irrigation methods used. Sprinklers or furrow irrigation provide continual drainage of excess soil salt, whereas sub-irrigation using "spud" ditches allows salt to accumulate during the growing season.

Salt concentrations in drainage water are highly variable because: 1) the salt concentration in applied irrigation water changes with upstream sources or salinity intrusion in the Delta, 2) the amount of excess salt that is removed from the soil salt storage varies with irrigation scheduling and farming practices, and 3) the amount of excess water siphoned into Delta island irrigation ditches is unpredictable. Drainage salt concentrations will therefore fluctuate between relatively low values characteristic of the applied water salt concentration and very high values characteristic of the soil salt concentrations at the end of the growing season (or after a sequence of years) when a maximum of salt has accumulated.

If drainage volumes and associated salt concentrations are carefully monitored for several years, the average salt load in the drainage water should equal the average applied salt load, unless a source of salt exists in Delta croplands (e.g., salt originating from fertilizer application or from dissolution of minerals in the soil). There would be seasonal and year-to-year changes in soil salt and drainage salt concentrations.

Salt Concentrations in Irrigation and Drainage Water

DWR Report No. 4 (DWR 1956) provided estimates of applied and drained salt budget terms for water year 1955 for the 24 groups of Delta islands and tracts. Some of the drainage salt estimates were extremely high compared with the expected accumulation from ET or the estimated applied salt terms.

Figure C2-5 shows estimates of average monthly applied irrigation salt concentrations in TDS for the four study units containing the DW project islands for water year 1955. The TDS concentrations ranged from 100 mg/l to 500 mg/l and were apparently estimated from measured channel salt concentrations for each study unit area. Other study units in the Delta had different TDS concentrations because of salinity intrusion effects and different drainage and salt leaching practices (Table C2-1).

Figure C2-6 shows the estimates of average monthly drainage salt concentrations for the four study units containing the DW project islands for water year 1955. These drainage TDS concentrations, estimated from measured drainage salt concentrations, ranged from 200 mg/l to 1,400 mg/l. Other study units had different drainage concentrations because of salinity intrusion effects and different drainage and salt leaching practices (Table C2-1).

The ratio between average drainage TDS concentration and average applied TDS concentration is a general indicator of the volume of drainage compared with the volume of applied water (including seepage) if the salt load is balanced. For example, if the drainage volume was one-third of the applied water volume, the drainage salt concentration should be three times as high as the average salt concentration in the applied water if the salt load is balanced. Table C2-1 indicates that the average ratio of drainage salt to applied salt concentration ranged from about 1 to 6, although the majority of the study units had ratios between 2 and 4.

Salt Loads in Irrigation and Drainage Water

Table C2-1 indicates that the annual applied salt load for all the study units averaged 0.44 tons/acre, but ranged from about 0.2 tons/acre to 2.0 tons/acre.

Figure C2-7 shows the estimates of average monthly applied irrigation salt loads (tons/acre) for the four study units containing the DW project islands for water year 1955. The monthly salt loads, ranging from 0.05 tons/acre to 0.25 tons/acre, were estimated from measured channel salt concentrations and the estimated irrigation volumes for each study unit area during the irrigation season. The salt load from seepage or other missing water is not included. Other study units had different monthly salt loads because of salinity intrusion effects and different drainage and salt leaching practices.

Figure C2-8 shows the average monthly drainage salt loads (tons/acre), estimated from measured drainage salt concentrations and volumes, for the four study units containing the DW project islands for water year 1955. The monthly drainage salt loads ranged from 0.05 tons/acre to 0.60 tons/acre. Other study units had different drainage salt loads because of salinity intrusion effects and different drainage and salt leaching practices.

Table C2-1 indicates that the annual drainage salt load for all the DWR (1956) study units averaged 1.27 tons/acre, but ranged from about 0.2 to more than 4.0 tons/acre. The large difference between the measured drainage salt load and the estimated applied salt load for some of the study units indicates that the salt budget is out of balance, just as the water budget terms did not balance for some of the study units. If the missing water is assumed to have the same average salt concentration as the applied water, a substantial portion of the missing salt term can be accounted for.

The Delta drainage water and salt measurements indicate that the amount of water and salt drained from various study units varies widely. Nevertheless, the water and salt budgets must be balanced and consistent. Monthly drainage salt concentrations vary dramatically, but the average drainage salt concentration is approximately 2-4 times as high as the average applied salt concentration (Figures C2-5 and C2-6), suggesting that the drainage volume is 25%-50% of the applied water if the overall Delta lowlands salt load was in balance during the study period.

DELTA AGRICULTURAL DISSOLVED ORGANIC CARBON BUDGET

The DOC budget terms for Delta agricultural islands are identical to the salt budget terms, with the addition of source terms representing residues of vegetation decay and peat soil decomposition and sink terms representing the decomposition of DOC (to carbon dioxide or methane) (Figure C2-1). If the decomposition of DOC is assumed to be relatively slow (see Appendix C3, "Water Quality Experiments on Potential Sources of Dissolved

Organics and Trihalomethane Precursors for the Delta Wetlands Project"), then DOC in the soil column is diluted by rainfall and concentrated by ET water loss, just as soil salt is. DOC is added to the soil DOC storage term by the applied irrigation and seepage water, just as salt is added.

In addition, DOC is added to the soil column from crop vegetation residues and from decomposition of organic peat soil. Although most decomposition of vegetation or peat soil produces carbon dioxide that is lost from the soil, a small amount of DOC is added to the soil column by decomposition. DOC may accumulate in the soil column or be leached out of the soil column like salt.

Drainage water DOC concentrations are determined by initial DOC concentration in Delta channel water, effects of accumulation from ET and leaching from the crop root zone, the addition of DOC from vegetation decay and peat decomposition, and the possible accumulation of the DOC in the soil column. If sources or sinks of DOC existed, drainage DOC concentrations would be expected to fluctuate just as the drainage salt concentrations do, reflecting the same patterns of accumulation and leaching from the soil column.

Island drainage from peat soils is a likely source of DOC. Therefore, drainage concentrations of DOC in excess of those calculated from the drainage EC and DOC/EC ratios for applied water provide a direct measure of the fraction of the drainage DOC originating from various sources of DOC. Alternatively, the accumulation or decomposition of applied DOC in the soil column can be calculated as the difference between the DOC concentration expected from the drainage EC and the applied water channel DOC/EC ratio and the measured drainage DOC.

For example, assume that Sacramento River water with an average EC value of 200 μS/cm and an average DOC concentration of 2.5 mg/l is applied onto Bouldin Island as irrigation water. If drainage water samples from Bouldin Island had an EC value of about 450 μS/cm, the expected DOC concentration (assuming no source or loss of DOC) would be 6.25 mg/l ($450/200 \cdot 2.5 = 6.25$). Each drainage sample would have a different EC value, indicating some salinity increase from ET and salt leaching.

The DOC concentration in each drainage sample is expected to increase accordingly. If the observed DOC concentration is higher than the expected DOC concentration, a source of DOC is indicated. If the observed DOC concentration is less than the expected DOC concentration, a loss of DOC is indicated. The average DOC concentration increase (above the expected DOC concentration) can be multiplied by the drainage depth (m) to estimate the source of DOC in units of g/m2. Several examples of these DOC source calculations are given in the next section.

Peat soils in the central Delta may produce more than the average Delta drainage volume per acre (Table C2-1). DWR (1990) therefore suggested that the mass loading of DOC from the central Delta would be correspondingly higher. This prediction can only be demonstrated by a combination of higher drainage volume and equal or greater drainage concentrations. The DWR (1990) report does not provide drainage volume estimates; therefore, the relative contribution of various Delta islands and tracts remains uncertain.

DWR MWQI AGRICULTURAL DRAINAGE MEASUREMENTS FROM 1986 TO 1991

Figure C2-2 shows locations where Delta agricultural drainage samples were collected by the DWR MWQI program during the 1986-1991 period (the study is ongoing). The data are summarized in Table C2-3 by groups of drainage pumps sampled and are described in this section. Data collection goals and protocols are described in a series of reports from the MWQI program (DWR 1990).

The MWQI measurements of drainage EC from many of the drains show a strong seasonal pattern, with the highest EC values in drainage water during winter (DWR 1990). EC values for each group of drainage pumps generally range from the low values characteristic of Delta channel water (200-400 μS/cm) to much higher values (1,000-2,000 μS/cm). This range in drainage EC values is expected because of the variation in Delta irrigation, leaching, and drainage practices.

Bacon Island

Figure C2-9 shows drainage measurements for chloride (Cl^-) and DOC as a function of the drainage EC value in Bacon Island samples. The range of drainage EC values varied from about 0.4 mS/cm to 1.0 mS/cm, with a mean EC value for these samples of about 0.65 mS/cm.

Cl^- is used as an indicator of the source of irrigation water, as described in Appendix C1, "Analysis of Delta Inflow and Export Water Quality Data". The Cl^-/EC ratio of almost 0.2 in the drainage water indicates a substantial

influence from seawater intrusion in Bacon Island drainage (at least during the drought period sampled).

DOC is used as the general indicator of organic compounds in drainage samples that may form disinfection byproducts (DBP) such as THM when water is chlorinated. DOC concentrations are plotted as a function of EC to investigate the possible relationship between drainage EC and DOC. If DOC behaves as a conservative dissolved substance, it is reasonable to suppose that DOC accumulates in soil moisture in the same manner that salt does.

The same leaching and drainage processes that eventually return salt to Delta channels in agricultural drainage should also return accumulated DOC material. A range of DOC values should be observed, just as a range of EC values is measured. Whereas no significant source or sink for salt exists on Delta islands, a significant source or sink for DOC material may exist. If an island source of DOC exists, DOC concentrations in drainage water would exceed DOC values expected based on DOC concentrations in applied irrigation water.

Figure C2-9 indicates that DOC concentrations in Bacon Island drainage are variable but do not increase with drainage sample EC values. The mean Bacon Island drainage DOC concentration of 9.4 mg/l is higher than concentrations in Delta inflows (discussed in Appendix C1) but only moderately high relative to other drainage samples (see Table C2-3). The average of the drainage sample DOC concentrations only roughly approximates the average DOC concentration from Bacon Island because the volume of drainage associated with each sample is not known.

The mean EC value in drainage water can be used to estimate the expected average increase from channel EC values to drainage EC values. For example, if the average channel EC value used for irrigation of Bacon Island was assumed to be similar to the lowest EC value of about 400 μS/cm observed in drainage and the average drainage EC value is 650 μS/cm, the ratio of drainage EC to applied EC would be 1.62. This ratio is near the low end of the typical ratio values identified in the 1955 DWR study of Delta drainage (see last column in Table C2-1).

This moderate increase in drainage EC values above channel EC values for Bacon Island drainage is consistent with the measured 1988-1992 Bacon Island drainage volumes. The drainage volumes from Bacon Island were very high (69 inches) compared with those from other DW islands (see annual summary at the bottom of Table C2-2) and other DWR study units (Table C2-1). Therefore, the expected increase in drainage salt concentration from Bacon Island would be relatively low because of the dilution effect.

If the drainage-to-applied EC ratio is used with the measured DOC concentrations, the expected average increase from channel DOC to drainage DOC concentrations would also be a factor of 1.62. If the average channel DOC concentration was assumed to be 3 mg/l (Appendix C1), an average of 4.8 mg/l (3 x 1.62) of DOC would be expected in drainage water if a source of DOC did not exist on the island.

The difference between the measured DOC (9.4 mg/l) and the expected DOC (4.8 mg/l) of 4.6 mg/l (g/m^3) can be used as an estimate of the contribution of DOC from agricultural practices. Thus, the DOC concentrations being discharged in drainage water can be partitioned into estimates of the agricultural contribution of DOC and the channel contribution of DOC. Multiplying the source concentration by the average drainage depth gives a DOC loading estimate for Bacon Island of about 8 grams per square meter per year (g/m^2/year) (4.6 g/m^3 x 69 inches x 0.25 m/inch = 8 g/m^2).

Bouldin Island

Figure C2-10 shows drainage measurements of DOC, Cl^-, and EC for Bouldin Island. Sampling at the Bouldin Island drainage pumps began in 1986, so more samples have been collected and analyzed for the three constituents. Drainage EC values are generally 200-300 μS/cm in the summer irrigation season, suggesting very little increase above EC concentrations in water diverted onto the island in summer (the assumed source of Bouldin Island irrigation water is the Sacramento and Mokelumne Rivers). Winter EC values in Bouldin Island drainage are generally several times higher than summer values, with a maximum observed EC of about 950 μS/cm. The average EC value was 430 μS/cm, about 2.5 times the minimum observed value of 180 μS/cm. This ratio of drainage-to-applied EC is larger than the Bacon Island ratio and consistent with the average measured volume of Bouldin Island drainage of 33 inches, less than half of the average drainage volume for Bacon Island (Table C2-2).

The average Cl^- concentration was 32 mg/l and the Cl^-/EC value for Bouldin Island drainage samples was less than 0.1, indicating that Sacramento River was the primary source of irrigation water.

Figure C2-10 indicates that the drainage DOC concentrations generally increased with drainage EC values; the mean of 34.3 mg/l is much greater than the

average DOC for Bacon Island. Because Sacramento River DOC concentrations (see Appendix C1) are relatively constant at about 2.3 mg/l (with an EC value of 163 μS/cm), the expected DOC concentration in drainage water having a EC value of 1,000 μS/cm would be 14 mg/l (1,000/163 x 2.3).

A line can be drawn on Figure C2-10 from the origin through the assured source water quality (2.3 mg/l DOC at 163 μS/cm EC). Drainage DOC concentrations above this line would suggest a source of DOC; drainage DOC concentrations below this line would suggest a sink of DOC. DOC concentrations in all of the Bouldin Island drainage samples are located above this line (i.e., greater than expected DOC concentrations), suggesting a major source of DOC.

Based on the mean values shown in Figure C2-10, the expected DOC at an EC of 430 μS/cm would be about 6.5 mg/l. Apparently, the additional 27.8 mg/l (34.3 - 6.5) represents the average DOC concentration contributed by sources on Bouldin Island. Multiplying the source concentration by the average drainage depth gives a DOC loading estimate for Bouldin Island of 23 g/m^2/year (27.8 g/m^3 x 33 inches x 0.025 m/inch = 23 g/m^2).

Holland Tract

Drainage EC values for Holland Tract were much higher than for Bacon and Bouldin Islands, with values between about 600 and 2,000 μS/cm (Figure C2-11). The average drainage EC value was 1,090 μS/cm, about 1.8 times the minimum observed value of 600 μS/cm (assumed EC of applied water). Holland Tract is located across the Old River channel from Bacon Island, so water quality of applied irrigation water is assumed to be similar. Irrigation practices are apparently much different, however, yielding a different drainage quality. The higher EC values in Holland Tract drainage are consistent with the lower average measured volume of Holland Tract drainage water of less than 20 inches.

The average Cl^- concentration in Holland Tract drainage water was 199 mg/l; the Cl^-/EC value for Holland Tract drainage samples was about 0.2, similar to the value for Bacon Island. This Cl^-/EC value indicates that seawater intrusion was a significant source of salt in Holland Tract irrigation water.

Figure C2-11 indicates that the drainage DOC concentrations generally did not increase dramatically with drainage EC values, with a mean of only 19.3 mg/l, about twice the average DOC for Bacon Island. The expected DOC at an EC of 1,000 μS/cm would be about 5 mg/l. The estimated source loading of DOC would be about 6 g/m^2/year ([19.3-5] x 16 inches x 0.025 m/inch).

Webb Tract

Most drainage EC values for Webb Tract ranged between about 500 μS/cm and 1,500 μS/cm, but three values were between 2,000 μS/cm and 2,500 μS/cm (Figure C2-12). The Webb Tract drainage concentrations were similar to those in the Holland Tract samples. The concentration similarity is generally consistent with the similar source for irrigation water and the measured drainage volumes of less than 20 inches for both islands.

For Webb Tract drainage samples, the average Cl^- concentration was 160 mg/l; the Cl^-/EC value was about 0.2, similar to the values for Holland Tract and Bacon Island. Thus, seawater intrusion was also a significant source of salt in Webb Tract irrigation water.

Figure C2-12 indicates that the drainage DOC concentrations generally did not increase dramatically with drainage EC values; the mean of 25.1 mg/l is slightly higher than Holland Tract DOC concentration and more than twice the average DOC concentration for Bacon Island. The expected DOC concentration in Webb drainage at an average EC of 1,000 μS/cm would be about 5 mg/l. The estimated source loading of DOC would be about 10 g/m^2/year (20 g/m^3 x 20 inches x 0.025).

Other Delta Island Drainage Samples

Figures C2-13 through C2-24 show drainage EC and concentrations of Cl^- and DOC from 12 additional Delta locations. Some data are from a single island, while others are from several nearby islands. Table C2-3 provides a summary of the average values of water quality measurements for each group of drainage samples. The entire data set used to perform this analysis of Delta agricultural drainage is available from the lead agencies.

For each set of drainage measurements, the range of drainage EC values corresponds to variations in drainage and leaching practices. The average EC value is typically two to three times the minimum observed EC. The Cl^-/EC values given in Table C2-3 indicate the likely source of the irrigation water applied to each island. Cl^-/EC values are normally between 0.05 (Sacramento River source) and 0.15 (San Joaquin River source);

values approaching 0.20 indicate a significant seawater influence (or a groundwater source).

Average DOC values indicate the magnitude of the on-island source of organic precursors of DBP. If the DOC average is greater than two or three times the assumed channel DOC concentrations (3-4 mg/l), a significant source of DOC is present. Interestingly, some islands have average drainage DOC concentrations that are less than the values expected based on the average EC increase, suggesting that some of the applied DOC is adsorbed, retained, or otherwise lost from the drainage on these islands.

DWR MWQI AGRICULTURAL DRAINAGE MEASUREMENTS OF UVA AND C-THM

Important variables related to the presence of organic precursors of DBP are ultraviolet absorbance (UVA, at a wavelength of 254 nanometers [nm]) and the carbon portion of THM molecules (C-THM). The available drainage measurements suggest that both of these variables are directly related to DOC (see Figures C2-25 through C2-29). Because UVA and DOC are both relatively easy to measure in comparison with the 7-day chlorination and analytical procedure for THM concentrations, additional attention should be given to UVA and DOC as monitoring variables for potential sources of THM precursors in the Delta.

Figure C2-25 shows the relationships of UVA (1/cm) and C-THM (μg/l) with DOC (mg/l) concentrations for Bacon Island. As a general guide, the C-THM concentration in a water sample, after a 7-day chlorination with an initial chlorine dose of 120 mg/l, is about 1% of the DOC concentration. The Bacon Island drainage samples appear to follow this rule.

Also as a general guide, the UVA value, in units of 1/cm, is about 5% of the DOC concentration (mg/l). The data from Bacon Island drainage samples also follow this rule.

Figure C2-26 shows the UVA and C-THM data from Bouldin Island drainage samples. The available UVA values (measurements began in 1990) follow the relationship of 5% of DOC to maximum observed DOC concentrations of about 55 mg/l.

The relationship between C-THM and DOC appears reasonably linear at DOC concentrations of less than 30 mg/l (see Appendix C3, "Water Quality Experiments on Potential Sources of Dissolved Organics and Trihalomethane Precursors for the Delta Wetlands Project"); about 1% of the DOC ends up as C-THM, for DOC values of less than about 30 mg/l (Figure C2-26). For higher DOC concentrations, however, a plateau of C-THM values is apparent, with an average of about 300 μg/l of C-THM for all DOC values above 30 mg/l. This apparent "saturation" effect of the C-THM measurements at high DOC concentrations has been explored in recent studies by DWR and the Metropolitan Water District of Southern California (MWD) (DWR 1992). These studies have found that a certain amount of chlorine is required to fully process DOC and yield the maximum possible THM molecules. Recent MWQI measurement procedures have incorporated this effect of variable chlorine dose.

To overcome the saturation effect, MWD has selected a chlorine dose of three times the DOC concentration for its THMFP testing program. In contrast, as drainage DOC concentration increases above 40 mg/l, the standardized chlorine dose in the THMFP test used by DWR (120 mg/l of chlorine) is insufficient to fully process the DOC and form the maximum THM concentration. The standard test for THMFP used by DWR is an adequate indicator of organic precursors for DOC concentrations below about 30 mg/l, representing the majority of Delta drainage samples (see Appendix C3 for additional discussion).

Figure C2-27 shows UVA and C-THM data from Holland Tract drainage samples. The UVA values follow the 5% of DOC guideline, and the C-THM values are slightly greater than 1% of the DOC concentrations. The relationship between C-THM and DOC remains linear because no DOC values above 40 mg/l were detected, and thus the standard THMFP test with 120 mg/l of chlorine provided the maximum yield of C-THM.

Figure C2-28 shows UVA and C-THM data from Webb Tract drainage samples. The UVA values again represent about 5% of the DOC concentration, and the C-THM values are approximately 1% of the DOC concentrations. The relationships between DOC and both UVA and C-THM appear to be consistent for drainage samples from the four DW project islands.

Figure C2-29 indicates that the relationships between DOC and UVA measurements and C-THM yield from DWR's standardized test procedure for THMFP are relatively consistent for the DWR MWQI program samples. These samples, with DOC concentrations ranging from less than 5 mg/l to more than 50 mg/l and from a wide variety of Delta drainage locations in all seasons of the year, show a consistent pattern between these three variables.

It is possible that the C-THM values could be adjusted to estimate the maximum yield of C-THM from a sufficiently high chlorine dose. This adjustment would allow all historical THMFP measurements to be used. The possibility of relying on the physical UVA measurement and the semi-automatic DOC analyzer results for monitoring of Delta drainage and other effluents with suspected organic precursors should be actively pursued. The measurement difficulties and delay times between sampling and analyses associated with the traditional THMFP testing may thus be avoided for routine monitoring and control applications.

SUMMARY OF AGRICULTURAL DRAINAGE DATA ANALYSIS

Although much more about Delta agricultural drainage needs to be studied, the following conclusions can be drawn from the available information:

- Agricultural drainage volume within the Delta is highly variable because of differences in irrigation method, seepage, salt leaching practices, and other factors related to soil type and crop requirements. Drainage concentrations of salt are variable because of seasonal irrigation, accumulation of soil salt from ET, drainage of excess water following rainfall events, and periodic leaching practices. The ratio of drainage water EC to applied water EC can be used to indicate the net effect of these variable processes on drainage water quality. The volume of drainage cannot be determined, however, from the salt concentration itself; direct measurements of the drainage volume are needed to estimate drainage loads of salt or other water quality variables of interest in the Delta.

- The range of measured monthly drainage volumes from the four DW islands during 1986-1991 (dry years) was similar to the range of drainage estimates from DWR's Report No. 4 (DWR 1956) for water year 1955. Drainage estimates differed greatly, however, between islands and between years. Based on the DWR 1955 study, drainage EC averaged between 2 and 4 times applied water EC. This relationship indicates that drainage volumes were generally 25%-50% of the applied water volume during 1955. Average drainage EC values for the four DW islands during the 1986-1991 drought period were also about 2 to 4 times the applied water EC values. Drainage volumes will increase with excess rainfall and excess irrigation and during salt leaching. Direct measurements are required to accurately determine drainage volumes.

- DOC concentrations in Delta agricultural drainage have been measured only since 1986. Measured DOC concentrations are highly variable because of the processes that influence salt concentrations and the variable sources and sinks for DOC on Delta islands. The expected drainage DOC concentration, based on the measured drainage EC value, can be used to estimate the net increase of DOC concentration in each drainage sample. Because the drainage volume associated with each sample is not known, however, accurate estimates of the net contribution of DOC mass from island sources cannot be determined.

- UVA values and DOC concentrations are strongly correlated, and C-THM and DOC concentrations are apparently directly related. Therefore, relatively simple UVA and DOC measurements may be preferable to more expensive and time-consuming THMFP measurements for monitoring the concentrations of potential DBP in Delta water.

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Table C2–1. Summary of Delta Island Water Budgets and Salt Budgets for Water Year 1955

DW Island Location	DWR–4 Unit No.	Drained Land (acres)	Irrigated Land (%)	DWR Drainage Water (inches)	DWR Applied Water (inches)	Missing Water[1] (inches)	DWR Drainage Salt (mg/l)	DWR Drainage Salt (tons/acre)	DWR Applied Salt (mg/l)	DWR Applied Salt (tons/acre)	Missing Salt[2] (tons/acre)	Salt in Missing Water[3] (tons/acre)	Ratio of Drainage to Applied Salt Conc.
	2	11,202	48	1.7	24.2	−4.1	835	0.16	132	0.18	−0.02	−0.06	6.3
	3	5,465	75	10.8	17.5	12.3	193	0.24	126	0.25	−0.01	0.18	1.5
	6	33,027	75	4.4	18.5	4.9	535	0.26	119	0.25	0.01	0.07	4.5
	7	7,510	80	4.8	19.9	3.9	443	0.24	119	0.27	−0.03	0.05	3.7
	8	22,103	75	15.9	19.7	15.2	240	0.43	117	0.26	0.17	0.20	2.1
	9	16,085	48	8.5	14.2	13.3	440	0.42	132	0.21	0.21	0.20	3.3
	10	11,067	76	6.9	16.4	9.5	327	0.26	133	0.25	0.01	0.14	2.5
	11	14,365	78	10.2	23.2	6.0	337	0.39	119	0.31	0.08	0.08	2.8
	12	16,877	77	20.7	23.0	16.7	324	0.76	121	0.31	0.45	0.23	2.7
	13	16,641	63	10.2	20.7	8.5	377	0.44	129	0.30	0.14	0.12	2.9
	14	14,671	29	16.2	7.6	27.6	932	1.71	912	0.78	0.93	2.85	1.0
Webb Tract	15	26,424	51	17.1	18.0	18.1	806	1.56	246	0.50	1.06	0.50	3.3
Holland Tract	16	18,343	74	15.8	21.8	13.0	818	1.46	260	0.64	0.82	0.38	3.1
	17	10,191	60	24.9	12.8	31.1	1,046	2.95	230	0.33	2.62	0.81	4.5
Bouldin Island	18	18,504	69	37.7	22.9	33.8	365	1.56	140	0.37	1.19	0.54	2.6
	19	17,917	72	17.5	21.8	14.7	483	0.96	121	0.30	0.66	0.20	4.0
	20	21,302	78	52.7	22.6	49.1	688	4.11	164	0.42	3.69	0.91	4.2
	21	14,846	72	41.2	16.6	43.6	549	2.56	193	0.36	2.20	0.95	2.8
Bacon Island	22	19,357	75	74.4	16.7	76.7	374	3.15	183	0.35	2.80	1.59	2.0
	23	24,493	81	22.9	17.2	24.7	501	1.30	211	0.41	0.89	0.59	2.4
	24	32,879	73	15.9	18.4	16.5	753	1.36	281	0.58	0.78	0.53	2.7
	25	33,212	78	10.7	19.1	10.6	670	0.81	321	0.70	0.11	0.39	2.1
	26	2,810	23	8.7	9.4	18.3	737	0.73	310	0.33	0.40	0.64	2.4
	27	10,148	85	6.6	29.2	−3.6	776	0.58	587	1.94	−1.36	−0.24	1.3
Average			70	20.1	18.8	20.3	556	1.27	225	0.44	0.83	0.49	3.0
Total		419,439											

Source: DWR 1956.

Notes: Rainfall in the Delta for water year 1955 was 14.2 inches, and average evapotranspiration was 33.2 inches, resulting in a net evapotranspiration of 19 inches.

[1] Missing Water = Net Evaporation (19 inches) + Drainage − Applied

[2] Missing Salt = Drainage Salt − Applied Salt

[3] Salt in Missing Water = Missing Water (inches) * Applied Salt (mg/l) * 0.0014

Table C2–2. Drainage Pumping Estimates for the DW Project Islands for 1986–1992 based on PG&E Pumping Tests (af/kWh) and Power Consumption Records

Water Year	Month	Bouldin Island 5,985 acres (af)	Bouldin Island 5,985 acres (inches)	Bacon Island 5,539 acres (af)	Bacon Island 5,539 acres (inches)	Webb Tract 5,469 acres (af)	Webb Tract 5,469 acres (inches)	Holland Tract 4,187 acres (af)	Holland Tract 4,187 acres (inches)
1986	OCT	87	0.2						
	NOV	2,217	4.4						
	DEC	3,387	6.8						
	JAN	2,125	4.3						
	FEB	2,771	5.6						
	MAR	3,944	7.9						
	APR	558	1.1						
	MAY	1,292	2.6						
	JUN	1,553	3.1						
	JUL	2,688	5.4						
	AUG	2,939	5.9						
	SEP	1,102	2.2						
1987	OCT	245	0.5						
	NOV	1,932	3.9						
	DEC	3,419	6.9						
	JAN	2,074	4.2						
	FEB	3,736	7.5						
	MAR	1,377	2.8						
	APR	837	1.7						
	MAY	909	1.8						
	JUN	804	1.6						
	JUL	1,113	2.2						
	AUG	1,740	3.5						
	SEP	1,125	2.3						
1988	OCT	621	1.2	1,834	4.0				
	NOV	1,248	2.5	655	1.4				
	DEC	1,785	3.6	3,243	7.0				
	JAN	2,701	5.4	2,185	4.7				
	FEB	574	1.2	590	1.3				
	MAR	501	1.0	721	1.6				
	APR	758	1.5	1,852	4.0				
	MAY	378	0.8	2,981	6.5				
	JUN	542	1.1	1,506	3.3				
	JUL	1,064	2.1	5,624	12.2				
	AUG	780	1.6	4,679	10.1				
	SEP	54	0.1	3,412	7.4				
1989	OCT	449	0.9	2,085	4.5				
	NOV	1,177	2.4	216	0.5				
	DEC	2,960	5.9	1,042	2.3				
	JAN	3,929	7.9	4,265	9.2				
	FEB	690	1.4	2,292	5.0				
	MAR	272	0.5	1,294	2.8				
	APR	647	1.3	1,755	3.8				
	MAY	702	1.4	4,091	8.9				
	JUN	1,451	2.9	4,309	9.3				
	JUL	2,072	4.2	3,486	7.6				
	AUG	1,775	3.6	3,618	7.8				
	SEP	408	0.8	3,932	8.5				

Table C2–2. Continued

Water Year	Month	Bouldin Island 5,985 acres (af)	Bouldin Island 5,985 acres (inches)	Bacon Island 5,539 acres (af)	Bacon Island 5,539 acres (inches)	Webb Tract 5,469 acres (af)	Webb Tract 5,469 acres (inches)	Holland Tract 4,187 acres (af)	Holland Tract 4,187 acres (inches)
1990	OCT	81	0.2	1,520	3.3	0	0.0	216	0.6
	NOV	304	0.6	923	2.0	36	0.1	269	0.8
	DEC	51	0.1	3,843	8.3	46	0.1	840	2.4
	JAN	1,226	2.5	2,286	5.0	1,545	3.4	525	1.5
	FEB	486	1.0	1,698	3.7	830	1.8	506	1.4
	MAR	757	1.5	972	2.1	733	1.6	477	1.3
	APR	1,376	2.8	1,594	3.5	733	1.6	473	1.3
	MAY	458	0.9	2,938	6.4	730	1.6	488	1.4
	JUN	367	0.7	3,640	7.9	81	0.2	301	0.9
	JUL	1,169	2.3	3,380	7.3	188	0.4	146	0.4
	AUG	821	1.6	3,532	7.7	188	0.4	171	0.5
	SEP	138	0.3	4,079	8.8	85	0.2	124	0.4
1991	OCT	798	1.6	1,465	3.2	233	0.5	218	0.6
	NOV	2,596	5.2	897	1.9	1,230	2.7	722	2.0
	DEC	2,596	5.2	5,316	11.5	2,223	4.9	549	1.6
	JAN	1,873	3.8	2,197	4.8	2,042	4.5	1,317	3.7
	FEB	1,831	3.7	1,845	4.0	1,487	3.3	1,701	4.8
	MAR	1,831	3.7	1,281	2.8	1,360	3.0	544	1.5
	APR	368	0.7	786	1.7	245	0.5	160	0.5
	MAY	158	0.3	4,268	9.2	78	0.2	157	0.4
	JUN	724	1.5	4,153	9.0	80	0.2	293	0.8
	JUL	1,650	3.3	4,153	9.0	52	0.1	64	0.2
	AUG	2,757	5.5	4,995	10.8	44	0.1	675	1.9
	SEP	65	0.1	3,940	8.5	69	0.2	347	1.0
1992	OCT	128	0.3	1,424	3.1	203	0.4	284	0.8
	NOV	1,547	3.1	442	1.0	788	1.7	232	0.7
	DEC	1,940	3.9	4,051	8.8	1,871	4.1	290	0.8
	JAN	1,811	3.6	1,936	4.2	1,891	4.1	616	1.7
	FEB	3,287	6.6	1,826	4.0	1,279	2.8	1,001	2.8
	MAR	3,287	6.6	1,826	4.0	2,699	5.9	906	2.6
	APR	264	0.5	1,275	2.8	2,349	5.2	508	1.4
	MAY	122	0.2	5,147	11.2	456	1.0	359	1.0
	JUN	1,061	2.1	4,295	9.3	291	0.6	391	1.1
	JUL	1,614	3.2	2,486	5.4	416	0.9	436	1.2
	AUG	1,245	2.5	3,433	7.4	582	1.3	430	1.2
	SEP	1,250	2.5	3,807	8.2	413	0.9	287	0.8
Annual Totals									
1986		24,663	49						
1987		19,311	39						
1988		11,006	22	29,282	63				
1989		16,532	33	32,385	70				
1990		7,234	15	30,405	66	5,195	11	4,536	13
1991		17,247	35	35,296	76	9,143	20	6,747	19
1992		17,556	35	31,948	69	13,238	29	5,740	16
Average		16,221	33	31,863	69	9,192	20	5,674	16

Combined DW Islands (21,180 acres)

Annual Pumping (inches)	1990	27
	1991	39
	1992	39

Table C2–3. Summary of Average DWR MWQI Data on Water Quality of Delta Island Drainage for 1986–1991

Drainage Location	DWR–4 Unit No.	Drainage Samples	EC (µS/cm)	Cl^- (mg/l)	Br^- (mg/l)	Cl^-/EC Ratio	Br^-/EC Ratio	DOC (mg/l)	UVA (1/cm)	Color (Units)	C–THM (µg/l)	THMFP (µg/l)	SO_4^{2-} (mg/l)	NO_3^- (mg/l)
Bacon Island	22	23	652	114	0.40	0.18	0.0036	9.4	0.36	92	107	1,077	63.5	7.4
Bouldin Island	18	89	431	32	0.19	0.07	0.0064	34.3	1.41	217	253	2,348	61.0	11.1
Holland Tract	16	39	1,090	199	0.65	0.18	0.0034	19.3	0.90	153	224	2,220	92.0	4.3
Webb Tract	15	22	1,036	160	0.58	0.16	0.0042	25.1	1.05	225	220	2,150	169.0	13.7
Brannan Island	13	89	708	100	0.37	0.14	0.0041	18.8	0.87	159	170	1,612	73.0	16.1
Egbert Tract	9	48	758	44	--	0.06	--	16.4	--	79	181	1,667	114.0	6.6
Empire Island	20	101	1,361	291	1.02	0.18	0.0038	46.7	1.34	202	301	2,847	106.0	15.6
Grand Island	12	83	433	25	--	0.05	--	11.9	--	72	151	1,358	44.0	7.6
Jones Tract	23	52	730	115	0.31	0.16	0.0032	11.3	0.49	101	134	1,287	81.0	8.1
King Island	20	73	639	77	0.33	0.10	0.0054	10.9	0.43	78	127	1,230	28.0	8.3
Mossdale Tract	24	81	1,054	138	--	0.13	--	8.0	--	42	81	803	94.0	8.6
Pescadero Tract	27	69	1,869	355	1.14	0.19	0.0033	6.5	0.16	52	68	795	234.0	13.6
Rindge Tract	21	43	954	161	0.70	0.16	0.0050	21.4	1.11	121	202	1,963	95.0	5.8
Rio Blanco Tract–Shima Tract	21	26	856	116	--	0.12	--	6.1	--	35	76	774	36.0	6.3
Terminous Tract	20	24	728	118	--	0.16	--	13.2	--	88	169	1,624	38.0	9.2
Tyler Island	13	25	553	61	--	0.10	--	17.5	--	108	217	2,006	58.0	15.0
Mandeville Island	22	8	523	74	0.27	0.14	0.0036	22.0	1.15	227	263	2,489	48.0	--
McCormick Tract–Pierson Dist	8	32	353	22	--	0.06	--	7.3	--	55	88	811	24.0	6.3
Prospect Island–Ryer Island	11	11	648	24	--	0.04	--	10.5	--	63	141	1,181	84.0	6.2
Woodward Island–Palm Tract	25	13	771	127	0.37	0.17	0.0030	8.4	0.39	110	121	1,220	89.0	--
Staten Island–Venice Island	18	9	440	58	0.21	0.12	0.0035	17.3	0.93	181	189	1,800	22.0	--
Clifton Court [1]	17	21	4,845	1131	3.06	0.23	0.0029	9.4	0.49	76	103	1,432	530.0	33.0
Netherland	10	22	648	82	--	0.10	--	4.5	--	31	65	635	45.0	3.0

Source: DWR MWQI data, 1986–1991 (analyzed in spreadsheet file AGDRAINS.WK1)
Notes: -- = No data available.
[1] Agricultural drainage into Clifton Court does not represent export water quality.

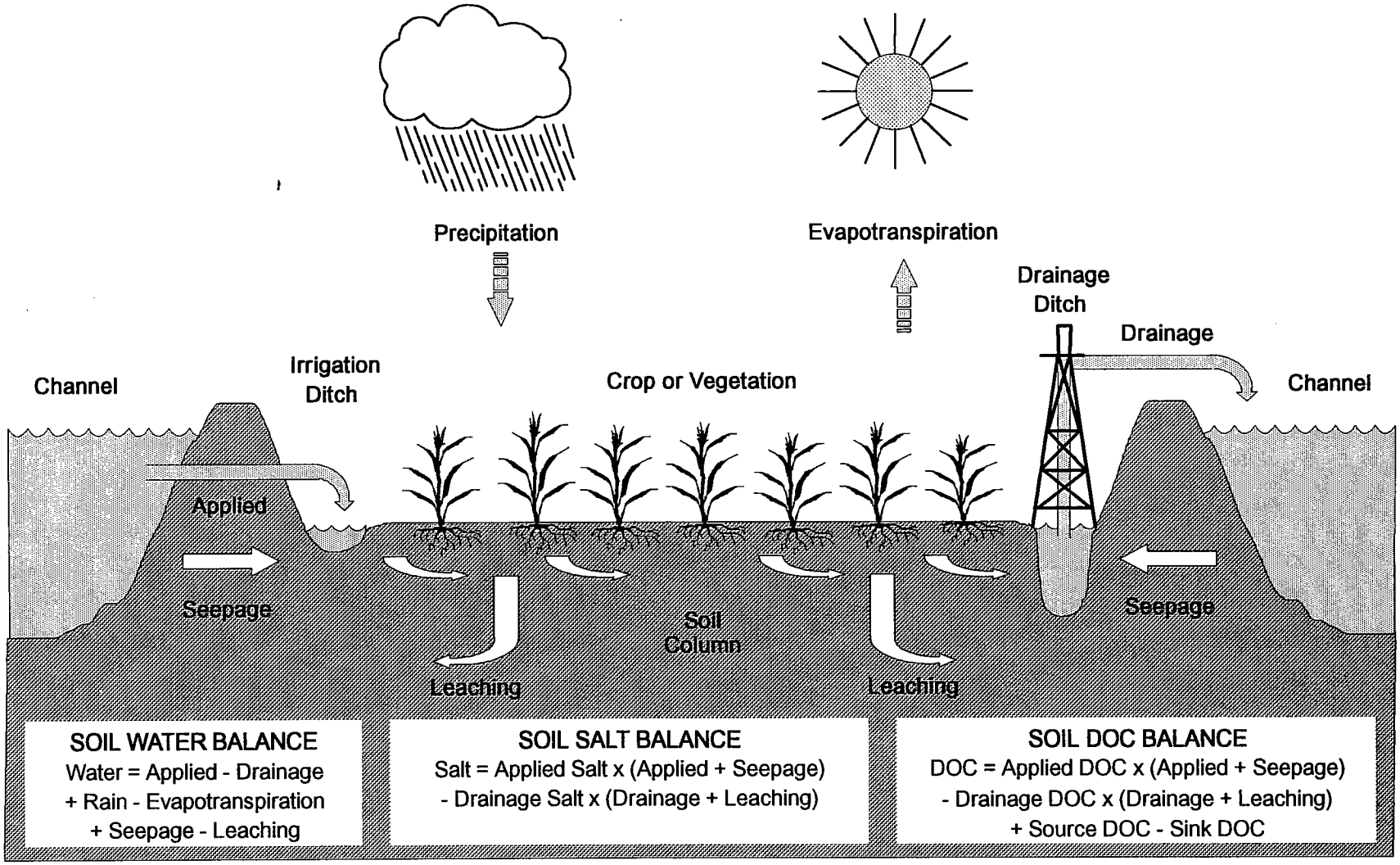

Figure C2-1.
Conceptual Water, Salt, and Dissolved Organic Carbon Budgets for Delta Agricultural Islands

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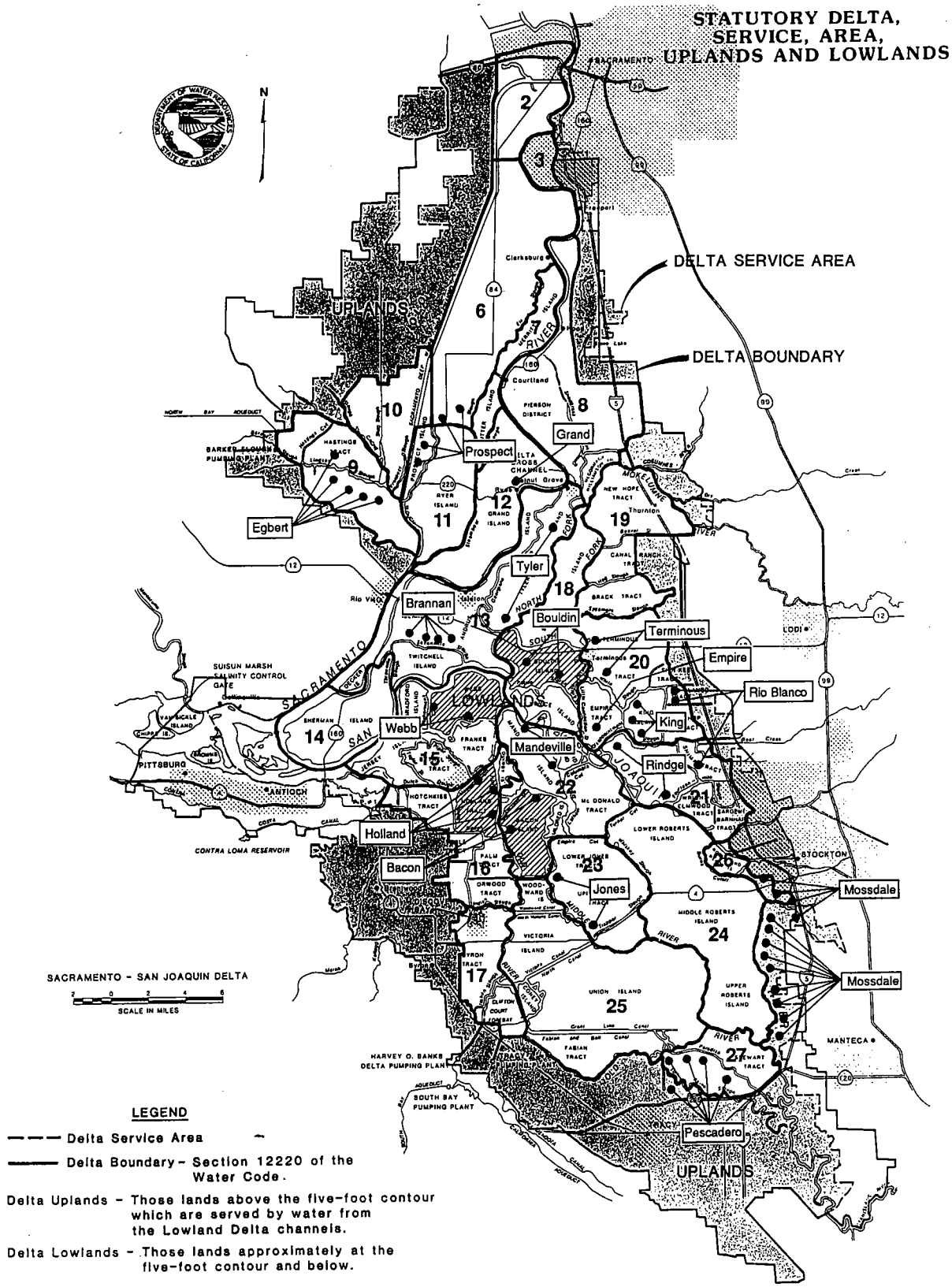

Figure C2-2.
Location of DWR Report No. 4 Study Unit Areas (1955) and DWR Municipal Water Quality Investigation Drainage Samples (1986–1991)

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Prepared by: Jones & Stokes Associates

Figure C2-3.
Delta Lowlands Monthly Irrigation Depth Estimates
from DWR Report No. 4 for Water Year 1955

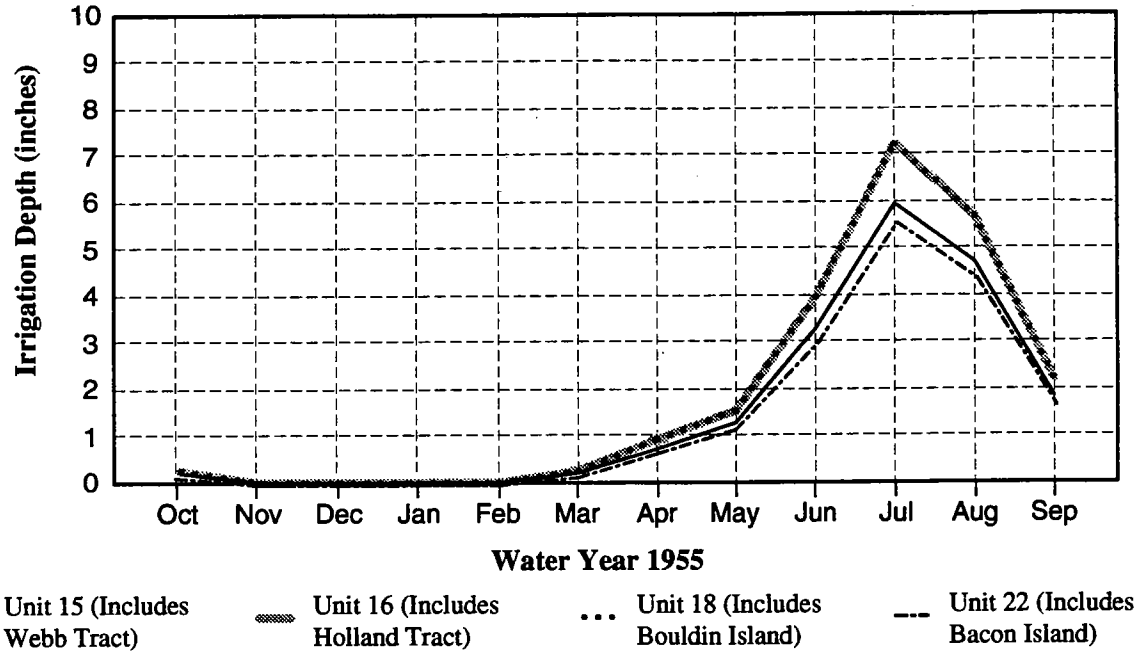


Figure C2-4.
Delta Lowlands Monthly Drainage Depth Estimates
from DWR Report No. 4 for Water Year 1955

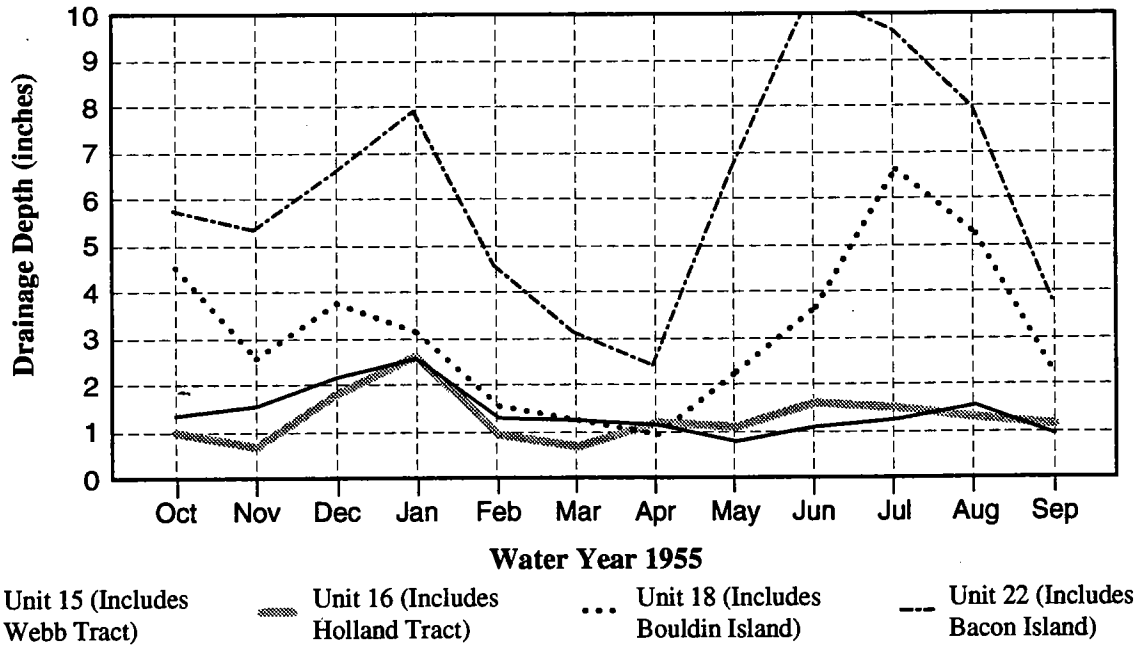


Figure C2-5.
Delta Lowlands Monthly Irrigation TDS Concentrations
from DWR Report No. 4 for Water Year 1955

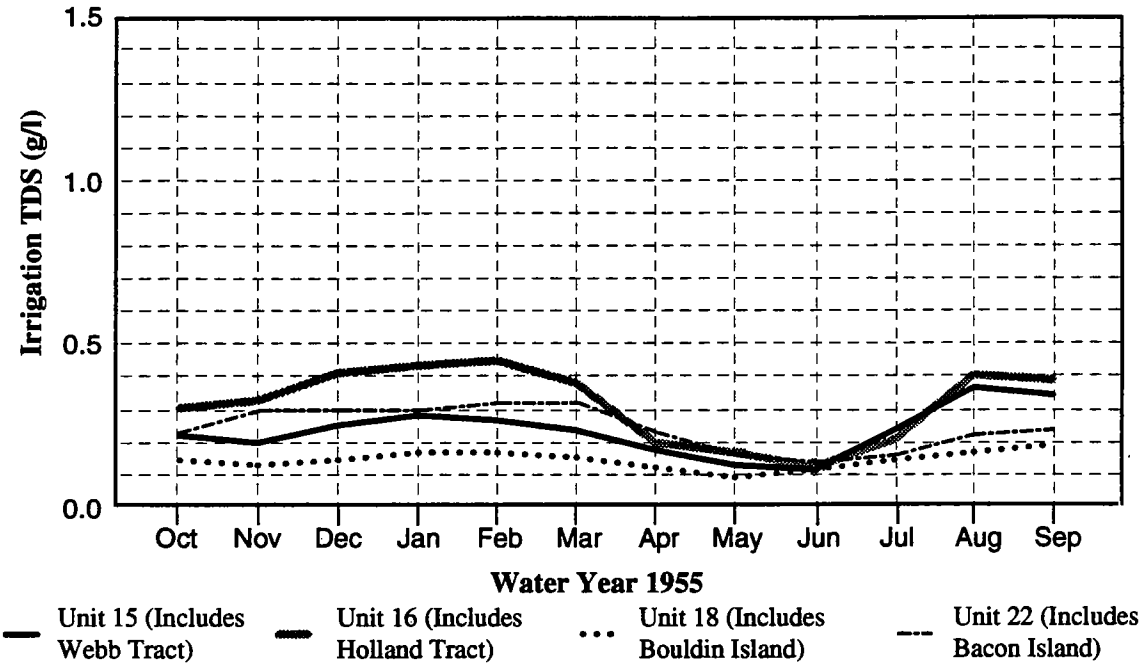


Figure C2-6.
Delta Lowlands Monthly Drainage TDS Concentrations
from DWR Report No. 4 for Water Year 1955

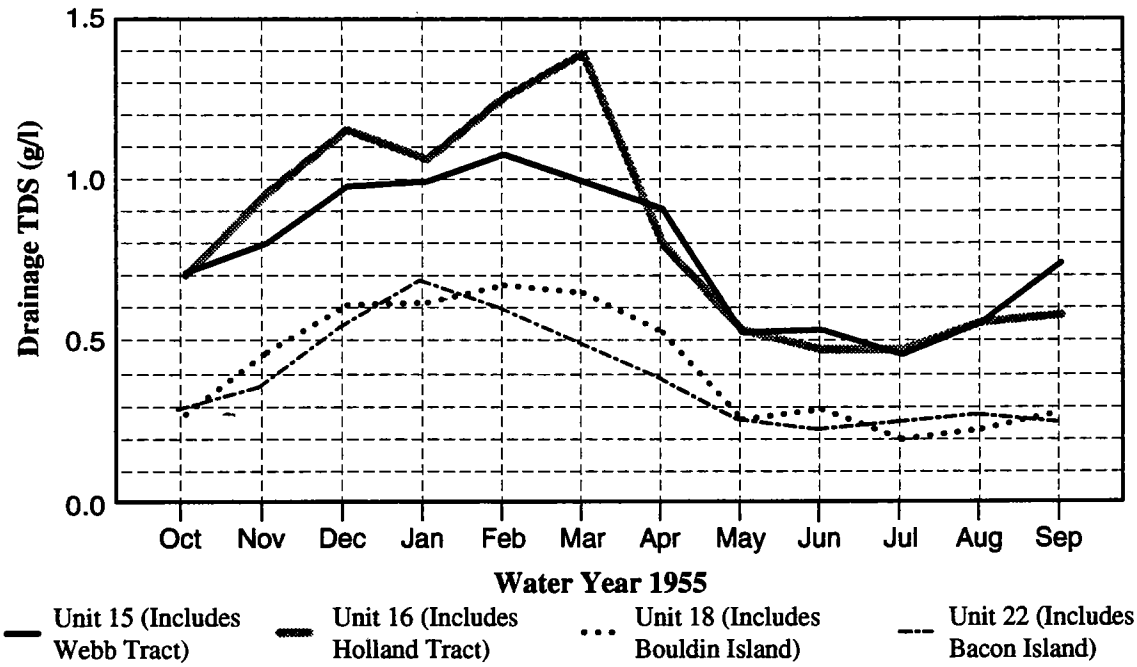


Figure C2-7.
Delta Lowlands Monthly Irrigation Salt Load
from DWR Report No. 4 for Water Year 1955

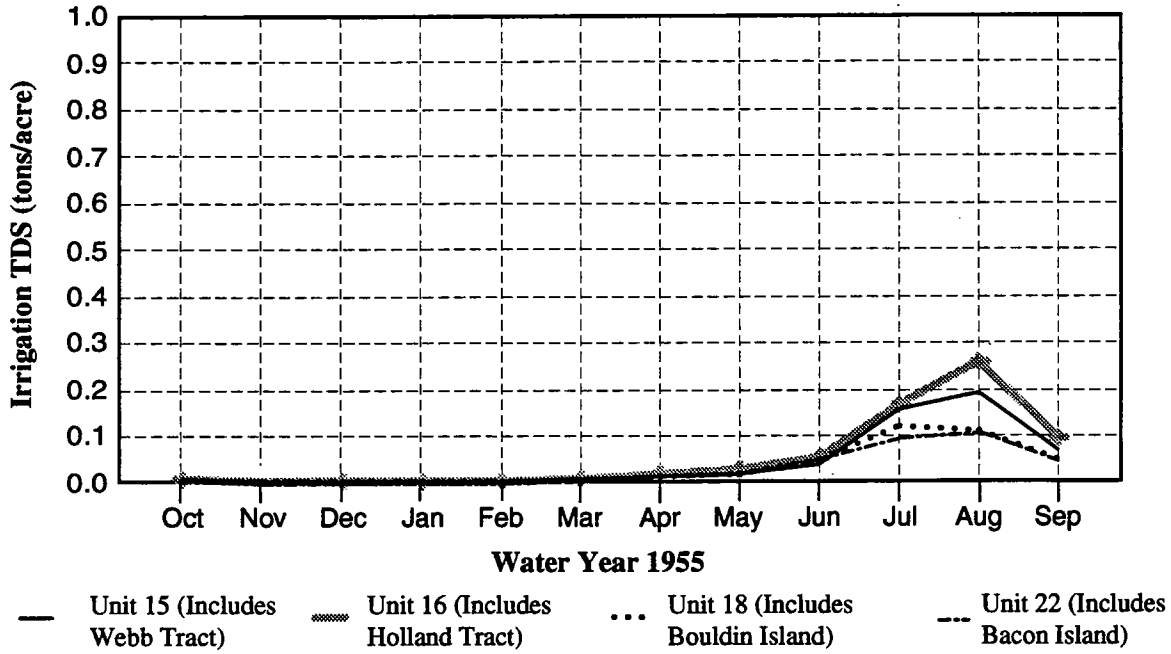


Figure C2-8.
Delta Lowlands Monthly Drainage Salt Load
from DWR Report No. 4 for Water Year 1955

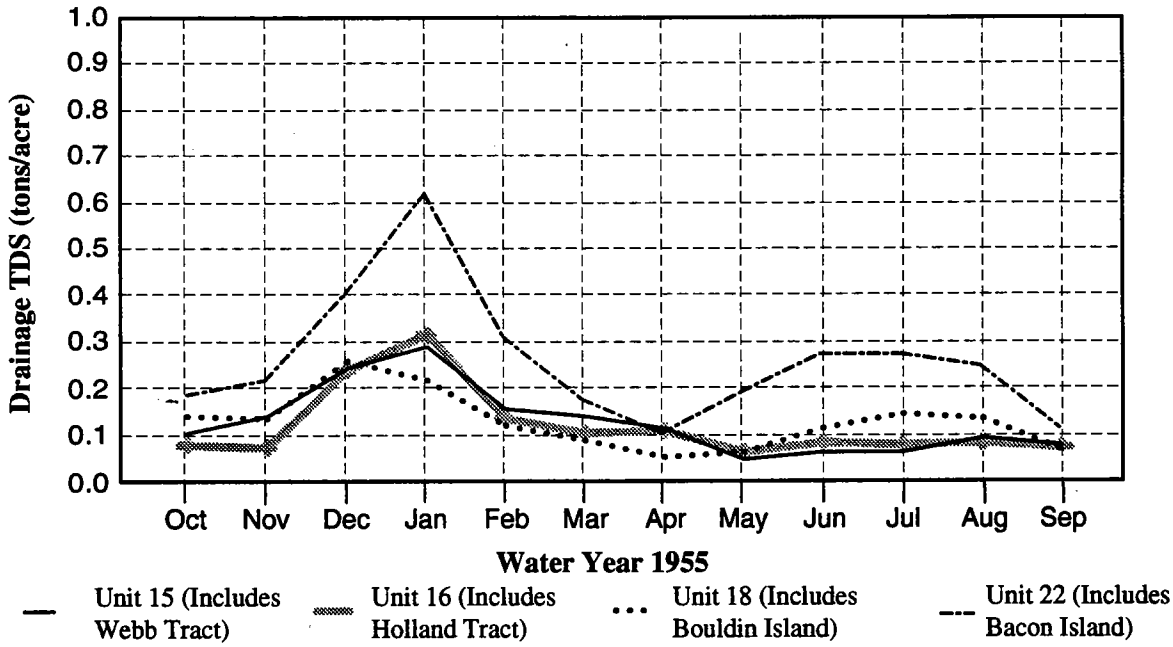


Figure C2-9.
DOC and Chloride Concentrations
in Bacon Island Drainage Based on DWR MWQI 1986-1991 Data

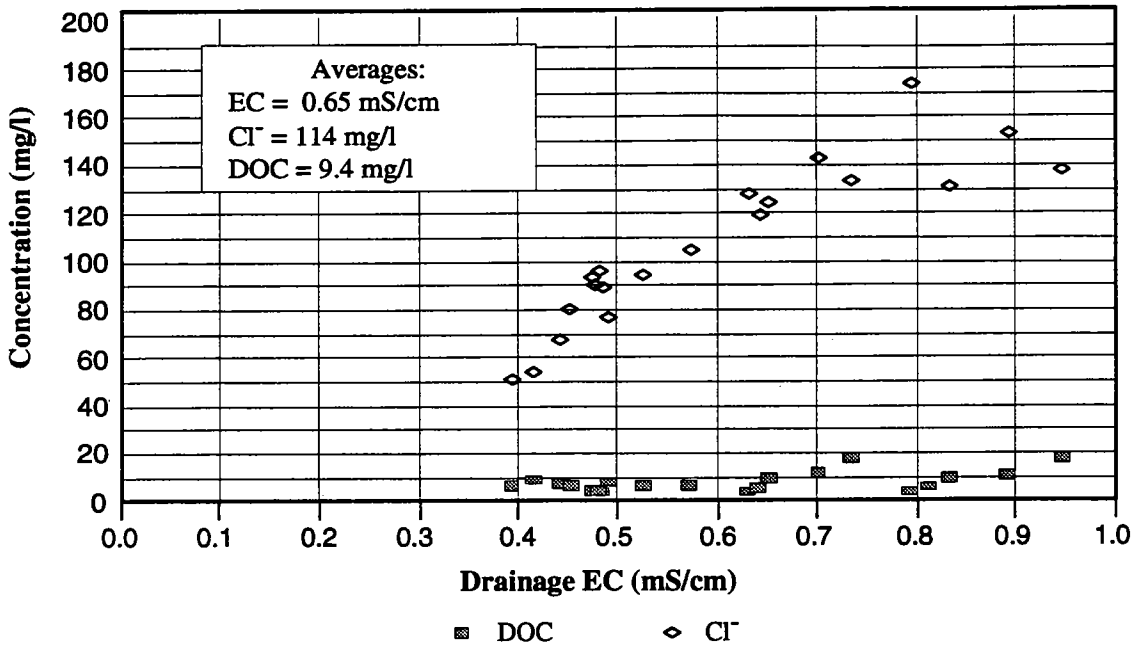


Figure C2-10.
DOC and Chloride Concentrations
in Bouldin Island Drainage Based on DWR MWQI 1986-1991 Data

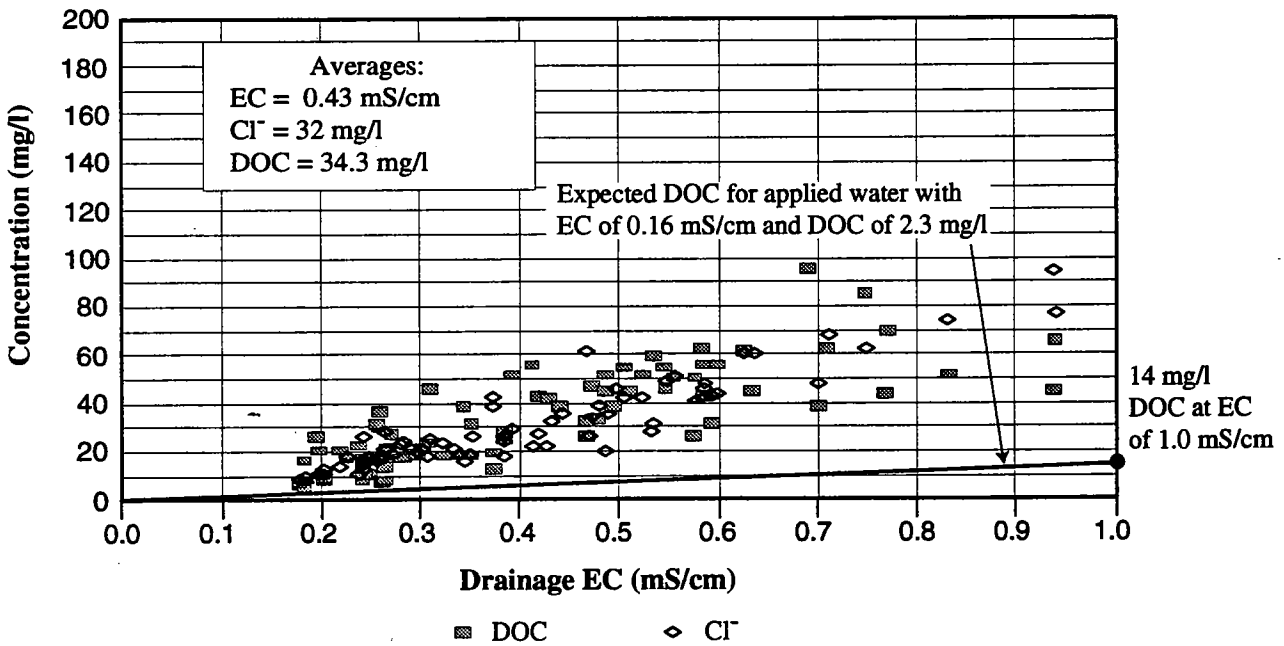


Figure C2-11.
DOC and Chloride Concentrations
in Holland Tract Drainage Based on DWR MWQI 1986-1991 Data

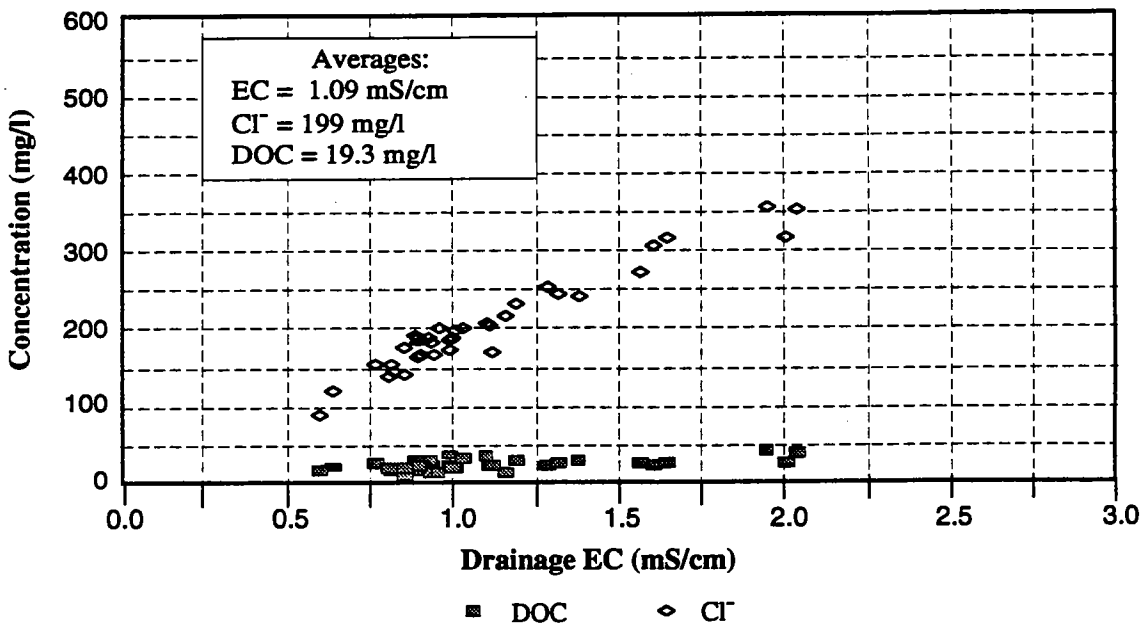


Figure C2-12.
DOC and Chloride Concentrations
in Webb Tract Drainage Based on DWR MWQI 1986-1991 Data

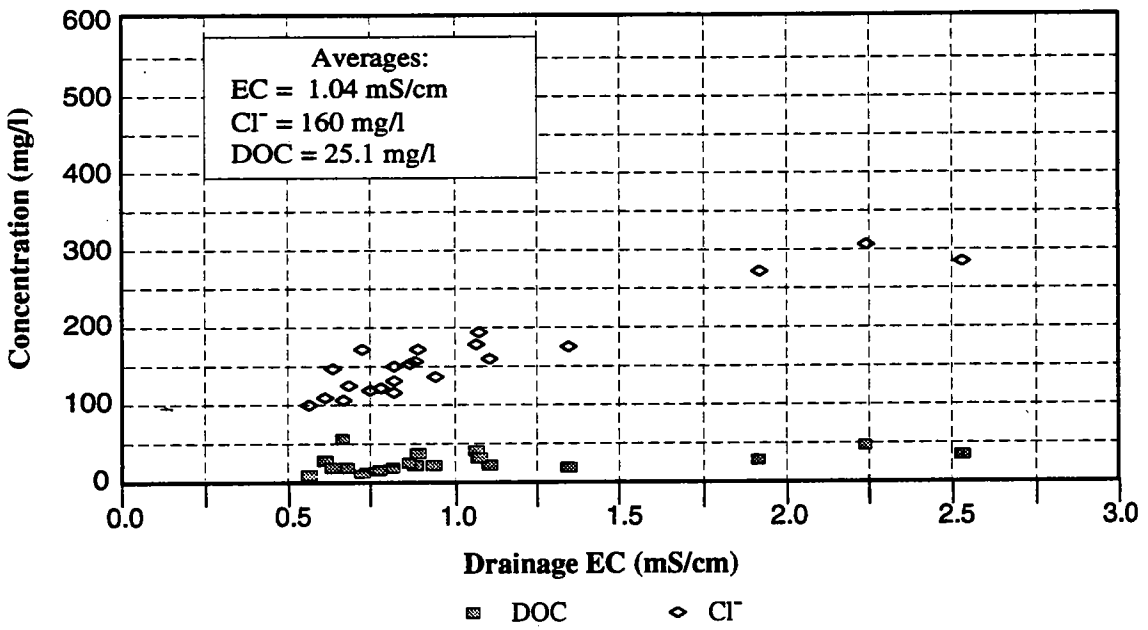


Figure C2-13.
DOC and Chloride Concentrations
in Grand Island Drainage Based on DWR MWQI 1986-1991 Data

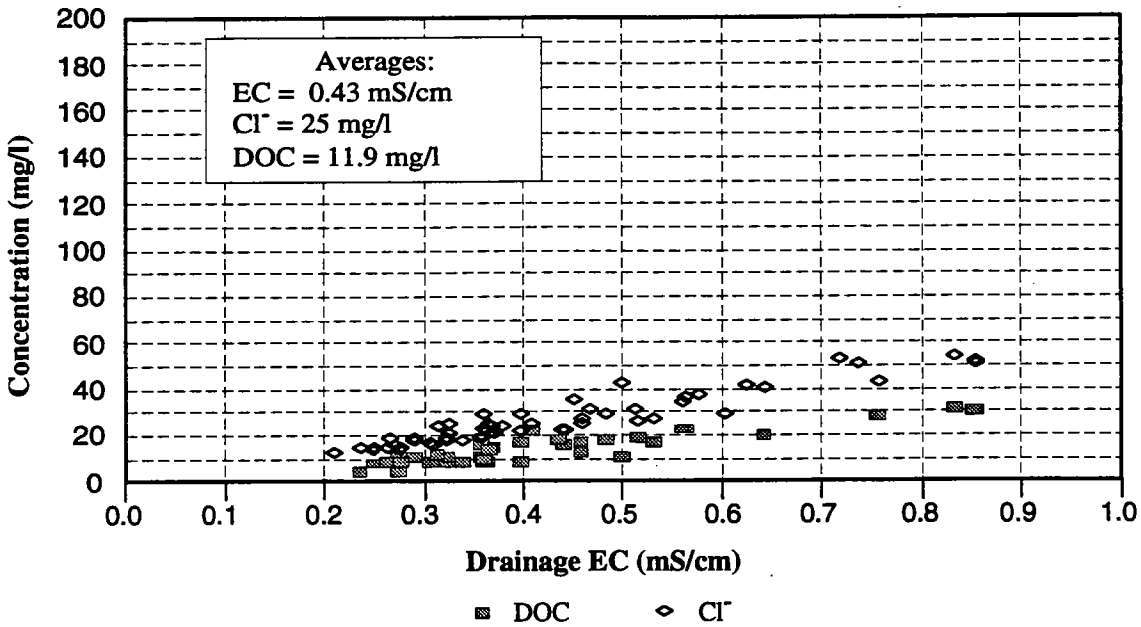


Figure C2-14.
DOC and Chloride Concentrations
in Tyler Island Drainage Based on DWR MWQI 1986-1991 Data

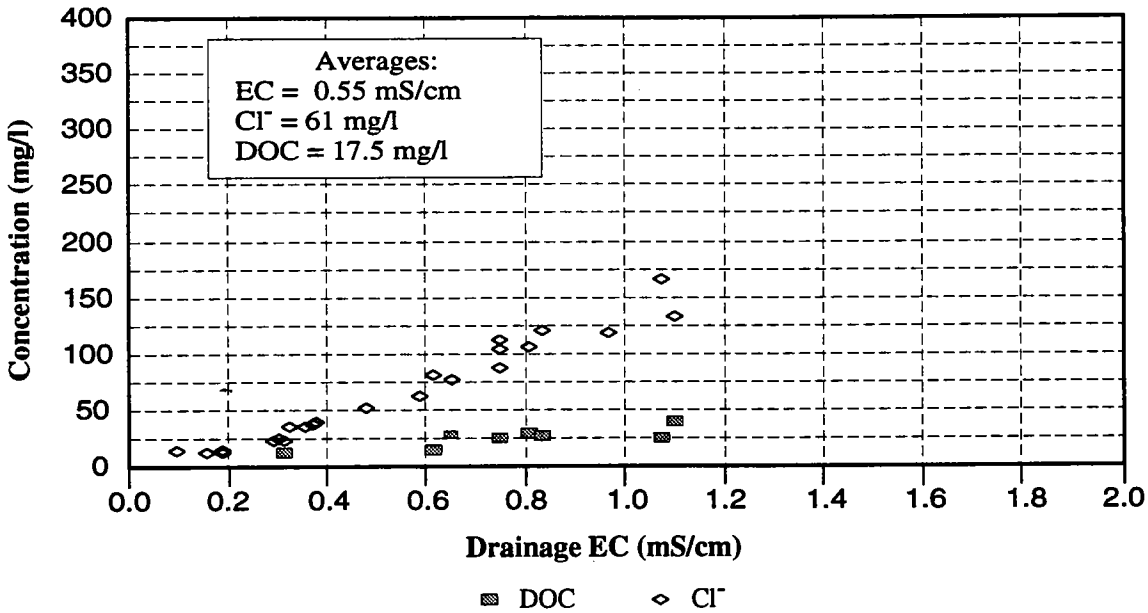


Figure C2-15.
DOC and Chloride Concentrations
in Brannan Island Drainage Based on DWR MWQI 1986-1991 Data

