California State Water Project

WATERSHED SANITARY SURVEY

2006 UPDATE

Prepared for

THE STATE WATER PROJECT
CONTRACTORS AUTHORITY

by

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Desert Water Agency
Dudley Ridge Water District
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Oak Flat Water District
Palmdale Water District
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San Bernardino Valley Municipal Water District
San Gabriel Valley Municipal Water District
San Gorgonio Pass Water Agency
San Luis Obispo County Flood Control and Water Conservation District
Santa Clara Valley Water District
Solano County Water Agency
Tulare Lake Basin Water Storage District

ACRONYMS AND ABBREVIATIONS

AAR	After Action Report
AB	Assembly Bill
ACWD	Alameda County Water District
AFB	Air Force Base
Arvin	Arvin Edison Water Storage District
AVEK	Antelope Valley East Kern Water Agency
AwwaRF	American Water Works Association Research Foundation
BAER	Burn Area Emergency Rehabilitation
Banks	H.O. Banks Delta Pumping Plant
Barker Slough	Barker Slough Pumping Plant
Basin Plan	Water Quality Control Plan for the Sacramento River and San Joaquin River Basins
BMP	Best Management Practice
Boating & Waterways	California Department of Boating and Waterways
BRP	Business Recovery Plan
BTEX	Benzene, toluene, ethylene, and xylene
Buena Vista	Buena Vista Aquatic Lakes
CALFED	California Bay-Delta Program
Caltrans	California Department of Transportation
CBDA	California Bay-Delta Authority
CCWA	Central Coast Water Authority
CCWD	Contra Costa Water District
CDBW	California Department of Boating and Waterways
CDHS	California Department of Health Services
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CLAWA	Crestline Lake Arrowhead Water Agency
CLWA	Castaic Lake Water Agency
Coastal Commission	California Coastal Commission
CSD	Crestline Sanitation District
CSD-1	Sacramento County Sanitation District 1
CTR	California Toxics Rule
CUWA	California Urban Water Agencies
CV Canal	Cross Valley Canal
CVP	Central Valley Project
CWP	County Watershed Program
CWTP	Combined Wastewater Treatment Plant
DAF	Dissolved Air Flotation
DBCP	1,2-dibromo-3-chloropropane
DBP	Disinfection Byproduct

D/DBP	Disinfectants/Disinfection Byproducts
Delta	Sacramento-San Joaquin Delta
Devil Canyon	Devil Canyon Afterbay
DFG	Department of Fish and Game
DLR	Detection Limit for Purposes of Reporting
DMC	Delta Mendota Canal
DMC @ McCable	Delta Mendota Canal at McCabe Road
DO	Dissolved oxygen
DOC	Dissolved organic carbon
DRMS	Delta Risk Management Strategy
DSM2	Delta Simulation Model 2
DV Check 7	Del Valle Check 7
DVL	Diamond Valley Lake
DWR	California Department of Water Resources
EAP	Emergency Action Plan
EBRPD	East Bay Regional Park District
EC	Electrical Conductance
E. coli	*Escherichia coli*
EDCs	Endocrine Disrupting Chemicals
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ELCOM	Estuary and Lake Computer Model
ELPH	Equivalent Level of Public Health Protection
ERP	Emergency Response Plan
ERPP	Ecosystem Restoration Program Plan
FEMA	Federal Emergency Management Agency
FOC	Flood Operations Center
FU	Fluorometric Units
HAA	Haloacetic Acids
HAA5	Five Haloacetic Acids
ICP	Incident Command Post
ICR	Information Collection Rule
IDSE	Initial Distribution System Evaluation
IEP	Interagency Ecological Program
IESWTR	Interim Enhanced Surface Water Treatment Rule
ITF	Initial Technical Framework
LID	Low Impact Development
LRAA	Locational Running Annual Average
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
Kern	Kern Water Bank Authority

MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MEP	Maximum Extent Practicable
mgd	million gallons per day
M&I	Municipal and Industrial
MIB	2- methyl-isoborneol
MIEX®	Magnetic Ion Exchange Resin
MOU	Memorandum of Understanding
MRDL	Maximum Residual Disinfectant Level
MS4	Municipal Separate Storm Sewer System
MSD	Marine Sanitation Device
MTBE	Methyl tert-butyl ether
MWDSC	Metropolitan Water District of Southern California
MWQI	Municipal Water Quality Investigations
N	Nitrogen
NAS	National Academy of Sciences
Napa County	Napa County Flood Control and Water Conservation District
NBA	North Bay Aqueduct
NBR	North Bay Regional
NDEA	N-Nitrosodiethylamine
NDMA	N-nitroso-dimethylamine
NDPA	N-Nitrosodi-n-propylamine
NEMDC	Natomas East Main Drainage Canal
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resources Conservation Service
NWIS	National Water Information System
OEHHA	California Office of Environmental Health Hazard Assessment
OES	California Office of Emergency Services
O&M	DWR's Division of Operations and Maintenance
OSPR	Office of Spill Prevention and Response
P	Phosphorus
Pacheco	Pacheco Pumping Plant
Palmdale	Palmdale Water District
PCP	Personal Care Product
PCR	Polymerase Chain Reaction
PDBE	Polybrominated diphenylether
PhACs	Pharmaceuticals or Pharmaceutically Active Chemicals
PHG	Public Health Goal
PPCPs	Pharmaceuticals and Personal Care Products
PPWTP	Polonio Pass Water Treatment Plant

RAA	Running Annual Average
RAP	Recovery Action Plans
Regional Water Board	California Regional Water Quality Control Board
ROD	Record of Decision
RWCF	Regional Wastewater Control Facility
SBA	South Bay Aqueduct
SBPP	South Bay Pumping Plant
SCVWD	Santa Clara Valley Water District
SCWA	Solano County Water Agency
SDWA	Safe Drinking Water Act
Semitropic	Semitropic Water Storage District
SEMS	Standardized Emergency Management System
SID	Solano Irrigation District
SQIP	Stormwater Quality Improvement Plan
SRA	State Recreation Area
SRCSD	Sacramento Regional County Sanitation District
SRWTP	Sacramento Regional Wastewater Treatment Plant
SSMP	Sewer System Management Plans
SSO	Sanitary Sewer Overflow
State Water Board	California State Water Resources Control Board
SUVA	Specific Ultraviolet Light Absorbance
SWC	State Water Contractors
SWP	State Water Project
SWP WQMP	SWP Water Quality Monitoring Program
SWTR	Surface Water Treatment Rule
TCDD	Dioxins
TCE	Trichloroethylene
TDS	Total Dissolved Solids
Terminal Tank	Santa Clara Terminal Reservoir
THMFP	Trihalomethane Formation Potential
TID	Turlock Irrigation District
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
T&O	Taste and Odor
TOC	Total Organic Carbon
TRC	Technical Review Committee
TSS	Total Suspended Solids
TTHM	Total Trihalomethanes
U.C. Berkeley	University of California, Berkeley
U.C. Davis	University of California Davis
UCMR2	Unregulated Contaminant Monitoring Rule 2
USACE	United States Army Corps of Engineers

USBR	United States Bureau of Reclamation
USEPA	United States Environmental Protection Agency
U.S. Forest Service	United States Department of Agriculture's Forest Service
USGS	United States Geological Survey
UV	Ultra-violet Light
VAMP	Vernalis Adaptive Management Program
VOC	Volatile Organic Compounds
WDR	Waste Discharge Requirements
Wheeler	Wheeler Ridge-Maricopa Water Storage District
WPPP	Watershed Protection Program Plan
WRP	Water Recycling Plant
WTP	Water Treatment Plant
WTP-2	Water Treatment Plant No. 2
WWTP	Wastewater Treatment Plant
Zone 7 Water Agency	Zone 7 Water Agency of the Alameda County Water Conservation and Flood Control District

EXECUTIVE SUMMARY

CALIFORNIA STATE WATER PROJECT
WATERSHED SANITARY SURVEY
2006 UPDATE

EXECUTIVE SUMMARY

The State Water Project (SWP) provides drinking water to approximately two-thirds of California's population and is the nation's largest state-built water development project. The SWP extends from the mountains of Plumas County in the Feather River watershed to Lake Perris in Riverside County. It is linked with the Central Valley Project (CVP) that extends from southern Oregon in the Sacramento River watershed to the Mendota Pool. The watershed of the SWP is vast; encompassing the 27,000-square-mile Sacramento River and 13,000-square-mile San Joaquin River watersheds and at times, the 13,000-square-mile Tulare Basin watershed.

The contaminant sources in the SWP watersheds have been well documented in the three previous sanitary surveys. The California Department of Health Services (CDHS) requested that the 2006 Update address the Jones Tract levee failure and emergency response procedures, efforts to coordinate pathogen monitoring in response to the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), and a review of significant changes to the watersheds and their impacts on water quality. A Technical Review Committee (TRC) was formed to guide development of the scope of work and provide technical expertise and review of the draft report. In addition to addressing the issues raised by CDHS, the TRC determined that the 2006 Update should focus on evaluating the sources of the water quality problems that the SWP Contractors face and recommending actions that the SWP Contractors can take that will lead to improvements in water quality over the next five years.

This report is organized in seven chapters, including the introduction. The issues covered in each of the six technical chapters are briefly discussed in this Executive Summary.

CHAPTER 2 REGULATORY SETTING

Chapter 2 contains a discussion of changes in drinking water and source water protection regulations during the five years since the 2001 Sanitary Survey Update was prepared. A summary of the California Bay-Delta Program (CALFED) Water Quality Program activities and the development of the Central Valley drinking water policy are also included.

DRINKING WATER REGULATIONS

The U.S. Environmental Protection Agency (USEPA) and CDHS have promulgated a number of complex rules in the last five years that have significantly affected the SWP Contractors who treat water from the Sacramento-San Joaquin Delta (Delta). The Stage 1 and Stage 2 Disinfectants and Disinfection Byproducts (D/DBP) Rule and the Interim Enhanced Surface Water Treatment Rule (IESWTR) and the LT2ESWTR are of particular importance to the SWP Contractors as treatment requirements are based on source water quality.

Stage 1 D/DBP Rule and IESWTR

The Stage 1 D/DBP Rule was promulgated by USEPA in December 1998, along with the IESWTR. USEPA released these two complex regulations together to balance the short-term microbial risk with long-term chronic risk from disinfection byproducts (DBPs). Large water systems were required to comply with the provisions of these rules by January 2002. The Stage 1 D/DBP Rule reduced the Maximum Contaminant Level (MCL) for total trihalomethanes (TTHM) from 0.10 to 0.08 mg/L, established an MCL for the sum of five haloacetic acids (HAA5) of 0.06 mg/L, and established MCLs for chlorite (1.0 mg/L) and bromate (0.010 mg/L). The rule also requires systems using surface water to remove specific amounts of total organic carbon (TOC) prior to adding disinfectants by implementing a treatment technique, either enhanced coagulation or enhanced softening. The percent removal required depends on the source water TOC and alkalinity. The IESWTR established a Maximum Contaminant Level Goal (MCLG) for *Cryptosporidium* of zero and established a treatment technique requirement of 2-log (99 percent) removal of *Cryptosporidium*.

Stage 2 D/DBP Rule and LT2ESWTR

The Stage 2 D/DBP Rule was promulgated by USEPA in January 2006, along with the LT2ESWTR. The Stage 2 D/DBP Rule maintained the MCLs for TTHM, HAA5, chlorite, and bromate established in the Stage 1 D/DBP Rule but requires compliance at all points in the distribution system. The LT2ESWTR requires public water systems using surface water sources to conduct source water monitoring to determine if additional treatment is needed to reduce *Cryptosporidium*. Most of the SWP Contractors were required to start monitoring in October 2006 or April 2007, unless they submitted previously collected data that met all of the sampling and analytical requirements of the LT2ESWTR. Filtered water systems will be classified in one of four bins based on their monitoring results. Systems classified in Bins 2, 3, and 4 must provide 1.0-log to 2.5-log additional reduction of *Cryptosporidium* levels.

SOURCE WATER PROTECTION REGULATIONS

Protection of source water quality is a key component of the multiple barrier approach to providing safe drinking water to customers. The Central Valley Regional Water Quality Control Board (Central Valley Regional Water Board) is responsible for protecting water quality in the Sacramento and San Joaquin basins, the source waters for the SWP, and in the Tulare Basin, which occasionally provides water to the SWP. During the five years since the 2001 Update was completed, regulation of agricultural discharges and the development of total maximum daily loads (TMDLs) are the major new source water protection programs in the Central Valley.

Agricultural Discharges

The Central Valley has over seven million acres of irrigated cropland. Discharges of irrigation water and stormwater runoff from agricultural fields were largely unregulated until the Central Valley Regional Water Board adopted the Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands (Agricultural Waiver) in December 2002. Agricultural dischargers are allowed to comply with the Agricultural Waiver by joining a coalition group or filing for an individual waiver. Although several large water districts opted to apply for individual waivers, most growers have joined coalition groups. The Agricultural Waiver requires coalition groups to monitor agricultural drainage for a variety of constituents, including TOC, total dissolved solids (TDS), nutrients, and bacteria during the irrigation season and during storm events. When water quality objectives are exceeded, the coalition group must submit a management plan. Numerous management plans are in various stages of development due to exceedance of objectives for pesticides, TDS, and bacteriological contaminants.

Total Maximum Daily Loads

The Clean Water Act section 303(d) requires that states develop a list of waters that are not attaining water quality standards and that they develop TMDLs for each constituent that results in the exceedance of a standard. TMDLs have been established for cadmium, copper, zinc, diazinon, chlorpyrifos and mercury in various reaches of the Sacramento River Basin. In the San Joaquin Basin, TMDLs have been established for dissolved oxygen (DO), selenium, diazinon, chlorpyrifos, salt, and boron. The Central Valley Regional Water Board is currently developing a general pesticide TMDL for the Sacramento and San Joaquin basins, and additional mercury, DO, pathogen, diazinon, and chlorpyrifos TMDLs. A TMDL for nutrients in Clear Lake has been adopted by the Central Valley Regional Water Board and will be considered by the State Water Resources Control Board (State Water Board) in the next few months.

CALFED WATER QUALITY PROGRAM

The CALFED Bay-Delta Program is a joint state-federal effort to improve water supply reliability, water quality, and levee reliability, and to restore the ecosystem of the Delta. CALFED is implemented by several state and federal agencies, with oversight and coordination by the California Bay-Delta Authority. A Water Quality Program Plan was developed through a stakeholder-driven process over several years. In the last six years, the CALFED Water Quality Program has funded research and implementation of source control projects, treatment demonstration projects, and development of regional water quality plans.

One of the key activities partially funded by the CALFED Water Quality Program is development of a drinking water policy for the Central Valley. In the 1990s California Urban Water Agencies (CUWA) recognized that many of the constituents of concern to drinking water suppliers (disinfection byproduct precursors, pathogens, nutrients) are not included as objectives in the Water Quality Control Plan (Basin Plan) or the current objectives are not based on drinking water concerns (salinity, chloride). As a result, there is limited ability to require dischargers to monitor or control these constituents. Population in the Central Valley is rapidly increasing so there are concerns that water quality will degrade without a regulatory mechanism to control discharges of the drinking water constituents. The Central Valley Regional Water Board is working with a stakeholder group to conduct the technical studies needed to develop a drinking water policy for the Central Valley. The technical studies are needed to support a Basin Plan amendment that may include water quality objectives for some of the constituents of concern and an implementation program requiring management practices to prevent or reduce the quantities of these constituents discharged to Central Valley receiving waters. The policy will likely be considered by the Central Valley Regional Water Board in 2009.

CHAPTER 3 WATER QUALITY IN THE WATERSHEDS AND THE STATE WATER PROJECT

Chapter 3 contains a description of the key features of the SWP, a brief description of Delta hydrology, a discussion of the key water quality concerns in the SWP, a discussion of the decreasing concern with methyl tertiary butyl ether (MTBE), and a discussion of emerging contaminants. The TRC identified organic carbon, salinity, bromide, nutrients, turbidity, trace elements, organics, and pathogens as the key water quality constituents of concern. Water quality data for the Sacramento and San Joaquin rivers and numerous locations along the SWP were analyzed to evaluate changes in water quality constituent concentrations as water flows from the rivers, through the Delta, and into the SWP system. Data from 2001 to 2005 were compared to data collected during the prior five years covered in the 2001 Update. The highlights of the water quality analysis are presented in this section.

ORGANIC CARBON

Organic carbon is a precursor to many DBPs that have been associated with an increased risk of cancer; liver, kidney and central nervous system problems; and adverse reproductive effects. Source water TOC concentrations are also important to the SWP Contractors because the Stage 1 D/DBP Rule regulates the amount of removal required in water treatment plants (WTPs) on the basis of the source water TOC and alkalinity. The key findings from the analysis of the organic carbon data are:

- TOC concentrations are measured with both the combustion and oxidation methods at various locations in the SWP. The combustion method consistently produces higher concentrations than the oxidation method.

- TOC concentrations in the Sacramento River are considerably lower than concentrations in the San Joaquin River.

- TOC concentrations are much higher in the North Bay Aqueduct (NBA) than any other location in the SWP. Wet season peak concentrations are in the range of 14 to 20 mg/L. The local Barker Slough watershed is the source of this TOC.

- The dissolved organic carbon (DOC) fingerprints indicate that the San Joaquin River is the primary source of DOC at the south Delta pumping plants when flows on that river are high. During dry years, the Sacramento River has more influence on DOC concentrations at the pumping plants. Delta agricultural drainage is also a source of DOC at the pumping plants.

- TOC concentrations do not change as water flows from the Delta through the South Bay Aqueduct (SBA) and the Califonia Aqueduct. San Luis Reservoir and Castaic Lake have less variability in TOC concentrations than the aqueduct due to the dampening effect of reservoir mixing. The dampening effect is not seen in Silverwood Lake on the East Branch due to its limited hydraulic residence time.

- There is a distinct seasonal pattern in TOC concentrations in the rivers, the Delta, and the aqueducts. High concentrations (5 to 8 mg/L) occur during the wet season and low concentrations (2 to 3 mg/L) occur in the late summer months.

- There are no apparent long term trends at any of the locations included in this analysis. TOC data were generally available from 1998 through 2005. During this time, water years varied from dry to wet but no apparent relationship between water year type and TOC concentrations is evident in the data.

- The real-time monitoring data from the Sacramento River at Hood (Hood), the San Joaquin River at Vernalis (Vernalis), and the Harvey O. Banks Delta Pumping Plant (Banks) has shown that TOC peaks are higher than previously measured in discrete samples.

- While quantitative changes appear not to be evident, it is far less clear whether qualitative temporal or spatial changes are occurring as TOC moves through the system.

- The existing monitoring program is inadequate to evaluate operational changes or to forecast TOC concentrations in the aqueducts as a result of changing water quality in the Delta. It is particularly important to obtain real-time data on the movement of water into and out of O'Neill Forebay and San Luis Reservoir.

SALINITY

High levels of TDS in drinking water can cause a salty taste and be aesthetically objectionable to consumers. In addition, high TDS concentrations can shorten the life of plumbing fixtures and appliances, and restrict the ability to recycle water or recharge groundwater. The key findings from analysis of the TDS and electrical conductance (EC) data are:

- EC levels in the Sacramento River are considerably lower than levels in the San Joaquin River. At flows over 2,000 cubic feet per second (cfs), EC at Vernalis is inversely related to flow.

- EC levels in the NBA are higher and more variable than at Hood but lower than the levels at Banks. Peak EC levels are found in April with a clear indication that the local Barker Slough watershed is a contributor of salinity.

- The EC fingerprints indicate that the San Joaquin River, seawater intrusion, and Delta agricultural drainage are the primary sources of EC at the south Delta pumping plants. The San Joaquin River has a greater influence on EC at the Tracy Pumping Plant than at Banks.

- There is a substantial increase in EC between Banks and San Luis Reservoir; however the variability of EC in the reservoir is greatly reduced. EC levels do not change between San Luis Reservoir and the bifurcation of the aqueduct. EC levels in Castaic Lake are less variable than the aqueduct locations, due to the dampening effect of about 500,000 acre-feet of storage on the West Branch. The dampening effect is not seen in Silverwood Lake on the East Branch due to its limited hydraulic residence time.

- There are distinct seasonal patterns in EC levels but they vary between locations. In the Sacramento River, EC levels are lowest in the early summer, steadily increase until flows increase in the river in the late fall or early winter, and then drop back to the summer lows. In the San Joaquin River, EC levels are lowest in the spring, increase during the summer months due to agricultural drainage discharges, continue to climb during the fall due to seawater intrusion, and remain high until late winter or early spring when flow increases on the river. The seasonal pattern at Banks is similar to the San Joaquin River except that EC levels generally start to decrease earlier in the winter.

- There is tremendous variability in the load of TDS pumped into the SWP system, largely due to pumping rates. TDS loads are lowest in the spring when pumping is curtailed and highest in the winter months (up to 8,000 tons per day) when TDS concentrations are highest at Banks and pumping rates are high.

- There are no apparent long term trends at any of the locations included in this analysis. Continuous EC data were available from 1996 through 2005 at many locations. During this time, water years varied from dry to wet but no apparent relationship between water year type and EC concentrations is evident in the data.

- The existing monitoring program is inadequate to evaluate operational changes or to forecast EC concentrations in the aqueducts as a result of changing water quality in the Delta.

BROMIDE

Bromide is present in seawater that intrudes in the Delta, primarily in the fall months and during dry years. Bromide reacts with disinfectants to form DBPs. Bromide reacts with chlorine to form TTHMs and HAA5s and it reacts with ozone to form bromate. The key findings from analysis of the bromide data are:

- Bromide concentrations in the Sacramento River are low, often at or near the detection limit of 0.01 mg/L. Conversely, bromide concentrations are high in the San Joaquin River (median of 0.28 mg/L).

- Bromide concentrations in the NBA are higher and more variable than at Hood but substantially lower than the levels at Banks. The Barker Slough watershed is the source.

- Seawater intrusion is the primary source of bromide at the south Delta pumping plants. The concentrations at the pumping plants are inversely related to Delta outflow. The San Joaquin River and Delta agricultural drainage are secondary sources.

- There is a substantial increase in bromide between Banks and San Luis Reservoir; however, the variability of bromide in the reservoir is greatly reduced. Bromide concentrations do not change between San Luis Reservoir and the bifurcation of the aqueduct. Bromide concentrations in Castaic Lake are slightly less variable than the aqueduct locations; however, the dampening effect is not seen in Silverwood Lake.

- There are distinct seasonal patterns in bromide concentrations but they vary between locations. In the Sacramento River, bromide concentrations are low all year. In the San Joaquin River, bromide concentrations are lowest in the spring, increase during the summer months due to agricultural drainage discharges, continue to climb during the fall due to seawater intrusion, and remain high until late winter or early spring when flow increases on the river. The seasonal pattern at Banks is similar to the San Joaquin River except that bromide concentrations generally start to decrease earlier in the winter. The SBA and California Aqueduct locations show the same seasonal pattern as Banks with the highest concentrations during the fall months. There is a secondary peak along the aqueduct in May that appears to be related to releases from San Luis Reservoir.

- There are no apparent long term trends at any of the locations included in this analysis. Bromide data are available for ten years at many locations. During this time, water years varied from dry to wet and bromide concentrations were lowest in the wet years of 1996 and 1997.

NUTRIENTS, ALGAL BLOOMS, AND TASTE AND ODOR INCIDENTS

In excessive concentrations nutrients can stimulate algal growth in the Delta and SWP reservoirs and aqueducts. Blue-green algae (more correctly known as cyanobacteria) produce chemical compounds such as 2-methylisoborneol (MIB) and geosmin that require specific treatments to avoid or minimize taste and odor (T&O) complaints in treated drinking water. The key findings from the analysis of nutrient data are:

- Total N and total P concentrations in the San Joaquin River are considerably higher and more variable than concentrations in the Sacramento River. The highest concentrations occur in the wet winter months in both rivers.

- Nutrient concentrations in the NBA are higher than in the Sacramento River. The highest concentrations occur in the winter months due to the influence of runoff from the local Barker Slough watershed.

- Total nitrogen (total N) and total phosphorus (total P) concentrations in water exported from the Delta at Banks are sufficiently high to cause algal blooms in the aqueducts and downstream reservoirs.

- Nutrient concentrations do not change as water flows from the Delta through the SBA. Peak concentrations occur in the winter months at Banks and Del Valle Check 7 (DV Check 7).

- There are limited nutrient data for the Delta Mendota Canal (DMC); however, the available nitrate data indicate that the DMC may be a significant source of nitrogen south of O'Neill Forebay. Nitrate concentrations exceeding 8 mg/L occur in the winter months.

- Total N concentrations are slightly higher south of O'Neill Forebay but total P concentrations remain similar to those found at Banks. The higher total N concentrations may be due to the influence of the DMC or to the filling of San Luis Reservoir during the winter months when peak concentrations occur at Banks.

- Total N and total P concentrations are substantially lower in Castaic Lake. Algal uptake and subsequent settling of particulate matter, due at least in part to the unique configuration and operational pattern of this part of the SWP system, may be responsible for the lower nutrient concentrations.

- There is a shorter period of record for nutrient data than for other water quality constituents such as organic carbon and EC, at many of the key locations. Other than seasonal patterns, no other patterns related to water year types or long-term changes are apparent in the data for the rivers and the aqueduct. Limited evidence exists to suggest there may have been a trend of increasing nutrient concentrations in Castaic Lake between 1998 and 2003 that was unrelated to concentrations in the upstream aqueduct.

- The existing monitoring program is inadequate to evaluate operational changes or to fully understand the impacts of the DMC on nutrient levels in the California Aqueduct. It is particularly important to obtain better data on the movement of water into and out of O'Neill Forebay and San Luis Reservoir.

The key findings from analysis of the MIB and geosmin data are:

- Monitoring of MIB and geosmin was initiated at a number of locations in the SWP between 2001 and 2005. The samples are quickly analyzed and email reports are sent to the SWP Contractors alerting them to potential T&O problems.

- MIB and geosmin peaks in excess of 10 ng/L occur at Clifton Court and at Banks every summer. Concentrations exceeding 10 ng/L can be detected by most people and result in customer complaints to drinking water providers. MIB concentrations have been more problematic in recent years.

- The peak levels of MIB and geosmin at Banks are quickly transported to the SBA. These compounds were present at levels known to cause complaints during the summers of 2003, 2004, and 2005.

- MIB from the Delta is transported down the California Aqueduct but the concentrations decrease with distance down the aqueduct. There is evidence that MIB and geosmin are produced at high levels in the aqueduct.

- San Luis Reservoir has low levels of MIB and geosmin (usually less than 4 ng/L). In contrast, high levels of MIB and geosmin are generated in the southern California reservoirs. Castaic Lake has high levels of geosmin every summer (up to 830 ng/L) and occasional MIB peaks greater than 10 ng/L. Lake Perris has exceedingly high concentrations of geosmin (up to 1,660 ng/L) and MIB (up to 107 ng/L). Silverwood Lake has peaks of both compounds that exceed 10 ng/L but do not reach the high levels found in the other reservoirs.

TURBIDITY

Excessive turbidity in source waters can create challenges with adequately clarifying and disinfecting drinking water and can increase expenses for treatment chemicals and sludge handling. The key findings from analysis of the turbidity data are:

- Turbidity levels in the Sacramento River are related to flows, with higher turbidities associated with higher flows. The San Joaquin River shows the same pattern of rapidly increasing turbidity when flows first increase in the winter months; however during prolonged periods of high flows, turbidity drops back down.

- The turbidity levels at Barker Slough are substantially higher and more variable than at Hood or any other SWP monitoring location. Peak turbidity levels occur in the winter months and in June. The high turbidity levels create treatment challenges for the NBA Contractors.

- The median turbidity at Banks is lower than in the Sacramento and San Joaquin rivers, reflecting settling in Delta channels and Clifton Court Forebay. Although the median turbidity is low, there is tremendous variability in turbidity at Banks. Peak turbidities, up to 100 NTU, occur during the spring and summer months. The turbidity levels in the SBA are similar to those at Banks and show the same seasonal trend.

- The SBA experiences high and variable turbidity events that can evolve quickly and cause treatment challenges.

- There is a substantial decrease in turbidity between Banks and Check 13 due to settling in O'Neill Forebay and San Luis Reservoir. This same dampening effect is seen in Castaic and Silverwood reservoirs.

- Turbidity increases and becomes more variable as water moves down the aqueduct south of San Luis Reservoir. Potential sources of turbidity are floodwater inflows to the San Luis reach and the Kern River, diverted into the aqueduct at the Kern River Intertie. Project operations also affect turbidity by creating diurnal fluctuations due to pumping cycles.

- There are no apparent long term trends at any of the locations included in this analysis. Continuous turbidity data were available from 1996 through 2005 at many locations.

During this time, water years varied from dry to wet and the highest turbidity levels at many locations occurred during the extremely wet years of 1997 and 1998.

TRACE ELEMENTS AND PESTICIDES

The California Department of Water Resources (DWR) collects samples three times each year for chlorinated organic chemicals, organ-phosphorus pesticides, herbicides, carbamate pesticides, and a variety of other synthetic organics throughout the SWP. Few of these compounds are detected. Those that are detected are found at concentrations well below MCLs. Arsenic is the only inorganic trace element that is potentially problematic in the SWP. This is a result of inflows of groundwater from the southern San Joaquin Valley that have arsenic concentrations exceeding the 0.010 mg/L MCL

PATHOGENS AND INDICATOR ORGANISMS

The pathogen and indicator organism data were examined to evaluate the appropriate levels of removal for *Cryptosporidium*, *Giardia*, and viruses. The key findings from the analysis of these data are:

- The NBA Contractors and DWR initiated LT2ESWTR monitoring in October 2006. Historic protozoan and coliform data indicate that Barker Slough has the highest levels of microbial contaminants in the SWP system, possibly due to the extensive cattle grazing in the watershed. The NBA Contractors have installed fencing along Barker Slough to restrict animal access and are currently evaluating the water quality impacts. The LT2ESWTR monitoring will provide additional data to determine if the current 2-log *Cryptosporidium*, 3-log *Giardia*, and 4-log virus removal requirements are adequate for the WTPs that treat NBA water.

- The SBA Contractors have completed the LT2ESWTR monitoring and CDHS has determined that 2-log removal of *Cryptosporidium* is appropriate for all WTPs treating SBA water. The monthly median total coliform and *E. coli* data indicate that 3-log *Giardia*, and 4-log virus removal is the appropriate level of treatment.

- Santa Clara Valley Water District (SCVWD) has completed the LT2ESWTR monitoring for the Santa Teresa WTP, which receives water from San Luis Reservoir. CDHS has provided unofficial notification that this source will be classified as Bin 1. The consistently low levels of total coliform and *E. coli* indicate that 3-log *Giardia*, and 4-log virus removal is the appropriate level of treatment.

- Central Coast Water Agency (CCWA) started LT2ESWTR monitoring in October 2006. The protozoan data that have been collected to date indicate that the Polonio Pass WTP will likely be in Bin 1 and no additional removal will be required. The coliform data indicate that 3-log removal of *Giardia* and 4-log removal of viruses are appropriate for the Polonio Pass WTP.

- There are limited data on the microbial quality of the California Aqueduct between San Luis Reservoir and the bifurcation of the aqueduct.

- Metropolitan Water District of Southern California (MWDSC) and Castaic Lake Water Agency (CLWA) have initiated LT2ESWTR monitoring. The historic coliform and protozoan data indicate that 3-log removal of *Giardia* and 4-log removal of viruses are appropriate for the treatment plants treating water from the West Branch. These plants will likely be placed in Bin 1 after LT2ESWTR monitoring is completed.

- Antelope Valley East Kern Water Agency (AVEK) and Palmdale Water District have completed the LT2ESWTR monitoring and have submitted their data to CDHS. MWDSC initiated monitoring in October 2006 and Crestline Lake Arrowhead Water Agency (CLAWA) will start monitoring in April 2008. The historic coliform and protozoan data indicate that 3-log removal of *Giardia* and 4-log removal of viruses are appropriate for the treatment plants treating water from the East Branch. The LT2ESWTR monitoring data collected by AVEK indicates the East Branch will likely be placed in Bin 1.

Potential Actions

The SWP Contractors and DWR are in the process of developing a comprehensive plan to conduct real-time monitoring and develop forecasting tools to alert the SWP Contractors to water quality conditions as they are developing. This program will require significant additional funding from the Contractors and close coordination with DWR. The SWP Contractors should support development and implementation of this program.

CHAPTER 4 KEY CONCERNS IN THE CENTRAL VALLEY WATERSHED AND THE DELTA

The watersheds of the Sacramento and San Joaquin rivers and the Delta are the primary source of water to the SWP. As the water from the tributaries to the Sacramento and San Joaquin rivers flows out of the foothills and through the Central Valley, contaminants from a variety of urban, industrial, agricultural, and natural sources affect the quality of the water, leading to drinking water treatment challenges and potential public health concerns. Chapter 4 contains a discussion of the impacts of urbanization on wastewater and urban runoff discharged to the rivers and the Delta; changes in land use in the Delta; and impacts from recreational use of the Delta.

URBANIZATION OF THE WATERSHED AND THE DELTA

The Central Valley's population is growing faster than that of California or the United States. This growth raises serious questions about the impacts on water quality as primarily agricultural land is converted to urban areas that generate wastewater and urban runoff.

Wastewater

The increasing population of the Central Valley results in increasing amounts of wastewater discharged to source waters of the SWP. Of particular concern is the increased volume of wastewater discharged into Delta waterways in close proximity to drinking water diversion locations. The volume of treated wastewater discharged to the Delta increased from approximately 194 mgd in 1990, when the first sanitary survey of the SWP was completed, to 220 mgd in 2006. In recent years, the Central Valley Regional Water Board has required many Delta dischargers to install tertiary treatment processes. The largest discharger, Sacramento Regional Wastewater Treatment Plant, provides secondary treatment. Information on the treatment processes, future plans for expansion and treatment plant upgrades, disposal options, use of recycled water, and pertinent information from the National Pollutant Discharge Elimination System (NPDES) permits are presented in Chapter 4 for each of the major wastewater plants that discharge into the Delta. Appendix B contains more information on the wastewater treatment plants that discharge in the Sacramento and San Joaquin watersheds.

There are limited data on the concentrations of many of the key drinking water constituents of concern because they are not currently regulated by the Central Valley Regional Water Board (see previous discussion on the Central Valley drinking water policy). The data that are available indicate that *Giardia* and *Cryptosporidium* are frequently detected in treated wastewater, nutrient concentrations are variable depending upon whether nutrient removal is required, and TOC concentrations vary from about 5 to 50 mg/L.

Urban Runoff

Stormwater and dry season runoff from the major urban areas of Sacramento, Stockton, Modesto, and some portions of Fresno, along with a number of smaller communities, is discharged to waterways of the Central Valley. Urban runoff contains numerous contaminants as a result of vehicle emissions, vehicle maintenance wastes, landscaping chemicals, household hazardous wastes, pet wastes, trash, and other waste from anthropogenic sources. As the Central Valley communities increase in population, natural and agricultural lands are converted to urban areas with an associated increased volume of urban runoff and increased load of contaminants.

Urban runoff in the Central Valley and Delta is regulated by the Central Valley Regional Water Board through municipal separate storm sewer (MS4) NPDES permits. These permits require large (greater than 250,000 population) and medium (100,000 to 250,000 population) municipalities to develop stormwater management plans and conduct monitoring of stormwater discharges and receiving waters. The permits also require programs to control runoff from construction sites, industrial facilities, and municipal operations; eliminate or reduce the frequency of non-stormwater discharges to the stormwater system; educate the public on stormwater pollution prevention: and better control and treat urban runoff from new developments. Small communities (less than 100,000 population) are required to develop management plans but do not have to conduct monitoring. Chapter 4 provides further details on the stormwater management programs and efforts being made to reduce drinking water contaminants in urban runoff for the Sacramento area, Stockton, and Eastern Contra Costa County.

The monitoring data for Sacramento and Stockton are discussed in Chapter 4. These data indicate that urban runoff, particularly stormwater, is highly variable from one location to another, from storm to storm, and from hour to hour during an event. High levels (in excess of 1 million MPN/100 ml) of indicator bacteria are found in urban runoff, nutrient concentrations are lower than in wastewater but often exceed the concentrations found in the receiving waters, and TOC is variable, ranging from 3 to 69 mg/L.

Potential Actions

Recommended potential actions to address wastewater and urban runoff in the Sacramento and San Joaquin watersheds are to support development of the Central Valley drinking water policy, specifically: 1) provide financial support of technical studies, 2) provide written and verbal testimony in support of the drinking water policy when it is considered by the Central Valley Regional Water Board, and 3) provide a forum for discussion of the policy elements with agricultural districts. Other recommended actions are 1) review and comment on environmental documents and tentative waste discharge permits to ensure that drinking water quality impacts on SWP source waters are evaluated; 2) ensure that drinking water constituents are included in the monitoring programs for the evaluation of management practices targeted to improve the quality of urban runoff discharged to receiving waters; and 3) request a position on the advisory committee for the Regional Board's Salinity Management Plan and work to ensure that salinity discharges from wastewater treatment plants are considered in the plan

DELTA LAND CONVERSIONS

In addition to urbanization of the Delta and the Central Valley watershed, two other areas of concern associated with land use have arisen in the Delta. One of the goals of the CALFED Ecosystem Restoration Program is to restore large expanses of all major aquatic, wetland, and riparian habitats to support recovery and restoration of native species. Some Delta farmers are replacing traditional corn and vegetable crops with rice. Both of these activities have the potential to increase the load of organic carbon discharged to Delta waterways and to potentially increase the organic carbon concentrations at Delta pumping plants. The potential impacts of these land use changes are discussed in Chapter 4.

Potential Actions

Recommended potential actions are to: 1) encourage DWR to support research to evaluate management measures that would reduce the load of organic carbon discharged from rice fields, and 2) work with the University of California Cooperative Extension and Ducks Unlimited and urge them to educate Delta farmers on the importance of minimizing the loads of DOC pumped off of Delta islands into the channels.

RECREATIONAL USAGE OF THE DELTA

Approximately two million people visit the Delta annually to boat, fish, water-ski, and participate in other recreational activities along the Delta's waterways. Recreational usage of the Delta can contribute trace metals from boat hull paints; petroleum hydrocarbons from fueling, spills, and fuel combustion from outboard motors; and pathogens from boat sewage discharges and personal sanitary habits. The primary impact of recreation on Delta water supplies is the release of human pathogens through body contact recreation and dumping of sewage from boats. Squatters living on abandoned and derelict boats are another potential source of pathogens. Chapter 4 contains a discussion of the current programs in place to prevent water quality impacts from recreational use of the Delta.

Potential Actions

Recommended potential actions are to send letters of support to the agencies that are currently working to reduce the impact of recreational use on the Delta and to work with the Delta Protection Commission on developing a Delta-wide approach to regulating and removing abandoned vessels.

CHAPTER 5 KEY CONCERNS WITH STATE WATER PROJECT FACILITIES

Previous sanitary surveys of the SWP have documented the potential contaminant sources in the watersheds. As a result, the SWP Contractors have initiated a number of programs to improve water quality. This chapter contains a discussion of the efforts to improve water quality for the NBA Contractors; the watershed management program undertaken by the SBA Contractors; SCVWD's project to address T&O problems when San Luis Reservoir is drawn down; MWDSC's efforts to address cattle grazing and bird roosting in the Castaic Lake watershed, and recreational usage, the anoxic hypolimnion, and seismic hazards in Lake Perris.

NORTH BAY AQUEDUCT

Monitoring has shown that the NBA has some of the poorest source water quality in the SWP due to high levels of organic carbon, turbidity, and coliform bacteria. Rapid fluctuations in water quality, including sudden drops in alkalinity, create major challenges for treatment plant operators during the wet season. The local Barker Slough watershed is responsible for the variability in water quality.

Under the leadership of Solano County Water Agency (SCWA), the NBA Contractors have taken a multi-pronged approach to improving water quality. In conjunction with DWR's Municipal Water Quality Investigations (MWQI) Program they embarked in 1996 on a multi-year study of the Barker Slough watershed that led to installation of fencing to prevent cattle from having access to Barker Slough; they are in the process of developing a hydrodynamic model of the Barker Slough area to determine the sources of water to the NBA under a variety of hydrologic conditions; they are currently evaluating the feasibility of exchanging NBA water for higher quality Solano Project water that is currently used for agricultural irrigation; they conducted a study to evaluate the effectiveness of a magnetic ion exchange treatment process to remove organic carbon; and they have explored alternate intake locations on the Sacramento River and Sutter Slough.

The NBA Contractors are currently awaiting the completion of the hydrodynamic model. Upon completion of the model, the NBA Contractors will evaluate the various options for improving water quality (watershed management practices, water exchanges, treatment options, and alternate intake) and determine the most cost-effective program for improving NBA water quality. No further actions are recommended at this time.

SOUTH BAY AQUEDUCT

The SBA Contractors and DWR have taken a number of actions since the 2001 Sanitary Survey Update was prepared. Actions taken are the SBA Improvement and Enlargement Program, assessment of watershed contaminant sources, and development of a watershed program. The on-going concerns are algal growth in the SBA, cattle grazing in the Bethany Reservoir watershed, and a proposed trail along the open canal sections of the SBA. The following is a brief summary of each of these actions and concerns.

Actions Taken

The SBA Improvement and Enlargement Project consists of increasing the design capacity of part of the SBA, construction of Dyer Reservoir, removing all existing major drainage to the SBA's open canal sections, grading the canal right-of-ways to drain away from the canal, replacing the wooden slat farm bridges that allow animal wastes to enter the water with concrete bridges, and removing 2,000 to 3,000 cubic yards of sediment in the Bethany intake channel just upstream of the South Bay Pumping Plant. The project is scheduled for completion in 2009.

The SBA Contractors conducted a study to assess the contaminant sources in the watersheds draining to Bethany Reservoir, the open canal sections of the SBA, and Lake Del Valle. This effort was followed by development of a Watershed Protection Program Plan (WPPP) under the guidance of a stakeholder-based Watershed Workgroup. The WPPP project included monitoring stormwater inflows to Lake Del Valle and Bethany Reservoir during the winter of 2005-2006. The general findings of the stormwater monitoring were that the Bethany Headlands drainage had the highest concentrations of most constituents that were monitored, and the concentrations of most constituents at the Lake Del Valle intake to the SBA were substantially lower than the concentrations in the major watershed inflows. Additionally, *Giardia* and *Cryptosporidium* were detected in every sample collected from the Bethany Headlands drainage. The WPPP contains a number of recommendations for managing contaminant sources in the watersheds.

Continuing Concerns

The high concentrations of nutrients, combined with abundant sunshine and warm water temperatures during the spring, summer, and fall months leads to excessive algal growth in the SBA. This results in T&O problems due to the formation of MIB and geosmin, and shorter filter run times, which can substantially reduce plant production and create difficulties meeting customer demands. Excessive algal growth also results in daily fluctuations in pH, which can reduce the effectiveness of coagulants and other chemicals. Nutrient rich water imported from the Delta, combined with the shallow depth of the SBA, provides ideal growing conditions for phytoplankton. The diatom *Melosira varians* accounts for most of the phytoplankton biomass.

Melosira is a filter clogging alga but it is not a known T&O producing species. Benthic blue-green algae are also abundant in the SBA and are thought to be responsible for the production of MIB and geosmin and the resultant T&O problems in the treated water.

Cattle grazing occurs on both private and state-owned land in the Bethany Reservoir watershed. Cattle have access to the western shore of Bethany Reservoir and have been observed standing in the water. The state owns the land on the western side of Bethany Reservoir within 300 to 500 feet of the shoreline. This property is managed by DWR and much of it is leased for cattle grazing. The leases request that good grazing practices be used, but there are no requirements for specific measures such as keeping cattle out of the water. As discussed previously, the Bethany Headlands drainage contains high levels of *Giardia* and *Cryptosporidium* relative to other sources of water to the SBA. Since cattle grazing is the primary use of this land and cattle are known carriers of these pathogens, cattle are the likely source of these pathogens.

The open canal sections of the SBA are fenced and are currently not accessible to the public. The East Bay Regional Park District (EBRPD) Master Plan includes a multi-use trail (hiking, bicycling, and equestrian) along portions of the SBA. EBRPD is not currently actively pursuing this project. There are a number of potential measures to protect water quality that should be considered if a trail is proposed in the future.

Potential Actions

Recommended potential actions are to: continue close coordination between DWR and the SBA Contractors on the Algal Management Program; 2) explore the possibility of using photovoltaics to limit light to the SBA; 3) improve range management and restrict cattle access to Bethany Reservoir; 4) address water quality concerns associated with EBRPD proposed trail; and 5) continue open communications with SBA watershed stakeholders.

SAN LUIS RESERVOIR

San Luis Reservoir is a key component of both the SWP and the CVP, serving as the major storage facility south of the Delta. Water is released from San Luis Reservoir on the west side through the Pacheco Pumping Plant, to meet the needs of federal CVP San Felipe Division Contractors in Santa Clara and San Benito counties. SWP and CVP Contractors in the San Joaquin Valley and southern California are served by releases from the east side of the reservoir through the William R. Gianelli Pumping-Generating Plant.

Currently, state and federal water projects cannot fully utilize water stored in San Luis Reservoir without impacting the reliability of water deliveries to San Felipe Division Contractors. The location of the San Felipe Division intake, Delta operations, system-wide demands and diminished water quality together reduce project water supplies south of the Delta. These constraints are collectively known as the San Luis low-point problem. Water quality is one component of the low point problem: When the reservoir is substantially drawn down, the quality of water delivered via the Pacheco Pumping Plant can be adversely affected by algal growth in the reservoir. SCVWD has experienced severe T&O incidents and other treatment problems at its water treatment plants when algae are drawn into the Pacheco intake.

SCVWD obtained Proposition 13 funds and began the San Luis Reservoir Low-Point Improvement Project in early 2001. Although the CALFED Record of Decision (ROD) identified a bypass canal as the solution, SCVWD is evaluating a number of alternative solutions. The U.S. Bureau of Reclamation (USBR) is conducting a feasibility study along with the local partners, the San Luis Delta Mendota Water Authority and SCVWD. It is anticipated that the study will be completed by June 2009. The first phase of the feasibility study, the Initial Alternatives Report, is scheduled for completion in June 2007.

NON-PROJECT INFLOWS TO CALIFORNIA AQUEDUCT

During the historic drought of 1976 to 1977, supplies of SWP water were drastically reduced. As a result, groundwater in the southern San Joaquin Valley was pumped into the California Aqueduct and transported to areas of need. The acceptance of non-Project inflows has become a critical component of managing water in California. A key concern associated with the acceptance of non-Project inflows into the SWP system is to protect against water quality degradation that could affect drinking water quality.

The original policy governing acceptance of non-Project inflows, developed to cope with the 1976 to 1977 drought, was directed primarily at concerns over water quality degradation. The policy has been reviewed and updated periodically in subsequent years; the current policy governing acceptance of non-Project inflows was adopted in March 2001. A revised policy was proposed in March 2005.

Non-Project inflows enter the California Aqueduct at a number of locations between Check 21 and Check 66. During the 2001 to 2004 period, a total of about 360,000 acre-feet of water was accepted from seven entities. About two-thirds of the inflow volume was from the Kern Water Bank Authority (Kern). Non-project inflows can contribute a large percent of the water in the aqueduct. During the study period, inflows contributed 40 to 50 percent of the water in the East Branch at Check 66 for a number of months.

Chapter 5 contains an analysis of the water quality impacts of the inflows. The quality of inflows is variable. Compared to the quality of water in the California Aqueduct, most inflows during the 2001 to 2004 period had higher concentrations of nitrate, arsenic, sulfate, and chromium VI and lower concentrations of bromide and TOC. Many inflows contained lower concentrations of TDS than the aqueduct but a couple had higher concentrations. Based on the available data on the quality of the inflows and the background concentrations in the California Aqueduct, a simple mass loading calculation was performed to predict concentrations of TDS, bromide, TOC, nitrate, arsenic, chromium VI, and sulfate in the aqueduct as a result of the inflows. The predicted concentrations were compared to actual monitored concentrations. In most cases, the predicted concentrations were substantially lower than the actual concentrations in the aqueduct. This indicates that the existing monitoring program is inadequate to properly evaluate the impacts of non-Project inflows.

Potential Actions

Recommended potential actions are to: 1) improve monitoring of inflows and aqueduct water quality, 2) investigate inconsistencies in TDS/EC data, 3) add phosphorus to the list of constituents of concern, and 4) prepare annual reports to assess water quality impacts of inflows.

CASTAIC LAKE

As identified in the previous sanitary survey, cattle grazing is a potentially contaminating activity in the Castaic Lake watershed. The presence of gulls roosting at Castaic Lake has been identified as a new potentially contaminating activity in the Castaic Lake watershed. In cooperation with DWR staff, MWDSC has spent considerable time and resources to address these potentially contaminating activities. This section briefly describes the current status of grazing and gull roosting, and actions taken since the last sanitary survey.

Cattle Grazing

Beginning in 1996, small groups of cattle (less than 20) were observed in the water by MWDSC staff near Elderberry Forebay. The presence of cattle in the watershed became more prevalent after the August 1996 Marple fire that burned several cattle exclusion fences. In the spring of 2001, cattle in the Elderberry Forebay were noticed more frequently by DWR and MWDSC staff. By the fall of 2001, cattle droppings were prevalent along the main access road on the west side of Elderberry Forebay, confirming the increased presence of cattle. Since coliforms and *E. coli* are often used as indicators for the presence of *Cryptosporidium parvum*, MWDSC became concerned when *E. coli* levels began increasing in late 1997 to early 1998, particularly during the winter months, and peaking during the winters of 2000 and 2001.

After several meetings with the affected parties, DWR agreed to install 3.5 miles of new fence to protect the entire west side of Elderberry Forebay. The new fencing would supplement existing fencing owned by the rancher. The cost of the fencing was approximately $50,000 and the fence was completed in the summer of 2003. In the fall of 2004, the access road did not have any new cattle droppings, and was much cleaner than in 2001.

To further investigate the increasing levels of *Escherichia coli* (*E. col)i*, MWDSC initiated a limited microbial source tracking study in 2001 to determine the relative contribution of cows, gulls, and tributary creeks to the seasonal *E. coli* contamination within Castaic Lake. A total of 427 *E. coli* isolates were collected over a non-sequential three year period (2001, 2002, and 2004), and were analyzed by a polymerase chain reaction (PCR) targeting repetitive DNA sequences. Overall, these results demonstrated that gulls contributed more *E. coli* contamination to the lake than cows.

Gull Roosting

In 2001, MWDSC contracted with Dr. Richard Golightly, Humboldt State University, to begin tracking the number of gulls at Castaic Lake every 10 days. Surveys were conducted from March 2002 through July 2002 and from December 2002 through June 2003 to ascertain the number of gulls using the lake. Dr. Richard Golightly was retained for a second study, where 15 ground counts of gulls were conducted from October 2004 through May 2005, and in January 2005 radio transmitters were attached to a sample of Western gulls to monitor their daily movements. The highlights from this study were:

- Gull populations at Castaic Lake rapidly increased from October through November. Numbers of gulls at the lake then fluctuated December through March, and then decreased again at the onset of breeding in March and April. In March, all radio marked gulls were at marine locations, specifically Anacapa Island.

- From October 2004 to May 2005, the peak number of gulls was approximately 7,000 which occurred on February 16, 2005. This is similar to the peak number of gulls from the March 2002 to June 2003 study, which was 8,000 gulls on January 3, 2003.

- It is speculated that during inclement weather in the marine environment, food access may be poorer. Thus, storm events at sea may result in significant number of gulls traveling inland to Castaic Lake.

- Gulls were found at the Simi Valley landfill, the Chiquita Canyon landfill, and the Calabasas sanitary landfill.

MWDSC has decided to proceed with best management practices to address the presence of gulls at Castaic Lake. Gull management practices will be implemented to discourage birds from roosting at Castaic Lake and will include educational pamphlets, food management within the local areas, and a more direct means of discouraging gulls from roosting at night near the Castaic Lake outlet tower. Pilot-scale best management practices to discourage gulls from roosting at night were implemented in January and February 2007 with limited success. Gulls were chased off the lake surface using a motorized boat for four consecutive nights. The percentage of gulls successfully managed from the system each night ranged from 15 to 64 percent.

Potential Actions

The only recommended potential action at this time is to determine if other locations along the SWP may benefit from gull management programs, and if so, these SWP Contractors may want to collaborate on an experimental program designated to actively discourage gull roosting.

LAKE PERRIS

Historically, key water quality concerns associated with Lake Perris have limited MWDSC's ability to withdraw their full entitlement from the lake. Current water quality concerns are pathogens, taste and odor, algal toxins, and anoxia in the hypolimnion. Since the previous sanitary survey, MWDSC has embarked on various water quality studies and is in various planning stages for projects that are designed to address these concerns, to enable MWDSC to use Lake Perris year-round.

Recreational Usage

To address microbial contamination from body-contact recreation occurring at Lake Perris, MWDSC completed a multi-pronged study to determine the potential impact of swimming on Lake Perris water quality. The multi-pronged study consisted of: 1) fecal coliform and *E. coli* sampling at eleven locations and at multiple lake depths for a period of 18 months; 2) fingerprinting analysis by repetitive-PCR of *E. coli* isolates from the beaches and the outlet tower; 3) hydraulic modeling of Lake Perris under five different scenarios of body-contact recreational use and lake conditions; and 4) risk assessment modeling to determine impacts to downstream consumers of water from Lake Perris using a well-established dose response model.

The goals of the studies were to: 1) further understand the fate and transport of fecal coliforms in Lake Perris, 2) characterize fecal coliform and *E. coli* levels at various locations and depths throughout the lake, 3) determine if any relationships exist between *E. coli* found at the swimming beaches and at the outlet tower where water is withdrawn for municipal supply, and 4) predict pathogen concentrations and consumer risk levels at Lake Perris due to current levels of body-contact recreation. Chapter 5 contains a discussion of the bacteriological monitoring, fingerprinting analyses, hydraulic modeling, and the pathogen risk assessment.

To reduce the risk of waterborne pathogens at Lake Perris, MWDSC is proposing voluntary swimming alternatives (i.e. swim lagoons, water play areas and other water features) to swimming in the reservoir. Solutions under consideration are pending approval by MWDSC management and its Board. Final selection and location of recreational facilities will be based on close coordination with Lake Perris State Recreation Area (SRA) staff.

Anoxic Hypolimnion

During thermal stratification, Lake Perris has two recurring problems; algal produced T&O in the epilimnion and hypolimnetic anaerobic conditions. When the hypolimnion becomes anoxic, T&O compounds, nutrients, and metals can be released into the water column from the sediments. As these two conditions can occur simultaneously during the stratified period, there are times when the entire lake is unacceptable as a source of drinking water.

On behalf of MWDSC, FlowScience completed an initial review of hypolimnetic oxygenation and destratification alternatives to prevent low oxygen levels in the hypolimnion. Based on the FlowScience report, MWDSC is moving forward with plans for a diffused oxygenation system, or hypolimnetic oxygenation system. MWDSC has also received grant funding to assist with a portion of the project cost. Currently, the diffused oxygenation system is scheduled to be on-line by March 2008.

Seismic Hazard

In June 2005, DWR released a study that determined that a portion of the Lake Perris Dam foundation is potentially susceptible to liquefaction and severe loss of strength during a large earthquake event. To mitigate the seismic risk while a permanent solution is being determined by DWR, Lake Perris has been temporarily lowered 25 feet below the spillway level, to elevation 1,563 feet.

Water quality is a key concern if the current elevation of Lake Perris were to be altered permanently from its previous normal elevation of 1,588 feet. Changing the lake elevation will affect thermal structure and the proportional volumes of water in the hypolimnion, metalimnion, and epilimnion. A reduced lake elevation leads to a reduced hypolimnetic volume, which means that there is less oxygen mass, and the hypolimnion will become anoxic much quicker. This will reduce operational flexibility if water cannot be drawn from the hypolimnion.

Since the lake was lowered**,** there has been an increase in T&O problems from benthic algae. The most severe T&O problem caused by benthic algae at Lake Perris occurred in August 2006 when the entire shoreline of Lake Perris was impacted by a benthic algae *(Oscillatoria curviceps)* bloom. This particular benthic algae was extremely unusual, as it caused MIB levels to increase from less than 10 ng/L to over 200 ng/L within a two week period. Although copper sulfate treatments were conducted to control the benthic algal bloom, peak MIB concentrations at the outlet tower reached 292 ng/L. It is expected that taste and odor problems will continue from macrophytes and benthic algae, as long as the lake is lowered.

As requested by the State Water Contractors (SWC), DWR is currently evaluating future options for Lake Perris, beyond remediating the dam. The eight reservoir options studied included a range from permanently emptying the reservoir to increasing the normal reservoir level to 1,814 feet for a total volume of 1,000,000 acre-feet. The evaluation recommended that a further benefit/cost analysis be conducted on the two reservoir levels at 1,588 feet and 1,640 feet. The cost analysis will be completed in 2007. Design work, environmental documentation and permitting will take approximately two to three years, followed by construction work.

Potential Actions

Recommended potential actions are to: 1) lobby and/or seek funding to construct alternative swimming solutions, and 2) conduct additional water quality monitoring if size of Lake Perris is changed.

CHAPTER 6 INCIDENTS AND EMERGENCY RESPONSE MEASURES

In the past five years there have been a number of incidents that could potentially adversely affect water quality in the Delta and the SWP. Chapter 6 contains a description of the Jones Tract Levee Failure, wastewater spills in the Delta, wastewater spills in Silverwood Lake, high runoff and turbidity events in Silverwood and Castaic lakes, and an oil spill in Pyramid Lake.

JONES TRACT LEVEE FAILURE

A portion of the west levee of Upper Jones Tract, located in the southern Delta, failed on June 3, 2004 resulting in the flooding of Upper and Lower Jones tracts. A number of agencies, including DWR, responded to the levee break. By June 30, the breach had been closed and protection of the interior levees completed. Dewatering of the island and water quality monitoring began on July 12 and continued until December 18, 2005.

Despite the complexity of the incident, the number of involved entities, the lack of clear jurisdiction over the failed non-project levee, and early problems with communications and coordination, the incident was successfully brought to a close without loss of human life or serious injury. Also, DWR's objectives of minimizing salt water intrusion into the Delta, protecting the Jones Tract levees from further damage, and repairing the breached levee were attained in a timely manner. From this perspective, response to the emergency would be characterized as a qualified success. Costs attributable to the incident are estimated at nearly $100 million.

Water quality impacts of the emergency were modest and short-lived. The fingerprint modeling technique estimated that there was a short-term EC increase of about 100 µS/cm Although TOC concentrations in water pumped off of Jones Tract reached as high as 25 mg/L, the increase at Banks ranged from 0.5 to 2.0 mg/L. The water quality consequences may have been more severe if hydrologic and other conditions had been less favorable. The levee break occurred at a time when upstream reservoirs were at or near capacity so releases of freshwater could be made to repel seawater intrusion. The impacts of a levee break during drought conditions could potentially have far more adverse impacts on EC at the Delta pumping plants.

There is no information to indicate whether the SWP Contractors were given adequate notice of the potential for adverse water quality changes, or whether ongoing communications with drinking water suppliers were adequate. Evidence does exist to suggest there was a lack of water quality expertise in the management of the emergency, and that involvement of water quality specialists was delayed.

Potential Actions

Recommended potential actions are to: 1) reassess water quality impacts of Jones Tract levee failure; 2) encourage DWR to establish a policy on protecting source water quality; 3) broaden scope of levee risk assessments; 4) request DWR include water quality staff in emergency response teams; 5) request DWR revise emergency planning and response documents to better address water quality concerns; and 6) participate in Delta Risk Management Strategy Project.

WASTEWATER SPILLS IN THE DELTA WATERSHED

There were a number of spills of raw or partially treated wastewater in the Sacramento and San Joaquin watersheds during the study period. The spills of raw wastewater from the cities of Stockton, Lathrop, and Isleton and Sacramento County Sanitation District 1 into Delta waterways are of most concern due to the proximity to drinking water intakes. On December 30 and 31, 2005 record amounts of rainfall fell in the Sacramento and San Joaquin watersheds. Numerous dischargers reported problems with collection systems and overloaded wastewater treatment plants. There were spills of raw wastewater, partially treated wastewater, and instances of rivers overflowing and inundating wastewater ponds. Chapter 6 contains a list of the major spills in the Sacramento and San Joaquin valleys downstream of the large dams on the rivers, and additional detail is provided on a few of the larger spills near the Delta.

The State Water Board adopted Statewide General Waste Discharge Requirements (WDRs) for Sanitary Sewer Systems, Water Quality Order No. 2006-03 (Sanitary Sewer Order) on May 2, 2006 to provide a consistent, statewide regulatory approach to address sanitary sewer overflows (SSOs). The Sanitary Sewer Order requires public agencies that own or operate sanitary sewer systems to develop and implement sewer system management plans (SSMPs) and report all SSOs to the State Water Board's online SSO database. The SSMP must contain a spill response plan that establishes standard procedures for immediate response to an SSO in a manner designed to minimize water quality impacts and potential nuisance conditions.

Actions taken since the 2001 Sanitary Survey include the formation of a Sewage Spills Work Group consisting of CUWA members and staff from DWR and CDHS. Additionally, CUWA requested that the Central Valley Regional Water Board include a provision in NPDES permits requiring that downstream drinking water suppliers be notified of spills at wastewater treatment plants. Central Valley Regional Water Board staff is now requiring dischargers to notify water suppliers who request to be notified when spills occur in the Delta.

Potential Actions

The recommended potential action is that SWP Contractors should participate in the Sewage Spills Work Group and determine how they can best support the efforts of the Work Group to implement their recommendations.

WASTEWATER SPILLS IN SILVERWOOD LAKE

Wastewater generated in the small communities in the Silverwood Lake watershed and in the Silverwood SRA near the lake shore is treated and transported out of the watershed so there are no permitted discharges to the lake or its tributary streams. During 2005 there were three wastewater spills into Silverwood Lake.

Secondary Effluent Spill, January 9 and 10, 2005

On January 9 and January 10, 2005 the Crestline Sanitation District's (CSD) effluent outfall line, which transports chlorine-disinfected secondary treated wastewater, was damaged in two locations due to extremely heavy rain and the high water level in the lake. Portions of the effluent outfall line are located near the shoreline of the lake. CSD estimated that 9.2 million gallons of treated chlorinated wastewater was released into the Silverwood watershed as a result of the first pipeline break, and an additional 2.1 million gallons as a result of the second pipeline break.

In response to the first pipeline break, MWDSC initiated a monitoring program for coliforms, *Cryptosporidium,* and *Giardia* and CLAWA collected bacteriological samples at their WTP intake. In summary, *Cryptosporidium* and *Giardia* were detected in an effluent sample collected directly from the first pipeline break, in untreated source water samples (Devil Canyon Afterbay and Mills WTP influent), but not in Mills WTP treated water. Average concentrations were eight *Giardia* cysts and two *Cryptosporidium* oocysts per 10 L at Devil Canyon Afterbay, and five cysts and one oocyst per 10 L in Mills WTP influent (average for all samples that were positive for at least one organism). These detections are considered significant when compared to historical *Cryptosporidium* and *Giardia* data at Mills WTP influent. Water quality at Silverwood Lake was likely impacted by both the wastewater spill and increased runoff due to the heavy storms.

Raw Wastewater and Secondary Effluent Spills, March 26 and April 1, 2005

On March 26, 2005, a California State Parks' sewer main carrying raw wastewater broke as a result of earth movement caused by flooding, near the intersection of Highway 138 and Cleghorn Road. An estimated 250 gallons of raw wastewater entered Cleghorn Creek, approximately ¼ mile upstream of the lake. The spill was stopped and contained within 3½ hours. On April 1, 2005, while the contractor was trying to locate the California State Parks' sewer main, the CSD's forcemain carrying chlorinated secondary effluent from the Cleghorn WWTP was punctured. This led to the release of approximately 300 gallons of chlorinated secondary effluent to Cleghorn Creek. Repairs were made to both pipelines by April 2, 2005.

Water quality samples were taken by the CSD from March 27 to April 6, 2005 in Cleghorn Creek upstream and downstream from the break. Downstream samples showed high levels of fecal coliforms, indicating contamination as a result of the raw wastewater spill. MWDSC conducted follow-up pathogen sampling on March 28, 2005. No *Cryptosporidium* was detected, and *Giardia* was detected in one sample at the Silverwood outlet tower.

Raw Wastewater Spill, July 27, 2005

On July 27, 2005 a wastewater lift station maintained by the California State Parks for the Silverwood Lake SRA failed. This caused a backup of wastewater from a restroom at Sawpit Beach, spilling about 50 to 100 gallons into the lake before it was stopped. *Cryptosporidium* sampling was conducted by MWDSC and it was detected only at the site of the spill.

Potential Actions

Recommended potential actions are to: 1) recommend that DWR develop emergency wastewater spill procedures; 2) request DWR to provide a summary report to impacted contractors; 3) consider discussion with Crestline Sanitation District regarding future plans for wastewater facilities in the watershed; and 4) clarify support roles with DWR.

HIGH RUNOFF AND TURBIDITY IN SILVERWOOD AND CASTAIC LAKES

Silverwood and Castaic lakes were both temporarily impacted by high runoff in the winter of 2004 to 2005, which increased turbidity and possibly pathogens and/or pathogen indicators in the lakes. The Silverwood watershed was also impacted by a major wildfire in 2003.

Silverwood Lake

The Silverwood Lake watershed experienced heavy rain throughout the winter season of 2004 to 2005. From 2001 to 2005, the highest monthly rainfall was 27.89 inches in January 2005. Turbidity at Devil Canyon increased as natural runoff into the lake increased. Turbidity at Devil Canyon remained above 20 NTU for one month, from the end of December 2004 to the end of January 2005, peaking at 322 NTU on January 11, 2005. At CLAWA's WTP intake, turbidity peaked at 239 NTU on January 10, 2005 and remained above 20 NTU for over ten days.

In addition to heavy rains, the Silverwood watershed was also impacted by the Old Fire in October 2003. Approximately 8,900 acres of the burn area was within the watershed, representing about 40 percent of the Silverwood Lake watershed. On December 25, 2003, the Silverwood watershed received over five inches of rain within a 24-hour period, which was the first heavy rain since the fire. Large amounts of debris entered the lake. In an attempt to characterize the post-fire impact to source water quality, MWDSC staff collected water samples on December 26, 2003, first from Devil Canyon Afterbay and then from the Silverwood Lake outlet tower. In summary, most of the metals regulated for drinking water were elevated. Fortunately, the Mills WTP was shutdown during this time period, due to maintenance of the Santa Ana Valley pipeline. High turbidities did reach the Weymouth and Diemer WTPs one day after the storm, but the WTPs remained in compliance with all drinking water regulations by increasing chemical dosage and increasing Colorado River blends. The main impact to the Diemer and Weymouth WTPs were T&O related, as flavor profile analysis deemed the water unacceptable with a burnt wood and ashy taste. CLAWA staff indicated that their plant remained in operation, but flows were reduced.

Potential Actions

The recommended potential action is for DWR to assess fire-impacted watersheds and determine if further actions are needed to protect water quality.

Castaic Lake

The Castaic Lake watershed also experienced heavy rain throughout the winter season of 2004 to 2005. From 1999 to 2005, the highest monthly rainfall was 13.5 inches in January 2005. The amount of natural inflow in 2005 equaled approximately 41 percent of the lake storage capacity. Daily turbiditity at the Castaic Lake outlet tower was less than 1 to 2 NTU over the entire 2001 to 2005 reporting period, except in early 2005. From January through April 2005, turbidities remained over 2 NTU for four months due to heavy rains and high runoff into both Elderberry Forebay and Castaic Lake, peaking at 58 NTU on January 15, 2005. The peak influent turbidity at the Jensen WTP was 93 NTU. Although plant influent turbidity was higher than normal, all drinking water standards were met. CLWA was also impacted; peak turbidity at CLWA's Rio Vista WTP was 105 NTU on January 12, 2005. Both MWDSC and CLWA incurred additional treatment costs as a result of the high turbidity.

OIL SPILL IN PYRAMID LAKE

On March 23, 2005, an estimated 126,000 gallons of oil spilled into Posey Canyon, approximately 1.3 miles upstream from Pyramid Lake. Due to heavy rainfall, a landslide broke the pressurized 14-inch pipeline carrying light crude oil. The spill was somewhat naturally contained in a cove of the lake.

Samples were collected by DWR beginning March 24, 2005 through approximately April 5, 2005 and analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds, total extractable petroleum hydrocarbons, oil and grease, gasoline range organics, diesel range organics, and oil range organics. There were a few low level detections of toluene, total xylenes, MTBE, and ethylbenzene. There was one detection of bis(2-ethylhexyl)phthalate at 6.7 μg/L, which was above the MCL of 4.0 μg/L.

Samples were collected by MWDSC from March 26 through April 7, 2005 at Pyramid Lake center, the Pyramid outlet tower, and the Piru Creek release point. No target VOCs were detected at or above the MWDSC laboratory's minimum reporting levels in any of the samples. In summary, strong evidence of oil contamination was observed through analytical and olfactory techniques in the upper layers of the water in samples collected five days after the spill. Although very low level detections decreased over the 13-day sampling period, strong petroleum odors persisted in the upper 10 meters of the lake.

There was no immediate water quality threat to SWP Contactors, as MWDSC and CLWA receive water from Castaic Lake, and not directly from Pyramid. Water was not exchanged between Pyramid and Elderberry Forebay until oil contamination had diminished greatly at Pyramid. Additionally, water is withdrawn deep from both the Pyramid and Castaic outlet towers, which remained unaffected by the oil spill.

Response activities were directed by the unified command consisting of the USEPA, Department of Fish and Game's (DFG) Office of Spill Prevention and Response (OSPR), and Pacific Energy Partners. The pipeline was immediately shut down and a culvert was bulldozed to minimize the flow to Pyramid Lake. Primary and secondary containment booms were placed across the mouth of Posey Canyon cove to isolate and contain the oil, vacuum trucks were sent to the site to vacuum up the oil from the water, and skimmers were used to remove surface oil. Oily debris (mostly twigs, sticks, and other vegetation) were removed from the lake and shore.

Potential Actions

Recommended potential actions are to: 1) request DWR to provide a summary report to impacted contractors; 2) request DWR to seek containment equipment from oil companies to be placed near reservoir; 3) coordinate emergency response drills with oil companies; and 4) encourage installation of devices to prevent or reduce oil spill volume when new oil pipelines are installed.

CHAPTER 7 CONCERNS WITH SYSTEM OPERATION AND MAINTENANCE

The SWP Contractors and DWR work cooperatively to address operations and maintenance issues in the SWP. The TRC identified several issues for discussion and analysis as part of this sanitary survey. This chapter contains a discussion of sedimentation in Clifton Court Forebay, forebay and storage tank maintenance on the Coastal Branch, the Hesperia Master Drainage Plan, and water quality changes due to MWDSC's demand pattern changes.

CLIFTON COURT FOREBAY SEDIMENTATION

As water enters Clifton Court, the velocity of water decreases and sediment entrained in the water column settles out. Since the reservoir was constructed in the late 1960's, it has retained sediments that have been removed periodically to maintain reservoir capacity. The reservoir was last dredged in 1992, when approximately 400,000 cubic yards of sediments were removed. Its current capacity is unknown. Sedimentation reduces the depth of the forebay, increasing the area where light can penetrate to the bottom. This leads to growth of benthic cyanobacteria that produce T&O compounds.

To provide further evidence that sedimentation is occurring in Clifton Court, turbidity and grab sample total suspended solids (TSS) data were compared at Clifton Court and Banks. The average TSS at Clifton Court intake was 13.2 mg/L, whereas the average at Banks was 9.7 mg/L, based on grab sample data from 2000 to 2006. Similarly, data from turbidimeters at Clifton Court intake and Banks showed that daily turbidities averaged 16 NTU at Clifton Court intake and 11 NTU at Banks from 2001 to 2005. Both of these indicators demonstrate that there is an overall net sediment accumulation in the forebay.

Benthic cyanobacteria grow in Clifton Court and in the Delta and produce MIB and geosmin. These compounds quickly move into the SBA and result in T&O problems for the SBA Contractors. The SBA Contractors have experienced severe T&O episodes every summer since 2003 that have resulted in numerous customer complaints. Early detection of potential problems in the Delta and Clifton Court would enable the SBA Contractors to plan for these events.

Turbidity, pH, fluorescence, DO, and total and volatile suspended solids data were evaluated as potential tools for early detection of algal blooms and T&O incidents. In summary, fluorescence, pH, and turbidity measurements appear to lack the sensitivity to provide early warning of impending algal blooms and consequent T&O incidents. Analysis of discrete samples for total and volatile suspended solids are generally not useful due to the limited data that can be produced, particularly since algal blooms and the production of T&O compounds can change quickly. Continuous measurement of DO appears to have the most potential to provide early warning of impending T&O problems.

Potential Actions

Recommended potential actions are to 1) investigate current equipment capabilities, 2) consider continuous measurement of DO, 3) support Interagency Ecological Program grant application for fluid imaging instruments, and 4) investigate alternatives for controlling nutrient loading to Clifton Court.

FOREBAY AND STORAGE TANK MAINTENANCE ON COASTAL BRANCH

Sediment accumulation in the forebays and storage tanks of the Coastal Branch presents water quality concerns because sediments can support biological growths that can be a source of T&O compounds in treated drinking water. Five pumping plants lift water to the CCWA system, and each has a forebay that serves as the pool from which water is pumped. Sediment has accumulated in the forebays of the Devil's Den, Bluestone, and Polonio Pass pumping plants, and in storage tanks located just upstream of the Polonio Pass WTP.

Since October 1999, CCWA has experienced periodic T&O episodes that have not coincided with T&O incidents in other parts of the SWP system. In 2003 CCWA experienced a serious T&O incident that resulted in numerous customer complaints. MIB concentrations in the Polonio Pass WTP influent peaked in September at 33 ng/L. During late August 2004, MIB concentrations rose sharply to 35 ng/L. MIB was not effectively removed by the WTP, entered the distribution system, and resulted in customer complaints. Based on the 2003 and 2004 data, CCWA staff suspected the source of MIB and geosmin was in the Coastal Branch system.

High concentrations of geosmin were detected in Polonio Pass WTP sludge lagoons in 2003, indicating that T&O compounds could be associated with sediment. CCWA staff surveyed sediment depths at the Polonio Pass Pumping Plant forebay during the summer of 2005. The survey revealed that sediment depths ranged from 1 to over 7 feet, and averaged 3.4 feet. Sediments were removed from the forebay during the summer of 2005. A post-removal survey of the forebay indicated that the sediment depth ranged from 0 to about 3 feet, and averaged 1.2 feet.

During the summer and early fall of 2005, the maximum MIB concentration detected in the Polonio Pass WTP influent was 11 ng/L, and MIB concentrations in the treated water did not exceed 9 ng/L. Customer T&O complaints diminished to insignificant levels during this period. CCWA staff believes that an association exists between sediments in the Coastal Branch system and T&O incidents, but this association has not been proven to date with scientific certainty. Further work is underway to confirm or disprove this.

To minimize sediment deposition, CCWA staff installed a SolarBee®, which is a solar powered reservoir circulator, in Polonio Pass Pumping Plant forebay. The SolarBee® appears to be effective in keeping sediment in suspension, as sediment levels in the forebay did not accumulate to a large degree during the period of the experiment. Experimentation continued in 2006, with a re-survey of the forebay on March 30, 2006 indicating average sediment depth was 0.9 feet. However, experimentation with this equipment continues and no conclusions as to its effectiveness have been drawn to date.

Potential Actions

Recommended potential actions are to continue experimentation with the SolarBee, and prevent sediment accumulation in the three forebays and storage tanks with proper maintenance.

HESPERIA MASTER DRAINAGE PLAN

When the East Branch was constructed, the natural drainage pattern in the Hesperia area was interrupted so overchutes and culverts were constructed to convey drainage over and under the California Aqueduct. There is a two mile stretch of the aqueduct beginning at Mile 397, where urban runoff is directly discharged into the aqueduct through 45 drop inlets.

Hesperia's population has increased by an estimated 28.2 percent from 62,582 in 2000 to 80,268 in 2006. According to DWR staff, there are twenty-five home developments in some stage of planning or construction within one mile of the aqueduct in the Hesperia area. As Hesperia becomes more urbanized, more urban runoff will be discharged into the aqueduct. Since urban stormwater runoff contains nutrients, suspended solids, organic carbon, bacteria, hydrocarbons, trace metals, and pesticides, downstream water users remain concerned about impacts to source water quality. Pollutant loads to the aqueduct from the drop inlets is unknown since information is not available on the quality or quantity of urban runoff discharged through the drop inlets. It has been estimated that a 24-hour, 100-year storm event could generate up to 5,010 cfs. The capacity of the California Aqueduct along the East Branch ranges from 2,630 to 2,880 cfs.

The San Bernardino County Flood Control District (SBCFCD) developed a Master Plan of Drainage in May 1996 for the City of Hesperia that proposes two infrastructure alternatives to control flows and convey runoff for a 100-year storm event. The "South Community Alternative Plan" includes a small detention basin located near the aqueduct to temporarily detain storm flows, and assumes that urban runoff will continue to be conveyed to the aqueduct via the drop inlet structures. The "Design 4" Plan includes a larger detention basin and eliminates discharges into the aqueduct.

DWR has formally communicated to the SBCFCD that the continued use of the drop inlets is unacceptable. However, the SBCFCD will only move forward with the larger detention basin if DWR funds the $10.9 million difference between the two alternatives. DWR and interested SWP Contractors have reviewed the Hesperia Basin Report. This report contains design criteria and preliminary design for the detention basin. DWR is in the process of submitting comments to the County.

Potential Actions

Recommended potential actions are to 1) develop a coordinated plan with all of the impacted SWP Contractors and DWR to determine the appropriate cost share between Hesperia and DWR to eliminate storm water runoff into the aqueduct; and 2) monitor urban runoff through the drop inlets to determine the quantity and quality of the runoff flows.

WATER QUALITY CHANGES DUE TO DEMAND PATTERN CHANGES

MWDSC has experienced a dramatic increase in its reliance on SWP water since 1999. Record volumes of SWP supplies were needed to fill MWDSC's newest reservoir, Diamond Valley Lake (DVL), when it became operational in late 1999, and to supplement cutbacks on Colorado River water supplies which began in 2003. Before DVL became operational, MWDSC had primarily taken East Branch SWP deliveries from late spring to early fall, with a reduction in flows in winter. Within the last five years, this historical pattern has changed as high delivery volumes are beginning earlier in the year and occurring nearly year-round

Due to changes in East Branch source water quality within the last five years, MWDSC has experienced various treatment challenges in complying with drinking water regulations. Although all drinking water standards have been met, changes in source water quality have necessitated changes in operational procedures and MWDSC has incurred additional treatment costs.

The following is a summary of how water quality has changed from the pre-DVL to the post-DVL time periods along the East Branch. TOC, bromide, phosphorus, nitrogen, and T&O compounds were selected for evaluation. For simplicity, the data are categorized into two groups: 1) "pre-Diamond Valley Lake", from earliest record to 1999, and 2) "post-DVL" from 2000 to 2005.

- Organic Carbon - The pre-DVL median for TOC at Banks increased slightly from 3.4 mg/L to 4.0 mg/L post-DVL. The pre-DVL median for TOC at Devil Canyon increased dramatically from 2.8 mg/L to 3.8 mg/L post-DVL. TOC water quality changes over the last five years at Devil Canyon appear to be related to increased deliveries, timing of deliveries, changes in upstream water quality, and hydrology. In short, the timing and volume of deliveries can result in water quality changes downstream.

- Bromide - Bromide generally peaks at both Banks and Devil Canyon during the September to December time period due to seawater intrusion in the Delta. Monthly median bromide levels increased at Banks from pre-DVL to post-DVL during the months of August to November. Monthly median bromide levels increased at Devil Canyon from pre-DVL to post-DVL during the months of November to March. However, the post-DVL 90^{th} percentiles at both sites do not exceed the pre-DVL 90^{th} percentiles, and are therefore within the historical range.

- Nutrients - Phosphorus has remained the same at Devil Canyon for both time periods, and decreased slightly at Banks over the last five years. Both phosphorus and nitrogen are higher at upstream locations such as Banks and Check 41, compared to Devil Canyon. Nitrogen levels at Check 41 are more variable compared to Devil Canyon. Nitrogen levels at Devil Canyon appear to be more variable in the last five years.

- T&O - T&O events along the East Branch and at Lake Skinner have increased in recent years, but the cause is unknown. Previous studies conducted by MWDSC have linked increased algae production potential with increasing amounts of SWP water added to Colorado River water, which may explain the increase of T&O events at Lake Skinner.

The increased TOC concentrations at Devil Canyon have required that MWDSC operate the Mills WTP with both ozone and enhanced coagulation, resulting in additional chemical and operational costs. The increased T&O events also result in additional operational and chemical costs.

Potential Actions

Recommended potential actions are to 1) study operational alternatives to enhance water quality; 2) study nutrient loading to terminal reservoirs; and 3) develop tools for better real-time monitoring and forecasting which would provide advance warning of impending treatment challenges.

CHAPTER 1

Introduction

CHAPTER 1
INTRODUCTION

The State Water Project (SWP) provides drinking water to approximately two-thirds of California's population and is the nation's largest state-built water development project. The SWP extends from the mountains of Plumas County in the Feather River watershed to Lake Perris in Riverside County. It is linked with the Central Valley Project (CVP) that extends from southern Oregon in the Sacramento River watershed to the Mendota Pool. The watershed of the SWP is vast; encompassing the 27,000-square-mile Sacramento River and 13,000-square-mile San Joaquin River watersheds and at times, the 13,000-square-mile Tulare Basin watershed. There are numerous activities in the watershed that can affect drinking water quality. In addition, the watersheds of Del Valle, San Luis, Pyramid, Castaic, Silverwood, and Perris reservoirs contribute potential contaminants to the SWP system. There are also a few locations along the California Aqueduct where Coastal Range drainage enters the system during flood events. The Barker Slough watershed influences water quality for the North Bay Aqueduct (NBA), possibly to a greater extent than any other local watershed within the SWP. With a watershed of this size and complexity, the SWP watershed sanitary survey is, by necessity, more complex than sanitary surveys completed for smaller watersheds.

HISTORY OF THE SWP SANITARY SURVEY

Three sanitary surveys have been completed for the SWP. The 1990 Sanitary Survey of the SWP was the first sanitary survey conducted in the state for the California Department of Health Services (CDHS) as required by the Surface Water Treatment Rule (Brown and Caldwell, 1990). There was no guidance on how to conduct a sanitary survey and no information on what should be included. The sheer scale of the watersheds of the SWP proved daunting. As a result, the SWP Contractors worked closely with the CDHS Regional Engineers, Department of Water Resources (DWR) staff and the consultant team to develop the scope. The 1990 Sanitary Survey focused on reviewing available water quality data and providing an inventory of contaminant sources in the Sacramento, San Joaquin, and Tulare watersheds and along the aqueducts, with minimal effort on the contaminant sources in the SWP reservoir watersheds. The SWP Sanitary Action Committee, formed to follow up on the recommendations contained in the 1990 Sanitary Survey, produced the SWP Sanitary Survey Action Plan (State Water Contractors, 1994). A number of the recommendations from the 1990 Sanitary Survey were addressed between 1990 and 1996.

The 1996 Update focused on the recommendations from the 1990 Sanitary Survey and major changes in the watersheds between 1990 and 1996 (DWR, 1996). In addition, the 1996 Update provided more details on contaminant sources in the watersheds of Del Valle, San Luis, Pyramid, Castaic, Silverwood, and Perris reservoirs; the NBA Barker Slough watershed; and the open canal section of the Coastal Branch.

The 2001 Update provided more details on contaminant sources in the watersheds of the SWP reservoirs and along the aqueducts (DWR, 2001). It also contains a detailed analysis of indicator organism and pathogen data from the SWP. A major objective of the 2001 Update was to provide the SWP Contractors with information needed to comply with CDHS' Drinking Water Source Assessment Program requirements. The contaminant sources in the SWP watersheds have been well documented in the three previous sanitary surveys.

SCOPE AND OBJECTIVES OF 2006 UPDATE

A Technical Review Committee (TRC) was formed to guide development of the scope of work and provide technical expertise and review of the draft report. The TRC consists of the SWP Contractors who take water from the SWP, CDHS engineers responsible for overseeing the water systems, DWR staff, and staff from other agencies with interests in SWP water quality. Rather than simply updating all of the information from the previous three sanitary surveys, the TRC decided that this update provided an opportunity to concentrate on the key water quality issues that challenge the SWP Contractors. CDHS requested that the 2006 Update address the Jones Tract levee failure and emergency response procedures, efforts to coordinate pathogen monitoring in response to the Long Term 2 Enhanced Surface Water Treatment Rule, and a review of significant changes to the watersheds and their impacts on water quality. In the summer and fall of 2005, the TRC members worked with the consultant team to develop the scope of work for this update.

The 2006 Update focuses on evaluating the sources of the water quality problems that the SWP Contractors face and recommending actions that the SWP Contractors can take that will lead to improvements in water quality over the next five years. The objectives of the 2006 Update are to:

- Satisfy the CDHS requirements to update the sanitary survey every five years.
- Provide the information requested by CDHS.
- Highlight and focus on the SWP Contractors' key source water quality issues
- Develop an Action Plan to guide the SWP Contractors' efforts to protect and improve water quality for the next five years.

REPORT ORGANIZATION

This report is organized in the following manner:

Chapter 1 – Introduction

Chapter 2 – Regulatory Setting

This chapter contains a discussion of changes in drinking water and source water protection regulations during the five years since the 2001 Sanitary Survey Update was prepared. A summary of the California Bay-Delta Program Water Quality Program activities is also included.

Chapter 3 – Water Quality in the Watersheds and the State Water Project

This chapter addresses concerns over water quality constituents having the capacity to cause drinking water standards to be violated or to reduce the quality of drinking water supplies conveyed through the SWP. Although there are potentially numerous constituents in drinking water sources, the key water quality challenges facing the Contractors who treat water from the SWP are balancing the formation of disinfection by-products, due to high concentrations of organic carbon and bromide in the source water, with removing and inactivating pathogens such as *Giardia* and *Cryptosporidium*; high nutrient concentrations that lead to algal blooms, taste and odor problems, and operational problems; and high levels of total dissolved solids that create challenges with blending, groundwater recharge, and wastewater recycling. This chapter also contains a discussion of why methyl tertiary butyl ether is no longer a concern in the SWP and a discussion of emerging contaminants.

Chapter 4 - Key Concerns in the Central Valley Watershed and the Delta

The watersheds of the Sacramento and San Joaquin rivers and the Sacramento-San Joaquin Delta (Delta) are the primary source of water to the SWP. As the water from the tributaries to the Sacramento and San Joaquin rivers flows out of the foothills and through the Central Valley, contaminants from a variety of urban, industrial, agricultural, and natural sources affect the quality of the water, leading to drinking water treatment challenges and potential public health concerns. The key contaminant sources that are addressed in this chapter are increased wastewater and urban runoff as a result of urbanization of the Central Valley, land use changes due to ecosystem restoration activities in the Delta, agricultural crop changes in the Delta, and recreational usage of the Delta.

Chapter 5 – Key Concerns with State Water Project Facilities

Previous sanitary surveys of the SWP have documented the potential contaminant sources in the watersheds. As a result, the SWP Contractors have initiated a number of programs to improve water quality. This chapter contains a discussion of the efforts to improve water quality in the NBA, the South Bay Aqueduct (SBA), San Luis Reservoir, Castaic Lake, and Lake Perris watersheds. There is also a discussion of the water quality impacts of pumping non-project water into the California Aqueduct.

Chapter 6 – Incidents and Emergency Response Measures

In the past five years there have been a number of incidents that could potentially adversely affect water quality in the Delta and the SWP. This chapter contains a discussion of the Jones Tract Levee failure in 2004, the on-going concern over spills of untreated and partially treated wastewater in the Delta, wastewater spills in Silverwood Lake in 2005, the impacts of heavy winter rainfall and wildfires on water quality in Silverwood and Castaic lakes, and an oil spill in Pyramid Lake in 2005. Emergency response measures are evaluated to determine if water quality is appropriately considered while responding to incidents.

Chapter 7 – Concerns With System Operation and Maintenance

The SWP is a complex system that provides irrigation and drinking water to most regions of the State. As with any complex system, operation and maintenance problems are a continuous challenge. This chapter contains a discussion of the potential role sedimentation in Clifton Court Forebay plays in stimulating taste and odor (T&O) producing algae in the SBA, the potential impacts of sedimentation in forebays and storage tanks on T&O episodes in the Coastal Branch, efforts to remove urban runoff from the East Branch of the California Aqueduct (East Branch), and the impacts of increased SWP deliveries and shifts in the timing of those deliveries on water quality in the East Branch

ACTION PLAN

Each chapter of the report lists potential actions that the SWP Contractors can take to improve water quality. The TRC will consider these actions and develop an Action Plan that will be a separate companion document to the 2006 Update. The Action Plan will be a living document that will be updated as progress is made. The Action Plan will then be able to guide development of the scope of work for the next five-year update of the sanitary survey.

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CHAPTER 2

Regulatory Setting

CALIFORNIA STATE WATER PROJECT
WATERSHED SANITARY SURVEY
2006 UPDATE

CHAPTER 2
REGULATORY SETTING

This chapter contains a discussion of changes in drinking water and source water protection regulations during the five years since the 2001 Sanitary Survey Update was prepared. A summary of the California Bay-Delta Program (CALFED) Water Quality Program activities is also included.

DRINKING WATER REGULATIONS

The U.S. Environmental Protection Agency (USEPA) is responsible for implementing the Safe Drinking Water Act (SDWA). Congress passed the SDWA in 1974 and significantly amended it in 1986 and 1996. The California Department of Health Services (CDHS) is responsible for implementing the federal regulations and for developing regulations specific to protection of drinking water supplies in California. CDHS is required to adopt Maximum Contaminant Levels (MCLs) that are at least as stringent as the federal MCLs established by USEPA and are as close to the Public Health Goals (PHGs) as is economically and technically feasible. The California Office of Environmental Health Hazard Assessment (OEHHA) is responsible for establishing PHGs in California. A PHG is the level of a contaminant in drinking water that does not pose a significant risk to public health.

Several major rules have been promulgated and a number of MCLs, PHGs, and notification levels have been revised in the last five years. The highlights of the changes are discussed in this chapter. **Table 2-1** contains a list of contaminants for which revised or new MCLs and/or PHGs have been established since 2001.

FEDERAL REGULATIONS

USEPA has promulgated a number of complex rules in the last five years that have significantly affected the State Water Project (SWP) Contractors who treat water from the Sacramento-San Joaquin Delta (Delta).

Stage 1 Disinfectants and Disinfection Byproducts Rule

The Stage 1 Disinfectants and Disinfection Byproducts (D/DBP) Rule was promulgated by USEPA on December 16, 1998, along with the Interim Enhanced Surface Water Treatment Rule (IESWTR). USEPA released these two regulations together to balance the short-term microbial risk with long-term chronic risk from disinfection byproducts (DBPs). The Stage 1 D/DBP Rule applies to public water systems that are community water systems or non-transient non-community water systems. Large water systems were required to comply with the provisions of this rule by January 2002. CDHS incorporated the provisions of this rule into Title 22 in 2006.

Table 2-1. New or Revised Maximum Contaminant Levels and Public Health Goals

Contaminant	MCL	Date MCL Established	PHG	Date PHG Established
Inorganics (mg/L)				
Arsenic	0.01	2006	0.000004	2004
Asbestos	7	1994	7	2003
Barium	1	1977	2.0	2003
Beryllium	0.004	1994	0.001	2003
Cadmium	0.005	1994	0.00004	2006
Cyanide	0.15	2003	0.15	1997
Perchlorate	-		0.006	2004
Thallium			0.0001	1999
Radionuclides (pCi/L)				
Radium-226	-		0.05	2006
Radium-228	-		0.019	2006
Radium-226 +Radium-228	5	2006	-	
Strontium-90	8	2006	0.35	2006
Tritium	20,000	2006	400	2006
Uranium	20	2006	0.43	2001
Gross alpha particle activity	15	2006	[a]	
Gross beta particle activity (millirem/yr)	4	2006	[a]	
Volatile Organic Chemicals (mg/L)				
1,1-Dichloroethane	0.005	1990	0.003	2003
cis-1,2-Dichloroethylene	0.006	1994	0.10	2006
Trans-1,2-Dichloroethylene	0.01	1994	0.06	2006
Ethylbenzene	0.3	2003	0.3	1997
Monochlorobenzene	0.07	1994	0.2	2003
1,2,4-Trichlorobenzene	0.005	2003	0.005	1999
1,1,2,2-Tetrachloroethane	0.001	1989	0.0001	2003
1,1,1-Trichloroethane	0.2	1989	1	2006
1,1,2-Trichloroethane	0.005	1994	0.0003	2006
Synthetic Organic Chemicals (mg/L)				
Atrazine	0.001	2003	0.00015	1999
Di (2-ethylhexyl) adipate	0.4	1994	0.2	2003
Ethylene dibromide	0.00005	1994	0.00001	2003
Methoxychlor	0.03	2003	0.03	1999
Oxamyl	0.05	2003	0.05	1997
2,4,5-TP (Silvex)	0.05	1994	0.025	2003
Toxaphene	0.003	1994	0.00003	2003
Disinfection Byproducts (mg/L)				
Total trihalomethanes	0.080	2006	-	
Haloacetic acids (five)	0.060	2006	-	
Bromate	0.010	2006	-	
Chlorite	1.0	2006	-	
N-Nitrosodimethylamine	-		0.000003	2006

[a] OEHHA established PHGs for specific radioactive elements and did not establish PHGs for gross alpha and gross beta particle activity as these are used to trigger analyses for specific radioactive elements.

The Stage 1 D/DBP Rule requires water systems to comply with a combination of new MCLs, maximum residual disinfectant levels (MRDLs) and a treatment technique to improve control of disinfectants and disinfection byproducts. The total trihalomethanes (TTHM) MCL was reduced from 0.10 to 0.08 mg/L and a 0.06 mg/L MCL was established for the sum of five haloacetic acids (HAA5). In addition, MCLs were established for chlorite (1.0 mg/L) for plants using chlorine dioxide and bromate (0.010 mg/L) for plants using ozone. Compliance with the TTHM and HAA5 MCLs is based on the running annual average of quarterly averages of all distribution system samples. This rule also requires systems using surface water to remove specific amounts of total organic carbon (TOC) prior to adding disinfectants by implementing a treatment technique, either enhanced coagulation or enhanced softening. The percent removal required depends on the source water TOC and alkalinity. **Table 2-2** provides a summary of the removal requirements. TOC removal compliance is based on the running annual average (RAA) of quarterly averages of monthly removal ratios. The removal ratio is the ratio of the removal achieved divided by the removal required. The RAA of the removal ratios needs to equal or exceed 1.0.

Table 2-2. Percent TOC Removal Requirements

TOC (mg/L)	**Alkalinity (mg/L as $CaCO_3$)**		
	0 – 60	> 60 – 120	> 120
> 2.0 – 4.0	35.0	25.0	15.0
> 4.0 – 8.0	45.0	35.0	25.0
> 8.0	50.0	40.0	30.0

The USEPA has also provided alternative compliance criteria from the treatment technique requirements. Water systems are not required to achieve the specified TOC removals provided one of the following conditions is met:

- Source water TOC is less than 2.0 mg/L.
- Treated water TOC is less than 2.0 mg/L.
- Source water TOC is less than 4.0 mg/L, source water alkalinity is greater than 60 mg/L, and distribution system TTHM is less than 0.04 mg/L and HAA5 is less than 0.03 mg/L.
- Distribution system TTHM is less than 0.04 mg/L and HAA5 is less than 0.03 mg/L and, only chlorine is used for primary disinfection and distribution system residual.
- Source water specific ultraviolet absorbance (SUVA), prior to any treatment, is less than or equal to 2.0 L/mg-m.
- Treated water SUVA is less than or equal to 2.0 L/mg-m.

Stage 2 Disinfectants and Disinfection Byproducts Rule

The Stage 2 D/DBP Rule was promulgated by USEPA on January 4, 2006, along with the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). CDHS has not started the process to incorporate the provisions of the Stage 2 D/DBP Rule into Title 22. This rule applies to community and non-transient non-community water systems that use disinfectants other than ultraviolet light. The goal of the Stage 2 D/DBP Rule is to reduce the risk of exposure to DBPs. The rule retains the MCLs for TTHM, HAA5, chlorite, and bromate established in the Stage 1 D/DBP Rule but requires compliance at every monitoring location in the distribution system. The rule requires an Initial Distribution System Evaluation (IDSE) to identify the locations in the distribution system that have the highest concentrations of TTHM and HAA5. Most of the SWP Contractors (those serving populations greater than 100,000) were required to submit their IDSE plans by October 1, 2006. Compliance with the Stage 2 D/DBP Rule will be based on calculating a locational running annual average (LRAA), where compliance means maintaining the LRAA at each compliance monitoring location in the distribution system at or below 0.080 mg/L for TTHMs and 0.060 mg/L for HAA5. This is in lieu of the RAA calculation under the Stage 1 D/DBP Rule that allowed all distribution system samples to be averaged to determine compliance. Monitoring for the LRAA will occur at compliance monitoring locations identified in the IDSE report at specific frequencies based on population served. For systems serving more than 100,000 people, monitoring must start by April 1, 2012 and compliance with the Stage 2 MCLs must be achieved one year after monitoring is started. If capital improvements are needed to meet the MCLs, CDHS may allow an additional 24 months before compliance is required.

Interim Enhanced Surface Water Treatment Rule

The IESWTR was promulgated by USEPA on December 16, 1998. Public water systems that use surface water or groundwater under the direct influence of surface water and serve at least 10,000 people were required to comply with the provisions of this rule by January 2002. CDHS issued a Notice of Proposed Rulemaking and solicited comments by March 30, 2007. The IESWTR applies to public water systems that use surface water or groundwater under the direct influence of surface water and serve more than 10,000 people. This rule established a Maximum Contaminant Level Goal (MCLG) for *Cryptosporidium* of zero and established a treatment technique requirement of 2-log (99 percent) removal of *Cryptosporidium*. The rule provides that systems with conventional or direct filtration water treatment plants are granted the 2-log removal credit, provided turbidity requirements are met. Turbidity must be continuously monitored for all filters and the combined filter effluent turbidity must be less than or equal to 0.3 NTU in at least 95 percent of measurements taken each month. The combined filter effluent must not exceed 1.0 NTU for more than one hour. The CDHS proposed regulations require additional monitoring.

Long Term 2 Enhanced Surface Water Treatment Rule

USEPA promulgated the LT2ESWTR on January 5, 2006 to provide additional *Cryptosporidium* protection for drinking water consumers supplied from surface water sources. CDHS has not started the process to incorporate the provisions of the LT2ESWTR into Title 22. This regulation requires public water systems using surface water sources to conduct source water monitoring to determine if additional action is needed to reduce *Cryptosporidium*. Filtered systems are not required to conduct source water monitoring if the system will provide a total of at least 5.5-log of treatment for *Cryptosporidium*. Public water systems serving at least 10,000 people must sample their source water for *Cryptosporidium*, *E. coli*, and turbidity at least monthly for 24 months. The *Cryptosporidium* samples must be analyzed using either USEPA Method 1623 or Method 1622. There are specific quality assurance and quality control requirements. Starting dates for monitoring are staggered by system size. Most of the SWP Contractors were required to start monitoring in October 2006, unless they submitted previously collected data that met all of the sampling and analytical requirements of the LT2ESWTR.

Filtered water systems will be classified in one of four bins based on their monitoring results, as shown in **Table 2-3**. Systems classified in Bins 2, 3, and 4 must provide 1.0-log to 2.5-log additional treatment for *Cryptosporidium*. Systems will select from a wide range of treatment and management strategies in the microbial toolbox to meet their additional treatment requirements. The microbial toolbox contains various methods of achieving the additional treatment requirements including watershed management, pretreatment, additional treatment, and optimizing existing treatment processes. SWP *Cryptosporidium* monitoring results and SWP Contractor plans to comply with the LT2ESWTR are discussed in Chapter 3.

Table 2-3. Bin Classification and Action Requirements

Bin Classification	Maximum Running Annual Average (oocysts/L)	Action Required (log)
1	< 0.075	none
2	0.075 to < 1.0	1
3	1.0 to < 3.0	2
4	≥ 3.0	2.5

Radionuclides Rule

USEPA promulgated the Radionuclides Rule on December 7, 2000, revising earlier requirements for radionuclides for community water systems. This rule retained the previously adopted MCLs for combined radium 226 and radium 228, gross alpha particle radioactivity, and beta particle and photon activity. A new primary MCL for uranium was adopted that is less stringent than California's MCL (California's MCL was adopted in 1989). The federal rule also requires an initial monitoring program conducted quarterly for gross alpha particle activity, combined radium 226/228, and uranium. Monitoring frequency is reduced to one sample every three to nine years based on the initial monitoring results. Vulnerable community water systems must monitor for gross beta particle activity quarterly and for tritium and strontium-90 once. CDHS incorporated the provisions of this rule into Title 22 in 2006 but retained the California MCL for uranium of 20 pCi/L, required community water systems to also monitor for radium-228 and required nontransient noncommunity water systems to monitor for and comply with radionuclide MCLs. OEHHA established PHGs for four radionuclides in 2006 and had previously established the PHG for uranium. The PHGs are substantially lower than the MCLs.

Arsenic Rule

The Final Arsenic Rule was promulgated by USEPA on January 22, 2001. The rule applies to community and non-transient non-community water systems and sets an MCLG of 0 mg/L and an MCL of 0.010 mg/L for arsenic. The federal MCL has been in effect in California since January 2006. OEHHA developed a PHG for arsenic of 0.004 µg/L in 2004, based on lung and urinary bladder cancer risk. CDHS expects to propose an MCL at least as stringent as the federal MCL in early 2007. The level at which CDHS sets the arsenic MCL is important to the SWP due to the storage of surplus supplies in groundwater basins and subsequent extraction of the groundwater and conveyance in the California Aqueduct. Due to naturally occurring arsenic, groundwater in the southern San Joaquin Valley exceeds the federal MCL in some cases. The impact of groundwater inflows on water quality in the California Aqueduct is discussed in Chapter 5.

Unregulated Contaminant Monitoring Regulation for Public Water Systems Revisions

The Unregulated Contaminant Monitoring Regulation for Public Water Systems Revision (UCMR2) was published in the Federal Register on January 4, 2007. The objective of the UCMR2 is to collect data on contaminants in treated drinking water that are not currently regulated. The contaminants are listed in **Table 2-4**.

Table 2-4. Contaminants to be Monitored

Assessment Monitoring	Screening Survey
Dimethoate	Acetochlor
Terbufos sulfone	Alachlor
2,2′,4,4′-tetrabromodiphenyl ether (BDE-47)	Metolachlor
2,2′,4,4′,5-pentabromodiphenyl ether (BDE-99)	Acetochlor ethane sulfonic acid (ESA)
2,2′,4,4′5,5′-hexabromobiphenyl (HBB)	Acetochlor oxanilic acid (OA)
2,2′,4,4′,5,5′-hexabromodiphenyl ether (BDE-153)	Alachlor ethane sulfonic acid (ESA)
2,2′,4,4′,6-pentabromodiphenyl ether (BDE-100)	Alachlor oxanilic acid (OA)
1,3-dinitrobenzene	Metoloachlor ethane sulfonic acid (ESA)
2,4,6-trinitrotoluene (TNT)	Metolachlor oxanilic acid (OA)
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	N-nitroso-diethylamine (NDEA)
	N-nitroso-dimethylamine (NDMA)
	N-nitroso-di-n-butylamine (NDBA)
	N-nitroso-di-n-propylamine (NDPA)
	N-nitroso-methylethylamine (NMEA)
	N-nitroso-pyrrolidine (NPYR)

All community and non-transient non-community water systems serving more than 10,000 people and a representative sample of 800 public water systems serving 10,000 or fewer people are required to conduct assessment monitoring for ten chemicals. All public water systems serving more than 100,000 people, 320 selected public water systems serving 10,001 to 100,000 people, and 480 selected public water systems serving 10,000 or fewer people are required to conduct the screening survey for 15 contaminants. Samples must be collected quarterly between January 2008 and December 2010 at the entry point of the distribution system. The six nitrosamines must also be analyzed in samples from the part of the distribution system that has maximum residence time. These data will be used by USEPA to determine if any of these contaminants warrant regulation.

CALIFORNIA REGULATIONS

This discussion focuses on changes in California drinking water regulations that were initiated by specific concerns in the state and not required by promulgation of new federal regulations.

Review of Maximum Contaminant Levels

CDHS is required to review its MCLs at least once every five years to ensure that California MCLs are at least as stringent as federal MCLs and to determine if the MCLs are as close to the PHGs as is technically and economically feasible. In 2003 CDHS revised the MCLs for cyanide, ethylbenzene, 1,2,4-trichlorobenzene, methoxychlor, and oxamyl to be equal to the PHGs. The MCL for atrazine was reduced from 0.003 mg/L to 0.001 mg/L to be as close to the PHG as technically possible. In 2006 CDHS conducted a screening level review of all 70 contaminants for which PHGs had been established by 2005 and a detailed review of 14 contaminants (CDHS, 2006). The contaminants that received detailed review are listed in **Table 2-5**.

Table 2-5. Contaminants Reviewed in 2006

1,1-Dichloroethane	Ethylene dibromide (EDB)
1,2-Dibromo-3-chloropropane (DBCP)	Mercury
1,2-Dichloropropane	Nickel
Benzene	Tetrachloroethylene (PCE)
Beryllium	Trichloroethylene (TCE)
Cadmium	Uranium
Carbon tetrachloride	Vinyl chloride

This list was developed by eliminating any contaminant that has an MCL lower than the PHG and eliminating contaminants that had not been detected at or above the detection limit for purposes of reporting (DLR) in at least one drinking water source between 2002 and 2005. The DLR is the level at which CDHS is confident about the quantity of contaminant being reported by analytical laboratories. This screening process resulted in the 14 contaminants listed in **Table 2-5** and arsenic. CDHS staff is currently revising the arsenic MCL in response to the federal arsenic MCL. CDHS did not recommend revision of any of the MCLs due primarily to a lack of information on changes in treatment techniques, no new public health risk information, few detections in drinking water sources and the inability to set an MCL below the DLR. CDHS acknowledged that 1,2-dibromo-3-chloropropane (DBCP) was frequently detected in drinking water sources and that the MCL (0.0002 mg/L) is considerably higher than the PHG (0.0000017 mg/L) but that it is not economically feasible to reduce the MCL. OEHHA plans to review the

PHG for trichloroethylene (TCE). CDHS will review the TCE and tetrachloroethylene MCLs after OEHHA completes its assessment of the PHG for TCE. In 2006 OEHHA established PHGs for cadmium, four radionuclides, four organics, and N-nitroso-dimethylamine (NDMA). NDMA does not have a federal or state MCL. The PHGs for three organics are greater than the current MCLs so CDHS will not revise them. CDHS will have to consider revising the MCLs for the other contaminants when it conducts its next review.

Perchlorate

Perchlorate interferes with iodide uptake by the thyroid gland. Monitoring conducted in the late 1990s showed perchlorate to be a widespread contaminant in groundwater wells in southern California. It has subsequently been found in groundwater wells in other parts of the state and in the Colorado River. CDHS currently has a notification level for perchlorate of 6 µg/L. OEHHA published a final PHG for perchlorate of 6 µg/L in March 2004. The National Academy of Sciences (NAS) reviewed USEPA's 2002 Draft Toxicological and Risk Characterization for Perchlorate after OEHHA established the PHG of 6 µg/L. OEHHA scientists reviewed the NAS report and determined that there was no need to revise the perchlorate PHG (OEHHA, 2005a). CDHS proposed a draft MCL of 6 µg/L in October 2006 and closed the second public comment period on April 20, 2007. CDHS is currently reviewing comments and expects to promulgate a final MCL in 2007.

Chromium (VI)

Chromium (VI), or hexavalent chromium, has been found in groundwater supplies in California. Chromium (VI) causes acute gastritis when ingested in high doses and is an established human lung carcinogen when inhaled. There is conflicting information on its carcinogenicity when ingested. At OEHHA's request, the National Toxicology Program is conducting a study on the carcinogenicity of chromium (VI) (National Toxicology Program, 2006). Chromium (VI) is currently regulated under the 50 µg/L MCL for total chromium. OEHHA published a PHG of 2.5 µg/L for total chromium in 1999 but then withdrew the PHG in 2001 after discovering flaws in one of the studies used to support the PHG. OEHHA recommended a PHG for chromium (VI) of 0.2 µg/L, in a 2005 "pre-release" draft (OEHHA, 2005b). OEHHA will develop a PHG after obtaining the results of the National Toxicology Program study. CDHS will establish an MCL after the final PHG is established by OEHHA.

Nitrosamines

In 1998, NDMA was found in a drinking water well in the County of Sacramento and was subsequently found in other wells. It has also been found in drinking water disinfected with chlorine and chloramines. NDMA and other nitrosamines are probable human carcinogens. OEHHA established a PHG of 3 ng/L for NDMA in 2006. CDHS first established a notification level of 2 ng/L for NDMA in 1998 and then revised it to 10 ng/L in 2002. Notification levels of 10 ng/L were established in 2004 for N-Nitrosodiethylamine (NDEA) and in 2005 for N-Nitrosodi-n-propylamine (NDPA) in 2005. As discussed previously. six nitrosamines are included in the screening survey monitoring to be conducted under the federal UCMR2 Rule.

Secondary MCLs

USEPA and CDHS have established secondary MCLs for contaminants that are not health threatening but can make drinking water aesthetically unpleasing. The federal MCLs are unenforceable guidelines but the state MCLs are enforceable. An internal CDHS work group developed revisions to the secondary drinking water standards regulations to improve clarity and specify a procedure for determining compliance with the secondary MCLs. If a secondary MCL is exceeded in annual monitoring, quarterly monitoring must be conducted. Compliance is based on an average of four consecutive quarterly samples. Provisions for public notification of exceedance of secondary MCLs and for applying for a waiver of a secondary MCL are included. The revised regulations did not add any contaminants to the secondary MCL list or change any of the MCLs. The revised regulations were effective in September 2006.

Notification and Response Levels

CDHS has established health based notification levels for contaminants that have no MCLs but are thought to pose a risk to drinking water supplies. Notification levels have been established in response to detection in drinking water supplies or in anticipation of possible contamination. Chemicals for which notification levels are established may eventually be regulated by MCLs. To date, 38 of the 93 chemicals for which notification levels have been established, are now regulated by MCLs. Of the remaining 55 chemicals, 30 currently have notification levels, as shown in **Table 2-6**, and 25 are chemicals with archived advisory levels. Notification levels are calculated using standard risk assessment procedures. If a chemical is present in a water supply at a concentration that exceeds the notification level, the water system must inform its customers. If a chemical is present at the response level concentration, CDHS recommends taking the source out of service. If the drinking water system does not take the source out of service, more extensive public notification is required.

SOURCE WATER PROTECTION REGULATIONS

Protection of source water quality is a key component of the multiple barrier approach to providing safe drinking water to customers. The California State Legislature passed the Porter-Cologne Water Quality Control Act in 1969 to protect water quality throughout the state. This Act established the State Water Resources Control Board (State Water Board) and the nine Regional Water Quality Control Boards (Regional Water Boards). In 1972 Congress passed the Federal Water Pollution Control Act (now known as the Clean Water Act). The State Water Board and the nine Regional Water Boards are charged with implementing both the federal and state water quality regulations. The Central Valley Regional Water Board is responsible for protecting water quality in the Sacramento and San Joaquin basins, the source waters for the SWP, and in the Tulare Basin, which occasionally provides water to the SWP. The State Water Board adopts Water Quality Control Plans and Water Quality Policies to protect water quality throughout the state. Key plans and policies that protect drinking water source quality and recent changes in source water protection are discussed in this section.

Table 2-6. Notification and Response Levels

Contaminant	Notification Level (mg/L)	Response Level (mg/L)
Boron	1	10
n-Butylbenzene	0.26	2.6
sec-Butylbenzene	0.26	2.6
tert-Butylbenzene	0.26	2.6
Carbon disulfide	0.16	1.6
Chlorate	0.8	8.0
2-Chlorotoluene	0.14	1.4
4-Chlorotoluene	0.14	1.4
Dichlorodifluoromethane (Freon 12)	1	10
1,4-Dioxane	0.003	0.3
Ethylene glycol	14	140
Formaldehyde	0.1	1.0
HMX	0.35	3.5
Isopropylbenzene	0.77	7.7
Manganese	0.5	5.0
Methyl isobutyl ketone (MIBK)	0.12	1.2
Naphthalene	0.017	0.17
N-Nitrosodiethylamine (NDEA)	0.00001	0.0001
N-Nitrosodimethylamine (NDMA)	0.00001	0.0002
N-Nitrosodi-n-propylamine (NDPA)	0.00001	0.0005
Perchlorate	0.006	0.06
Propachlor	0.09	0.9
n-Propylbenzene	0.26	2.6
RDX	0.0003	0.03
Tertiary butyl alcohol (TBA)	0.012	1.2
1,2,3-Trichloropropane	0.000005	0.0005
1,2,4-Trimethylbenzene	0.33	3.3
1,3,5-Trimethylbenzene	0.33	3.3
2,4,6-Trinitrotoluene (TNT)	0.001	0.1
Vanadium	0.05	0.5

STATE POLICIES AND PLANS

The State Water Board adopted the San Francisco Bay/Sacramento-San Joaquin Delta Water Quality Control Plan (Bay-Delta Water Quality Control Plan). In addition, there are several policies that have been adopted by the State Water Board that must be implemented in the Sacramento and San Joaquin basins by the Central Valley Regional Water Board.

San Francisco Bay/Sacramento-San Joaquin Delta Water Quality Control Plan

The original Bay Delta Water Quality Control Plan was adopted in 1978, revised in 1991, and then substantially revised in 1995. The State Water Board made minor revisions to the 1995 Plan and adopted a new plan in 2006. The Bay Delta Water Quality Control Plan establishes water quality control measures that protect the beneficial uses of San Francisco Bay and the Delta, that require control of salinity (caused by sea water intrusion, municipal discharges, and agricultural drainage) and water project operations (flows and diversions). The plan contains specific numeric standards for Delta inflow and outflow, and standards for chloride and electrical conductance (EC) at various locations in the Delta. The California Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR) are responsible for meeting the flow objectives; salinity objectives are met through a combination of flow and salinity control measures. The State Water Board held a workshop in January 2007 to obtain more information on South Delta salinity objectives and problems associated with meeting those objectives.

Antidegradation Policy

In 1968 the State Water Board adopted Resolution No. 68-16, *"Statement of Policy With Respect to Maintaining High Quality of Waters in California,"* known as the Antidegradation Policy. Under the Antidegradation Policy, whenever the existing quality of water is better than that needed to protect existing and probable future beneficial uses, such existing high quality is to be maintained until it is demonstrated to the state that any change in water quality will be consistent with the maximum benefit to the people of the state; will not unreasonably affect present or probable future beneficial uses; and will not result in water quality less than prescribed in state policies. The effect of this policy is to define a range of water quality between natural background levels and water quality objectives that must be maintained. The policy also specifies that discharges of waste to existing high quality waters are required to use "best practicable treatment or control" to protect the high quality water.

Sources of Drinking Water Policy

In 1988 the State Water Board adopted Resolution No. 88-63, *Adoption of Policy Entitled "Sources of Drinking Water."* This policy specifies that, except under specifically defined circumstances, all surface water and groundwater of the state are to be protected as existing or potential sources of municipal and domestic supply, unless this beneficial use is explicitly excluded in a Water Quality Control Plan. The policy lists the following circumstances under which surface waters may be excluded from the municipal and domestic supply beneficial use:

- Waters with total dissolved solids (TDS) concentrations greater than 3,000 mg/L;
- Water with contamination, unrelated to a specific pollution incident, that cannot reasonably be treated for domestic use;
- Water in systems designed to collect or treat municipal or industrial wastewater, process water, mining wastes, or stormwater runoff;

- Water in systems designed for the primary purpose of conveying or holding agricultural drainage.

Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California

USEPA promulgated water quality criteria for toxic contaminants in the National Toxics Rule in 1992 and the California Toxics Rule (CTR) in 2000. The CTR covers 126 priority pollutants and includes criteria for the protection of human health and aquatic life. The human health criteria are derived for drinking water sources considering exposure from consumption of both water and fish that had lived in the water. The *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California*, adopted by the State Water Board in March 2000, establishes state policy implementing numeric toxic pollutant criteria and objectives for inland surface waters and enclosed bays and estuaries. Some of the human health criteria in the CTR are more stringent than drinking water MCLs because economics and treatment feasibility are not considered. For example, the CTR requires compliance with individual trihalomethane criteria, listed in **Table 2-7**. The result is that some dischargers, particularly those that discharge to effluent dominated waterways, have to discharge water with lower concentrations of trihalomethanes than required in drinking water. This policy has ramifications for water providers implementing recycled water programs and groundwater recharge programs.

Table 2-7. California Toxics Rule Criteria and Maximum Contaminant Levels for Trihalomethanes

THM Species[a]	Criterion (µg/L)	MCL (µg/L)
Bromodichloromethane	0.56	-
Dibromochloromethane	0.41	-
Bromoform	4.3	-
TTHM	-	80

[a] The CTR did not establish a criterion for chloroform.

CENTRAL VALLEY PLANS AND PROGRAMS

The Central Valley Regional Water Board is responsible for protecting water quality in the Sacramento, San Joaquin, and Tulare basins. In the last five years, point source dischargers have faced increasingly stringent regulations and more prescriptive National Pollutant Discharge Elimination System (NPDES) permits. The Central Valley Regional Water Board has also placed a great deal of emphasis on regulating nonpoint source discharges.

Water Quality Control Plan for the Sacramento River and San Joaquin River Basins

The Central Valley Regional Water Board adopted the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Basin Plan) in 1975, and has periodically updated the plan. The Basin Plan designates beneficial uses and water quality objectives for waters of the Sacramento and San Joaquin basins and contains an implementation plan for achieving the water quality objectives. Water quality standards consist of both the beneficial use and the water quality objectives (water quality criteria in the federal regulations) to protect the use. To protect both existing and potential future beneficial uses, water quality standards normally apply throughout the bodies of surface water and groundwater for which they were established rather than at points of current water use or withdrawal. The Basin Plan designates many waterways in the Sacramento and San Joaquin basins with the MUN (municipal and domestic supply) beneficial use. Due to the number of small streams and creeks that flow into major waterways in the Sacramento and San Joaquin basins, it is not possible to designate specific beneficial uses for each waterway. The Central Valley Regional Water Board relies on the Sources of Drinking Water Policy and the Tributary Rule to establish the MUN beneficial use for waterways not specifically mentioned in the Basin Plan. The Tributary Rule simply states that beneficial uses of a waterway apply to all tributaries of that waterway. As a result of application of the Tributary Rule, the MUN designation is applied to many small tributaries, to effluent dominated waterways, and to agricultural drains that do not support this use.

The Basin Plan for the Sacramento and San Joaquin basins contains both numeric and narrative water quality objectives to protect the MUN beneficial use, as well as other beneficial uses. Numeric objectives are established for bacteria, EC, TDS, turbidity, dissolved oxygen (DO), pH, pesticides, temperature, and trace elements. Many of the numeric objectives are specific to individual waterbodies and were established to protect aquatic life. The fecal coliform bacteria objectives were established to protect contact recreational use (REC-1), rather than drinking water (MUN). The fecal coliform objective is a 30-day geometric mean of 200 MPN/100 ml and no more than 10 percent of the samples in a 30-day period can exceed 400 MPN/100ml. MCLs established by CDHS are incorporated into the Basin Plan as numeric objectives for the protection of the MUN beneficial use. The narrative water quality objectives are listed below:

- Chemical Constituents – Waters shall not contain chemical constituents in concentrations that adversely affect beneficial uses.

- Taste and Odor – Water shall not contain taste or odor-producing substances in concentrations that impart undesirable tastes or odors to domestic or municipal water supplies or to fish flesh or other edible products of aquatic origin, or that cause nuisance or otherwise adversely affect beneficial uses.

- Sediment – The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.

- Suspended Material – Water shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.

- Toxicity – All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life.

> This objective applies regardless of whether the toxicity is caused by a single substance or the interactive effects of multiple substances.

Under current regulations, once water quality objectives are adopted into an approved Basin Plan, the Regional Board is responsible for ensuring compliance with the objectives through adoption of discharge permits and implementation of other water quality control programs. Point source discharges to surface waters, such as wastewater treatment plants and industries, are regulated under NPDES permits. NPDES permits, excluding stormwater permits, normally include effluent and receiving water limits to protect the beneficial uses of the receiving water. Urban runoff dischargers are also required to obtain NPDES permits but they are not assigned effluent limitations. Urban runoff permits generally require the discharger to implement best management practices (BMPs) to reduce pollutant loadings to the maximum extent practicable. The Central Valley Regional Water Board regulates nonpoint source discharges through waste discharge requirements (WDRs), conditional waivers, or discharge prohibitions. Nonpoint source regulation typically entails discharger implementation of BMPs to control pollutant sources. Agricultural discharges are currently regulated under a conditional waiver. More detail on the specifics of these control programs is provided in the following sections.

Wastewater Discharges

Municipal and industrial wastewater dischargers are required to obtain NPDES permits and the permits are reviewed and readopted by the Central Valley Regional Water Board every five years or whenever there is a proposed change in discharge quality or quantity that is not included within the existing permit. As described previously, the beneficial uses and receiving water objectives to protect those uses are established in the Basin Plan. The Central Valley Regional Water Board establishes effluent limitations for wastewater dischargers based on the beneficial uses and the water quality objectives of the water body that receives the discharge and the state's antidegradation policy. There are specific steps necessary to determine whether a discharge permit needs a limit for a constituent and if so, what the limit should be. To determine a permit limit the Central Valley Regional Water Board determines whether a discharge has reasonable potential to cause or contribute to an exceedance of a receiving water objective for a particular constituent or parameter, identifies the water quality objectives for the protection of the beneficial uses that have been designated for the receiving water body, and selects criteria (numerical water quality objectives or water quality goals that implement a narrative objective). The permit limit derivation procedures take into account acute and chronic aquatic life toxicity effects, human health effects, dilution, ambient background concentrations and antidegradation requirements. For drinking water constituents, if a discharge has the reasonable potential to cause an excursion above an existing objective or MCL, then the discharge permit will include a limit and requirements for monitoring that constituent. However, this process does not apply to constituents for which objectives do not already exist (for example, TOC and pathogens). If a discharge is to an ephemeral stream or a stream that the Central Valley Regional Water Board determines does not have any assimilative capacity for a contaminant, the discharger must meet the receiving water quality objectives in the effluent. If there is dilution capacity available in the receiving water, the Central Valley Regional Water Board may establish effluent limitations that allow for a mixing zone and dilution of the effluent in the receiving water. More detail on wastewater discharges in the Sacramento and San Joaquin basins is provided in Chapter 4.

Urban Runoff

In 1990 USEPA published final regulations that established stormwater permit application requirements for municipalities, specified categories of industries, and construction sites. Municipal urban runoff in the Central Valley and Delta is regulated by the Central Valley Regional Water Board through municipal separate storm sewer system (MS4) NPDES permits. These permits require large (greater than 250,000 population) and medium (100,000 to 250,000 population) municipalities to develop stormwater management plans and require large municipalities to conduct monitoring of stormwater discharges and receiving waters. The permits also require programs to control runoff from construction sites, industrial facilities, and municipal operations; eliminate or reduce the frequency of non stormwater discharges to the stormwater system; public education programs, and requirements to better control and treat urban runoff from new developments. MS4 permits require that the discharge of pollutants be reduced to the maximum extent practicable. More detail on stormwater dischargers in the Sacramento and San Joaquin basins is provided in Chapter 4.