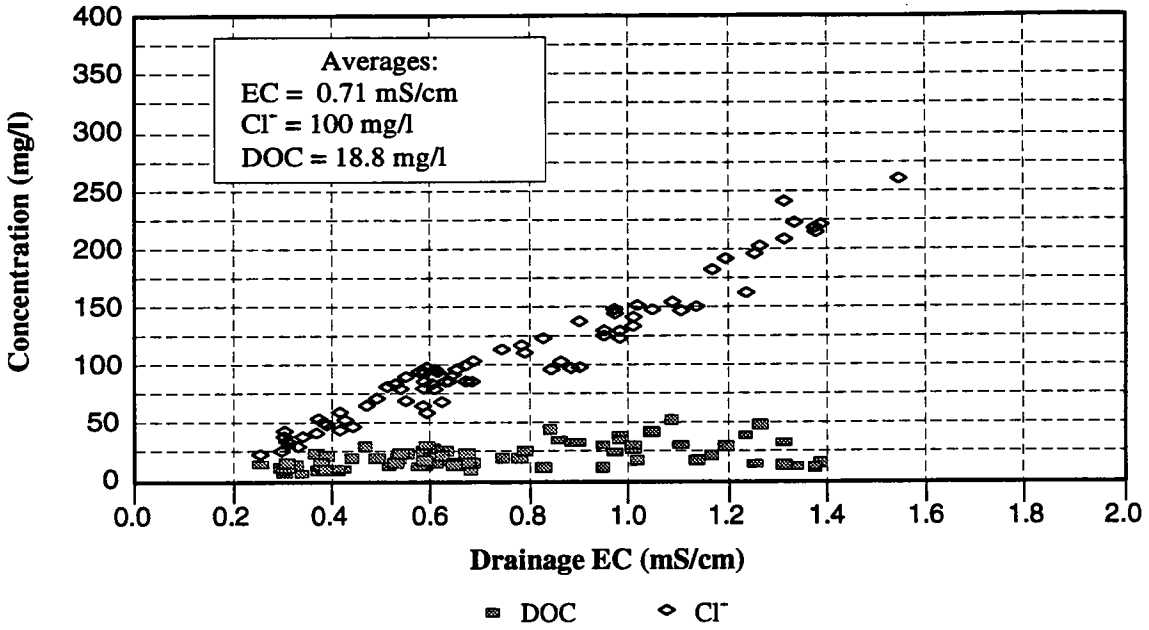


Figure C2-16.
DOC and Chloride Concentrations
in Egbert Tract Drainage Based on DWR MWQI 1986-1991 Data

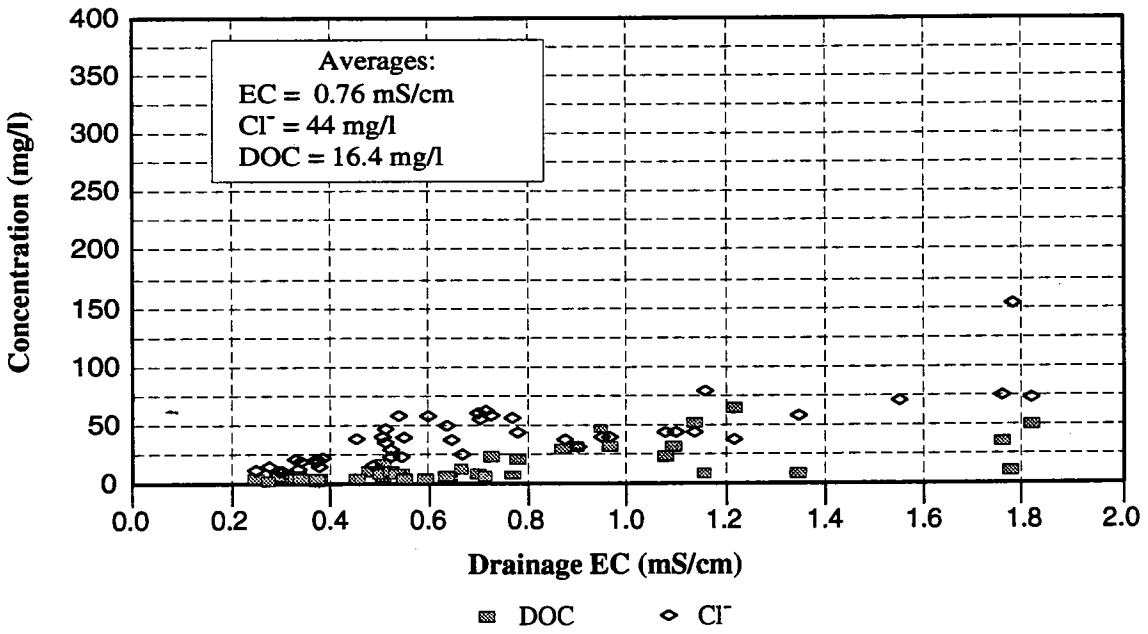


Figure C2-17.
DOC and Chloride Concentrations
in Empire Island Drainage Based on DWR MWQI 1986-1991 Data

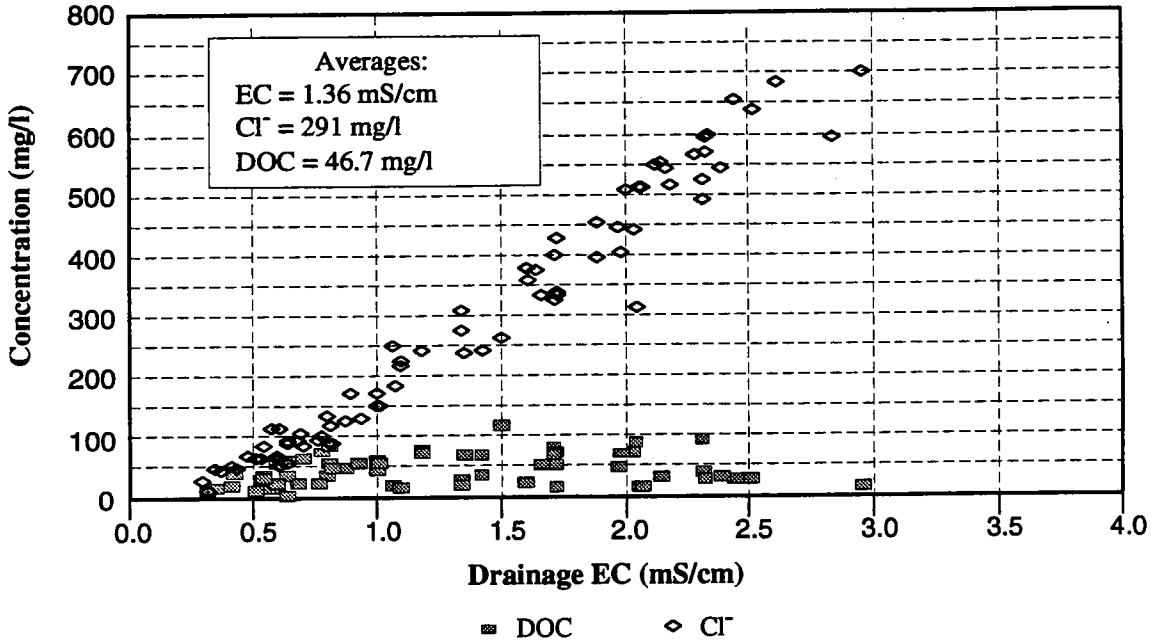


Figure C2-18.
DOC and Chloride Concentrations
in Pescadero Tract Drainage Based on DWR MWQI 1986-1991 Data

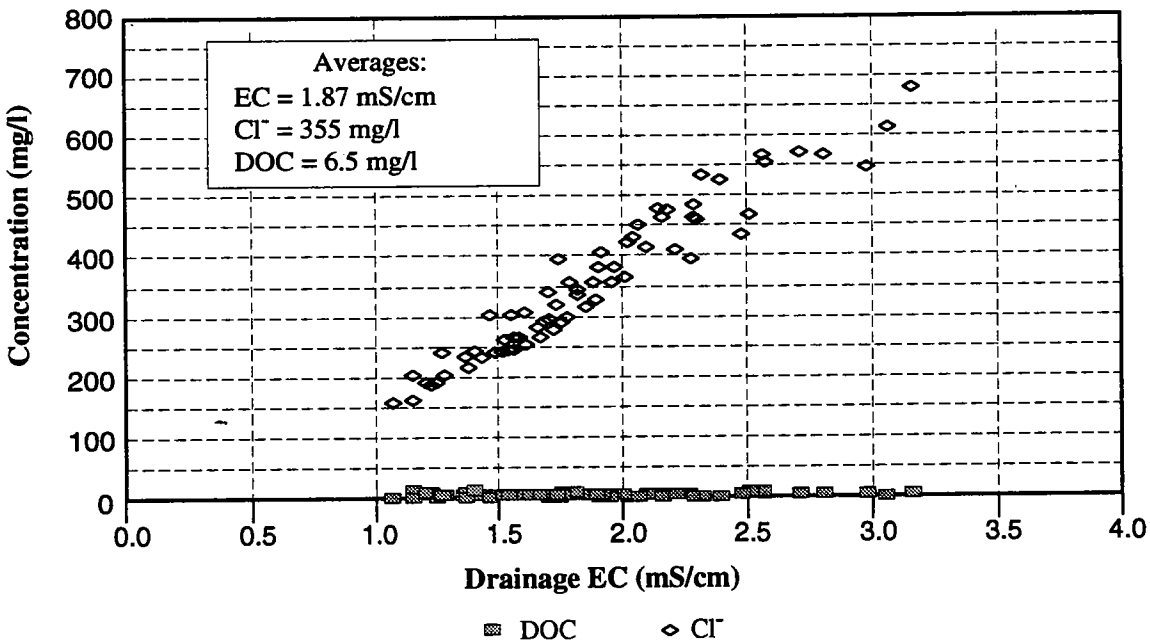


Figure C2-19.
DOC and Chloride Concentrations
in Jones Island Drainage Based on DWR MWQI 1986-1991 Data

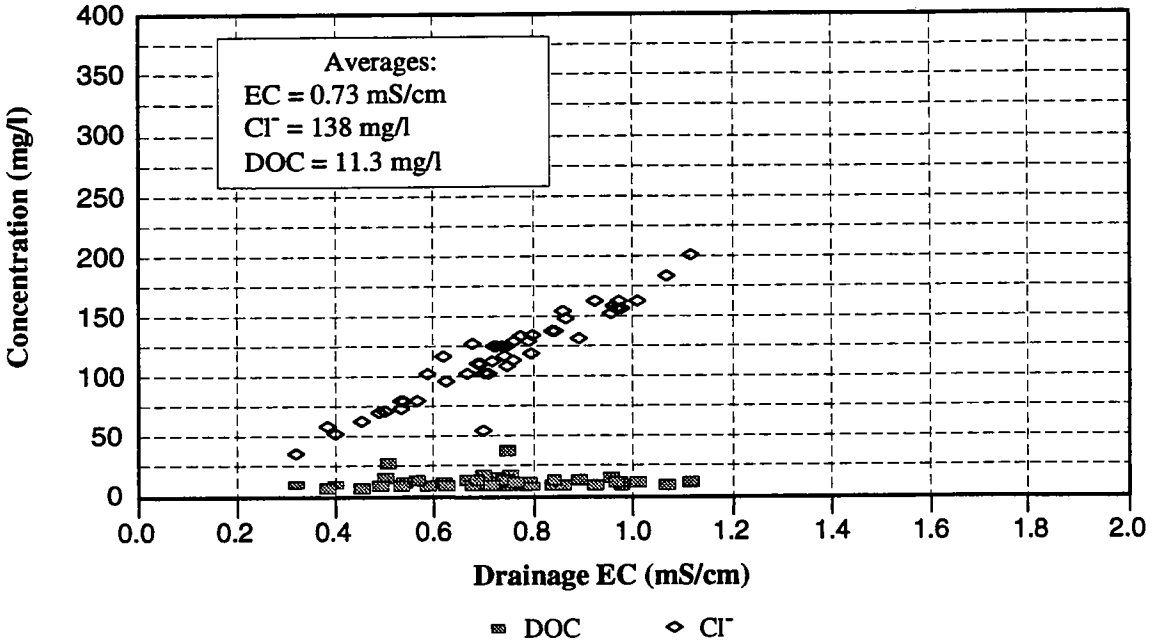


Figure C2-20.
DOC and Chloride Concentrations
in Mossdale Tract Drainage Based on DWR MWQI 1986-1991 Data

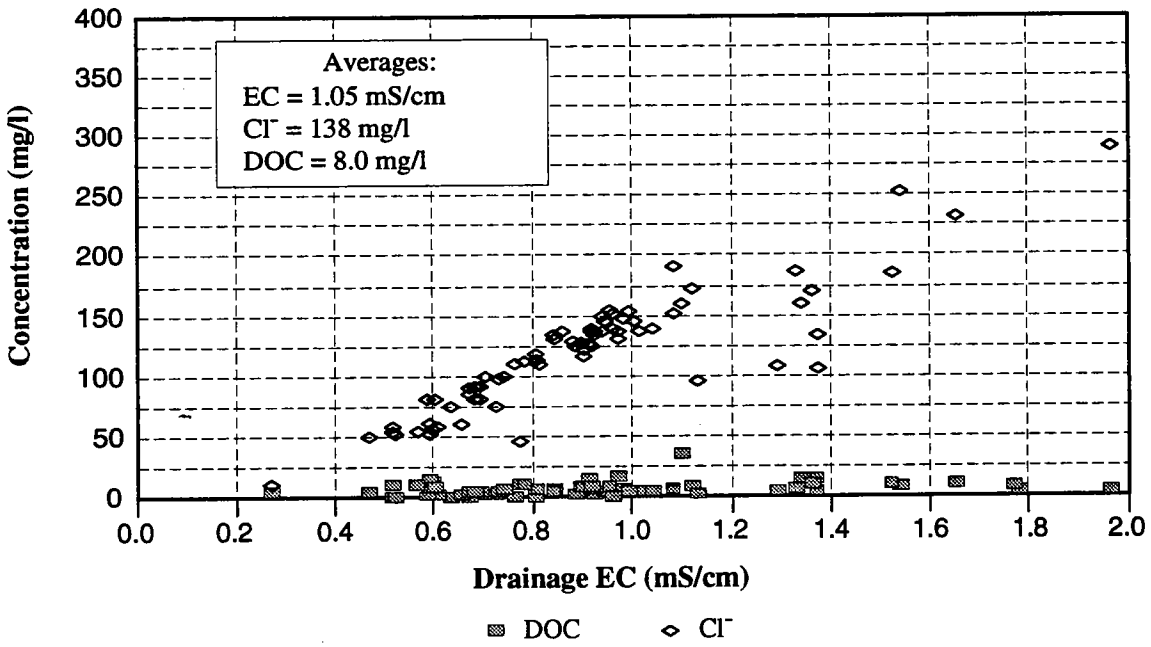


Figure C2-21.
DOC and Chloride Concentrations
in King Island Drainage Based on DWR MWQI 1986-1991 Data

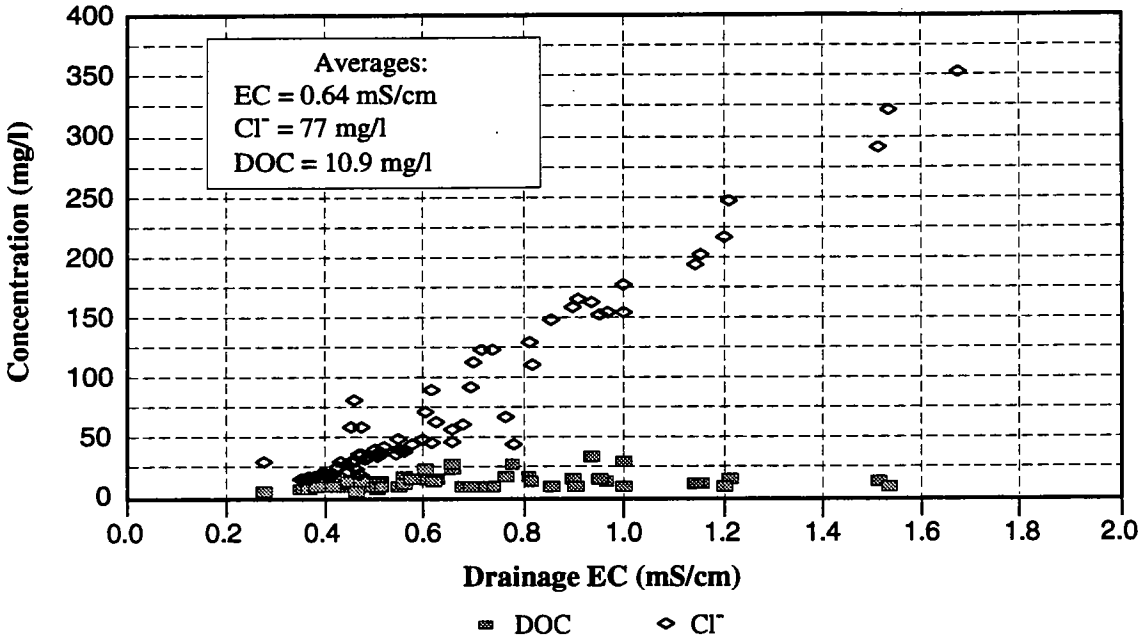


Figure C2-22.
DOC and Chloride Concentrations
in Rindge Tract Drainage Based on DWR MWQI 1986-1991 Data

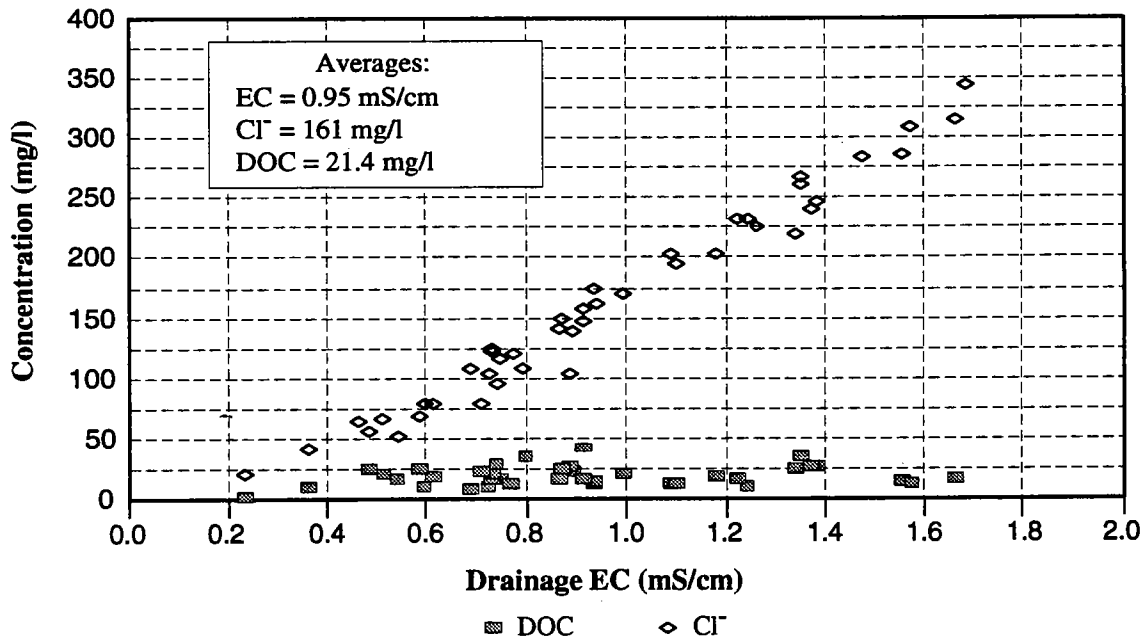


Figure C2-23.
DOC and Chloride Concentrations
in Rio Blanco Tract Drainage Based on DWR MWQI 1986-1991 Data

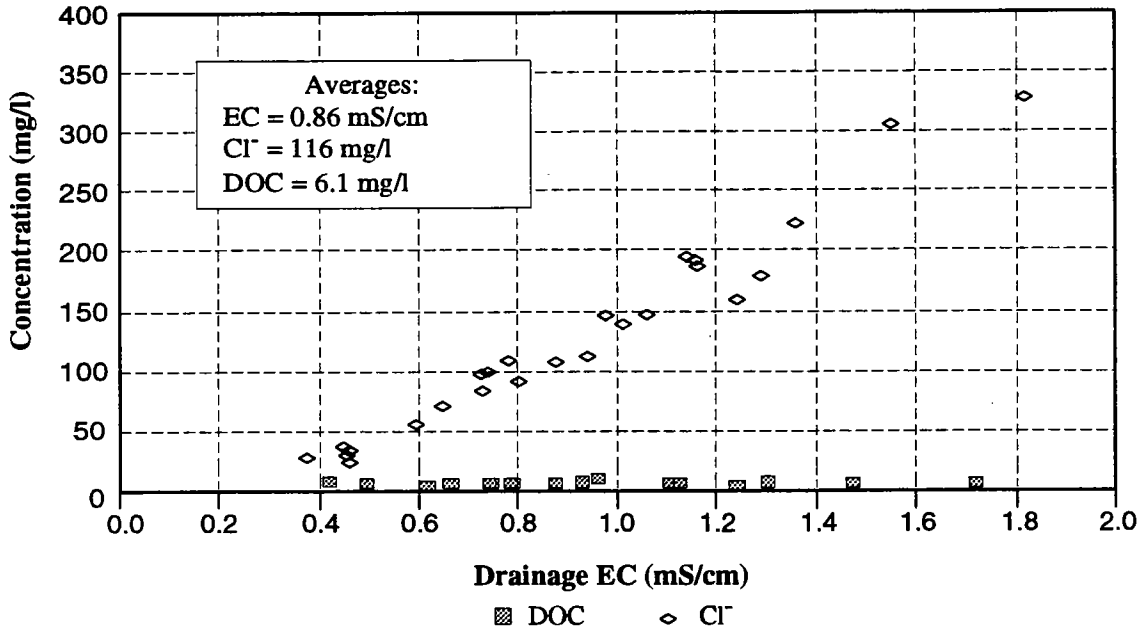
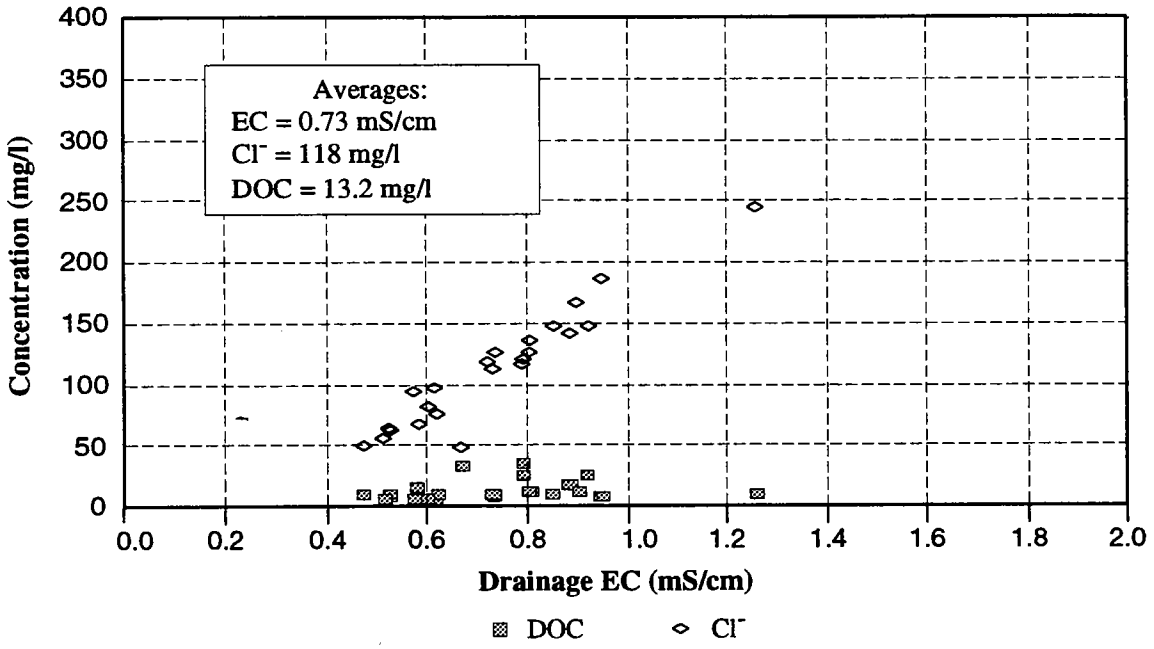


Figure C2-24.
DOC and Chloride Concentrations
in Terminous Island Drainage Based on DWR MWQI 1986-1991 Data



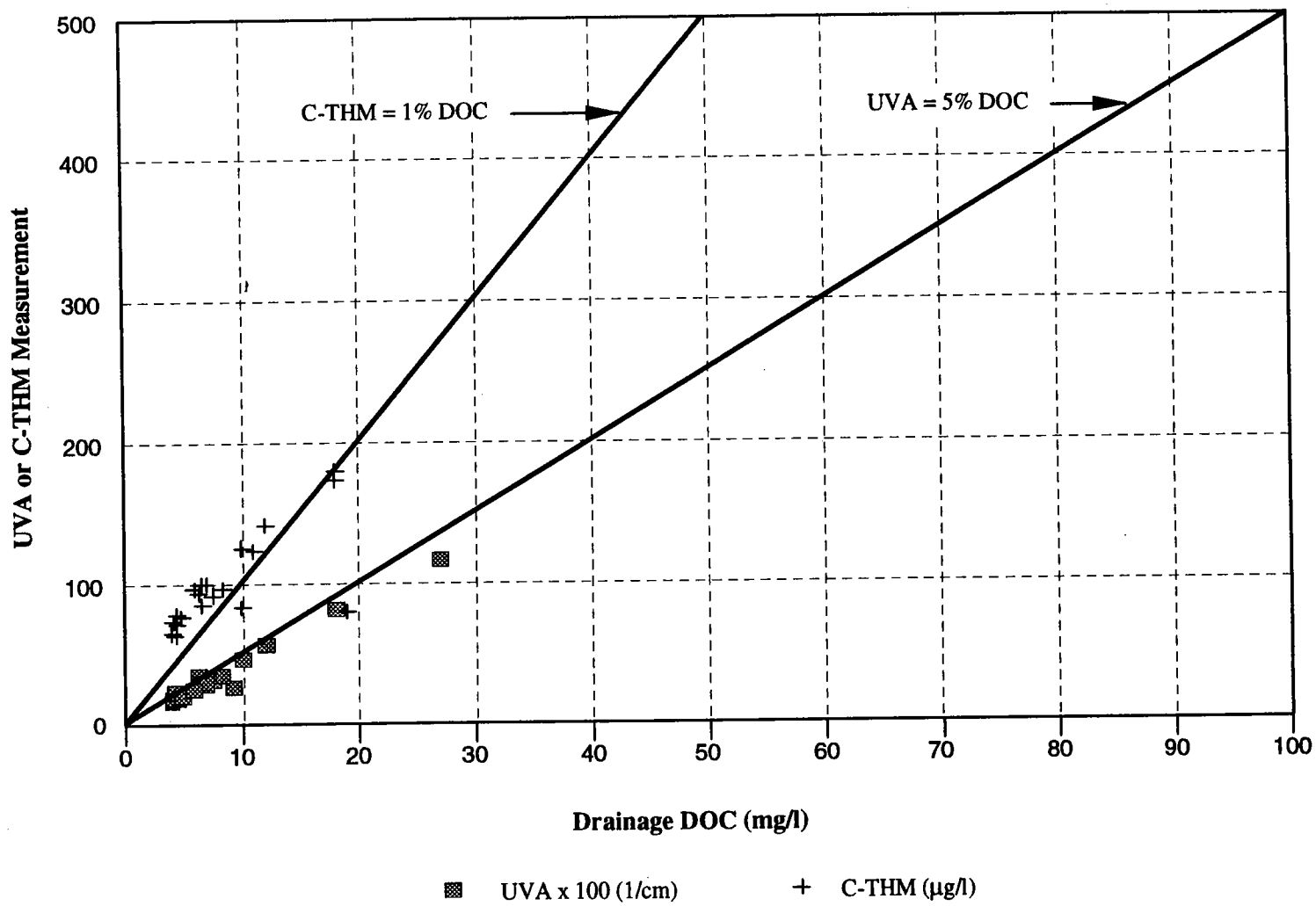


Figure C2-25.
Observed UVA Values and C-THM Concentrations
as a Function of DOC Concentrations from Bacon Island
DWR MWQI Drainage Samples for 1986-1991

DELTA WETLANDS
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Prepared by: Jones & Stokes Associates

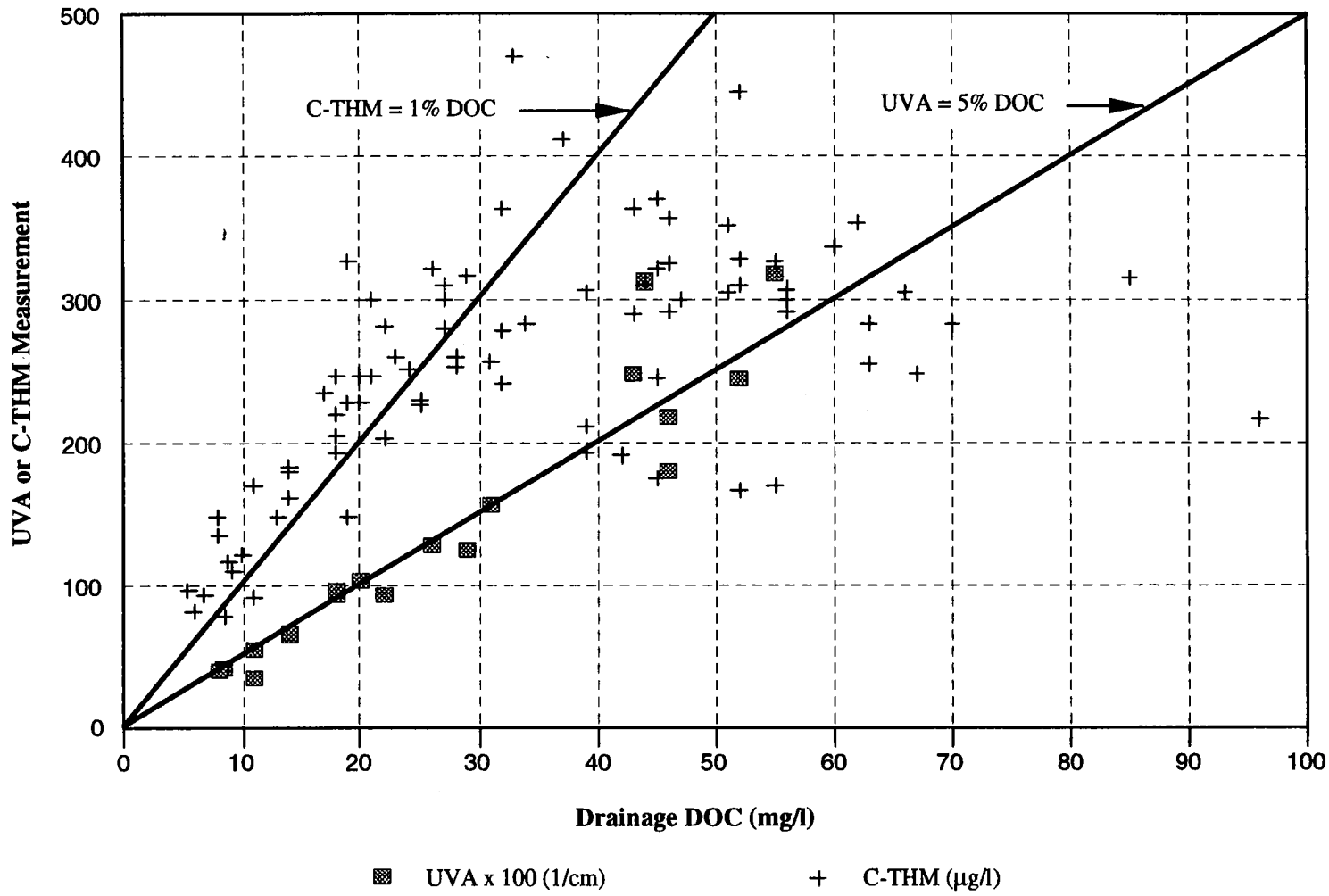

Figure C2-26.
Observed UVA Values and C-THM Concentrations
as a Function of DOC Concentrations from Bouldin Island
DWR MWQI Drainage Samples for 1986-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

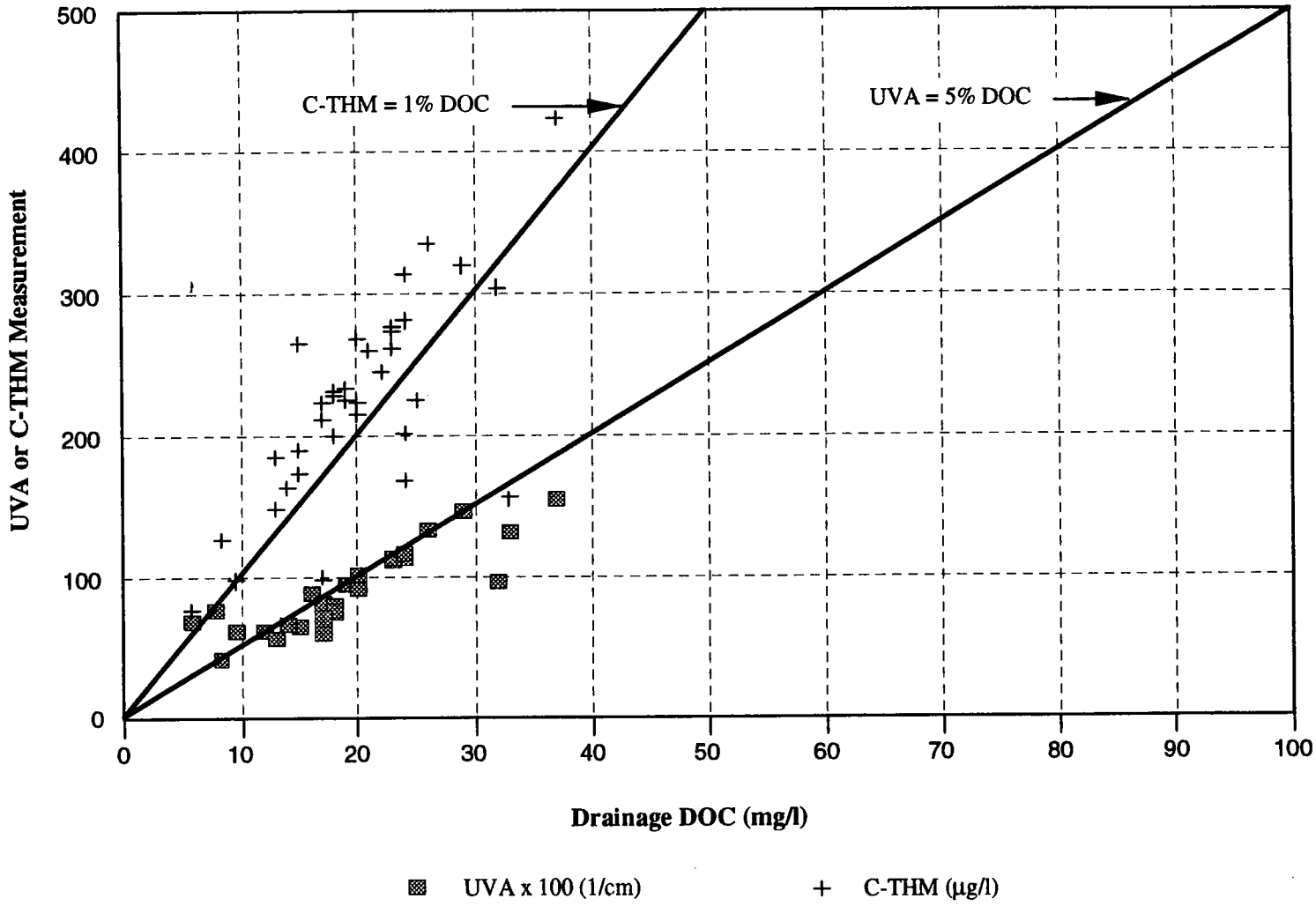

Figure C2-27.
Observed UVA Values and C-THM Concentrations as a Function of DOC Concentrations from Holland Tract DWR MWQI Drainage Samples for 1986-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

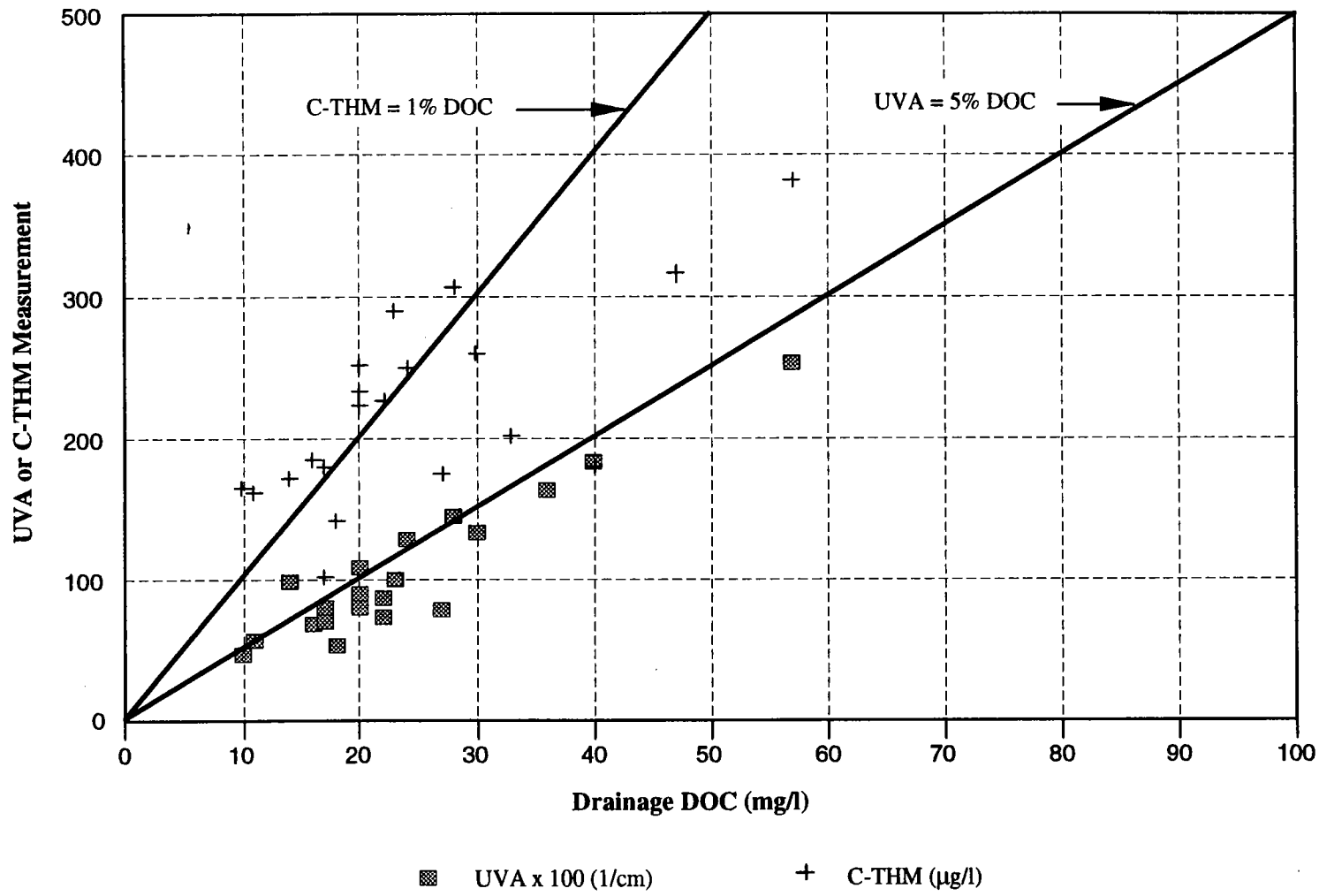

Figure C2-28.
Observed UVA Values and C-THM Concentrations as a Function of DOC Concentrations from Webb Tract DWR MWQI Drainage Samples for 1986-1991

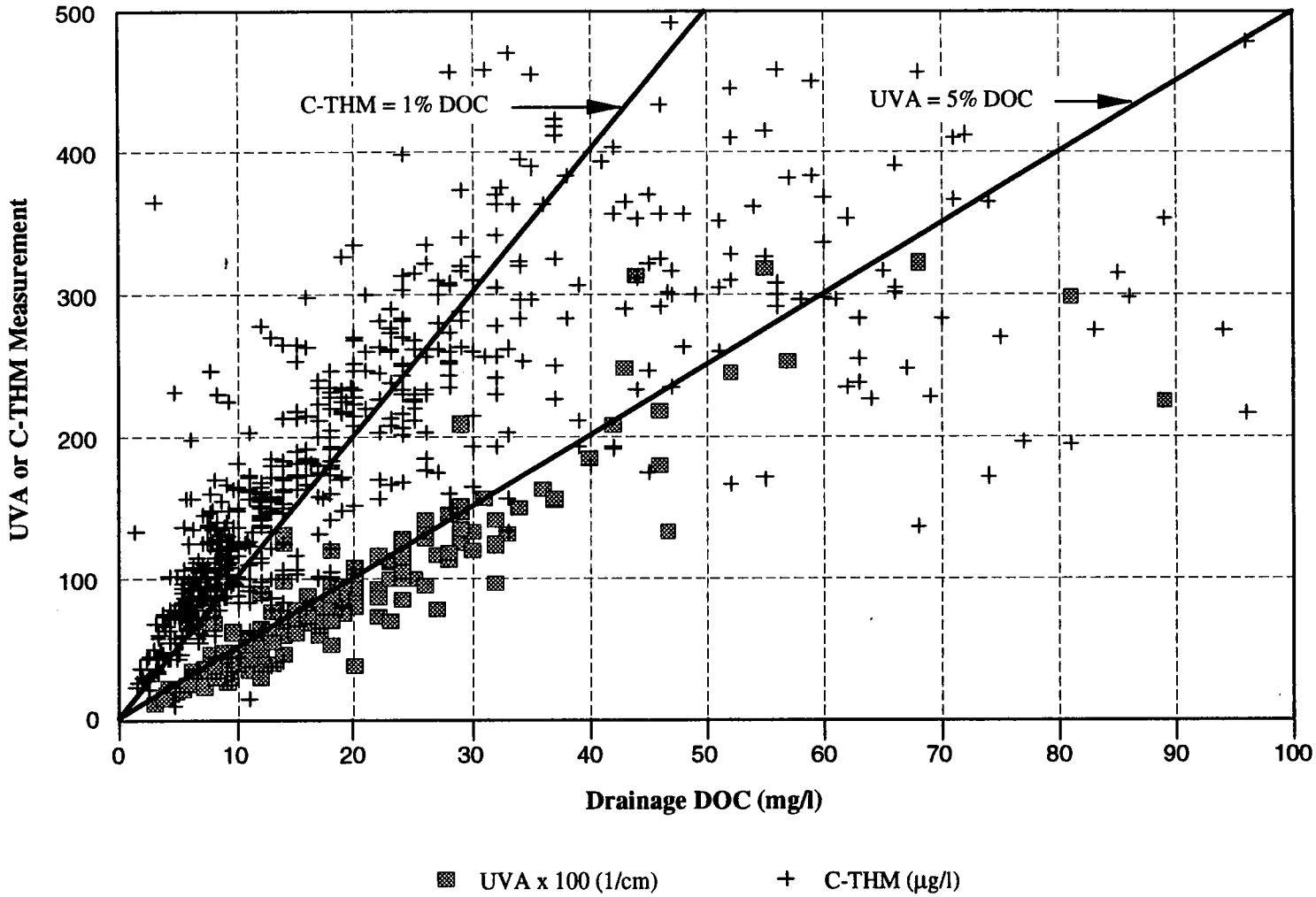

Figure C2-29.
Observed UVA Values and C-THM Concentrations as a Function of DOC Concentrations from All DWR MWQI Drainage Samples for 1986-1991

DELTA WETLANDS
PROJECT EIR/EIS

Prepared by: Jones & Stokes Associates

Appendix C3. Water Quality Experiments on Potential Sources of Dissolved Organics and Trihalomethane Precursors for the Delta Wetlands Project

Appendix C3. Water Quality Experiments on Potential Sources of Dissolved Organics and Trihalomethane Precursors for the Delta Wetlands Project

SUMMARY

This appendix describes four water quality experiments conducted as part of the analysis of impacts of the Delta Wetlands (DW) project on Delta water quality. The Holland Tract flooded wetland and seasonal storage experiments were designed to determine what water quality changes can be expected in the flooded wetland habitat on the DW project islands during October-January and what further changes can be expected during the anticipated water storage period of February-July. The vegetation decay experiment was designed to determine what the expected contribution from decomposition of wetland vegetation would be to levels of dissolved organic carbon (DOC) and associated variables in ponded water in the seasonal wetland. The soil water extraction experiment was designed to determine what relative contributions of DOC and associated variables may be expected from agricultural and wetland soils; it was also used to test the hypothesis that peat soils may leach large quantities of materials to ponded water.

The original DW project concept included wetland vegetation growth in summer, waterfowl habitat flooding in fall, and winter-spring seasonal water storage operations on all four DW project islands. The DW project now being proposed involves two habitat islands and two reservoir islands, as described in Chapter 2, "Delta Wetlands Project and Alternatives". These water quality experiments are interpreted to provide information about likely effects of the DW project as currently conceived.

Analysis of the experimental results focused on DOC concentrations because DOC is recognized as the major precursor of trihalomethanes (THMs) in water disinfected through chlorination for municipal use, and contributions of DOC in discharge from the DW project islands to Delta channels may therefore affect THM levels in Delta exports that are treated by chlorination. The appendix also describes a method to estimate THM concentrations for any combinations of DOC, bromide (Br^-), and chlorination dose.

The data from the Holland Tract wetland experiments suggest that substantial leaching of peat soil is not likely to occur under flooded wetland conditions and that moderate DOC increases would be associated with vegetation decomposition. Most of the available loading of DOC and other water quality variables would be released to the water in the flooded wetlands during October-January, and very little additional release of materials would occur during the February-July water storage period. The estimated areal loading from flooded wetlands was approximately 21 g/m^2 per year.

The results of the vegetation decay experiment were used to calculate the areal leaching of DOC from wetland vegetation. Areal loading from vegetation was found to be approximately 7.5 g/m^2 per year. This result can be used to compare DOC loading from decaying wetland vegetation with loading from other DOC sources in the Delta.

In the soil water extraction experiment, soil water was extracted for analysis from surface and deeper samples of soil from the Holland Tract wetland and adjacent agricultural fields. Analysis of the samples found that availability of DOC was two to three times greater in surface agricultural soils than in the wetland soils or deeper agricultural soils. The peat soils were not found to exhibit substantial leaching of DOC over time.

Although these experiments indicate that concentrations of DOC are greater in agricultural soils than in wetland soils, these differences are only important if the DOC concentrations are leached and transported to Delta channels. These experiments did not quantify the volumes of water affected by leaching, agricultural drainage, or runoff because such water volume data are not available; therefore, the experiments can only be used to provide a relative index of the potential for these soils to contribute to DOC concentrations in drainage or ponded water.

INTRODUCTION

Delta waters serve many beneficial uses, each of which has water quality concerns associated with it. Levels of disinfection byproducts (DBP) are of particular concern in water that has been exported from the Delta and treated for municipal use. The most common DBP is THM compounds, which are produced in the primary disinfection of water by chlorination. THMs are considered a human health risk by the U.S. Environmental Protection Agency (EPA) and are subject to federal drinking water standards. Among the constituents of raw water from the Delta are DOC and Br^-, both of which might be increased in Delta water under some conditions as a result of DW project operations. DOC is the major precursor of THMs in treated drinking water.

The proposed DW project entails potential year-round storage of water on two Delta islands, Bacon Island and Webb Tract, and creation and management of wetlands for wildlife habitat on two other islands, Bouldin Island and Holland Tract. Under the proposed project, the water diverted by DW onto the reservoir islands would be stored for later sale as export or outflow during periods of demand. Water may also be diverted to the reservoir islands for creation of wetland habitat in fall during nonstorage periods; diversion would probably begin after September 1, after an appropriate dry period to allow for growth of wetland plants of value to wintering waterfowl as forage and cover. DW diversions onto the habitat islands would most likely begin in September, and water would be circulated throughout winter. Water used on the habitat islands would be discharged on a schedule related to wetland and wildlife values, with drawdown typically occurring by May. Water discharged into Delta channels under DW project operations would mix with Delta inflows and would be available for Delta outflow or Delta exports.

In comparison with existing agricultural management practices on the DW project islands, these storage and wetland management activities may substantially reduce the amount of annual biomass residue production and the rate of peat soil oxidation on the islands. Because vegetation decomposition and soil oxidation are the main sources of DOC on the DW project islands, DW project operations could affect concentrations of DOC discharged into Delta channels from the islands and could therefore affect concentrations of THMs in treated water produced from Delta exports.

Jones & Stokes Associates (JSA) conducted the four water quality experiments described below as part of its analysis of impacts of the DW project on Delta water quality. The analysis was performed to support preparation of the environmental impact report/environmental impact statement (EIR/EIS) for the DW project. The four experiments and the question each was designed to answer are as follows:

1. Holland Tract flooded wetland experiment (1989-1990): What water quality changes can be expected in flooded wetland habitat on DW project islands during October-January?

2. Holland Tract seasonal storage experiment (1990): What further water quality changes can be expected during the proposed water storage period of February-July?

3. Vegetation decay experiment (1992): What is the expected contribution from decomposition of wetland vegetation to levels of DOC and associated variables in ponded water in the seasonal wetland?

4. Soil water extraction experiment (1992): What are the expected relative contributions of DOC and associated water quality variables from soils in active agricultural fields and in the demonstration wetland on Holland Tract?

Holland Tract Flooded Wetland and Seasonal Storage Experiments, 1989-1990

The first and second experiments were conducted in the Holland Tract demonstration wetland between October 1989 and July 1990. These experiments were designed to determine the changes in water quality likely to occur when seasonal wetlands are flooded to shallow depths to provide waterfowl habitat and when water is stored to greater depths on the proposed DW project

islands. Although many water quality variables were measured in these experiments, DOC is now known to be the major precursor of THMs. Therefore, DOC and associated variables, such as THM formation potential (THMFP), ultraviolet absorption (UVA), and organic nutrients, are emphasized in discussions of these experiments in this appendix.

The demonstration wetland on Holland Tract was originally constructed to show that plants used by waterfowl could be grown on DW project islands during the late summer-fall period after August 1. The initial DW project design would have involved seasonal storage and seasonal wetland habitat management on each DW island. The current DW project design includes two habitat islands and two reservoir islands. These experiments were conducted with the objective of identifying and quantifying the likely sources of DOC, and the results remain relevant to assessment of water quality impacts of the proposed DW project.

Results of the 1989-1990 Holland Tract experiments were originally presented in the draft EIR/EIS on the DW project (JSA 1990). This appendix summarizes those results.

Vegetation Decay and Soil Water Extraction Experiments, 1992

The vegetation decay and soil water extraction experiments, initially suggested in October 1991, were conducted to verify previous estimates of organic loadings from the DW project demonstration wetland on Holland Tract. Critical water-year conditions in 1992 prevented repetition of the demonstration wetland flooding experiment. JSA initiated the vegetation decay experiment on February 12, 1992, and obtained the last set of biweekly samples on April 29, 1992. JSA obtained soil samples for the soil water extraction experiment on February 27, 1992, and the 1-month soil water extraction was completed in April 1992.

JSA designed the 1992 experiments with suggestions from staff members of the California Department of Water Resources (DWR), Division of Local Assistance (Rick Woodard, Bruce Agee, consultant Marvin Jung), the Metropolitan Water District (MWD) of Southern California (Stuart Krasner, research chemist), the U.S. Geological Survey (USGS) (Steve Deverel), the California State Water Resources Control Board, and DW (consultant Jim Yost). JSA distributed a memorandum describing the experimental protocol for review on January 27, 1992, and MWD (February 4, 1992) and DWR (February 21, 1992) provided written comments. Several meetings with interested agency staff members were held during this period. The vegetation experiment was designed to determine the contribution of wetland vegetation to DOC concentrations in ponded water (on habitat reservoir islands). The soil experiment was designed to evaluate the relative contribution of wetland and agricultural peat soils to DOC leaching.

JSA distributed a draft report on the experimental results for review on May 28, 1992, and held a meeting to discuss the results on June 3, 1992. DWR and MWD provided written comments on the draft report. The final report on the experiments and analyses of the results (JSA 1993) incorporated the suggestions and comments of the reviewers and included copies of memoranda and comment letters submitted by the technical reviewers. This appendix summarizes these results.

OVERVIEW OF SOIL ORGANIC CARBON SOURCES

DOC measurements were important in the experiments performed to determine possible effects of DW project operation on Delta water quality because DOC is the major precursor of THMs and other types of DBP in treated drinking water. This section provides an overview of sources of organic carbon in Delta soils and the possible mechanisms through which organic material is dissolved and transported from Delta soils to Delta channels. This discussion provides a framework for interpreting the results of the experiments presented below.

Organic material in both peat and mineral Delta soils originates from the decay of vegetation. The peat soils that characterize the Delta lowlands originated from the accumulation of partially decomposed residue of wetland marsh plants. The organic material in mineral soils that characterize the Delta uplands is partially decomposed residue of agricultural crops or natural vegetation. The difference between peat and mineral soils is the amount of organic material present, not the fundamental nature of the organic material. Mineral soils generally have an organic content of 1-20%, whereas peat soils have an organic content of 25-95% (Buckman and Brady 1960).

Carbon Cycle

Figure C3-1 shows the general carbon cycle for agricultural soils in the Delta. During net primary pro-

duction of organic material, atmospheric CO_2 and necessary nutrients and minerals are incorporated from the soil into growing plant tissue. Plant respiration in shoots and roots consumes oxygen and releases CO_2. Net primary production can be measured by the accumulation of plant biomass. Dry plant tissue has a carbon content of approximately 40%; therefore, biomass and carbon units can be interchanged quite easily (e.g., 1 gram per square meter [g/m^2] of biomass contains 0.4 g/m^2 of carbon). This carbon content percentage was used in several of the experimental calculations described in the following sections.

All decomposition processes in soils can be described as enzymic digestion of plant residues and soil organic matter (Buckman and Brady 1960). Microbial decomposition processes in the warm, aerated topsoil differ greatly from those in deeper, saturated anaerobic soil. Fresh plant residues at the surface or in deeper soil are decomposed and digested by soil organisms of all kinds to produce decay products at the soil surface or in the soil column.

The complex chemical nature of plant tissues gives rise to a wide variety of decomposition products. Some plant tissue is easily decomposed and produces relatively simple end products, such as carbon dioxide (CO_2) and nutrients (e.g., nitrogen, phosphorus, and potassium). Most of the CO_2 is lost to the atmosphere, but some becomes dissolved in the soil water and reacts to form carbonates and bicarbonates. Other plant tissue is more difficult to decompose (refractory), and its decomposition results in intermediate products, such as lignins and humus material. These intermediate decomposition products remain in the soil or become dissolved in the soil water as compounds collectively measured as DOC. Soil microbes (bacteria, fungi, and actinomycetes) consume the available nutrients and minerals, and create additional compounds and end products, such as methane and nitrogen gas.

The general carbon cycle shown in Figure C3-1 becomes useful for impact assessment if the factors influencing each major term can be identified and quantified. Each of the DW-water quality experiments was generally aimed at quantifying these terms. The following sections present general discussions of the possible contributions of plant decomposition and soil oxidation on the DW project islands to concentrations of DOC in Delta waters.

Plant Decomposition

The amount of net primary productivity of organic material in Delta soils can be characterized by corn crop measurements made for the Delta corn salt-tolerance studies (Hoffman et al. 1983), corn crop measurements made for the 1990 DW project EIR/EIS, and measurements of seasonal wetland plants in the Holland Tract demonstration wetland.

Measurements indicated that corn grown on Terminous Tract in the Delta had a root biomass of about 250 g/m^2, grain biomass averaging about 1,250 g/m^2, and shoot growth biomass averaging about 2,500-3,000 g/m^2 (Hoffman et al. 1983). Aboveground corn crop residue on Bouldin Island was calculated from measurements of stalks and stalk density estimates to be about 1,750 g/m^2 (Table C3-1). Corn grain had been harvested and removed from the fields on Bouldin Island. Adding the Terminous Tract corn root biomass to the aboveground residue on Bouldin Island produces an estimated 2,000 g/m^2 of annual biomass residue added to Delta soil from a corn crop.

The plant biomass from seasonal wetlands was measured in the Holland Tract demonstration wetland for 1989 and 1991. The 1989 measurements are summarized in Table C3-1. The average aboveground biomass was 500 g/m^2. The wetland roots probably contribute a relatively small additional biomass, certainly less than the corn root biomass of 250 g/m^2. The maximum possible seasonal wetland biomass is therefore approximately 750 g/m^2.

Most plant residue from corn or wetland plants is decomposed rapidly (within several months) to yield atmospheric CO_2 and soluble nutrients. The longer lasting (more slowly decomposing) portion of the biomass can be roughly approximated by the lignin content of the vegetation because lignin is the most refractory portion of plant tissue (Buckman and Brady 1960). Corn plants had a lignin content of about 7% and wetland plants had a lignin content of about 6% (Table C3-1). The mass of lignin added to the soil from plant residue can be estimated from the total biomass to be about 140 g/m^2 (2,000 g/m^2 x 0.07) for corn and about 45 g/m^2 (750 x 0.06) for wetland plants. These measurements do not indicate the amount of lignin material that may become dissolved in the soil water, but they provide a comparison between the possible amounts of DOC from the two sources.

If fresh plant residue were the only major source of organic material that might become dissolved in the soil water and if the yield of DOC from lignin were always the same, these lignin measurements could indicate that the relative DOC contribution from corn plants would be approximately three times the contribution of DOC from wetland plants. The yield of DOC from organic material may vary, however, if conditions in the soil that control decomposition are different. Furthermore, oxidation and decomposition of the peat soil itself may create a significant source of DOC. An accurate assessment of DOC formation potential must attempt to quantify these factors.

Peat Soil Decomposition

One of the distinctive characteristics of the Delta peat soils is that they have been slowly subsiding at estimated maximum rates of 2-3 inches per year as a result of oxidation and wind erosion of the powdery "muck" soils (SCS 1989). Drying, shrinking, and periodic burning of the peat soils may also play a role in subsidence of the Delta agricultural islands. Several studies have demonstrated that microbial oxidation is probably the major contributor to peat soil subsidence. Thus, the observed subsidence of Delta peat soils may provide evidence that oxidation of these soils is an ongoing process; this oxidation could be contributing DOC to agricultural drainage and runoff that mix with Delta channel waters. Direct evidence of peat soil oxidation would consist of a greater measured loss of CO_2 from the soil surface than could be accounted for by the decomposition of fresh vegetation residue (Broadbent 1960, DWR 1980, Newmarch 1981).

Indirect evidence that the major contributor to peat soil subsidence is microbial oxidation is suggested by studies showing that copper toxicity inhibits the soil microbial activity and reduces subsidence (Mather et al. 1979). Because copper is sometimes required as a fertilizer, the possibility that copper may also control subsidence is of interest for Delta agricultural management.

Other indirect evidence that microbial oxidation is the major contributor to peat soil subsidence is suggested by correlations between the depth to water table and oxidation rate in experiments at the Florida Everglades. Saturated conditions reduce the rate of oxidation of peat soils. The Everglades research results suggest that 50%-75% of the subsidence (average of 1.25 inches/year) has been caused by biochemical oxidation. Seasonal or global correlations with temperature also offer indirect evidence that microbial processes control subsidence rates (Stephens and Stewart 1976).

Research has demonstrated that flooding peat soils creates anaerobic conditions that reduce the overall rate of microbial activity and shift the microbial processes to facultative and anaerobic metabolism. Denitrification of nitrate to nitrogen gases (N_2 and N_2O) increases dramatically under flooded conditions (Tate 1979, Terry & Tate 1980). A combination of biochemical indicators may provide the clearest picture of peat soil decomposition processes.

Studies by USGS may verify that microbial oxidation is the predominant process contributing to peat subsidence on Delta islands and that physical processes, such as drying, wind erosion, and fire, are of less importance (Deverel et al. in press).

Dissolved Organic Carbon in Soil Water and Agricultural Drainage

The most direct method for determining the magnitude of DOC contributions from Delta soils is measuring DOC and associated nutrients in soil water and agricultural drainage water. For the mass of contributed DOC to be calculated, however, the volume of soil water leaching or draining must be estimated. The experiments described in the following sections determined relative contributions of DOC and associated water quality variables from agricultural and wetland vegetation and soils; the results cannot be used to determine the magnitude of contributions from the DW project island soils to Delta waters because volumes of soil water leaching and drainage are not known. Standard irrigation practice in the peat soils of the Delta includes "spud ditching" to subirrigate and drain fields. This could increase the contribution of DOC relative to the contribution from wetlands and reservoir operations.

The DWR Municipal Water Quality Investigations (MWQI) program has sampled Delta agricultural drainage for several years (DWR 1989, 1990). Agricultural drainage volumes have not yet been measured directly, so the absolute magnitude of DOC sources produced by the various drains cannot be calculated. The relative magnitude of measured DOC concentrations can be used to indicate those drains that are probably the major sources of DOC in the Delta if it is assumed that the drainage volumes per acre are similar for each Delta drain (Table C2-1 in Appendix C2, "Analysis of Delta Agricultural Drainage Water Quality Data", suggests that they

are not uniform). Information on the drainage acreages might allow the drainage volumes to be estimated.

THMFP is measured in the MWQI samples as an index of THM concentrations that could be produced by maximum chlorination of Delta water. Several types of laboratory tests have been developed to measure THMFP in water samples.

The DWR MWQI assay for THMs is performed by spiking a water sample with an initial 120-mg/l concentration of chlorine (Cl_2), holding the sample for 7 days (168 hours) at 25°C, then measuring the THM species with standard EPA analytical laboratory procedures (gas chromatograph purge and trap, EPA method 502.2). This method was recently revised to also control the pH of the sample. The 120 mg/l chlorine dose may not be great enough to produce the maximum THMFP concentration in samples with high DOC concentrations (greater than 30 mg/l). The gas chromatograph method determines concentrations of the four types of THM molecules separately. Each THM molecule resembles methane (CH_4), except that three of the four hydrogen atoms are replaced with a halogen (chlorine or bromine). The four types of THM molecules are chloroform ($CHCl_3$), dichlorobromomethane ($CHCl_2Br$), dibromochloromethane ($CHClBr_2$), and bromoform ($CHBr_3$). Each type of THM molecule has a different molecular weight because of the difference between the atomic weight of chlorine (35.45) and bromine (79.90). Chloroform has a molecular weight of 119.36, whereas bromoform has a molecular weight of 252.71.

Total THM concentration (by weight) is the basis for current EPA drinking water standards. The greater weight of total THMs resulting from increased bromine incorporation, however, complicates comparison of THM precursors from two water samples with different bromide (Br^-) concentrations. One method to normalize THM concentrations is to measure only the carbon weight of each THM molecule, because each molecule has one carbon atom. The carbon-fraction concentrations of the four THM molecule concentrations are added together to calculate the carbon content of the THM concentration (C-THM), called the "total formation potential carbon" (TFPC) in the DWR MWQI program. Dividing the C-THM concentration by the DOC concentration in a water sample gives the fraction of DOC molecules that were converted to THM molecules during the THMFP assay. This C-THM/DOC ratio is called the THM yield.

HOLLAND TRACT WETLAND EXPERIMENTS

The first two water quality experiments were conducted at the demonstration wetland on Holland Tract. The Holland Tract demonstration wetland has an approximately 62-acre surface area with a total storage capacity of about 164 acre-feet (af) and a mean depth of 2.65 feet (0.8 m) (Figure C3-2). Construction of the pond levees and water control structure began on December 1, 1987, and was completed by January 22, 1988. The low dikes of the demonstration wetland were constructed from material scraped from an agricultural field that consisted of a mosaic of sand and peat soils. The water supply for the demonstration wetland was Old River.

Flooded Wetland Experiment

The first water quality experiment was conducted between October 1989 and January 1990. The objective of this study was to evaluate the contribution of wetland vegetation decomposition and soil leaching to concentrations of THM precursors in flooded wetland water. DOC and associated variables are of primary concern in interpretation of these results because DOC has been determined to be the major precursor of THM. Measurements of organic carbon were not filtered in this experiment and are given as concentrations of total organic carbon (TOC). However, the organic carbon is assumed to be predominantly dissolved; therefore, TOC is assumed to be equivalent to DOC.

Methods

Approximately 25 acres of the demonstration wetland's 62 acres were flooded beginning on October 19, 1989, to an average depth of about 0.5 m (1.5 feet) (see Figure C3-2). No additional siphoning of water into the wetland was required after initial flooding to maintain wetland water depths. Evapotranspiration and rainfall (with runoff from the unflooded portion of the wetlands) were balanced during the sampling period so that the water depth remained nearly constant. A composite sample (several samples mixed together) of the water siphoned from Old River to flood the wetland was used to characterize the initial water quality.

Composite water samples were collected from the flooded wetland approximately every week from November 3, 1989, to January 15, 1990. Samples were collected in a pre-rinsed plastic sampling jug slowly lowered from the water surface down to the wetland bottom. Subsamples were collected at random throughout the pond and composited to form one water sample on each date. A total of 10 composite samples were collected. Samples were labeled and transferred to ice chests for delivery to the contract laboratory.

Results

Measurements of the composite sample used to characterize initial water quality showed electrical conductivity (EC) of 677 microsiemens per centimeter (µS/cm), 556 milligrams per liter (mg/l) total dissolved solids (TDS), 177 mg/l chloride (Cl^-) (Cl^- /EC = 0.26), 0.55 mg/l bromide (Br^-) (Br^-/Cl^- = 0.0031), 18 mg/l calcium (Ca^{2+}), 18 mg/l magnesium (Mg^{2+}), 97 mg/l sodium (Na^+), 30 mg/l sulfate (SO_4^{2-}), 4.3 mg/l TOC, and THMFP of 404 micrograms per liter (µg/l) (Table C3-2). Color was not measured but was assumed to be 20 units based on MWQI Rock Slough measurements made on October 2, 1989. These channel water values are assumed to be representative of the initial concentrations of water quality variables in the flooded wetlands, which were flooded on October 19, 1989.

Changes in wetland water quality would have resulted mainly from peat soil leaching and decomposition of the wetland vegetation biomass and associated surface detritus. Rainfall on the entire pond area may have produced runoff and carried organics into the flooded area. Peat soil leaching would be expected to yield salt, minerals, nutrients, and organics. Vegetation residues would also be expected to produce dissolved organics with associated minerals and nutrients.

Several of the dissolved inorganic variables showed no net change over the duration of the experiment. EC and concentrations of TDS, sodium, chloride, and bromide showed no net increase (Figure C3-3). The data suggest that substantial leaching of the peat soil did not occur because these inorganic variables typically increase during soil leaching in agricultural operations.

In contrast, calcium, magnesium, sulfate, color, TOC, and THMFP increased in the demonstration wetland water during the 2-month sampling period (Figures C3-4, C3-5, and C3-6). TOC levels increased from 4.3 mg/l to 38.6 mg/l, as shown in Figure C3-5. THMFP concentrations increased dramatically; the THMFP concentration carbon component (C-THM) increased from 33 µg/l to a maximum of 420 µg/l (Figure C3-6). These materials originated either from vegetation decay in the flooded wetland basin or as runoff from the surrounding area within the wetlands that were not flooded. The observed increases may be higher than would be expected if a greater proportion of the wetland basin had been flooded. Increases of approximately 250 color units, 34 mg/l TOC, 50 mg/l sulfate, 20 mg/l calcium, 10 mg/l magnesium, and 300 µg/l C-THM were observed (Table C3-2).

Based on an estimated increase in TOC of 34 mg/l during the flooded wetland condition and an average pond depth of 0.5 meter, the estimated TOC loading is estimated to be about 17 g/m^2 (34 $g/m^3 \cdot 0.5m = 17$ g/m^2). If the 34-mg/l increase in TOC was contributed from the entire 62-acre wetland area, the estimated TOC loading would be about 7 g/m^2 (17 g/m^2 x 25/62).

Conclusions based on this experiment are presented following the description of the seasonal storage experiment, under "Conclusions of the Holland Tract Wetland Experiments".

Seasonal Storage Experiment

The second experiment was conducted during April-July 1990. The objective of this experiment was to evaluate changes in water quality during the water storage period. The initial concentrations provided an estimate of flooded wetland load from the entire pond because the wetland water was not drained between the two experiments. This experiment tested the magnitude of potential leaching of the peat soils during extended water storage periods

Methods

The entire demonstration wetland on Holland Tract was filled to a mean depth of approximately 0.8 m (2.5 feet) during the week of April 16, 1990, to simulate proposed DW storage operations. Composite water samples were collected from the pond's surface water and separately from the bottom on six dates between April 23, 1990, and July 25, 1990 (3-month period), according to procedures described previously for the flooded wetland experiment. The surface and bottom composite samples provided replicate measurements because stratification was not indicated.

Results

Flooded wetland water remaining from winter was mixed with Delta channel water to fill the wetland to capacity, resulting in initial pool concentrations of about 940 µS/m EC, 600 mg/l TDS, 80 mg/l alkalinity, 150 mg/l sodium, 230 mg/l chloride (Cl^-/EC = 0.24), 1 mg/l bromide (Br^-/Cl^- = 0.0044), 30 mg/l calcium, 25 mg/l magnesium, 43 mg/l sulfate, 250 color units, 30 mg/l TOC, and 150 µg/l C-THM (Table C3-3). MWQI measurements from Rock Slough on April 25 were generally less than the initial pool concentrations (Table C3-3).

The initial mixed concentrations may provide more accurate estimates of the areal load of TOC from the flooded wetland because the entire demonstration wetland area was inundated after being filled to the full water storage capacity. With a pond depth of 0.8 m and an increase in TOC concentration of 26 mg/l (from the channel concentration of 4 mg/l to 30-mg/l initial pool concentration), the TOC load was estimated at 21 g/m^2 (26 mg/l · 0.8m = 20.8 g/m^2). The C-THM load was estimated to be 0.1 g/m^2, based on a depth of 0.8 m and a 120 mg/l increase (from the channel concentration of 30 µg/l to the 150-µg/l initial pool concentration).

Additional siphoning of channel water was required to maintain the water storage depth, but Delta water quality improved during the storage period of mid-April through July, and as a result, EC values and concentrations of sodium, chloride, and bromide remained nearly constant (Figure C3-7). The constant levels of inorganic variables suggest that soil leaching with associated release of salts did not occur during the storage period.

Measurements also indicated that color and concentrations of calcium, magnesium, and TOC remained fairly constant during the storage period, suggesting that relatively little additional organic material was released from vegetation decay or peat soil leaching processes during the storage period (Figures C3-8 and C3-9). Sulfate concentrations declined by 50%. THMFP values also remained relatively constant, with a moderate increase in the C-THM component from about 150 µg/l to about 200 µg/l (Figure C3-10).

Conclusions of the Holland Tract Wetland Experiments

The seasonal water storage experiment results generally suggest that little additional increase in organic concentrations occurred in the water storage pool. Therefore, the overall TOC loading from the combined flooded wetland and water storage periods was estimated to be about 21 g/m^2 and the corresponding C-THM load about 0.1 g/m^2, most of which occurred during the vegetation decay period. These experiments indicate that the majority of loading was from vegetation decay; peat soil leaching was apparently a minor source of loading.

Measurements obtained from water temporarily stored on Tyler Island (cornfields) for the DWR emergency water bank in April and May 1991 provide another example of possible DOC loading for comparison. These measurements indicate that DOC concentrations in water stored for about 1 month increased by 50-60 mg/l. The estimated mean depth of the stored water was about 0.6 m (734 af/370 acres). Thus, estimated DOC loading was approximately 30-36 g/m^2. This loading is assumed to have originated from rapid vegetation decay and dissolving of surface organic residues, rather than prolonged leaching from peat, because the water was stored for only one month.

These experiments directly answered questions 1 and 2 (What water quality changes can be expected in flooded wetland habitat on DW project islands during October-January? What further water quality changes can be expected during the proposed water storage period of February-July?). The results of these experiments indicate that most of the available loading of DOC and other water quality variables from vegetation and surface soil residues will be released to water in the flooded wetlands during the initial flooding period. Very little, if any, additional release of materials will occur during the water storage period. This suggests that the surface vegetation and soil oxidation residues are the predominant source of DOC; peat soil leaching during water storage periods is a smaller potential source of DOC.

1992 WATER QUALITY EXPERIMENTS

Vegetation Decay Experiment

The 1992 vegetation decay experiment was designed to quantify the possible contribution of decaying wetland vegetation to dissolved organics and associated variables (especially UVA and THMFP) in ponded water in seasonal wetlands. This experiment was intended to verify the results from the 1990 experiments that indicated vegetation to be a major source of DOC.

Methods

Vegetation biomass samples (1-square-foot clippings) were collected on November 22, 1991, from the demonstration wetland on Holland Tract. The vegetation was dominated by smartweed, watergrass, and swamp timothy, similar to the vegetation cover of previous years. Biomass from 38 samples averaged about 435 g/m^2, and lignin content averaged 9.5% (determined by JL Analytical Services, Modesto, CA). Based on an assumed maximum carbon content in lignin of 50%, the carbon source from lignin was estimated to be about 20 g/m^2.

In comparison, plant material collected in 1989 at the demonstration wetland averaged 500 g/m^2 dry weight of biomass with 6% lignin content, for an estimated lignin carbon source of 15 g/m^2. The total corn shoot and grain biomass measured from Terminous Island was 4,000-4,500 g/m^2, and the shoot biomass was approximately 2,500-3,000 g/m^2 (Hoffman et al. 1983).

For the vegetation decay experiment, JSA filled five barrels with water obtained from Rock Slough on January 23, 1992. The barrels were situated outdoors at the JSA office in Sacramento. Approximately 1 gallon of pond water from the Holland Tract demonstration wetland was added to biologically inoculate each barrel with microorganisms.

Dried and pulverized wetland vegetation (as returned from JL Analytical Services) from the Holland Tract demonstration wetland was added to four of the five barrels on February 12, 1992. The fifth barrel (control barrel), with no vegetation biomass, served as a control for the experimental treatments. Each barrel had a bottom area of 2 square feet, a mean depth of 2 feet (0.6 m), and a volume of 4 cubic feet (30 gallons).

Two replicate barrels (barrels #1 and #2; 1X barrels) received approximately the biomass density measured in the wetland (500 g/m^2) and therefore simulated concentrations that would result from decay of vegetation in an average water depth of 0.6 m. The other two replicate barrels (barrels #3 and #4; 2X barrels) received twice the measured biomass density (1,000 g/m^2) and therefore simulated a pond of shallower depth (0.3 m), as illustrated in Figure C3-11. In comparison, the flooded demonstration wetland on Holland Tract in 1989 had an estimated mean depth of 0.5 m. Temporary water storage on Tyler Island in 1991 (part of the DWR emergency water bank) had a mean depth of 0.6 m. Concentrations in the 2X barrels (two times the areal load) were expected to be twice those in the 1X barrels (one times the areal load). Both sets of concentrations should yield the same areal loading estimates, as described below.

DWR commented in its June 23, 1992 letter that natural vegetation would not be pulverized and might therefore decay more slowly; because of this, the experiment could measure only the load (i.e., mass) of organic material dissolved in barrel water, not the rate of loading (i.e., mass per unit time). In this comment letter, DWR also expressed concern that water quality was not measured in all five barrels before vegetation was added, to demonstrate that they had the same initial water quality as the control barrel, which was sampled.

The vegetation decay experiment was designed to determine final differences in concentrations of dissolved organics between treatment barrels and the control barrel. Initial water quality was assumed to be the same in all barrels because all barrel water originated from the same source. Changes in water quality between sampling dates were only noted because they provided a means for determining when the concentrations of organic materials from the added biomass had stabilized. Therefore, it was concluded that measurements of initial water quality in all barrels were unnecessary.

Water samples were collected at 2-week intervals from the barrels on February 27, March 10, March 31, April 14, and April 29, 1992. Primary samples were analyzed by Anlab Analytical Laboratory (Anlab) in Sacramento. Duplicate samples from the barrels were sent to Stuart Krasner at MWD for analyses of several parameters of direct interest to MWD. Duplicate analyses allowed comparison of those variables analyzed by both laboratories.

This report uses only the THMFP values measured by MWD. The THMFP values determined by Cal-Enseco Laboratory, under a subcontract to Anlab, were unreliable and were rejected. THMFP values estimated by the MWD method, which used a reactivity-based chlorine (Cl^+) dose (3 x DOC + 8 x NH_3), must be adjusted (i.e., increased) to expected values for the standard 120 mg/l chlorine dose used by DWR, as described below under "Relationship between Dissolved Organic Carbon, Bromide, Chlorination, and Trihalomethane".

A large group of chemical parameters was measured in each sample. According to the study protocol, the vegetation decay experiment was to be terminated after 10 weeks if the organic loading calculated from sampled water concentrations had stabilized. Measurements of the two key organic variables (DOC and 254-nm UVA) had

stabilized and the experiment was terminated following the April 29, 1992 sampling.

In its comment letter on the draft report, DWR expressed concern that water quality concentrations had not stabilized because the ratio of UVA to DOC was still increasing. However, concentrations of DOC and UVA had remained approximately the same since the first samples were collected on February 27, 1992, 2 weeks after the vegetation was added. DOC and UVA values were both slightly higher in the fifth set of samples collected on April 29, 1992. Some portion of this increase was caused, however, by evaporation and a decreasing water volume in the barrels, as shown by the increased chloride and bromide measurements (see discussion of results below).

Results

Results of the chemical analyses by Anlab and MWD are shown in Table C3-4 through C3-6. Table C3-4 contains the results for the control barrel, Table C3-5 provides the results for the 1X barrels, and Table C3-6 shows the results for the 2X barrels.

In their comment letters on the draft report, MWD and DWR noted the high variability in many of the Anlab measurements. Although Anlab followed and reported standard quality assurance/quality control procedures, variability was substantial. The fact that these were outdoor experiments is not sufficient to explain the variations. MWD suggested that relatively simple anion-cation and EC checks might have alerted Anlab to measurement problems; Anlab did not use anion-cation balance as a quality assurance/ quality control measure.

Comparison of variables presented in Tables C3-4 through C3-6 can be used to determine the most likely interpretation of the measurements. In the case of parameters not showing excessive variability (20% of mean), differences observed between the treatment and control barrel samples can provide evidence of effects of vegetation decay. Some variables cannot be used to differentiate effects because the variability between measurements was too great. Similar results for related parameters increase confidence in the bulk of the data and support reliable conclusions.

Salts. Because all barrels were filled with the same water in January, salt concentrations in each barrel were expected to be similar and to remain relatively constant throughout the experiment. Sampling decreased the remaining water volumes but would not change salt concentrations in the barrels. Evaporation and rainfall could, however, change the salt concentrations in the remaining water.

Figures C3-12 and C3-13 show the chloride and bromide concentrations measured on the five sample dates in samples from the five barrels by Anlab and MWD. Ignoring the Anlab data from March 10, 1992, chloride varied from approximately 130 mg/l to 200 mg/l during the experiment, with the variation on each sample date usually less than 20 mg/l. Agreement between the Anlab and MWD data was best on the last sample date, with an average value of 180 mg/l (range of 170-190 mg/l). In the MWD data, chloride values increased by approximately 20% from 150 mg/l on February 27 to 180 mg/l on April 29, 1992, showing a moderate effect of evaporation.

Bromide concentrations ranged from 0.4 to 0.75 mg/l (Figure C3-13). Average bromide concentrations appear to have increased from about 0.60 to 0.70 mg/l because of evaporative effects (using MWD data). The average ratio of bromide to chloride (MWD data) was approximately 0.0030, slightly lower than the ratio for ocean water of 0.0035.

Other anions and cations were measured by Anlab only; measurements are shown in Tables C3-4, C3-5, and C3-6. Sodium values were quite similar for all five barrels on each sample date, ranging from about 80 mg/l to 110 mg/l during the course of the experiment. Sulfate values were more variable between barrels, with final concentrations between 30 mg/l and 40 mg/l. Sulfate concentrations may have actually decreased during the experiment. MWD commented that a sulfate decrease might have been the result of anaerobic processes that reduce sulfate and release hydrogen sulfide gas to the atmosphere.

Calcium and magnesium measurements were relatively uniform between sample dates. Calcium varied between 20 mg/l and 30 mg/l, and magnesium varied between 20 mg/l and 25 mg/l. The control concentrations of these cations, about 20 mg/l, were large compared with the possible increases resulting from vegetation decay. The final set of analyses indicated that calcium concentrations were 30 mg/l in the 2X barrels, compared with 20 mg/l in the control barrel. Magnesium concentrations were 25 mg/l in the 2X barrels, compared with 18 mg/l in the control barrel.

In its comment letter on the draft report, MWD suggested that calcium and magnesium concentrations might have been influenced by precipitation and dissolution processes caused by changing pH values. Because vegetation is known to contain moderate concentrations

of calcium (0.2-3.5%) and magnesium (0.1-1.0%), simple release from vegetative decay is also a possible explanation. The increased potassium concentrations discussed in the next section appear to confirm that the vegetation decay and release mechanism was the likely source of the calcium and magnesium increases.

Figure C3-14 shows the measurements of EC in the five barrels. These measurements suggest that vegetation may have released enough salts or nutrients to slightly increase EC values relative to the control barrel EC. On April 29, 1992, conductivity ranged from 800 μS/cm in the control barrel to 1,000 μS/cm in the 2X barrels.

Nutrients. Potassium concentrations showed the most dramatic increase as a result of vegetation decay because the potassium concentration of 5 mg/l in the control barrel was low relative to the measured increases from vegetation decay (Figure C3-15). By the final sampling date of April 29, 1992, potassium concentrations had increased to 17 mg/l in the 1X barrels (representing a 12-mg/l increase) and had increased to 27 mg/l in the 2X barrels (a 22-mg/l increase). Potassium may be a useful indicator for determining vegetation effects on water quality in the Delta because vegetation has a high potassium content (between 0.5% and 5.0%).

Substantial increases in organic nitrogen and total phosphorus were also observed. By the final sampling date, concentrations of organic nitrogen had increased by 20 mg/l in all barrels with vegetation added, and phosphorus concentrations had increased by almost 2 mg/l, representing a typical nitrogen-to-phosphorus ratio of 10:1 for vegetation. These high-nutrient concentrations could contribute to algal productivity and subsequent food chain processes.

An elemental analysis of the wetland vegetation was not obtained but elemental content may be calculated to confirm the apparent nutrient release concentrations. The content of potassium, calcium, and manganese in the wetland vegetation can be indirectly estimated in the following way. Because the 2X barrels had a biomass loading of 1,000 g/m^2 and a mean depth of 0.6 m, the concentration of total biomass, if completely dissolved, would be 1,000/0.6 = 1,667 g/m^3, which is equal to 1,667 mg/l. Therefore, 16.67 mg/l of any substance in the 2X barrels would represent 1% of the total biomass; similarly, 8.3 mg/l of any substance in the 1X barrels would represent 1% of the total biomass.

The final magnesium difference between the 2X barrels and the control barrel was about 8 mg/l, representing 0.5% of the total biomass. The final calcium difference was about 12 mg/l, representing 0.7% of the biomass. The potassium difference was 22 mg/l (Figure C3-15), representing 1.25% of the biomass. The nitrogen difference was about 25 mg/l, representing 1.5% of the biomass. The phosphorus difference was approximately 2 mg/l, representing 0.12% of the biomass. Each of these values is comparable with vegetation composition percentages for these elements cited in agricultural textbooks (see Table C3-7). These differences between the 2X barrel and control barrel mineral and nutrient concentrations therefore confirm that the observed water quality changes were the result of vegetation biomass decomposition. The 1X barrels showed similar changes.

Organics. Observed DOC concentrations were comparable in the two barrels at each biomass loading level (Figure C3-16), and most of the increase in concentration occurred within the first month. DOC concentration in Rock Slough water (control) was approximately 5 mg/l; the DOC concentration in the 1X barrels increased to about 15 mg/l by February 27, 1992, and remained at that level until April 29, 1992. DOC concentration in the 2X barrels increased to about 30 mg/l (according to the MWD data).

Based on the estimation of biomass content presented in the previous section, it might be expected that carbon, assumed to compose about 40% of the total biomass, would produce an increased DOC concentration in the 2X barrels of approximately 40 x 16.67 mg/l = 667 mg/l. However, not all carbon is converted to DOC: only about 25 mg/l (4%) of the possible increase in carbon was measured in the 2X barrels because some of the carbon remained in the vegetation detritus and most of the carbon was released as CO_2 during the decay processes. About 3% of the possible increase in DOC was observed in the 1X barrels (9 mg/l of DOC compared with 333 mg/l of biomass - C).

DOC analyses by MWD were generally quite similar to Anlab values, except for the 2X barrels (Figure C3-16). On the first sampling date, the MWD DOC measurements showed more than twice the increase in DOC for the 2X barrels than the Anlab measurements showed. In DOC procedures at both laboratories, samples are diluted so that a DOC concentration of less than 10 mg/l is measured, and measurements are then multiplied by the dilution factor to estimate the concentration in the sample. The scatter between the laboratories in data on the DOC concentrations from the 2X barrels is quite unfortunate because these are important measurements from the vegetation decay experiment. Fortunately, other measurements, described below, can be used to confirm the general results of the experiment.

Ultraviolet Absorption and Color. UVA appears to be an excellent measurement of organic content because it is known to exhibit a linear increase with DOC. The Anlab and MWD measurements of UVA were quite similar in the vegetation decay experiment. UVA in the control barrel remained at approximately 0.1 cm^{-1} throughout the experiment (Figure C3-17). UVA values for the 1X barrels were about 0.4 cm^{-1} on February 27, 1992, and increased slightly to 0.45 cm^{-1} by April 29, 1992. Much of this increase may be the result of evaporation, as indicated by similar increases in chloride and bromide (Figures C3-12 and C3-13). UVA values for the 2X barrels were about 0.6 cm^{-1} on February 27, 1992, and increased to more than 0.8 cm^{-1} in the last sample collected on April 29, 1992.

The ratio between UVA (cm^{-1}) and DOC (mg/l) was relatively constant at values of 0.02 to 0.03 in most samples (Figure C3-18). The low UVA/DOC ratio of 0.015 calculated by MWD for the 2X barrels on the first three sampling dates indicates that reported DOC values were higher than DOC values expected based on the corresponding measured UVA values. Data from the last measurement date for samples from all barrels (including the control) suggested that the average UVA/DOC ratio for organics from vegetation decay is between 0.025 and 0.030. Amy et al. (1990) found a UVA/DOC ratio of 0.025 for river samples and 0.045 for drainage samples. The ratio based on MWQI data from the Banks and Tracy Pumping Plants ranges from 0.025 to 0.035 (see Figure C1-9 in Appendix C1, "Analysis of Delta Inflow and Export Water Quality Data").

Color measurements were increased by vegetation decay, but the scatter in the data reported by Anlab makes these values less precise than the values from the UVA or DOC analyses. The control barrel had a color value of approximately 10 units. An increase of nearly 100 color units was associated with vegetation decay in the 1X barrels, and an increase of about 200 color units was observed in the 2X barrels.

Carbon Content of Trihalomethane. The carbon content of THM (C-THM) is equal to the molar concentration times 12. C-THM concentrations measured by MWD were quite consistent between the replicate barrels and among sample dates (Figure C3-19).

In its comment letter on the draft report, MWD stated that the chlorine dose used for the 2X barrels in the THMFP test was generally close to the 120 mg/l used in the standard DWR test procedure for THMFP. Samples from the control and 1X barrels were dosed, however, with considerably less than the 120 mg/l of chlorine used by DWR. An adjustment can be made to obtain estimates of the THMFP values that would be produced using the standard DWR test, as described below under "Relationship between Dissolved Organic Carbon, Bromide, Chlorination, and Trihalomethanes". However, the relative values from these MWD measurements of THMFP provide the basis for making an approximate comparison of the effects of vegetative decay on THMFP.

On April 29, 1992, the control C-THM concentration was approximately 50 $\mu g/l$, the 1X barrels had C-THM concentrations of about 150 $\mu g/l$, and the 2X barrels had C-THM concentrations of 300 $\mu g/l$. The C-THM concentration in the 2X barrels was approximately twice that of the 1X barrels (Figure C3-19). The data indicate that the increase in C-THM concentrations occurred within 2 weeks of initial loading of biomass into the barrels as determined from the control barrel concentrations. C-THM concentrations (and other measures of organic content) were judged by JSA to have stabilized sufficiently after 10 weeks for the experiments to be terminated as planned.

Figure C3-20 shows that the ratio of C-THM ($\mu g/l$) to DOC (mg/l) was very uniform, with a value of approximately 10 $\mu g/mg$ (range of 8-12 $\mu g/mg$) indicating that approximately 1% of the DOC had become THM molecules during the MWD test for THMFP.

Bromine Incorporation. Incorporation of bromine in THM molecules (Br-THM) from inorganic bromine can be estimated from the ratio of Br-THM to bromide ion (Figure C3-21). The ratio was approximately 40-50% in most samples.

Each THM molecule has three halogen sites. The bromine incorporation value is the average number of halogen sites occupied by bromine; the value (n) varies from 0 to 3. The value can be estimated as:

$$n = \frac{\text{Br-THM}/80}{3 \cdot \text{C-THM}/12}$$

$$= \text{Br-THM}/(\text{C-THM} \cdot 20)$$

where 80 and 12 represent the molar weights of bromine and carbon, respectively, and 3 represents the number of halogen sites.

The bromine incorporation value was about 0.27 for the control barrel, about 0.08 for the 1X barrels, and about 0.04 for the 2X barrels. Because the bromide concentration remained constant at about 0.4 mg/l in all barrels, it can be concluded that the bromine incorporation decreased as the total THMFP concentration increased.

Recent work by MWD and DWR (1992) suggests that bromine incorporation in THM molecules increases as a function of the ratio of chlorine dose to DOC (approximately 3.0 in the MWD measurements), and the ratio of bromide to DOC (0.015 to 0.030 in these experiments). DWR and MWD commented that the incorporation of bromine into THM molecules in actual drinking water will be higher than these experimental measurements, and therefore these bromine incorporation factors should not be used directly in the water quality assessment for the DW project (see Appendix C5, "Modeling Trihalomethane Production at a Typical Water Treatment Plant Using Delta Export Water", for further discussion). The estimation of bromine incorporation is described in the method for adjusting MWD and DWR measurements of THMFP under "Relationship between Dissolved Organic Carbon, Bromide, Chlorination, and Trihalomethanes", below.

Conclusions

Differences in final DOC concentrations between the two wetland vegetation treatments and the control observed in this experiment can be used to estimate the mass loading per surface area, as illustrated in Figure C3-11. For each treatment, the concentration difference from the control (in mg/l) times the mean depth (in m) is the equivalent loading per unit area (g/m^2). Areal loading estimates (g/m^2) can be converted to pounds/acre units by multiplying by 8.92. Using this approach, observed DOC loading from decaying wetland vegetation can be described relative to other DOC sources in the Delta.

This experiment directly answered question 3 (What is the expected contribution from decomposition of wetland vegetation to levels of DOC and associated variables?) and provided estimates of the contribution of vegetation to the areal loading of DOC and other water quality variables. DOC concentrations increased by approximately 9 mg/l in the 1X barrels and approximately 25 mg/l in the 2X barrels (Figure C3-16). Based on these concentration increases, areal DOC loading was calculated to be approximately 5.4 g/m^2 in the 1X barrels (i.e., 9 mg/l X 0.6 m = 5.4 g/m^2), and 40% higher, at 7.5 g/m^2, in the 2X barrels (i.e., 25 mg/l X 0.3 m = 7.5 g/m^2). The 2X barrels might provide the more accurate estimate because the change in concentration was greater and, therefore, analytical measurement errors would likely be a smaller percentage of the measured value. Comparing these results with those of the flooded wetlands experiments indicates that about 25% of the observed DOC loading of approximately 25 g/m^2-year may have been contributed from decay of fresh wetland vegetation.

Soil Water Extraction Experiment

The soil water extraction experiment was designed to quantify and compare potential concentrations of DOC and associated variables in soil samples collected from agricultural field and wetland locations in the Delta. This experiment does not quantify the actual release of these variables into Delta channels because the water movement through or from the soil water is not evaluated and the possible conversion or uptake of DOC within the soil column is not quantified. As a secondary objective, the chemical composition of the peat soil samples provided a general characterization of peat soil on Holland Tract.

Methods

Soil samples were collected on February 27, 1992, with a scoop from the soil surface and from the bottom of holes 2 feet (0.6 m) deep at two arbitrarily selected locations in the Holland Tract demonstration wetland and at two arbitrarily selected locations in an adjacent field that had been farmed during 1991. Thus, a total of eight soil samples were collected, two from each of the four locations. Each of the soil samples was then split into three 1-kilogram (kg) portions for saturated soil water extraction, as described below. Thus, a total of 24 samples were analyzed.

The standard agricultural soil "saturated paste" technique was used to extract soil water from the samples. In this technique, just enough water is added to saturate the soil sample. This technique is used to extract concentrations of soil water salts and nutrients to which crop roots would be exposed. The saturated extract concentrations of constituents should approximate soil water concentrations for saturated soil conditions. This technique was used in experiments on salt tolerance of Delta corn (Hoffman et al. 1983).

In the standard extraction technique, the soil paste is allowed to stand for 2 hours before the soil water sample is vacuum extracted for chemical analyses. For this experiment, saturated soil samples were also held for 7 days and 30 days to determine whether the extracted water concentrations would change with a longer saturation period. This was to test the hypothesis that peat soils may leach large quantities of materials, as a tea bag does.

Wet soil samples of approximately 1 kg were saturated with the addition of deionized water. The extracted water (250-500 milliliters [ml]) was diluted to obtain approximately 1.5 liters needed for chemical

analyses. The required dilution factors were recorded. The primary chemical analyses were made by Anlab. Subsamples from these diluted extract volumes were sent to Stuart Krasner at MWD. The MWD-measured DOC, UVA, and THMFP data from these subsamples are presented and described here. Tables C3-8 (wetland soils) and C3-9 (agricultural soils) show all chemical analyses of the eight soil samples for the three holding times.

In its comment letter on the draft report, DWR commented that the initial soil moisture content is an important variable for determining the original quantity of soil material. Anlab determined initial soil moisture in the samples by drying a subsample of the soil. The solids content (percentage) and the volatile solids fraction (percentage) of the dry soil material were both measured for each sample. The moisture content can be calculated by subtracting the solids percentage from 100%. The initial water weight (in grams) is another expression of the moisture content in the initial weight of wet soil (grams). These soil moisture values are listed in Tables C3-8 and C3-9.

The extracted percentage of the total water and the carbon content of the soil were calculated for comparing and normalizing concentrations. The total water in the saturated soil sample is the original water content plus the added deionized water required to saturate the sample. The extracted fraction of the total soil water is the actual volume obtained following vacuum extraction. The carbon content of the soil was estimated from the initial (dry) weight of organic matter (volatile solids) in the soil, assuming a carbon content of 40% (average carbon content of organic materials). The percentages of solids, volatile solids, and extracted water volumes were quite consistent between the three holding-time treatments for each soil sample.

Results

The results of the soil analyses and the soil water extract concentrations for the three holding times are compared for groups of related parameters. Because separate soil subsamples were used for the three holding-time treatments, some variability in the soil properties and extracted water concentrations was expected. The mass of DOC or other chemical constituent in the saturated soil water volume can be calculated by multiplying the concentration observed in the extracted volume by the total estimated soil water volume (extract volume/percent water extracted/100).

Soil Properties. The wet weight and the dried weight for each soil extract sample were used to estimate the initial water weight (and volume) of each sample. The solids content varied from about 30% to 60%, which is typical of peat soils (Buckman & Brady 1960).

The initial volume of soil water was calculated from the weight of initial water (assuming 1 ml/g). The volume of water added to saturate the soil sample was recorded, and the total volume of water in the saturated sample was calculated. The extracted volume was recorded, and the portion of the total soil water volume represented by the extracted volume was calculated. The extracted portion of the total saturated soil water volume varied from about 25% to 50%. The remainder is retained in the soil under the vacuum conditions used for extraction.

The organic content of the soil samples was estimated from the volatile solids fraction and varied from 20% to 60% (Figure C3-22), which is typical of peat soils (Buckman & Brady 1960). The estimated mass of organic carbon in the soil samples was calculated, based on the assumption that 40% of the organic content of the soil was carbon, and ranged between 30 g and 90 g. This soil organic carbon content value was used to determine the fraction of soil organic carbon measured in the extracted water DOC.

Organics. DOC concentrations in the extracted water did not consistently increase with longer holding times (Figure C3-23). Some concentrations differed a great deal between the three holding-time treatments, but this variability between replicate soil samples was expected because they were separate subsamples. The highest DOC concentrations and the greatest differences between soil samples were observed in the two surface agricultural soil samples. Although other samples had DOC concentrations between 30 mg/l and 90 mg/l, the agricultural surface samples had DOC values between 110 mg/l and 240 mg/l. These soil water concentrations represent the highest possible DOC concentrations in drainage water from these soil samples because drainage processes would normally provide some dilution of these soil water concentrations.

Ultraviolet Absorption. The UVA values for the extracted water samples showed a similar pattern (Figure C3-24), with no consistent increases related to holding time. The UVA values were generally similar (1-2 cm^{-1}) for all the bottom samples and the surface wetland soils. The UVA values were much higher (4-12 cm^{-1}) for the surface agriculture soils. These represent the highest possible UVA values in drainage or leaching

water from these soil samples because drainage processes would provide some dilution of these values.

Figures C3-23 and C3-24 indicate that the Anlab and MWD measurements for both DOC and UVA from the soil extract samples were quite similar, increasing confidence in the general results of this experiment.

The ratios of UVA to DOC were similar for all wetland and bottom agricultural samples, with values generally of 0.025-0.040 (Figure C3-25), similar to the ratios from barrel sample measurements from the vegetation decay experiment (Figure C3-18). The surface agricultural samples gave UVA/DOC values greater than 0.04. Amy et al. (1990) reported that the UVA/DOC ratio for river inflow water was about 0.025 and for several Delta agricultural drainage samples averaged 0.045.

DWR's comment letter suggested that the ratio of UVA to DOC may indicate the reactivity of the DOC material to form THM. UVA, rather than the more general DOC measurement, has been used in other studies to indicate the presence of reactive THM precursors (suspected to be fulvic and humic acids). If the ratio between UVA and DOC is slightly different for each source of DOC, possible source variation in the yield of THM from DOC can be estimated by using this UVA measure. Therefore, UVA may provide a much simpler measurement and perhaps a more direct index of THM precursors.

Delta peat soils appear to have somewhat higher UVA/DOC ratios (0.025-0.060 in Figure C3-25) than decaying vegetation samples (0.025-0.030 in Figure C3-18). In comparison, DWR MWQI data for 1990-1991 showed that samples of Delta export water had UVA/DOC ratios of 0.025-0.035, whereas the Sacramento River has lower UVA/DOC ratios of 0.020-0.025. MWQI data for 1990-1991 from agricultural drains on the DW project islands (Bouldin and Bacon Islands and Webb and Holland Tracts) had average UVA/DOC ratios of 0.035-0.050. UVA values may therefore differ slightly between water from wetlands (fresh vegetation) and from agricultural (soil and organic residue) drainage, with agricultural drainage contributing higher UVA values for the same DOC concentration.

Ratio of Dissolved Organic Carbon to Soil Organic Carbon. DOC measurements in the extracted water can be compared with the estimated soil sample organic carbon content (actual carbon content measurements were not included in study design) to provide an index of the fraction of the organic carbon in the soil that is dissolved as DOC. If the total DOC mass (mg) in the saturated soil water volume is compared with the TOC content of the soil sample (g), the relative magnitude of the potential source of DOC from these soil samples can be indexed and comparatively assessed. Measurement of the soil-sample carbon content should be made in future tests of this sort.

Soil sample carbon content was estimated from the measured volatile solids fraction, based on an assumed carbon content of 40%. For example, the first column of Table C3-8 indicates that the 2-hour holding time sample from the surface of wetlands site 1 had an initial weight of 1,200 g, a solids content of 58%, and a volatile solids content of 28%. The soil sample is calculated to have a carbon content of 78 g (1,200g · .58 · .28 · .40 = 78g). The corresponding ratio of DOC to soil organic carbon was 0.39 mg/g (30mg/78g = .39 mg/g).

In this experiment, the bottom samples from all four locations had similar ratios of DOC to soil organic carbon of 0.4-0.8 milligrams per gram (mg/g), suggesting that only 0.04% to 0.08% of the soil organic carbon is dissolved in the soil water (Figure C3-26). The surface wetland samples also had similar ratios of DOC to soil organic carbon of 0.4-0.8 mg/g. In contrast, the surface agricultural soil samples had ratios of DOC to soil organic carbon of 1.0-2.2 mg/g. The magnitude of these ratios suggests that only a very small fraction of the soil organic carbon is readily dissolved in the saturated soil water, even with a holding time of 30 days. The ratios of DOC to carbon in surface agricultural soil samples of 1-2 mg/g suggest that only 0.1% to 0.2% of the organic carbon in the soil samples is dissolved in the soil water. The availability of DOC is considerably greater (two to three times) in the surface agricultural soils than in the wetland soils or deeper agricultural soils.

Carbon Content of Trihalomethane. Figure C3-27 shows the C-THM values measured by MWD. By calculating the C-THM/DOC ratio, the yield of C-THM from DOC can be determined. As shown in Figure C3-28, the C-THM/DOC ratio was between 4.5 μg/mg and 9 μg/mg, suggesting that about 0.5-1.0% of the DOC becomes THM molecules during the THMFP assay performed by MWD. These ratios for the soil extract samples are similar to those obtained by MWD for the vegetation decay experiment samples (7-12 μg/mg, or 0.7-1.2%), as shown in Figure C3-20.

Recent work by DWR and MWD indicates that the yield of C-THM from DOC depends on the strength of the chlorine dose relative to the DOC concentration (DWR 1992). This relationship is described below, under "Relationship between Dissolved Organic Carbon, Bromide, Chlorination, and Trihalomethanes". The

MWD technique, however, uses a constant chlorine-to-DOC ratio of about 3. The similar C-THM/DOC ratios from the vegetation and soil experiments suggest that the reactivity of DOC to form THM molecules during chlorination is generally similar for both vegetation decay and soil extract sources of DOC.

MWD commented on the draft report that the similar relative yield of C-THM from DOC for both agricultural and wetlands soils emphasized the need to quantify the mass balance of DOC from Delta soils under alternative land management practices. The greater concentrations of DOC in agricultural soils are only significant if the DOC concentrations are leached and transported to the Delta drains by agricultural water management. These soil water measurements suggest that the maximum possible DOC concentrations in drainage water from agricultural surface soils are considerably higher than concentrations from wetland or subsurface soils. Because it is likely that the movement of water through the agricultural soils during irrigation and salt leaching is greater than the movement through wetland soils, the mass of DOC from agricultural soils is likely to be higher than from wetlands. However, these DOC mass measurements were not made in this experiment.

Salts. Extract concentrations of salts were somewhat variable among the soil samples and the holding-time treatments, as shown for the general variables of TDS and EC in Figure C3-29. The agricultural-2 samples had extremely high salt concentrations. Calcium and magnesium showed a similar pattern, with variations not related to the extract holding time. Individual anions and cations generally show constant ratios in each soil sample, independent of the saturated holding time. Salt concentrations did not show consistent increases with saturation holding time, perhaps because soluble salts are readily available and dissolve quickly.

pH. DWR recommended that reduction-oxidation (redox) potential be measured for each soil sample to demonstrate the general chemical conditions for each sample. Alternatively, the pH of a soil water extract provides an indication of the general chemical conditions of the soils. Table C3-9 indicates that extracts from all agricultural soil samples had pH values between 5.6 and 6.6. The surface wetland soil extracts had pH values between 5.0 and 5.6, and the bottom (2-foot-deep) wetland soil extracts had the lowest pH values, between 4.5 and 5.1 (Table C3-8). These pH values generally confirm the hypothesis that agricultural soils would be more oxidized (with higher pH) than wetland soils and may therefore contribute more DOC than wetland soils would contribute to Delta waters.

Conclusions

The soil sample extracts provide a relative index of the potential for soil drainage or leaching to contribute to UVA, DOC, minerals, and nutrients in drainage or ponded water. This experiment generally confirmed the hypothesis that surface agricultural soils constitute the greatest potential source of DOC and that wetlands soils are less of a potential source than agricultural soils. This provides an answer for question 4 (What are the relative contributions of DOC and associated water quality variables from agricultural and wetland soils?): agricultural surface soil has approximately twice the DOC yield index as wetland soils (Figure C3-26).

Salts, UVA, and DOC (humic material) appear to be rapidly dissolved from the soil matrix into the saturated water. The potential contribution of these materials from different soils can be determined from the soil water extraction procedure demonstrated with this experiment, but the actual movement of these materials from soils into drainage or leaching water depends on water movement and other factors that were not addressed by these experiments.

The ratio of DOC to soil organic carbon provides an appropriate index for comparing the potential DOC contribution from soils, but the actual amount of DOC released from the soils cannot be determined unless it is known what volume of soil water is removed during agricultural practices or is leached into a flooded wetland or storage water volume. It does appear, however, that wetland soils would yield lower DOC loading than agricultural soils if a similar volume of soil water were extracted during agricultural practices and wetland flooding.

Similar experiments might be performed to characterize the potential for release of DOC from other Delta soils. It appears that the basic 2-hour holding time is sufficient to obtain representative extract water concentrations for salts and organics. The similarity between the 2-hour measurements and 7-day and 30-day measurements suggests that the DOC contribution from peat soils does not increase with holding time. These soil extract water concentrations characterize the potential sources of organics from the soil matrix but cannot be directly used to estimate the loading to agricultural drainage water or to flooded wetlands or storage water.

RELATIONSHIP BETWEEN DISSOLVED ORGANIC CARBON, BROMIDE, CHLORINATION, AND TRIHALOMETHANE

One of the major purposes of measuring the contributions to Delta waters of DOC from Delta agricultural and wetland islands is to calculate the increase in DOC at the Delta export locations and estimate the anticipated THM concentrations in treated drinking water resulting from these increases. Increased bromide concentrations during periods of seawater intrusion or from San Joaquin River sources may also affect the anticipated THM concentrations in treated drinking water. Two basic methods can be used to estimate the THM concentrations in treated drinking water:

- Predict THM based on levels of basic water quality variables and the expected chlorination dose and time in the water treatment plant, using a regression equation developed from previous THM tests. This is the method used in the EPA water treatment plant (WTP) THM model (Appendix C5, "Modeling Trihalomethane Production at a Typical Water Treatment Plant Using Delta Export Water").

- Estimate the THMFP from a chemical assay procedure to identify the relative potential to form THM (but not the actual THM concentration). This is the method used by DWR in its THMFP assay for Delta channel water and drainage water and the method used by MWD in its simulated distribution system (SDS) assay.

Following the analysis of available DWR and MWD data and the experimental results described in this appendix, a generalized method for estimating THM concentrations for any combination of DOC, bromide, and chlorination dose has been developed that is sufficiently accurate for impact assessment purposes. This generalized method provides a conceptual framework for understanding the yield of C-THM from DOC and the incorporation of bromine into the THM molecules. This method is applicable for the full range of possible chlorination doses, and therefore can be used to predict THMFP assay, SDS assay, or actual treatment plant THM data. Figure C3-30 illustrates the method for estimating THM concentrations from DOC, bromide, and chlorination (Cl^+) dose.

Yield of C-THM from Dissolved Organic Carbon

The first step in the generalized method is to describe the expected yield of C-THM from the DOC concentration. The DWR MWQI data for Delta water indicates that the yield of C-THM is approximately 1-2% of the DOC concentration. However, it is recognized that this THM yield is a function of chlorine dose and is therefore much lower in the SDS assay or actual treated water than in the THMFP assay.

The THMFP assay used by DWR MWQI to estimate the THMFP of Delta water and agricultural drainage uses a relatively strong initial chlorine dose (120 mg/l Cl^+) with an incubation time of 7 days at 25°C (DWR 1992). The ratio of chlorine to DOC would be 40:1 for low DOC concentrations (3 mg/l) and would decrease to 4:1 for high DOC concentrations (30 mg/l). The SDS assay, used by MWD to estimate actual distribution system THM concentrations, uses a variable chlorination dose ($3 \times DOC + 8 \times NH_3$) to oxidize the ammonia and provide a chlorine-to-DOC ratio of about 3:1 at 25°C (Symons et al. 1993). Actual chlorine doses at typical water treatment plants may be characterized by a chlorine-to-DOC ratio of less than 1 (Appendix C5, "Modeling of Trihalomethane Production at a Typical Water Treatment Plant Using Delta Export Water").

Results from several special THMFP and SDS assays with variable chlorine doses performed by MWD and DWR (DWR 1992) suggest that the yield of C-THM would increase rapidly at low chlorine-to-DOC ratios and level off at relatively high chlorine-to-DOC ratios. A half-saturation curve was tested as a reasonable way to describe this tendency for the C-THM yield to saturate at high chlorine doses. The yield of C-THM as a percentage of DOC was estimated as a function of the chlorine-to-DOC ratio that was used as the chlorine saturation variable.

The maximum yield of C-THM was estimated as 2%, based on the maximum yield observed in the MWQI Delta channel data, having chlorine saturation values (120/DOC) of greater than about 20 (see Figure C1-8 in Appendix C1, "Analysis of Delta Inflow and Export Water Quality Data"). The half-saturation value for chlorine saturation could not be estimated from the MWQI Delta channel data, because few of these samples had low chlorine saturation values. The MWQI agricultural drainage samples, however, had much lower chlor-

ine saturation values (1-20) because the DOC concentrations were much higher in these samples. The chlorine saturation value that gives a C-THM yield of 1% DOC is the half-saturation coefficient. This coefficient was estimated as a chlorine-to-DOC ratio of approximately 5. The yield of C-THM is therefore estimated as:

$$\text{C-THM/DOC (\%)} = 2 \cdot Cl^{+}/DOC/(5+Cl^{+}/DOC)$$

This relationship was then tested with the MWD SDS data, which represented relatively low chlorine saturation values (1-3). All three data sets generally followed (with considerable scatter) this estimated half-saturation curve for C-THM yield. (Figures 3C-31 [channels], 3C-33 [drains], and 3C-35 [SDS]).

Bromine Incorporation

The second step in the general method to estimate THM concentrations is to calculate the bromine incorporation (n), with a value between 0 and 3, as a function of the bromine saturation, defined as the molar ratio of bromine to THM halogen sites (3 · THM). Another half-saturation relationship between the bromine incorporation and the bromine saturation variable was tested as a reasonable way to describe this bromine saturation. The bromine saturation value is calculated as:

$$\text{Br saturation} = \frac{Br/79.9}{3 \cdot \text{C-THM}/12}$$

$$= Br/(\text{C-THM} \cdot 20)$$

The maximum possible bromine incorporation value is 3, so the half-saturation coefficient was estimated as the bromine saturation value that gave a bromine incorporation (n) of 1.5. This half-saturation coefficient was approximately 2. The half-saturation curve for bromine incorporation (n) is:

$$n = 3 \cdot \text{Br saturation} / (2 + \text{Br saturation})$$

The bromine concentration was estimated for some samples without bromine measurements as 0.0035 · chloride, using the ocean ratio of bromide to chloride. All MWQI and MWD data generally follow (with some scatter) this bromine incorporation curve (Figures 3C-32 [channels], 3C-34 [drains] and 3C-36 [SDS]).

Trihalomethane Concentration

The third step in the general method to estimate THM concentration is to calculate the final THM concentration from the C-THM and bromine incorporation (n) estimates. With no bromine incorporation (n=0), the THM molar weight is 119 g/mole. With complete bromine incorporation (n=3), the THM molar weight is 252.5 g/mole, for an incremental molar weight of 44.5g for each integer of bromine incorporation (n). The THM concentration is therefore:

$$\text{THM } (\mu g/l) = \text{C-THM}/12 \cdot (119 + n \cdot 44.5)$$

Trihalomethane Species

A simple probability calculation can be used to estimate the concentration of individual THM molecules (Hutton and Chung 1994). Because the probability that any one halogen site is occupied by bromine is n/3, the probability that a site is occupied by chlorine is 1-n/3. The distribution (fraction) of THM species can then be estimated as:

$$CHCl_3 = (1-n/3)^3 = 1 - n + 1/3\, n^2 - 1/27\, n^3$$

$$CHBrCl_2 = 3\,(1-n/3)^2\,(n/3) = n - 2/3\, n^2 + 1/9\, n^3$$

$$CHBr_2Cl = 3\,(1-n/3)\,(n/3)^2 = 1/3\, n^2 - 1/9\, n^3$$

$$CHBr_3 = (n/3)^3 = 1/27\, n^3$$

Figures C3-31 and C3-32 show the DWR MWQI Delta channel measurements of C-THM yield and bromine incorporation (n). These data have relatively high chlorine-to-DOC ratios and provide an estimate of the maximum yield of C-THM from DOC of about 2%. There is certainly a great deal of scatter about the proposed chlorine saturation curve, caused by possible variations in the assay conditions or deviations from the general saturation curve.

The bromine incorporation curve for the DWR MWQI Delta channel measurements follows the proposed bromine saturation curve through the entire range of bromine saturation, including some high bromide concentration samples from Mallard Island.

Figures C3-33 and C3-34 show the DWR MWQI Delta agricultural drainage measurements of C-THM yield and bromine incorporation (n). These data have lower chlorine-to-DOC ratios and provide an estimate of the half-saturation coefficient for chlorine saturation of about 5. The C-THM yield appears to be limited at lower chlorine-to-DOC ratios, confirming the general saturation curve description. There is certainly a great deal of scatter about the proposed chlorine saturation curve, caused by possible variations in the assay conditions or deviations from the general saturation curve.

The bromine incorporation curve for the DWR MWQI Delta agricultural drainage measurements follows the proposed bromine saturation curve in the lower range of bromine saturation, caused by much higher C-THM formation with relatively little bromide concentration in the samples.

Figures C3-35 and C3-36 show the MWD SDS assay results for C-THM yield and bromine incorporation (n) from Delta water. These data have much lower chlorine-to-DOC ratios and are more representative of actual water treatment plant conditions. The C-THM yield appears to be definitely limited at these low chlorine-to-DOC ratios, confirming the general chlorine saturation curve description and the half-saturation coefficient for chlorine saturation of approximately 5. There is some remaining scatter about the proposed chlorine saturation curve, caused by variations in the assay conditions (incubation time and temperature) or deviations from the general saturation curve.

The bromine incorporation curve for the MDW SDS assay results for Delta water, including some bromine spike experiments, follows the proposed bromine saturation curve throughout the range of bromine saturation, caused by much lower C-THM formation compared with the available bromide concentration in the samples.

These three independent data sets of THM assay measurements provide some confirmation of the general conceptual framework for estimating THM concentrations from the DOC, bromide, and chlorination conditions. This method can-be used for assessment of the potential effects of DW project discharges on Delta channel DOC concentrations and the expected change in THM concentrations in treated drinking water exported from the Delta. It therefore can be used for mitigation monitoring of DW discharges to prevent significant adverse impacts on treated drinking water THM concentrations.

SUMMARY OF RESULTS

The water quality experiments described in this appendix demonstrate that concentrations of organic THM precursors are consistently related to concentrations of other nutrients and minerals in the Delta. Vegetation and soils in the Delta each have characteristic chemical compositions that produce distinctive residual chemical compounds during decay and oxidation.

Many of the observed relationships among these organic variables are similar to those described by the DWR MWQI data from Delta channels and agricultural drains (see Appendix C1, "Analysis of Delta Inflow and Export Water Quality Data", and Appendix C2, "Analysis of Delta Agricultural Drainage Water Quality Data"). DOC is the major variable of concern as a measurement of organic THM precursors produced from vegetation and peat soils. DOC exhibits consistent relationships with UVA and C-THM. The consistent relationships among these variables provide a solid basis for developing impact assessment models and for specifying mitigation monitoring requirements for DW operations.

The vegetation decay experiment in 1992 demonstrated that little (approximately 3-4%) of the organic carbon produced by decaying vegetation remains in the water as DOC; most is lost as CO_2 during aerobic decomposition. Most of the minerals (calcium, magnesium, and potassium) and nutrients (nitrogen and phosphorus), however, remain dissolved in the water in concentrations that reflect the original plant composition.

DOC concentrations produced by decaying vegetation may be most closely related to the lignin content of the vegetation. The observed DOC load produced by wetland vegetation was estimated to be between 5 g/m^2 and 7.5 g/m^2. The expected DOC load from corn crop residues left in agricultural fields is estimated to be approximately four times as much, based on a much larger biomass, with approximately the same lignin content. Contributions of DOC from corn crop residues in the Delta have not been measured directly.

The 1992 soil water extraction experiment demonstrated that little (less than 0.2%) of the organic carbon in Delta peat soils was dissolved in the soil water. The ratio of DOC to soil carbon was greater (two times), however, in surface samples from the agricultural field than in the deeper samples from the agricultural field or in samples from the demonstration wetland. This experiment indicated that the availability of DOC in soil water is greater in surface peat soils under agricultural conditions than in wetland soils.

The 1989-1990 flooded wetland and seasonal water storage experiments in the Holland Tract demonstration wetland indicated a DOC load in the wetland of approximately 25 g/m^2. Apparently, almost all this DOC load originated from the vegetation and surface residues on the wetland soil; the DOC load did not increase substantially during the 3-month water storage period from peat soil leaching. The vegetation experiment DOC estimate of 5-7.5 g/m^2 indicated that decay of fresh wetland vegetation may account for only 25% of the estimated DOC load from the wetland. Therefore, the remainder must have originated from surface peat soil oxidation or vegetation residues from previous growing seasons.

A direct estimate of DOC load from agricultural drainage on Holland Tract or any other Delta island is not available because the MWQI does not yet have access to drainage volumes to combine with the DOC concentration measurements. For the EIR/EIS impact assessment, the probable DOC load conditions for the DW project and for no-project agricultural drainage from the DW islands must be estimated.

Because direct measurements are not available, the most reasonable procedure for assessing the potential effects of DW project operation on DOC is to combine available measurements in a conceptual model of Delta island agricultural water and salt management. Such a model can then be used to estimate drainage quality for the Delta agricultural islands and DW project islands. Such a conceptual model of Delta agricultural water management, salt balance, and organic carbon cycle is presented in Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model". Potential effects of Delta export water quality (especially bromide and DOC concentrations) on THM concentrations in treated drinking water are presented in Appendix C5, "Modeling of Trihalomethane Production at a Typical Water Treatment Plant Using Delta Export Water".

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Table C3-1. Demonstration Wetland Biomass Composition Compared with Bouldin Island Corn Biomass Composition

Sample	Dry Weight (gram)	Cellulose (percent)	Hemi-cellulose (percent)	Lignin (percent)	Biomass (ton/acre)	Biomass (kg/sq. m)	Lignin (kg/sq. m)
Holland Tract Demonstration Wetlands Vegetation Samples[a]							
October 1989							
1	107	35.4	27.7	4.6	1.71	0.38	0.02
2	153	36.2	28.2	4.0	2.45	0.55	0.02
3	130	33.6	24.3	5.7	2.08	0.47	0.03
4	184	32.9	27.4	5.5	2.94	0.66	0.04
5	191	28.5	35.5	4.0	3.06	0.68	0.03
6	260	25.6	30.4	6.6	4.16	0.93	0.06
7	123	22.9	34.4	3.8	1.97	0.44	0.02
8	197	37.9	22.8	5.8	3.15	0.71	0.04
Average	168.1	31.6	28.8	5.0	2.69	0.60	0.03
November 1989							
1	82	35.4	27.0	4.2	1.31	0.29	0.01
2	129	35.4	26.0	4.2	2.06	0.46	0.02
3	108	35.8	21.1	7.4	1.73	0.39	0.03
4	116	38.3	25.6	4.7	1.86	0.42	0.02
5	204	32.2	28.2	5.7	3.26	0.73	0.04
6	126	34.7	20.7	10.9	2.02	0.45	0.05
7	112	37.7	25.2	6.6	1.79	0.40	0.03
8	222	40.8	23.2	5.5	3.55	0.80	0.04
Average	137.4	36.3	24.6	6.2	2.20	0.49	0.03
January 1990							
1	83	36.7	26.6	5.1	1.33	0.30	0.02
2	71	39.7	26.9	3.8	1.14	0.25	0.01
3	114	36.5	21.9	8.3	1.82	0.41	0.03
4	103	41.6	27.7	4.9	1.65	0.37	0.02
5	168	30.1	30.1	7.8	2.69	0.60	0.05
6	71	33.3	25.0	6.3	1.14	0.25	0.02
7	143	37.6	23.9	6.8	2.29	0.51	0.03
8	148	40.7	24.5	6.8	2.37	0.53	0.04
Average	112.6	37.0	25.8	6.2	1.80	0.40	0.03
Grand Average	139.4	35.0	26.4	5.8	2.23	0.50	0.03
Bouldin Island Corn Stalks[b]							
November 1989							
1	201	42.2	29.9	7.2	6.6	1.5	0.11
2	213	40.7	27.9	7.1	7.0	1.6	0.11
3	280	36.8	28.8	7.4	9.2	2.1	0.15
Average	231	39.9	28.9	7.2	7.6	1.7	0.12

[a] Each sample was composite of three 1-ft^2 clip plots of aboveground biomass. Species composition varied and was dominated by watergrass and smartweed. Samples 1-4 were flooded vegetation; samples 5-8 were dry vegetation.

[b] Each sample was one stalk with roots but without the ear. Corn is planted at a density of 30,000 stalks per acre.

Table C3–2. Water Quality of the Holland Tract Demonstration Wetland during the Flooded Wetland Period of October 1989–January 1990

Variables	Units	Rock Slough at Old River Oct 2	Composite Inflow Oct 19	Sampling Dates										
				Nov 3	Nov 10	Nov 17[a]	Nov 17[a]	Nov 30	Dec 8	Dec 15	Dec 22	Dec 29	Jan 5	Jan 15
Water depth gage	inches		NA	NA	23.25	22.25		23.75	23.75	23.25	23.00	23.00	23.25	24.75
Field temperature	°C		21.0	NA	14.0	11.0		10.5	9.5	9.5	5.3	6.3	7.8	11.5
TOC[b]	mg/l	3.5	4.3	14.3	16.9	20.4	20.4	30.7	32.0	32.1	35.6	38.6	37.5	38.4
Color	units	20	NA	100	200	200	150	240	350	350	300	310	325	250
pH	units		7.8	6.6	8.2	6.8	6.9	6.8	6.9	6.8	7.0	7.0	7.0	7.1
EC	µS/cm	520	677	826	809	831	840	816	891	737	725	746	715	680
TDS	mg/l		556	590	501	511	485	578	557	570	471	415	456	434
Chloride	mg/l	97	177	188	169	202	197	187	178	191	172	158	159	175
Sulfate	mg/l		30	65	66	80	78	105	88	99	97	92	90	83
Nitrate–N	mg/l		0.31	<.05	<.05	<.05	<.05	<0.5	<0.5	<.05	<.05	<.05	<.05	<.05
Bromide	mg/l		0.55	0.61	0.64	0.68	0.67	0.58	0.56	0.62	0.65	0.60	0.54	0.57
Alkalinity	mg/l		67	58	60	66	66	66	72	68	73	77	72	81
Calcium	mg/l		18	27	29	29	33	36	38	36	40	40	40	38
Magnesium	mg/l		18	22	23	22	24	27	27	26	28	28	27	26
Sodium	mg/l	62	97	106	108	110	114	111	113	104	108	104	101	102
Chloroform	µg/l	250	130	1,500	1,300	1,800	1,800	3,500	2,900	2,800	3,300	2,300	2,800	2,600
Bromodichloroform	µg/l	83	120	320	240	250	230	400	470	350	320	250	390	320
Dibromochloromethane	µg/l	82	130	42	33	25	24	50	47	32	42	19	30	37
Bromoform	µg/l	9	24	ND	ND	ND	ND	4	ND	ND	ND	ND	ND	ND
THMFP	µg/l	424	404	1,862	1,573	2,075	2,054	3,954	3,417	3,182	3,662	2,569	3,220	2,957
C–THM	µg/l	40	33	193	164	220	218	420	359	338	391	274	341	314
Cl–THM	µg/l	272	189	1,480	1,266	1,714	1,705	3,296	2,791	2,648	3,082	2,158	2,665	2,458
Br–THM	µg/l	112	182	189	143	142	131	238	266	196	189	137	214	185

Notes:
NA = Not analyzed.
ND = Not detected.
[a] Replicate samples.
[b] Organic carbon measured in this experiment is assumed to be dissolved; therefore, TOC is equivalent to DOC.

Table C3–3. Water Quality of the Holland Tract Demonstration Wetland during the Seasonal Water Storage Period of April–July 1990

Variables	Units	Rock Slough at Old River	Surface Samples						Bottom Samples					
		April 25	April 23	May 7	May 18	June 4	June 25	July 25	April 23	May 7	May 18	June 4	June 25	July 25
Water depth gage[a]	inches		53	58	57	56	52	56						
Field temperature	°C		19.5	22	21	21.8	23.5	26	19.3	22	21	21.5	23	23.5
Field dissolved oxygen	mg/l		6	5.5	5.8	6.8	6.8	8.8	5.5	4.3	5.8	6.4	6.2	6.6
Secchi depth	feet		2.9–3.1	1.9–2.8	3.1–3.4	3.0–3.5	3.0–4.0	3.2	2.9–3.1	1.9–2.8	3.1–3.4	3.0–3.5	3.0–4.0	3.2
TOC[b]	mg/l	3	30	32	32	33	31	31	29	32	31	32	31	31
Color	units	20	250	200	250	200	200	200	250	250	250	200	225	200
pH	units		7.5	7.7	7.6	7.8	7.6	7.7	7.6	7.7	7.7	7.7	7.6	7.8
Organic nitrogen	mg/l		1	1.5	1.5	1.1	1.5	1.3	1.9	1.5	1.4	1.3	1.2	1.5
Ammonia–N	mg/l		0.58	0.59	0.41	0.53	<.1	0.14	0.58	0.62	0.44	0.5	0.35	0.13
Total phosphorus	mg/l		0.18	<.05	<.05	<.05	<.05	0.07	0.2	<.05	<.05	<.05	<.05	0.15
Ortho phosphorus	mg/l		0.1	<.05	<.05	<.05	<.05	<.05	0.11	<.05	<.05	<.05	<.05	<.05
EC	µS/cm	864	938	940	988	964	955	807	937	938	984	965	965	803
TDS	mg/l	466	605	607	622	637	590	485	584	636	617	582	575	538
Chloride	mg/l	195	229	260	243	238	235	211	226	268	242	242	238	202
Sulfate	mg/l	39	43	43	40	38	33	23	43	43	40	39	34	23
Nitrate–N	mg/l	1.2	0.12	0.19	0.19	0.16	<.05	<.05	0.12	0.2	0.18	0.16	<.05	<.05
Bromide	mg/l	0.66	0.97	1	0.9	0.92	0.96	0.98	0.98	1	0.89	0.93	1	0.99
Alkalinity	mg/l	65	82	92	92	93	102	104	83	91	93	93	104	104
Calcium	mg/l	18	30	33	32	32	31	28	30	33	31	33	31	28
Magnesium	mg/l	20	25	26	27	25	25	23	25	26	26	25	25	23
Sodium	mg/l	120	147	158	159	152	153	137	147	158	156	153	153	136
Chloroform	µg/l	140	1,100	1,600	1,000	1,700	1,600	1,600	1,100	730	1,100	1,700	1,600	1,400
Bromodichloroform	µg/l	130	390	460	310	500	440	490	380	310	410	500	440	430
Dibromochloromethane	µg/l	130	69	93	100	69	100	95	48	62	97	100	100	79
Bromoform	µg/l	39	3	5	7	3	4	ND	3	6	5	3	3	ND
THMFP	µg/l	439	1,562	2,158	1,417	2,272	2,144	2,185	1,531	1,108	1,612	2,303	2,143	1,909
C–THM	µg/l	36	156	219	141	231	217	221	154	109	160	233	217	193
Cl–THM	µg/l	203	1,158	1,638	1,040	1,740	1,630	1,651	1,151	794	1,172	1,745	1,630	1,444
Br–THM	µg/l	201	247	302	236	301	296	313	226	205	280	325	295	272

Notes:

ND = Not detected.

[a] Some siphoning of Old River water was used to maintain pond depth during the experiment.

[b] Organic carbon measured in this experiment is assumed to be dissolved; therefore, TOC is equivalent to DOC.

Table C3–4. Evaporation Effects: Water Quality Variables in the Control Samples for the Vegetation Decay Experiment

Barrel 5 Variables	Units	Sample Dates 1/23/92	2/27/92	3/10/92	3/10/92	3/31/92	3/31/92	4/14/92	4/14/92	4/29/92	4/29/92
Laboratory		AAL	MWD			AAL	MWD	AAL	MWD	AAL	MWD
DOC	mg/l	8.2	4.74			4.3	4.27	7.2	4.33	5.8	4.86
Color	units	30				15		10		10	
UVA @ 254nm	1/cm	0.164	0.129			0.129	0.113	0.12	0.112	0.132	0.124
UVA/DOC		0.0200	0.0272				0.0265	0.0167	0.0259	0.0228	0.0255
pH	units	7.3				8.5		7.4		7.6	
Organic nitrogen	mg/l	<0.5				2		<1.6		<1.7	
Ammonia–N	mg/l	0.26	<0.03			<0.05	<0.03	<.05	<0.03	<.05	<0.03
Total phosphorus	mg/l	0.13				0.03		0.09		0.08	
Ortho phosphorus	mg/l	0.11				<0.02		<.02		<.02	
EC	μS/cm	747				668		664		796	
TDS	mg/l							460		420	
Chloride	mg/l	160	136			130	141	180	144	170	170
Sulfate	mg/l	40				33		35		39	
Nitrate–N	mg/l	0.84				<0.02		0.02		0.03	
Bromide	mg/l		0.42			0.37	0.41	0.3	0.4	0.5	0.48
Bicarbonate	mg/l							76		83	
Anions	meq/l	5.4				4.4		7.0		7.0	
Calcium	mg/l	39				17		17		19	
Magnesium	mg/l	20				16		16		18	
Potassium	mg/l	6.1				5.3		5.6		5.6	
Sodium	mg/l	96				85		82		100	
Cations	meq/l	7.9				6.0		5.9		6.9	
Anions/Cations		0.68				0.72		1.20		1.00	
Sum of Ions	mg/l	367				291		419		442	
EC/Sum of Ions		2.0				2.3		1.6		1.8	
EC/TDS								1.4		1.9	
Bromide/Chloride		<0.0031	0.0031			0.0028	0.0029	0.0017	0.0028	0.0029	0.0028
Bromodichloromethane	μg/l		160				153		178		180
Bromoform	μg/l		26				32		37		37
Chloroform	μg/l		160				150		179		180
Dibromochloromethane	μg/l		138				141		173		165
THMFP	μg/l		484				476		567		562
Chlorine dose	mg/l		14.2				12.9		13		15.1
Chlorine residual	mg/l		3.75				6.25		4.25		5
pH of THMFP test	units		8.2				8.3		8.26		8.2
C–THM	μg/l		40				39		46		46
Cl–THM	μg/l		235				223		265		266
Br–THM	μg/l		209				214		256		250
Br–THM/Br^-	μg/mg		0.50				0.52		0.64		0.52
Bromine–Incorporation (n)			0.26				0.28		0.28		0.27
C–THM/DOC	μg/mg		8.4				9.1		10.7		9.5
C–THM/UVA			310				343		412		371

Table C3–5. Natural Loading Effects: Water Quality Variables in the Single–Dose (1X) Samples for the Vegetation Decay Experiment

Barrel 1		Sample Dates									
Variables	Units	2/27/92	2/27/92	3/10/92	3/10/92	3/31/92	3/31/92	4/14/92	4/14/92	4/29/92	4/29/92
Laboratory		AAL	MWD	AAL	MWD	AAL	MWD	AAL	MWD	AAL	MWD
DOC	mg/l	15	16.94	16	12.44	13	13.59	14	13.23	18	15.4
Color	units	60		100		150		100		100	
UVA @ 254nm	1/cm	0.362	0.397	0.354	0.373	0.382	0.389	0.388	0.399	0.469	0.456
UVA/DOC		0.0241	0.0234	0.0221	0.0300	0.0294	0.0286	0.0277	0.0302	0.0261	0.0296
pH	units	6.7		6.7		6.8		6.6		6.8	
Organic nitrogen	mg/l	2.6				7.6		18		20	
Ammonia–N	mg/l	< 0.5	0.07	< 0.5	0.03	< 0.05	0.05	0.05	<.03	<.05	<.03
Total phosphorus	mg/l	1.1		1.6		1		1.7		1.9	
Ortho phosphorus	mg/l	0.74		0.39		0.23		0.07		0.04	
EC	μS/cm	732		748		773		773		913	
TDS	mg/l							460		510	
Chloride	mg/l	180	152	61	152	160	154	190	157	180	188
Sulfate	mg/l	44		16		32		38		36	
Nitrate–N	mg/l	<.02		<.02		<0.02		0.05		<.02	
Bromide	mg/l	0.39	0.49	0.31	0.47	0.4	0.4	0.4	0.46	0.5	0.52
Bicarbonate	mg/l							120		150	
Anions	meq/l	6.0		2.1		5.2		8.1		8.3	
Calcium	mg/l	19		20		23		24		28	
Magnesium	mg/l	19		18		20		20		24	
Potassium	mg/l	14		15		15		15		18	
Sodium	mg/l	79		88		86		90		110	
Cations	meq/l	6.3		6.7		6.9		7.2		8.6	
Anions/Cations		0.95		0.31		0.75		1.13		0.96	
Sum of Ions	mg/l	361		220		342		506		555	
EC/Sum of Ions		2.0		3.4		2.3		1.5		1.6	
EC/TDS								1.7		1.8	
Bromide/Chloride		0.0022	0.0032	0.0051	0.0031	0.0025	0.0026	0.0021	0.0029	0.0028	0.0028
Bromodichloromethane	μg/l		280		280		280		317		380
Bromoform	μg/l		1		1.5		1.5		1.6		2
Chloroform	μg/l		1,040		860		840		1,069		1,080
Dibromochloromethane	μg/l		55		73		71		76		84
THMFP	μg/l		1,376		1,214		1,193		1,463		1,546
Chlorine dose	mg/l		51.4		37.5		41		39.7		46.2
Chlorine residual	mg/l		6		2.95		4.25		3.4		5.5
pH of THMFP Test	units		8.2		8.23		8.24		8.23		8.16
C–THM	μg/l		140		121		119		148		154
Cl–THM	μg/l		1,055		898		880		1,101		1,139
Br–THM	μg/l		181		195		193		215		253
Br–THM/Br^-	μg/mg		0.37		0.41		0.48		0.47		0.49
Bromine–Incorporation (n)			0.064		0.080		0.081		0.073		0.082
C–THM/DOC	μg/mg		8.3		9.8		8.8		11.2		10.0
C–THM/UVA			353		326		306		370		338

Table C3–5. Continued

Barrel 2 Variables	Units	Sample Dates 2/27/92	2/27/92	3/10/92	3/10/92	3/31/92	3/31/92	4/14/92	4/14/92	4/29/92	4/29/92
Laboratory		AAL	MWD	AAL	MWD	AAL	MWD	AAL	MWD	AAL	MWD
DOC	mg/l	13	13.06	13	12.39	11	12.29	13	11.94	17	13.7
Color	units	70		100		100		100		100	
UVA @ 254nm	1/cm	0.384	0.39	0.337	0.352	0.365	0.373	0.386	0.387	0.458	0.433
UVA/DOC		0.0295	0.0299	0.0259	0.0284	0.0332	0.0303	0.0297	0.0324	0.0269	0.0316
pH	units	6.8	8.28	6.7		6.7		6.6		6.8	
Organic nitrogen	mg/l	3.4				9.4		16		19	
Ammonia–N	mg/l	ND	0.03		<0.03	0.05	0.04	0.05	<.03	<.05	<.03
Total phosphorus	mg/l	1.1		1.5		1.2		1.6		1.7	
Ortho phosphorus	mg/l	0.66		0.48		0.43		0.2		0.22	
EC	μS/cm	708		723		737		735		859	
TDS	mg/l							420		470	
Chloride	mg/l	180	149	110	143	150	144	190	147	190	175
Sulfate	mg/l	41		23		32		33		34	
Nitrate–N	mg/l	<.02		<.02		<.02		<.02		0.03	
Bromide	mg/l	0.34	0.5	0.35	0.45	0.33	0.41	0.3	0.45	0.4	0.49
Bicarbonate	mg/l							120		140	
Anions	meq/l	5.9		3.6		4.9		8.0		8.4	
Calcium	mg/l	18		20		22		23		25	
Magnesium	mg/l	18		18		19		19		22	
Potassium	mg/l	13		15		14		15		17	
Sodium	mg/l	72		88		82		82		110	
Cations	meq/l	5.9		6.7		6.6		6.7		8.3	
Anions/Cations		1.01		0.53		0.74		1.20		1.01	
Sum of Ions	mg/l	348		278		324		490		547	
EC/Sum of Ions		2.0		2.6		2.3		1.5		1.6	
EC/TDS								1.8		1.8	
Bromide/Chloride		0.0019	0.0034	0.0032	0.0031	0.0022	0.0028	0.0016	0.0031	0.0021	0.0028
Bromodichloromethane	μg/l		300		280		267		309		372
Bromoform	μg/l		1.1		1.5		1.3		1.5		1.8
Chloroform	μg/l		1,080		780		796		1,040		1,056
Dibromochloromethane	μg/l		55		73		63		71		80
THMFP	μg/l		1,436		1,134		1,127		1,421		1,510
Chlorine dose	mg/l		39.4		37.5		37.5		35.8		40.9
Chlorine residual	mg/l		1.8		5.7		4.5		3.4		5.3
pH of THMFP Test	units		8.3		8.21		8.24		8.24		8.15
C–THM	μg/l		146		113		113		143		151
Cl–THM	μg/l		1,100		827		834		1,071		1,113
Br–THM	μg/l		190		195		181		208		246
Br–THM/Br^-	μg/mg		0.38		0.43		0.44		0.46		0.50
Bromine–Incorporation (n)			0.065		0.086		0.080		0.072		0.081
C–THM/DOC	μg/mg		11.2		9.1		9.2		12.0		11.0
C–THM/UVA			375		320		302		371		348

Note:
ND = Not detected.

Table C3–6. Double Loading Effects: Water Quality Variables in the Double–Dose (2X) Samples for the Vegetation Decay Experiment

Barrel 3		Sample Dates									
Variables	Units	2/27/92	2/27/92	3/10/92	3/10/92	3/31/92	3/31/92	4/14/92	4/14/92	4/29/92	4/29/92
Laboratory		AAL	MWD	AAL	MWD	AAL	MWD	AAL	MWD	AAL	MWD
DOC	mg/l	20	39.62	26	36.74	22	34.58	26	29.73	42	34.43
Color	units	150		100		150		100		250	
UVA @ 254nm	1/cm	0.595	0.611	0.613	0.645	0.671	0.625	0.636	0.691	0.944	0.883
UVA/DOC		0.0298	0.0154	0.0236	0.0176	0.0305	0.0181	0.0245	0.0232	0.0225	0.0256
pH	units	6.5		6.5		6.8		6.6		6.7	
Organic nitrogen	mg/l	8.2				14		32		28	
Ammonia–N	mg/l	0.05	0.21	0.1	0.16	0.06	0.4	0.12	0.45	0.14	0.91
Total phosphorus	mg/l	2.2		3		2.1		2.9		3.1	
Ortho phosphorus	mg/l	1.1		0.51		0.86		0.96		1.14	
EC	μS/cm	770		834		866		802		939	
TDS	mg/l							480		580	
Chloride	mg/l	170	145	110	143	140	146	180	150	180	175
Sulfate	mg/l	45		23		32		25		28	
Nitrate–N	mg/l	<.02		<.02		< 0.02		0.1		0.03	
Bromide	mg/l	0.39	0.43	0.34	0.42	0.37	0.42	0.3	0.43	0.5	0.55
Bicarbonate	mg/l							180		210	
Anions	meq/l	5.7		3.6		4.6		8.5		9.1	
Calcium	mg/l	22		24		27		28		31	
Magnesium	mg/l	22		21		22		22		25	
Potassium	mg/l	23		24		23		23		27	
Sodium	mg/l	88		93		88		84		100	
Cations	meq/l	7.3		7.6		7.6		7.5		8.7	
Anions/Cations		0.78		0.47		0.61		1.14		1.05	
Sum of Ions	mg/l	376		299		337		551		611	
EC/Sum of Ions		2.0		2.8		2.6		1.5		1.5	
EC/TDS								1.7		1.6	
Bromide/Chloride		0.0023	0.0030	0.0031	0.0029	0.0026	0.0029	0.0017	0.0029	0.0028	0.0031
Bromodichloromethane	μg/l		364		350		324		360		364
Bromoform	μg/l		0.55		0.19		0.32		0.33		0.29
Chloroform	μg/l		2,534		2,400		2,228		2,491		2,400
Dibromochloromethane	μg/l		33		35		36		42		39
THMFP	μg/l		2,932		2,785		2,588		2,893		2,803
Chlorine dose	mg/l		120.7		111		107.3		92.8		111
Chlorine residual	mg/l		21.5		19.8		16.3		4		1.75
pH of THMFP Test	units		8.3		8.23		8.26		8.25		8.06
C–THM	μg/l		310		294		273		305		295
Cl–THM	μg/l		2,417		2,292		2,128		2,379		2,299
Br–THM	μg/l		204		199		187		209		209
Br–THM/Br^-	μg/mg		0.48		0.47		0.44		0.49		0.38
Bromine–Incorporation (n)			0.033		0.034		0.034		0.034		0.035
C–THM/DOC	μg/mg		7.8		8.0		7.9		10.3		8.6
C–THM/UVA			507		456		437		442		335

Table C3–6. Continued

Barrel 4 Variables	Units	Sample Dates 2/27/92	2/27/92	3/10/92	3/10/92	3/31/92	3/31/92	4/14/92	4/14/92	4/29/92	4/29/92
Laboratory		AAL	MWD	AAL	MWD	AAL	MWD	AAL	MWD	AAL	MWD
DOC	mg/l	22	38.2	30	36	23	33.02	27	30.5	34	31.16
Color	units	100		150		100		150		200	
UVA @ 254nm	1/cm	0.53	0.544	0.58	0.593	0.54	0.663	0.60	0.66	0.77	0.826
UVA/DOC		0.0242	0.0142	0.0194	0.0165	0.0238	0.0201	0.0223	0.0216	0.0229	0.0265
pH	units	6.4	8.25	6.6		6.8		6.6		6.8	
Organic nitrogen	mg/l	11				7.5		29		23	
Ammonia–N	mg/l	ND	0.07	0.1	0.05	< 0.05	0.2	0.09	0.5	0.09	0.09
Total phosphorus	mg/l	2.2		3.7		1.7		2.1		1.8	
Ortho phosphorus	mg/l	0.9		0.51		0.9		0.54		0.47	
EC	μS/cm	867		840		866		914		984	
TDS	mg/l							530		610	
Chloride	mg/l	200	171	180		140	163	180	160	180	186
Sulfate	mg/l	54		37		32		29		33	
Nitrate–N	mg/l	< 0.02		< 0.02		< 0.02		0.47		0.05	
Bromide	mg/l	0.35	0.49	0.31	0.46	0.46	0.49	0.4	0.46	0.5	0.52
Bicarbonate	mg/l							170		200	
Anions	meq/l	6.8		5.8		4.6		8.5		9.0	
Calcium	mg/l	23		25		27		28		31	
Magnesium	mg/l	25		24		25		25		27	
Potassium	mg/l	27		27		26		26		29	
Sodium	mg/l	91		94		89		88		110	
Cations	meq/l	7.9		8.0		8.0		8.0		9.3	
Anions/Cations		0.86		0.73		0.58		1.06		0.97	
Sum of Ions	mg/l	427		393		344		555		620	
EC/Sum of Ions		2.0		2.1		2.5		1.6		1.6	
EC/TDS								1.7		1.6	
Bromide/Chloride		0.0018	0.0029	0.0017		0.0033	0.0030	0.0022	0.0029	0.0028	0.0028
Bromodichloromethane	μg/l		405		380		331		358		384
Bromoform	μg/l		1		0.25		0.41		0.46		0.34
Chloroform	μg/l		2,300		2,200		1,959		2,311		2,280
Dibromochloromethane	μg/l		45		41		41		42		42
THMFP	μg/l		2,751		2,621		2,331		2,711		2,706
Chlorine dose	mg/l				109		100.9		95.7		94.6
Chlorine residual	mg/l				20.5		13.8		3.7		2.25
pH of THMFP Test	units				8.22		8.25		8.24		8.07
C–THM	μg/l		288		275		244		285		284
Cl–THM	μg/l		2,229		2,128		1,893		2,218		2,201
Br–THM	μg/l		234		218		194		208		221
Br–THM/Br^-	μg/mg		0.48		0.47		0.40		0.45		0.42
Bromine–Incorporation (n)			0.041		0.040		0.040		0.036		0.039
C–THM/DOC	μg/mg		7.5		7.6		7.4		9.4		9.1
C–THM/UVA			530		464		369		432		344

Note:
ND = Not detected.