The State Water Board has issued general NPDES permits for stormwater discharges from construction sites greater than one acre in size (General Construction Permit) and for industrial discharges (General Industrial Permit). These two permits require that the permittees prepare stormwater pollution prevention plans that identify BMPs to be implemented to control stormwater runoff. The State Water Board has also issued a statewide permit for the California Department of Transportation (Caltrans). This permit regulates stormwater discharges from all Caltrans properties, facilities, and activities.

As stated previously, stormwater permits do not generally contain numeric effluent limitations because the State Water Board determined that it was not feasible to develop effluent limitations for stormwater due to the episodic nature of storm events and variable quality of stormwater. In 2005 the State Water Board convened an expert panel to revisit the issue of numeric effluent limits for stormwater permits. The panel concluded that it is not feasible to set numeric effluent limits in municipal permits however, requirements for better designed and maintained management practices could be included in permits. In addition, the panel recommended setting action levels for contaminants which are clearly above the normal variability in runoff quality to alert stormwater managers to areas that should be investigated. The panel concluded that numeric effluent limitations are feasible for large construction sites and some industries.

Agricultural Discharges

The Central Valley has over seven million acres of irrigated cropland. Discharges of irrigation water and stormwater runoff from agricultural fields were largely unregulated until the Central Valley Regional Water Board adopted the Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands (Agricultural Waiver) in December 2002. Agricultural dischargers are allowed to comply with the Agricultural Waiver by joining a coalition group or filing for an individual waiver. Alternatively, they can file a Report of Waste Discharge and seek coverage under WDRs. In June 2006, the Central Valley Regional Water Board adopted a new waiver that will expire on June 30, 2011. The key components of the Agricultural Waiver are discussed in the following paragraphs.

Coalition Groups

Although several large water districts opted to apply for individual waivers, most growers have joined coalition groups. There are eight coalition groups that cover agricultural areas of the Central Valley and one commodity specific (rice) coalition group. One issue that has plagued the Agricultural Waiver Program is that the coalition groups have relatively low participation by growers in some areas. The Central Valley Regional Water Board voted in June 2006 to require coalition groups to submit lists of their members and set a deadline of December 31, 2006 to join a coalition group. Prior to the deadline, Central Valley Regional Water Board staff estimated that 3.8 million acres were covered by the coalition groups. Central Valley Regional Water Board staff and the coalition groups conducted a major outreach effort during the fall of 2006 and there was a significant increase in growers contacting the Central Valley Regional Water Board in December. The Central Valley Regional Water Board set a deadline of February 15, 2007 for the coalition groups to provide updated information on their members and the number of acres of irrigated land included in their coalition. Coalition groups are required to provide updated information on July 31 of each year for the duration of the Agricultural Waiver.

Monitoring Program

The Agricultural Waiver requires coalition groups to monitor agricultural drainage for a variety of constituents, including TOC, TDS, nutrients, and bacteria during the irrigation season and during storm events. A Technical Issues Committee consisting of various stakeholders was formed to work with Central Valley Regional Water Board staff on modification to the monitoring program. The modifications will be considered at a Central Valley Regional Water Board meeting in the summer of 2007.

Water Quality Exceedances

The Agricultural Waiver requires agricultural dischargers to meet water quality objectives in receiving waters but the Waiver states that the Central Valley Regional Water Board does not expect that all applicable water quality standards will be achieved in the five-year period covered by the Agricultural Waiver. They do expect that compliance with the requirements of the Agricultural Waiver will lead to actions on the part of the agricultural community that will lead to achieving water quality objectives. When a water quality objective is exceeded, the coalition group is required to file various reports with the Central Valley Regional Water Board. If a water quality objective is exceeded more than once in three years, the coalition group must submit a management plan. Numerous management plans are in various stages of development due to exceedances of objectives for pesticides, TDS, and bacteriological contaminants. The management plan must evaluate the effectiveness of existing management practices in achieving applicable water quality objectives, identify additional actions, including different or additional management practices or education outreach that the coalition group and/or its participants propose to implement to achieve applicable water quality objectives, and identify how the effectiveness of those additional actions will be evaluated.

Long-term Program

The Central Valley Regional Water Board is currently developing a long-term program for regulating agricultural discharges in the Central Valley. The Central Valley Regional Water Board has contracted with Jones & Stokes to assist with development of the long-term program and the environmental documentation for the program. An Existing Conditions Report was released in February 2006 (Jones & Stokes, 2006). This report is a first step towards describing the existing regulatory setting, surface and groundwater conditions, and management practices within the Central Valley Region, and it will serve as a foundation to develop alternatives for a long-term water quality regulatory program to address discharges from irrigated agriculture.

Confined Animal Facilities

Confined animal facilities are defined as any place where cattle, calves, sheep, swine, horses, mules, goats, fowl, or other domestic animals are corralled, penned, tethered, or otherwise enclosed or held and where feeding is by means other than grazing. Until January 2003, most confined animal facilities in the Central Valley operated under a 1982 conditional waiver of waste discharge requirements. The conditional waiver expired on December 31, 2002. The Central Valley Regional Water Board adopted a General Order that serves as Waste Discharge Requirements (WDRs) for existing milk cow dairies on May 9, 2007 and intends to develop regulatory programs for other types of confined animal facilities in the future. The key requirements of the General Order are discussed in the following paragraphs.

Background

There are approximately 1600 milk cow dairy operations in the Sacramento, San Joaquin, and Tulare basins. The General Order defines dairy waste as "manure, leachate, process wastewater, and any water, precipitation or rainfall runoff that comes into contact with raw materials, products, or byproducts such as manure, compost piles, feed, silage, milk, or bedding." Waste generated at dairies is stored dry in piles or in liquid form in waste retention ponds. The wastes are then applied to cropland or transported off-site for utilization on cropland as a nutrient source. Dairy wastes contain high concentrations of nutrients (organic nitrogen, ammonia, phosphorus, and potassium), organic carbon, salts, and pathogens. Although the waste materials provide nutrients to crops, they can create nuisance conditions if improperly managed or cause degradation of surface waters and groundwater.

Discharge Prohibitions

The General Order requires protection of both surface water and groundwater quality. To protect surface water quality, the General Order prohibits discharges of: (1) waste and/or stormwater to surface water from the production area, (2) wastewater to surface water during or following application to cropland, (3) stormwater to surface water from the land application area where manure or process wastewater has been applied, unless the land application has been managed consistent with a certified nutrient management plan. To protect groundwater quality, the General Order requires: (1) management of manure to prevent leaching of nutrients to groundwater, (2) reconstruction of waste storage ponds that have impacted groundwater quality, and (3) elimination of cross connections that would allow backflow of wastewater into a water supply or irrigation well. The General Order also prohibits discharges that cause or contribute to exceedances of water quality objectives in surface water and groundwater.

Monitoring

The General Order requires monitoring of discharges, surface water, groundwater, stormwater, and tailwater for general physical characteristics, nutrients, TDS, and bacteria.

Reports

The General Order requires each dairy to submit annual reports demonstrating that they are taking specific steps toward complying with all terms and conditions of the General Order within five years. Each dairy must also submit a waste management plan, a nutrient management plan, and a salinity report to demonstrate that they have adequate waste containment to prevent discharges to surface water, have adequate flood protection to comply with state regulations, can operate and maintain their facilities in compliance with the General Order, and can manage their waste applications to land application areas in a manner that will minimize or eliminate the transport of nutrients to surface water.

Aquatic Pesticides

The use of aquatic pesticides, such as copper sulfate to control algae, is regulated under the Statewide General NPDES Permit for the Discharge of Aquatic Pesticides for Aquatic Weed Control in Waters of the U.S, adopted by the State Water Board in May 2004. In November 2006, USEPA adopted a regulation that adds pesticide application to waters of the U.S. to the list of discharges that do not require NPDES permits. It is uncertain if the State Water Board will rescind the General Permit in response to the USEPA regulation. The State Water Board's chief counsel has recommended that the permit not be rescinded, pending judicial review of the USEPA regulation as a result of a suit filed by a number of environmental organizations. Permittees can file a Notice of Termination to terminate coverage under the General Permit or continue coverage until the State Water Board determines if any action is needed.

Total Maximum Daily Loads

The Clean Water Act section 303(d) requires that states develop a list of waters that are not attaining water quality standards and that they develop total maximum daily loads (TMDLs) for each constituent that results in the exceedance of a standard. The TMDLs generally consist of a maximum allowable load of a water quality constituent that will allow the water quality standard to be met. The load is allocated to both point and non-point sources contributing to the water quality standard exceedance. TMDLs have been established for cadmium, copper, zinc, diazinon, chlorpyrifos and mercury in various reaches of the Sacramento River Basin. In the San Joaquin Basin, TMDLs have been established for dissolved oxygen (DO), selenium, diazinon, chlorpyrifos, salt, and boron. The Central Valley Regional Water Board is currently developing a general pesticide TMDL for the Sacramento and San Joaquin basins, and additional mercury, DO, pathogen, diazinon, and chlorpyrifos TMDLs. A TMDL for nutrients in Clear Lake has been adopted by the Central Valley Regional Water Board and will be considered by the State Water Board in the next few months. The TMDLs for drinking water constituents addressed in this sanitary survey are briefly described.

San Joaquin River Salt and Boron TMDL

The Central Valley Regional Water Board adopted a TMDL for salt and boron in the San Joaquin River in 2004. The TMDL was adopted by the State Water Board in 2005 and by the USEPA in February 2007. This TMDL requires that the existing water quality objectives for EC of 700 µS/cm during the irrigation season and 1,000 µS/cm during the non-irrigation season be met in the San Joaquin River at Vernalis. The San Joaquin River Water Quality Management Group, consisting of stakeholders in the San Joaquin Basin, is working cooperatively to meet the water quality objectives. The Central Valley Regional Water Board is currently working on a TMDL for the upstream reach of the San Joaquin River between Friant Dam and Vernalis.

Clear Lake Nutrient TMDL

Clear Lake drains to the Yolo Bypass, which flows into the Sacramento River in the western Delta. Blue-green algae (cyanobacteria) blooms have impaired Clear Lake for a number of years. The Central Valley Regional Water Board adopted a TMDL in June 2006 that limits the phosphorus load and establishes a target of 73 µg/L of chlorophyll a in Clear Lake. The State Water Board requested comments on the TMDL by March 19, 2007. A date has not been set for consideration of this TMDL by the State Water Board..

Stockton Urban Sloughs DO and Pathogen TMDL

The lower Calaveras River and five sloughs that drain the Stockton urban area and flow into the eastern Delta do not meet the DO and fecal coliform bacteria objectives in the Basin Plan, primarily due to the discharge of urban runoff to these waters. The Central Valley Regional Water Board staff is currently developing a TMDL for DO and fecal coliform bacteria.

Central Valley Salinity Alternatives for Long-Term Sustainability

The Central Valley Regional Water Board and the State Water Board are working collaboratively on the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) project. The goal of this effort is to develop a comprehensive salinity management program for the Central Valley. This effort was initiated in January 2006 and a background report on the salinity issues in the Central Valley was prepared in May 2006 (Central Valley Regional Water Board, 2006). The State Water Board has allocated $1 million to fund the initial work on developing the comprehensive plan.

CALFED WATER QUALITY PROGRAM

A number of state and federal agencies signed an agreement in June 1994 to coordinate their actions to meet water quality standards to protect the Delta, coordinate the operation of the SWP and Central Valley Project (CVP) more closely with environmental mandates, and develop a process to establish a long-term Bay-Delta solution to restore the ecosystem health of the Delta while improving water supply reliability, water quality, and levee stability. This agreement laid the foundation for the Bay-Delta Accord and the CALFED Bay-Delta Program (CALFED). The Accord detailed interim measures for environmental protection and regulatory stability in the Bay-Delta. CALFED is implemented by a number of state and federal agencies, with oversight and coordination by the California Bay-Delta Authority. In 2000 CALFED completed a Programmatic Environmental Impact Statement/Environmental Impact Report (EIS/EIR) and a Record of Decision (ROD) that identifies the long-term plan (preferred program alternative) and a strategy for implementing the plan (CALFED, 2000a).

The preferred program alternative consists of a through-Delta conveyance approach, coupled with ecosystem restoration, water quality improvements, levee system improvements, increased water use efficiency, improved water transfer opportunities, watershed restoration, and additional surface water and groundwater storage. The CALFED Program is structured to be implemented in stages to allow for assessment and revision of the Program. The ROD contains hundreds of actions that were to be implemented during Stage 1 of the implementation program (2000 to 2007). The following paragraphs present a summary of the Water Quality Program.

WATER QUALITY PROGRAM TARGETS

The general target of the Water Quality Program is to continuously improve Delta water quality for all uses. The specific target of the Water Quality Program is to provide safe, reliable, and affordable drinking water in a cost-effective way by achieving either:

- Average concentrations at Clifton Court Forebay and other southern and central Delta drinking water intakes of 50 µg/L bromide and 3.0 mg/L total organic carbon, or

- An equivalent level of public health protection using a cost-effective combination of alternative source waters, source control and treatment technologies.

A substantial effort has gone into defining an equivalent level of public health protection (known as ELPH). Although there is not a precise definition of how to measure ELPH, the concept is that rather than relying solely on improvements in Delta water quality, water providers will achieve overall improvement in the quality of water supplied to their customers through many actions, including Delta water quality improvement, advanced treatment technologies, blending with other sources, and exchanging Delta water for higher quality sources. Although the CALFED ROD contains actions to reduce salinity in Delta water supplies, the ROD did not adopt a numeric target for salinity.

WATER QUALITY PROGRAM ACTIONS

A Water Quality Program Plan was developed through a stakeholder-driven process over several years (CALFED, 2000b). A number of the actions called for in the Water Quality Program Plan were incorporated into the ROD. The ROD identified a number of drinking water program actions to be undertaken in Stage 1. The Water Quality Program conducted an assessment of progress toward meeting its ROD commitments in 2005 (Brown and Caldwell, 2005) and is currently conducting a comprehensive assessment of the Stage 1 program. The results from the 2005 assessment and recent discussions with CALFED staff (Personal Communication, Lisa Holm, CALFED) are summarized in this section.

- Address drainage problems in the San Joaquin Valley to improve downstream water quality – A salinity and boron TMDL and Basin Plan Amendment for the lower San Joaquin River were adopted by the Central Valley Regional Water Board in September 2004. Ten projects ($5.3 million) addressing the recycling of salts from agricultural drainage and dairy farming, and animal feeding operations have been completed or are nearing completion. Four San Joaquin salinity projects were awarded $3 million of Proposition 50 CALFED Drinking Water Quality funding and the region received $25 million of Proposition 50 Integrated Regional Water Management funds. There is also $40 million of Proposition 84 funding dedicated to San Joaquin salinity issues. This should enable significant progress toward meeting this goal.

- Implement source controls in the Delta and its tributaries – A total of 33 projects ($30 million) ranging from improving agricultural runoff impairing Delta water quality to supporting development of the Central Valley Drinking Water Policy were funded. Progress on this ROD commitment is in the early stages.

- Support the ongoing efforts of the Delta Drinking Water Council or its successor - The Drinking Water Subcommittee replaced the Delta Drinking Water Council in 2002. Efforts to date have included developing a definition of ELPH, holding a workshop on drinking water quality issues, developing regional ELPH plans for three regions, and providing a forum for stakeholder involvement in the CALFED Water Quality Program.

- Invest in treatment technology demonstrations – Four projects ($1.9 million) investigated drinking water treatment, including pH suppression to reduce bromate formation during ozonation, ion exchange resins to remove TOC, and ultraviolet light disinfection. Although CALFED determined that this ROD commitment was completed, many treatment challenges remain for agencies treating Delta water.

- Control runoff into the California Aqueduct and other similar conveyances – Eight projects ($17 million) address nonpoint source runoff into the Contra Costa Canal, the SBA, and the California Aqueduct. This ROD commitment has been completed but additional actions may be needed to improve water quality.

- Address water quality problems at the North Bay Aqueduct – Two projects ($558,000) address the water quality problems of the NBA. The NBA projects are discussed in more detail in Chapter 5.

- Study recirculation of export water to reduce salinity and improve dissolved oxygen in the San Joaquin River – A pilot study was conducted in the fall of 2004, which showed a water quality improvement in the San Joaquin River at Vernalis. This action is being considered as part of the solution to the San Joaquin Valley drainage problem. The USBR recently released a notice of preparation of an EIS/EIR for this project.

- Establish a Bay Area blending/exchange project – The Bay Area Water Quality and Water Supply Reliability Program examined the feasibility of blending or exchanging source waters among Bay Area utilities to improve water quality.

- Facilitate water quality exchanges and similar programs – The Metropolitan Water District of Southern California Water Quality Exchange Partnership Program is evaluating the feasibility of water quality exchanges with San Joaquin Valley partners and working to implement pilot projects.

- Develop and implement within two years a plan to meet all existing water quality standards and objectives for which the state and federal water projects have responsibility – DWR and USBR are responsible for meeting objectives in the Delta. The most problematic objective is south Delta EC. The USBR is developing a plan that that is scheduled for release in 2007.

Implementation of significant portions of the CALFED water quality program was delayed due to funding constraints. When the ROD was signed in 2000, the funding required for the first four years of the Water Quality Program was estimated to be $311 million. At the end of four years, approximately $78 million in project funds and $37 million in matching funds had been awarded to a number of agencies and other entities. The types of projects that have been funded have been constrained by the source of funding in many cases. Funding has come from various grant programs, each of which has specific goals and constraints so it has been difficult to fund a comprehensive program.

END OF STAGE 1 DECISIONS

The CALFED ROD requires an assessment of the Water Quality Program's progress towards meeting water quality targets by the end of 2007. This assessment, along with an assessment towards meeting ecosystem restoration goals, will be used to determine if additional conveyance facilities or water management actions are needed to meet the goals. The CALFED Water Quality Program is currently developing an assessment of drinking water quality within the CALFED solution area, to support conveyance decisions and Stage 2 priorities. DWR is preparing a summary of information on potential conveyance projects and preparing for an intensive field study in the fall of 2007. The CALFED agencies and stakeholders are also developing retrospective and prospective information on the performance of the program (performance measures.).

In June 2006, a CALFED Delta Science Panel released a report that identified six foreseeable risks to the future of the Delta: climate change, seismicity, subsidence and integrity of Delta islands, invasive species, and population growth (Mount et al, 2006). The policy implications of this report, combined with the nation's experience with the devastation of Hurricane Katrina in New Orleans, sparked a multiple resource policy effort called the "Delta Vision Process." A blue ribbon panel and stakeholder group will receive and discuss information on the many beneficial uses of the Delta, as well as the risks to these uses, and formulate a future vision for the Delta by early 2008 and an implementation plan by the end of 2008.

CENTRAL VALLEY DRINKING WATER POLICY

In the 1990s California Urban Water Agencies (CUWA) recognized that many of the constituents of concern to drinking water suppliers are not included as objectives in the Basin Plan (disinfection byproduct precursors, pathogens, nutrients) or the current objectives are not based on drinking water concerns (salinity, chloride). As a result, there is limited ability to require dischargers to monitor or control these constituents. In addition, since there are no objectives for these constituents, drinking water constituents are not considered when the Central Valley Regional Water Board develops recommendations to the State Water Board for its list of impaired water bodies (303d list) which triggers the development of TMDLs. As discussed in Chapter 4, the population of the Central Valley is rapidly increasing so there are concerns that water quality will degrade without a regulatory mechanism to control discharges of the drinking water constituents. CUWA worked with the Central Valley Regional Water Board and CALFED to include the development of a drinking water policy for the Central Valley in the CALFED ROD. As a result, the Central Valley Regional Water Board is engaged in a multi-year effort to develop a policy for protecting source water for the beneficial use of drinking water.

In 2002, the Central Valley Drinking Water Policy Work Group was formed to help Central Valley Regional Water Board staff develop and implement a work plan that describes the technical studies needed to develop a drinking water policy for the Central Valley. The work group consists of stakeholders representing drinking water, wastewater, agricultural, urban runoff, and public interests. The drinking water policy work plan lays out a comprehensive watershed-based strategy for identifying contaminant sources and cost-effective control strategies. The technical studies needed to support the policy are underway and are expected to lead to the establishment of water quality objectives for some of the constituents of concern and to the development of management practices to prevent or reduce the quantities of these constituents discharged to Central Valley receiving waters. A database was developed to compile the existing data on the drinking water constituents of concern. Conceptual models have been finalized for organic carbon and nutrients and draft conceptual models have been prepared for salinity, bromide and pathogens. The work group is working with modelers from DWR to develop an organic carbon model for the San Joaquin River and has plans to develop an organic carbon model for the Sacramento River. Efforts are underway to investigate plans, policies, and objectives established in other states and countries for the drinking water constituents of concern. The work group will work with CALFED to gather information on the costs and effectiveness of controlling the drinking water constituents in the watershed and the costs of water treatment to remove the constituents.

The ROD called for development of the policy by the end of 2004, which was an unrealistic deadline given the amount of technical work to be completed and the timeframe for adopting a Basin Plan amendment. In July 2004, the Central Valley Regional Water Board adopted a resolution supporting the need for the policy. The policy will likely be considered by the Central Valley Regional Water Board in the form of a Basin Plan amendment in 2009.

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CHAPTER 3

Water Quality in the Watersheds and the State Water Project

Water Quality in the Watersheds and the State Water Project

CALIFORNIA STATE WATER PROJECT
WATERSHED SANITARY SURVEY
2006 UPDATE

CHAPTER 3
WATER QUALITY IN THE WATERSHEDS AND THE STATE WATER PROJECT

The water quality conditions in the State Water Project (SWP) are described in this chapter. The discussion is organized to cover the following topics:

- Description of the SWP – Brief overview of the major facilities of the SWP.

- Hydrology – Since hydrology has an impact on water quality, the hydrologic conditions of the past ten years are described.

- Continuing Water Quality Concerns – The on-going concerns with levels of organic carbon, salinity, bromide, nutrients and algal growth, turbidity, pesticides, and pathogens in the SWP are described.

- Decreasing Concerns – Methyl tertiary butyl ether (MTBE) was previously identified as a major concern in SWP reservoirs; however it is no longer a concern since it has been phased out as a gasoline additive in California.

- Emerging Contaminants – A description of the issues associated with pharmaceuticals and endocrine disruptors and the status of knowledge about their presence in the SWP.

THE STATE WATER PROJECT

The SWP extends from the mountains of Plumas County in the Feather River watershed to Lake Perris in Riverside County. **Figure 3-1** shows the major features of the SWP. The Sacramento and San Joaquin rivers are the two major rivers providing water to the Sacramento-San Joaquin Delta (Delta), the source of water for the SWP.

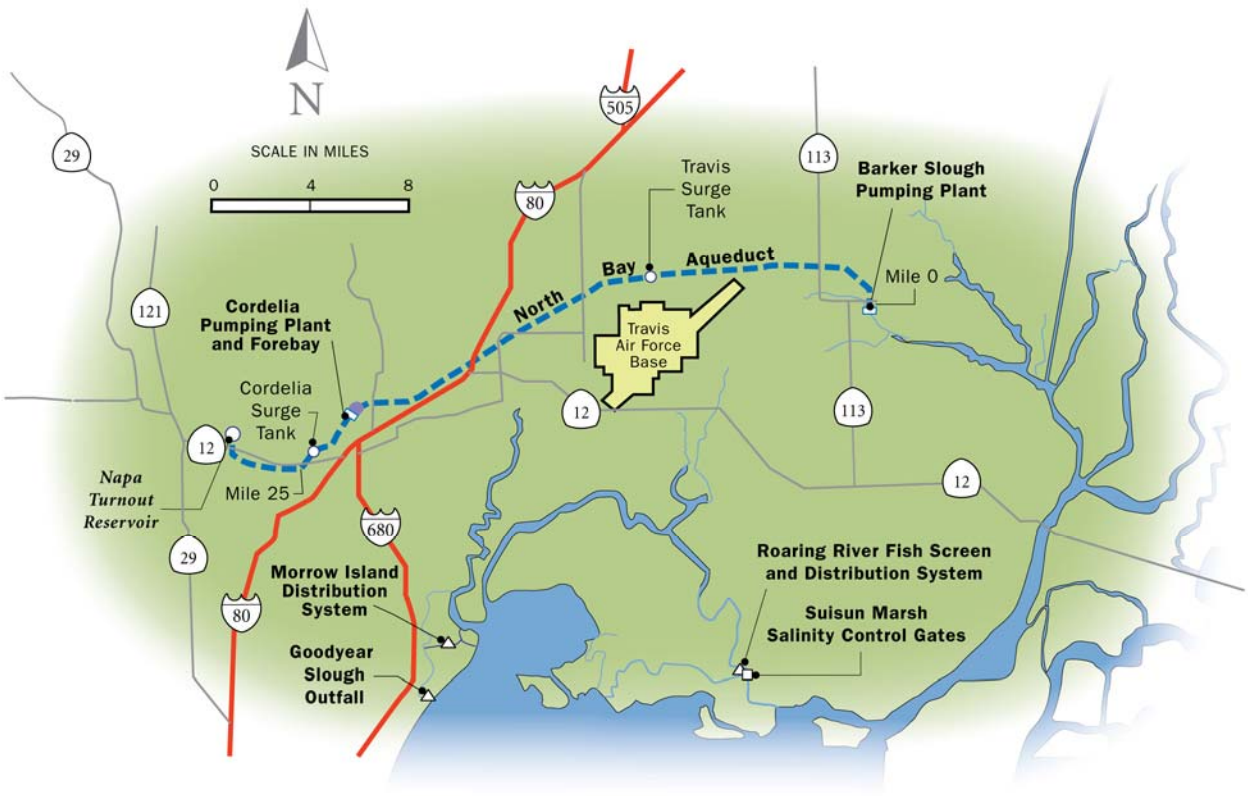
Water from the north Delta is pumped into the North Bay Aqueduct at the Barker Slough Pumping Plant, as shown in **Figure 3-2**. The sources of water to the NBA are the Sacramento River and the local watershed of Barker Slough. The NBA pipeline extends 21 miles from Barker Slough to Cordelia Forebay and Pumping Plant, and then 7 miles to its terminus at the Napa Turnout Reservoir. The NBA serves communities in Napa and Solano counties.

In the southern Delta, water enters SWP facilities at Clifton Court Forebay (Clifton Court), and flows across the forebay about 3 miles to the H.O. Banks Delta Pumping Plant (Banks), from which the water flows southward in the California Aqueduct. Water is diverted into the South Bay Aqueduct (SBA) at Bethany Reservoir, 1.2 miles downstream from Banks. **Figure 3-3** is a map showing the locations of the SBA facilities. The SBA consists of about 11 miles of open aqueduct followed by about 34 miles of pipeline and tunnel serving East and South Bay communities through the Zone 7 Water Agency of the Alameda County Flood Control and Water

Conservation District (Zone 7 Water Agency), Alameda County Water District (ACWD), and Santa Clara Valley Water District (SCVWD). Water from the SBA can be pumped into or released from Lake Del Valle at the Del Valle Pumping Plant. Lake Del Valle has a nominal capacity of 77,110 acre-feet, with 40,000 acre-feet for water supply. The terminus of the SBA is the Santa Clara Terminal Reservoir (Terminal Tank).

Figure 3-1. The State Water Project

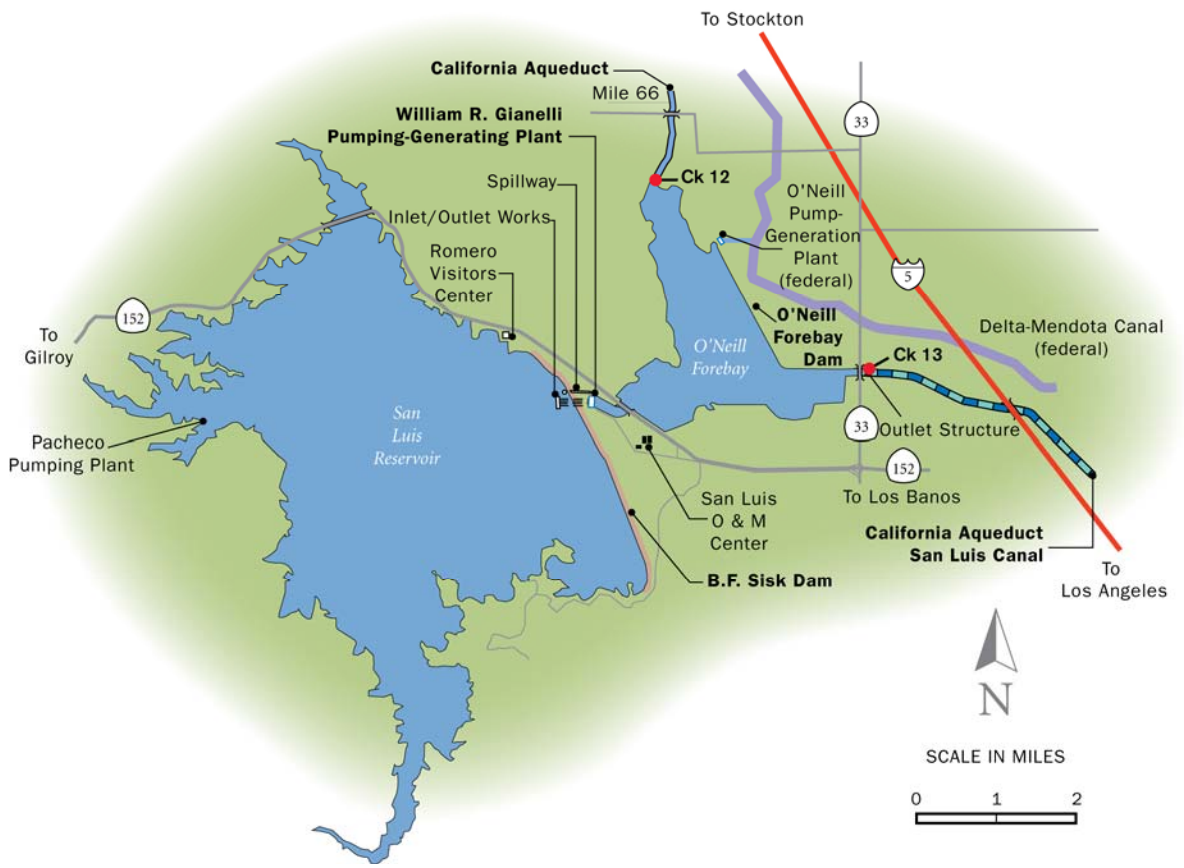
Figure 3-2. The North Bay Aqueduct



From Bethany Reservoir, water flows in the California Aqueduct about 59 miles to O'Neill Forebay. The forebay is the start of the San Luis Joint-Use Facilities, which serve both SWP and federal Central Valley Project (CVP) customers. CVP water is pumped into O'Neill Forebay from the Delta Mendota Canal (DMC). The DMC conveys water from the Tracy Pumping Plant to, and beyond, O'Neill Forebay. The O'Neill Pumping Plant, located on the northeast side of O'Neill Forebay, enables water to flow between the forebay and the DMC. San Luis Reservoir is connected to O'Neill Forebay through an intake channel located on the southwest side of the forebay. **Figure 3-4** is a location map that shows these features. Water in O'Neill Forebay can be pumped into San Luis Reservoir by the William R. Gianelli Pumping-Generating Plant or released from the reservoir to the forebay to generate power. Generally, water is pumped into the reservoir during nighttime hours when power costs are reduced, and water is usually released and power generated during the day when power demands and value are higher. San Luis Reservoir, with a capacity of 2.03 million acre-feet, is jointly owned by the SWP and CVP, with 1.06 million acre-feet being the state's share. An intake on the west side of the reservoir provides drinking water supplies to SCVWD. Water enters SVCWD facilities at Pacheco Pumping Plant (Pacheco), from which it is pumped by tunnel and pipeline to water treatment and ground water recharge facilities in the Santa Clara Valley.

Figure 3-3. The South Bay Aqueduct

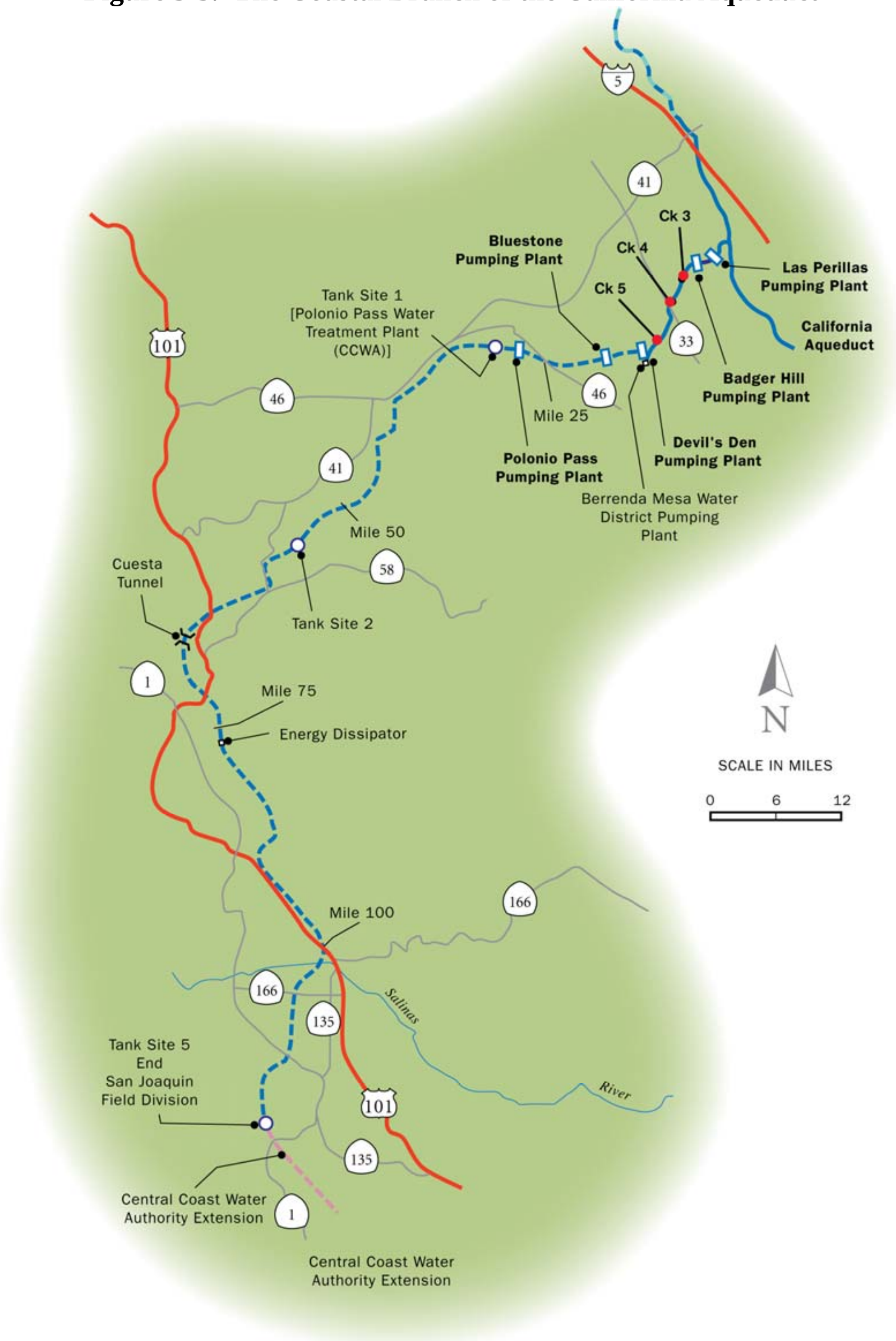
Figure 3-4. O'Neill Forebay and San Luis Reservoir



Water released from the reservoir co-mingles in O'Neill Forebay with water delivered to the forebay by the California Aqueduct and the DMC, and exits the forebay at Check 13, located on the southeast side of the forebay. Check 13 is the inception of the San Luis Canal reach of the California Aqueduct. The San Luis Canal extends about 100 miles to Check 21, near Kettleman City. The San Luis Canal reach of the aqueduct serves mostly agricultural CVP customers and conveys SWP waters to points south. Unlike the remainder of the California Aqueduct that was constructed by the state, the San Luis Canal reach was federally constructed and was designed to allow drainage from adjacent land to enter the aqueduct. This is generally not the case for the other reaches of the aqueduct.

The junction with the Coastal Branch of the aqueduct is located 185 miles downstream of Banks and about 12 miles south of Check 21. The Coastal Branch provides drinking water supplies to Central California coastal communities through the Central Coast Water Authority (CCWA). **Figure 3-5** is a map showing locations of these facilities. The Coastal Branch is 115 miles long; the first 15 miles are open aqueduct and the remainder is a pipeline.

Figure 3-5. The Coastal Branch of the California Aqueduct

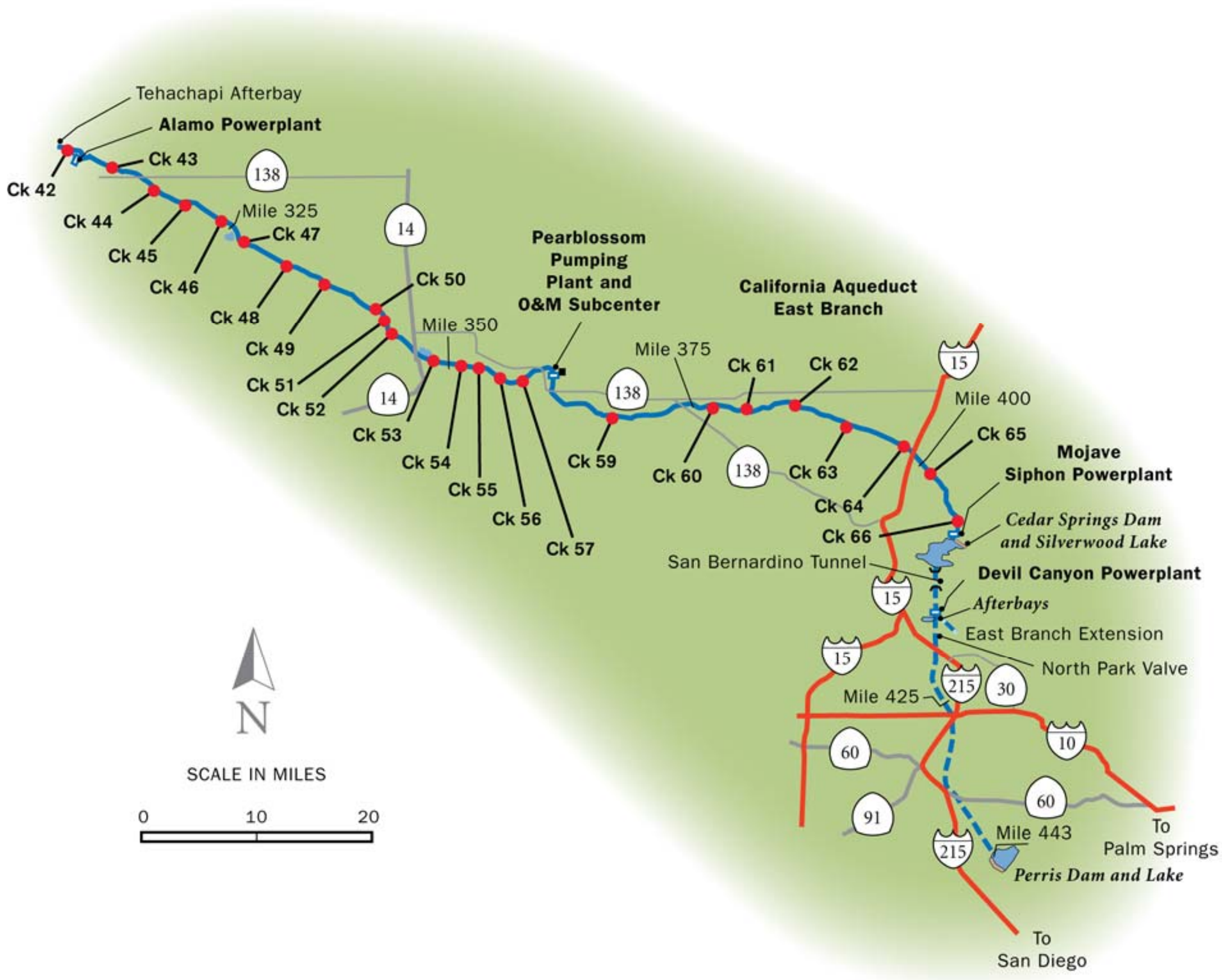


From the junction with the Coastal Branch, water continues southward in the California Aqueduct, providing water to both agricultural and drinking water customers in the service area of Kern County Water Agency (KCWA). Local streams that run eastward from the Coastal Range Mountains bisect the aqueduct at various points. During storms, water from some of these streams enters the aqueduct. The Kern River Intertie, located at Milepost 241, is designed to permit Kern River water to enter the aqueduct during periods of high flow. In the southern San Joaquin Valley, groundwater has occasionally been pumped into the aqueduct to alleviate drought emergencies. Due to increasingly scarce California water supplies, the SWP is used to convey water acquired through transfers and exchanges among local agencies. Edmonston Pumping Plant is at the northern foot of the Tehachapi Mountains, at Milepost 293. This facility lifts SWP water about 2000 feet by multi-stage pumps through tunnels to Check 41, located on the south side of the Tehachapi Mountains. About a mile downstream, the California Aqueduct divides into the West and East Branches. The West Branch flows 14 miles to Pyramid Lake, then another 17 miles to the outlet of Castaic Lake, the drinking water supply intake of the Metropolitan Water District of Southern California (MWDSC) and Castaic Lake Water Agency (CLWA). Pyramid Lake has a capacity of 171,200 acre-feet and Castaic Lake has a capacity of 323,700 acre-feet. **Figure 3-6** is a map showing locations of West Branch features.

Figure 3-6. The West Branch of the California Aqueduct

From the bifurcation of the East and West Branches, water flows in the East Branch to high desert communities in the Antelope Valley served by the Antelope Valley East Kern Water Agency (AVEK) and the Palmdale Water District. **Figure 3-7** is a map showing East Branch features. As in the southern San Joaquin Valley, groundwater from the local area has occasionally been allowed into the aqueduct to alleviate drought emergencies. On the East Branch near Hesperia, surface water drainage from part of that city enters the aqueduct during storm events. The inlet to Silverwood Lake is located on the north side of the reservoir at Milepost 406. Silverwood Lake has a capacity of 74,970 acre-feet and serves as a drinking water supply for the Crestline Lake Arrowhead Water District. Water is drawn from the south side of the reservoir and sent further south via tunnel to Devil Canyon Afterbay. Drinking water supplies are delivered to Contractors in the Riverside area from this point, and water is also transported by pipeline to Lake Perris, which is the terminus of the East Branch. MWDSC occasionally takes water from Lake Perris.

Figure 3-7. The East Branch of the California Aqueduct



DELTA HYDROLOGY

The Delta is located at the confluence of the Sacramento and San Joaquin rivers and San Francisco Bay. Water quality at the SWP export locations is greatly affected by hydrologic conditions in the Sacramento and San Joaquin basins, operations of reservoirs, and operations of the Delta Cross Channel and barriers in the South Delta. A brief overview of Delta hydrology is provided in this section to place the water quality discussion that follows in the proper context.

The two major sources of freshwater inflow to the Delta are the Sacramento and San Joaquin rivers. Additional flows come from the eastside tributaries: the Mokelumne, Calaveras, and Cosumnes rivers. The Sacramento River provides approximately 75 to 85 percent of the freshwater flow to the Delta and the San Joaquin River provides about 10 to 15 percent of the flow. Daily flows measured at Freeport on the Sacramento River are shown in **Figure 3-8** for the period of January 1996 through December 2005. This period of record was selected because water quality data from the current study period (2001 to 2005) are compared to data from the previous five years covered in the 2001 Update. During wet years, Sacramento River flows can exceed 100,000 cubic feet per second (cfs) at Freeport. An additional 400,000 to 500,000 cfs can be diverted to the Yolo Bypass, upstream of Sacramento. **Figure 3-9** indicates that the flows in the San Joaquin River at Vernalis are substantially lower than flows in the Sacramento River. Peak flows can exceed 50,000 cfs but flows are normally much lower.

Flows on the Sacramento and San Joaquin rivers are highly managed. CVP and SWP reservoirs on the rivers and their tributaries attenuate the highly variable natural flows, capturing high volume flows during short winter and spring periods and releasing water throughout the year. The California Department of Water Resources (DWR) classifies each water year based on the amount of unimpaired runoff that would have occurred in the watershed unaltered by water diversions, storage, exports, and imports. **Table 3-1** presents the water year classifications for the Sacramento and San Joaquin basins between 1996 and 2005. The period between 1996 and 2000 was characterized by wet and above normal years with high flows on the rivers, as shown previously. The 2001 to 2005 period was much drier with three dry or below normal years in the Sacramento Basin and four dry or below normal years in the San Joaquin Basin.

Table 3-1. Water Year Classifications

Water Year	Sacramento Basin	San Joaquin Basin
1996	Wet	Wet
1997	Wet	Wet
1998	Wet	Wet
1999	Wet	Above Normal
2000	Above Normal	Above Normal
2001	Dry	Dry
2002	Dry	Dry
2003	Above Normal	Below Normal
2004	Below Normal	Dry
2005	Above Normal	Wet

Source: http://cdec.water.ca.gov/cgi-progs/iodir/wsihist

Figure 3-8. Flow in the Sacramento River

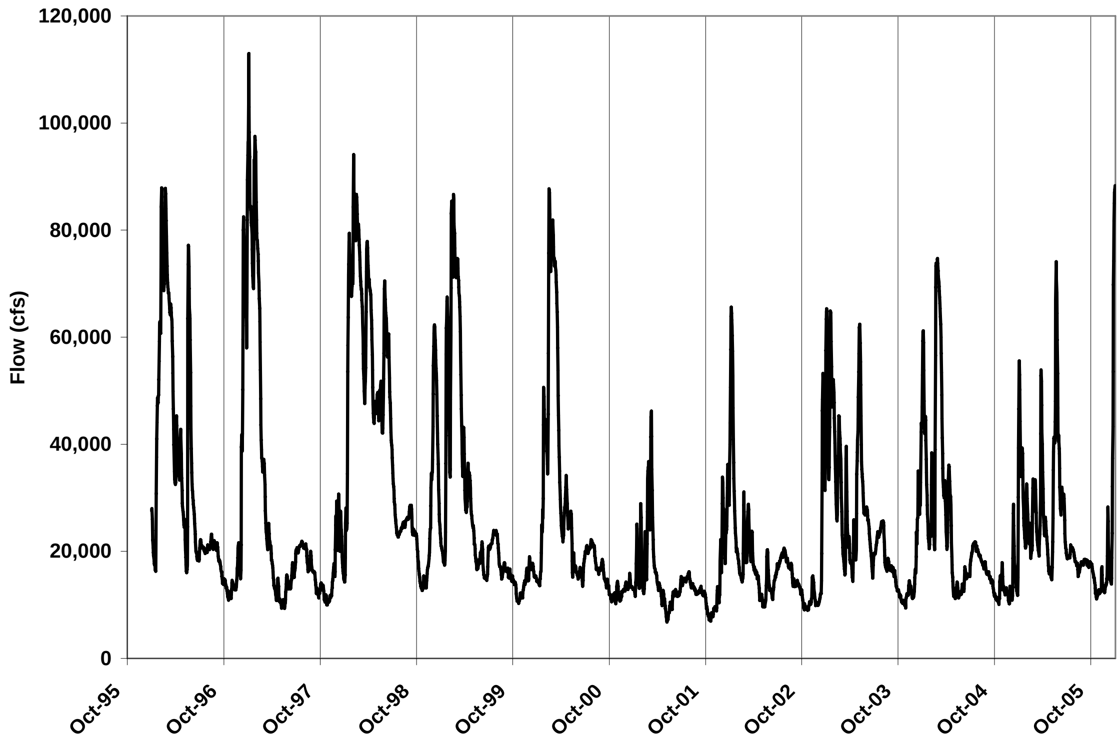
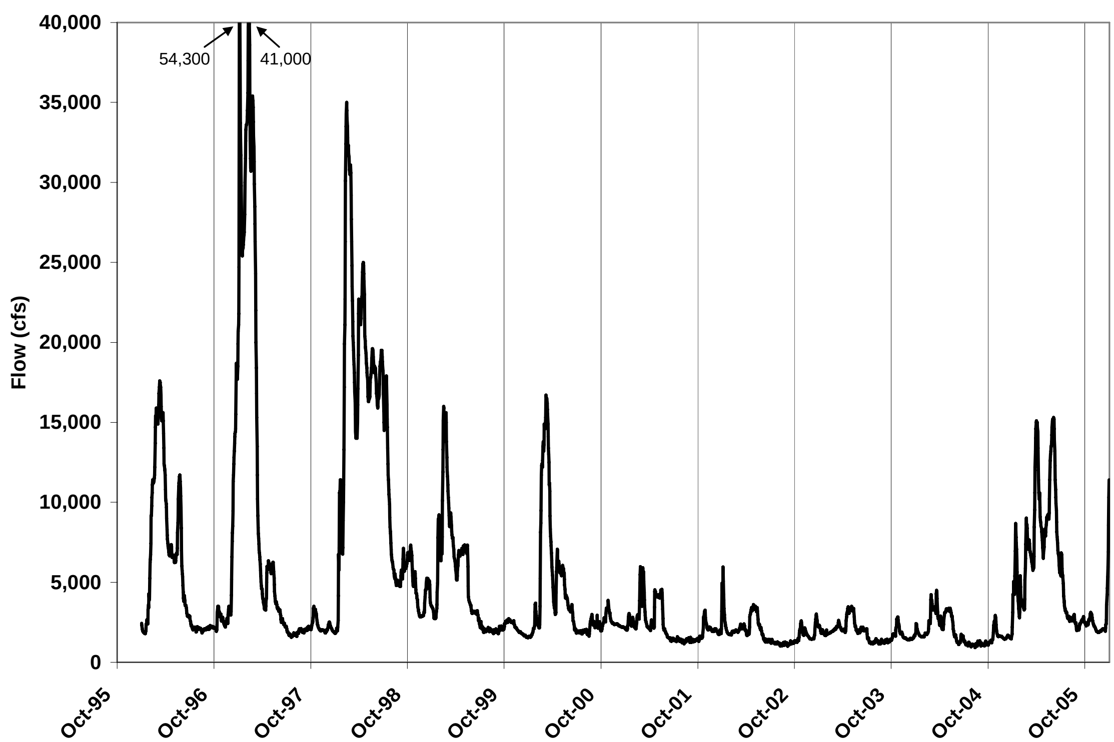
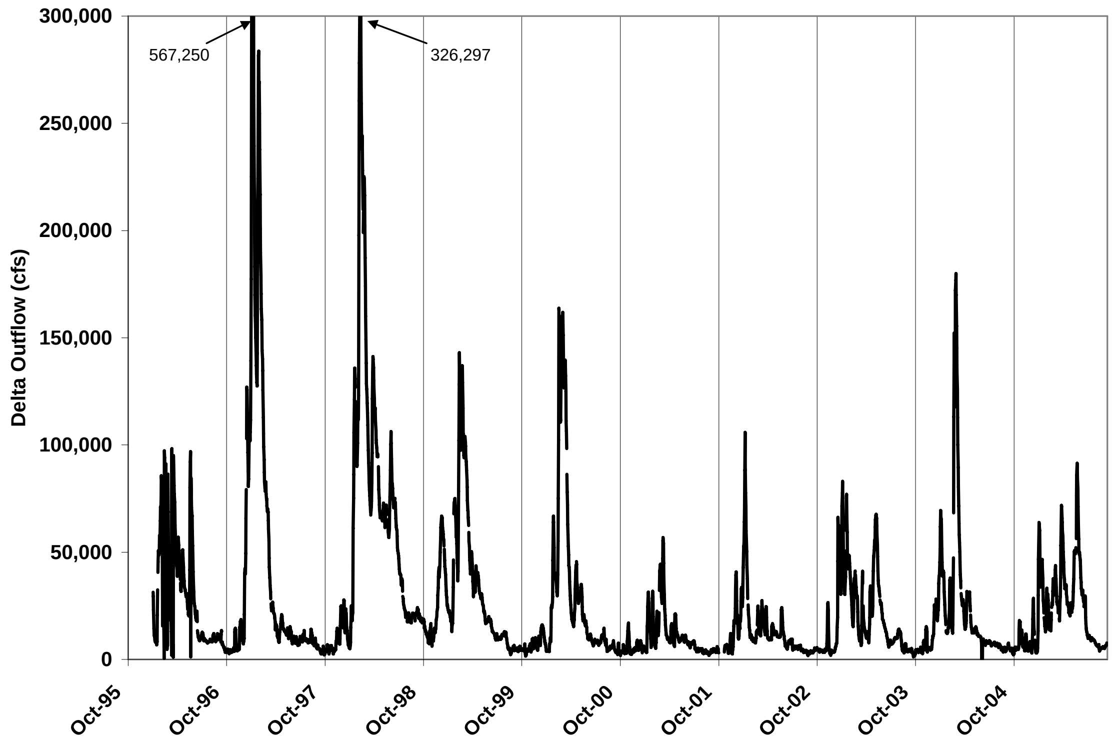


Figure 3-9. Flow in the San Joaquin River



Delta outflow, inflow that is not exported at the SWP and CVP pumps or diverted for use within the Delta, is the primary factor controlling salinity in the Delta. Except under conditions of high winter runoff, Delta outflow is dominated by tidal ebb and flood. Over the tidal cycle, flows move downstream toward San Francisco Bay during ebb tides and move upstream during flood tides. Freshwater flows provide a barrier against seawater intrusion. When Delta outflow is low, seawater can intrude further into the Delta, increasing salinity and bromide concentrations at the export locations. **Figure 3-10** shows the variable and seasonal nature of Delta outflow.

Figure 3-10. Delta Outflow



Water from the Sacramento River flows into the central Delta via Georgiana Slough and the Delta Cross Channel, which connects the Sacramento River to the Mokelumne River via Snodgrass Slough. Flows of Sacramento River water through the Delta Cross Channel improve central Delta water quality by increasing the flow of higher quality (lower salinity, lower organic carbon) Sacramento River water into the lower San Joaquin River. The Delta Cross Channel is closed at times to prevent flooding in the north Delta and to aid salmon smolt migrating down the Sacramento River.

DWR installs temporary rock barriers in south Delta channels to improve water quality in the south Delta for agricultural diversions and to aid fish migration in the San Joaquin River. These barriers reduce the amount of San Joaquin River water entering the Tracy Pumping Plant and thus affect the quality of water that enters the California Aqueduct when DMC water is pumped into O'Neill Forebay.

DWR uses results from the Delta Simulation Model 2 (DSM2) to identify the contributing sources of water volume, electrical conductance (EC), and dissolved organic carbon (DOC) at each of the Delta intakes; this technique is known as fingerprinting. The fingerprinting technique has been described by DWR (DWR, 2005). The volumetric fingerprint, which shows the relative volumes of water from various sources at Clifton Court Forebay is shown in **Figure 3-11**. This figure shows that the Sacramento River is the predominant source of water for the SWP at Clifton Court; however, during wet and above normal years in the San Joaquin Basin when flow in the San Joaquin River is relatively high, the San Joaquin River contributes more water to the SWP. The volumetric fingerprint for the Tracy Pumping Plant is shown in **Figure 3-12**. This figure clearly shows the greater influence of the San Joaquin River at the Tracy Pumping Plant. **Figures 3-11 and 3-12** also show that during the 1996 to 2000 period, the San Joaquin River contributed more water to both pumping plants than during the drier 2001 to 2005 period. The eastside streams (Cosumnes, Mokelumne, and Calaveras rivers) contribute small volumes of water (average of 5 percent) to the Delta relative to the Sacramento and San Joaquin rivers.

Seawater intrusion is represented on the fingerprints as “Martinez”; Martinez represents the western boundary of the Delta in the DSM2 model. Seawater intrusion is most significant during the fall months, when river flows are minimal. At those times, the Martinez water volume can sometimes be 2 percent of the total volume at Clifton Court. However, being seawater, that small volume can contribute significant salinity, as described later in this chapter.

Drainage from Delta islands also contributes an average of 7 percent of the water volume at Clifton Court. During the 1996 to 2005 period, the maximum contribution of water volume from agricultural drains was 25 percent. As discussed later in this chapter, due to the high concentrations of DOC in agricultural drainage, this is a significant source of organic carbon at Clifton Court.

On June 3, 2004, a levee failed on Upper Jones Tract, resulting in flooding of both Upper and Lower Jones tracts (see Chapter 6). The fingerprints show the estimated percentage of water volume at Clifton Court and Tracy that came from the flooded island, initially as the island was opened to the adjacent Delta channel and subject to tidal flow, then later as water was pumped from the island into Delta channels after the levee break had been repaired.

Figure 3-11. Volumetric Fingerprint at Clifton Court

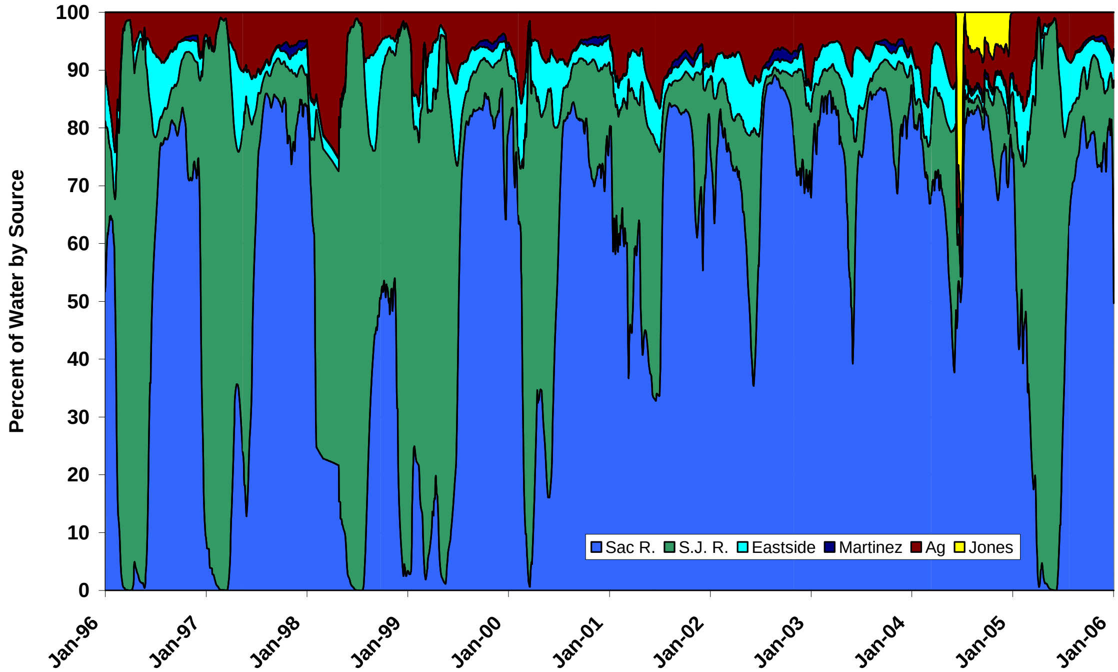
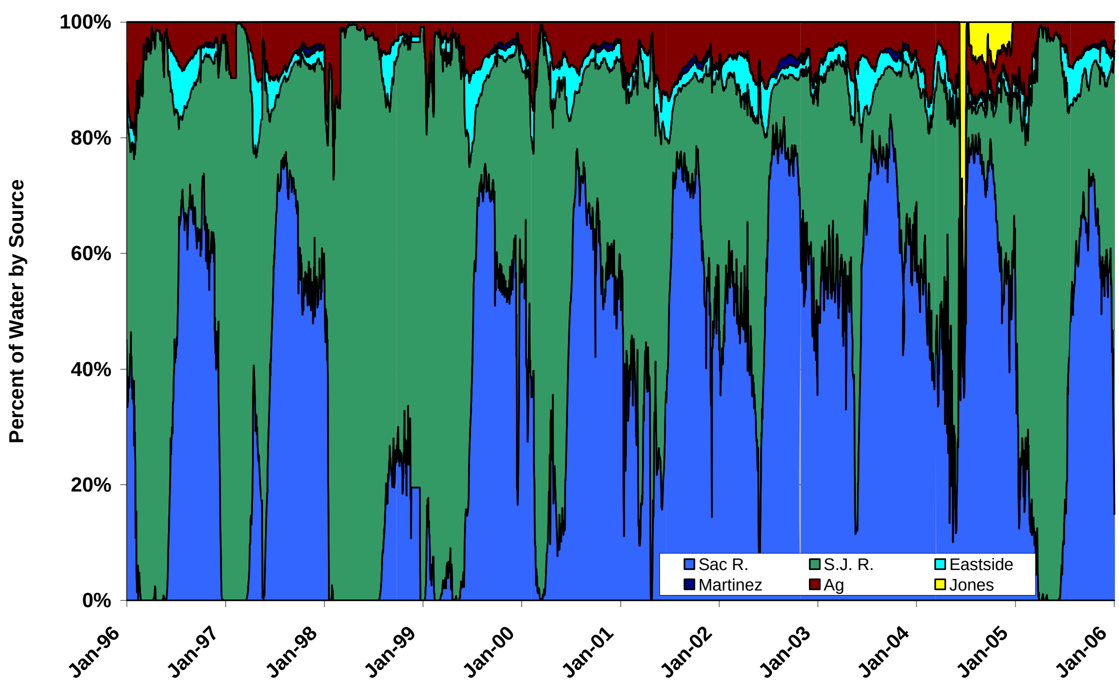


Figure 3-12. Volumetric Fingerprint at Tracy



CONTINUING WATER QUALITY CONCERNS

The Technical Review Committee (TRC) participated in establishing the scope of work for this project, including the water quality constituents to be evaluated. The TRC identified organic carbon, salinity, bromide, nutrients, turbidity, toxic trace elements, potentially harmful synthetic organic substances such as pesticides, and pathogens as the key constituents requiring evaluation. The goal of this water quality analysis is to evaluate spatial and temporal variability of the key water quality constituents to identify significant changes that have occurred in the five-year period covered by this study (2001 to 2005), and to identify potential actions that could be taken to improve source water quality in the SWP. Data from the 1996 to 2000 period were discussed in the 2001 Update. These data are compared to the data from 2001 to 2005 to determine if there have been any changes in water quality. As described in Chapter 1, more detailed evaluations of water quality in various parts of the SWP system are included in Chapters 4 through 7.

Sources of data for this chapter include flow data from the U.S. Geological Survey (USGS) and DWR, as well as discrete (grab) sample water quality data and continuous recorder water quality data from DWR monitoring stations in the Delta and SWP. **Appendix A** contains a detailed list of data used in this analysis and the period of record for each constituent. Ancillary data were supplied by the California Department of Boating and Waterways and U.S. Bureau of Reclamation. A number of SWP Contractors provided pathogen and indicator organism data. This chapter contains a discussion of data collected at numerous locations along the SWP, with varying periods of record. **Figure 3-13** shows the monitoring locations along the SWP, **Figure 3-14** shows the monitoring locations in the Delta, and **Table 3-2** provides a brief explanation of the monitoring locations that are referred to in this chapter.

Figure 3-13. SWP Monitoring Locations

Figure 3-14. Monitoring Locations in the Delta

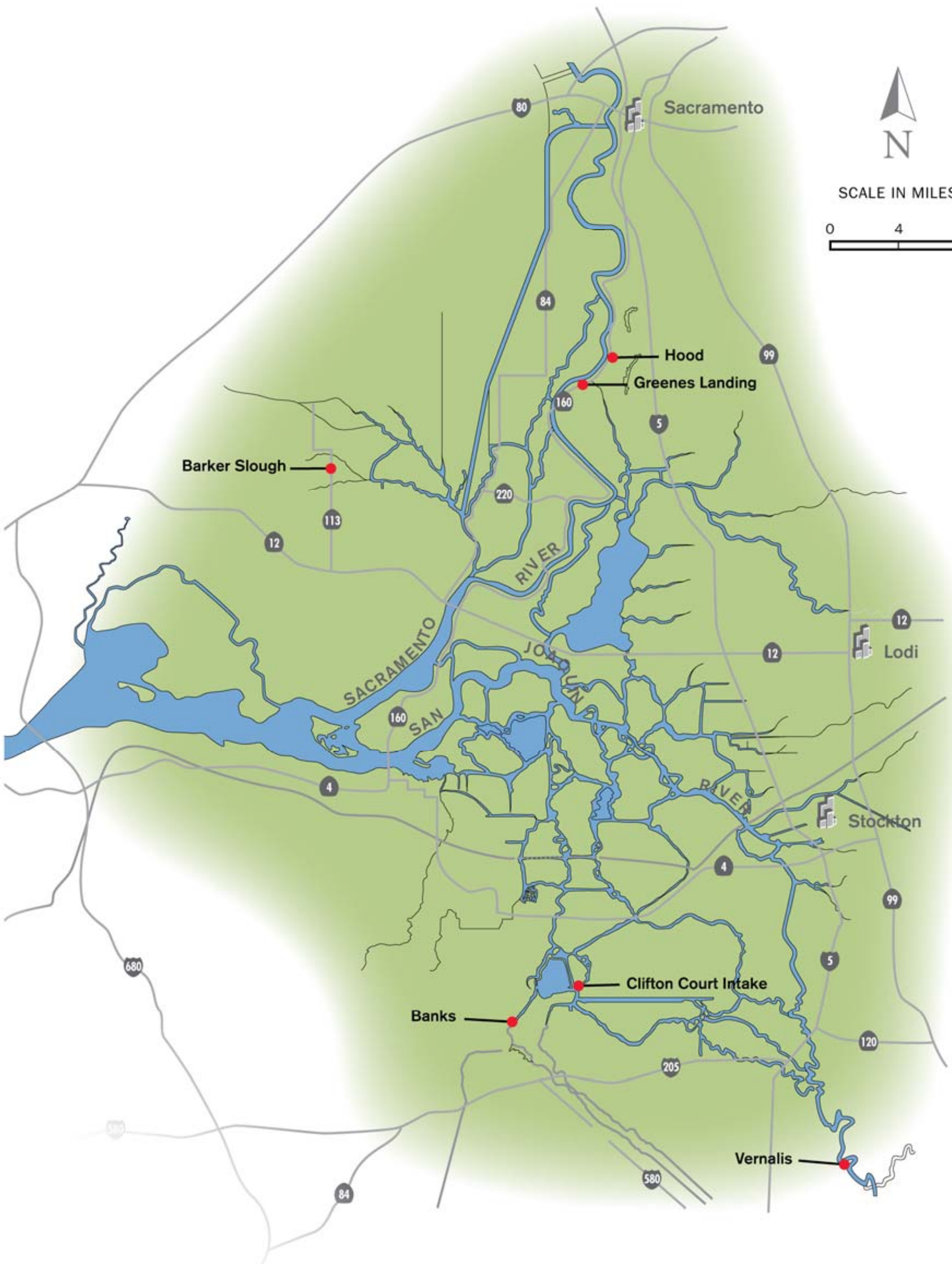


Table 3-2. Water Quality Monitoring Locations

Monitoring Location	Acronym or Abbreviated Name	Description
Sources to the Delta		
Sacramento River @ Hood	Hood	Sacramento River inflow to the Delta
San Joaquin River near Vernalis	Vernalis	San Joaquin River inflow to the Delta
North Bay Aqueduct	NBA	
Barker Slough Pumping Plant	Barker Slough	Inlet to North Bay Aqueduct (supplies Fairfield and Vacaville)
Cordelia Pumping Plant Forebay	Cordelia	Supplies Vallejo, Benicia, and Napa
South Bay Aqueduct		
Del Valle Check 7	DV Check 7	SBA upstream of Lake Del Valle
Vallecitos Turnout	Vallecitos or ACWD WTP-2	SBA downstream of Lake Del Valle
Santa Clara Terminal Reservoir	Terminal Tank	Terminus of the SBA at SCVWD intake
Delta Mendota Canal		
Delta Mendota Canal @ McCabe Road	DMC @ McCabe	DMC upstream of O'Neill Forebay at McCabe Road bridge
California Aqueduct		
Clifton Court Forebay Inlet Structure	Clifton Court Intake	Inlet to Clifton Court Forebay from Old River
Harvey O. Banks Delta Pumping Plant Headworks	Banks	Inception of California Aqueduct
Check 13	Check 13	California Aqueduct at O'Neill Forebay outlet
Check 21	Check 21	California Aqueduct at end of San Luis Canal reach. Represents water quality in Coastal Branch Aqueduct.
Check 29	Check 29	California Aqueduct 3.5 miles downstream of Kern River Intertie
Check 41	Check 41	Inlet to Tehachapi Afterbay near bifurcation of East and West Branches
Check 66	Check 66	East Branch, near Silverwood Lake inlet
Reservoirs		
Pacheco Pumping Plant	Pacheco	SCVWD intake on west side of San Luis Reservoir
Castaic Lake Outlet Tower	Castaic Outlet	Outlet to Castaic Lake on the West Branch and intake for MWDSC's Jensen WTP
Silverwood Lake at San Bernardino Tunnel	Silverwood Outlet	Outlet from Silverwood Lake via the San Bernardino Tunnel to Devil Canyon.
Devil Canyon Afterbay	Devil Canyon	Devil Canyon Afterbay, intake for MWDSC's Mills WTP
Lake Perris	Perris Outlet	Outlet to Lake Perris and intake for MWDSC, terminus of East Branch.

ORGANIC CARBON

Water Quality Concern

Organic matter in a waterbody consists of dissolved and particulate materials of plant, animal, and bacterial origins, in various stages of growth and decay. Total organic carbon (TOC) exists as particulate organic carbon (POC) and DOC and can be divided into humic and non-humic substances. Humic substances are high molecular weight compounds largely formed as a result of bacterial and fungal action on plant material and include soluble humic and fulvic acids and insoluble humin. Non-humic substances include proteins, carbohydrates, and other lower molecular weight substances that are more available to bacterial degradation than humic substances. Strong oxidants, such as chlorine and ozone, are used to destroy pathogenic organisms in drinking water treatment plants, but these oxidants also react with organic carbon compounds (primarily humic substances) present in the water to produce disinfection byproducts (DBPs).

TOC is a precursor to many DBPs. Increased levels of TOC in source waters affect DBP concentrations by increasing the amount of precursor material available to react with the disinfectant and by increasing the amount of disinfectant required to achieve adequate disinfection. According to the U.S. Environmental Protection Agency (USEPA), DBPs have been associated with an increased risk of cancer; liver, kidney and central nervous system problems; and adverse reproductive effects (USEPA, 2001a). While many DBPs have been identified, only a few are currently regulated. Concern over potential health effects of total trihalomethanes (TTHMs) and haloacetic acids (HAA5) has resulted in federal and state drinking water regulations controlling their presence in treated drinking water. As discussed in Chapter 2, the Stage 1 Disinfectants and Disinfection Byproducts (D/DBP) Rule reduced the TTHM Maximum Contaminant Level (MCL) from 100 µg/L to 80 µg/L and established an MCL for HAA5 of 60 µg/L. In addition, this rule established treatment requirements based on the concentrations of organic carbon and the levels of alkalinity in source waters, as shown in **Table 3-3**. TOC removal compliance is based on the running annual average (RAA) of quarterly averages of monthly removal ratios. The removal ratio is the removal achieved divided by the removal required. The RAA of the removal ratios needs to equal or exceed 1.0. The Stage 2 D/DBP Rule maintained the MCLs for TTHM and HAA5 but made compliance more difficult by requiring that the MCLs be met at all locations in the distribution system.

Table 3-3. Percent TOC Removal Requirements

TOC (mg/L)	Alkalinity (mg/L as $CaCO_3$)		
	0 – 60	> 60 – 120	> 120
> 2.0 – 4.0	35.0	25.0	15.0
> 4.0 – 8.0	45.0	35.0	25.0
> 8.0	50.0	40.0	30.0

Organic carbon is a concern for drinking water agencies receiving their source water through the SWP because TOC concentrations fall in the range that require action under this Rule. Based on data from discrete samples collected by the DWR Municipal Water Quality Investigations

(MWQI) Program, the average TOC concentration at Banks (the inception of the California Aqueduct), as measured by the wet oxidation method, was 3.1 mg/L during the five-year period 2001 through 2005. During the same period, total alkalinity at this location averaged 69 mg/L as $CaCO_3$. This corresponds to a requirement for 25 percent TOC removal. The average TOC and alkalinity at Barker Slough during this period was 5.8 mg/L and 97 mg/L as $CaCO_3$, respectively. At these concentrations, 35 percent removal of TOC is required. As discussed in Chapter 2, there are alternative compliance criteria but, clearly, organic carbon is currently a constituent of concern to the SWP Contractors treating SWP waters.

Water Quality Evaluation

Organic carbon can be present in source waters in dissolved and particulate forms. Although the Stage 1 D/DDP rule refers only to TOC which includes both dissolved and particulate matter, DOC is also of interest to the SWP Contractors. DOC is measured in a sample that has been filtered through a 0.45 µM filter to remove particulate matter. Therefore, measured DOC concentrations should consist of dissolved organic carbon plus any particulate matter smaller than 0.45 µM in diameter. DOC is of interest because filtration processes employed in drinking water treatment plants treating SWP waters remove most particulate matter. Therefore, DOC may be a better indicator of organic carbon that passes beyond filters and is available to form DBPs. Accordingly, this analysis includes both TOC and DOC.

The organic carbon data used in this evaluation include continuous recorder and discrete sample data from the MWQI Program and discrete sample data from the DWR Division of Operations and Maintenance (O&M) SWP Water Quality Monitoring Program (SWP WQMP). ACWD provided additional TOC data for the SBA. Continuous recorder fluorescence data were obtained from the SWP WQMP. Data are available for varying periods of record at different locations. **A** detailed list of the data used and the period of record is provided in Appendix A.

Comparison of Organic Carbon Methods

TOC analyses were performed by the DWR laboratory beginning in 1983, using a wet oxidation method. Beginning in 1989, DOC analyses were performed using the wet oxidation method on filtered samples. In November 2000, a new combustion method came into use. The combustion method is thought to result in a more complete oxidation of organic carbon, as TOC concentrations measured by this method are consistently higher than TOC measured by the wet oxidation method. **Figure 3-15** compares DOC and TOC concentrations in samples collected at Banks from September 2003 to December 2005. This figure demonstrates that DOC and TOC analyses, measured with the wet oxidation method, are similar. Mean TOC for this period of record was 3.3 mg/L and mean DOC was 3.2 mg/L. Median TOC and DOC concentrations were also similar, with median TOC equal to 3.0 mg/L and median DOC equal to 2.9 mg/L, indicating that most organic carbon present at Banks is in dissolved form, as measured by the oxidation method. **Figure 3-15** shows that TOC concentrations measured using the combustion method are somewhat higher, indicating the combustion and oxidation methods may not produce comparable data. Mean and median TOC measured by combustion were 3.6 mg/L and 3.4 mg/L, respectively.

Figure 3-15. Comparison of Organic Carbon Methods with Discrete Samples at Banks

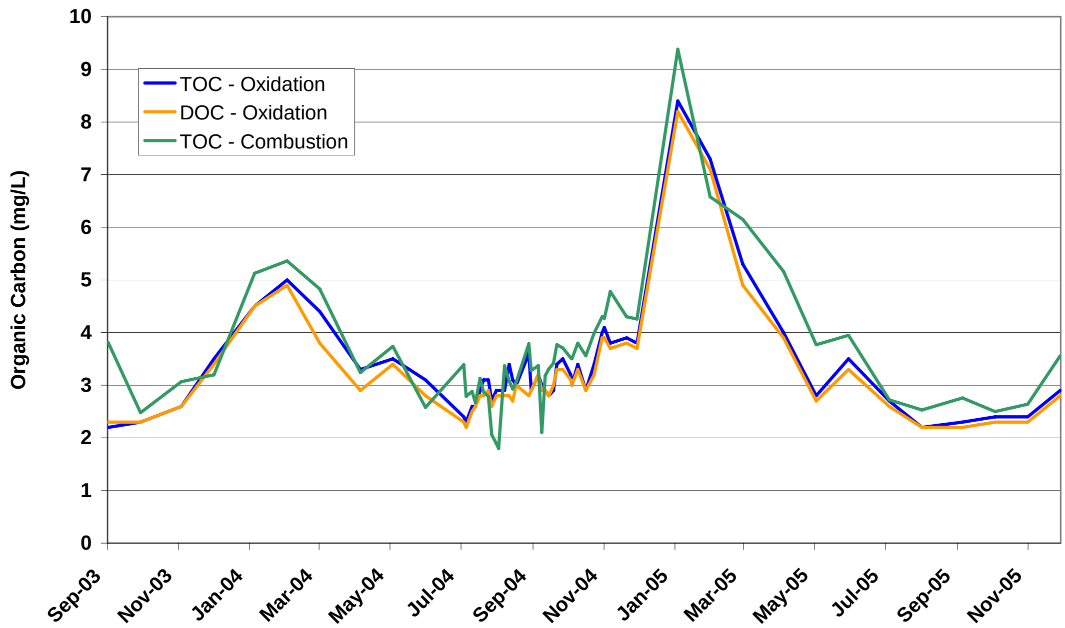
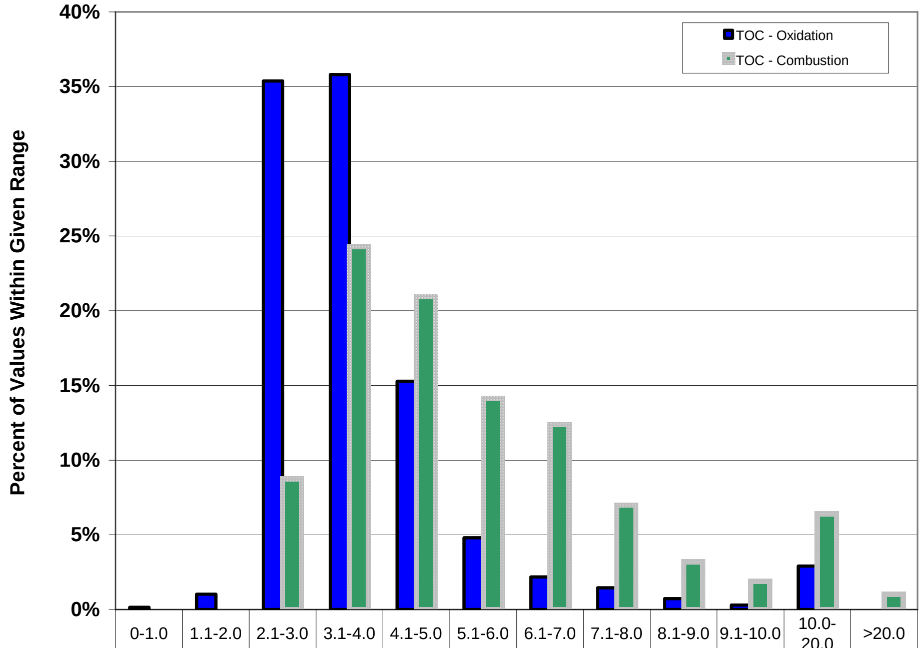


Figure 3-16 presents a frequency histogram of the results from 687 samples collected from a number of locations in the SWP between 2000 and 2005, and analyzed by both methods. TOC was most frequently detected between 2 and 4 mg/L with the wet oxidation method and between 3 and 5 mg/L with the combustion method, clearly demonstrating a tendency for the combustion method to produce higher results.

In addition to collecting discrete samples at Banks and analyzing them for TOC and DOC, DWR also measures TOC and DOC continuously using automated equipment employing the combustion method. **Figure 3-17** depicts TOC and DOC concentrations from September 2001 when the auto-sampler was installed through 2005. TOC and DOC track closely together (r = 0.91). As measured by the automated equipment, TOC averages 4.1 mg/L and DOC averages 3.6 mg/L, a 12 percent difference. Median concentrations of TOC and DOC were 3.8 mg/L and 3.3 mg/L, respectively.

There is, as yet, no clear consensus on whether the oxidation or combustion method produces the more useful information, or whether DOC or TOC is more useful. Therefore, DOC and TOC continue to be measured using both the oxidation and combustion methods, in anticipation that further experience will demonstrate which methodology best predicts organic carbon behavior in drinking water treatment processes.

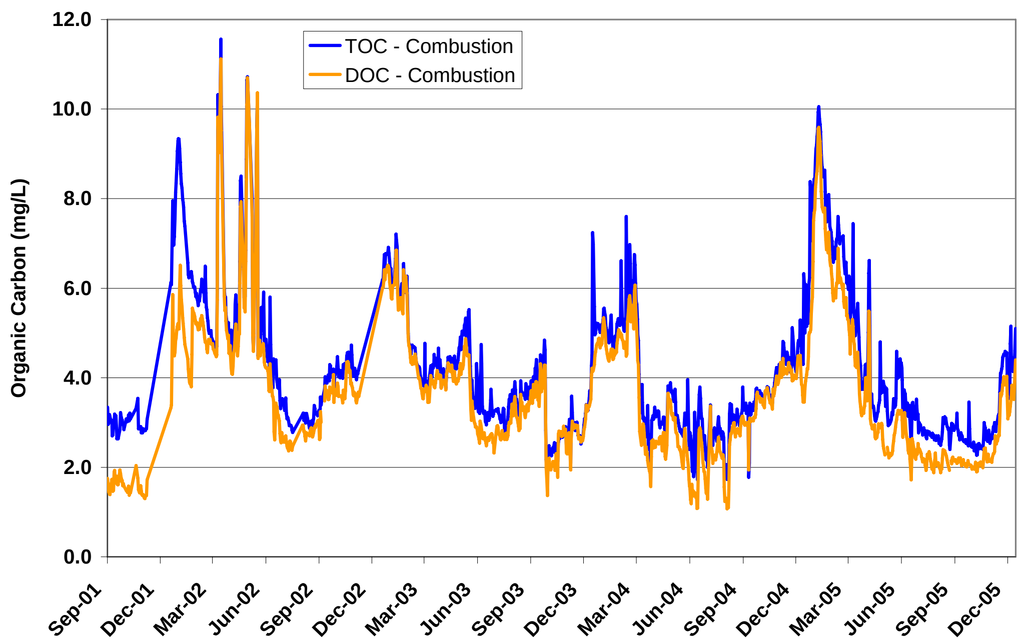
Figure 3-16. Comparison of Organic Carbon Methods with Discrete Samples in the SWP



	0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	9.1-10.0	10.0-20.0	>20.0
TOC - Oxidation	0%	1%	35%	36%	15%	5%	2%	1%	1%	0%	3%	0%
TOC - Combustion	0%	0%	9%	24%	21%	14%	12%	7%	3%	2%	6%	1%

TOC Range (mg/L)

Figure 3-17. Auto-Sampler TOC and DOC Concentrations at Banks



Organic Carbon Fingerprints

DWR uses the fingerprinting method to identify the sources of DOC at Clifton Court and the Tracy Pumping Plant. The DOC fingerprints for the 1996 to 2005 period are shown in **Figures 3-18 and 3-19**. These figures show that the three primary sources of DOC at the south Delta pumping plants are the Sacramento and San Joaquin rivers and Delta agricultural drainage. During wet years when flows on the San Joaquin River are high, most of the DOC at the pumping plants comes from that river. During dry years, the Sacramento River has more influence on DOC concentrations at the pumping plants. **Figure 3-19** also shows the greater influence of the San Joaquin River on water quality at the Tracy Pumping Plant. In the summer of 2004 water pumped off of Jones Tract, after the levee break was repaired, added to the DOC concentrations at the pumping plants. The water quality impacts of the Jones Tract incident are discussed in Chapter 6.

Organic Carbon Concentrations in the SWP

Organic carbon data are analyzed in this section to examine changes in concentrations as the water travels through the SWP system and to determine if there have been any changes over time. Data from the 2001 to 2005 time period are compared to data from the previous five years. All available organic carbon data from January 2001 through December 2005 were obtained for a number of locations along the SWP to evaluate changes in organic carbon concentrations as the water travels from the source waters to the Delta and through the SWP. **Figure 3-20** depicts the spatial distribution of TOC concentrations, measured in discrete samples by the wet oxidation method, at various locations in the system. TOC data are not available for the Terminal Tank. Percentile rankings are presented because these are typically less affected by extremes and often provide a better indication of central tendency than means and standard deviation. TOC data produced by the wet oxidation method are analyzed and presented in this section because the period of record is longer than for TOC measured by the combustion method. Unless otherwise indicated, discrete sample data are discussed in this section.

Sources of Water to the Delta

Data from the Sacramento River at Hood (Hood) were used to represent the quality of water flowing into the Delta from the Sacramento River and data collected in the San Joaquin River near Vernalis (Vernalis) were used to represent the San Joaquin River inflow. **Figure 3-20** indicates that TOC concentrations are lower in the Sacramento River than the San Joaquin River. The median TOC measured at Hood during the 2001 to 2005 study period was 1.9 mg/L, compared to 3.8 mg/L at Vernalis.

Figure 3-18. DOC Fingerprint at Clifton Court

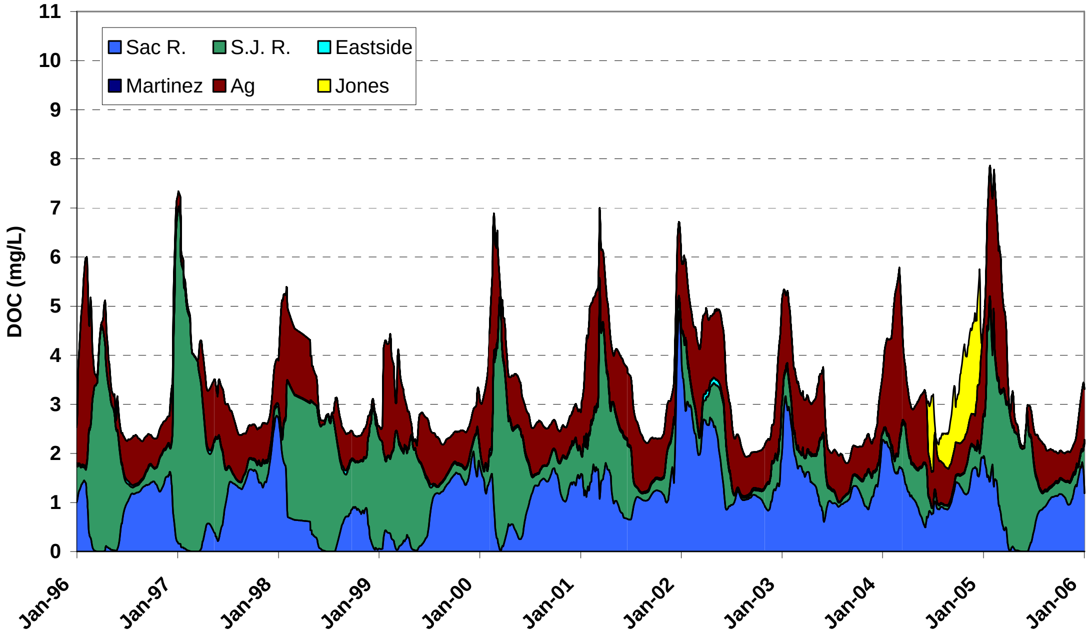


Figure 3-19. DOC Fingerprint at Tracy

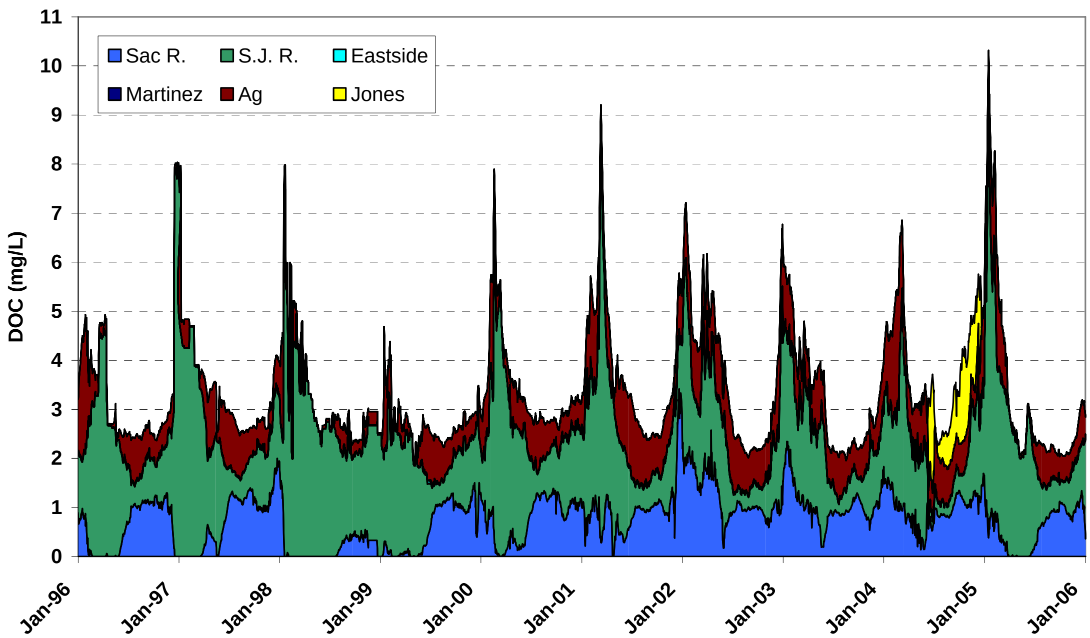


Figure 3-20. TOC Concentrations in the SWP

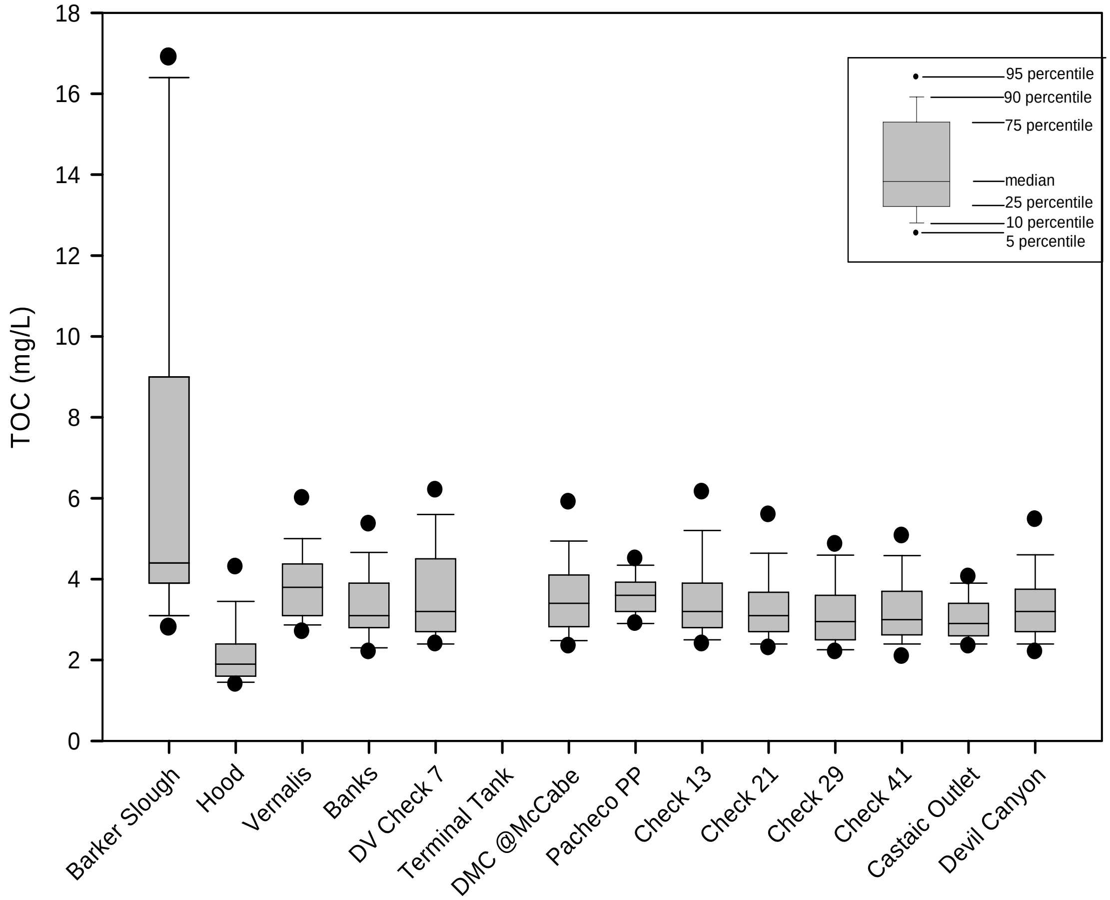


Figure 3-21 presents the available TOC data for the 1996 to 2005 period for Hood and **Figure 3-22** presents the data for Vernalis. Both the discrete sample data and the continuous recorder data are shown on these figures. **Figure 3-23** shows the monthly mean concentrations for the 2001 to 2005 period at these two locations. There is a strong seasonal pattern in the Sacramento River with TOC concentrations generally below 2 mg/L during the dry season and peak concentrations of 4 to over 6 mg/L during most wet seasons. During the dry season, high quality water is released from upstream reservoirs to maintain flows in the river. During the wet season, runoff from undeveloped, agricultural, and urban areas is discharged to the river resulting in higher TOC concentrations. The seasonal pattern is somewhat different on the San Joaquin River. TOC concentrations are highest during the wet season, with peaks of 7 to 8 mg/L in most years. Concentrations decline during the early spring months to about 3 mg/L, increase to 4 to 5 mg/L in the summer, and then drop back to around 3 mg/L in the fall. Surface runoff from the watershed is responsible for the wet season peaks, while the probable cause of the dry season peaks is the discharge of agricultural drainage to the river. During the summer months, flows in the San Joaquin River are low, generally below 2,000 cfs, so there is minimal dilution of agricultural drainage.

Figure 3-21. TOC Concentrations at Hood

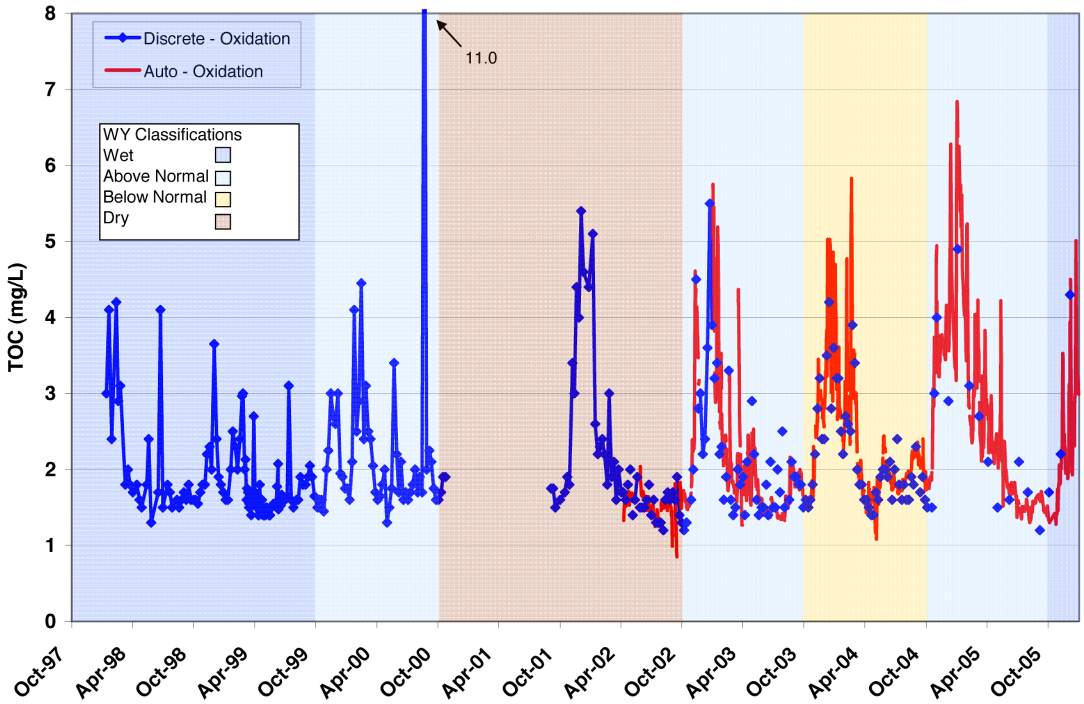


Figure 3-22. TOC Concentrations at Vernalis

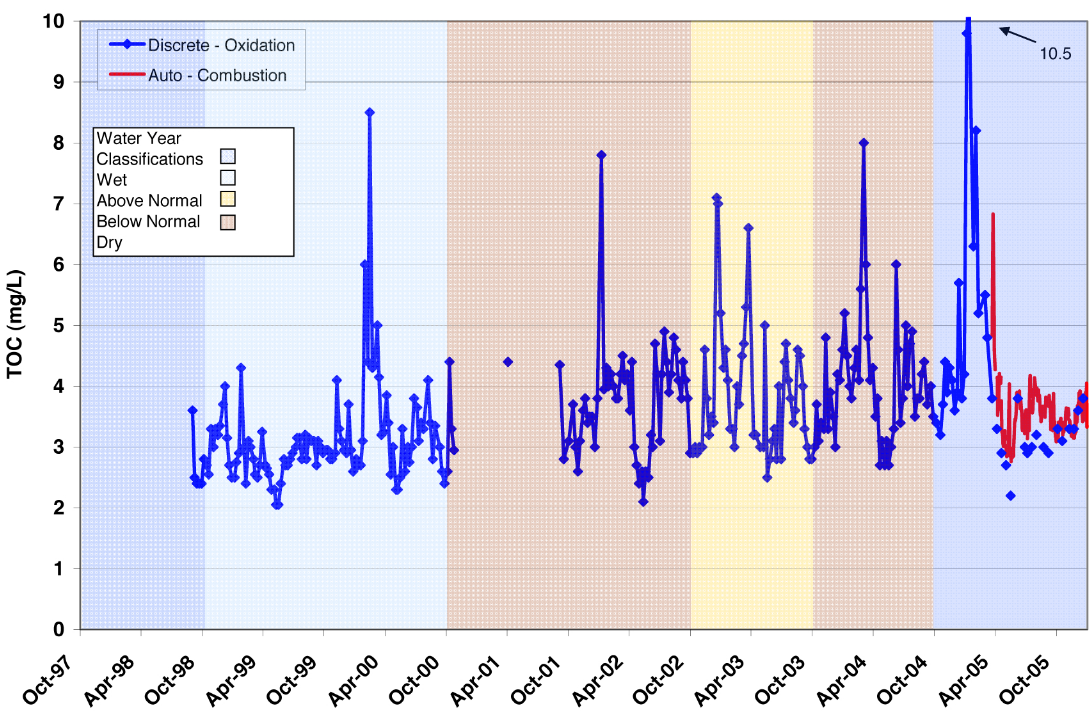


Figure 3-23. Monthly Mean TOC Concentrations at Hood and Vernalis

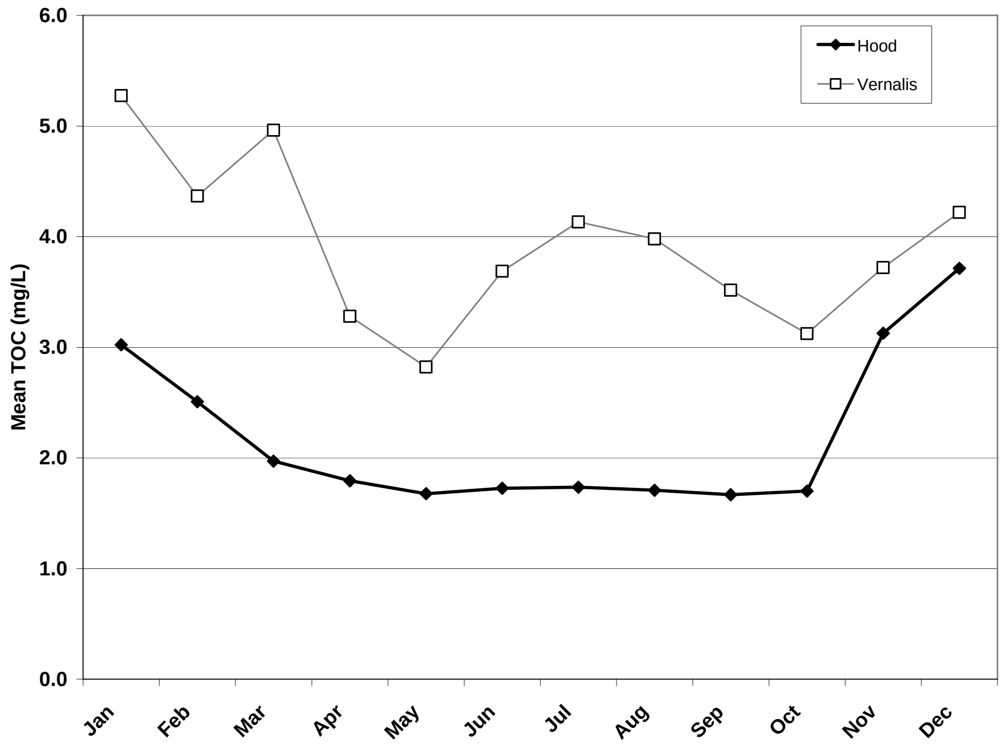


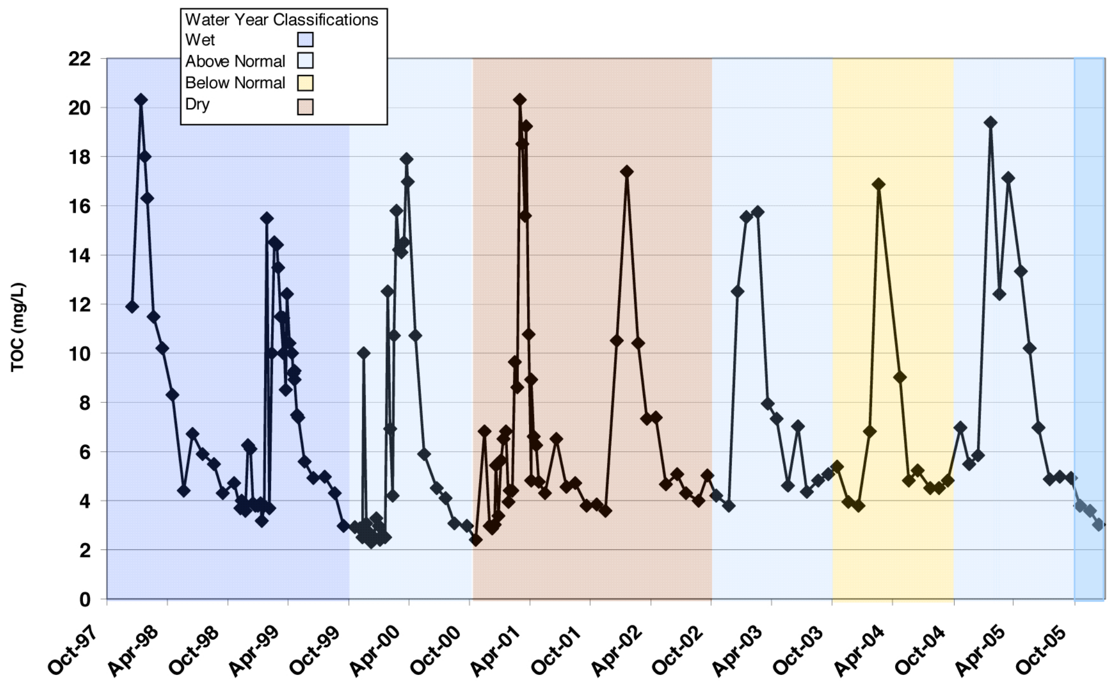
Figure 3-21 compares the discrete sample oxidation data to the auto-sampler oxidation data at Hood. These data show the same strong seasonal pattern but the peak concentrations during the wet season are generally higher with the auto-sampler data, as would be expected with more frequent data collection. **Figure 3-22** compares discrete sample oxidation data to the auto-sampler combustion data at Vernalis because there isn't an oxidation method auto-sampler at Vernalis. There is less than a year of data to compare but the same general pattern is seen in both data sets. Apart from seasonal fluctuations, no longer term trends in TOC concentrations are apparent at Hood and Vernalis.

<u>North Bay Aqueduct</u>

As shown in **Figure 3-20**, Barker Slough has substantially higher and more variable TOC concentrations than other SWP locations. The median TOC concentration at Barker Slough during the 2001 to 2005 period was 4.4 mg/L. The Sacramento River is the primary source of water to the NBA but the local Barker Slough watershed contributes a great deal of TOC during the wet months.

Figure 3-24 shows sharp TOC concentration increases at Barker Slough during the wet season; typically 14 mg/L to 20 mg/L during the study period. This pattern appears to be relatively insensitive to hydrology, as the seasonal fluctuations tend to be similar in dry and wet years. No discernable change in this pattern is seen in the 1998 to 2000 period compared to the 2001 to 2005 period of this study.

Figure 3-24. TOC Concentrations at Barker Slough

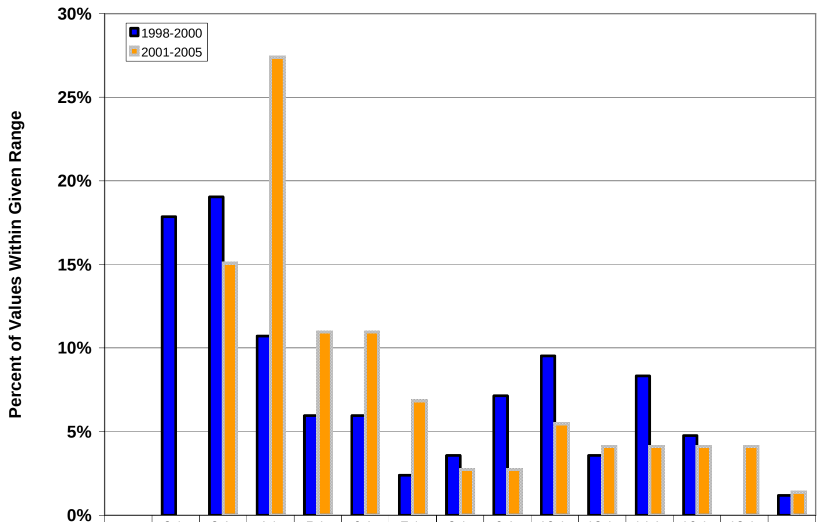


A frequency histogram of TOC at Barker Slough is presented as **Figure 3-25**. During the 2001 to 2005 period the most frequently measured TOC concentrations were between 3.0 mg/L and 5.0 mg/L, whereas during the 1998 to 2000 period, TOC was most frequently detected between 2.0 and 4.0 mg/L. This apparent difference may be due to the fact that data were collected more frequently between 1998 and 2000 as part of the Barker Slough watershed studies. During the last eight years, DWR and the North Bay Aqueduct (NBA) Contractors have conducted a detailed evaluation of the watershed. The results are discussed in Chapter 5.

Banks Pumping Plant

Although the Sacramento River is the primary source of water diverted through Banks into the SWP system, TOC concentrations at Banks (median of 3.1 mg/L) are substantially higher than Hood concentrations (median of 1.9 mg/L) due to inflow from the San Joaquin River, discharges from Delta islands, and possibly primary productivity in the channels of the Delta. **Figure 3-26** compares the available continuous TOC monitoring data (combustion method) and the longer-term TOC discrete data (oxidation method) from Banks. This figure shows a clear seasonal pattern with minimum concentrations of about 2 to 3 mg/L in the late summer and wet season peaks. The discrete sample data produce peaks of about 8 mg/L whereas the continuous monitoring data indicate that the peaks can be as high as 11 mg/L. Some of the difference may be attributed to the different methods and to field instrumentation calibration problems in the first two years.

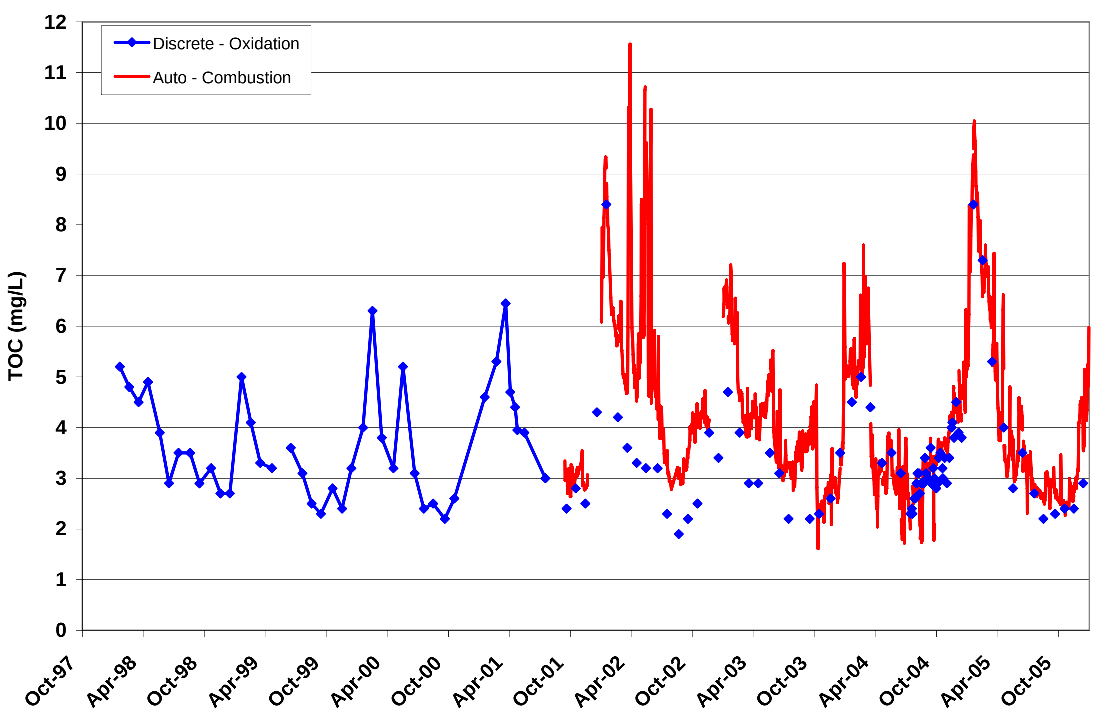
Figure 3-25. Comparison of Study Period to Prior Years at Barker Slough



	0-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	9.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	>20
1998-2000	0%	18%	19%	11%	6%	6%	2%	4%	7%	10%	4%	8%	5%	0%	1%
2001-2005	0%	0%	15%	27%	11%	11%	7%	3%	3%	5%	4%	4%	4%	4%	1%

TOC Range (mg/L as C)

Figure 3-26. TOC Concentrations at Banks



However, this figure clearly shows how peaks can be missed with infrequent discrete samples. During the period of January to March 2004 the peak TOC concentrations measured with the auto-sampler were missed completely with the discrete monitoring. The highest concentrations during the 1998 to 2005 period of record occurred in 2002 (a dry year in both basins) and in 2005 (an above normal year in the Sacramento Basin and a wet year in the San Joaquin Basin). In 2002, the primary source of water at Banks was the Sacramento River while in 2005 the primary source was the San Joaquin River (see **Figure 3-11**). Peak TOC concentrations at Hood in 2002 were about 5 mg/L (see **Figure 3-19**) while peak TOC concentrations at Vernalis in 2005 were about 10 mg/L. These data illustrate the complex interactions between hydrology and water quality in the Delta.

South Bay Aqueduct

Figure 3-20 shows that median TOC concentrations at Del Valle Check 7 (DV Check 7), located just upstream of the Del Valle Branch Pipeline, where Lake Del Valle water is released into the SBA, and Banks are similar (3.2 mg/L and 3.1 mg/L, respectively). A time-series plot of TOC at DV Check 7 is shown in **Figure 3-27.** Additional TOC data were available for the intake to ACWD's Water Treatment Plant No. 2 (WTP-2), located downstream of the Del Valle Branch Pipeline connection. **Figure 3-28** compares monthly mean TOC concentrations at Banks, DV Check 7 and the ACWD WTP-2. TOC concentrations in the SBA show the same seasonal trend as Banks with the highest concentrations during the wet months and the lowest concentrations during the summer. Although water is released from Lake Del Valle between DV Check 7 and ACWD WTP-2, there is no apparent difference in TOC concentrations between these two locations. Lake Del Valle receives runoff from the local watershed in addition to Delta water pumped into the lake. There are limited TOC data available for Lake Del Valle. Based on 10 samples collected in 2004 and 2005 from the Conservation Outlet Works station at the base of the dam, the median TOC is 4.2 mg/L. Since data from this location represent water that is being released from the lake and SBA water that is being pumped into the lake, the actual TOC concentrations in Lake Del Valle can't be determined without examining the pumping records. Since there are only data for ten dates, this was not done.

Delta Mendota Canal

Water from the DMC is pumped into O'Neill Forebay and mixes with water from Banks. Between 2001 and February 2005, the period that operations data were available, water pumped into O'Neill Forebay from the DMC made up 34 percent of the water flowing down the California Aqueduct at Check 13. The DMC at the McCabe Road Bridge (DMC @ McCabe) reflects the quality of DMC water pumped into O'Neill Forebay. The median TOC during the 2001 to 2005 period was 3.4 mg/L. The median concentration at Banks during this time period was 3.1 mg/L, indicating a 10 percent difference in TOC concentrations between DMC and SWP water sources during the study period. TOC in the DMC @ McCabe is shown in **Figure 3-29.** Concentrations range from about 2 to 10 mg/L, the higher values being in wet months. There is considerable variability among water years, but the limited available data do not suggest a strong relationship with water year type. The highest measured concentrations were in January 2002 and January 2005, the former being a wet year in the Sacramento and San Joaquin basins, while the latter peak occurred during drier conditions.

Figure 3-27. TOC Concentrations at DV Check 7

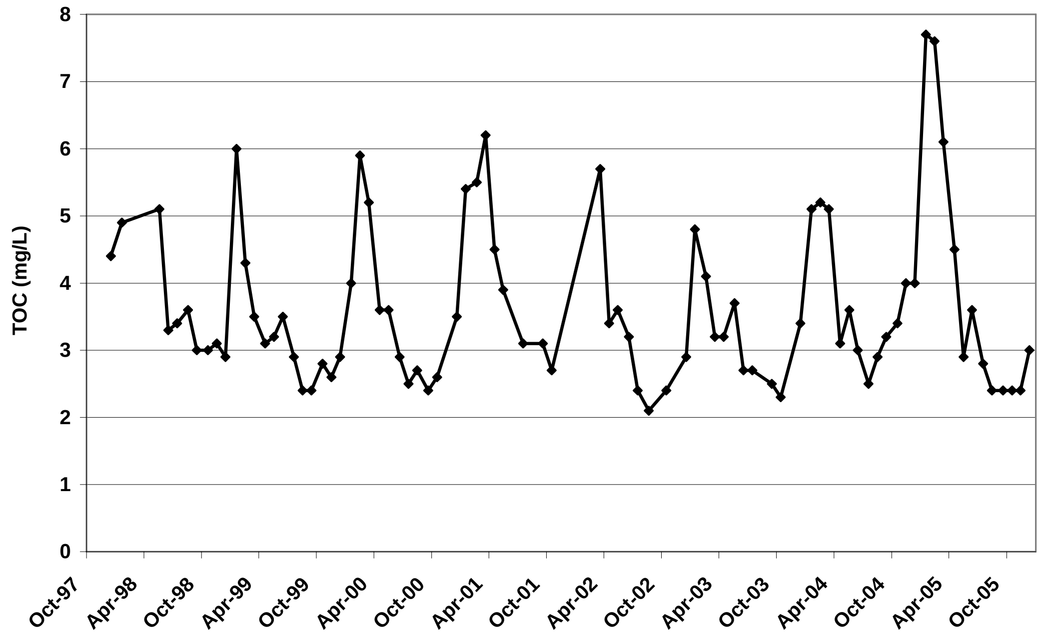


Figure 3-28. Monthly Mean TOC Concentrations at Banks and DV Check 7

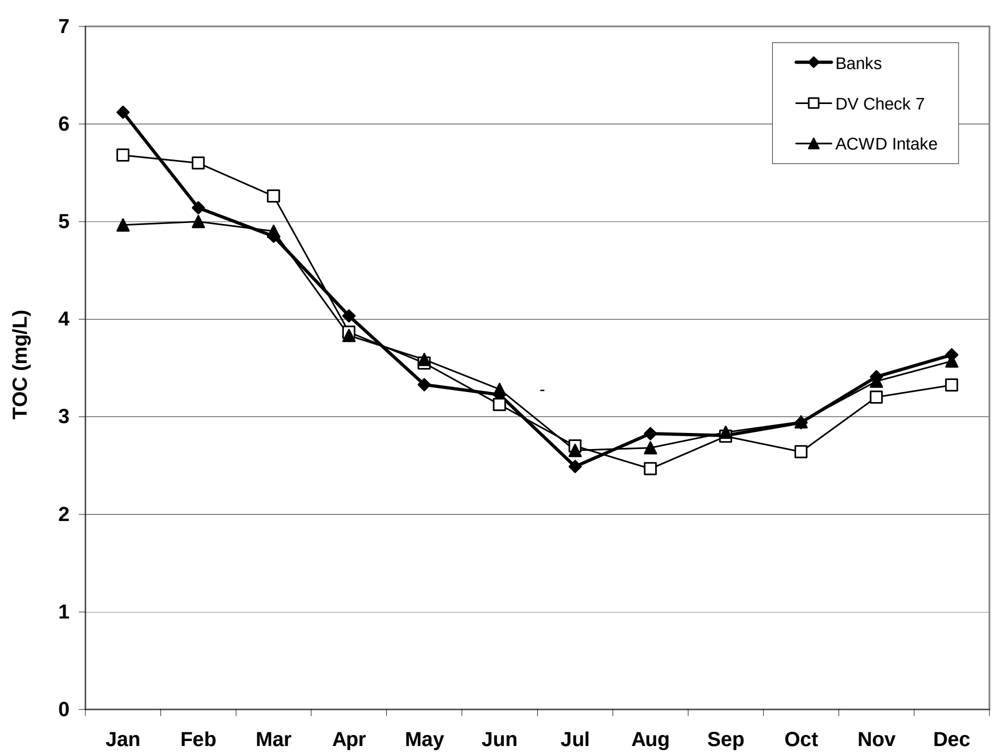
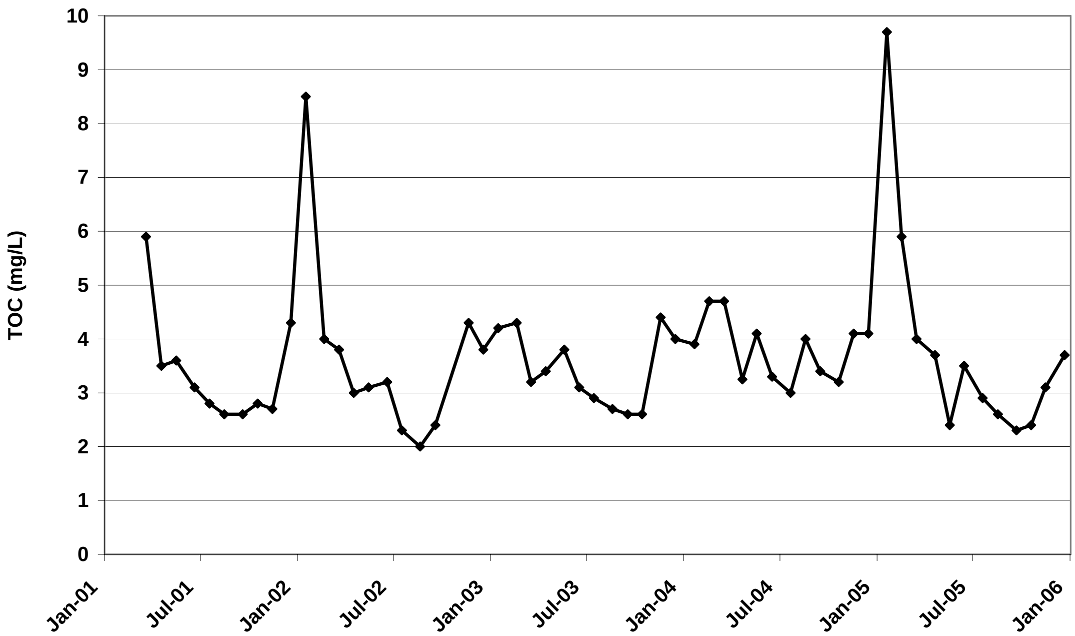


Figure 3-29. TOC Concentrations in the DMC



<u>California Aqueduct</u>

As shown in **Figure 3-20**, once the water enters the California Aqueduct, TOC concentrations generally do not change appreciably. There is some reduction in variability in concentrations leaving San Luis and Castaic reservoirs due to the blending of water with varying concentrations over time in the reservoirs. Median TOC concentrations along the California Aqueduct range from 2.9 to 3.2 mg/L, and do not exhibit a clear pattern of change as water flows south in the SWP system. However, concentrations exceed 4 mg/L approximately 25 percent of the time at all locations except Castaic Outlet. As discussed previously, if concentrations exceed 4 mg/L for an extended period of time, SWP Contractors may be required to remove 35 percent, rather than 25 percent, of TOC in their water treatment plants or implement TOC removal in addition to ozone disinfection. As a consequence, SWP Contractors treating this water are particularly interested in controlling sources of TOC to limit DBP formation and to avoid having to remove even greater amounts of TOC in the influent water.

Figure 3-30 presents the data from 2001 to 2005 for Check 13 (the outlet of O'Neill Forebay), Check 21 (just upstream of the point where the Coastal Branch takes off from the California Aqueduct), and Check 41 (the bifurcation of the aqueduct into the East and West branches). This figure shows the distinct seasonal pattern with the highest TOC concentrations (5 to 7 mg/L) occurring in the wet months of January to March and the lowest concentrations (2 to 3 mg/L) occurring in September. Between Check 13 and Check 21 floodwater enters the aqueduct from creeks draining the Diablo Range to the west, and water ponding against the western side of the aqueduct. Groundwater is also pumped into this reach of the aqueduct. The 2001 Update contains a detailed discussion of the inflows to this reach of the aqueduct. DWR collected TOC data on a variety of inflows between 1996 and 1998 and found concentrations ranging from 4 to 49 mg/L. During the 2001 to 2005 period, limited amounts of inflows occurred. During March and April 2001, 2,122 acre-feet of inflows were allowed into the aqueduct, and between December 2004 and June 2005, 2,080 acre-feet were allowed in. The monthly monitoring data collected at Checks 13 and 21 (**Figure 3-30**) did not reflect an increase in TOC that might be expected with inflows. The TOC concentrations at Check 21 are generally the same or slightly lower than the concentrations at Check 13.

As discussed in Chapter 5, large volumes of groundwater and some surface water enter the aqueduct between Checks 21 and 41. **Figure 3-30** shows that the TOC concentrations at Check 41 are substantially lower than the concentrations at Check 21 during several months of the study period. The largest difference of about 1 mg/L occurred between August and December 2004. During this period, almost 100,000 acre-feet of non-Project inflows were allowed into the aqueduct, constituting up to 22 percent of the flow in the aqueduct at Check 41. As discussed in Chapter 5, the non-Project inflows typically have lower TOC concentrations than the water in the aqueduct. The effect of non-Project inflows can also be seen in March 2001 and January to February 2003.