Table C3-7. Comparison of Chemical Composition of Plant Tissue and Observed Concentrations in the Vegetation Decay Experiment (in Percentages)

Chemical Element	Corn Shoots	General Plants	2X Barrels (1,000 g/m^2)
K	1.9	0.50-0.60	1.25
Ca	0.4	0.20-3.50	0.70
Mg	0.3	0.10-0.80	0.50
N	2.8	1.00-4.00	1.50
P	0.3	0.10-0.80	0.12
S	0.2	0.05-1.00	

Table C3–8. Holland Tract Demonstration Wetland Soil Sample Results

Variables	Units	Site 1						Site 2					
		Surface Samples			Bottom Samples			Surface Samples			Bottom Samples		
		2–Hour Holding Time	7–Day Holding Time	30–Day Holding Time	2–Hour Holding Time	7–Day Holding Time	30–Day Holding Time	2–Hour Holding Time	7–Day Holding Time	30–Day Holding Time	2–Hour Holding Time	7–Day Holding Time	30–Day Holding Time
Initial Weight [a]	g	1,200	1,000	1,000	1,000	1,000	755	1,000	1,000	1,000	1,000	1,000	1,000
Solids [a]	%	58	58	59	29	40	29	59	58	58	40	55	48
Percent Volatile [a]	%	28	27	29	58	36	58	21	24	24	18	21	21
Initial Water [a]	g	504	420	410	710	600	536	410	420	420	600	450	520
Deionized Water [a]	ml	500	260	250	100	25	70	250	270	216	10	96	0
Extract Volume [a]	ml	465	274	280	420	340	315	255	300	235	134	235	255
Percent Water Extracted [a]	%	46	40	42	52	54	52	39	43	37	22	43	49
Dilution Factor [a]		3	6	5	4	5	5	6	5	6	8	7	6
Organic Carbon–40% [a]	g	78	63	68	67	58	51	50	56	56	29	46	40
DOC [a]	mg/l	30	43	52	37	40	66	34	40	71	30	31	25
DOC [b]	mg/l	33	46	NA	34	41	NA	NA	38	NA	24	37	NA
Color [a]	units	120	90	150	160	120	180	180	180	210	220	100	90
UVA @254 nm [a]	1/cm	1.19	1.16	1.58	1.49	1.21	1.58	1.48	1.25	1.90	0.84	0.75	0.91
UVA @254 nm [b]	1/cm	1.08	1.27	1.25	1.28	1.26	1.32	1.15	1.23	1.5	0.7	0.74	0.62
UVA/DOC [a]		0.0397	0.0269	0.0304	0.0403	0.0301	0.0239	0.0436	0.0313	0.0268	0.0281	0.0242	0.0364
UVA/DOC [b]		0.0327	0.0276		0.0376	0.0307			0.0324		0.0292	0.0200	
DOC/Soil Organic Carbon [a]	mg/g	0.39	0.47	0.50	0.45	0.43	0.79	0.45	0.50	0.81	0.64	0.37	0.32
pH [a]	units	5	5.4	5.6	4.5	4.7	4.6	5.3	5.3	5.6	4.8	5	5.1
Organic nitrogen [a]	mg/l	2.5	3.5	6.5	3.8	< 0.25	<2.5	4.6	< 0.25	<3.2	4.6	4.4	<5.6
Ammonia–N [a]	mg/l	0.17	<0.3	0.43	0.83	0.28	0.99	0.35	1.6	0.36	0.69	< 0.39	0.44
Total phosphorus [a]	mg/l	<.09	0.12	<.1	<.08	<0.10	<.1	<.12	< 0.10	<.12	<.16	< 0.14	<.12
EC [a]	µS/cm	1,056	1,990	1,770	1,604	1,790	1,550	612	795	990	1,520	1,460	1,510
TDS [a]	mg/l	600	1,100	1,100	840	1,000	880	370	495	580	820	770	750
Chloride [a]	mg/l	80	300	180	210	310	220	25	42	80	160	420	200
Sulfate [a]	mg/l	220	450	400	210	420	210	140	370	340	140	250	210
Nitrate–N [a]	mg/l	16	21	0.85	4.1	11	<.1	11	3	1.8	4.4	6.6	0.8
Bromide [a]	mg/l	<1.8	< 12	<.15	<1.2	4	<.15	<3		<.6	<1.6	< 1.4	<.18
Bicarbonate [a]	mg/l	<7	22	<12	<10	<12	<12	<15	18	<15	24	< 17	<15
Anions [a]	meq/l	7.09	18.53	13.42	10.36	17.71	10.57	3.80	9.23	9.37	7.89	17.15	10.02

Table C3–8. Continued

Variables	Units	Site 1						Site 2					
		Surface Samples			Bottom Samples			Surface Samples			Bottom Samples		
		2–Hour Holding Time	7–Day Holding Time	30–Day Holding Time	2–Hour Holding Time	7–Day Holding Time	30–Day Holding Time	2–Hour Holding Time	7–Day Holding Time	30–Day Holding Time	2–Hour Holding Time	7–Day Holding Time	30–Day Holding Time
Calcium [a]	mg/l	54	120	130	96	110	80	19	34	52	56	55	72
Magnesium [a]	mg/l	23	41	46	34	36	30	11	16	22	26	24	31
Potassium [a]	mg/l	8.4	9	8.5	10	6.5	6	14	10	6	4	3.8	4.8
Sodium [a]	mg/l	100	130	150	160	130	120	55	80	120	100	120	160
Cations [a]	meq/l	9.18	15.30	17.07	14.85	14.32	11.87	4.62	6.77	9.80	9.42	10.06	13.26
Anions/Cations [a]		0.77	1.21	0.79	0.70	1.24	0.89	0.82	1.36	0.96	0.84	1.70	0.76
Sum of Ions [a]	mg/l	501	1,060	915	724	1,028	666	275	546	622	478	879	679
Sum Ions/TDS [a]		0.84	0.96	0.83	0.86	1.03	0.76	0.74	1.10	1.07	0.58	1.14	0.90
EC/TDS [a]		1.8	1.8	1.6	1.9	1.8	1.8	1.7	1.6	1.7	1.9	1.9	2.0
Bromodichloromethane [b]	µg/l	62	72		122	86			40	90	110	63	
Bromoform [b]	µg/l	<1.2	<2.4			<2.0			NA	NA	NA	NA	
Chloroform [b]	µg/l	2,400	2,688		2,140	2,640			2,090	4,950	1,280	1,449	
Dibromochloromethane [b]	µg/l	4	6		5	4			NA	NA	10	NA	
TTHMFP [b]	µg/l	2,472	2,760		2,260	2,720			2,130	5,040	1,400	1,512	
Chlorine dose [b]	mg/l	99	139		102	122			96	282	73	110	
Chlorine residual [b]	mg/l	47	84		33	80			26	81	25	52	
pH of THMFP test [b]	units	8.2	8		8.3	8.1			8.3	8.3	8.3	8.3	
C–THM [b]	µg/l	269	302		245	298			233	552	150	164	
C–THM/DOC [b]	µg/mg	8	7		7	7			6		6	4	
C–THM/UVA [b]		249	238		192	236			190	368	215	222	

Notes:

All soil samples were collected on 2/27/92. Surface samples were collected by scraping the ground surface with a small trowel; bottom samples were collected from a 2–foot–deep hole.

NA = Not analyzed (some samples were not analyzed by MWD because of insufficient extracted soil water).

[a] Analyzed by AAL.

[b] Analyzed by MWD.

Table C3–9. Agricultural Soil Sample Results

Variables	Units	Site 1						Site 2					
		Surface Samples			Bottom Samples			Surface Samples			Bottom Samples		
		2–Hour Holding Time	7–Day Holding Time	30–Day Holding Time	2–Hour Holding Time	7–Day Holding Time	30–Day Holding Time	2–Hour Holding Time	7–Day Holding Time	30–Day Holding Time	2–Hour Holding Time	7–Day Holding Time	30–Day Holding Time
Initial Weight [a]	g	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Solids [a]	%	46	45	45	38	34	29	57	55	55	54	58	55
Percent Volatile [a]	%	49	49	46	46	42	40	35	34	36	30	32	34
Initial Water [a]	g	540	550	550	620	660	710	430	450	450	460	420	450
Deionized Water [a]	ml	235	202	160	154	30	26	280	284	274	230	250	210
Extract Volume [a]	ml	300	335	345	315	305	350	295	305	335	280	245	260
Percent Water Extracted [a]	%	39	45	49	41	44	48	42	42	46	41	37	39
Dilution Factor [a]		5	5	4	5	5	4	5	5	5	5	6	6
Organic Carbon–40% [a]	g	90	88	83	70	57	46	80	75	79	65	74	75
DOC [a]	mg/l	190	130	120	60	44	41	130	110	240	65	85	56
DOC [b]	mg/l	178	148	NA	58	43	NA	131	113	NA	82	92	NA
Color [a]	units	2,000	750	600	220	150	180	350	500	2,000	180	210	240
UVA @254 nm [a]	1/cm	11.10	6.05	5.05	2.11	1.36	1.69	4.04	4.54	12.40	2.22	2.38	1.97
UVA @254 nm [b]	1/cm	10.7	5.98	4.48	1.86	1.36	1.44	4.06	4.56	NA	2.05	2.38	NA
UVA/DOC [a]		0.0584	0.0465	0.0421	0.0351	0.0308	0.0412	0.0310	0.0413	0.0517	0.0342	0.0280	0.0352
UVA/DOC [b]		0.0601	0.0404		0.0321	0.0316		0.0310	0.0404		0.0250	0.0259	
DOC/Soil Organic Carbon [a]	mg/g	1.63	1.11	1.03	0.66	0.53	0.65	1.16	1.08	2.19	0.69	0.77	0.49
pH [a]	units	5.8	6	6.2	5.8	6.4	6.3	5.7	6.1	6.6	5.6	5.7	6.2
Organic nitrogen [a]	mg/l	12	6.8	5.7	5.9	3	<2.2	11	6.2	10	6.2	5.5	3
Ammonia–N [a]	mg/l	0.32	< 0.30	0.67	0.46	< 0.28	0.56	1.6	< 0.33	0.76	0.58	< 0.30	<.3
Total phosphorus [a]	mg/l	0.2	< 0.10	0.12	<.1	<0.10	<.08	0.2	<0.10	0.39	<.1	< 0.12	<.12
EC [a]	µS/cm	455	1,440	2,610	3,225	2,700	1,800	9,000	2,710	525	7,200	11,500	4,300
TDS [a]	mg/l	640	1,000	1,900	1,900	1,400	1,100	6,000	1,800	740	6,500	6,600	2,600
Chloride [a]	mg/l	9	52	180	390	290	230	1,100	64	16	870	1,800	570
Sulfate [a]	mg/l	80	380	830	630	890	320	1,900	1,200	75	1,500	3,000	940
Nitrate–N [a]	mg/l	3.1	1.6	<.08	43	32	1.7	100	1.2	0.57	73	120	57
Bromide [a]	mg/l	<1	< 0.15	0.16	<10	< 4.0	0.32	<20	< 1.0	0.28	<20	< 1.0	<3.6
Bicarbonate [a]	mg/l	10	24	49	12	18	29	18	24	130	12	24	44
Anions [a]	meq/l	2.14	9.80	23.17	25.00	27.52	13.65	72.48	27.22	4.16	57.13	115.53	37.28

Table C3–9. Continued

Variables	Units	Site 1						Site 2					
		Surface Samples			Bottom Samples			Surface Samples			Bottom Samples		
		2–Hour Holding Time	7–Day Holding Time	30–Day Holding Time	2–Hour Holding Time	7–Day Holding Time	30–Day Holding Time	2–Hour Holding Time	7–Day Holding Time	30–Day Holding Time	2–Hour Holding Time	7–Day Holding Time	30–Day Holding Time
Calcium [a]	mg/l	26	90	210	220	160	120	850	160	42	650	840	280
Magnesium [a]	mg/l	9.5	38	92	100	80	60	410	75	16	310	450	160
Potassium [a]	mg/l	1.2	7	12	4.8	1.4	1.2	60	27	10	12	24	40
Sodium [a]	mg/l	48	180	230	190	170	170	650	230	80	650	480	400
Cations [a]	meq/l	4.21	15.67	28.47	27.72	22.09	18.42	106.47	24.94	7.17	86.90	100.98	45.75
Anions/Cations [a]		0.51	0.63	0.81	0.90	1.25	0.74	0.68	1.09	0.58	0.66	1.14	0.81
Sum of Ions [a]	mg/l	172	737	1,530	1,572	1,614	889	5,061	1,745	175	4,059	6,702	2,425
Sum Ions/TDS [a]		0.27	0.74	0.81	0.83	1.15	0.81	0.84	0.97	0.24	0.62	1.02	0.93
EC/TDS [a]		0.7	1.4	1.4	1.7	1.9	1.6	1.5	1.5	0.7	1.1	1.7	1.7
Bromodichloromethane [b]	µg/l	210	190	240	180	140	192	660	174		178	302	120
Bromoform [b]	µg/l	1						<2.0	<2.0				
Chloroform [b]	µg/l	14,260	9,820	8,440	3,180	2,600	4,768	7,680	7,980		3,475	4,320	4,440
Dibromochloromethane [b]	µg/l	4	1	12	12	10		46	11		10	26	ND
TTHMFP [b]	µg/l	14,470	10,010	8,680	3,375	2,750	4,960	8,400	8,160		3,650	4,680	4,560
Chlorine dose [b]	mg/l	537	452	580	172	130	257	400	344		245	279	697
Chlorine residual [b]	mg/l	66	132	236	56	46	31	276	100		98	223	408
pH of THMFP test [b]	units	8.2	8	8.2	8.2	8.2	8.3	8.2	8.2		8.3	8.3	8.3
C–THM [b]	µg/l	1,586	1,095	948	365	298	540	900	892		397	501	498
C–THM/DOC [b]	µg/mg	9	7		6	7		7	8		5	5	
C–THM/UVA [b]		148	183	212	196	219	375	222	196		194	210	

Notes:
All soil samples were collected on 2/27/92. Surface samples were collected by scraping the ground surface with a small trowel; bottom samples were collected from a 2–foot–deep hole.
NA = Not analyzed (some samples were not analyzed by MWD because of insufficient extracted soil water).
ND = Not detected.
[a] Analyzed by AAL.
[b] Analyzed by MWD.

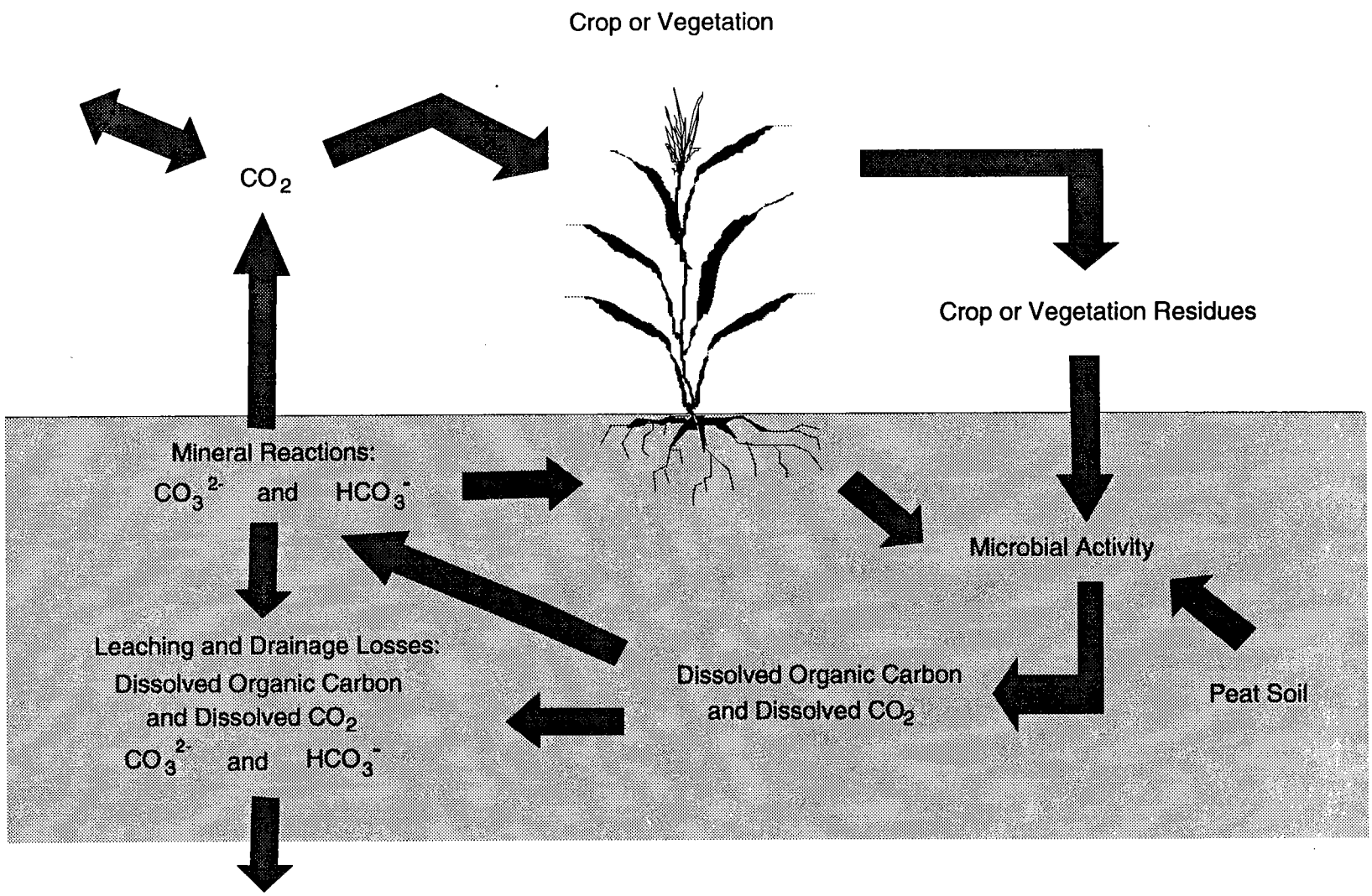

Figure C3-1.
Generalized Carbon Cycle in the Delta

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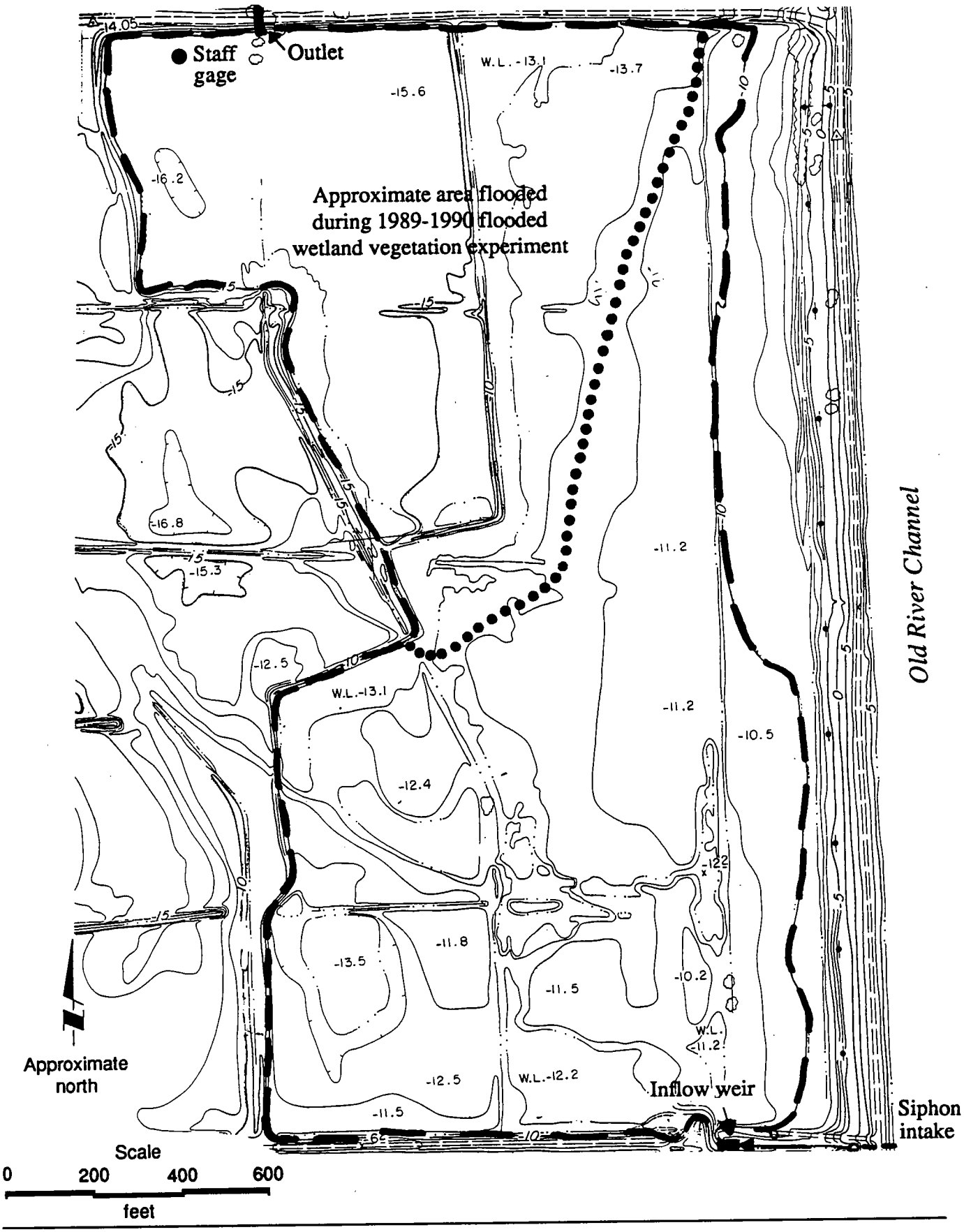

Figure C3-2.
Holland Tract Demonstration Wetland

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PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

Figure C3-3.
Concentration of Minerals during the
1989-1990 Flooded Wetland Period

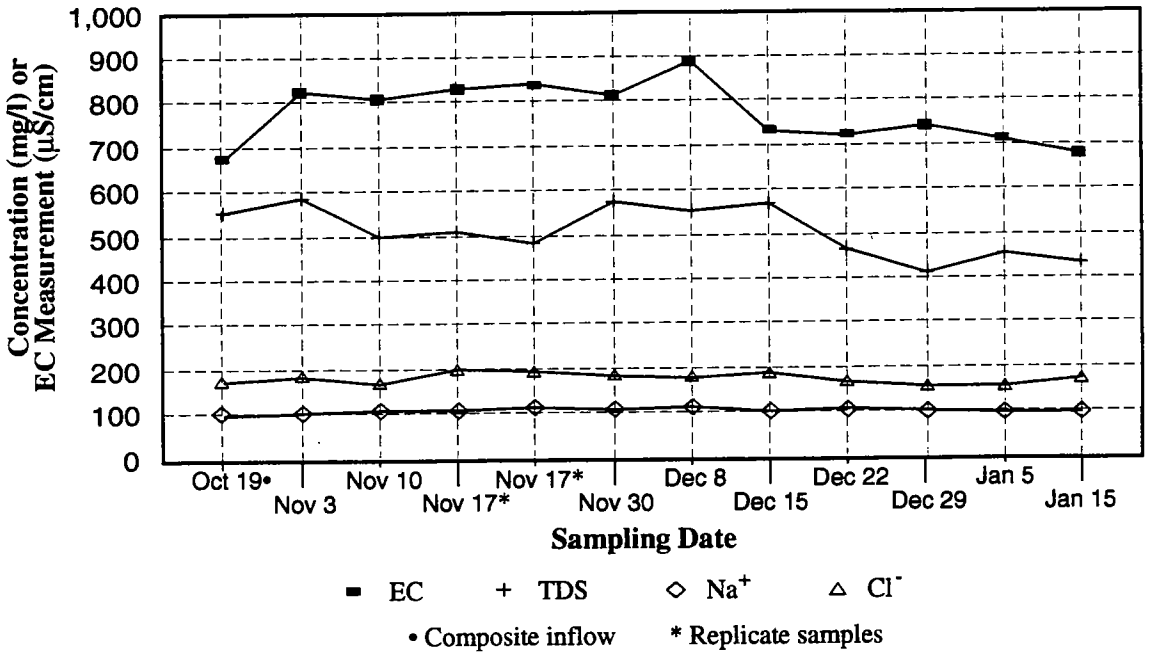


Figure C3-4.
Concentration of Plant Nutrients during the
1989-1990 Flooded Wetland Period

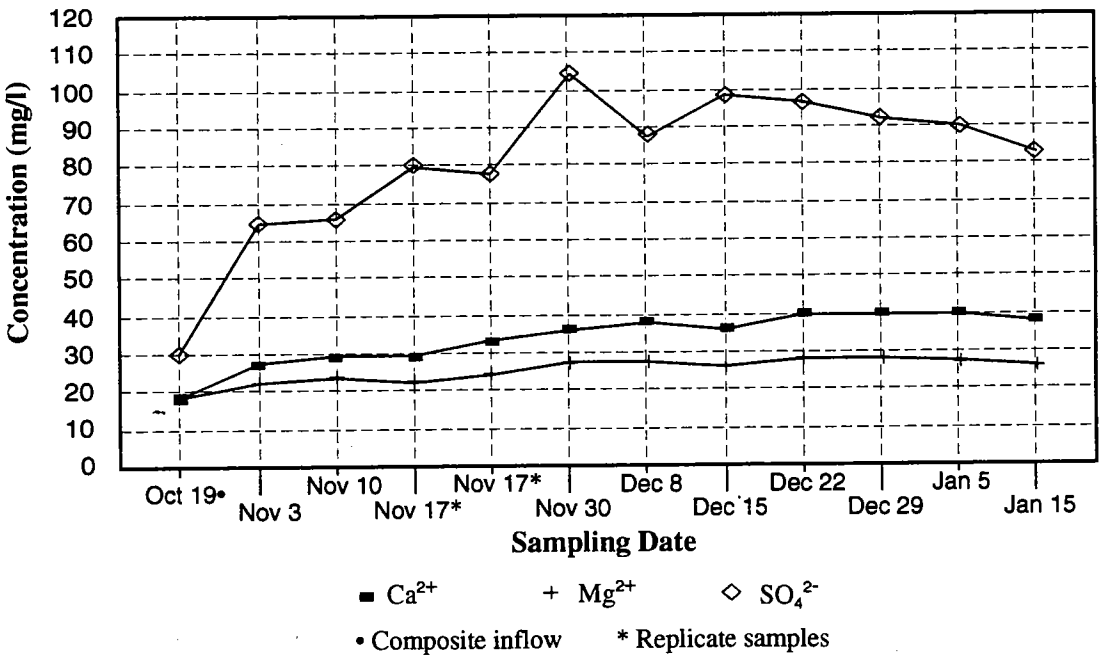


Figure C3-5
Concentration of TOC during the
1989-1990 Flooded Wetland Period

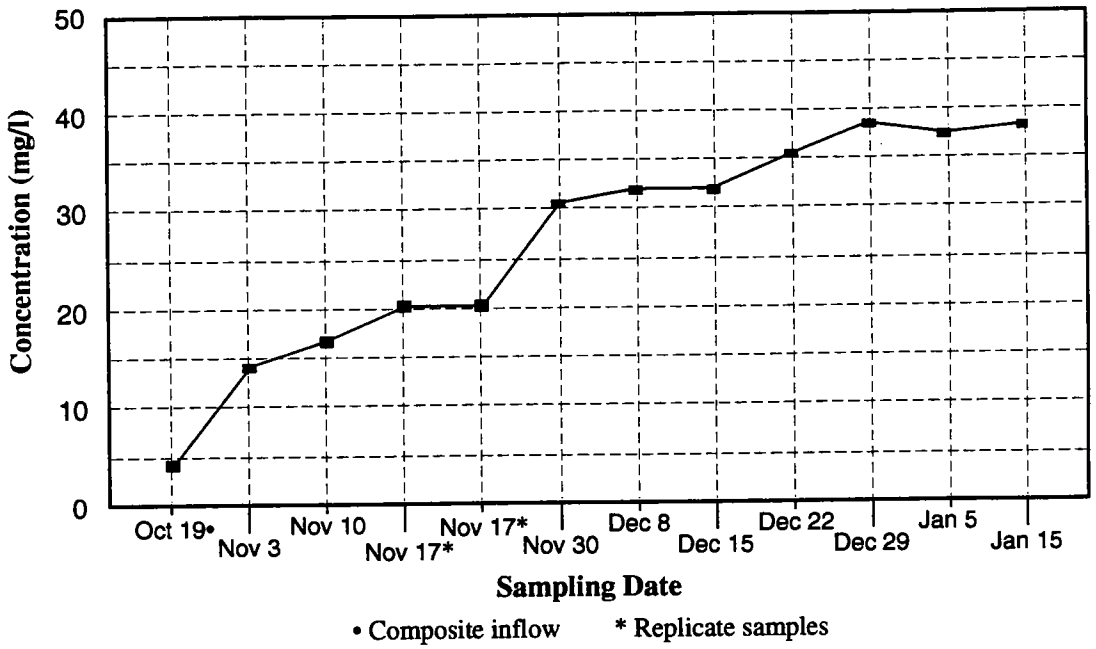


Figure C3-6.
Concentration of THMFP Components during the
1989-1990 Flooded Wetland Period

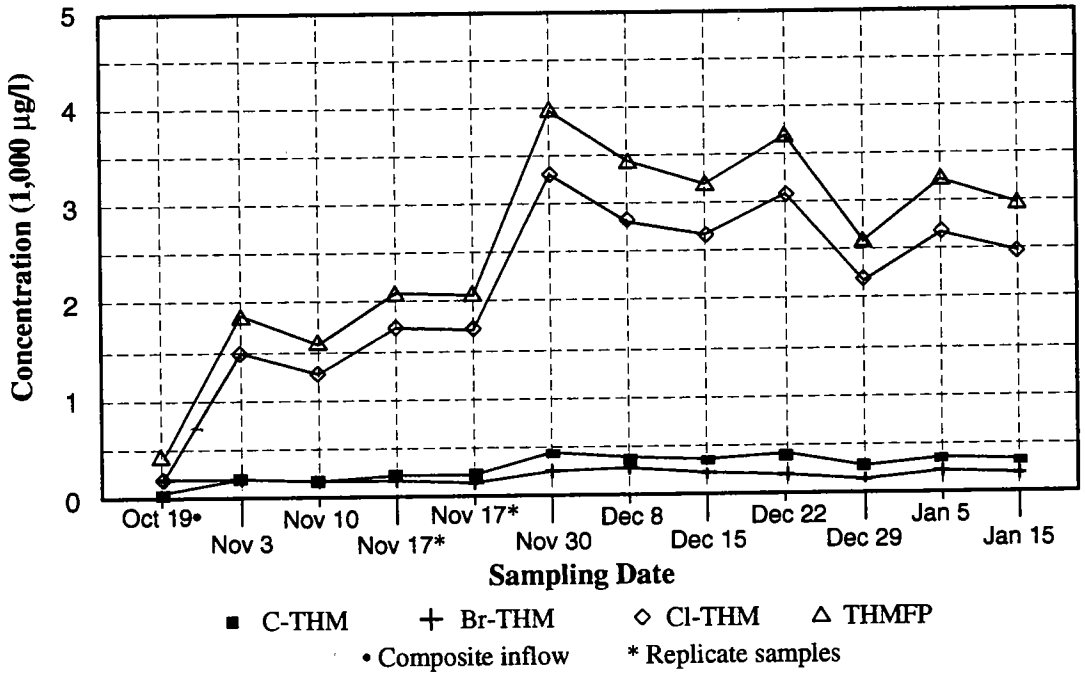


Figure C3-7.
Concentration of Minerals during the 1990 Seasonal Storage Period

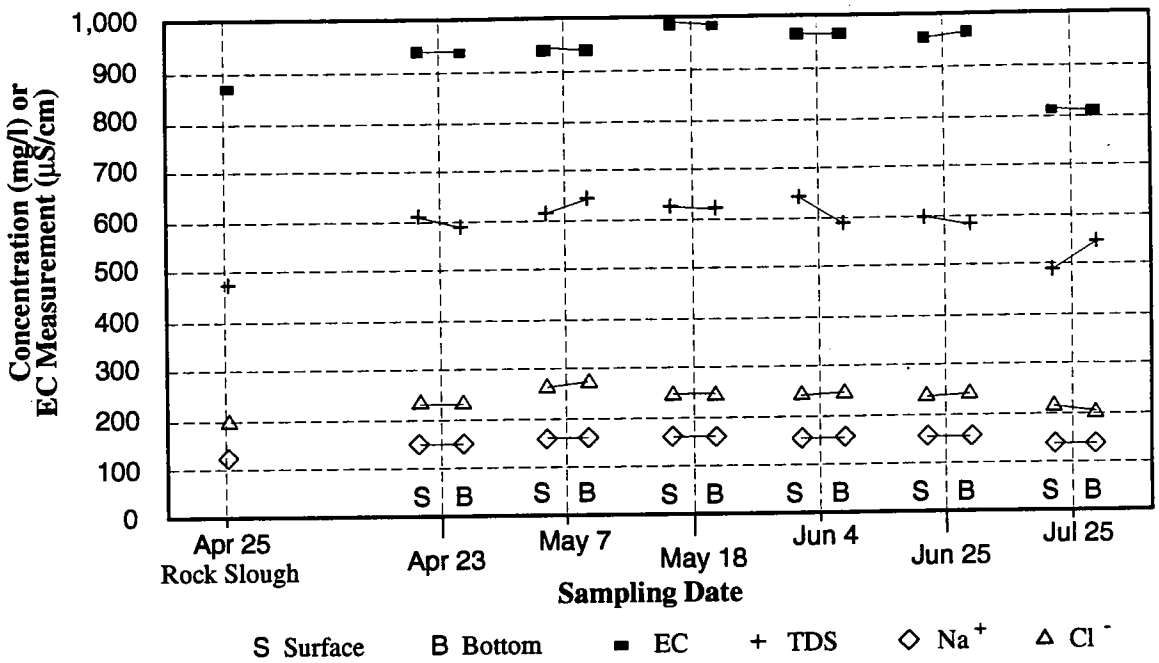


Figure C3-8.
Concentration of Plant Nutrients during the 1990 Seasonal Storage Period

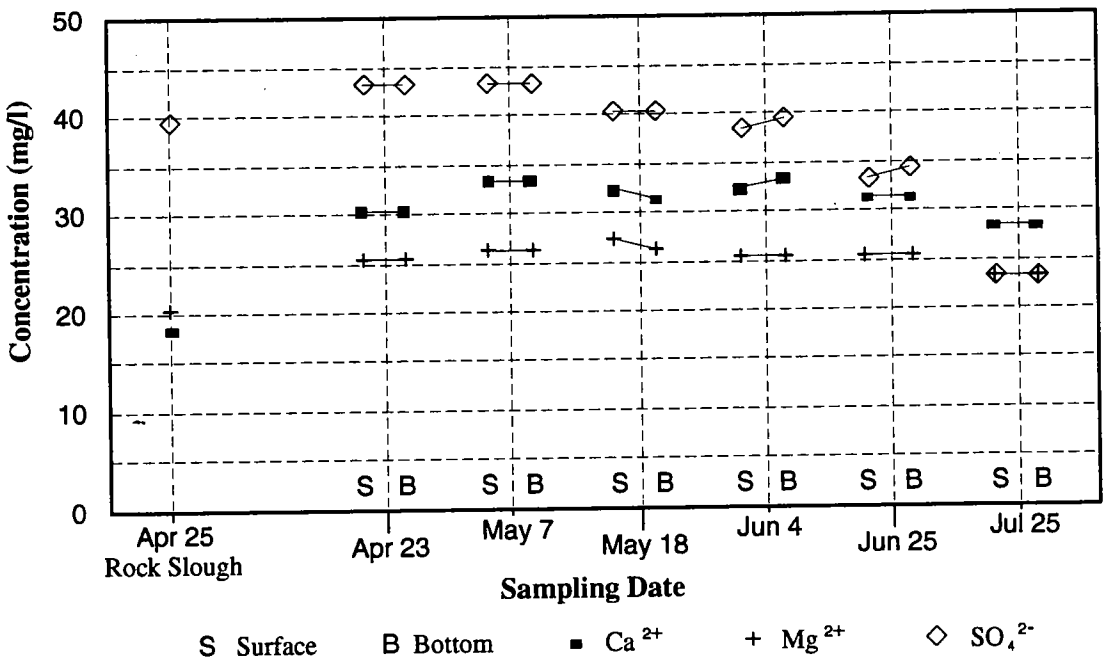


Figure C3-9.
Concentration of TOC during the
1990 Seasonal Storage Period

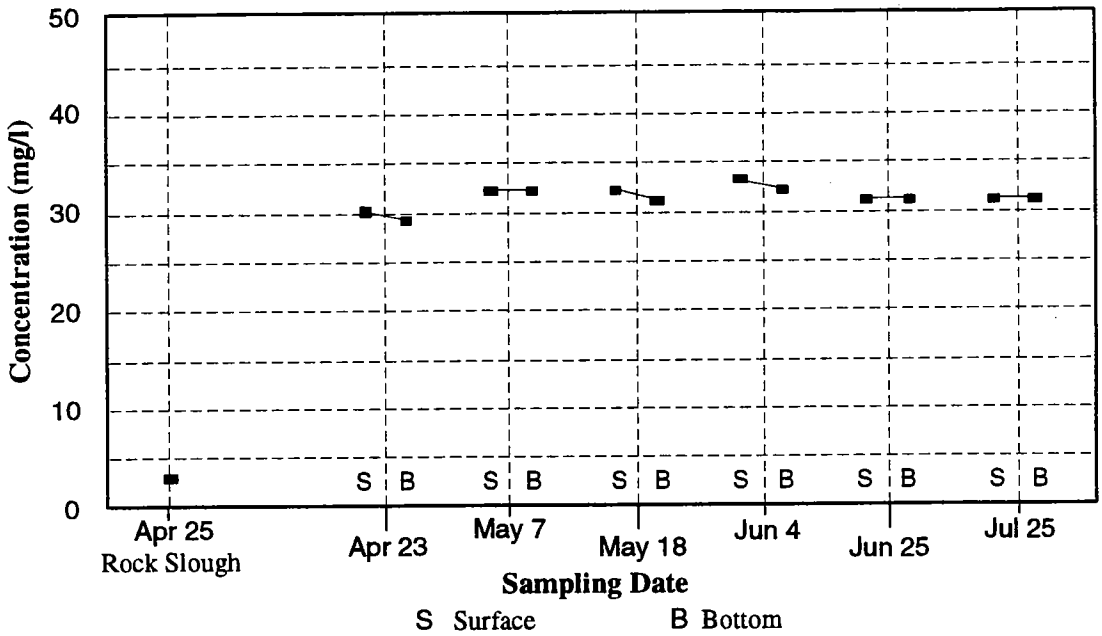
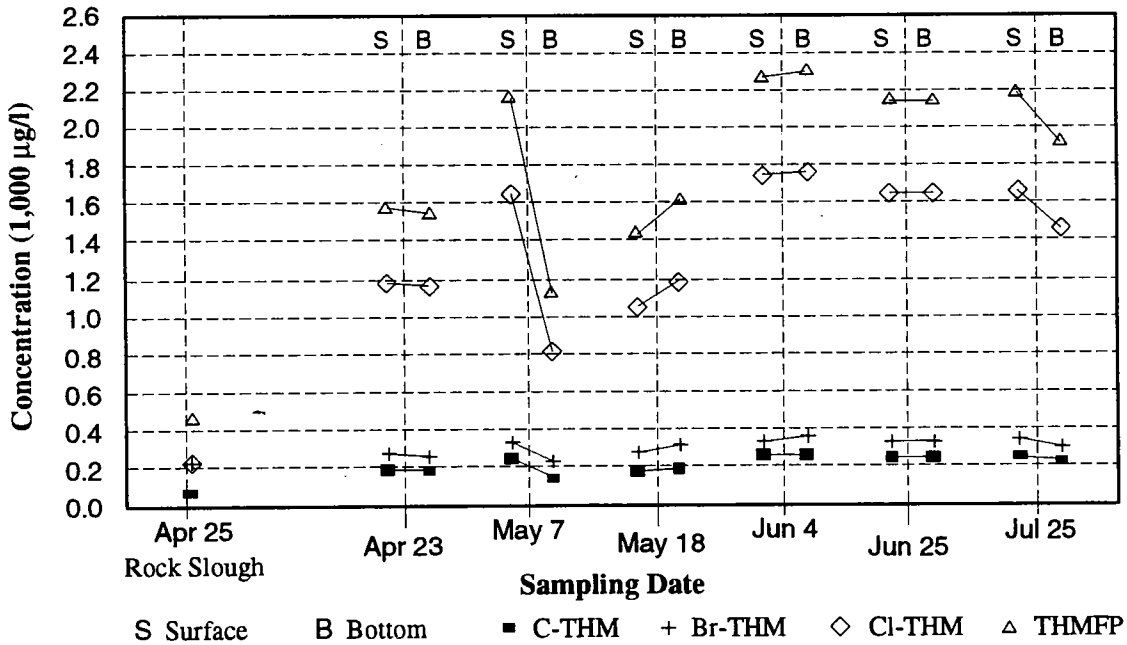


Figure C3-10.
Concentration of THMFP Components during
the 1990 Seasonal Storage Period



Load (g/m²) = Concentration (mg/l) x Mean Depth (m)

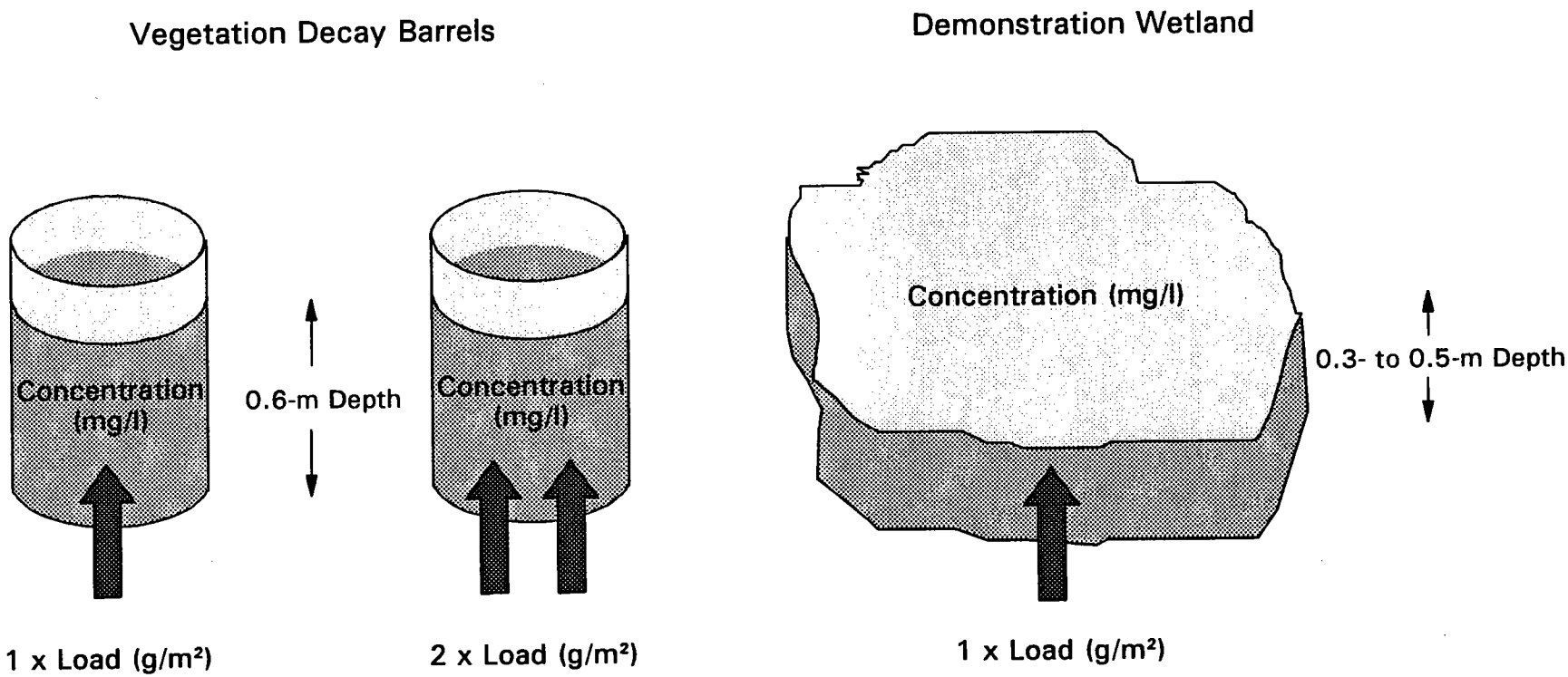


Figure C3-11.
Relationship between Load, Depth, and Concentration

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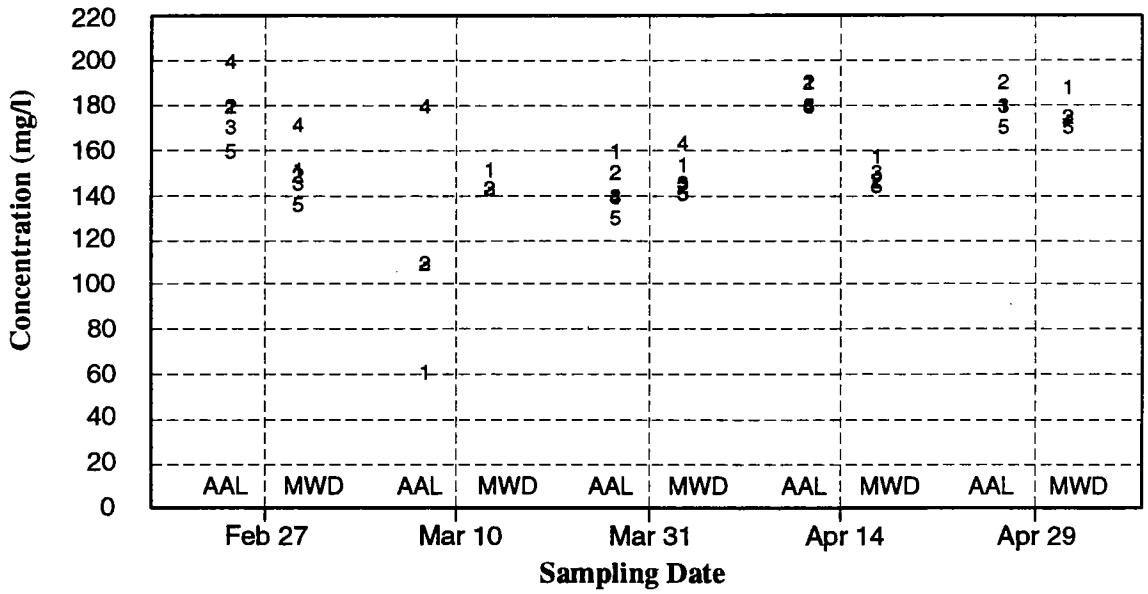
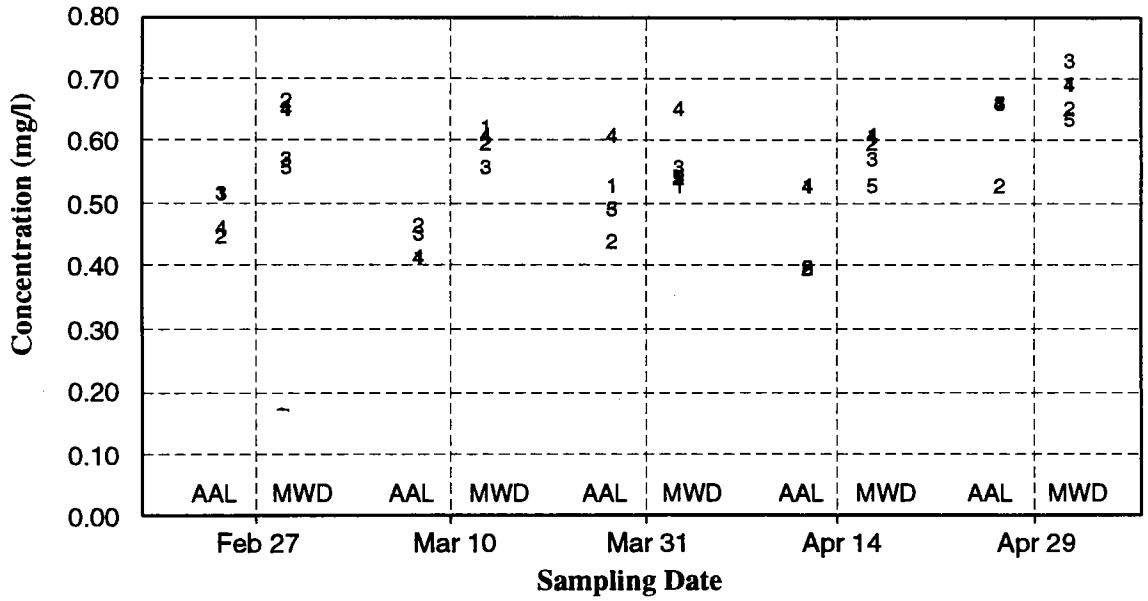
Figure C3-12.
Concentration of Chloride during the 1992
Wetland Vegetation Decay Experiment



1 Barrel 1 2 Barrel 2 3 Barrel 3 4 Barrel 4 5 Control

Figure C3-13.
Concentration of Bromide during the 1992
Wetland Vegetation Decay Experiment



1 Barrel 1 2 Barrel 2 3 Barrel 3 4 Barrel 4 5 Control

Figure C3-14.
EC during the 1992
Wetland Vegetation Decay Experiment

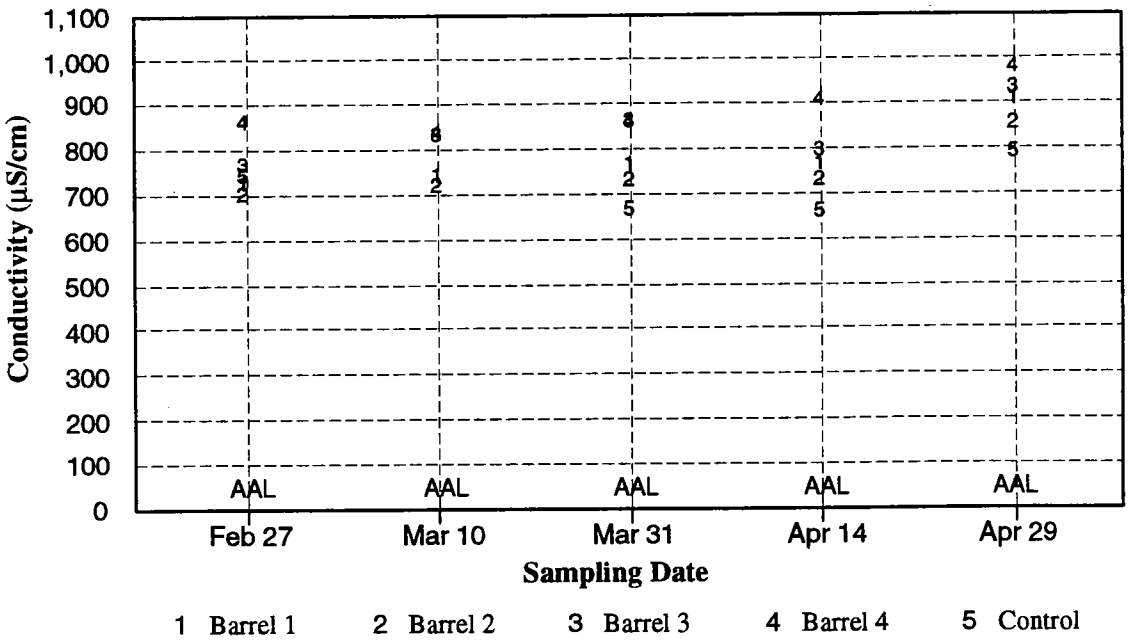


Figure C3-15.
Concentration of Potassium during the 1992
Wetland Vegetation Decay Experiment

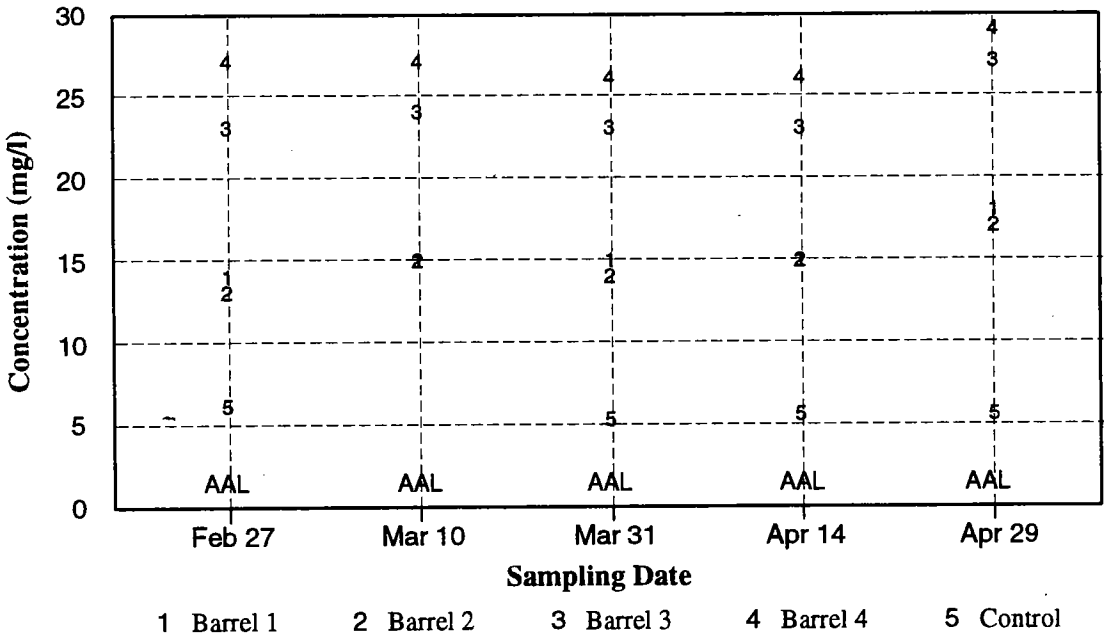


Figure C3-16.
Concentration of DOC during the 1992
Wetland Vegetation Decay Experiment

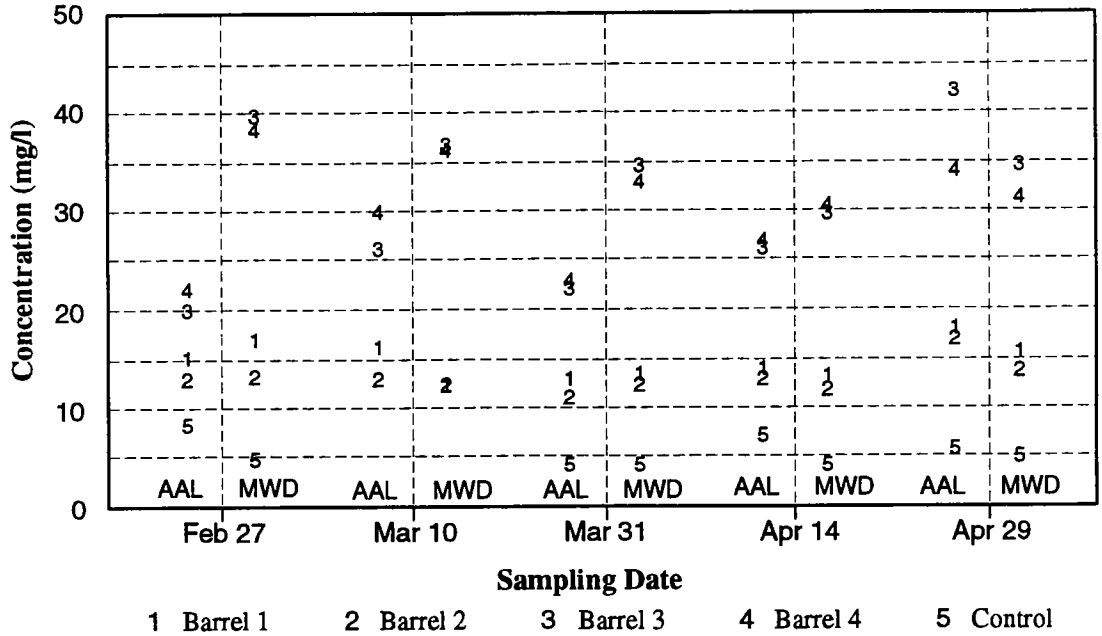


Figure C3-17.
UVA during the 1992
WetlandVegetation Decay Experiment

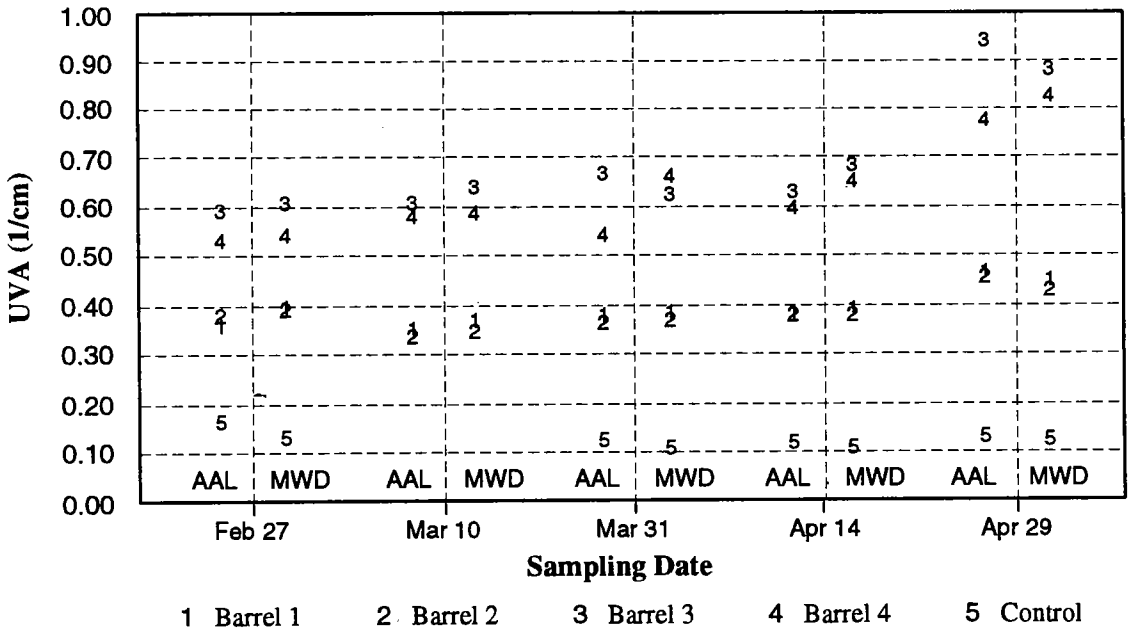


Figure C3-18.
UVA/DOC Ratio during the 1992 Wetland Vegetation Decay Experiment

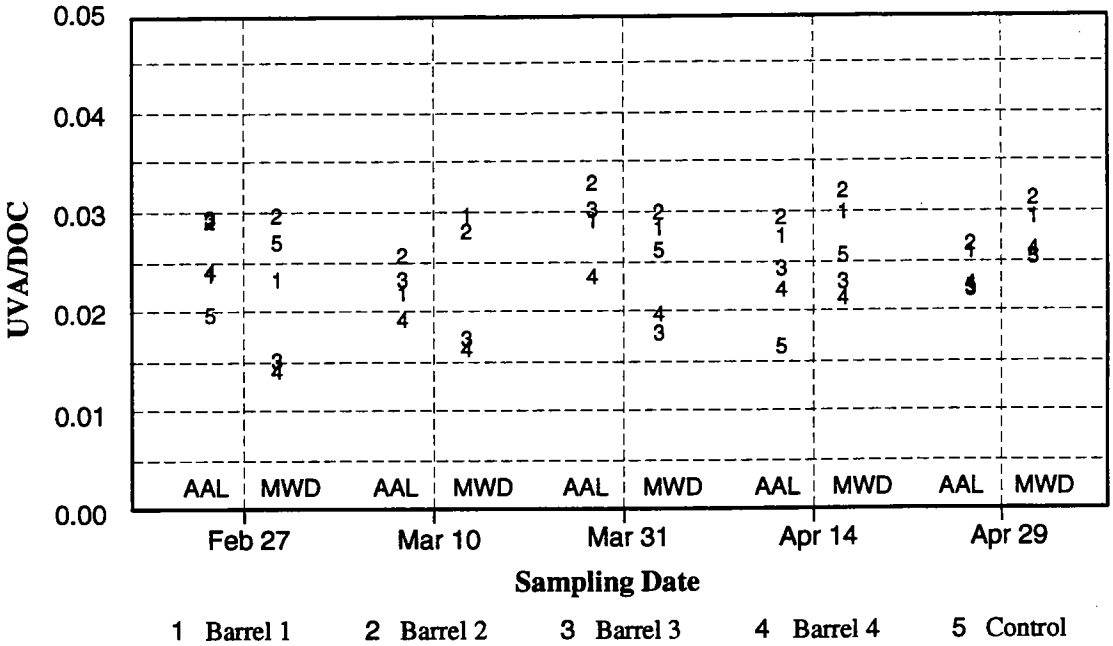


Figure C3-19.
Concentration of C-THM during the 1992 Wetland Vegetation Decay Experiment

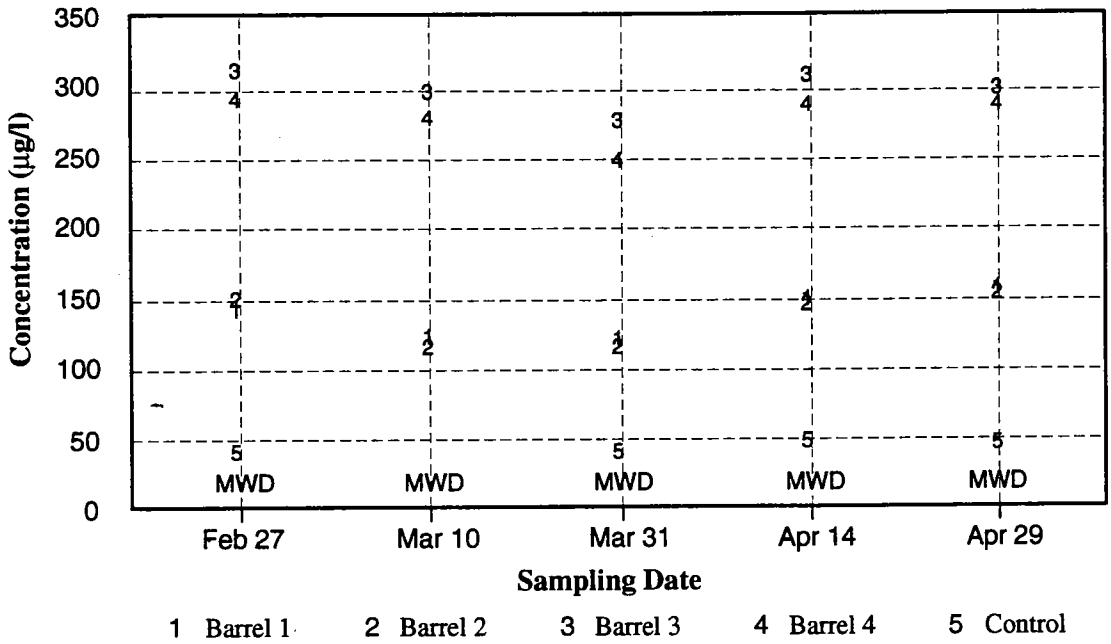


Figure C3-20.
C-THM/DOC Ratio during the 1992
WetlandVegetation Decay Experiment

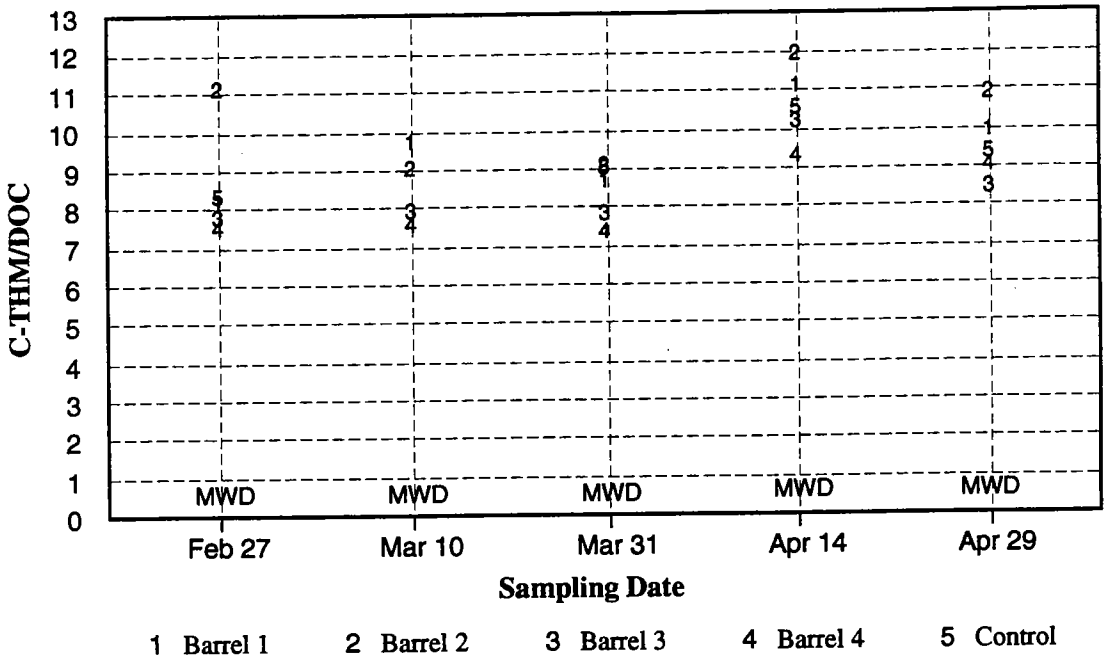


Figure C3-21.
Br-THM/Bromide Ratio during the 1992
Wetland Vegetation Decay Experiment

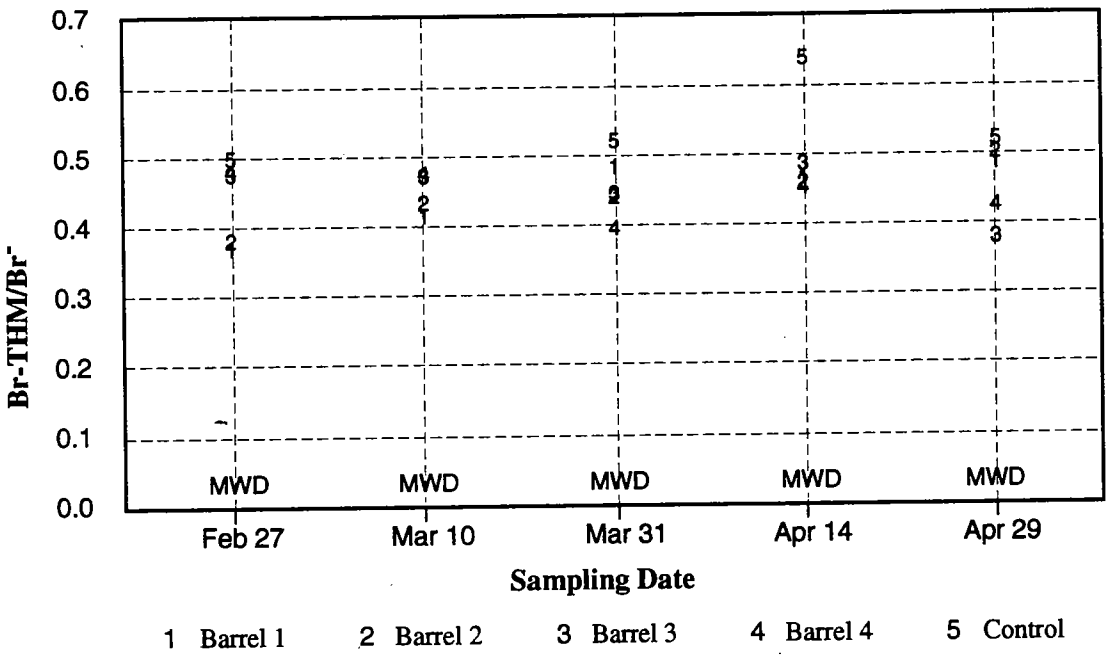


Figure C3-22.
Organic Content of Soil Samples from Holland Tract during the 1992 Soil Water Extraction Experiment

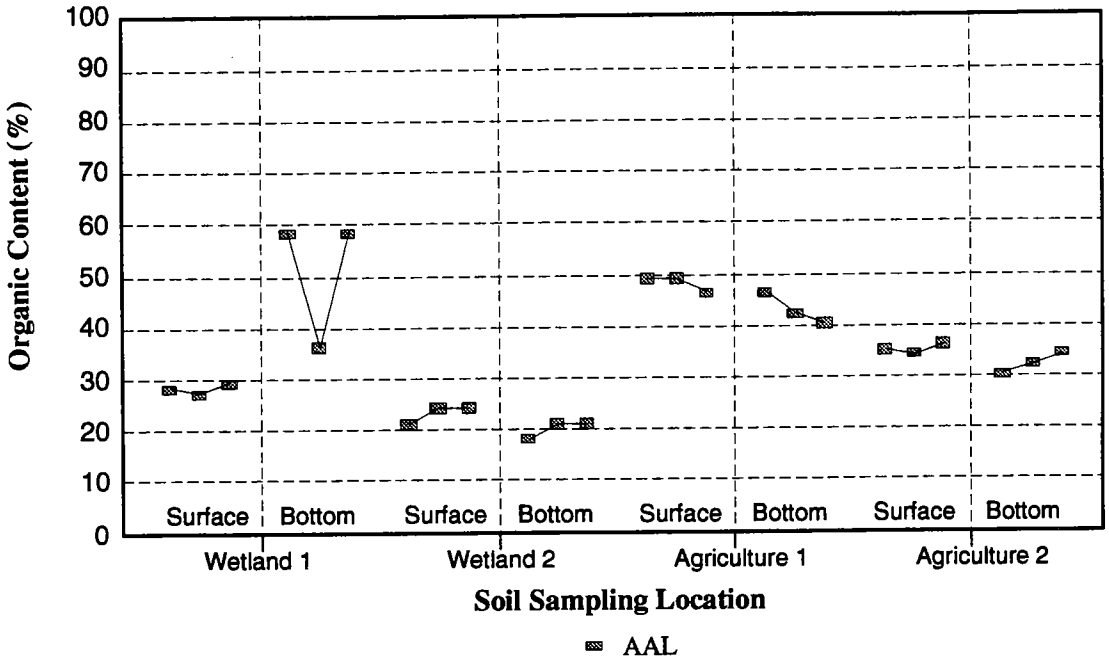


Figure C3-23.
Concentration of DOC during the 1992 Soil Water Extraction Experiment

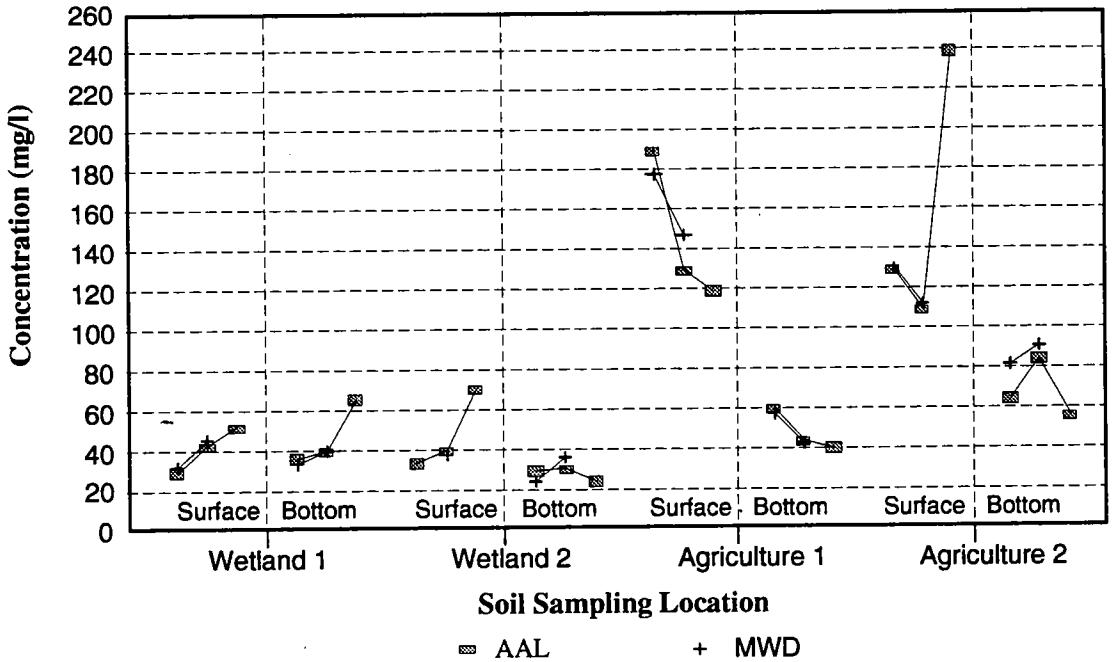


Figure C3-24.
UVA during the 1992 Soil
Water Extraction Experiment

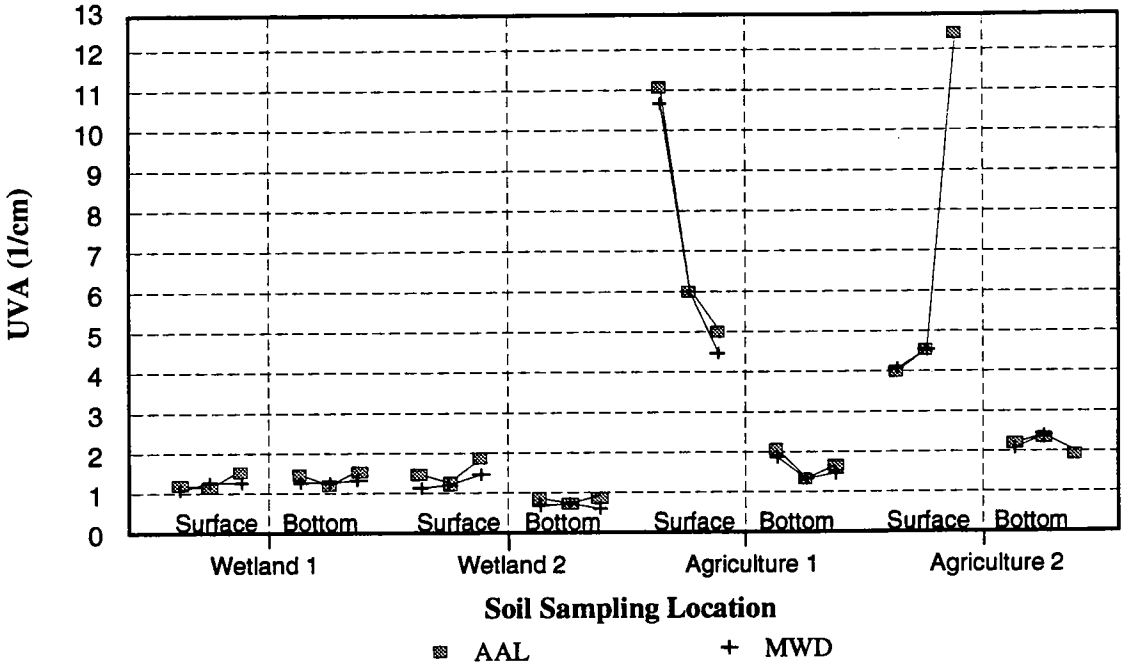


Figure C3-25.
UVA/DOC Ratio during the 1992
Soil Water Extraction Experiment

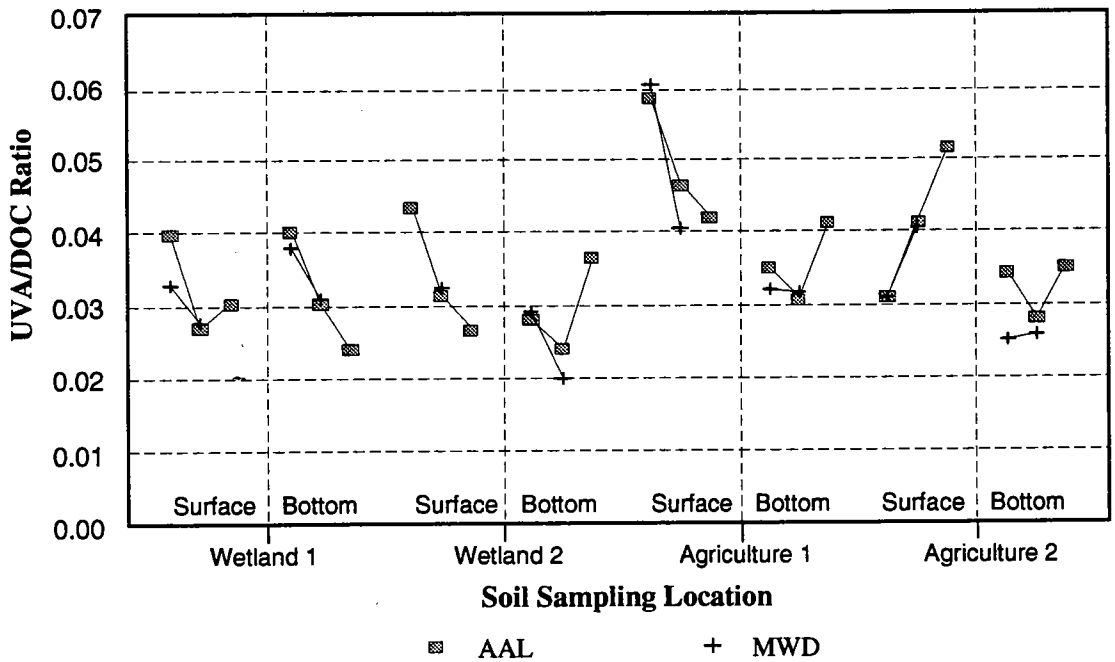


Figure C3-26.
DOC/Soil Organic Carbon Index of Soil Samples from Holland Tract during the 1992 Soil Water Extraction Experiment