Figure 3-30. TOC Concentrations in the California Aqueduct

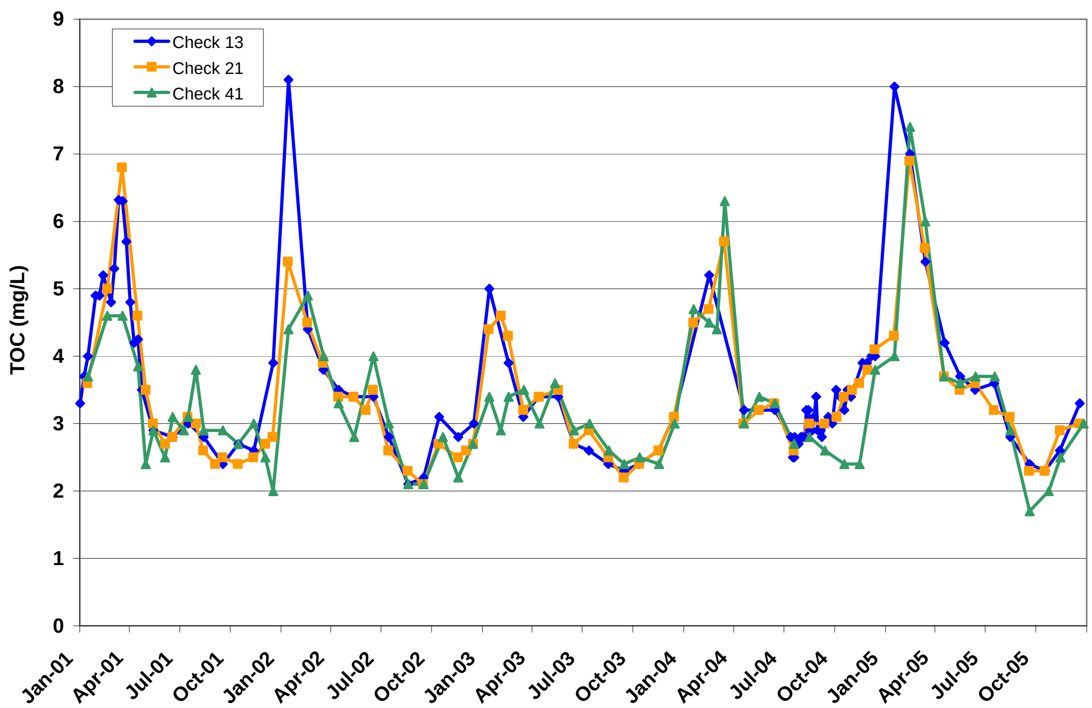


Figure 3-31 compares the TOC concentrations at Check 41 to Castaic Outlet and illustrates the effect of reservoir storage on dampening TOC fluctuations. In contrast, the concentrations at Devil Canyon are similar to the concentrations at Check 41, as shown in **Figure 3-32**. Although Silverwood Lake lies between these two points, the small capacity of the lake (74,970 acre-feet) does not provide the same dampening effect as the 0.5 million acre-feet of storage provided by Pyramid and Castaic lakes on the West Branch.

Figure 3-31. TOC Concentrations in the West Branch

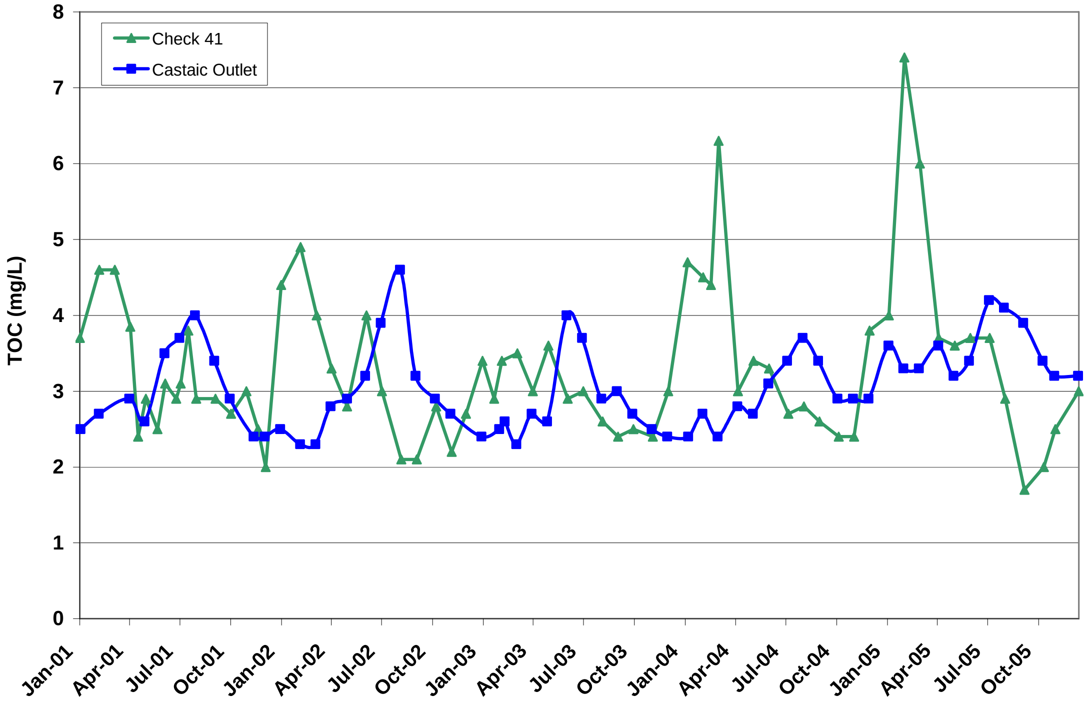
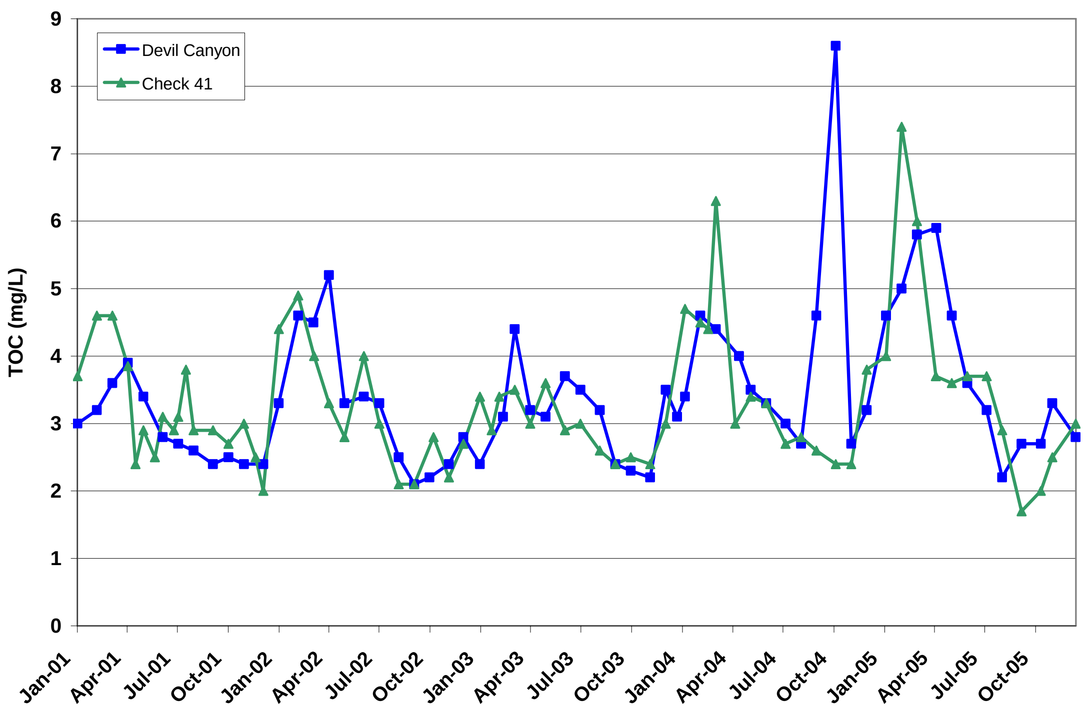


Figure 3-32. TOC Concentrations in the East Branch



Coastal Branch

Check 21, located on the California Aqueduct 12 miles upstream of the Coastal Branch junction is the site where the quality of water entering the Coastal Branch is measured. Over the course of the study period, the median TOC concentration was 3.1 mg/L, similar to concentrations at other California Aqueduct locations.

Indirect Measurement of Organic Carbon by UVA_{254}

The previous discussion of TOC throughout the SWP was based on analysis of discrete sample data that are generally collected once a month. Automated monitoring for DOC and TOC is only done at Banks. However, automated monitoring of ultraviolet absorbance at a wavelength of 254 nm (UVA_{254}) is conducted at Banks, Check 13, Edmonston Pumping Plant Forebay (just upstream of the pumps that carry water over the Tehachapi Mountains from the San Joaquin Valley to Southern California), and at Check 41. Monitoring at Edmonston started in January 2006, so data from that location are unavailable for the 2001 to 2005 study period.

Continuous monitoring of DOC and TOC by the combustion method was initiated at Banks in September 2001. The continuous organic carbon data were compared to the continuous UVA_{254} measurements to determine if there is a useful relationship between the two. Daily mean values of TOC and UVA_{254} are compared in **Figure 3-33**. There is good correspondence, particularly at TOC concentrations above 3 to 4 mg/L and for the period after October 2003. Before that time there was a persistent offset in the instrument data (Personal Communication, Ted Swift, DWR). However, this figure also demonstrates that UVA_{254} measurements are less precise at lower TOC concentrations (UVA_{254} measurements below about 0.1/cm). UVA254 is primarily a function of DOC, and linear regression of UVA_{254} versus DOC for the post-October 2003 data produced a correlation of 0.73, as shown in **Figure 3-34**.

To provide further insight into spatial variability of TOC in the system, UVA_{254} measurements for Banks, Check 13, and Check 41 are shown in **Figure 3-35**. Data were only available for Check 41 between December 2002 and December 2004 so that period is used to compare the three locations. UVA_{254} measurements at the three locations were generally similar. Banks appears to have somewhat higher measurements than the other two locations during the summer months of 2003 and 2004. San Luis Reservoir lies between Banks and the other two locations and can at times influence the downstream locations. Check 41 appears to have been generally lower during the winter months. Otherwise, no clear trends are apparent.

Figure 3-33. Comparison of Auto-Sampler UVA_{254} and TOC at Banks

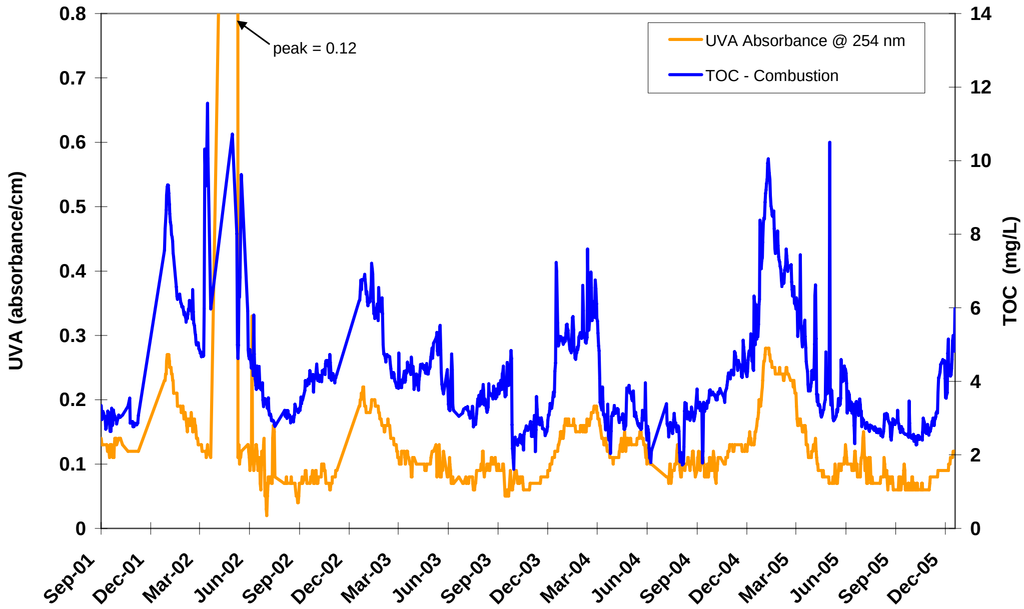


Figure 3-34. Comparison of Auto-Sampler UVA_{254} and DOC at Banks

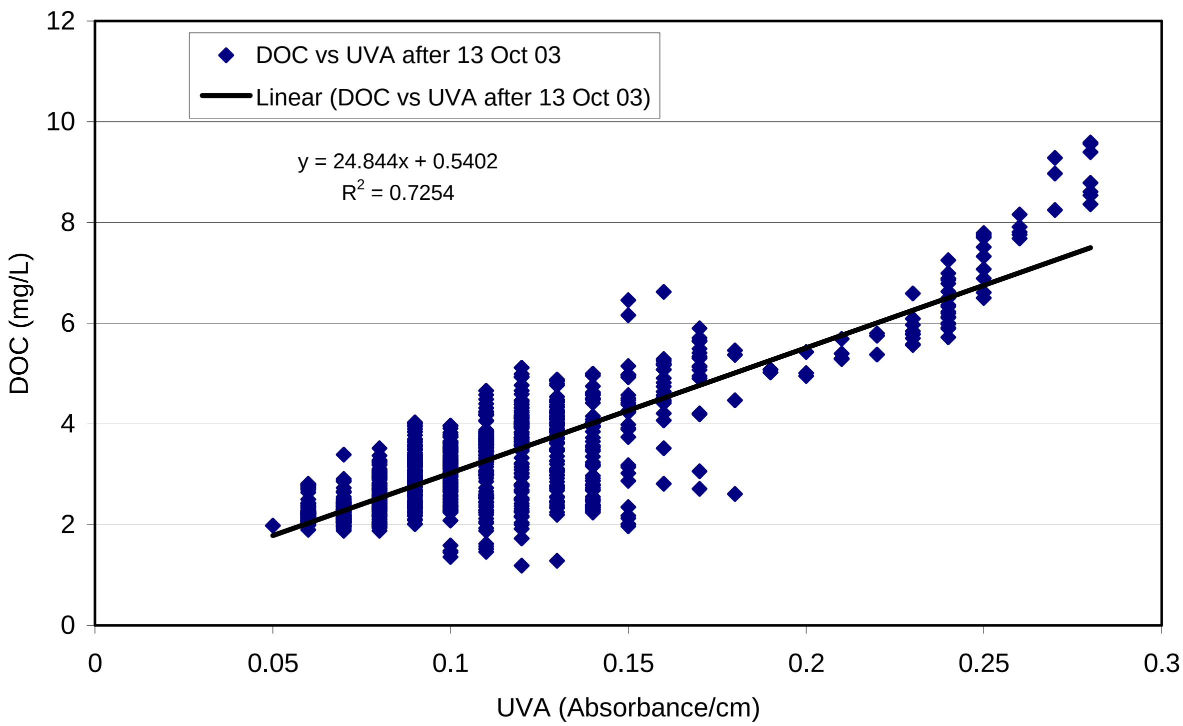
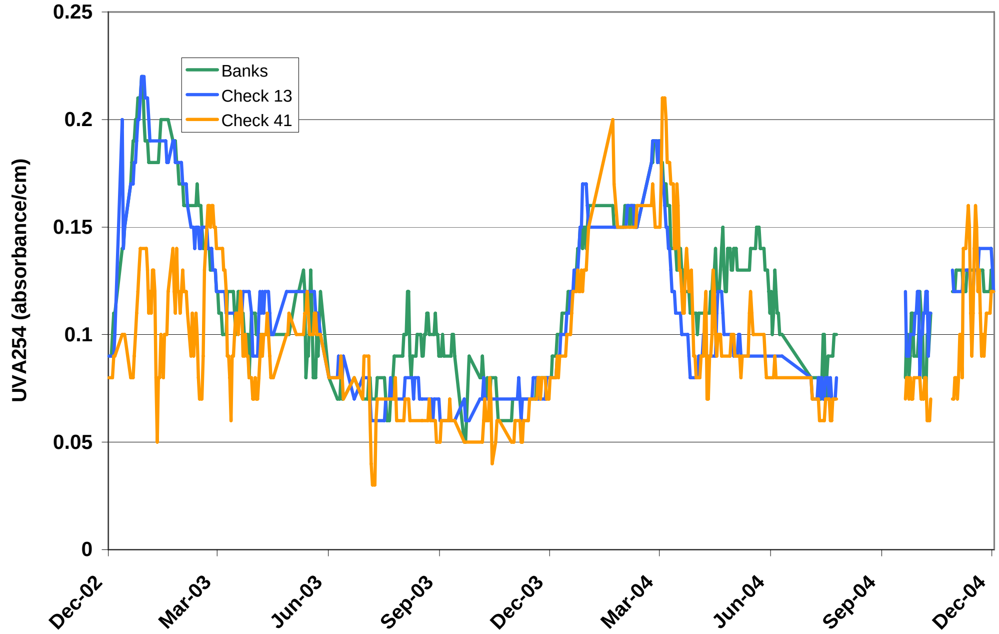
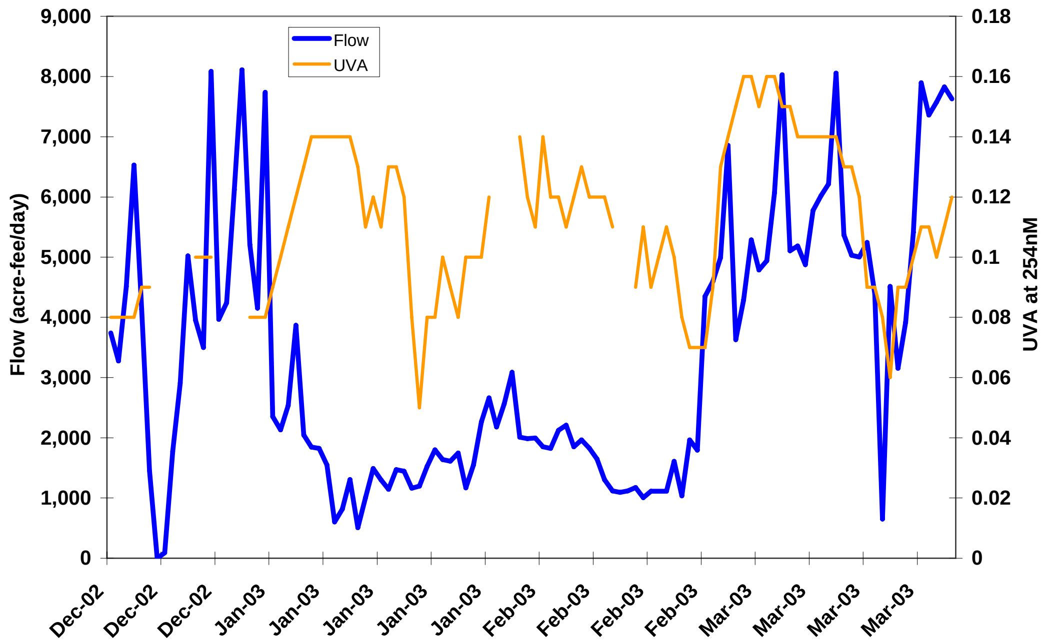


Figure 3-35. Comparison of Auto-Sampler UVA_{254} in the California Aqueduct



As shown in **Figure 3-35**, UVA_{254} was most different at Check 41 compared to the other stations during the period December 2002 through March 2003. There are several possible explanations for the difference. During periods of low flow in the aqueduct between Check 13 and Check 41 the water being measured at Check 41 would be representative of water from a significantly earlier time. **Figure 3-36** demonstrates that, while flows at Edmonston Pumping Plant varied significantly over this period, these variations do not appear to provide an explanation for the lower UVA_{254} measured at Check 41. Another possibility is the observed difference reflects actual changes in concentrations of the substances measured by the instrument during the 233 mile trip from Check 13 to Check 41. Low TOC non-Project water pumped into the aqueduct between Check 13 and Check 41 could potentially explain the difference. As discussed in Chapter 5, substantial amounts of groundwater were pumped into the aqueduct during this period. Large amounts of groundwater were also pumped in between June 2004 and December 2004. UVA_{254} data were not available for August and September 2004 so it's difficult to determine if groundwater is responsible. TOC data do not, however, demonstrate that the change is due to loss of TOC in the system. Another possibility that probably cannot be discounted is instrument malfunction.

Figure 3-36. Flow at Edmonston Pumping Plant and UVA_{254} at Check 41



Qualitative Determination of Organic Carbon by Specific Ultra-Violet Absorbance

Specific ultra-violet absorbance, or SUVA, is the ratio of UVA_{254} to DOC, and is a qualitative measure of the aromatic fraction of the humic and fulvic organic acids comprising the DOC. Aromatic compounds absorb light more strongly than non-aromatic compounds; thus, a higher SUVA indicates increased aromaticity. SUVA calculations therefore provide a means of evaluating whether certain types of qualitative changes in organic carbon occur as water flows through the SWP. While SUVA is potentially useful for evaluating organic carbon, other molecular structures are capable of absorbing ultra-violet light at the 254 nm wavelength, so SUVA does not provide a complete measurement of the complex organic compounds that may be present in SWP water supplies.

SUVA was computed using DOC (measured by the combustion method) and UVA_{254} data from the continuous recorders at Banks during the period September 2001 through 2005. The results, presented in **Figure 3-37,** demonstrate considerable variability, but no clear temporal pattern is identified. The variability in SUVA is an indication that there are qualitative temporal changes in TOC and DOC, and these changes could be significant to water treatment processes. The data do not, however, markedly improve the ability to understand the cause of these changes, or suggest a practical way of predicting them.

Figure 3-37. SUVA at Banks

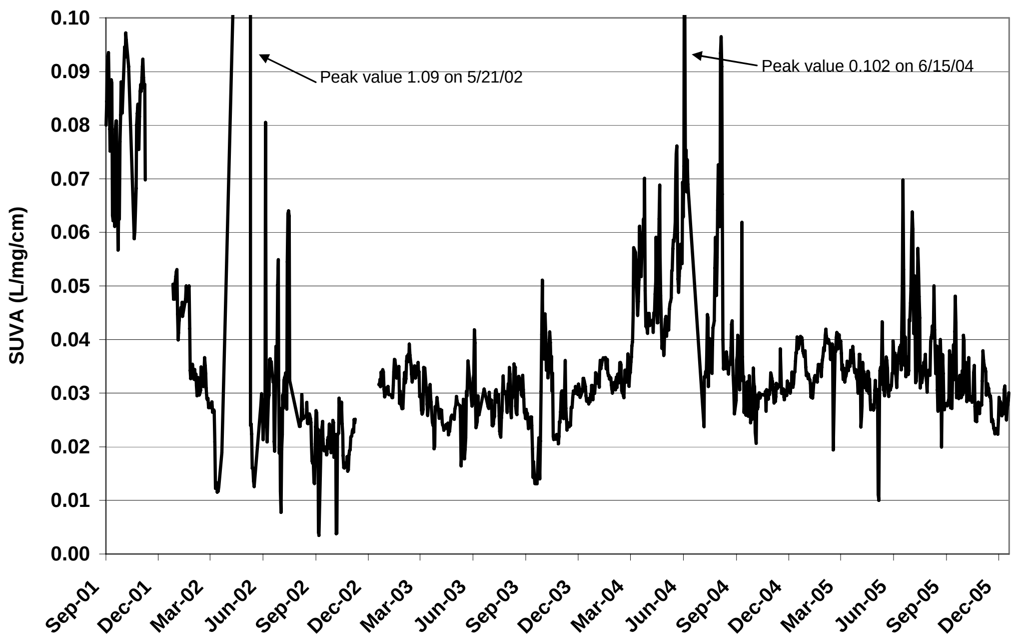


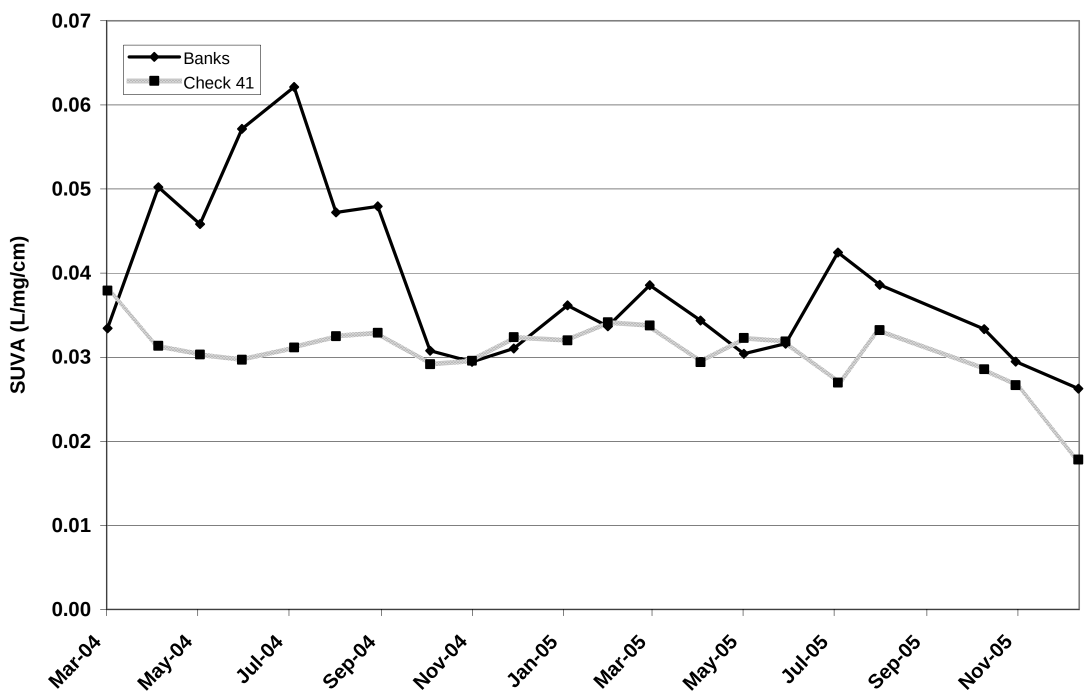
Figure 3-38 compares monthly average SUVA measured by automated equipment at Banks to SUVA measured during the same months at Check 41 in discrete samples (DOC is not measured with auto-samplers at Check 41). SUVA at Check 41 appears to be more stable, based on the observation that samples taken during the spring and summer of 2004 do not reflect the significant excursions that were observed at Banks. Also, SUVA at Check 41 appears to be generally lower than Banks. This may be an indication of the effect of storage in San Luis Reservoir, or biological changes in DOC or UV absorption as water flows southward in the SWP. Data are, however, too limited to draw conclusions on the spatial character of SUVA in the system.

<u>Impacts of Operations on TOC Concentrations</u>

The 1995 Bay-Delta Plan established new water quality objectives for the Delta that resulted in lower diversions of water from the Delta in the spring and higher diversions in the fall, starting in 1998. **Figure 3-39** shows average monthly diversions at Banks between 1998 and 2005 and the previous ten years. The monthly average TOC concentrations at Banks, using the auto-sampler combustion data from 2001 to 2005 are also shown. This figure illustrates that in recent years more water has been diverted from the Delta during the summer and fall months when TOC concentrations are lowest. Water is pumped into San Luis Reservoir from O'Neill Forebay and then released back into the forebay to generate power throughout the year; however the reservoir is generally filled during the fall and winter months and drawn down during the spring and summer months. Monthly average net pumping was calculated as the total amount of water pumped into the reservoir minus the amount released. **Figure 3-40** shows that during the fall and winter months, when San Luis Reservoir is filled, TOC concentrations are highest at Banks.

This may be partially responsible for the median TOC in San Luis Reservoir, measured at Pacheco Pumping Plant (3.6 mg/L), being 0.5 mg/L higher than the median at Banks (3.1 mg/L). Pacheco Pumping Plant is on the western side of the reservoir and may not be representative of the quality of water released from San Luis Reservoir on the eastern side. Water is released from the reservoir during the summer months when concentrations at Banks are low. This should result in the concentrations at Check 13 being higher than the concentrations at Banks during the summer months. **Figure 3-41** is a plot of the difference between Check 13 concentrations and Banks concentrations for the entire period of record. A positive number indicates that the concentrations at Check 13 are higher than at Banks. There is no apparent relationship to summer releases from San Luis Reservoir, although the variability between Banks and Check 13 is noticeably lower in recent years.

Figure 3-38. SUVA at Banks and Check 41



The current SWP WQMP does not collect data on the quality of water entering or leaving San Luis Reservoir at the Gianelli Pumping Generating Plant. The DMC input to O'Neill is monitored monthly and the water entering the California Aqueduct at Check 13 is monitored monthly. With the current limited monitoring of the SWP, it is not possible to fully evaluate how changes in operations impact TOC concentrations. The DSM2 Model has been extended to include the California Aqueduct, SBA, and DMC. When fully operational, this model will be used to model the impacts of operations on water quality and to forecast water quality conditions along the SWP. This will require continuous monitoring at many points in the system. Monitoring of the water entering and leaving O'Neill Forebay and San Luis Reservoir will be a critical component of the real-time monitoring and forecasting program.

Figure 3-39. Average Monthly Banks Diversions and TOC Concentrations

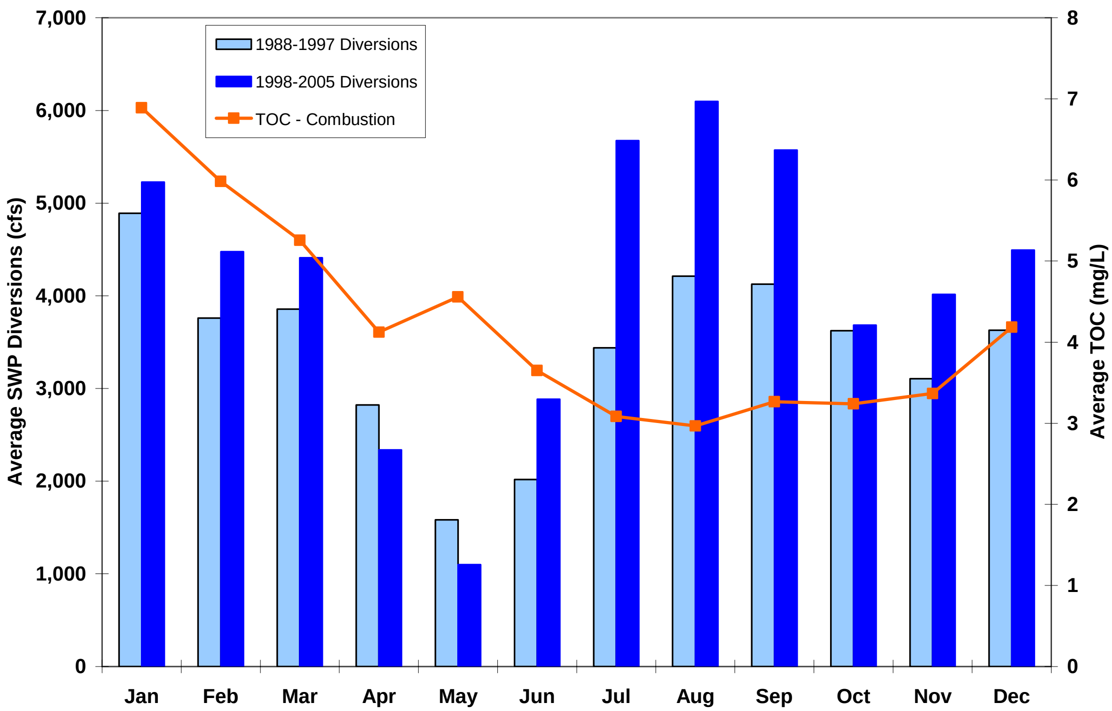


Figure 3-40. Net Pumping to San Luis Reservoir and TOC Concentrations

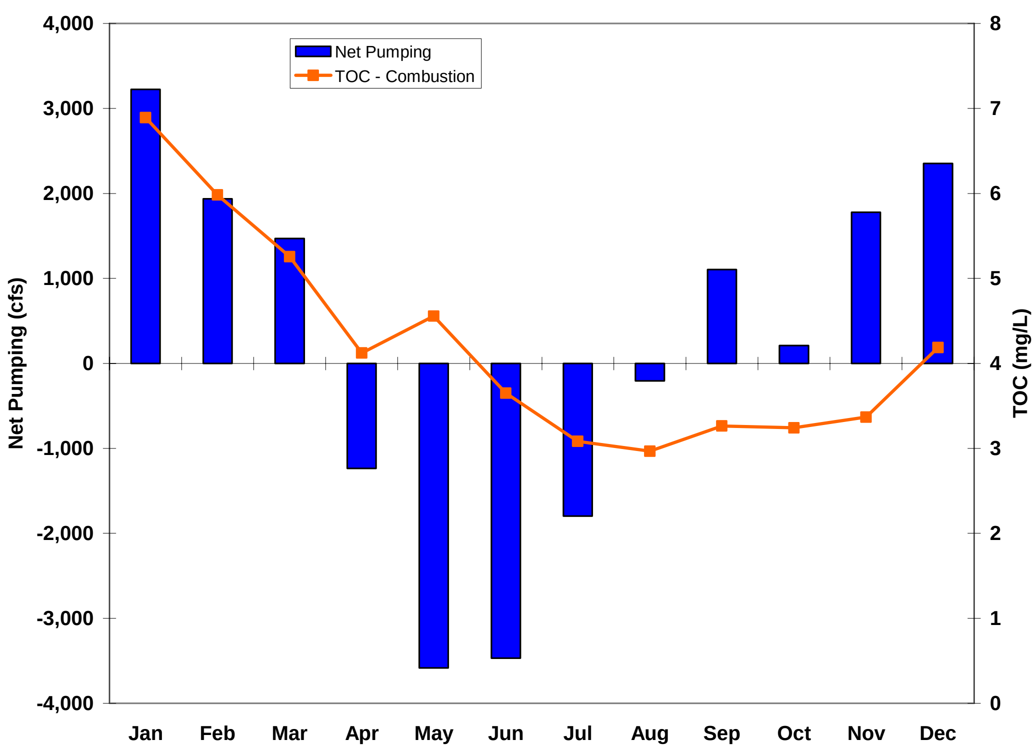
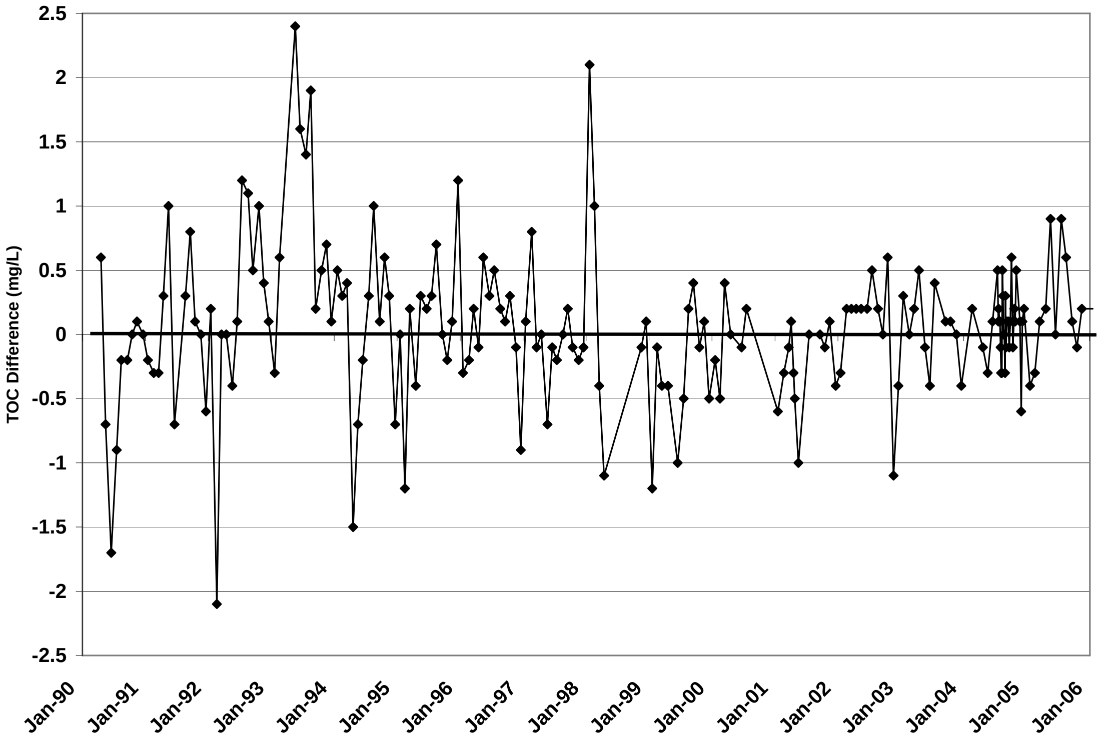


Figure 3-41. Difference Between TOC Concentrations at Banks and Check 13



Summary

- TOC concentrations are measured with both the combustion and oxidation methods at various locations in the SWP. The combustion method consistently produces higher concentrations than the oxidation method.

- TOC concentrations in the Sacramento River are considerably lower than concentrations in the San Joaquin River.

- TOC concentrations are much higher in the NBA than any other location in the SWP. Wet season peak concentrations are in the range of 14 to 20 mg/L. The local Barker Slough watershed is the source of this TOC.

- The DOC fingerprints indicate that the San Joaquin River is the primary source of DOC at the south Delta pumping plants when flows on that river are high. During dry years, the Sacramento River has more influence on DOC concentrations at the pumping plants. Delta agricultural drainage is also a source of DOC at the pumping plants.

- TOC concentrations do not change as water flows from the Delta through the SBA and the Califonia Aqueduct. San Luis Reservoir and Castaic Lake have less variability in TOC concentrations than the aqueduct due to the dampening effect of reservoir mixing.

The dampening effect is not seen in Silverwood Lake on the East Branch due to its limited hydraulic residence time.

- There is a distinct seasonal pattern in TOC concentrations in the rivers, the Delta, and the aqueducts. High concentrations (5 to 8 mg/L) occur during the wet season and low concentrations (2 to 3 mg/L) occur in the late summer months.

- There are no apparent long term trends at any of the locations included in this analysis. TOC data were generally available from 1998 through 2005. During this time, water years varied from dry to wet but no apparent relationship between water year type and TOC concentrations is evident in the data.

- The real-time monitoring data from Hood, Vernalis, and Banks has shown that TOC peaks are higher than previously measured in discrete samples.

- While quantitative changes appear not to be evident, it is far less clear whether qualitative temporal or spatial changes are occurring as TOC moves through the system.

- The existing monitoring program is inadequate to evaluate operational changes or to forecast TOC concentrations in the aqueducts as a result of changing water quality in the Delta. It is particularly important to obtain real-time data on the movement of water into and out of O'Neill Forebay and San Luis Reservoir.

SALINITY

Water Quality Concern

Salinity of water is caused by dissolved anions (sulfate, chloride, bicarbonate) and cations (calcium, magnesium, sodium, and potassium). Salinity is measured as total dissolved solids (TDS) and electrical conductivity (EC). High levels of TDS in drinking water can cause a salty taste, and become aesthetically objectionable to consumers. The USEPA and the California Department of Health Services (CDHS) have established secondary MCLs for TDS and a number of other constituents that affect the aesthetic acceptability of drinking water. The federal standards are unenforceable guidelines, but the California standards are enforceable, and are based on the concern that aesthetically unpleasant water may lead consumers to unsafe sources. The secondary MCLs related to salinity are listed in **Table 3-4**. Conventional water treatment adds chemicals and increases salinity. Therefore, the concentration of dissolved minerals in the source water is a significant factor determining the palatability of the treated drinking water.

Table 3-4. Secondary Maximum Contaminant Levels

Constituent (units)	Maximum Contaminant Level Ranges		
	Recommended	Upper	Short Term
TDS, mg/L	500	1,000	1,500
EC, µS/cm	900	1,600	2,200
Chloride, mg/L	250	500	600
Sulfate, mg/L	250	500	600

High TDS in drinking water supplied to consumers can have economic impacts, in that mineralized water can shorten the life of plumbing fixtures and appliances, and create unsightly mineral deposits on fixtures and outdoor structures. An important economic effect can be the reduced ability to recycle water or recharge groundwater high in dissolved solids. For example, the Santa Ana Regional Water Quality Control Board is implementing a Watershed Management Initiative that has salt management as a main component. In that area, it is not permissible to discharge recycled water or recharge groundwater if TDS concentrations exceed established limits. The trend has been toward increasingly stringent limits.

The Sacramento and San Joaquin rivers contain salts from natural sources, urban discharges, and agricultural discharges. As the water from the rivers flows through the Delta, salinity intrusion from the Pacific Ocean and agricultural and urban discharges in the Delta contribute additional salt. The Delta is connected to the Pacific Ocean through San Pablo Bay and San Francisco Bay. Freshwater outflow from the watersheds of the Delta repels seawater and maintains the Delta as a freshwater source. Because the flows of freshwater vary with hydrologic conditions and releases from upstream reservoirs, there is variation in how much seawater intrudes into the Delta. Therefore, the salinity levels in Delta waters are also impacted by hydrologic conditions and releases from upstream reservoirs, and are generally inversely related to the amount of freshwater outflow from the Delta.

Water Quality Evaluation

EC Fingerprints

DWR uses the fingerprinting method to identify the sources of EC at Clifton Court and the Tracy Pumping Plant. The EC fingerprints for the 1996 to 2005 period are shown in **Figures 3-42 and 3-43. Figure 3-42** shows that the primary sources of EC at Clifton Court are seawater intrusion, Delta agricultural drainage, and the San Joaquin River. During wet years when seawater intrusion is reduced, the San Joaquin River and Delta agricultural drainage are the primary sources. While the Sacramento River is often the primary source of water at Clifton Court, (see **Figure 3-11**), it contributes less salt than the other sources. **Figure 3-43** shows the San Joaquin River, seawater intrusion, and Delta agricultural drainage are the primary sources of EC at the Tracy Pumping Plant. The San Joaquin River has a greater influence on EC at Tracy than at Clifton Court.

Figure 3-42. EC Fingerprint for Clifton Court

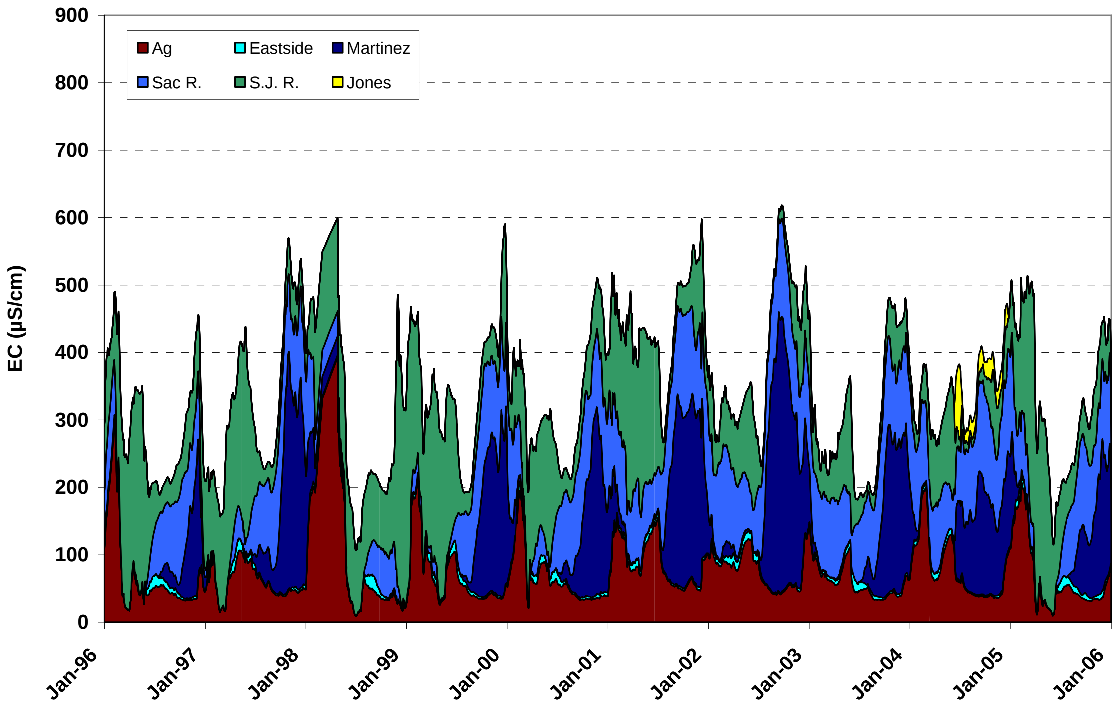
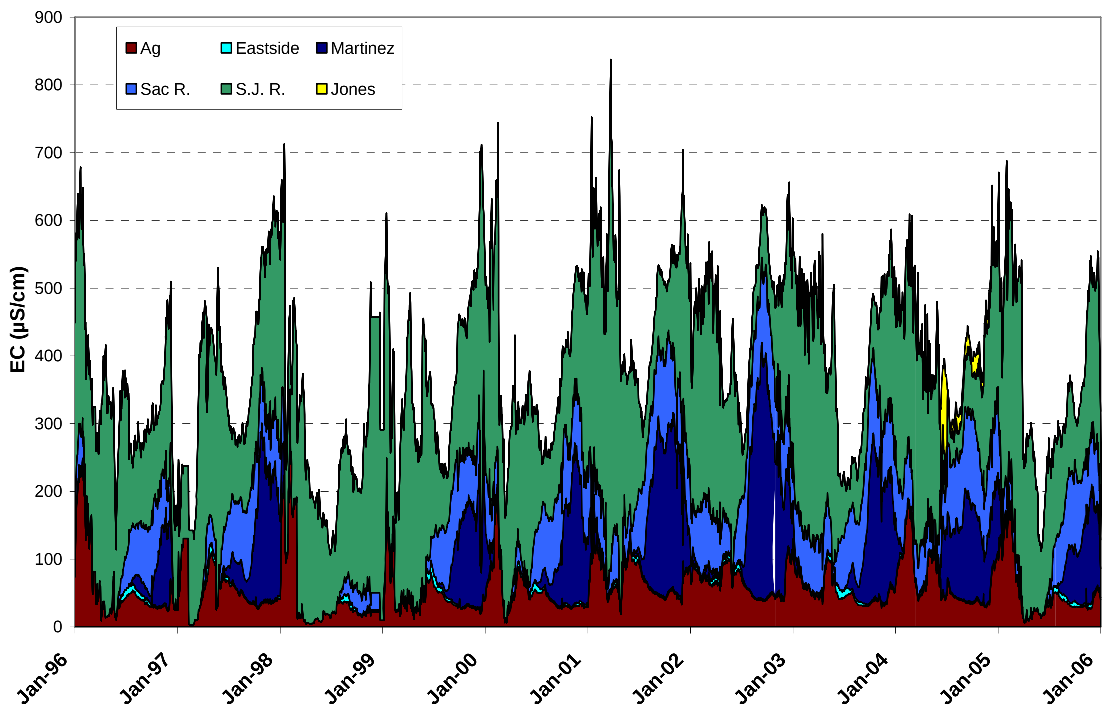


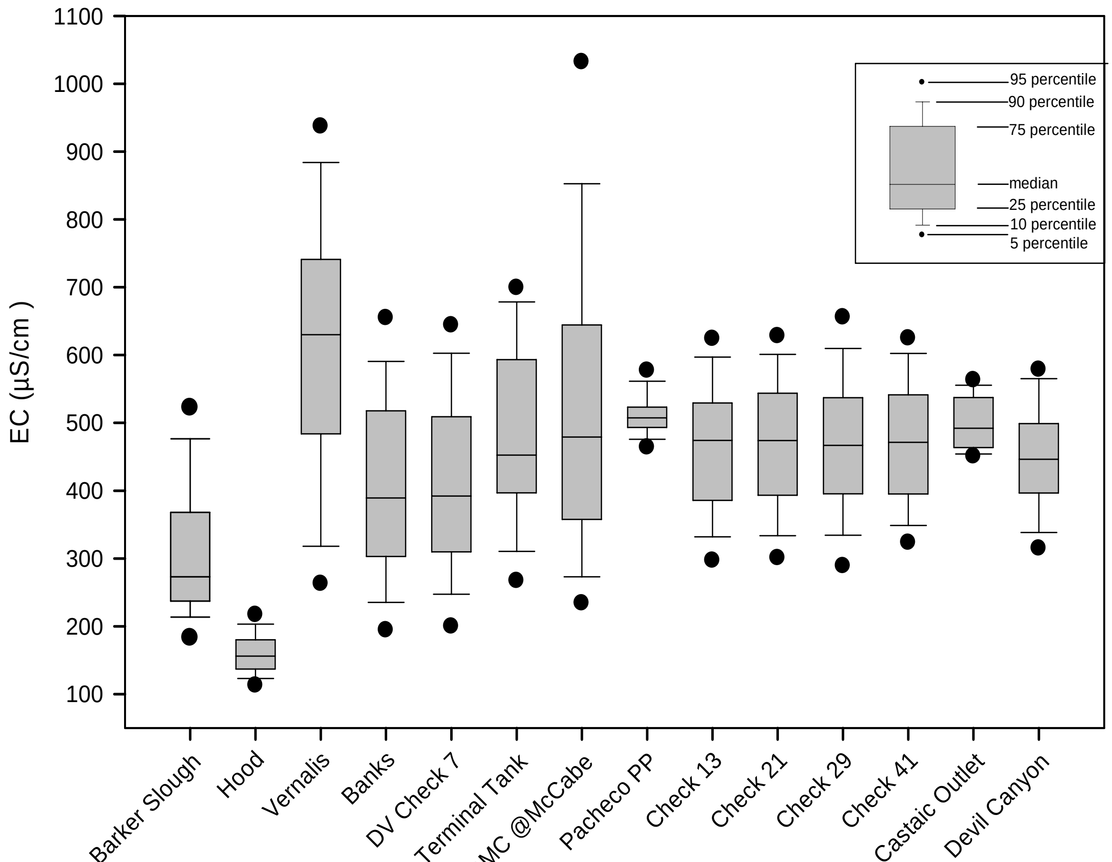
Figure 3-43. EC Fingerprint for Tracy



EC Levels in the SWP

The water quality evaluation of salinity was performed using EC data from continuous recorders from the SWP WQMP, and the MWQI Program. Only discrete sample data were available for the DMC @ McCabe. The data were analyzed to determine if there are any changes in salinity as water travels from the Delta through the SWP system. The data were also analyzed to identify any changes over time. **Figure 3-44** depicts spatial relationships of EC at various locations within the Delta and SWP for the period 2001 through 2005.

Figure 3-44. EC Levels in the SWP



Sources of Water to the Delta

Figure 3-44 clearly demonstrates that Sacramento River water contains much lower mineral concentrations than the San Joaquin River. The median EC measured at Hood during the 2001 to 2005 period was 156 µS/cm, compared to 630 µS/cm at Vernalis. As discussed previously, flows in the San Joaquin River are much lower than in the Sacramento River. In addition, a considerable amount of agricultural drainage is discharged to the San Joaquin River. The source of irrigation water for the west side of the San Joaquin Valley is the Delta, so Delta water picks up additional salts through soil leaching, and is recirculated to the Delta via the San Joaquin River.

Figure 3-45 presents the EC data for the 1999 to 2005 period for Hood and flows in the Sacramento River at Freeport, a few miles upstream from Hood. **Figure 3-46** presents the data for Vernalis. The 1999 to 2005 time period was selected because prior to 1999, there were relatively few discrete samples for EC. The continuous EC data are shown on these figures. **Figure 3-47** shows the monthly means for the 2001 to 2005 period at these two locations. There is little variability in EC at Hood, although there is a seasonal pattern of low levels (100 to 150 µS/cm) in the late spring and early summer when high quality water is released from reservoirs and higher levels (150 to 250 µS/cm) in the fall and early winter when flows in the river are low or influenced by storm events. At flows in excess of 60,000 cfs, EC drops to low levels. San Joaquin River EC levels fluctuate over a wide range (100 to 1,100 µS/cm). EC levels at Vernalis are lowest during the spring months when high quality water is released from reservoirs on the east side of the San Joaquin Basin. During the summer and fall months, EC levels increase due to low river flows and the release of agricultural drainage into the river. The high EC levels generally persist until late winter when there is sufficient rain to increase flows in the river. It isn't possible to compare the 1996 to 2000 period to the 2001 to 2005 period because there are relatively few discrete samples for the earlier period and continuous data for the later period.

TDS at Vernalis was estimated from a regression analysis of 277 measurements of EC and TDS performed by staff of the MWQI Program. The equation TDS = EC * 0.582 was derived, having an R^2 of 0.999. **Figure 3-48** is a plot of EC versus San Joaquin River flow that demonstrates that when flows are less than 2,000 cfs, EC can vary widely, from about 400 µS/cm (233 mg/L TDS) to over 1,000 µS/cm (580 mg/L TDS). EC declines with increasing flow, with values as low as 100 µS/cm (58 mg/L TDS).

Figure 3-45. EC and Flow in the Sacramento River

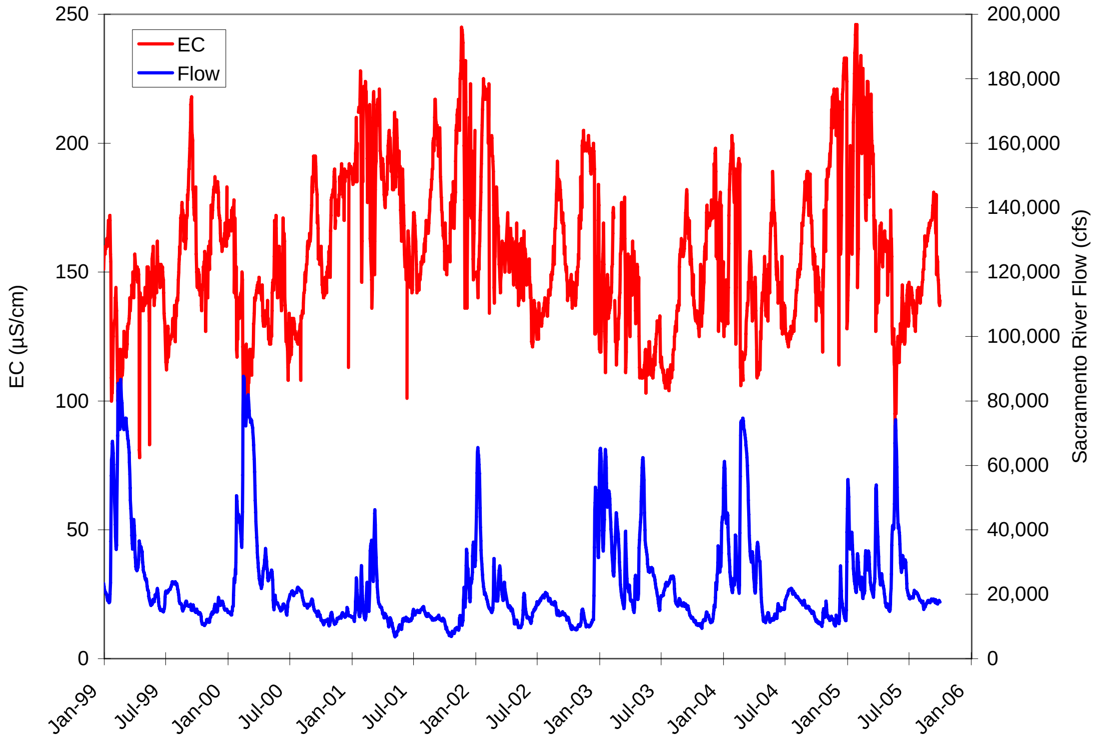


Figure 3-46. EC and Flow in the San Joaquin River

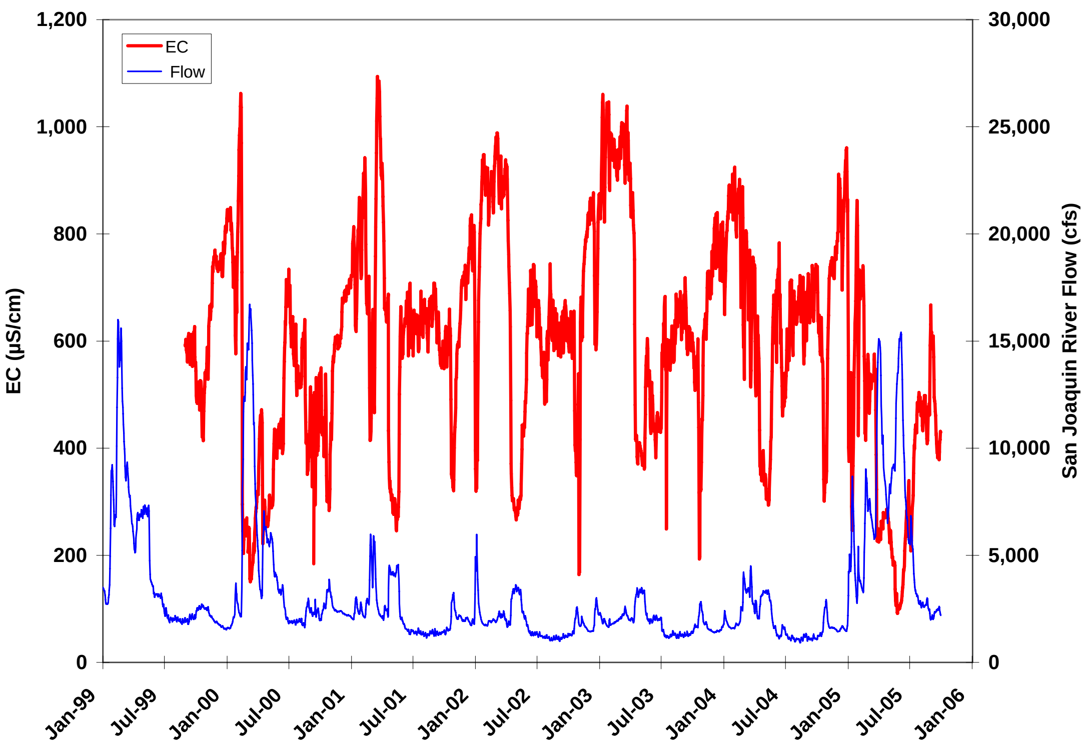


Figure 3-47. Monthly Mean EC at Hood and Vernalis

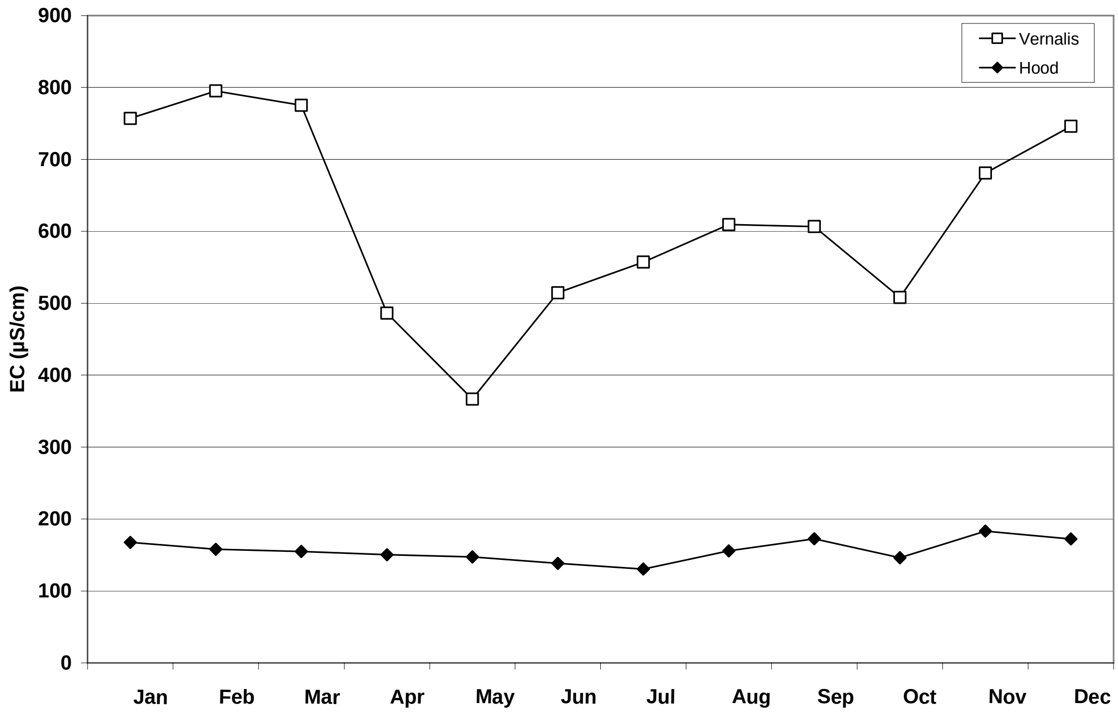
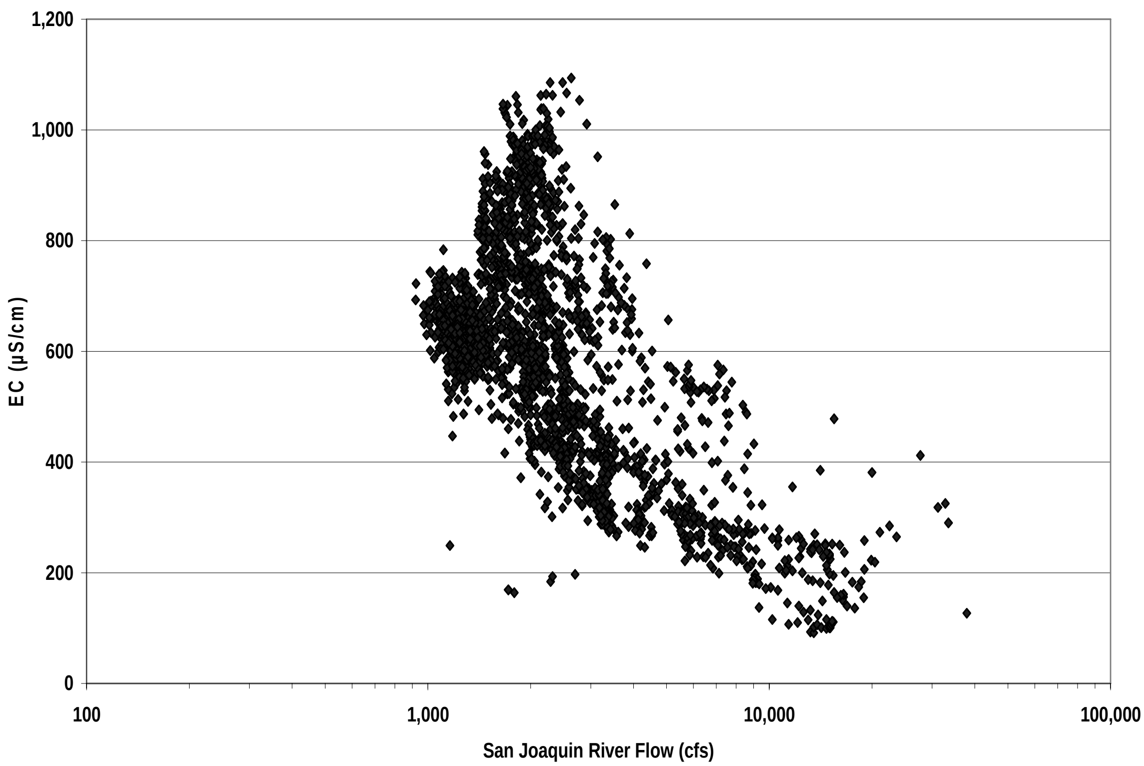


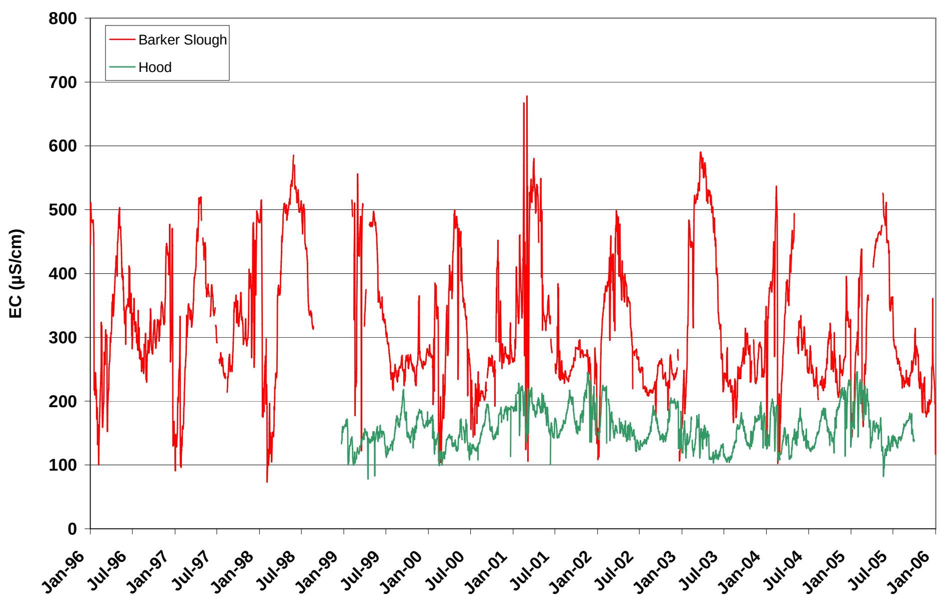
Figure 3-48. Relationship Between EC and Flow at Vernalis



North Bay Aqueduct

The median EC level at Barker Slough was 273 µS/cm during the 2001 to 2005 period. As shown on **Figure 3-44**, the EC levels at Barker Slough are higher and more variable than at Hood but lower than the levels at Banks. **Figure 3-49** compares EC at Barker Slough to EC at Hood. This figure shows a clear seasonal pattern of EC at Barker Slough. EC levels increase sharply during the winter and early spring months, decline during the late spring months and show minimal fluctuation during the summer months. The seasonal peak EC at Barker Slough typically occurs in the spring whereas the peak at Hood normally occurs in the winter. Runoff from the Barker Slough watershed in the winter and the spring results in the springtime peaks. As discussed in Chapter 5, the NBA Contractors are conducting a hydrodynamic study to better understand the factors influencing water quality at the Barker Slough Pumping Plant. It isn't possible to compare the 1996 to 2000 period to the 2001 to 2005 period because there are relatively few discrete samples for the earlier period and continuous data for the later period.

Figure 3-49. Comparison of EC at Barker Slough and Hood



Banks Pumping Plant

The Sacramento River is the primary source of water at Banks but the EC levels at Banks (median of 389 µS/cm) are substantially higher than in the Sacramento River (median of 156 µS/cm) due to inflow from the San Joaquin River, discharges from Delta islands, and seawater intrusion. **Figure 3-50** presents the continuous EC data for Banks and **Figure 3-51** compares the monthly mean concentrations at Banks for the 1996 to 2000 and 2001 to 2005 periods. These figures show that the lowest EC levels (300 to 400 µS/cm) occur during the late spring and early summer when flows in the rivers are highest. EC generally increases from August to December due to low river flows, agricultural drainage from the San Joaquin Valley and the Delta, and seawater intrusion.

Figure 3-50. EC at Banks

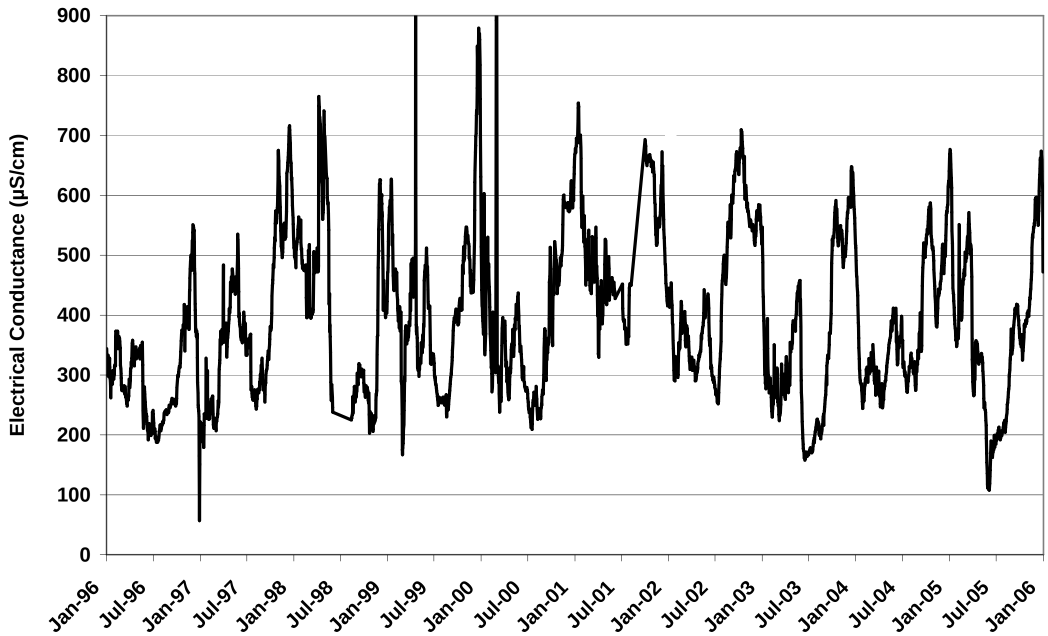
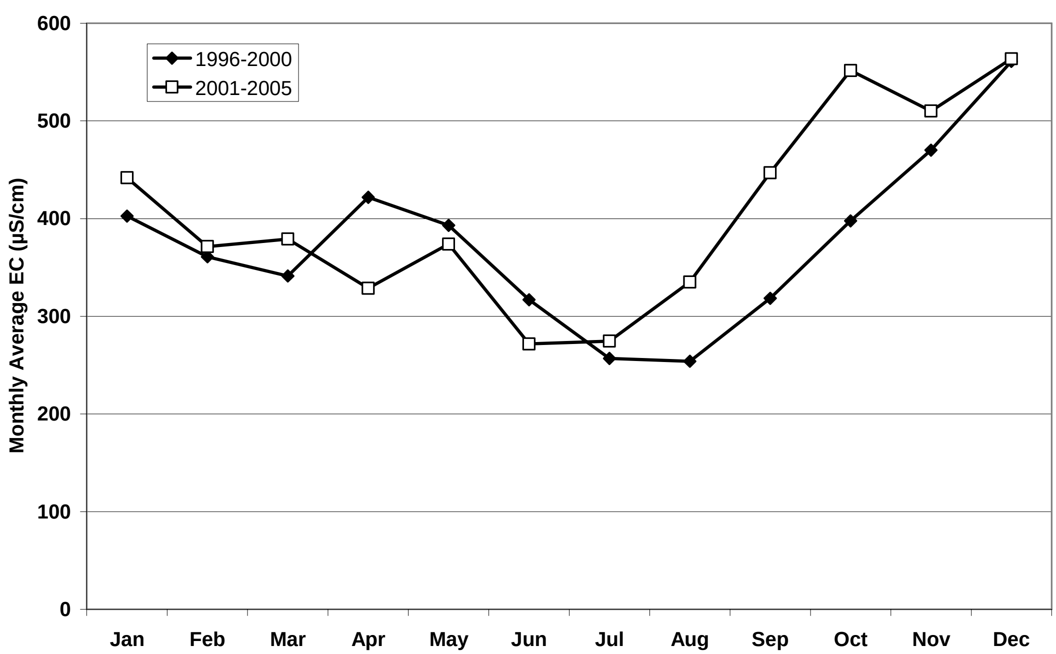


Figure 3-51. Comparison of Monthly Mean EC at Banks

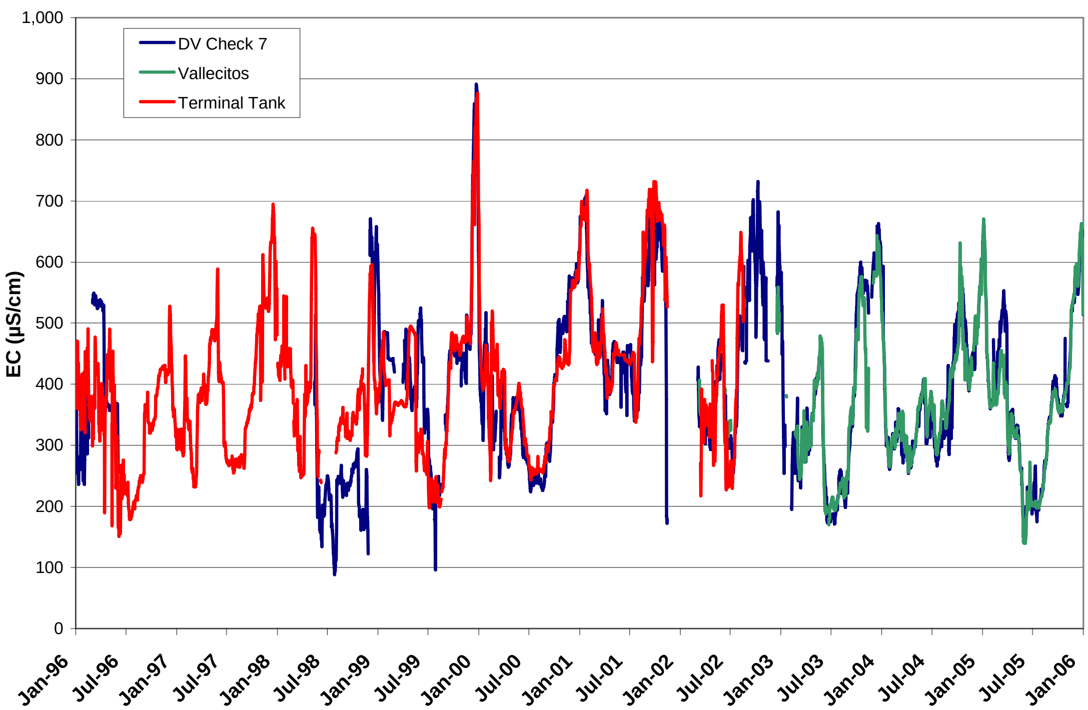


Hydrologic conditions affect the timing of the seasonal EC peaks, as seen in **Figure 3-51**. During the 2001 to 2005 period, EC increased earlier in the summer, compared to 1996 to 2000, due to the drier conditions prevalent during 2001 to 2005. Though timing shifts occurred, EC maxima were the same. DWR conducted an assessment of long-term salinity trends at Banks using data from 1970 to 2002 and concluded that the salinity in SWP exports has neither increased nor decreased over that period (DWR, 2004).

South Bay Aqueduct

Figure 3-44 demonstrates that median salinity changes little as water travels between Banks and DV Check 7 but increases between DV Check 7 and the Terminal Tank. The change between DV Check 7 and the Terminal Tank is an artifact of the period of record. **Figure 3-52** presents the EC data from the continuous recorders at DV Check 7, Vallecitos, and the Terminal Tank. There are varying periods of record for each location; however, for the periods where data overlap there are no apparent differences between the locations. Peak EC levels (600 to 900 µS/cm) occur during the fall and early winter months and the lowest EC levels (100 to 300 µS/cm) occur in the summer. Water is released from Lake Del Valle to the SBA just downstream form DV Check 7. Releases typically occur during the fall and, occasionally at other times to alleviate water quality problems with Delta water. The impact of Del Valle releases is not readily apparent in the EC data.

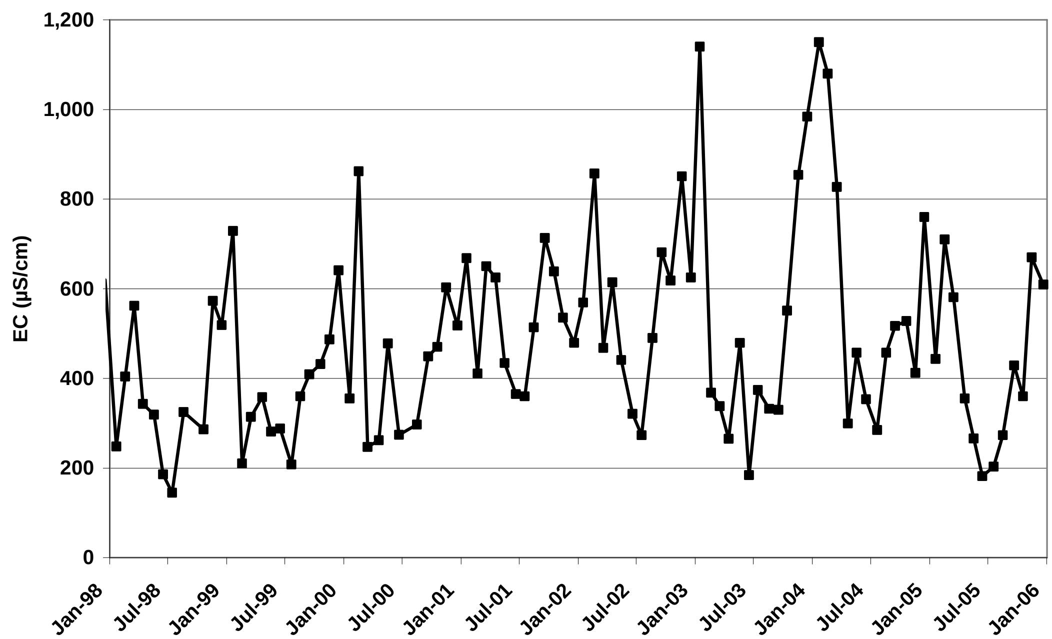
Figure 3-52. EC in the SBA



Delta Mendota Canal

As depicted in **Figure 3-44**, EC levels at DMC @ McCabe are higher and more variable than at Banks. The median EC at DMC @ McCabe (479 µS/cm) is substantially higher than the median EC at Banks (389 µS/cm) due to the greater influence of the San Joaquin River on the quality of water that is diverted into the DMC and, possibly due to discharges to the DMC between the Tracy Pumping Plant and McCabe Road. **Figure 3-53** is a plot of EC measured in discrete samples from the DMC @ McCabe. There is considerable variability in the data with EC levels ranging from less that 200 to over 1,100 µS/cm. There is a distinct seasonal pattern with EC reaching its lowest levels during the spring months when Delta inflow is high and then increasing from the summer to the early winter. The increase during the summer months is due to agricultural drainage in the Delta and the San Joaquin Basin, and to seawater intrusion. The relative importance of each source varies from year to year with hydrologic conditions playing an important role, as shown previously in **Figure 3-43**.

Figure 3-53. EC in the DMC



California Aqueduct

As shown in **Figure 3-44**, there is a substantial increase in EC between Banks (median of 389 µS/cm) and San Luis Reservoir (median of 507 µS/cm at Pacheco); however the variability of EC in the reservoir is greatly reduced. The higher EC in San Luis Reservoir is likely due to a combination of evaporation, pumping of water into San Luis during periods when Delta salinity is high, and to the blending of water from the DMC in O'Neill Forebay. Downstream of San Luis Reservoir, EC remains fairly constant until the bifurcation of the California Aqueduct. The median EC values along the aqueduct range from 467 to 474 µS/cm. West Branch salinity is affected by reservoir storage in Pyramid Lake, Elderberry Forebay, and Castaic Lake, as illustrated by the narrow range of EC measured at Castaic Outlet and the slight increase in the median EC from 471 µS/cm at Check 41 to 492 µS/cm at Castaic Outlet. The median EC at Devil Canyon (446 µS/cm) on the East Branch is slightly lower than the EC at Check 41.

EC of water leaving O'Neill Forebay at Check 13, just upstream of the Coastal Branch at Check 21, and near the bifurcation of the aqueduct at Check 41 is shown in **3-54**. EC varies seasonally and shows a distinct bimodal pattern with the highest levels in the fall or early winter and a secondary peak in May or June. EC levels are lowest in July and August. During the 2001 to 2005 study period, there was little variability in EC between Check 13 and Check 41, indicating that floodwaters and non-Project inflows did not generally affect EC. There is considerably more variability during the wet years between 1996 and 2000. During the winter and spring of 1998, over 21,000 acre-feet of floodwaters entered the aqueduct between Checks 13 and 21. During this time, the EC at Check 21 was up to 300 µS/cm higher than the EC at Check 13. Monitoring of the inflows conducted by DWR between 1996 and 1998 show that EC ranges from 161 to 3,560 µS/cm, with most being higher than the levels found in the aqueduct at Check 13.

Figure 3-54. EC in the California Aqueduct

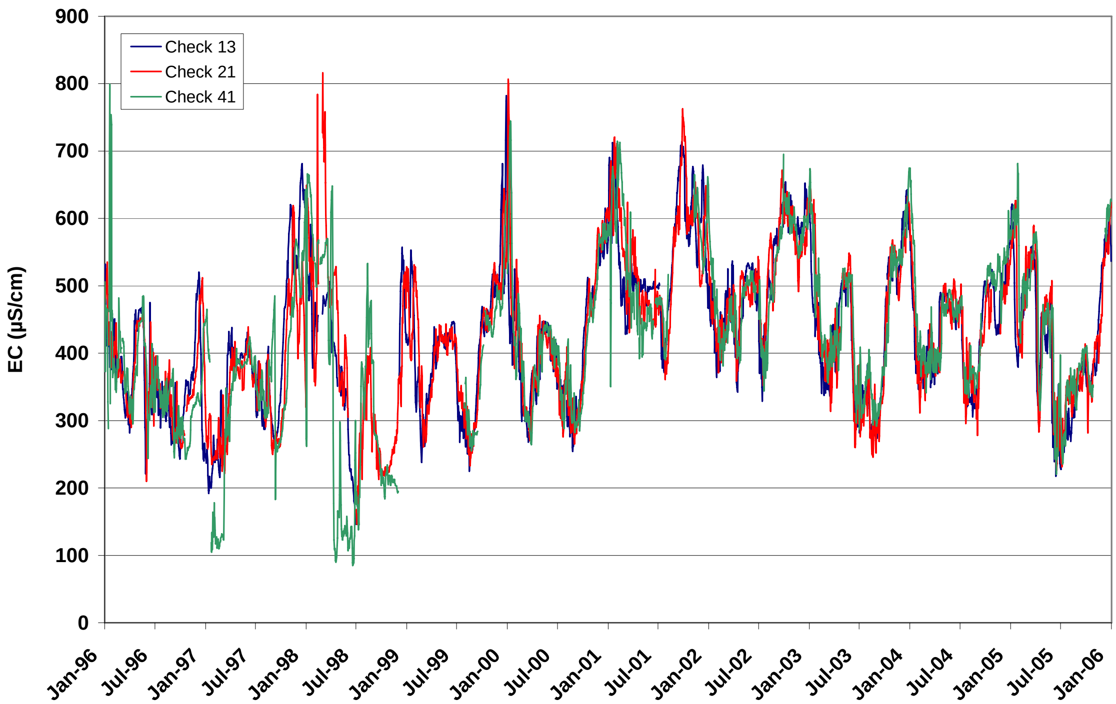


Figure 3-54 shows that EC dropped dramatically at Check 41 in the springs of 1997 and 1998. This was due to inflows from the Kern River intertie. In 1997, almost 53,000 acre-feet of Kern River water entered the aqueduct between January and February. In 1998, 188,000 acre-feet of Kern River water entered the aqueduct between April and July. The average EC of the Kern River inflows was 91 µS/cm in 1997 and 104 µS/cm in 1998. During these periods, EC levels at Check 41 dropped to 100 µS/cm.

Figure 3-55 compares the EC data for Check 41 and Castaic Outlet. Castaic Outlet EC levels are dampened over those found in the aqueduct but there is a strong seasonal pattern that is the opposite of the aqueduct. Peak EC levels occur in the spring and lowest EC levels occur in the fall months. During the wet years (1997 to 2000) the EC concentrations were lower and the seasonal fluctuations are not as apparent. Water years 2001 and 2002 were dry and may be responsible for the higher EC levels and more pronounced seasonal fluctuations in 2002 and 2003.

Figure 3-56 compares the EC data for Check 13 and Devil Canyon**.** While there is some dampening of the EC fluctuations that occur at Check 13, Devil Canyon has larger variations than Castaic Lake due to the relatively small storage capacity of Silverwood Lake. The peak EC levels occur between November and February and, there is about a one month to six weeks time lag between Check 13 and Devil Canyon.

Coastal Branch

Check 21 is 12 miles upstream of the Coastal Branch junction, and reflects the quality of water in the Coastal Branch. As shown in **Figures 3-44 and 3-54**, the EC of water at Check 21 is similar to that observed at Check 13.

Impacts of Operations on TDS Concentrations and Loads

A regression analysis was performed using data from 35 EC and TDS analyses of discrete samples collected from Banks, which produced the equation: TDS= EC * 0.58, R^2=0.997. This regression analysis, incidentally, produced essentially the same results as a similar analysis using data from the San Joaquin River near Vernalis. Daily TDS concentrations were estimated using this equation and daily EC measurements from the continuous recorder at Banks. The TDS estimates were combined with daily pumping at Banks to calculate the loads of TDS pumped into the California Aqueduct for the 2001 to 2005 period. **Figure 3-57** indicates that there is tremendous variability in the loads, largely due to pumping rates. TDS loads are lowest in the spring when pumping is curtailed and highest in the winter months (up to 8,000 tons per day) when TDS concentrations are highest at Banks and pumping rates are high.

Figure 3-55. EC in the West Branch

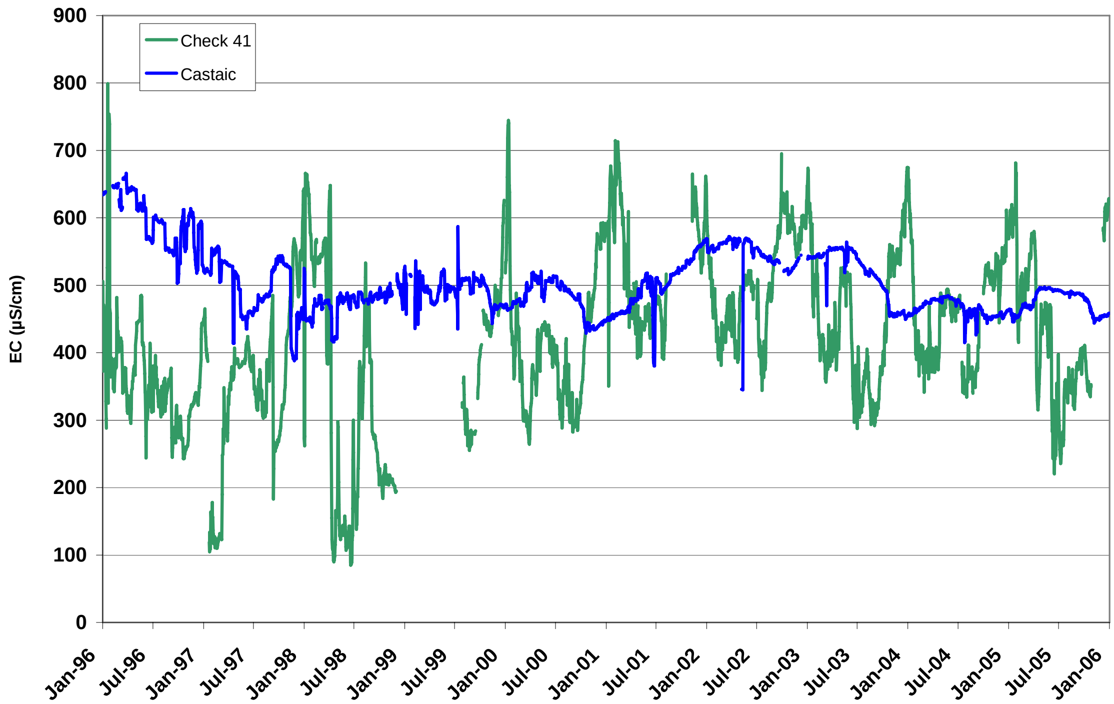


Figure 3-56. EC in the East Branch

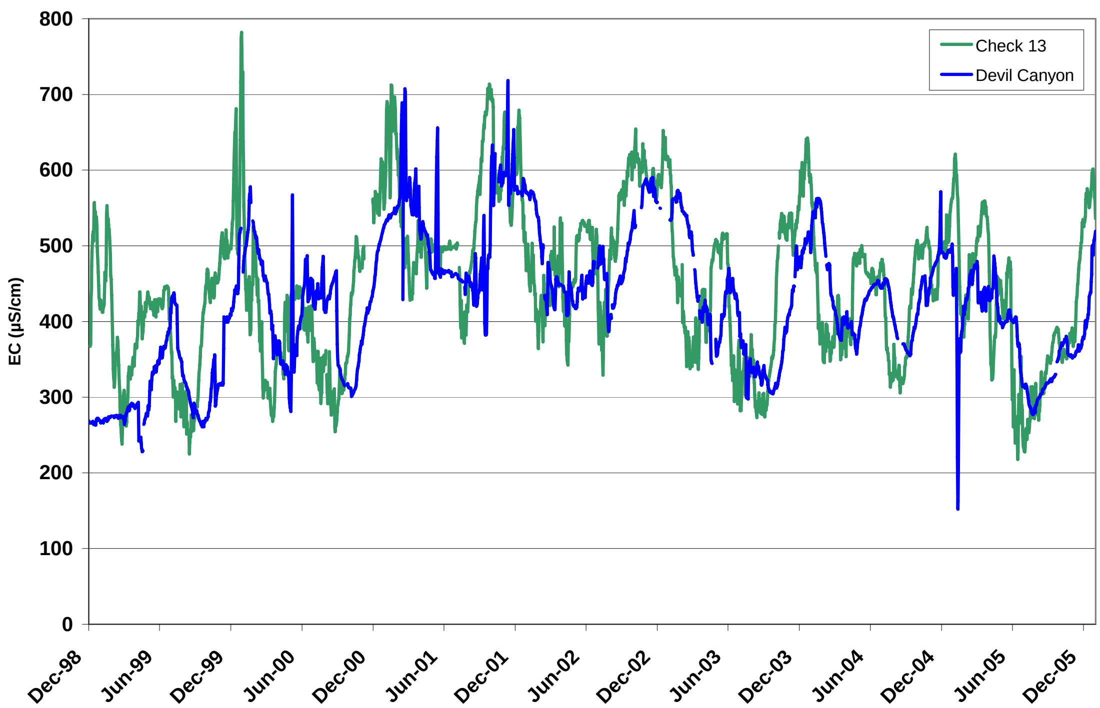


Figure 3-57. TDS Load Exported to the SWP at Banks

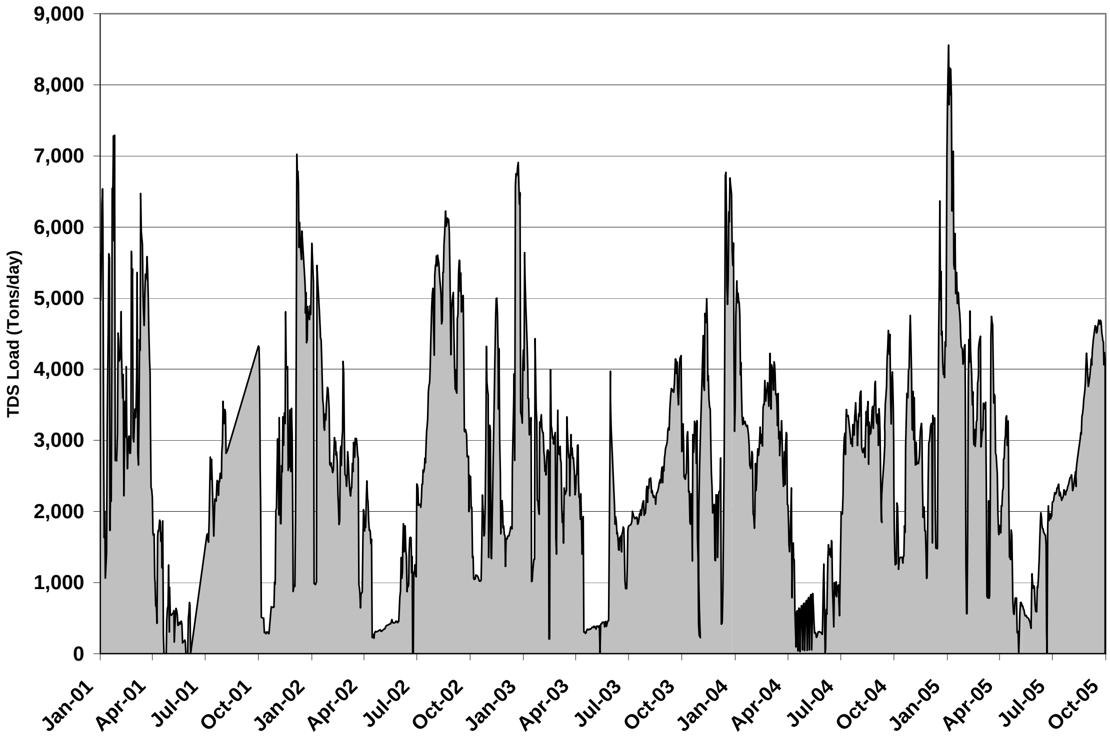


Figure 3-58 shows average monthly diversions at Banks between 1998 and 2005 and the previous ten years. The monthly average TDS concentrations at Banks, calculated from EC measurements, for the 2001 to 2005 period are also shown. In recent years more water has been pumped from the Delta during the summer and fall months when TDS concentrations are steadily increasing. **Figure 3-59** shows that San Luis Reservoir is filled during the fall and winter months when TDS concentrations are moderate to high at Banks. This may be partially responsible for the median TDS in San Luis Reservoir, measured at Pacheco (507 µS/cm), being substantially higher than the median at Banks (389 µS/cm), although evaporation and DMC inflows are other factors. This higher TDS water is released from the reservoir during the spring and summer months when EC at Banks is decreasing. With the current limited monitoring of the SWP, it is not possible to fully evaluate how changes in operations impact TDS concentrations.

Figure 3-58. Average Monthly Banks Diversions and EC

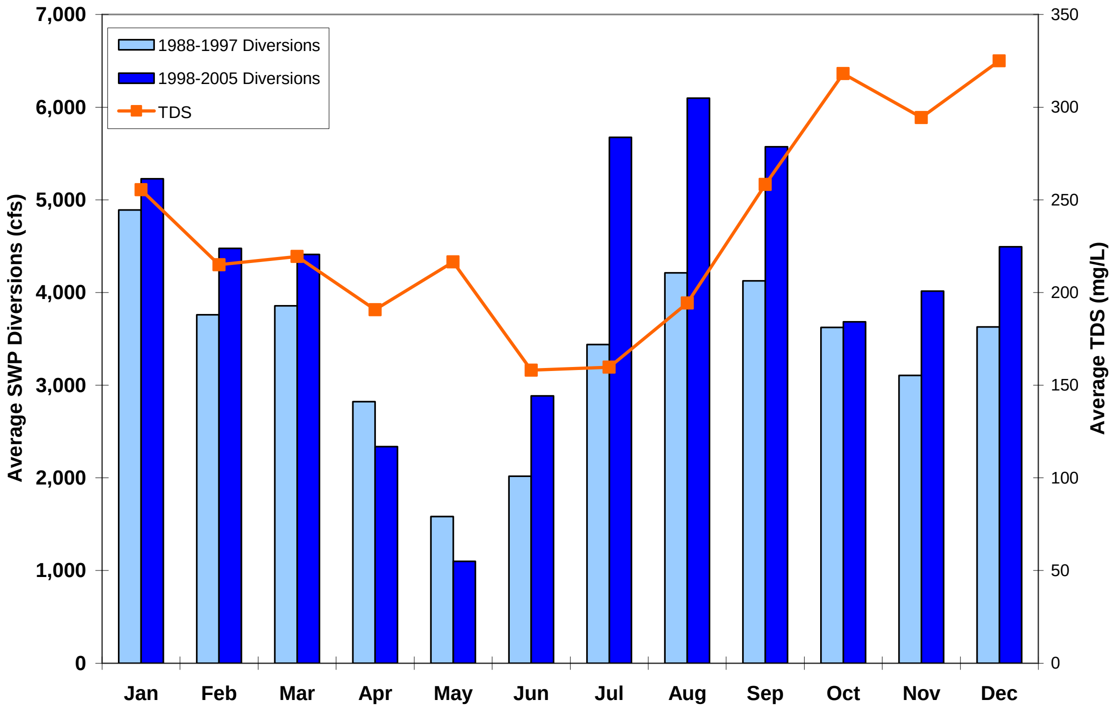
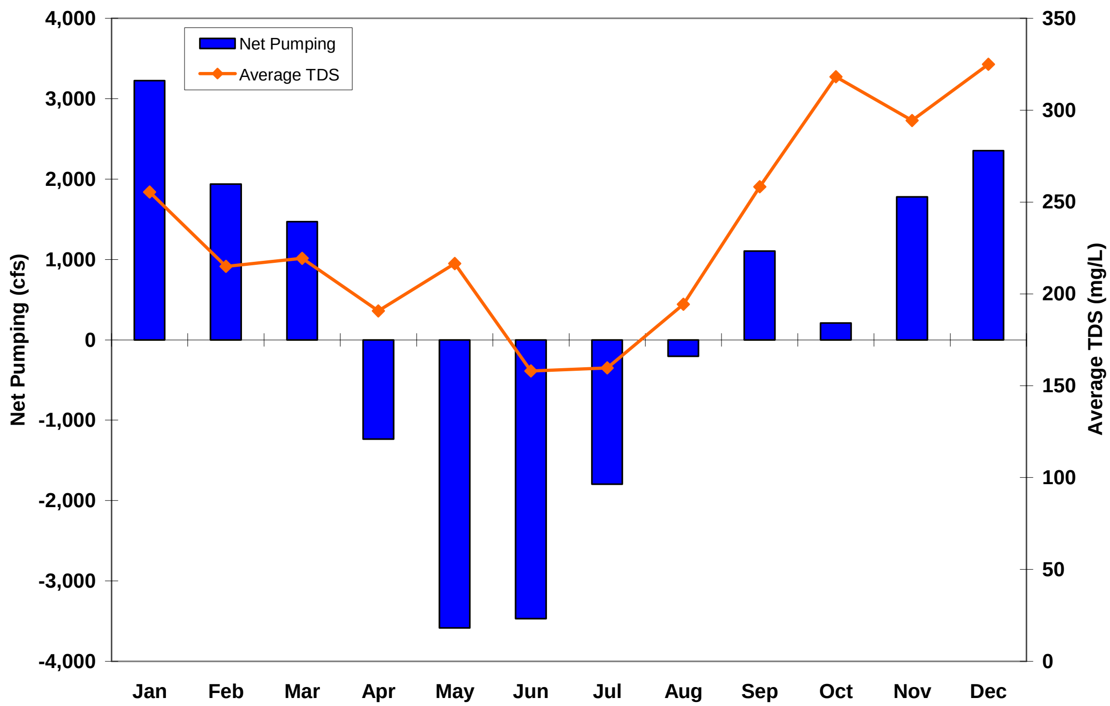


Figure 3-59. Net Pumping to San Luis Reservoir and EC



Summary

- EC levels in the Sacramento River are considerably lower than levels in the San Joaquin River. At flows over 2,000 cfs, EC at Vernalis is inversely related to flow.

- EC levels in the NBA are higher and more variable than at Hood but lower than the levels at Banks. Peak EC levels are found in April with a clear indication that the local Barker Slough watershed is a contributor of salinity.

- The EC fingerprints indicate that the San Joaquin River, seawater intrusion, and Delta agricultural drainage are the primary sources of EC at the south Delta pumping plants. The San Joaquin River has a greater influence on EC at Tracy than at Banks.

- There is a substantial increase in EC between Banks and San Luis Reservoir; however the variability of EC in the reservoir is greatly reduced. EC levels do not change between San Luis Reservoir and the bifurcation of the aqueduct. EC levels in Castaic Lake are less variable than the aqueduct locations, due to the dampening effect of about 500,000 acre-feet of storage on the West Branch. The dampening effect is not seen in Silverwood Lake on the East Branch due to its limited hydraulic residence time.

- There are distinct seasonal patterns in EC levels but they vary between locations. In the Sacramento River, EC levels are lowest in the early summer, steadily increase until flows increase in the river in the late fall or early winter, and then drop back to the summer lows. In the San Joaquin River, EC levels are lowest in the spring, increase during the summer months due to agricultural drainage discharges, continue to climb during the fall due to seawater intrusion, and remain high until late winter or early spring when flow increases on the river. The seasonal pattern at Banks is similar to the San Joaquin River except that EC levels generally start to decrease earlier in the winter.

- There is tremendous variability in the load of TDS pumped into the SWP system, largely due to pumping rates. TDS loads are lowest in the spring when pumping is curtailed and highest in the winter months (up to 8,000 tons per day) when TDS concentrations are highest at Banks and pumping rates are high.

- There are no apparent long term trends at any of the locations included in this analysis. Continuous EC data were available from 1996 through 2005 at many locations. During this time, water years varied from dry to wet but no apparent relationship between water year type and EC concentrations is evident in the data.

- The existing monitoring program is inadequate to evaluate operational changes or to forecast EC concentrations in the aqueducts as a result of changing water quality in the Delta.

BROMIDE

Water Quality Concern

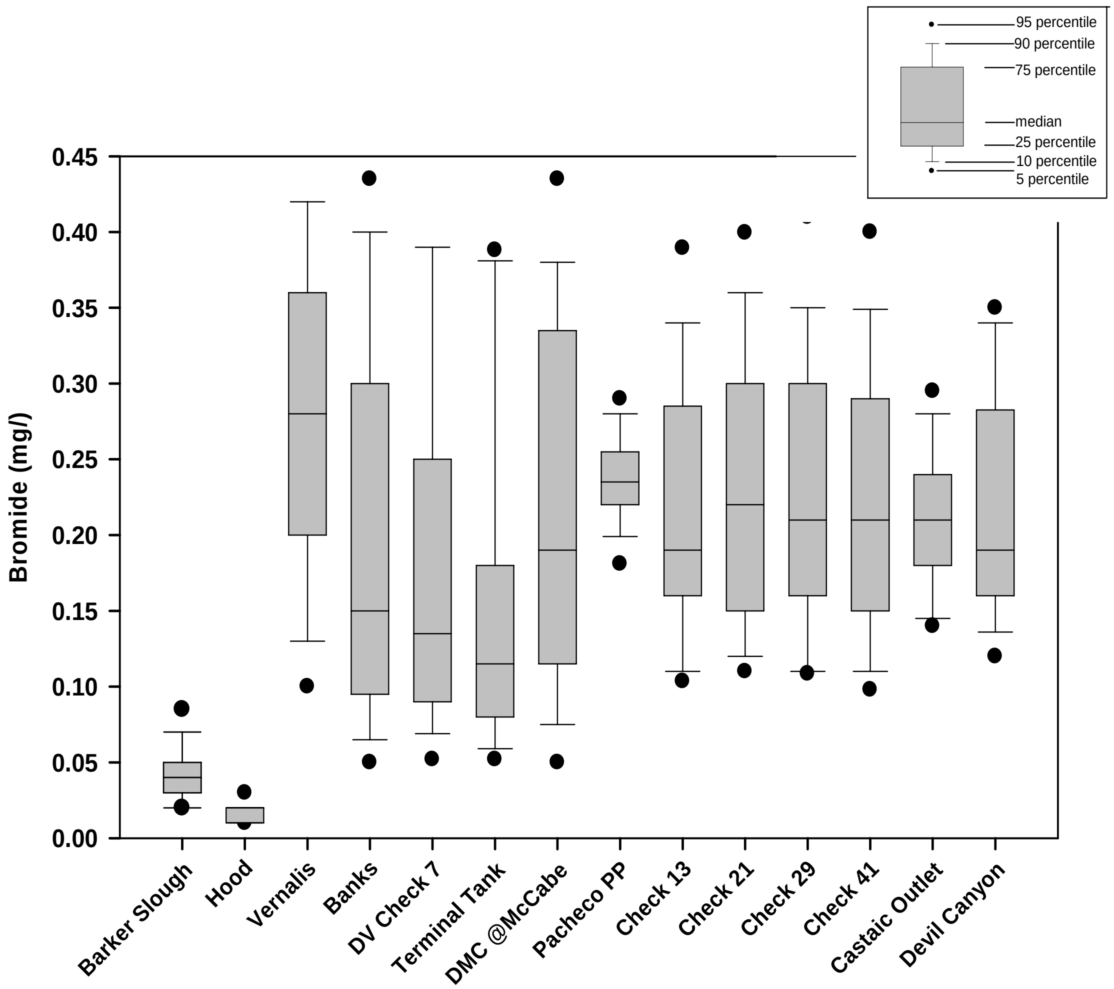
Bromide is of concern to SWP Contractors because it reacts with oxidants used for disinfection in water treatment to form DBPs. When chlorine is used as a disinfectant, bromide reacts with chlorine and TOC to form TTHMs and HAA5s. The Stage 1 D/DDP Rule limits the concentration of TTHMs to 0.080 mg/L and HAA5 to 0.060 mg/L as a running annual average in drinking water distribution systems. Three of the four regulated trihalomethanes, bromo-dichloromethane, dibromochloromethane, and bromoform contain bromide and two of the regulated HAA5s, monobromoacetic acid and dibromoacetic acid contain bromide. Another DBP, bromate, is formed when ozone is used for disinfection. The Stage 1 MCL for bromate is 0.010 mg/L, measured at the entrance to the distribution system. Compliance with the Stage 1 and Stage 2 D/DBP Rules presents challenges for the SWP Contractors whose source water contains both bromide and organic carbon. A 1998 study on the treatability of organic carbon and bromide in source waters concluded that waters diverted from the Delta for drinking water treatment should contain bromide concentrations no greater than 0.050 mg/L (Owen et al, 1998). This was subsequently adopted by the CALFED Bay-Delta Program (CALFED, 2000) as a target.

Water Quality Evaluation

Bromide Concentrations in the SWP

Bromide data from DWR's MWQI Program, the SWP WQMP, and ACWD were used to evaluate changes in bromide concentrations as the water travels from the Delta through the SWP system. Data from the 2001 to 2005 time period are compared to data from the previous five years. Data were not available for the entire ten years at all locations. **Figure 3-60** compares bromide concentrations in the Delta and various locations in the SWP system.

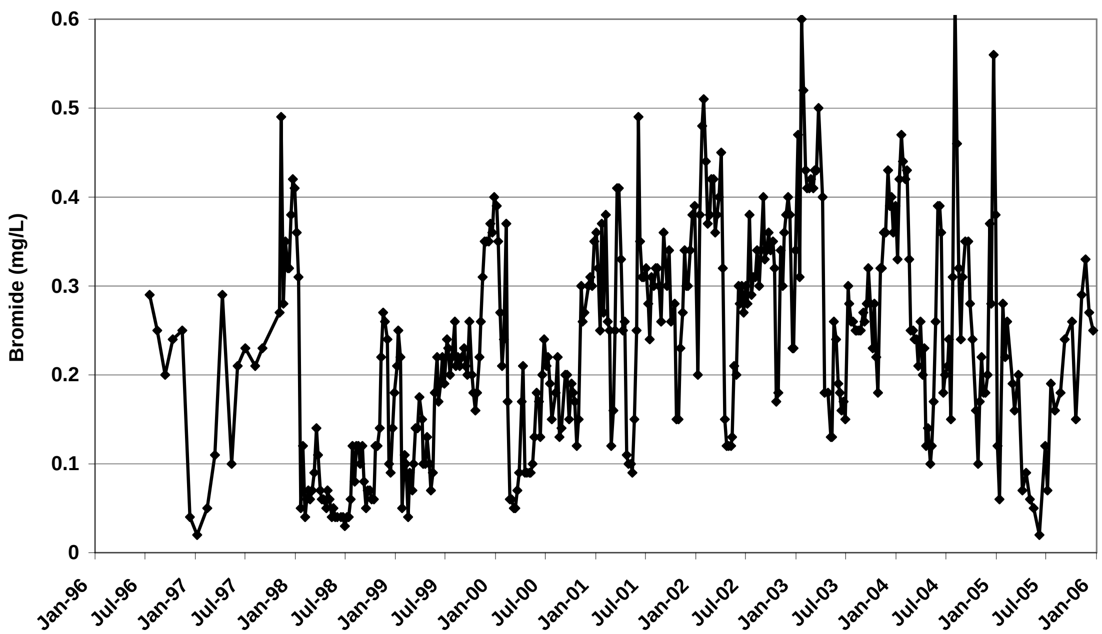
Figure 3-60. Bromide Concentrations in the SWP



Sources of Water to the Delta

Figure 3-60 clearly demonstrates that bromide concentrations in the Sacramento River are quite low, with a median concentration of 0.01 mg/L during the 2001 to 2005 period. There is little variability in the bromide concentrations at Hood because that location is not substantially impacted by seawater intrusion. The maximum concentration ever measured at Hood was 0.05 mg/L in June 2002. The San Joaquin River had a median concentration (0.28 mg/L) an order of magnitude higher than Hood. **Figure 3-61** indicates that peak bromide concentrations at Vernalis (0.4 to 0.6 mg/L) occur during the late fall and early winter of most years. Concentrations decline during the early spring months and then increase again in the summer. The primary source of bromide at Vernalis is agricultural irrigation waters diverted from the Delta at the Tracy Pumping Plant and returned to the river as drainage. During the summer months, there is minimal flow in the river to dilute the agricultural drainage. The lowest bromide concentrations occur during wet years when the San Joaquin River receives large amounts of water from the high quality tributaries. High levels of bromide occur during the dry season of all water year types.

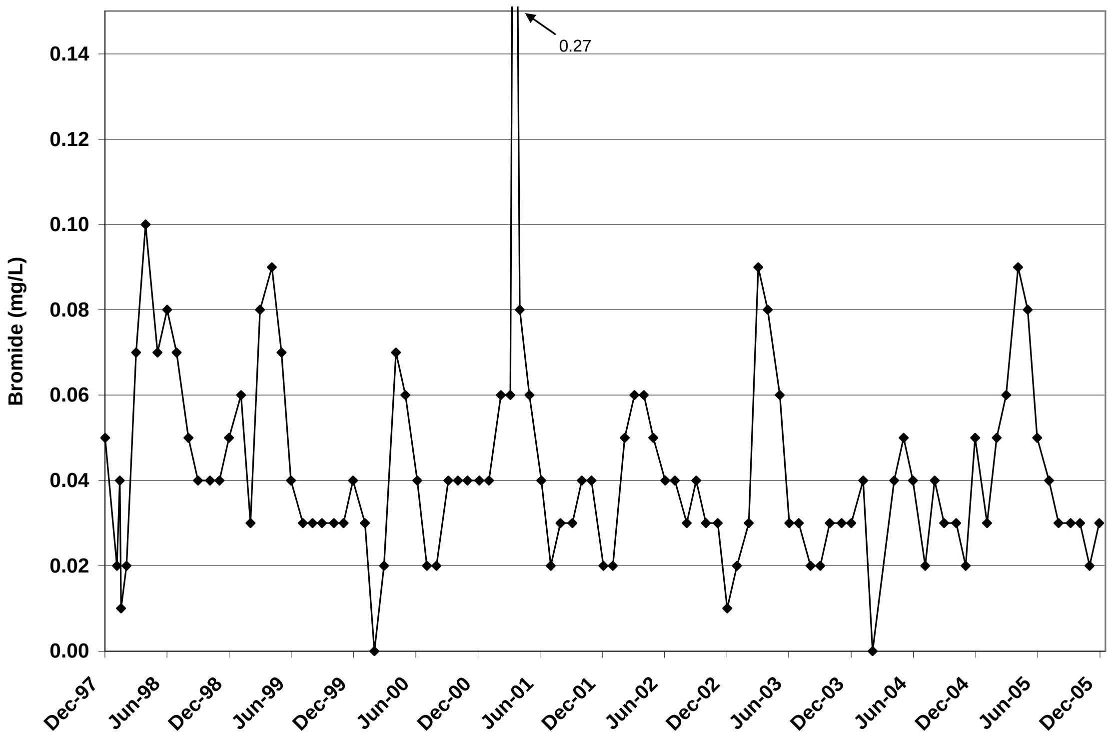
Figure 3-61. Bromide Concentrations at Vernalis



North Bay Aqueduct

As shown in **Figure 3-60**, Barker Slough is relatively low in bromide, with a median concentration of 0.04 mg/L during the 2001 to 2005 period. This is higher than the median concentration in the Sacramento River, indicating there is a source of bromide in the Barker Slough watershed. As shown in **Figure 3-62**, bromide concentrations generally vary between the reporting limit (0.01 mg/L) and 0.1 mg/L. The highest concentration ever measured at Barker Slough was 0.27 mg/L in the spring of 2001. There is a seasonal pattern of low concentrations during the winter months and peak concentrations in the spring. There is no apparent relationship to water year types and no long term trends are evident in the data.

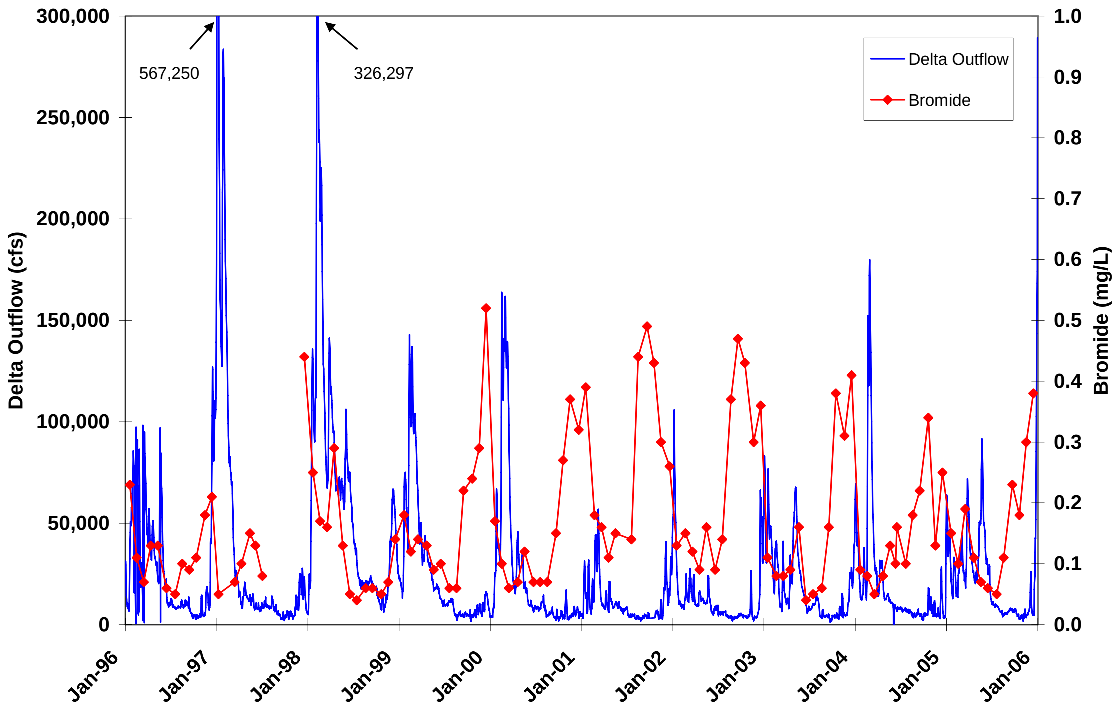
Figure 3-62. Bromide Concentrations at Barker Slough



<u>Banks Pumping Plant</u>

As shown in **Figure 3-60**, the median bromide concentration at Banks (0.15 mg/L) was considerably higher and substantially more variable than the Sacramento River, reflecting the influence of seawater intrusion and the San Joaquin River. As discussed in the Salinity section, seawater intrusion is a major source of salinity in the Delta. Seawater contains about 68 mg/L of bromide; therefore, during periods of significant seawater intrusion, substantial amounts of bromide are mixed into the Delta. **Figure 3-63** compares bromide concentrations at Banks to Delta outflow. This figure clearly shows pronounced increases in bromide concentrations at Banks during dry fall months when Delta outflow is low. Concentrations generally rise above 0.2 mg/L and may reach 0.5 mg/L during the fall. Bromide concentrations decrease to less than 0.1 mg/L during winter and spring months when Delta outflow increases. Bromide concentrations were lower during the 1996 to 2000 period than during the 2001 to 2005 period due to the amount of Delta outflow in the earlier period. Although seawater intrusion is the greatest source of bromide in the Delta, other factors can influence the bromide concentrations at Banks, including inflow from the San Joaquin River which contains bromide from irrigation drainage water originally diverted from the Delta. San Joaquin River water probably also contains bromide from natural sources within the San Joaquin River watershed. Some Delta islands have connate groundwater containing bromide from ancient sources (DWR, 1994). Previous studies have demonstrated these non-ocean sources are, however, minimal compared to bromide from ocean origin (DWR, 1998 and Krasner et al, 1993).

Figure 3-63. Bromide Concentrations at Banks and Delta Outflow



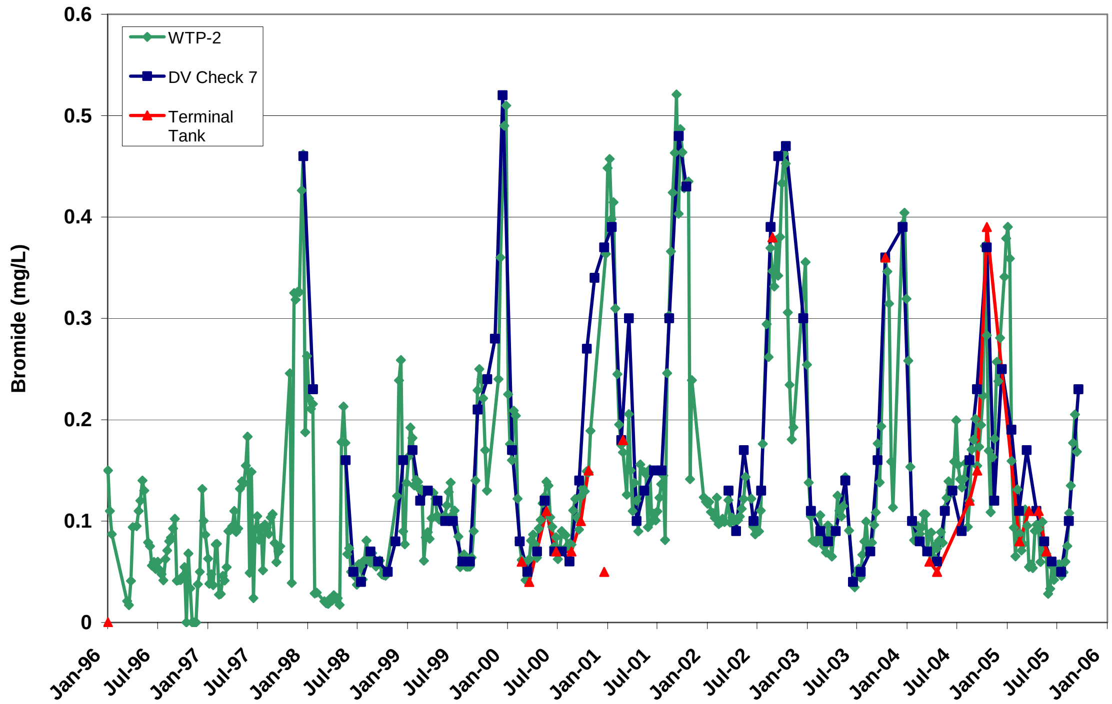
South Bay Aqueduct

Figure 3-60 shows that the median bromide concentration at DV Check 7 (0.14 mg/L) is similar to Banks (0.15 mg/L). This figure shows an apparent decrease in bromide concentrations (median of 0.11 mg/L) at the Terminal Tank. This is likely an artifact of the limited data, collected mainly during 2004 and 2005 from the Terminal Tank. ACWD provided additional bromide data at the intake of WTP-2. Bromide data from DV Check 7, WTP-2 intake, and the Terminal Tank are compared in **Figure 3-64.** This figure indicates that the concentrations are similar at all three locations and the seasonal pattern observed at Banks is also found in the SBA. Bromide concentrations are highest in the fall and early winter and lowest in the spring and summer. The ACWD data indicate that bromide concentrations were substantially lower in the extremely wet years of 1996 and 1997. There are no apparent long-term trends in the data.

Delta Mendota Canal

The median concentration of bromide during the study period in the DMC @ McCabe was 0.19 mg/L. The median concentration at Banks during this time period was 0.15 mg/L. The higher concentrations in the DMC are a result of more San Joaquin River water (with median bromide of 0.28 mg/L) being diverted at Tracy than at Banks. Bromide concentrations in the DMC @ McCabe are quite variable, ranging from 0.04 to 0.52 mg/L during the 2001 to 2005 period. The 2001 Update included a discussion of a loading study conducted by DWR O&M staff (DWR, 2001). The loading study showed that in 1995 the DMC contributed 47 percent of the inflow to O'Neill Forebay and almost 60 percent of the bromide load. This study illustrates that the DMC can greatly influence the quality of water in the Aqueduct south of O'Neill Forebay.

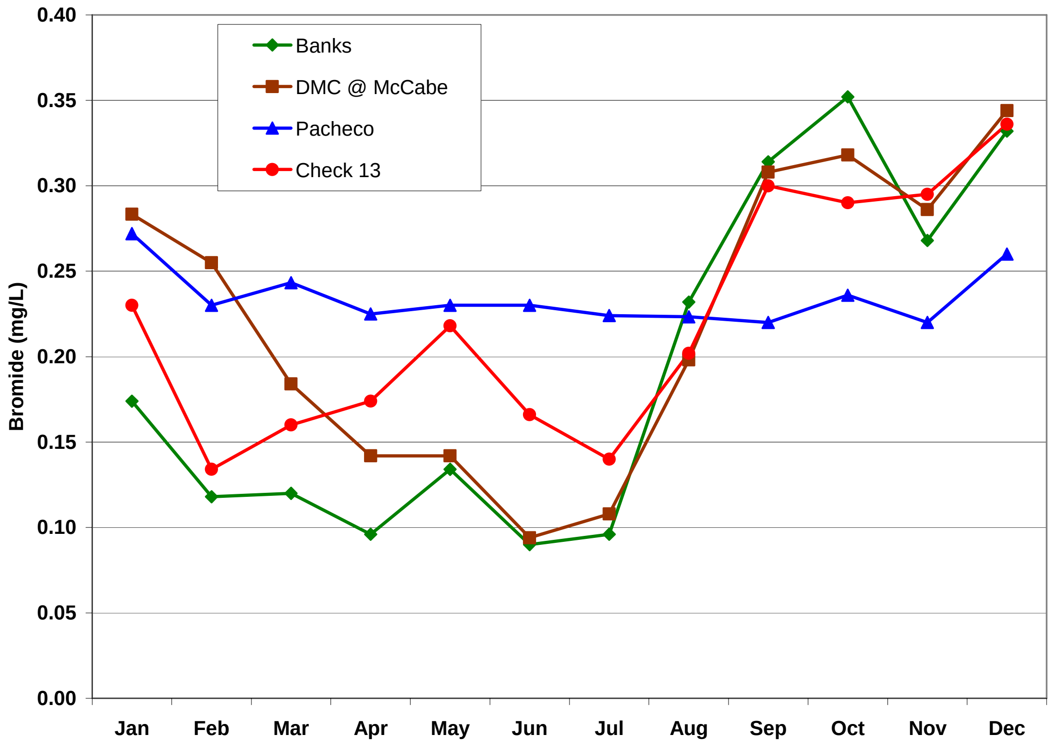
Figure 3-64. Bromide Concentrations in the SBA



California Aqueduct

As shown in **Figure 3-60**, there is a considerable increase in bromide concentrations between Banks and San Luis Reservoir, although there is far less variability in the reservoir. The median concentration at Pacheco is 0.24 mg/L, compared to a median of 0.15 mg/L at Banks. Monthly median bromide concentrations during the 2001 to 2005 study period for the northern part of the California Aqueduct are presented in **Figure 3-65.** This figure also includes data for the DMC and San Luis Reservoir. Bromide concentrations in the aqueduct and the DMC are seasonal, with the highest concentrations occurring during the fall when freshwater inflows to the Delta are minimal. Bromide concentrations in the DMC are substantially higher than Banks from January through April due to the greater influence of the San Joaquin River on the DMC. Bromide concentrations decline rapidly at Banks in December and January due mainly to higher flows in the Sacramento River; however, the concentrations remain high at Vernalis until March or April. The figure also shows the smoothing effect of mixing in San Luis Reservoir, as average monthly concentrations at Pacheco range from 0.220 to 0.272 mg/L, varying much less than the aqueduct stations. The maximum concentrations in San Luis Reservoir occur in December and January, likely due to filling of the reservoir during the fall months when bromide concentrations are high in the Delta. Bromide concentrations at Check 13 were higher than Banks and the DMC during the spring months due to the release of water from San Luis Reservoir.

Figure 3-65. Monthly Mean Bromide Concentrations in the Northern California Aqueduct



Downstream of San Luis Reservoir, bromide concentrations in the California Aqueduct do not vary as the water travels south, with median concentrations between 0.19 and 0.22 mg/L. **Figure 3-66** presents the average monthly concentrations at four checks between O'Neill Forebay and the bifurcation of the aqueduct. Bromide concentrations are similar at all four locations and highest from September to January. There is also a peak in May that appears attributable to releases from San Luis Reservoir. **Figure 3-67** is a similar plot of monthly mean concentrations that shows the differences between the East and West branches of the aqueduct. The reservoirs on the West Branch dampen the fluctuations in bromide concentrations, as shown by the Castaic Outlet data. Conversely, the limited storage along the East Branch has only a minor impact on the variability in bromide concentrations.

Coastal Branch

As shown in **Figures 3-60 and 3-67**, the bromide concentrations at Check 21, just upstream from the junction with the Coastal Branch, are similar to other California Aqueduct locations downstream of San Luis Reservoir. The median bromide concentration between 2001 and 2005 was 0.22 mg/L.

Figure 3-66. Monthly Mean Bromide Concentrations in the Central California Aqueduct

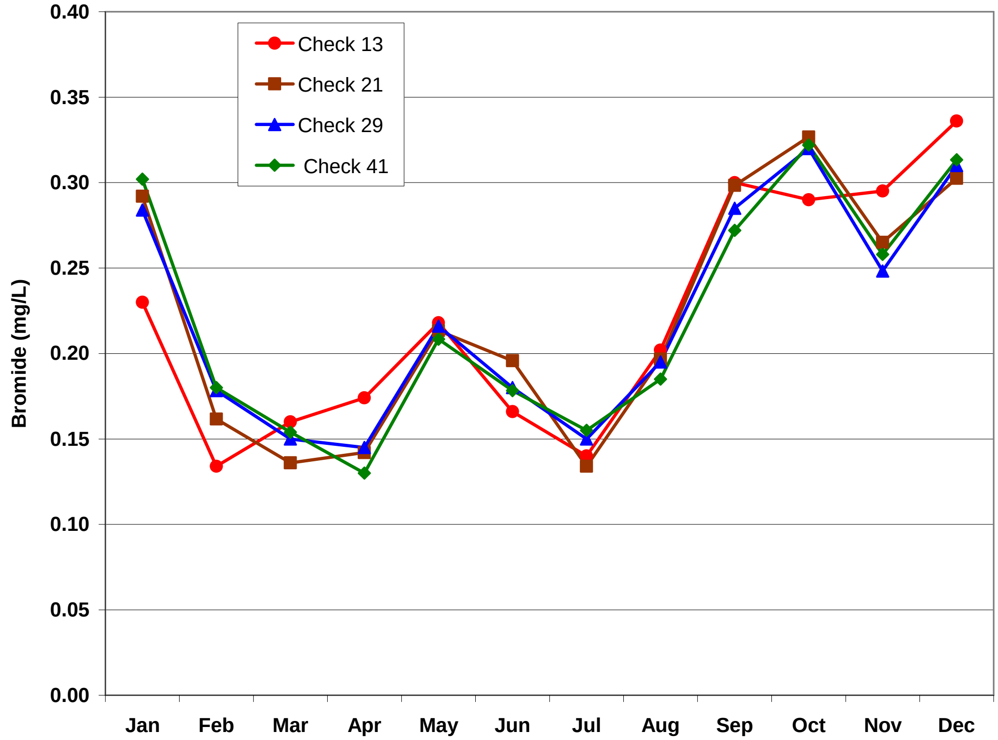
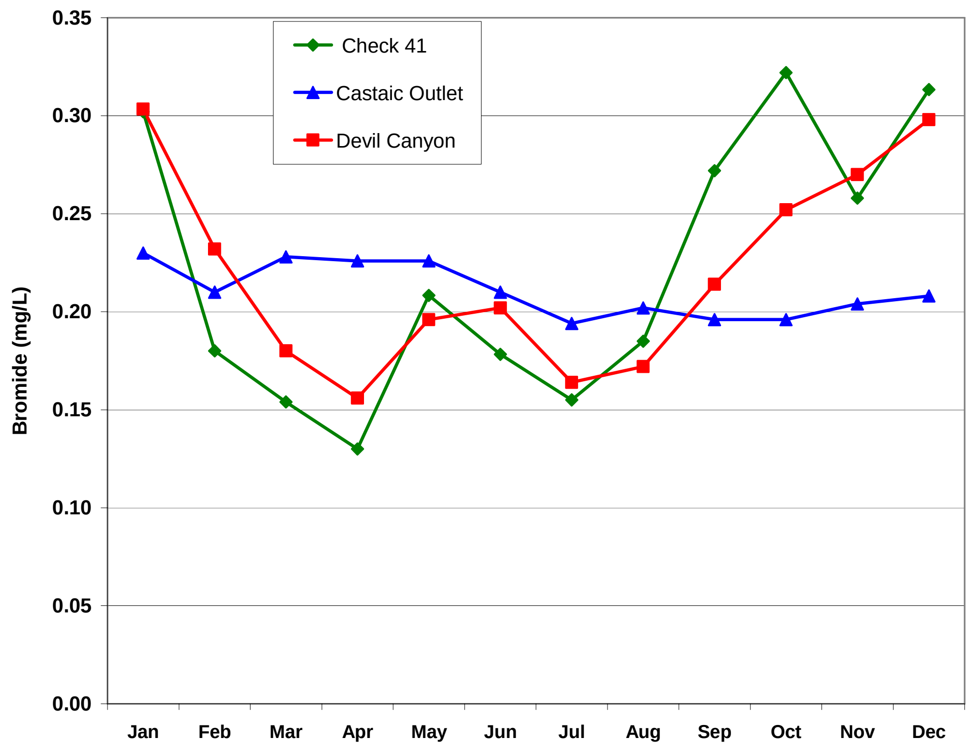


Figure 3-67. Monthly Mean Bromide Concentrations in the East and West Branches



Impacts of Operations on Bromide Concentrations

Figure 3-68 shows average monthly diversions at Banks between 1998 and 2005 and the previous ten years. The monthly average bromide concentrations at Banks for the 2001 to 2005 period are also shown. In recent years more water has been pumped from the Delta during the summer and fall months when bromide concentrations are steadily increasing. **Figure 3-69** shows that San Luis Reservoir is filled during the fall months when average bromide concentrations are in the range of 0.20 to 0.35 mg/L and during the winter months when bromide concentrations are lower. The median bromide concentration in San Luis Reservoir is almost 0.1 mg/L higher than at Banks and a peak in bromide concentrations in the California Aqueduct in May corresponds with releases from San Luis Reservoir.

Summary

- Bromide concentrations in the Sacramento River are low, often at or near the detection limit of 0.01 mg/L. Conversely, bromide concentrations are high in the San Joaquin River (median of 0.28 mg/L).

- Bromide concentrations in the NBA are higher and more variable than at Hood but substantially lower than the levels at Banks. The Barker Slough watershed is the source.

- Seawater intrusion is the primary source of bromide at the south Delta pumping plants. The concentrations at the pumping plants are inversely related to Delta outflow. The San Joaquin River and Delta agricultural drainage are secondary sources.

- There is a substantial increase in bromide between Banks and San Luis Reservoir; however, the variability of bromide in the reservoir is greatly reduced. Bromide concentrations do not change between San Luis Reservoir and the bifurcation of the aqueduct. Bromide concentrations in Castaic Lake are slightly less variable than the aqueduct locations; however, the dampening effect is not seen in Silverwood Lake.

- There are distinct seasonal patterns in bromide concentrations but they vary between locations. In the Sacramento River, bromide concentrations are low all year. In the San Joaquin River, bromide concentrations are lowest in the spring, increase during the summer months due to agricultural drainage discharges, continue to climb during the fall due to seawater intrusion, and remain high until late winter or early spring when flow increases on the river. The seasonal pattern at Banks is similar to the San Joaquin River except that bromide concentrations generally start to decrease earlier in the winter. The SBA and California Aqueduct locations show the same seasonal pattern as Banks with the highest concentrations during the fall months. There is a secondary peak along the aqueduct in May that appears to be related to releases from San Luis Reservoir.

- There are no apparent long term trends at any of the locations included in this analysis. Bromide data are available for ten years at many locations. During this time, water years varied from dry to wet and bromide concentrations were lowest in the wet years of 1996 and 1997.

Figure 3-68. Average Monthly Banks Diversions and Bromide Concentrations

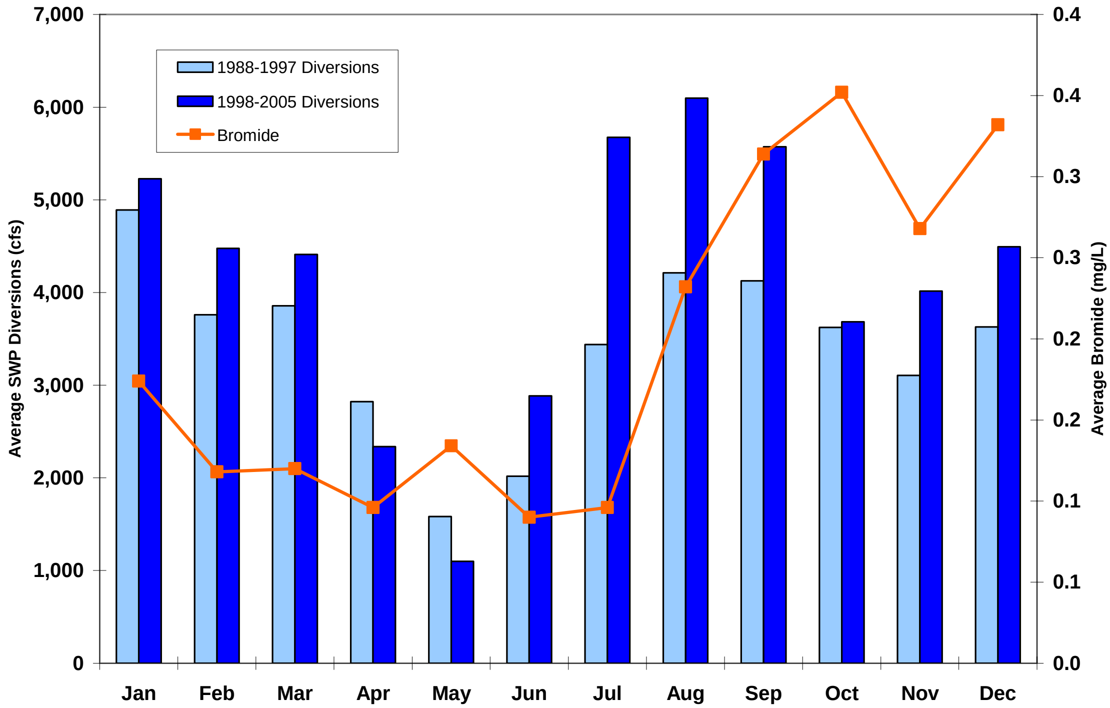
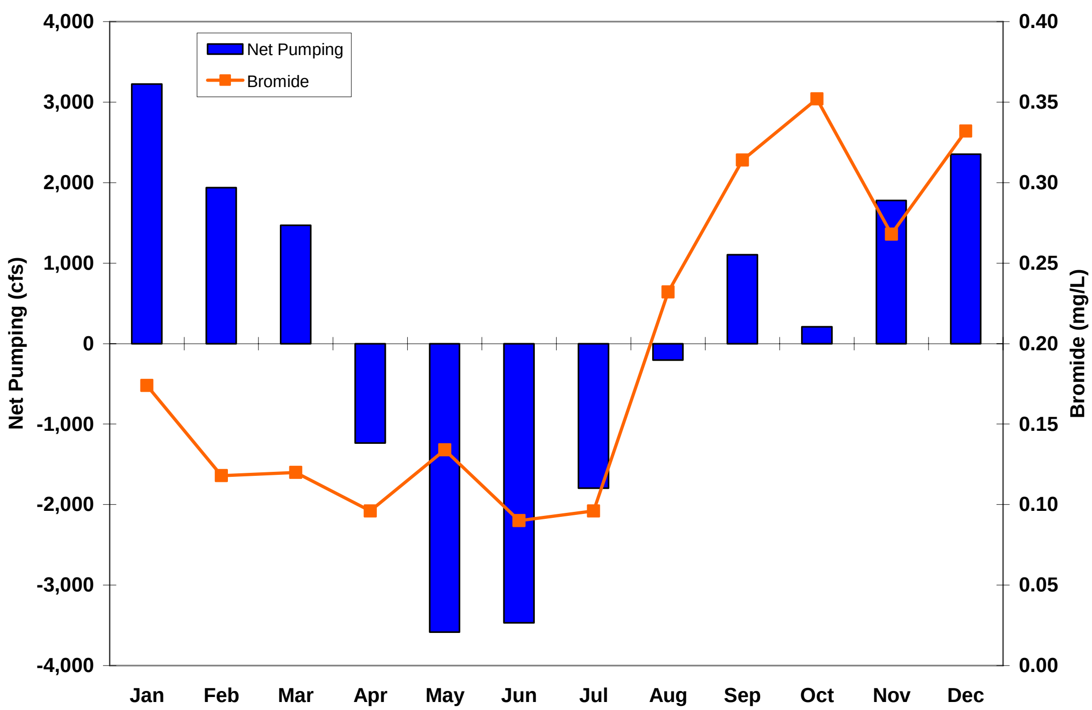


Figure 3-69. Net Pumping to San Luis Reservoir and Bromide Concentrations



NUTRIENTS, ALGAL BLOOMS, AND TASTE AND ODOR INCIDENTS

Water Quality Concern

Nutrients are required for the proper functioning of aquatic ecosystems but when they are present in drinking water supplies at concentrations that exceed natural background levels, a number of adverse impacts occur. When nutrients are readily available and other environmental conditions favorable, algal growth can reach levels that cause taste and odor in drinking water, add organic carbon, obstruct water conveyance facilities, clog filters and increase the quantity and expense of handling solid waste from the treatment process.

Algal "blooms" occur when the population of a species of algae suddenly increases exponentially to dominate a water body. The species dominance that occurs during a bloom is generally temporary, lasting for a period of days to weeks, before the population crashes, returning to pre-bloom levels. Blooms are believed to be the result of environmental conditions that, temporarily, favor a particular species. Factors that may favor individual species include relative availability of nitrogen and phosphorus, temperature, and light conditions. Algal population dynamics are highly complex, and are not addressed in this section.

Algae and certain bacteria produce chemical compounds that are not removed in conventional water treatment processes and are capable of causing unpleasant tastes and odors in drinking water. Taste and odor (T&O) incidents in the SWP are commonly associated with geosmin and 2-methylisoborneol (MIB) that are produced by certain algae and bacteria. The ability of individuals to detect these chemicals varies, but the general population can detect either compound at a concentration of about 10 ng/L (parts per trillion) and sensitive individuals can detect even lower concentrations.

Growths of attached and planktonic algae and rooted vascular plants are sufficiently troublesome in the SWP that chemical treatment and/or physical removal is periodically required in Clifton Court, trashracks along the California Aqueduct, the SBA, Coastal Branch, and Southern California SWP reservoirs. Copper sulfate is used to treat algal blooms in the SWP but, in addition to the expense associated with its use, undesirable consequences are possible. Treated algae can die in large numbers, causing taste and odor spikes and clogging of treatment plant filters. Copper in treatment plant solid waste can be classified as hazardous waste, greatly increasing the cost and difficulty of disposal. Taste and odor incidents that occurred during the 2001 to 2005 period of this study resulted in customer complaints to SWP Contractors treating water from the SBA, Coastal Branch, and California Aqueduct. Chapters 5 and 7 contain more detailed descriptions of the problems faced by the SBA and Coastal Branch Contractors.

Some blue-green algae (more correctly known as cyanobacteria), one of which is *Microcystis aeruginosa*, are capable of emitting potent toxins when cells die and release their contents. Blooms of *Microcystis aeruginosa* have occurred in the Delta during each of the years covered by this study, although there have been no documented cases of humans or animals affected by the blooms in the Delta. There are currently no regulatory limits for algal toxins in drinking water supplies. Cyanobacteria and their toxins are on the federal Drinking Water Contaminant Candidate List, indicating they may be regulated in the future.

The USEPA has established nitrogen and phosphorus reference conditions for Ecoregion I, which includes California's Central Valley. The reference concentration for total nitrogen (total N) is 0.31 mg/L, and for total phosphorus (total P) it is 0.047 mg/L (USEPA, 2001). Nitrogen and phosphorus are essential to the ecosystem but, the concentrations present in the SWP are in excess of the levels required to maintain a healthy ecosystem and far in excess of the reference conditions.

Water Quality Evaluation - Nutrients

Measurement of nutrient concentrations provides an indication of the potential for algal and vascular plant growth in systems that are not limited by other factors, such as light availability or adverse temperatures. Of the required nutrients, nitrogen and phosphorus are most important, but potassium and silicon, in addition to small quantities of various other elements are also required. Potassium is believed to be in sufficient supply in the aquatic environment of California that it does not limit algal production. Silicon is required by diatoms for growth of their "frustules," or silicon outer bodies, but it is generally present in sufficient quantities to support diatom growth. Nitrogen and phosphorus are, therefore, the subjects of this analysis.

Nitrogen in the aquatic environment can be present in several forms; organic nitrogen, ammonia, nitrite, nitrate, and gaseous nitrogen; that are biochemically inter-convertible. Although gaseous (atmospheric) nitrogen is actually part of the biochemical cycle, its relationship to the other nitrogen forms is complex. Nitrogen is discussed here as the summation of the forms for which SWP waters are analyzed. Total nitrogen as used in this report does not include nitrogen gas, but does include its other forms, nitrate, nitrite, ammonia, and organic nitrogen.

Phosphorus is present in both dissolved and particulate forms. Particulate phosphorus consists of organic phosphorus incorporated in planktonic organisms, inorganic mineral phosphorus in suspended sediments, and phosphate adsorbed to inorganic particles and colloids. The dissolved forms include dissolved organic phosphorus, orthophosphate, and polyphosphates. Dissolved orthophosphate is the only form that is generally available for algal and plant uptake; however total P is a better indicator of the productivity of a system.

<u>Nutrient Concentrations in the SWP</u>

Nutrient data used in this analysis were drawn from DWR's MWQI Program and from the SWP WQMP. Unlike water quality constituents such as salinity, nitrogen and phosphorus are not conservative in the environment, but change forms as they are incorporated into living organisms and released back into the water at the end of the organisms' life cycles. As a consequence, examining trends can be somewhat more complex than for conservative constituents. The nutrient data were analyzed to determine if there are any changes in concentrations as water travels through the SWP system, and to identify seasonal patterns and changes over time. The spatial distribution of total N and total P for the 2001 to 2005 time period are shown in **Figures 3-70** and **3-71**, respectively. As described in more detail in the following sections, the period of record was shorter for some locations**.** Total N and total P data are not available for the Terminal Tank and the DMC @ McCabe.

Figure 3-70. Total Nitrogen Concentrations in the SWP

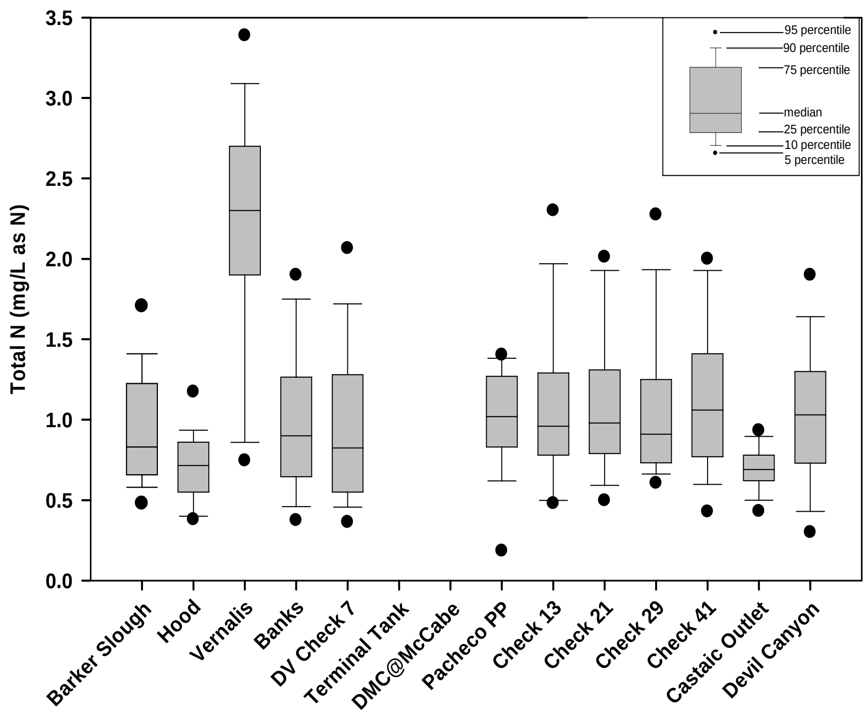
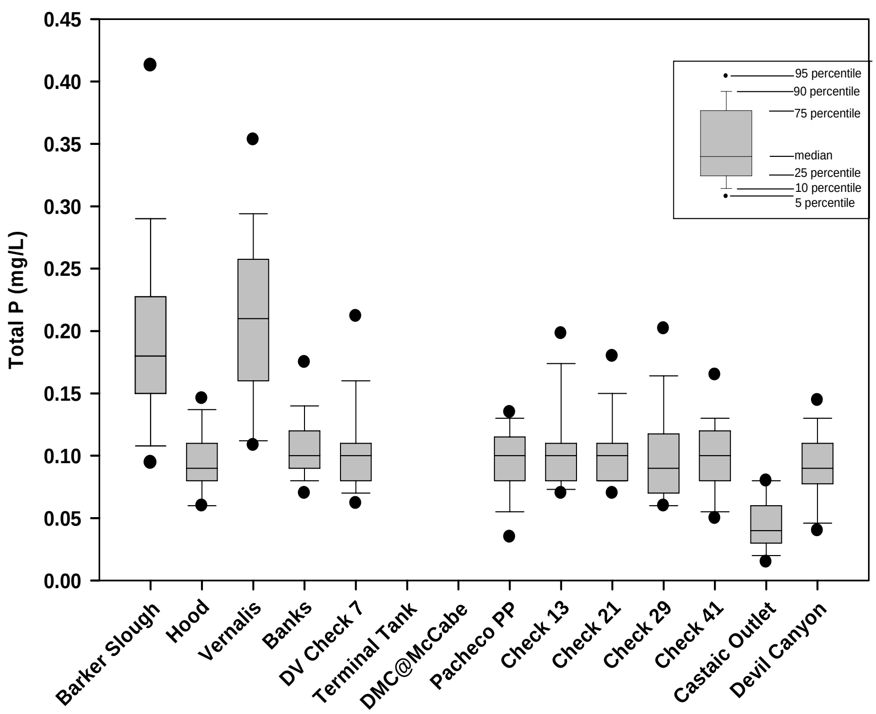


Figure 3-71. Total Phosphorus Concentrations in the SWP



Sources of Water to the Delta

Total N and total P data have only been available for Hood and Vernalis since the fall of 2002. As shown in **Figure 3-70**, the total N concentrations at Hood are substantially lower and less variable than at Vernalis. The median concentration at Hood during the 2002 to 2005 period was 0.72 mg/L, whereas the median at Vernalis was 2.3 mg/L. **Figure 3-71** shows that the total P concentrations at Hood are also substantially lower and less variable than at Vernalis. The median concentration at Hood during the 2002 to 2005 period was 0.09 mg/L, whereas the median at Vernalis was 0.21 mg/L. Although the concentrations at Hood are lower than those at Vernalis, the medians are still more than twice the EcoRegion I reference conditions of 0.31 mg/L for total N and 0.047 mg/L for total P.

Figure 3-72 presents the available total N data at Hood and Vernalis and **Figure 3-73** displays the total P data. **Figure 3-74** displays monthly average total N and total P concentrations at Hood and **Figure 3-75** presents the monthly averages for Vernalis. Total N concentrations at Hood range from 0.38 to 1.27 mg/L and total P concentrations range from 0.06 to 0.15 mg/L. Concentrations are lowest in the spring and summer and increase during the fall months. Potential sources of nutrients in the Sacramento watershed include wastewater discharges and agricultural drainage. At Vernalis, total N concentrations range from 0.38 to 3.9 mg/L and total P concentrations ranged from 0.08 to 0.45 mg/L. Both nutrients are at their lowest levels in the spring months, increase during the summer months, due to a combination of agricultural drainage and low river flows, and remain high until San Joaquin River flows increase in the spring.

Figure 3-72. Total Nitrogen Concentrations at Hood and Vernalis

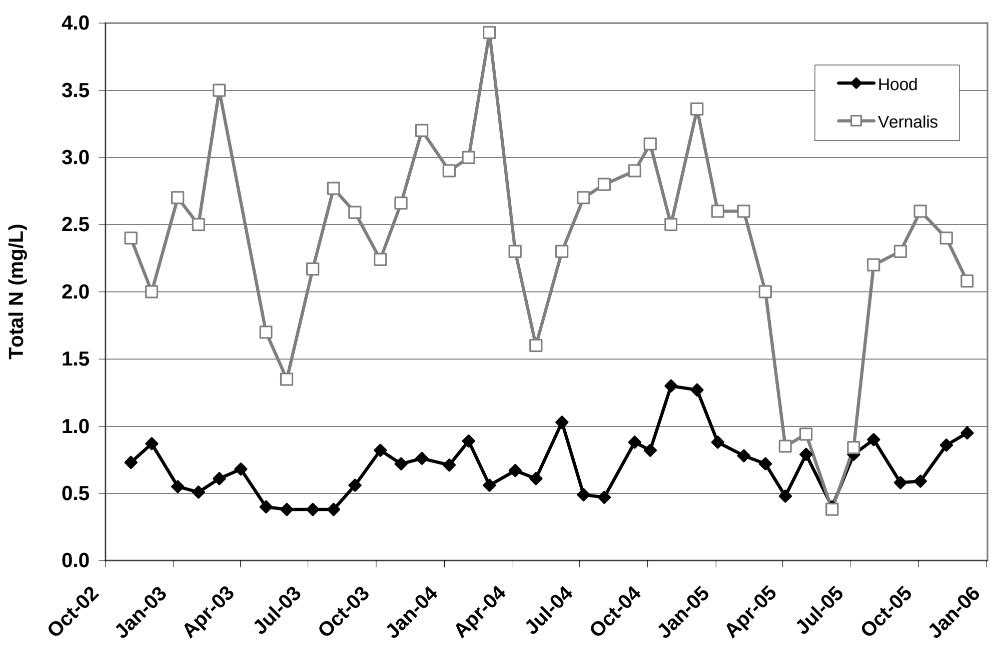


Figure 3-73. Total Phosphorus Concentrations at Hood and Vernalis

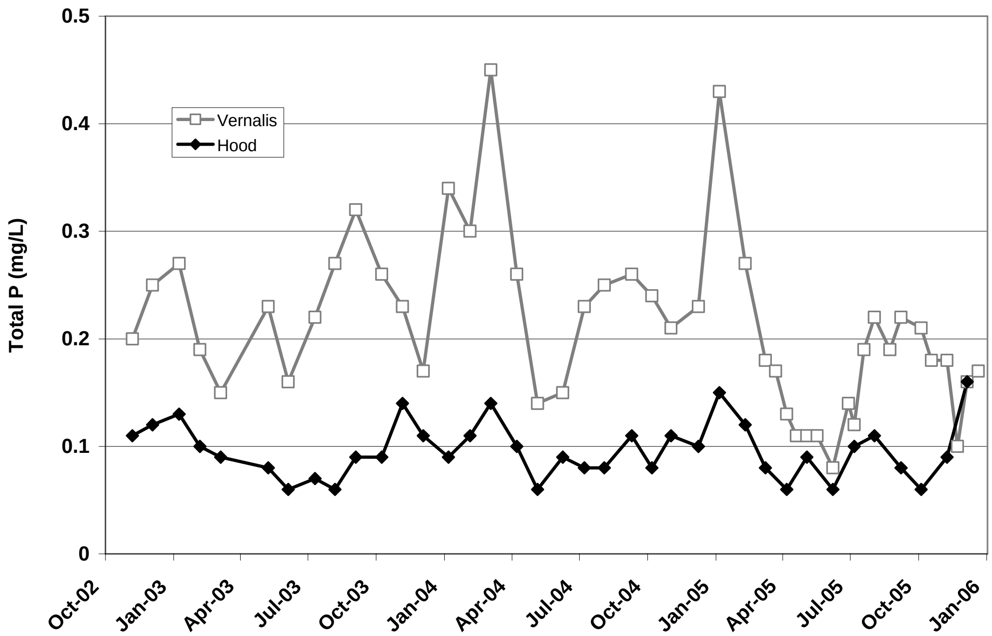


Figure 3-74. Monthly Average Nutrient Concentrations at Hood

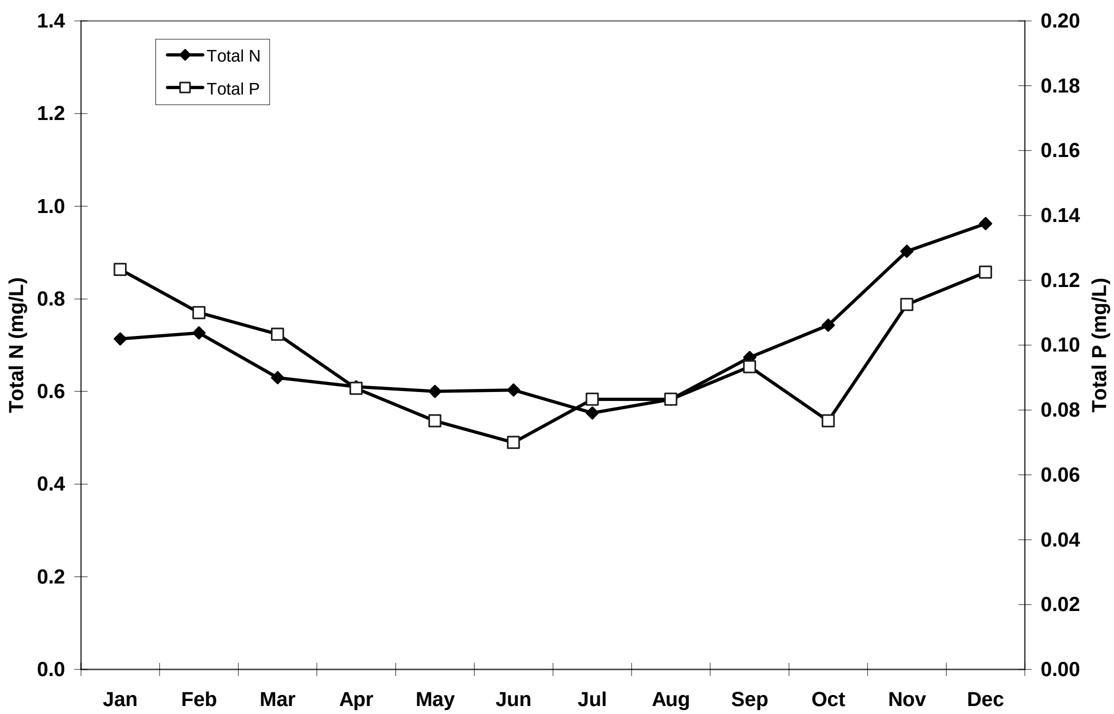
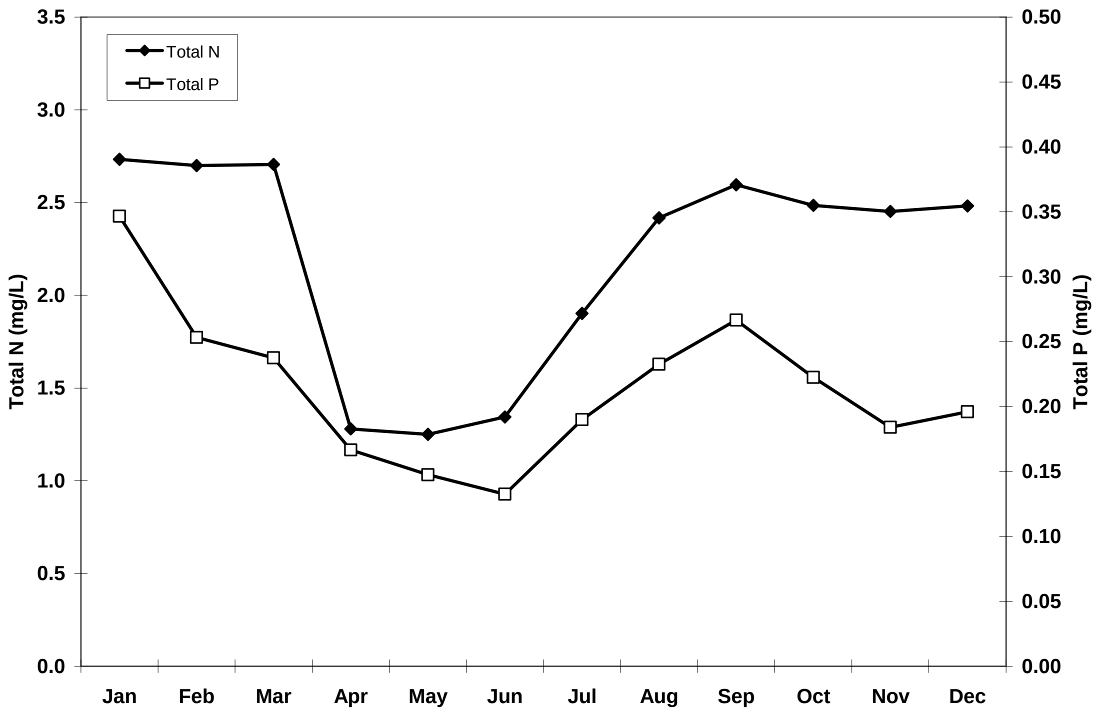


Figure 3-75. Monthly Average Nutrient Concentrations at Vernalis



North Bay Aqueduct

As shown in **Figure 3-70,** Barker Slough has a median total N concentration of 0.83 mg/L, about 15 percent higher than at Hood, and the concentrations are more variable. **Figure 3-71** shows that the median total P concentration (0.18 mg/L) is twice the median of the Sacramento River. The Sacramento River is the primary source of water to Barker Slough, so it is evident that the local watershed supplies some nitrogen and a substantial amount of phosphorus to the NBA. There is extensive cattle grazing and farming throughout the watershed, and there is a golf course in the upper part of the watershed; all potential sources of nutrients.

Figure 3-76 presents the available total N and total P data for Barker Slough and **Figure 3-77** shows the monthly means during the 2001 to 2005 study period. Both nutrients show the same seasonal variability with the highest concentrations in the winter months and lowest concentrations in the summer and fall. There seems to be a general pattern of higher concentrations in wetter years; however, the highest concentrations during the period of record (total N of 2.2 mg/L and total P of 0.6 mg/L) occurred in February 2004, a below normal water year.

Figure 3-76. Nutrient Concentrations at Barker Slough

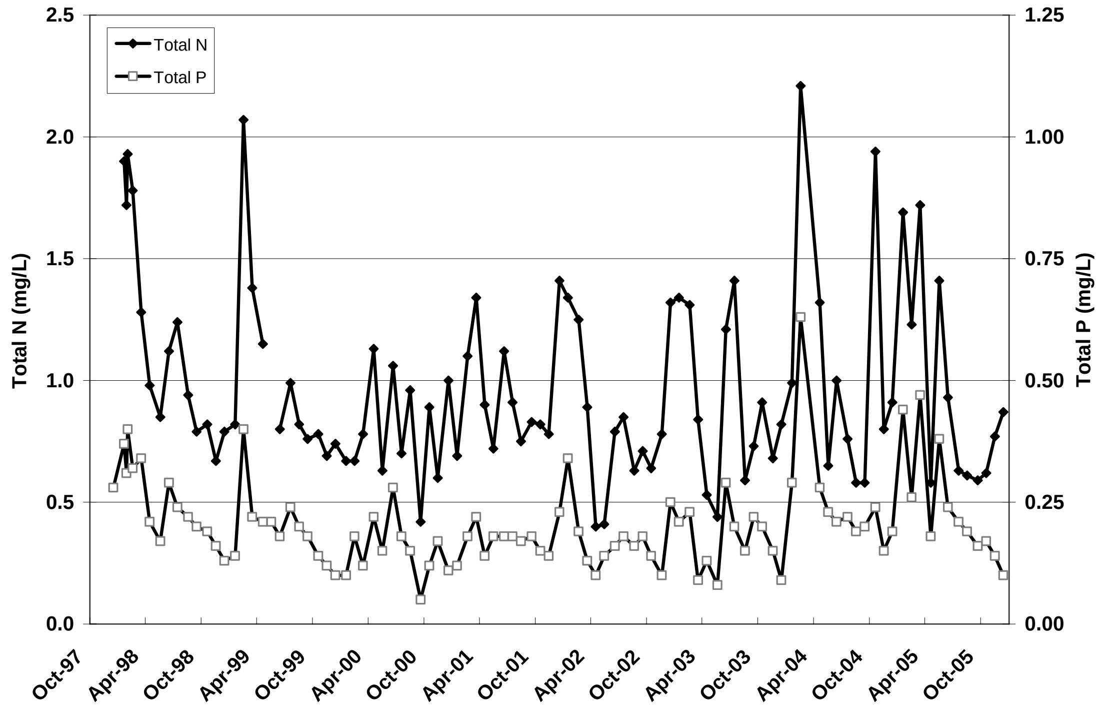
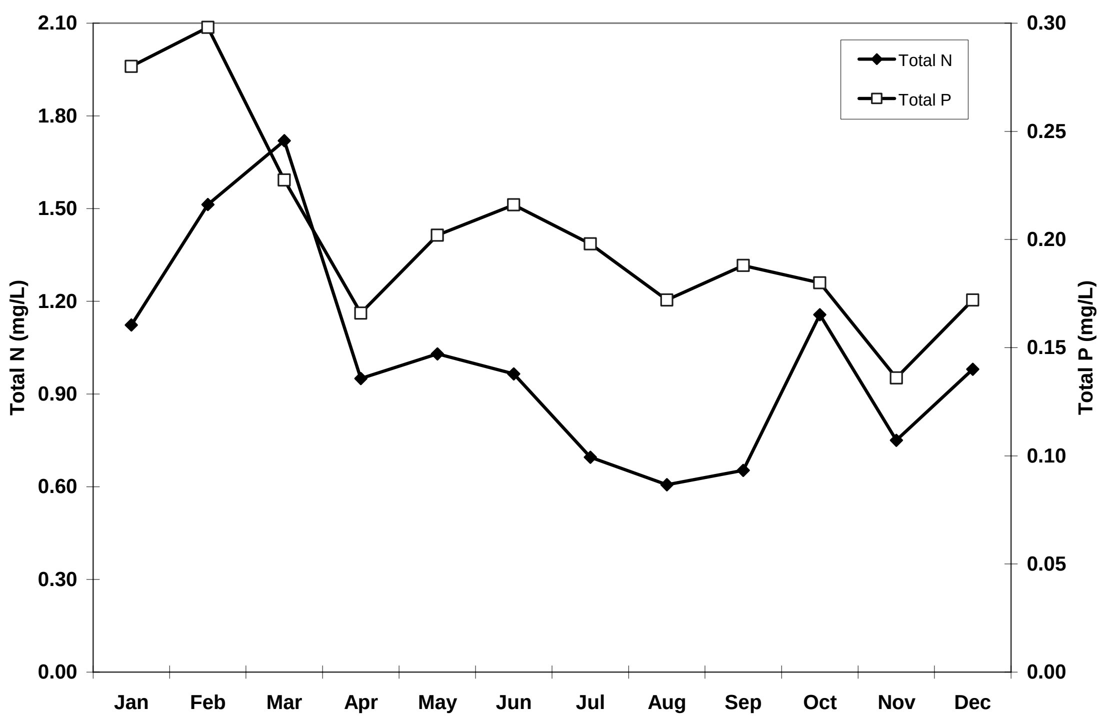


Figure 3-77. Monthly Average Nutrient Concentrations at Barker Slough



Banks Pumping Plant

Although the Sacramento River is the primary source of water diverted through Banks into the SWP system, the total N concentration at Banks (median of 0.9 mg/L) is about 25 percent higher than Hood (median of 0.72 mg/L) and the data are more variable. The median total P concentration at Banks (0.1 mg/L) is comparable to the median at Hood (0.09 mg/L) and the Banks data exhibit about the same variability as the Hood data. As discussed previously, the median total N concentration of the San Joaquin River is more than triple the median concentration in the Sacramento River whereas the median total P is about double. This may partially explain why the total N concentrations at Banks increase more than the total P concentrations; however there are also in-Delta sources of nutrients. Another complicating factor is that nutrients are not conservative constituents.

Figure 3-78 presents the available total N and total P data for Banks and **Figure 3-79** presents the monthly means for the 2001 to 2005 period. There is a seasonal pattern with both nutrients but no obvious relationship to water year types. Total N concentrations are highest in the winter months, with peaks up to 2.5 mg/L, and reach their lowest levels of about 0.5 mg/L in the summer. There is also a secondary peak of about 1.0 mg/L in June each year. Total P peaks occur in the winter (up to 0.28 mg/L during the period of record) and in June, with the June peaks of 0.12 to 0.16 mg/L often equaling or exceeding the winter peaks. The winter peaks generally occur in the same months as the peaks at Hood and Vernalis. The highest total N (2.5 mg/L) and total P (0.28 mg/L) concentrations measured at Banks during the 1998 to 2005 period both occurred on January 19, 2005. In December 2005 and early January 2006 there were record amounts of rain in the Sacramento basin and substantial amounts of rain in the San Joaquin Basin. As shown on **Figure 3-11**, the percent of San Joaquin River and Delta agricultural drainage at Clifton Court rose sharply in January and are likely responsible for the high concentrations of both nutrients at Banks. The June peaks in both total N and total P at Banks are also likely due to the influence of the San Joaquin River and Delta agricultural drainage. As shown on **Figure 3-11**, the San Joaquin River contributes substantially to the water at Clifton Court in late May and June. Although nutrient concentrations are lowest in the San Joaquin River in the summer months (monthly means for total N of 1.2 mg/L and total P of 0.12 mg/L), these levels are about equal to the peaks observed at Banks in June.

South Bay Aqueduct

Figures 3-70 and 3-71 indicate that total N and total P concentrations in the SBA at DV Check 7 are similar to the concentrations at Banks, as would be expected due to the short travel time in the SBA and since DV Check 7 is upstream of the releases from Lake Del Valle. **Figure 3-80** presents the available total N and total P data and **Figure 3-81** shows the monthly means for 2001 to 2005. As with Banks, both total N and total P concentrations are highest in the winter months and lowest in the summer months. The June peak is also present at DV Check 7. The January 2005 peak in both nutrients was also seen at DV Check 7 on January 17, 2005, eleven days earlier than the peak at Banks. Nutrient data are only collected once a month in the SWP but the fact that high levels were measured at DV Check 7 eleven days before the samples were collected at Banks indicates that high levels of nutrients may have been present at Banks for an extended period of time.

Figure 3-78. Nutrient Concentrations at Banks

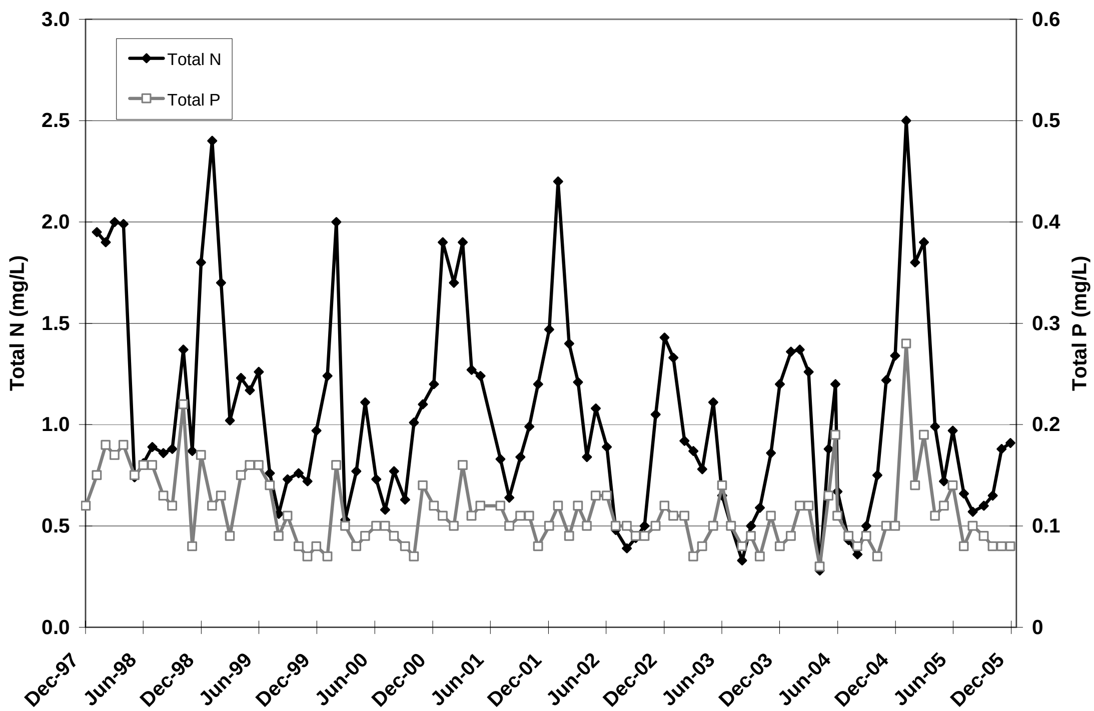


Figure 3-79. Monthly Average Nutrient Concentrations at Banks

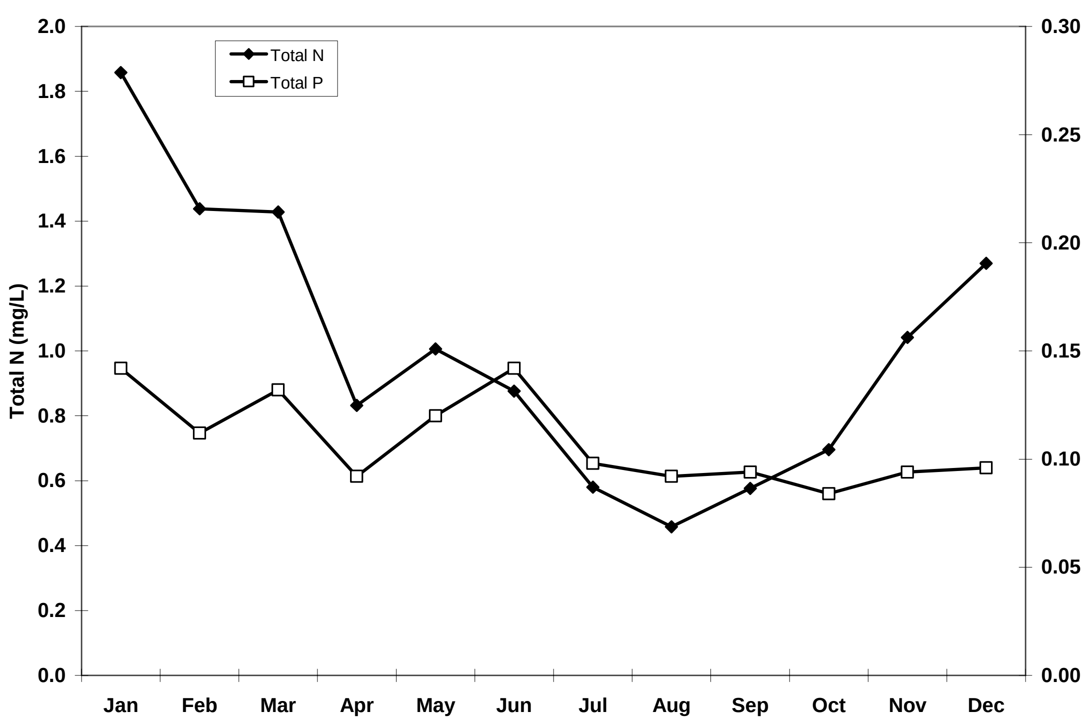


Figure 3-80. Nutrient Concentrations in the SBA

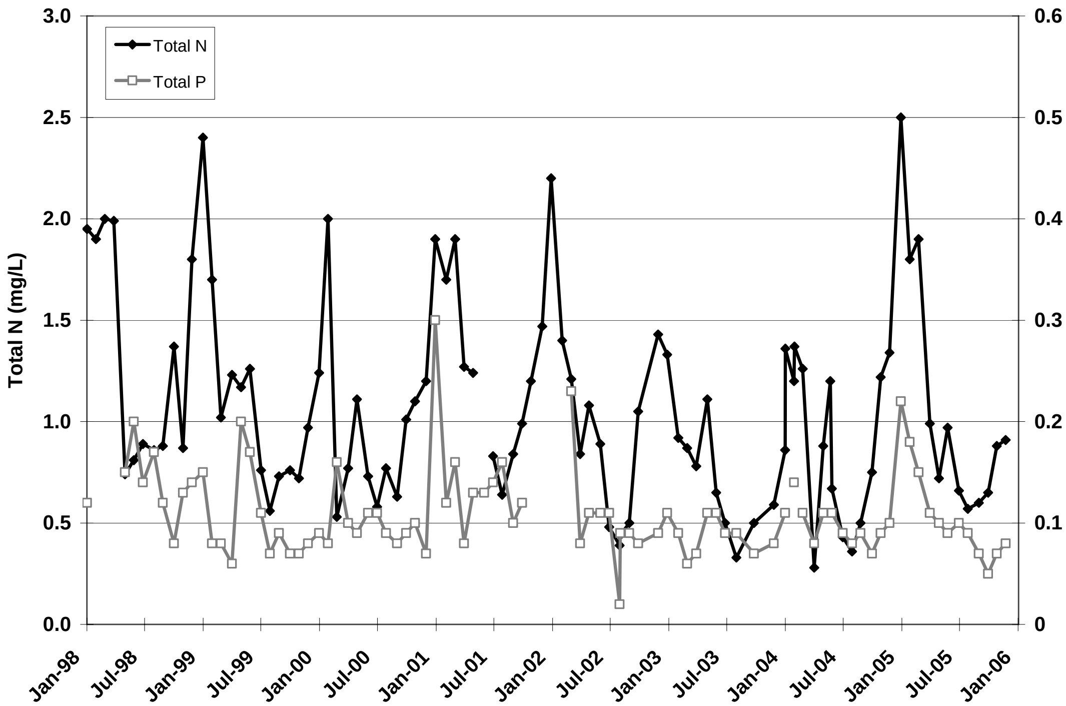
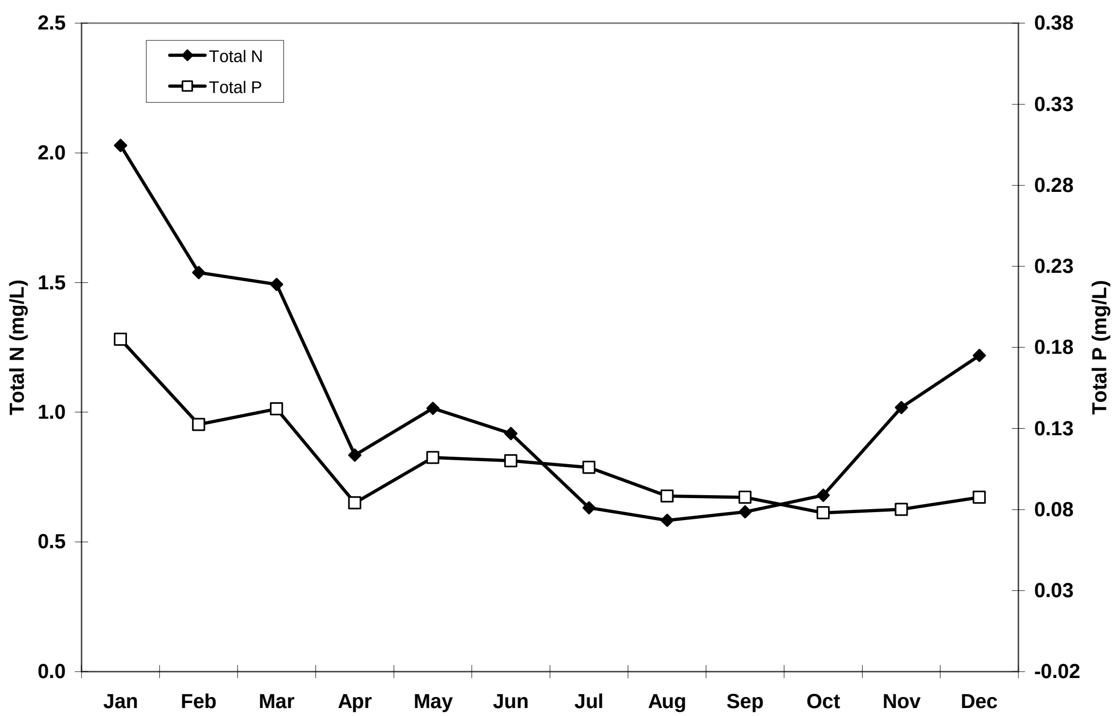


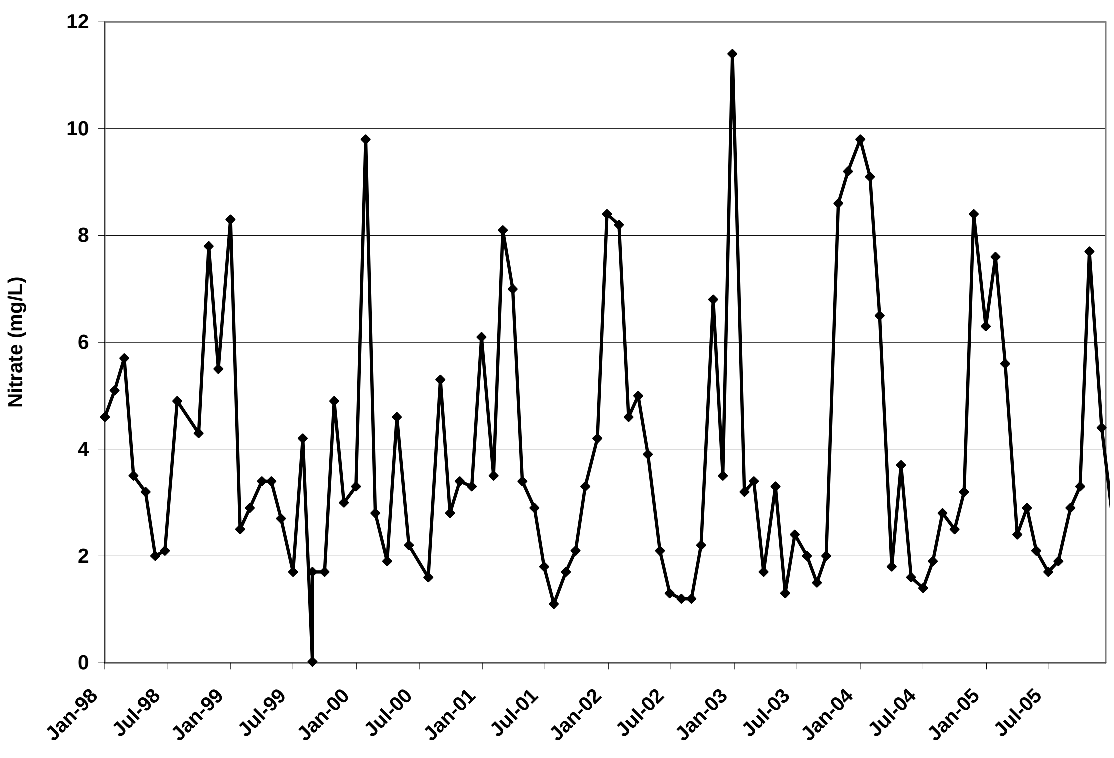
Figure 3-81. Monthly Average Nutrient Concentrations in the SBA



Delta Mendota Canal

Nutrient monitoring is limited for the DMC; there are no phosphorus data and nitrate is the only form of nitrogen measured. **Figure 3-82** shows that the nitrate concentrations are exceedingly high in the DMC. Peak concentrations of 8 to 11 mg/L occur during the winter months. The peak total N concentrations at Banks are less than 2.5 mg/L and the peak total N concentrations at Vernalis are less than 4 mg/L. This indicates there is a source of nitrate between the Delta and the DMC @ McCabe. Unlike the stretch of the California Aqueduct between Banks and O'Neill Forebay, drainage and groundwater are allowed into the DMC. A field survey of the DMC was conducted for the 1990 Sanitary Survey (Brown and Caldwell, 1990). There are 191 drain inlets that convey agricultural drainage into the DMC above the intake channel to O'Neill Forebay. There are also numerous "weep holes" through which shallow groundwater can rise up into the canal. Both agricultural drainage and groundwater are potential sources of nitrate to the DMC. The 2001 Update included a discussion of a loading study conducted by DWR O&M staff (DWR, 2001). The loading study showed that in 1995 the DMC contributed 47 percent of the inflow to O'Neill Forebay and almost 60 percent of the nitrate load.

Figure 3-82. Nitrate Concentrations in the DMC



California Aqueduct

Figures 3-71 shows that median total N concentrations along the California Aqueduct cluster around 1 mg/l and **Figure 3-72** indicates that median total P concentrations are about 0.1 mg/L. The median total N concentrations in the aqueduct south of O'Neill Forebay are about 0.1 mg/L higher than the median at Banks; however total P medians do not increase. The dampening effect of reservoir storage is seen in the lower medians (total N of 0.69 mg/L and total P of 0.04 mg/L) and reduced variability at Castaic Outlet.

Nutrient data are collected at a number of locations along the California Aqueduct. The longest period of record exists for Checks 21, 41, and 66. **Figure 3-83** shows that total N concentrations exhibit the same general pattern and do not change appreciably as water flows down the aqueduct. Peak concentrations of 2.0 to 3.0 mg/L occur in the winter months and minimum concentrations of about 0.5 mg/L occur in the late summer months. The lowest concentrations in the aqueduct occur about one month after the minimum concentrations at Banks. Total N data have only been collected at Checks 13 and 29 since June 2004; however, the monthly means from these checks is shown with the longer period of record from the other checks in **Figure 3-84**. Checks 13 and 29 show the same seasonal pattern based on the limited data. The differences shown in January and February are due to only one sample taken during these months in 2005 at Checks 13 and 29. **Figure 3-85** shows the monthly mean total N concentrations for Check 41 and the East and West branches. The concentrations at Castaic Outlet are lower and less variable, whereas the concentrations at Devil Canyon are similar to those of the aqueduct.

Figure 3-83. Total Nitrogen Concentrations in the California Aqueduct

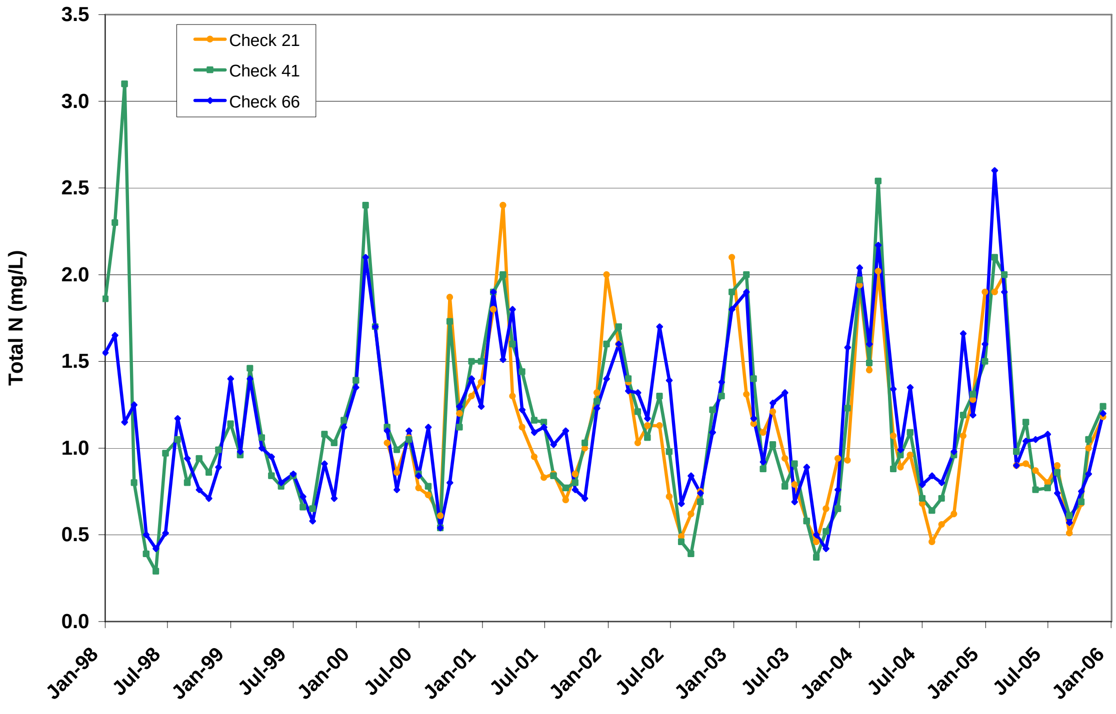


Figure 3-84. Monthly Mean Total Nitrogen Concentrations in the California Aqueduct

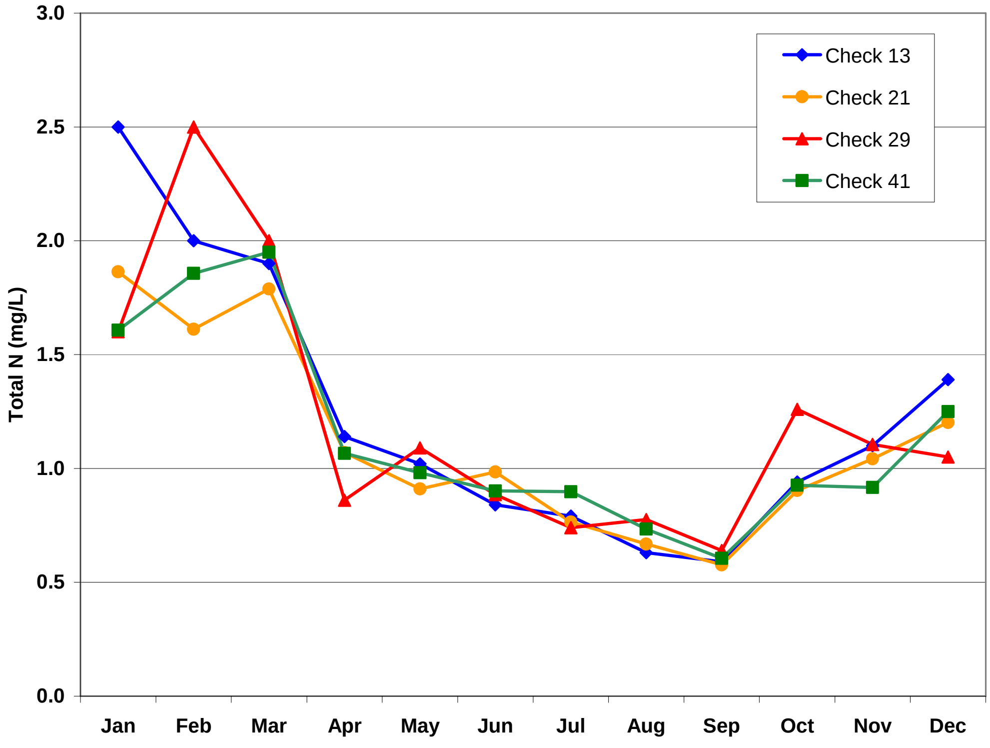


Figure 3-85. Monthly Mean Total Nitrogen Concentrations in the East and West Branches

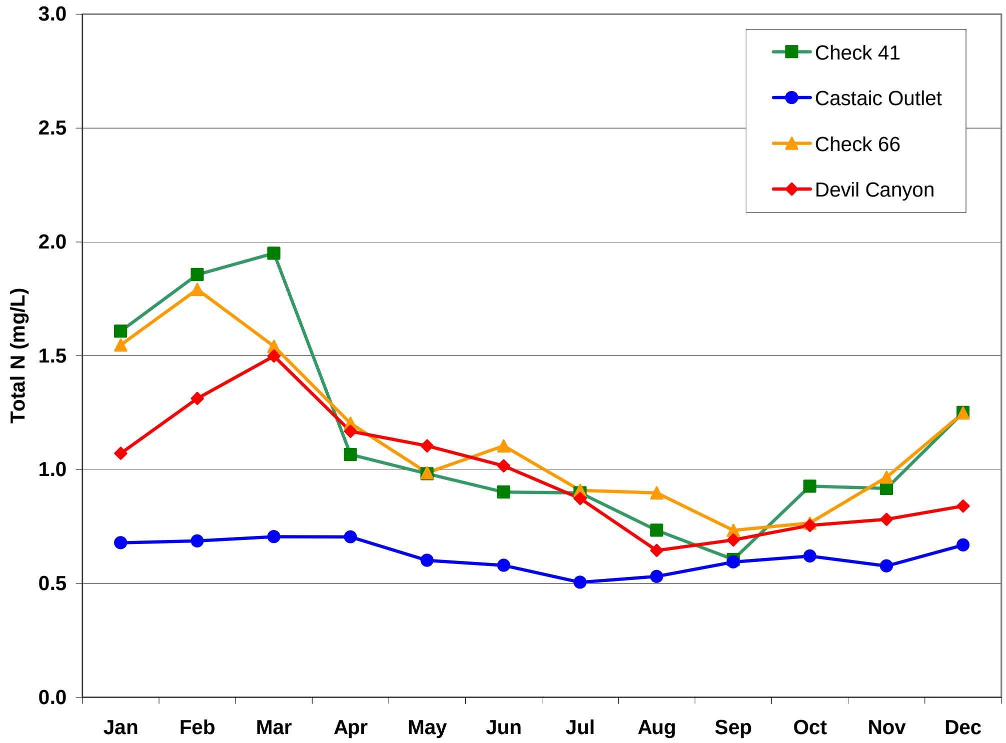


Figure 3-86 presents the total P data for the California Aqueduct. The total P data appear more erratic than the total N data. There are differences between the locations and the seasonal pattern is not as distinct as for total N; however, total P only varies by 0.3 mg/L, whereas total N varies by 2.5 mg/L. **Figures 3-87 and 3-88** show the monthly mean total P concentrations for the California Aqueduct and the East and West branches. The total P concentrations are highest in the winter months and then decrease throughout the spring and summer. The concentrations in Devil Canyon Afterbay are similar to aqueduct concentrations with the exception of October. In October 2004, there was a peak total P concentration of 0.46 mg/L that greatly affected the monthly mean concentration. The concentrations in Castaic Lake are lower and less variable than the upstream aqueduct concentrations.

The median total N (0.69 mg/L) and total P (0.04 mg/L) concentrations at Castaic Outlet are considerably lower than other SWP locations south of the Delta. These data show the effect of reservoir storage in moderating the range of nutrient concentrations and, perhaps, indicate a loss of nutrients due to algal uptake and settling of organic detritus in the West Branch reservoirs. Water flows from Pyramid Lake, at an outlet portal located at about 160 feet depth, through Elderberry Forebay, through a valve that entrains air, and then into Castaic Lake. The entrained air tends to cause water entering Castaic Lake to rise to the surface where biologically available nutrients drawn from the hypolimnion of Pyramid Lake are available for algal uptake. Algal uptake and subsequent settling of organic matter in Castaic Lake, due at least in part to the unique configuration and operational pattern of this part of the SWP system, may be responsible for the lower nutrient concentrations in Castaic Outlet water, which generally is discharged from the hypoliminion.

Figure 3-86. Total Phosphorus Concentrations in the California Aqueduct

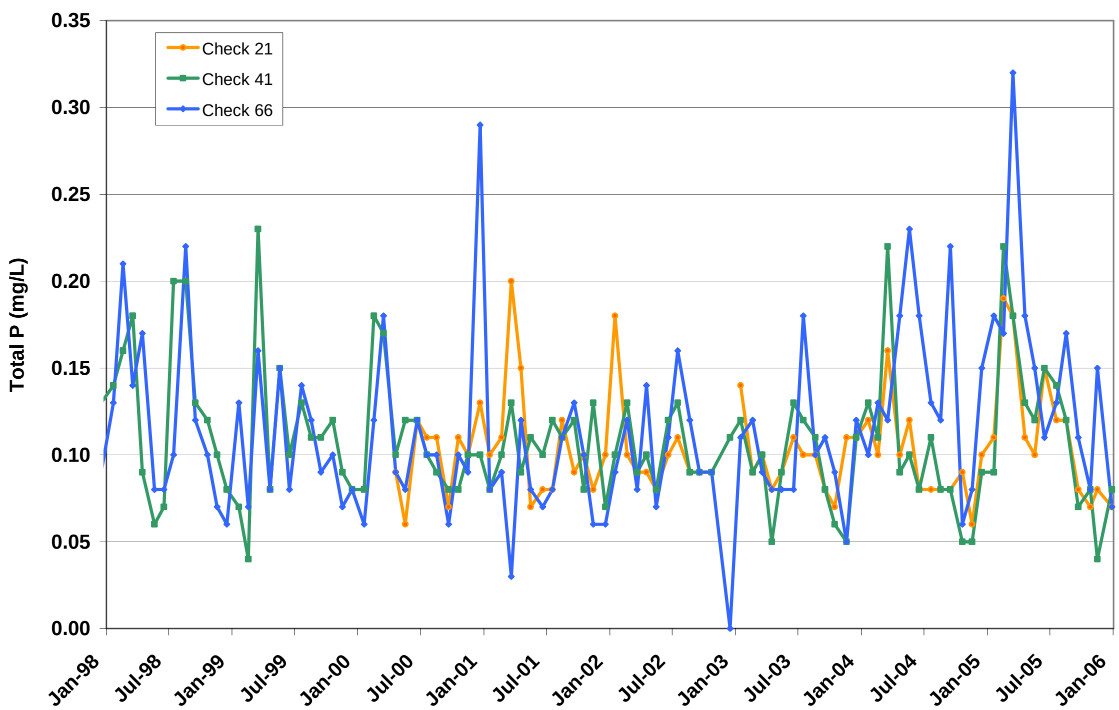


Figure 3-87. Monthly Mean Total Phosphorus Concentrations in the California Aqueduct

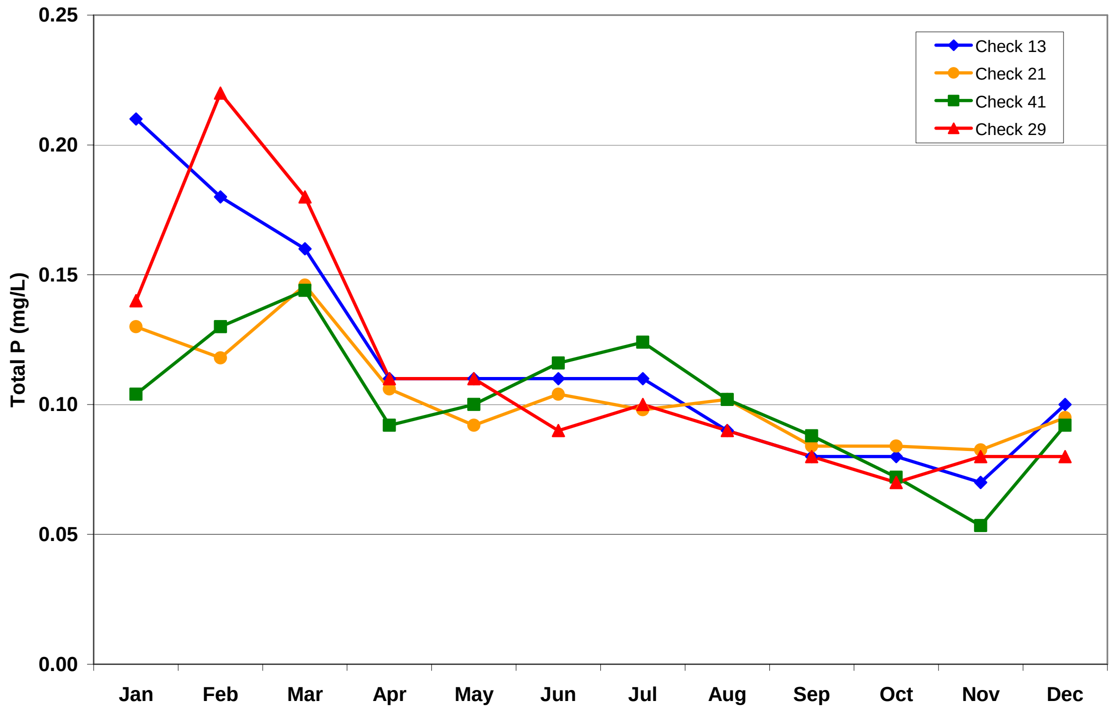


Figure 3-88. Monthly Mean Total Phosphorus Concentrations in the East and West Branches

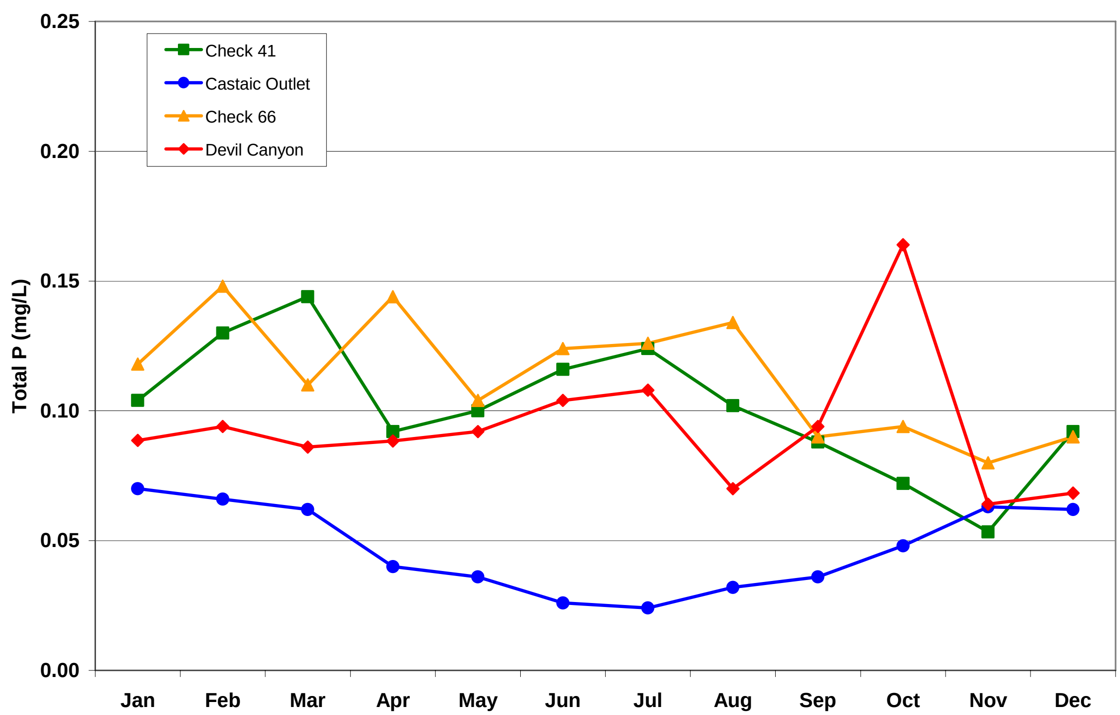


Figure 3-89 presents the available total N and total P data for Castaic Outlet. Total N and total P show the same general trend with concentrations generally being highest in the spring and dropping to low levels during the summer months, likely due to algal uptake and settling of organic matter. Total N concentrations range from 0.3 to 1.2 mg/L and, total P concentrations are an order of magnitude lower, ranging from 0.01 to 0.1 mg/L. From the beginning of data collection in 1998 until early 2003, it appeared as though nutrient concentrations were increasing, although the upstream aqueduct locations did not show any apparent increase. This period was followed by lower concentrations in the two subsequent years, again without any apparent change in the aqueduct concentrations. **Figure 3-90** shows that total N and total P concentrations are quite variable at Devil Canyon. In general, the highest total N concentrations are found in the late winter and early spring months and the lowest concentrations occur in the summer. There isn't a clear seasonal pattern for total P.

Coastal Branch

The median total N and total P concentrations at Check 21 during the study period were 0.98 mg/L and 0.10 mg/L, respectively. As shown on a number of the figures in this section, the nutrient concentrations at Check 21 are similar to those observed at Check 13, indicating that any inflows that may have occurred in the San Luis Reach of the aqueduct had minimal effect on aqueduct nutrient concentrations.

Impacts of Operations on Nutrient Concentrations

Figure 3-91 shows average monthly diversions at Banks between 1998 and 2005 and the previous ten years. The monthly average total N concentrations at Banks for the 2001 to 2005 period are also shown. As discussed previously, total P concentrations are lower than total N concentrations but show the same seasonal trend. In recent years more water has been pumped from the Delta during the summer and fall months when nutrient concentrations are relatively low, although a substantial amount of water is pumped from the Delta in the winter months when nutrient concentrations are at their highest levels. **Figure 3-92** shows that San Luis Reservoir is filled during the fall and winter months when Banks nutrient concentrations are highest.

Figure 3-89. Nutrient Concentrations in Castaic Lake

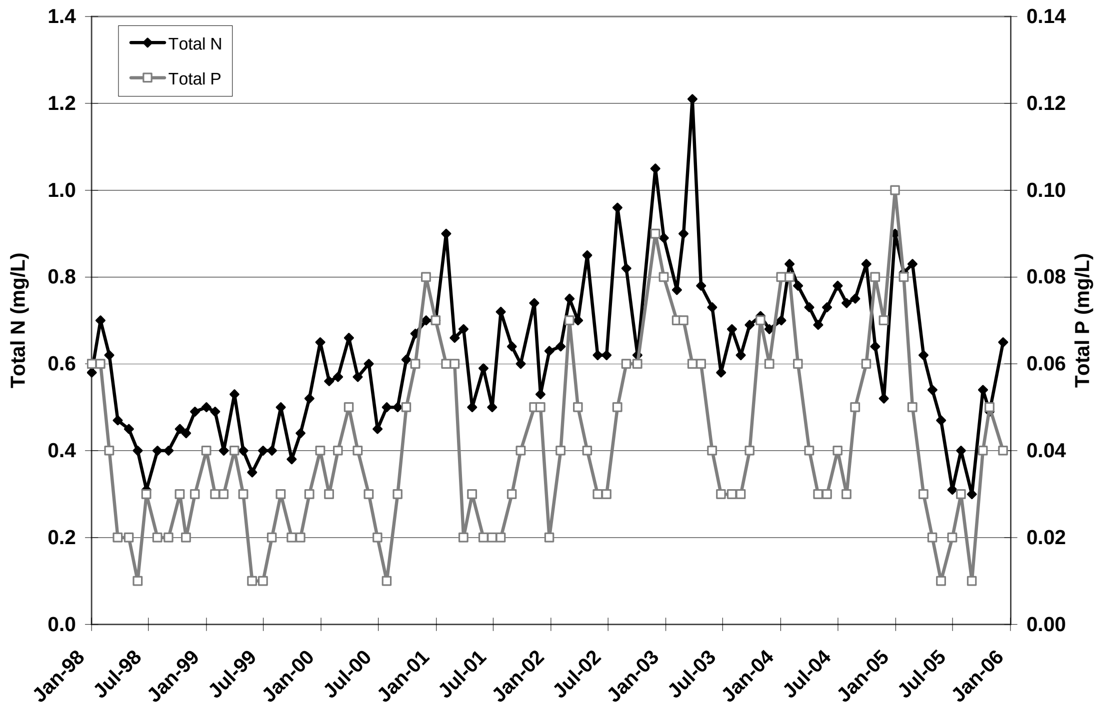


Figure 3-90. Nutrient Concentrations at Devil Canyon

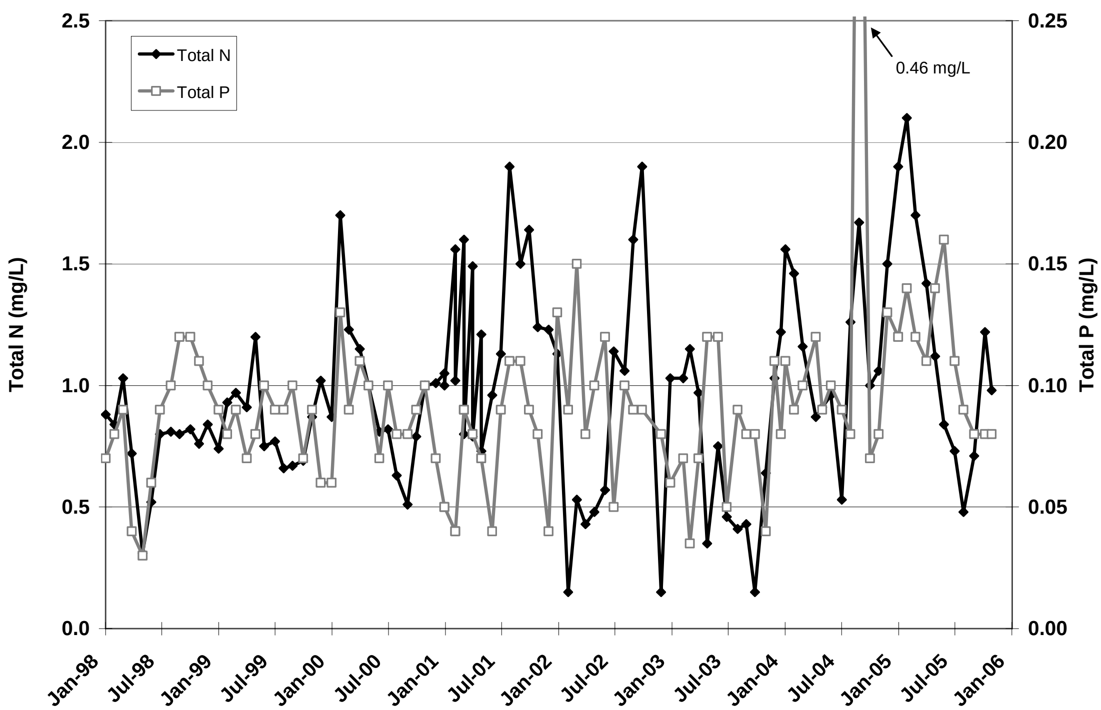


Figure 3-91. Average Monthly Banks Diversions and Total Nitrogen Concentrations

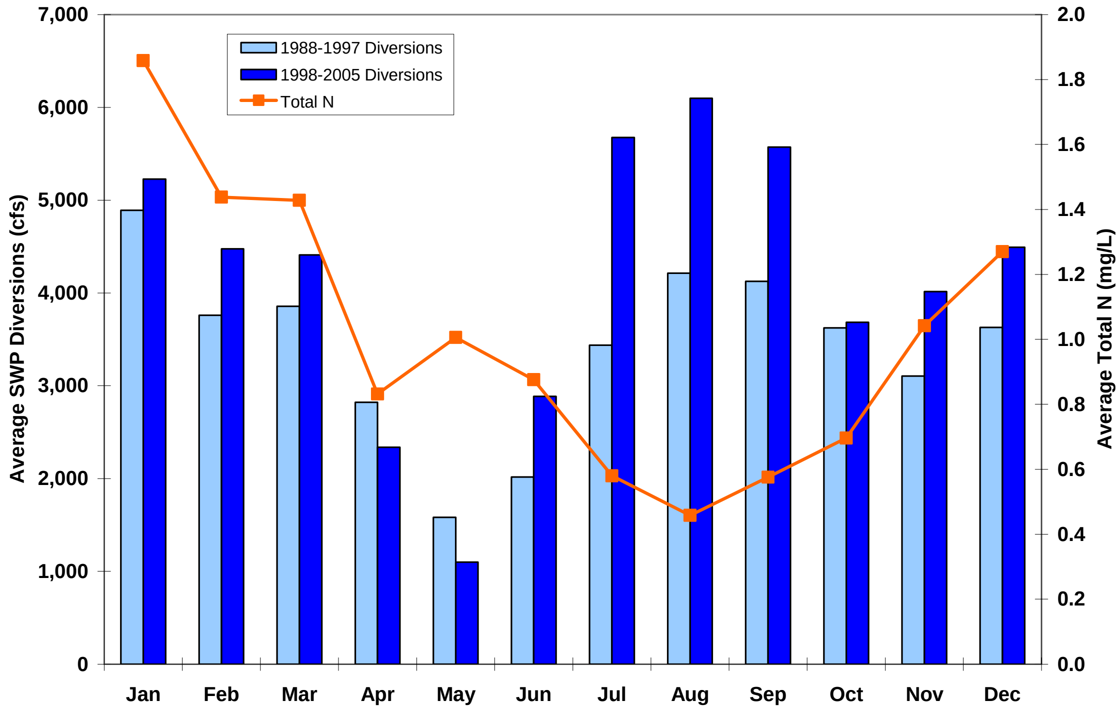
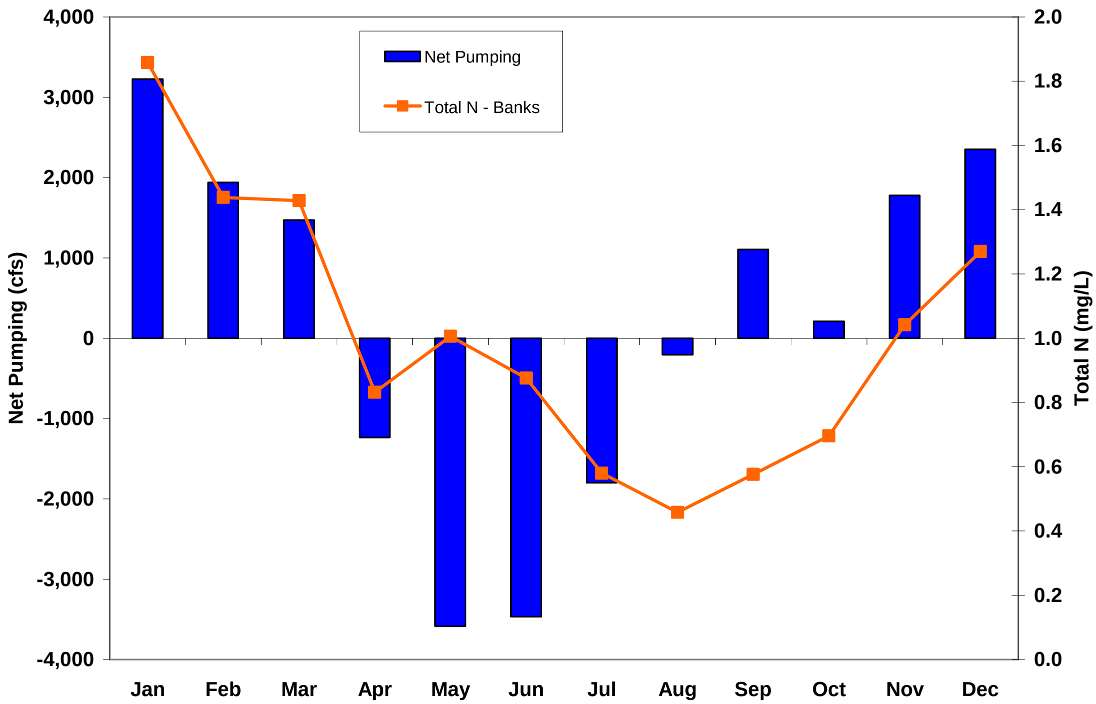
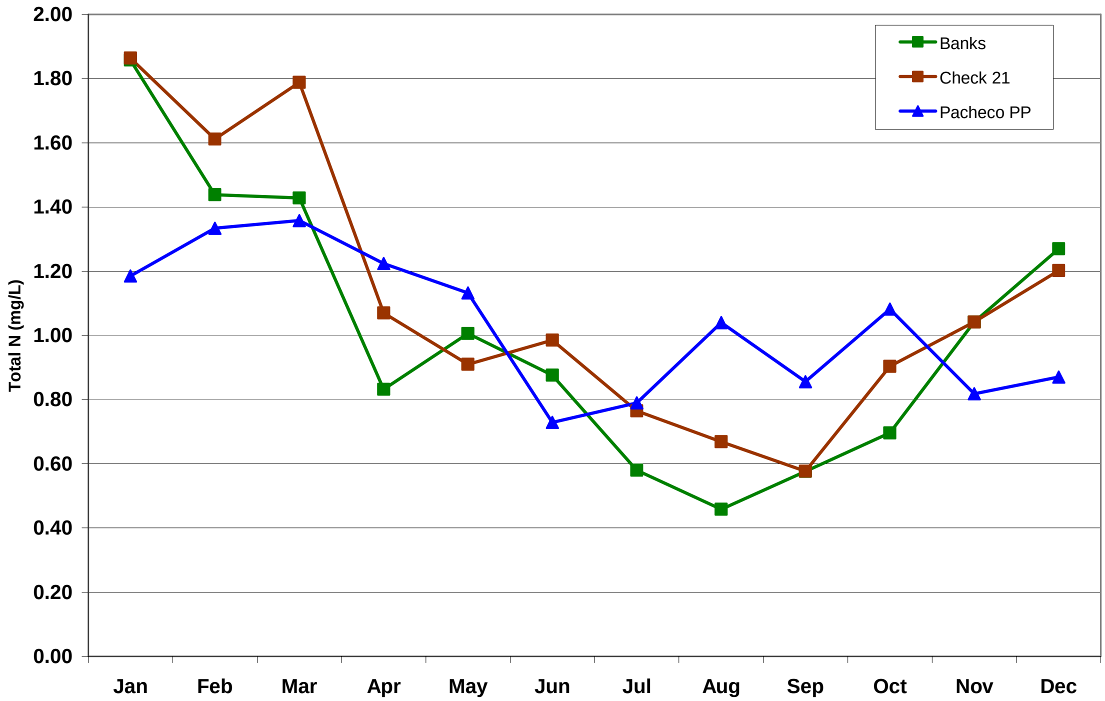


Figure 3-92. Net Pumping to San Luis Reservoir and Total Nitrogen Concentrations



The total N data were further examined to determine if the effects of pumping water with high nutrient concentrations into San Luis could be detected in the data. The monthly mean total N concentrations for Banks, Pacheco PP, and Check 21 are shown in **Figure 3-93**. Banks data are used to represent the quality of water entering San Luis Reservoir, although these data do not reflect the impact of the DMC on nutrient concentrations in O'Neill Forebay. Check 21 data are shown to illustrate the quality of water downstream of San Luis because there is a much more limited dataset for Check 13, and Pacheco data are shown to illustrate the quality of water leaving San Luis because there are no data for the Gianelli Pumping-Generating Plant. This figure indicates that during the months when San Luis is being filled, there is about a two month lag between Banks and Pacheco (peak total N concentrations occur at Banks in January and at Pacheco in March). Pacheco is on the opposite side of the reservoir, and the total N data indicate that Pacheco may not be representative of the quality of water released to the California Aqueduct in the spring. The figure also illustrates that Check 21 monthly mean total N concentrations are generally about 0.1 to 0.2 mg/L higher than the concentrations at Banks, possibly reflecting the influence of pumping high nutrient concentration water into San Luis in the winter months. This may also be due to the influence of the DMC on water quality in O'Neill Forebay and San Luis Reservoir. This analysis demonstrates that the existing monitoring program is inadequate to properly evaluate nutrient concentrations in the SWP.

Figure 3-93. Monthly Mean Total Nitrogen Concentrations at Banks, Pacheco, and Check 21



Summary

- Total N and total P concentrations in the San Joaquin River are considerably higher and more variable than concentrations in the Sacramento River. The highest concentrations occur in the wet winter months in both rivers.

- Nutrient concentrations in the NBA are higher than in the Sacramento River. The highest concentrations occur in the winter months due to the influence of runoff from the local Barker Slough watershed.

- Total N and total P concentrations in water exported from the Delta at Banks are sufficiently high to cause algal blooms in the aqueducts and downstream reservoirs.

- Nutrient concentrations do not change as water flows from the Delta through the SBA. Peak concentrations occur in the winter months at Banks and DV Check 7.

- There are limited nutrient data for the DMC; however, the available nitrate data indicate that the DMC may be a significant source of nitrogen south of O'Neill Forebay. Nitrate concentrations exceeding 8 mg/L occur in the winter months.

- Total N concentrations are slightly higher south of O'Neill Forebay but total P concentrations remain similar to those found at Banks. The higher total N concentrations may be due to the influence of the DMC or to the filling of San Luis Reservoir during the winter months when peak concentrations occur at Banks.

- Total N and total P concentrations are substantially lower in Castaic Lake. Algal uptake and subsequent settling of particulate matter, due at least in part to the unique configuration and operational pattern of this part of the SWP system, may be responsible for the lower nutrient concentrations.

- There is a shorter period of record for nutrient data than for other water quality constituents such as organic carbon and EC, at many of the key locations. Other than seasonal patterns, no other patterns related to water year types or long-term changes are apparent in the data for the rivers and the aqueduct. Limited evidence exists to suggest there may have been a trend of increasing nutrient concentrations in Castaic Lake between 1998 and 2003 that was unrelated to concentrations in the upstream aqueduct.

- The existing monitoring program is inadequate to evaluate operational changes or to fully understand the impacts of the DMC on nutrient levels in the California Aqueduct. It is particularly important to obtain better data on the movement of water into and out of O'Neill Forebay and San Luis Reservoir.

Water Quality Evaluation - Algal Blooms and Taste and Odor Incidents

The Water Quality Section of the DWR O&M Division publishes a monthly water quality summary report (DWR Monthly Reports). Since February 2003, this report has included descriptions of T&O events in the SWP system. Additional information on algal blooms was obtained from DWR staff. Geosmin and MIB data for the SWP were provided by the O&M Division staff and by MWDSC. Samples have been collected from SWP facilities and analyzed for the T&O producing compounds, MIB and geosmin, since 2000. Since that time, sampling has expanded from a few Southern California locations to a more general monitoring program. This monitoring provides a direct measurement of T&O potential in drinking water supplies. DWR O&M Division staff sends out weekly email reports to the SWP Contractors with the results from the previous week's monitoring. This provides the Contractors with advanced notice of potential T&O problems.

MIB and Geosmin Concentrations in the SWP

All available data are discussed in this chapter however the period of record varies from location to location. More detailed evaluations of T&O problems are described in other chapters of this report. Chapter 5 contains a discussion of the algal and T&O issues in the South Bay Aqueduct. Chapter 7 contains a section on the possible role sedimentation of Clifton Court plays in stimulating algal blooms and a discussion of the T&O problems along the Coastal Branch.

Sources of Water to the Delta

Although some of the nutrients responsible for algal blooms come from the Sacramento and San Joaquin rivers, the algal blooms responsible for T&O incidents occur in the Delta and the aqueducts and reservoirs of the SWP system. The rivers are not monitored for MIB and geosmin.

North Bay Aqueduct

No T&O incidents attributable to MIB and geosmin have been reported by NBA Contractors.

Banks Pumping Plant

MIB and geosmin are monitored at Clifton Court Intake and at Banks. Monitoring started at Clifton Court in 2003 and at Banks in 2001. **Figures 3-94** and **3-95** show that peak concentrations of MIB and geosmin occur each summer and levels exceeding 10 ng/L have been present for a number of weeks each summer in recent years. MIB has been more problematic than geosmin in the last three years. In July 2003, MIB reached 31 ng/L at Banks but was present at only 7 ng/L at Clifton Court Intake. DWR attributed the peaks to benthic cyanobacteria growing in Clifton Court. An MIB peak of 55 ng/L occurred at Clifton Court in late July 2004 and a peak of 74 ng/L was found at Banks less than a week later. These peaks were attributed to pumping water off of Jones Tract after the levee break (see Chapter 6). In August 2005, MIB peaked at 78 ng/L at Clifton Court and at 43 ng/L at Banks. This was followed by elevated concentrations at both locations in mid-September. The timing and amplitude of these spikes clearly indicate the origin of the T&O event was the Delta, rather than Clifton Court. These data indicate that T&O issues can arise both in the Delta and within Clifton Court Forebay. This issue is discussed in more detail in Chapter 7.

Figure 3-94. MIB and Geosmin in Clifton Court

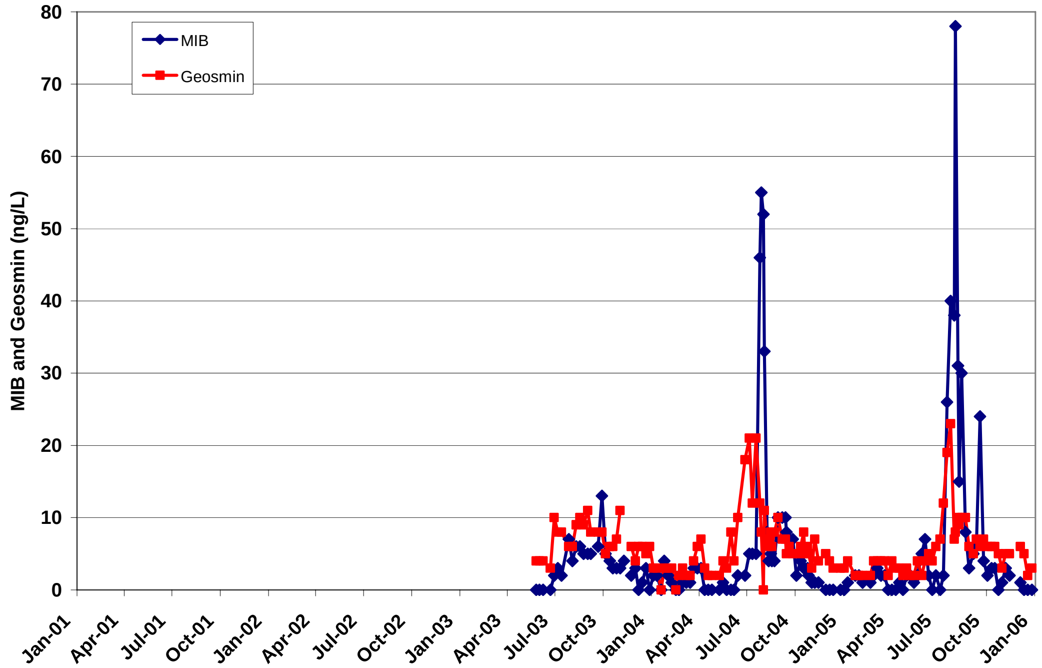
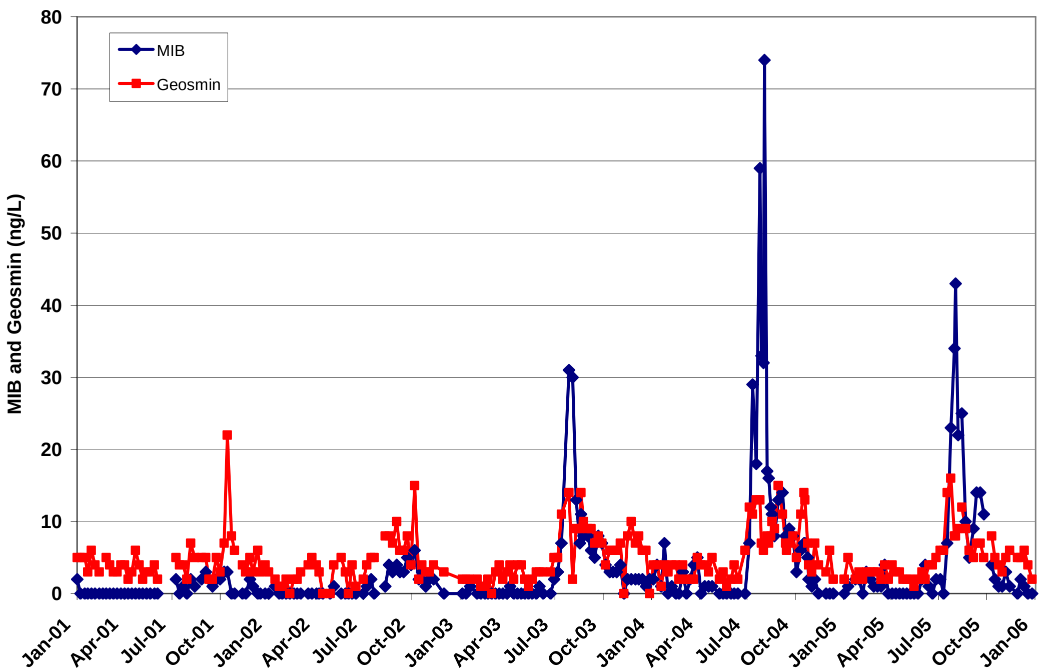


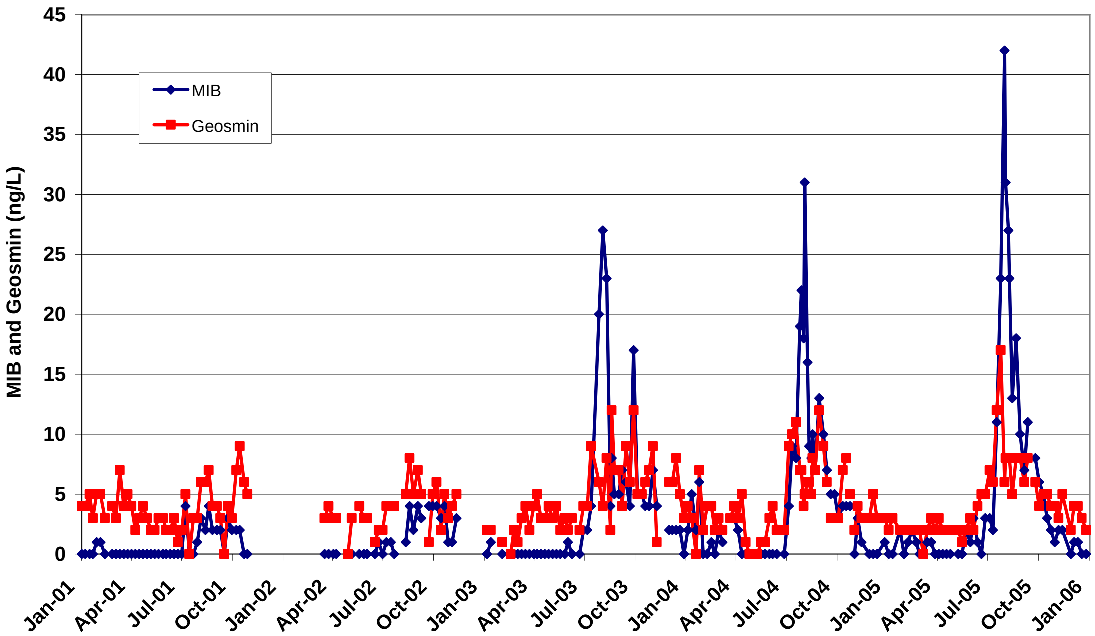
Figure 3-95. MIB and Geosmin at Banks



South Bay Aqueduct

Figure 3-96 shows that the peak levels of MIB at Banks rapidly show up at DV Check 7. During the summers of 2003, 2004, and 2005, MIB and geosmin were both found at levels that resulted in customer complaints. Chapter 5 contains a more detailed discussion of the algal and T&O challenges facing the SBA Contractors.

Figure 3-96. MIB and Geosmin at DV Check 7



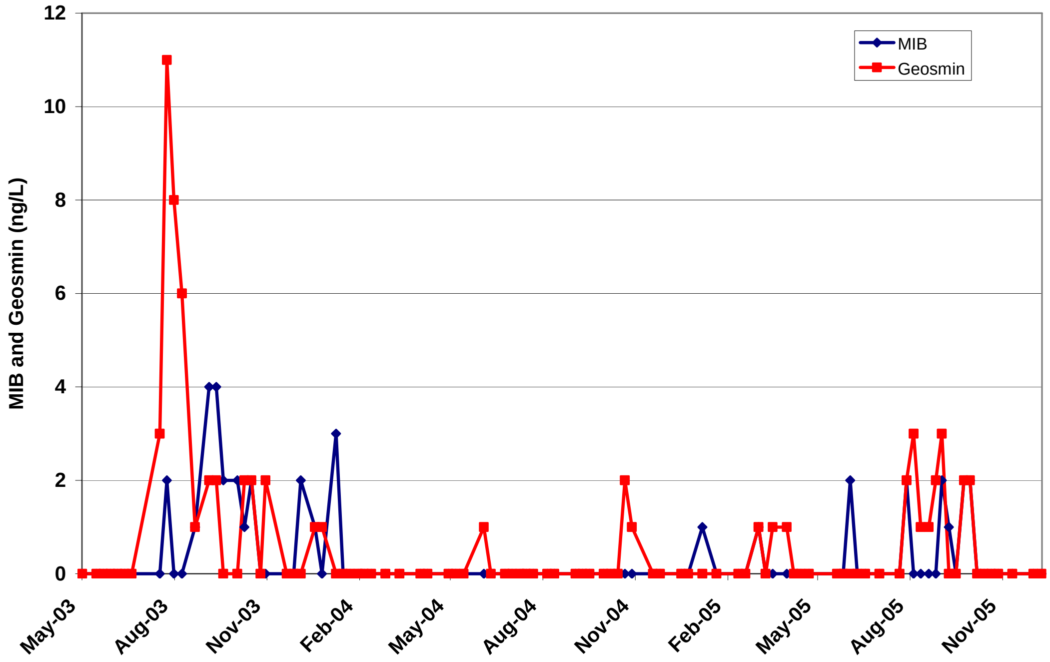
Delta Mendota Canal

MIB and geosmin data are not collected in the DMC.

California Aqueduct

Figure 3-97 depicts results from monitoring at Pacheco in San Luis Reservoir. The MIB spikes that were observed in August of 2003 to 2005 at Banks did not show up at Pacheco, but geosmin was measured at 11 ng/L in August 2003. San Luis Reservoir has often had summer blooms of cyanobacteria. This figure suggests that, while the volume and operation of San Luis Reservoir is such as to avoid T&O compounds produced during the summer in the Delta/California Aqueduct system, T&O compounds are occasionally created in the reservoir, though at concentrations that are not particularly high.

Figure 3-97. MIB and Geosmin at Pacheco Pumping Plant



Monitoring was initiated at Check 13 at the end of 2002. **Figure 3-98** shows that peak levels of MIB occur in August and generally occur five days to two weeks after the peaks occur at Banks, 68 miles upstream. The peak concentrations found at Check 13 (13 to 21 ng/L) are lower than those found at Banks but because samples are collected only once a week, it's not possible to accurately track water moving down the aqueduct. **Figure 3-99** shows that peaks also occurred in August of 2003 to 2005 at Check 41. The peak concentration in 2004 and 2005 was 14 ng/L, similar to the levels found upstream at Check 13. In late May 2003, a significant geosmin peak (50 ng/L) was detected at Check 41 that evidently did not originate in the Delta or Clifton Court. Presumably this compound was generated in the aqueduct downstream of Check 13. These data indicate that MIB and geosmin generated in the Delta or in Clifton Court Forebay can persist at levels of concern to the bifurcation of the aqueduct.

Castaic Lake has annual geosmin spikes occurring in June or July, as shown in **Figure 3-100**. T&O compounds are generated within West Branch reservoirs, sometimes at very high concentrations. In June 2004, geosmin was measured as high as 830 ng/L. After three years of peaks of 200 to 830 ng/L, the levels were substantially reduced in 2005, although the maximum concentration of 34 ng/L was in excess of the 10 ng/L threshold that commonly results in customer complaints. A significant MIB spike (38 ng/L) was seen in July 2005.

Figure 3-98. MIB and Geosmin at Check 13

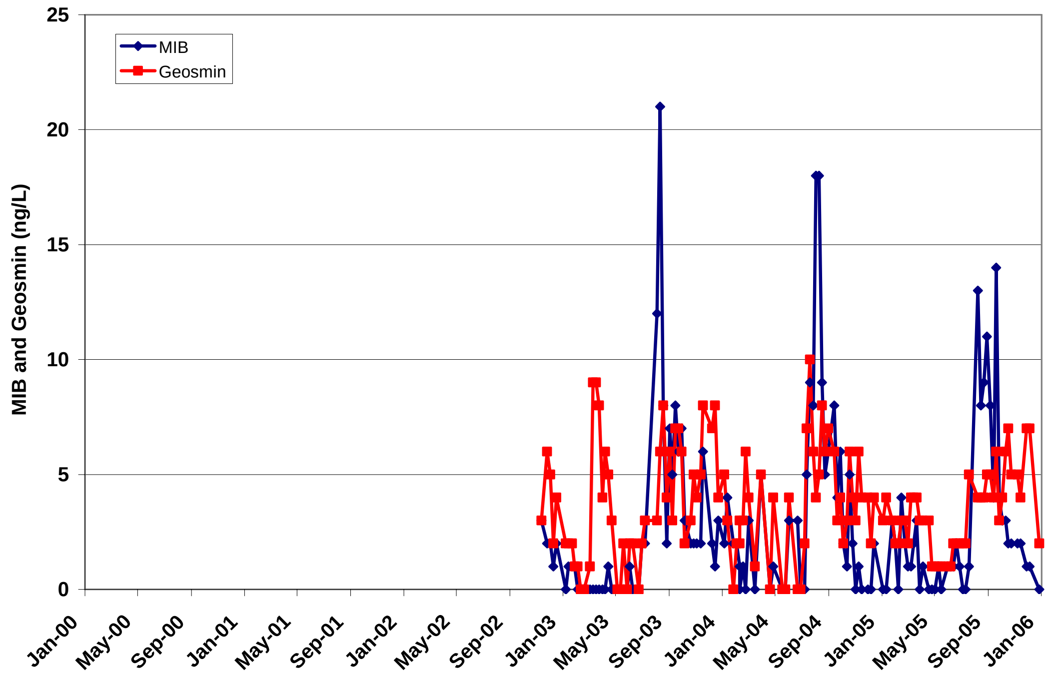


Figure 3-99. MIB and Geosmin at Check 41

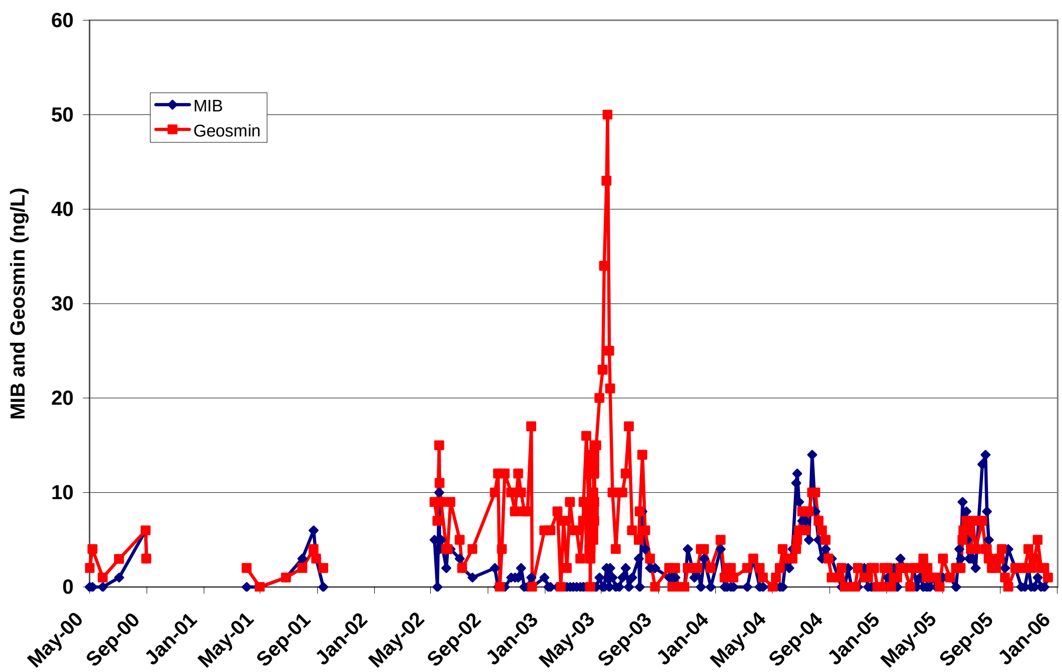


Figure 3-100. MIB and Geosmin at Castaic Outlet

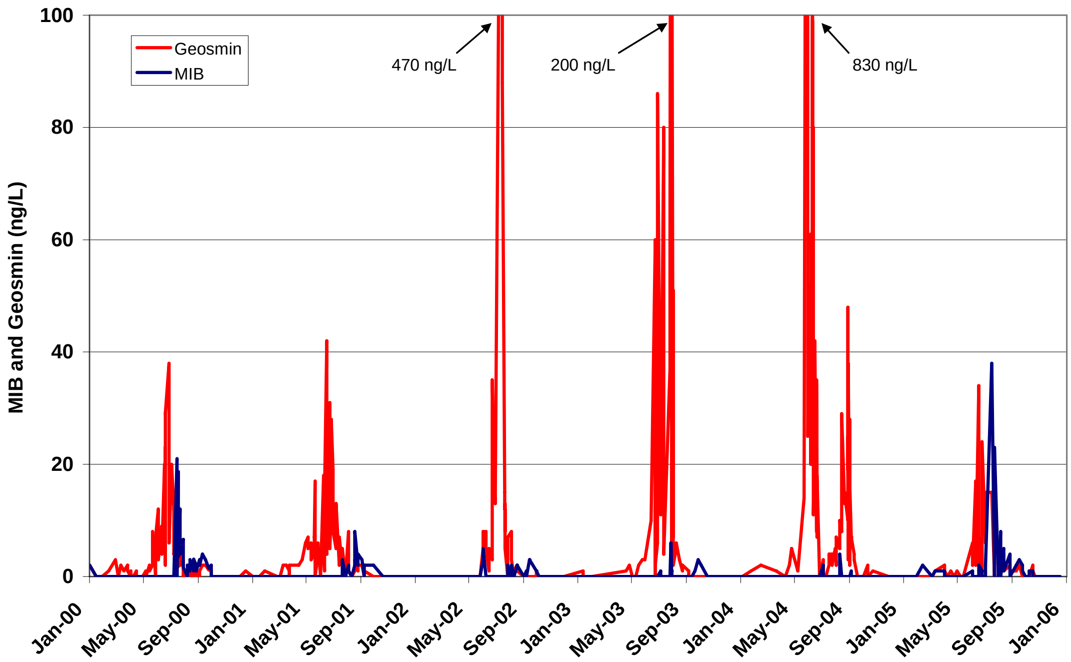


Figure 3-101 shows that MIB and geosmin are both found at high concentrations at Check 66 in the East Branch of the aqueduct. The maximum concentrations recorded were 130 ng/L of MIB in September 2001 and 240 ng/L of geosmin in May 2003. The MIB peak did not originate upstream as the levels found at Check 41 (**Figure 3-99**) were less than 5 ng/L at this time. The Check 66 geosmin peak was also likely generated in the East Branch. Although levels of geosmin up to 50 ng/L were found at Check 41 in May 2003, it is unlikely that a peak of over 200 ng/L was missed because Check 41 samples were being analyzed every two to three days at that time. DWR attributed the high levels of geosmin and moderate levels of MIB to benthic algae growing in the East Branch. Peaks of MIB in July 2004 and 2005 also appear to have been generated in the East Branch.

Figure 3-102 depicts the results of monitoring at the outlet to Silverwood Lake. MIB and geosmin concentrations show the same general pattern as at Check 66; however the summer peak concentrations at Check 66 are seen in Silverwood Lake a day or two later at much lower concentrations. These data indicate that the source of MIB and geosmin is the California Aqueduct rather than algal growth in the lake.

Figure 3-103 presents a highly complex picture of MIB and geosmin in Lake Perris. These patterns do not appear to coincide with upstream locations and suggest significant production of T&O compounds in Lake Perris. The period April and May 2005 is of particular interest, in that concentrations of geosmin as high as 1,660 ng/L were measured at the reservoir outlet, which is an intake of the MWDSC system (although water is typically not drawn from Lake Perris when T&O conditions are adverse).

Figure 3-101. MIB and Geosmin at Check 66

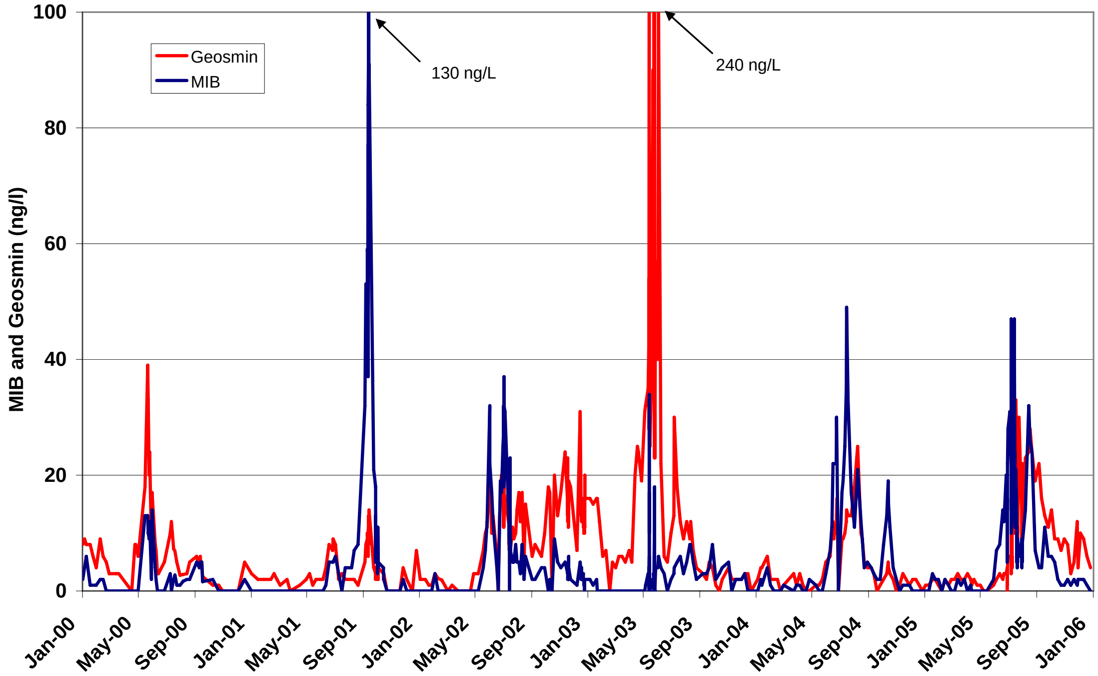


Figure 3-102. MIB and Geosmin at Silverwood Outlet

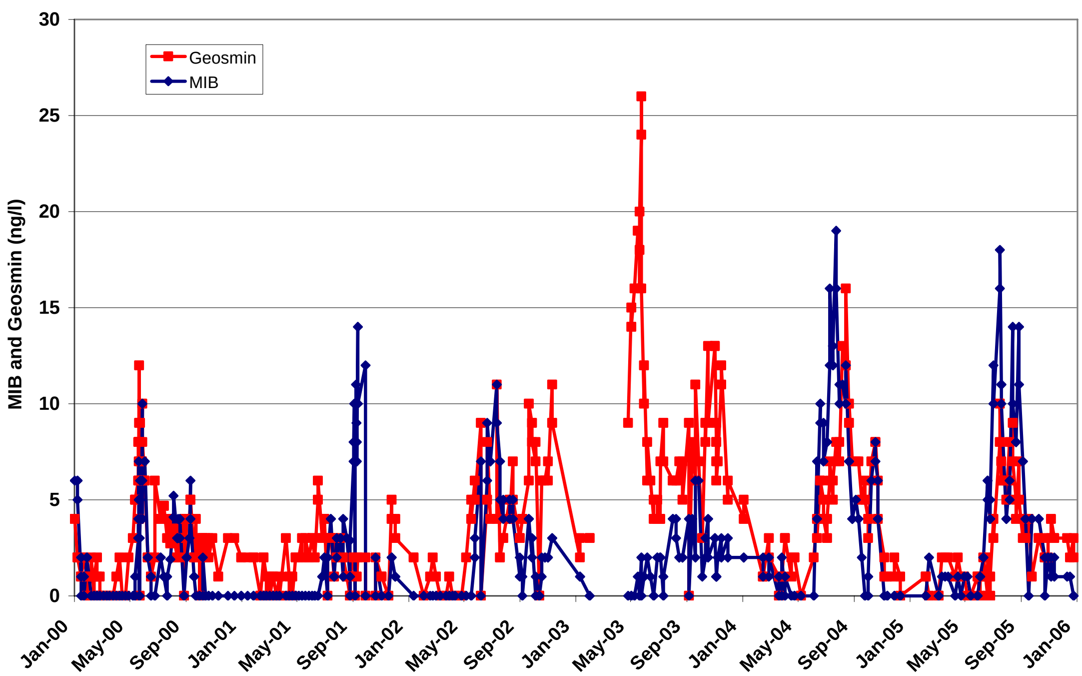
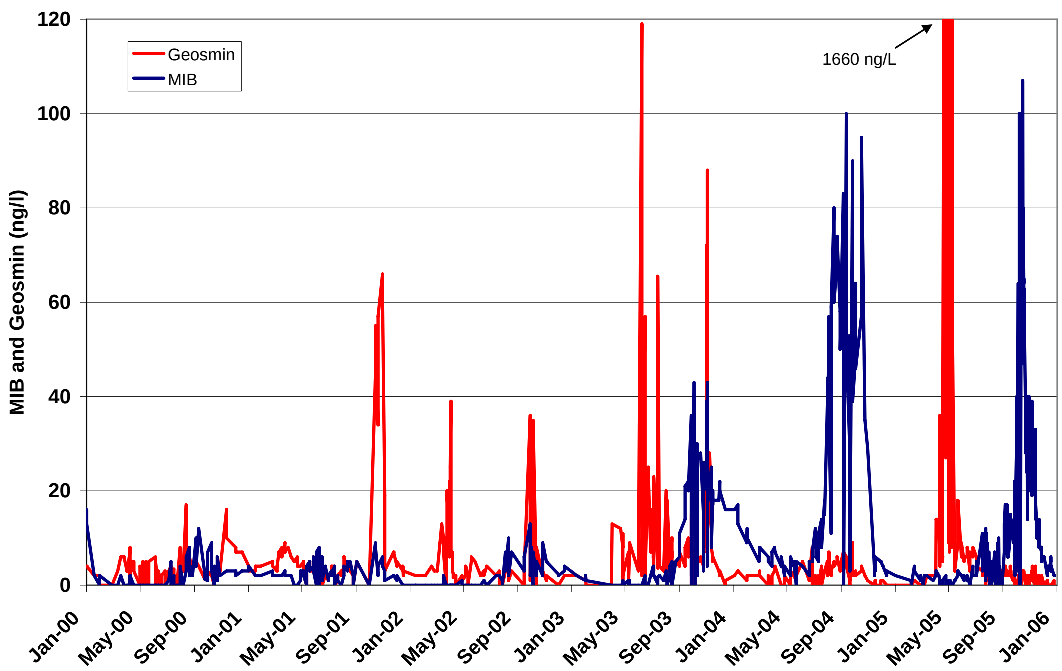


Figure 3-103. MIB and Geosmin at Perris Outlet



<u>Coastal Branch</u>

Taste and odor incidents have been reported by CCWA that are suspected to be related to sedimentation in forebays of the Coastal Branch pumping plants. This topic is addressed in Chapter 7 of this report.

Summary

- Monitoring of MIB and geosmin was initiated at a number of locations in the SWP between 2001 and 2005. The samples are quickly analyzed and email reports are sent to the SWP Contractors alerting them to potential T&O problems.

- MIB and geosmin peaks in excess of 10 ng/L occur at Clifton Court and at Banks every summer. Concentrations exceeding 10 ng/L can be detected by most people and result in customer complaints to drinking water providers. MIB concentrations have been more problematic in recent years.

- The peak levels of MIB and geosmin at Banks are quickly transported to the SBA. These compounds were present at levels known to cause complaints during the summers of 2003, 2004, and 2005.

- MIB from the Delta is transported down the California Aqueduct but the concentrations decrease with distance down the aqueduct. There is evidence that MIB and geosmin are produced at high levels in the aqueduct.

- San Luis Reservoir has low levels of MIB and geosmin (usually less than 4 ng/L). In contrast, high levels of MIB and geosmin are generated in the southern California reservoirs. Castaic Lake has high levels of geosmin every summer (up to 830 ng/L) and occasional MIB peaks greater than 10 ng/L. Lake Perris has exceedingly high concentrations of geosmin (up to 1,660 ng/L) and MIB (up to 107 ng/L). Silverwood Lake has peaks of both compounds that exceed 10 ng/L but do not reach the high levels found in the other reservoirs.