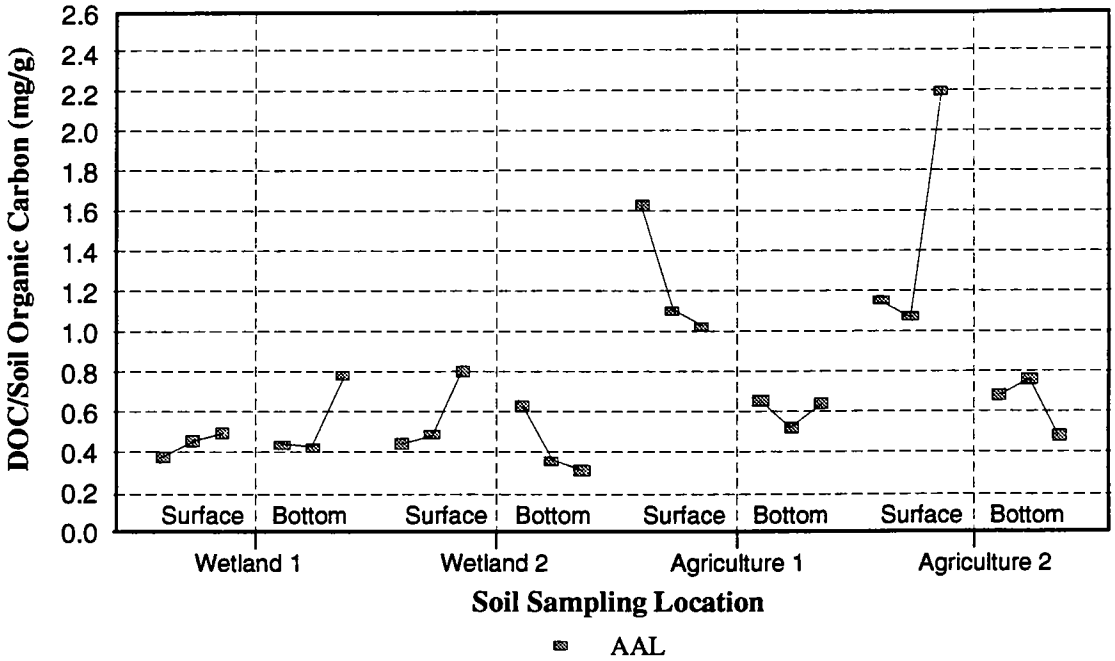


Figure C3-27.
C-THM Concentration during the 1992 Soil Water Extraction Experiment

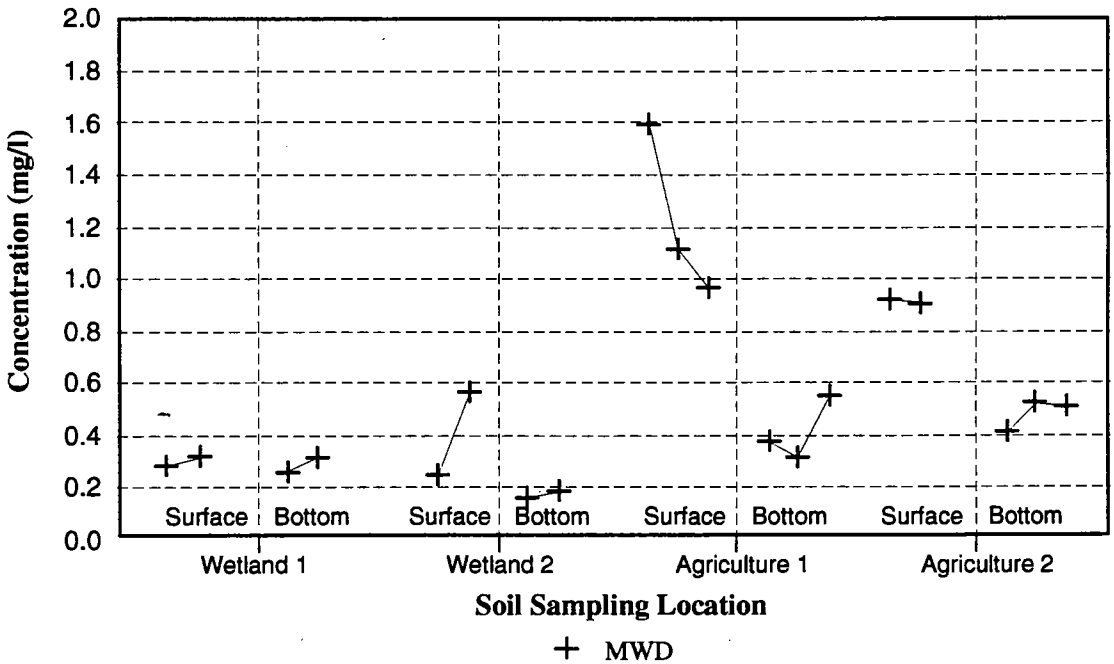


Figure C3-28.
C-THM/DOC Ratio of Soil Samples from Holland Tract during the 1992 Soil Water Extraction Experiment

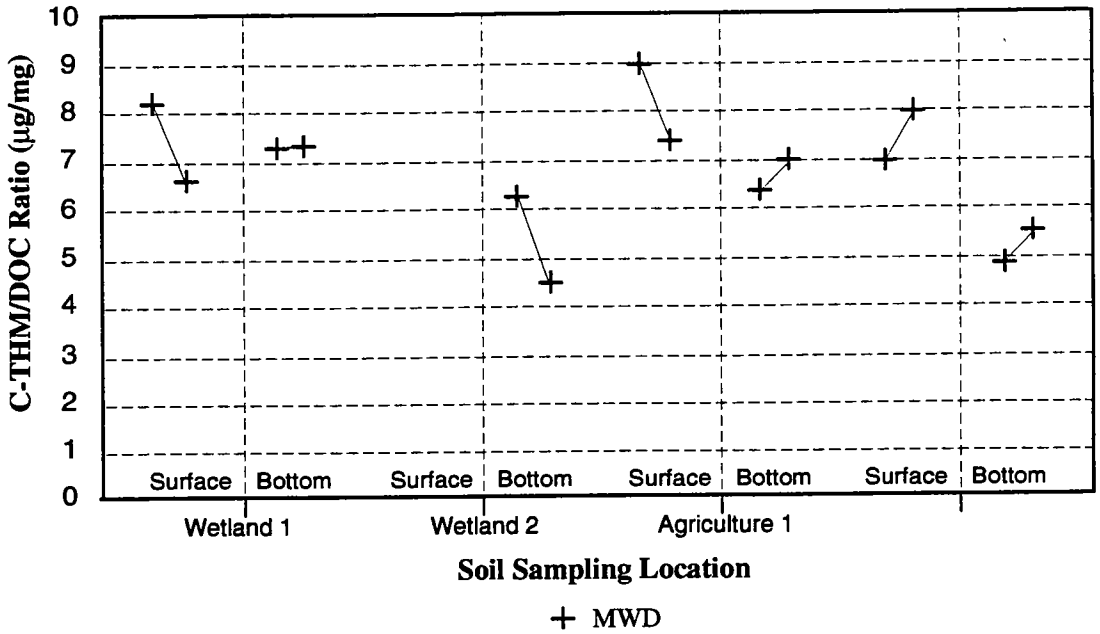
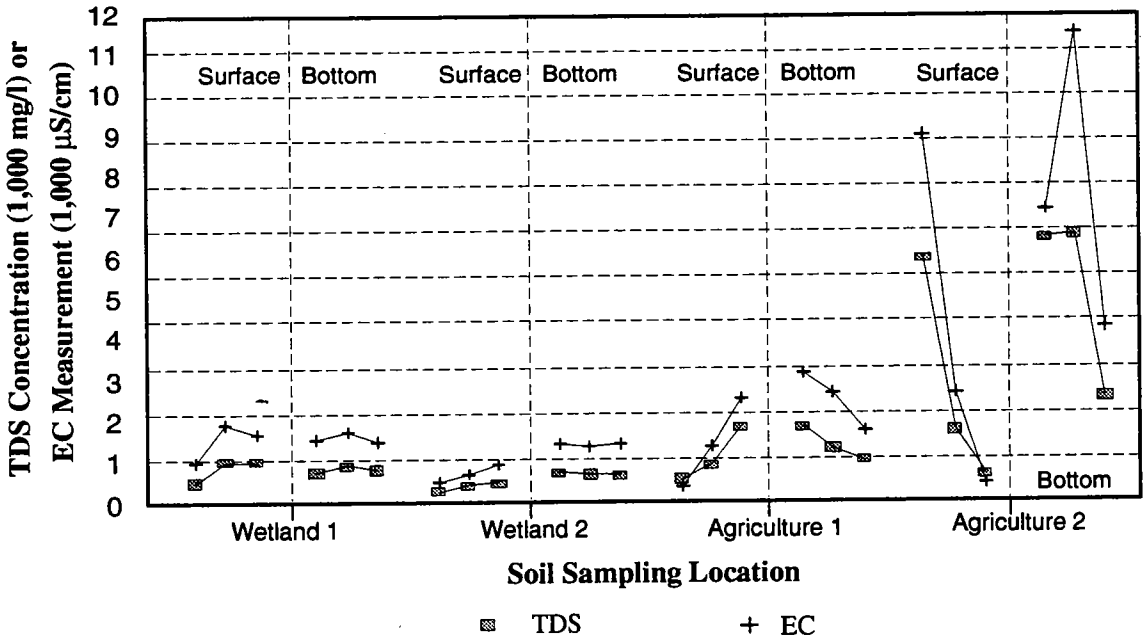
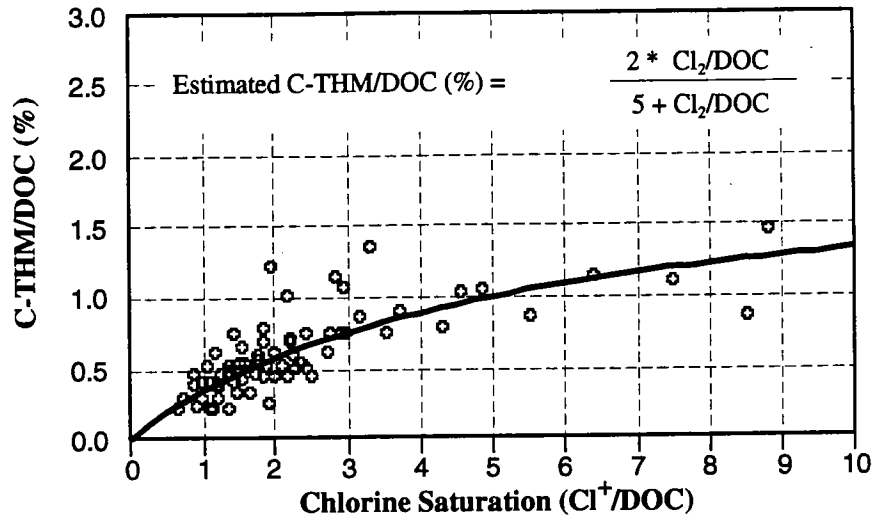


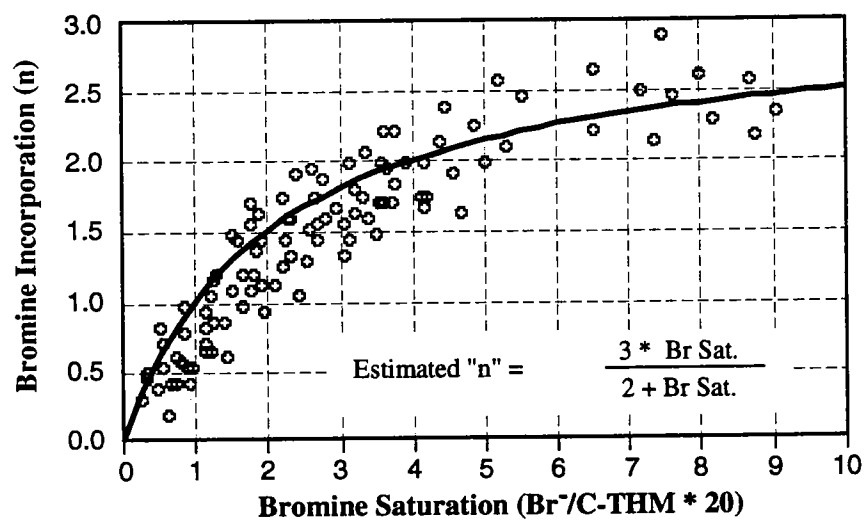
Figure C3-29.
TDS Concentration and EC during the 1992 Soil Water Extraction Experiment



Step 1: From measured DOC and chlorine dose, estimate the THM yield (the fraction of DOC that will become C-THM):



Step 2: From calculated bromide (chloride * 0.0035) and estimated C-THM, estimate bromine saturation and bromine incorporation (n):



Step 3: Estimate the THM molar weight and the distribution of THM species as a function of "n":

THM (Molar Weight) = 119 + 44.5 * n

$$CHCl_3 = \left(1 - \frac{1}{3}n\right)^3 = 1 - n + \frac{1}{3}n^2 - \frac{1}{27}n^3$$

$$CHCl_2Br = 3 * \left(1 - \frac{1}{3}n\right)^2 * \frac{1}{3}n = n - \frac{2}{3}n^2 + \frac{1}{9}n^3$$

$$CHClBr_2 = 3 * \left(1 - \frac{1}{3}n\right) * \left(\frac{1}{3}n\right)^2 = \frac{1}{3}n^2 - \frac{1}{9}n^3$$

$$CHBr_3 = \left(\frac{1}{3}n\right)^3 = \frac{1}{27}n^3$$

Figure C3-30.
General THM Prediction Model

DELTA WETLANDS
PROJECT EIR/EIS
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Figure C3-31.
C-THM Yield from DOC in DWR MWQI Delta Channel Measurements for 1982-1991

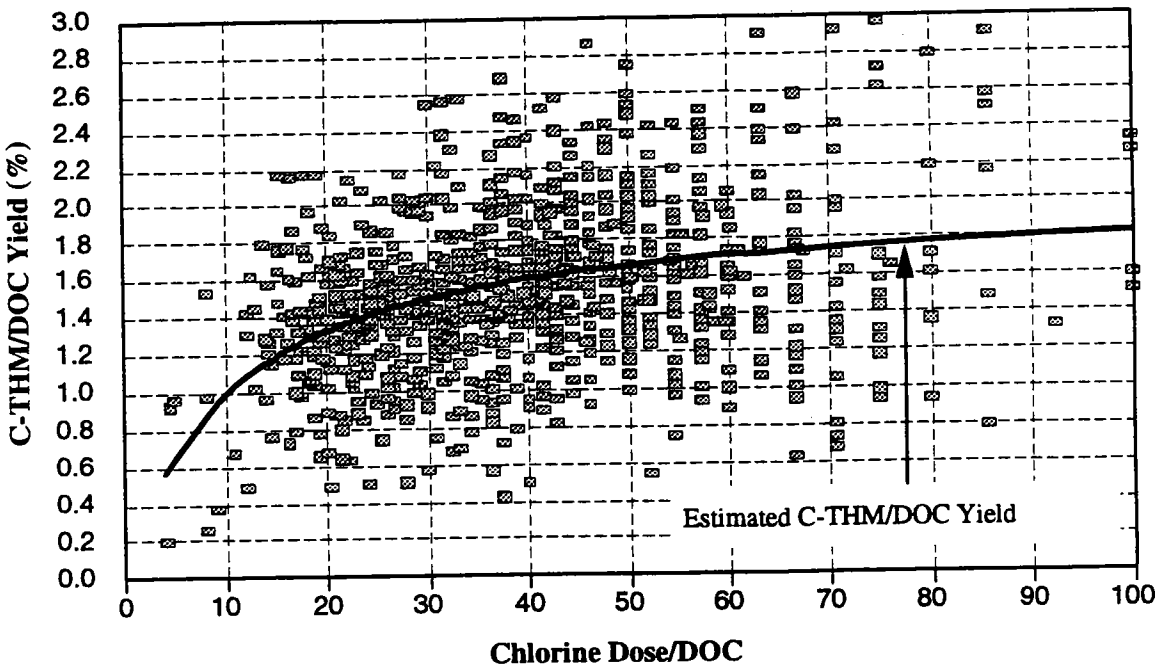


Figure C3-32.
Bromine Saturation of THM in DWR MWQI Delta Channel Measurements for 1982-1991

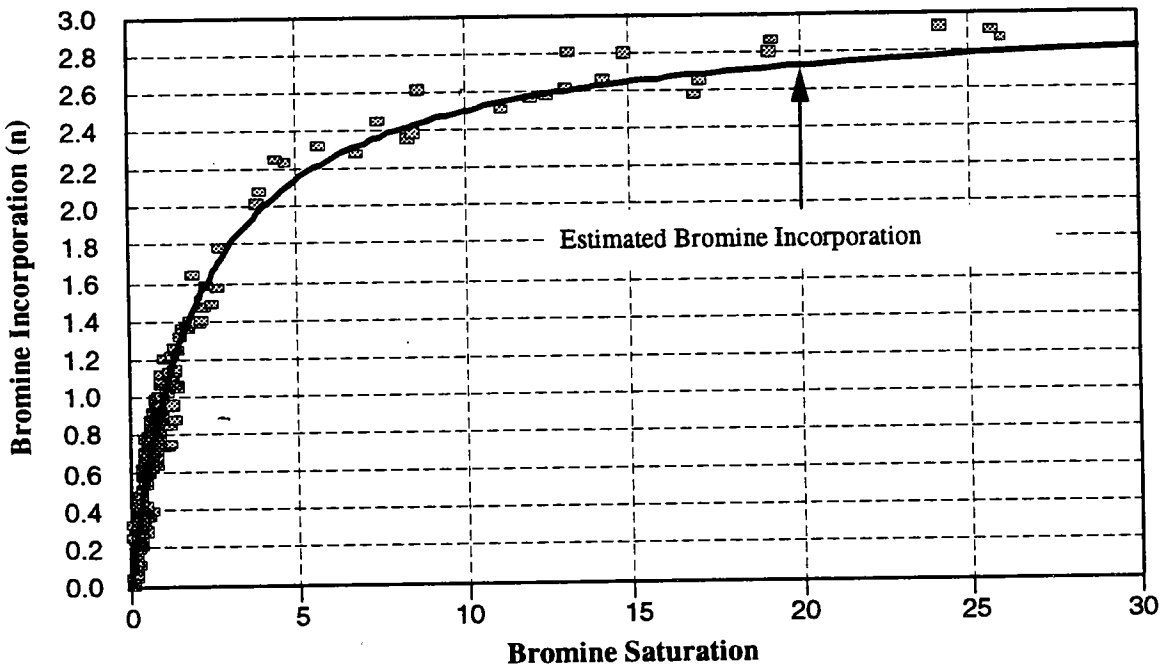


Figure C3-33.
C-THM Yield from DOC in DWR MWQI Delta Agricultural Drainage Measurements for 1985-1991

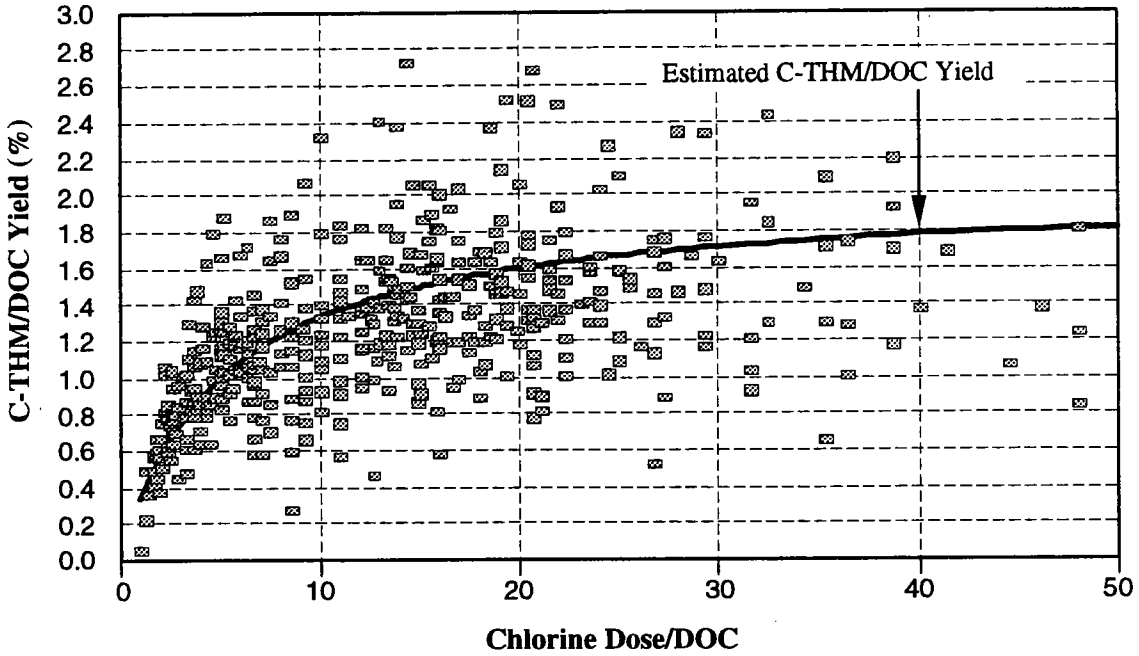


Figure C3-34.
Bromine Saturation of THM in DWR MWQI Delta Agricultural Drainage Measurements for 1985-1991

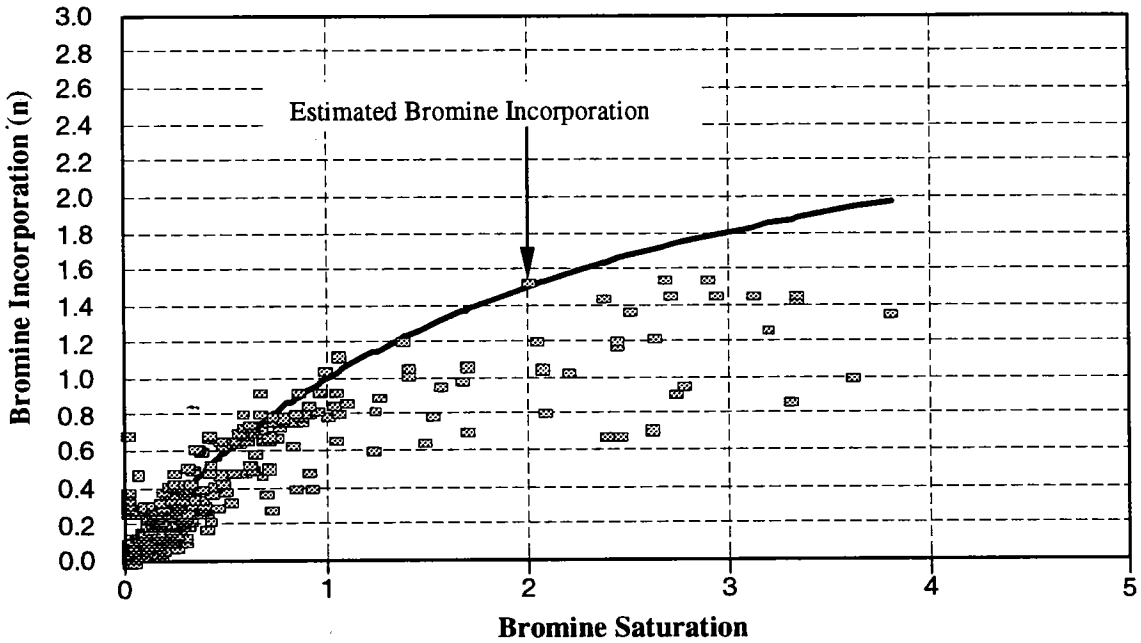


Figure C3-35.
C-THM Yield from DOC in MWD
SDS Assays of THM for 1991-1993

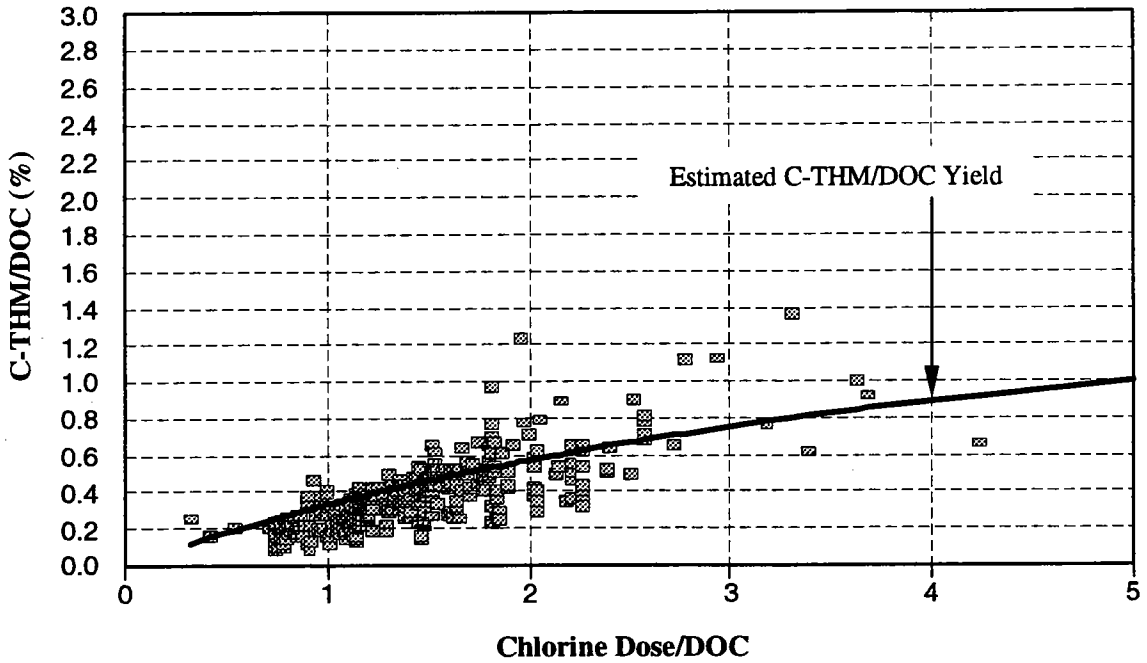
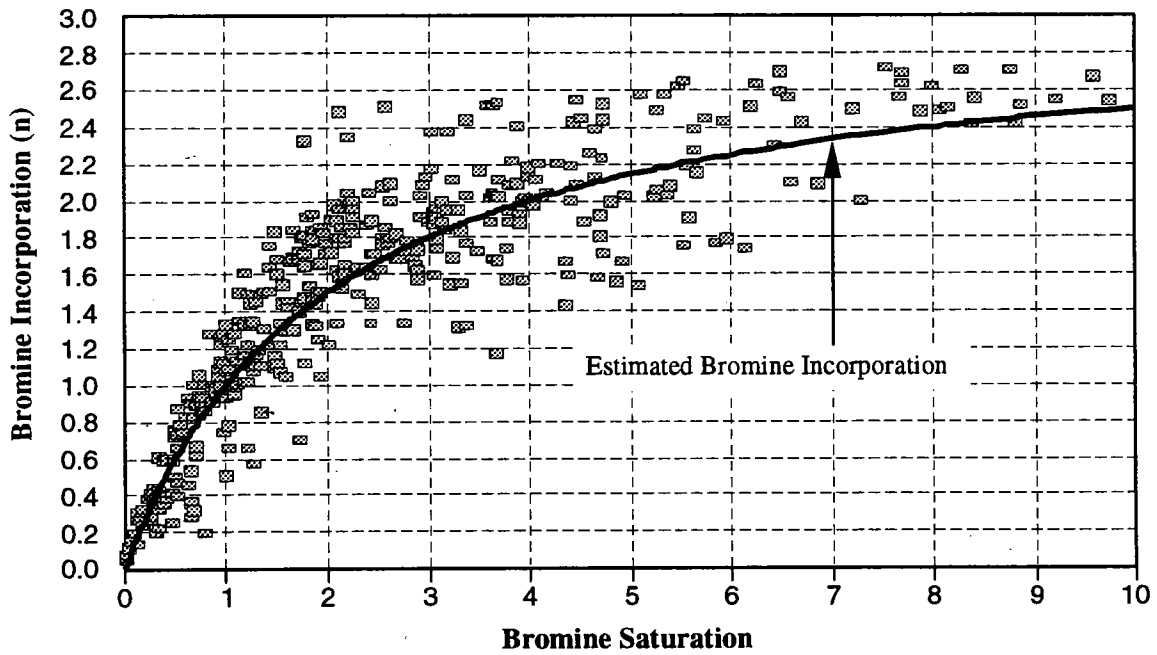


Figure C3-36.
Bromine Saturation of THM in MWD
SDS Assays of THM for 1991-1993



Appendix C4. DeltaDWQ: Delta Drainage Water Quality Model

Appendix C4. DeltaDWQ: Delta Drainage Water Quality Model

SUMMARY

This appendix describes the Delta Drainage Water Quality model (DeltaDWQ), which was developed for estimating monthly Delta agricultural island drainage and Delta export water quality. The model represents monthly water, salt, and dissolved organic carbon (DOC) budgets for agricultural islands in both the Delta lowlands and the Delta uplands. Delta export water quality is determined from approximate percentage source contributions and source water quality estimates. DeltaDWQ was used to analyze the effects of Delta Wetlands (DW) project discharges on Delta export water quality. This appendix summarizes DeltaDWQ estimates of electrical conductivity (EC) values and DOC concentrations in DW discharges and in Delta exports.

INTRODUCTION

The available Delta channel and agricultural drainage water quality data have been reviewed and evaluated in Appendices C1, "Analysis of Delta Inflow and Export Water Quality Data"; C2, "Analysis of Delta Agricultural Drainage Water Quality Data"; and C3, "Water Quality Experiments on Potential Sources of Dissolved Organics and Trihalomethane Precursors for the Delta Wetlands Project". The data are not sufficient for estimating average Delta agricultural drainage volumes and EC or DOC concentrations. For impact assessment purposes, a water quality model of Delta drainage effects on Delta export concentrations of salt and DOC was required. The model, DeltaDWQ, was used to integrate and interpret the available water quality data and estimate likely effects of DW project operations on Delta export salt and DOC concentrations. DeltaDWQ was used to estimate monthly Delta EC and DOC for the 25-year period of 1967-1991.

Estimates of Island Discharge Water Quality

DeltaDWQ simulates monthly patterns of Delta agricultural water management, soil salt buildup and leaching, and DOC loading. DeltaDWQ-estimated concentrations of salt and DOC in proposed DW project discharges were compared with estimated drainage concentrations under current agricultural practices on Delta lowland islands. DeltaDWQ results were used to estimate effects of the proposed DW project discharges from the reservoir and habitat islands on the overall Delta water, salt, and DOC budgets.

Effects on Delta Export Water Quality

Patterns of Delta island drainage water quality estimated with DeltaDWQ were then used to estimate likely effects on Delta export water quality. The movement of DW discharges and agricultural drainage to Delta export locations was determined from the results of hydrodynamic transport modeling performed by Resource Management Associates (RMA) with its Delta transport model. The RMA Delta transport model was used to simulate the movement of tracers from various inflow locations, including DW discharges and agricultural drainage, to Delta export locations at Rock Slough intake of Contra Costa Water District (CCWD), Banks Pumping Plant of the State Water Project (SWP), and Tracy Pumping Plant of the Central Valley Project (CVP). The RMA Delta transport model results have been used in DeltaDWQ to estimate the monthly average proportion of Delta exports that is discharged from the DW islands under DW project operations for each month of Delta inflow and export conditions. Estimates of DW discharge contribution to export volume were then used to estimate possible changes in monthly average DOC concentrations in Delta exports that may be attributable to DW project

discharges, or the reduced agricultural drainage from the DW project islands.

DESCRIPTION OF THE DELTA DRAINAGE WATER QUALITY MODEL

The DeltaDWQ model simulates Delta agricultural island drainage water quality by simultaneously accounting for water, salt, and DOC budgets on agricultural Delta uplands and lowlands. Figure C4-1 shows the assumed water, salt, and DOC budget terms for Delta agricultural islands. The following sections describe the basic assumptions for each of these mass-balance DeltaDWQ modules and presents general results from DeltaDWQ modeling.

Delta Water Budget Terms

DeltaDWQ estimates water budgets for three types of Delta landscapes. These types and their corresponding water budget terms are as follows:

- **Open-water, riparian, and urban acreage.** Water budget terms include only evapotranspiration (ET) and rainfall; there are no soil moisture terms.

- **Delta upland agricultural island acreage.** Water budget terms include ET, rainfall, soil moisture storage, applied irrigation water, and pumped drainage water (all drainage is assumed to return to Delta channels without infiltration losses to regional groundwater recharge). Salt leaching is not included in the upland water budget terms because rainfall and irrigation drainage are sufficient to prevent salt buildup.

- **Delta lowland agricultural island acreage.** Water budget terms include ET, rainfall, soil moisture storage, seepage, water applied for irrigation and for salt leaching, and pumped drainage water.

Table C4-1 gives the average monthly water budget values for the open-water, riparian, and urban acreage. Table C4-2 gives average monthly values for the Delta upland region water budget. Table C4-3 gives average monthly values for the Delta lowland region water budget. The monthly water budget terms in DeltaDWQ are specified as inches of water.

Monthly rainfall is measured at several Delta locations and the estimated average is recorded in California Department of Water Resource's (DWR's) DAYFLOW database. Monthly average ET rates for open water, uplands, and lowlands are estimated from pan evaporation data, crop acreage, and assumed crop ET rates. A repeating monthly evaporation pattern totaling 55.4 inches per year was assumed for DeltaDWQ (Table C4-1). Estimates of irrigation leaching fraction (the ratio of drainage water to applied water), lowland seepage rates, minimum and maximum monthly soil moisture depths, and monthly drainage depths for salt leaching are more difficult to obtain. Because few of the Delta water budget terms are measured directly, confirmation of the assumed DeltaDWQ values is difficult. The model allows the uncertainty associated with these assumed water budget terms to be identified through sensitivity testing. The selected values for the DW impact assessments are described in the following sections.

Delta Consumptive Use

Comparison of DeltaDWQ estimates with those of other monthly water budget models of net consumptive use for the entire Delta cannot confirm individual water budget term assumptions. Net channel depletion values for the Delta as a whole are bounded by total rainfall and gross ET estimates, but net monthly water use patterns on Delta islands are modified by soil moisture storage changes and salt leaching practices, and the irrigation efficiency (ET/applied water) must be estimated independently.

Figure C4-2 shows simulated monthly net consumptive use, or "channel depletion", from the entire Delta for water years 1982-1991 from the DWR statewide operations model DWRSIM, the DWR Delta water budget database DAYFLOW, and DeltaDWQ. Figure C4-2 indicates that the maximum monthly channel depletion estimated with DeltaDWQ is slightly (300 cfs) higher than the values provided by DAYFLOW and DWRSIM. The DeltaDWQ estimate of average annual Delta net consumptive use of 820 thousand acre-feet per year (TAF/yr) was close to the average used in DWRSIM (844 TAF/yr) and about 15% higher than the DAYFLOW value (702 TAF/yr) for the same period (1967-1991).

Net channel depletion (i.e., consumptive use) is the only Delta water budget term required as input for

monthly operations models (e.g., DWRSIM). Net channel depletion does not represent a complete Delta water budget because diversion and drainage terms are not specified.

Cropland Evapotranspiration

Tables C4-2 and C4-3 present monthly crop ET values assumed in DeltaDWQ for Delta uplands and lowlands that were obtained from the consumptive use model used by DWR for the Delta uplands and lowlands (DWR 1979). These ET values are the basis for Delta channel depletion estimates for summer months. Only irrigated portions of Delta uplands and lowlands contribute to net channel depletion volumes; idle or natural lands generally retain rainfall until ET losses deplete the soil moisture. In its consumptive use analysis, DWR uses estimates of about 50,000 acres of idle and natural land in the Delta uplands (26% of total) and about 54,000 acres in the Delta lowlands (14% of total).

Leaching Fraction

A common estimate of irrigation efficiency is 70%; thus, a leaching fraction of 30% is often assumed for estimating drainage volume associated with irrigation water. Under this assumption, for each inch of water required for crop ET, 1.43 inches (1.0/0.7) of water would be applied as irrigation water, and 0.43 inch (30% of water applied) would leach and appear as drainage. DeltaDWQ assumes this 30% leaching fraction for Delta uplands for all months with applied irrigation water (Table C4-2). The leaching fraction assumed in DeltaDWQ for Delta lowlands is 50% because water use is generally higher on Delta lowland islands, reflecting the peat soils, irrigation methods, and crop types of the Delta lowlands.

For the Delta lowlands, DeltaDWQ also assumes constant seepage from Delta channels of 1 inch per month (Table C4-3). Seepage is assumed to flow directly to drainage ditches and is therefore not used to satisfy crop ET. Delta lowlands also have a significant amount of salt leaching water applied and drained during winter to remove accumulated salts from the soil crop root zone. Applied leaching water was simulated in DeltaDWQ through specification of additional seepage (and drainage) depths during winter months. For December, January, and February, an additional 2 inches of applied water per month (6 inches per year) were specified to approximate salt leaching water practices on the Delta lowland islands (Table C4-3). DeltaDWQ can be used to determine the sensitivity of water use to different assumed ET, irrigation efficiency, leaching, and seepage rates, but these water budget terms were assumed to remain constant for DW impact assessment purposes.

Soil Moisture Storage

Because soil water (moisture) storage is difficult to estimate or measure, fairly simple assumptions are made in DeltaDWQ. These assumptions follow methods used in the DWR monthly consumptive use model of the Delta uplands and lowlands (DWR 1979). A minimum and maximum soil water storage depth is specified for each month. Rainfall increases soil water storage to the maximum specified depth before drainage occurs. Irrigation is required only if the soil water storage falls below the specified minimum storage depth.

The DWR consumptive use model represents several crop types with separate minimum and maximum soil water storage depths (corresponding to the root zone depth of each crop type). DeltaDWQ uses a single minimum and maximum soil water depth representing the average soil water depths of the irrigated crops for each month. The uplands and lowlands are modeled separately with different specified monthly soil water storage depths. Tables C4-2 and C4-3 give the assumed minimum and maximum monthly soil moisture storage depths for Delta uplands and Delta lowlands, respectively.

DW Island Drainage Records

The best available data for confirming Delta agricultural island water balance terms are records of drainage-pump power consumption. Power consumption is converted to flow volumes, using pump efficiency test results expressed as acre-feet per kilowatt-hour (af/kWh). Monthly pumping records for the four DW islands have been obtained for 1986-1991. Monthly pumping records are available beginning in 1986 for Bouldin Island, beginning in 1988 for Bacon Island, and beginning in 1990 for Webb and Holland Tracts.

Figure C4-3 compares DeltaDWQ estimates of Delta lowland drainage and measured pumping from the four lowland DW islands. Monthly pumping measurements from the four DW islands vary from 0 to 10 inches per month. Simulated pumping generally follows a double-peak pattern, with high pumping in winter in response to excess rainfall and salt leaching practices, and high summer pumping in response to excess irrigation drainage. There is considerable variation in the measured

drainage between the four islands and from one year to the next. DeltaDWQ represents as assumed average lowland water budget that is required for incremental impact assessment of the DW project. The simulated drainage patterns are substantially different from some of the measured drainage patterns. Uncertainties in the estimated drainage volumes will not change the impact assessment results.

Simulated Drainage and Application Volumes

DeltaDWQ simulated Delta lowland drainage averaged 42.4 inches per year, for an annual Delta lowland island drainage volume of 1,210 TAF. Approximately one-half of annual lowlands island drainage occurs during the irrigation season, and the remainder occurs in winter following rainfall or salt leaching periods. Delta rainfall averaged 16.3 inches per year but varied from about 8 inches to 30 inches during 1967-1991 (DAYFLOW). The corresponding applied water simulated by DeltaDWQ, including seepage and water applied for salt leaching, averaged about 57 inches, for a total volume of 1,632 TAF/yr. About 342 TAF/yr (1 inch per month) was assumed to be seepage, and the remainder of 1,290 TAF/yr was assumed to be diverted through unscreened siphons in the Delta lowlands.

The lowland island drainage pattern simulated by DeltaDWQ most closely matches measured drainage pumping for Bouldin Island (Figure C4-3). Bacon Island drainage pumping was similar to modeled drainage in winter, but measured drainage on Bacon Island during the irrigation season was much higher than simulated drainage, averaging 8 inches per month. High summer pumping was apparently a result of the water management required for the row crops grown on Bacon Island soils. Drainage pumping from Webb and Holland Tracts for 1990 and 1991 was lower than simulated Delta lowlands drainage because of reduced agricultural irrigation during levee rehabilitation work and participation in the DWR emergency water bank program.

Delta Salt Budget Terms

Salt budget terms in DeltaDWQ are directly associated with the water budget terms. Salt concentrations are represented by EC because this is the most common field measurement of salinity. Agricultural island soil water EC values are lowered by rainfall and raised by water loss through ET. ET is the basic mechanism for salt buildup in soil water and for increases in salt concentrations between applied water and drainage water.

Seawater intrusion and other source water may increase salt concentrations in applied water and influence soil water and drainage salinity on agricultural islands. Because of different salinity conditions in Delta channels, DeltaDWQ separately represents salinity budgets for the Sacramento River and San Joaquin River regions of both the Delta uplands and lowlands. Channel water salinities in these four regions of the Delta are estimated separately. The water budgets are identical in the two uplands and two lowlands regions.

Applied Water Salinity

DeltaDWQ estimates applied water salinity (EC) for Delta uplands from Sacramento and San Joaquin River flow-EC regressions (power equations) and includes the effects of Delta outflow on seawater intrusion into the Sacramento and San Joaquin River lowlands with outflow-EC regressions (negative exponential equations). More accurate estimates of channel salinity can be obtained from a Delta hydraulic and salt transport model such as the RMA Delta transport model or the DWR Delta Simulation Model (DWRDSM) but may not be necessary for impact assessment of likely DW project operations on Delta export salinity.

Historical monthly EC measurements were used to adjust the DeltaDWQ estimates of inflow salinity and seawater intrusion effects. Figure C4-4 shows the simulated and measured monthly average EC values for the Sacramento River (Greene's Landing), the San Joaquin River (Vernalis), and Jersey Point. Simple flow regressions are sufficiently reliable for an assessment model such as DeltaDWQ for evaluating relative differences between DW project alternatives.

Salt Leaching Factors

DeltaDWQ estimates salt concentrations (EC) of soil water by mass balancing separately for the Sacramento and San Joaquin regions of the Delta uplands and lowlands. Mass balancing starts with the previous salt content of soil water plus the salt in the applied water minus the salt in the drainage water, assuming some monthly ratio between the drainage EC value and the soil water EC value. This monthly ratio is called the "leaching factor" in DeltaDWQ. Monthly "leaching factors" are the only salt budget coefficients required by the DeltaDWQ model. The leaching factor is an estimate of how

effectively the salt in the soil moisture is removed by the drainage water.

The available drainage EC data indicate that the salt leaching factor is relatively high in winter, when rainfall and leaching water efficiently moves salt from the soil water to island drainage networks. The salt leaching factor generally decreases to relatively low values during the summer irrigation season because most excess applied water goes directly to drainage water, bypassing the soil water in the crop root zone, and does not provide efficient salt leaching.

The salt leaching factors used in DeltaDWQ were derived to match the seasonal patterns observed in drainage EC measurements from DW islands obtained as part of the DWR Municipal Water Quality Investigations (MWQI) program (see Table C2-3 in Appendix C2, "Analysis of Delta Agricultural Drainage Water Quality Data"). Monthly salt leaching factors for the Delta uplands and lowlands are shown in Tables C4-2 and C4-3. These fixed monthly values are only approximations; actual salt leaching will depend on the rainfall, soil moisture salt storage, and irrigation practices (DWR 1994). The uncertainty in the assumed salt leaching factor will not change the impact assessment results but will change the simulated drainage EC patterns.

Electrical Conductivity Measurements of DW Island Drainage

Figure C4-5 shows periodic EC grab-sample measurements from Webb Tract and Bouldin Island (from two drainage pumping plants on each island) for 1987-1991 (see Appendix C2) compared with the monthly average drainage EC values simulated by DeltaDWQ for Delta lowlands in both the Sacramento and San Joaquin regions. The EC measurements show a seasonal pattern, with the highest EC values in drainage water during winter. Bouldin Island EC values were generally 0.2-0.4 millisiemens per centimeter (mS/cm) in the summer irrigation season, indicating very little increase above the EC values of water diverted onto the island in summer. For Bouldin Island, winter EC values were generally several times higher than summer values. The Bouldin Island measurements generally confirm the simulated pattern for Sacramento lowlands shown in Figure C4-5. The available drainage EC data for Webb Tract are higher than drainage EC data for Bouldin Island.

Figure C4-5 also shows periodic EC grab-sample measurements from Bacon Island and Holland Tract (with two pumping plants on Bacon Island and three on Holland Tract) during 1990 and 1991 (see Appendix C2). Reduced farming during levee rehabilitation and participation in the DWR emergency water bank program reduced drainage pumping from these islands during both years with EC measurements. DeltaDWQ simulates average conditions for the overall San Joaquin region Delta lowlands. The EC measurements from Bacon Island and Holland Tract generally follow the basic simulated pattern for San Joaquin lowlands shown in Figure C4-5. Much more drainage EC data will be needed to confirm the simulated Delta lowland drainage EC patterns.

Estimated Electrical Conductivity of Soil Water

Confirmation of simulated soil-water EC values is difficult because relatively few measurements of soil-water EC are available. Soil-water EC values simulated by DeltaDWQ for the Sacramento region of the Delta lowlands fluctuated from about 1 mS/cm to 3 mS/cm (Figure C4-6). Simulated soil-water EC values for the San Joaquin region of Delta lowlands fluctuated between about 1 mS/cm and 10 mS/cm (Figure C4-6). Most of the variation in soil-water EC is caused by dilution as the soil-water storage is increased by rainfall and leaching water.

Several field observations are available to confirm the approximate magnitude of DeltaDWQ simulations of soil-water EC. Saturated soil-water EC measurements from Holland Tract in 1992 were generally in the range of 0.5-5 mS/cm (see Table C3-7 in Appendix C3, "Water Quality Experiments on Potential Sources of Dissolved Organics and Trihalomethane Precursors for the Delta Wetlands Project"). In August 1989, 18 soil samples for Holland and Webb Tracts were analyzed for agricultural nutrients; 10 saturated soil extract samples from Holland Tract had EC values that averaged 7.9 mS/cm (range of 2.8-21.0 mS/cm) and eight samples from Webb Tract had EC values that averaged 6.0 mS/cm (range of 2.5-7.8 mS/cm) (Taylor pers. comm.). The model simulates soil-water EC values of 3 mS/cm for Delta lowlands with Sacramento River source water, and 10 mS/cm for San Joaquin River source water (Figure C4-6).

Delta Dissolved Organic Carbon Budget Terms

DOC budget terms in DeltaDWQ for Delta uplands and lowlands are similar to the EC budget terms, with the addition of source terms representing residues of vege-

tation decay and peat soil decomposition. Once released through vegetation decay or peat soil oxidation, DOC is assumed to be conservative and to accumulate like salt in the soil water of the crop root zone (see Appendix C2 for further discussion of DOC characteristics). Salt leaching factors used in the EC budget are also used in the DOC budget to account for leaching and drainage of accumulated soil water DOC.

Dissolved Organic Carbon Sources

Inflowing DOC concentrations are estimated using flow-DOC regressions for the Sacramento and San Joaquin Rivers that are similar to those for estimating inflowing EC. The only additional model coefficients required for the DOC budget are monthly DOC source terms for the Delta uplands and lowlands, and DOC source terms for DW reservoir islands and habitat islands.

Monthly DOC source terms for agricultural operations and DW project operations on the two habitat islands and two reservoir islands have been estimated from the water quality experiments described in Appendix C3. The annual load of DOC from Delta lowland islands was estimated from data presented in Appendix C3 to be approximately 12 g/m^2 (Table C4-3). The monthly distribution of DOC loading from Delta lowland agricultural islands was assumed to be uniform at 1 g/m^2. The loading of DOC from Delta uplands was estimated from data presented in Appendix C3 to be considerably less than that from the Delta lowlands. The annual upland DOC loading is assumed to be 6 g/m^2 with a uniform monthly distribution of 0.5 g/m^2 in DeltaDWQ (Table C4-2).

For the habitat islands, DOC was assumed to be released from decaying vegetation in flooded wetlands at a uniform rate of 3 g/m^2/month during the flooded wetland period of November through January, and to be released from peat soil leaching at a uniform rate of 1 g/m^2/month for the remainder of the flooded period, giving a total assumed loading of 12 g/m^2/year (Table C4-4).

For the DW reservoir islands, the source of DOC may depend on the sequence of water storage operations. If the islands are flooded, the peat soil oxidation will likely be lower than on Delta lowland agricultural islands because of expected moisture and temperature conditions. DeltaDWQ assumes 50% of the lowland agricultural loading rate of 1.0 g/m^2/month. If the reservoir islands are dry, the monthly rate is equal to the assumed lowland agricultural loading rate of 1.0 g/m^2/month. Wetland vegetation is simulated to grow during May-September. The additional loading of 8 g/m^2/year was assumed if vegetation was fully developed (dry conditions for 5 months). The loading was assumed to be proportional to the number of dry months during the growing season.

The assumed total loading from dry wetlands would be 20 g/m^2/year, corresponding to the experimental results from the Holland Tract demonstration wetlands (Appendix C3). The vegetation loading of 8 g/m^2 corresponds to the results from the vegetation experiments (Appendix C3). The assumed loading from "wet" DW reservoir islands with no vegetative growth would be reduced to 6 g/m^2/year.

Although these assumed DOC loading rates are somewhat uncertain for both lowland agricultural islands and the DW project islands, the magnitude of DOC loading from lowland agricultural islands and the DW project islands is assumed to be approximately the same (each about 12 g/m^2).

The possible effects of DW project operations on DOC concentrations will depend on the estimated discharge of DOC loading from the DW project islands compared with the agricultural drainage of DOC loading from the DW project islands under No-Project Alternative conditions. Because the entire Delta lowland region contributes DOC loading at about the same rate as the DW project islands, likely impacts result from the assumed seasonal shift in DOC loading from the DW project islands. The DeltaDWQ results for DOC will be described in the following sections.

Dissolved Organic Carbon Concentrations in DW Island Drainage

Figure C4-7 shows periodic grab-sample DOC measurements from drains on the four DW project islands (see Appendix C2 for other Delta drainage DOC measurements) compared with monthly average DOC simulations of lowland agricultural DOC drainage concentrations from DeltaDWQ. Like EC, DOC concentrations are generally lower during the summer irrigation period and are much greater during winter. The DeltaDWQ simulated DOC concentration pattern for Delta lowlands agricultural islands appears consistent with the available data. DOC concentrations generally remained less than 20 mg/l during the irrigation season but increased to greater than 50 mg/l during winter. Grab samples collected once per month may not correspond

well to average monthly concentrations that DeltaDWQ is estimating.

Many of the measured DOC concentrations from Webb Tract and Bouldin Island (Figure C4-7) are greater than the DeltaDWQ-simulated values. However, the measurements from Bacon Island and Holland Tract (Figure C4-7) are considerably lower than the simulated values. DeltaDWQ simulates the average drainage concentration with average drainage volumes for Delta lowland islands. Increasing the assumed DOC loading may provide a better match with the measured Webb Tract and Bouldin Island DOC concentrations, but this would increase the simulated Delta export DOC concentrations above the measurements, as described in a later section of this appendix. These simulated Delta lowland agricultural drainage DOC concentrations provide a reasonable basis for impact assessment of DW project effects on DOC concentrations in the Delta.

Estimated Soil-Water Dissolved Organic Carbon

Verification of the simulated soil-water DOC values is difficult because relatively few measurements of soil-water DOC are available. Delta lowland soil-water DOC values simulated by DeltaDWQ fluctuated between about 60 mg/l and 180 mg/l (Figure C4-8). Saturated soil-water DOC measurements from Holland Tract (described in Appendix C3) were generally in the range of 50-250 mg/l. Simulated soil-water DOC patterns are similar for the Sacramento and San Joaquin regions of the Delta lowlands because the applied water has about the same DOC concentrations, and the loading from vegetation and peat soil decay is the major source for the soil-water DOC concentrations.

Both EC values and DOC concentrations in the soil water increase as a result of ET, but DOC concentrations are also increased by the addition of DOC from vegetation and soil decomposition processes. Therefore, the ratio of DOC to EC in the drainage water increases above that of the applied Delta channel water. Drainage DOC concentrations in excess of those calculated from the drainage water EC value and the applied water DOC/EC ratio can provide an indirect measure of the fraction of the drainage DOC originating in the Delta lowland island peat soil and vegetation decomposition processes.

Figure C4-9 shows measured DOC concentrations plotted against measured EC values for the DW island drainage samples. The DOC/EC ratio of 0.01 (2 mg/l DOC: 200 mS/cm EC), which is the expected ratio based on Sacramento River DOC and EC data, is shown as a line in Figure C4-9. The DOC/EC ratio for the San Joaquin River is approximately 0.005 (3 mg/l DOC: 600 mS/cm EC). DOC values above these lines are higher than expected (in the absence of an island source of DOC). The fraction of the DOC value above this line provides a rough estimate of the portion of the drainage DOC in that sample that originated on the island from decomposition sources. The portion of the DOC below the line can be explained by ET accumulation and salt leaching practices, without an island source of DOC from vegetation decay and peat soil oxidation.

DW DISCHARGE ELECTRICAL CONDUCTIVITY VALUES AND CONCENTRATIONS OF DISSOLVED ORGANIC CARBON

The DeltaDWQ model estimated monthly average EC values and DOC concentrations in discharges from the proposed DW project using the results of DeltaSOS simulations of the proposed DW project for 1967-1991 (see Appendix A3). Monthly diversion, storage, and discharge volumes for the reservoir islands simulated in DeltaSOS were used in DeltaDWQ to estimate EC and DOC concentrations in drainage from the reservoir islands.

Under the proposed DW project, two of the DW islands would be managed for wildlife habitat. A portion of these habitat islands would be flooded to provide waterfowl habitat beginning in September and continuing through May. A specified volume of water (1 TAF) is assumed to remain in borrow ponds and ditches throughout the year. During the waterfowl habitat period, some water from the flooded wetlands (0.5 TAF) would be circulated (discharged and diverted) each month. An assumed water budget for the habitat islands is used in DeltaDWQ to estimate EC and DOC concentrations in drainage water from the specified acreage of habitat islands. The assumed water budget terms for the habitat islands are given in Table C4-4.

Figure C4-10 shows the simulated monthly storage volume for the DW reservoir islands for 1967-1991 for Alternative 2 (slightly greater average DW discharges than under Alternative 1). During some years, the reservoir islands were simulated to fill and empty more than once, while in other simulated years water was not available and the reservoir islands remained empty. In a few years, the reservoir islands were simulated to remain full for an extended period until pumping capacity was available at the Delta export locations. Figure C4-10 shows

the simulated discharge flows corresponding to the storage patterns. DeltaDWQ assumes that a specified minimum seepage flow of 30 cfs would circulate each month (2 inches/month), so that the buildup of DOC concentrations from the continuous loading would be limited during periods when the reservoir islands are empty.

Figure C4-11 shows monthly DOC concentrations simulated by DeltaDWQ for DW habitat islands. The DeltaDWQ estimates of Delta lowland agricultural drainage DOC concentrations are shown for comparison. Although the specified annual DOC loading is assumed to be the same for agricultural and habitat islands, the monthly patterns of DOC loading, drainage discharge, and resulting DOC concentrations are somewhat different.

Figure C4-11 also shows monthly DOC concentrations simulated by DeltaDWQ for the DW reservoir islands under Alternative 2. The annual DOC loading from flooded reservoir islands is assumed to be half that from agricultural and habitat islands because the leaching of peat soil is expected to be less and vegetation will be greatly reduced. During periods when the reservoir islands would be empty, however, decay of vegetation is assumed to add 8 g/m^2 of DOC to the reservoir islands and greatly increase the DOC concentration in the small amount of circulating water. The reservoir island DOC concentrations would be reduced by filling of DW storage water, so the possible effect on export concentrations would be limited. The monthly pattern of discharge concentrations from the DW reservoir islands is therefore quite different from the pattern of agricultural drainage concentrations (Figure C4-7).

The simulated annual loading from the DW reservoir islands for Alternative 2 averaged 11.8 g/m^2 which was about the same as the assumed loading from agricultural drainage. These DeltaDWQ-simulated EC and DOC concentrations of discharges from the DW project habitat and reservoir islands cannot be directly confirmed because there are no measurements from existing habitat or reservoir islands in the Delta lowlands. The DeltaDWQ model can be used to determine the sensitivity of the simulated discharge EC and DOC concentrations to the specified water budget, salt leaching factors, and DOC loading terms, but these were all assumed to remain constant for impact assessment purposes. Simulation of the 25-year period (water years 1967-1991) provides an indication of the range of possible discharge concentrations caused by variations in Delta hydrologic conditions. Similarly, in the next section, the possible effects of DW operations on Delta export EC and DOC concentrations are estimated for the range of Delta hydrologic conditions represented by the 1967-1991 period.

ESTIMATED ELECTRICAL CONDUCTIVITY AND CONCENTRATIONS OF DISSOLVED ORGANIC CARBON IN DELTA EXPORTS

Water quality of Delta exports can be estimated using percentage contributions from each source of Delta water and estimated EC and DOC concentrations in the source water. Sources of Delta export water include the Sacramento and San Joaquin Rivers, Yolo Bypass and eastside rivers, tidal exchange (seawater intrusion), agricultural drainage, and DW discharges. DeltaDWQ uses simplified estimates of the source contributions to calculate expected EC values and DOC concentrations in Delta exports.

Figure C4-12 shows the simplified Delta flow pathways assumed in DeltaDWQ. Sacramento River water flows through half the Delta uplands acreage, and some portion of the Sacramento River flow (determined by DeltaSOS model) enters the Delta lowlands through the Delta Cross Channel (DCC), Georgiana Slough, and Threemile Slough. San Joaquin River water flows through the other half of the Delta uplands and is exported directly or enters the Delta lowlands. Eastside streams enter the Delta lowlands directly. Tidal exchange (seawater intrusion) in the vicinity of Jersey Point increases EC in Delta lowland channels.

DeltaDWQ assumes that each Delta export location has identical water quality, with water flowing from the Delta lowland channels with agricultural drainage and DW discharges added in. The RMA Delta transport model was used to provide more accurate estimates of agricultural drainage and DW discharge contributions to water at each of the export locations (CCWD, SWP, and CVP). The RMA Delta transport model uses the monthly Delta upland and lowland drainage volumes that are estimated with DeltaDWQ but accounts for actual discharge locations and monthly flow patterns within the Delta to calculate the percentage of agricultural drainage that is transported to each export location (see Appendix B1, "Hydrodynamic Modeling Methods and Results for the Delta Wetlands Project"). The differences between the export locations was not considered substantial, so the DeltaDWQ assessment model was used.

Figure C4-13 shows estimated EC values in Delta exports simulated by DeltaDWQ using historical inflows

without the proposed DW project for 1982-1991. Periods of high San Joaquin River inflows and seawater intrusion episodes contribute to the highest simulated EC values in Delta exports. Observed EC values at the three export locations (see Appendix C2) are shown for comparison in Figure C4-13. The simulated export EC values generally are representative of measured EC at the three Delta export locations.

Figure C4-14 shows the DeltaDWQ-simulated DOC concentrations in Delta exports, using historical inflows without the DW project for 1982-1991. The observed DOC concentrations at the three export locations (see Appendix C2) are shown for comparison. The simulated export DOC concentrations generally are representative of measured DOC at the three export locations.

Figure C4-15 shows the measured and predicted Sacramento and San Joaquin River DOC concentrations for 1982-1991. Many months had measured DOC concentrations that were higher than the DeltaDWQ estimates for both the Sacramento and San Joaquin Rivers. During these months, the expected Delta export DOC concentrations may actually be higher than the simulated concentrations.

Simulated Delta export DOC concentrations are often higher than the measured DOC at the three export locations, suggesting that the assumed DOC loading from Delta agricultural drainage or the inflow DOC estimates are too high in DeltaDWQ. However, the estimated inflow DOC concentrations are often lower than measured and the specified upland DOC load of 6 g/m^2/year and the specified lowland DOC load of 12 g/m^2/year are relatively low compared with estimates from available field data described in Appendix C3, "Water Quality Experiments on Potential Sources of Dissolved Organics and Trihalomethane Precursors for the Delta Wetlands Project". Although there are remaining uncertainties in simulating Delta drainage water quality, the DeltaDWQ simulations of export EC and DOC concentrations are determined to be adequate for impact assessment of DW project operations.

Figure C4-16 shows DeltaDWQ monthly simulations of DOC at the export locations with Alternative 2 operations. The difference in DOC concentration in Delta exports from the No-Project Alternative is also shown. The maximum increase in DOC predicted during months of DW storage discharges is about 1.0 mg/l, and simulated DW operations reduced Delta export DOC concentrations during most months. The simulated export DOC concentrations without any Delta agricultural drainage are shown for comparison. Simulated DOC without Delta agricultural drainage averaged 2.75 mg/l for the 1967-1991 period. Delta export DOC with Delta agricultural drainage but without DW operations averaged 4.06 mg/l. Delta export DOC with DW operations averaged 4.00 mg/l. Estimated DOC concentrations in Delta exports constitute the primary input required for the water treatment plant simulation model, described in Appendix C5, "Modeling of Trihalomethane Concentrations at a Typical Water Treatment Plant Using Delta Export Water".

CITATIONS

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California. Department of Water Resources. 1979. A computer program to estimate monthly consumptive use and water requirements. Hydrology and Water Operations, Statewide Planning Branch. Sacramento, CA. Unpublished report.

_____. Department of Water Resources. 1994. Mathematical models for estimating Delta island diversions and drainage flows. Division of Planning, Delta Modeling Section. Sacramento, CA.

Personal Communications

Taylor, Randy. Laboratory specialist. Harvey Laboratories, Inc., Patterson, CA. March 1994 - telephone conversation.

Table C4-1. Monthly Water Budget Terms for Delta Open-Water, Riparian, and Urban Acreage

Month	Water Evapotranspiration[a] (inches)	Rain[b] (inches)
October	3.7	0.8
November	1.7	2.2
December	0.9	2.6
January	1.0	3.2
February	1.9	2.5
March	3.4	2.7
April	5.1	1.2
May	6.9	0.4
June	7.9	0.1
July	9.0	0.1
August	8.0	0.1
September	5.9	0.4
Annual	55.4	16.3

Notes: Acreages by landform category:

Open water = 54,000 acres
Riparian = 9,000 acres
Urban (rain only) = 26,200 acres.

[a] Davis Evaporation Pan (adjusted for open water) monthly averages.

[b] Historical monthly rainfall values from DAYFLOW.

Table C4-2. Monthly Water, Salt, and DOC Budget Terms for the Delta Uplands

Month	Assumed Crop ET (inches)	Leaching Fraction	Minimum Soil Moisture Depth (inches)	Maximum Soil Moisture Depth (inches)	Leaching Factor (drainage EC/soil water EC)	DOC Load (g/m_2)
October	1.8	0.30	2	4	0.2	0.5
November	1.2	0.30	2	4	0.3	0.5
December	0.6	0.30	2	4	0.4	0.5
January	0.7	0.30	2	4	0.5	0.5
February	1.5	0.30	2	4	0.4	0.5
March	2.1	0.30	2	4	0.3	0.5
April	2.7	0.30	2	4	0.2	0.5
May	4.1	0.30	2	4	0.1	0.5
June	5.6	0.30	2	4	0.1	0.5
July	6.9	0.30	2	4	0.1	0.5
August	5.4	0.30	2	4	0.1	0.5
September	3.3	0.30	2	4	0.1	0.5
Total						6.0

Notes:

Irrigated	142,500 acres	
Idle and natural	49,900 acres	(26%)
Total	192,400 acres	

Table C4-3. Monthly Water, Salt, and DOC Budget Terms for the Delta Lowlands

Month	Assumed Crop ET (inches)	Leaching Fraction	Minimum Soil Moisture Depth (inches)	Maximum Soil Moisture Depth (inches)	Seepage and Leaching Applied (inches)	Leaching Factor (drainage EC/soil water EC)	DOC Load (g/m^2)
October	1.4	0.50	4	8	1.0	0.2	1.0
November	1.1	0.50	4	8	1.0	0.3	1.0
December	0.6	0.50	4	8	3.0	0.4	1.0
January	0.7	0.50	4	8	3.0	0.5	1.0
February	1.5	0.50	4	8	3.0	0.4	1.0
March	2.1	0.50	4	8	1.0	0.3	1.0
April	2.7	0.50	4	8	1.0	0.2	1.0
May	3.8	0.50	4	8	1.0	0.1	1.0
June	4.9	0.50	4	8	1.0	0.1	1.0
July	5.8	0.50	4	8	1.0	0.1	1.0
August	4.3	0.50	4	8	1.0	0.1	1.0
September	2.3	0.50	4	8	1.0	0.1	1.0
Total					18.0		12.0

Notes: Acreages by land use category:

DW Project	Lowlands Total			
Irrigated	342,400		17,000	
Idle and natural	54,200	(14%)	3,000	(15%)
Total	396,600		20,000	

Table C4-4. Monthly Water and DOC Budget Terms
for the DW Reservoir and Habitat Islands

	Reservoir Islands		Habitat Islands			
Month	Vegetation DOC Load (g/m^2)	Peat DOC Load[a] (g/m^2)	Active Storage[b] (TAF)	Diversion[c] (TAF)	Discharge[c] (TAF)	DOC Load (g/m^2)
October	2.0	1.0	2.0	1.4	0.6	1.0
November	2.0	1.0	3.4	2.4	1.0	3.0
December	2.0	1.0	5.0	3.3	1.7	3.0
January	2.0	1.0	4.5	2.0	2.5	3.0
February	0.0	1.0	4.3	2.0	2.2	1.0
March	0.0	1.0	1.4	0.0	2.9	1.0
April	0.0	1.0	0.5	0.0	0.9	0.0
May	0.0	1.0	0.0	0.0	0.5	0.0
June	0.0	1.0	0.0	0.0	0.0	0.0
July	0.0	1.0	0.0	0.0	0.0	0.0
August	0.0	1.0	0.0	0.0	0.0	0.0
September	0.0	1.0	1.2	1.2	0.0	0.0
Total	8.0	12.0				12.0

Note: Minimum circulation flow of 30 cfs (1.8 TAF) on reservoir islands.

[a] Assuming dry conditions; 0.5 g/m2 assumed for flooded periods because of lower oxidation rates.

[b] Based on the HMP for Holland and Bouldin Islands. Minimum storage of 1 TAF includes wetlands and ponds.

[c] Rainfall would be added to discharge or subtracted from diversion.