VASCULAR PLANT GROWTHS

Water hyacinth (*Echhornia crassipes*), a non-native, invasive aquatic macrophyte, was introduced to the Delta from South America about 100 years ago, and was probably brought to California because of its attractive flowers and leaves. With a growth rate higher in warm weather than any other known plant, it has become a nuisance in the Delta, producing plant masses up to six feet in depth and spreading throughout Delta channels. The infestation results in obstruction of navigation and water conveyance structures, increased channel sedimentation, reduced dissolved oxygen in Delta waters, and exclusion of other plant and animal species. Water hyacinth has no known natural enemies in the Delta, and with the ability to double in size in as little as ten days, human intervention has been required to prevent its continued spread.

In 1982 the California Department of Boating and Waterways (Boating and Waterways) was designated lead agency for managing the infestation. Although introduction of a plant parasite is currently being investigated as a possible means of exerting control over the infestation, treatment with chemical herbicides has been the only approach that has met with success to date. Chemical control applied by Boating and Waterways was highly successful at controlling the pest in earlier years. In 2001, the requirement to obtain a Chapter 7 permit from the National Oceanic and Atmospheric Administration (NOAA) Fisheries under the Endangered Species Act resulted in restriction of chemical treatments to the period July 1 through October 15. This restriction was an outgrowth of concerns over potential impacts of herbicide use on Chinook salmon. Because chemical treatments are more successful when used early in the annual growth cycle while the plants are small and have not begun to multiply, it has not been possible to reduce the overall extent of the infestation below its current level of about 4,000 acres since the use restriction came into effect. During the months when chemical use is allowed, temporary reduction of the infestation has, however, been observed.

About 40 years ago another non-native plant species, Brazilian elodea (*Egeria densa*) was introduced to the Delta. This submerged plant inhabits shallow waters and is used in aquariums, which probably explains its introduction to the Delta. Like the water hyacinth, elodea has no known natural enemies. Therefore, control of this plant has, like the water hyacinth, been possible only by herbicidal application that is subject to the July 1 to October 15 use restriction. By legislative mandate, the elodea infestation was made the responsibility of Boating and Waterways in 1997 and chemical control applications began in 2001. Unlike the water hyacinth control program, treatments for elodea control have not contained the extent of the infestation. There are few herbicides registered for use in California that will affect the growth of elodea, and the particular herbicide used for treating it needs to be applied when it is most vulnerable during its early season growth period.

Boating and Waterways conducts annual hyperspectral aerial surveys to quantify the extent of the aquatic weed growths in the Delta, and operates an innovative geospatial weed mapping program (Jarnagin, 2004). The aerial survey technique has been very effective in quantifying water hyacinth growths but, because elodea is submerged, has not as yet proven as effective for mapping the extent of that infestation. Boating and Waterways staff is working on methods to measure the extent of elodea growth. Meanwhile, staff estimates the current extent of the infestation to be about 10,000 acres in the Delta, and increasing annually (Personal Communication, Marcia Carlock, Boating and Waterways.).

Operation of the Aquatic Weed Control Program by Boating and Waterways is permitted by NOAA Fisheries, the U.S. Fish and Wildlife Service, and the Central Valley Regional Water Board. Water quality measurements are required to be performed in conjunction with chemical treatments to assure water quality is appropriately protected. Currently, the herbicides 2,4-D, glyphosate, and fluridone are used in the Aquatic Weed Control Program.

Infestations of non-native aquatic vascular plants in the Delta almost certainly affect the ecology of the region, but to an extent that is not fully understood. Whether water quality impacts are occurring, or will occur, as a result of their spread is largely unknown and, as yet, unpredictable.

TURBIDITY

Water Quality Concern

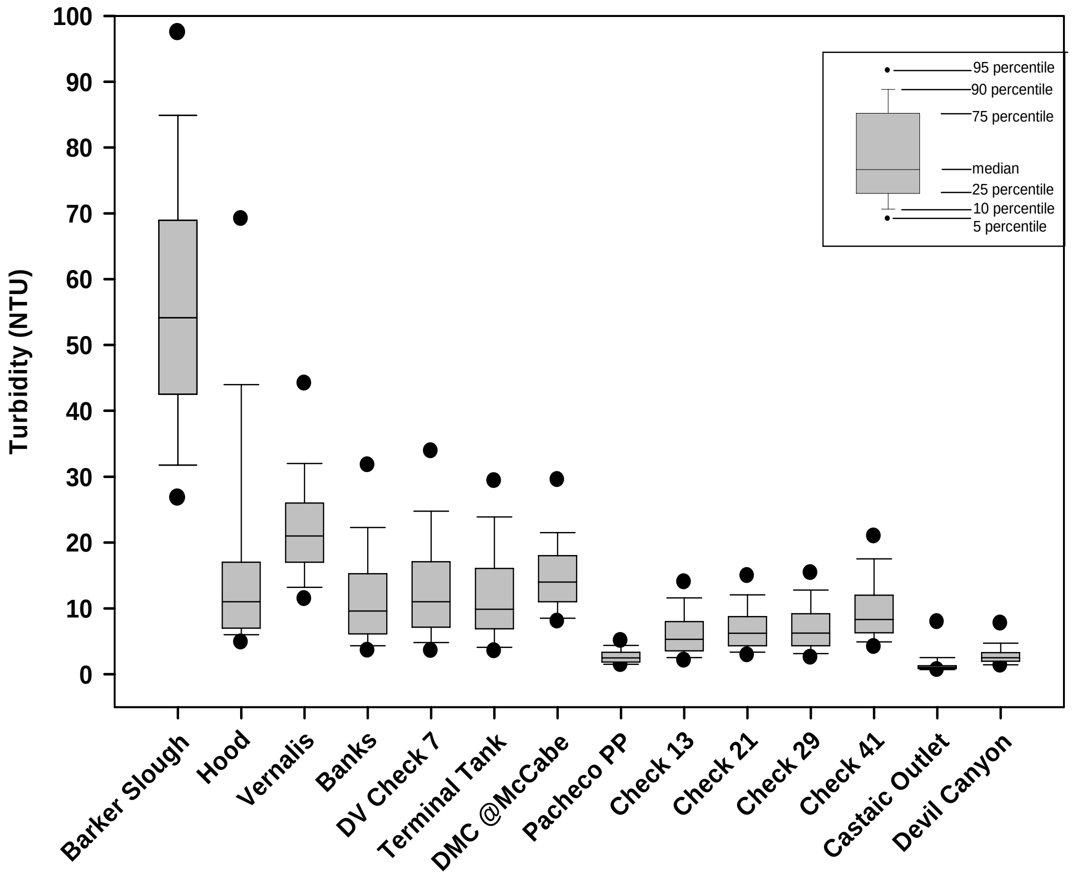
Turbidity refers to the ability of particulate matter in a solution to scatter or absorb light. It is measured in water samples by passing light through a chamber of calibrated size and detecting the light exiting the chamber. The difference between the intensity of the light entering and exiting the chamber is proportional to the concentration of particulates in the sample. Turbidity in drinking water supplies has both beneficial and undesirable aspects. The water supplies of the SWP generally contain ample nutrient concentrations to permit growths of algae and cyanobacteria to levels that can obstruct water treatment facilities and cause T&O in treated drinking water. Turbidity can limit these growths by reducing light penetration in the water column. In water treatment, the presence of some turbidity can be helpful in attaining efficient flocculation and sedimentation. On the negative side, excess turbidity can create challenges with adequately clarifing and disinfecting the water, and can increase expenses for treatment chemicals and sludge handling. In parts of the SWP where water velocity tends to be slower, such as in reservoirs and forebays to pumping plants, turbidity can settle, forming sediment beds. These sediment beds can reduce the capacity of the system, and encourage growths of cyanobacteria responsible for T&O in drinking water. Sediment-related T&O has been a particular problem for CCWA on the Coastal Branch, and is discussed further in Chapter 7.

Water Quality Evaluation

Turbidity Levels in the SWP

Presently, there are 14 *in-situ* recorders continually monitoring turbidity in the SWP. Data are available from most of these recorders since 1996. Data from these recorders, along with discrete sample data from Hood, Vernalis, and the DMC @ McCabe, were used in the analysis of turbidity. **Figure 3-104** provides a spatial comparison of turbidity at key locations in the SWP system during the 2001 to 2005 period.

Figure 3-104. Turbidity in the SWP



Sources of Water to the Delta

As shown in **Figure 3-104**, turbidity in the San Joaquin River was generally about twice that of the Sacramento River. (median 21 NTU and 11 NTU, respectively) during the 2001 to 2005 period. **Figure 3-105** presents the discrete sample data collected at Hood during the 1996 to 2005 period and **Figure 3-106** presents the data for Vernalis. Flow data for the two rivers are also shown. These figures indicate that turbidity is highly variable on both rivers. On the Sacramento River, turbidity is directly related to flow in the river. When flows increase, turbidity increases (maximum measured value of 145 NTU). When flows drop below about 20,000 cfs, turbidity is generally less than 10 NTU. The San Joaquin River shows the same pattern of rapidly increasing turbidity when flows first increase in the winter months (maximum measured value of 178 NTU); however during prolonged periods of high flows, such as in 1999 and 2005, turbidity drops down to 20 to 40 NTU. During the summer months, turbidity is in the range of 20 to 50 NTU and appears to be inversely proportional to flow. As the river flows decrease in the summer, a larger percent of the water in the river is agricultural drainage, which could be the source of the summer high turbidity levels.

Figure 3-105. Turbidity at Hood

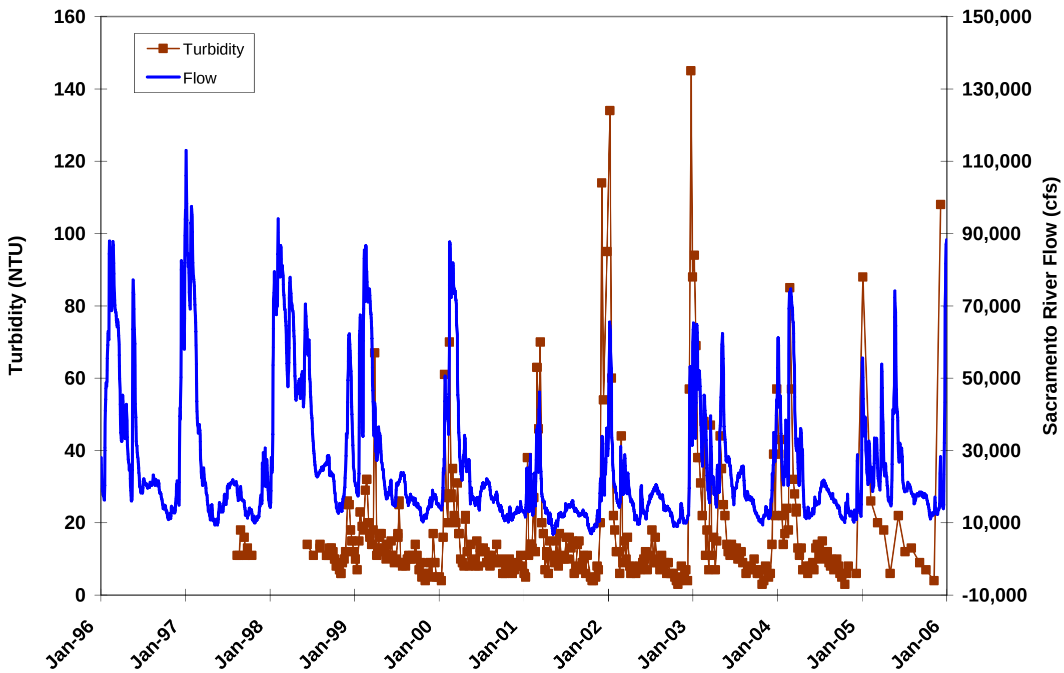
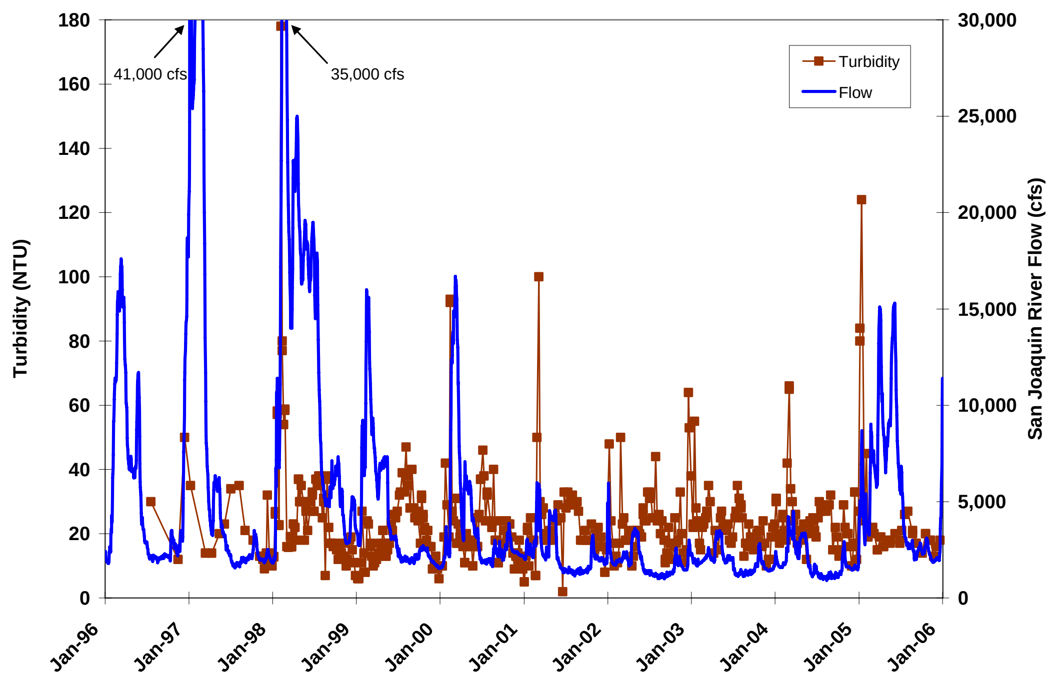


Figure 3-106. Turbidity at Vernalis



North Bay Aqueduct

The turbidity levels at Barker Slough are substantially higher and more variable than at Hood or any other SWP monitoring location. As shown in **Figure 3-104**, the median turbidity was 54 NTU and 25 percent of the turbidity measurements exceeded 70 NTU. As described in more detail in Chapter 5, the high levels of turbidity at Barker Slough present treatment challenges for the NBA Contractors. **Figure 3-107** shows the extreme fluctuations in turbidity that occur at Barker Slough. Turbidity has reached over 300 NTU on several occasions. The winter months of the wet years 1997 and 1998 were associated with the highest turbidities of the ten year period but, rather than indicating a trend, this probably only reflects the association between runoff from the watershed and turbidity. The seasonal pattern of turbidity in the NBA during the 2001 to 2005 study period is illustrated in **Figure 3-108.** This figure presents data from both Barker Slough and Cordelia Forebay. Although turbidity peaks of 200 to 375 NTU occur during winter storm events, the month with the highest monthly mean turbidity is June. The reason for this is unclear. Although the NBA is an enclosed pipeline between Barker Slough and Cordelia, the turbidity levels at Cordelia are higher. One possible explanation is that sediment that has accumulated in the forebay is resuspended when the pumps are operating.

Figure 3-107. Turbidity at Barker Slough

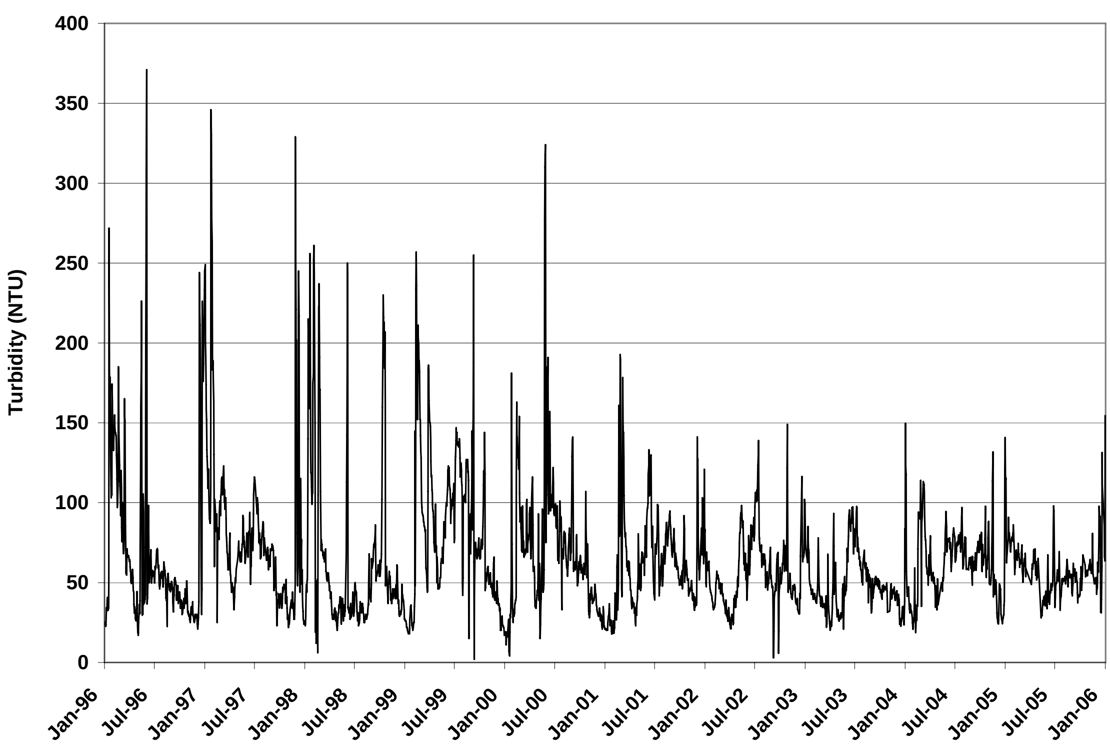
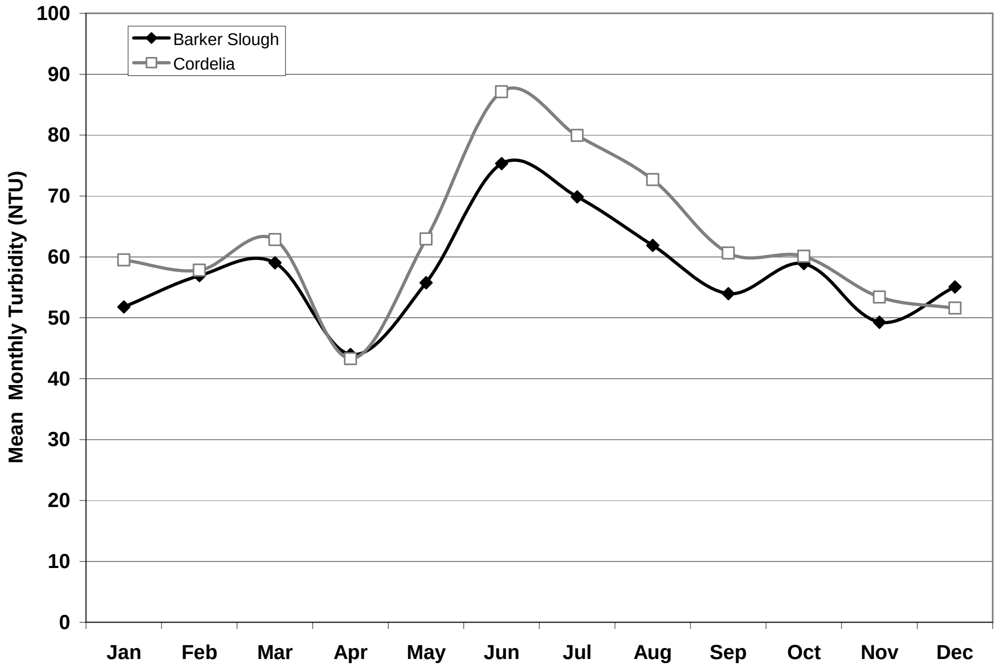


Figure 3-108. Monthly Mean Turbidity in the NBA

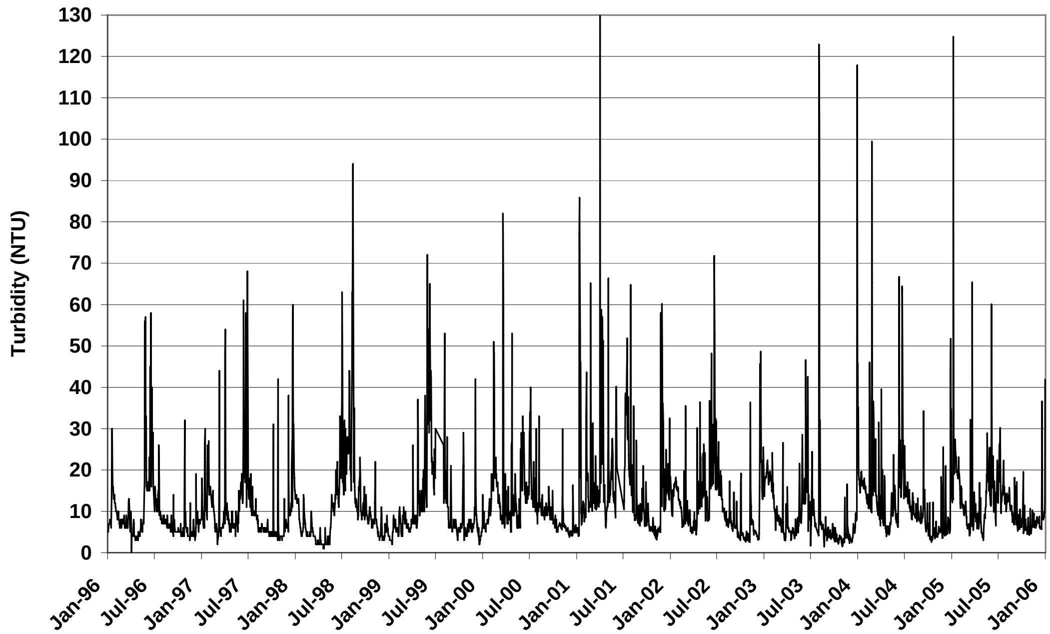


Banks Pumping Plant

As shown in **Figure 3-104**, the median turbidity at Banks (9.6 NTU) is slightly lower than the median at Hood and substantially lower than the median at Vernalis, probably due to some settling of sediment in Delta channels and Clifton Court Forebay. Reservoirs and forebays, such as Clifton Court, act as settling basins due to the low velocity of water in the reservoir compared to the channels that feed the reservoir. For example, water leaving Clifton Court has about a 27 percent lower suspended solids concentration than water entering the reservoir. Chapter 7 contains a detailed discussion of sedimentation in this facility. As a result, sediment has accumulated in all of the reservoirs and forebays of the SWP system.

Figure 3-109 presents the turbidity data for Banks. Although the median turbidity is low, there is tremendous variability in turbidity at Banks. Peak turbidities, up to 100 NTU, occur during the spring and summer months. The peaks are not as high in the winter months but there are more prolonged periods of high turbidity. DWR O&M staff conducted an analysis of turbidity at Banks for the SBA Contractors in 2002 that indicated that the summer peaks in turbidity are potentially due to the resuspension of sediment in Clifton Court Forebay due to high winds in the Delta during the summer months (Personal Communication, Laura Hidas, ACWD). The high turbidity in the winter is due to the higher levels found in the Sacramento and San Joaquin rivers.

Figure 3-109. Turbidity at Banks



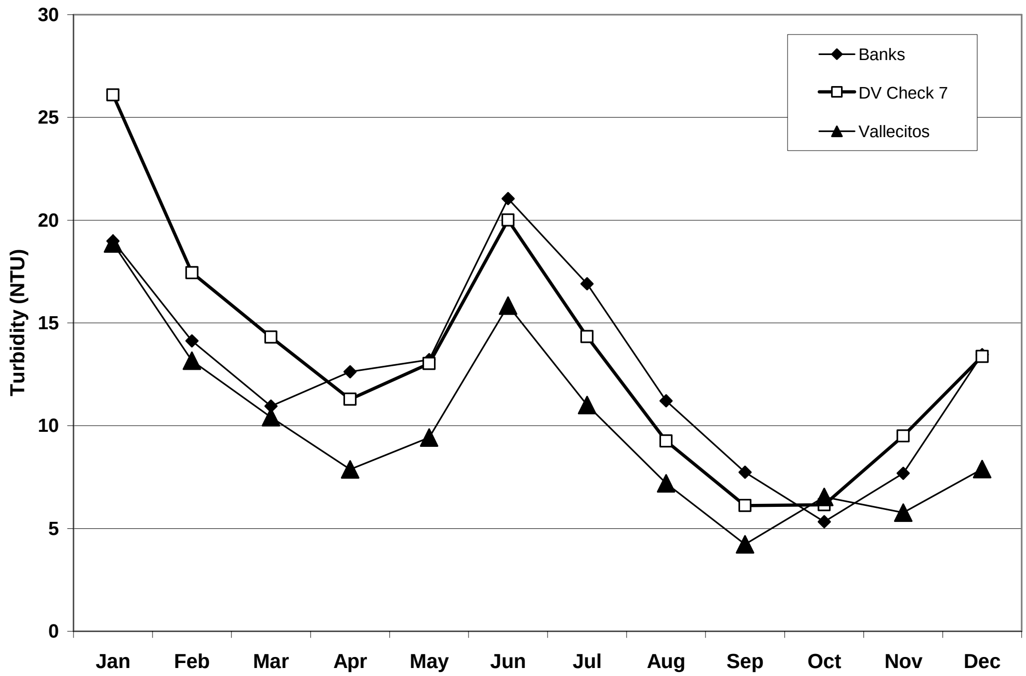
South Bay Aqueduct

Figure 3-104 shows that median turbidity at DV Check 7 (11 NTU) and the Terminal Tank (9.8 NTU) is similar to that found at Banks (9.6 NTU). **Figure 3-110** is a plot of mean monthly turbidity for the period March 2002 through December 2005 for which data exist at Banks, DV Check 7 and Vallecitos. All three locations show the same pattern with peak turbidity in January and June. The January peak is due to winter storms when turbidity in the rivers and Delta is high. The June peak is generated in the Delta and may be due to wind-driven suspension of sediment in Clifton Court or to higher pumping. During most months there is about a 2 to 4 NTU difference between DV Check 7 and Vallecitos, which may be due to settling of sediment in the aqueduct or blending of Lake Del Valle water into the SBA. The Terminal Tank shows higher turbidity than Vallecitos (median of 9.8 NTU), but this may be an artifact, as the Terminal Tank recorder was taken out of service in August 2002. While this figure represents mean data, on a real-time basis, the SBA water treatment plants experience variable and high turbidity events that rapidly evolve. These events can cause significant treatment challenges

Delta Mendota Canal

The median turbidity of the DMC @ McCabe was 14 NTU, measured in discrete samples collected monthly. The higher median, compared to Banks (9.6 NTU), may be an indication of the greater influence of the San Joaquin River on the DMC. As discussed previously, during the period 2001 through February 2005, 34 percent of the water flowing down the California Aqueduct at Check 13 came from the DMC. Although the turbidity of the DMC was about 30 percent higher than water pumped at Banks, DMC water would be expected to raise the median turbidity of water flowing south of O'Neill Forebay only by a fraction over 1 NTU if there wasn't any settling of sediment in O'Neill Forebay.

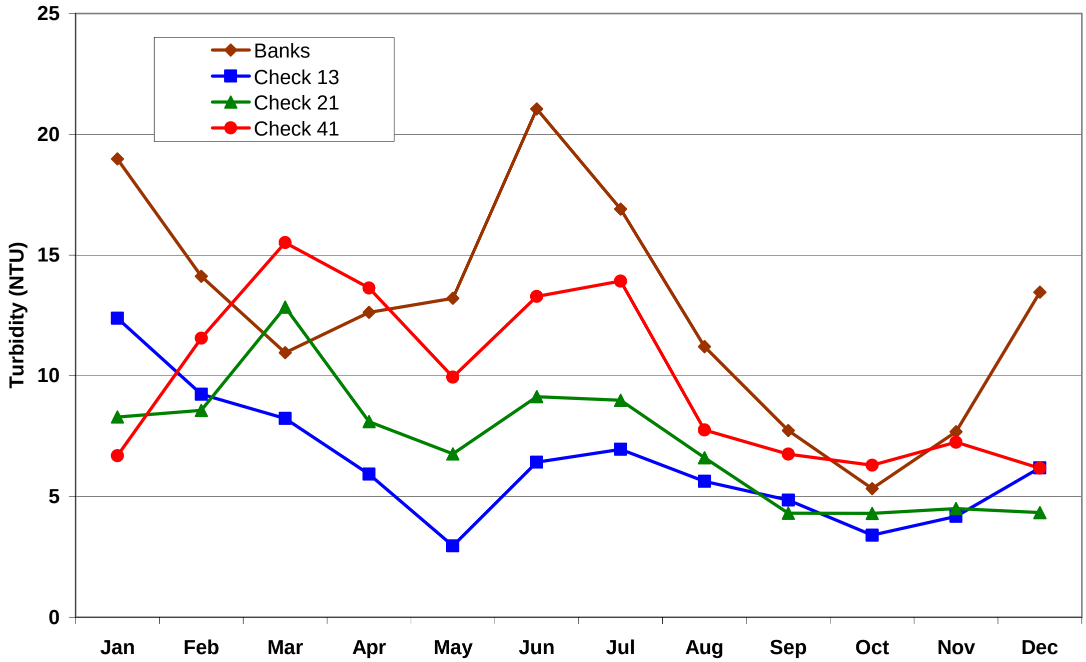
Figure 3-110. Monthly Mean Turbidity in the SBA



<u>California Aqueduct</u>

As indicated in **Figure 3-104**, there is a substantial decrease in turbidity between Banks and Check 13 due to settling in O'Neill Forebay and San Luis Reservoir. This figure also shows that turbidity increases gradually as water flows down the aqueduct to Check 41 and, there is a reduction in turbidity in both the East Branch and West Branch reservoirs. Monthly mean turbidity data at Banks and at several check structures south of San Luis Reservoir are shown in **Figure 3-111**. This figure shows that turbidity levels at Check 13 are lower and less variable than at Banks but turbidity increases and becomes more variable as water moves down the aqueduct south of San Luis Reservoir. The increase in turbidity could be due to wind-blown sediment that enters the aqueduct in the San Joaquin Valley, drainage that is conveyed into the aqueduct in the San Luis Reach, non-Project water that is transferred to the aqueduct in the southern San Joaquin Valley (see Chapter 5), or to the manner in which the SWP is operated. **Figures 3-112 and 3-113** show the average daily turbidities calculated from the continuous turbidity data for Checks 21 and 41, respectively. At Check 21, peak turbidities of more than 70 NTU occurred in the springs of 1998 and 2001. During the winter and spring of 1998, over 21,000 acre-feet of floodwaters entered the aqueduct between Checks 13 and 21, and in March 2001, 2,106 acre-feet entered the aqueduct. DWR collected a minor amount of turbidity data on the inflows between 1996 and 1998 that showed a range of 12 to 9,920 NTU. According to the 2001 Update, field division staff has described the floodwaters as looking like chocolate milk (DWR, 2006). The turbidity peak in March 2001 appeared at Check 41 about one week after it appeared at Check 21. Based on these limited data, it is entirely possible that the peak turbidities seen in 1998 and 2001 were due to the floodwater inflows in the San Luis reach. In the springs of 1996 and 1997 peak turbidity at Check 41 was higher than at Check 21, indicating a source between the two locations. Turbidity was elevated for about two months during the summer of 1998 with a peak of 93 NTU in mid-July. Between April and early July, over 188,000 acre-feet of Kern River water entered the aqueduct. Turbidity of the inflow water was generally in the range of 20 to 45 NTU, substantially higher than turbidity levels that are typically seen at Check 41 during the summer months.

Figure 3-111. Monthly Mean Turbidity in the California Aqueduct



Project operations can also affect turbidity in the aqueduct. The velocity of water in the aqueduct is controlled by pumping plants along the system. These plants are generally operated off-peak, meaning that pumps are turned on during night time hours when energy costs are lower and turned off during times of peak energy costs. This operating pattern has significant effects on suspended sediments, causing settling during the day and re-suspension at night. Hourly turbidity data from the continuous recorder at Check 29 are plotted in **Figure 3-114.** This location was chosen because it is in the area of the San Joaquin Valley where wind-blown sediments are problematic and, it is downstream of the San Luis Reach and some of the major non-Project turn-ins. The plot depicts the daily variability in turbidity over a particular 12 day period when fluctuations were pronounced. Daily fluctuations over 30 NTU were observed at this location, but the amount of daily fluctuation was variable. This figure clearly demonstrates the turbidity consequences of night-time pumping. Maximum turbidities occur in the early morning hours and minimum turbidities generally occur just before midnight. This evaluation demonstrates that continuous monitoring of turbidity is critical to understanding the conditions in the aqueduct.

Figure 3-112. Turbidity at Check 21

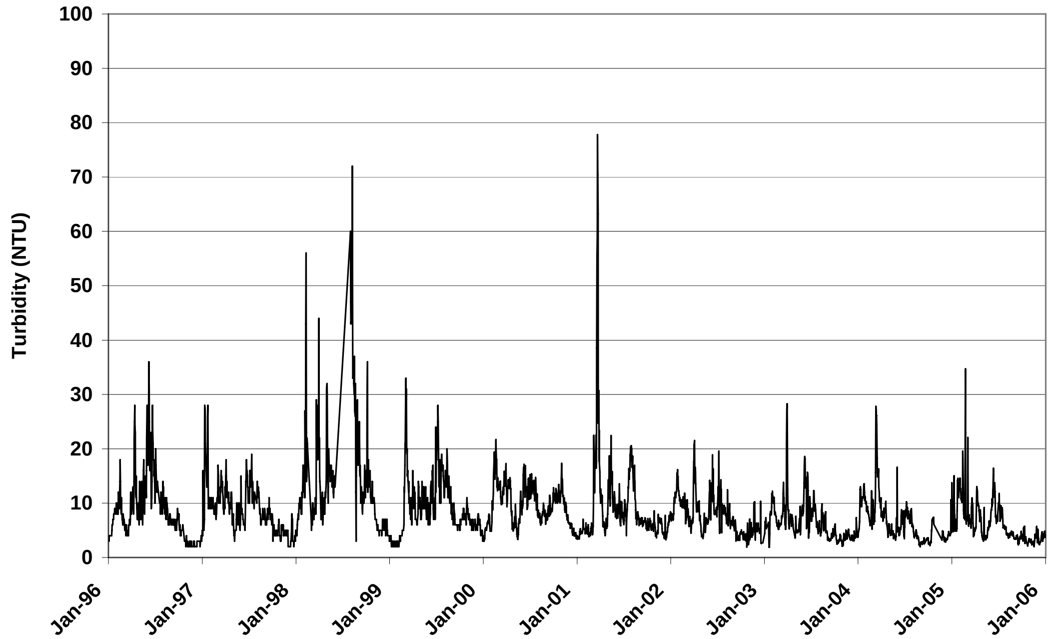


Figure 3-113. Turbidity at Check 41

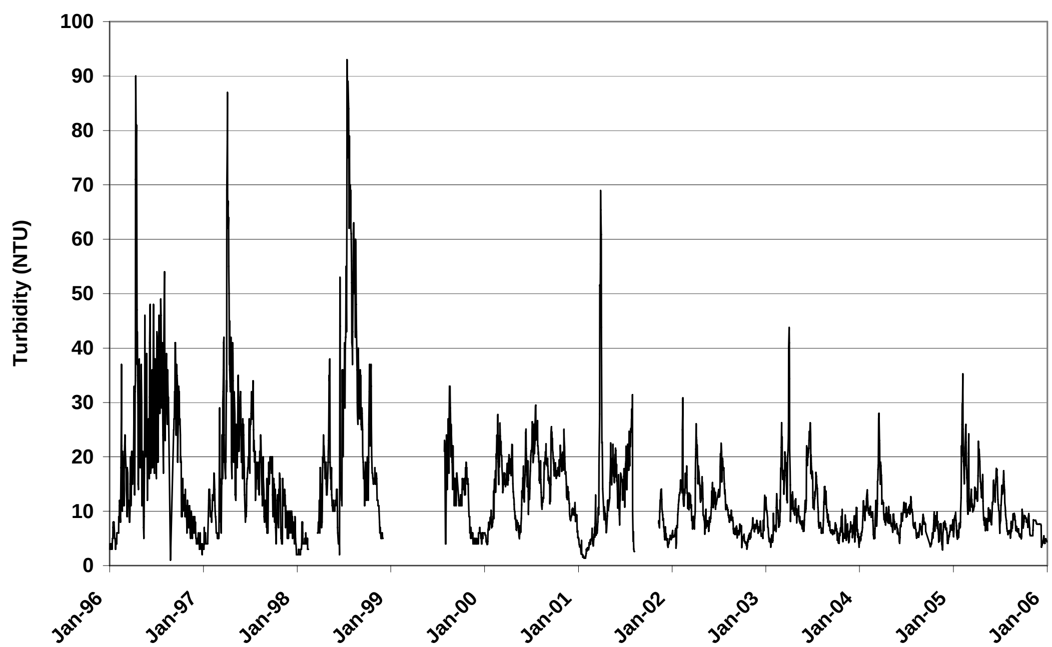
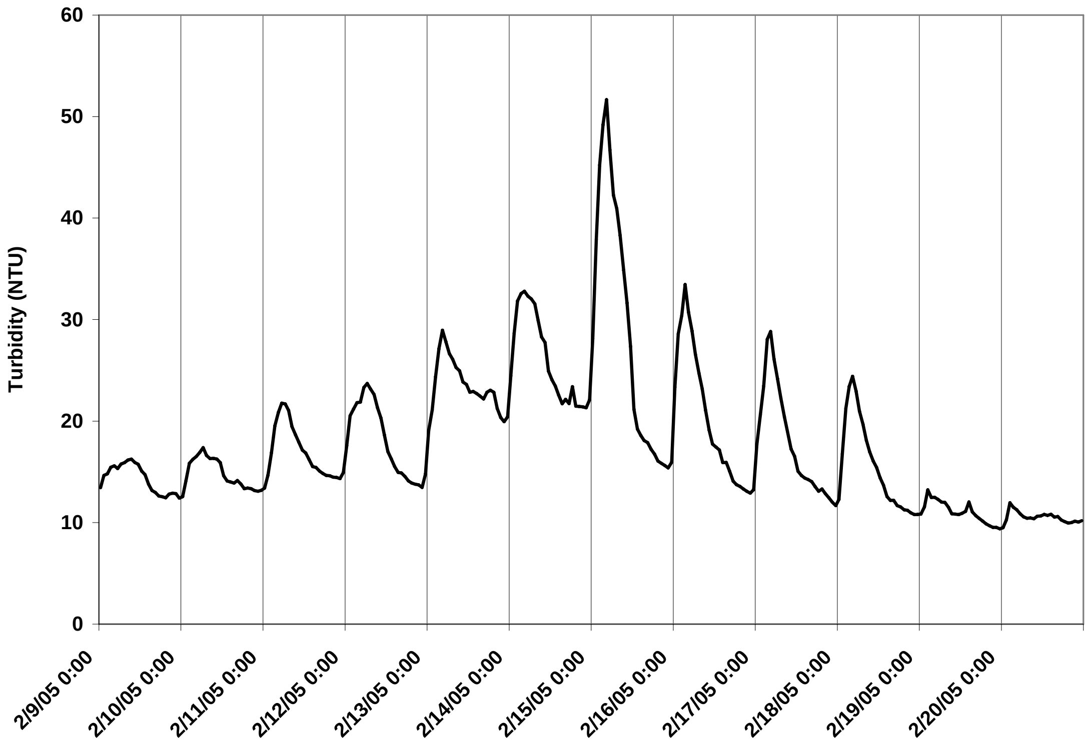


Figure 3-114. Daily Turbidity Variability



Impoundment of water in San Luis Reservoir, Castaic Lake, and Silverwood Lake cause pronounced reductions in turbidity due to settling of entrained sediments. This effect is seen in the fact that median turbidities at Pacheco (2.5 NTU), Castaic Outlet (1.0 NTU), and Devil Canyon (2.5 NTU) are well below turbidities observed at the aqueduct monitoring stations. The effects of sediment settling in O'Neill Forebay and San Luis Reservoir are evident in that turbidity at Check 13 (median 5.3 NTU) is only half that of the water entering the system at Banks.

Coastal Branch

The median turbidity during the 2001 to 2005 period at Check 21 was 6.2 NTU. The variability in turbidity at Check 21 is discussed in the previous section. Accumulation of sediment in the pumping plant forebays of the Coastal Branch aqueduct has resulted in T&O problems for CCWA. Attempts to address this problem have led to physical removal of sediments from portions of the Coastal Branch, and also to installation of equipment intended to reduce sedimentation. This subject is discussed in some detail in Chapter 7.

Summary

- Turbidity levels in the Sacramento River are related to flows, with higher turbidities associated with higher flows. The San Joaquin River shows the same pattern of rapidly increasing turbidity when flows first increase in the winter months; however during prolonged periods of high flows, turbidity drops back down.

- The turbidity levels at Barker Slough are substantially higher and more variable than at Hood or any other SWP monitoring location. Peak turbidity levels occur in the winter months and in June. The high turbidity levels create treatment challenges for the NBA Contractors.

- The median turbidity at Banks is lower than in the Sacramento and San Joaquin rivers, reflecting settling in Delta channels and Clifton Court Forebay. Although the median turbidity is low, there is tremendous variability in turbidity at Banks. Peak turbidities, up to 100 NTU, occur during the spring and summer months. The turbidity levels in the SBA are similar to those at Banks and show the same seasonal trend.

- The SBA experiences high and variable turbidity events that can evolve quickly and cause treatment challenges.

- There is a substantial decrease in turbidity between Banks and Check 13 due to settling in O'Neill Forebay and San Luis Reservoir. This same dampening effect is seen in Castaic and Silverwood reservoirs.

- Turbidity increases and becomes more variable as water moves down the aqueduct south of San Luis Reservoir. Potential sources of turbidity are floodwater inflows to the San Luis reach and the Kern River, diverted into the aqueduct at the Kern River Intertie. Project operations also affect turbidity by creating diurnal fluctuations due to pumping cycles.

- There are no apparent long term trends at any of the locations included in this analysis. Continuous turbidity data were available from 1996 through 2005 at many locations. During this time, water years varied from dry to wet and the highest turbidity levels at many locations occurred during the extremely wet years of 1997 and 1998.

TRACE ELEMENTS AND PESTICIDES

Water Quality Concern

MCLs have been established by CDHS for a number of organic chemicals that pose a risk in drinking water supplies. Most of these chemicals have never been detected in the SWP and those that have been detected are found at concentrations well below the MCLs. However, the watershed for the SWP receives agricultural drainage, treated wastewater from urban areas, and urban runoff, all potential sources of organic chemicals. As a result, DWR conducts monitoring three times each year for chlorinated organic chemicals, organo-phosphorus pesticides, herbicides, carbamate pesticides, and a variety of other synthetic organics throughout the SWP.

Water Quality Evaluation

DWR collects samples in March, June, and September of each year for organic chemicals. Results of sampling during the 2001-2005 study period, along with a list of monitored constituents, are presented in **Appendix A,** and summarized in **Table 3-5.** The summary table shows the chemicals that were detected, the number of times they were detected (out of 15 samples) and the maximum concentration detected. The left column of the table lists the relevant MCL, if one exists. Inspection of the table demonstrates that none of the detected chemicals was present in concentrations approaching an MCL. Water treatment would be expected to further reduce the concentrations of these chemicals in drinking water. These data provide confidence that regulated organic chemicals in SWP water supplies are not present at levels constituting a health threat.

A vast array of exotic synthetic organic chemicals now exists, and it would be technically impossible to monitor for all compounds that could potentially be present in the watersheds of the Delta, that comprise roughly one-third of the land mass of California. DWR and the SWP Contractors are constantly on the alert for reports of new detections, and modify their monitoring as information becomes available on new potential water quality threats.

Of the inorganic chemicals for which MCLs exist, only arsenic is believed to have the potential to be a problem in SWP supplies, on the basis that some groundwater in the San Joaquin Valley can contain substantial concentrations of arsenic and groundwater is sometimes permitted to enter the California Aqueduct. Groundwater inflows to the SWP system are discussed in more detail in Chapter 5. The MCL for arsenic is 0.010 mg/L. Routine monitoring of arsenic at key SWP locations (Banks, Check 13, Check 21, Check 41, Castaic Outlet, and Devil Canyon) have resulted in the finding of a maximum concentration of 0.004 mg/L, with a median of 0.002 mg/L, from samples collected during the 2001 to 2005 study period. Water treatment would be expected to further reduce arsenic levels.

Table 3-5. Summary of Detected Pesticides and Other Synthetic Organic Chemicals (µg/L)

Compound	MCL	Barker		Banks		Check 13		Delta Mendota Canal		Check 21		Check 29		Check 41		Devil Canyon	
		#	**Max**	#	**Max**	#	**Max**	#	**Max**	#	**Max**	#	**Max**	#	**Max**	#	**Max**
2,4-D	70	1	0.32	3	0.30	3	0.20	4	0.43	3	0.20	2	0.11	0		1	0.10
Atrazine	1	0		0		0		1	0.02	0		0		0		0	
Chlorpyrifos	none	0		1	0.03	1	0.02	0		0		1	0.01	1	0.06	0	
Diazinon	none	1	0.01	1	0.01	1	0.01	2	0.01	2	0.01	3	0.03	1	0.01	1	0.01
Diuron	none	3	0.89	4	1.10	4	3.20	4	1.00	3	1.50	3	0.94	4	2.10	3	1.70
Metolachlor	none	1	0.10	1	0.10	1	0.10	0		1	0.10	2	0.10	1	0.10	0	
MTBE	13	0		0		0		3	2.20	0		0		0		0	
Pentachlorophenol	1	0		0		0		1	0.10	0		0		0		0	
Simazine	4	3	0.24	3	0.12	4	0.14	4	0.09	5	0.12	5	0.15	5	0.20	5	0.20
Styrene	100	1	0.70	1	0.80	0		0		0		0		0		0	
Toluene	150	1	1.10	1	0.73	0		0		0		0		0		0	
Trifluralin	none	1	0.01	1	0.01	0		0		0		1	0.08	0		0	

Data Source: Department of Water Resources, Division of Operations and Maintenance, Water Quality Section, online publications available at: *http://wwwomwq.water.ca.gov/GrabSamplepage/Pesticidepage/index.cfm*

PATHOGENS AND INDICATOR ORGANISMS

Source waters may be contaminated with a number of pathogenic bacteria, viruses, and protozoans, along with non-pathogenic naturally occurring microorganisms. Routine monitoring for all possible pathogens is impractical so the focus of most source water monitoring is on indicator bacteria and the pathogenic protozoans, *Giardia* and *Cryptosporidium.*

Under the Surface Water Treatment Rule (SWTR), the general requirements are to provide treatment to ensure at least 3-log reduction of *Giardia lamblia* cysts and at least 4-log reduction of viruses. The California SWTR Staff Guidance Manual provides a description of source waters that require additional treatment above the minimum 3-log *Giardia* and 4-log virus reduction (CDHS, 1991). The Guidance Manual states:

> *"...in a few situations, source waters are subjected to significant sewage and recreational hazards, where it may be necessary to require higher levels of virus and cyst removals..."*

Due to the expense and uncertainties associated with pathogen monitoring, CDHS staff historically relied on monthly median total coliform levels as a guide for increased treatment. When monthly medians exceeded 1000 most probable number per 100 milliliters (MPN/100 ml), CDHS staff considered requiring additional log removal. Coliform bacteria have been used for decades to assess the microbiological quality of drinking water. These bacteria are present in the intestines of humans and other warm-blooded animals and are found in large numbers in fecal wastes. Most species occur naturally in the aquatic environment so their presence does not always indicate fecal contamination. More recently, CDHS staff has started to rely upon fecal coliform and *Escherichia coli* (*E. coli)* as more specific indicators of mammalian fecal contamination. When the monthly median *E. coli* or fecal coliform density exceeds 200 MPN/100 ml, CDHS staff considers requiring additional log removal. Evaluation of pathogen reduction levels based on coliform bacterial density is not as scientifically valid as basing them on actual pathogen concentrations. The relationship between coliforms and pathogenic cysts is tenuous, but in the absence of other information, CDHS uses coliform density to determine required pathogen reduction levels for individual water treatment plants.

The Interim Enhanced Surface Water Treatment Rule (IESWTR) requires 2-log reduction of *Cryptosporidium*. Additional removal/inactivation of *Cryptosporidium* may have to be provided based on source water monitoring for *Cryptosporidium* that will be conducted to comply with the recently promulgated Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR).

To the extent data are available, both protozoan and coliform densities are presented and discussed in this chapter for the SWP Contractors treating water from the various reaches of the SWP. Data were provided by a number of SWP Contractors and by DWR's SWP WQMP. There is considerable variability in the data that were provided including varying sampling frequencies (daily to monthly), different methods for determining indicator bacteria densities, and different periods of record. All useful, available data are included in this chapter.

North Bay Aqueduct

The Solano County Water Agency (SCWA) and Napa County Flood Control and Water Conservation District (Napa County) have contracts with DWR for NBA water. SCWA provides untreated water to Travis Air Force Base (AFB) and the cities of Benicia, Fairfield, Vacaville, and Vallejo. Fairfield and Vacaville receive treated water from the 40-million gallons per day (mgd) North Bay Regional (NBR) WTP, Benicia treats water at the 12-mgd Benicia WTP, and Vallejo treats NBA water at the 42-mgd Fleming Hill WTP. Napa County provides untreated water to the cities of American Canyon, Calistoga, Napa, and Yountville. The City of Napa treats water at the 12-mgd Jameson Canyon WTP and provides treated water for the cities of Napa, Calistoga, and Yountville. The NBA is an enclosed pipeline, with the exception of the Cordelia Forebay (surface area of 2 acres) and the Napa Turnout Reservoir (diameter of 190 feet). While there is variability in some water quality constituents between Barker Slough and the WTP intakes, microbiological data collected at Barker Slough and at the NBR WTP intake are considered to be representative of the quality of water received by all of the cities and Travis AFB.

Protozoans

DWR's O&M Division has collected *Giardia* and *Cryptosporidium* data at Barker Slough since 1996. The samples collected prior to August 1999 were analyzed with the Information Collection Rule (ICR) method. The data collected from 2000 to 2005, analyzed by Biovir using Method 1623, are presented in this chapter. Most of the samples were reported as non-detects, with the detection limit of 0.1 cysts or oocysts/L in most samples. In a few samples the detection limit ranged up to 0.4 cysts or oocysts/L. **Table 3-6** presents the data collected on days that *Giardia* or *Cryptosporidium* was detected. These data indicate that when *Cryptosporidium* is detected, fecal coliform and *E. coli* levels are generally above 300 MPN/100 ml.

Table 3-6. Protozoan Detections at Barker Slough Pumping Plant

Date	*Giardia* (cysts/L)	*Crypto-sporidium* (oocysts/L)	Turbidity (NTU)	Total Coliform (MPN/100 ml)	Fecal Coliform (MPN/100 ml)	*E. coli* (MPN/100 ml)
1/25/00	< 0.4	0.8	218	> 1,600	> 1,600	> 1600
2/23/00	< 0.2	0.6	187	5,000	3,000	3,000
9/28/00	0.1	0.1	51	500	300	300
2/18/04	1.4	0.2	177	1,600	1,600	1,600
7/21/04	0.3	< 0.1	76	500	140	140
8/18/04	0.1	< 0.1	52	500	110	110
9/15/04	0.3	< 0.1	57	220	30	30
6/15/05	< 0.1	0.1	53	900	110	110
12/14/05	0.1	< 0.1	32	130	30	30

These samples were analyzed prior to the release of the LT2ESWTR, and were not collected and analyzed as prescribed by the rule (e.g. there are months when no samples were collected and sample volumes were less than 10 liters on several occasions). Nevertheless, the mean concentrations of *Cryptosporidium* were calculated for each year from 2001 to 2005 for comparison to the bin levels in the rule. As shown in **Table 3-7**, the mean concentration for each year are lower than the 0.075 oocysts/L level that would trigger the requirement to achieve additional log removal of *Cryptosporidium* at the water treatment plants treating NBA water.

Table 3-7. Mean *Cryptosporidium* Levels at Barker Slough Pumping Plant

Year	Mean *Cryptosporidium*, oocysts/L
2001	0
2002	0
2003	0
2004	0.018
2005	0.008

Between August 1999 and August 2003, samples were spiked with *Giardia* and *Cryptosporidium* approximately quarterly. The recovery of *Giardia* ranged from 0 to 66 percent, with a mean recovery of 11 percent. BioVir reported that the laboratory's mean recovery for all samples analyzed from a variety of sources was 52 percent. Recoveries of *Cryptosporidium* ranged from 0 to 68 percent with a mean of 18 percent. BioVir's mean recovery for all samples was 57 percent during this period. In February 2005, another sample was spiked and a recovery rate of 53 percent was achieved for *Cryptosporidium*. BioVir reported the laboratory's mean recovery was 73 percent at that time. These data indicate that recovery rates are low in NBA water.

The NBA Contractors and DWR entered into a joint LT2ESWTR compliance monitoring plan agreement. Monitoring was initiated in October 2006 at the Barker Slough Pumping Plant and will continue for two years.

Indicator Organisms

The available total and fecal coliform data were also analyzed to provide more information on the microbial quality of the NBA. The most comprehensive data are collected at the NBR WTP intake. NBA water is treated at the NBR WTP primarily from May or June through November or December and Solano Project water from Lake Berryessa is treated during the wet season. During 2004 NBA water was treated for the entire year at the NBR WTP. During the periods when NBA water is treated, daily coliform samples are collected from the NBR WTP intake. Coliform samples are collected monthly by DWR's SWP WQMP at Barker Slough. The NBA is an enclosed pipeline between Barker Slough and the NBR WTP so the data should be comparable.

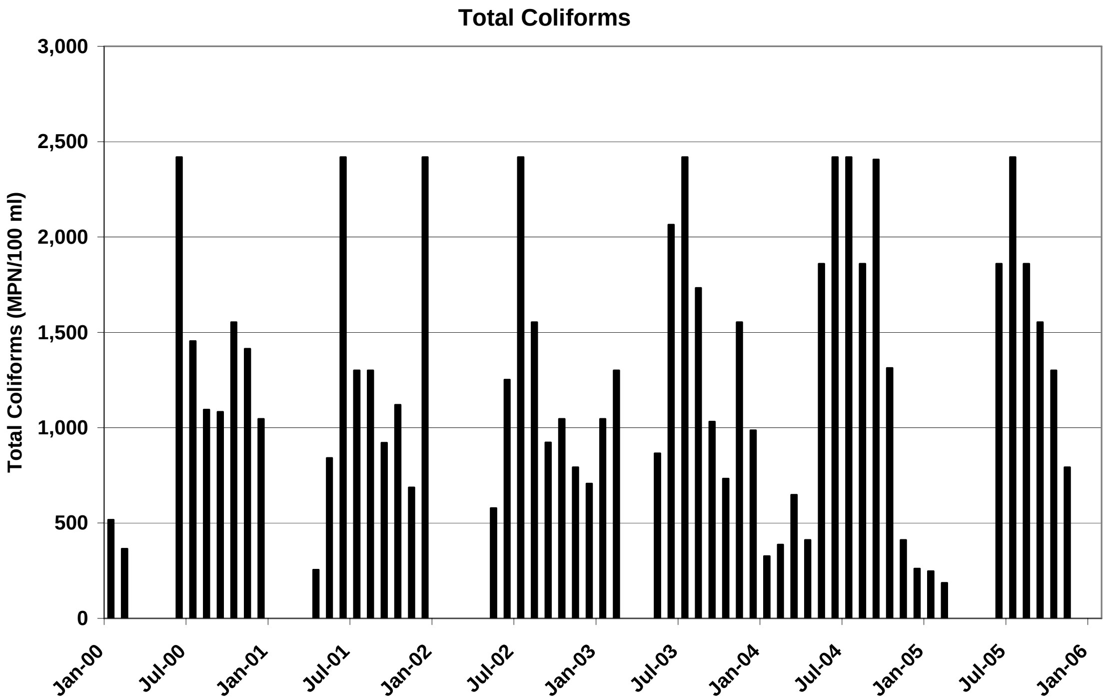
Figure 3-115 presents the monthly median total and fecal coliform data for the NBR WTP intake. Fecal coliforms were not measured prior to June 2003. These data indicate that during the summer months median total coliform densities often exceed 1,000 MPN/100 ml. The peak total coliform density measured at the NBR WTP intake was 35,768 MPN/100 ml on September 30, 2000. A number of samples collected were reported as greater than 2,419 MPN/100 ml, so the actual peak levels cannot be determined. The monthly median fecal coliform densities were below 200 MPN/100 ml with the exception of December 2003. Peak fecal coliform densities of greater than 1,600 MPN/100 ml occurred in January and February 2004.

Since the NBR WTP does not generally treat NBA water during the wet season, DWR's data from Barker Slough were examined to evaluate wet season coliform levels. DWR collects samples once a month so monthly medians could not be calculated. **Figure 3-116** compares the Barker Slough coliform levels to coliform levels measured on the same day at the NBR WTP. Due to the variability in the data, a log scale is used on this figure. This figure shows that the data collected at the two locations are similar and show the same general trends. The DWR data indicate that fecal coliform levels increase in the fall and early winter, likely due to the flushing of the Barker Slough watershed during rain events, and then drop back to below 200 MPN/100 ml.

Evaluation of Pathogen Reduction/Inactivation Requirements

Although the monthly median total coliform densities exceed 1,000 MPN/100 ml during several months of the year at the intake to the NBR WTP, median fecal coliform densities are generally less than 200 MPN/100 ml during the months that the NBR treats NBA water. Sufficient data were not available during the wet season to fully evaluate median levels. The monthly protozoan monitoring that has been conducted at the Barker Slough Pumping Plant indicates that *Giardia* and *Cryptosporidium* are occasionally detected. Although the Barker Slough watershed does not contain significant sources of human wastes, a large amount of the watershed is devoted to cattle and sheep grazing. As discussed in Chapter 5, SCWA has installed fencing along Barker Slough to restrict animal access and is currently evaluating the impact on water quality. The monthly monitoring for *Cryptosporidium* and *E. coli* required by the LT2ESWTR will provide additional data to determine if the current 2-log *Cryptosporidium*, 3-log *Giardia*, and 4-log virus removal requirements are adequate for the WTPs that treat NBA water. The current 2/3/4-log removal should be required by CDHS until the LT2ESWTR data and the data on the effectiveness of restricting animal access to the slough are available.

Figure 3-115. Monthly Median Coliforms in the NBA at North Bay Regional WTP Intake



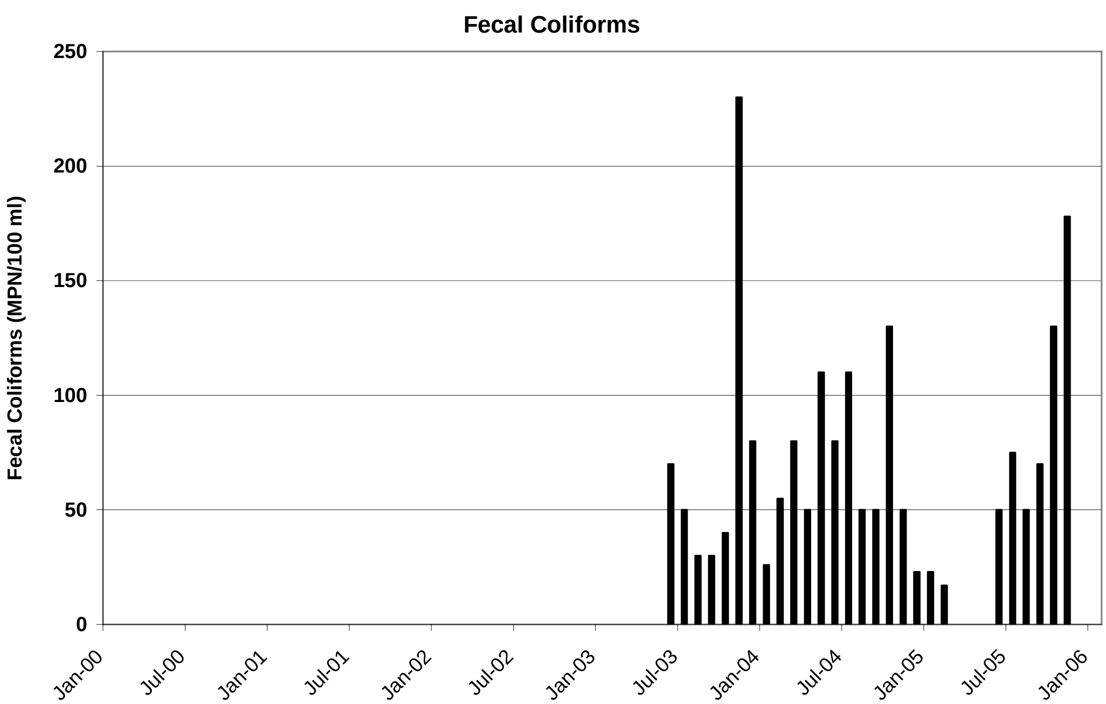
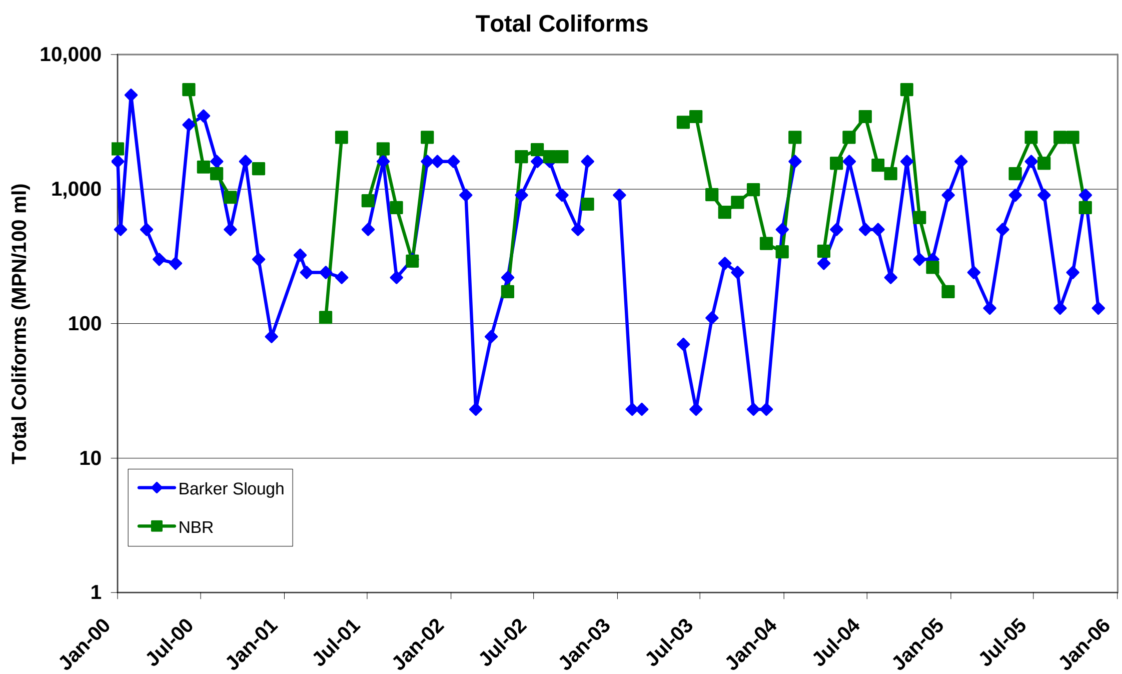
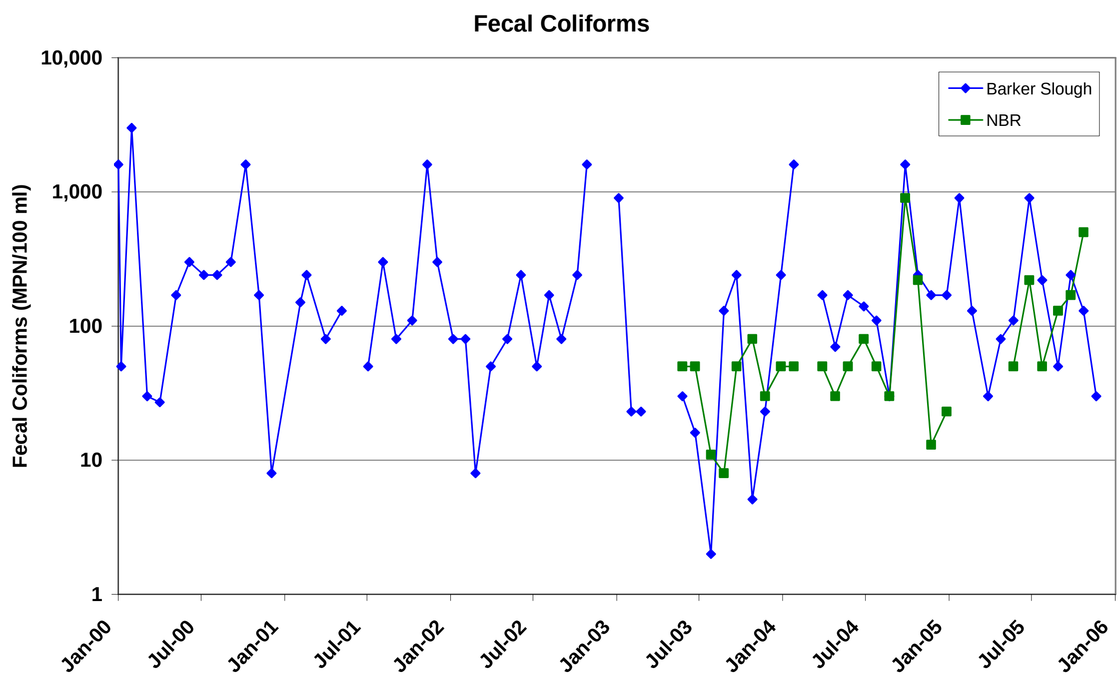


Figure 3-116. Coliforms in the NBA at Barker Slough Pumping Plant and the North Bay Regional WTP Intake





South Bay Aqueduct

Three water agencies have contracts with DWR to receive water from the SBA: Zone 7 Water Agency, ACWD, and SCVWD. Together, the SBA Contractors provide treated drinking water to nearly two million people in the San Francisco Bay Area. Zone 7 Water Agency provides drinking water from two water treatment plants (12-mgd Patterson Pass and 36-mgd Del Valle) to four retailer water systems in the Livermore Valley. Zone 7 Water Agency also provides drinking water to 13 direct users, including a local vineyard, hospital, and park. The Patterson Pass WTP intake is upstream of the point where Lake Del Valle enters the SBA so it treats 100 percent SBA water, whereas the Del Valle WTP treats varying blends of SBA and Del Valle water. ACWD provides drinking water to customers in Fremont, Newark, and Union City. ACWD operates two surface water treatment plants, the 8.5-mgd Mission San Jose and 21-mgd WTP-2. The intakes to these two WTPs are next to each other and downstream of the point where Lake Del Valle enters the SBA so they treat varying blends of SBA and Del Valle water. SCVWD provides treated water from the 40-mgd Penitencia, 80-mgd Rinconada, and 100-mgd Santa Teresa WTPs to seven retailers in Santa Clara County. The Penitencia WTP primarily treats varying blends of SBA and Lake Del Valle water but at times water from San Luis Reservoir and Anderson Reservoir (a local SCVWD reservoir) are treated at the Penitencia WTP. Since the SBA is an enclosed pipeline after water from Lake Del Valle enters it, the microbial quality of Del Valle, Mission San Jose, WTP-2, and Penitencia WTPs should be similar.

Protozoans

The SBA contractors have collected a large number of *Giardia* and *Cryptosporidium* samples, as shown in **Table 3-8**. *Cryptosporidium* has never been detected and *Giardia* was detected at 0.1 cyst/L in only one sample collected at the intake of the Penitencia WTP in August 2000. During 2003 and 2004, the SBA Contractors conducted a joint Method 1623 *Cryptosporidium* monitoring program with one sample collected at ACWD WTP-2 intake and the remaining samples collected at the Penitencia WTP intake. While limited monitoring with Method 1623 has been conducted at ACWD, ICR monitoring conducted between October 1997 and September 1998 at WTP-2 did not detect either organism.

Table 3-8. SBA *Giardia* and *Cryptosporidium* Data

WTP	Monitoring Period	No. of Samples	No. of *Crypto* Detects	No. of *Giardia* Detects	*E. coli* Range (MPN/100 ml)	Turbidity Range (NTU)
Patterson Pass	6/01 – 11/05	32	0	0	0 – 48[a]	0.7 - 16
Del Valle	6/01 – 9/03	8	0	0	Not sampled	2.9 – 19.9
Penitencia	1/00 – 12/05	54	0	1	2-300[b]	1.6 - 22

[a] During LT2ESWTR monitoring period (12/03 – 11/05).
[b] During LT2ESWTR monitoring period (1/03 – 12/04).

The LT2ESWTR allows water suppliers to "grandfather" data collected prior to promulgation of the rule as long as the monitoring was conducted as prescribed by the rule. The SBA contractors decided to grandfather their coordinated monitoring data set. SCVWD submitted their data in May 2006 and has received an unofficial notification that their source waters are classified as Bin 1. Zone 7 Water Agency and ACWD submitted data on the Patterson Pass, Del Valle, and Penitencia WTPs to CDHS in June 2006. In August, CDHS notified them that they had accepted the grandfathered data and determined that the SBA and Del Valle source waters were placed in the Bin 1 classification.

Indicator Organisms

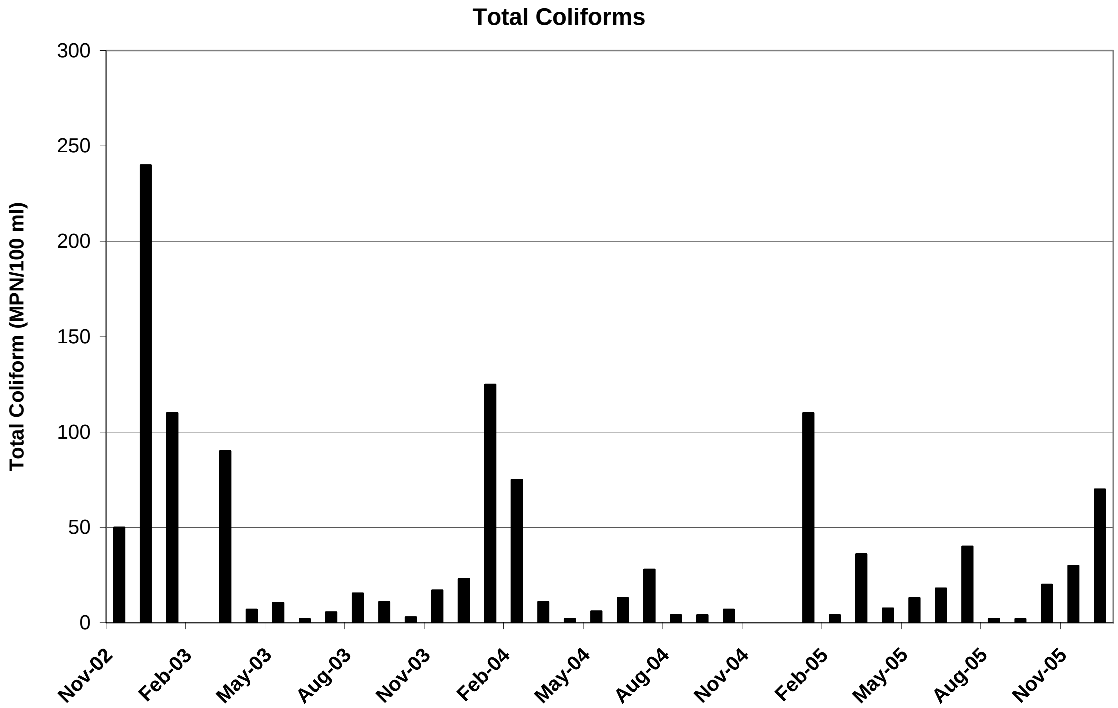
Coliform data were available for varying periods of time for each of the treatment plants that treats water from the SBA. The monthly median total coliform and *E. coli* densities are presented in **Figures 3-117 to 3-120**. The total coliform medians for the Patterson Pass and Del Valle WTPs are generally less than 100 MPN/100 ml. The monthly medians for WTP-2 exceed 1,000 MPN/100 ml in many months and occasionally exceed 10,000 MPN/100 ml. The Penitencia WTP is downstream of WTP-2 and has slightly higher monthly medians (generally less than 200 MPN/100 ml) than Patterson Pass and Del Valle WTPs but much lower than WTP-2). ACWD uses the Colilert Quantitray method, whereas the other agencies use the multiple tube fermentation method for enumerating total coliforms. The SBA Contractors conducted a coordinated study of coliform monitoring methods in 2002. Comparison of data using Colilert and membrane filtration methods showed that the Colilert method gives higher total coliform results than membrane filtration. The multiple tube fermentation method yielded results similar to membrane filtration.

The *E. coli* monthly medians were generally less than 50 at the Patterson Pass and Del Valle WTPs, less than 150 at WTP-2, and less than 100 at Penitencia WTP. Although the total coliform monthly medians at WTP-2 are an order of magnitude higher than those found at the other intakes on the SBA, the *E. coli* monthly medians are only slightly higher. The monthly *E. coli* median never exceeded 200 MPN/100 ml at the Patterson Pass, Del Valle, and Penitencia WTP intakes and only exceeded 200 MPN/100 ml in one month (December 2002) at the WTP-2 intake.

Evaluation of Pathogen Reduction/Inactivation Requirements

The monthly median total coliform and *E. coli* data and the protozoan monitoring conducted to comply with the LT2ESWTR indicate that 2-log *Cryptosporidium*, 3-log *Giardia*, and 4-log virus removal is appropriate for the Patterson Pass, Del Valle, and Penitencia WTPs. Although the monthly median total coliform densities exceed 1,000 MPN/100 ml at the intakes for the Mission San Jose WTP and WTP-2, the *E. coli* monthly medians were below 200 MPN/100 ml except for one month in the six years evaluated for this project; these samples were analyzed with the Colilert method, which yields higher results than the methods used at the other plants. This indicates that 3-log *Giardia* and 4-log virus removal are appropriate. CDHS has determined that 2-log removal of *Cryptosporidium* is appropriate for all WTPs treating SBA water based on the LT2ESWTR monitoring conducted at the Patterson Pass and Penitencia WTP intakes.

Figure 3-117. Monthly Median Coliforms in the SBA at Patterson Pass WTP Intake



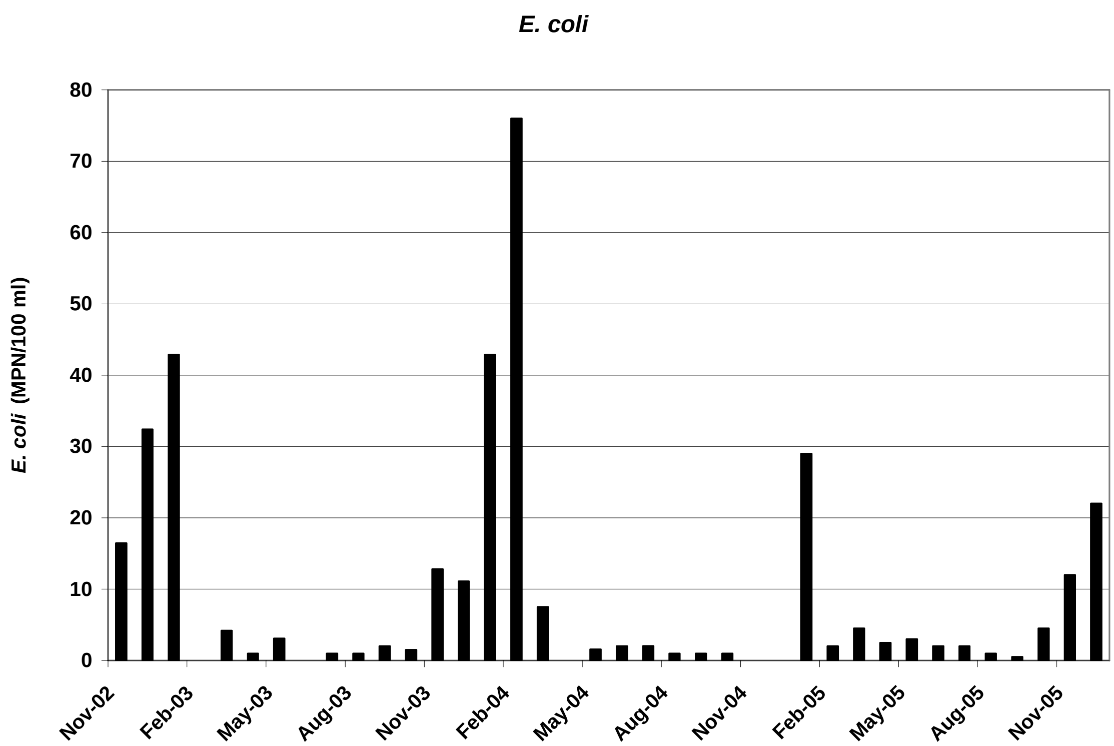
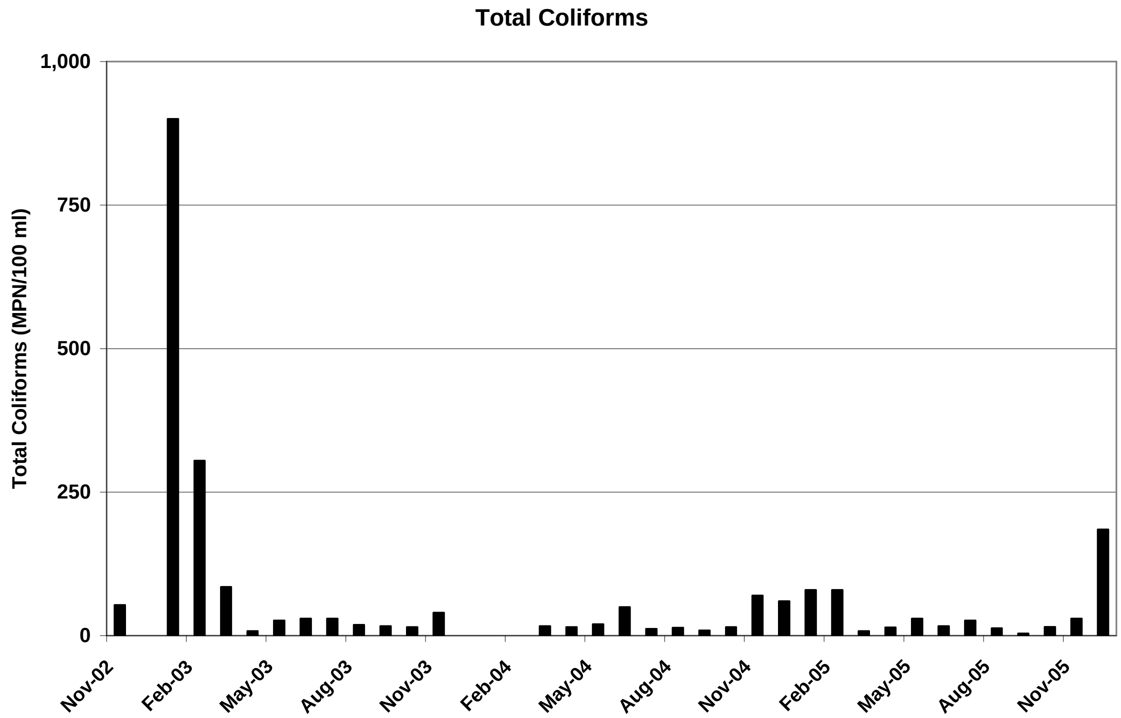


Figure 3-118. Monthly Median Coliforms in the SBA at Del Valle WTP Intake



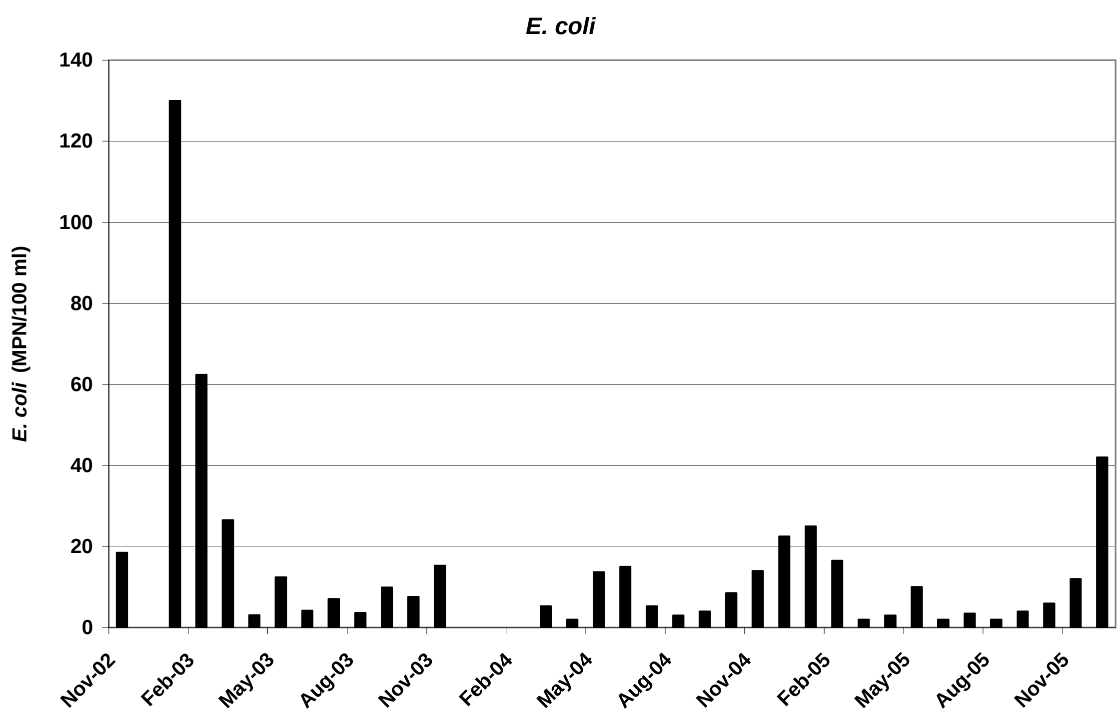
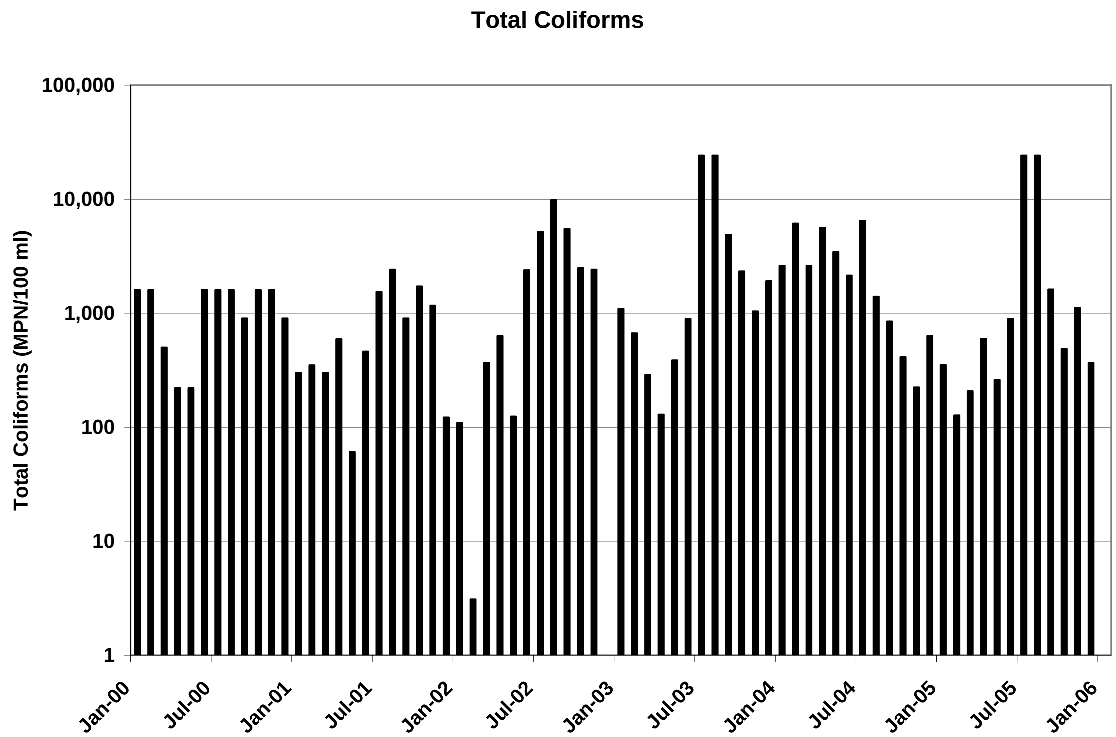


Figure 3-119. Monthly Median Coliforms in the SBA at WTP-2 Intake



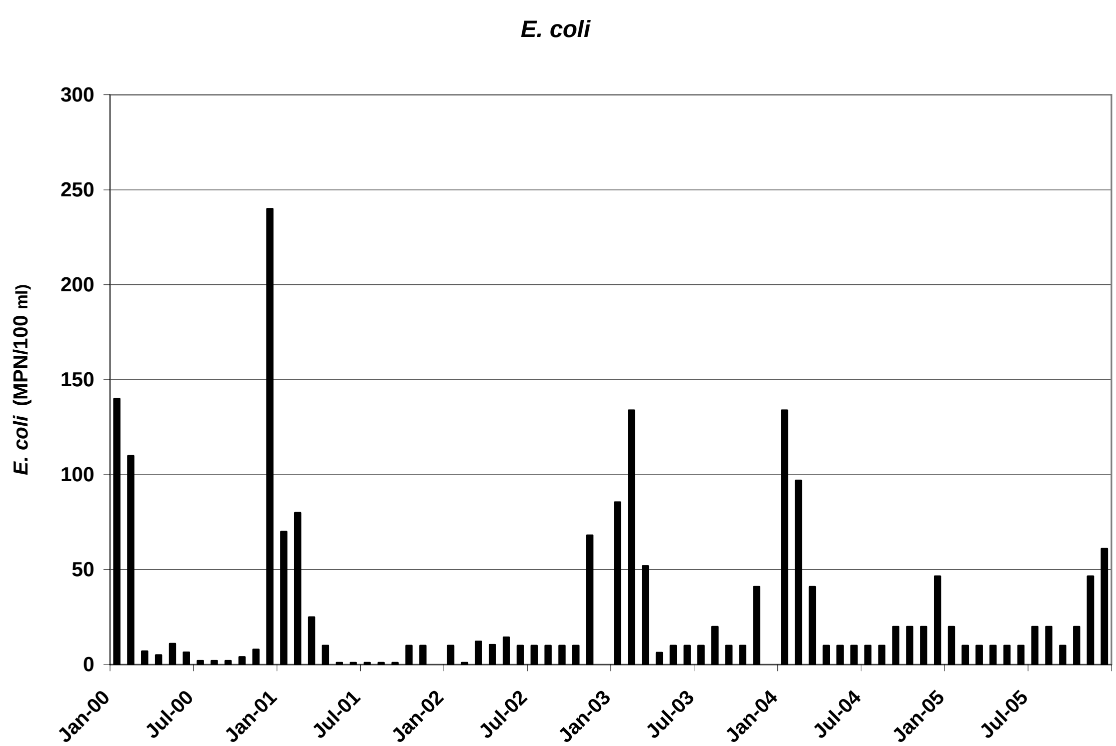
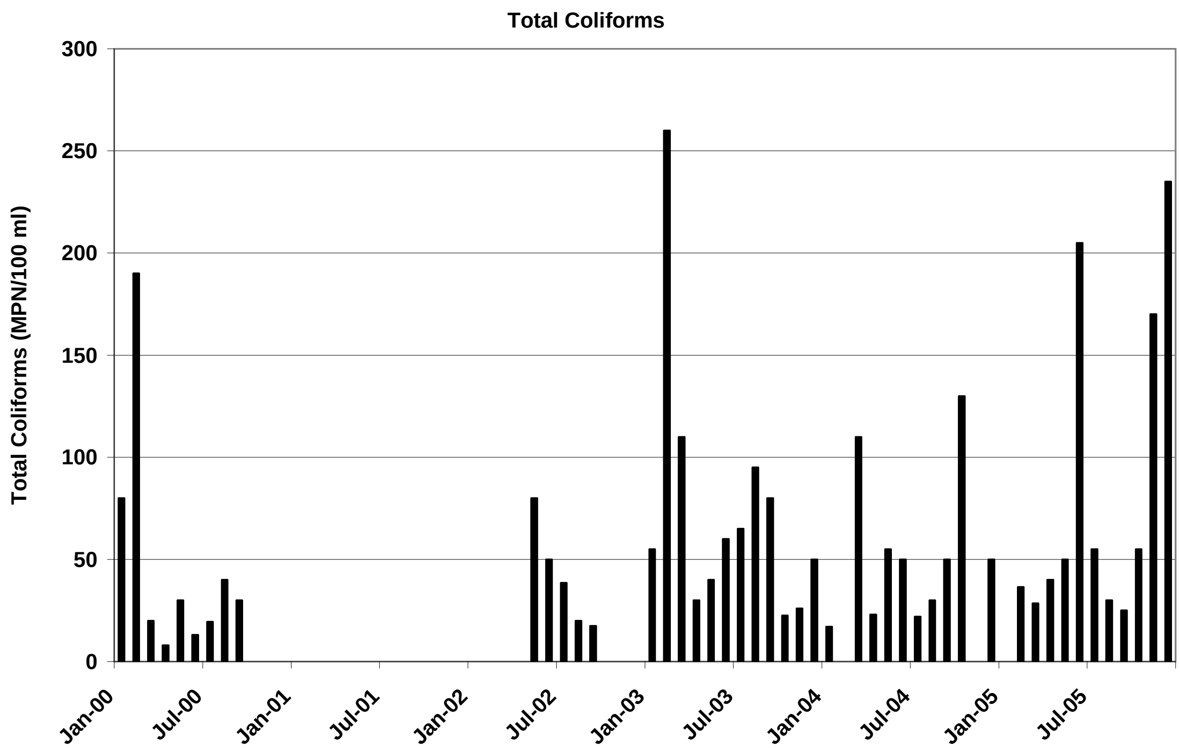
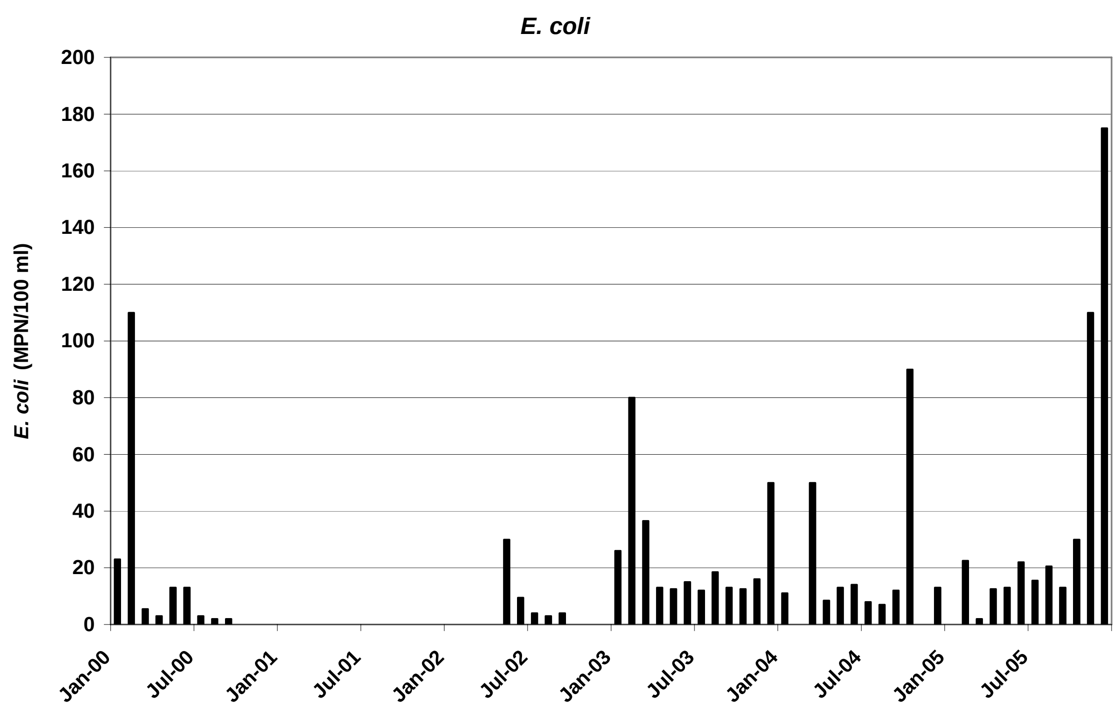


Figure 3-120. Monthly Median Coliforms in the SBA at Penitencia WTP Intake





San Luis Reservoir

SCVWD is the only Contractor who diverts municipal and industrial (M&I) water from San Luis Reservoir. Water is diverted from the western side of the reservoir at the Pacheco Pumping Plant and flows through the Santa Clara Tunnel to SCVWD's service area. Although San Luis water can be treated at all of SCVWD's WTPs, the Santa Teresa WTP treats primarily San Luis water.

DWR operates a small WTP at the San Luis O&M Center. This WTP treats 6.7 million gallons per year and provides water for DWR employees. The WTP draws water from penstocks 1 and 4 of the Gianelli Pumping Generating Plant. When water is being pumped from O'Neill Forebay into San Luis Reservoir, the source of water to the WTP is O'Neill Forebay. When power is being generated, the source of water is San Luis Reservoir.

Protozoans

SCVWD has monitored for *Giardia* and *Cryptosporidium* since January 2000 at the intake of the Santa Teresa WTP. Samples are collected once or twice a month and as of December 2005, 98 samples had been analyzed. *Cryptosporidium* was not detected and *Giardia* was found at 0.1 cysts/L in only one sample collected on June 14, 2005. SCVWD decided to grandfather their data and submitted it to CDHS in May 2006. They have received an unofficial notification that their source waters are classified as Bin 1.

DWR has not collected pathogen data at the intake of their WTP.

Indicator Organisms

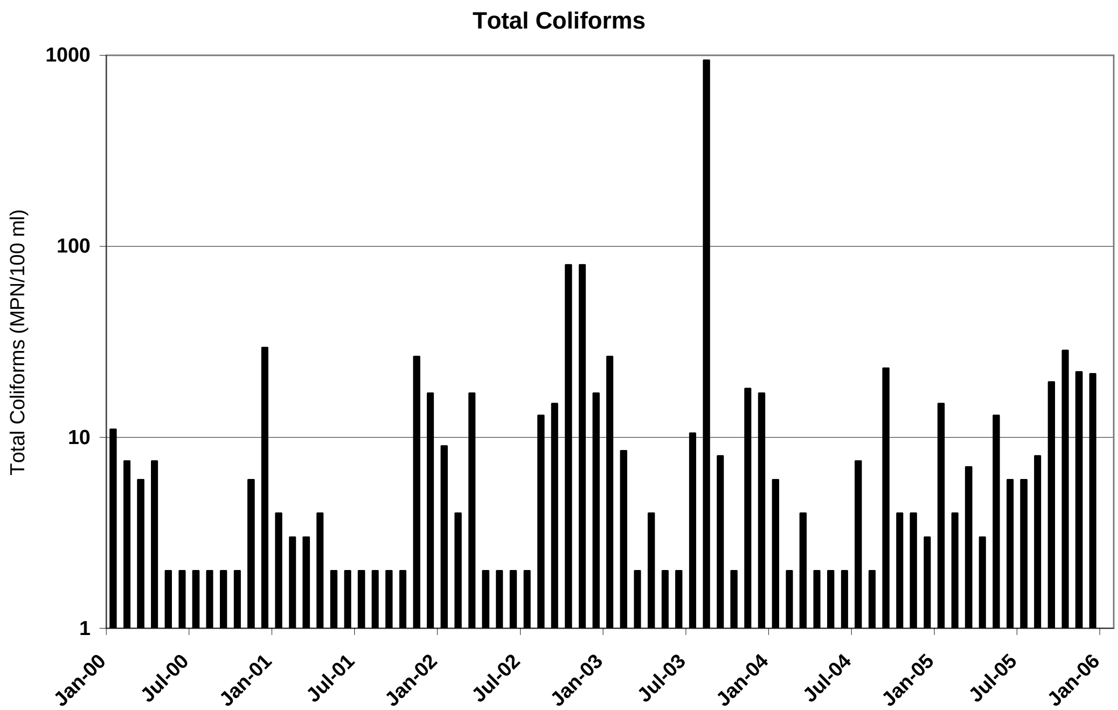
Water pumped from San Luis Reservoir at Pacheco has low levels of coliform bacteria, as demonstrated by **Figure 3-121.** Total coliform monthly medians were consistently less than 100 MPN/100 ml with the exception of August 2003. The *E. coli* monthly medians were always less than 20 and generally less than 2 MPN/100 ml.

Figure 3-122 presents the coliform data for the DWR WTP. Since only one sample is collected each month, monthly medians could not be calculated. Both total and fecal coliform levels were low until 2005. In May and June 2006, both total and fecal coliforms were reported as greater than 1,600 MPN/100 ml. From September 2005 to April 2006 both total and fecal coliforms were reported as greater than 23 MPN/100 ml so it is not clear when the higher levels of coliforms first appeared at the WTP intake. Due to the complex operations of O'Neill Forebay and San Luis Reservoir, it is difficult to determine the source of the higher coliforms; however, water is normally being released from San Luis Reservoir during the summer months when the highest coliform levels were reported.

Evaluation of Pathogen Reduction/Inactivation Requirements

The pathogen and indicator organism data demonstrate that 2-log removal of *Cryptosporidium*, 3-log removal of *Giardia* and 4-log removal of viruses are appropriate for the Santa Teresa WTP.

Figure 3-121. Monthly Median Coliforms in San Luis Reservoir Water at Santa Teresa WTP Intake



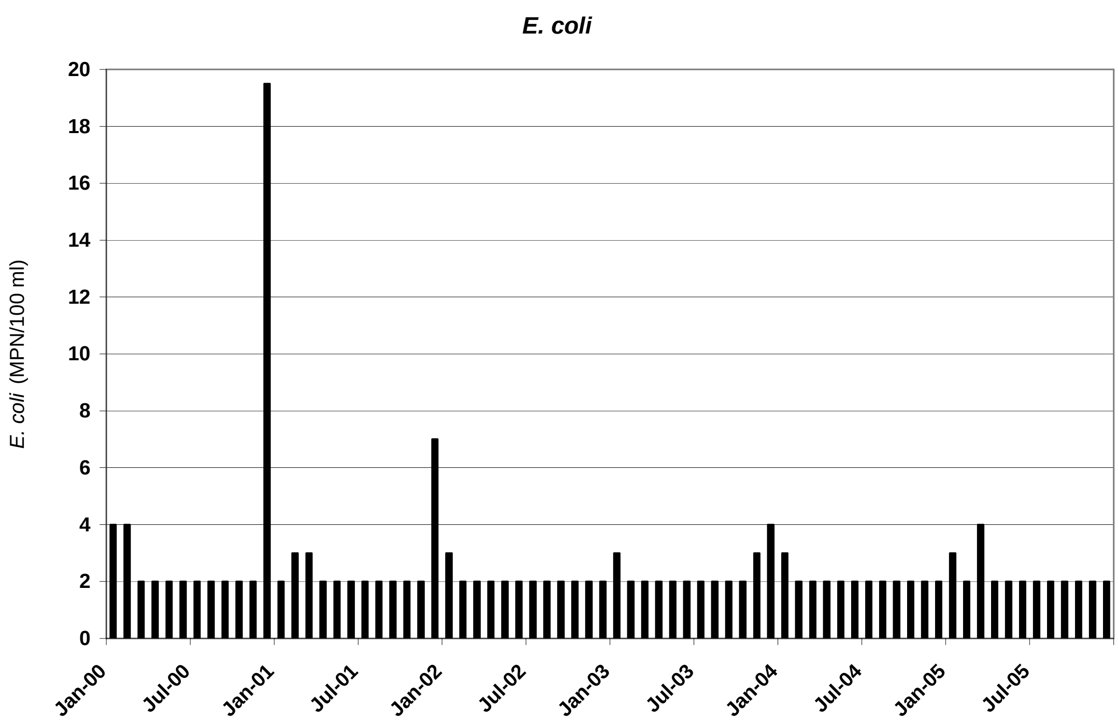
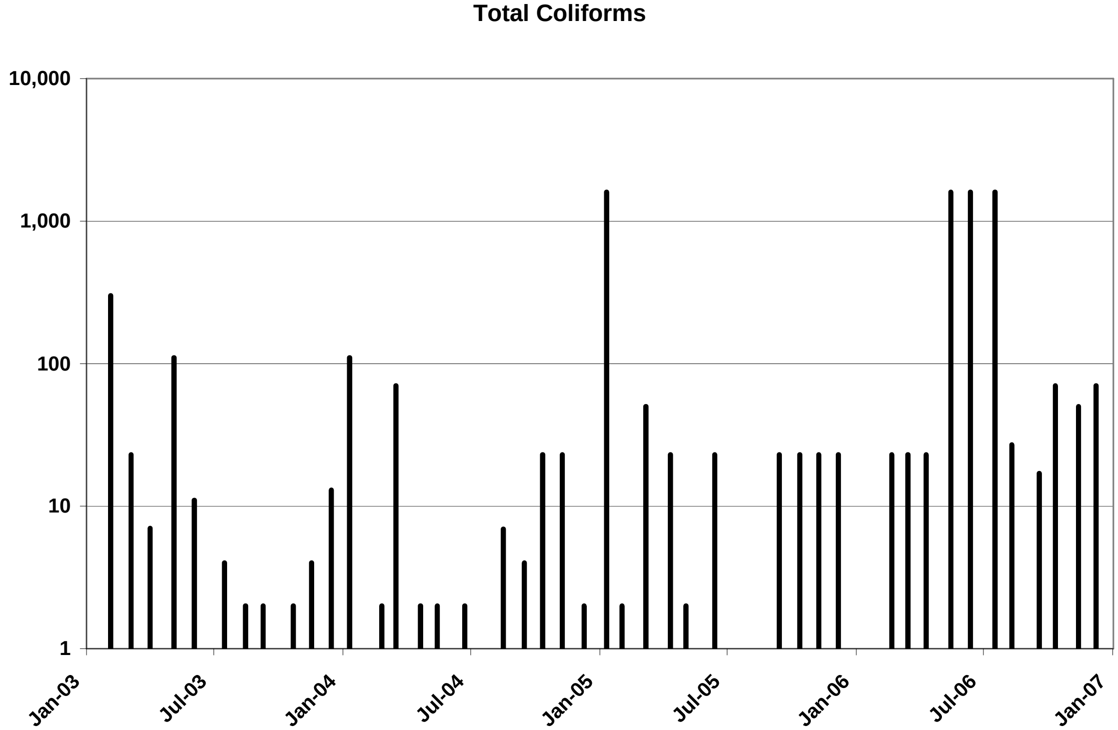
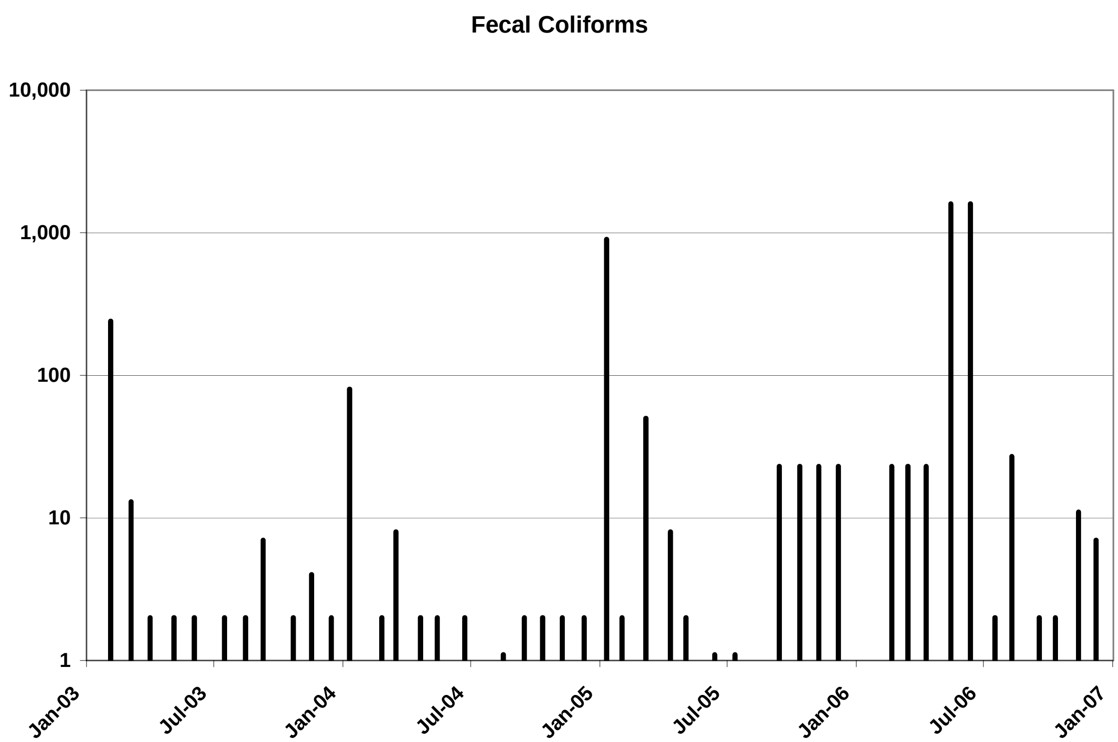


Figure 3-122. Coliforms at DWR San Luis O&M Center WTP Intake





California Aqueduct, San Luis Canal (Check 13 to Check 21)

The small cities of Coalinga, Huron, and Avenal divert water from the San Luis Canal portion of the California Aqueduct. They are federal CVP Contractors; therefore, an evaluation of source water quality in this portion of the aqueduct is not included in this report.

Coastal Branch of the California Aqueduct

CCWA treats water at the 42-mgd Polonio Pass WTP. Treated water is delivered via pipeline from Polonio Pass WTP to a number of communities in San Luis Obispo and Santa Barbara counties. The source water quality data evaluated in this chapter is applicable to all of the communities that receive the treated water.

Protozoans

CCWA has collected samples approximately quarterly since February 2003 and had them analyzed by Biovir for *Giardia* and *Cryptosporidium*. *Cryptosporidium* has never been detected and *Giardia* was found in only one sample, collected on February 6, 2003 at 0.6 cysts/L. CCWA started the monthly LT2ESWTR monitoring in April 2007.

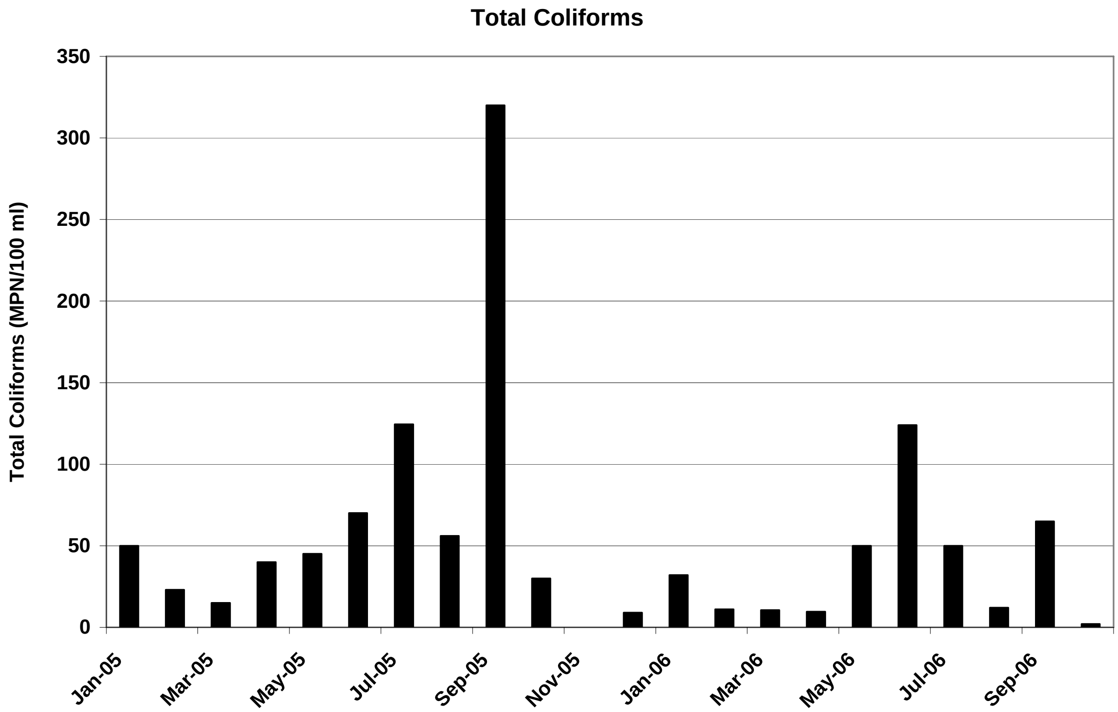
Indicator Organisms

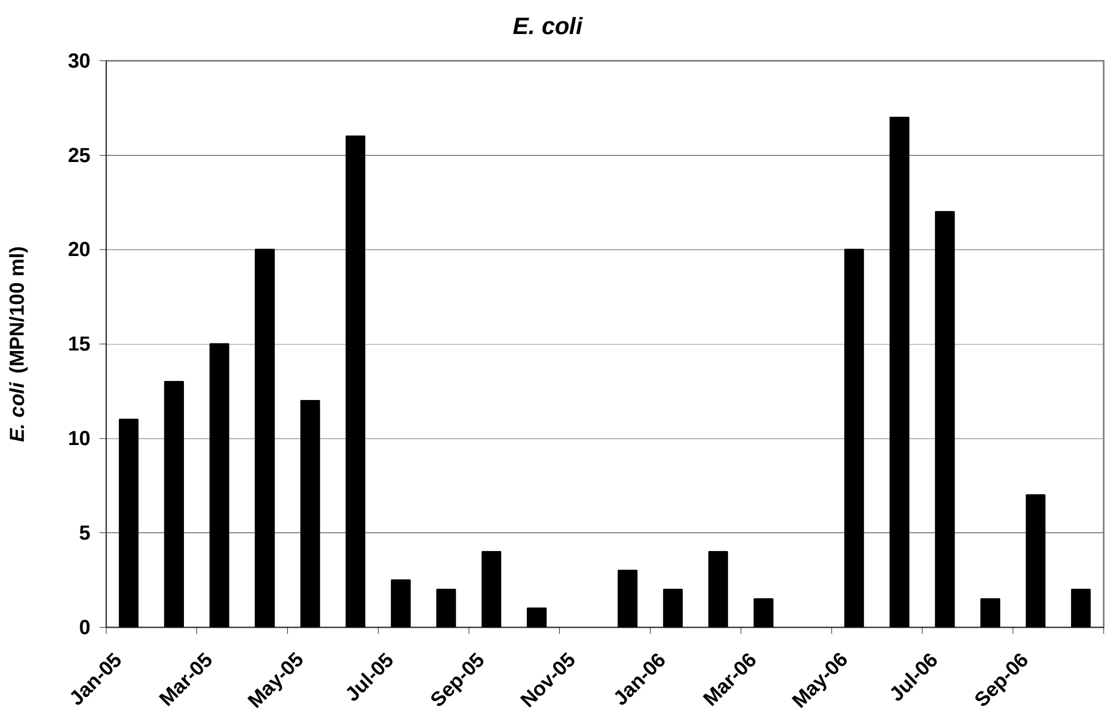
CCWA provided weekly coliform data from January 2005 through October 2006 from the intake to the Polonio Pass WTP. As shown in **Figure 3-123**, the monthly median total coliform levels are always less than 350 MPN/100 ml and generally below 100 MPN/100 ml. The monthly median *E. coli* levels are always less than 25 MPN/100 ml.

Evaluation of Pathogen Reduction/Inactivation Requirements

CCWA initiated LT2ESWTR monitoring in April 2007. The protozoan data that have been collected to date indicate that the Polonio Pass WTP will likely be in Bin 1 and no additional removal will be required. The coliform data indicate that 3-log removal of *Giardia* and 4-log removal of viruses are appropriate for the Polonio Pass WTP.

Figure 3-123. Monthly Median Coliforms in the Coastal Branch at Polonio Pass WTP Intake





California Aqueduct, San Joaquin Field Division (Check 21 to Check 39)

KCWA is the only SWP Contractor who diverts municipal and industrial (M&I) water from this reach of the California Aqueduct. Water is diverted from the aqueduct and conveyed in the 22-mile-long Cross Valley Canal to the 38-mgd Henry C. Garnett Water Purification Plant. Treated water is sold to several retail agencies that provide drinking water for the metropolitan Bakersfield area. SWP water is exchanged whenever possible for Kern River water due to the higher quality of the Kern River. Therefore, Kern River water is used more frequently than SWP water as the source water for the Henry C. Garnett Water Purification Plant.

Protozoans

The SWP water is monitored infrequently because it is rarely used as a source of drinking water by KCWA. Six samples were collected and analyzed for *Giardia* and *Cryptosporidium* between September 2001 and March 2004. These samples were collected from the California Aqueduct at milepost 236.47, approximately 1.5 miles upstream of the Cross Valley Canal turnout. Neither of these pathogens was detected in any of the samples. KCWA initiated LT2ESWTR monitoring in October 2006.

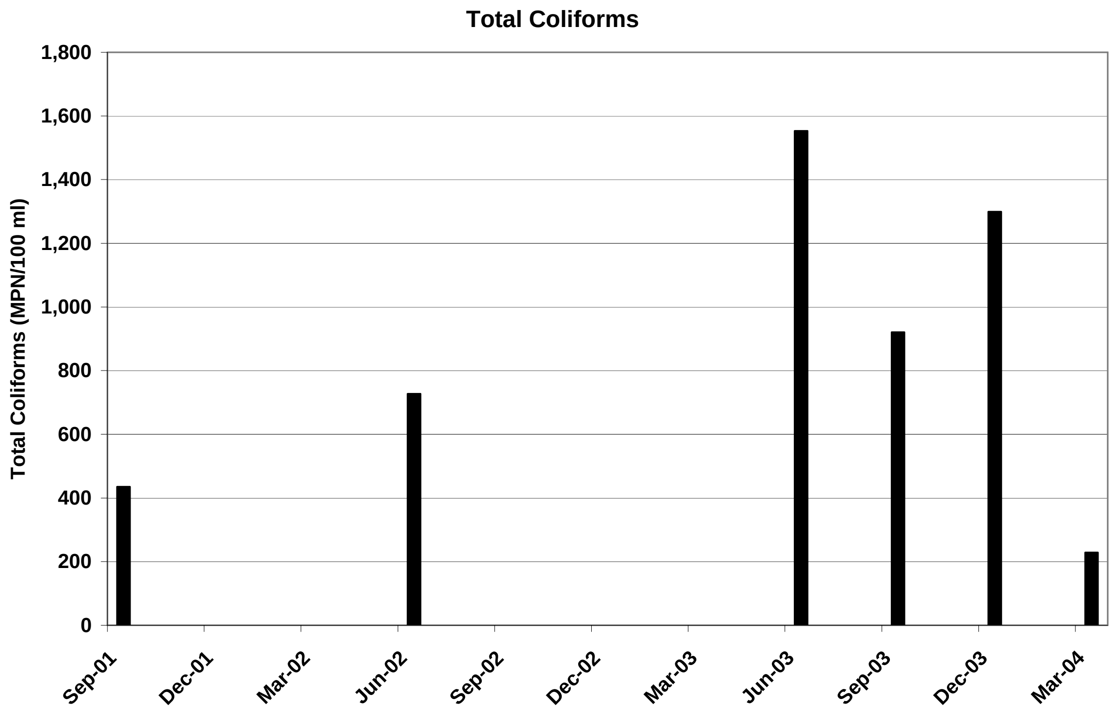
Indicator Organisms

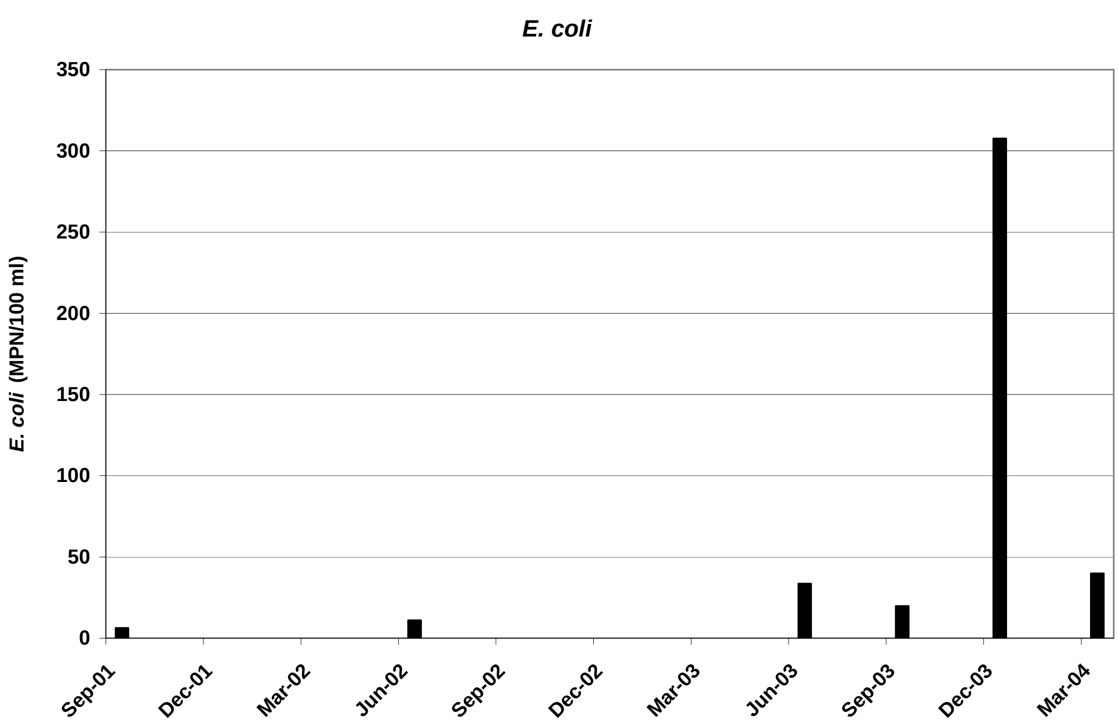
Total coliforms and *E. coli* were analyzed on the same six dates that pathogen data were collected. These data are shown in **Figure 3-124**. With such limited data, it is not possible to draw any conclusions about the bacterial quality of this reach of the Aqueduct.

Evaluation of Pathogen Reduction/Inactivation Requirements

Since the Kern River is the primary source of water for the Henry C. Garnett Water Purification Plant, log removals are based primarily on Kern River water quality rather than the microbial quality of the California Aqueduct.

Figure 3-124. Coliforms in the California Aqueduct near the KCWA Turnout





West Branch of the California Aqueduct

MWDSC and CLWA take water from Castaic Lake on the West Branch. MWDSC is a consortium of 26 member agencies that provides drinking water to communities in Los Angeles, Orange, San Diego, Riverside, San Bernardino, and Ventura counties. Water is diverted from Castaic Lake and travels through the Foothill Feeder to the 750-mgd Joseph Jensen (Jensen) WTP, which serves the San Fernando Valley, Ventura County, west Los Angeles, Santa Monica, and the Palos Verdes Peninsula. CLWA treats water from Castaic Lake at the 56-mgd Earl Schmidt Filtration Plant and the 30-mgd Rio Vista Treatment Plant. CLWA provides treated water to four retailers in the Santa Clarita Valley. Data from the Jensen WTP intake are evaluated in this chapter.

Protozoans

MWDSC has collected monthly samples for *Giardia* and *Cryptosporidium* at the Jensen WTP intake since January 2000. As of December 2005, *Giardia* had not been detected and *Cryptosporidium* was detected in one sample collected in October 2000 at 0.1 oocyst/L. These data indicate that West Branch water will likely be placed in the LT2ESWTR Bin 1 classification. MWDSC does not intend to grandfather these data and initiated LT2ESWTR monitoring in October 2006. CLWA initiated monitoring in April 2007.

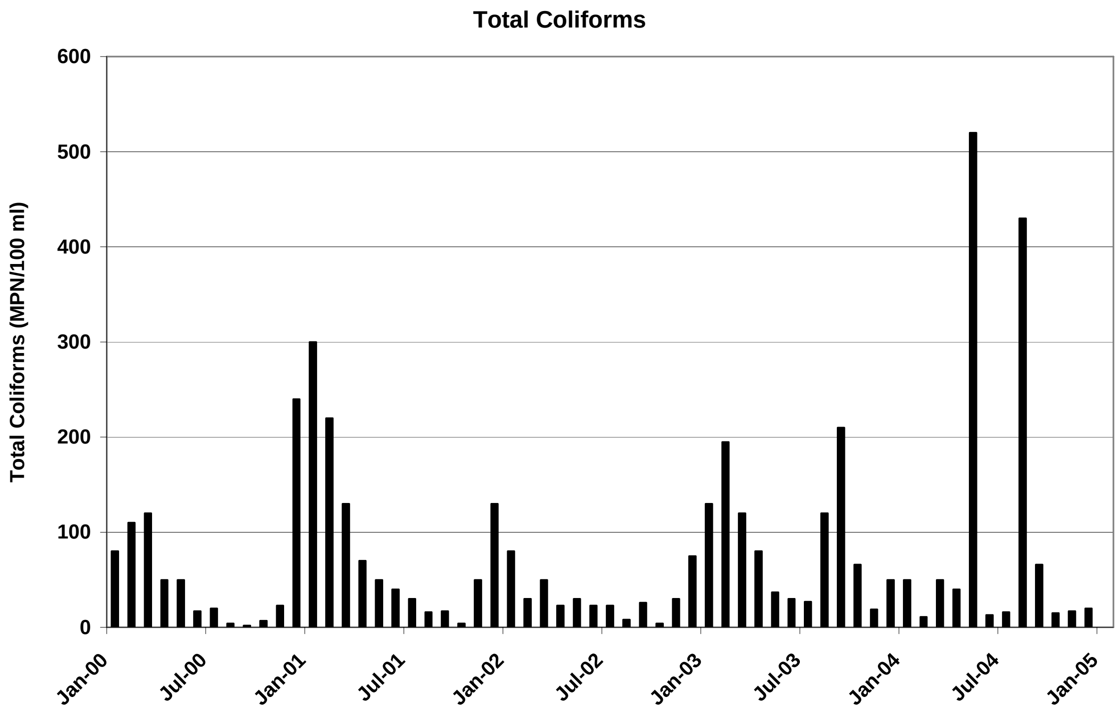
Indicator Organisms

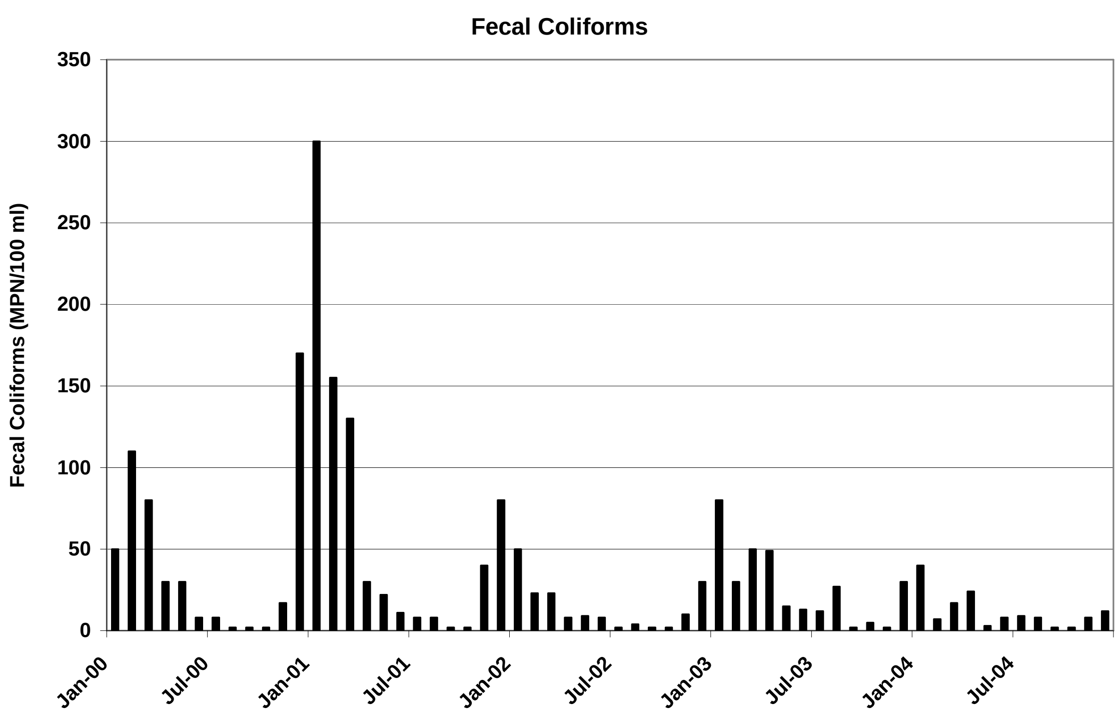
MWDSC provided indicator organism data for the period of January 2000 through December 2004. The monthly medians for total coliforms and *E. coli* are shown in **Figure 3-125.** These data indicate that median total coliform densities never exceed 1,000 MPN/100 ml and are generally below 300 MPN/100 ml. The monthly median *E. coli* densities were below 200 MPN/100 ml with the exception of January 2001. There is a distinct seasonal pattern with the highest coliform levels occurring in the winter months and lowest levels in summer and early fall months. The highest monthly total coliform medians occurred in May and August 2004. Chapter 5 contains a discussion of the potential sources of coliforms in Castaic Lake.

Evaluation of Pathogen Reduction/Inactivation Requirements

Both the indicator organism data and the five years of *Giardia* and *Cryptosporidium* data indicate that 2-log removal of *Cryptosporidium*, 3-log removal of *Giardia*, and 4-log removal of viruses are appropriate for the treatment plants treating water from the West Branch.

Figure 3-125. Monthly Median Coliforms in the West Branch at Jensen WTP





East Branch of the California Aqueduct (Check 42 to Check 66)

AVEK and Palmdale Water District (Palmdale) divert water from this reach of the East Branch and provide drinking water to customers in the Mojave Desert. AVEK diverts M&I water at four locations and treats it at the 4-mgd Acton WTP, 10-mgd Eastside WTP, 65-mgd Quartz Hill WTP, and the 14-mgd Rosamond WTP. Palmdale treats water at the 30-mgd Palmdale Water District WTP.

Protozoans

AVEK collected samples twice each month between February 2004 and February 2006 at the intakes of all four of their treatment plants. *Giardia* and *Cryptosporidium* were not detected in any of the samples. AVEK intends to grandfather these data. Palmdale conducted monitoring through March 2007. Palmdale intends to grandfather previously collected data and has submitted the data to USEPA and CDHS.

Indicator Organisms

AVEK provided coliform data from January 2000 to December 2003 at all four of their WTPs. The monthly medians for total coliforms and *E. coli* for the Quartz Hill WTP are shown on **Figure 3-125** and the data for all four WTPs are summarized in **Table 3-9**. These data indicate that the monthly median total coliform levels are well below 1,000 MPN/100 ml and the *E. coli* and fecal coliform medians are well below 200 MPN/100 ml.

Table 3-9. Summary of AVEK Coliform Data

WTP	Total Coliforms (MPN/100mL)		*E. coli* (MPN/100mL)	
	Monthly Median Range	Maximum Detected	Monthly Median Range	Maximum Detected
Acton	2 - 90	170	No data	No data
Eastside	2 - 50	300	2 - 50	170
Quartz Hill	2 – 30	240	2 – 50	30
Rosamond	2 – 105	170	2 – 19[a]	70[a]

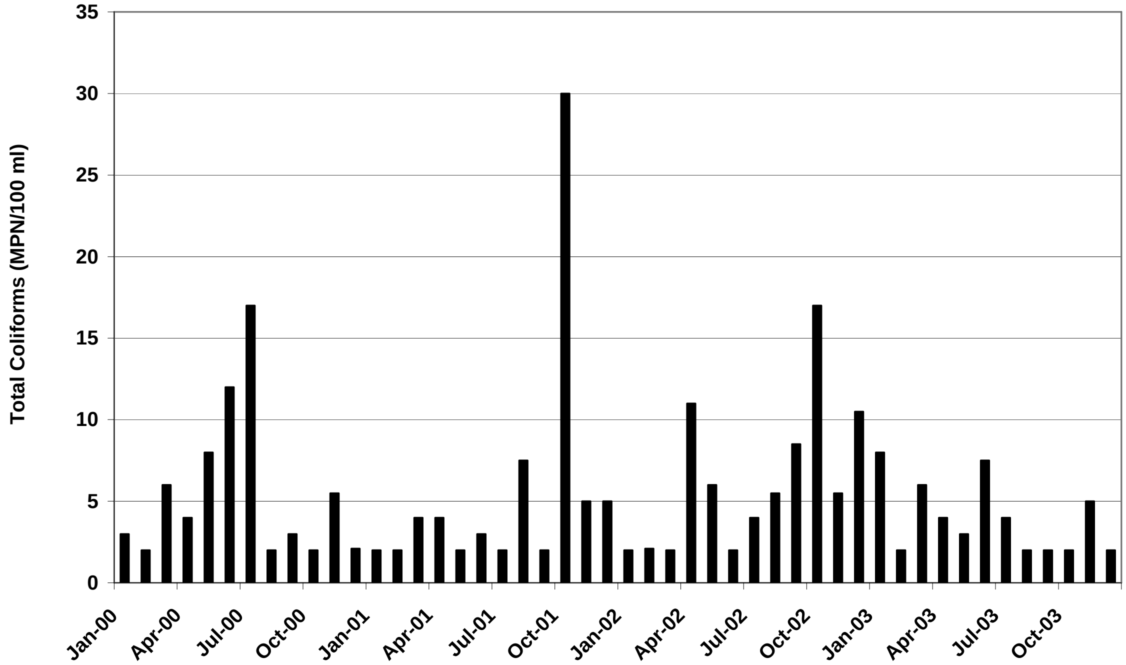
[a] Fecal coliform is measured at the Rosamond WTP.

Evaluation of Pathogen Reduction/Inactivation Requirements

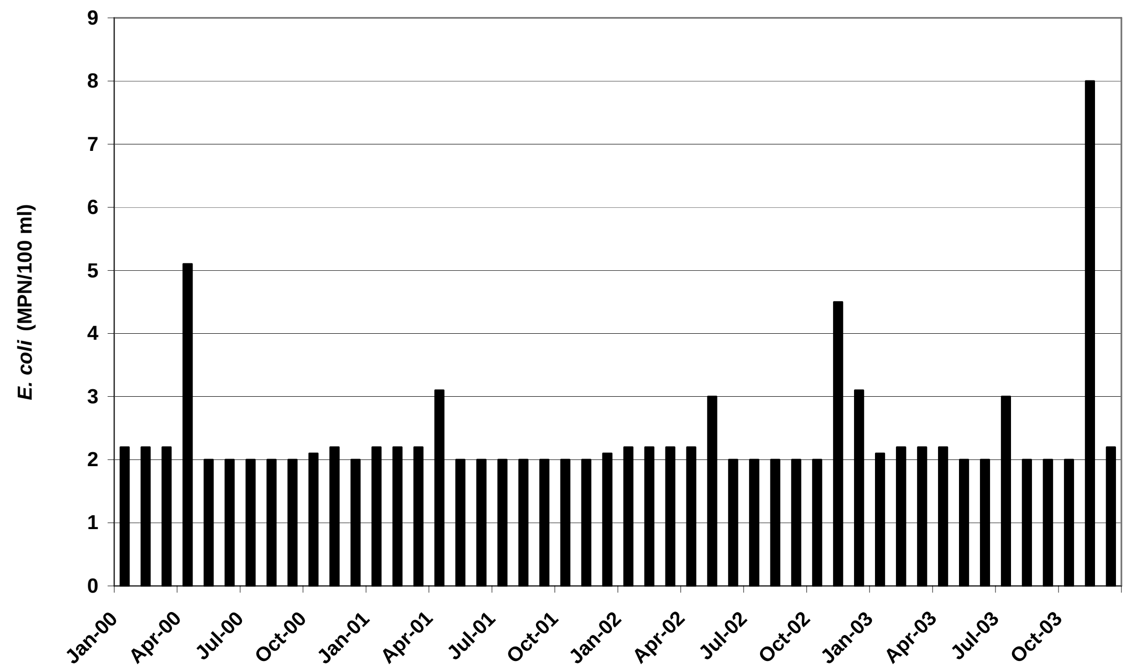
Both the indicator organism data and the two years of *Giardia* and *Cryptosporidium* data indicate that 2-log removal of *Cryptosporidium*, 3-log removal of *Giardia*, and 4-log removal of viruses are appropriate for the treatment plants treating water from this reach of the East Branch.

Figure 3-126. Monthly Median Coliforms in the East Branch at Quartz Hill WTP

Total Coliforms



E. coli



East Branch of the California Aqueduct (Silverwood Lake to Lake Perris)

MWDSC and Crestline Lake Arrowhead Water Agency (CLAWA) are the only two agencies that divert water from this reach of the East Branch for direct use. Other agencies use East Branch water for groundwater recharge. CLAWA diverts water directly from the south side of Silverwood Lake and treats it at the 3-mgd CLAWA WTP. CLAWA delivers water to wholesale and residential customers in the San Bernardino Mountains. MWDSC diverts water from Devil Canyon Afterbay, downstream of Silverwood Lake and treats it at the 326-mgd Henry J. Mills (Mills) WTP. MWDSC rarely takes water from Lake Perris due to water quality concerns. When water is taken from Lake Perris it is typically blended with Colorado River water and treated at the 520-mgd Robert A. Skinner WTP, but it can also be treated at the Mills WTP. Data from the Mills WTP intake are evaluated in this chapter.

Protozoans

MWDSC has collected monthly samples for *Giardia* and *Cryptosporidium* at the Mills WTP intake since January 2000. As of December 2005, *Giardia* had not been detected and *Cryptosporidium* was detected in two samples collected in December 2000 and November 2003. Both samples had 0.1 oocyst/L. These data indicate that this reach of the East Branch will likely be placed in the LT2ESWTR Bin 1 classification. MWDSC does not intend to grandfather these data and initiated LT2ESWTR monitoring in October 2006. CLAWA serves 35,000 people and will initiate monitoring in April 2008 to comply with the LT2ESWTR.

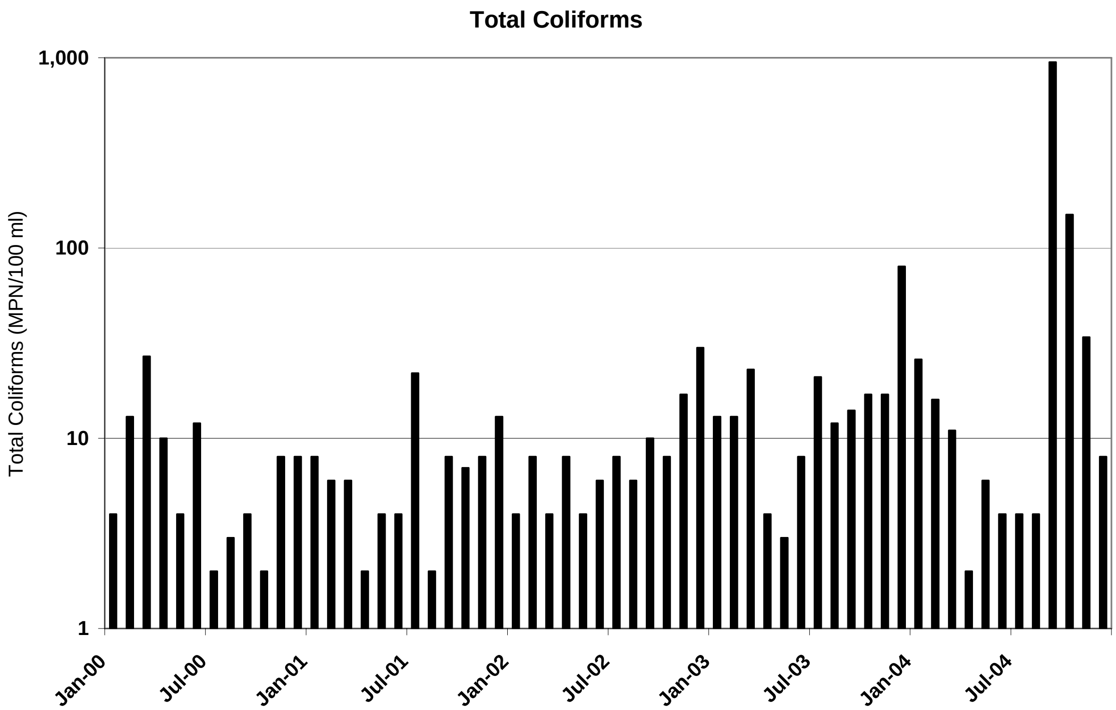
Indicator Organisms

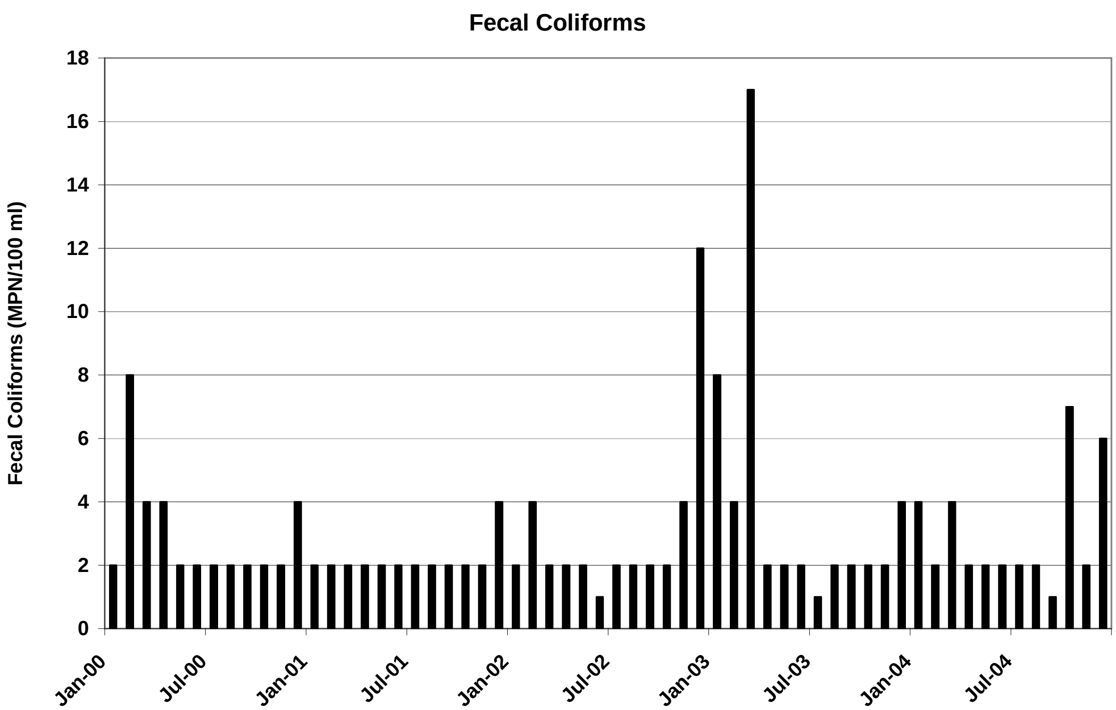
MWDSC provided indicator organism data for the period of January 2000 through December 2004. The monthly medians for total coliforms and *E. coli* are shown in **Figure 3-127**. These data indicate that median total coliform densities never exceed 1,000 MPN/100 ml and are generally below 20 MPN/100 ml (note that the total coliform data are plotted on a log scale due to the wide range in the data). The highest monthly median of 950 MPN/100 ml occurred in September 2004. The monthly median *E. coli* densities were consistently below 20 MPN/100 ml and most were less than 2 MPN/100 ml.

Evaluation of Pathogen Reduction/Inactivation Requirements

Both the indicator organism data and the five years of *Giardia* and *Cryptosporidium* data indicate that 2-log removal of *Cryptosporidium*, 3-log removal of *Giardia*, and 4-log removal of viruses are appropriate for the treatment plants treating water from this reach of the East Branch.

Figure 3-127. Monthly Median Coliforms in the East Branch at Mills WTP





Summary

- The NBA Contractors and DWR initiated LT2ESWTR monitoring in October 2006. Historic protozoan and coliform data indicate that Barker Slough has the highest levels of microbial contaminants in the SWP system, possibly due to the extensive cattle grazing in the watershed. The NBA Contractors have installed fencing along Barker Slough to restrict animal access and are currently evaluating the water quality impacts. The LT2ESWTR monitoring will provide additional data to determine if the current 2-log *Cryptosporidium*, 3-log *Giardia*, and 4-log virus removal requirements are adequate for the WTPs that treat NBA water.

- The SBA Contractors have completed the LT2ESWTR monitoring and CDHS has determined that 2-log removal of *Cryptosporidium* is appropriate for all WTPs treating SBA water. The monthly median total coliform and *E. coli* data indicate that 3-log *Giardia*, and 4-log virus removal is the appropriate level of treatment.

- SCVWD has completed the LT2ESWTR monitoring for the Santa Teresa WTP, which receives water from San Luis Reservoir. CDHS has provided unofficial notification that this source will be classified as Bin 1. The consistently low levels of total coliform and *E. coli* indicate that 3-log *Giardia*, and 4-log virus removal is the appropriate level of treatment.

- CCWA started LT2ESWTR monitoring in October 2006. The protozoan data that have been collected to date indicate that the Polonio Pass WTP will likely be in Bin 1 and no additional removal will be required. The coliform data indicate that 3-log removal of *Giardia* and 4-log removal of viruses are appropriate for the Polonio Pass WTP.

- There are limited data on the microbial quality of the California Aqueduct between San Luis Reservoir and the bifurcation of the aqueduct.

- MWDSC and CLWA have initiated LT2ESWTR monitoring. The historic coliform and protozoan data indicate that 3-log removal of *Giardia* and 4-log removal of viruses are appropriate for the treatment plants treating water from the West Branch. These plants will likely be placed in Bin 1 after LT2ESWTR monitoring is completed.

- AVEK and Palmdale have completed the LT2ESWTR monitoring and have submitted their data to CDHS. MWDSC initiated monitoring in October 2006 and CLAWA will start monitoring in April 2008. The historic coliform and protozoan data indicate that 3-log removal of *Giardia* and 4-log removal of viruses are appropriate for the treatment plants treating water from the East Branch. The LT2ESWTR monitoring data collected by AVEK indicates the East Branch will likely be placed in Bin 1.

POTENTIAL ACTIONS – CONTINUING WATER QUALITY CONCERNS

The SWP Contractors Should Support Development and Implementation of DWR's Comprehensive Plan

There is a great deal of water quality data on the Sacramento and San Joaquin rivers, the Delta, and the SWP system. Most of the locations have been monitored weekly to monthly since 1998. In recent years, real-time monitoring has provided valuable information on fluctuations in water quality that occur on hourly and daily time scales at a number of locations. The DSM2 Model has been extended to include the California Aqueduct, SBA, and DMC. When fully operational, this model will be used to model the impacts of operations on water quality and to forecast organic carbon, bromide, and salinity conditions along the SWP. This will require continuous monitoring at many points in the system.

DWR and the SWP Contractors have worked together to create the Real Time Data and Forecasting project to:

- Review existing DWR water quality monitoring programs on an ongoing basis.
- Identify the need for new monitoring activities, particularly real-time data collection, to enhance the ability to rapidly detect and react to water quality events, and to forecast water quality conditions in the SWP.
- Coordinate monitoring, assessment, and forecasting activities between DWR and SWP Contractors, and within various DWR units.
- Provide resources to implement necessary improvements to monitoring programs.
- Provide continuing oversight and coordination for monitoring, assessment, and forecasting activities.

The SWP Contractors have invited DWR management to work together to develop and implement a comprehensive plan to accomplish these objectives. DWR management is currently actively working on a proposal. A funding and staff augmentation proposal is presently in the approval process to enable the early stages of the project to be undertaken. This effort will be successful if the individual SWP Contractors are actively involved, and if the project enjoys the full support of DWR management and the managements of the participating SWP Contractors.

DECREASING CONCERNS – MTBE

MTBE was first used in gasoline in 1979 as an octane enhancer resulting from the phase-out of leaded gasoline. As a result of the Clean Air Act Amendments of 1990, the use of reformulated gasoline is required in California to meet carbon monoxide and ozone air quality standards. One of the requirements for reformulated gasoline is that it contains 2 percent oxygen by weight (11 percent by volume). Starting in the mid-1990s, MTBE was used as an oxygenate in almost all reformulated gasoline in California, prior to the discovery that MTBE had contaminated groundwater supplies and was also found in surface water supplies. MTBE was banned in California as of December 31, 2003, although the concentration of MTBE in gasoline blends was voluntarily reduced starting in January 2003. MTBE has subsequently been replaced by ethanol. While the primary source of MTBE in groundwater supplies was leaking underground storage tanks and pipelines, the primary source in surface water sources was recreational boating. Two-stroke engines used on jet skis and many outboard motors discharge up to 25 percent of fuel/oil mixture into surface waters. Although many groundwater supplies remain contaminated with this highly soluble chemical, contamination of surface water supplies is no longer a problem.

MTBE is considered to be an animal carcinogen with the potential to cause cancer in humans. In addition, it imparts a turpentine-like taste and odor at low concentrations, rendering drinking water unpalatable. The Office of Environmental Health Hazard Assessment established a public health goal (PHG) of 13 μg/L in 1999. CDHS subsequently established a primary MCL of 13 μg/L and a secondary MCL of 5 μg/L.

MTBE IN SWP FACILITIES

MTBE monitoring has been conducted by DWR's SWP WQMP throughout the SWP and by MWDSC in the southern California reservoirs. DWR is continuing to monitor MTBE at a number of locations in the SWP.

DWR 1997 Reservoir Study

DWR conducted a study of MTBE on eight of the SWP reservoirs, one forebay, and one afterbay during the summer of 1997. Samples were collected around the Memorial Day, Fourth of July, and Labor Day weekends from Lake Davis, Lake Oroville, Thermalito Afterbay, Lake Del Valle, San Luis Reservoir, O'Neill Forebay, Pyramid Lake, Castaic Lake, Silverwood Lake, and Lake Perris. The key findings from the DWR monitoring program were:

- A large percentage of samples collected from the surface of the lakes had MTBE concentrations above the 1.0 μg/L reporting level.
- MTBE was detected in 76 percent of the samples (54 of 71).
- The four southern California reservoirs, Pyramid, Castaic, Silverwood, and Perris, had higher concentrations than the northern California reservoirs. MTBE was detected in 94 percent of the surface samples from the southern California reservoirs (31 of 33), with the mean concentrations ranging from 6 to 14 μg/L.

- MTBE declined with depth in the thermally stratified reservoirs.
- The highest concentrations were found near the boat launching facilities in the four southern California reservoirs. Mean concentrations ranged from 9 to 22 µg/L.

DWR Monitoring (1998 to 2005)

DWR collected samples from the source waters of the SWP and at a number of locations in the SWP between 1997 and 2005. Samples were collected at varying frequencies and for varying periods of time at different locations. **Table 3-10** present a summary of the data collected before and after the MTBE ban.

Table 3-10. MTBE Monitoring in the SWP

Location	Before MTBE Ban (1997 to 2003)			After MTBE Ban (2004 to 2005)		
	N	Median (µg/L)	Maximum (µg/L)	N	Median (µg/L)	Maximum (µg/L)
Hood	94	2.1	5	0		
Vernalis	20 7	< 1.0	2.8	0		
Barker Slough	45	< 1.0	< 1.0	23	< 1.0	< 1.0
DMC Headworks	9	4.2	5.6	0		
DMC @ McCabe	8	< 1.0	2.8	6	< 1.0	< 1.0
Banks	43	< 1.0	1.9	24	< 1.0	< 1.0
DV Check 7	12	< 1.0	1.2	24	< 1.0	< 1.0
Del Valle Glory Hole	71	1.1	4.3	53	< 1.0	< 1.0
Pacheco	6	< 1.0	< 1.0	0		
Check 13	9	< 1.0	< 1.0	5	< 1.0	< 1.0
Check 21	10	< 1.0	< 1.0	6	< 1.0	< 1.0
Check 29	11	< 1.0	< 1.0	2	< 1.0	< 1.0
Check 41	10	< 1.0	< 1.0	6	< 1.0	< 1.0
Pyramid, surface	4	7.5	12.2	0		
Castaic, surface	13	4.4	20.8	0		
Silverwood, surface	11	2.1	7.9	0		
Perris, surface	17	11.1	25.1	0		

The key findings from these data are:

- Prior to the ban in 2004, MTBE was detected in the Sacramento River and San Joaquin River at low concentrations.
- MTBE has never been detected at Barker Slough.

- MTBE was never detected in the California Aqueduct and only detected twice in the SBA prior to the ban. It has not been detected in the SBA since the ban on MTBE.

- MTBE has not been detected in Lake Del Valle since the ban.

- With the exception of San Luis reservoir, MTBE was detected in all of the SWP reservoirs included in the monitoring program.

- The highest concentrations of MTBE were found in the surface waters of the southern California reservoirs.

MWDSC Monitoring

MTBE was first detected in Lake Perris in June 1996. MWDSC initiated monthly monitoring of Lake Perris, Castaic Lake, Lake Matthews, Lake Skinner, and Silverwood Lake in 1997. Monitoring of Diamond Valley Lake started in April 2000. The reservoirs were sampled at multiple locations and at multiple depths. The key findings from the MWDSC monitoring program were:

- The highest concentrations were found in Lake Perris (17 μg/L) and Castaic Lake (6.5 μg/L).

- MTBE concentrations showed seasonal variation with highest concentrations during the summer months.

- During periods of thermal stratification in the lakes, the highest concentrations of MTBE were found in the surface waters.

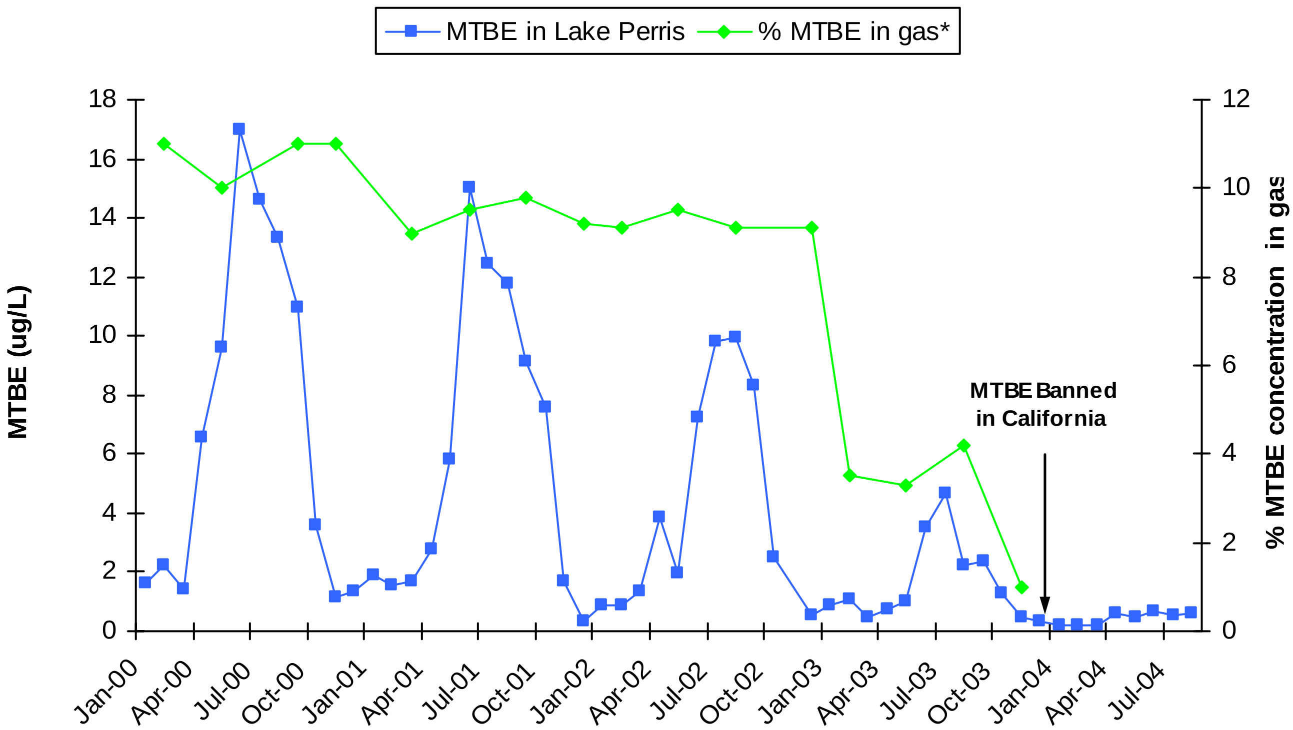
- MTBE was related to recreational boating because no MTBE was detected in Lake Mathews where no boating is allowed or in Diamond Valley Lake where MTBE-free fuel is required.

- MTBE concentrations were reduced in all reservoirs in 2003 as a result of the voluntary reduction in MTBE concentrations in gasoline. As a result of the ban on MTBE in gasoline starting in January 2004, MTBE was reduced to 1 μg/L or less. **Figure 3-128** illustrates the decline in MTBE concentrations in the surface waters of Lake Perris.

Summary of Monitoring Results

The data collected by DWR and MWDSC clearly indicate that while MTBE was a concern in SWP reservoirs prior to the ban on its usage in gasoline in California, MTBE is no longer present in the SWP.

Figure 3-128. MTBE Concentrations in Lake Perris - MWDSC Data



POTENTIAL ACTIONS

Discontinue SWP Monitoring for MTBE

DWR's SWP WQMP has continued to monitor MTBE at Banks, the DMC @ McCabe, DV Check 7, and several checks along the California Aqueduct. MTBE has not been detected at any of these locations since 2003. Since MTBE has been banned in gasoline in California, it is unlikely that MTBE would be detected in the SWP unless groundwater previously contaminated with MTBE was seeping into the system. The data collected during the past three years indicate that MTBE monitoring is no longer needed.

EMERGING CONTAMINANTS

Caffeine, antibiotics, detergents, perfumes, disinfectants, insecticides, pain killers, steroids, and many other personal care products, drugs, and natural and synthetic hormones are being detected in surface waters as a result of recent advances in analytical chemistry methods. Chemicals known as endocrine disruptors are thought to be adversely affecting the reproductive systems of fish that inhabit waters that also serve as drinking water sources. This chapter provides a brief overview of the issues associated with these emerging contaminants and what is currently known about the presence of these contaminants in the watersheds of the SWP.

CLASSES OF EMERGING CONTAMINANTS

Pharmaceuticals or pharmaceutically active chemicals (PhACs), personal care products (PCPs), and endocrine disrupting chemicals (EDCs) have been labeled as emerging environmental contaminants due to recent advances in analytical chemistry that have allowed many of them to be detected at ng/L (parts per trillion) concentrations. In reality, many of them have been in use and probably present in surface waters for years, but the knowledge that they are present in surface waters is relatively new.

PhACs and PCPs are often grouped together and called pharmaceuticals and personal care products (PPCPs). PPCPs include a diverse group of thousands of chemicals that are ingested by humans and animals or applied to the bodies of humans and animals. This wide-ranging class includes prescription and non-prescription drugs (for both humans and animals), soaps, fragrances, insect repellant and sunscreen, among others. These chemicals enter sewer systems when they are excreted or washed off the body. Unused medications are also disposed of by flushing them down the toilet or pouring them down the drain. Incomplete removal in wastewater treatment plants results in numerous PPCPs being discharged to surface waters at very low (µg/L to ng/L) concentrations. They can also enter surface waters from land application of organic materials and by runoff contaminated by animal excrement.

EDCs are chemicals that interfere with the normal functioning of hormones in the bodies of humans and animals. Modes of action of EDCs include mimicking natural hormones, interfering with hormone function, and degrading hormones. Some PPCPs such as phthalates, used in hair spray, fingernail polish, and cosmetics, and hormones contained in oral contraceptives are EDCs but not all EDCs are PPCPs. For example, industrial waste products such as dioxins (TCDD) and furans, industrial chemicals such as perchlorate, PCBs and organometals (e.g. tributyltin, an anti-fouling agent in boat paint), organochlorine pesticides and their degradation products, and flame retardants such as polybrominated diphenylethers (PDBEs) are all endocrine disruptors. In addition, potential EDCs are contained in natural products such as soybeans and alfalfa. EDCs enter surface waters from a variety of sources including industrial and municipal wastewater discharges and runoff from urban and agricultural areas.

The term xenobiotics, meaning foreign to the body, has been used as a general classification for all of these emerging contaminants, although natural hormones that are excreted from humans and animals are biotic. In addition, these chemicals exhibit different physical properties, chemical properties, and health effects (Sakaji et al, 2004). The USGS uses the term organic wastewater contaminants to refer to hormones, pharmaceuticals, and other organic chemicals likely to be present in wastewater.

OCCURRENCE IN THE ENVIRONMENT

EDCs and PPCPs were first recognized as potential contaminants when they were linked to adverse impacts on aquatic organisms. Aquatic organisms, particularly freshwater and anadromous fish, live in streams and lakes used as sources of drinking water so effects on fish can be a first sign of the presence of these compounds in drinking water sources.

Effects on Aquatic Organisms

Aquatic organisms are sensitive to low levels of exposure and are particularly vulnerable when exposure occurs during developmentally sensitive times such as before birth and during juvenile stages of growth. There are a number of studies that have shown developmental and reproductive effects on fish exposed to wastewater effluent, shellfish exposed to organotins, and alligators and frogs exposed to pesticides. Exposure to estrogenic hormones can result in more females than males in a given fish population, the presence of both male and female reproductive organs within an individual organism, and reduced reproductive success. USGS has reported finding intersex or feminized male fish in many locations throughout the country. A nationwide USGS study that analyzed the concentrations of two hormones (17β-estradiol and 11-ketotestosterone) in the blood plasma of carp from 25 sites showed that fish from New Don Pedro Reservoir on the Tuolumne River had the highest concentrations (Goodbred et al, 1997). Fish collected from the San Joaquin River at two locations had lower concentrations of the two hormones.

A more recent study of Chinook salmon collected from 13 locations in the Sacramento and San Joaquin watersheds indicated that up to 38 percent of the male fish exhibited complete sex reversal. The highest percent was found in the Mokelumne River, which is generally considered to be a high quality source of drinking water. The feminization of male salmon is potentially attributed to steroid hormones in wastewater effluent, agricultural wastes, and fish hatchery discharges; detergent metabolites used as carriers in pesticide formulations; and pyrethroid pesticides and their metabolites (Sedlak, 2006).

Occurrence in Surface Waters

PPCPs and EDCs have been detected in very small amounts in surface waters in the United States and Europe. In a 1999 to 2000 study, USGS sampled 139 streams in 30 states and found low levels of pharmaceuticals, antibiotics, and other organic wastes (Barnes et al, 2002). Samples were collected from sites downstream of urban and agricultural activities and analyzed for 95 chemicals. In 80 percent of the samples analyzed, one or more chemicals were detected, typically at ng/L concentrations. Steroids, non-prescription drugs (acetaminophen and ibuprofen), and insect repellants were the chemical groups most frequently detected.

Six of the locations studied by USGS are in the Central Valley: the Sacramento River at Freeport; the San Joaquin River near Vernalis; Mud Slough and Orestimba Creek, west-side tributaries to the San Joaquin River that are dominated by agricultural drainage; Turlock Irrigation District (TID) Lateral 5, a canal that receives agricultural drainage and municipal wastewater effluent and drains to the San Joaquin River; and French Camp Slough, a tributary to the San Joaquin River that is dominated by urban runoff. The key findings for the Central Valley sites are:

- Steroid and Hormone Compounds – Samples were collected from the Sacramento River at Freeport and TID Lateral 5 and analyzed for seven steroid and hormone compounds. Cholesterol was detected at 0.383 µg/L in the Sacramento River and at 1.11 µg/L in TID Lateral 5. Coprostanol was found at 0.624 µg/L in TID Lateral 5.

- Pharmaceuticals – The samples were analyzed for ten pharmaceuticals. None of the pharmaceuticals was detected in the Sacramento River at Freeport, Mud Slough, and French Camp Slough. Acetaminophen was estimated to be 0.004 µg/L in Orestimba Creek and the San Joaquin River at Vernalis. Five pharmaceuticals were detected in TID Lateral 5; acetaminophen at 0.39 µg/L, caffeine at 0.68 µg/L, diltiazem at 0.017 µg/L, 1,7-Dimethylxanthine at 0.21 µg/L and codeine was estimated at 0.019 µg/L.

- Antibiotics – The USGS study reported that the antibiotic data were not yet analyzed for the sites in the Central Valley. The data are not available through the USGS National Water Information System (NWIS) database.

- Selected Organic Wastewater Contaminants – The samples were analyzed for eight organics that the USGS has identified as being present in wastewater. TID Lateral 5 was estimated to contain 0.01 µg/L of 1,4-dichlorobenzene and 0.04 µg/L of 2,6-di-tert-p-benzoquinone. None of the organics was detected at the other five sites.

These data indicate that TID Lateral 5, which receives municipal wastewater from the City of Turlock contained a number of compounds associated with human wastewater at low concentrations. Although the Freeport site on the Sacramento River is downstream of the Sacramento urban area, it is upstream of the discharge from the Sacramento Regional Wastewater Treatment Plant (SRWTP). Due to tidal influence in the Sacramento River, the Freeport site can be influenced by the discharge from the treatment plant but these data do not adequately characterize the quality of water downstream from the discharge.

USGS followed up with a study at the intake to West Sacramento's Bryte Bend WTP on the Sacramento River just upstream from the confluence with the American River. This location is upstream of the urban Sacramento area and downstream of a number of large agricultural drains. Eleven samples were collected between October 2004 and June 2005 and analyzed for 63 organic compounds that USGS has found to be associated with wastewater discharges. Nine pesticides were detected and nine organics were verified but not quantified in the samples, including caffeine, cholesterol, and the insect repellant, DEET. The Bryte Bend site does not adequately characterize the quality of water entering the Delta because the largest wastewater discharger in the watershed (SRWTP) is downstream of this site.

Researchers at the University of California, Berkeley (U.C. Berkeley) have conducted several studies and are involved in an on-going CALFED-funded project in the Central Valley. One study targeted streams draining land devoted to cattle grazing and dairy farming and aquaculture discharges. This study found concentrations of the steroid hormone, estrone, typically in the range of 0.2 to 2 ng/L and as high as 17 ng/L. The highest concentrations were found in small streams draining rangeland. Samples from the American River and Mokelumne River contained 0.2 and 0.3 ng/L, respectively (Sedlak, 2006).

The Central Valley Regional Water Quality Control Board (Central Valley Regional Water Board) teamed with researchers from the University of California, Davis (U.C. Davis) to develop a rainbow trout test to screen water samples for estrogenic EDCs. In one study, 113 water samples were collected from surface waters dominated by agricultural runoff, urban runoff, and wastewater discharges throughout the Central Valley and the North Coast Region. Low-level EDC effects were observed in rainbow trout exposed to six of these samples, all collected in the Central Valley (Central Valley Regional Water Board, 2006).

Although several studies in the Central Valley have indicated that low levels of EDCs and PPCPs are present in source waters of the SWP, little is known about the fate, transport, and transformation of emerging contaminants when they are discharged to surface water sources. Many EDCs and PCPPs are highly soluble and non-volatile, meaning they will persist in water. In addition, many EDCs and PCPPs that are widely used have not been monitored (Daughton, 2006b).

Occurrence in Drinking Water

Some pharmaceuticals and their metabolites have been reported to occur at very low concentrations in some finished drinking water samples in the U.S. These include caffeine, analygesics/anti-inflammatories, anti-convulsants, anti-anxiety medications, x-ray contrast media, lipid regulators, antibiotics or their metabolites, and metabolites of nicotine and a hypertension medication. Known or suspected EDCs detected in U.S finished drinking water samples include a synthetic musk, a polycyclic aromatic hydrocarbon compound, a plant sterol, lactic components, an insecticide, certain degradation products of nonionic surfactants, a fixative used in perfumes and soaps, and a flame retardant (Snyder et al, 2005).

Monitoring of Source Waters and Treated Drinking Water

Numerous chemicals could potentially be present in source waters and treated drinking water. Due to the low levels (generally ng/L) of EDCs and PPCPs in surface waters and treated drinking water, monitoring can be difficult and costly. The American Water Works Research Foundation (AwwaRF) recommends that drinking water utilities consider answering the following list of questions to clarify their purpose before embarking on a monitoring program:

- Specifically, which compounds are you attempting to monitor?
- At what level?

- For what reason?
- Are wastewater treatment plants located upstream in surface water sources?
- Are you attempting to address regulations?
- What is your budget for monitoring and measuring?
- How do you intend to use the data you gather?

A model was developed in Australia to predict pharmaceuticals that could be present in treated wastewater based on usage rates of the drugs and expected removal in wastewater treatment plants (Ongerth and Khan, 2004). The authors believe the model could be used to target monitoring at drinking water intakes and in treated drinking water. Compounds that are poorly removed in wastewater treatment will tend to persist in surface waters because these compounds are likely to be hydrophilic and resistant to degradation. In addition, the compounds will not likely be removed in conventional water treatment processes that depend on solids removal.

HEALTH EFFECTS

The initial concerns when EDCs and PPCPs were first reported in surface waters were focused on increased bacterial resistance to antibiotics and interference with growth and reproduction of aquatic organisms. More recently, concerns for human health due to exposure in drinking water have been expressed. Although no known health effects have been linked to exposure to drinking water with EDCs and PPCPs at trace levels, drinking water providers are concerned about potential effects and their consumers' perception of the safety of drinking water. Human and animal studies of the effects of long-term exposure to environmentally relevant doses are lacking for most known or potential EDCs, but results of some animal studies indicate that certain EDCs can produce effects at low doses. However, to date there is little evidence that levels of EDCs found in source waters have produced adverse endocrine effects in humans (Snyder et al, 2005).

Toxicological information is available for pharmaceuticals however the effects of unintended chronic exposure to subtherapeutic doses that could occur via consumption of drinking water are often not known. Risk assessments conducted to date have not reported that the trace concentrations of pharmaceuticals detected in drinking water pose a health risk to consumers, and likewise, no evidence that EDCs in drinking water have produced adverse effects in humans exists. People are commonly exposed to pharmaceuticals and EDCs in greater amounts through medications and other sources and through routes other than drinking water including diet, inhalation of airborn chemicals, and dermal absorption. Consequently, the contribution of drinking water to total exposure and its relative importance should be considered in risk assessments for these contaminants (Snyder et al, 2005). However, limited information is available on the potential health effects to humans and aquatic organisms from low-level, long-term exposure to single chemicals or chemical combinations. Atypical dose-response relationships and potential additive toxicity or interactions among chemicals within mixtures to which people are commonly exposed (including mixtures occurring in drinking water) complicate toxicological risk assessments for these chemicals (Daughton, 2006c). Simple comparisons of the concentrations found in drinking water to therapeutic doses may understate the risk due to life-long exposure to minute quantities of numerous chemicals.

AwwaRF and the WateReuse Foundation are supporting research on the toxicological relevance of endocrine disruptors and pharmaceuticals in drinking water. The project involves synthesizing current understanding of methods, occurrence, treatment, and health effects of endocrine disrupting chemicals and pharmaceuticals in drinking water and comparing drinking water risks from similar air and foodborne chemicals (AwwaRF, 2006a). This project is scheduled for completion in 2007.

REMOVAL IN WASTEWATER AND WATER TREATMENT PLANTS

Although PPCPs and EDCs can potentially originate from numerous sources and enter the environment by many routes, municipal wastewater treatment plant effluents have been identified as a major source of these chemicals in surface waters (Daughton, 2006a, Snyder et al, 2005). Wastewater treatment plants are designed to remove conventional pollutants such as suspended solids and biodegradable organic material. Discharges of toxic substances to sewer systems are controlled by industrial pretreatment programs. Discharges from medical facilities are covered by the pretreatment program but the discharge of PPCPs and EDCs from individual homes is not covered. EDCs and PCPPs are biologically active compounds. These compounds and their metabolites are not completely removed by current wastewater treatment technologies and are often found in treated effluents. As discussed in Chapter 4, approximately 350 mgd of treated wastewater is discharged to surface waters in the Sacramento, San Joaquin and Delta watersheds.

An AwwaRF study, entitled, Occurrence Survey of Pharmaceutically Active Compounds, focused on PhACs likely to be present in wastewater at 18 wastewater treatment plants (AwwaRF, 2006b). The key findings from that study are:

- Hundreds of PhACs could be present in untreated wastewater at detectable concentrations.

- PhACs are detectable in the effluent of conventional wastewater treatment plants. Diclofenac, gemfibrozil, metoprolol, naproxen, sulfamethoxazole, and trimethoprim were detected in almost all of the wastewater effluent samples. The median concentrations of the PhACs in effluent ranged from less than 10 to 1,400 ng/L.

- Reverse osmosis treatment plants remove most PhACs however metoproiol and propranolol were detected in the effluent from one reverse osmosis plant.

Some preliminary work by researchers at U.C. Berkeley indicates that hormones such as estradiol are not transformed or removed by secondary treatment and that more advanced treatment is required before significant removals are observed. Others have reported similar results on a range of pharmaceutical compounds (Sakaji, 2004).

Because EDCs and pharmaceuticals with widely varying properties might occur in the environment, a single treatment process is unlikely to be effective and feasible for all contaminants of potential concern. Little is known about the occurrence and potential toxicity of degradation products of EDCs and PCPPs that might result from treatment processes such as oxidation that alter chemical structures rather than removing chemicals from water. UV and ozone are possible treatment schemes but they create numerous oxidation products, thereby increasing the number of chemicals present (Daughton, 2006c).

An AwwaRF study titled "Evaluation of Conventional and Advanced Treatment Processes to Remove Endocrine Disruptors and Pharmaceutically Active Compounds" identified "target" compounds that they expected to be present in wastewater and evaluated the ability of various water treatment processes to remove these compounds (AwwaRF, 2006c; Snyder et al, 2003). The key findings from this study are:

- Conventional Processes - Coagulation, flocculation, and sedimentation are ineffective for removing the majority of EDCs and PPCPs that were evaluated.

- Disinfectants - Free chlorine disinfection can remove many target compounds depending on the structure of the contaminant. Chloramines are less effective than free chlorine at removing EDCs and PPCPs. Ozone is more effective than chlorine, and is able to significantly remove the majority of target analytes. UV irradiation at disinfection doses is ineffective for removing most EDCs and PCPs; however, high energy UV at oxidative doses can be effective. Advanced oxidation processes such as ozone/peroxide are highly effective at removing EDCs and PPCPs.

- Activated Carbon – Activated carbon is highly effective, although exhausted activated carbon is ineffective.

- Magnetic Ion Exchange – Magnetic ion exchange processes are ineffective.

- Membranes – Reverse osmosis and nanofiltration are highly effective while ultrafiltration and microfiltration are largely ineffective.

REGULATIONS

The chemicals that are regulated in source waters and in treated drinking water by USEPA and the State of California represent a minor subset of chemicals that are potentially present due to natural occurrence and human actions. Regulatory programs are only just beginning to address these emerging contaminants.

Drinking Water Regulations

The concentrations of most PPCPs and EDCs are not regulated in drinking waters in the U.S. Some chemicals (e.g. several pesticides, PCBs) that are regulated in drinking water are not currently regulated based on their potential endocrine disrupting effects. One exception is perchlorate. OEHHA has adopted a public health goal of 6 µg/L and CDHS has proposed an

MCL of 6 µg/L based on perchlorate interfering with iodide uptake in the thyroid gland which leads to decreased production of thyroid hormones. MCLs are generally developed following detection of contaminants in drinking water sources at levels that are thought to potentially have an impact on human health. The development of MCLs also requires identification of best available technologies for contaminant removal and the ability to monitor and detect the contaminants at levels of concern. The analytical methods for many EDCs and PCPPs are still being developed and most commercial laboratories are not capable of measuring these contaminants at the levels found in source waters and treated drinking water. It may be appropriate to include some of the emerging contaminants on future USEPA drinking water Contaminant Candidate Lists.

Based on the large number of potential endocrine disruptors, new regulations could shift towards regulating compounds as a class based on a common mechanism for toxicity (e.g. endocrine disruption) or similar chemical structure rather than by individual compound. Another possible regulatory approach could require a specific treatment technology (e.g. granular activated carbon) for an array of chemicals, instead of setting standards for a class of chemicals or a proliferation of specific MCLs (AwwaRF, 2005).

Wastewater Effluent Limitations

The concentrations of most PPCPs and EDCs are not regulated in wastewater discharge permits. As with drinking water standards, a few chemicals that have been found or suspected to be EDCs, are regulated based on other effects such as acute and chronic toxicity to aquatic organisms. Currently wastewater is primarily regulated on a chemical by chemical basis. It is not possible to test all chemicals and possible combinations of chemicals that may occur in wastewater effluent. As a result, National Pollutant Discharge Elimination System (NPDES) permits include a requirement for Whole Effluent Toxicity (WET) testing to determine the aggregate toxicity of an effluent in the aquatic environment. WET testing exposes laboratory populations of aquatic organisms (fish, invertebrates, and algae) to diluted and undiluted effluent samples to determine environmental toxicity of that sample. Acute and chronic tests focus on how well an organism survives, grows, and reproduces. However, current toxicity tests do not screen for endocrine disrupting effects. Daughton (2006b) advocates that a more accurate assessment of risks is needed; measuring and assigning toxicity based on the total amount of chemicals in wastewater that share the same mode of action or way of working.

Groundwater Recharge Regulations

CDHS has proposed monitoring for several EDCs and PhACs in the January 2007 Draft Groundwater Recharge Reuse Regulations. The draft regulations require annual monitoring requirements for three hormones, seven “industrial” endocrine disruptors, and 16 pharmaceuticals and other substances. The draft regulations also contain restrictions on the amount of organic carbon that can be in recycled water that is used for recharge. In addition, when more than 50 percent of the water used for recharge comes from wastewater, the draft regulations call for additional organics removal in the treatment process.

Environmental Risk Assessments

The U.S. Food and Drug Administration requires environmental risk assessments for new pharmaceuticals with predicted environmental concentrations greater than 1 µg/L (Snyder et al, 2005). Daughton (2006b) points out that the conventional toxicological procedures used in these risk assessments may not screen for the types of subtle effects that could occur from exposure to the low-levels found in surface waters.

Endocrine Disruptor Screening Program

Congress passed the Food Quality Protection Act in 1996, requiring that USEPA initiate an endocrine disruptor screening program to screen pesticide chemicals and environmental contaminants for their potential to affect the endocrine systems of humans and wildlife. The 1996 amendments to the Safe Drinking Water Act authorize USEPA to screen substances that may be found in sources of drinking water for endocrine disruption potential. USEPA has developed a two-tiered Endocrine Disruptor Screening Program to identify screening methods and toxicity testing methods to determine if chemicals are EDCs. In Tier 1, USEPA will identify chemicals that have the potential to interact with the endocrine system. In Tier 2, USEPA will determine the specific effect caused by each endocrine disruptor and establish the dose at which the effect occurs. The initial focus of the screening program is on pesticides. USEPA has some data on endocrine-disrupting pesticides; however, insufficient scientific data are available for most of the estimated 87,000 chemicals produced today to allow for an evaluation of endocrine associated risks (Daughton, 2006b). On October 23, 2006, USEPA representatives told the Congressional Government Reform Committee that the agency would speed up its efforts to regulate endocrine disruptors. The hearing was called after USGS issued a report finding that 80 percent of the male smallmouth bass in tributaries of the Potomac River were developing eggs.

Chemical Bans

In August 2003, California banned the use of the two most mobile forms of commercially used Polybrominated diphenyl ether (PBDE) mixtures (penta-mix and octa-mix). PBDEs are generally used as flame retardants in manufactured products, such as polyurethane foam padding used in furniture and carpets. PBDEs persist in the environment for years and accumulate in marine biota and other animals. The California Environmental Protection Agency found high levels of PBDEs in breast tissues of women. The new law requires that these flame retardants be phased out by January 2008 when the manufacturing, distribution, and selling of materials containing these compounds will be prohibited in California.

VOLUNTARY CONTROL PROGRAMS

The California Integrated Waste Management Board requests that pharmaceuticals not be disposed in the sewer system and provides guidance on disposal of PPCPs on its website (www.ciwmb.ca.gov/wpie/HealthCare/PPCP.htm#WhereHGP):

- Chemotherapy Pharmaceuticals – should be returned to the clinic that dispensed them.

- All Other Pharmaceuticals – There is no method that applies to everyone in California. Options include returning pharmaceuticals to pharmacies operating "take-back" programs, disposing at household hazardous waste collection facilities, and properly packing and disposing in the trash.

- Personal Care Products – Dispose in the trash.

Some communities have taken a proactive approach and started to educate their customers on proper disposal practices for unused pharmaceuticals. One example is the "No Drugs Down the Drain" Program sponsored by the City of Los Angeles, Sanitation Districts of Los Angeles County, Orange County Sanitation District, and the City of San Diego. These agencies have developed a web page that describes the issues associated with disposal of pharmaceuticals to the sewer system and provides advice on how to dispose of drugs. The two recommended options are 1) take to a household hazardous waste collection center and 2) put in a sturdy and sealed container and then in the trash.

Websites for the cities of Sacramento and Stockton and the counties of Sacramento and San Joaquin were searched for information on disposal of PPCPs. Although there is information on disposal of household hazardous waste, electronic wastes, and universal wastes (e.g. batteries, fluorescent light bulbs), no information could be located on disposal of PPCPs in the two largest urban areas in the Central Valley.

POTENTIAL ACTIONS

Track Research on the Occurrence, Fate, and Removal of PPCPs and EDCs.

AwwaRF, the Water Environment Research Foundation, WateReuse, and CALFED are sponsoring numerous studies on the occurrence of these chemicals in surface waters, wastewaters, and drinking water, conventional and advanced treatment for removing EDCs and PCPPs, and the toxicological relevance of these compounds in drinking water. Some of the SWP Contractors are participating in these studies. The SWP Contractors should stay apprised of recent research.

Develop a Plan for Communicating Risk to the Public.

Due largely to news reports about fish that have been adversely affected by emerging contaminants, consumers are concerned about whether PPCPs and EDCs that may be present in drinking water pose a risk to their health. The AwwaRF (2000d) report, Risk Communication for Emerging Contaminants, offers a diagnostic guide to aid utilities in assessing the need to communicate about specific emerging contaminant risks. The SWP Contractors could develop informational materials to assist with communications with the public when reports or news articles appear on the presence of these contaminants in SWP supplies. Consideration should be given to working with the wastewater community to jointly develop materials.

Work with Central Valley Communities on Proper Disposal Instructions

Controlling these contaminants at the source will likely be most cost-effective and will result in benefits to drinking water and aquatic organisms. The SWP Contractors could work with Central Valley communities on proper disposal of unused PPCPs. There is conflicting information available to consumers on the proper disposal of pharmaceuticals. Many consumers are advised by their pharmacists to dispose of unneeded drugs by flushing them down the toilet or pouring them down the drain.

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CHAPTER 4

Key Concerns in the Central Valley Watershed and the Delta

CALIFORNIA STATE WATER PROJECT
WATERSHED SANITARY SURVEY
2006 UPDATE

CHAPTER 4
KEY CONCERNS IN THE
CENTRAL VALLEY WATERSHED AND THE DELTA

The watersheds of the Sacramento and San Joaquin rivers and the Sacramento-San Joaquin Delta (Delta) are the primary source of water to the State Water Project (SWP). As the water from the tributaries to the Sacramento and San Joaquin rivers flows out of the foothills and through the Central Valley, contaminants from a variety of urban, industrial, agricultural, and natural sources affect the quality of the water, leading to drinking water treatment challenges and potential public health concerns. The sources of contaminants in the watersheds have been examined in previous SWP sanitary surveys. The Technical Review Committee for the 2006 Update determined that this report should focus on the following contaminant sources:

- Urbanization of the Central Valley – The impacts on water quality as a result of increased wastewater and urban runoff discharges.

- Delta Land Conversions – Potential water quality impacts of ecosystem restoration and agricultural crop changes in the Delta.

- Recreational Usage of the Delta – The impacts of body contact recreation and boating in the Delta.

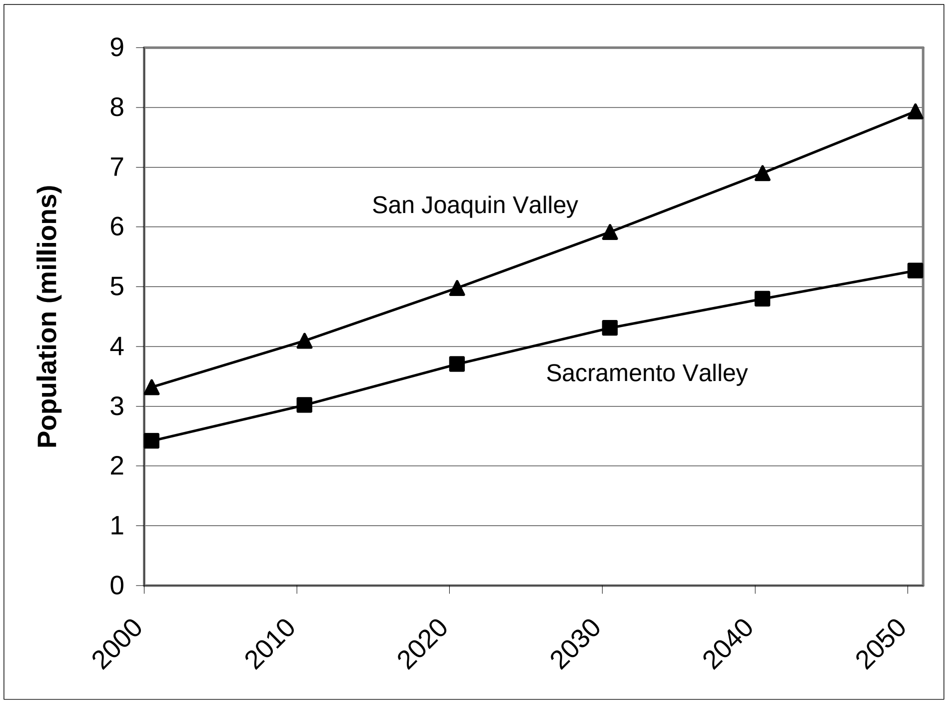
URBANIZATION OF THE WATERSHED AND THE DELTA

KEY CONCERNS

The Central Valley's population is growing faster than that of California or the United States. The rapid rate of population growth has been attributed to the lower cost of housing in the Central Valley compared to coastal communities. This growth raises serious questions about the impacts on water quality as primarily agricultural land is converted to urban areas that generate wastewater and urban runoff.

California's population is projected to grow from 34 million in 2000 to 43.9 million in 2020 and 54.8 million in 2050. This represents a population increase of 29 percent by 2020 and 61 percent by 2050. As shown in **Figure 4-1**, the Sacramento Valley's population is projected to grow from 2.42 million in 2000 to 3.71 million in 2020 (53 percent increase) and to 5.27 million in 2050 (118 percent increase). The San Joaquin Valley's population is projected to grow from 3.32 million in 2000 to 4.98 million in 2020 (50 percent increase) and to 7.94 million by 2050 (139 percent increase). The population of California grew by 1.2 percent between 2004 and 2005. Many of the urban areas in the Delta are growing much more rapidly. **Table 4-1** presents the population estimates for all cities that are physically located in the Delta and for cities such as Sacramento and West Sacramento that are not located in the Delta but whose wastewater and some urban runoff are discharged to the Delta. The population estimates for the four counties in which the Delta is located are also shown.

Figure 4-1. Population Projections for the Central Valley



Data Source: Department of Finance Demographic Research Unit
Graph Source: The Great Valley Center (www.greatvalley.org)

Table 4-1. 2006 Population Estimates for Delta Cities and Counties

County and City	Population, Jan 1, 2006	Percent Change Since Jan 1, 2005
Contra Costa Co.	1,029,377	1.0
Antioch	100,945	0.0
Brentwood	45,892	9.1
Pittsburg	62,979	0.7
Sacramento Co.	1,385,607	1.4
San Joaquin Co.	668,265	2.0
Lathrop	14,625	13.5
Manteca	63,703	2.6
Stockton	286,041	2.1
Tracy	80,461	2.5
Solano Co.	422,848	0.6
Rio Vista	7376	8.3
Vacaville	96,395	0.0
Yolo Co.	190,344	1.5
West Sacramento	43,183	7.5

Data Source: Department of Finance Demographic Research Unit.

There is no one agency with jurisdiction over land use decisions in the Delta so numerous housing developments are being constructed without an examination of the cumulative impacts on water quality of the increased population in the Delta. The increase in population in the watersheds of the SWP will result in greater quantities of wastewater and urban runoff discharged to the tributaries to the Delta and to Delta waterways.

Wastewater

Wastewater discharged into Central Valley waterways contains numerous contaminants including human pathogens, organic carbon, nutrients that stimulate algal growth, and, in some cases, elevated levels of salinity. The increasing population of the Central Valley results in increasing amounts of wastewater discharged to source waters of the SWP. Of particular concern is the increased volume of wastewater discharged into Delta waterways in close proximity to drinking water diversion locations. Discharges of treated wastewater are discussed in this chapter and spills of untreated or partially treated wastewater are discussed in Chapter 6. **Table 4-2** presents a list of the major wastewater dischargers in the watershed. The Central Valley Regional Water Quality Control Board (Central Valley Regional Water Board) defines major dischargers as those that exceed 1 million gallons per day (mgd). The dischargers are grouped by the location in which the discharge occurs (the Delta, Sacramento River watershed, San Joaquin River watershed). The 1990 SWP Sanitary Survey indicated that average daily flow of major wastewater discharges was 268 mgd (Brown and Caldwell, 1990). The California Department of Water Resources (DWR) estimated that major wastewater flows were up to 329 mgd in the 2001 Update of the SWP Sanitary Survey (DWR, 2001). As indicated in Table 4-2, major discharger flows are now up to 352 mgd. Direct discharges to the Delta increased from 194 mgd in 1990 to 220 mgd in 2006. Wastewater flow volumes are shown in **Figure 4-2**.

Figure 4-2. Wastewater Flows in the Central Valley

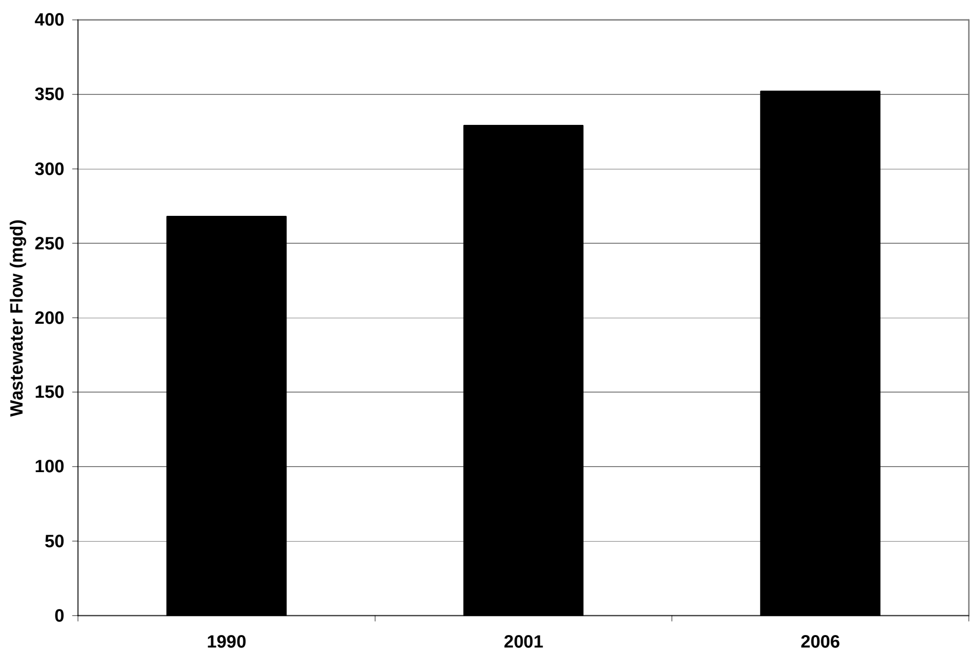


Table 4-2. Wastewater Dischargers in the Central Valley and Delta

Discharger	Average Flow (mgd)	Design Flow (mgd)	Level of Treatment
Delta			
Sacramento	157	207	Secondary
Stockton	34	55	Secondary / Tertiary
Vacaville	8	15	Secondary
Tracy	7.1	9	Secondary / Tertiary by 2008
Manteca/Lathrop	5.7	7.0	Secondary / Tertiary by 2007
West Sacramento	5.1	7.5	Secondary / To SRWTP by 2007
Brentwood	2.2	4.5	Tertiary
Discovery Bay	1.1	2.1	Tertiary
Mountain House	0.3	3.0	Tertiary
Total Delta	**220**	**310**	
Sacramento Basin			
Roseville - Dry Creek	13	18	Tertiary
Chico	6.5	9	Secondary
Redding - Clear Creek	6.5	8.8	Tertiary
Roseville - Pleasant Grove	6	12	Tertiary
Woodland	6	7.8	Tertiary
Yuba City	6	7	Secondary
Davis	5.5	7.5	Secondary
Oroville	3.2	6.5	Secondary
Redding - Stillwater	2.8	4.0	Tertiary
Lincoln	2.4	3.3	Tertiary
Placerville	2.3	3.0	Tertiary
Grass Valley	2.1	2.78	Tertiary
Olivehurst	1.8	1.8	Secondary
Placer County	1.67	2.18	Tertiary
University of California Davis	1.5	2.7	Tertiary
Red Bluff	1.4	2.5	Tertiary
Anderson	1.4	2.0	Tertiary
Auburn	1.34	1.67	Tertiary
Linda	1.24	1.8	Secondary
Willows	1.22	1.12	Secondary / Tertiary by 2007
Corning	1.0	1.4	Secondary
Total Sacramento Basin	**75**	**107**	
San Joaquin Basin			
Modesto	25	70	Secondary
Turlock	12	20	Secondary
Merced	7.4	10	Secondary
Lodi	5.9	7.0	Tertiary
El Dorado Irrigation District Deer Creek	2.86	3.6	Tertiary
Galt	1.83	3.0	Secondary / Tertiary by 2009
El Dorado Hills	1.8	3.0	Tertiary
Total San Joaquin Basin	**57**	**117**	
Total Watershed	**352**	**534**	

Wastewater Discharged to the Delta

Wastewater discharged directly to the Delta is of particular concern due to the proximity of the discharges to drinking water intakes, especially those along the South Bay Aqueduct (SBA). **Figure 4-3** shows the locations of the Delta dischargers. Information is provided on the treatment processes and plans for expansion for each of the Delta dischargers in this section. **Appendix B** contains more information on the wastewater treatment plants that discharge in the Sacramento and San Joaquin watersheds.

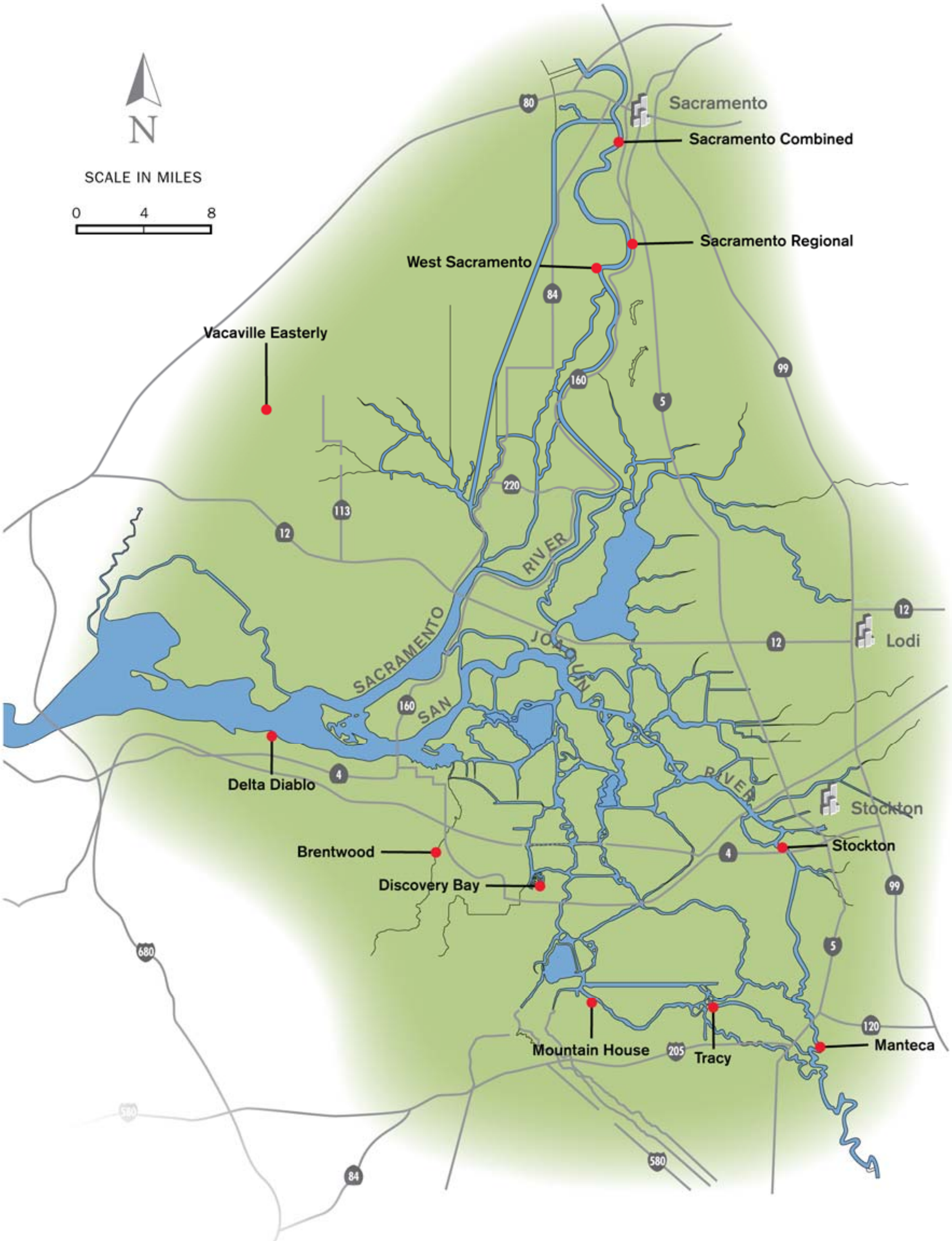
Sacramento Regional County Sanitation District

Sacramento Regional County Sanitation District (SRCSD) operates the Sacramento Regional Wastewater Treatment Plant (SRWTP) which is the largest inland discharger in the state. SRCSD provides wastewater treatment for over 1.2 million residents of the cities of Sacramento, Elk Grove, Folsom, Rancho Cordova, and Citrus Heights and most of the urbanized unincorporated areas in Sacramento County. The City of West Sacramento, located across the Sacramento River in Yolo County, is expected to be annexed to SRCSD in 2007. According to the Report of Waste Discharge filed with the Regional Water Board in 2006, the SRWTP currently has a design capacity of 207 mgd and an average annual flow of 157 mgd. Treated wastewater is discharged to the Sacramento River at Freeport, which is 20 miles upstream of the Delta Cross Channel. In the Environmental Impact Report (EIR) prepared on the expansion of the plant, SRCSD estimated peak hourly flows during a 100-year storm event to be 369 mgd in 2000 (SRCSD, 2004).

The SRWTP treatment processes consist of influent barscreening, primary clarification, high purity oxygen activated sludge, and secondary clarification. The secondary effluent is disinfected with chlorine and then dechlorinated prior to discharge to the Sacramento River via a 120-inch multi-port diffuser. Biosolids are thickened and digested in anaerobic digesters and then pumped to onsite solids storage basins. Solids are stored in the solids storage basins for four to five years and then injected into surface soils onsite. The SRWTP also has five emergency storage basins that serve multiple purposes including storage during wet weather flow events and storage of chlorinated effluent. The National Pollutant Discharge Elimination System (NPDES) permit requires SRCSD to store chlorinated effluent and not discharge to the Sacramento River whenever the ratio of river to effluent flow drops below 14:1 as a result of tidal reversals and low river flows.

SRCSD prepared a master plan and EIR on expansion of the plant to 218 mgd average dry weather flow to meet the 2020 demands of the service area. SRCSD estimates that 2020 peak hourly flows during a 100-year storm event will be 567 mgd. The plant expansion involves construction of additional primary and secondary treatment facilities and solids handling facilities. The Central Valley Regional Water Board is currently evaluating SRCSD's Report of Waste Discharge and expects to issue a tentative permit by the end of 2007 (Personal Communication, James Marshall). Although SRCSD concluded that their increased discharge would not adversely affect downstream drinking water supplies, the State Water Contractors (SWC) and Contra Costa Water District claim there are significant impacts and have filed a lawsuit claiming the EIR is inadequate.

Figure 4-3. Locations of Wastewater Treatment Plants in the Delta

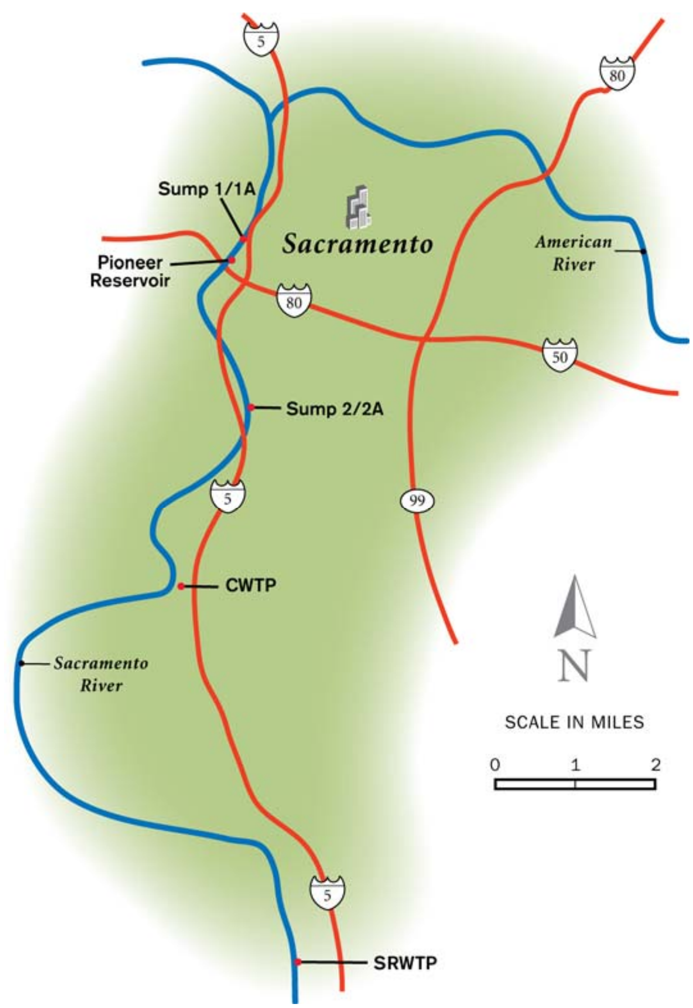


SRCSD constructed a 5 mgd water recycling plant adjacent to the SRWTP that became operational in 2003. Secondary effluent from the SRWTP is filtered and disinfected at the recycling plant. Recycled water from the plant is used to irrigate parks, school sites, and landscaped medians in the Elk Grove and Laguna areas south of the SRWTP. In 2004, the SRCSD Board of Directors approved a goal of expanding the recycling program to 30 to 40 mgd by 2020. SRCSD is currently preparing a recycled water master plan.

City of Sacramento Combined System

The City of Sacramento owns and operates a combined wastewater and stormwater system that serves 7,510 acres in the older neighborhoods of Sacramento, some of which date back to the late 1800s. An additional 3,690 acres with separate sewers contributes wastewater to the combined system. The key features of the combined system are shown in **Figure 4-4**.

Figure 4-4. Discharge Locations for Sacramento Combined System



During dry weather, about 25 mgd of combined flow from the combined system service area is collected at Sump 2/2A and pumped to the SRWTP where it receives secondary treatment prior to discharge to the Sacramento River. During wet weather, Sacramento pumps up to 60 mgd of combined flow to the SRWTP. Flows above 60 mgd are directed to one or both of the two combined wastewater storage and treatment facilities, Pioneer Reservoir and the Combined Wastewater Treatment Plant (CWTP). These facilities are first used to store up to 30 million gallons of combined wastewater but as flows increase, the City may discharge from these facilities after the combined wastewater has received primary treatment, chlorination and dechlorination. Pioneer Reservoir has a capacity of 250 mgd and the CWTP has a capacity of 130 mgd. Flows greater than 440 mgd (60 mgd to SRWTP, 250 mgd to Pioneer Reservoir, 130 mgd to CWTP) up to approximately 540 mgd are diverted to Pioneer Reservoir for disinfection and discharge to the Sacramento River. During extremely high flow conditions, discharges of untreated combined wastewater to the Sacramento River may occur from Sump 2/2A or Sump 1/1A.

In the past, the combined wastewater system has had inadequate hydraulic capacity. Since many of the pipelines are small and have too flat a slope to accommodate flows during moderate and intense storms, outflows of combined sewage and stormwater have occurred at plumbing fixtures in basements and low-lying drop inlets and maintenance holes onto the streets. The City has made numerous system improvements including additional storage capacity and conversion of Pioneer Reservoir to a primary treatment facility with disinfection. **Table 4-3** presents a summary of discharges from the combined system between 2000 and 2006. Although there have been discharges of primary treated combined wastewater (Pioneer Reservoir and CWTP) every year, untreated wastewater (Sump 2/2A) was only discharged in two of the six periods shown in the table. The most recent discharge occurred on December 31, 2005.

Table 4-3. Discharges to the Sacramento River from Combined System

Discharge Location	**Volume Discharged[a] (million gallons)**					
	2000-2001	**2001-2002**	**2002-2003**	**2003-2004**	**2004-2005**	**2005-2006**
Pioneer Reservoir	153.2	76.7	125.9	166.9	36.7	623.5
CWTP	90.8	0	5.4	49.5	32.1	125.2
Sump 2/2A	82.9	0	0	0	0	61.1

[a] Periods shown are July 1 to June 30
Data Source: City of Sacramento, Department of Utilities, Plant Services Division

Stockton

Wastewater from the City of Stockton is treated at the Stockton Regional Wastewater Control Facility (RWCF) and discharged to the San Joaquin River about 1.5 miles upstream of the Stockton Deepwater Ship Channel. In 2003 Stockton contracted with OMI-Thames Water to manage, operate, and maintain the City’s wastewater collection and treatment system. The RWCF treats domestic and industrial wastewaters from a population of about 300,000 in Stockton and surrounding unincorporated areas. The RWCF consists of a secondary treatment plant and a tertiary treatment plant. The secondary plant currently treats average flows of 34 mgd and is being expanded to have a design flow of 48 mgd. The RWCF secondary treatment plant consists of headworks, primary sedimentation, followed by high rate trickling filters and settling basins. The wastewater from the secondary plant is piped under the San Joaquin River to a tertiary plant which consists of approximately 630 acres of unlined facultative oxidation ponds, followed by dissolved air flotation mixed-media filters and chlorination and dechlorination. The tertiary plant has a design flow of 55 mgd. The tertiary plant is currently being upgraded to provide tertiary treatment year-round, rather than just in the summer months. Biosolids are treated by anaerobic digestion, dewatered by belt-press and removed by a private contractor for off-site use.

Stockton conducted a study in 1996 to evaluate the potential for use of recycled water. Stockton concluded that the use of recycled water is not feasible due to the cost of recycled water compared to the cost of water available to farmers, customer concerns over the impacts of recycled water, and the reduction in potable water rights. Under California Water Code Section 1485, Stockton receives credit for wastewater that is returned to the system and can seek a water right to divert the amount of water that is returned. The RWCF supplied approximately 107 acre-feet/year of recycled water for irrigation of alfalfa and safflower crops to a privately owned 14-acre farm for over 20 years. The farmer recently declined to renew the NPDES permit.

Vacaville

The City of Vacaville is located in Solano County. The Easterly Wastewater Treatment Plant (WWTP) treats wastewater from Vacaville and the unincorporated community of Elmira. Currently average dry weather flow of 8 mgd of treated municipal wastewater is discharged to Old Alamo Creek, which flows to Alamo Creek, then to Ulatis Creek to Cache Slough and finally the Sacramento River. The Easterly WWTP consists of two plants that operate in parallel with a design flow of 15 mgd. The treatment processes consist of headworks, primary clarifiers, activated sludge reactors, secondary clarifiers with nitrification capacity of 6 mgd, chlorination and dechlorination. During extreme wet weather events, primary treated wastewater is blended with secondary treated wastewater and then discharged to Old Alamo Creek. The NPDES permit adopted by the Central Valley Regional Water Board in 2001 required Vacaville to install tertiary treatment and eliminate blending during storm events. The stringent effluent limits in the 2001 permit were driven by the designation of Old Alamo Creek as a source of drinking water and as habitat for coldwater aquatic life. Old Alamo Creek is an ephemeral stream with no natural flow during dry weather. Vacaville appealed its permit to the State Water Resources Control Board (State Water Board) and the State Water Board directed the Central Valley Regional Water Board to conduct a use attainability analysis to determine the appropriate beneficial uses for this ephemeral stream. In 2005 the Central Valley Regional Water Board adopted a Basin Plan amendment to de-designate these beneficial uses in Old Alamo Creek. Vacaville has also filed a legal challenge questioning the basis of the stringent effluent limitations prescribed by the Central Valley Regional Water Board in the 2001 permit. That challenge will be heard by the Court in the fall of 2007.

City of Tracy

Wastewater from the City of Tracy, located in the south Delta, is treated at the Tracy WWTP. Currently 7.1 mgd of treated wastewater is discharged to Old River, approximately 7 miles upstream of Clifton Court Forebay. The Tracy WWTP consists of a main treatment facility and an industrial pretreatment facility. The main treatment facility consists of raw influent bar screening, primary sedimentation, biofiltration, conventional activated sludge, and secondary sedimentation. Secondary effluent is disinfected by chlorination and then dechlorinated prior to discharge to Old River. Biosolids are thickened by dissolved air flotation, anaerobically digested and dewatered in drying beds. The dried biosolids are hauled off-site for land application or for disposal in a landfill. The industrial pretreatment facility consists of four unlined industrial ponds. In addition, Leprino Foods Company, a local cheese manufacturer, leases two aerated lagoons and one unlined oxidation pond from Tracy for pretreatment of its industrial food processing wastewater. Following pretreatment, the industrial waste enters the main treatment facility for further treatment. Tracy is currently upgrading the facility to improve treatment and expand capacity. The treatment system will be expanded to 16 mgd through a four-phase expansion that will be completed in 2016. Tertiary treatment will be provided in the first phase by 2008. The improvements include nitrification/denitrification and tertiary filtration.

<u>Manteca and Lathrop</u>

The cities of Manteca and Lathrop are rapidly growing urban areas located in San Joaquin County in the south Delta. The City of Manteca owns and operates the Manteca Wastewater Control Facility which serves both cities. The existing plant provides secondary treatment consisting of headworks, primary sedimentation, biofiltration, activated sludge, and secondary sedimentation. Approximately 2 mgd of secondary effluent is applied to agricultural fields. Excess wastewater is chlorinated and dechlorinated and discharged to the San Joaquin River. Currently the average discharge to the San Joaquin River is 5.7 mgd. Biosolids are disposed in an offsite landfill. Manteca is currently expanding and upgrading the treatment plant to provide tertiary filtration, nitrification and denitrification, and ultra-violet light (UV) disinfection. The expanded plant will have a design flow of 9.87 mgd. Approximately 0.55 mgd of food processing wastewater will be treated separately in an aeration basin and applied to land. Discharge from the expanded plant will be timed so that effluent is released when there are positive downstream flows in the San Joaquin River. The expansion is expected to be completed by June 2007.

Lathrop currently owns and operates a wastewater recycling plant (WRP-1) with a capacity of 0.75 mgd. Lathrop has filed a Report of Waste Discharge and requested that the Central Valley Regional Water Board modify their waste discharge requirements to allow the city to expand WRP-1 to 1.5 mgd by the end of 2007 and to construct WRP-2 which will have an initial capacity of 0.75 mgd at the end of 2007. The wastewater recycling plants are needed to treat wastewater from several new developments in Lathrop. Eventually both recycling plants will treat 3.12 mgd of wastewater. The wastewater will be treated to tertiary standards and meet Title 22 requirements for reclaimed water. The recycled water will be used to irrigate agricultural crops, parks and median strips. Lathrop has notified the Central Valley Regional Water Board that it expects to apply for an NPDES permit to discharge recycled water to surface waters as the population of the city continues to grow.

West Sacramento

The City of West Sacramento is located in Yolo County, across the Sacramento River from the City of Sacramento. Currently, average dry weather flow of 5.1 mgd of wastewater is discharged to the Sacramento River near Clarksburg (**Figure 4-3**). The treatment plant consists of headworks, aeration basins that are operated to nitrify and denitrify, secondary clarifiers, chlorination and dechlorination. There are also emergency storage ponds located at the plant. Biosolids are disposed offsite. West Sacramento will abandon this plant and connect to the SRCSD system in 2007. The SRCSD is constructing an interceptor through West Sacramento that will serve areas of Sacramento that are north of West Sacramento and will allow West Sacramento to connect to the system.

Brentwood

The City of Brentwood is located in eastern Contra Costa County and is one of the most rapidly growing urban areas in the Delta. In 2002, Brentwood completed construction of a 4.5 mgd tertiary treatment plant that is designed to produce effluent suitable for unrestricted irrigation reuse. The tertiary plant consists of screens, oxidation and nitrification by extended aeration activated sludge, denitrification by anoxic basins, coagulation, tertiary filtration, chlorination and dechlorination. Ultimately the plant will be expanded to 10 mgd. Biosolids are treated in an aerobic digester, dewatered in sludge drying beds, and disposed offsite. The Brentwood plant currently treats average dry weather flows of 2.2 mgd and has three disposal options: offsite reclamation, land disposal to existing percolation ponds, and discharge to Marsh Creek. To minimize discharge to Marsh Creek, Brentwood has received a master reclamation permit for the distribution and use of recycled water in its service area. The City proposes to distribute recycled water in two phases. In Phase 1, the City will use recycled water for irrigation of parks and median strips, and possibly for other uses such as dust control at construction sites. In Phase 2, the City will distribute recycled water for use on golf courses in the area. The Central Valley Regional Water Board is requiring that the City conduct a groundwater study to determine if storage of recycled water in ponds at the golf courses would degrade groundwater quality.

Discovery Bay

The Town of Discovery Bay is located in eastern Contra Costa County. The wastewater collection, treatment, and disposal system is owned by the town but operated by ECO Resources, Inc. The existing plant has a capacity of 2.1 mgd and serves a population of 9,500; however, there are plans for more than 2,000 more homes in the town. Currently 1.1 mgd of treated wastewater is discharged to Old River. The WWTP provides tertiary treatment and consists of bar screens, a comminutor, an oxidation ditch, secondary clarifiers and UV disinfection. The oxidation basin is operated to provide nitrification/denitrification. Biosolids are stored in a facultative lagoon and periodically dewatered and disposed of at a licensed biosolids facility.

Mountain House Community Services District

Mountain House is a new residential, commercial, and industrial community being developed in western San Joaquin County between Interstate 205 and Old River. This community is approximately 3 miles west of Tracy and will eventually have up to 43,500 residents. The Mountain House Phase I WWTP treats domestic, commercial, and light industrial wastewater collected via the Mountain House wastewater collection system. ECO Resources maintains the collection system and operates the WWTP under contract with Mountain House Community Services District. The Mountain House WWTP currently discharges almost 0.3 mgd of treated wastewater to land. The WWTP has a design flow of 0.45 mgd and consists of headworks, four aerated lagoons in series, chemical addition, two dissolved air flotation units to remove algae, a flocculation unit, two filters, a clear well, two chlorine contact basins, bisulfite dechlorination, sludge drying beds, two effluent storage reservoirs, a reclamation area, and a tail water return system. When flows reach 0.3 mgd, Mountain House will commence treating wastewater with the Phase II WWTP. The Phase II WWTP will utilize portions of the Phase I WWTP but will also include nitrification/denitrification, tertiary filtration, and UV disinfection, prior to discharge to Old River. The Phase II WWTP currently has a design flow of 3.0 mgd and will eventually be expanded to 5.4 mgd at full build-out. Biosolids will be hauled offsite to a licensed biosolids facility.

Antioch and Pittsburg

Wastewater from Antioch and Pittsburg is treated at the Delta Diablo Sanitation District WWTP which discharges to New York Slough, a section of the San Joaquin River near the confluence with the Sacramento River. Average dry weather flows of 14.2 mgd receive tertiary treatment and 9.9 mgd are discharged. The remaining 4.4 mgd of treated water is used for irrigation and cooling tower make-up at two power plants. The discharge is located in the western Delta and modeling results show that it does not affect SWP water quality (Personal Communication, Leah Orloff, Contra Costa Water District). Therefore, the discharge data are not shown in **Table 4-2.**

Wastewater Quality and Effluent Limitations for Drinking Water Constituents

As described in more detail in Chapter 2, the beneficial uses and receiving water objectives to protect those uses are established in the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins, known as the Basin Plan (Central Valley Regional Water Board, 1998). The Central Valley Regional Water Board establishes effluent limitations for wastewater dischargers based on the beneficial uses and the water quality objectives of the water body that receives the discharge. Effluent limitations are specific to each discharge and vary throughout the Central Valley. If a discharge is to an ephemeral stream or a stream that the Central Valley Regional Water Board determines does not have any assimilative capacity for a contaminant, the discharger must meet the receiving water quality objectives in the effluent. If there is dilution capacity available in the receiving water, the Central Valley Regional Water Board establishes effluent limitations that allow for a mixing zone and dilution of the effluent in the receiving water. The Central Valley Regional Water Board establishes effluent limitations for a number of contaminants in waste discharge permits. The discussion in this section is limited to those constituents that have been identified by the Technical Review Committee as being of primary concern for SWP drinking water providers (see Chapter 3). As described in Chapter 2, the Basin Plan does not contain water quality objectives for some of the key drinking water constituents of concern (disinfection byproduct precursors, pathogens, nutrients) or the current objectives are not based on drinking water concerns (salinity, chloride). As a result, there are limited data on the quality of wastewater effluent for many of these constituents because the dischargers are not required to conduct monitoring. The data that are available are discussed in this section.

Pathogens and Indicator Organisms

Untreated wastewater contains human bacteria, parasites, and viruses. The Basin Plan contains a fecal coliform objective to protect contact recreation:

> *"In waters designated for contact recreation (REC-1), the fecal coliform concentration based on a minimum of not less than five samples for any 30-day period shall not exceed a geometric mean of 200/100 ml, nor shall more than ten percent of the total number of samples taken during any 30-day period exceed 400/100ml."*

The Basin Plan does not contain a coliform objective for the protection of drinking water sources or objectives for actual pathogens such as *Giardia* and *Cryptosporidium*. The Central Valley Regional Water Board establishes effluent limitations for total coliform bacteria for all wastewater discharges but does not establish effluent limitations for actual pathogens. Wastewater treatment plants that provide secondary treatment are required to have a monthly median total coliform count of 23 MPN/100 ml and a daily maximum of 500 MPN/100 ml. In recently issued permits, the daily maximum has been reduced to 230 MPN/100 ml. If the Central Valley Regional Water Board determines that the receiving water does not have sufficient dilution capacity and beneficial uses of the receiving water include municipal and domestic supply, water contact recreation, or agricultural supply for food crops, more stringent effluent limitations are included in waste discharge permits. The more stringent requirements are based on reclamation criteria for the reuse of wastewater established in Title 22 of the California Code of Regulations. Title 22 requires that for spray irrigation of food crops and public access areas such as parks, wastewater must be adequately treated so that effluent total coliform levels do not exceed 2.2 MPN/100 ml as a 7-day median or 23 MPN/100 ml as a daily maximum. Title 22 also requires that recycled water used as a source of water supply for non-restricted recreational impoundments receive tertiary treatment and be disinfected. The Central Valley Regional Water Board also establishes an effluent limitation for turbidity of 2 NTU to ensure that filters are operating properly to remove pathogens. The coliform effluent limitations for several wastewater treatment plants that discharge to the Delta are shown in **Table 4-4** to show the variability in effluent limitations among plants.

SRCSD conducted monitoring of the SRWTP effluent for *Giardia* and *Cryptosporidium* from January 1997 to August 2002. These data were summarized in the EIR on the expansion of the plant (SRCSD, 2004). **Table 4-4** presents the data from the EIR. No information is available on the recovery rates of *Giardia* and *Cryptosporidium* in the treated wastewater. These data indicate that disinfected effluent that meets total coliform effluent limitations contains *Giardia* and *Cryptosporidium* and possibly other pathogens. The significance of this pathogen loading to drinking water intakes in the Delta is unknown.

Table 4-4. Total Coliform Effluent Limitations

Discharger	Total Coliform Effluent Limitations (MPN/100 ml)	
	Weekly Median	Daily Maximum
SRCSD	23	500[a]
Stockton	2.2	23[b]
Tracy	2.2	23/240[c]
Manteca/Lathrop	2.2	23/240[c]
Brentwood	2.2	23[b]
Discovery Bay	23	240

[a] Cannot be exceeded in two consecutive days.
[b] Cannot exceed more than once in any 30-day period.
[c] Cannot exceed 23 MPN/100 ml in more than one sample in any 30-day period. No sample shall exceed 240 MPN/100 ml.

Table 4-5. Pathogens in SRWTP Effluent

	Giardia **(cysts/L)**	***Cryptosporidium*** **(oocysts/L)**
No. of Samples	61	61
Percent Detected	100	80
Range	2 - 192	0.08 - 84
Mean	44.7	7.3
Median	39	1.9

Source: EIR for SRWTP Expansion (SRCSD, 2004)

Nutrients

Untreated municipal wastewater contains high concentrations of nitrogen and phosphorus. The concentrations in the effluent depend upon the types of treatment processes that are employed to treat the wastewater. The Basin Plan does not have numeric water quality objectives for nutrients based on the potential to cause algal growth but does have the following narrative objective:

> *"Water shall not contain biostimulatory substances which promote aquatic growths in concentrations that cause nuisance or adversely affect beneficial uses."*

The narrative objective is included in every waste discharge permit as a receiving water limitation but Central Valley Regional Water Board staff state that they do not have a method of translating this narrative objective to specific numeric effluent limitations (Personal Communication, Karen Larsen, Central Valley Regional Water Board). Therefore, discharge permits do not contain an effluent limitation for phosphorus. Effluent limitations for nitrate and ammonia are established in some waste discharge permits for Delta dischargers. The effluent limitations for ammonia are based on aquatic toxicity and are determined based on the dilution capacity of the receiving water. The effluent limitations for nitrate and nitrite are based on another narrative objective that is included in the Basin Plan:

> *"Water shall not contain chemical constituents in concentrations that adversely affect beneficial uses."*

This narrative objective is used to incorporate by reference all of the maximum contaminant levels (MCLs) established by the U.S. Environmental Protection Agency (USEPA) and the California Department of Health Services (CDHS). Therefore, the Basin Plan establishes receiving water quality objectives of 10 mg/L as N for nitrate and 1 mg/L as N for nitrite for all waters designated with the municipal and domestic beneficial use, based on the MCLs. If the receiving water has sufficient assimilative capacity so that the discharge does not cause an exceedence of these objectives beyond the mixing zone in the water body, the Central Valley Regional Water Board does not establish an effluent limitation. If the receiving water does not contain assimilative capacity, the Central Valley Regional Water Board requires that the effluent limitations be set at 10 mg/L as N for nitrate and 1 mg/L as N for nitrite.

Effluent quality data are presented for SRWTP, which is a secondary plant, and for Brentwood, which has been a tertiary plant since the summer of 2002. Many of the other dischargers have recently or will soon undergo treatment upgrades so historical data are of limited value. **Figures 4-5 and 4-6** present the ammonia and nitrate data for SRWTP and Brentwood respectively. The sampling frequencies vary between the two plants. SRWTP ammonia is monitored twice a week whereas nitrate samples are only collected three times each year. Brentwood collects one sample each month for both ammonia and nitrate. The effluent for the SRWTP contains primarily ammonia since it is a secondary treatment plant and does not have nitrification/denitrification processes. Brentwood is a tertiary plant with nitrification/denitrification so ammonia is converted to nitrate and some of the nitrate is converted to nitrogen gas. Therefore, nitrate is the dominant form of nitrogen in the effluent and the concentrations of nitrate plus ammonia are less than one third of the concentrations in the SRWTP effluent. Total phosphorus (total P) concentrations for the two wastewater treatment plants are shown in **Figures 4-7 and 4-8**. Total P samples are collected monthly at both plants. The SRWTP concentrations are generally in the range of 1.5 to 3 mg/L. There are fewer data available for Brentwood but concentrations range from 0.5 to about 3.5 mg/L.

A conceptual model of nutrients has recently been completed for the Central Valley Drinking Water Policy Work Group (Tetra Tech, 2006a). This effort included developing preliminary information on the loads of nutrients from various sources, including wastewater. Based on these preliminary estimates, wastewater discharged in the Central Valley and Delta constitutes roughly half of the total nitrogen load and almost 65 percent of the total phosphorus load discharged to the system during dry years. The Work Group intends to refine these estimates by collecting additional data on the quality of wastewater discharges and other sources.

Figure 4-5. Ammonia and Nitrate Concentrations in SRWTP Effluent

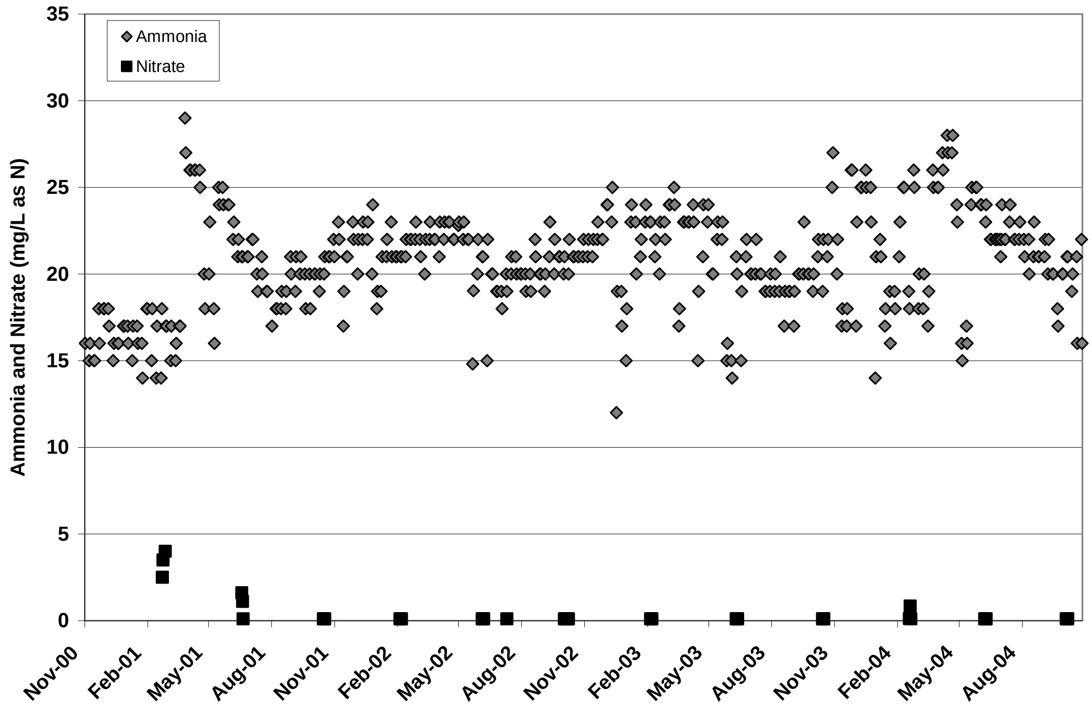


Figure 4-6. Ammonia and Nitrate Concentrations in Brentwood WWTP Effluent

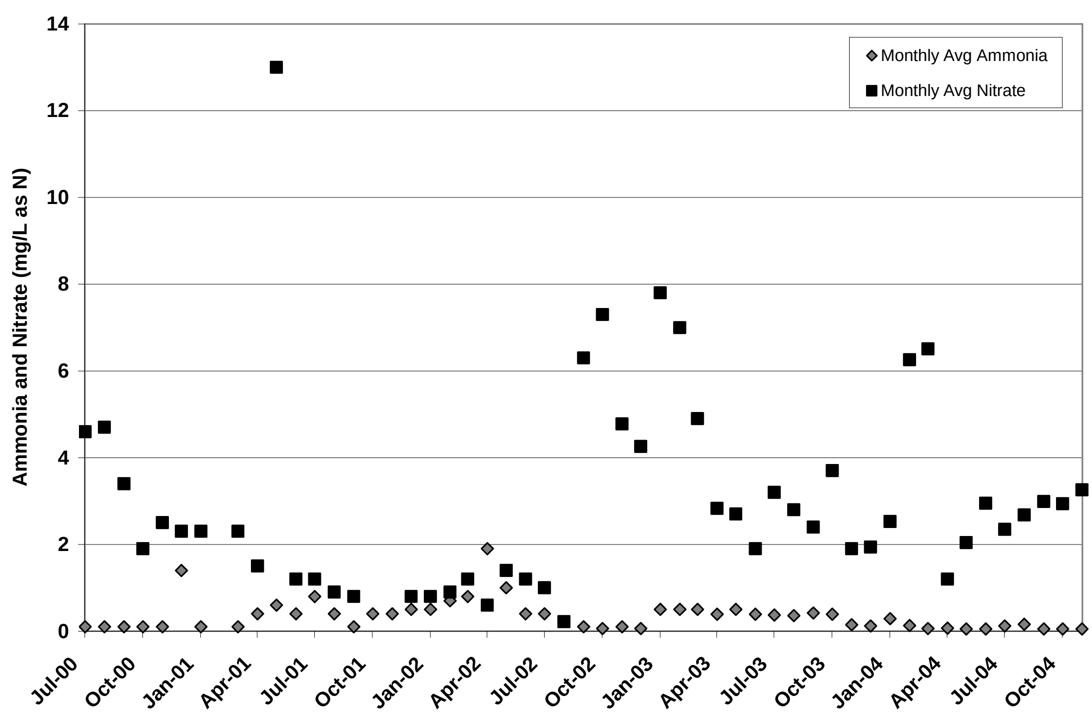


Figure 4-7. Total Phosphorus Concentrations in SRWTP Effluent

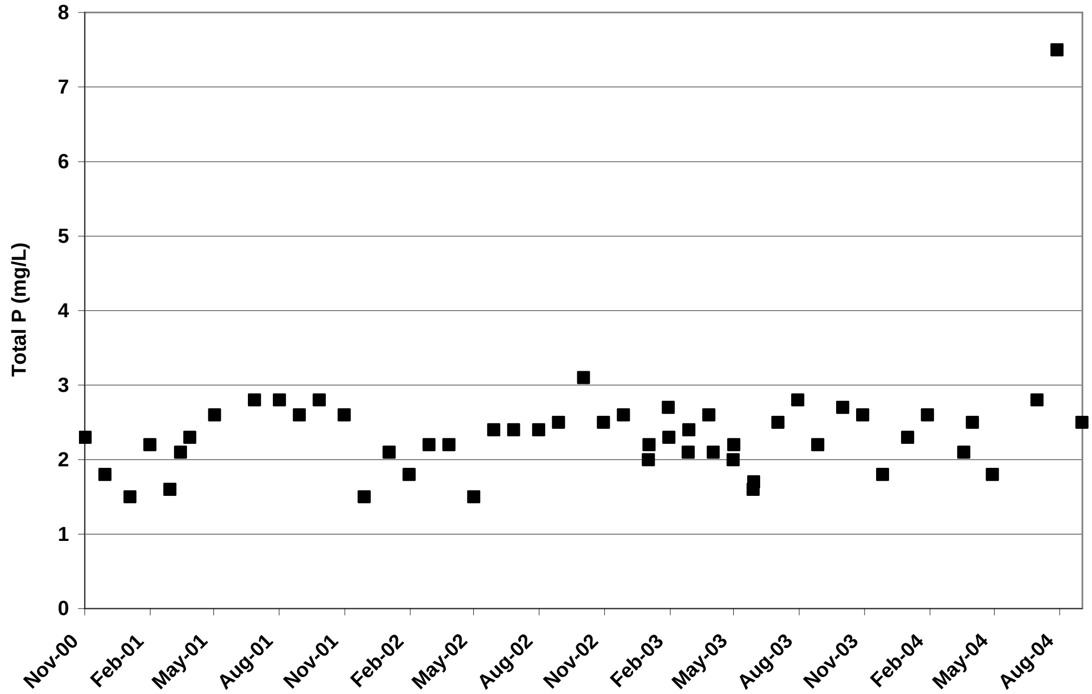
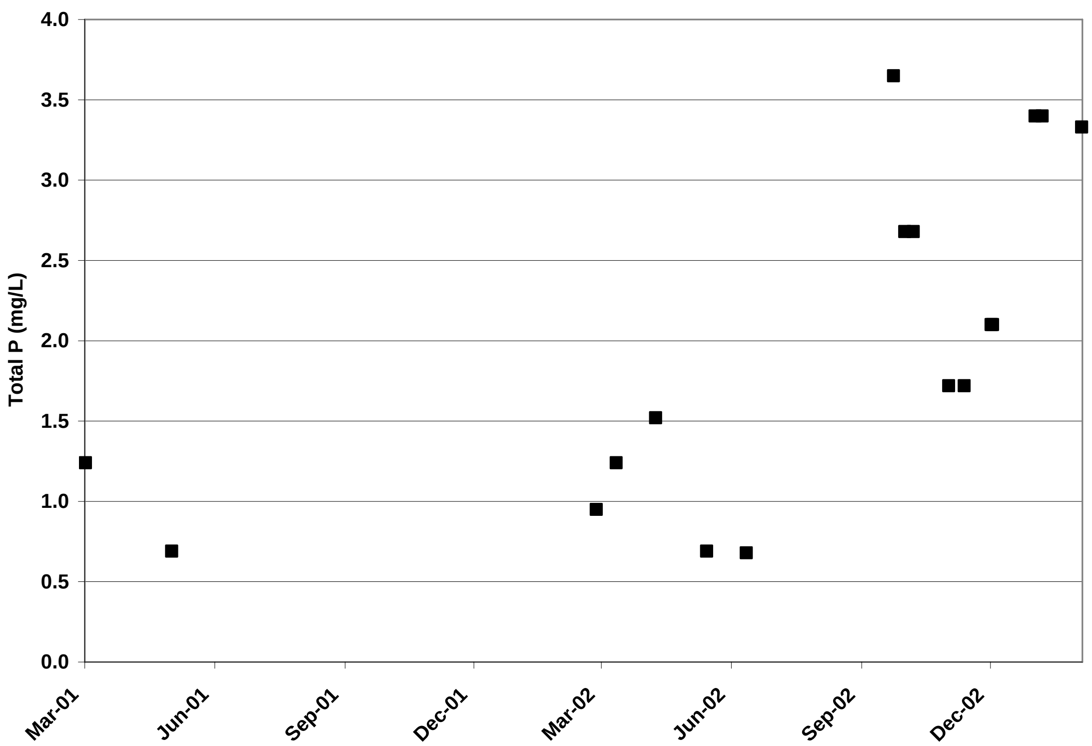


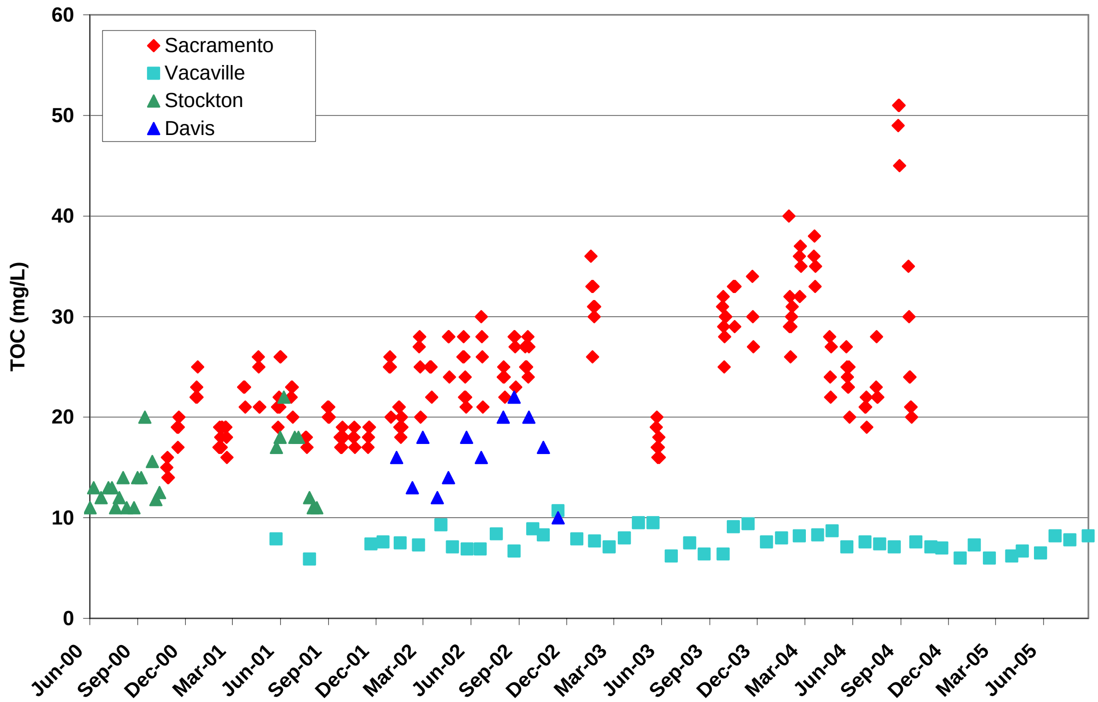
Figure 4-8. Total Phosphorus Concentrations in Brentwood WWTP Effluent



Organic Carbon

The Basin Plan does not contain a water quality objective for total organic carbon (TOC) so the Central Valley Regional Water Board does not establish effluent limitations and has historically not required wastewater dischargers to monitor their effluent for TOC. Four of the dischargers in the watershed have voluntarily monitored their effluent for organic carbon. Data are available for the two largest wastewater treatment plants that discharge to the Delta, SRWTP and Stockton, and for the Vacaville Easterly WWTP and the City of Davis WWTP. SRWTP collected TOC data for four to five consecutive days each month, Stockton monitored weekly for four months, and Vacaville and Davis collected one sample per month. **Figure 4-9** indicates that TOC is quite variable among the four plants. The Vacaville Easterly WWTP consistently produces effluent with TOC concentrations between 6 and 11 mg/L. The Stockton and Davis effluent is generally in the range of 10 to 20 mg/L. The TOC concentrations in the SRWTP effluent are quite variable ranging from 14 to 51 mg/L with a median concentration of 23 mg/L. When compared to the organic carbon concentrations that trigger additional treatment under the Stage 1 Disinfectants and Disinfection Byproducts Rule (2, 4, and 8 mg/L) or the CALFED goal of 3 mg/L for the Delta, wastewater contains high concentrations of organic carbon.

Figure 4-9. Total Organic Carbon Concentrations in Wastewater Effluent



The preliminary conceptual model of organic carbon prepared for the Central Valley Drinking Water Policy Work Group estimated the total load of organic carbon to the Delta from the watersheds and in-Delta sources during dry years as 81,000 tons/year (Tetra Tech, 2006b). The load from the SRWTP was calculated as 5,500 tons/year using the average flow of 157 mgd and the median concentration of 23 mg/L. Currently SRWTP represents about 45 percent of the wastewater flow discharged to the watershed, but based on limited data, the TOC concentrations in SRWTP effluent appear higher than other wastewater discharges. The total load from wastewater discharges is likely in the range of 8,000 to 12,000 tons/year or roughly 10 to 15 percent of the TOC load discharged to the Delta. These estimates will be refined based on additional data collected by the Central Valley Drinking Water Policy Work Group.

Salinity

The salinity of a wastewater discharge is largely determined by the salinity of the drinking water supplied to the area served by the discharger. Additional salt is added through human usage and industrial dischargers. Central Valley Regional Water Board staff estimate that the electrical conductance (EC) of municipal wastewater is approximately 500 µS/cm greater than the water supply EC (Central Valley Regional Water Board, 2006).

The State Water Board established salinity standards at various locations in the Delta in the Bay-Delta Water Quality Control Plan that provide protection for drinking water, agricultural water and fish and wildlife beneficial uses (SWRCB, 1995). The SWP and Central Valley Project are required to meet salinity standards at various compliance points in the Delta. This generally requires that water be released from upstream reservoirs. The addition of salt from wastewater discharges has recently become a significant issue, particularly in the South Delta. The Central Valley Regional Water Board recently issued revised NPDES permits for Tracy and Mountain House. As described previously, both of these communities are growing rapidly so the treatment plants are being expanded, resulting in a greater load of salt from wastewater discharged to Old River. Groundwater is the primary source of drinking water in both of these communities. The Tracy WWTP also receives highly saline cheese processing wastes. The revised NPDES permits require that both dischargers submit Salinity Plans to the Regional Board that evaluate methods for reducing the EC of the effluent. The Salinity Plans must evaluate methods of obtaining lower salinity water sources and investigate salinity source control. In addition, the dischargers must contribute financial resources to the Central Valley Salinity Management Plan (discussed in Chapter 2).

Urban Runoff

Stormwater and dry season runoff from the major urban areas of Sacramento, Stockton, Modesto, and some portions of Fresno, along with a number of smaller communities, is discharged to waterways of the Central Valley. Urban runoff contains numerous contaminants as a result of vehicle emissions, vehicle maintenance wastes, landscaping chemicals, household hazardous wastes, pet wastes, trash, and other waste from anthropogenic sources. As the Central Valley communities increase in population, natural and agricultural lands are converted to urban areas with an associated increased volume of urban runoff and increased load of contaminants. Natural vegetated areas absorb rainfall and remove contaminants through soil filtration. When these areas are converted to urban areas, the impervious surface area increases, which results in an increase of runoff and contaminants from urban activities. The relative volume of runoff and load of contaminants from agricultural land and urban land is currently not well understood so the relative increase, or potential decrease, in load associated with converting agricultural land to urban land is unknown.

As described in Chapter 2, urban runoff in the Central Valley and Delta is regulated by the Central Valley Regional Water Board through municipal separate storm sewer system (MS4) NPDES permits. These permits require large (greater than 250,000 population) and medium (100,000 to 250,000 population) municipalities to develop stormwater management plans and conduct monitoring of stormwater discharges and receiving waters. The permits also require programs to control runoff from construction sites, industrial facilities, and municipal operations; eliminate or reduce the frequency of non-stormwater discharges to the stormwater system; educate the public on storm water pollution prevention: and better control and treat urban runoff from new developments. Small communities (less than 100,000 population) are required to develop management plans but do not have to conduct monitoring.

Urban Runoff Discharged to the Delta

Urban runoff from Sacramento, Stockton, and eastern Contra Costa County is discharged directly to the Delta. This section presents information on the stormwater programs for these major urban areas and the efforts that are aimed at reducing the contaminants of most concern to drinking water providers.

Sacramento

The Sacramento Stormwater Management Program was initiated in 1990. Urban runoff from the urban area of Sacramento County and the cities of Sacramento, Elk Grove, Citrus Heights, Rancho Cordova, Galt, and Folsom is regulated under a MS4 permit that is issued by the Central Valley Regional Water Board to all of these entities as co-permittees. Runoff from the Sacramento urban area drains to the American and Sacramento rivers, to the Natomas East Main Drainage Canal (NEMDC) and to Morrison Creek. NEMDC and Morrison Creek drain to the Sacramento River. The stormwater program for Sacramento County and all of the cities except Sacramento is described in the Sacramento County Stormwater Quality Improvement Plan, or SQIP (Sacramento County et al, 2003). The City of Sacramento prepared a separate SQIP to describe its proposed activities between 2003 and 2008 (City of Sacramento, 2004). These plans identify diazinon, chlorpyrifos, copper, lead, mercury, and coliform bacteria as the contaminants of most concern. The SQIPs describe activities to be undertaken to control these contaminants. Coliform bacteria are a drinking water concern, as it is an indicator of pathogens. The other contaminants are problematic for aquatic life (pesticides and metals) and public health due to fish consumption (mercury), but are generally not a concern in Central Valley and Delta drinking water supplies.

The SQIPs identify numerous programs and activities undertaken by Sacramento County and the cities to reduce contaminants in stormwater to the maximum extent practicable. The activities most related to reducing contaminants of concern to drinking water providers are briefly described.

- Fecal Waste Reduction Strategy - The permittees have developed a fecal waste reduction strategy that aims to reduce both human and domestic animal wastes from entering receiving waters. This is being implemented by identifying and removing any illicit cross-connections from the sanitary sewer system to the storm drain system, responding to spills to the storm drain system, implementing procedures for preventing sewage spills from entering receiving waters, educating the public to pick-up pet waste and dispose of it in the garbage, funding pet waste bag dispenser stations and informational kiosks along the American River Parkway and local parks, performing kennel inspections, and managing manure at livestock facilities in the urban area. The effectiveness of these measures is unknown at this time. The permittees are working with University of California Davis (U.C. Davis) researchers to conduct studies of the sources of pathogens in the urban runoff discharged to the American and Sacramento rivers.

- Containerized Green Waste Collection - The City of Sacramento allows residents to place green waste in the street for collection by the Solid Waste Division. Residents of Sacramento rejected a measure to prohibit this activity in 1977. The City has implemented a volunteer containerized green waste collection program. There are no data available on the water quality impacts of placing green wastes in streets but there is the potential for green waste (and all of the carbon and nutrients tied up in it) to be transported via the storm drain system to receiving waters. The City is considering a modification to the ordinance that would prohibit green waste from being placed in the street more than 48 hours before the scheduled pick-up.

- Requirements for New Developments - New developments are required to install stormwater quality treatment facilities to reduce the impact on receiving waters. These include detention basins, vegetated swales, infiltration basins and trenches, sand filters, and porous paving blocks. Low impact development (LID) is encouraged. LID is a stormwater management strategy that emphasizes conservation and use of existing natural site features integrated with distributed, small-scale stormwater controls to more closely mimic natural hydrologic patterns in residential, commercial, and industrial settings (City of Sacramento, 2006a). Long-term maintenance of these treatment facilities is needed to ensure that they operate as designed. The Sacramento permittees require maintenance agreements by property owners. The degree to which these treatment facilities remove the contaminants of most concern to drinking water providers (pathogens, nutrients, organic carbon, and salinity) is being studied.

- Study on Feasibility of Diverting Dry Weather Flows to SRWTP - The permittees conducted a study on the feasibility of diverting dry weather urban runoff from the City and a portion of the County to the SRWTP (City of Sacramento et al, 2006b). The study concluded that diversion is feasible but not cost-effective due to the cost of connecting to the SRWTP collection system and the use of capacity at SRWTP. In addition, issues associated with the SRWTP's NPDES permit effluent limitations would need more study. The permittees recommended investigation of onsite treatment of dry weather flows rather than diversion to the sanitary sewer system. In the City of Sacramento, dry weather and some wet weather flows from the older parts of the city are already diverted to the SRWTP via the city's combined sewer system, described previously.

Stockton

Urban runoff from the City of Stockton and urbanized areas of San Joaquin County is regulated under a MS4 permit issued jointly to the City and County. The Port of Stockton has a separate permit. Runoff from the Stockton area is discharged to the Calaveras River and a number of sloughs and creeks that are tidally influenced and flow to the San Joaquin River. The Stockton Stormwater Management Program Plan (SMPP) was submitted to the Central Valley Regional Water Board in 1999 and updated in 2003 (Larry Walker Associates, 2003). The SMPP identifies pesticides (including diazinon and chlorpyrifos), pathogens, and dissolved oxygen as the contaminants of concern. The SMPP identifies numerous programs and activities undertaken by the permittees to reduce contaminants in stormwater to the maximum extent practicable. The activities most related to reducing contaminants of concern to drinking water providers are briefly described.

- Pathogen Plan – Several water bodies that receive Stockton area runoff are impaired due to the presence of fecal indicator bacteria. The permittees were required to develop a Pathogen Plan to identify, monitor, and mitigate pathogen sources. The Pathogen Plan outlines four phases:
    - Characterization Monitoring – monitoring for fecal indicator bacteria in impaired water bodies and in runoff discharges.
    - Source Identification Studies – microbial source tracking studies to evaluate whether the indicator bacteria are of human or non-human sources and upstream monitoring to identify the sources of fecal indicator bacteria.
    - Best Management Practice (BMP) Development and Implementation – implementation of programs such as pet waste stations and kennel inspections, followed by additional control measures for high priority sites identified through the characterization monitoring and source identification studies. Pet waste stations have been installed in 14 parks and kennel inspections have been conducted.
    - Effectiveness Monitoring and Plan Assessment – monitoring of the effectiveness of BMPs in reducing fecal indicator bacteria.

  The Pathogen Plan is being implemented in phases with a completion date of 2013. Source identification studies and monitoring to locate the high risk sources within the storm drain system were initiated on Mormon Slough and Smith Canal in January 2006 and will continue until through 2007.

- Requirements for New Developments – The Stormwater Quality Control Criteria Plan (City of Stockton, 2003) describes source control and treatment control measures that must be incorporated into site designs for new development and infill development for projects of a certain size or type. This plan contains a table that lists the effectiveness (high, medium, and low) of various treatment measures (e.g. buffer strips, detention basins) in removing bacteria. However, no data are provided to substantiate the claims that many treatment measures are highly effective at removing bacteria. Developers must submit Project Stormwater Quality Control Plans and Maintenance Plans to the City. The City may also require a maintenance agreement.

- Study on Feasibility of Diverting Dry Weather Flows to the Sanitary Sewer System - The MS4 permit requires the permittees to conduct a study on the feasibility of diverting dry weather urban runoff to the sanitary sewer system. The City and County submitted a treatment feasibility study to the Central Valley Regional Water Board and are awaiting comments.

- Detention Basin Study - Influent, effluent, and sediment chemistry sampling and analysis of three detention basins receiving runoff from industrial, commercial, and residential watersheds were conducted for the second (2003-2004) and fourth (2005-2006) years of the permit. Samples were analyzed for bacteria, turbidity, total suspended solids (TSS), total dissolved solids (TDS), and organophosphate pesticides. The results are inconclusive as to the effectiveness of detention basins in improving the quality of urban runoff (City of Stockton, 2006). In some events, there were reductions in concentrations in one detention basin but increases in concentrations in another basin. Bacteria concentrations were high in all influent and effluent samples. TDS was relatively similar in influent and effluent.

- Media Filter Study - The City installed a media filter at one of their urban runoff pump stations and is currently monitoring to evaluate the effectiveness of the filter in removing metals, pesticides, bacteria, and nutrients.