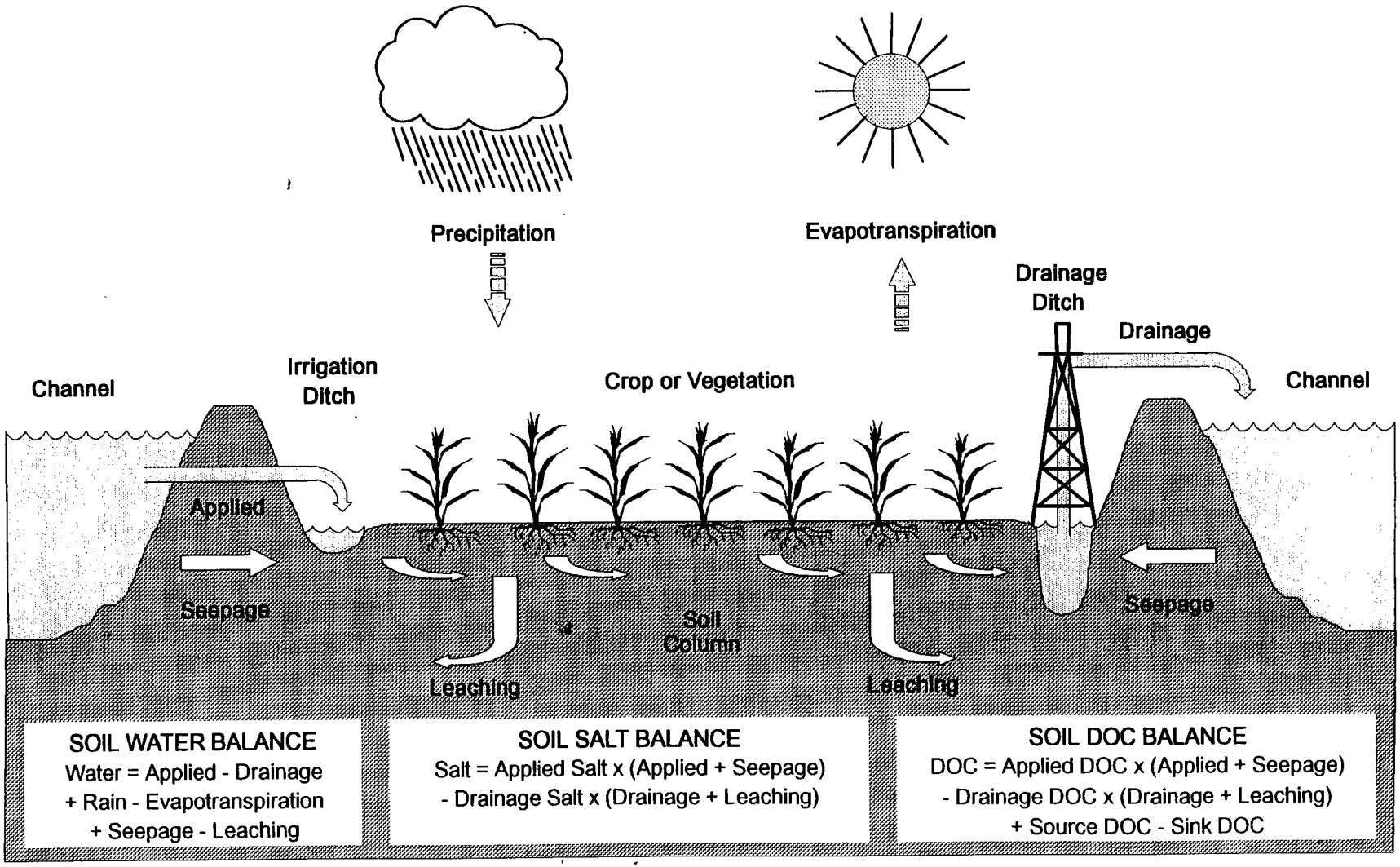

Figure C4-1.
Conceptual Water, Salt, and Dissolved Organic Carbon Budgets for Delta Agricultural Islands

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

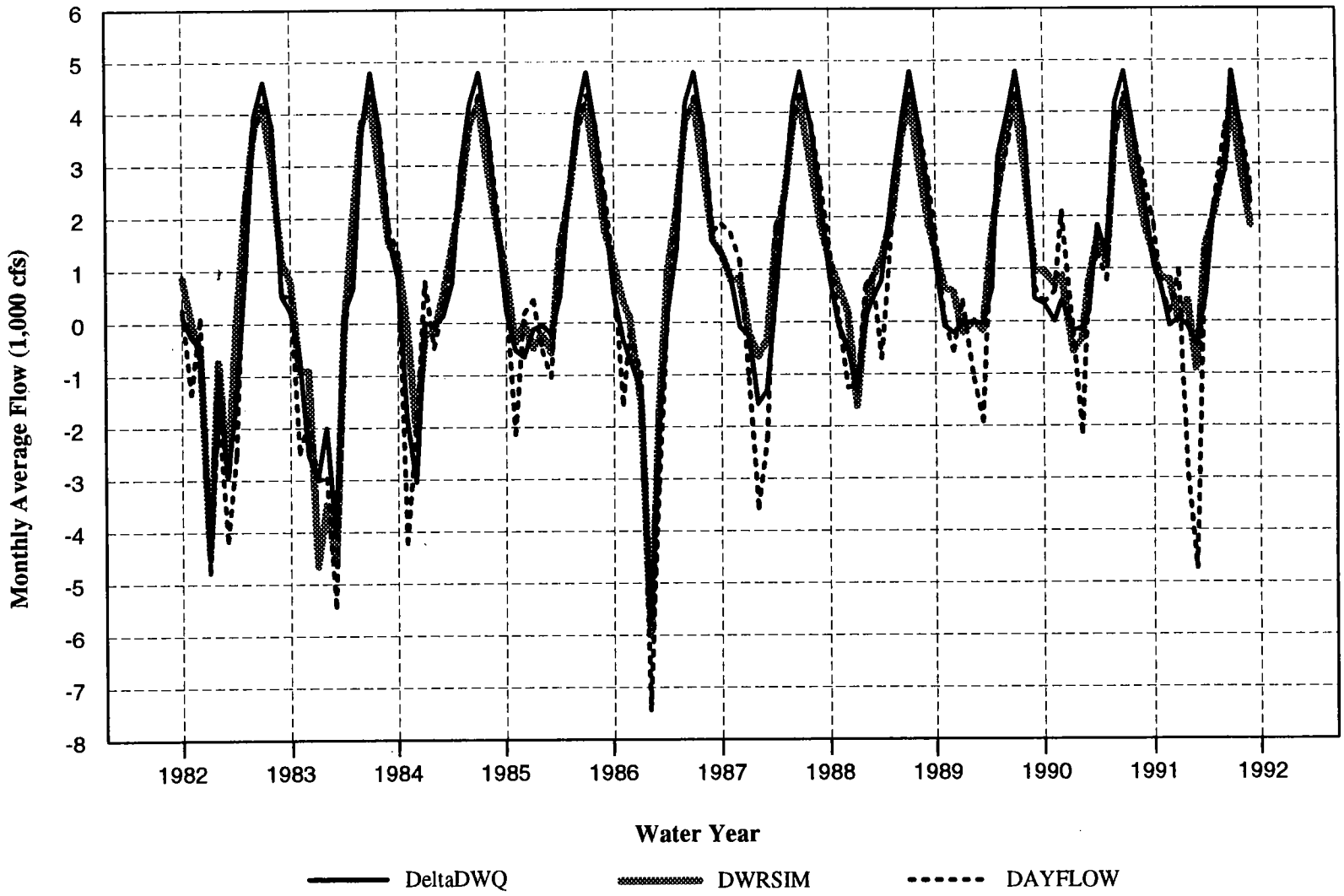

Figure C4-2.
Comparison of Estimated Net Delta Depletion for Water Years 1982-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

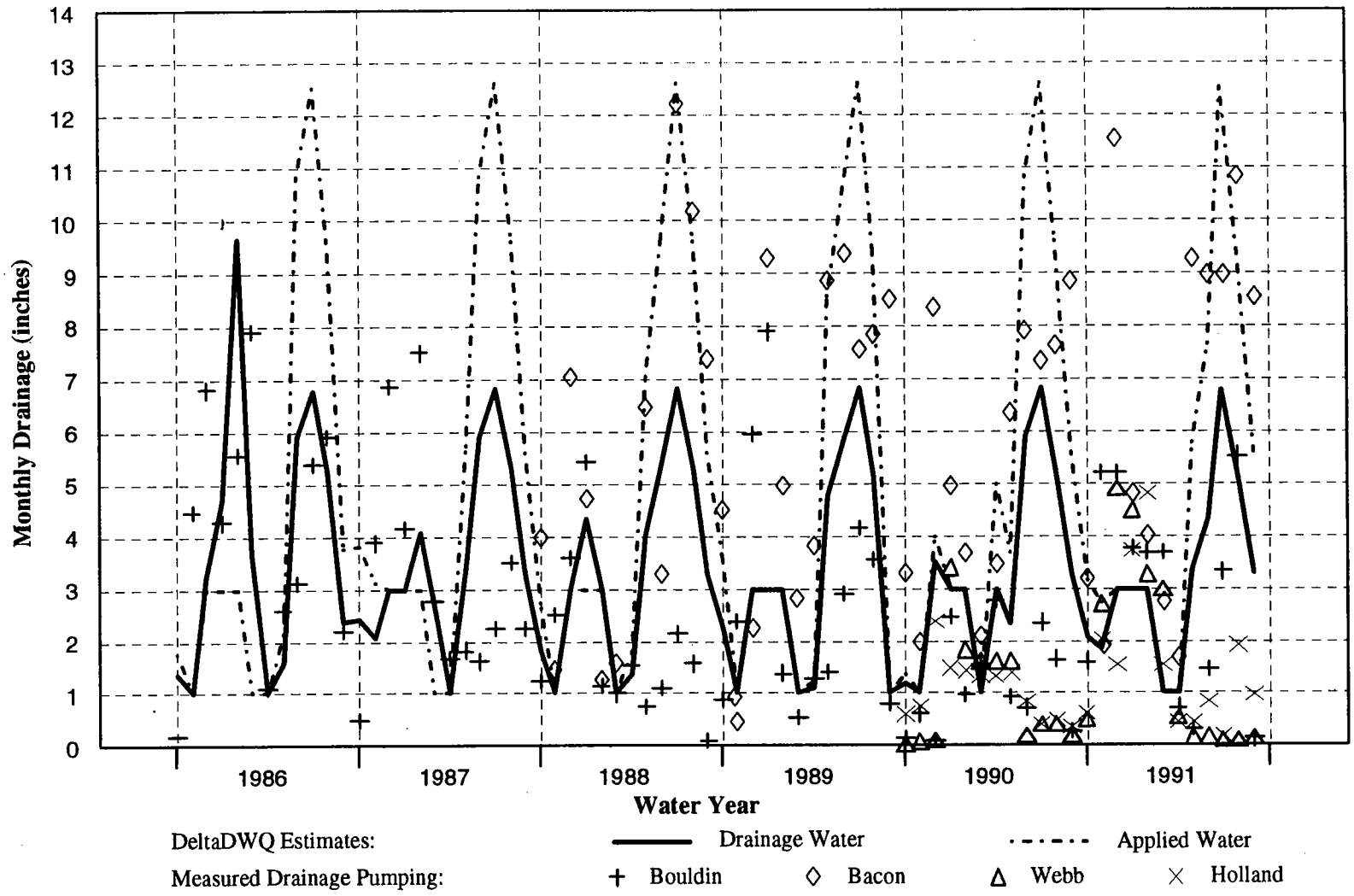

Figure C4-3.
DeltaDWQ Estimates of Delta Lowlands Drainage and Measured Drainage Pumping from the DW Project Islands for Water Years 1986-1991

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Prepared by: Jones & Stokes Associates

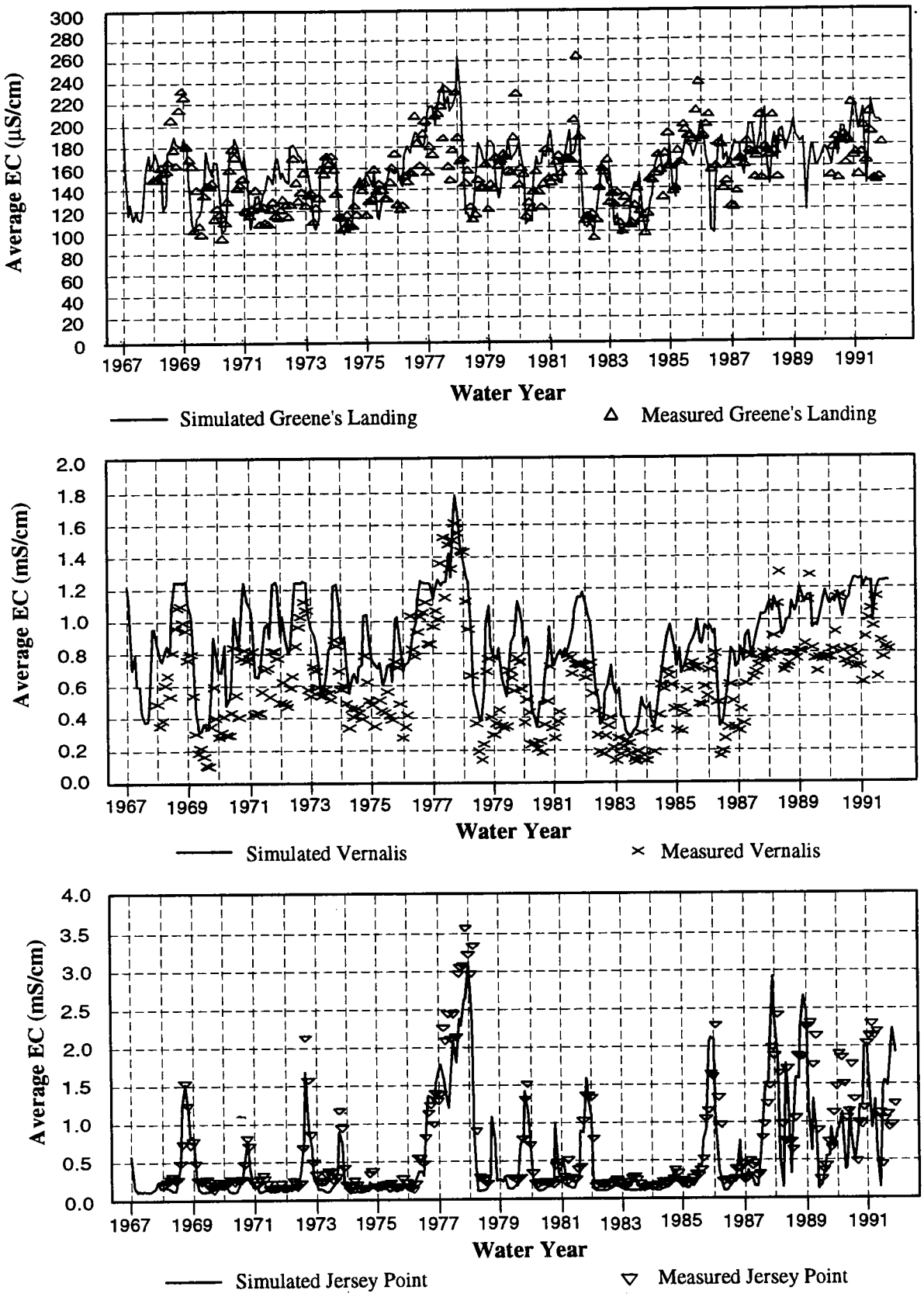
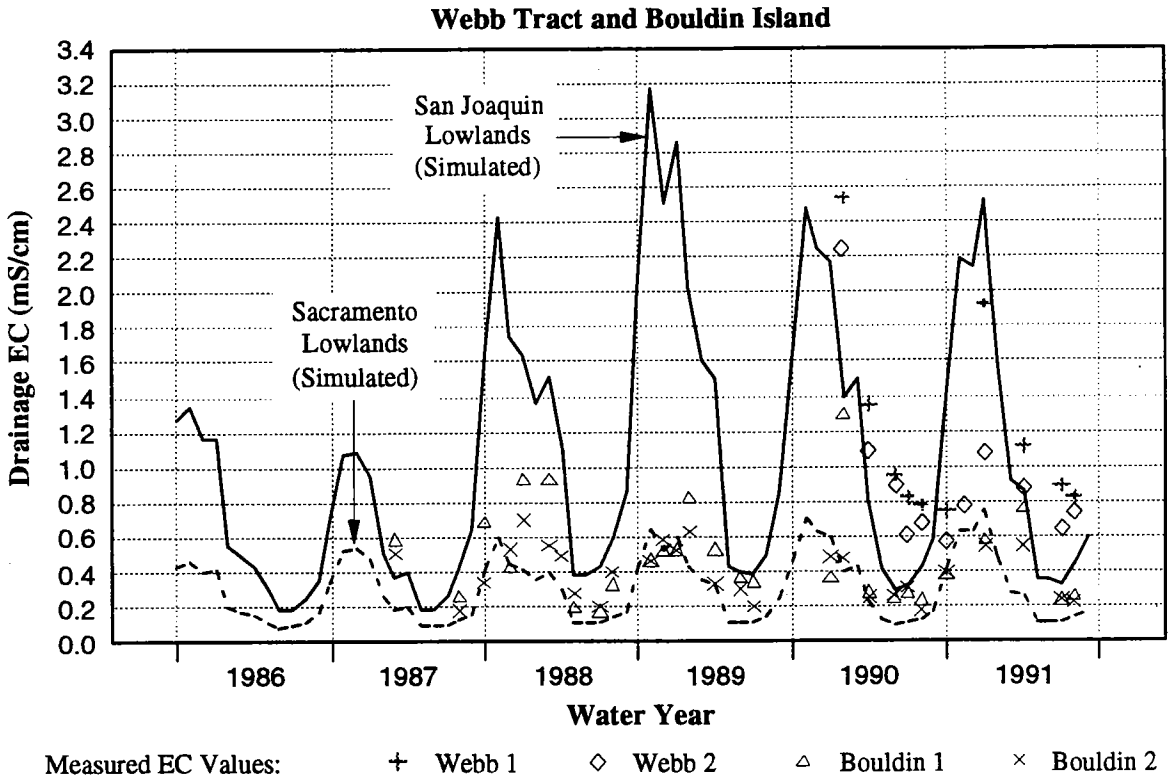


Figure C4-4.
Measured and Simulated Monthly EC at Greene's Landing, Vernalis, and Jersey Point for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



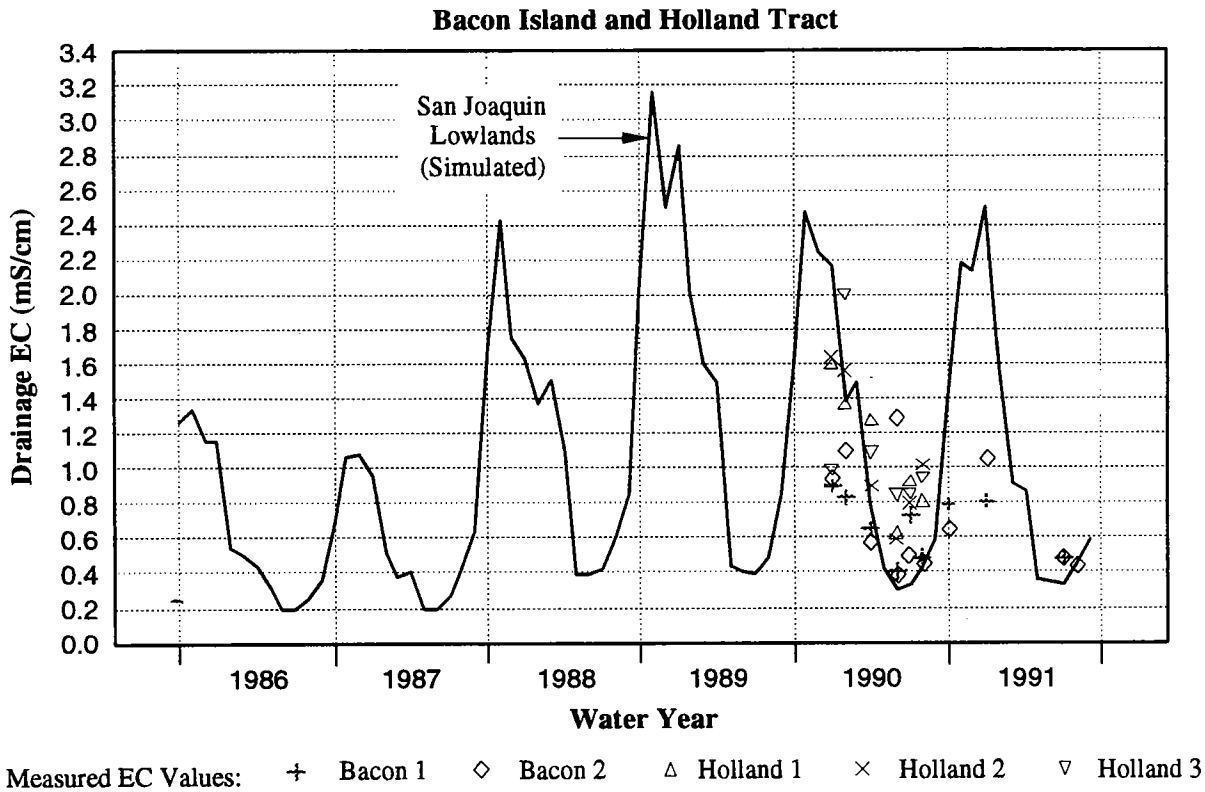
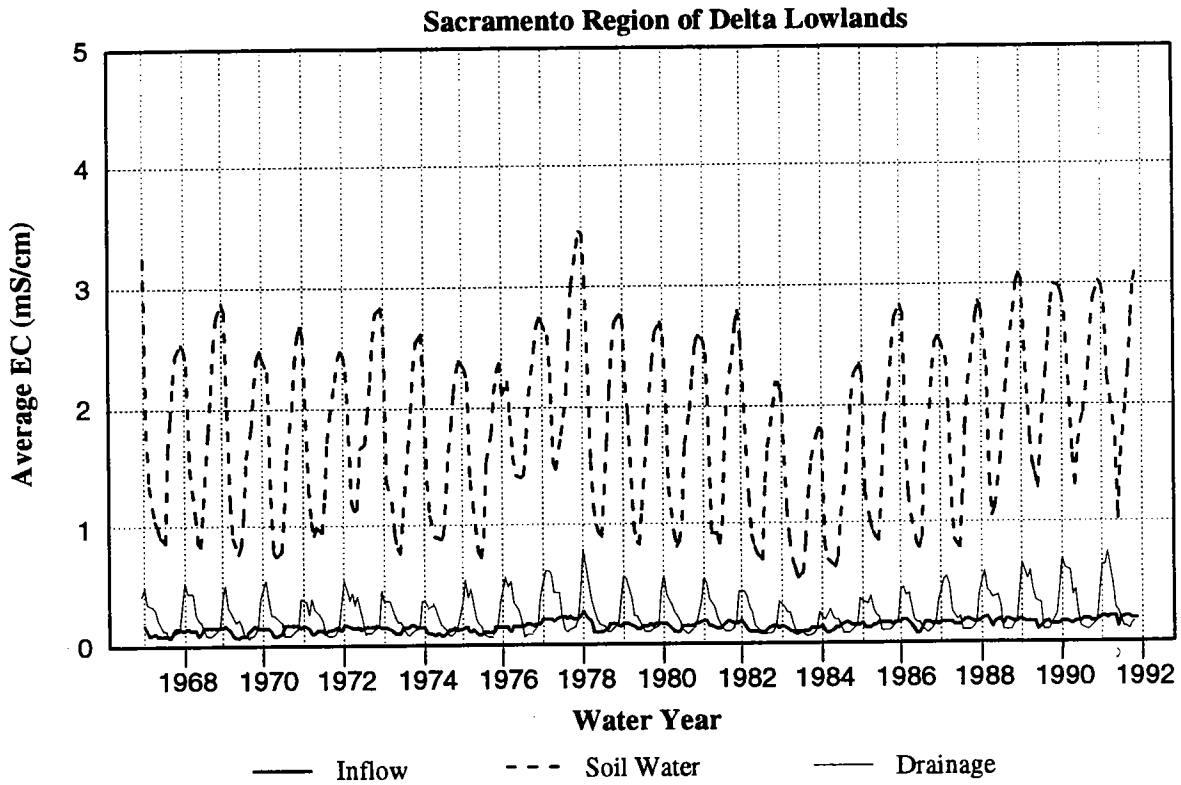


Figure C4-5.
Measured and Simulated Drainage EC Values for the DW Project Islands for 1986-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



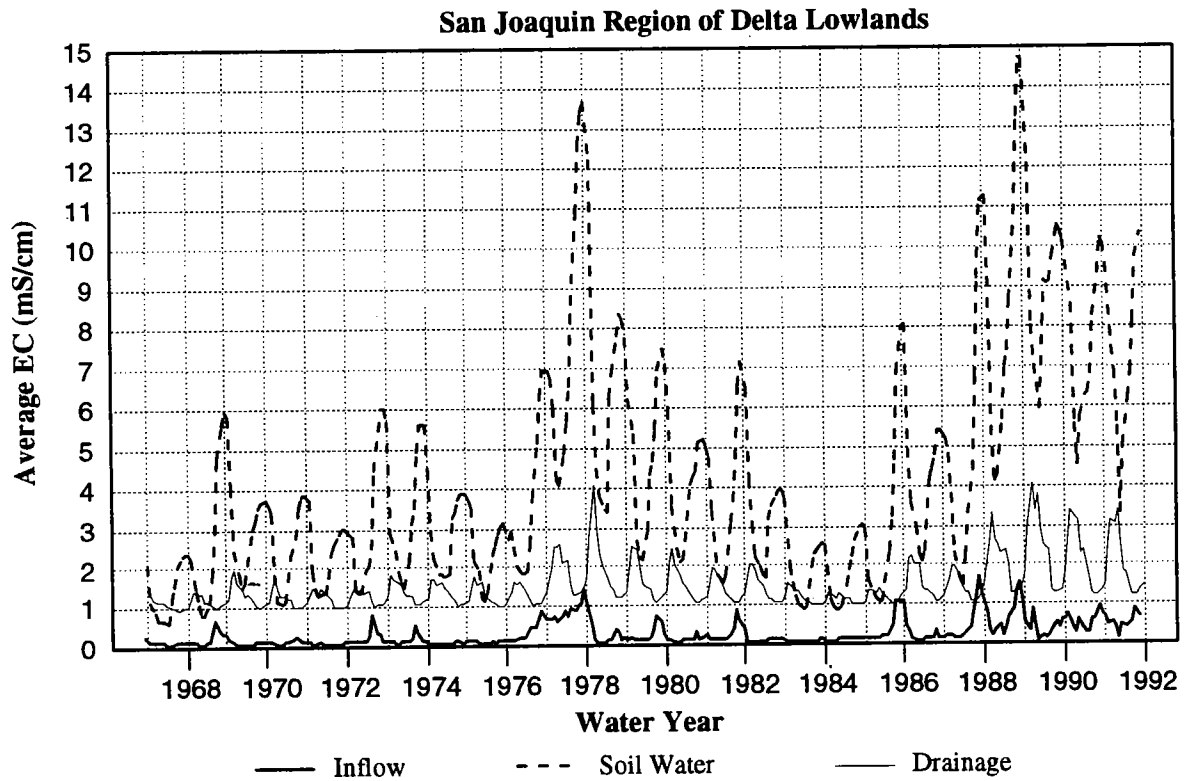
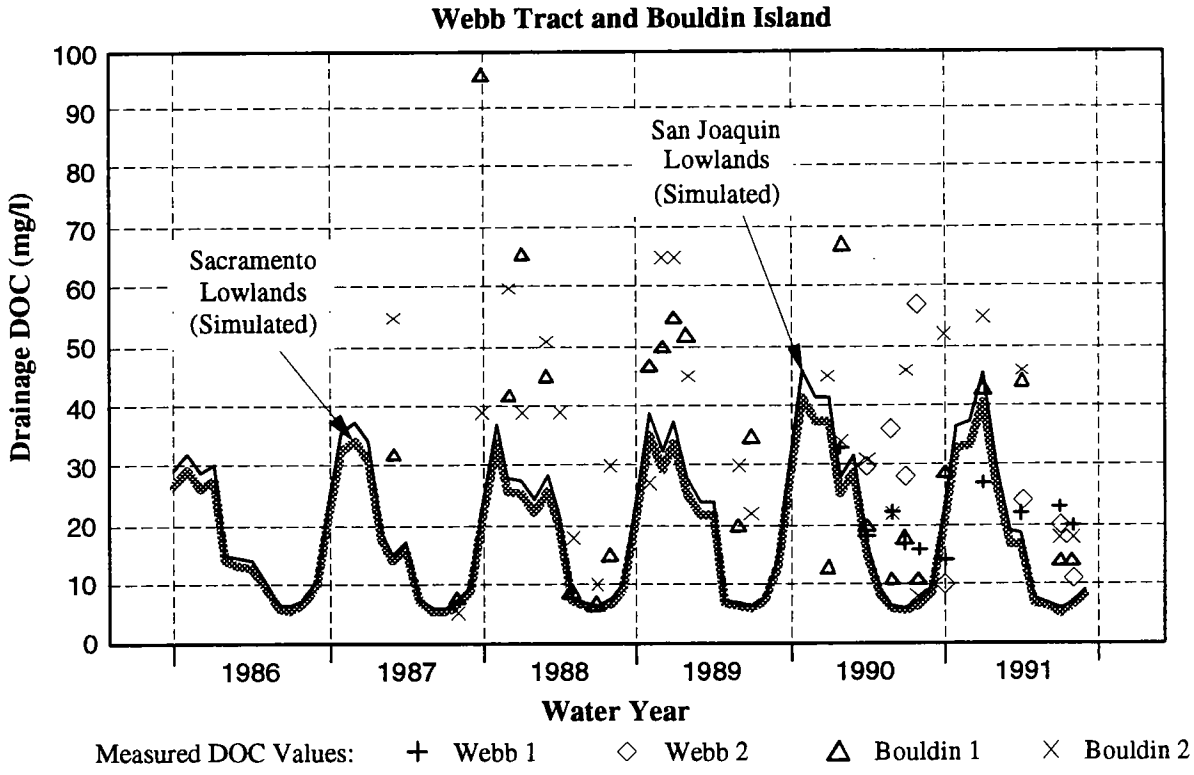


Figure C4-6.
Simulated Soil-Water EC for the Sacramento and San Joaquin Regions of Delta Lowlands with Historical Inflows and Exports for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



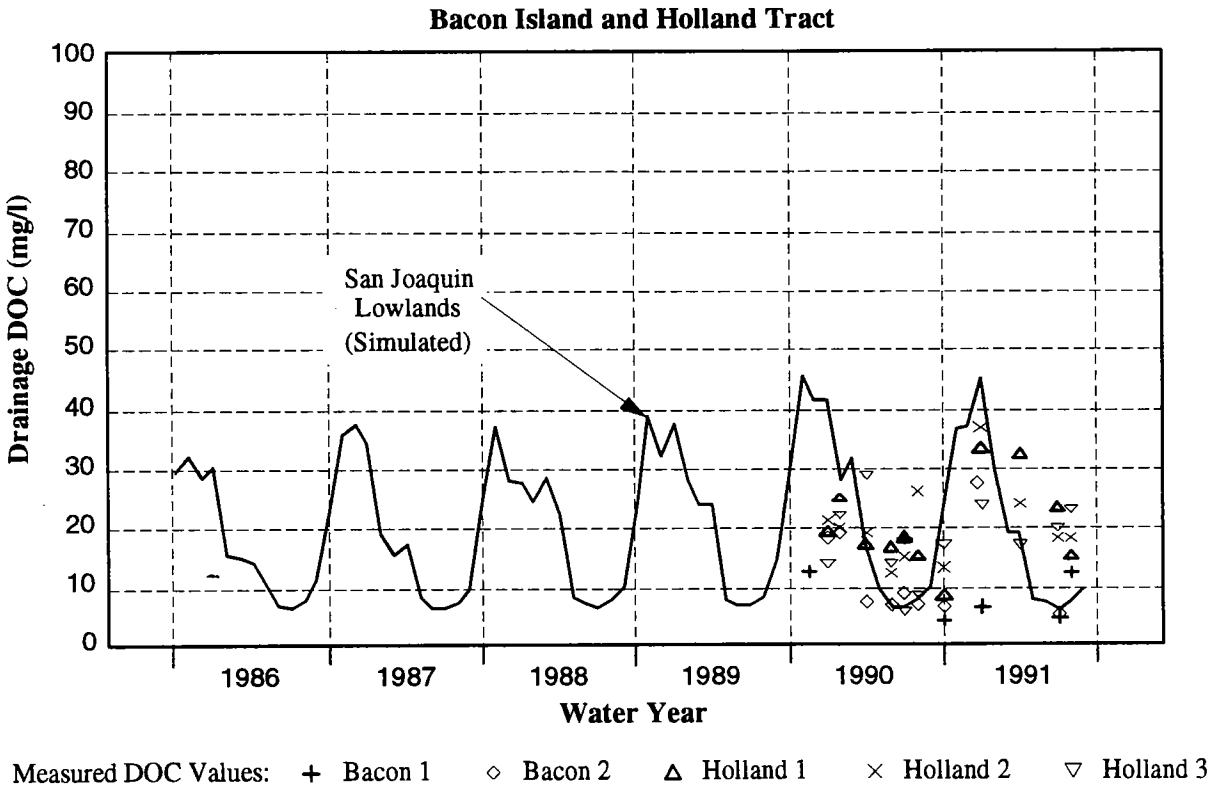


Figure C4-7.
Measured and Simulated Drainage DOC Values for the DW Project Islands for 1986-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

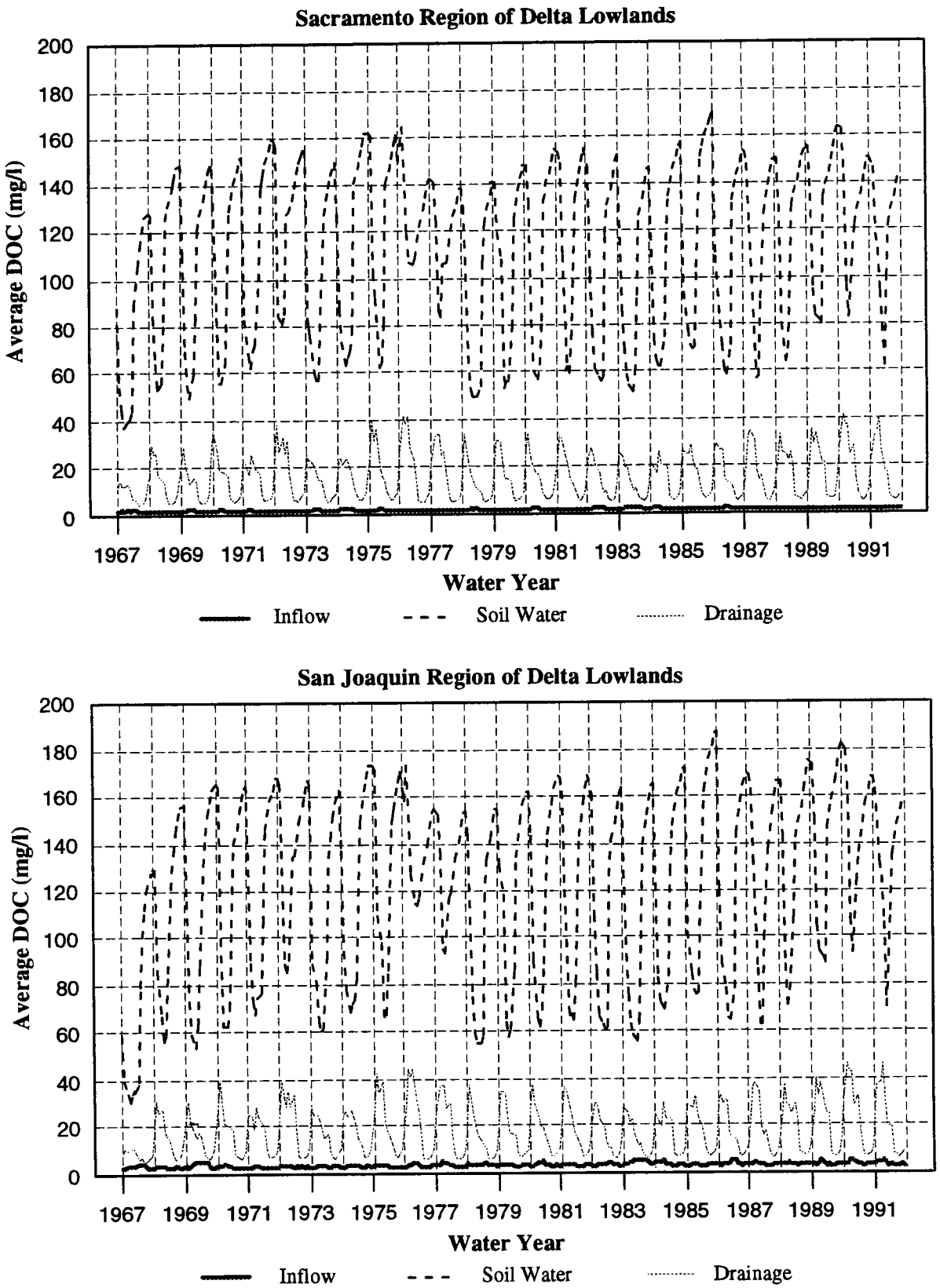


Figure C4-8.
Simulated Soil-Water DOC for the Sacramento and San Joaquin Regions of Delta Lowlands with Historical Inflows and Exports for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

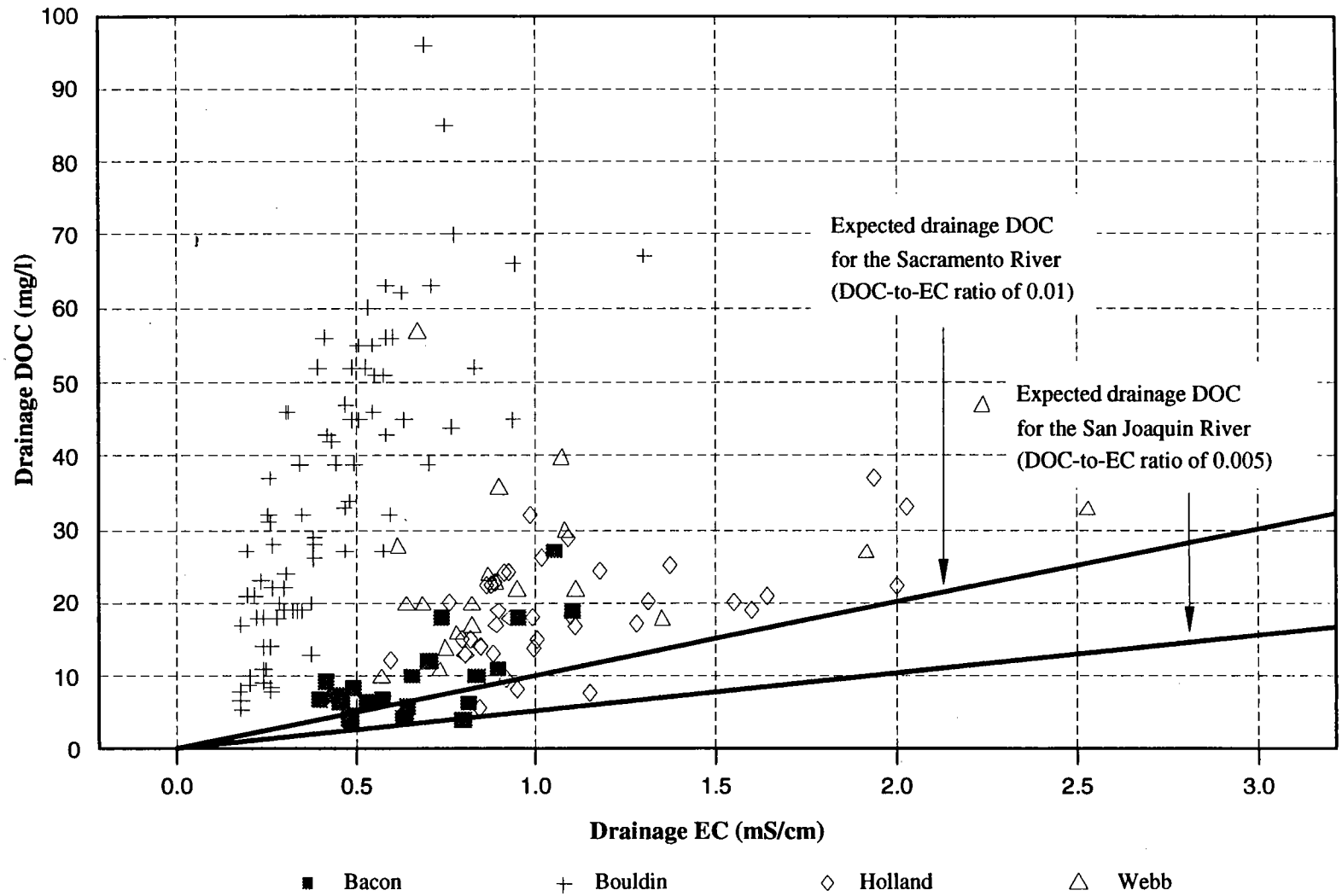


Figure C4-9.
Relationship between DW Island Drainage DOC Concentrations and EC Values for 1986-1991

DELTA WETLANDS
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Prepared by: Jones & Stokes Associates

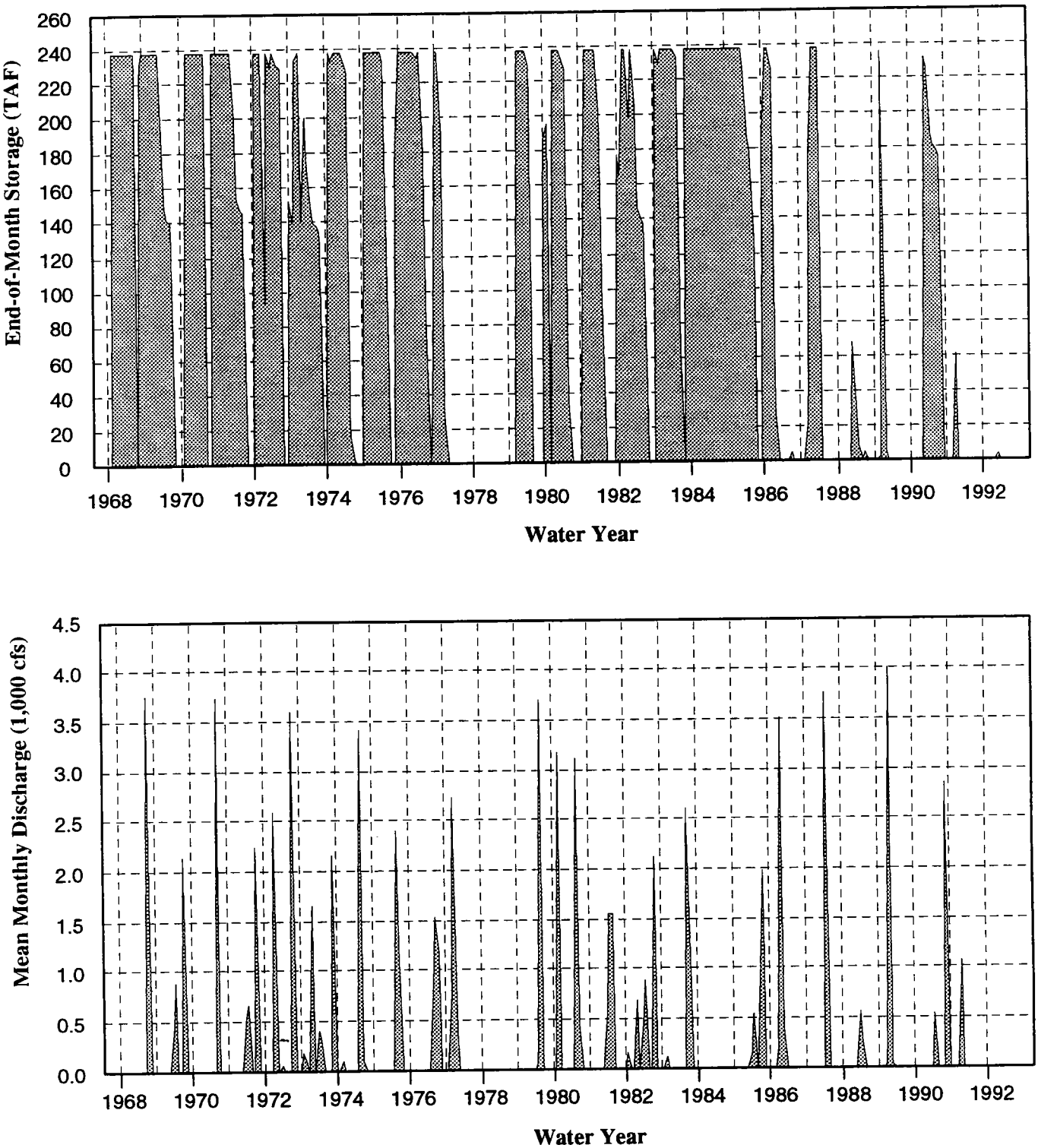
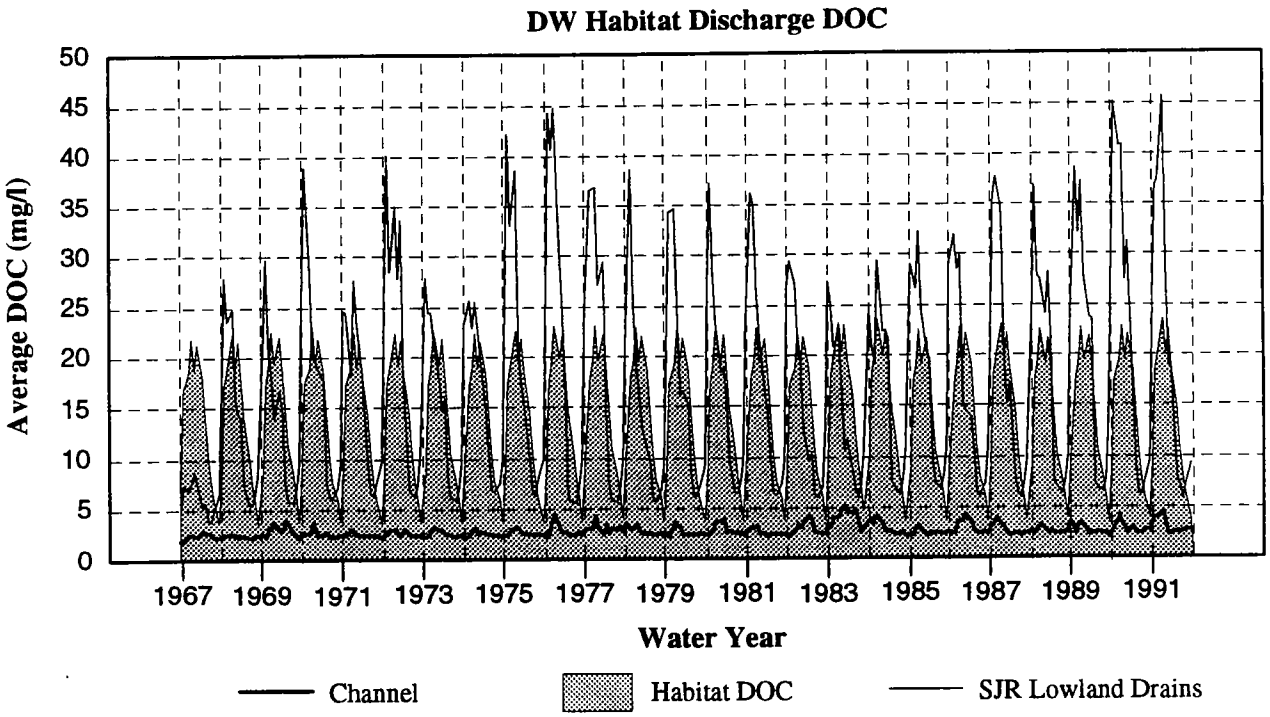


Figure C4-10.
Simulated End-of-Month Storage Volumes and Discharges for DW Reservoir Islands under Alternative 2 for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



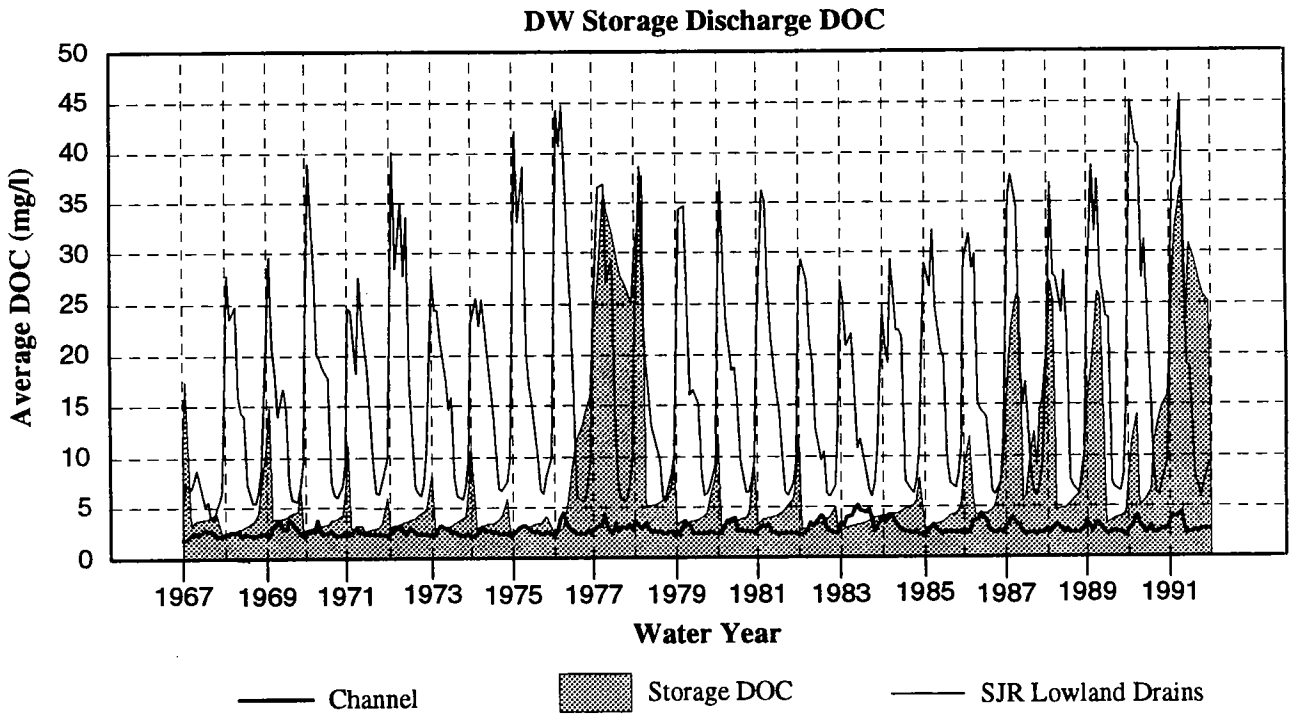
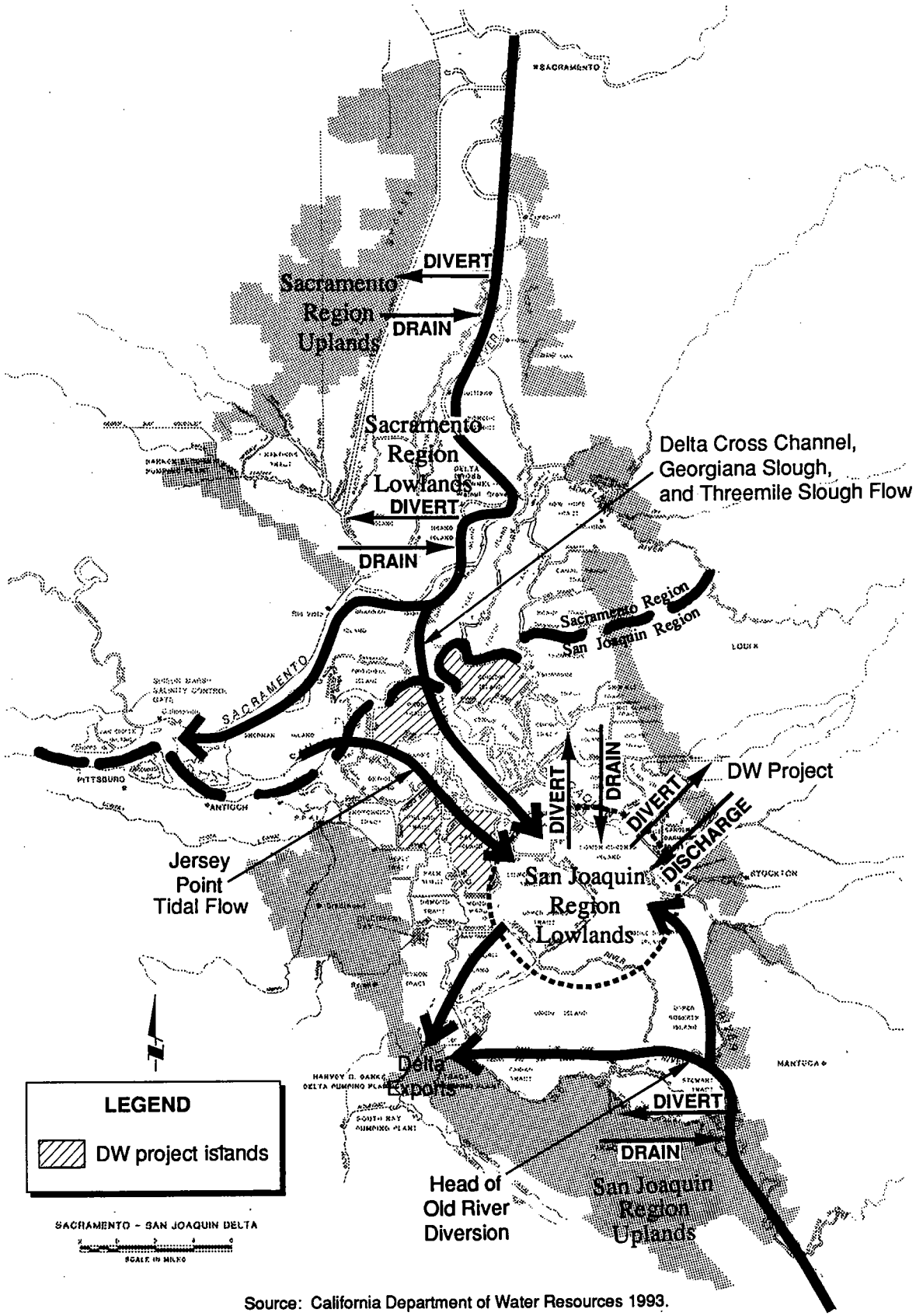


Figure C4-11.
Simulated Discharge DOC Concentrations from DW Habitat and Reservoir Islands for Alternative 2 for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



Source: California Department of Water Resources 1993.

Figure C4-12.
DeltaDWQ Delta Regions and Flow Pathways

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

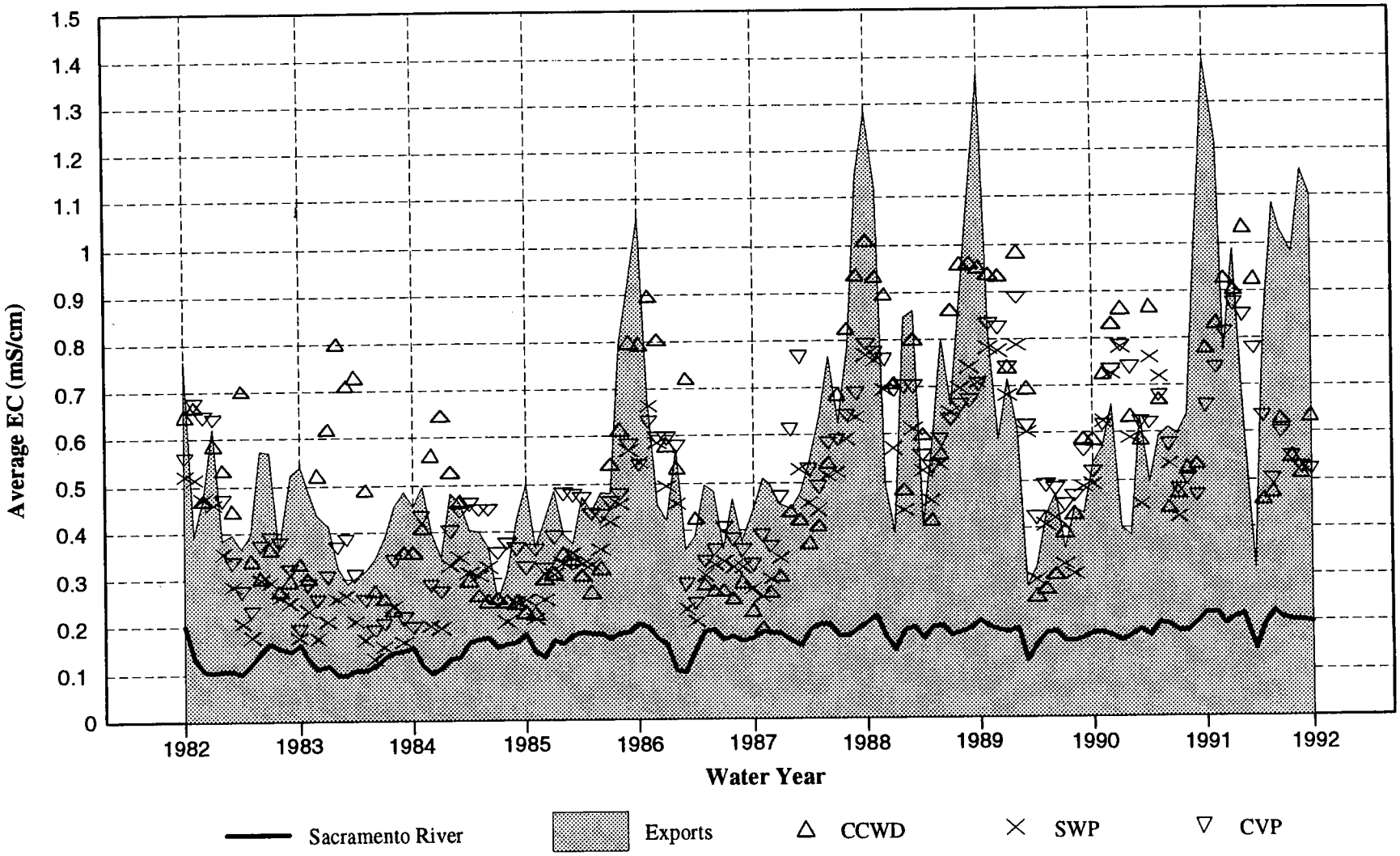


Figure C4-13.
DeltaDWQ Estimated Monthly Average Delta Export EC Values with Historical Inflows and Exports for 1982-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

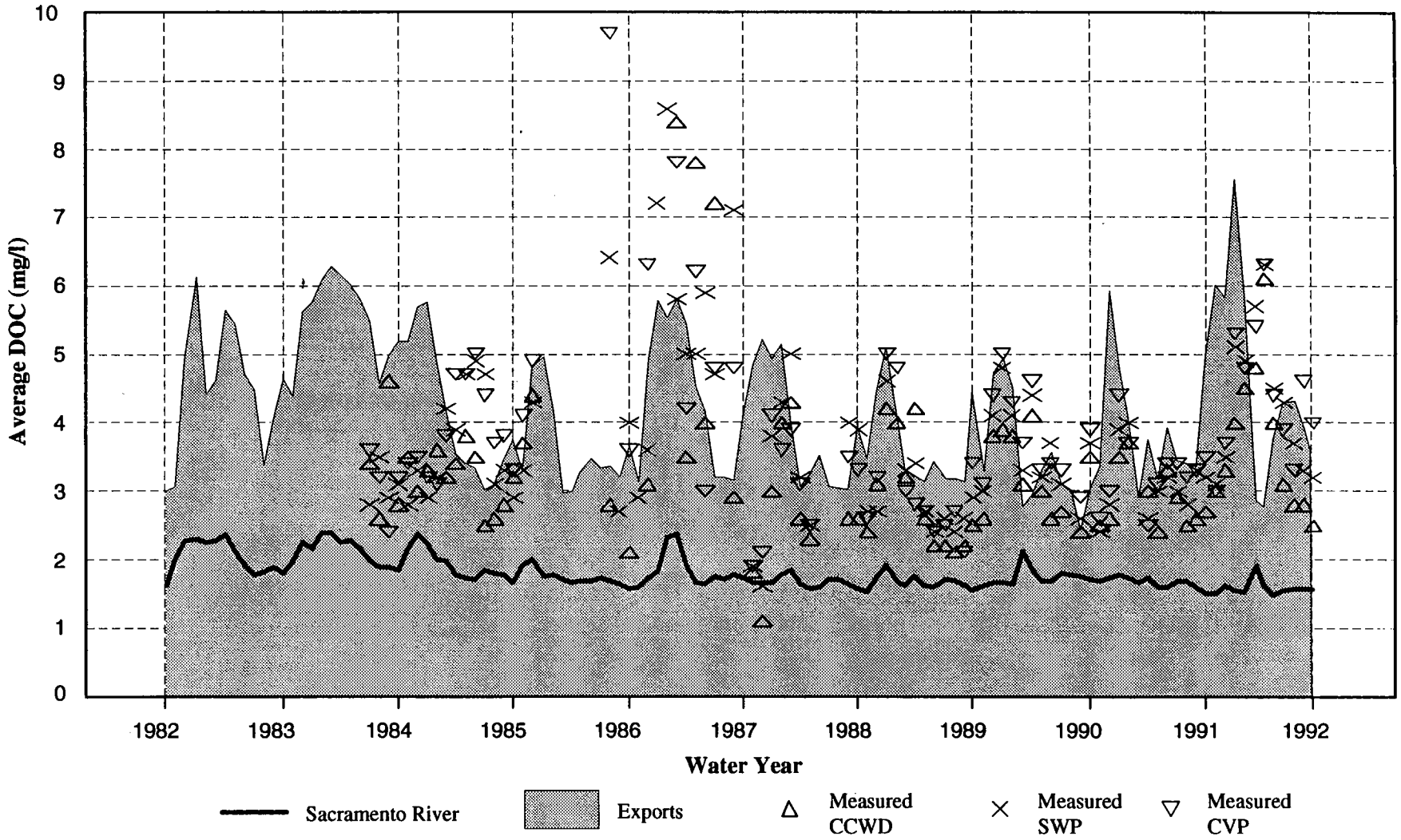


Figure C4-14.
DeltaDWQ Estimated Monthly Average Delta Export DOC Concentrations with Historical Inflows and Exports for 1982-1991 Compared with DWR-MWQI Measurements

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

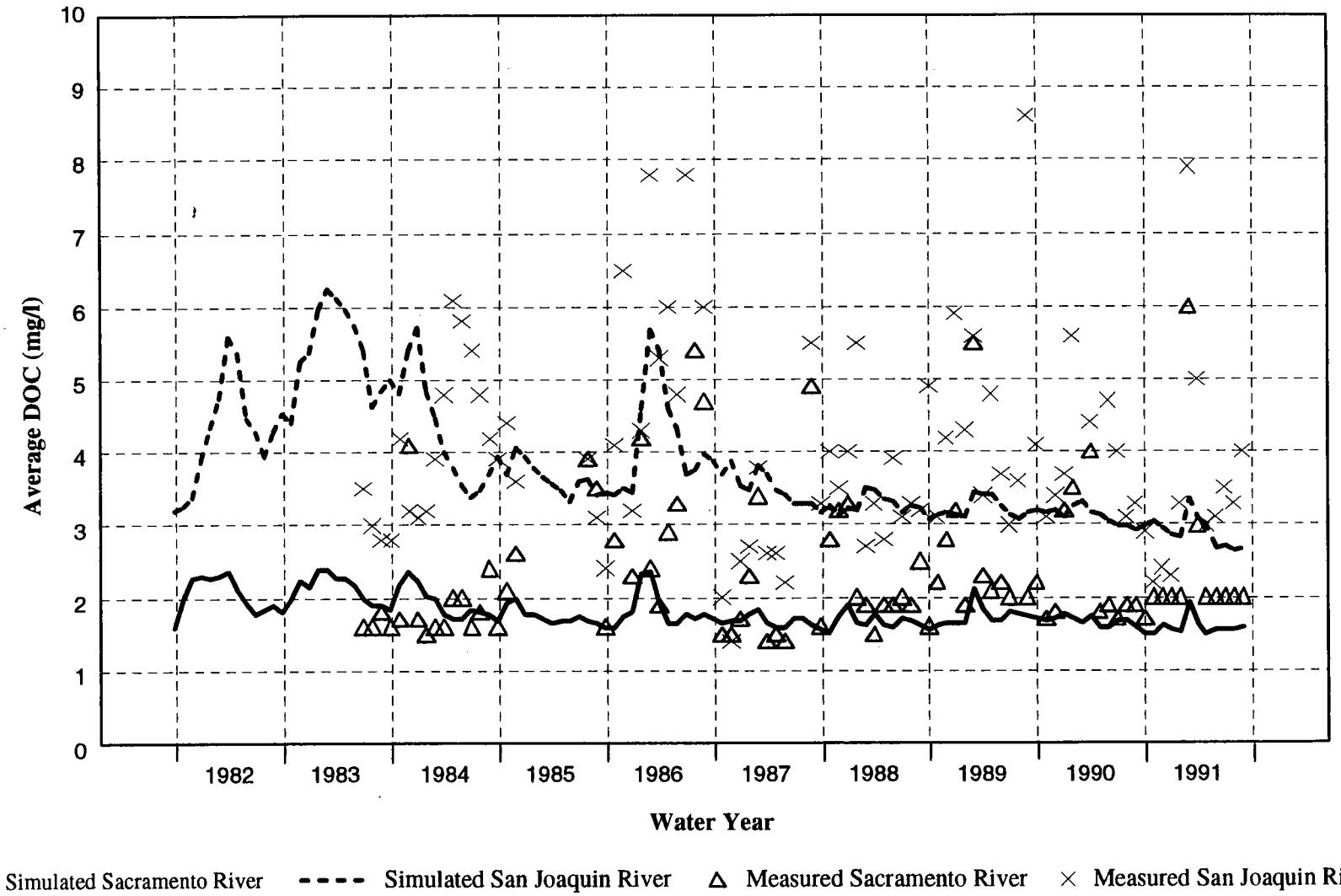


Figure C4-15.
Measured and Simulated Monthly DOC Concentrations in the Sacramento and San Joaquin Rivers with Historical Inflows for 1982-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

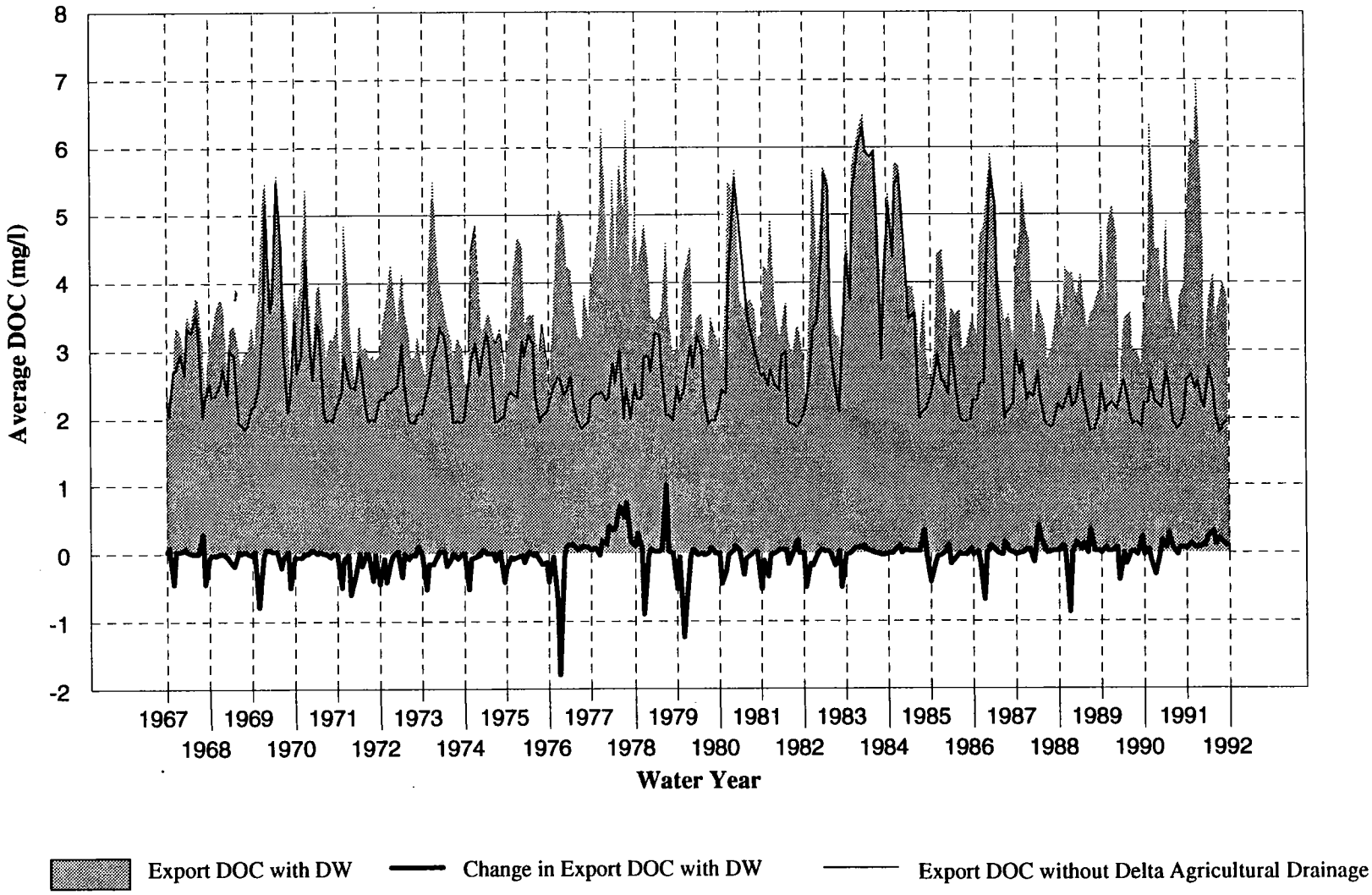


Figure C4-16.
Effects of DW Project Operations on Estimated Delta Export DOC Concentrations for Alternative 2 for 1967-1991

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates

Appendix C5. Modeling Trihalomethane Concentrations at a Typical Water Treatment Plant Using Delta Export Water

Appendix C5. Modeling Trihalomethane Concentrations at a Typical Water Treatment Plant Using Delta Export Water

SUMMARY

This appendix describes the modeling performed to estimate Delta Wetlands (DW) project effects on Delta export water used as influent to a typical water treatment plant. The selected impact assessment model was developed by Malcolm Pirnie, Inc. (Malcolm Pirnie), for the U.S. Environmental Protection Agency (EPA) to simulate trihalomethane (THM) concentrations in water that has been treated at water treatment plants. The EPA water treatment plant (WTP) model was confirmed with available measurements from the Penitencia Water Treatment Plant, operated by Santa Clara Valley Water District. Export water quality for the No-Project Alternative and the DW project alternatives simulated with the Delta Drainage Water Quality model (DeltaDWQ) was used as input for the EPA WTP model to evaluate the likely changes in THM resulting from DW project operations. The analysis estimates changes in THM concentrations at a representative water treatment plant that could result from changes in concentrations of dissolved organic carbon (DOC) and bromide (Br^-) in Delta export water attributable to operations under each DW project alternative. The appendix describes the model formulation, presents confirmation of model results, and presents results of water quality simulations for the No-Project Alternative and each of the DW project alternatives.

INTRODUCTION

THMs, produced during the primary disinfection of water by chlorination, are considered a human health risk by EPA and are subject to federal drinking water standards. EPA has established a maximum contaminant level (MCL) of 100 micrograms per liter (μg/l) for total THMs in drinking water; this standard is under review by EPA and may be reduced to 80 μg/l or less.

Among the constituents of raw water that are treated in the disinfection process are DOC and Br^-, both of which may be increased in Delta exports by operation of the proposed DW project. DW project water may be diverted for municipal use from the Delta at the Rock Slough intake of Contra Costa Water District (CCWD) or exported at Banks Pumping Plant of the State Water Project (SWP) or Tracy Pumping Plant of the Central Valley Project (CVP); this water may subsequently be treated for domestic consumption at municipal water treatment plants. The DW project may therefore contribute to increasing the concentration of THMs in water used for domestic consumption by increasing the concentrations of DOC and Br^- in Delta water that may be exported and subsequently treated for domestic use.

This appendix describes modeling of relationships between DOC and Br^- in Delta export water used as raw water influent to a typical water treatment plant and THM concentrations in treated water produced by the plant. The modeling was performed to support assessment of DW project effects on treated municipal water quality and compliance of treated drinking water with the current EPA drinking water standard for THMs.

The analysis estimated the incremental changes in THM concentrations at a representative water treatment plant that could result from changes in DOC and Br^- concentrations in Delta export water attributable to operations under each DW project alternative. Increases in the frequency, magnitude, or duration of exceedances of the current EPA standard were estimated for each DW project alternative.

This assessment of treatment plant effects was suggested by California Department of Water Resources (DWR), Metropolitan Water District of Southern

California (MWD), and CCWD staff members during the peer review process for the 1990 draft environmental impact report/environmental impact statement (EIR/EIS) on the DW project as the most complete method for analyzing potential drinking water impacts of DW project discharges.

Background

Data on contributions of salt and DOC from DW project operations to salt and DOC levels in Delta exports were derived through the use of the Delta Drainage Water Quality model (DeltaDWQ), which is described in Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model". Jones & Stokes Associates (JSA) developed DeltaDWQ to simulate relationships between water management on Delta islands and salt and DOC concentrations in discharges from the islands to Delta channels.

JSA used results from DeltaDWQ to determine relationships between assumed DOC loading on the DW project islands and levels of DOC in Delta exports (see Appendix C4). DOC levels in Delta exports under the No-Project Alternative and the DW project alternatives were compared. The results of this comparison are presented in Chapter 3C, "Water Quality".

As described in the following sections, possible impacts of changes in DOC concentrations in Delta exports (representative of CCWD diversions and SWP and CVP exports) were then assessed through simulation of expected THM concentrations at a typical water treatment plant using chlorination for primary disinfection.

Objectives of Modeling

JSA contracted with Malcolm Pirnie, Inc. (Malcolm Pirnie) to adapt the EPA Water Treatment Plant (WTP) model to a typical water treatment plant using Delta export water. The WTP model had been developed by Malcolm Pirnie for nationwide use by EPA.

Malcolm Pirnie's subcontract with JSA had three specific objectives:

- to confirm the accuracy of WTP model simulations of THM production using data from a typical conventional water treatment plant that uses Delta export water as influent,
- to modify the WTP model to accept 25-year data sets of monthly Br^-, DOC, and other estimated water quality variables for Delta exports, and
- to apply the WTP model to several data sets representing Delta export water quality to test the sensitivity of the model to changes in the input variables (e.g., DOC, Br^-, and temperature).

JSA used the modified model to assess impacts of Br^- and DOC concentration changes in Delta exports on THM levels for each of the DW project alternatives.

Organization of the Appendix

This appendix is organized into the following sections:

- description of the WTP model developed by Malcolm Pirnie,
- confirmation of the WTP model results for a typical water treatment plant using Delta export water, and
- application of the model to a 25-year estimate of Delta export water quality for each DW project alternative.

DESCRIPTION OF THE WTP SIMULATION MODEL

This section presents a general overview of the WTP simulation model for THMs. Malcolm Pirnie prepared a report for JSA that provides greater detail on model background, predictive equations, and algorithms (Malcolm Pirnie 1992).

Model Development

The WTP simulation model was developed for EPA to support analyses of alternative combinations of the Surface Water Treatment Rule (SWTR) and a new Disinfection By-Products (DBP) Rule (EPA 1992). The SWTR specifies minimum levels of disinfection to protect against human exposure to pathogens. Increased

disinfection may result in higher concentrations of DBP. The new DBP rule may contain more stringent limits for municipal water suppliers. The WTP model was developed to assist water utilities in analyzing various treatment options for meeting the requirements of these rules.

The primary purpose of the WTP model is to jointly simulate DBP formation and disinfection levels in water treatment plants and distribution systems based on specified raw water quality, treatment process characteristics, and treatment chemical dosages. The model predicts THM formation based on data collected nationwide from various water treatment plants and experimental data on the kinetics of THM formation.

Basic Model Formulations

The WTP simulation model is based on a series of predictive regression equations that were developed through several previous studies. Figure C5-1 is a conceptual diagram of the various components of the WTP model.

For a treatment plant to be simulated, treatment process characteristics specific to the plant being modeled must be specified. These characteristics include hydraulic detention times, treatment chemical dosages, and target disinfection residuals. Raw water quality variables (DOC; ultraviolet [254-nm] light absorption [cm^{-1}], referred to as UVA; pH; temperature; Br^-; alkalinity; calcium hardness; ammonia; and turbidity) must also be specified. DOC and UVA are described in Appendix C3, "Water Quality Experiments on Potential Sources of Dissolved Organics and Trihalomethane Precursors for the Delta Wetlands Project".

The major output from the WTP model is an estimate of THM levels resulting from use of existing or proposed treatment technologies. The model reports values for the following variables after each of the treatment plant processes:

- THM precursors (DOC and UVA),
- disinfectant residuals (chlorine),
- THM concentrations, and
- proportion of required disinfection contact time achieved (based on concentration-time [CT] values specified in the EPA SWTR guidance manual).

The model consists of a series of subroutines that simulate removal of organic THM precursor compounds and adjustments of pH that occur as chemicals are added. When free chlorine is added, subroutines for estimating chlorine demand, chlorine decay, and THM formation are invoked. These subroutines proceed until the treatment processes and disinfectant dosage sequence are completed. A more detailed description of the operation of the WTP program is provided in the EPA program user's manual (EPA 1992).

The original WTP program is operated interactively, specifying inputs through screen prompts. For the DW impact assessment, however, the model was reprogrammed to permit prediction of THM formation for 300 monthly water quality conditions (i.e., 12 months per year for the 25-year period) using a specified treatment process train, DOC removal target, and chlorine residual targets.