<u>Eastern Contra Costa County</u>

Contra Costa County, its 19 incorporated cities, and the Contra Costa County Flood Control and Water Conservation District joined together to form the Contra Costa County Clean Water Program to develop and implement a comprehensive storm water program. The county falls within the jurisdiction of both the Central Valley and San Francisco Bay Regional Water Boards. The cities of Antioch, Brentwood, Oakley and eastern Contra Costa County discharge to the Delta and are under the purview of the Central Valley Regional Water Board. The program currently operates under two permits for the two regions. The permit for Antioch, Brentwood, Oakley, and the portion of Contra Costa County that drains to the Delta was issued in 2000 and has been administratively extended by the Central Valley Regional Water Board. The San Francisco Bay Regional Water Board is in the process of developing one comprehensive permit for the entire county. The Central Valley Regional Water Board would then likely adopt that same permit so there would be one program for the entire county. The activities being conducted that are related to drinking water contaminants are briefly described.

- Requirements for New Developments – The program developed a New Development and Construction Controls Program that requires BMPs for new development. The cities of Brentwood, Antioch, and Oakley are not required to implement this program because it has not been included in their permit. They are currently voluntarily doing so (Personal Communication, Christine Sotelo, Central Valley Regional Water Board).

- BMP Effectiveness Studies – The Clean Water Program is conducting studies on the effectiveness of vegetated buffers along roadsides and on upslope eroding areas and a filtration system to prevent contaminants from entering the storm drain system. The results of the studies were not available.

Urban Runoff Quality for Drinking Water Constituents

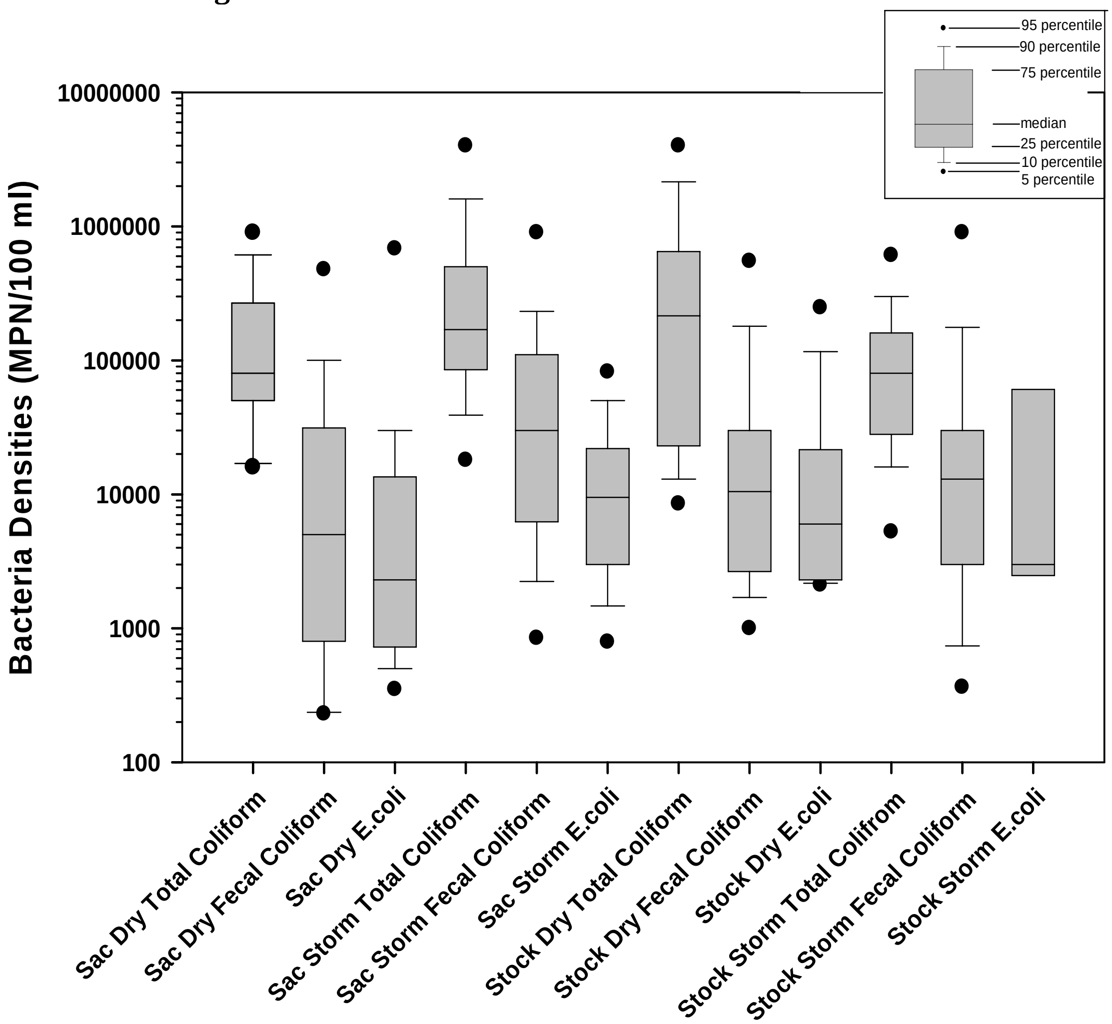
The MS4 permits do not contain effluent limitations for specific water quality constituents but do require municipalities to reduce urban runoff pollution to the maximum extent practicable (MEP) through implementation of BMPs. Water quality data obtained by Sacramento and Stockton over a number of years and from a number of storm drain discharge points are summarized in this section. The Municipal Water Quality Investigations (MWQI) Program staff recently completed a study on the NEMDC in Sacramento. This study is significant because NEMDC is a rapidly urbanizing watershed and it has been extensively investigated for seven years. Information presented in the Initial Technical Report is included in this section (DWR, 2003). MWQI staff is currently analyzing data and producing the final report. Data presented in this section provides a general understanding of the quality of urban runoff in the Central Valley. It should be noted that urban runoff, particularly stormwater, is highly variable during storm events, from one location to another, and from storm to storm.

Pathogens and Indicator Organisms

Urban runoff contains high levels of coliform bacteria, relative to the levels found in receiving waters. Sources of fecal contamination in urban runoff include domestic and wild animals, in addition to human sources from illegal camping, illicit connections to the storm drain system or sewage spills to the storm drain system. Since fecal coliforms are used as indicators of fecal contamination, their presence indicates that urban runoff carries a significant amount of fecal material into the Delta and its tributaries. The primary impact of fecal contamination on water bodies is the potential presence of pathogens that may be associated with feces. The actual amount of pathogens discharged in urban runoff cannot be extrapolated from the indicator organism data.

Figure 4-10 presents the total and fecal coliform and *Escherichia coli* (*E. coli)* data for Sacramento and Stockton dry weather and stormwater runoff. These data indicate that high levels (10,000 to 1 million MPN/100 ml) of all three indicator bacteria are found in both dry weather and stormwater runoff. These data are consistent with the data collected in the NEMDC study.

Figure 4-10. Total Coliform Densities in Urban Runoff



Sacramento has developed a statistically based model for estimating the loads of certain contaminants from Sacramento urban runoff (Armand Ruby Consulting et al, 2005). This effort focused mainly on metals and pesticides but also included *E. coli* bacteria. The report authors cautioned that bacteria are less suitable for this type of numerical characterization because they are subject to die-off and regrowth. The model estimates that the annual loading of *E. coli* bacteria from the Sacramento urban area is 1.58×10^{16} organisms, with most of the load entering receiving waters during storm events. These exceedingly high levels of indicator bacteria are found in urban runoff throughout California and have led the Central Valley Regional Water Board to require additional studies on pathogens in the MS4 permits.

- Sacramento Studies – In 2001 and 2002, samples of dry weather and stormwater were collected from three storm drain channels and analyzed for *Giardia*, *Cryptosporidium*, and pathogenic *E. coli*. These data showed few protozoa detections in dry weather runoff and generally low level detections in wet weather runoff. The exception was high levels of *Giardia* and *Cryptosporidium* in wet weather samples from an early season storm. None of the samples was positive for pathogenic *E. coli* (Montgomery Watson

Harza, 2006). Sacramento is conducting a study to identify the sources of bacteria in urban runoff. The results of this study are not yet available.

- Stockton Studies – In 2005 and 2006, Stockton initiated microbial source tracking studies at several locations in their stormwater system. These studies are designed to determine if the bacteria present in urban runoff come from human or non-human sources. The targeted organism is *Bacteroidales prevotella*, a bacterium found in abundance in the intestines of warm blooded animals. The Stockton studies are being conducted by U.C. Davis researchers who have developed a polymerase chain reaction (PCR) method that can identify bacteria from four source categories (universal – general warm blooded animals; humans; cows and horses; and dogs). Data are presented in the 2006 Annual Report but no conclusions are drawn (City of Stockton, 2006). Universal and human bacteria were detected in every sample, cow/horse bacteria and dog bacteria were detected in some samples.

The International BMP Database is an on-line searchable database on the effectiveness of urban runoff BMPs (www.bmpdatabase.org). The database summary report does not contain any information on the effectiveness of urban runoff BMPS in removing bacteria or pathogens (GeoSyntec Consultants et al, 2006). A brief search of the database did not reveal any information on removals of pathogens and indicator organisms.

<u>Nutrients</u>

Fertilizer usage in urban areas contributes nutrients to urban runoff. Urban runoff also delivers nutrients in leaves, woody debris, and insects that are carried to receiving waters, which degrade and release nutrients. Nutrient concentrations have been monitored in Sacramento and Stockton dry weather and stormwater runoff. These data are presented to give a general sense of the concentrations of nutrients present in Central Valley urban runoff. Total Kjeldahl nitrogen (TKN) includes organic nitrogen and ammonia and is presented in **Figure 4-11.** **Figure 4-12** presents the nitrate data. Total nitrogen is the sum of TKN and nitrate and nitrite. Nitrite data are limited, but available data indicate nitrite concentrations are low (< 0.2 mg/L as N). Total nitrogen (total N) concentrations are quite variable, ranging from about 0.1 to 26 mg/L. Median concentrations of TKN in Stockton and Sacramento dry weather and stormwater runoff range from 1 to 1.8 mg/L. The nitrate data are more variable with higher concentrations in Sacramento dry weather and stormwater runoff than in Stockton. Total P data are presented in **Figure 4-13**. Total P concentrations vary from 0.05 to 3.6 mg/L. Median concentrations range from 0.25 to 0.5 mg/L. The concentrations of nutrients from the NEMDC study are similar to those found in Sacramento and Stockton urban runoff.

The nutrient conceptual model developed for the Central Valley Drinking Water Policy Work Group estimated the loads of nutrients discharged to Central Valley rivers and the Delta (Tetra Tech, 2006a). Based on these preliminary estimates, urban runoff discharged in the Central Valley and Delta constitutes roughly 4 percent of the total N load in both wet and dry years and 3 percent of the total P load in dry years and 4 percent in wet years. The Work Group intends to refine these estimates with additional data.

Figure 4-11. Total Kjeldahl Nitrogen Concentrations in Urban Runoff

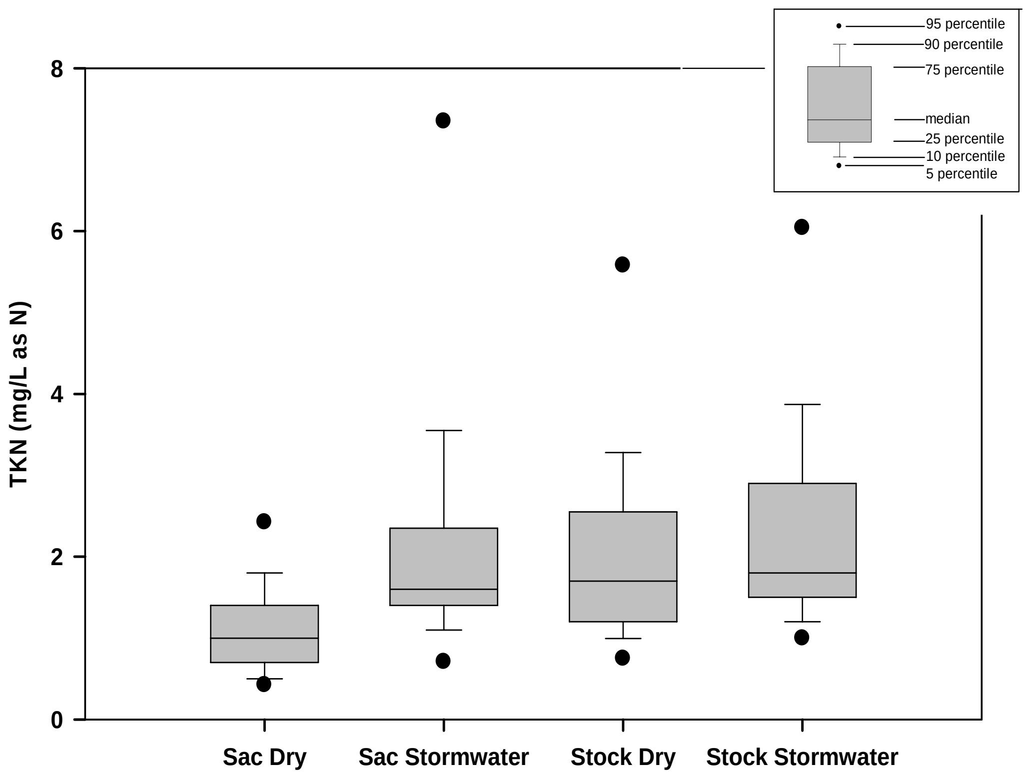


Figure 4-12. Nitrate Concentrations in Urban Runoff

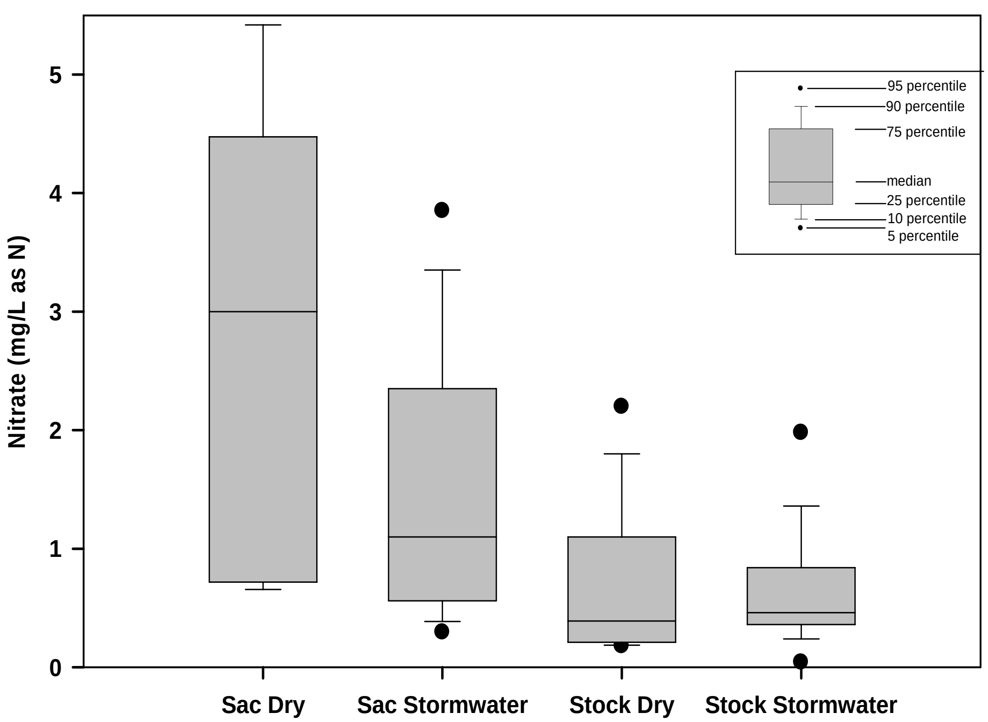
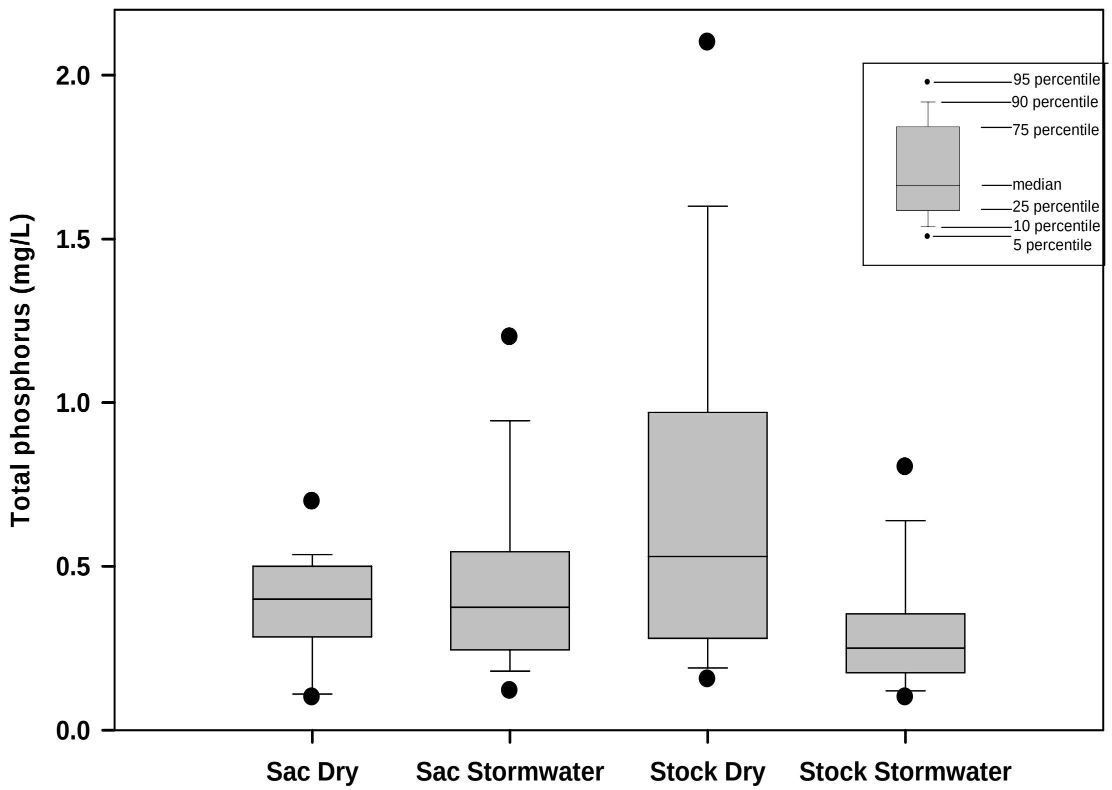


Figure 4-13. Total Phosphorus Concentrations in Urban Runoff

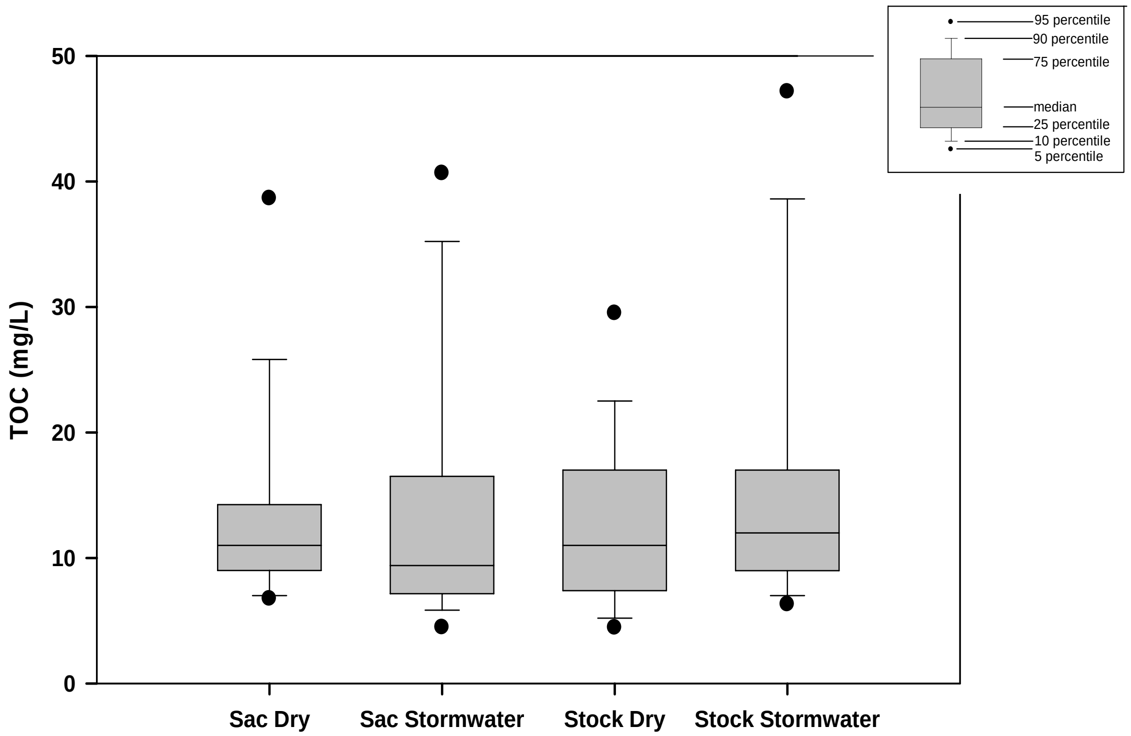


The International BMP Database summary report contains information on the effectiveness of several BMPs in removing total and dissolved N and P (GeoSyntec Consultants et al, 2006). The results vary with the different nutrient species but in general, retention ponds and wetland basins were judged to remove significant amounts of phosphorus and nitrogen.

Organic Carbon

Urban runoff carries organic carbon to receiving waters in a variety of forms ranging from small soil particles to woody debris and small animals, such as rodents. TOC concentrations have been monitored in Sacramento and Stockton dry weather and stormwater runoff, as shown in **Figure 4-14**. The concentrations are quite variable ranging from 3 to 69 mg/L. Median concentrations range from 9.4 to 12 mg/L. MWQI measured TOC by both the oxidation and combustion methods in the NEMDC study. The median TOC concentration with the oxidation method was 6 mg/L whereas the median with the combustion method was 9 mg/L. The TOC concentrations from the NEMDC study were generally lower than those found in urban runoff. The highest concentrations from the NEMDC study were found after high intensity storm events and the lowest concentrations were found during extended dry periods.

Figure 4-14. Total Organic Carbon Concentrations in Urban Runoff



The organic carbon conceptual model developed for the Central Valley Drinking Water Policy Work Group estimated the load of organic carbon discharged to the Delta from the tributaries and in-Delta sources (Tetra Tech, 2006b). Urban runoff was estimated to contribute about 4 to 5 percent of the total load of organic carbon. The loading estimates are currently being refined by the Work Group.

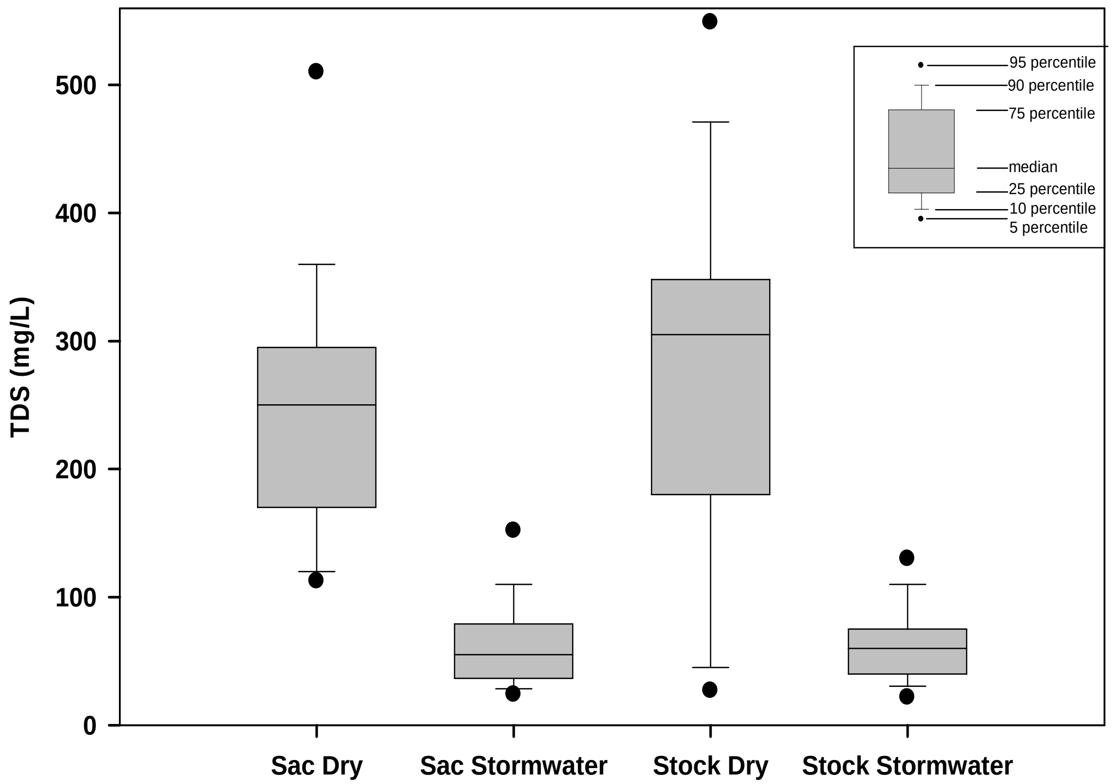
The International BMP database summary report did not contain any information on organic carbon removal. A brief search of the database revealed that several BMPs increased organic carbon or did not remove a statistically significant amount.

<u>Salinity</u>

The TDS concentrations in urban runoff are quite variable as shown in **Figure 4-15**. During the first part of a storm, runoff tends to have higher TDS concentrations as the impervious areas are washed of matter that has accumulated since the previous storm. As the storm progresses, TDS concentrations tend to decrease as there is less material to pick up. California Bay-Delta Program (CALFED) staff is currently preparing a salinity conceptual model for the Central Valley Drinking Water Policy Work Group.

The International BMP database summary report found that all BMPs evaluated either increased TDS or did not produce a statistically significant reduction in TDS between the influent and effluent.

Figure 4-15. Total Dissolved Solids Concentrations in Urban Runoff



POTENTIAL ACTIONS

Support Development of the Central Valley Drinking Water Policy

The technical studies to develop a drinking water policy for the Central Valley are currently underway and, as discussed in Chapter 2, the stakeholder Work Group guiding this effort expects to work with Central Valley Regional Water Board staff to develop an amendment to the Basin Plan that will be considered by the Central Valley Regional Water Board in 2009. Part of this effort includes gaining a better understanding of the impacts of wastewater and urban runoff on drinking water quality. Possible actions the SWC could take to support this effort include:

- Provide financial support of technical studies.
- Provide written and verbal testimony in support of the policy when it is considered by the Central Valley Regional Water Board.
- Provide a forum for discussion of the policy elements with agricultural water districts.

Provide Comments on Waste Discharge Permits and EIRs

The SWC and individual SWP Contractors should review Central Valley environmental documents and tentative waste discharge permits to ensure that drinking water quality impacts on SWP source waters are evaluated.

Encourage Inclusion of Drinking Water Constituents in Studies on Effectiveness of Management Practices

The MS4 permits require municipalities to reduce urban runoff pollution to the MEP through implementation of BMPs. A basic premise of this requirement is that BMPs will improve the quality of urban runoff discharged to receiving waters; however, there are limited data available on the effectiveness of these management measures for organic carbon, pathogens, and indicator bacteria. It is possible that some BMPs designed to remove nutrients may increase the organic carbon concentrations discharged to receiving waters due to growth of algae and vegetation. The SWC should work with the Sacramento, Stockton, and eastern Contra Costa County stormwater permittees and the Central Valley Regional Water Board to ensure that drinking water constituents are included in the monitoring programs for the evaluation of management practices.

Participate in Development of the Salinity Management Plan

The Central Valley Regional Water Board recently received funding from the State Water Board to initiate work on the Salinity Management Plan. The SWC should request that they have a position on the advisory committee for this effort and should work to ensure that salinity discharges from wastewater treatment plants are considered in the plan.

DELTA LAND CONVERSIONS

KEY CONCERNS

In addition to urbanization of the Delta and the Central Valley watershed, two other areas of concern associated with land use have arisen in the Delta. One of the goals of the CALFED Ecosystem Restoration Program is to restore large expanses of all major aquatic, wetland, and riparian habitats to support recovery and restoration of native species. Some Delta farmers are replacing traditional corn and vegetable crops with rice. Both of these activities have the potential to increase the load of organic carbon discharged to Delta waterways and to potentially increase the organic carbon concentrations at Delta pumping plants.

Increased Wetland Acreage

The Ecosystem Restoration Program Plan (ERPP) calls for the restoration of 30 percent to 50 percent of the freshwater tidal wetlands lost from the Delta since 1900. This translates to about 30,000 to 50,000 acres of tidal wetland restoration in the Delta, in addition to restoration of 7,000 acres of shallow subtidal habitat (CALFED, 2000). The ERPP also calls for restoration of 5,000 to 7,000 acres of brackish water tidal wetlands and 1,500 acres of shallow subtidal habitat in Suisun Marsh and Suisun Bay. Tidal wetland restoration is intended to provide habitat for fish and other organisms and to improve ecosystem productivity through export of organic carbon in algae and plant detritus from the wetlands.

The impact of tidal wetland restoration on drinking water supplies is being evaluated in various studies conducted by the U.S. Geological Survey (USGS). Based on a review of the literature, Jassby and Cloern (2000) estimated an export rate of 150 $gC/m^2/yr$ and estimated that there are 8,150 acres of tidal wetlands in the Delta. The USGS has conducted studies on a managed wetland on Twitchell Island but the data have not yet been published. Preliminary export rates are 140 $gC/m^2/yr$ annual average; 124 $gC/m^2/yr$ for the Dec-Apr period; and 150 $gC/m^2/yr$ for the May-Nov period (Personal Communication, Jacob Fleck, USGS). USGS scientists have cautioned that the export rates from flooded wetlands on Twitchell Island may not be representative of the flux of carbon out of a tidal wetland. USGS is currently conducting a study of the carbon flux out of a natural tidal wetland on Brown’s Island; however, the results are not yet available.

The organic carbon conceptual model developed for the Drinking Water Policy Work Group used the literature value of 150 $gC/m^2/yr$ and the 8,150 acres of tidal wetlands and estimated that 5,000 tons of organic carbon is released from the Delta tidal wetlands to the surrounding waters each year (Tetra Tech, 2006b). Other in-Delta sources estimated for the conceptual model included agricultural drainage (14,800 tons/yr) and primary productivity in Delta channels (7,000 tons/yr). These are preliminary estimates that will be refined based on on-going studies and data collection efforts.

The impact of tidal wetland restoration on organic carbon concentrations in water diverted from the Delta will depend on the location of the wetlands relative to the water diversion locations and on the relative quantity and quality of the carbon from the wetlands compared to the previous land use of the restored wetland. CALFED does not maintain readily available information on the locations and acreage of restored wetlands in the Delta (Personal Communication, Lisa Holm, CALFED). Based on a review of several CALFED documents, most of the restoration activity appears to be taking place in the western Delta, Suisun Marsh and the Bay and not in close proximity to southern Delta pumping plants that supply water to the SWP (CALFED, 2005 and 2006). The USGS studies are looking at the reactivity of carbon exported from the wetlands on Twitchell Island but the results are not yet available.

Conversion to Rice in the Delta

The predominant crops grown in the Delta are corn and other field and vegetable crops, but some farmers are beginning to grow rice. CALFED funded a project to evaluate the water quality impacts of converting from corn to rice (Bachand & Associates et al, 2006). The information presented in this section is taken largely from the draft final report. Factors that could result in increased rice acreage in the Delta include:

- Rice varieties have recently been developed that are suitable for Delta climatic conditions.
- Economic analyses indicate that rice is more profitable than corn.
- Studies on wetlands at Twitchell Island suggest that rice production may help mitigate subsidence on peat islands.
- Incorporating rice into a crop rotation may help control crop specific weeds and nematodes.
- Flooded rice fields may benefit birds.

Rice requires an entirely different water management scheme than row crops such as corn. Corn is irrigated during the growing season but it is necessary to keep the root zone relatively dry and aerated. Excess irrigation water seeps down into the shallow groundwater and drains to the drainage ditches alongside the fields. This water is then pumped into Delta channels during the summer months. Root zone aeration results in biochemical oxidation of the soil organic matter, which results in dissolved organic carbon (DOC) production and subsidence of the land surface. DOC produced during the dry season is mobilized by flooding of Delta islands during the winter and early spring months to leach salts from the agricultural soils. Rainfall onto the islands also mobilizes DOC. This DOC is pumped into Delta channels.

In the Delta experimental plots, rice fields were flooded in the spring of 2004 when the rice plants were approximately 6 inches high and remained flooded throughout the summer. The fields were drained in September prior to harvest. Following harvest, the fields were flooded in December to decompose rice straw and provide wildlife habitat. The fields were drained in March 2005 and prepared for planting. The fields were flooded again and then drained in September 2005. The authors of the CALFED study hypothesized that flooding fields for rice production could eliminate subsidence and reduce the load of carbon discharged to Delta channels. This hypothesis was derived from a study on Twitchell Island that showed that a field flooded from early spring to midsummer had carbon outputs approximately equal to carbon inputs. It should be noted that DWR's experience with the Jones Tract levee failure produced entirely different results. Flooding of Jones Tract resulted in high carbon concentrations in the water pumped from the island for a prolonged period of time (see Chapter 6).

The CALFED study attempted to quantify the surface and subsurface loads of DOC, trihalomethane formation potential (THMFP), nitrate, ammonia, and TDS from 100-acre rice fields on Bouldin Farms on Bouldin Island in the central Delta and Muzio Farms on Wright-Elmwood Tract in the southeastern Delta. **Figure 4-16** shows the locations of the two islands. The DOC results are discussed in this section. There is seepage from shallow groundwater and surface runoff into the drains that drain the fields on both islands. DOC concentrations and loads from both sources were measured. Loads were calculated for the following conditions:

- Corn - Traditional Delta crop.
- New Rice, High Drainage – Rice fields planted in 2004 where the water in the drainage ditch was maintained at a high level.
- New Rice, Low Drainage – Rice fields planted in 2004 where the water in the drainage ditch was maintained at a low level.
- Old Rice **–** Rice fields planted in 2003.

The hypothesis was that maintaining the water at a high level in the drainage ditches would reduce the hydraulic gradient and result in lower subsurface flows to the drain.

Figure 4-17 presents the mean DOC concentrations in surface drainage and **Figure 4-18** presents the concentrations in subsurface drainage from the different fields on Bouldin Island. The DOC data for Bouldin Island are presented in this section because Bouldin Island soils have a higher peat content than those of Wright Elmwood Tract and therefore a greater potential to impact Delta drinking water quality. The mean surface water drainage concentrations of DOC varied from year to year and between the different fields with no apparent difference between the fields. There was no surface drainage from the corn field. Subsurface DOC concentrations also showed considerable variability. The mean concentrations from the corn field varied between 7.6 and 16.8 mg/L compared to a range of 18.4 to 83.9 mg/L from the rice fields.

Figures 4-19 and 4-20 present the surface and subsurface loads of DOC from the fields. The authors of the study acknowledged that managing and accurately measuring flows on Bouldin Island was difficult, especially for the subsurface flows, so the results should be considered preliminary. The subsurface DOC load from the corn field was lower than the loads from any of the rice fields and there was no surface load from the corn field because there was no surface drainage. These preliminary data indicated that drainage from rice fields is considerably higher in DOC than from corn fields.

Figure 4-16. Locations of Experimental Rice Plots

Adapted from Bachand & Associates et al, 2006

Table 4-6 presents the median DOC loads measured for Wright Elmwood Tract. The report authors were more confident of the loads from Wright Elmwood Tract because it was easier to measure flows off of the fields. As with Bouldin Island, the load of DOC from rice fields is higher than from corn fields. Surface loads from rice fields had a median of 250 g/acre/day whereas corn fields did not have any surface runoff. During the second year of the study, surface flows on the island were managed and there was a substantial decrease in the surface loads (Personal Communication, Phil Bachand, Bachand & Associates). The subsurface loads of DOC for corn were lower than rice when the drain water level was low. When the water in the drain was regulated to keep it at a high level, the subsurface load of DOC was eliminated. Better management of surface flows and maintenance of high water levels in the drains have the potential to reduce the overall load of DOC from rice fields.

Figure 4-17. DOC Concentrations in Bouldin Surface Water Drainage

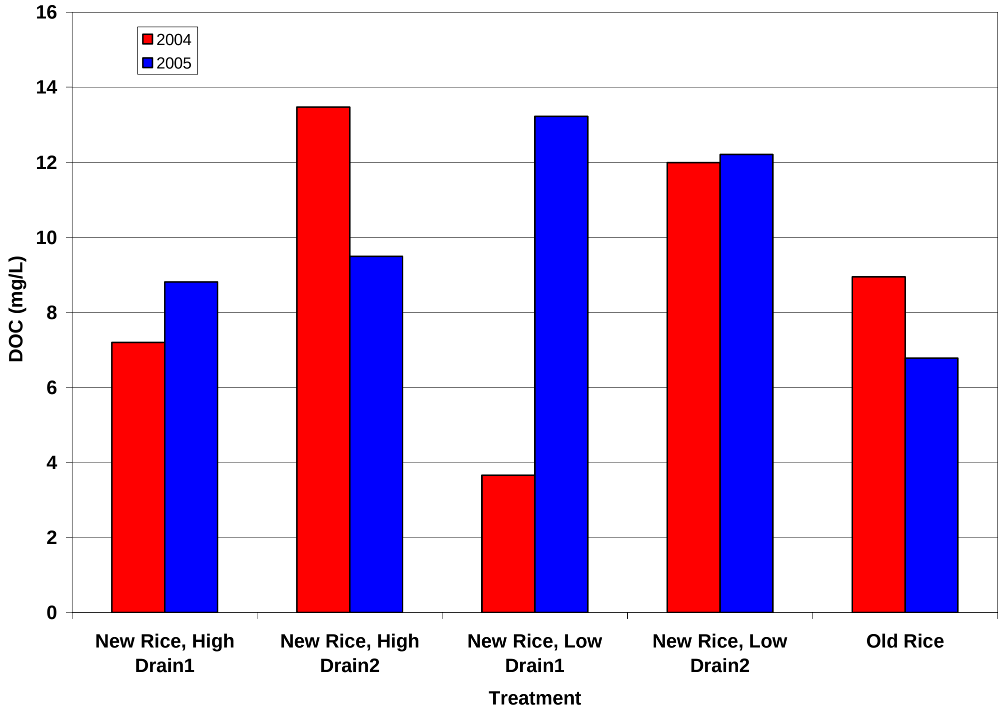


Figure 4-18. DOC Concentrations in Bouldin Subsurface Drainage

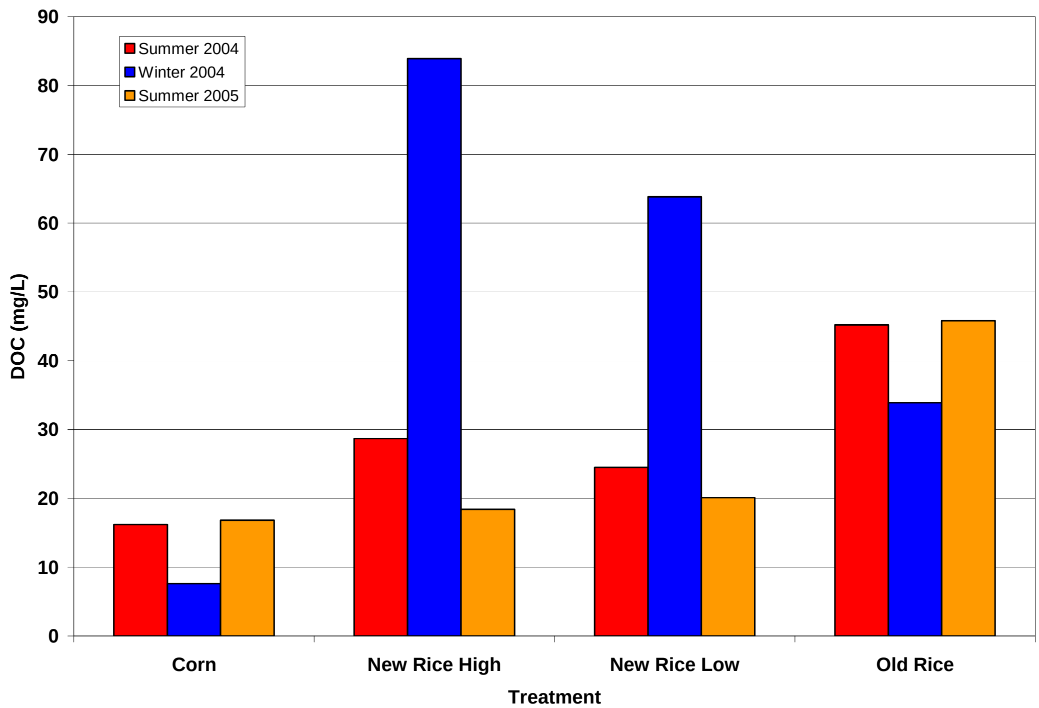


Figure 4-19. Net DOC Loads in Bouldin Surface Water Drainage

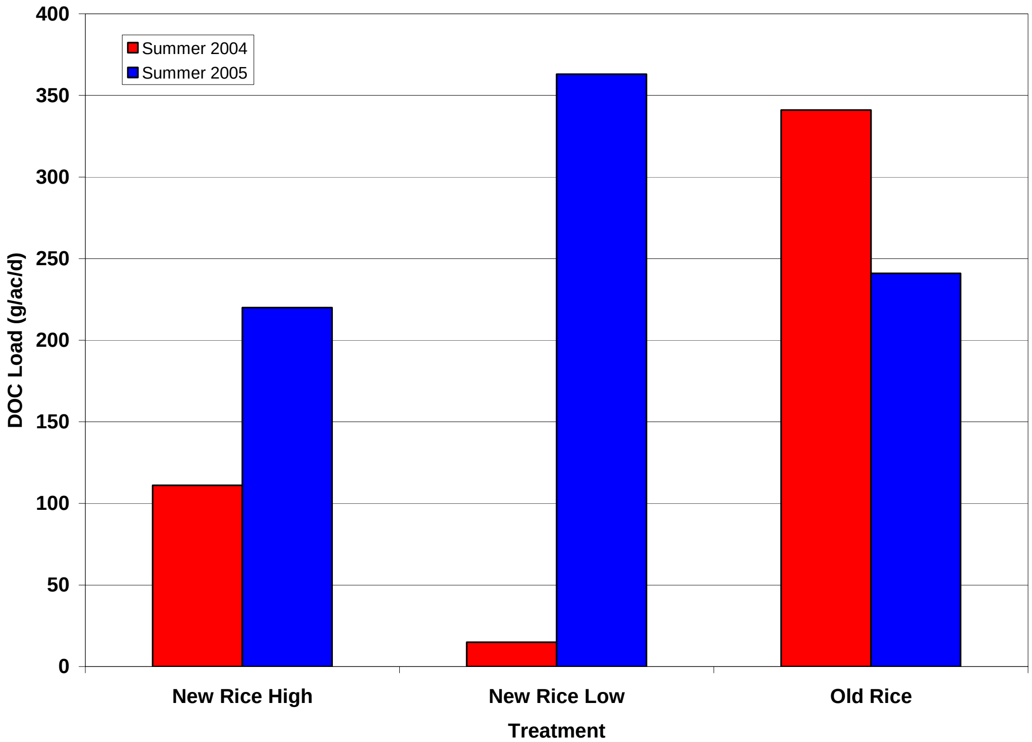


Figure 4-20. DOC Loads in Bouldin Subsurface Water Drainage

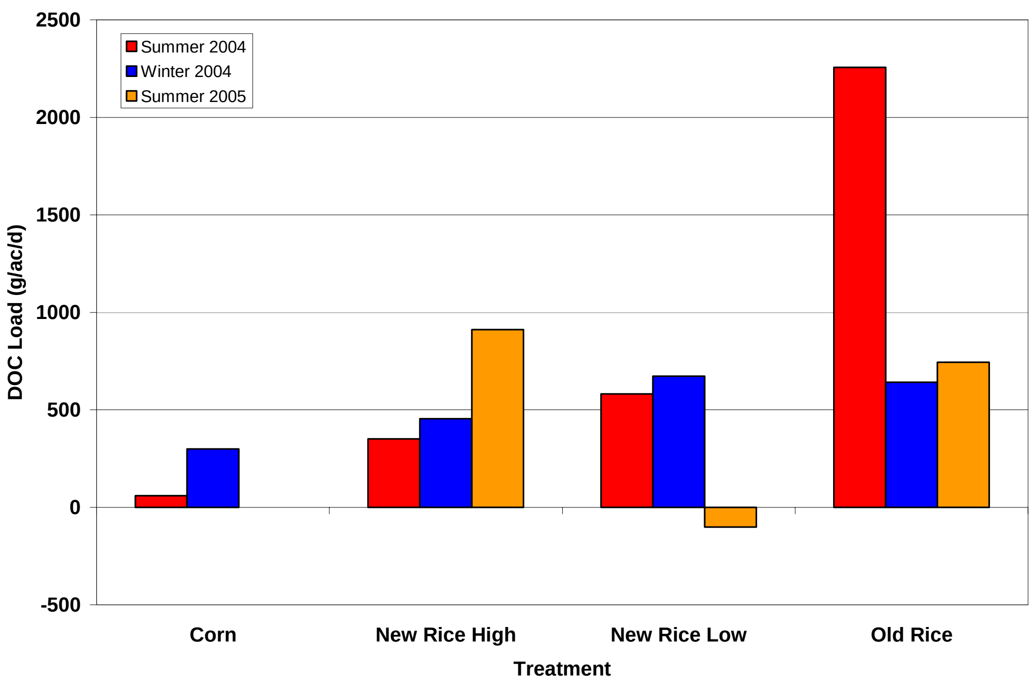


Table 4-6. DOC Load from Corn and Rice Crops

Crop	Median DOC Load (g/acre/day)	
	Surface	Subsurface
Corn	0	31
Rice with Low Water Level	250	122
Rice with High Water Level	250	0

The loads presented in **Table 4-6** are median loads from the fields, calculated from a number of instantaneous measurements, so they do not represent annual loads to the Delta. These results should be considered preliminary since this is the first study evaluating the loads from rice fields in the Delta. The impact on Delta water quality would depend on how well the water is managed on the rice fields and how much of the drainage is pumped off of the island versus held on the island and used to maintain flooded conditions on the rice fields or to irrigate other crops on adjoining fields. Converting to rice fields would also impact the timing of the discharges to the Delta since more water would be retained on the fields during the summer months but large amounts of water would be discharged in September and early spring.

POTENTIAL ACTIONS

Support Research on Management Practices

Conversion of corn fields to rice fields may adversely affect Delta water quality but the SWP Contractors have no control over which crops are planted by Delta farmers. The SWP Contractors should encourage DWR to support research to evaluate management measures that would reduce the load of organic carbon discharged from rice fields. Since the load of carbon discharged from agricultural islands in the Delta is largely dependent upon how water is managed on the island, efforts to better manage water for any agricultural crop should be supported.

Support Farmer Education

If effective BMPs are developed, the SWP Contractors could work with the University of California Cooperative Extension and Ducks Unlimited to urge them to educate Delta farmers on the importance of minimizing the loads of DOC pumped off of Delta islands into the channels. The San Joaquin Cooperative Extension has been working with growers who are interested in growing rice in the Delta. Ducks Unlimited has found funding sources to aid growers in their conversion to rice production, and has provided expertise in rice agronomic practices to growers throughout their conversion process.

RECREATIONAL USAGE OF THE DELTA

KEY CONCERNS

Approximately two million people visit the Delta annually to boat, fish, water-ski, and participate in other recreational activities along the Delta's waterways. In addition to distinct water-based activities, the Delta also provides a resource for water-enhanced recreation such as hiking, camping, hunting, and picnicking, which also have impacts on water quality in the Delta. Recreational usage of the Delta occurs throughout the year but is most significant on weekends between Memorial Day and Labor Day, with peak usage over the Fourth of July weekend. Demand for recreational usage of the Delta is expected to increase as the population of communities in and near the Delta grows. Annual visitor days are projected to grow from 6.5 million in 2000 to 7.8 million in 2020 (Dangermond, 2006).

Recreational usage of the Delta can contribute trace metals from boat hull paints; petroleum hydrocarbons from fueling, spills, and fuel combustion from outboard motors; and pathogens from boat sewage discharges and personal sanitary habits. As discussed in Chapter 3, the release of methyl tertiary butyl ether (MTBE) from boat engines is no longer a concern since its usage has been phased out in California. Other petroleum hydrocarbons are still released into Delta waters but hydrocarbon contamination of Delta water supplies has not been identified by the Technical Review Committee as a significant concern. The primary impact of recreation on Delta water supplies is the release of human pathogens through body contact recreation and dumping of sewage from boats.

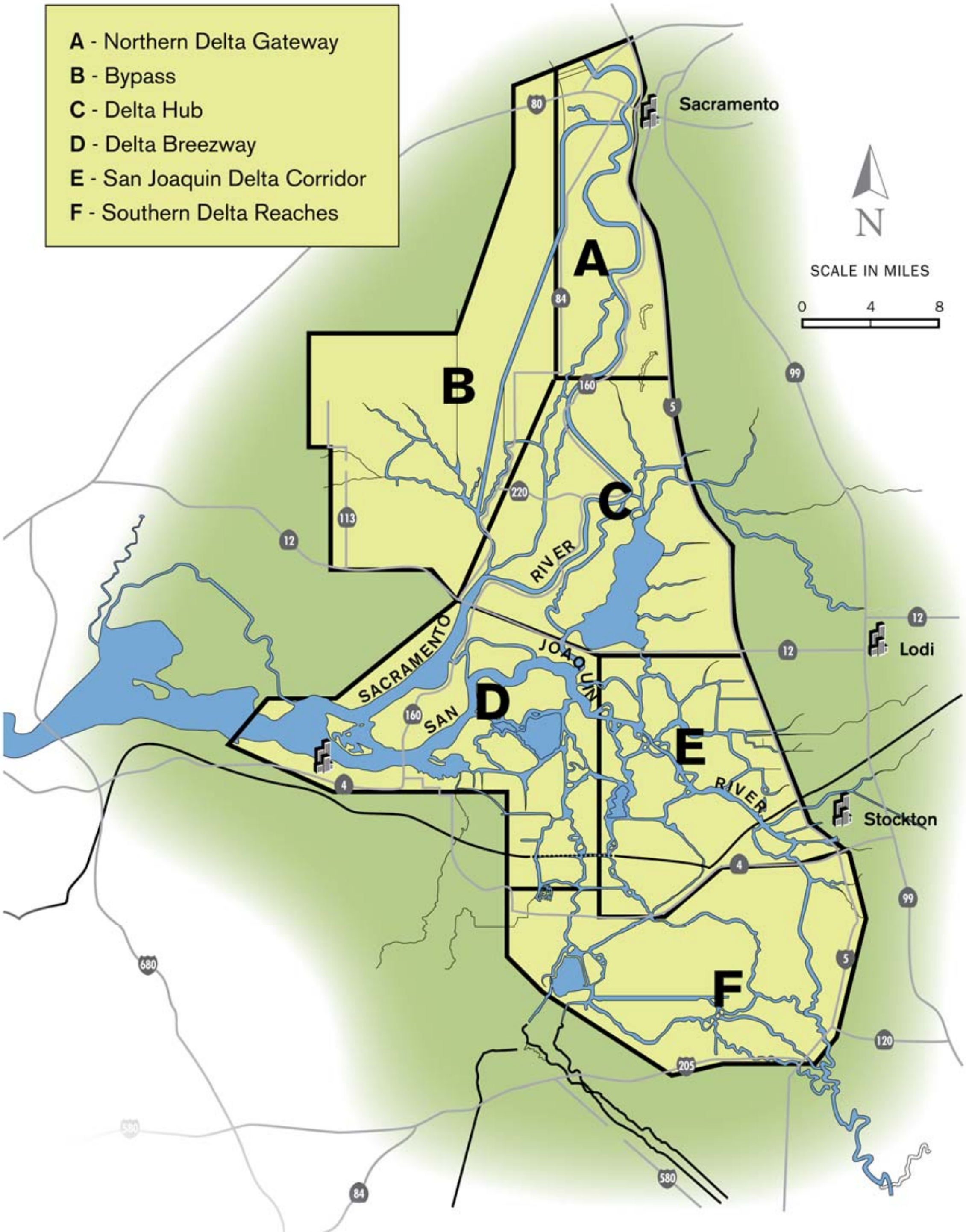
Recreational Zones

The Delta Protection Commission recently completed a strategic plan for Delta recreation (Dangermond, 2006). This report identified six recreational zones, as shown in **Figure 4-21**.

- Northern Delta Gateway – This zone includes the Sacramento River Corridor from the City of Sacramento to the community of Courtland. There are eight marinas with a total of 988 boat slips. Recreational activities include boating, water skiing, use of personal watercraft, and fishing.

- Bypass - Yolo Bypass, Cache Slough, and parts of the Sacramento Deep Water Ship Channel comprise this zone. There is one marina that provides 76 boat slips. Boating is not the primary use of this zone, as the Bypass is not safe for this type of activity. The predominant forms of recreation in this zone are fishing, hunting for waterfowl, and wildlife viewing.

Figure 4-21. Delta Recreational Zones



- Delta Hub – This zone includes the north central portion of the Delta, and contains Miner's Slough, Steamboat Slough, Sutter Slough, Snodgrass Slough, Georgiana Slough, and portions of the Mokelumne River and Sacramento River. There are 12 marinas in this zone, providing approximately 1,271 boat slips. In addition, there are numerous boating-associated facilities and clubs in this area, including boat accessed restaurants, resorts, and yacht clubs. The predominant recreational uses in this zone are boating, fishing, water-skiing, boat camping, and sailing.

- Delta Breezeway – This zone encompasses the western limits of the Delta and provides direct access to both San Pablo Bay and San Francisco Bay. The Breezeway is the most commonly used zone for boating. There are 56 marinas with 5,990 boat slips.

- San Joaquin Delta Corridor – This zone is comprised of the Southeastern part of the Delta. There are 13 marinas in this zone, providing 2,786 boat slips. In addition, there are also a few private yacht clubs. This zone is primarily used for shore fishing and leisurely travel of the waterways.

- The Southern Delta Reaches – This zone is comprised of the entire southern portion of the Delta. There are 5 marinas, providing 563 boat slips in this zone. Recreational activities include water-skiing, wakeboarding, and fishing. There are substantially fewer recreational opportunities in this zone compared to the more northern zones.

Water Quality Impacts

Several waterways in the eastern Delta near Stockton are listed as impaired for bacteria and/or pathogens. Potential sources of impairment are listed as Stockton urban runoff and recreation (State Water Board, 2002 and 2006). Another potential source is the frequent spills of untreated and partially treated wastewater (see Chapter 6). DeltaKeeper used volunteers to collect total coliform and *E. coli* data in Stockton area waterways, the San Joaquin River, local marinas, and other recreational areas between 2000 and 2004. The samples were analyzed at DeltaKeeper's laboratory. The focus of this effort was on the quality of water for recreational purposes rather than to identify the impact of recreation on drinking water quality. The data indicate that high levels of total coliforms (maximum of 242,000 MPN/100 ml) and *E. coli* (maximum of > 48,384 MPN/100 ml) are found in the Delta waterways around Stockton. In general, the highest levels were found in sloughs impacted by urban runoff from Stockton and lower levels were found near several Delta marinas that were monitored. Although high levels of indicator bacteria have been found in waterways near Stockton, the indicator bacteria data that have been collected at the pumping plants that supply the SWP are much lower, and the levels of indicator bacteria at SWP Contractors' intakes are also much lower, as discussed in Chapter 3. In addition, the SWP Contractors who have conducted monitoring for *Cryptosporidium* have had few, if any, detections and will likely be placed in Bin 1 of the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) and will not be required to provide further removal or inactivation (see Chapter 3).

There are many sources of pathogens and indicator organisms in Delta waters, including recreation, discharges of treated wastewater, faulty septic systems, urban runoff, animal operations such as dairies, and wildlife. Although the contribution from recreation has not been quantified relative to other sources of contamination, those working in various aspects of recreation management consider recreation to be a source of human pathogens. Sources of human pathogens due to recreation can be attributed to three areas:

- Recreational Users - The Delta is primarily used for boating and associated body-contact recreation such as water-skiing. There are few swimming beaches in the Delta. Pathogens are introduced to Delta waterways through shedding and personal sanitary habits during body-contact recreation and through dumping of untreated wastewater from boats. Even boats with marine sanitation devices (MSDs) may be sources of pathogens if the devices are not adequate or properly maintained. Sewage from boats is concentrated because MSDs use little water for flushing. Surveys conducted for the Delta Protection Commission found that there are few public restrooms in the Delta and 60 percent of Delta boaters consider the number of restrooms inadequate (California Department of Parks and Recreation, 1997).

- Marinas and Liveaboards – Inadequate facilities or improper handling of sewage at marinas can be a source of pathogens. Liveaboards are people who live on their own boats or with the boat owner's permission. Some marinas allow people to live on boats that are moored at the marina, often permanently. Some marinas have adequate restroom and pumpout facilities; however, some marinas have no restroom or pumpout facilities so liveaboards use the Delta to dispose of their waste. There are also people living on boats that are moored to private property.

- Abandoned Vessels and Squatters –Another problem is squatters living on abandoned derelict boats. Some boat owners illegally abandon their boats in Delta channels rather than paying to properly dispose of them when they are no longer wanted. The abandoned boats are often not seaworthy and do not have adequate restroom facilities, therefore sewage is routinely dumped overboard.

Existing Programs to Protect Water Quality in the Delta

The Clean Water Act prohibits untreated vessel discharge in U.S. waters and the Porter Cologne Act prohibits untreated sewage discharges throughout the state. Marinas and recreational boating are considered nonpoint sources of pollution and are regulated by the State Water Board's Nonpoint Source Program. The Central Valley Regional Water Board has the authority and responsibility to enforce these acts but lacks staff resources to operate a program to inspect boats or take enforcement actions against illegal dumpers. Enforcement of existing laws has been mainly by local agencies. Local agencies that patrol the Delta are the five county sheriff departments and the police departments of the cities of Sacramento and West Sacramento.

Under current law, law enforcement officers can inspect a boat to determine if it has an operating MSD. If the boat has a working MSD, there is nothing else that can be done regardless of whether the officers believe the boat is not capable of traveling to a pumpout facility. Law enforcement officers must observe dumping of sewage or must have photos or video from a witness before any further action can be taken. Due to limited staffing associated with enforcing existing laws, there is virtually no chance that a law enforcement officer would actually observe a dumping incident. Programs aimed at reducing the discharge of untreated sewage into Delta waterways have focused on recreational boater education and marina operations. There has also been state legislation and local ordinances to address the issue of derelict boats.

<u>Recreational Boater Education</u>

There are a number of boater education programs that provide information on boating safety, proper disposal of hazardous wastes, and proper sewage handling facilities.

- California Clean Boating Network – This program, established by the California Coastal Commission (Coastal Commission) in 1995, consists of a collaboration of government, environmental, business, boating, and academic organizations working to improve clean boating education efforts in California. They publish a quarterly newsletter, "The Changing Tide" which aims to educate boaters about clean boating in California.

- Boating Clean and Green Campaign - This program is a statewide boater education and technical assistance program conducted by the Coastal Commission in partnership with the California Department of Boating and Waterways (Boating and Waterways) that promotes environmentally sound boating practices to marine businesses and boaters. Most of the funding is from the California Integrated Waste Management Board's Used Oil Program so the focus has been on oil and recycling issues. The program distributes boater kits, participates in boat shows, posts signs at boat launch ramps, provides displays at marinas, advertises in boating publications and trains Dockwalkers. Dockwalkers are volunteers trained to talk to other boaters about clean and safe boating.

- Contra Costa County Watershed Program (CWP) – The CWP obtained grant funding from Proposition 13 for the Marina and Recreational Boating Program, entitled "Keep the Delta Clean, You Play In It, You Drink It Too!" The CWP teamed with the Coastal Commission and Boating and Waterways to implement the program. The CWP is working with five pilot marinas to establish pollution prevention policies that include sewage pump-outs. The primary focus of the program is boater education and prevention of spills or purposeful disposal of hazardous materials such as motor oil. The CWP teamed with volunteer Dockwalkers to distribute free boater kits in the Delta. The kits included a Delta map showing the locations of marinas with sewage pumpout facilities and providing advice on proper handling of sewage. The program includes monitoring at marinas for pathogens but the data could not be obtained. The Coastal Commission has recently been awarded additional grant funding to extend this program into other Delta counties (Personal Communication, Vivian Matuk, Coastal Commission).

- The Estuary Project - Funded by Clean Vessel Act funds administered by Boating and Waterways, this program focuses on location, use, and grant funds for pumpouts as well as MSD information and requirements. It publishes materials for distribution including fact sheets, maps showing locations of pumpouts and dump stations, a slide show, and a bill insert.

- Boating and Waterways Media Campaign – Boating and Waterways funds an ongoing media campaign devoted to comprehensive boater safety. The program puts on a Lakes and Reservoirs Appreciation Week every year, at which environmentally mindful ways of enjoying lakes and reservoirs are promoted. The program also airs radio advertisements that focus on boater safety, including messages on sewage pollution prevention.

- The Sacramento River Pumpout and Restroom Public Education Campaign – This program is funded by the City of Sacramento, the City of West Sacramento, East Bay Municipal Utility District, and the Sacramento County Department of Water Resources. The campaign focuses primarily on identifying and promoting the use of pumpouts and restrooms in Sacramento area waterways. The program includes partner marinas flying flags that show the location of their pumpouts, and distribution of maps showing the location of pumpouts and restrooms at marinas, boater events, and through boat stores.

Marina Operations

Boating and Waterways administers a grant program that reimburses private marina owners and local governments for 75 percent of the cost for construction, renovation, operation, and maintenance of pumpout and dump stations that are open to the public. The goal of the program is to reduce discharge of vessel sewage into the state's waters.

There is a considerable amount of information available to marina operators on how to operate an environmentally sound clean marina.

- The Nonpoint Source Plan includes 16 voluntary management measures for new and expanding marinas (State Water Board et al, 2000). Two of the management measures deal with the design and maintenance of sewage facilities at marinas. The California Nonpoint Source Encyclopedia provides guidance on identification and implementation of management practices to protect water quality from nonpoint sources (Tetra Tech, 2006c). This document has a section devoted to marinas.

- In 2003, the San Diego Regional Water Board issued a draft NPDES permit for recreational boat marinas due to concerns that marinas were a significant source of unregulated contaminants. In response to the draft permit, marina operators worked with the San Diego Regional Water Board to develop a Clean Marina Program that is administered by the Marina Recreation Association. This program relies on marinas to voluntarily implement management measures and apply for certification as a clean marina. A certification checklist and guidance document was developed to assist marina owners in obtaining certification. Once obtained, the certification is good for three years. The program has expanded throughout California. Forty-two marinas have been certified, mostly in the San Diego and Los Angeles areas. No Delta marinas have been certified. Many Delta marinas are small and have no incentive to pay the $250 fee to become certified even if they are operating in an environmentally safe manner (Personal Communication, Vivian Matuk, Coastal Commission).

- The California Coastal Commission developed a Clean Marina Toolkit to provide marina operators with information on management measures they could voluntarily implement to operate a marina with minimal impacts on water quality (Coastal Commission, 2004). The Toolkit also contains fact sheets and other public information materials, including a fact sheet on sewage.

Sewage Management Strategies from the California Clean Marina Toolkit

The following strategies can help reduce overboard discharges of raw or poorly treated sewage.

- Select appropriate sewage disposal systems for the types of boaters at your facility (tenants and guests).
- Select a convenient and accessible location for sewage pumpouts and dump stations.
- Have an attendant available for the sewage pumpout to encourage usage and to educate boaters about proper use of the equipment.
- Regularly maintain and inspect the pumpout system to keep it in good working order.
- Decide whether or not a fee will be assessed.
- Provide adequate, convenient, and comfortable shower and restroom facilities.
- Provide adequate sewage management services for liveaboards.
- When you offer public sewage pumpout services, make sure they are identified in maps, boating publications, and other boating resources.
- Educate boaters about sound sewage management practices.
- If boat sewage discharge is severely affecting water quality in and around your marina, consider working with government agencies to declare your harbor a No-Discharge Area (once adequate sewage pumpout facilities are in place).

Abandoned Vessels

There are several state and local programs that address the issue of abandoned vessels and squatters. Boating and Waterways administers the Abandoned Vessel Abatement Program that provides grants to public agencies to remove, store, and properly dispose of abandoned vessels that pose a substantial hazard to navigation. As of the end of 2004, almost $2.8 million had been awarded to local agencies to remove 427 abandoned vessels throughout the state. Contra Costa County has prepared grant proposals and been awarded funds to remove abandoned boats in its portion of the Delta but the other Delta counties have not been as active. One of the obstacles is the lack of staff to prepare grant proposals so the Delta Protection Commission has organized an abandoned vessels group to address some of these issues (Personal Communication, Vivian Matuk, Coastal Commission).

Efforts to prevent abandonment of boats and address untreated sewage dumping have also been pursued, primarily by Assembly Member Canciamilla.

- Assembly Bill (AB) 2362, which became law in 2003, authorized law enforcement officers to inspect boats to determine if they have operating MSDs and to introduce dye tablets into holding tanks to determine if they are leaking. This legislation was originally more comprehensive. The bill addressed squatters by making it a misdemeanor to anchor and moor un-seaworthy boats. It explicitly authorized local law enforcement officers to remove un-seaworthy vessels when the vessel posed a threat to water quality. The bill also addressed problems with liveaboards by making it a misdemeanor to be a liveaboard without authorized liveaboard status, through a permit program run by counties. These more comprehensive provisions were not passed by the Legislature.

- AB 1014 required Boating and Waterways to establish an Abandoned Vessel Advisory Committee in 2003 to develop strategies to address boat abandonment. It resulted in passage of AB 716 in 2005 which makes it easier for local agencies to remove and dispose of abandoned boats. The law increased penalties for abandoning a boat, reduced the waiting time before a local agency can sell a boat at auction, and made boats operating with registration expired for more than one year one of the criteria for removing a boat from a waterway. Boating and Waterways plans to reconvene the advisory committee to examine recommendations it made on establishing a pilot vessel turn-in program.

A couple of local ordinances have been passed and one is currently being developed.

- Contra Costa County – After Bay Area counties adopted ordinances to restrict mooring of vessels, squatters, and liveaboards, there was a migration of squatters and liveaboards into Contra Costa County in the eastern Delta. In response, the County passed an ordinance that restricts mooring of vessels in waterways to 96 hours with the exception of houseboats and liveaboards that meet certain requirements. A houseboat or liveaboard can be moored at marinas or permitted docks if it is capable of self-propelled navigation and has an operable MSD or is connected to a sewer system at a marina. A properly equipped houseboat or liveaboard can also be moored in a waterway for up to 30 days if it does not impede navigation.

- City of Sacramento – The City has an ordinance that prohibits the discharge of sewage into waterways, prohibits anchoring or mooring vessels that are not seaworthy, and requires an anchorage permit for anchoring longer than 30 days. Permitted boats must maintain a sanitation log and discharge sewage to a pumpout every four days. This ordinance only covers the part of the Delta that is within the jurisdiction of the City of Sacramento (Sacramento River between I Street Bridge and Freeport). This ordinance has resulted in the removal of derelict boats from the area.

- Sacramento County – A county ordinance is being developed that is modeled after the Contra Costa County ordinance.

A local law enforcement officer who was contacted believes that there has been an increase in the number of abandoned boats, liveaboards, and squatters in the Delta in recent years due to enforcement of regulations in the Bay Area. He believes a state ordinance is needed or all of the Delta counties need equally stringent local ordinances to effectively deal with abandoned boats and squatters (Personal Communication, Sergeant Charlie Slabaugh, Sacramento County Boat Patrol.

POTENTIAL ACTIONS

Send Letters of Support to Coastal Commission and Boating and Waterways

There are existing programs aimed at educating boaters and marina operators in the proper handling of human wastes and there are on-going efforts to better control and manage abandoned boats and squatters. The SWP Contractors could send letters of support to the Coastal Commission and Boating and Waterways to alert these agencies to the fact that their programs to protect water quality are important to the SWP Contractors. The letters of support could offer to support these agencies in obtaining funding for their programs.

Contact Delta Protection Commission to Discuss Abandoned Vessels

The Delta Protection Commission would like to have a Delta-wide approach to regulating and removing abandoned vessels. The SWP Contractors could contact the Delta Protection Commission to discuss how the water providers can best support the Commission’s efforts.

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CHAPTER 5

Key Concerns with State Water Project Facilities

CALIFORNIA STATE WATER PROJECT
WATERSHED SANITARY SURVEY
2006 UPDATE

Key Concerns with State Water Project Facilities

CHAPTER 5
KEY CONCERNS WITH STATE WATER PROJECT FACILITIES

Previous sanitary surveys of the State Water Project (SWP) have documented the potential contaminant sources in the watersheds. As a result, the SWP Contractors have initiated a number of programs to improve water quality. The Technical Review Committee (TRC) for the 2006 Update identified the following issues for discussion and analysis as part of this sanitary survey:

- North Bay Aqueduct (NBA) - Efforts to improve the quality of water provided to the NBA Contractors.
- South Bay Aqueduct (SBA) – Efforts to better understand the contaminant sources in the SBA watersheds and the continuing concerns of algal growth, cattle grazing and a proposed trail along the SBA.
- San Luis Reservoir - Efforts to improve the reliability and quality of water delivered to Santa Clara Valley Water District (SCVWD).
- Non-Project Inflows – The impact of groundwater and surface water inflows on water quality in the California Aqueduct.
- Castaic Lake – Efforts to address cattle grazing in the watershed and bird roosting on the lake.
- Lake Perris – Efforts to address recreational usage, the anoxic hypolimnion, and seismic hazards.

NORTH BAY AQUEDUCT

The NBA serves as a municipal water supply source for a number of municipalities in Solano and Napa counties. The Solano County Water Agency (SCWA) and the Napa County Flood Control and Water Conservation District are wholesale buyers of water from the SWP. This water is delivered to Travis Air Force Base and the cities of Benicia, Fairfield, Vacaville, Vallejo, Napa, and American Canyon via the NBA, a 27.6-mile long underground pipeline. Water is pumped from Barker Slough into the NBA at the Barker Slough Pumping Plant. Barker Slough is a tidally influenced slough which is tributary to Lindsey Slough. Lindsey Slough is tributary to the Sacramento River. The Barker Slough Pumping Plant draws water from both the Barker Slough watershed and from the Sacramento River, via Lindsey Slough. Other local sloughs may also contribute water to the NBA. The NBA facilities were previously shown in Figure 3-2.

The Barker Slough watershed and the potential contaminant sources present in the watershed have been adequately described in the three previous watershed sanitary surveys (Brown and

Caldwell, 1990; DWR, 1996; and DWR, 2001). The TRC members for the 2006 Update determined that this report should focus on the activities that have been undertaken to improve NBA water quality since the 2001 report was prepared and any changes in water quality resulting from those activities.

KEY CONCERNS

Water Quality Challenges

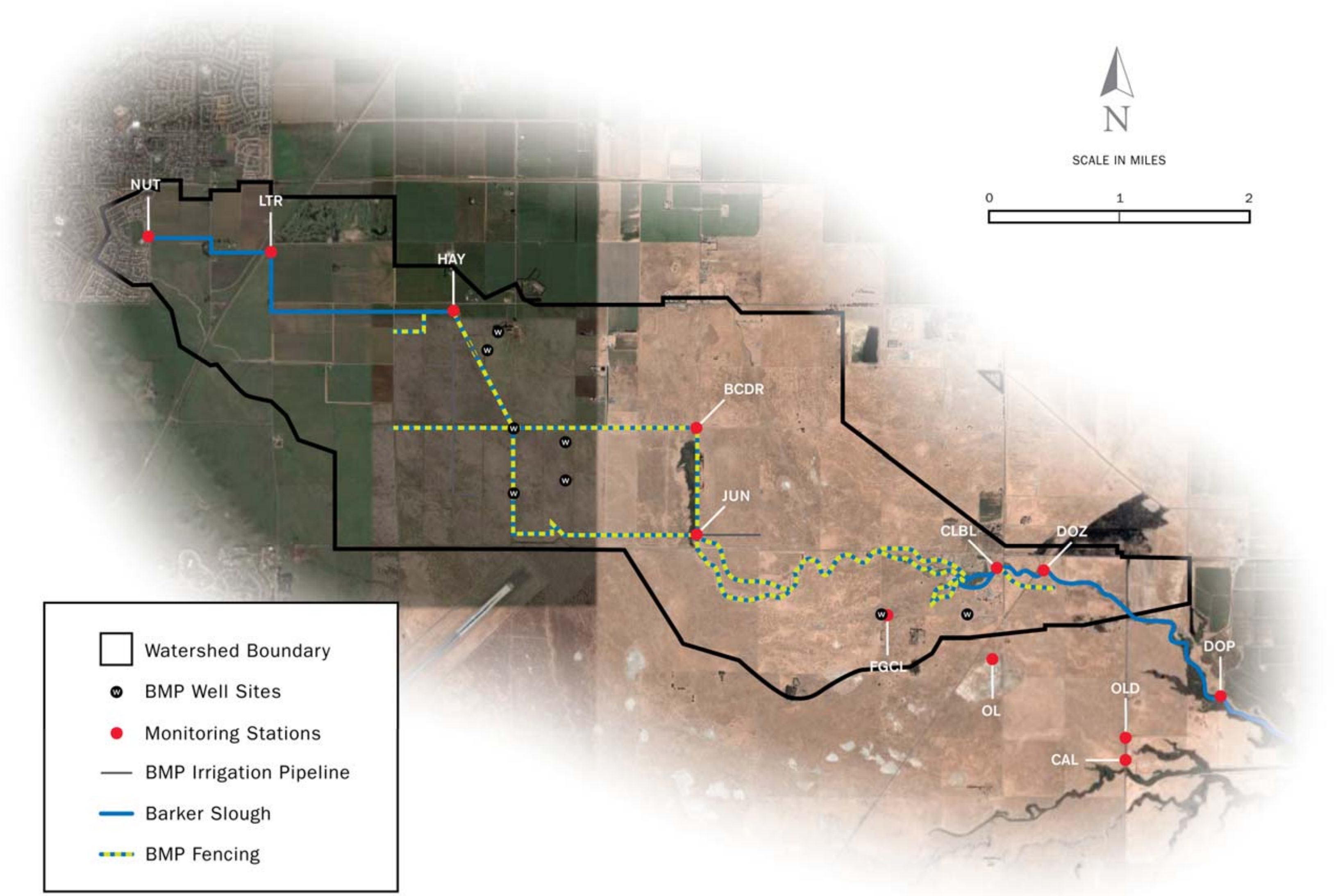
Monitoring has shown that the NBA has some of the poorest source water quality in the SWP due to high levels of organic carbon, turbidity, and coliform bacteria (see Chapter 3). Rapid fluctuations in water quality, including sudden drops in alkalinity, create major challenges for treatment plant operators during the wet season. The NBA water is also high in color with an average of 465 color units (Personal Communication, Scott Rovanpera, City of Benicia). Some of the cities treating NBA water have the ability to switch to other surface or groundwater sources or to blend NBA water with other sources; however, the NBA supply is becoming increasingly important as these areas grow in population.

Overview of Contaminant Sources

The Barker Slough watershed, shown in **Figure 5-1**, is approximately 14.5 square miles. The primary contaminant sources in the watershed are related to agriculture, particularly grazing of sheep and cattle. Approximately 85 percent of the watershed is grazing land or irrigated pastures. The Barker Slough watershed is occupied by up to 3,000 head of cattle from late summer to early spring months and by up to 1,500 head of sheep in the winter/spring period (Hydro Science, 2002). In the past, cattle and sheep have had direct access to Barker Slough and its tributaries, resulting in severe bank erosion and deposition of manure in and near waterways. Grazing practices in the watershed are not well documented and the impact of grazing is unknown. A vernal pool mitigation project is proposed for some of the land that is currently grazed. The potential impact of this project on water quality is unknown.

Approximately seven percent of the watershed is devoted to annual crops of corn, safflower, and Sudan grass. The fields are normally left fallow in the fall with bare soils exposed during the wet season. Farming practices for corn and Sudan grass leave visible crop residue on the surface of plowed fields, allowing the residue to decompose and then be transported to Barker Slough during the wet season. Winter wheat is occasionally planted in the watershed. This provides a cover crop during the wet season (Hydro Science, 2002). Urban runoff from approximately 256 acres of Vacaville's Foxboro subdivision flows into a channel that joins the Noonan Main Drain, a channelized portion of Barker Slough in the upper watershed. The urban area of the watershed is approximately 2.5 percent of the watershed. Another potential contaminant source is the recreational activities at Argyll Park and the Cypress Lakes Golf Course. The 320-acre Argyll Park is primarily used for go-cart and motocross racing and has areas of disturbed soil. Argyll Park is located in the lower portion of the watershed approximately two miles upstream from the Barker Slough Pumping Plant. The Cypress Lakes Golf Course is located in the upper northwest part of the watershed.

Figure 5-1. The Barker Slough Watershed



Base map source: Google

Campbell Lake is a 40-acre impoundment on the Argyll Park property. Although the lake itself is not a contaminant source, the manner in which it is operated affects downstream water quality. Most irrigation water and irrigation return water from the upper watershed is stored in the lake during the summer months and does not flow downstream to the Barker Slough Pumping Plant. Water is released through a pipe with a valve control and, at the property owner's discretion, by the removal of stacked boards that form the dam outlet. Data collected between 1996 and 1999 indicate that Campbell Lake does not act as a settling basin but rather as a holding basin for highly turbid water. When the property owner removes the stacked boards at the beginning of the wet season, a slug of highly turbid water with high TOC concentrations flows down the slough to the pumping plant.

The Solano Land Trust is applying for grant funds to construct a project to restore tidal wetlands in the Calhoun Cut watershed. Calhoun Cut is a direct tributary to Barker and Lindsey Sloughs. If Calhoun Cut is a source of water to the NBA, there is a potential for increased loads of organic carbon from the wetlands. Hydrodynamic modeling is being conducted by SCWA to determine if Calhoun Cut is a significant source of water at the Barker Slough Pumping Plant (see Hydrodynamic Modeling). Solano Land Trust plans to monitor water quality conditions as part of the grant project (Personal Communication, David Okita).

ACTIONS TAKEN SINCE 2001 SANITARY SURVEY

Under the leadership of SCWA, the NBA Contractors have taken a multi-pronged approach to improving water quality. In conjunction with the Department of Water Resources (DWR) Municipal Water Quality Investigations (MWQI) Program they embarked in 1996 on a multi-year study of the Barker Slough watershed that led to implementation of management practices; they are in the process of developing a hydrodynamic model of the Barker Slough area to determine the sources of water to the NBA under a variety of hydrologic conditions; they are currently evaluating the feasibility of exchanging NBA water for higher quality Solano Project water that is currently used for agricultural irrigation; they conducted a study to evaluate the effectiveness of a magnetic ion exchange treatment process to remove organic carbon; and they have explored an alternate intake location.

Watershed Management

As a result of recommendations in the 1990 and 1996 watershed sanitary surveys, the NBA Contractors and MWQI conducted a series of special studies between 1996 and 1999 to understand the relative contributions of different surface waters to water quality in the NBA. Key conclusions from these studies include:

- The majority of water quality problems occur during the winter wet season.
- During the wet season, the Barker Slough watershed appears to be the primary source of water to the NBA.

- During the dry season, the Barker Slough watershed provides little water to the NBA and the primary sources are the Sacramento River and sloughs downstream of the pumping plant.

- Total organic carbon (TOC) concentrations at the Barker Slough Pumping Plant remain elevated (7 to 15 mg/L) throughout the wet season. One hypothesis is that TOC from the watershed remains in the vicinity of the pumping plant due to the tidal sloshing back and forth of the water coming out of Barker Slough.

- The soils in the watershed are fine textured silts and clays that contain high levels of sodium, resulting in conditions that lead to higher turbidity and less sorption of organic carbon onto the soil particles.

In 1999, SCWA was awarded a grant from the State Water Resources Control Board (State Water Board) to evaluate and begin implementation of management practices in the watershed and to conduct monitoring to determine the effectiveness of the practices. Hydro Science prepared a Barker Slough Watershed Water Quality Improvement Plan (2001) and a Barker Slough Watershed Management Plan (2002).

Hydro Science reviewed the water quality data collected in previous studies and concluded that the principal source of turbidity in the watershed is disturbed channel banks and that organic carbon was coming mainly from unrestricted cattle access to the waterways. Management practices were evaluated to determine their potential to reduce turbidity and organic carbon, their cost, and feasibility of implementation. Hydro Science concluded that control of turbidity and dissolved organic carbon (DOC) is confounded by the fact that many of the strategies used to control erosion and turbidity, such as wetlands enhancement or creation, flow through vegetated filter strips, or elimination of fallow fields, all tend to increase DOC export rates.

Hydro Science developed a water quality improvement plan which consisted of four tiers of management practices to be implemented in a progressive manner.

- Tier I includes fencing to exclude cattle from the Noonan Drain to the Junction and erosion control measures on Campbell Ranch (Argyll Park).

- Tier II includes additional fencing to exclude cattle from Barker Creek and some tributary drainages and potential alum treatment of Campbell Lake.

- Tier III includes improved management of Campbell Lake during wet and dry periods, improved irrigation practices, conversion of cropland to pasture, and soil treatments to reduce erosion.

- Tier IV includes channel restoration and potential modification of land use practices that would only be implemented if water quality does not improve significantly after implementation of the first three tiers of management practices.

The management practices in the first tier are expected to provide the greatest improvement in water quality at the lowest cost. Hydro Science and the NBA Contractors determined that the most effective practice to initially implement in the Barker Slough watershed was to restrict livestock access to Barker Slough and its tributaries by installing fencing, and providing alternate water supplies for livestock. This should also promote natural re-vegetation of the channels. The Campbell Ranch erosion control management practices were postponed pending the results of the hydrodynamic study (see discussion below).

If these management practices do not result in improvements in water quality, the NBA Contractors can determine if they want to implement more expensive management practices such as controlling operations of Campbell Lake or rerouting flows from the watershed around the pumping plant. SCWA applied for and was awarded additional grant funding in 2004. The following sections describe the management practices installed as a result of both grants.

Restrict Livestock Access to Waterways

The first step in restricting the access of livestock was to identify the property owners who conducted livestock grazing on lands adjacent to Barker Slough and its tributaries and to negotiate agreements with them for implementation of management practices and access for water quality monitoring. Fencing, wells to provide livestock water, watering troughs, and irrigation pipe were installed in three phases as shown in **Table 5-1** and previously on **Figure 5-1.** The Tier I and Tier II fencing has been completed at a cost of $670,000. Cattle are now excluded from the watershed upstream of Campbell Lake. SCWA is working with the property owners to ensure that the fencing is maintained, gates are closed, and cattle are not allowed access to the waterways.

Table 5-1. Management Practices Installed in Barker Slough Watershed

Phase and Year	Fencing (linear feet)	Wells	Watering Troughs	Irrigation Pipe (linear feet)
1 - 2001	7,300	1 Solar 3 Wind Powered	8	
2 - 2002	31,700	2 Electric	6	11,200
3 – 2006	37, 850	2 Electric	12	3,550

Project Effectiveness Monitoring

The NBA Contractors have employed two methods of monitoring the effectiveness of the management practices: photo-monitoring and water quality monitoring. The results are described in detail in the final report prepared for the Proposition 13 grant (SCWA, 2006) and summarized in the following sections.

Photo-monitoring

Photo-monitoring is used to qualitatively assess changes in stream bank stability and vegetation conditions in the areas where cattle have been excluded from the waterways. Photographs are taken at a number of locations in the watershed to document the vegetation and stream bank conditions and the presence or absence of grazing animals. Photo-monitoring was initiated in 2003 and is conducted twice a year in late spring and late summer/early autumn. The number of sites monitored has increased as management practices have been implemented. As of 2005, 20 sites throughout the watershed were monitored. Photo-monitoring has revealed that there is greater vegetative cover in some areas of the watershed as a result of excluding cattle from the waterways. The usefulness of photo-monitoring will increase over time as trends may be more evident after several years of monitoring.

Water Quality Monitoring

SCWA has conducted water quality monitoring in the Barker Slough watershed since 1997. Turbidity is monitored continuously at six locations from the upper urbanized area of the watershed to below the Barker Slough Pumping Plant. Continuous monitoring for conductivity, temperature, stage level, and flow is conducted at several locations. Several storm events have been monitored each year since December 2003. Grab samples are collected at a number of locations and autosamplers are used to collect hourly samples at three locations, one in the upper watershed (LTR), one in the middle of the watershed (JUN), and one downstream of Campbell Lake but upstream of the Barker Slough Pumping Plant (DOZ). **Figure 5-1** shows the location of the monitoring stations in relationship to the management practices that have been installed.

The water quality data were analyzed to evaluate the effectiveness of the management practices for the final grant report (SCWA, 2006). The report concluded that it is too soon to evaluate their effectiveness because the management practices have only been in effect in the last several years and hydrologic conditions vary from year to year, complicating the analysis. The data analysis showed that organic carbon concentrations were generally similar during the two years that data were collected throughout the watershed, and coliform levels were highest in the upper watershed, likely due to a combination of urban runoff and runoff from grazed lands. The continuous turbidity data were inconclusive due to equipment problems. During the times that the equipment was functioning well, the turbidity was highest in the watershed above Campbell Lake and somewhat lower below Campbell Lake.

The TOC concentrations at the Barker Slough Pumping Plant are discussed in Chapter 3 (Figure 3-24). These data show a distinct annual trend with higher concentrations during the wet season but they do not indicate any temporal trend that would indicate that the management practices have had any effect on TOC concentrations at the pumping plant.

Hydrodynamic Modeling

The Barker Slough Pumping Plant is located on an embayment along the side of Barker Slough. When there is runoff from the watershed, it must pass by the pumping plant forebay on its way to Lindsey Slough. However, the water levels in the slough are tidally influenced and during the summer and fall when releases from Campbell Lake are at a minimum, the amount of water pumped into the NBA exceeds the runoff from the watershed. Therefore, the pumping plant creates reverse flow conditions and water is drawn up Lindsey Slough to Barker Slough.

The flow hydraulics when there is runoff from the Barker Slough watershed are much more complicated and not well understood. The NBA Contractors are studying the circulation in Barker Slough to determine if poor quality water is being drawn from tributaries to Barker Slough downstream of the pumping plant or if the sole source of the poor quality water is runoff from the watershed. One theory is that poor quality water from the watershed is trapped in the Barker Slough waterway and must be pumped by the Barker Slough Pumping Plant into the NBA before better quality water is drawn from downstream of the pumping plant. A hydrodynamic model has been developed and is being calibrated with data collected in the 2005/2006 and 2006/2007 wet seasons. When fully functional, operation of this model should enable a better understanding of the hydrodynamics of the watershed.

Exchange of NBA Water for Solano Project Water

High quality water from Lake Berryessa is currently delivered via the Putah South Canal of the Solano Project to both agricultural and municipal customers in Solano County. SCWA is currently exploring options to exchange some of the lower quality NBA water that its municipal customers receive for the Solano Project water that agricultural customers receive. The Highline Canal Project is currently being evaluated. The proposed project involves pumping water from the NBA into Solano Irrigation District's (SID) Highline Canal, a conveyance for Solano Project water. The NBA water could then be delivered to agricultural customers in the SID service area. The cities of Fairfield, Vacaville, and Benicia would provide the NBA supply and would receive a portion of SID's Solano Project supply and the opportunity to take advantage of storage in Lake Berryessa. It is anticipated that 5,000 to 10,000 acre-feet per year of NBA water could be exchanged for an equivalent amount of Solano Project water. A pumping plant is needed to withdraw water from the NBA and a connection between the NBA and the Highline Canal would need to be constructed. An engineering consultant is currently updating a 1998 feasibility study.

Evaluation of Treatment Techniques

SCWA obtained grant funding to conduct bench- and pilot-scale evaluations of the use of magnetic strong base anion exchange resin for the removal of DOC and reduction of disinfection byproduct (DBP) formation. The information presented in this section is taken from the grant final report (Montgomery Watson Harza, 2004). Bench-scale tests using a series of ion exchange resins resulted in the selection of magnetic ion exchange (MIEX®) resin for pilot-scale studies. MIEX® resin was used in a pretreatment process at the pilot-scale. The MIEX® process is a continuous ion exchange process that removes negatively charged organic acids, which make up the majority of DOC found in natural water sources. The ion exchange occurs in a flow-through mixed tank, and the magnetized ion exchange resin particles are then recovered in a gravity separator for regeneration and recycle.

The pilot-scale study was conducted at the North Bay Regional Water Treatment Plant. Two parallel conventional treatment trains, one employing MIEX® resin pre-treatment and the other without, were used to determine the effectiveness of pretreatment with MIEX® resin. The MIEX® resin reduced the coagulant dose and reduced TOC, DOC, and DBP formation potential compared to the conventional treatment train. An engineering evaluation was conducted to estimate the construction and operational costs of MIEX® pretreatment based on the pilot-scale study. Unit construction costs for MIEX® ranged from \$0.25 to \$0.65 per gallon per day of treatment capacity. Operating costs for MIEX® pretreatment are partially offset by cost savings in downstream treatment processes, resulting in a net operational cost of \$0.02 to \$0.09 per 1000 gallons treated.

Alternate Intake Study

In addition to the water quality problems described previously, Barker Slough is not always a reliable supply of water. Barker Slough is a spawning area for Delta smelt and pumping has been restricted to 65 cubic feet per second (cfs) for a five-day period when larval Delta smelt are detected (this restriction is no longer in effect, but could be reinstituted in the future). The pumping restrictions and the degraded water quality during the wet season led the NBA Contractors to evaluate an alternate intake that could provide a more reliable supply and better quality water.

The NBA Contractors conducted an engineering feasibility study that explored five possible locations for an alternate intake, nine pipeline alignments, and three alternatives for connecting the new supply to the NBA (Bookman-Edmonston et al, 2003). The intake locations originally considered were the Deep Water Ship Channel at two locations (near Clarksburg and near Courtland); Elk Slough, Sutter Slough, and the Sacramento River (all near Courtland), and Miner Slough near Courtland. The sites were evaluated and ranked and two sites were advanced for further analysis – the Sacramento River at Courtland and Sutter Slough near Courtland. These two locations are shown in **Figure 5-2**. The feasibility study also recommended that the connection to the NBA not require that the water from the new intake be mixed with Barker Slough water. Two connection alternatives were advanced for further analysis. One alternative would allow mixing but also preserves the ability to convey only the new intake water to the water treatment plants. The other alternative is direct connection to the NBA. The construction cost for the intake, pipeline, and pumping stations is estimated at \$175 million (2004 dollars).

The NBA Contractors conducted a water quality monitoring program between August 2001 and August 2002 to evaluate the water quality at each of the sites originally considered. The data for the two recommended sites, the Sacramento River at Courtland and Sutter Slough near Courtland, are compared to data from the Barker Slough Pumping Plant.

Figure 5-2. Alternate Intake Locations

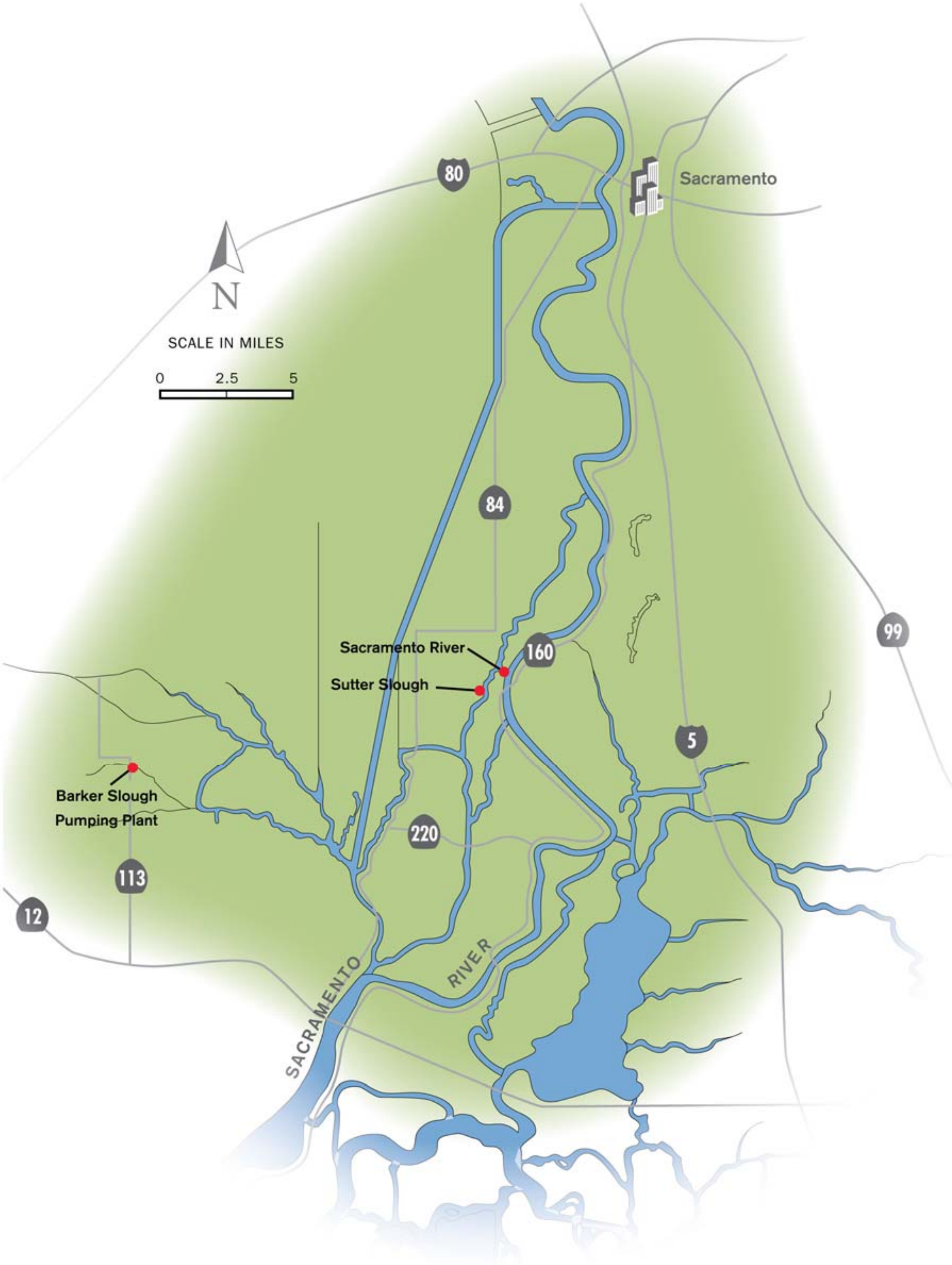
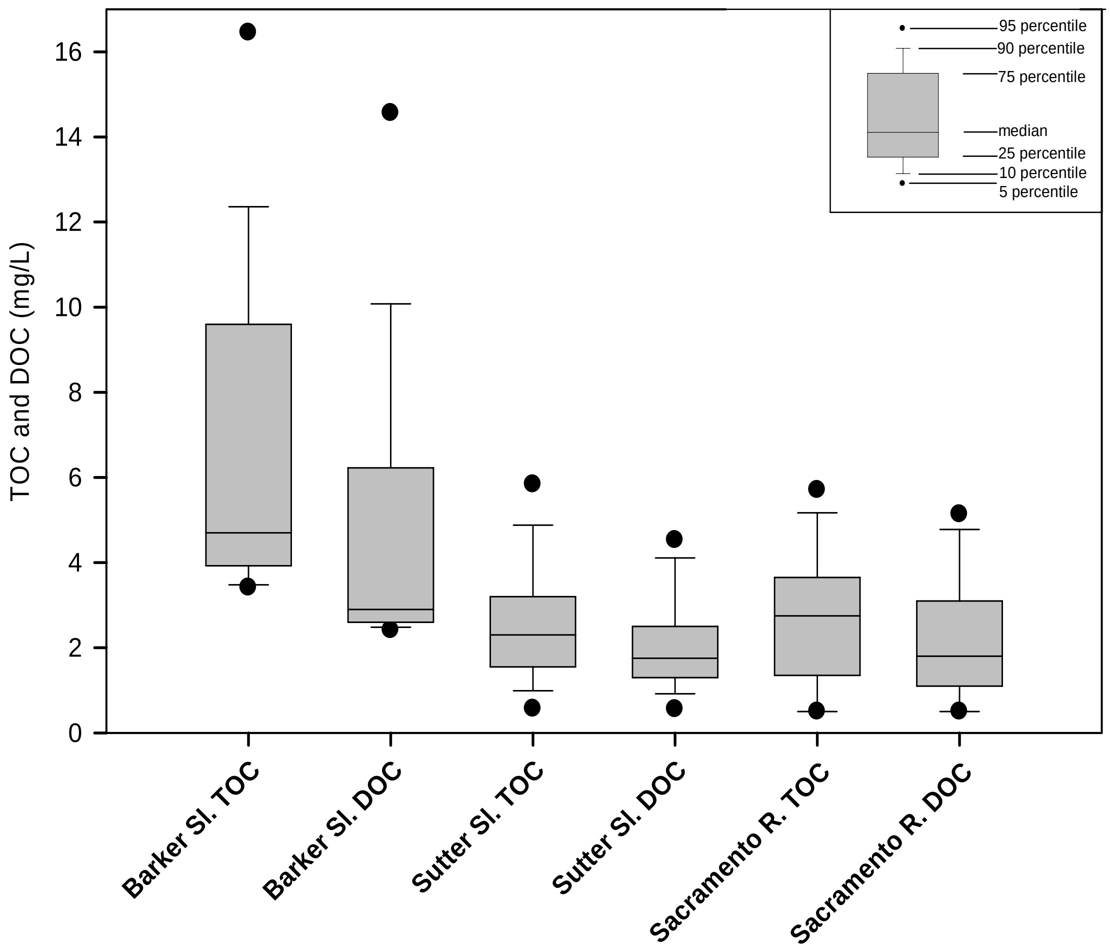


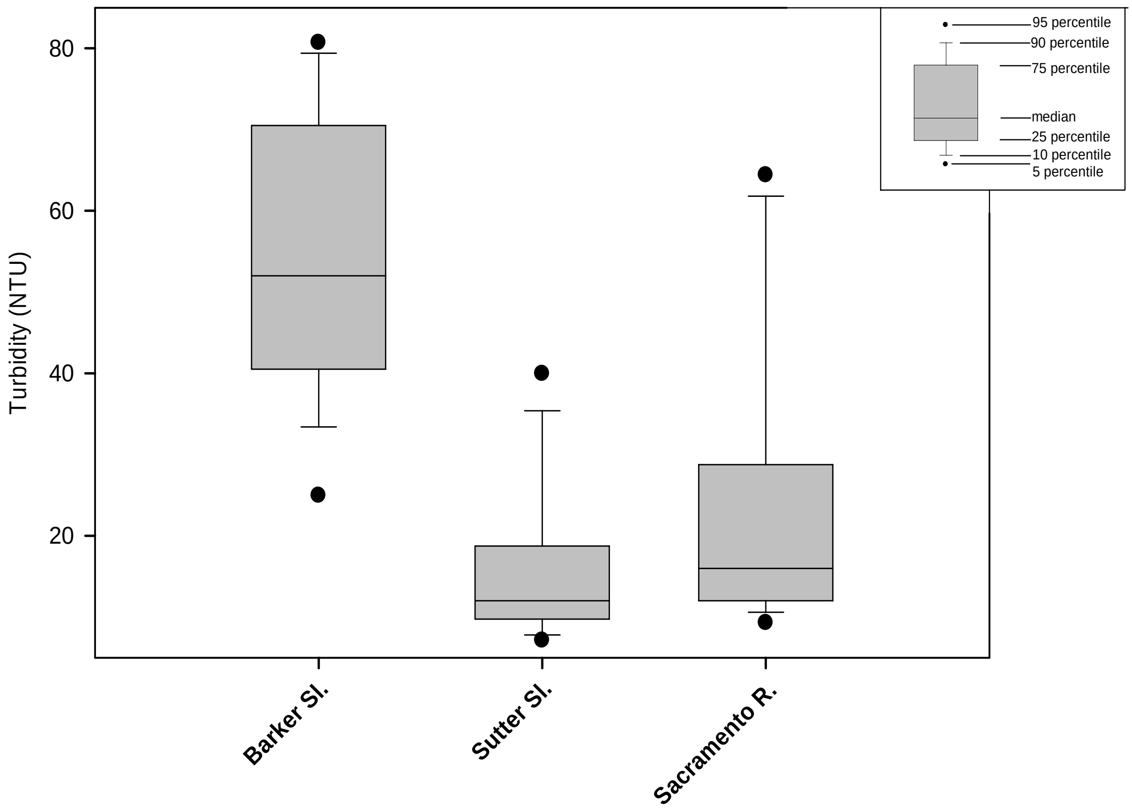
Figure 5-3 presents the TOC and DOC data for Barker Slough and the two alternate intake locations for the one year of monitoring. Chapter 3 presents additional data comparing TOC concentrations at Barker Slough and the Sacramento River at Hood, which is approximately five miles upstream from Courtland. These data confirm that if an alternate intake is constructed on the Sacramento River or on Sutter Slough, the NBA Contractors will receive water with much lower concentrations of TOC and DOC and with much less variability than the current supply from Barker Slough.

Figure 5-3. Organic Carbon Concentrations at Alternate Intake Locations



The turbidity data for Barker Slough are compared to the data for the two alternate intake locations in **Figure 5-4**. These data and additional data presented in Chapter 3 (see Figures 3-107 and 3-108) show that turbidity at Barker Slough is variable and can reach levels that create treatment challenges. The median turbidity of Sutter Slough and the Sacramento River at Courtland are lower than Barker Slough and there is less variability in the data.

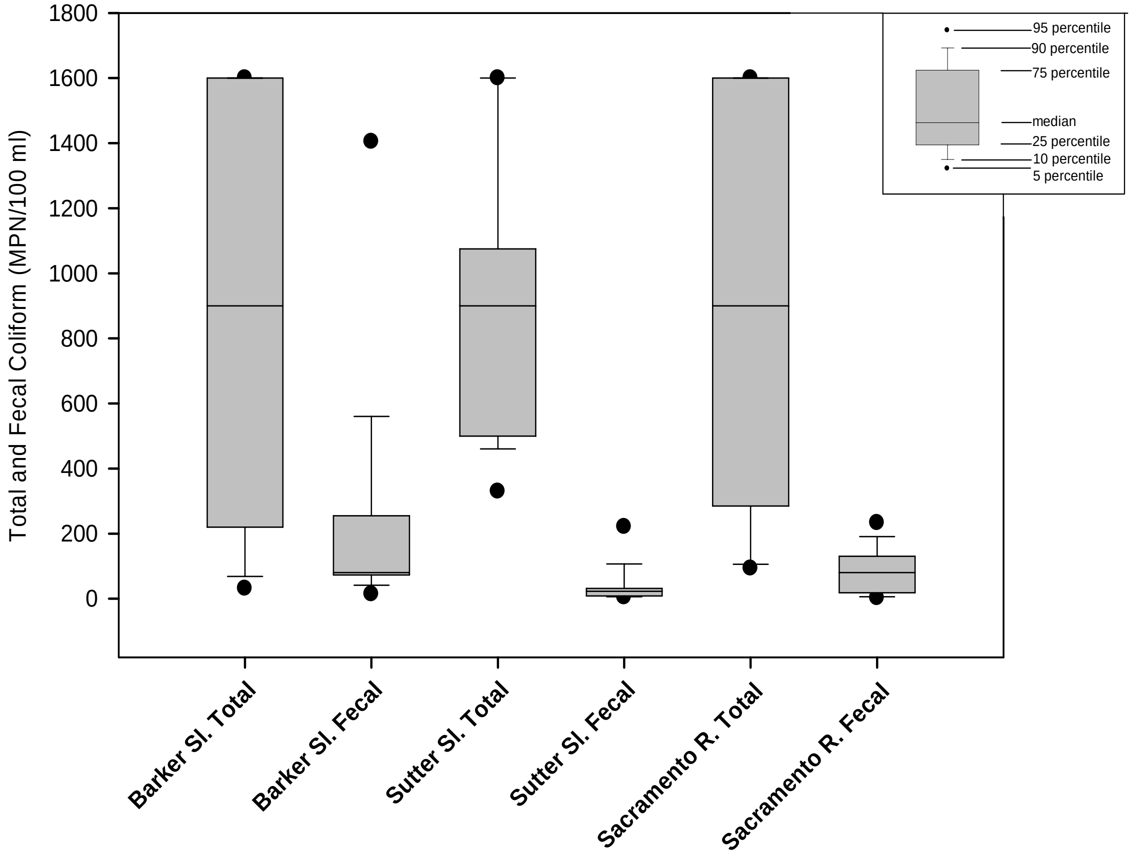
Figure 5-4. Turbidity Levels at Alternate Intake Locations



As shown in **Figure 5-5**, the total and fecal coliform bacteria densities are similar at the two alternate intake locations and Barker Slough. Median total coliform densities are 900 MPN/100 ml at all three locations. The upper detection limit was 1,600 MPN/100 ml meaning that coliforms at densities exceeding 1,600 MPN/100 ml could not be enumerated. The actual maximum coliform densities at the three locations could not be determined because all three locations had months when the densities were reported as greater than1,600 MPN/100 ml.

The total nitrogen data collected in the one year of monitoring for the alternate intake study indicated that total nitrogen concentrations are higher and more variable in Sutter Slough and the Sacramento River than Barker Slough. These data are inconsistent with data collected by MWQI over a longer period of record (see Figures 3-72 and 3-76). The longer period of record indicates that total nitrogen concentrations are generally higher and more variable in Barker Slough than in the Sacramento River at Hood. Total phosphorus concentrations are also higher and more variable in Barker Slough than in the Sacramento River (see Figures 3-73 and 3-76).

Figure 5-5. Coliform Densities at Alternate Intake Locations



An alternate intake location at Sutter Slough or the Sacramento River near Courtland would provide the NBA Contractors with a water supply that is generally less variable and has lower organic carbon concentrations and lower turbidity levels. The coliform data indicate that the alternate intake locations are similar to Barker Slough. Based on the longer term monitoring conducted by MWQI, an added benefit to the NBA Contractors would be water with lower nutrient levels.

POTENTIAL ACTIONS

The NBA Contractors are currently awaiting the completion of the hydrodynamic model. Upon completion of the model, the NBA Contractors will evaluate the various options for improving water quality (watershed management practices, water exchanges, treatment options, and alternate intake) and determine the most cost-effective program for improving NBA water quality. No further actions are recommended at this time.

SOUTH BAY AQUEDUCT

The SBA conveys water from Bethany Reservoir to large portions of Alameda and Santa Clara counties. The Zone 7 Water Agency of the Alameda County Water Conservation and Flood Control District (Zone 7 Water Agency), the Alameda County Water District (ACWD), and SCVWD treat water from the SBA and provide drinking water to nearly two million customers. These three agencies are referred to as the SBA Contractors.

The SBA system was shown previously in **Figure 3-3**. Water is pumped from the Sacramento-San Joaquin Delta (Delta) at the Harvey O. Banks Delta Pumping Plant (Banks). Water flows a short distance down the California Aqueduct to Bethany Reservoir. Bethany Reservoir is essentially a wide spot on the California Aqueduct with a capacity of 5,070 acre-feet. Water is pumped into the SBA at the South Bay Pumping Plant on Bethany Reservoir. The first three miles of the SBA are an enclosed pipeline. This is followed by two miles of open canal, a tunnel under Interstate 580, and another two miles of open canal between the tunnel and Patterson Reservoir (a 100 acre-feet storage facility adjacent to the SBA). Water continues to flow seven miles in an open canal to Del Valle Check 7 (DV Check 7). From there the water flows in an enclosed pipeline to the Santa Clara Terminal Reservoir (Terminal Tank). At mileage point, 18.63, SBA water can be pumped into Lake Del Valle and Lake Del Valle water can be released into the SBA via a 60-inch common inlet/outlet. Lake Del Valle is a multi-purpose reservoir with a storage capacity of 77,110 acre-feet. The reservoir has an extensive 95,000-acre watershed that contributes local runoff to the reservoir.

KEY CONCERNS

The SBA Contractors and DWR have taken a number of actions since the 2001 Sanitary Survey Update was prepared. These actions are described, followed by a discussion of the continuing water quality concerns for the SBA. The on-going concerns are algal growth in the SBA, cattle grazing in the Bethany Reservoir watershed and a proposed trail along the open canal sections of the SBA.

ACTIONS TAKEN SINCE 2001 SANITARY SURVEY

SBA Improvement and Enlargement Program

In 1998, Zone 7 Water Agency re-evaluated water supply needs within its service area. A Water Conveyance Study identified a conveyance capacity need of an additional 130 cfs to meet peak monthly demands at build-out under the approved General Plans within the Zone 7 Water Agency service area (CDM, 2001). DWR completed a feasibility study on improving and enlarging the SBA (DWR, 2003). The Improvement and Enlargement Project is scheduled for completion in 2009. The enlargement project will be funded by the Zone 7 Water Agency, and consists of increasing the design capacity by 130 cfs between the South Bay Pumping Plant and DV Check 7, construction of Dyer Reservoir, and other modifications. The improvement project will be funded by the three SBA Contractors and consists of improvements that will result in the delivery of the contractual design flow of 300 cfs. The current capacity is 260 to 270 cfs. The improvement project includes removing all existing major drainage to the SBA's open canal sections, grading the canal right-of-ways to drain away from the canal, replacing the wooden slat farm bridges that allow animal wastes to enter the water with concrete bridges, and removing 2,000 to 3,000 cubic yards of sediment in the Bethany intake channel just upstream of the South Bay Pumping Plant. These improvements are being made as a result of cooperation between the SBA Contractors and DWR to address water quality concerns. Construction is underway and will be completed by June 2009.

Assessment of Watershed Contaminant Sources

The SBA Contractors conducted a study to assess the contaminant sources in the watersheds draining to Bethany Reservoir, the open canal sections of the SBA, and Lake Del Valle in conjunction with preparing the Drinking Water Source Assessments for the California Department of Health Services (CDHS) (Archibald & Wallberg, 2005). The objectives of the study were:

- Compile and review relevant data and information on contaminants, land use activities, and current management measures for the SBA system.
- Determine potential contaminant sources between the Delta and the water treatment plant intakes that degrade water quality.
- Identify management measures for implementation by the SBA Contractors to improve water quality and prevent further degradation.

Although the Delta is the primary source of water to the SBA, this study focused on the activities occurring between the Delta and the water treatment plants. The SBA watershed consists of three distinct sections; the Bethany Reservoir watershed, the land that drains to the open canal sections of the SBA, and the Lake Del Valle watershed.

Bethany Reservoir

The Bethany Reservoir watershed consists of about 2,700 acres of largely undeveloped land. Potential contaminant sources to Bethany Reservoir include livestock with direct access to the reservoir, runoff from grazing land, wildlife, body contact recreation and wastewater handling facilities located at the South Bay Pumping Plant and recreation areas. The contaminant sources in the Bethany Reservoir watershed that were judged to be most significant are livestock with access to the water, runoff from grazing land, and wildlife (Archibald & Wallberg, 2005).

Open Canal Sections

Approximately 11 miles of the SBA are open canal and subject to contamination from runoff entering the canal at eight locations. Most of the land surrounding the open canal sections of the SBA is undeveloped and used as rangeland; however, vineyard acreage is rapidly increasing. In many areas along the open canal sections, drainage from adjacent lands is conveyed over the canal in overchutes and pipelines or under the canal in culverts. For the open canal sections, the key sources are currently runoff from grazing land and animal waste runoff washed from farm bridges that cross the canal. As discussed previously, the drainage will be rerouted and the farm bridges will be improved as part of the SBA Improvement and Enlargement Project. A potential future source is a proposed recreational trail along the canal (see discussion below.)

Lake Del Valle

Much of the Lake Del Valle watershed remains in a natural, undeveloped state. There are a number of potential contaminant sources in the Lake Del Valle watershed, including livestock grazing, recreational use, wastewater facilities, wildlife, and Delta water pumped into the lake. The dilution capacity of the lake and DWR's operating plan reduce the potential for contaminants in the Lake Del Valle watershed to adversely affect SBA water quality.

Recommended Actions

A number of activities were recommended in the Assessment of Watershed Contaminant Sources report (Archibald & Wallberg, 2005). Recognizing that the SBA Contractors could not immediately follow-up on all of the recommendations, the following priority activities were identified:

- Conduct stormwater monitoring to assess significance of sources, assess effectiveness of management practices currently in place, and determine status and trends of water quality parameters.

- Obtain more information on cattle and cattle grazing in the Bethany watershed on both private and state-owned property to better assess the potential for pathogens to be present in the watershed and to enter the water.

- Obtain more information on feral pigs in the Bethany watershed to better assess the potential for pathogens to be present in the watershed and enter the water.

- Encourage DWR to maintain its current policy of not allowing any additional discharges to the SBA and support DWR's plans to reroute all drainage that currently enters the SBA.

- Remove animal wastes from farm bridges that cross the open canal sections prior to and during the storm season.

Watershed Program

ACWD obtained a Proposition 13 Non-point Source Pollution Control Grant from the State Water Board in 2003 to follow up on the recommendations from the Assessment of Watershed Contaminant Sources project and to develop a Watershed Protection Program Plan (WPPP). The WPPP was developed under the guidance of a stakeholder-based Watershed Workgroup and is currently in the final stages of development.

Stormwater Monitoring

The WPPP project included monitoring stormwater inflows to Lake Del Valle and Bethany Reservoir during the winter of 2005-2006. Samples were collected from seven locations during five storm events and analyzed for a number of water quality constituents. The following locations were monitored.

- California Aqueduct – Samples were collected just upstream of Bethany Reservoir to measure the quality of Delta water entering the reservoir.
- Bethany Headlands Drainage – This drainage course enters the inlet channel to the SBA right next to the SBA Pumping Plant. Samples were collected upstream and downstream of a small wetland that has developed in the drainage course near the inlet channel.
- Dyer Surge Pool – Samples were collected in the surge pool, the beginning of the open canal section of the SBA, to measure the quality of water entering the SBA.
- Arroyo Valle – This is the major tributary to Lake Del Valle. Samples were collected near the mouth of the stream.
- Cedar Creek – This is a minor tributary to Lake Del Valle with some development in its watershed. Samples were collected near the mouth of the stream.
- Lake Del Valle – Samples were collected near the Del Valle Pumping Plant intake and the Conservation Outlet Works to measure the quality of water entering the SBA from Lake Del Valle.

The monitoring program and results are described in the SBA Watershed Protection Program Stormwater Monitoring Report (ESA, 2006). The general findings from the monitoring program are presented first and then followed by a more detailed discussion of the pathogen and indicator organism data.

General Findings

Only one sample was collected at each location during each storm event so the data provide a snapshot of water quality during storm events and do not adequately characterize the variability in concentrations that can be found during any given storm event. The data provide preliminary information on the relative quality of sources of water to the SBA.

- The Bethany Headlands drainage had the highest concentrations of most constituents that were monitored, although low flows were present during the events that were monitored.
- The quality of water in the Dyer Surge Pool was nearly identical to the quality of water entering Bethany Reservoir in the California Aqueduct, indicating that the Bethany Headlands drainage had no noticeable impact during the storms that were monitored.

- The concentrations of most constituents in Arroyo Valle and Cedar Creek were lower than the concentrations in the Bethany Headlands drainage but higher than the concentrations in the California Aqueduct and Dyer Surge Pool.

- The concentrations of most constituents at the Lake Del Valle intake to the SBA were substantially lower than the concentrations in the major watershed inflows. This may be due to dilution, settling, and biological uptake; however, the monitoring program was not designed to assess changes in water quality between the inflows and the intake.

Pathogens and Indicator Organisms

The pathogen and indicator organism data from the stormwater monitoring program are described in more detail because cattle grazing in the Bethany Watershed was identified as an on-going concern. **Table 5-2** presents the range of total coliforms, *Escherichia coli* (*E. coli)*, *Cryptosporidium*, and *Giardia* detected at each of the monitoring locations. Total coliform and *E. coli* levels were elevated at all locations except Lake Del Valle. The *Giardia* and *Cryptosporidium* data indicate that these pathogens were detected in every sample collected from the Bethany Headlands drainage. *Giardia* was detected once in the California Aqueduct and twice in the Dyer Surge Pool. *Cryptosporidum* was detected once in the Dyer Surge Pool. Although *Giardia* and *Cryptosporidium* were detected in Arroyo Valle and *Cryptosporidium* was detected in Cedar Creek, neither pathogen was detected in Lake Del Valle in the few samples collected.

Although the SBA Contractors have been placed in Bin 1 because *Cryptosporidium* was not detected during their Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) monitoring, the detection of *Cryptosporidium* in every sample from the Bethany Headlands drainage is a cause for concern due to the fact that this drainage enters the SBA inlet channel approximately 50 feet from the SBA Pumping Plant. During the storm events that were monitored there was minimal flow in the drainage (estimated at 0.1 cfs); however, it is conceivable that during a large storm event, the stock pond that dams the stream approximately 3,000 feet upstream of Bethany Reservoir could overtop and water containing relatively high levels of pathogens could be pumped into the SBA.

Table 5-2. Storm Event Pathogen and Indicator Organism Data

Location	Total Coliform (MPN/100 ml)	*E. coli* (MPN/100 ml)	*Giardia* (cysts/L)	*Cryptosporidium* (oocysts/L)
California Aqueduct	270 – 2,000	100 – 2,000	< 0.1 – 0.6	< 0.1 - <0.2
Bethany Headlands	1,180 - > 2,000	21 – 2,000	0.1 – 2.9	0.2 – 9.7
Dyer Surge Pond	160 – 2,000	83 - 190	< 0.1 – 0.6	< 0.1 – 0.1
Arroyo Valle	200 - > 2,000	14 – 1,450	< 0.1 – 0.8	< 0.1 – 1.5
Cedar Creek	1,650 - > 2,000	62 - > 2,000	< 0.1	< 0.1 – 0.1
Lake Del Valle	16 - 140	1 - 20	< 0.1	< 0.1

Recommended Strategy

The overall strategy for minimizing contamination risk in the SBA watershed is to focus on potentially contaminating activities within 400 feet of reservoir banks and primary stream boundaries, within 200 feet of tributaries, and within 2,500 feet of intakes. These zones of influence were taken from the CDHS Source Water Assessment Program Guidance (CDHS, 1999). For the remainder of the watershed area, the more general strategy is to reduce erosion and delivery of sediment and other contaminants to streams and reservoirs; and to reduce potential contamination of groundwater. In the sparsely populated lands of the SBA watershed, these strategies can be accomplished through appropriate vegetation management (including grazing management) to reduce the risk of fire, protect the ground surface, and keep decaying plant material out of the water; appropriate design and maintenance of roads and road crossings to minimize their sediment delivery to stream channels; and good housekeeping around rural residences and at facilities where livestock is concentrated, such as corrals and watering locations. Recommendations from the WPPP are discussed in the following paragraphs.

Bethany Reservoir

The WPPP recommended limiting cattle access to riparian zones, improving infrastructure to manage sediment loads (particularly yields from large events), altering road drainage to reduce erosion and sediment delivery to the reservoir, and public education about the fact that Bethany Reservoir is a source of drinking water. The specific recommendations from the WPPP are listed in **Table 5-3**.

Lake Del Valle

The WPPP recommended grazing management, road maintenance, erosion control, septic system design and maintenance and household hazardous waste management measures that could be recommended to private property owners. The WPPP also recommended measures for reducing the impact of recreation on water quality. **Table 5-4** contains the specific recommendations from the WPPP.

Table 5-3. WPPP Recommendations for Bethany Reservoir Watershed

1. Create capacity to store the estimated 100-year sediment load (Schaaf and Wheeler 2004) in watersheds (upstream of access-road crossing and downstream from access-road crossing to the concrete flume).
   a. Enlarge existing "basin-like sediment trap" upstream of access-road crossing above concrete intake chute, creating a 20 acre-feet capacity.
   b. Develop a smaller 0.9 acre-feet sediment basin between access-road and concrete flume.
2. Improve road drainage on DWR roads in the Forebay, including outsloping roads where feasible and redirecting roadside drainage to hillslopes and swales; disconnect ditches from the flume and from the reservoir.
3. Grazing Land Conservation Practices including
   a. Forage Management: work with NRCS and UCCE to set target RDM levels or other appropriate management guidelines.
   b. Structural Range Improvements: limit access to riparian and shoreline areas
   c. Land Treatments: adopt low-maintenance road practices.
   d. Livestock Management: develop a herd health program, including timing of calving, if one is not already in place.
4. Support DWR to Develop Grazing Lease Strategy based on AUMs[a] for DWR lands
5. Recreation Outreach
   a. Include discussion of Bethany Reservoir as a drinking water source and water quality protection in training sessions for State park rangers.
   b. Install signs explaining the role that Bethany Reservoir plays in drinking water delivery, and those activities that are appropriate and inappropriate in the watershed.

[a] AUMs = Animal Unit Months. One AUM is the amount of forage required by one animal unit (defined as a 1,000 lb beef cow with or without a nursing calf) for one month.

Source: ESA. 2007 (draft). SBA Watershed Management Program Development Watershed Protection Program Plan. January 2007 Draft. Prepared for Alameda County Water District.

Table 5-4. WPPP Recommendations for Lake Del Valle Watershed

1. Grazing Land Management

   a. Forage Management: Encourage private landowners and livestock operators to work with NRCS and UCCE to set target RDM levels or other appropriate management guidelines.

   b. Structural Range Improvements: Work with NRCS and UCCE to encourage private landowners and livestock operators to limit access to riparian and shoreline areas; to establish grassland buffers; fence riparian areas as appropriate; and to develop alternative drinking and feeding sites.

   c. Livestock Management: Encourage private landowners and livestock operators to develop a herd health program, and to schedule calving to occur during the dry season.

   d. Wildlife Control: Encourage feral pig control as appropriate for the landowner.

2. Road and Trail Design and Maintenance

   a. Work with NRCS, RCD and UCCE to provide assistance to private landowners to conduct inventories of their road systems, to develop road system plans, and to implement low-maintenance and low-impact design and maintenance practices.

3. Rural Residential – Encourage landowners to:

   a. Consult County standards for design, installation, and abandonment of septic systems and wells.

   b. Consider design principles to reduce erosion potential for any hillside construction and runoff management.

   c. Properly manage debris, household chemicals and household hazardous wastes.

4. Recreation

   a. Install signs explaining the role that Lake Del Valle plays in drinking water delivery, and those activities that are appropriate and inappropriate in the watershed.

   b. Include discussion of the Lake Del Valle watershed as a drinking water source during talks given by Park Rangers.

   c. Include discussion of the Lake Del Valle watershed as a drinking water source in water quality-related training sessions for Del Valle park rangers and lifeguards.

   d. Limit access to the area of the lake in close proximity to the SBA intake structure.

Source: ESA. 2007 (draft). SBA Watershed Management Program Development Watershed Protection Program Plan. January 2007 Draft. Prepared for Alameda County Water District.

CONTINUING CONCERNS

The SBA Contractors have conducted several studies since the 2001 Update was completed to better understand the contaminant sources in the Bethany Reservoir and Lake Del Valle watersheds. In addition, the SBA Improvement and Enlargement Project is addressing the concerns over drainage into the canal from adjoining lands and the discharge of animal wastes from farm bridges. Algal growth in the SBA, cattle grazing in the Bethany watershed, and a proposed trail along the open canal sections of the SBA are continuing concerns for the SBA Contractors. The potential for mercury and polychlorinated biphenyls (PCBs) to bioaccumulate in fish is a new concern in Lake Del Valle.