The model predicts total THM concentration and then determines the concentrations of different types of THM molecules by estimating relative concentrations from separate regression equations for each of the four types of THM molecules (chloroform [$CHCl_3$], dichlorobromomethane [$CHCl_2Br$], dibromochloromethane [$CHClBr_2$], and bromoform [$CHBr_3$]). All of the multiple-logarithmic regressions are similar but vary in the coefficient values for the independent variables. For example, the total THM equation is as follows:

$$THM\ (\mu g/l) = 0.3254 \cdot DOC^{0.44} \cdot UVA^{0.351} \cdot Cl_2^{0.409} \cdot hours^{0.265} \cdot Temp^{1.06} \cdot (pH\text{-}2.6)^{0.715} \cdot (Br^- + 1)^{0.516}$$

The magnitude of the coefficient for each independent variable indicates the degree to which THM concentrations will respond to a change in that variable when other conditions remain the same. For example, a temperature change from 10°C to 25 °C will increase THM by a factor of 2.6. Doubling DOC from 3 milligrams per liter (mg/l) to 6 mg/l will also double the UVA value because the two variables are linearly related (see "Raw Water Quality", below); this combination of DOC and UVA changes will increase THM by about 75%.

Higher DOC levels may require higher chlorine doses. Increasing the chlorine dose from 2 mg/l to 3 mg/l will increase THM by about 20%. According to the THM regression equation used in the model, increasing Br^- from 0.2 mg/l to 0.4 mg/l will increase THM by about 10%.

CONFIRMATION OF THE WTP SIMULATION MODEL RESULTS

Malcolm Pirnie selected the Penitencia Water Treatment Plant, operated by the Santa Clara Valley Water District, to represent a typical plant that uses chlorine for primary disinfection of water exported from the Delta. This section describes the Penitencia Water Treatment Plant and the data from the plant used to confirm WTP simulation model predictions (Malcolm Pirnie 1992).

Penitencia Water Treatment Plant

Delta exports are supplied to the Penitencia Water Treatment Plant through the South Bay Aqueduct and Del Valle Reservoir. Monthly measurements of raw water quality from January 1991 to August 1992 indicated moderate to high levels of DOC (3.0-6.7 mg/l) and Br^- (0.1-0.56 mg/l) in raw water from the Delta and relatively high levels of alkalinity and hardness because of drought conditions. Raw water during this period, therefore, had DOC and Br^- concentrations that were higher than normal.

General Description of the Penitencia Water Treatment Plant Process

The Penitencia Water Treatment Plant has a design capacity of 42 million gallons per day (mgd) and an average production of 25 mgd. Between January 1991 and August 1992, flows fluctuated seasonally from 20 mgd to 40 mgd. Figure C5-2 shows a schematic diagram of the Penitencia Water Treatment Plant process. The treatment process consists of conventional alum coagulation with flocculation, sedimentation, and dual-media filtration. The simulated alum dosage, required to match the effluent DOC concentrations, averaged 36 mg/l with a range of 25-52 mg/l (actual daily alum dosage was not recorded).

Highest THM concentrations are generally produced by conventional chlorination. Chlorine can be added at various points in the water treatment process for a variety of purposes. The term "prechlorination" refers to the addition of chlorine to raw water at the initial treatment stage, typically before flocculation and sedimentation occur. Chlorine (Cl_2) is also added before the water is filtered. Chlorine or chloramine (chlorine and ammonia) can also be added at the end of the treatment process to provide a "chlorine residual" in the distribution system; this process is commonly referred to as "postchlorination". Chlorine residual is maintained to provide disinfection while the water is transported through the distribution system.

At the Penitencia Water Treatment Plant, chlorine is used for primary disinfection and ammonia is added to the filtered water for chloramine secondary disinfection in the delivery system. During the period of record obtained by Malcolm Pirnie from the Penitencia Water Treatment Plant, raw water was prechlorinated at an average dosage of 2.75 mg/l, producing a settled water chlorine residual of 0.65 mg/l (actual daily chlorine dosage was not recorded). Chlorine was also applied to the settled water at a dosage of approximately 1 mg/l, producing a filtered water chlorine residual of about 1.5 mg/l. Ammonia was added to the filtered water at an average dosage of 0.5 mg/l before it reached the finished water reservoir. Small amounts of chlorine were also added as a "trimming dosage" to maintain a combined chlorine residual of 1.5 mg/l at the end of the distribution system.

The theoretical detention times for the various processes as a function of water treatment plant flow are summarized in Figure C5-2. Under average flow conditions (25 mgd) at the Penitencia Water Treatment Plant, the theoretical detention times for flocculation-sedimentation basins, filters, and finished water reservoir are approximately 140, 20, and 170 minutes, respectively.

Raw Water Quality

To confirm the WTP model results, Malcolm Pirnie used average monthly values for observed water quality data from the Penitencia Water Treatment Plant for 17 months between January 1991 and August 1992. These data are given in Table C5-1. Both water quality and plant flows varied significantly during this period. Following are the average values for selected raw water quality variables for the period of record:

- DOC = 4.6 mg/l,
- pH = 7.9,
- turbidity = 10.1 NTU,
- temperature = 17.1°C,
- alkalinity = 82 mg/l,
- calcium hardness = 57 mg/l as $CaCO_3$,
- total hardness = 122 mg/l as $CaCO_3$,
- ammonia nitrogen = 0.05 mg/l as N,
- chloride (Cl^-) = 107 mg/l, and
- Br^- = 0.34 mg/l.

Although the WTP model uses UVA in its predictive equations, the Penitencia Water Treatment Plant does not routinely monitor UVA in the raw water. MWD and Malcolm Pirnie (1991) found raw water UVA and DOC concentrations to be strongly correlated ($r^2 = 0.96$) in a study of SWP water (Figure C5-3):

$$\text{UVA } (cm^{-1}) = -0.0215 + 0.0382 \cdot \text{DOC } (mg/l)$$

Using this correlation with the confirmation data, raw water UVA at the Penitencia Water Treatment Plant was estimated to average 0.156 cm^{-1} over the period of record.

Model Accuracy and Performance

JSA tested the ability of the WTP model to accurately simulate water treatment plant operations, finished water quality, and THM concentrations by comparing WTP model results with monthly measurements collected from January 1991 to August 1992 at the Penitencia Water Treatment Plant. These comparisons are given in Table C5-1. Each set of values for influent and effluent variables was simulated using a separate run of the model, with the assumed alum and chlorine dosages adjusted to match the effluent DOC and chloramine residuals. Unfortunately, actual alum and chlorine dosages and settled chlorine residual for each sample were not recorded at the Penitencia Water Treatment Plant.

Dissolved Organic Carbon and pH

Figure C5-4 shows measured and predicted DOC and pH values at the Penitencia Water Treatment Plant for the period of record. Measured influent DOC ranged from 3.0 mg/l to 6.7 mg/l. Percentage DOC removal is shown indirectly in Figure C5-4 as the difference between the measured influent raw water DOC concentration and the measured effluent DOC concentration. The model accurately simulated DOC removal because the alum dosage was adjusted in the WTP model to achieve the observed DOC removal for each sample date. Simulated alum doses ranged from 25 mg/l to 52 mg/l and averaged approximately 35 mg/l.

Measured and predicted pH of effluent were similar. These comparisons suggest that the model simulated the physical-chemical treatment processes used at the Penitencia Water Treatment Plant fairly well.

Chlorine Doses and Residuals

Figure C5-5 shows simulated and measured chlorine residual concentrations. Chlorine doses varied according to inflow DOC concentrations, with higher doses required for waters higher in DOC. Higher chlorine doses during prechlorination produce more THM molecules. Chlorine doses simulated for the treatment process before alum coagulation varied from 1.6 mg/l to 3.4 mg/l.

Measured chlorine residuals in filtered water averaged about 1.5 mg/l, with a minimum concentration of 1.3 mg/l and a maximum of 2.1 mg/l. The model overpredicted the settled water chlorine residual concentrations, with a mean of 1.9 mg/l for predicted residuals, suggesting that the estimated prechlorination dosages used by Malcolm Pirnie may be high.

The general relationships between DOC, chlorination dose, and resulting C-THM (the carbon fraction of THM molecules) used to calculate THM concentration described in Appendix C3, "Water Quality Experiments on Potential Sources of Dissolved Organics and THM Precursors for the Delta Wetlands Project", suggest that the chlorine dose has a very important effect on THM concentration. Unfortunately, chlorine dose was not reported in the Penitencia Water Treatment Plant data (chlorine residual is the more important plant operation variable).

Table C5-1 gives the measured yield of C-THM from DOC as a percentage. The Penitencia Water Treatment Plant samples had a C-THM yield of approximately 0.07%-0.18% of the DOC (average of 0.12%). The yield of C-THM simulated by the WTP model was 0.09% of DOC, lower than the measured average.

Because these measured yields of C-THM from DOC are lower than data used to develop the "half-saturation" relationship between C-THM and the chlorination-to-DOC ratio (Cl_2/DOC) and because the Cl_2/DOC value was not calculated, there is some uncertainty regarding the general relationship of these low Cl_2/DOC dose values. The equation for C-THM given in Appendix C3, with a maximum yield of 2% and a half saturation of 5 Cl_2/DOC, suggests that the Cl_2/DOC dose value for a C-THM yield of 0.12% would have been only about 0.3. Typical Cl_2/DOC dose values in treatment plants are in the range of 0.5 to 1.0 and the WTP-simulated dose ratios were in this range. The C-THM yield estimates for the Penitencia Water Treatment Plant samples can be reconciled if the half-saturation value for the Cl_2/DOC dose value is higher than 5. If the half-saturation value is 10, then the estimated Cl_2/DOC dose value to produce a

0.12% yield of C-THM would be 0.6. If this adjustment is made, these Penitencia data are consistent with the other THM data analyzed in Appendix C3.

Trihalomethane Concentrations

Figure C5-6 shows measured and predicted total THM concentrations in treated water at the Penitencia Water Treatment Plant. Measured THM concentrations averaged 72 μg/l, whereas the predicted THM concentrations averaged 50 μg/l. Deviations in THM values in some months may be caused by the model's relative insensitivity to raw water Br^- concentrations. The regression equation used in the WTP model to predict THM was developed from source waters that were generally lower in Br^- concentrations than water from the Delta.

Figure C5-7 shows simulated and measured concentrations of C-THM, Cl-THM, and Br-THM, which are the carbon, chlorine, and bromine portions of the THM molecules, respectively. Comparison of measured and predicted data indicates that the model is able to predict C-THM and Cl-THM concentrations but that its ability to predict the Br-THM portion is relatively poorer.

Figure C5-8 shows the measured influent Br^- concentrations and the measured and simulated bromine incorporation factor, defined as the moles of bromine incorporated per mole of THM, with a maximum value of 3 for pure bromoform (Hutton and Chung 1994). Br^- concentration in raw water ranged from 0.1 mg/l to 0.55 mg/l. The measured bromine incorporation factor ranged from 0.25 to 1.75, and simulated incorporation generally followed the pattern of measured incorporation. Bromine incorporation is generally greater with increased Br^- concentration but is reduced when DOC concentrations and required prechlorination doses are higher, as for the April 1991 sample.

Malcolm Pirnie has recently completed a joint project with MWD and its member agencies to collect additional data and improve the Br-THM regression equations used in the WTP model (MWD 1994). With the new equations, the model simulates substantially higher Br-THM concentrations for raw water Br^- concentrations in the range of 0.1-1.0 mg/l. These recent model improvements are not expected to change the impact assessment results shown in this appendix.

Both the measured Br^- incorporation values and those simulated with the WTP model are consistent with the general relationship between the Br^- saturation ratio (Br^-/C-THM) and bromine incorporation (n) described in Appendix C3. This suggests that the general relationship between Br^- and Br-THM could be used as a reliable assessment method for estimating effects of Br^- concentrations on THM concentrations. This general relationship explains why bromine incorporation is so much greater in THM in treated drinking water than it is in DWR's THMFP assays or MWD's simulated distribution system (SDS) measurements (because the bromine saturation of THM sites is greater).

Some of the largest differences between measured and simulated THM concentrations were found for winter months, when water temperatures were low. In contrast, THM predictions were generally better during summer when water temperatures were higher. Ambient water temperature is a strong predictor variable in the regression equation used for THM formation, with the rate of THM formation increasing with increases in temperature. The model equation may, however, be oversensitive to the temperature effect. Although some uncertainties in the Penitencia Water Treatment Plant data and simulations results were identified, the EPA WTP model was determined to be adequate for impact assessment purposes.

APPLICATION OF THE WTP MODEL TO DELTA EXPORT WATER QUALITY

Estimated Historical Export Water Quality and Trihalomethane Concentrations

Table C5-2 gives the monthly values for Delta export water quality variables estimated from DeltaDWQ results for EC, Cl^-, and DOC for historical inflows and exports for 1967-1991 (see Appendix C4). The WTP model required values for pH, temperature, ammonia, alkalinity, hardness, calcium hardness, turbidity, Br^-, and DOC. Export water quality estimates were developed as follows:

- Export Cl^- concentration was calculated in DeltaDWQ using flow-EC regressions and the following Cl^-/EC ratios (see Appendix C1):
  - Sacramento River and Yolo Bypass, 0.04;
  - eastside streams, 0.05;

- Jersey Point seawater, 0.30; and
- San Joaquin River increasing from 0.08 to 0.15 at 1,000 cubic feet per second (cfs) or greater.

- Export DOC was calculated in DeltaDWQ.
- Export alkalinity, hardness, and calcium hardness were estimated with simple EC regressions based on available data from the Interagency Ecological Program (IEP) and DWR Municipal Water Quality Investigations (MWQI) program (see Appendix C1) and from the EC values calculated in DeltaDWQ.
- pH was set at a constant (7.5); temperature and ammonia were estimated as repeating monthly values based on available IEP and MWQI data (Appendix C1).
- Turbidity was estimated from regressions for Sacramento and San Joaquin River flow and suspended solids and from specified settling fractions, based on MWQI turbidity data.

The water quality variables that cause the greatest change in THM concentrations are DOC, Br^-, and ammonia (because ammonia requires higher chlorine doses). DW project operations may change export DOC concentrations by discharge of DOC that originates from peat oxidation or vegetation decay, and may change Br^- concentrations by increasing salinity intrusion. Because there are many assumptions and uncertainties in the modeling performed by JSA using the Delta Standards and Operations Simulation model (DeltaSOS) and DeltaDWQ to estimate Delta export water quality, it is important to compare the estimated historical export water quality with available MWQI grab samples from the three Delta export/diversion locations: Old River at Rock Slough (near the CCWD diversion), Banks Pumping Plant, and the Delta Mendota Canal (DMC) near Tracy Pumping Plant. Four of the most important export water quality variables are EC, Cl^-, Br^-, and DOC.

Figure C5-9 shows the monthly average DeltaDWQ estimates of Delta export EC (millisiemens per centimeter [mS/cm]) and Cl^- (mg/l) for 1982-1991 with historical inflows and exports. These estimates are compared with DWR's MWQI grab samples for Old River at Rock Slough, Banks Pumping Plant, and the DMC. As discussed in Appendix C1, there are many possible sources of variation in these measured export concentrations. The DeltaDWQ estimates match the seasonal patterns in several of the years (missing the measured EC data in other years) and reproduce the range of observed export EC and Cl^- concentrations. Historical measured EC at the Delta export locations has fluctuated between about 250 microsiemens per centimeter (μS/cm) and 1,250 μS/cm. The DeltaDWQ estimates of EC range from 250 to 1,400 μS/cm.

The historical measured Cl^- concentration at the Delta export locations has fluctuated between about 10 mg/l and 275 mg/l. The DeltaDWQ estimates of Cl^- concentration range from 20 mg/l to 300 mg/l.

Figure C5-10 shows the monthly average DeltaDWQ estimates of Delta export Br^- concentrations (mg/l) and DOC (mg/l) for 1982-1991 with historical inflows and exports. These DeltaDWQ estimates are compared with DWR's MWQI grab samples from Rock Slough, Banks Pumping Plant, and the DMC. The DeltaDWQ estimates match the measured range of observed Br^- and DOC concentrations. Historical measured Br^- concentrations at the Delta export locations have fluctuated from about 0.15 mg/l to about 0.9 mg/l. The DeltaDWQ estimates ($0.0035 \cdot Cl^-$) match this historical range. Historical DOC concentrations at the Delta export locations have fluctuated from about 2 mg/l to 7 mg/l. The DeltaDWQ estimates of DOC concentration match this historical range, with the exception that values of less than 3 mg/l were not estimated (Sacramento inflow DOC concentrations were lower than estimated).

The comparison of historical measurements and DeltaDWQ estimates of export water quality for historical inflows and exports provides an indication of the uncertainty in DeltaDWQ estimates of export water quality. DeltaDWQ estimates of Delta export water quality as a function of inflows, salinity intrusion (governed by outflow), and agricultural drainage are sufficiently accurate to provide a reasonable basis for impact assessment of DW project effects on export water quality and THM concentrations in treated (chlorinated) drinking water from the Delta. Because assessment of the impacts of DW project operations on export water quality and THM concentrations is based on differences in water quality estimates for the No-Project Alternative and each DW project alternative, uncertainties in the estimates of export water quality for the No-Project Alternative will not alter the impact assessment results.

Figure C5-11 shows the simulated THM concentrations as a function of export DOC for the 1967-1991 period with historical inflows and exports. The specified chlorine residual of the filters was 0.5 mg/l, the DOC removal with alum was 30%, and the chloramine residual

was 2.0 mg/l. The monthly THM concentrations ranged from about 30 μg/l to 220 μg/l. The simulated THM concentration increased with increasing DOC, but there was considerable variation in the ratio of THM to DOC caused by temperature, ammonia, or Br^- concentrations.

Figure C5-12 shows that the simulated total chlorination dosage was directly related to raw water DOC. Chlorination for ammonia oxidation is specified in the model to require a chlorine dose of 7.6 times the ammonia concentration. The simulated chlorine dose required for oxidation of DOC was about 40% of the DOC concentration. As a result, THM formation was directly related to DOC levels in raw water, when all other variables were constant, with water high in DOC producing high THM concentrations because of the higher chlorine dosage needed to oxidize the DOC.

Figure C5-13 shows that the simulated THM/DOC yield ratio increases with water temperature. The simulated prechlorination dosage of chlorine also increased with temperature, from 0.3 · DOC at 10°C to 0.4 · DOC at 25 °C. The simulated THM concentration (μg/l) was about seven to eight times the DOC concentration (mg/l) at 10°C and increased to about 16 to 22 times the DOC concentration (mg/l) at 25°C.

Figure C5-14 shows simulated monthly and annual moving-average THM concentrations in treated Delta export water for the 25-year simulation period with historical inflows and exports. Monthly simulated THM concentrations ranged from as low as 20 μg/l to as high as about 120 μg/l. The 1991 Penitencia data are shown for reference.

The simulated monthly THM concentrations meet the existing 100 μg/l drinking water MCL standard for THMs, except for a few months during the 25-year simulation period (Figure C5-14). The MCL drinking water standard is an annual moving average of quarterly samples; the annual average simulated THM concentration ranged between 40 μg/l and 100 μg/l.

Estimation of Delta Export Water Quality and Trihalomethane Concentrations for the No-Project Alternative and the DW Project Alternatives

Simulation Results for the No-Project Alternative

Table C5-3 gives the monthly Delta export water quality values estimated from DeltaDWQ results for EC, Cl^-, and DOC for DeltaSOS-simulated Delta flows for the No-Project Alternative for 1967-1991. These estimates of export water quality under the No-Project Alternative are very similar to estimates of historical export water quality (Table C5-2) because the river inflows, salinity intrusion, and agricultural drainage effects are generally the same. More exports were simulated for the No-Project Alternative than occurred during the 1967-1991 historical period but the sources of export water remained similar (see Appendix B1, "Hydrodynamic Modeling Methods and Results for the Delta Wetlands Project").

Table C5-3 gives the THM concentrations simulated by the WTP model for the No-Project Alternative. Because the export water quality was similar and the specified water treatment processes were identical to those used for the simulation of historical THM concentrations, THM concentrations simulated for the No-Project Alternative were almost the same as simulated historical THM concentrations (Figure C5-14). For the No-Project Alternative, the average estimated export EC value was 486 μS/cm, the average export Cl^- concentration was 62 mg/l, the average export Br^- concentration was 0.22 mg/l, and the average export DOC concentration was 3.86 mg/l. The simulated THM concentration for the No-Project Alternative was 47.4 μg/l for the 1967-1991 period (Table C5-3).

Simulation Results for Alternative 1

Figure C5-15 shows the estimated export DOC and the corresponding simulated THM concentrations for Alternative 1. The export DOC averaged 3.83 mg/l, 0.03 mg/l less than the DOC concentration simulated for the No-Project Alternative. Figure C5-15 also shows the difference in estimated DOC between Alternative 1 and the No-Project Alternative.

For some months (in 1977 and 1991), simulated export Br^- and DOC concentrations were higher for Alternative 1 than for the No-Project Alternative because of increased Br^- concentration from seawater intrusion or increased DOC concentration in DW reservoir island discharge when DOC from vegetation and peat oxidation was simulated. For most months, the estimated export DOC and Br^- concentrations were slightly lower for Alternative 1 than for the No-Project Alternative.

Figure C5-15 shows the simulated THM concentrations for Alternative 1 and the difference between simulated THM concentrations for Alternative 1 and the No-Project Alternative. The average THM concentration for Alternative 1 was 47.30 μg/l, 0.06 μg/l less than the

average THM concentration simulated for the No-Project Alternative. The largest differences in simulated THM concentration occurred during dry periods, when the estimated DOC concentrations in DW discharges were greater than the agricultural drainage DOC concentrations simulated for the No-Project Alternative (i.e., in 1977 and 1991).

Estimated export DOC and THM concentrates were often less for Alternative 1 than for the No-Project Alternative because DW diversions would increase the Sacramento River source contribution (which represents water having a low DOC concentration) (see Appendix B1) and DW discharges would usually have DOC concentrations that are slightly less than export DOC concentrations. The simulated reduction in THM concentrations generally ranges from 1 μg/l to 10 μg/l (Figure C5-15).

Simulation Results for Alternative 2

Figure C5-16 shows the estimated export DOC and the corresponding simulated THM concentrations for Alternative 2. The export DOC averaged 3.83 mg/l, 0.03 mg/l less than the DOC concentration simulated for the No-Project Alternative. Figure C5-16 also shows the difference in estimated DOC between Alternative 2 and the No-Project Alternative.

For some months (in 1977 and 1991), simulated export Br^- and DOC concentrations were higher for Alternative 2 than for the No-Project Alternative because of increased Br^- concentration from seawater intrusion or increased DOC concentration in DW reservoir island discharge when DOC from vegetation and peat oxidation was simulated. For most months, the estimated export DOC and Br^- concentrations were slightly lower for Alternative 2 than for the No-Project Alternative.

Figure C5-16 shows the simulated THM concentrations for Alternative 2 and the difference between simulated THM concentrations for Alternative 2 and the No-Project Alternative. The average THM concentration for Alternative 2 was 47.34 μg/l, 0.02 μg/l less than the average THM concentration simulated for the No-Project Alternative. The largest differences in simulated THM concentration occurred during dry periods, when the estimated DOC concentrations in DW discharges were greater than the agricultural drainage DOC concentrations simulated for the No-Project Alternative (i.e., in 1977 and 1991).

Estimated export DOC and THM concentrates were often less for Alternative 2 than for the No-Project Alternative because DW diversions would increase the Sacramento River source contribution (which represents water having a low DOC concentration) (see Appendix B1) and DW discharges would usually have DOC concentrations that are slightly less than export DOC concentrations. The simulated reduction in THM concentrations generally ranges from 1 μg/l to 10 μg/l (Figure C5-16).

Simulation Results for Alternative 3

Figure C5-17 shows the estimated export DOC and the corresponding simulated THM concentrations for Alternative 3. The export DOC averaged 3.72 mg/l, 0.14 mg/l less than the DOC concentration simulated for the No-Project Alternative. Figure C5-17 also shows the difference in estimated DOC between Alternative 3 and the No-Project Alternative.

For some months (in 1977 and 1991), simulated export Br^- and DOC concentrations were higher for Alternative 3 than for the No-Project Alternative because of increased Br^- concentration from seawater intrusion or increased DOC concentration in DW reservoir island discharge when DOC from vegetation and peat oxidation was simulated. For most months, the estimated export DOC and Br^- concentrations were slightly lower for Alternative 3 than for the No-Project Alternative.

Figure C5-17 shows the simulated THM concentrations for Alternative 3 and the difference between simulated THM concentrations for Alternative 3 and the No-Project Alternative. The average THM concentration for Alternative 3 was 46.27 μg/l, 1.09 μg/l less than the average THM concentration simulated for the No-Project Alternative. The largest differences in simulated THM concentration occurred during dry periods, when the estimated DOC concentrations in DW discharges were greater than the agricultural drainage DOC concentrations simulated for the No-Project Alternative (i.e., in 1977 and 1991).

Estimated export DOC and THM concentrates were often less for Alternative 3 than for the No-Project Alternative because DW diversions would increase the Sacramento River source contribution (which represents water having a low DOC concentration) (see Appendix B1) and DW discharges would usually have DOC concentrations that are slightly less than export DOC concentrations. The simulated reduction in THM concentrations generally ranges from 1 μg/l to 10 μg/l (Figure C5-17).

CONCLUSIONS

The WTP model developed by Malcolm Pirnie is responsive to changes in raw water quality and varying treatment processes that ultimately affect THM production in finished water supplies. Comparison of measured data collected at the Penitencia Water Treatment Plant with values predicted by the model showed that the model can be used as an impact assessment tool for the DW project.

The WTP model tended to underpredict THM concentrations primarily because of uncertain chlorine doses and an insensitivity to Br^- concentrations and Br-THM formation. The prediction of effects of increased DOC concentrations on THM formation, for a given Br^- concentration level, appears to be adequate. Because the DW project will not change export Br^- concentrations substantially (Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project"), the response to changes in export DOC concentrations is the most important response for accurate impact assessment of the DW project.

The WTP model is sensitive to changes in water temperatures, with higher THM production in warm waters. Therefore, natural seasonal variations in raw water temperatures may be partially responsible for increased THM concentrations during summer. The annual moving average MCL for THM is better simulated with annual moving averages of the simulated monthly THM values, a procedure that removes the effects of variable temperature.

The results of simulating DW project operation effects on export concentrations of DOC and Br^- on THM concentrations at a typical water treatment plant (Penitencia) suggest that an increase of 0.5 mg/l in DOC will produce approximately 5-10 μg/l of THM, depending on temperature. The maximum annual average increase attributable to DW project operations was less than 0.2 mg/l of DOC and therefore less than 4 μg/l of THM, which is less than 4% of the MCL for THM in drinking water. In simulations for almost all years, the annual average export DOC concentration was reduced by DW project operations.

CITATIONS

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Table C5–1. Penitencia Water Treatment Plant Water Quality Data and EPA WTP Model Calibration Results for January 1991 to August 1992

A. Penitencia Water Treatment Plant Data

Month – Year	Temp. (C)	Br^- (mg/l)	NH_3 (mg/l)	Raw TOC (mg/l)	Finished TOC (mg/l)	Chlorine Residual (mg/l)	Chloramine Residual (mg/l)	$CHCl_3$ (µg/l)	$CHCl_2Br$ (µg/l)	$CHClBr_2$ (µg/l)	$CHBr_3$ (µg/l)	Total THM (µg/l)	C–THM (µg/l)	Cl–THM (µg/l)	Br–THM (µg/l)	C–THM/DOC (%)	Bromine Incorporation (n)
Jan '91	5.8	0.56	<0.05	5.3	3.1	1.4	1.42					82					
Feb '91	11.2	0.46	<0.05	5.1	2.6	1.4	1.33	9	22	32	14	77	5	23	49	0.11	1.4
Mar '91	12.0	0.35	<0.05	4.2	3.0	1.6	1.39	9	20	31	10	70	5	22	43	0.12	1.3
Apr '91	15.3	0.50	<0.05	6.7	3.1	1.4	1.40	47	18	5	<1	70	7	50	13	0.10	0.3
Jun '91	17.5	0.29	<0.05	4.2	2.8	1.4	1.40	16	26	33	7	82	6	31	45	0.15	1.1
Jul '91	20.9	0.48	<0.05	4.5	2.7	1.4	1.40	12	24	35	10	81	6	27	48	0.13	1.2
Aug '91	21.8	0.28	<0.05	3.3	2.1	1.4	1.39	12	25	34	9	80	6	27	47	0.18	1.2
Sep '91	21.4	0.27	<0.05	4.7	2.3	1.3	1.37	12	21	23	6	62	5	24	34	0.10	1.1
Oct '91	20.6	0.26	<0.05	3.8	2.4	1.4	1.43	7	16	21	5	49	4	17	29	0.09	1.2
Nov '91	14.4	0.40	<0.05	3.0	2.2	1.4	1.40	5	17	31	16	69	5	17	47	0.15	1.6
Dec '91	10.0	0.50	<0.05	3.5	1.7	1.9	1.94	1	10	13	14	38	2	7	28	0.07	1.8
Jan '92	8.4	0.39	<0.05	5.3	2.5	1.5	1.62	10	21	25	8	64	5	22	37	0.09	1.2
Mar '92	14.4	0.10	<0.05	6.0	4.1	1.4	1.63	31	17	2	5	55	5	35	15	0.09	0.4
May '92	21.4	0.14	<0.05	5.4	3.8	1.8	1.97	34	23	13	2	72	6	42	23	0.12	0.5
Jun '92	24.7	0.43	<0.05	4.8	3.2	1.5	1.66	8	24	46	16	94	6	25	62	0.13	1.5
Jul '92	23.9	0.48	0.08	4.4	3.1	1.3	1.46	7	22	47	20	96	6	24	66	0.14	1.6
Aug '92	26.5	0.50	0.07	4.8	2.9	2.1	2.45	11	34	57	29	131	9	34	88	0.18	1.5

B. EPA WTP Model Calibration Results

Month – Year	Temp. (C)	Br^- (mg/l)	NH_3 (mg/l)	Raw TOC (mg/l)	Finished TOC (mg/l)	Chlorine Residual (mg/l)	Chloramine Residual (mg/l)	$CHCl_3$ (µg/l)	$CHCl_2Br$ (µg/l)	$CHClBr_2$ (µg/l)	$CHBr_3$ (µg/l)	Total THM (µg/l)	C–THM (µg/l)	Cl–THM (µg/l)	Br–THM (µg/l)	C–THM/DOC (%)	Bromine Incorporation (n)
Jan '91	5.8	0.56	<0.05	5.3	3.1	1.7	0.7	2	6	16	2	26	2	8	17	0.03	1.4
Feb '91	11.2	0.46	<0.05	5.1	2.7	1.8	0.9	7	11	18	2	38	3	14	21	0.06	1.1
Mar '91	12.0	0.35	<0.05	4.2	2.9	2.0	0.0	9	13	19	3	43	3	17	23	0.08	1.1
Apr '91	15.3	0.50	<0.05	6.7	3.3	1.7	0.7	23	19	19	1	63	5	32	25	0.08	0.7
Jun '91	17.5	0.29	<0.05	4.2	2.8	1.8	1.2	5	13	33	3	54	4	16	35	0.09	1.4
Jul '91	20.9	0.48	<0.05	4.5	2.7	1.8	1.0	18	18	22	2	60	5	28	28	0.11	0.8
Aug '91	21.8	0.28	<0.05	3.3	2.1	1.9	1.6	11	14	18	2	45	4	19	23	0.11	1.0
Sep '91	21.4	0.27	<0.05	4.7	2.5	1.8	1.3	11	17	32	3	62	5	23	35	0.10	1.1
Oct '91	20.6	0.26	<0.05	3.8	2.4	1.7	0.7	14	16	20	2	52	4	22	25	0.11	0.9
Nov '91	14.4	0.40	<0.05	3.0	2.0	1.8	1.7	2	7	23	3	35	2	9	24	0.08	1.6
Dec '91	10.0	0.50	<0.05	3.5	1.9	2.4	2.2	1	5	16	2	24	2	6	17	0.05	1.6
Jan '92	8.4	0.39	<0.05	5.3	2.7	1.8	0.9	4	8	15	2	29	2	10	17	0.04	1.2
Mar '92	14.4	0.10	<0.05	6.0	3.8	1.6	2.2	44	13	3	0	60	6	45	9	0.10	0.2
May '92	21.4	0.14	<0.05	5.4	3.5	2.1	2.2	57	21	8	1	87	8	61	17	0.16	0.3
Jun '92	24.7	0.43	<0.05	4.8	3.1	1.9	2.2	19	28	51	3	101	8	38	56	0.16	1.1
Jul '92	23.9	0.48	0.08	4.4	2.8	1.7	0.9	10	20	46	4	79	6	25	49	0.13	1.3
Aug '92	26.5	0.50	0.07	4.8	2.9	2.3	1.6	14	25	54	3	95	7	32	57	0.14	1.2

Table C5–2. Estimated Delta Export Water Quality for Historical Inflows and Exports for 1967–1991

Water Year	pH (units)	Temp. (C)	NH_3–N (mg/l)	Turbidity (NTU)	EC (mS/cm)	Total Alkalinity (mg/l)	Total Hardness (mg/l)	Ca^{2+} Hardness (mg/l)	Cl^- (mg/l)	Br^- (mg/l)	TOC (mg/l)	UVA (1/cm)
1967												
OCT	7.5	17.0	0.05	40	732	79	117	59	92	0.32	2.72	0.078
NOV	7.5	14.5	0.10	59	1,026	91	164	82	79	0.28	3.31	0.095
DEC	7.5	12.0	0.15	47	683	77	109	55	54	0.19	4.25	0.121
JAN	7.5	10.0	0.20	50	744	80	119	60	60	0.21	4.22	0.121
FEB	7.5	12.0	0.15	43	602	74	96	48	45	0.16	4.34	0.124
MAR	7.5	14.5	0.10	43	592	74	95	47	45	0.16	4.39	0.125
APR	7.5	17.0	0.05	37	430	67	69	34	32	0.11	5.10	0.146
MAY	7.5	19.5	0.04	34	379	65	61	30	28	0.10	5.48	0.157
JUN	7.5	22.5	0.03	34	381	65	61	30	29	0.10	5.46	0.156
JUL	7.5	25.0	0.02	39	493	70	79	39	37	0.13	4.86	0.139
AUG	7.5	22.5	0.03	29	379	65	61	30	30	0.11	2.98	0.085
SEP	7.5	19.5	0.04	45	517	71	83	41	37	0.13	3.34	0.095
1968												
OCT	7.5	17.0	0.05	51	825	83	132	66	62	0.22	4.31	0.123
NOV	7.5	14.5	0.10	49	797	82	127	64	60	0.21	4.33	0.124
DEC	7.5	12.0	0.15	48	751	80	120	60	56	0.20	3.92	0.112
JAN	7.5	10.0	0.20	51	855	84	137	68	65	0.23	4.60	0.131
FEB	7.5	12.0	0.15	51	849	84	136	68	65	0.23	4.92	0.141
MAR	7.5	14.5	0.10	39	473	69	76	38	34	0.12	3.38	0.097
APR	7.5	17.0	0.05	20	402	66	64	32	32	0.11	2.63	0.075
MAY	7.5	19.5	0.04	15	357	64	57	29	46	0.16	2.71	0.077
JUN	7.5	22.5	0.03	13	606	74	97	48	123	0.43	3.12	0.089
JUL	7.5	25.0	0.02	12	677	77	108	54	145	0.51	3.13	0.090
AUG	7.5	22.5	0.03	15	619	75	99	50	123	0.43	3.19	0.091
SEP	7.5	19.5	0.04	15	549	72	88	44	94	0.33	3.01	0.086
1969												
OCT	7.5	17.0	0.05	17	647	76	104	52	103	0.36	3.70	0.106
NOV	7.5	14.5	0.10	22	465	69	74	37	43	0.15	3.05	0.087
DEC	7.5	12.0	0.15	39	702	78	112	56	58	0.20	5.80	0.166
JAN	7.5	10.0	0.20	37	504	70	81	40	38	0.13	5.61	0.160
FEB	7.5	12.0	0.15	31	327	63	52	26	25	0.09	6.09	0.174
MAR	7.5	14.5	0.10	32	321	63	51	26	24	0.08	5.94	0.170
APR	7.5	17.0	0.05	34	369	65	59	30	28	0.10	5.59	0.160
MAY	7.5	19.5	0.04	33	354	64	57	28	27	0.09	5.71	0.163
JUN	7.5	22.5	0.03	32	337	63	54	27	25	0.09	5.86	0.167
JUL	7.5	25.0	0.02	44	614	75	98	49	46	0.16	4.53	0.129
AUG	7.5	22.5	0.03	29	373	65	60	30	27	0.09	3.36	0.096
SEP	7.5	19.5	0.04	50	666	77	107	53	49	0.17	4.08	0.116
1970												
OCT	7.5	17.0	0.05	47	719	79	115	58	54	0.19	4.36	0.125
NOV	7.5	14.5	0.10	46	712	78	114	57	53	0.19	4.45	0.127
DEC	7.5	12.0	0.15	52	888	86	142	71	67	0.23	4.41	0.126
JAN	7.5	10.0	0.20	39	534	71	86	43	40	0.14	5.69	0.163
FEB	7.5	12.0	0.15	40	521	71	83	42	39	0.14	4.69	0.134
MAR	7.5	14.5	0.10	42	577	73	92	46	43	0.15	4.48	0.128
APR	7.5	17.0	0.05	24	430	67	69	34	32	0.11	3.05	0.087
MAY	7.5	19.5	0.04	35	454	68	73	36	35	0.12	3.36	0.096
JUN	7.5	22.5	0.03	31	503	70	81	40	57	0.20	3.52	0.101
JUL	7.5	25.0	0.02	19	463	69	74	37	75	0.26	3.31	0.095
AUG	7.5	22.5	0.03	19	378	65	60	30	48	0.17	3.33	0.095
SEP	7.5	19.5	0.04	30	428	67	68	34	31	0.11	3.47	0.099
1971												
OCT	7.5	17.0	0.05	37	596	74	95	48	44	0.15	4.15	0.118
NOV	7.5	14.5	0.10	49	762	80	122	61	56	0.20	4.25	0.121
DEC	7.5	12.0	0.15	45	768	81	123	61	58	0.20	5.48	0.157
JAN	7.5	10.0	0.20	45	671	77	107	54	50	0.18	4.38	0.125
FEB	7.5	12.0	0.15	47	650	76	104	52	49	0.17	4.25	0.121
MAR	7.5	14.5	0.10	34	443	68	71	35	31	0.11	3.18	0.091
APR	7.5	17.0	0.05	32	417	67	67	33	29	0.10	3.26	0.093
MAY	7.5	19.5	0.04	29	362	64	58	29	24	0.09	3.12	0.089
JUN	7.5	22.5	0.03	28	323	63	52	26	22	0.08	3.30	0.094
JUL	7.5	25.0	0.02	17	228	59	37	18	15	0.05	3.13	0.089
AUG	7.5	22.5	0.03	16	225	59	36	18	14	0.05	3.11	0.089
SEP	7.5	19.5	0.04	24	331	63	53	26	21	0.07	3.33	0.095

Table C5–2. Continued

Water Year	pH (units)	Temp. (C)	NH_3–N (mg/l)	Turbidity (NTU)	EC (mS/cm)	Total Alkalinity (mg/l)	Total Hardness (mg/l)	Ca^{2+} Hardness (mg/l)	Cl^- (mg/l)	Br^- (mg/l)	TOC (mg/l)	UVA (1/cm)
1972												
OCT	7.5	17.0	0.05	35	540	72	86	43	39	0.14	4.28	0.122
NOV	7.5	14.5	0.10	34	579	73	93	46	42	0.15	4.52	0.129
DEC	7.5	12.0	0.15	53	766	81	123	61	57	0.20	5.09	0.146
JAN	7.5	10.0	0.20	50	822	83	131	66	62	0.22	3.95	0.113
FEB	7.5	12.0	0.15	40	539	72	86	43	39	0.14	4.63	0.132
MAR	7.5	14.5	0.10	19	347	64	55	28	22	0.08	3.65	0.104
APR	7.5	17.0	0.05	15	406	66	65	33	42	0.15	3.88	0.111
MAY	7.5	19.5	0.04	12	436	67	70	35	72	0.25	3.01	0.086
JUN	7.5	22.5	0.03	13	760	80	122	61	168	0.59	3.28	0.094
JUL	7.5	25.0	0.02	12	523	71	84	42	96	0.34	3.36	0.096
AUG	7.5	22.5	0.03	11	408	66	65	33	64	0.22	3.16	0.090
SEP	7.5	19.5	0.04	18	372	65	60	30	33	0.12	2.99	0.085
1973												
OCT	7.5	17.0	0.05	21	412	66	66	33	31	0.11	3.09	0.088
NOV	7.5	14.5	0.10	37	630	75	101	50	46	0.16	4.07	0.116
DEC	7.5	12.0	0.15	41	676	77	108	54	53	0.19	5.44	0.155
JAN	7.5	10.0	0.20	47	953	88	153	76	72	0.25	6.32	0.181
FEB	7.5	12.0	0.15	41	603	74	96	48	45	0.16	5.00	0.143
MAR	7.5	14.5	0.10	42	588	74	94	47	44	0.15	4.76	0.136
APR	7.5	17.0	0.05	47	622	75	99	50	46	0.16	3.91	0.112
MAY	7.5	19.5	0.04	27	382	65	61	31	28	0.10	3.10	0.089
JUN	7.5	22.5	0.03	22	387	65	62	31	40	0.14	3.14	0.090
JUL	7.5	25.0	0.02	14	438	68	70	35	76	0.26	3.00	0.086
AUG	7.5	22.5	0.03	14	419	67	67	34	68	0.24	2.99	0.085
SEP	7.5	19.5	0.04	20	371	65	59	30	32	0.11	3.05	0.087
1974												
OCT	7.5	17.0	0.05	26	425	67	68	34	30	0.11	2.99	0.086
NOV	7.5	14.5	0.10	34	440	68	70	35	32	0.11	3.44	0.098
DEC	7.5	12.0	0.15	49	725	79	116	58	55	0.19	5.30	0.151
JAN	7.5	10.0	0.20	42	638	76	102	51	48	0.17	5.25	0.150
FEB	7.5	12.0	0.15	44	502	70	80	40	38	0.13	4.45	0.127
MAR	7.5	14.5	0.10	41	418	67	67	33	31	0.11	3.62	0.103
APR	7.5	17.0	0.05	44	564	73	90	45	42	0.15	4.13	0.118
MAY	7.5	19.5	0.04	32	388	66	62	31	27	0.09	3.35	0.096
JUN	7.5	22.5	0.03	26	324	63	52	26	22	0.08	3.29	0.094
JUL	7.5	25.0	0.02	16	246	60	39	20	19	0.07	2.93	0.084
AUG	7.5	22.5	0.03	17	249	60	40	20	16	0.06	3.00	0.086
SEP	7.5	19.5	0.04	33	427	67	68	34	30	0.10	3.53	0.101
1975												
OCT	7.5	17.0	0.05	40	533	71	85	43	38	0.13	4.19	0.120
NOV	7.5	14.5	0.10	48	779	81	125	62	58	0.20	4.38	0.125
DEC	7.5	12.0	0.15	47	684	77	110	55	51	0.18	4.20	0.120
JAN	7.5	10.0	0.20	36	498	70	80	40	36	0.13	5.19	0.148
FEB	7.5	12.0	0.15	42	533	71	85	43	40	0.14	5.26	0.150
MAR	7.5	14.5	0.10	43	466	69	74	37	34	0.12	4.14	0.118
APR	7.5	17.0	0.05	35	419	67	67	34	30	0.10	3.34	0.095
MAY	7.5	19.5	0.04	38	433	67	69	35	31	0.11	3.62	0.103
JUN	7.5	22.5	0.03	44	535	71	86	43	39	0.14	4.37	0.125
JUL	7.5	25.0	0.02	24	310	62	50	25	22	0.08	3.43	0.098
AUG	7.5	22.5	0.03	17	287	61	46	23	22	0.08	3.06	0.087
SEP	7.5	19.5	0.04	23	346	64	55	28	23	0.08	3.22	0.092
1976												
OCT	7.5	17.0	0.05	31	422	67	68	34	29	0.10	3.47	0.099
NOV	7.5	14.5	0.10	28	412	66	66	33	28	0.10	3.93	0.112
DEC	7.5	12.0	0.15	28	430	67	69	34	30	0.10	5.56	0.159
JAN	7.5	10.0	0.20	23	465	69	74	37	37	0.13	6.46	0.185
FEB	7.5	12.0	0.15	18	448	68	72	36	42	0.15	5.37	0.153
MAR	7.5	14.5	0.10	17	416	67	67	33	41	0.14	3.91	0.112
APR	7.5	17.0	0.05	19	447	68	72	36	41	0.14	3.53	0.101
MAY	7.5	19.5	0.04	15	595	74	95	48	111	0.39	3.06	0.087
JUN	7.5	22.5	0.03	17	719	79	115	57	147	0.51	3.45	0.099
JUL	7.5	25.0	0.02	16	695	78	111	56	140	0.49	3.50	0.100
AUG	7.5	22.5	0.03	14	653	76	104	52	129	0.45	3.11	0.089
SEP	7.5	19.5	0.04	12	751	80	120	60	155	0.54	2.81	0.080

Table C5–2. Continued

Water Year	pH (units)	Temp. (C)	NH_3-N (mg/l)	Turbidity (NTU)	EC (mS/cm)	Total Alkalinity (mg/l)	Total Hardness (mg/l)	Ca^{2+} Hardness (mg/l)	Cl^- (mg/l)	Br^- (mg/l)	TOC (mg/l)	UVA (1/cm)
1977												
OCT	7.5	17.0	0.05	19	1,141	96	182	91	233	0.82	4.03	0.115
NOV	7.5	14.5	0.10	19	1,235	99	198	99	254	0.89	4.96	0.142
DEC	7.5	12.0	0.15	25	1,295	102	207	104	250	0.87	7.54	0.216
JAN	7.5	10.0	0.20	13	865	85	138	69	170	0.59	5.60	0.160
FEB	7.5	12.0	0.15	15	891	86	143	71	170	0.60	5.55	0.159
MAR	7.5	14.5	0.10	12	1,234	99	198	99	277	0.97	3.80	0.108
APR	7.5	17.0	0.05	17	1,617	115	259	129	350	1.22	7.58	0.217
MAY	7.5	19.5	0.04	13	1,109	94	177	89	257	0.90	3.34	0.095
JUN	7.5	22.5	0.03	22	1,531	111	245	122	296	1.04	6.48	0.185
JUL	7.5	25.0	0.02	16	1,528	111	244	122	302	1.06	6.08	0.174
AUG	7.5	22.5	0.03	11	1,599	114	256	128	368	1.29	4.83	0.138
SEP	7.5	19.5	0.04	11	1,811	122	290	145	444	1.55	4.21	0.120
1978												
OCT	7.5	17.0	0.05	34	2,916	167	467	233	653	2.29	9.16	0.262
NOV	7.5	14.5	0.10	15	1,737	119	278	139	422	1.48	3.94	0.113
DEC	7.5	12.0	0.15	10	790	82	126	63	135	0.47	5.34	0.153
JAN	7.5	10.0	0.20	25	649	76	104	52	86	0.30	5.99	0.171
FEB	7.5	12.0	0.15	35	506	70	81	41	53	0.18	4.81	0.137
MAR	7.5	14.5	0.10	39	509	70	81	41	38	0.13	5.09	0.145
APR	7.5	17.0	0.05	34	382	65	61	31	29	0.10	5.45	0.156
MAY	7.5	19.5	0.04	35	395	66	63	32	30	0.10	5.45	0.156
JUN	7.5	22.5	0.03	40	479	69	77	38	43	0.15	4.03	0.115
JUL	7.5	25.0	0.02	17	552	72	88	44	99	0.34	3.03	0.087
AUG	7.5	22.5	0.03	15	469	69	75	38	78	0.27	2.95	0.084
SEP	7.5	19.5	0.04	23	400	66	64	32	36	0.13	3.11	0.089
1979												
OCT	7.5	17.0	0.05	34	574	73	92	46	54	0.19	4.33	0.124
NOV	7.5	14.5	0.10	33	517	71	83	41	44	0.15	3.61	0.103
DEC	7.5	12.0	0.15	27	554	72	89	44	60	0.21	5.08	0.145
JAN	7.5	10.0	0.20	45	748	80	120	60	59	0.21	5.81	0.166
FEB	7.5	12.0	0.15	42	646	76	103	52	49	0.17	5.18	0.148
MAR	7.5	14.5	0.10	41	536	71	86	43	40	0.14	4.65	0.133
APR	7.5	17.0	0.05	32	453	68	72	36	33	0.12	3.19	0.091
MAY	7.5	19.5	0.04	26	366	65	59	29	27	0.09	3.04	0.087
JUN	7.5	22.5	0.03	22	504	70	81	40	72	0.25	3.25	0.093
JUL	7.5	25.0	0.02	14	415	67	66	33	67	0.24	2.89	0.083
AUG	7.5	22.5	0.03	13	588	74	94	47	116	0.41	2.91	0.083
SEP	7.5	19.5	0.04	16	598	74	96	48	107	0.38	2.93	0.084
1980												
OCT	7.5	17.0	0.05	22	531	71	85	42	67	0.23	3.12	0.089
NOV	7.5	14.5	0.10	25	453	68	72	36	38	0.13	3.37	0.096
DEC	7.5	12.0	0.15	26	481	69	77	38	40	0.14	4.63	0.132
JAN	7.5	10.0	0.20	38	531	71	85	42	40	0.14	5.74	0.164
FEB	7.5	12.0	0.15	35	404	66	65	32	30	0.11	5.57	0.159
MAR	7.5	14.5	0.10	33	348	64	56	28	26	0.09	5.71	0.163
APR	7.5	17.0	0.05	39	502	70	80	40	38	0.13	4.81	0.137
MAY	7.5	19.5	0.04	40	516	71	83	41	39	0.14	4.88	0.139
JUN	7.5	22.5	0.03	42	452	68	72	36	34	0.12	3.93	0.112
JUL	7.5	25.0	0.02	28	373	65	60	30	28	0.10	3.42	0.098
AUG	7.5	22.5	0.03	16	515	71	82	41	86	0.30	3.10	0.089
SEP	7.5	19.5	0.04	27	447	68	71	36	43	0.15	3.42	0.098
1981												
OCT	7.5	17.0	0.05	31	553	72	88	44	56	0.20	4.40	0.126
NOV	7.5	14.5	0.10	28	596	74	95	48	68	0.24	4.95	0.141
DEC	7.5	12.0	0.15	26	457	68	73	37	38	0.13	4.85	0.139
JAN	7.5	10.0	0.20	24	478	69	76	38	36	0.13	5.63	0.161
FEB	7.5	12.0	0.15	26	392	66	63	31	29	0.10	3.92	0.112
MAR	7.5	14.5	0.10	36	494	70	79	40	36	0.13	3.81	0.109
APR	7.5	17.0	0.05	21	363	65	58	29	26	0.09	2.63	0.075
MAY	7.5	19.5	0.04	28	449	68	72	36	39	0.14	3.12	0.089
JUN	7.5	22.5	0.03	25	596	74	95	48	96	0.34	3.62	0.104
JUL	7.5	25.0	0.02	16	455	68	73	36	78	0.27	3.19	0.091
AUG	7.5	22.5	0.03	13	653	76	104	52	135	0.47	3.05	0.087
SEP	7.5	19.5	0.04	15	716	79	115	57	142	0.50	3.12	0.089

Table C5–2. Continued

Water Year	pH (units)	Temp. (C)	NH_3-N (mg/l)	Turbidity (NTU)	EC (mS/cm)	Total Alkalinity (mg/l)	Total Hardness (mg/l)	Ca^{2+} Hardness (mg/l)	Cl^- (mg/l)	Br^- (mg/l)	TOC (mg/l)	UVA (1/cm)
1982												
OCT	7.5	17.0	0.05	17	765	81	122	61	136	0.48	2.99	0.085
NOV	7.5	14.5	0.10	27	391	66	63	31	29	0.10	3.06	0.087
DEC	7.5	12.0	0.15	34	473	69	76	38	40	0.14	4.92	0.141
JAN	7.5	10.0	0.20	42	621	75	99	50	50	0.18	6.11	0.175
FEB	7.5	12.0	0.15	36	383	65	61	31	30	0.10	4.41	0.126
MAR	7.5	14.5	0.10	39	395	66	63	32	30	0.10	4.60	0.131
APR	7.5	17.0	0.05	34	365	65	58	29	27	0.10	5.63	0.161
MAY	7.5	19.5	0.04	35	396	66	63	32	30	0.10	5.42	0.155
JUN	7.5	22.5	0.03	42	574	73	92	46	43	0.15	4.70	0.134
JUL	7.5	25.0	0.02	44	569	73	91	46	43	0.15	4.47	0.128
AUG	7.5	22.5	0.03	28	360	64	58	29	25	0.09	3.38	0.096
SEP	7.5	19.5	0.04	44	521	71	83	42	38	0.13	4.04	0.116
1983												
OCT	7.5	17.0	0.05	41	539	72	86	43	40	0.14	4.62	0.132
NOV	7.5	14.5	0.10	43	495	70	79	40	37	0.13	4.37	0.125
DEC	7.5	12.0	0.15	36	438	68	70	35	33	0.11	5.61	0.160
JAN	7.5	10.0	0.20	35	412	66	66	33	31	0.11	5.75	0.164
FEB	7.5	12.0	0.15	31	324	63	52	26	24	0.09	6.06	0.173
MAR	7.5	14.5	0.10	30	291	62	47	23	22	0.08	6.27	0.179
APR	7.5	17.0	0.05	31	300	62	48	24	22	0.08	6.14	0.175
MAY	7.5	19.5	0.04	31	317	63	51	25	24	0.08	5.99	0.171
JUN	7.5	22.5	0.03	33	344	64	55	28	26	0.09	5.78	0.165
JUL	7.5	25.0	0.02	35	389	66	62	31	29	0.10	5.47	0.156
AUG	7.5	22.5	0.03	40	454	68	73	36	33	0.12	4.55	0.130
SEP	7.5	19.5	0.04	39	484	69	77	39	36	0.13	4.98	0.142
1984												
OCT	7.5	17.0	0.05	37	455	68	73	36	34	0.12	5.17	0.148
NOV	7.5	14.5	0.10	39	494	70	79	40	37	0.13	5.17	0.148
DEC	7.5	12.0	0.15	35	398	66	64	32	30	0.10	5.67	0.162
JAN	7.5	10.0	0.20	33	345	64	55	28	26	0.09	5.74	0.164
FEB	7.5	12.0	0.15	39	481	69	77	38	36	0.13	4.88	0.139
MAR	7.5	14.5	0.10	42	459	68	73	37	34	0.12	4.13	0.118
APR	7.5	17.0	0.05	30	404	66	65	32	28	0.10	3.53	0.101
MAY	7.5	19.5	0.04	31	400	66	64	32	29	0.10	3.39	0.097
JUN	7.5	22.5	0.03	24	367	65	59	29	34	0.12	3.32	0.095
JUL	7.5	25.0	0.02	18	253	60	40	20	19	0.07	3.01	0.086
AUG	7.5	22.5	0.03	18	311	62	50	25	28	0.10	3.07	0.088
SEP	7.5	19.5	0.04	31	425	67	68	34	30	0.11	3.44	0.098
1985												
OCT	7.5	17.0	0.05	36	500	70	80	40	37	0.13	3.73	0.107
NOV	7.5	14.5	0.10	25	365	65	58	29	24	0.09	3.27	0.093
DEC	7.5	12.0	0.15	31	424	67	68	34	30	0.10	4.80	0.137
JAN	7.5	10.0	0.20	35	486	69	78	39	35	0.12	4.94	0.141
FEB	7.5	12.0	0.15	25	391	66	63	31	27	0.09	4.17	0.119
MAR	7.5	14.5	0.10	20	372	65	60	30	27	0.10	2.96	0.085
APR	7.5	17.0	0.05	21	471	69	75	38	51	0.18	2.97	0.085
MAY	7.5	19.5	0.04	22	439	68	70	35	48	0.17	3.26	0.093
JUN	7.5	22.5	0.03	19	481	69	77	38	72	0.25	3.46	0.099
JUL	7.5	25.0	0.02	19	479	69	77	38	74	0.26	3.33	0.095
AUG	7.5	22.5	0.03	17	798	82	128	64	166	0.58	3.35	0.096
SEP	7.5	19.5	0.04	16	927	87	148	74	201	0.70	3.19	0.091
1986												
OCT	7.5	17.0	0.05	18	1,065	93	170	85	226	0.79	3.65	0.104
NOV	7.5	14.5	0.10	18	673	77	108	54	112	0.39	3.12	0.089
DEC	7.5	12.0	0.15	17	453	68	73	36	47	0.16	4.90	0.140
JAN	7.5	10.0	0.20	18	419	67	67	34	35	0.12	5.77	0.165
FEB	7.5	12.0	0.15	41	571	73	91	46	43	0.15	5.52	0.158
MAR	7.5	14.5	0.10	33	357	64	57	29	27	0.09	5.80	0.166
APR	7.5	17.0	0.05	35	385	65	62	31	29	0.10	5.43	0.155
MAY	7.5	19.5	0.04	41	495	70	79	40	37	0.13	4.52	0.129
JUN	7.5	22.5	0.03	44	482	69	77	39	39	0.14	4.15	0.119
JUL	7.5	25.0	0.02	22	359	64	57	29	36	0.13	3.19	0.091
AUG	7.5	22.5	0.03	20	466	69	75	37	65	0.23	3.20	0.091
SEP	7.5	19.5	0.04	23	375	65	60	30	32	0.11	3.14	0.090

Table C5–2. Continued

Water Year	pH (units)	Temp. (C)	NH_3–N (mg/l)	Turbidity (NTU)	EC (mS/cm)	Total Alkalinity (mg/l)	Total Hardness (mg/l)	Ca^{2+} Hardness (mg/l)	Cl^- (mg/l)	Br^- (mg/l)	TOC (mg/l)	UVA (1/cm)
1987												
OCT	7.5	17.0	0.05	27	443	68	71	35	35	0.12	4.12	0.118
NOV	7.5	14.5	0.10	24	507	70	81	41	50	0.18	4.82	0.138
DEC	7.5	12.0	0.15	28	495	70	79	40	45	0.16	5.19	0.148
JAN	7.5	10.0	0.20	23	453	68	72	36	37	0.13	4.92	0.141
FEB	7.5	12.0	0.15	21	445	68	71	36	32	0.11	5.12	0.146
MAR	7.5	14.5	0.10	34	478	69	76	38	35	0.12	3.99	0.114
APR	7.5	17.0	0.05	24	552	72	88	44	69	0.24	3.05	0.087
MAY	7.5	19.5	0.04	25	640	76	102	51	100	0.35	3.23	0.092
JUN	7.5	22.5	0.03	24	765	81	122	61	145	0.51	3.50	0.100
JUL	7.5	25.0	0.02	15	625	75	100	50	127	0.44	3.05	0.087
AUG	7.5	22.5	0.03	14	781	81	125	63	170	0.60	3.02	0.086
SEP	7.5	19.5	0.04	14	1,147	96	184	92	271	0.95	3.01	0.086
1988												
OCT	7.5	17.0	0.05	17	1,283	101	205	103	289	1.01	3.92	0.112
NOV	7.5	14.5	0.10	19	1,126	95	180	90	236	0.83	3.46	0.099
DEC	7.5	12.0	0.15	14	493	70	79	39	66	0.23	4.43	0.127
JAN	7.5	10.0	0.20	16	390	66	62	31	36	0.13	5.07	0.145
FEB	7.5	12.0	0.15	12	849	84	136	68	180	0.63	3.98	0.114
MAR	7.5	14.5	0.10	18	861	84	138	69	170	0.60	3.27	0.093
APR	7.5	17.0	0.05	18	405	66	65	32	41	0.14	3.20	0.092
MAY	7.5	19.5	0.04	19	586	73	94	47	93	0.32	3.12	0.089
JUN	7.5	22.5	0.03	20	799	82	128	64	160	0.56	3.41	0.098
JUL	7.5	25.0	0.02	15	661	76	106	53	139	0.49	3.17	0.091
AUG	7.5	22.5	0.03	15	896	86	143	72	201	0.70	3.17	0.091
SEP	7.5	19.5	0.04	14	1,132	95	181	91	264	0.92	3.12	0.089
1989												
OCT	7.5	17.0	0.05	16	1,359	104	217	109	312	1.09	4.41	0.126
NOV	7.5	14.5	0.10	16	811	82	130	65	154	0.54	3.29	0.094
DEC	7.5	12.0	0.15	15	587	73	94	47	90	0.31	4.71	0.135
JAN	7.5	10.0	0.20	12	713	79	114	57	137	0.48	4.91	0.140
FEB	7.5	12.0	0.15	13	608	74	97	49	102	0.36	4.48	0.128
MAR	7.5	14.5	0.10	23	276	61	44	22	20	0.07	2.76	0.079
APR	7.5	17.0	0.05	17	319	63	51	25	24	0.09	2.93	0.084
MAY	7.5	19.5	0.04	21	428	67	68	34	46	0.16	3.30	0.094
JUN	7.5	22.5	0.03	21	472	69	75	38	63	0.22	3.57	0.102
JUL	7.5	25.0	0.02	14	355	64	57	28	51	0.18	3.11	0.089
AUG	7.5	22.5	0.03	12	439	68	70	35	75	0.26	3.01	0.086
SEP	7.5	19.5	0.04	13	430	67	69	34	62	0.22	2.41	0.069
1990												
OCT	7.5	17.0	0.05	13	536	71	86	43	87	0.30	3.03	0.086
NOV	7.5	14.5	0.10	13	572	73	92	46	96	0.34	3.34	0.095
DEC	7.5	12.0	0.15	13	660	76	106	53	117	0.41	5.90	0.169
JAN	7.5	10.0	0.20	13	401	66	64	32	48	0.17	4.81	0.137
FEB	7.5	12.0	0.15	13	382	65	61	31	44	0.15	4.01	0.115
MAR	7.5	14.5	0.10	13	635	75	102	51	114	0.40	2.89	0.083
APR	7.5	17.0	0.05	13	496	70	79	40	76	0.27	3.73	0.107
MAY	7.5	19.5	0.04	26	596	74	95	48	71	0.25	3.16	0.090
JUN	7.5	22.5	0.03	24	610	74	98	49	101	0.36	3.91	0.112
JUL	7.5	25.0	0.02	15	596	74	95	48	114	0.40	3.45	0.098
AUG	7.5	22.5	0.03	14	639	76	102	51	126	0.44	3.40	0.097
SEP	7.5	19.5	0.04	13	1,035	91	166	83	235	0.82	3.34	0.095
1991												
OCT	7.5	17.0	0.05	21	1,393	106	223	111	297	1.04	5.01	0.143
NOV	7.5	14.5	0.10	21	1,214	99	194	97	236	0.83	5.99	0.171
DEC	7.5	12.0	0.15	15	772	81	123	62	136	0.48	5.80	0.166
JAN	7.5	10.0	0.20	14	988	90	158	79	192	0.67	7.54	0.215
FEB	7.5	12.0	0.15	14	658	76	105	53	102	0.36	5.86	0.167
MAR	7.5	14.5	0.10	18	315	63	50	25	22	0.08	2.84	0.081
APR	7.5	17.0	0.05	13	831	83	133	66	167	0.59	2.76	0.079
MAY	7.5	19.5	0.04	27	1,084	93	173	87	217	0.76	3.77	0.108
JUN	7.5	22.5	0.03	25	1,029	91	165	82	215	0.75	4.27	0.122
JUL	7.5	25.0	0.02	20	983	89	157	79	206	0.72	4.31	0.123
AUG	7.5	22.5	0.03	14	1,157	96	185	93	269	0.94	3.89	0.111
SEP	7.5	19.5	0.04	13	1,100	94	176	88	255	0.89	3.55	0.102

Table C5–3. Estimated No–Project Export Water Quality and THM Concentrations and Changes Resulting from Operations of DW Alternatives for 1968–1991

Water Year	No–Project Alternative				Alternative 1 Changes				Alternative 2 Changes				Alternative 3 Changes			
	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)
1968																
OCT	21	0.07	3.1	36	1	0.00	(0.0)	(0)	1	0.00	(0.0)	(0)	0	0.00	(0.3)	(3)
NOV	32	0.11	3.2	33	0	0.00	(0.0)	(0)	0	0.00	(0.0)	(0)	0	0.00	(0.1)	(0)
DEC	45	0.16	3.6	32	0	0.00	(0.0)	(0)	0	0.00	(0.0)	(0)	0	0.00	(0.1)	(0)
JAN	20	0.07	3.8	27	(0)	(0.00)	0.0	0	(0)	(0.00)	0.0	0	(0)	(0.00)	(0.1)	(1)
FEB	20	0.07	3.6	31	(0)	(0.00)	0.0	0	(0)	(0.00)	0.0	0	(0)	(0.00)	(0.1)	(1)
MAR	17	0.06	2.7	27	(1)	(0.00)	(0.0)	(0)	(1)	(0.00)	(0.0)	(0)	(1)	(0.00)	(0.1)	(1)
APR	42	0.15	3.4	40	(4)	(0.01)	(0.1)	(1)	(3)	(0.01)	(0.0)	(1)	(3)	(0.01)	(0.1)	(1)
MAY	54	0.19	3.5	50	(12)	(0.04)	(0.2)	(4)	(9)	(0.03)	(0.1)	(2)	(9)	(0.03)	(0.2)	(4)
JUN	48	0.17	3.0	48	2	0.01	0.0	1	2	0.01	0.0	1	1	0.01	0.0	0
JUL	28	0.10	2.7	47	1	0.00	0.0	0	1	0.00	0.0	0	1	0.00	(0.0)	(1)
AUG	65	0.23	3.0	48	(14)	(0.05)	0.0	(1)	(18)	(0.06)	(0.0)	(2)	(27)	(0.09)	(0.1)	(4)
SEP	120	0.42	3.0	46	2	0.01	0.0	0	2	0.01	0.0	0	(17)	(0.06)	0.0	0
1969																
OCT	101	0.35	3.4	44	1	0.00	(0.0)	(0)	1	0.00	(0.0)	(0)	1	0.00	(0.0)	(0)
NOV	89	0.31	2.9	33	0	0.00	0.0	0	0	0.00	0.0	0	0	0.00	(0.0)	(0)
DEC	28	0.10	4.6	38	1	0.00	(0.8)	(6)	1	0.00	(0.8)	(6)	3	0.01	(1.1)	(8)
JAN	29	0.10	5.2	37	(0)	(0.00)	(0.1)	(0)	(0)	(0.00)	(0.1)	(0)	(1)	(0.00)	(0.2)	(1)
FEB	29	0.10	5.4	46	0	0.00	0.0	0	0	0.00	0.0	0	(0)	(0.00)	(0.0)	(0)
MAR	26	0.09	3.8	37	0	0.00	0.1	1	(0)	(0.00)	0.1	1	(0)	(0.00)	(0.0)	(0)
APR	28	0.10	3.9	46	(0)	(0.00)	0.0	0	(0)	(0.00)	0.0	0	(0)	(0.00)	(0.0)	(0)
MAY	28	0.10	5.5	77	0	0.00	0.0	0	0	0.00	0.0	0	0	0.00	0.0	0
JUN	29	0.10	4.8	78	(1)	(0.00)	(0.2)	(3)	(1)	(0.00)	(0.2)	(3)	(2)	(0.01)	(0.3)	(6)
JUL	41	0.14	3.8	69	(13)	(0.05)	(0.0)	(3)	(13)	(0.05)	(0.0)	(3)	(15)	(0.05)	(0.2)	(6)
AUG	66	0.23	3.3	55	2	0.01	0.0	1	2	0.01	0.0	1	(18)	(0.06)	0.1	(1)
SEP	21	0.07	2.9	38	2	0.01	(0.5)	(6)	2	0.01	(0.5)	(6)	6	0.02	(0.7)	(8)
1970																
OCT	28	0.10	3.9	45	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.0)	(0)	(1)	(0.00)	(0.2)	(3)
NOV	27	0.09	3.6	36	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.1)	(1)
DEC	23	0.08	4.0	34	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.1)	(1)
JAN	30	0.10	5.4	39	(0)	(0.00)	0.0	0	(0)	(0.00)	0.0	0	(0)	(0.00)	(0.1)	(1)
FEB	25	0.09	4.1	34	(0)	(0.00)	0.0	0	(0)	(0.00)	0.0	0	(0)	(0.00)	(0.1)	(0)
MAR	19	0.07	2.9	29	(0)	(0.00)	0.1	1	(0)	(0.00)	0.1	1	(1)	(0.00)	(0.2)	(2)
APR	38	0.13	3.9	46	(1)	(0.00)	(0.0)	(0)	(3)	(0.01)	(0.1)	(2)	(3)	(0.01)	(0.2)	(3)
MAY	48	0.17	3.9	55	0	0.00	0.0	0	(6)	(0.02)	(0.1)	(2)	(5)	(0.02)	(0.2)	(4)
JUN	39	0.14	3.2	50	1	0.00	0.0	1	1	0.00	0.0	1	1	0.00	0.0	0
JUL	20	0.07	2.8	47	1	0.00	(0.0)	(0)	1	0.00	(0.0)	(0)	1	0.00	(0.0)	(0)
AUG	60	0.21	3.2	53	(26)	(0.09)	(0.1)	(4)	(20)	(0.07)	0.0	(2)	(30)	(0.11)	(0.2)	(6)
SEP	127	0.45	3.1	49	3	0.01	(0.0)	0	3	0.01	0.0	0	3	0.01	(0.0)	0

Table C5–3. Continued

Water Year	No–Project Alternative				Alternative 1 Changes				Alternative 2 Changes				Alternative 3 Changes			
	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)
1971																
OCT	106	0.37	3.4	44	0	0.00	(0.0)	(0)	0	0.00	(0.0)	(0)	0	0.00	(0.0)	(0)
NOV	24	0.08	3.0	31	1	0.00	(0.5)	(4)	1	0.00	(0.5)	(4)	3	0.01	(0.7)	(7)
DEC	27	0.09	4.9	41	(1)	(0.00)	(0.1)	(1)	(1)	(0.00)	(0.1)	(1)	(2)	(0.01)	(0.3)	(3)
JAN	20	0.07	3.8	27	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.0)	(0)	(1)	(0.00)	(0.1)	(1)
FEB	22	0.08	3.8	32	(4)	(0.01)	(0.6)	(5)	(4)	(0.01)	(0.5)	(4)	(4)	(0.01)	(0.6)	(5)
MAR	17	0.06	2.8	28	(2)	(0.01)	(0.3)	(3)	(2)	(0.01)	(0.2)	(3)	(2)	(0.01)	(0.3)	(3)
APR	30	0.11	3.4	40	(0)	(0.00)	0.0	0	(0)	(0.00)	0.0	0	(0)	(0.00)	(0.0)	(1)
MAY	24	0.08	3.2	42	(1)	(0.00)	(0.2)	(2)	(1)	(0.00)	(0.2)	(2)	(2)	(0.01)	(0.4)	(5)
JUN	18	0.06	3.0	46	0	0.00	0.0	0	0	0.00	0.0	0	0	0.00	0.0	0
JUL	18	0.06	2.9	49	0	0.00	(0.0)	(1)	0	0.00	(0.0)	(1)	0	0.00	(0.0)	(1)
AUG	59	0.20	3.3	54	(28)	(0.10)	(0.4)	(9)	(27)	(0.10)	(0.3)	(8)	(30)	(0.10)	(0.4)	(9)
SEP	55	0.19	2.9	40	1	0.00	(0.0)	(0)	1	0.00	(0.0)	(0)	(9)	(0.03)	(0.1)	(1)
1972																
OCT	37	0.13	3.4	40	13	0.04	(0.4)	(4)	13	0.04	(0.4)	(4)	12	0.04	(0.4)	(4)
NOV	49	0.17	3.6	38	6	0.02	(0.1)	(0)	6	0.02	(0.1)	(0)	6	0.02	(0.1)	(1)
DEC	24	0.09	4.1	34	0	0.00	(0.4)	(3)	1	0.00	(0.4)	(3)	4	0.01	(0.8)	(6)
JAN	27	0.10	4.3	31	1	0.00	(0.1)	(1)	0	0.00	(0.1)	(0)	2	0.01	(0.1)	(1)
FEB	21	0.07	4.0	33	(0)	(0.00)	(0.0)	(0)	(1)	(0.00)	(0.4)	(3)	(2)	(0.01)	(0.5)	(4)
MAR	19	0.07	3.3	33	(0)	(0.00)	0.0	0	(1)	(0.00)	(0.1)	(1)	(1)	(0.00)	(0.2)	(2)
APR	44	0.15	4.5	54	(5)	(0.02)	(0.3)	(5)	(4)	(0.01)	(0.3)	(4)	(4)	(0.01)	(0.4)	(5)
MAY	52	0.18	3.6	50	(4)	(0.01)	(0.0)	(0)	(3)	(0.01)	(0.0)	(0)	(2)	(0.01)	(0.1)	(1)
JUN	47	0.16	3.3	53	1	0.00	(0.1)	(1)	1	0.00	(0.1)	(1)	0	0.00	(0.4)	(7)
JUL	29	0.10	2.9	50	1	0.00	(0.0)	(1)	1	0.00	(0.0)	(0)	1	0.00	(0.0)	(1)
AUG	33	0.12	2.9	45	1	0.00	(0.0)	(0)	1	0.00	(0.0)	(0)	2	0.01	(0.0)	(0)
SEP	125	0.44	3.1	49	(47)	(0.16)	0.1	(2)	(45)	(0.16)	0.1	(2)	(64)	(0.22)	(0.0)	(5)
1973																
OCT	88	0.31	2.8	36	0	0.00	(0.0)	0	0	0.00	(0.0)	0	(6)	(0.02)	0.0	0
NOV	24	0.08	3.1	32	0	0.00	(0.5)	(4)	0	0.00	(0.5)	(4)	2	0.01	(0.7)	(6)
DEC	23	0.08	4.4	37	(1)	(0.00)	(0.1)	(1)	(0)	(0.00)	(0.1)	(1)	(1)	(0.00)	(0.4)	(3)
JAN	28	0.10	5.6	40	(1)	(0.00)	(0.1)	(1)	(1)	(0.00)	(0.1)	(1)	(1)	(0.00)	(0.2)	(1)
FEB	23	0.08	4.3	36	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.1)	(1)
MAR	26	0.09	3.9	39	(0)	(0.00)	0.0	0	(0)	(0.00)	0.0	0	(0)	(0.00)	(0.1)	(1)
APR	31	0.11	3.5	41	(0)	(0.00)	0.0	0	(0)	(0.00)	0.0	0	(0)	(0.00)	(0.0)	(0)
MAY	29	0.10	3.5	47	(1)	(0.00)	(0.2)	(3)	(1)	(0.00)	(0.2)	(3)	(2)	(0.01)	(0.4)	(5)
JUN	26	0.09	3.2	49	(1)	(0.00)	(0.1)	(1)	(6)	(0.02)	(0.2)	(4)	(6)	(0.02)	(0.3)	(6)
JUL	18	0.06	2.8	47	0	0.00	0.0	0	0	0.00	0.0	0	0	0.00	0.0	0
AUG	69	0.24	3.2	54	(27)	(0.10)	(0.1)	(4)	2	0.01	0.0	1	(24)	(0.08)	(0.1)	(4)
SEP	119	0.42	3.0	47	2	0.01	(0.0)	0	2	0.01	0.0	0	2	0.01	(0.0)	0

Table C5–3. Continued

Water Year	No–Project Alternative				Alternative 1 Changes				Alternative 2 Changes				Alternative 3 Changes			
	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)
1974																
OCT	81	0.29	2.5	32	0	0.00	0.0	0	0	0.00	0.0	0	0	0.00	(0.0)	(0)
NOV	18	0.06	3.0	30	(2)	(0.01)	(0.5)	(5)	(2)	(0.01)	(0.5)	(5)	(3)	(0.01)	(0.7)	(7)
DEC	24	0.08	4.5	37	(0)	(0.00)	(0.1)	(0)	(0)	(0.00)	(0.1)	(0)	(1)	(0.00)	(0.3)	(2)
JAN	25	0.09	4.8	35	(1)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.0)	(0)	(1)	(0.00)	(0.1)	(2)
FEB	20	0.07	3.6	31	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.1)	(1)
MAR	18	0.06	3.1	31	(0)	(0.00)	0.1	1	(0)	(0.00)	0.1	1	(0)	(0.00)	(0.0)	(0)
APR	26	0.09	3.5	40	(0)	(0.00)	0.0	0	(0)	(0.00)	0.0	0	(0)	(0.00)	(0.0)	(0)
MAY	26	0.09	3.5	47	0	0.00	0.0	0	0	0.00	0.0	0	(0)	(0.00)	(0.0)	(0)
JUN	22	0.08	3.2	50	0	0.00	0.0	0	(4)	(0.01)	(0.1)	(2)	(4)	(0.01)	(0.2)	(5)
JUL	28	0.10	3.1	53	(9)	(0.03)	(0.1)	(3)	(4)	(0.01)	0.1	0	(8)	(0.03)	(0.2)	(4)
AUG	59	0.21	3.3	54	(2)	(0.01)	0.0	0	2	0.01	0.0	0	(2)	(0.01)	0.1	1
SEP	25	0.09	2.8	37	12	0.04	(0.4)	(4)	12	0.04	(0.4)	(4)	12	0.04	(0.4)	(4)
1975																
OCT	21	0.07	3.2	37	2	0.01	(0.2)	(2)	2	0.01	(0.2)	(2)	5	0.02	(0.6)	(6)
NOV	30	0.11	3.5	36	1	0.00	(0.0)	(0)	1	0.00	(0.0)	(0)	2	0.01	(0.1)	(1)
DEC	30	0.11	4.2	36	0	0.00	(0.1)	(1)	0	0.00	(0.1)	(1)	0	0.00	(0.1)	(1)
JAN	45	0.16	4.7	34	0	0.00	(0.1)	(0)	0	0.00	(0.1)	(0)	0	0.00	(0.1)	(1)
FEB	26	0.09	4.5	38	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.1)	(1)
MAR	20	0.07	3.5	35	(1)	(0.00)	(0.1)	(1)	(1)	(0.00)	(0.1)	(1)	(1)	(0.00)	(0.2)	(2)
APR	28	0.10	3.5	41	0	0.00	0.0	0	0	0.00	0.0	0	0	0.00	(0.0)	(0)
MAY	25	0.09	3.5	47	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.1)	(1)
JUN	19	0.06	3.1	47	0	0.00	0.0	0	(0)	(0.00)	(0.1)	(1)	(0)	(0.00)	(0.1)	(1)
JUL	26	0.09	3.0	51	(3)	(0.01)	(0.1)	(2)	(2)	(0.01)	(0.0)	(1)	(3)	(0.01)	(0.1)	(3)
AUG	63	0.22	3.4	55	(19)	(0.07)	(0.1)	(4)	(12)	(0.04)	0.0	(1)	(28)	(0.10)	(0.3)	(7)
SEP	43	0.15	2.9	40	5	0.02	(0.1)	(2)	5	0.02	(0.1)	(2)	6	0.02	(0.1)	(2)
1976																
OCT	20	0.07	2.7	32	2	0.01	(0.4)	(4)	2	0.01	(0.4)	(4)	6	0.02	(0.6)	(7)
NOV	24	0.08	3.5	35	1	0.00	(0.0)	(0)	1	0.00	(0.0)	(0)	2	0.01	(0.2)	(2)
DEC	50	0.18	5.6	49	(7)	(0.03)	(0.7)	(7)	(5)	(0.02)	(0.5)	(5)	(4)	(0.02)	(0.5)	(5)
JAN	69	0.24	6.8	52	(25)	(0.09)	(1.8)	(15)	(25)	(0.09)	(1.8)	(15)	(25)	(0.09)	(1.9)	(16)
FEB	29	0.10	4.8	41	(0)	(0.00)	(0.0)	(0)	(1)	(0.00)	(0.2)	(1)	(5)	(0.02)	(0.9)	(8)
MAR	35	0.12	4.1	42	0	0.00	0.1	1	0	0.00	0.1	1	(5)	(0.02)	(0.5)	(5)
APR	63	0.22	4.0	51	0	0.00	0.1	1	0	0.00	0.1	1	(2)	(0.01)	(0.2)	(3)
MAY	68	0.24	3.5	51	2	0.01	0.1	3	2	0.01	0.1	2	2	0.01	0.0	0
JUN	54	0.19	3.1	51	2	0.01	0.1	2	2	0.01	0.1	2	2	0.01	0.0	1
JUL	59	0.21	3.0	54	4	0.01	0.1	3	4	0.01	0.1	3	4	0.01	0.1	2
AUG	175	0.61	3.7	73	7	0.02	0.1	3	7	0.02	0.1	3	7	0.02	0.1	2
SEP	255	0.89	3.3	60	5	0.02	0.1	2	5	0.02	0.1	2	5	0.02	0.1	1

Table C5–3. Continued

Water Year	No-Project Alternative				Alternative 1 Changes				Alternative 2 Changes				Alternative 3 Changes			
	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)
1977																
OCT	271	0.95	3.9	63	2	0.01	0.1	1	2	0.01	0.1	1	2	0.01	0.0	1
NOV	172	0.60	4.3	54	1	0.00	0.1	1	1	0.00	0.1	1	1	0.00	0.0	0
DEC	72	0.25	4.9	44	(0)	(0.00)	(0.0)	(0)	0	0.00	(0.0)	(0)	(0)	(0.00)	(0.1)	(1)
JAN	144	0.51	6.1	51	1	0.00	0.2	2	1	0.00	0.2	2	1	0.00	0.0	0
FEB	68	0.24	4.6	42	0	0.00	0.1	1	0	0.00	0.1	1	0	0.00	0.0	0
MAR	77	0.27	3.6	40	1	0.00	0.4	4	1	0.00	0.4	4	0	0.00	0.1	1
APR	81	0.28	5.2	67	2	0.01	0.4	6	2	0.01	0.4	6	2	0.01	0.2	3
MAY	126	0.44	3.8	60	3	0.01	0.4	7	3	0.01	0.4	7	3	0.01	0.3	5
JUN	142	0.50	5.0	97	3	0.01	0.7	15	3	0.01	0.7	15	4	0.01	0.6	11
JUL	179	0.63	4.5	99	21	0.07	0.5	15	21	0.07	0.5	15	21	0.07	0.5	13
AUG	248	0.87	5.6	124	16	0.06	0.7	19	16	0.06	0.7	19	17	0.06	0.7	17
SEP	285	1.00	3.7	69	7	0.02	0.2	4	7	0.02	0.2	4	7	0.02	0.2	4
1978																
OCT	300	1.05	4.9	84	4	0.01	0.1	3	4	0.01	0.1	3	4	0.01	0.1	2
NOV	314	1.10	3.9	57	(0)	(0.00)	0.3	4	(0)	(0.00)	0.3	4	0	0.00	0.2	2
DEC	104	0.37	4.4	42	1	0.00	0.1	1	1	0.00	0.1	1	0	0.00	0.0	(0)
JAN	57	0.20	5.7	43	(9)	(0.03)	(0.9)	(7)	(9)	(0.03)	(0.9)	(7)	(13)	(0.05)	(1.3)	(10)
FEB	37	0.13	4.2	36	(1)	(0.00)	(0.0)	(0)	(1)	(0.00)	(0.0)	(0)	(2)	(0.01)	(0.2)	(2)
MAR	27	0.10	3.5	35	(0)	(0.00)	0.1	0	(0)	(0.00)	0.1	0	(1)	(0.00)	(0.1)	(1)
APR	27	0.10	3.4	40	(0)	(0.00)	0.0	0	(0)	(0.00)	0.0	0	(0)	(0.00)	(0.0)	(1)
MAY	30	0.11	3.5	47	0	0.00	0.0	0	(0)	(0.00)	0.0	0	(0)	(0.00)	(0.0)	(0)
JUN	40	0.14	3.5	56	(1)	(0.00)	0.1	1	(11)	(0.04)	0.5	7	(13)	(0.05)	0.2	2
JUL	49	0.17	3.6	64	(19)	(0.07)	1.0	17	1	0.00	0.1	2	(12)	(0.04)	0.5	10
AUG	84	0.29	3.5	59	2	0.01	0.0	1	3	0.01	0.1	1	2	0.01	0.0	1
SEP	85	0.30	2.9	43	1	0.00	0.0	0	1	0.00	0.0	0	1	0.00	0.0	0
1979																
OCT	42	0.15	3.6	42	11	0.04	(0.5)	(5)	11	0.04	(0.5)	(5)	10	0.04	(0.5)	(6)
NOV	51	0.18	3.0	32	9	0.03	(0.0)	0	9	0.03	(0.0)	0	9	0.03	(0.1)	(0)
DEC	109	0.38	5.3	50	(47)	(0.16)	(1.2)	(14)	(47)	(0.16)	(1.1)	(13)	(46)	(0.16)	(1.3)	(14)
JAN	34	0.12	5.0	36	(5)	(0.02)	(0.8)	(5)	(5)	(0.02)	(0.8)	(5)	(6)	(0.02)	(1.2)	(8)
FEB	31	0.11	4.5	38	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.0)	(0)	(1)	(0.00)	(0.2)	(2)
MAR	22	0.08	3.0	31	(0)	(0.00)	0.1	1	(0)	(0.00)	0.1	1	(0)	(0.00)	(0.0)	(0)
APR	33	0.11	3.5	41	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.1)	(1)
MAY	32	0.11	3.5	48	(0)	(0.00)	0.0	0	(0)	(0.00)	0.0	0	(0)	(0.00)	(0.0)	(0)
JUN	26	0.09	3.2	49	(1)	(0.00)	(0.0)	(0)	(6)	(0.02)	(0.1)	(1)	(6)	(0.02)	(0.1)	(2)
JUL	41	0.14	2.9	51	(11)	(0.04)	0.0	(1)	(2)	(0.01)	0.1	1	(10)	(0.04)	(0.0)	(1)
AUG	97	0.34	3.4	59	(8)	(0.03)	0.1	1	3	0.01	0.0	2	(5)	(0.02)	0.1	2
SEP	165	0.58	3.2	52	3	0.01	0.0	1	3	0.01	0.0	1	3	0.01	0.0	1

Table C5–3. Continued

Water Year	No–Project Alternative				Alternative 1 Changes				Alternative 2 Changes				Alternative 3 Changes			
	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)
1980																
OCT	166	0.58	3.0	44	(0)	(0.00)	0.0	0	0	0.00	0.0	0	0	0.00	0.0	0
NOV	47	0.17	3.2	33	11	0.04	(0.4)	(4)	11	0.04	(0.4)	(4)	10	0.04	(0.5)	(4)
DEC	29	0.10	4.1	34	2	0.01	(0.3)	(2)	2	0.01	(0.3)	(2)	5	0.02	(0.8)	(5)
JAN	35	0.12	5.5	40	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.1)	(1)
FEB	29	0.10	5.3	45	0	0.00	0.0	0	0	0.00	0.0	0	(0)	(0.00)	(0.0)	(0)
MAR	28	0.10	5.5	56	0	0.00	0.1	1	0	0.00	0.1	1	0	0.00	0.0	0
APR	33	0.11	3.7	43	0	0.00	0.0	1	(1)	(0.00)	(0.0)	(1)	(1)	(0.00)	(0.1)	(2)
MAY	35	0.12	3.9	53	(2)	(0.01)	(0.3)	(4)	(3)	(0.01)	(0.3)	(5)	(5)	(0.02)	(0.5)	(7)
JUN	44	0.16	3.7	60	(2)	(0.01)	(0.1)	(1)	(4)	(0.02)	(0.0)	(1)	(12)	(0.04)	(0.4)	(8)
JUL	48	0.17	3.7	67	(9)	(0.03)	(0.0)	(2)	1	0.01	0.1	1	1	0.00	0.0	0
AUG	79	0.28	3.6	60	3	0.01	0.0	1	3	0.01	0.0	1	3	0.01	0.0	1
SEP	71	0.25	3.1	45	1	0.00	0.0	0	1	0.00	0.0	0	1	0.00	0.0	0
1981																
OCT	41	0.14	3.8	45	11	0.04	(0.5)	(5)	11	0.04	(0.5)	(5)	10	0.04	(0.5)	(5)
NOV	59	0.21	4.3	45	6	0.02	(0.1)	(0)	6	0.02	(0.1)	(0)	7	0.02	(0.1)	(1)
DEC	49	0.17	4.5	39	8	0.03	(0.3)	(2)	8	0.03	(0.3)	(2)	9	0.03	(0.4)	(3)
JAN	28	0.10	4.9	35	0	0.00	(0.0)	(0)	0	0.00	(0.0)	(0)	(2)	(0.01)	(0.6)	(4)
FEB	23	0.08	3.6	30	(0)	(0.00)	0.0	0	0	0.00	(0.1)	(1)	(1)	(0.00)	(0.2)	(1)
MAR	20	0.07	3.1	31	(0)	(0.00)	0.0	0	(1)	(0.00)	(0.0)	(0)	(1)	(0.00)	(0.2)	(2)
APR	37	0.13	3.2	39	(1)	(0.00)	0.1	0	(1)	(0.00)	0.1	0	(2)	(0.01)	(0.0)	(1)
MAY	56	0.20	3.6	52	(9)	(0.03)	0.1	(0)	(8)	(0.03)	0.0	(0)	(8)	(0.03)	(0.1)	(2)
JUN	60	0.21	3.3	54	1	0.01	(0.1)	(3)	1	0.01	(0.1)	(3)	1	0.00	(0.2)	(3)
JUL	35	0.12	2.9	50	1	0.00	0.0	0	1	0.00	0.0	0	2	0.01	(0.0)	(1)
AUG	78	0.27	3.1	53	(14)	(0.05)	0.2	2	(20)	(0.07)	0.2	2	(31)	(0.11)	0.1	(0)
SEP	160	0.56	3.3	53	4	0.01	0.0	0	4	0.01	0.0	0	(23)	(0.08)	0.2	2
1982																
OCT	131	0.46	2.8	38	0	0.00	0.0	0	0	0.00	0.0	0	0	0.00	(0.0)	(0)
NOV	17	0.06	2.7	28	(2)	(0.01)	(0.5)	(5)	(2)	(0.01)	(0.5)	(5)	(3)	(0.01)	(0.7)	(7)
DEC	22	0.08	4.1	34	(1)	(0.00)	(0.1)	(1)	(1)	(0.00)	(0.1)	(1)	(2)	(0.01)	(0.3)	(2)
JAN	33	0.12	5.8	42	(1)	(0.00)	(0.2)	(2)	(1)	(0.00)	(0.1)	(1)	(1)	(0.00)	(0.2)	(2)
FEB	25	0.09	4.3	36	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.1)	(1)
MAR	29	0.10	4.8	49	(0)	(0.00)	0.1	1	(0)	(0.00)	0.1	1	(0)	(0.00)	(0.0)	(0)
APR	27	0.09	5.7	68	0	0.00	0.0	1	0	0.00	0.0	1	0	0.00	0.0	0
MAY	29	0.10	5.5	76	0	0.00	0.0	1	0	0.00	0.0	1	0	0.00	0.0	0
JUN	25	0.09	3.7	57	0	0.00	0.0	0	0	0.00	0.0	0	0	0.00	0.0	0
JUL	35	0.12	3.4	60	(9)	(0.03)	(0.2)	(4)	(9)	(0.03)	(0.2)	(5)	(9)	(0.03)	(0.3)	(7)
AUG	56	0.20	3.1	51	(8)	(0.03)	0.0	(1)	(8)	(0.03)	0.0	(1)	(22)	(0.08)	(0.2)	(5)
SEP	24	0.08	3.1	40	(2)	(0.01)	(0.5)	(6)	(2)	(0.01)	(0.5)	(6)	(1)	(0.00)	(0.6)	(8)

Table C5–3. Continued

Water Year	No–Project Alternative				Alternative 1 Changes				Alternative 2 Changes				Alternative 3 Changes			
	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)
1983																
OCT	30	0.10	4.6	55	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.0)	(0)
NOV	28	0.10	4.1	41	(0)	(0.00)	0.0	0	(0)	(0.00)	0.0	0	(0)	(0.00)	(0.0)	(0)
DEC	31	0.11	5.7	48	(0)	(0.00)	0.0	0	(0)	(0.00)	0.0	0	(0)	(0.00)	(0.0)	0
JAN	30	0.10	5.8	41	0	0.00	0.1	1	0	0.00	0.1	1	0	0.00	0.0	0
FEB	23	0.08	6.2	51	0	0.00	0.1	1	0	0.00	0.1	1	0	0.00	0.0	0
MAR	21	0.07	6.4	64	0	0.00	0.1	1	0	0.00	0.1	1	0	0.00	0.0	0
APR	24	0.08	5.9	71	0	0.00	0.1	1	0	0.00	0.1	1	0	0.00	0.0	0
MAY	25	0.09	5.8	81	0	0.00	0.0	0	0	0.00	0.0	0	0	0.00	0.0	0
JUN	24	0.09	5.9	95	0	0.00	0.0	0	0	0.00	0.0	0	0	0.00	0.0	0
JUL	29	0.10	5.3	95	(0)	(0.00)	0.0	0	(0)	(0.00)	0.0	0	(0)	(0.00)	(0.0)	0
AUG	31	0.11	3.5	55	1	0.00	(0.0)	(0)	1	0.00	(0.0)	(0)	1	0.00	(0.0)	(1)
SEP	29	0.10	4.3	58	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.0)	(0)
1984																
OCT	30	0.10	5.3	64	(0)	(0.00)	(0.0)	0	(0)	(0.00)	(0.0)	0	(0)	(0.00)	(0.0)	(0)
NOV	28	0.10	4.8	48	(0)	(0.00)	0.0	0	(0)	(0.00)	0.0	0	(0)	(0.00)	(0.0)	(0)
DEC	30	0.10	5.7	48	0	0.00	0.1	1	0	0.00	0.1	1	0	0.00	0.0	0
JAN	27	0.09	5.6	40	0	0.00	0.1	1	0	0.00	0.1	1	0	0.00	0.0	0
FEB	27	0.09	4.6	39	(0)	(0.00)	0.0	0	(0)	(0.00)	0.0	0	(0)	(0.00)	(0.1)	(1)
MAR	24	0.09	3.6	36	(0)	(0.00)	0.1	1	(0)	(0.00)	0.1	1	(0)	(0.00)	(0.0)	(0)
APR	33	0.12	3.9	46	(0)	(0.00)	0.0	0	(1)	(0.00)	0.0	0	(1)	(0.00)	(0.0)	(1)
MAY	38	0.13	3.9	53	0	0.00	0.0	1	(3)	(0.01)	0.0	0	(2)	(0.01)	(0.0)	(1)
JUN	33	0.12	3.3	52	1	0.00	0.0	0	1	0.00	0.0	0	1	0.00	0.0	0
JUL	21	0.07	2.9	49	(1)	(0.00)	0.0	1	(1)	(0.00)	0.1	1	(0)	(0.00)	0.0	0
AUG	62	0.22	3.4	57	(23)	(0.08)	0.3	2	(19)	(0.07)	0.3	3	(29)	(0.10)	0.4	4
SEP	64	0.22	2.9	42	1	0.00	(0.0)	0	1	0.00	(0.0)	0	1	0.00	(0.0)	0
1985																
OCT	33	0.11	2.9	34	10	0.04	(0.4)	(4)	10	0.04	(0.4)	(4)	10	0.03	(0.4)	(4)
NOV	21	0.07	3.2	32	(1)	(0.00)	(0.1)	(1)	(1)	(0.00)	(0.1)	(1)	(3)	(0.01)	(0.5)	(5)
DEC	25	0.09	4.4	37	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.0)	(0)	(0)	(0.00)	(0.1)	(1)
JAN	47	0.16	4.5	33	(0)	(0.00)	(0.0)	(0)	(1)	(0.00)	(0.1)	(1)	(1)	(0.00)	(0.2)	(1)
FEB	25	0.09	4.0	34	(0)	(0.00)	(0.0)	0	(3)	(0.01)	(0.7)	(5)	(5)	(0.02)	(0.9)	(7)
MAR	24	0.08	2.9	30	0	0.00	0.1	1	(0)	(0.00)	0.1	1	(4)	(0.01)	(0.3)	(3)
APR	56	0.19	3.7	46	(9)	(0.03)	(0.1)	(3)	(1)	(0.00)	0.0	0	(1)	(0.00)	(0.1)	(1)
MAY	38	0.13	3.6	49	(2)	(0.01)	(0.1)	(1)	0	0.00	0.1	1	0	0.00	0.0	0
JUN	54	0.19	3.5	57	2	0.01	0.0	1	2	0.01	0.1	1	2	0.01	0.0	1
JUL	35	0.12	3.0	52	1	0.00	(0.0)	0	1	0.00	0.0	1	2	0.01	(0.0)	0
AUG	50	0.17	3.1	49	(5)	(0.02)	(0.0)	(1)	1	0.01	0.0	1	2	0.01	0.0	1
SEP	136	0.48	3.3	53	(30)	(0.11)	0.1	(2)	3	0.01	0.0	1	3	0.01	0.0	0

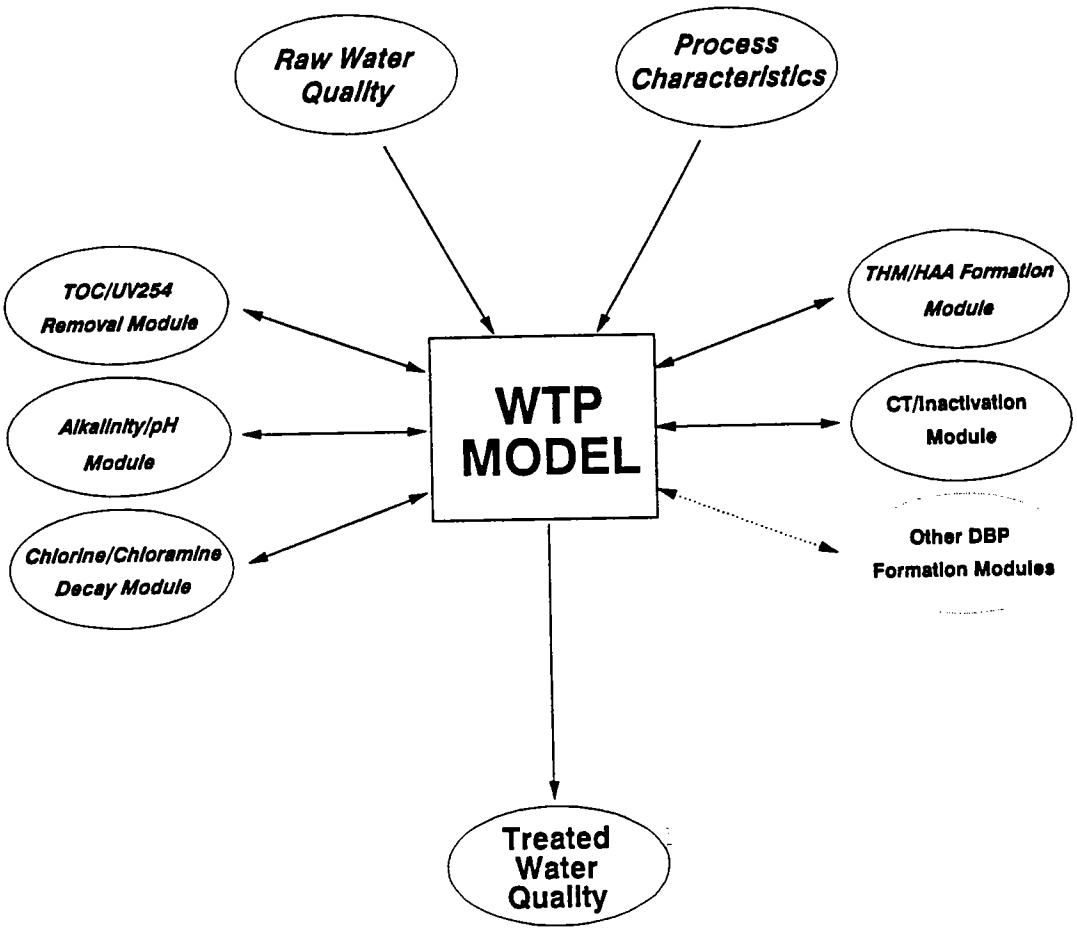
Table C5–3. Continued

Water Year	No-Project Alternative				Alternative 1 Changes				Alternative 2 Changes				Alternative 3 Changes			
	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)
1986																
OCT	122	0.43	3.4	46	0	0.00	(0.0)	(1)	0	0.00	0.0	0	1	0.00	0.0	0
NOV	110	0.39	3.2	37	0	0.00	0.0	0	0	0.00	0.1	1	0	0.00	0.0	1
DEC	59	0.21	4.8	42	2	0.01	(0.1)	(1)	2	0.01	(0.1)	(1)	2	0.01	(0.2)	(2)
JAN	31	0.11	5.5	39	3	0.01	(0.7)	(5)	3	0.01	(0.7)	(5)	3	0.01	(0.8)	(6)
FEB	28	0.10	5.2	44	(0)	(0.00)	0.0	0	0	0.00	0.0	0	(0)	(0.00)	(0.0)	(0)
MAR	27	0.09	5.8	59	0	0.00	0.1	2	0	0.00	0.1	2	0	0.00	0.0	0
APR	29	0.10	5.2	62	0	0.00	0.0	1	0	0.00	0.0	1	(0)	(0.00)	0.0	0
MAY	36	0.13	4.1	56	(0)	(0.00)	0.0	0	(7)	(0.02)	0.4	6	(7)	(0.02)	0.1	1
JUN	43	0.15	3.7	59	1	0.00	(0.0)	(0)	1	0.00	(0.0)	(0)	(13)	(0.05)	0.3	3
JUL	34	0.12	3.2	56	(9)	(0.03)	0.2	1	1	0.00	(0.2)	(3)	1	0.00	(0.2)	(4)
AUG	69	0.24	3.5	58	2	0.01	0.0	1	2	0.01	0.1	1	2	0.01	0.0	1
SEP	116	0.41	3.1	47	1	0.00	0.0	0	1	0.00	0.0	0	1	0.00	0.0	0
1987																
OCT	105	0.37	4.2	57	1	0.00	(0.0)	0	1	0.00	0.0	0	1	0.00	(0.0)	(0)
NOV	98	0.34	4.6	52	1	0.00	0.0	0	1	0.00	0.0	0	1	0.00	(0.0)	(1)
DEC	117	0.41	5.5	52	1	0.00	0.0	0	1	0.00	0.0	0	1	0.00	(0.0)	(1)
JAN	87	0.30	4.7	36	0	0.00	0.1	1	1	0.00	0.1	1	0	0.00	(0.0)	(0)
FEB	32	0.11	4.6	38	0	0.00	0.1	1	0	0.00	0.1	1	(0)	(0.00)	0.0	0
MAR	19	0.07	3.2	32	(1)	(0.00)	(0.1)	(1)	(1)	(0.00)	(0.1)	(1)	(1)	(0.00)	(0.2)	(2)
APR	42	0.15	3.3	40	(7)	(0.02)	0.4	4	(5)	(0.02)	0.4	5	(4)	(0.02)	0.3	4
MAY	53	0.18	3.4	47	(0)	(0.00)	0.2	3	(3)	(0.01)	0.4	5	(2)	(0.01)	0.4	6
JUN	57	0.20	3.3	53	2	0.01	0.1	1	2	0.01	0.1	1	2	0.01	0.1	1
JUL	35	0.12	2.8	49	1	0.00	0.0	0	1	0.00	0.0	1	2	0.01	(0.0)	0
AUG	60	0.21	3.0	48	2	0.01	0.0	2	2	0.01	0.0	2	2	0.01	0.0	2
SEP	153	0.54	3.2	52	3	0.01	0.0	1	3	0.01	0.1	1	4	0.01	0.1	1
1988																
OCT	171	0.60	3.8	55	1	0.00	0.0	1	1	0.00	0.0	1	1	0.00	0.0	0
NOV	155	0.54	3.3	40	0	0.00	0.1	1	0	0.00	0.1	2	0	0.00	0.1	1
DEC	67	0.23	4.2	38	1	0.00	0.0	0	1	0.00	0.0	0	1	0.00	(0.0)	(0)
JAN	27	0.09	5.0	35	(3)	(0.01)	(0.9)	(6)	(3)	(0.01)	(0.9)	(6)	(4)	(0.01)	(1.3)	(9)
FEB	28	0.10	4.1	35	0	0.00	0.0	0	(9)	(0.03)	(0.2)	(3)	(10)	(0.03)	(0.6)	(5)
MAR	51	0.18	3.5	37	(0)	(0.00)	0.2	2	(0)	(0.00)	0.2	2	(16)	(0.06)	(0.0)	(1)
APR	72	0.25	4.1	52	(14)	(0.05)	0.1	(1)	(0)	(0.00)	0.1	2	(0)	(0.00)	(0.0)	(0)
MAY	72	0.25	3.6	52	(9)	(0.03)	0.1	2	2	0.01	0.1	3	2	0.01	0.1	1
JUN	56	0.20	3.2	53	1	0.00	0.0	0	2	0.01	0.1	1	1	0.01	0.0	0
JUL	62	0.22	3.1	57	(19)	(0.07)	0.3	4	3	0.01	(0.0)	(0)	5	0.02	(0.3)	(6)
AUG	156	0.54	3.6	68	6	0.02	0.0	2	6	0.02	0.1	3	6	0.02	0.1	2
SEP	255	0.89	3.8	70	6	0.02	0.0	1	7	0.02	0.1	2	7	0.02	0.1	1

Table C5–3. Continued

Water Year	No-Project Alternative				Alternative 1 Changes				Alternative 2 Changes				Alternative 3 Changes			
	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)	Cl^- (mg/l)	Br^- (mg/l)	DOC (mg/l)	THM (µg/l)
1989																
OCT	276	0.97	4.8	81	3	0.01	0.0	1	3	0.01	0.1	1	3	0.01	0.0	1
NOV	210	0.74	3.4	44	0	0.00	0.1	1	0	0.00	0.1	2	0	0.00	0.1	1
DEC	130	0.46	4.8	47	1	0.00	0.0	0	1	0.00	0.1	1	1	0.00	(0.0)	(0)
JAN	98	0.34	5.1	40	0	0.00	0.0	0	0	0.00	0.1	1	0	0.00	(0.0)	(0)
FEB	60	0.21	4.5	40	0	0.00	0.1	1	0	0.00	0.1	1	(0)	(0.00)	0.0	0
MAR	16	0.06	2.6	27	(2)	(0.01)	(0.4)	(4)	(2)	(0.01)	(0.4)	(4)	(2)	(0.01)	(0.5)	(5)
APR	30	0.11	3.4	39	(0)	(0.00)	0.0	0	0	0.00	0.0	0	(0)	(0.00)	(0.0)	(0)
MAY	39	0.14	3.6	50	(6)	(0.02)	(0.1)	(3)	(4)	(0.01)	(0.0)	(2)	(4)	(0.01)	(0.1)	(2)
JUN	59	0.21	3.5	58	2	0.01	0.0	0	2	0.01	0.0	0	2	0.01	0.0	0
JUL	35	0.12	3.0	51	2	0.01	0.0	1	2	0.01	0.0	1	2	0.01	0.0	1
AUG	45	0.16	3.0	47	1	0.01	(0.0)	(0)	1	0.01	(0.0)	(0)	2	0.01	(0.0)	(0)
SEP	145	0.51	2.5	41	(67)	(0.24)	0.3	(1)	(72)	(0.25)	0.4	0	(63)	(0.22)	0.6	4
1990																
OCT	182	0.64	3.6	52	0	0.00	(0.0)	(0)	0	0.00	(0.0)	(0)	1	0.00	(0.0)	(1)
NOV	195	0.68	4.2	53	(0)	(0.00)	0.1	1	(0)	(0.00)	0.1	1	0	0.00	(0.0)	(0)
DEC	96	0.33	6.4	61	0	0.00	(0.1)	(1)	0	0.00	(0.1)	(1)	0	0.00	(0.1)	(2)
JAN	47	0.17	4.8	35	4	0.01	(0.3)	(2)	4	0.02	(0.3)	(2)	4	0.01	(0.4)	(3)
FEB	35	0.12	4.5	38	1	0.00	(0.0)	0	(1)	(0.00)	(0.1)	(1)	(1)	(0.00)	(0.2)	(2)
MAR	58	0.20	3.2	35	0	0.00	0.2	2	0	0.00	0.2	2	0	0.00	(0.0)	(0)
APR	49	0.17	4.8	59	(3)	(0.01)	0.1	1	0	0.00	0.1	2	0	0.00	(0.0)	(0)
MAY	86	0.30	3.5	52	(1)	(0.00)	0.3	4	1	0.00	0.1	3	1	0.00	0.1	1
JUN	55	0.19	3.4	55	2	0.01	0.1	2	2	0.01	0.1	2	2	0.01	0.1	2
JUL	67	0.23	3.2	59	5	0.02	(0.0)	0	5	0.02	(0.0)	0	5	0.02	(0.0)	0
AUG	153	0.54	3.7	70	7	0.02	0.1	2	7	0.02	0.1	2	7	0.02	0.1	2
SEP	248	0.87	3.9	70	6	0.02	0.1	2	6	0.02	0.1	2	6	0.02	0.1	2
1991																
OCT	277	0.97	4.8	81	3	0.01	0.1	1	3	0.01	0.1	1	3	0.01	0.1	1
NOV	258	0.90	5.9	83	2	0.01	0.1	3	2	0.01	0.1	3	2	0.01	0.1	1
DEC	199	0.70	6.0	64	1	0.01	0.1	1	1	0.01	0.1	1	1	0.00	(0.0)	(0)
JAN	159	0.56	6.9	59	0	0.00	0.1	1	1	0.00	0.1	1	0	0.00	(0.1)	(0)
FEB	73	0.25	4.8	43	1	0.00	0.1	1	1	0.00	0.1	1	(0)	(0.00)	0.0	0
MAR	18	0.06	2.7	28	1	0.00	0.1	1	1	0.00	0.1	1	0	0.00	0.0	0
APR	43	0.15	3.4	41	1	0.00	0.3	4	1	0.00	0.3	4	1	0.00	0.2	2
MAY	97	0.34	3.8	57	3	0.01	0.3	6	3	0.01	0.3	6	2	0.01	0.3	5
JUN	61	0.22	3.3	54	2	0.01	0.1	3	2	0.01	0.1	3	2	0.01	0.1	3
JUL	109	0.38	3.5	70	10	0.03	0.2	6	10	0.03	0.2	6	10	0.03	0.2	5
AUG	184	0.64	3.8	75	8	0.03	0.2	5	8	0.03	0.2	5	8	0.03	0.2	4
SEP	247	0.87	3.6	66	6	0.02	0.1	2	6	0.02	0.1	2	6	0.02	0.1	2

Note: Negative values shown in parentheses.



Source: Malcolm Pirnie 1992.

Figure C5-1.
Water Treatment Plant Model Components

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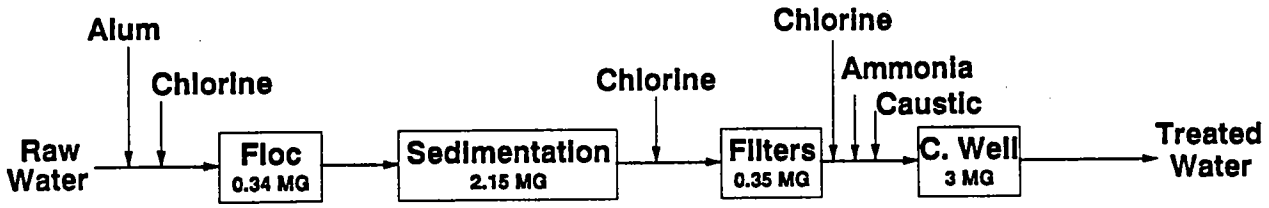
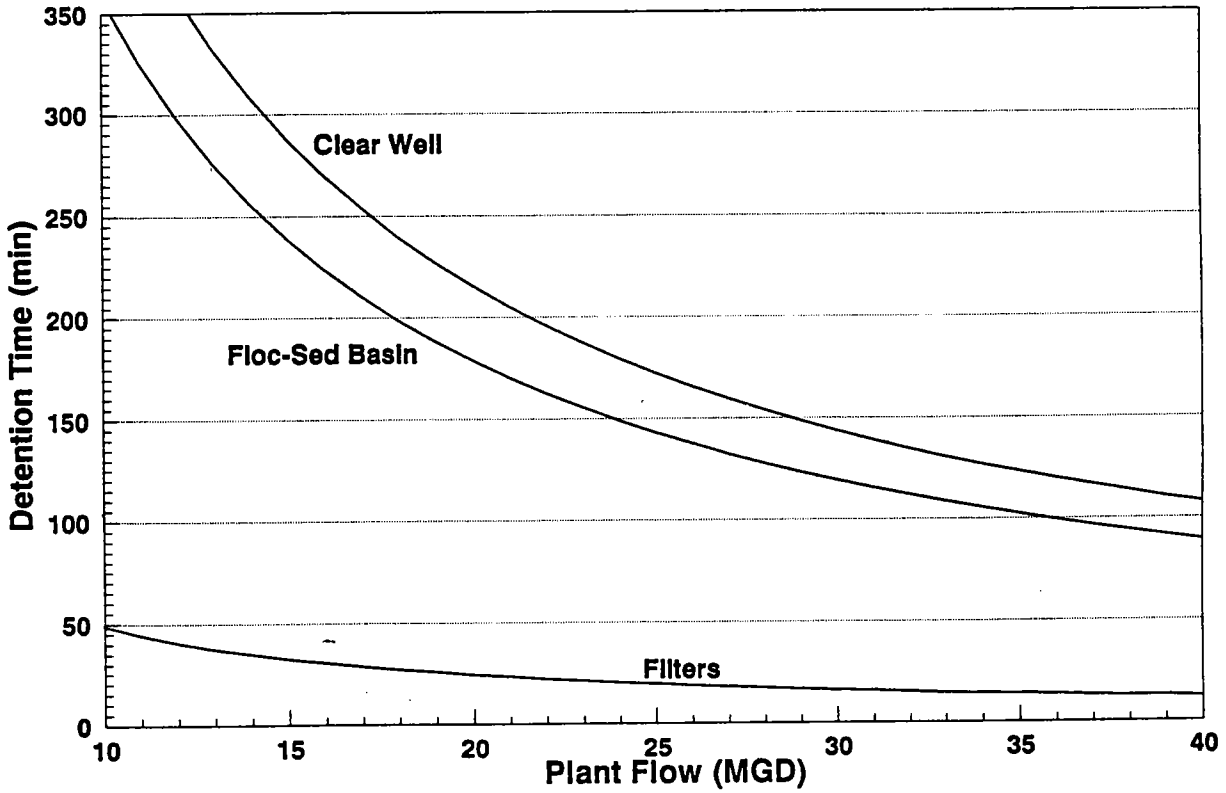
Process Flow Considerations for Modeling



Chemical Dosages (mg/L)

	Alum	Chlorine			Ammonia	Caustic
		Pre-Sed	Pre-Filt	Post-Filt.		
Minimum	25	2.0	1.0	0.3	0.34	5.0
Average	36	2.75	1.2	0.5	0.50	8.5
Maximum	52	3.5	1.5	1.0	1.0	15

Detention Times in Plant



Source: Malcolm Pirnie 1992.

Figure C5-2.
Penitencia Water Treatment Plant Process Parameters

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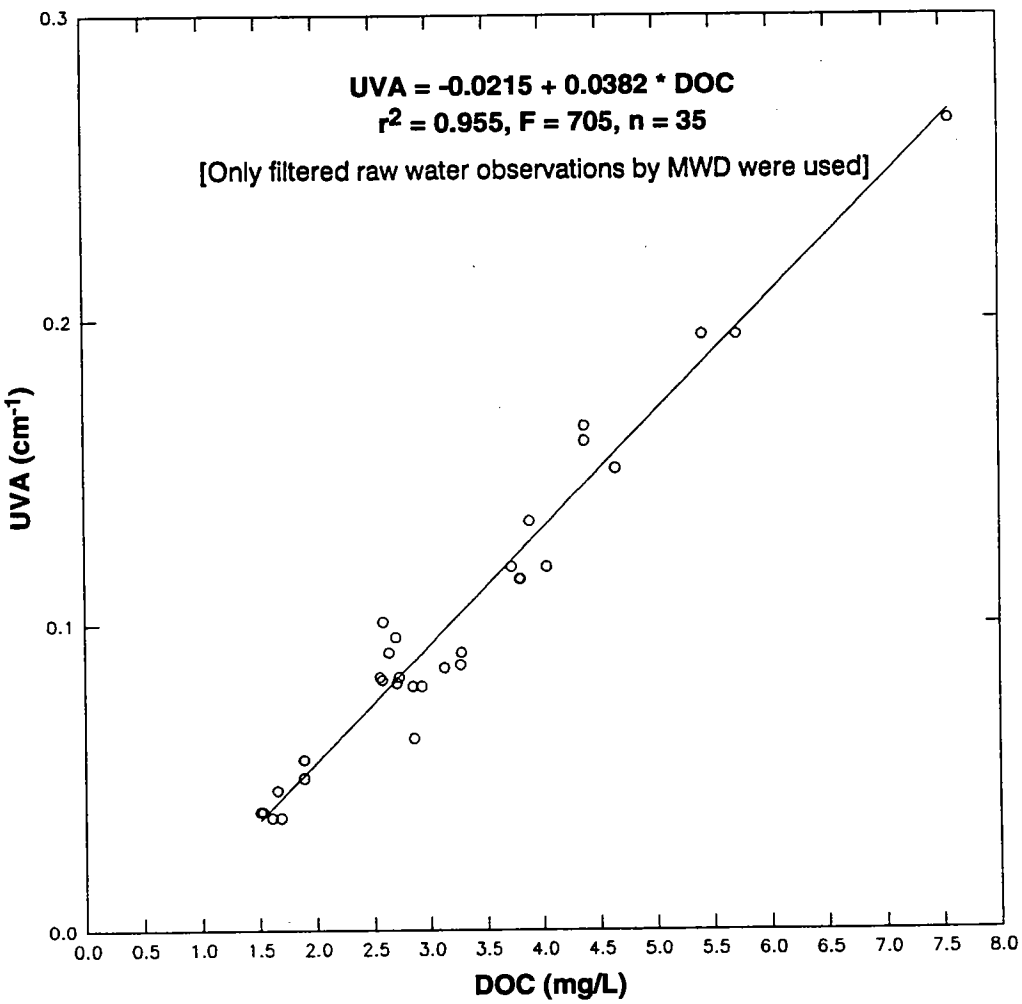

Source: Malcolm Pirnie 1992.

Figure C5-3.
Correlation between UVA and DOC in Metropolitan Water District Samples

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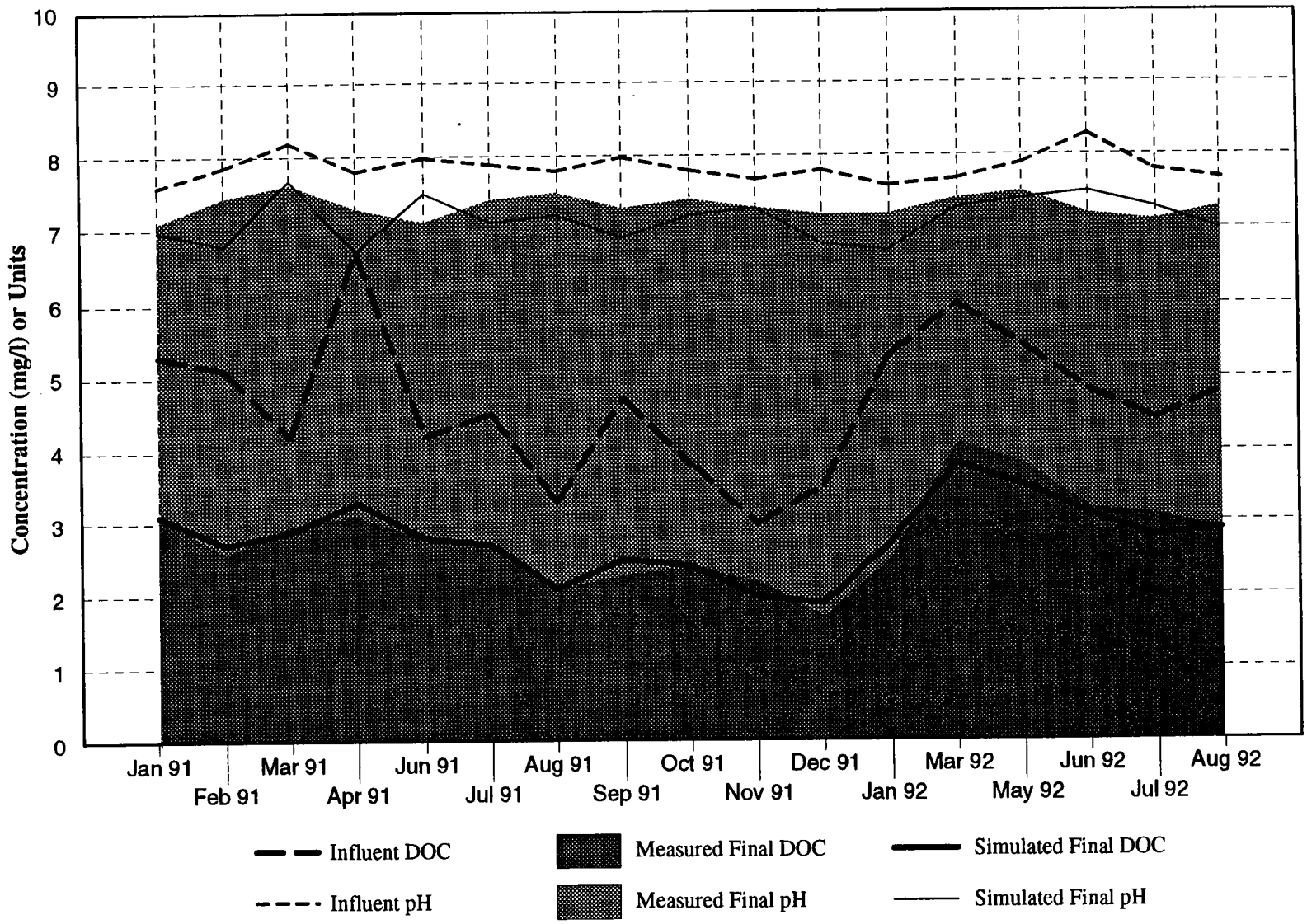

Figure C5-4.
Comparison of Simulated and Measured DOC and pH at the Penitencia Water Treatment Plant

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Prepared by: Jones & Stokes Associates

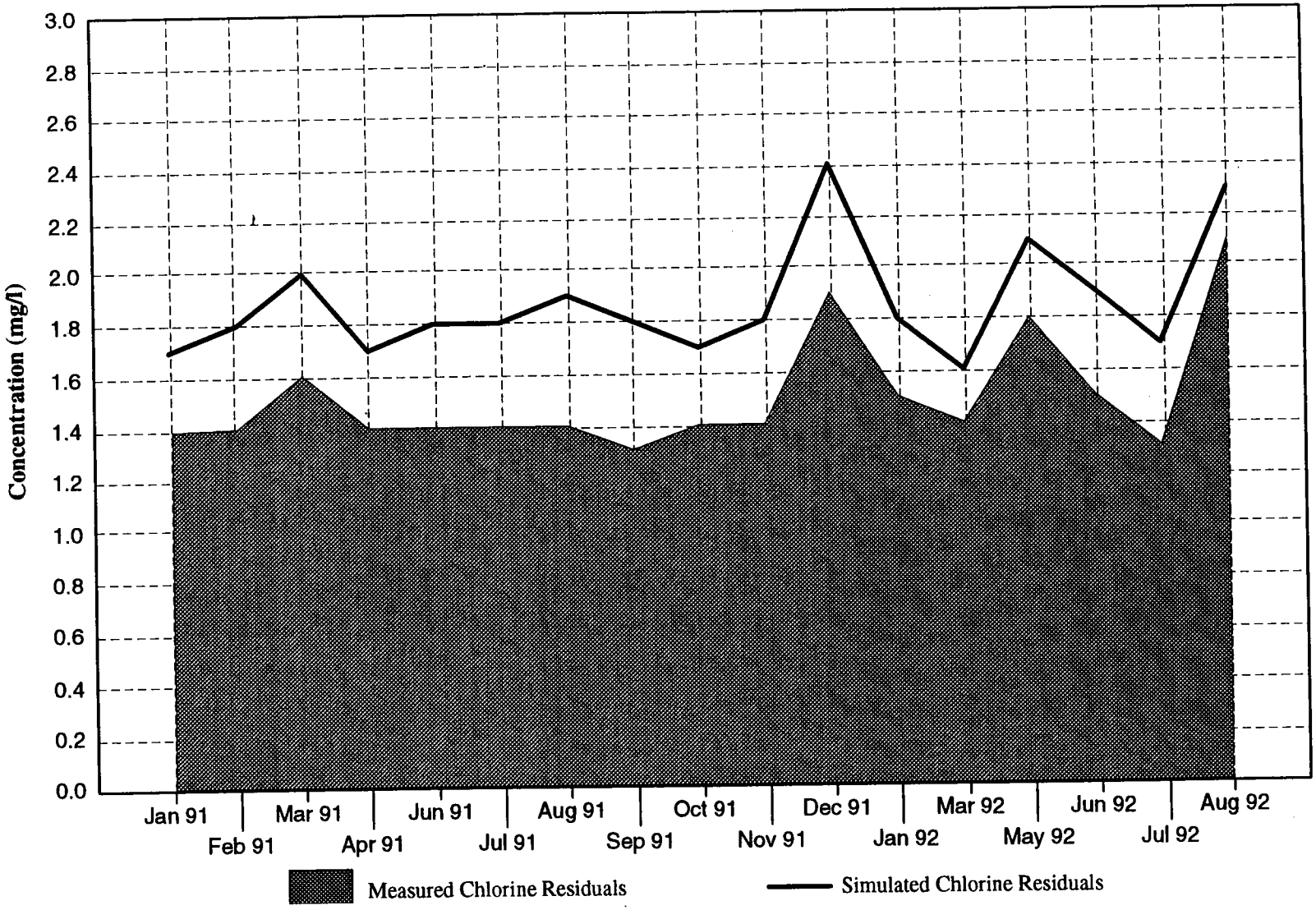

Figure C5-5.
Comparison of Simulated and Measured Chlorine Residuals at the Penitencia Water Treatment Plant

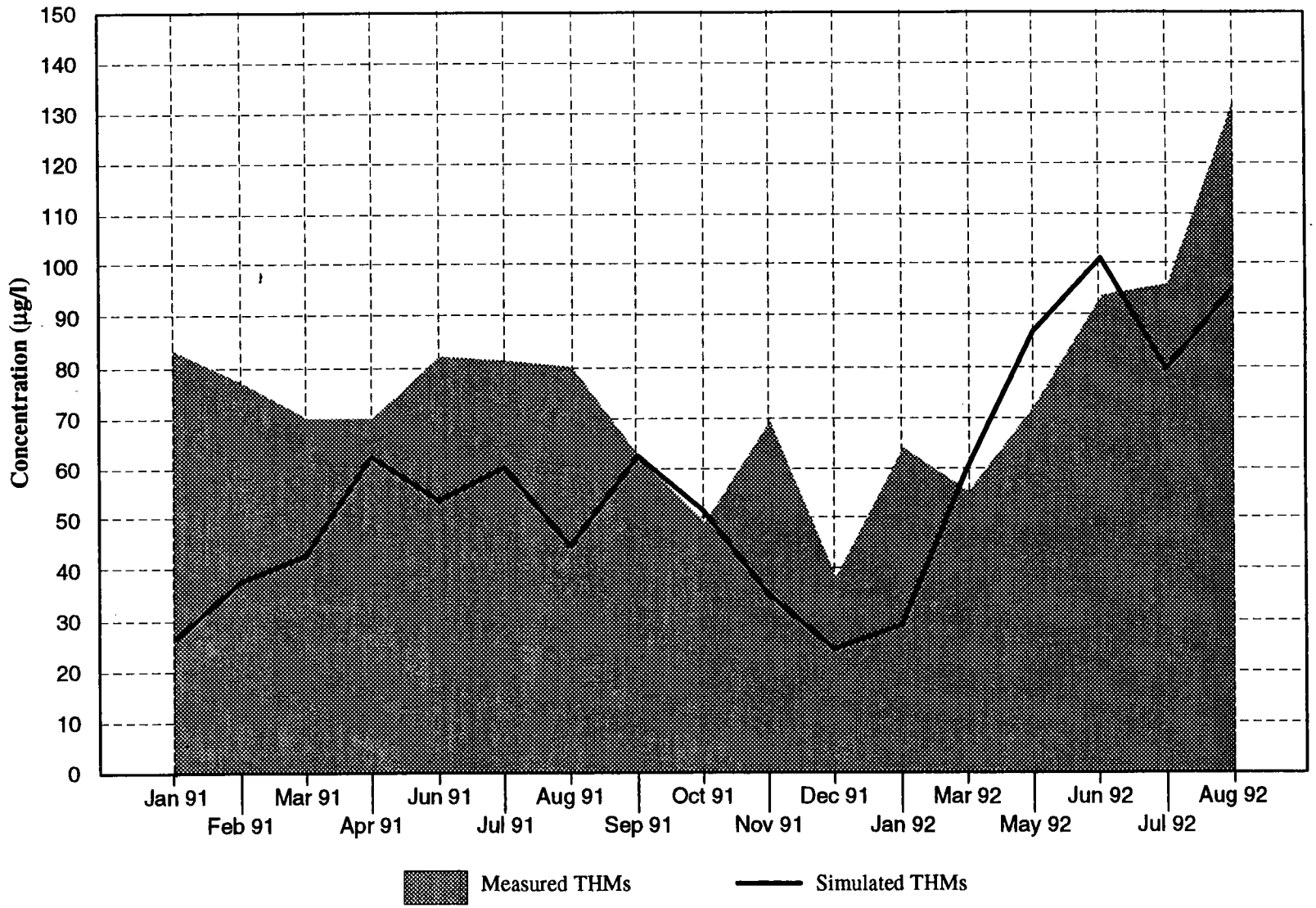

Figure C5-6.
Comparison of Simulated and Measured Total THMs at the Penitencia Water Treatment Plant

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Prepared by: Jones & Stokes Associates

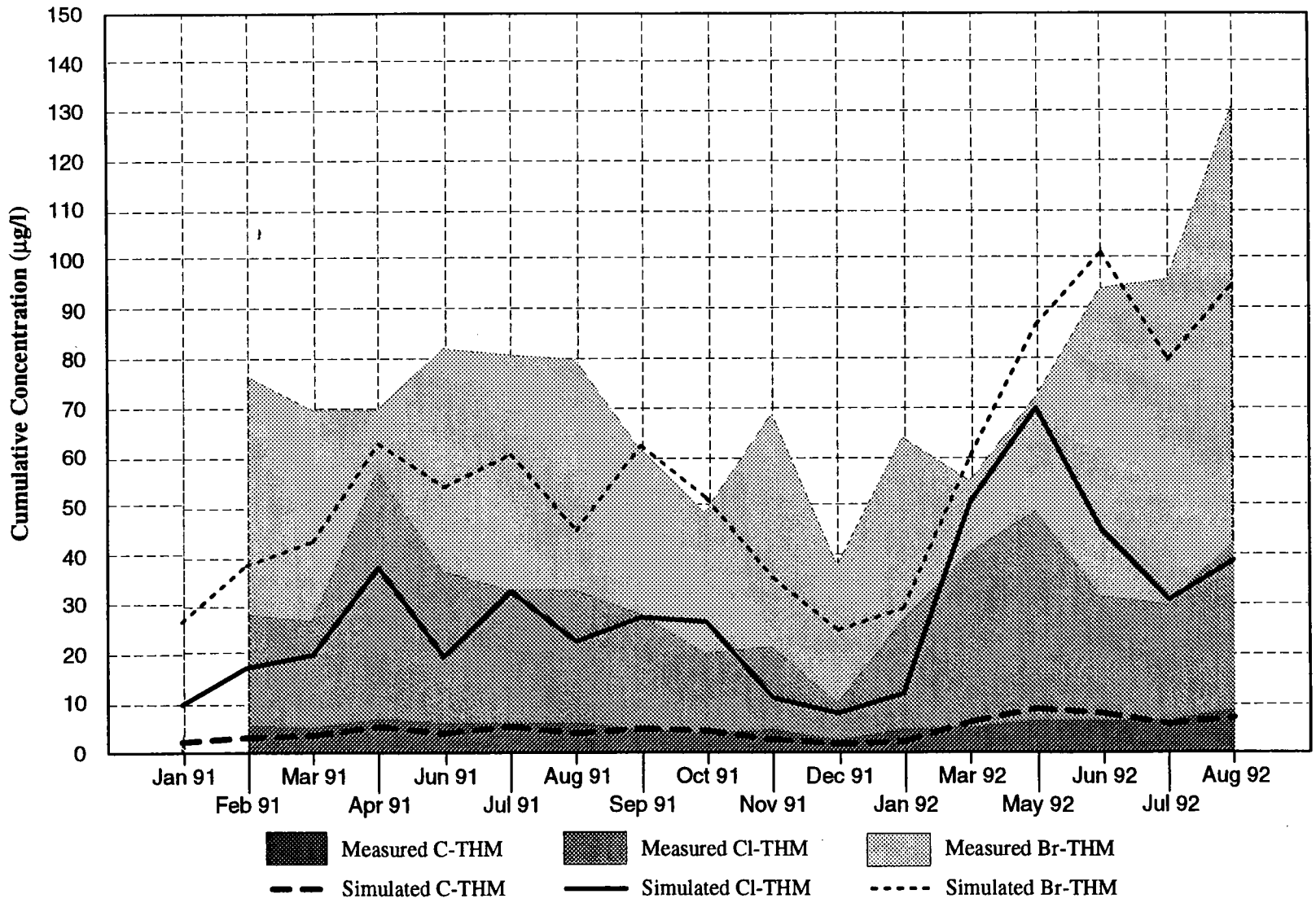

Figure C5-7.
Comparison of Simulated and Measured THM Species at the Penitencia Water Treatment Plant

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Prepared by: Jones & Stokes Associates

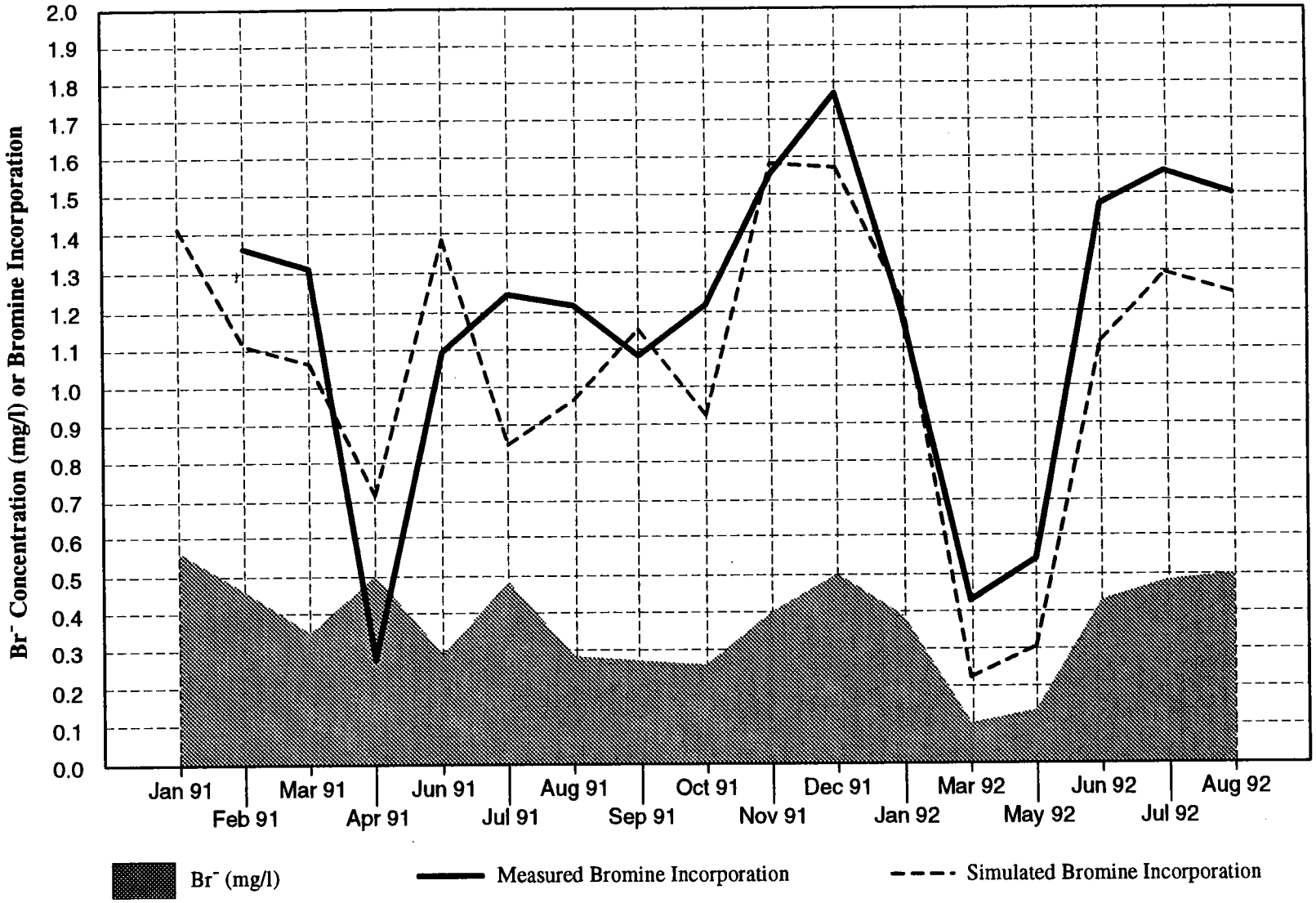

Figure C5-8.
Comparison of Simulated and Measured Bromine Incorporation at the Penitencia Water Treatment Plant

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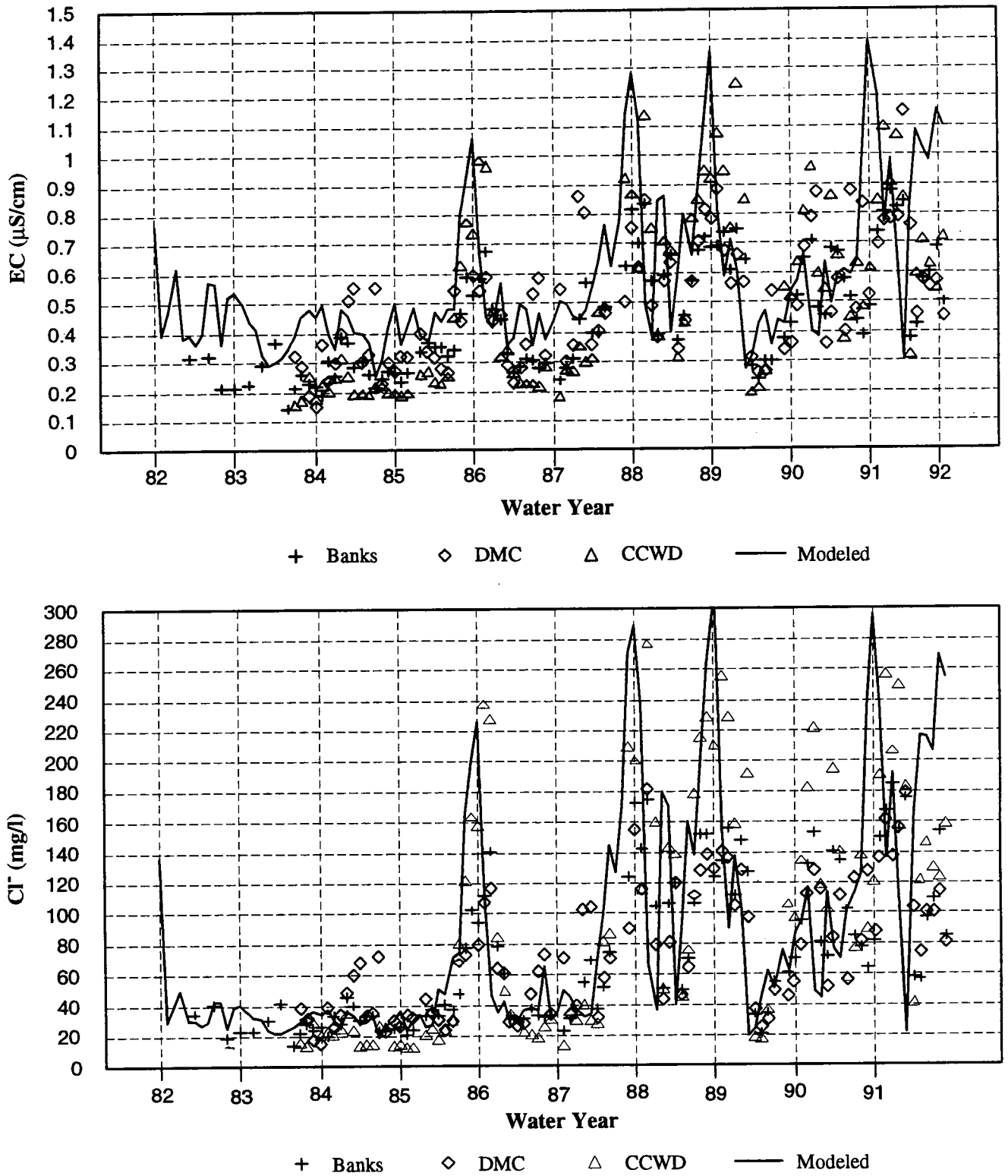
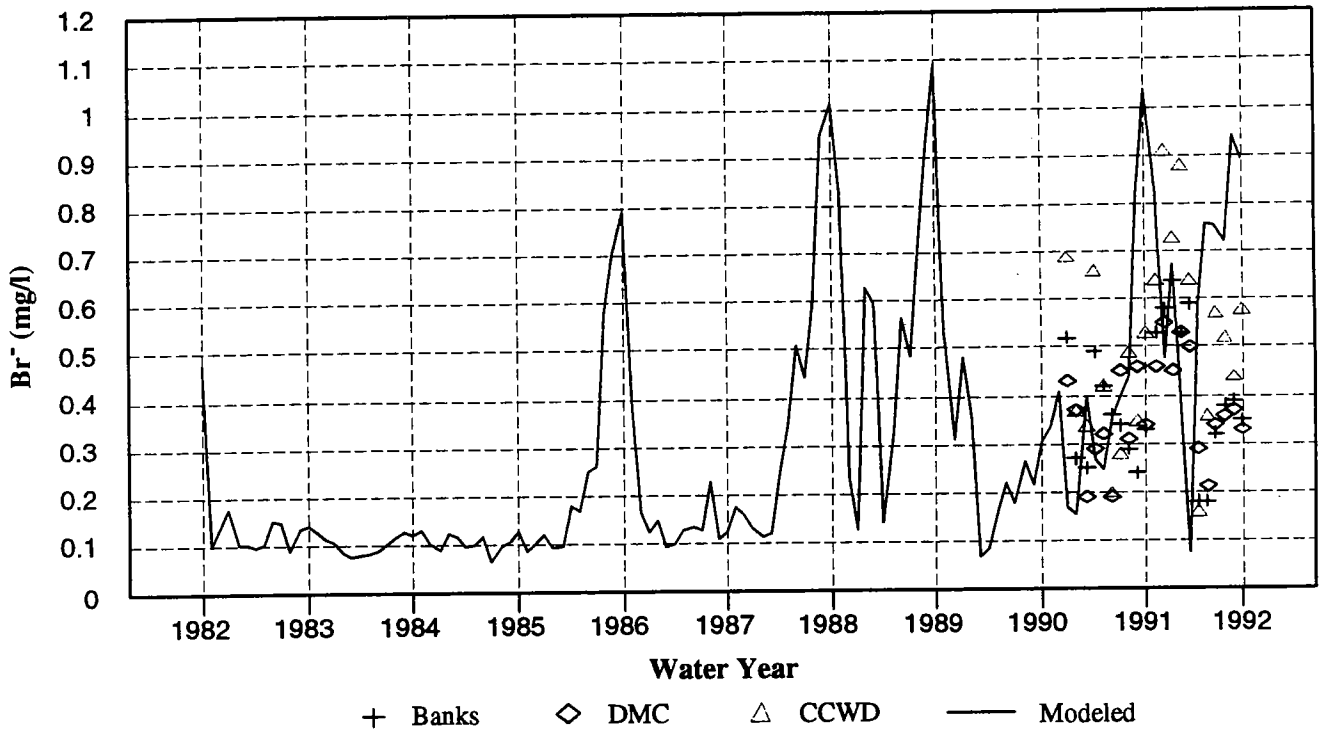


Figure C5-9.
DeltaDWQ - Estimated Delta Export EC and Chloride for 1982-1991 with Historical Inflows and Exports Compared with MWQI Grab Samples

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates



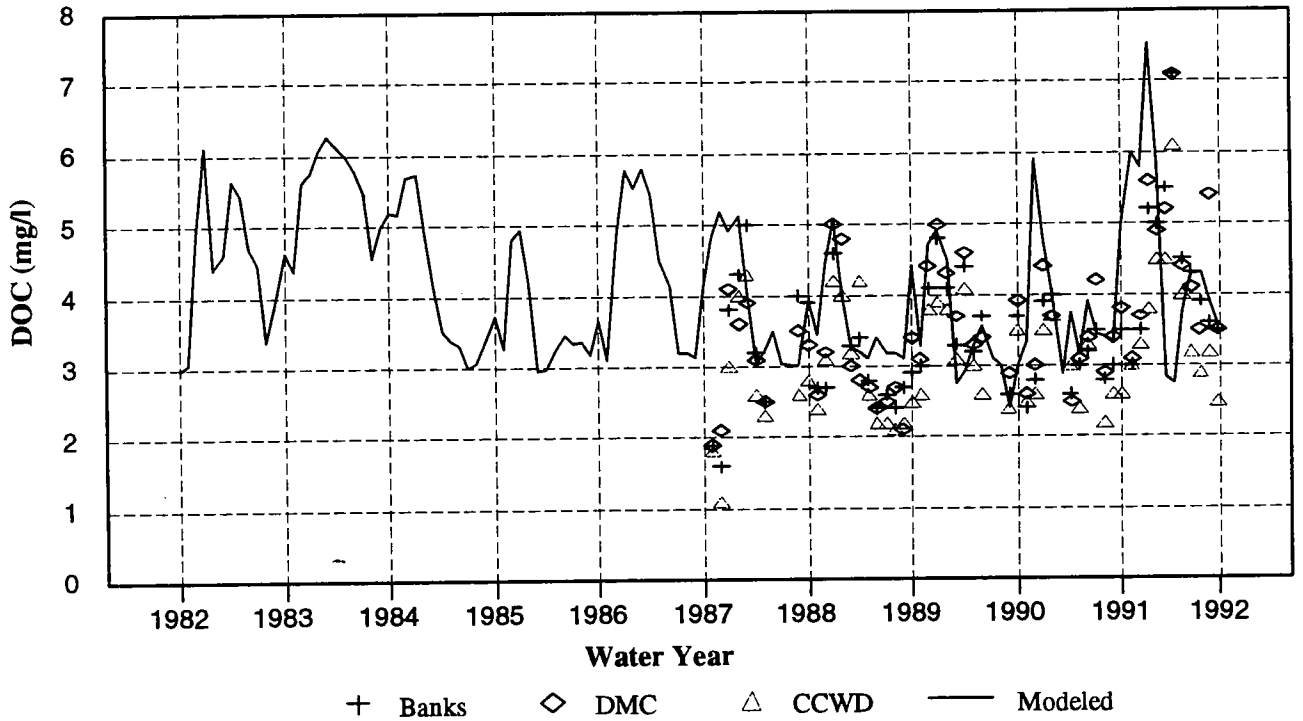


Figure C5-10.
DeltaDWQ - Estimated Delta Export Bromide and DOC for 1982-1991 with Historical Inflows and Exports Compared with MWQI Grab Samples

DELTA WETLANDS
PROJECT EIR/EIS
Prepared by: Jones & Stokes Associates