Algal Growth in SBA

The high concentrations of nutrients, combined with abundant sunshine and warm water temperatures during the spring, summer, and fall months leads to excessive algal growth in the SBA. This results in taste and odor (T&O) problems due to the formation of 2-methyl-isoborneol (MIB) and geosmin, and to shortened filter run times, which can substantially reduce plant production and create difficulties meeting customer demands. Excessive algal growth also results in daily fluctuations in pH, which can reduce the effectiveness of coagulants and other chemicals.

DWR's Division of Operations and Maintenance (O&M) provided phytoplankton (algae suspended in the water column) biomass data for Banks and DV Check 7 for the period December 2003 to April 2005. These data, shown in **Figures 5-6 and 5-7**, indicate that total biomass in the SBA is generally an order of magnitude higher than at Banks. Nutrient rich water imported from the Delta, combined with the shallow depth of the SBA, provides ideal growing conditions for phytoplankton. **Figure 5-7** shows that the diatom, *Melosira varians* accounts for most of the phytoplankton biomass. *Melosira* is a filter clogging alga but it is not a known T&O producing species.

Benthic blue-green algae, more correctly known as cyanobacteria, are also abundant in the SBA and are thought to be responsible for the production of MIB and geosmin and the resultant T&O problems in the treated water. Individual SWP Contractors use various thresholds of MIB and geosmin to indicate the likelihood of T&O problems. It appears that these compounds can result in T&O incidents when they are detected at concentrations as low as 4 to 5 ng/L. **Figure 5-8** compares MIB and geosmin data from Banks, DV Check 7, and the outlet of Lake Del Valle. The peak concentrations observed at DV Check 7 during August 2003, 2004, and 2005 appear to be due to algal blooms originating in the Delta. Much higher peak MIB and geosmin concentrations were observed at Banks and, as discussed in Chapter 3, the MIB and geosmin concentrations were elevated in the California Aqueduct as far south as the bifurcation of the East and West branches at Check 41.

Figure 5-6. Algal Biomass at Banks

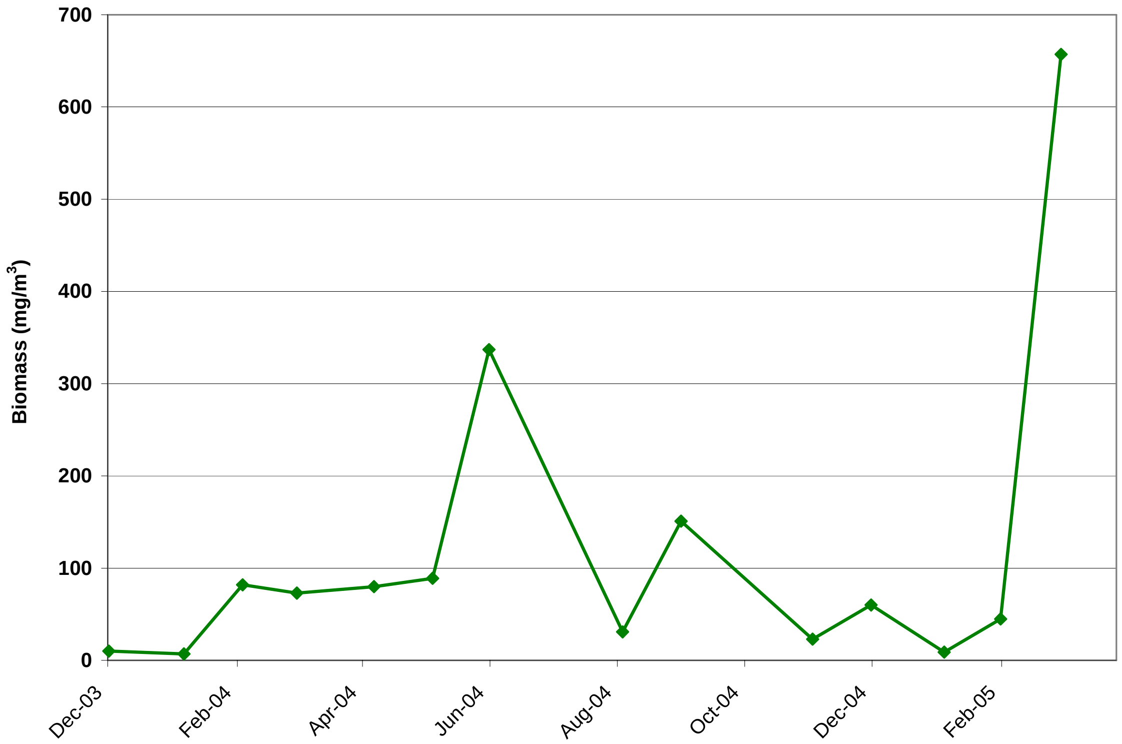


Figure 5-7. Total Biomass and Melosira Biomass at DV Check 7

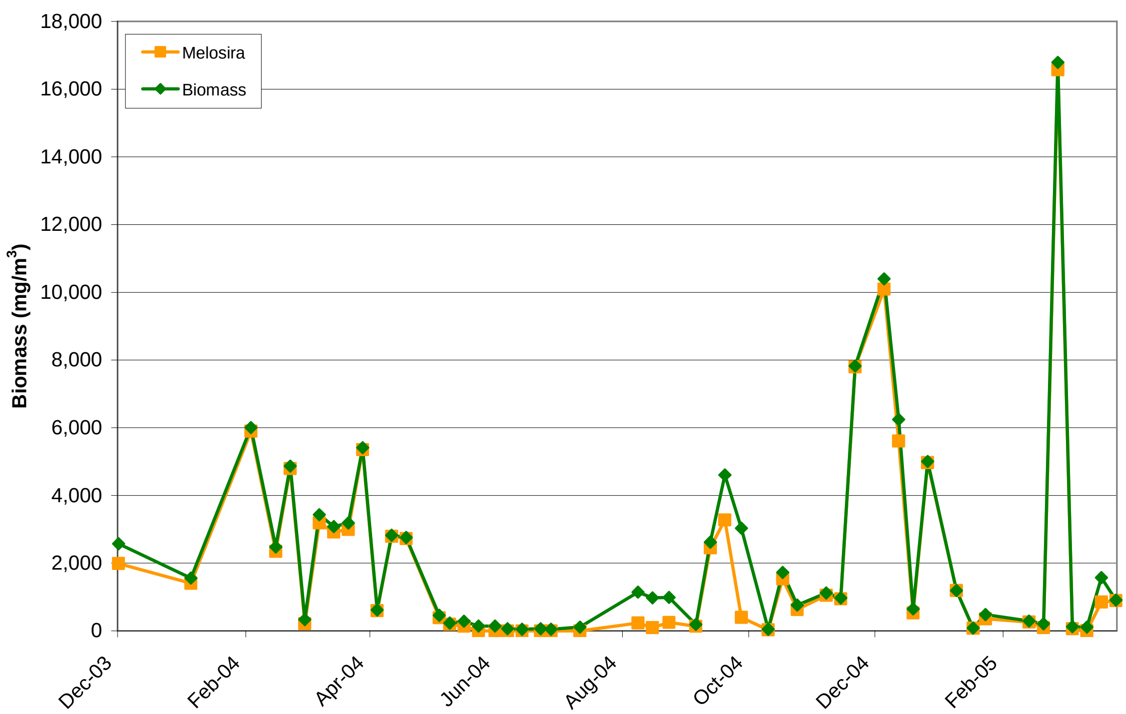
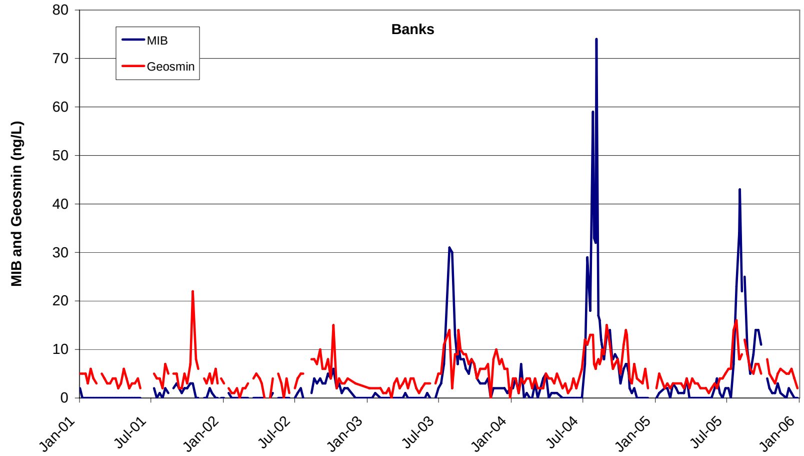
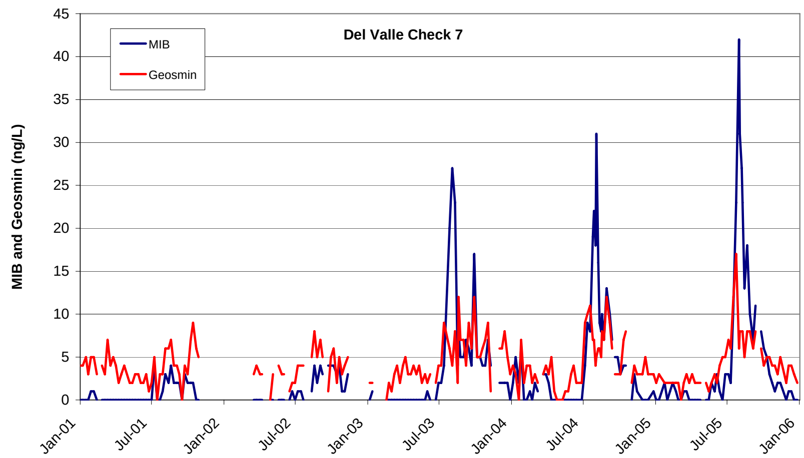
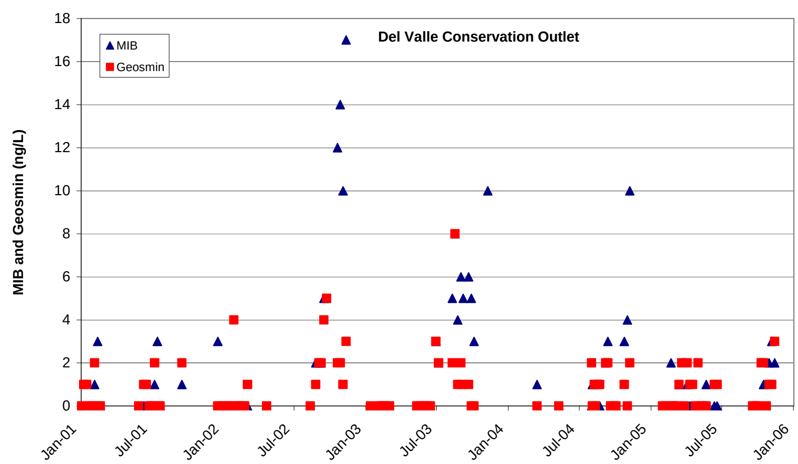


Figure 5-8. MIB and Geosmin at Banks and in SBA



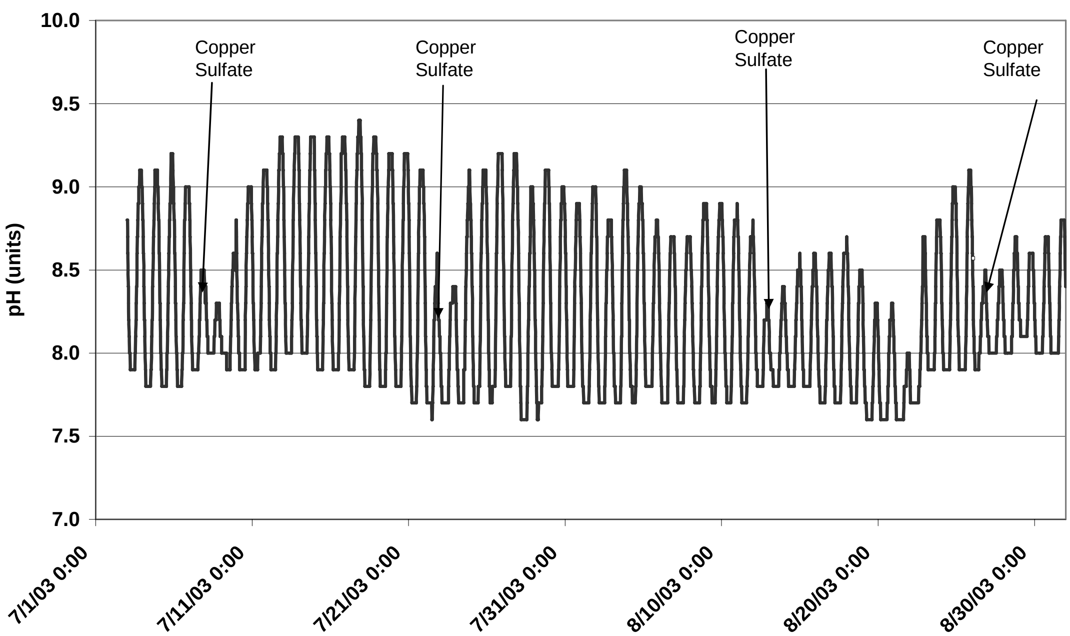




According to the monthly Division of O&M reports, the August 2003 incident was attributed to cyanobacteria growing in Clifton Court Forebay and the August 2004 incident may have been due to high levels of MIB and geosmin in waters pumped from Jones Tract after the levee break was repaired. DWR did not offer an explanation for the record high levels of MIB and geosmin in August 2005 and no algal species data were available. The role that sedimentation in Clifton Court Forebay plays in stimulating algal blooms in the Delta that lead to T&O incidents in the SBA is discussed in Chapter 7. As shown in **Figure 5-8**, the concentrations of MIB and geosmin are generally lower in water released from Lake Del Valle than in the SBA. When available, water is released from Lake Del Valle to reduce the impact of algal growth on the treatment plants downstream from the point where Lake Del Valle water enters the SBA.

The primary mechanism for controlling algal growth in the SBA is by the application of copper sulfate. Copper sulfate is applied from March or April until September, depending upon water temperatures and algal conditions. It effectively reduces algal populations but the dead algae release T&O producing compounds and result in filter clogging problems. Algae growing in the SBA cause pH to vary widely during the day as the algae take up carbon dioxide during the day and release it at night. **Figure 5-9** shows pH measurements taken every 15 minutes at the intake of ACWD's Water Treatment Plant No. 2 (WTP-2). This figure indicates that pH can change by almost 2 pH units in 24 hours. The figure also shows the impact of the copper sulfate applications. Immediately following a copper sulfate application, the daily variability in pH is reduced; however, the effect is short-lived, generally lasting about two to three days.

Figure 5-9. Daily pH Fluctuations at ACWD WTP-2



The use of copper sulfate to control algae is regulated under the Statewide General National Pollutant Discharge Elimination System (NPDES) Permit for the Discharge of Aquatic

Pesticides for Aquatic Weed Control in Waters of the U.S. Concern has been expressed that the use of copper sulfate may be further restricted in the future and result in the need for more costly control measures. As discussed in Chapter 2, the U.S. Environmental Protection Agency (USEPA) recently adopted a regulation that adds pesticide application to waters of the U.S. to the list of discharges that do not require NPDES permits. It is uncertain if the State Water Board will rescind the General Permit in response to the USEPA regulation. The State Water Board's chief counsel has recommended that the permit not be rescinded, pending judicial review of the USEPA regulation.

Cattle Grazing in the Bethany Watershed

Cattle grazing occurs on both private and state-owned land in the Bethany Reservoir watershed. Cattle have access to the western shore of Bethany Reservoir and have been observed standing in the water. Grazing animals may contribute pathogens, nutrients, and organic carbon to Bethany Reservoir from their manure and may lead to increased loading of sediment and other contaminants due to overgrazing of the watershed, or trampling of drainage courses and the shoreline of the reservoir. In addition, as discussed in Chapter 3, grazing animals may be a source of hormones. Animals with access to the water pose a greater risk than those that graze in upland areas of the watershed, away from Bethany Reservoir or drainage courses.

The state owns the land on the western side of Bethany Reservoir within 300 to 500 feet of the shoreline. This property is managed by DWR and much of it is leased for cattle grazing to two individuals in three separate lease agreements that total 284 acres. DWR negotiates four- to five-year leases. The leases request that good grazing practices be used, but there are no requirements for specific measures such as keeping cattle out of the water. DWR occasionally conducts inspections of the property, although in recent years it's been less frequent than once a year (Personal Communication, Diana Garofalo, DWR). Cattle grazing also occurs on private property in the watershed, but no information was readily available on the numbers of animals or grazing practices.

As discussed previously, the Bethany Headlands drainage contained high levels of *Giardia* and *Cryptosporidium* relative to other sources of water to the SBA. Since cattle grazing is the primary use of this land and cattle are known carriers of these pathogens, cattle are the likely source of these pathogens. Local wildlife may also be a source.

Proposed Trail Along the SBA

The open canal sections of the SBA are fenced and are currently not accessible to the public. The East Bay Regional Park District (EBRPD) 1997 Master Plan, the Livermore Area Regional Park District Master Plan (Personal Communication, Ken Craig, Livermore Area Regional Park District), and the City of Livermore Bikeways and Trails Master Plan (Wilbur Smith Associates et al, 2001) include a proposed trail along the SBA from Interstate 580 to Mines Road. The proposed trail is considered a high priority because it would link EBRPD's Brushy Peak Park to Del Valle Regional Park. In addition, it is in an area that would link job centers such as Lawrence Livermore Laboratory with residential areas and other parks (Personal Communication, Steve Fiala, EBRPD). EBRPD would like to develop a multi-use trail (hiking, bicycling, and equestrian) and several years ago suggested a cooperative study with DWR and the SBA Contractors to explore the possibility of developing a trail

The EBRPD 1997 Master Plan also includes a proposed trail along the upper section of the open canal portion of the SBA from the surge pool to Altamont Pass Road. This trail would then continue to Bethany Reservoir. This trail is a lower priority than the trail along the lower portion of the aqueduct, because it is not considered to be a major link in the EBRPD trails system (Personal Communication, Steve Fiala, EBRPD).

The primary concerns associated with a multi-use trail along the SBA are short-term construction and long-term traffic impacts that could lead to increased erosion and turbidity in the water. Other long-term impacts include animal usage of the trail and handling of human wastes, both of which could contribute pathogens to the water if not properly managed. There are also concerns that increased public access could increase the potential for dumping of refuse and hazardous substances into the canal. Since the public currently has access to the canal at several locations where bridges cross the canal, development of a trail would not likely increase the potential for an illegal dumping incident.

EBRPD is not currently actively pursuing this project. There are a number of potential measures to protect water quality that should be considered if a trail is proposed in the future.

- Not allowing animals (dogs or horses) on the trail. The CDHS draft recreational usage guidelines recommend that equestrian trails be set back at least 100 feet from the high water level of a reservoir. A 100-foot setback would not be feasible with the proposed SBA trail.
- If animals are allowed, require owners to remove any feces deposited by their animals on the trail. Consider having anchored pet clean-up dispensers and trash receptacles at entrances to the trail and along the trail. Work with local equestrian groups to educate horse owners about the need to clean up after their animals.
- Fencing to prevent people and domestic animals from having contact with the water.
- Staging areas for trail access should be designed to make it difficult for vehicular access to the canal so that illegal dumping would be difficult to accomplish.
- Locating and anchoring portable chemical toilets in areas that do not drain to the SBA so that spills due to vandalism or pump-outs do not enter the water.
- Signage to indicate that the SBA is a source of drinking water for the region.
- Development of an Integrated Pest Management and pesticide use plan for the trail.
- Usage only during daylight hours.
- Patrols by EBRPD.

- Development and implementation of a management plan for the trail that incorporates all of the water quality protection measures agreed to by the SBA Contractors, DWR, and EBRPD.

Mercury and Polychlorinated Biphenyls

Lake Del Valle is a candidate for inclusion on California's 2006 303(d) list of water quality-limited water bodies. The 303(d) list is revised every two years by the State Water Board, in fulfillment of a requirement under the federal Clean Water Act. The candidate listing is for two pollutants: mercury and PCBs. The source of these pollutants is not known; the candidate listing is based on a finding of elevated levels of these pollutants in the tissues of fish (likely stocked fish) taken from the lake in April 2001 (State Water Board, 2005). While little is known about the extent or source of this contamination, repeated samples of water from Lake Del Valle analyzed by DWR and Zone 7 Water Agency have shown no detectable levels of mercury or PCBs in the water column. It is possible, therefore, that if these contaminants are present in the Lake Del Valle system, they are confined to the lake's sediments, and bioaccumulate, but do not pose a threat to drinking water quality. Alternatively, it is possible that the samples were taken from stocked fish and the source of these contaminants is outside of the watershed.

POTENTIAL ACTIONS

Continue Close Coordination Between DWR and the SBA Contractors on the Algal Management Program

Delta water contains high nutrient concentrations that result in algal blooms in Clifton Court Forebay and in the SBA. The impact of algal blooms on the SBA Contractors is minimized by weekly monitoring of T&O compounds and by judicious use of copper sulfate. Chapter 7 contains additional actions to potentially improve the ability to detect algal blooms as they develop.

Explore the Possibility of Using Photovoltaics to Limit Light to the SBA

Limiting light to the SBA may be the best approach to controlling algal growth in the open canal sections. The SBA Contractors and DWR should consider conducting a pilot study to determine the costs and feasibility of installing photovoltaic panels to limit light and generate electricity.

Improve Range Management and Restrict Cattle Access to Bethany Reservoir

The WPPP recommends a number of measures that could be taken by DWR and private property owners to better manage cattle grazing in the Bethany watershed. The SBA Contractors and DWR should reach agreement on measures that will be included in DWR leases when they are renegotiated. Restricting the access of cattle to the Bethany shoreline, particularly in close proximity to the South Bay Pumping Plant should be a condition when the leases are renegotiated.

Address Water Quality Concerns Associated with Proposed Trail

The SBA Contractors and DWR are concerned that development of a trail along the SBA open canal section would lead to security and water quality problems. EBRPD is not currently actively working on the SBA trail. If this project is resurrected in the future, the SBA Contractors and DWR should meet with EBRPD staff to discuss their plans for a trail and identify security and water quality concerns associated with developing a trail along the SBA. EBRPD is receptive to working with the SBA Contractors and DWR to ensure that water quality concerns are addressed.

Continue Open Communications with SBA Watershed Stakeholders

The SBA Contractors should continue communicating with SBA watershed stakeholders and local agencies to monitor and track changing watershed conditions, development pressures, and opportunities for local water quality protection improvements.

SAN LUIS RESERVOIR

San Luis Reservoir is a key component of both the SWP and the Central Valley Project (CVP), serving as the major storage facility south of the Delta. The TRC identified the San Luis Low-Point Project as a topic for discussion in this report. DWR O&M staff identified cattle grazing in the San Luis watershed as a potential concern in comments provided on the draft report.

SAN LUIS LOW-POINT PROJECT

Water is released from San Luis Reservoir on the west side through the Pacheco Pumping Plant, to meet the needs of federal CVP San Felipe Division Contractors in Santa Clara and San Benito counties. SWP and CVP Contractors in the San Joaquin Valley and southern California are served by releases from the east side of the reservoir through the William R. Gianelli Pumping-Generating Plant. San Luis Reservoir has a capacity of 2.03 million acre-feet. It is generally filled with Delta water during the fall and winter months and then drawn down during the spring and summer months.

Currently, state and federal water projects cannot fully utilize water stored in San Luis Reservoir without impacting the reliability of water deliveries to San Felipe Division Contractors. The location of the San Felipe Division intake, Delta operations, system-wide demands and diminished water quality together reduce project water supplies south of the Delta. These constraints are collectively known as the San Luis low-point problem. Water quality is one component of the low point problem. When the reservoir is substantially drawn down, the quality of water delivered via the Pacheco Pumping Plant can be adversely affected by algal growth in the reservoir. The San Luis Low-Point Project is attempting to address both water supply reliability and water quality issues.

South of Delta CVP supplies are at increasing risk of interruption because of more aggressive operation of the CVP and the SWP to meet increasing statewide demands. If San Luis Reservoir storage drops too low, potential supply interruption threatens public health and safety, major agricultural and industrial economies, as well as the Delta and south of Delta environments.

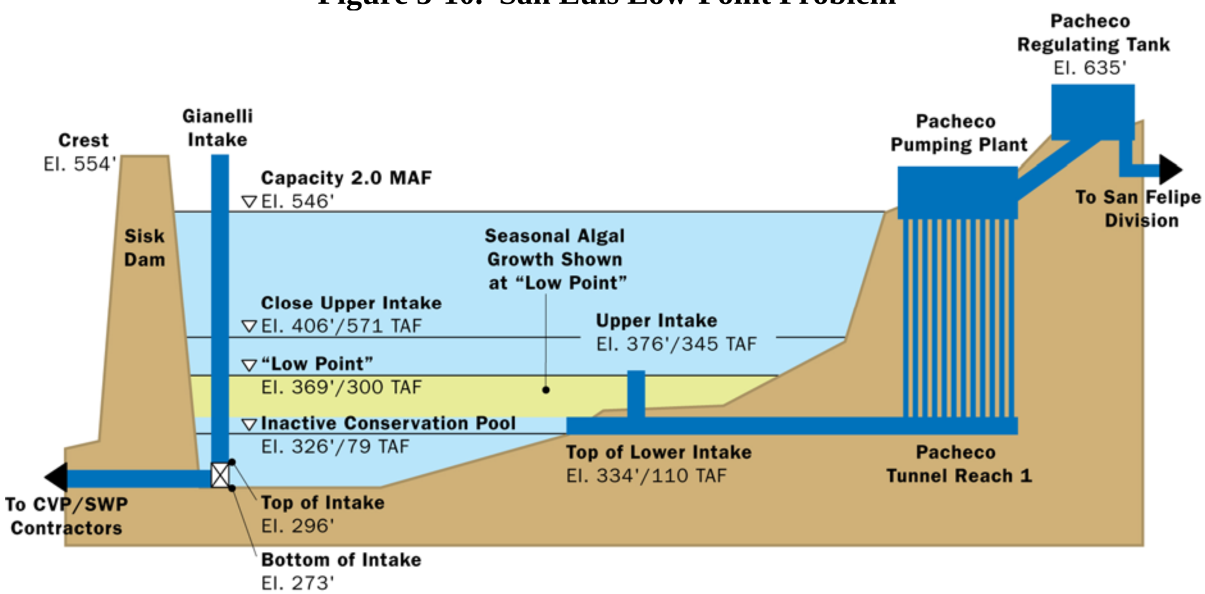
When the reservoir was constructed in 1968, the operational flexibility of both the SWP and CVP was greater. The location of the intake was not viewed as a constraint and the low-point problem did not exist. However, as flexibility has diminished due to increasing demands and operational restrictions, the low point has emerged as a persistent and serious problem with potential reliability impacts for all reservoir users.

Key Water Quality Concerns

Water levels in San Luis Reservoir typically reach their annual minimum elevations in late summer or early fall. The elevation of the water surface at the low point in a given year depends on the amount of water that the CVP and SWP operators were allowed to export from the Delta, the amount of water remaining in the reservoir from the prior year, and the water demands of the CVP and SWP Contractors. In any given year the reservoir can be substantially drawn down to meet Contractor demands.

Delta water stored in San Luis Reservoir contains sufficient nutrients to stimulate algal blooms in the reservoir, particularly when water levels are low in the late summer and early fall. Algae grow in the upper 30 feet of the reservoir. SCVWD has experienced severe T&O incidents and other treatment problems at its water treatment plants when algae are drawn into the Pacheco intake. The low-point begins to affect San Felipe Division operations when water level in the reservoir drops to an elevation of about 406 feet above mean sea level. At this elevation, 571,000 acre-feet of water are stored in the reservoir. When the water level approaches 406 feet, the upper intake of the Pacheco Pumping Plant (elevation 376 feet) is shut off to avoid drawing algae from the surface waters of the reservoir into the intake. If the water drops to an elevation of 369 feet (the low-point), algae can be drawn into the lower intake of the Pacheco Pumping Plant (elevation 334 feet). If the water level drops below the lower Pacheco intake, water deliveries to the San Felipe Division Contractors are interrupted. The top of the intake for the Gianelli Pumping-Generating Plant is 38 feet deeper than the lower Pacheco intake so it is not affected by algal growth as long as water levels are maintained at levels that allow withdrawal through the Pacheco intake. **Figure 5-10** is a schematic that illustrates the low- point problem.

Figure 5-10. San Luis Low-Point Problem



Source: SCVWD

The low-point problem restricts the operational flexibility of San Luis Reservoir for all CVP and SWP Contractors south of the Delta. The need to maintain the water level in the reservoir at or above 300,000 acre-feet to meet San Felipe Division allocations reduces the available supply by about 200,000 acre-feet. As the state's population continues to expand, and demand for water continues to grow, there will be increased need to use the 200,000 acre-feet of water stored below the low-point.

Actions Taken Since 2001 Sanitary Survey

The California Bay-Delta Program (CALFED) Record of Decision (ROD) identified the need for a canal to bypass San Luis Reservoir as a solution to the low-point problem (CALFED, 2000).

SCVWD obtained Proposition 13 funds and began the San Luis Reservoir Low-Point Improvement Project in early 2001. Although the CALFED ROD identified a bypass canal as the solution, SCVWD is evaluating a number of alternative solutions. A "Draft Alternatives Screening Report" was prepared in 2003 (SCVWD et al, 2003). In October 2004, Federal legislation was signed authorizing funding for CALFED conveyance programs including the San Luis Reservoir Low-Point Improvement Project, and the President's Fiscal Year Budget 2006 designated funding to begin the federal Feasibility Study.

Project Objectives

The objectives of the Low-Point Improvement Project are:

- Avoid supply interruptions when water is needed by increasing the certainty of meeting the requested delivery schedule of south of Delta CVP contractors dependent on San Luis Reservoir.
- Increase the reliability and quality of annual allocations to south of Delta CVP contractors dependent on San Luis Reservoir.
- Forecast earlier in the season the final allocation to CVP Contractors dependent on San Luis Reservoir.
- In addition to the above objectives, modify operations of San Luis Reservoir where possible to improve water quality conditions for the San Felipe Division Contractors and provide ecosystem restoration opportunities.

Description of Alternatives

In compliance with the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA), public input and ideas for alternatives were solicited and incorporated into the scope of this project. A multi-level screening process was used to evaluate 75 conceptual alternatives. The following alternatives were recommended for further consideration after the lengthy screening process.

- Algae Management – Algal growth would be controlled through the application of algacides and/or algae harvesting. This alternative only addresses water quality issues associated with the low-point problem, and would need to be implemented in conjunction with another alternative to address operational flexibility.
- Dissolved Air Flotation (DAF) Treatment - DAF is a proven method for removing algae in water treatment plants. A centralized treatment plant would be constructed or DAF would be installed at individual water treatment plants. Similar to algae management, DAF treatment only addresses water quality issues, and would be combined with other alternatives to meet all project objectives.

- Lower San Felipe Intake – The intake would be extended and lowered so that water could be drawn from lower elevations, comparable to the Gianelli intake.

- Bypass San Luis Reservoir - The original CALFED option, the bypass canal would extend from the DMC, near the turnout to O'Neill Forebay, to the Pacheco Regulating Tank.

- Expand Pacheco Reservoir - Pacheco Reservoir would be expanded to allow water to be pumped from San Luis Reservoir during the wet season and stored in Pacheco Reservoir for use during low-point months.

- Combined Solution – A combined solution could involve modified operations of existing reservoirs, desalination, and other regional water planning efforts, such as expanding Los Vaqueros Reservoir and tying into the San Francisco Public Utilities Commission's Hetch Hetchy system.

- No Project/No Action - This alternative is required to be in compliance with CEQA and NEPA regulations. If the no project alternative is selected, no actions would be taken to solve the low-point problems.

Next Steps

The USBR is conducting a feasibility study with the local partners, the San Luis Delta Mendota Water Authority and SCVWD. It is anticipated that the study will be completed by June 2009. The first phase of the feasibility study, the Initial Alternatives Report, is scheduled for completion in June 2007. Much of the work completed under the state study will be incorporated into the Initial Alternatives Report, including all project alternatives described above.

Potential Actions

No actions are recommended at this time.

CATTLE GRAZING

DWR O&M staff identified cattle grazing in the San Luis watershed as a potential concern in comments on the draft 2006 Update report. Due to the need to meet the CDHS deadline for the final report, there was not sufficient time to determine the extent of cattle grazing in the watershed. As described previously in the SBA section, grazing animals may contribute pathogens, nutrients, and organic carbon from their manure and may lead to increased loading of sediment and other contaminants due to overgrazing of the watershed, or trampling of drainage courses and the shoreline of the reservoir. In addition, as discussed in Chapter 3, grazing animals may be a source of hormones. Animals with access to the water pose a greater risk than those that graze in upland areas of the watershed, away from the reservoir or drainage courses. The TRC determined that the issue of cattle grazing in the San Luis watershed will be addressed when the Action Plan is developed and implemented.

NON-PROJECT INFLOWS TO CALIFORNIA AQUEDUCT

During the historic drought of 1976 to 1977, supplies of SWP water were drastically reduced, placing great strain on the system's customers. The need to cope with this emergency encouraged creative approaches to meeting critical water demands. Realizing that agricultural SWP Contractors were hardest hit, urban SWP Contractors made part of their water allocations available for agricultural use. Another approach was to use aqueduct capacity to move water from locations where it was available to locations of critical shortage. This amounted to pumping groundwater from local areas in the San Joaquin Valley into the California Aqueduct and conveying it to other farmers in need.

Prior to the drought emergency, DWR had no explicit policy for acceptance of non-Project waters into the system, but a policy was developed to address the drought emergency and a groundwater pump-in program implemented until the end of the drought in 1978. The program provided significant flexibility for mitigating impacts of the 1976 to 1977 drought, and was validated as a water management tool. Accordingly, this tool has continued to be employed in recent years.

The ability to use aqueduct capacity to move water from a point of availability to a point of need is a potentially valuable means of balancing increasing demands with limited supplies of California's water resources. The prospect is for greater use of this tool as California's water resources must be managed under increasingly severe constraints. Use of SWP facilities for conveying non-Project waters must, however, be made with the realization that efficient use of water supplies is inexorably linked to water quality. The water quality impacts of the inflows must be understood so that operational decisions can be based on water quality, along with other factors such as water supply needs. Adequate water quality monitoring and forecasting are critical to good operational decision making, and are necessary components of the DWR program.

KEY CONCERNS

A key concern associated with the acceptance of non-Project inflows into the SWP system is to protect against water quality degradation that could affect drinking water quality. Looking toward the future, increased reliance on non-Project inflows into the SWP must not cause significant impacts on drinking water quality. In this section the term "inflows" is used to describe non-Project groundwater and surface water that is conveyed in the California Aqueduct.

Policy for Acceptance of Non-Project Inflows to the SWP

The original policy governing acceptance of non-Project inflows, developed to cope with the 1976 to 1977 drought, was directed primarily at concerns over water quality degradation. The policy has been reviewed and updated periodically in subsequent years, but has consistently maintained focus on protection of water quality. The current policy governing acceptance of non-Project inflows was adopted in March 2001. A revised policy was proposed in March 2005. **Appendix C** contains both the adopted and proposed policies. A summary of the policy follows.

The policy establishes two categories of inflows based on water quality. The water quality of Tier 1 inflows is equal to or better than the historical SWP water quality, measured at Check 13, and therefore should not result in any degradation of water quality in the California Aqueduct. Inflows meeting this "no adverse impact" criterion are accepted, provided the project proponent follows established procedures for proposing, constructing, operating, and monitoring the project, and producing appropriate documentation.

A Tier 2 inflow is defined in the policy as containing constituents at concentrations that exceed the historical concentrations at Check 13 that could adversely affect SWP Contractors. Tier 2 proponents are referred to a Facilitation Group comprised of SWP Contractors. The Facilitation Group is an advisory body that reviews proposals, may consult with the project proponent, state or federal agencies, and others as appropriate, makes recommendations to DWR for acceptance or rejection of proposals, and recommends conditions for DWR acceptance. DWR has the ultimate responsibility for determining if an inflow will be accepted.

The proponent of an inflow program is required to submit detailed information on the project, including volumes and quality of inflow. Water quality monitoring is required and the policy sets forth several options that include monitoring of wells and monitoring at the point where the inflow is discharged to the aqueduct. Monitoring is required for all drinking water constituents for which there are Maximum Contaminant Levels (MCLs) listed in Chapter 15 of Title 22 of the California Code of Regulations (Title 22). In addition to these criteria, constituents of concern are identified for each proposed inflow, based on the proposed water quality. In past programs, these have included electrical conductance (EC) as an indicator of total dissolved solids (TDS), bromide, TOC, nitrate, arsenic, chromium VI, and sulfate. Although MCLs do not exist for bromide, TOC and chromium VI, these constituents may be present in inflows to the SWP and can affect drinking water quality. The other constituents of concern have primary or secondary MCLs. Phosphorus has not been included in the monitoring because it is typically low in groundwater.

The policy and its accompanying implementation procedures set forth an orderly process whereby proposed projects are evaluated and a decision made by DWR for acceptance or rejection of proposals. A process for appealing DWR decisions is provided and there is a provision for majority and minority opinions from the Facilitation Group in case unanimity is not achieved in the deliberations of that group. Approved inflow projects are reviewed annually and evaluated to determine the need for additional information or modification of project operating requirements. DWR is required to prepare annual reports on the water quality impacts of the non-Project inflows.

WATER QUALITY CONSEQUENCES OF NON-PROJECT INFLOWS

Non-Project inflows enter the California Aqueduct at a number of locations between Check 21, near Kettleman City, and Check 66, on the East Branch of the California Aqueduct just upstream of Silverwood Lake. **Figure 5-11** shows the locations of inflows that occurred between 2001 and 2005.

Figure 5-11. Location of Inflows on the California Aqueduct

Water quality monitoring programs are unique to each inflow program. Some programs have conducted detailed monitoring on all of the wells involved in the inflow program and others have conducted more limited monitoring. Some programs pump water into the aqueduct from wells that have similar water quality, whereas other programs pump from numerous wells with great variations in quality. Some inflow project proponents work cooperatively to model the impacts on aqueduct water quality to prevent degradation of drinking water supplies, whereas others operate independently. In general, each project proponent is required to monitor the quality of water entering the aqueduct daily or weekly when the inflows are started. After the quality of water entering the aqueduct has stabilized, quarterly monitoring is required for the constituents of concern.

The daily and weekly data collected by the project proponents were not available for this analysis. Data on the quality and quantity of inflows to the SWP were obtained from the DWR Division of O&M Water Quality Section. Data on the aqueduct quality were obtained from DWR's Water Data Library. **Table 5-5** displays the monthly volumes of inflows between 2001 and 2004. **Table 5-6** shows the same information for 2002 and 2003 and **Table 5-7** shows the inflow volumes for 2004. There were no inflows to the aqueduct during 2005. The row labeled "Inflows @ Ck 29" is the sum of inflows occurring upstream. The rows "Inflows @ Ck 41" and "Inflows @ Ck 66" are the total inflows between Check 21 and each of those checks. The rows labeled "% of Flow" at each of the check structures are the computed proportion of inflow waters to total flow past the given check structure.

Table 5-5. Non-Project Inflow Volumes in 2001

	Volume (acre-feet)									
	Mar	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Check 21	151,673	96,029	179,800	201,042	231,094	208.526	168,083	161,853	123,447	99,717
Semitropic	0	1,273	184	1,629	0	0	0	0	14,364	7,455
CV Canal	0	0	0	0	0	0	0	0	0	0
Kern	6,363	22,953	26,972	23,956	21,232	20,827	6,639	1,471	0	1,815
Buena Vista	168	0	0	0	0	0	0	0	0	0
Inflows @ Ck 29	6,531	24,226	27,156	25,585	21,232	20,827	6,639	1,471	14,634	9,270
% of Flow @ Ck 29	7	26	17	19	14	15	5	1	11	10
Check 29	88,061	91,715	159,413	137,242	147,537	139,048	138,887	138,276	126,178	93,059
Wheeler	0	16	189	125	153	90	65	0	0	0
Arvin	0	0	0	0	0	0	0	0	0	0
Inflows @ Ck 41	6,531	24,242	27,345	25,710	21,385	20,917	6,704	1,471	14,364	9,270
% of Flow @ Ck 41	8	29	19	23	17	17	5	1	11	10
Check 41	79,541	83,772	141,622	110,059	122,730	121,116	128,021	132,801	126,339	92,651
Antelope	0	0	0	62	66	24	0	0	0	0
Inflows @ Ck 66	6,531	24,242	27,345	25,772	21,451	20,941	6,704	1,471	14,364	9,270
% of Flow @ Ck 66	13	48	44	44	33	33	11	2	26	20
Check 66	51,974	50,907	62,860	58,370	65,753	62,522	58,999	60,837	56,199	47,294

Table 5-6. Non-Project Inflow Volumes in 2002 and 2003

	Volume (acre-feet)								
	2002					2003			
	Apr	**May**	**Jun**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
Check 21	213,326	239,035	365,089	175,959	161,019	63,578	80,696	241,663	204,188
Semitropic	0	0	0	0	0	0	0	0	0
CV Canal	3,775	918	0	5,645	4,300	1,569	3,504	439	4,731
Kern	9,959	11,631	571	0	0	10,718	11,805	2,239	15,077
Buena Vista	0	0	0	0	0	0	0	0	0
Total Inflows	13,734	12,549	571	5,645	4,300	12,287	15,309	2,678	19,808
% of Flow @ Ck 29	9	7	0	4	3	23	31	2	11
Check 29	150,332	186,960	188,800	157,404	141,643	54,149	49,857	178,448	178,358
Wheeler	0	0	0	0	0	0	0	0	0
Arvin	0	0	0	0	0	5,795	5,688	897	0
Total Inflows	13,734	12,549	571	5,645	4,300	18,082	20,997	3,575	19,808
% of Flow @ Ck 41	10	7	0	4	3	31	40	2	12
Check 41	138,202	169,524	161,200	156,915	139,498	57,494	52,450	171,074	169,940
Antelope	0	0	0	0	0	0	0	0	0
Total Inflows	13,734	12,549	571	5,645	4,300	18,082	20,997	3,575	19,808
% of Flow @ Ck 66	24	18	1	8	8	42	50	4	26
Check 66	56,131	70,993	72,116	73,437	54,861	42,905	42,232	79,952	75,607

Table 5-7. Non-Project Inflow Volumes in 2004

	Volume (acre-feet)						
	Jun	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Check 21	342,120	384,530	311,988	214,312	153,684	110,422	169,736
Semitropic	0	0	0	8,965	12,501	6,602	0
CV Canal	0	0	0	0	0	0	0
Kern	0	0	8,841	15,249	16,483	8,226	0
Buena Vista	0	0	0	0	0	0	0
Total Inflows	0	0	8,841	24,214	28,984	14,828	0
% of Flow @ Ck 29	0	0	4	12	19	13	0
Check 29	207,335	228,154	218,675	200,396	154,711	115,347	173,846
Wheeler	0	0	0	0	0	0	0
Arvin	1,664	1,982	2,829	5,098	4,293	4,957	4,689
Total Inflows	1,664	1,982	11,670	29,312	33,277	19,785	4,689
% of Flow @ Ck 41	1	1	6	15	22	17	3
Check 41	181,917	204,626	204,653	195,604	154,112	118,938	178,054
Antelope	0	0	0	0	0	0	0
Total Inflows	1,664	1,982	11,670	29,312	33,277	19,785	4,689
% of Flow @ Ck 66	2	2	12	31	38	25	5
Check 66	88,331	97,410	96,238	95,872	88,357	79,622	87,317

During the 2001 to 2004 period, a total of about 360,000 acre-feet of water was accepted from seven entities. All but two of these, the Cross Valley Canal (CV Canal) constituting 7 percent of the total, and Buena Vista Aquatic Recreation Area (Buena Vista), comprising less than 1 percent of the total, were groundwater. The CV Canal is operated by the CVP, and supplies water from the Delta. Buena Vista is a mix of surface and groundwater. About two-thirds of the inflow volume was from the Kern Water Bank Authority (Kern). These calculations over-estimate the proportion of inflow water because they do not account for the fact that deliveries to customers along the aqueduct contain a mix of aqueduct and inflow waters. The cumulative effects of inflows and project deliveries cause the highest proportions of inflow waters to be present in the farthest aqueduct reaches. **Figure 5-12** shows the calculated proportion of aqueduct water comprised of inflows. Inflows can reach up to 50 percent of aqueduct flow at Check 66.

Figure 5-12. Inflow Proportion of Aqueduct Flow

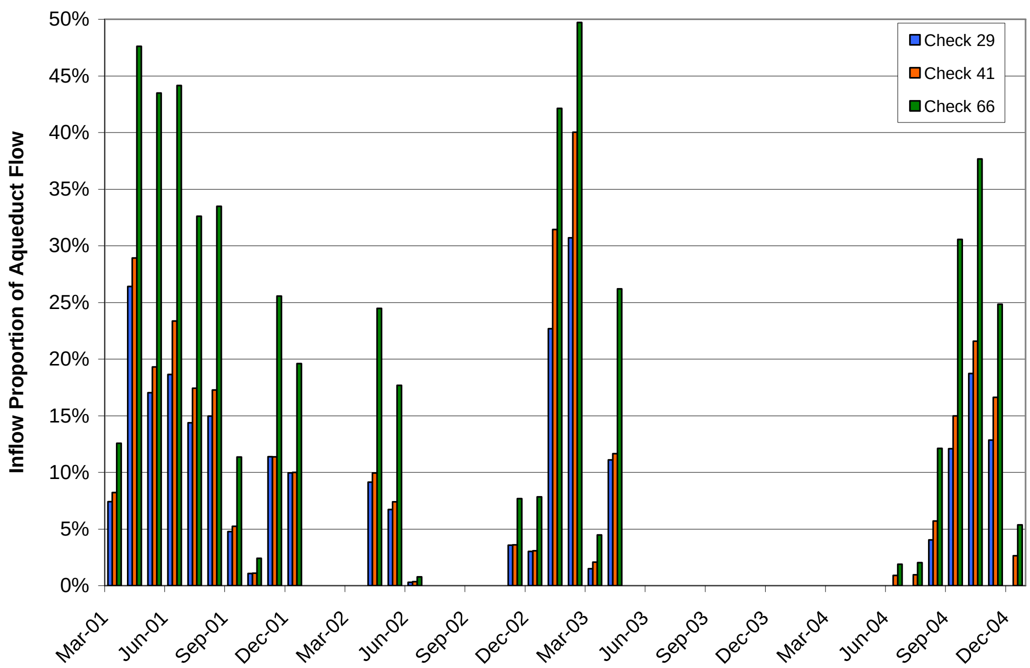


Table 5-8 is a summary of the quantity and average quality of inflow waters, compared to the quality of water measured at Checks 21, 29, and 41 of the California Aqueduct. The table also shows the drinking water MCLs and other objectives. Inflow volumes ranged from the Antelope Valley East Kern Water Agency (Antelope) inflow of 152 acre-feet to the Kern inflow of 243,027 acre-feet. **Table 5-8** shows in bold constituents that were present in inflows from individual entities that exceeded aqueduct concentrations. As shown in **Table 5-8**, the quality of non-Project inflows varies significantly. The concentrations of some constituents, such as organic carbon and bromide, are generally lower than the concentrations in the aqueduct. Other constituents such as nitrate and arsenic are generally found at higher concentrations in the inflows than in the aqueduct. This indicates that inflows have the potential to both improve and degrade water quality in the aqueduct.

Table 5-8. Comparison of Water Quality in Inflows and the California Aqueduct

	Inflow Volume (acre-feet)	EC (µS/cm)	TDS (mg/L)	Bromide (mg/L)	DOC or TOC (mg/L)	Nitrate (mg/L as NO_3)	Chromium VI (µg/L)	Arsenic (µg/L)	Sulfate (mg/L)
Inflows[a]									
Semitropic	52,973	**687**	**412**	**0.32**	1.2	**5.2**	**4.9**	**11**	**93**
CV Canal	24,881	437	263	0.17	0.5	**9.1**	**2.0**	**3**	**54**
Kern	243,027	421	261	0.18	1.2	**8.2**	**1.1**	**3**	**44**
Buena Vista	168	No data	345	**0.29**	**4.2**	0.6	No data	**6**	**41**
Wheeler	638	**1683**	**1366**	0.12	0.6	0.8	< 0.5	2	**837**
Arvin	37,892	367	208	0.10	1.2	**7.4**	**2.5**	**3**	25
Antelope	152	450	270	No data	No data	2.8	< 1	**<2**	**51**
California Aqueduct[b]									
Check 21		489	281	0.23	3.3	3.0	0.4	2	38
Check 29		491	287	0.23	2.8	3.2	0.6	2	39
Check 41		479	271	0.22	3.0	3.3	No data	2	39
Regulatory or Advisory Limit									
Primary MCL						45		10	
Secondary MCL		900	500						250
PHG						45		0.004	
Other				0.05[c]	< 4.0[d] 3.0[c]				

[a] Flow weighted average concentration of inflow waters.
[b] Average concentrations during months that inflows were occurring.
[c] Calfed target
[d] Federal Stage 1 Disinfectants and Disinfection Byproducts Rule limit for avoiding requirements for additional TOC removal.

Changes in aqueduct water quality as a result of inflows were evaluated in detail for three aqueduct sections: Check 21 to Check 29, Check 29 to Check 41, and Check 41 to Check 66. These sections were chosen for analysis because the check structures are also water quality monitoring sites and inflows occurred within each of these sections, making possible an analysis of their localized effects. During the 2001 to 2005 period, waters from Semitropic Water Storage District (Semitropic), CV Canal, Kern, and Buena Vista were discharged to the aqueduct in the 72-mile long section between Check 21 (mile 172.26) and Check 29 (mile 244.54). The CV Canal inflow is surface water, Buena Vista is a combination of surface and groundwater, and the other two are groundwater sources. In the 59-mile long aqueduct stretch between Check 29 and Check 41 (mile 303.41), groundwater from Wheeler Ridge-Maricopa Water Storage District (Wheeler) and Arvin Edison Water Storage District (Arvin) was allowed into the aqueduct. During the summer of 2001, Antelope discharged a small volume to the aqueduct between Check 41 and Check 66 (mile 403.41).

Continuous water quality recorders are installed at the four checks, monitoring EC, temperature, and turbidity. Of these, EC data were used for this analysis. The recorder at Check 66 was, installed in July 2003, so a full period of record was not available. The following paragraphs discuss the impact of inflows on water quality constituents. With the exception of TDS, this analysis is based on discrete (grab) samples collected monthly or occasionally more frequently from the aqueduct at Checks 21, 29, and 41, and from analysis of discrete samples of inflow waters. The TDS discussion is based largely on continuous EC data and the relationship between EC and TDS.

The analysis of impacts was complicated because water is pumped through the California Aqueduct mostly at night when energy demand is low and costs are reduced. On the other hand, inflows are generally in constant operation. The result can be uneven mixing of inflow and aqueduct waters, and discrete (grab) samples for water quality analyses may not always be representative of a fully mixed water body. In addition, with the limited available data, it was not possible to consider travel times in the aqueduct between the checks. The primary objective of this analysis was to determine if existing monitoring programs are adequate for evaluating the impacts of inflows on aqueduct quality.

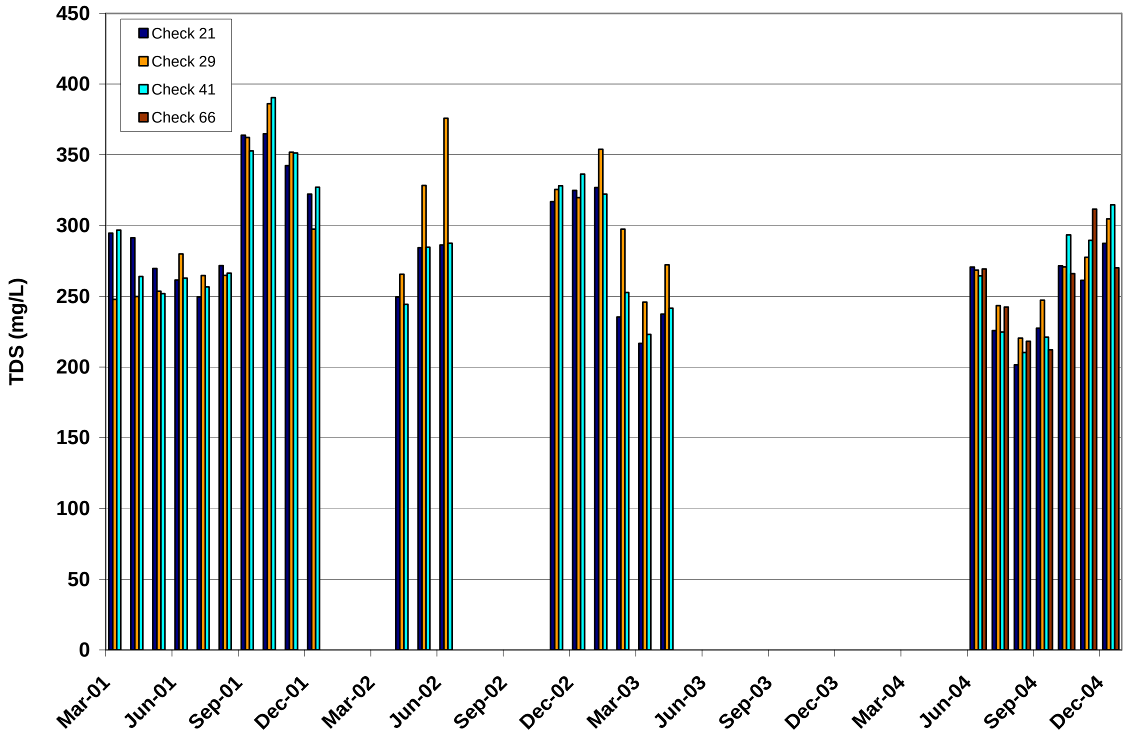
Total Dissolved Solids

As discussed in Chapter 3, TDS can make drinking water unpalatable, can shorten the life of plumbing fixtures and appliances, and create unsightly mineral deposits on fixtures and outdoor structures. An important economic effect can be the reduced ability to recycle water or recharge groundwater high in dissolved solids. The average TDS concentrations in the California Aqueduct during the period when inflows occurred ranged from 271 mg/L to 287 mg/L. Average TDS concentrations in inflows ranged from 208 mg/L in Arvin inflows to 1,366 mg/L in Wheeler inflows. The largest inflow (Kern) had an average TDS concentration slightly lower than the average in the aqueduct. The second largest inflow (Semitropic) had an average TDS concentration (412 mg/L) that was 50 percent higher than the average aqueduct concentration. Wheeler was the only inflow that exceeded the secondary MCL of 500 mg/L but the quantity of inflow water from this source was relatively small.

While data from discrete samples exist for Check 21 and Check 29, the number of samples is relatively few, in comparison to the continuous streams of EC data produced by the auto-recorders at those locations. Therefore, rather than use discrete sample data for the analysis, TDS was derived from continuously monitored EC to produce concentration estimates that should better represent true values of TDS in the aqueduct. To do this, a regression analysis was performed using 108 discrete samples collected from Check 21. The analysis produced the following equation: TDS = EC * 0.57 (R^2 = 0.997, indicating the relationship is strong). Mean monthly EC data for the months inflows occurred were converted to TDS by this formula, and used in the analysis.

Figure 5-13 compares TDS at Checks 21, 29, 41, and 66. TDS changes of less than 10 to 90 mg/L occur. These data suggest the direction of change is inconsistent, with downstream locations sometimes higher and sometimes lower than upstream locations. These apparent changes could be due to the actual influence of inflows, lag times in water flowing from one monitoring location to another, or may in some cases relate to difficulties with instrument calibration.

Figure 5-13. Total Dissolved Solids Changes Between Checks 21 and 66



To better understand the nature of the apparent changes, computations were made of the TDS changes that would be expected at Checks 29 and 41 based on aqueduct flow and quality, and the quality and quantity of inflows delivered into the aqueduct. This was a simple mass loading calculation. The actual change in TDS measured by the continuous recorders at the three checks were compared to the predicted changes. **Figure 5-14** presents the results for the aqueduct reach between Checks 21 and 29. The zero on the y-axis represents no change in TDS between the two checks, values above zero indicate TDS is higher at Check 29 by the indicated amount, and values less than zero indicate TDS is lower at Check 29. For the most part, where change was predicted, the predictions were matched by measured change in the same direction. However, there was typically a striking difference in the magnitude of change that was actually measured, compared to that predicted. Predicted TDS changes were less than 10 mg/L, whereas TDS concentrations at Check 29 were up to 90 mg/L higher than at Check 21. **Figure 5-15** shows the increment of predicted change attributed to each of the inflows in a given month. As described previously, the actual changes in TDS concentrations were quite different from the predicted changes. The Kern inflow had the largest influence on predicted TDS change in the Checks 21 to 29 section. The second largest influence was Semitropic. In September 2004, DWR limited the amount of water that Semitropic was discharging to the aqueduct due to high levels of TDS, bromide and arsenic (DWR, 2004).

Figure 5-14. Total Dissolved Solids, Predicted vs. Actual - Checks 21 to 29

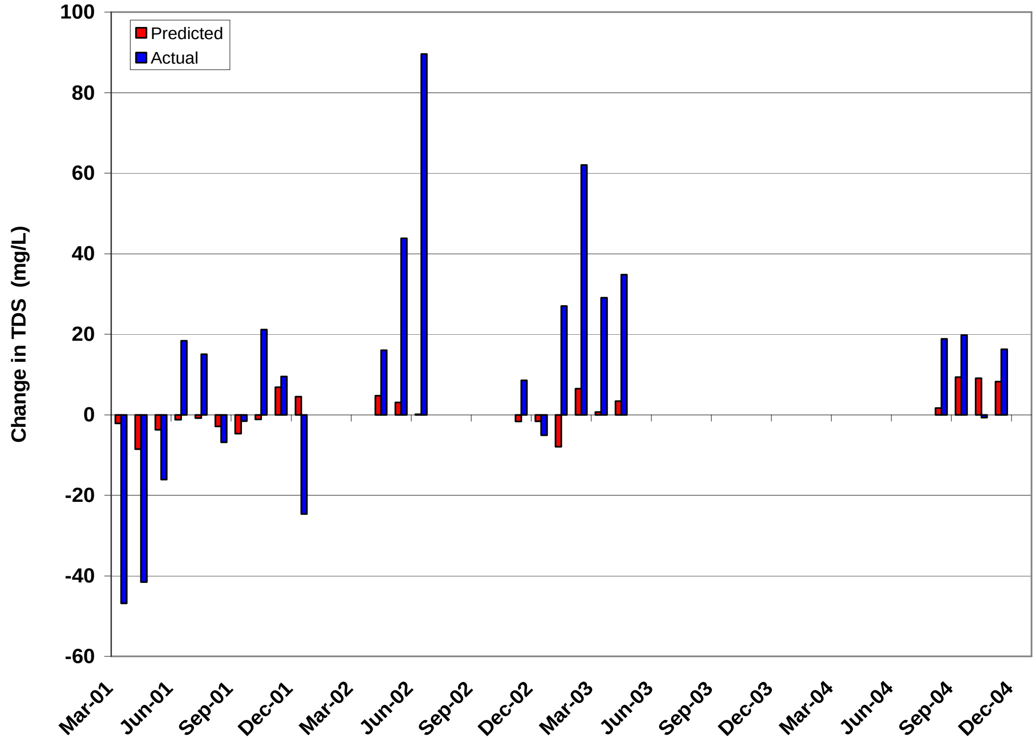


Figure 5-15. Total Dissolved Solids, Predicted Changes from Inflows - Checks 21 to 29

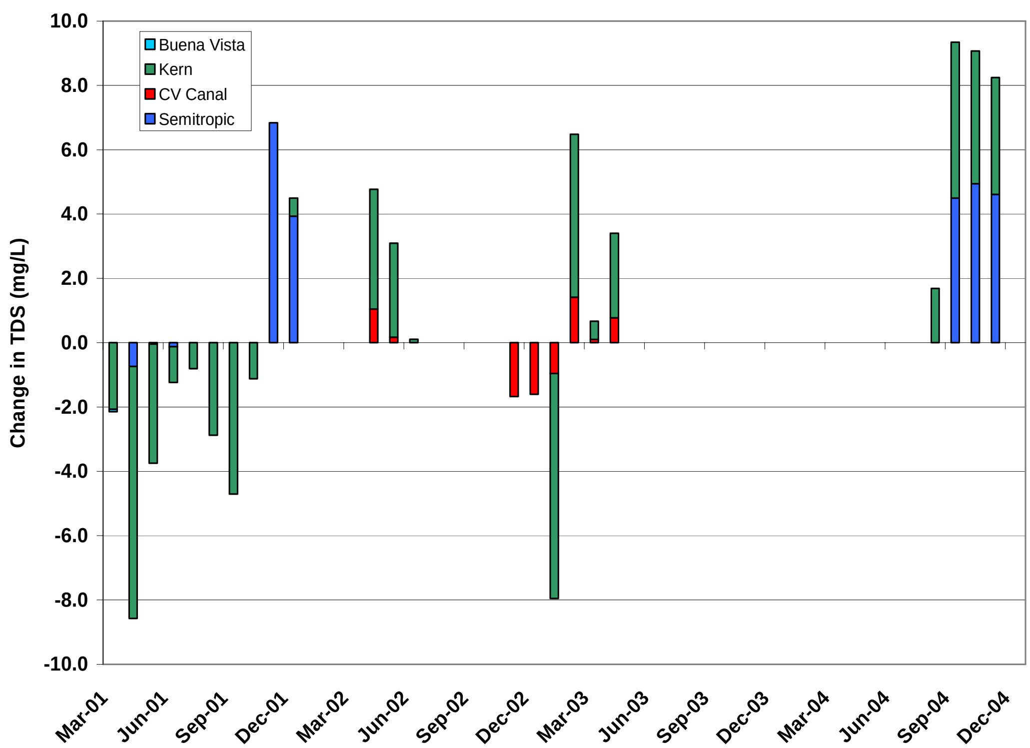


Figure 5-16 shows predicted versus measured TDS in the aqueduct section between Checks 29 and 41. In this section of aqueduct, predicted changes were minor. During the period inflows occurred, measured TDS changes ranged from a 46 mg/L decrease to a 23 mg/L increase. **Figure 5-17** shows Wheeler may have been responsible for a small TDS increase in 2001, while Arvin is predicted to have reduced aqueduct TDS in 2004.

Between Checks 41 and 66, there was a minor inflow of 152 acre-feet from Antelope, which represented 0.04 percent of the total flow in the aqueduct. Calculations were performed to identify any change in aqueduct water quality that would have been attributable to the Antelope inflow, and these computations indicated their effect was negligible on all water quality constituents for which data were available. Based on this analysis, the influence of Antelope on aqueduct water quality was below the threshold of concern and, accordingly, effects of this inflow are omitted from further analysis and discussion.

Because TDS is conservative in the system, this should be a reliable parameter for detecting water quality changes due to inflows. The inconsistency between predicted and measured differences shown in **Figures 5-14** and **5-16** indicates that existing monitoring is inadequate to detect the actual impacts of the inflows on aqueduct water quality.

Bromide

Bromide is a disinfection byproduct precursor, producing brominated trihalomethanes and haolacetic acids by reacting with chlorine, and bromate by reacting with ozone. Average bromide concentrations in inflows varied from 0.1 to 0.32 mg/L, and the average bromide concentrations in the aqueduct were 0.22 to 0.23 mg/L. The average concentration in the Kern inflow was slightly lower than the aqueduct, whereas the average bromide concentration in Semitropic inflows (0.32 mg/L) was substantially higher.

Figure 5-18 depicts bromide concentrations measured in monthly discrete samples collected at Checks 21, 29, and 41. Bromide data are not available for Check 66. Bromide concentrations did not change much as water flowed down the aqueduct, and the direction of change was inconsistent. Substantial differences occurred in January 2003 when Checks 21, 29, and 41 had concentrations of 0.34 mg/L, 0.23 mg/L, and 0.32 mg/L, respectively, a range of 0.11 mg/L.

Figure 5-19 shows that predicted bromide concentration changes in the aqueduct section between Checks 21 and 29 were less than the 0.03 mg/L, whereas measured changes were as great as 0.24 mg/L, a decrease observed in October 2004. Predicted changes were often, but not always, matched by measured changes in the same direction. According to **Figure 5-20**, most of the changes predicted to have occurred in the Checks 21 to 29 reach were due to Kern inflows. Kern reduced bromide concentrations by up to 0.02 mg/L in 2001, early 2003, and fall 2004, while slightly increasing concentrations during the latter months of 2003 and 2004. Based on the limited data available for this analysis, Semitropic inflows were predicted to reduce bromide concentrations by 0.02 mg/L in October 2004, and had immeasurable, or only minor, effects in other months. From September 7 to October 16, 2004, Semitropic was increasing bromide levels (Personal Communication, Karen Scott, MWDSC). CV Canal appears to have been responsible for slight changes during the period April 2002 through April 2003 period.

Figure 5-16. Total Dissolved Solids, Predicted vs. Actual - Checks 29 to 41

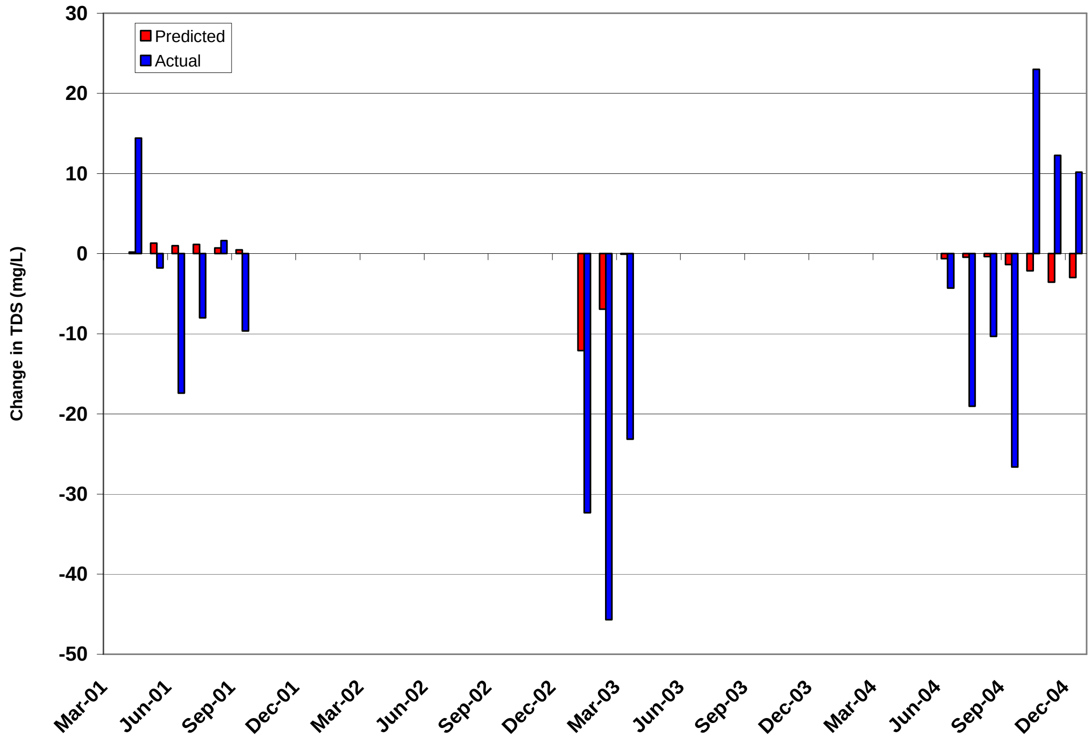


Figure 5-17. Total Dissolved Solids, Predicted Changes from Inflows - Checks 29 to 41

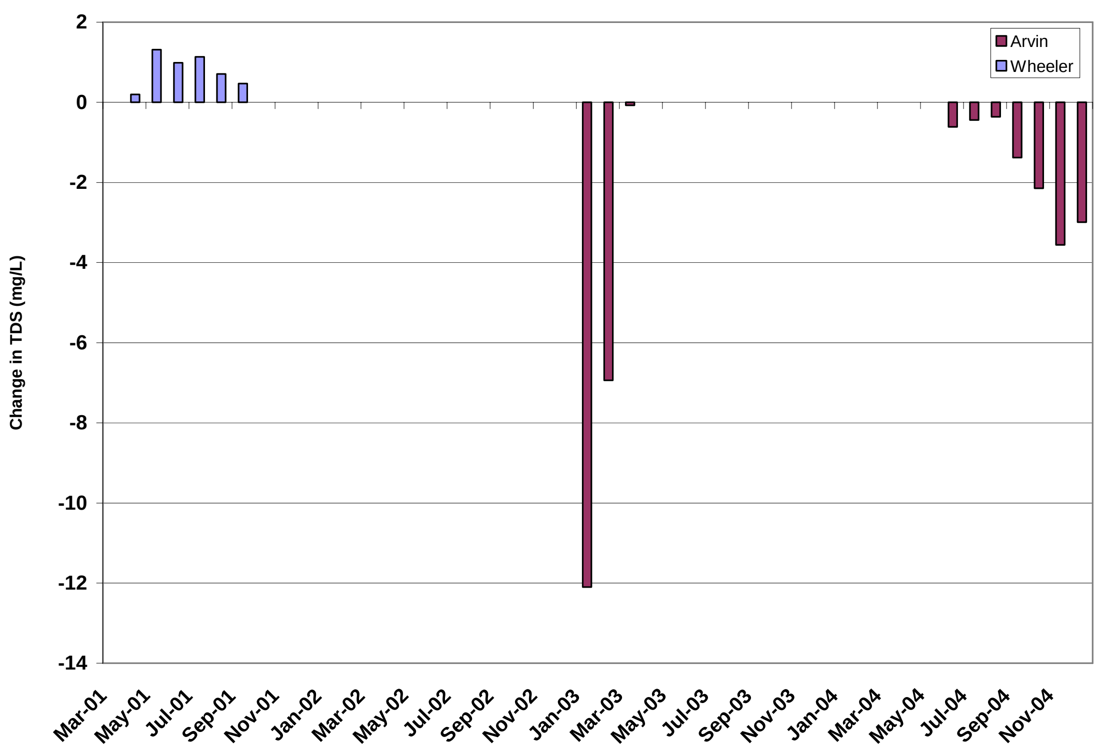


Figure 5-18. Bromide Changes Between Checks 21 and 41.

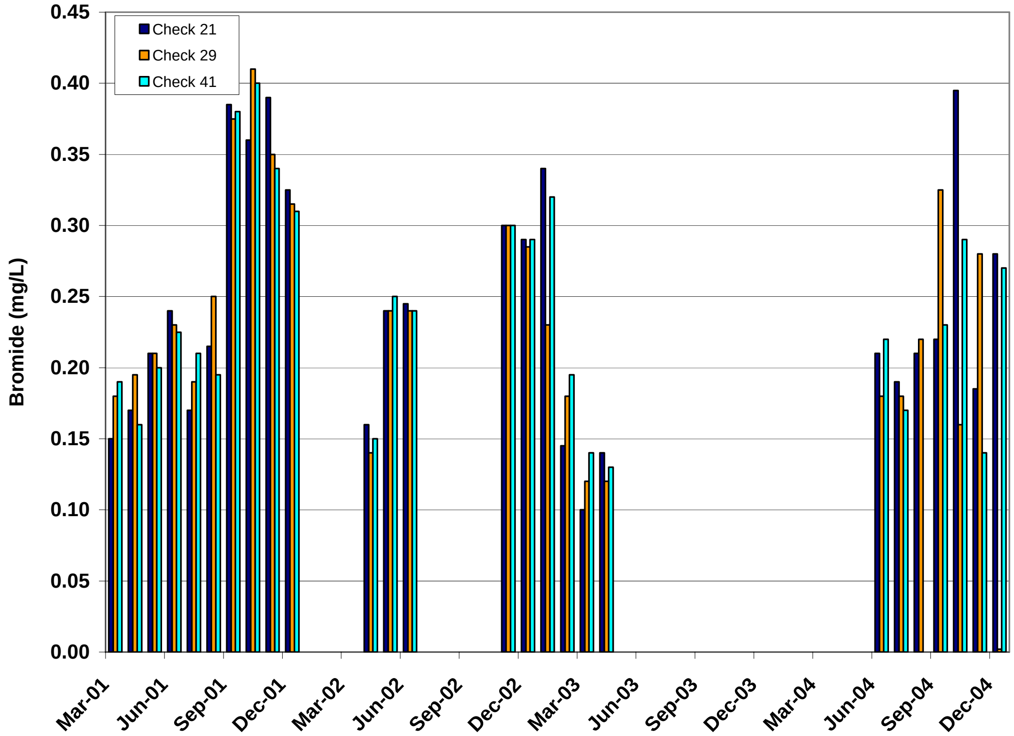


Figure 5-21 depicts changes between Checks 29 and 41. Predicted changes were generally less than 0.01 mg/L, whereas measured changes were as great as a 0.055 mg/L decrease in August 2001 and a 0.09 mg/L bromide increase in January 2003. **Figure 5-22** indicates that the Arvin inflow generally reduced bromide concentrations and that Wheeler had no influence on bromide concentrations.

Total Organic Carbon

TOC is a disinfection byproduct precursor. As described in Chapter 3, if the annual average TOC exceeds 4 mg/L, additional removal of TOC is required at water treatment plants. The average TOC concentrations in the aqueduct during the 2001 to 2004 period when inflows occurred ranged from 2.8 to 3.3 mg/L. With the exception of Buena Vista, the average TOC concentrations in the inflows were substantially lower than the aqueduct, ranging from 0.5 to 1.2 mg/L. The average TOC concentration in the Buena Vista inflow was 4.2 mg/L; however, this was a small volume inflow. This indicates that inflows have the potential to improve TOC concentrations in the California Aqueduct.

Figure 5-19. Bromide, Predicted vs. Actual - Checks 21 to 29

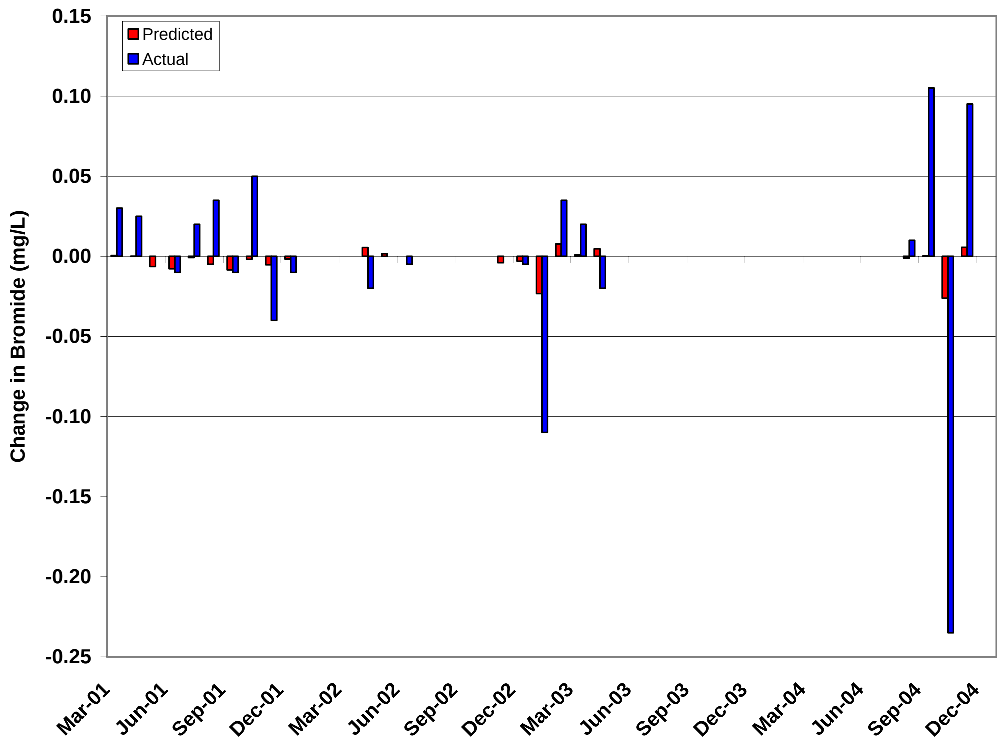


Figure 5-20. Bromide, Predicted Changes from Inflows - Checks 21 to 29

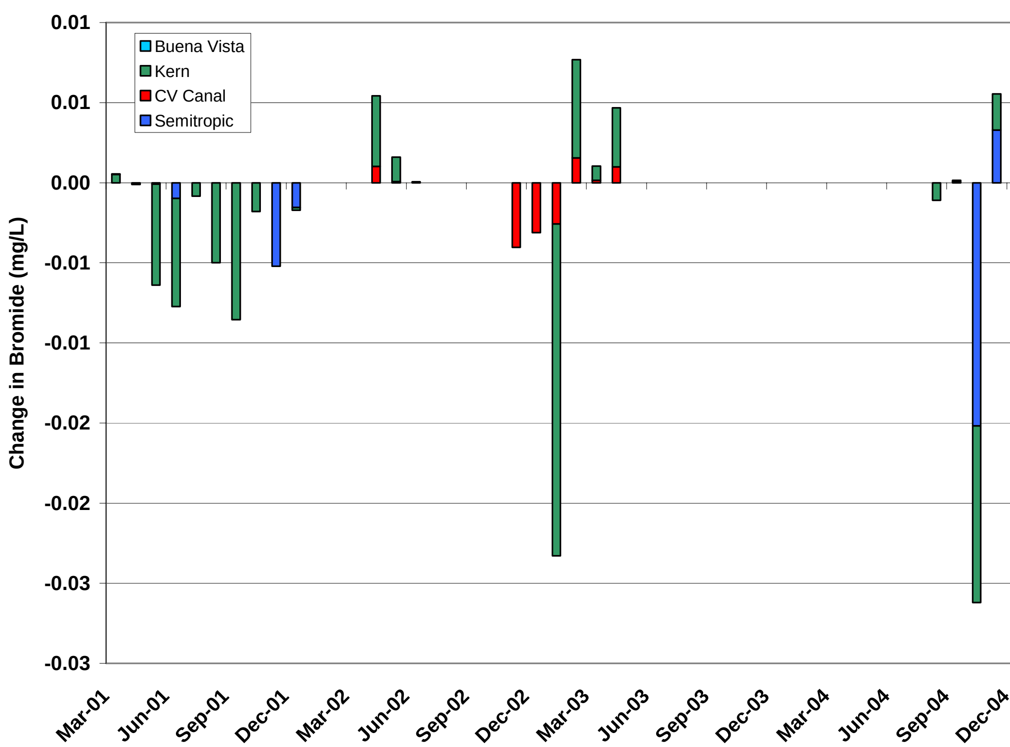


Figure 5-21. Bromide, Predicted vs. Actual - Checks 29 to 41

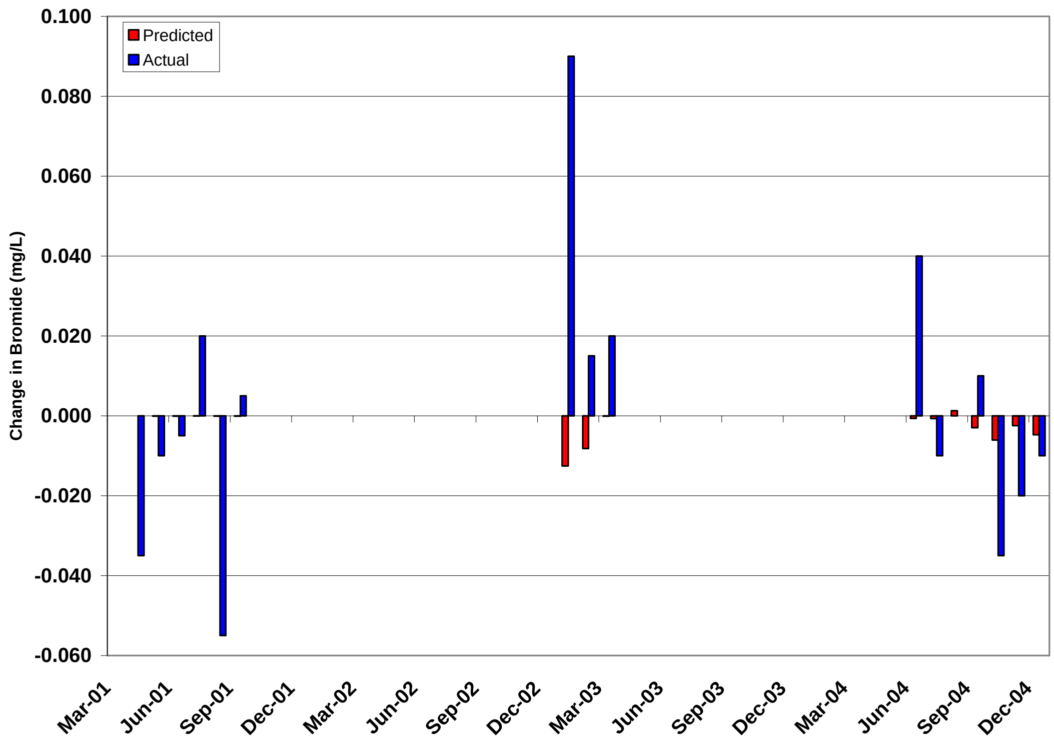
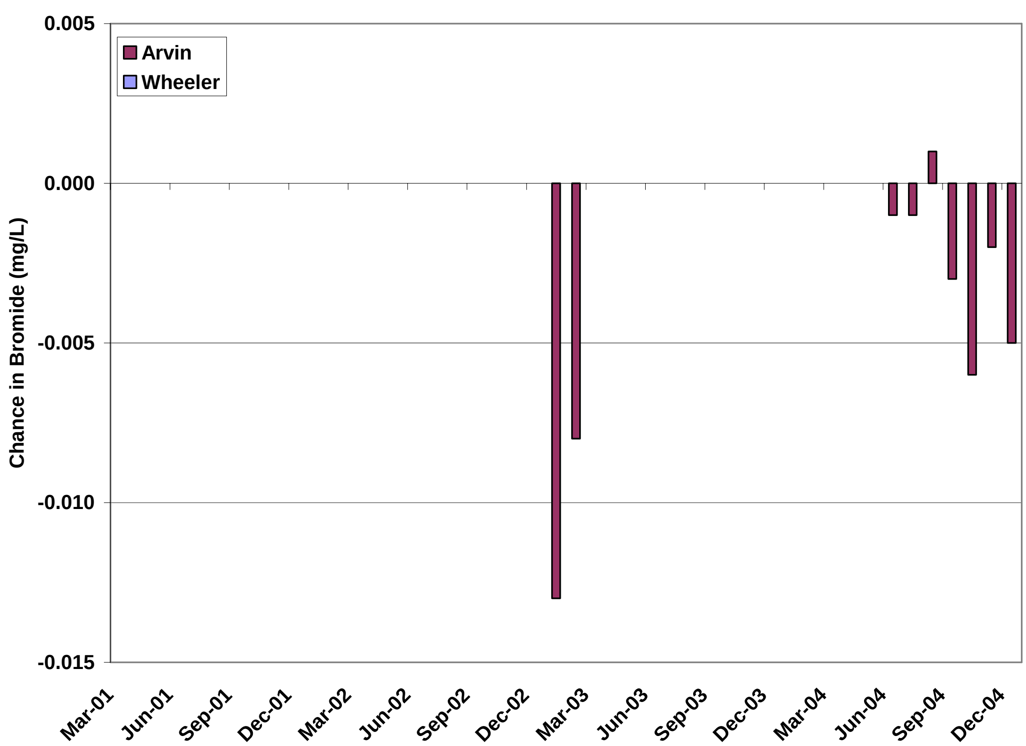


Figure 5-22. Bromide, Predicted Changes from Inflows - Checks 29 to 41



TOC concentrations in the aqueduct are depicted in **Figure 5-23.** There are periods of time, such as the winter of 2003 and the fall of 2004 when TOC decreased between Checks 21 and 41 and times when the concentration increased from upstream to downstream. Changes were generally less than 0.5 mg/L.

Figure 5-23. Total Organic Carbon Changes Between Checks 21 and 41

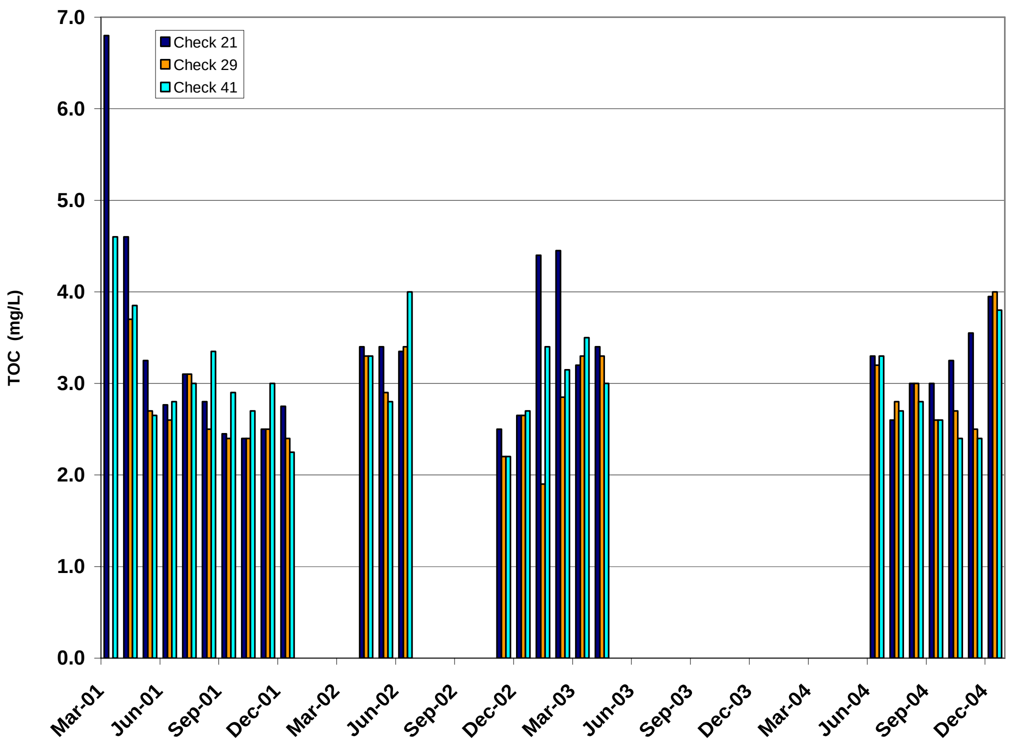


Figure 5-24 shows predicted versus measured TOC concentrations in the Checks 21 to 29 reach. Both predicted and actual changes were generally in the direction of TOC reduction. The actual reductions in TOC were almost always greater than the predicted concentration changes. As shown in **Figure 5-25**, Kern is predicted to have had the greatest impact on TOC in the Checks 21 to 29 stretch of aqueduct, reducing TOC by as much as 0.6 mg/L. The CV Canal is predicted to have had a modest positive influence as well, reducing concentrations about 0.1 mg/L during 2003. Semitropic inflows were predicted to reduce TOC by 0.1 to 0.2 mg/L.

Figure 5-26 shows little predicted change in TOC concentrations and observed changes of up to 1.5 mg/L between Checks 29 and 41. Predicted reductions were generally less than about 0.1 mg/L. As indicated in **Figure 5-27**, the minor predicted reductions in TOC in this reach were almost entirely due to Arvin inflows.

Figure 5-24. Total Organic Carbon Predicted vs. Actual - Checks 21 to 29

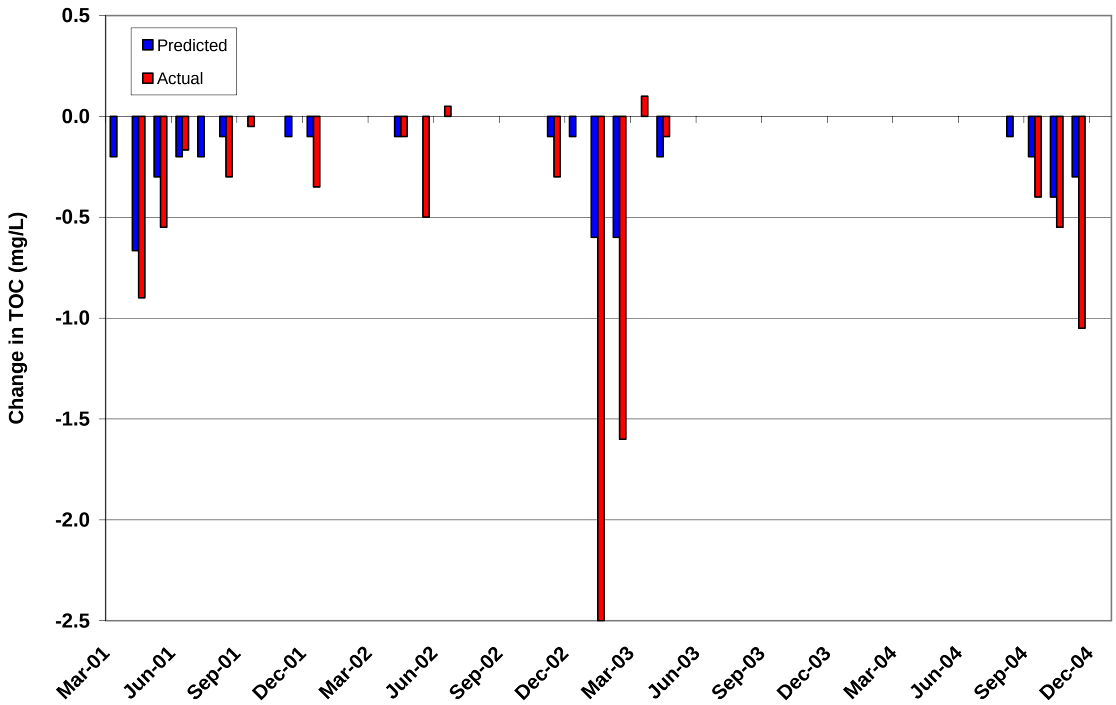


Figure 5-25. Total Organic Carbon, Predicted Changes from Inflows - Checks 21 to 29

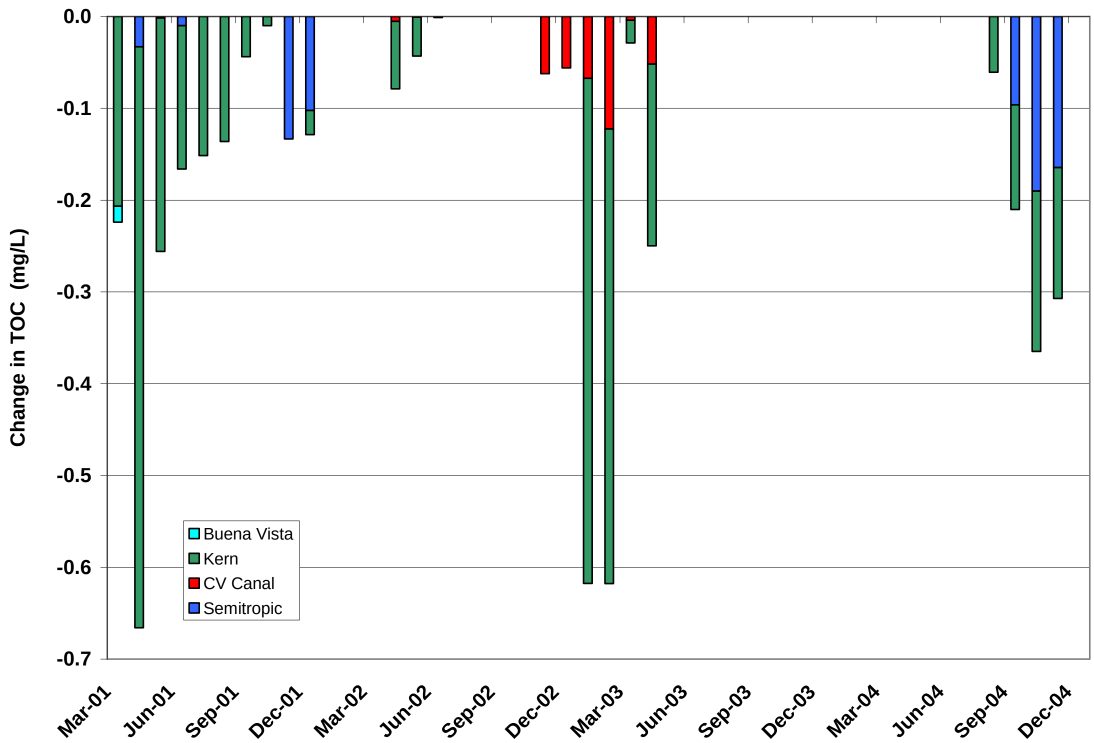


Figure 5-26. Total Organic Carbon, Predicted vs. Actual - Checks 29 to 41

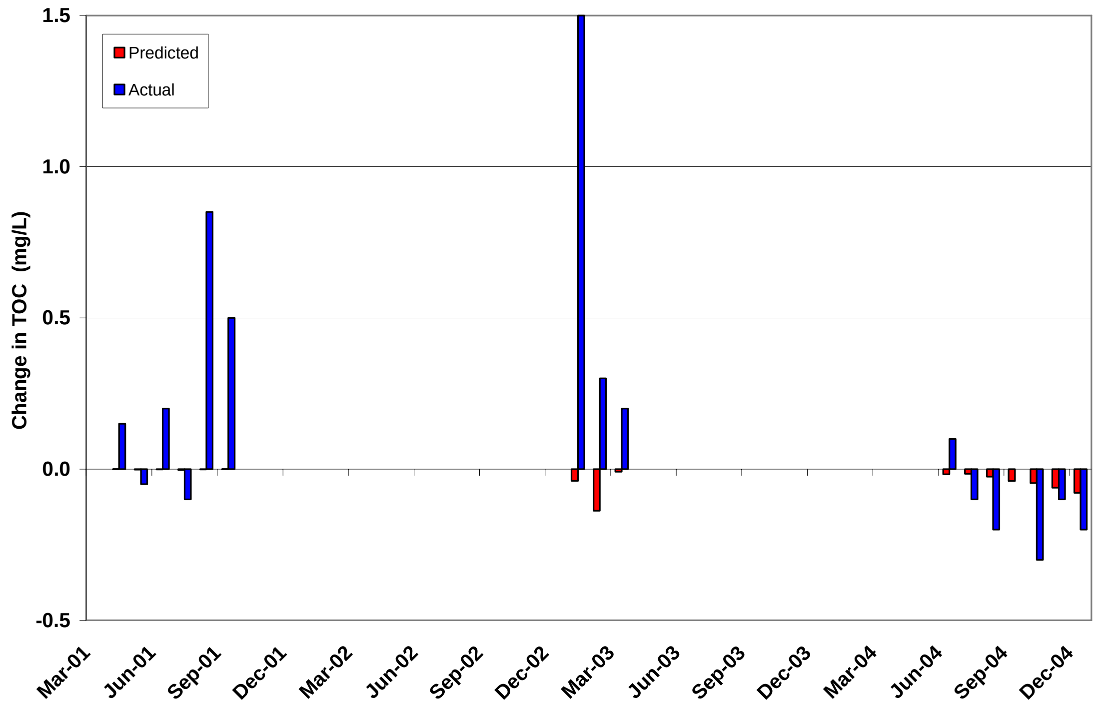
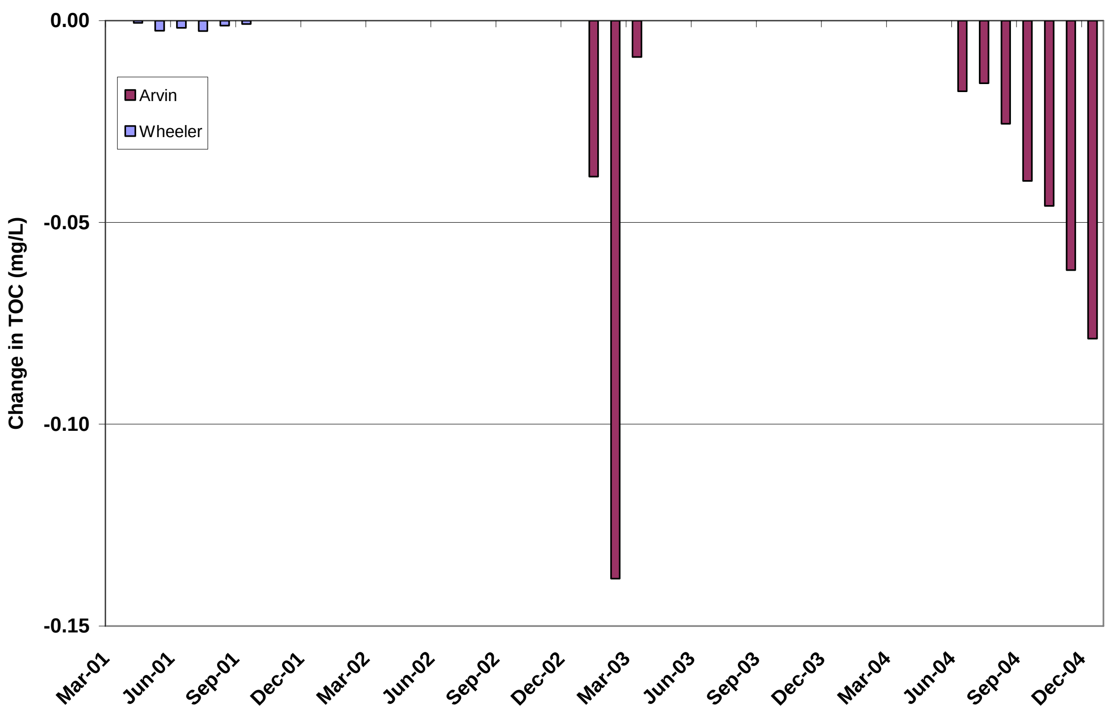


Figure 5-27. Total Organic Carbon, Predicted Changes from Inflows - Checks 29 to 41

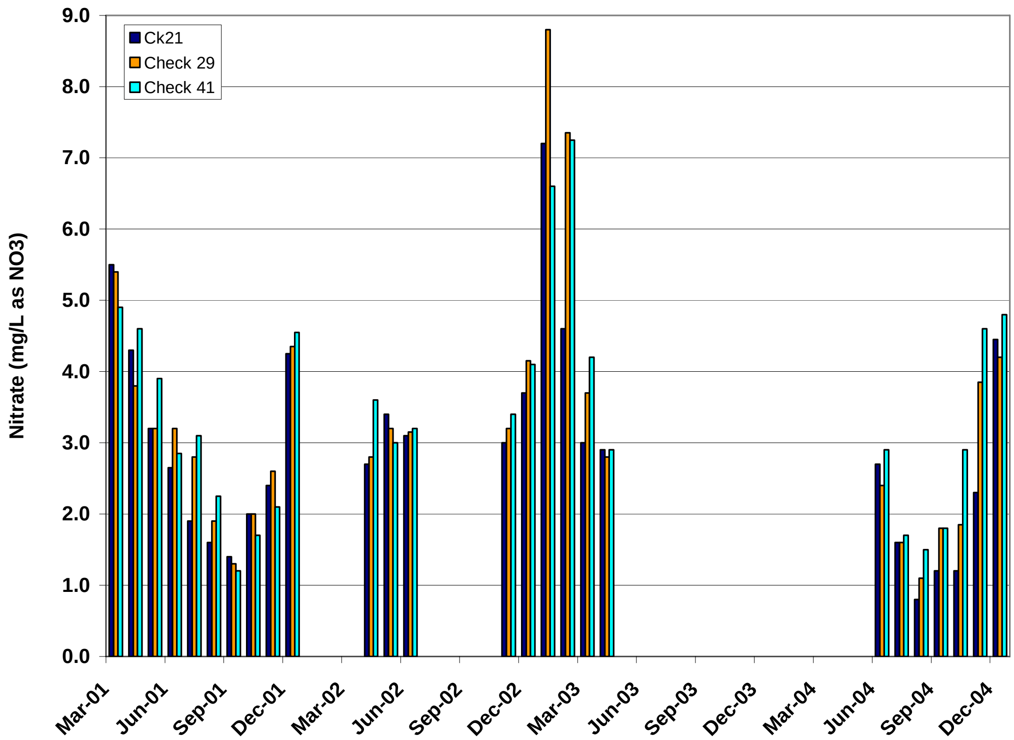


Nitrate

Although nitrate concentrations in the SWP never approach the MCL or Public Health Goal (PHG) of 45 mg/L as NO_3, nitrate is a nutrient that stimulates algal growth leading to taste and odor problems, physical obstruction of water conveyance and treatment facilities, and increased treatment costs. Nitrate concentrations in the aqueduct averaged 3.0 to 3.3 mg/L as NO_3 during the period of inflows. All concentrations of nitrate referred to in this section are reported as NO_3. The average nitrate concentrations of the inflows ranged from 0.6 to 9.1 mg/L, far below the MCL. The average nitrate concentrations in the two largest volume inflows were 8.2 mg/L for Kern and 5.2 mg/L for Semitropic. Although inflows are not likely to result in an exceedance of the nitrate MCL in the aqueduct, concentrations are sufficiently high to stimulate algal growth.

Figure 5-28 shows nitrate concentrations in the aqueduct between Checks 21 and 41 were less than 9 mg/L, and were often below 5 mg/L during the months when inflows were permitted. During 9 of the 26 months when inflows occurred, nitrate progressively increased from Check 21 to Check 29 to Check 41. During other months changes were inconsistent. As nitrate is bio-transformed into other forms of nitrogen, concentration changes may reflect the effects of inflows, but may also reflect unrelated biological activity in the aqueduct.

Figure 5-28. Nitrate Changes Between Checks 21 and 41



Predicted versus measured changes in the aqueduct section between Checks 21 and 29 are depicted in **Figure 5-29.** Nitrate concentrations were predicted to increase as a result of inflows, with the largest increase predicted to be 1.1 mg/L. Actual nitrate concentrations decreased by as much as 0.5 mg/L and increased up to 2.8 mg/L. Predicted nitrate increases were larger than actual increases in a number of months. As shown in **Figure 5-30**, the Kern inflow was responsible for most of the predicted increase in nitrate concentrations.

Figure 5-29. Nitrate, Predicted vs. Actual - Checks 21 to 29

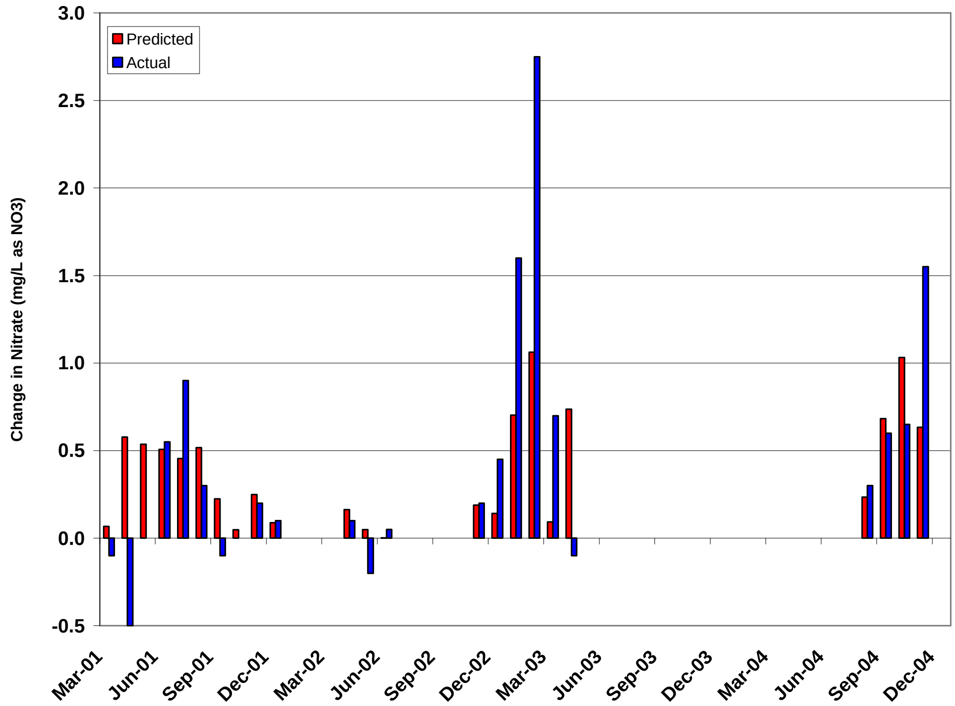


Figure 5-30. Nitrate Predicted Changes from Inflows - Checks 29 to 41

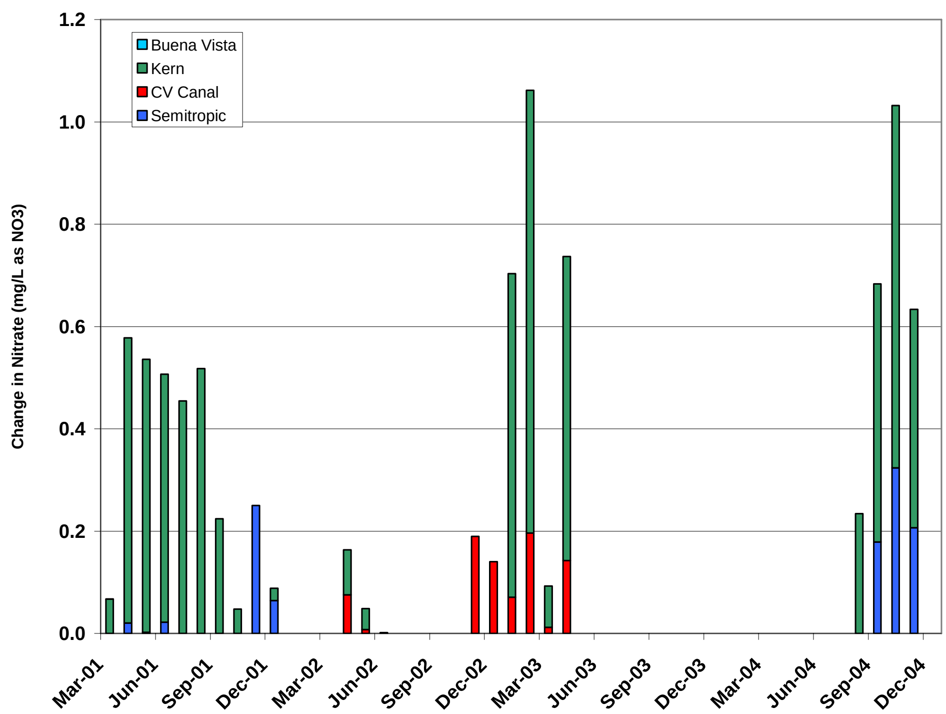


Figure 5-31 depicts predicted versus measured changes in nitrate concentrations between Checks 29 and 41. The direction of change predicted was reasonably consistent with the observed changes, but the degree of change was consistently underestimated. The largest observed change was a decrease of 2.2 mg/L that occurred in January 2003. During the other years, changes were smaller, ranging from a decrease of 0.5 mg/L to an increase of 1.1 mg/L. In **Figure 5-32**, it is clear that Arvin inflows were responsible for predicted nitrate reductions in 2003 and nitrate increases in 2004. The fact that a reduction of 2.2 mg/L was measured during January 2003, and increases as high as 1 mg/L were measured during 2004 indicates that the Arvin inflow did affect the quality of aqueduct water, but to a considerably larger degree than was predicted.

Arsenic

Arsenic is a human carcinogen with a PHG of 0.004 µg/L. The MCL for arsenic was reduced from 50 µg/L to 10 µg/L in 2006. CDHS may propose a more stringent MCL in the future. The average arsenic concentration in the California Aqueduct during the period of inflows was 2 µg/L and the average concentrations in inflows ranged from less than 2 to 11 µg/L. The average concentration in the largest volume inflow, Kern, was 3 ug/L. The 10 µg/L MCL was exceeded in inflows from Semitropic.

As demonstrated in **Figure 5-33**, arsenic concentrations were generally similar in the aqueduct between Checks 21 and 41, and ranged from about 0.7 µg/L to 4 µg/L during the months when inflows occurred. In months where differences were measured between check structures, the direction of change was inconsistent. In 8 of these months, concentrations increased a maximum of 2 µg/L, decreased a maximum of 2.3 µg/L in 6 of the months, and remained unchanged in 12 of the months. Aqueduct concentrations easily met the 10 µg/L MCL, but clearly did not meet the 0.004 µg/L PHG.

Figure 5-31. Nitrate Predicted vs. Actual - Checks 29 to 41

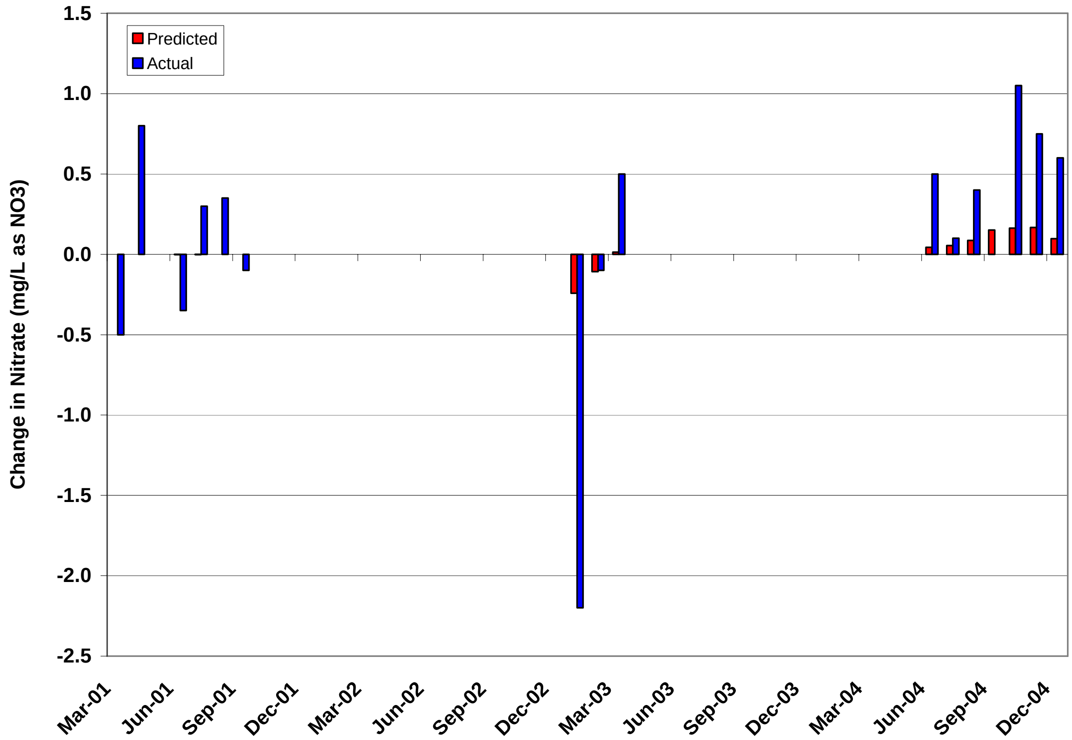


Figure 5-32. Nitrate Predicted Changes from Inflows - Checks 29 to 41

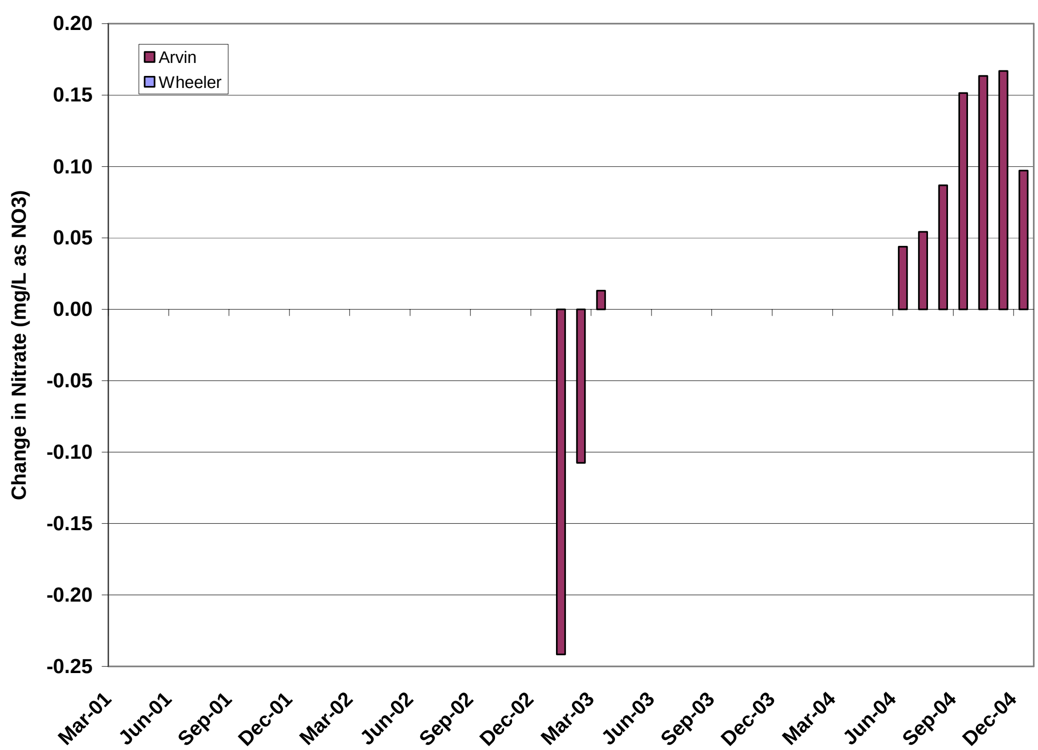


Figure 5-33. Arsenic Changes Between Checks 21 and 41

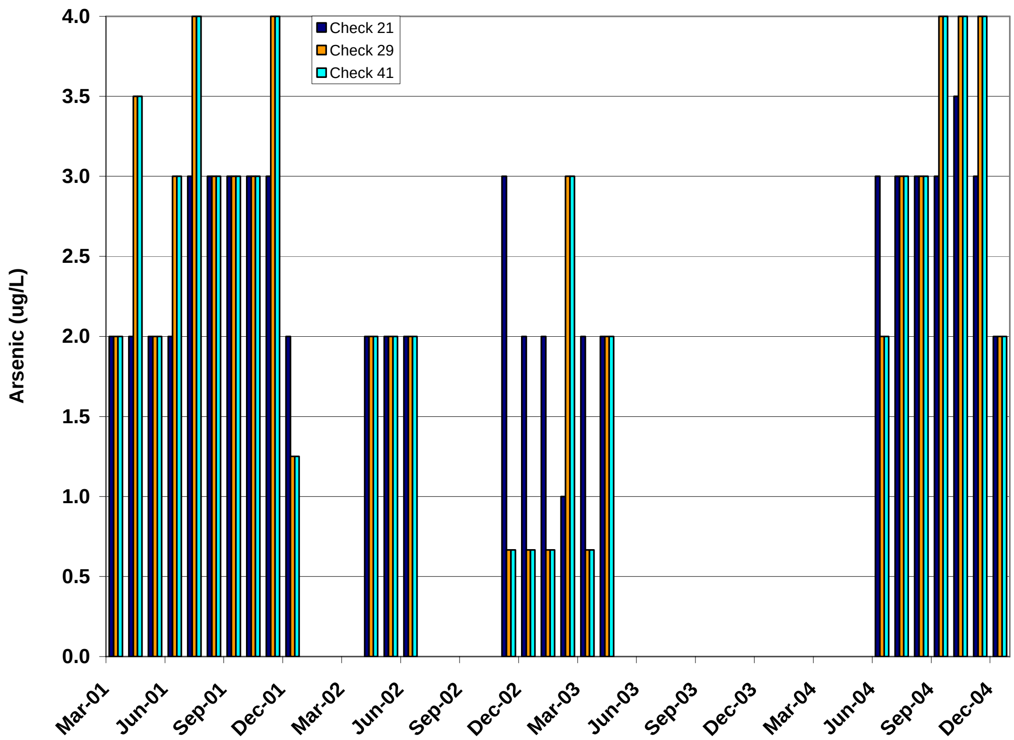


Figure 5-34 shows the predicted versus measured changes in arsenic concentrations between Checks 21 and 29. Predicted concentration increases due to inflows are between 0 and 0.6 µg/L. Measured concentration changes were of a greater magnitude, ranging from a decrease of 2.3 µg/L to an increase of 2 µg/L. **Figure 5-35** shows that Semitropic inflows were responsible for most of the predicted arsenic concentration increases.

Interestingly, **Figure 5-36** shows a close correspondence between predicted and actual changes in arsenic concentrations between Checks 29 and 41. Increases up to 2 µg/L during February 2003, and reductions as large as 1.3 µg/L in January and March 2003 were both predicted and measured. Of the water quality constituents included in this analysis, the correspondence of predicted to measured concentrations is best for arsenic in this reach of the aqueduct. The sources of changes in arsenic concentrations between Checks 29 and 41 are shown in **Figure 5-37**. In 2001, Wheeler inflows were predicted to increase aqueduct concentrations by as much as 1.5 µg/L. Inflows from Arvin were responsible for the predicted changes that occurred in 2003 and 2004, which amounted to reductions as great as 1.3 µg/L and increases as large as 1.9 µg/L.

Figure 5-34. Arsenic, Predicted vs. Actual - Checks 21 to 29

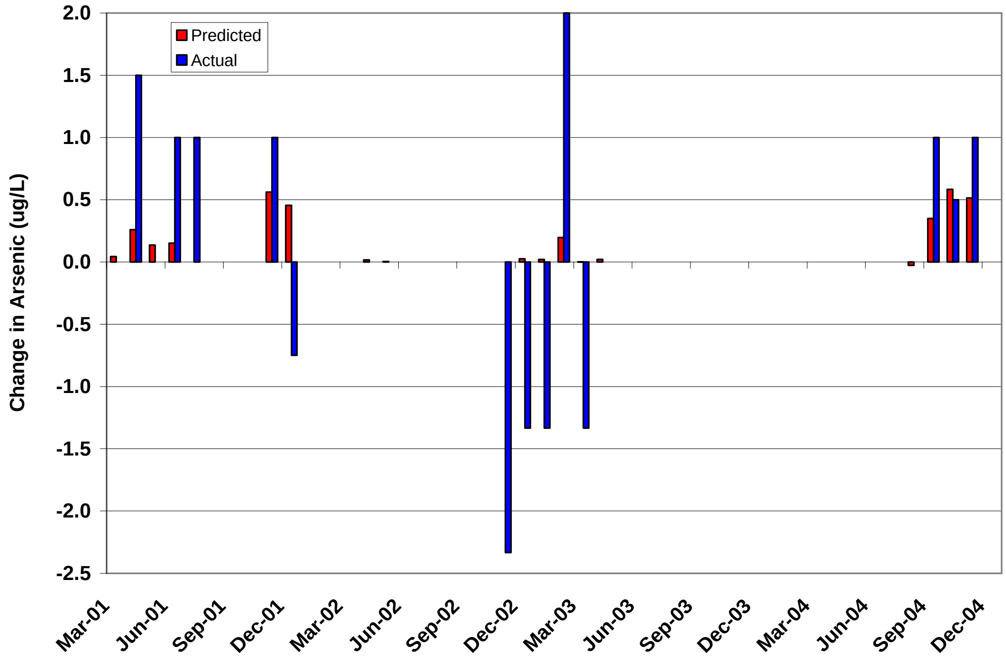


Figure 5-35. Arsenic, Predicted Changes from Inflows - Checks 21 to 29

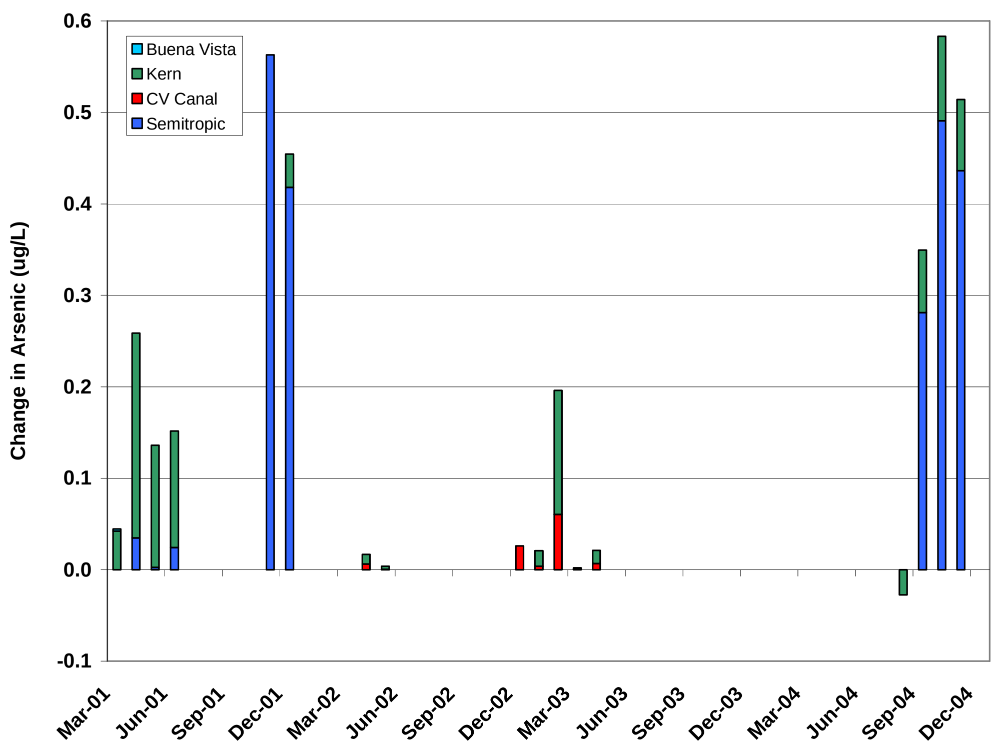


Figure 5-36. Arsenic, Predicted vs. Actual - Checks 29 to 41

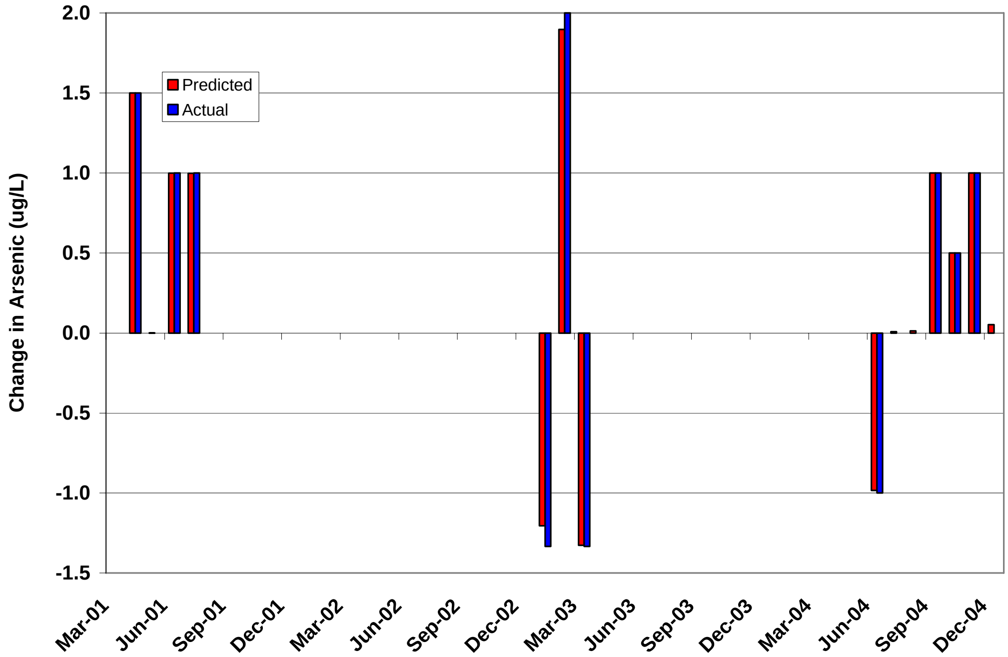
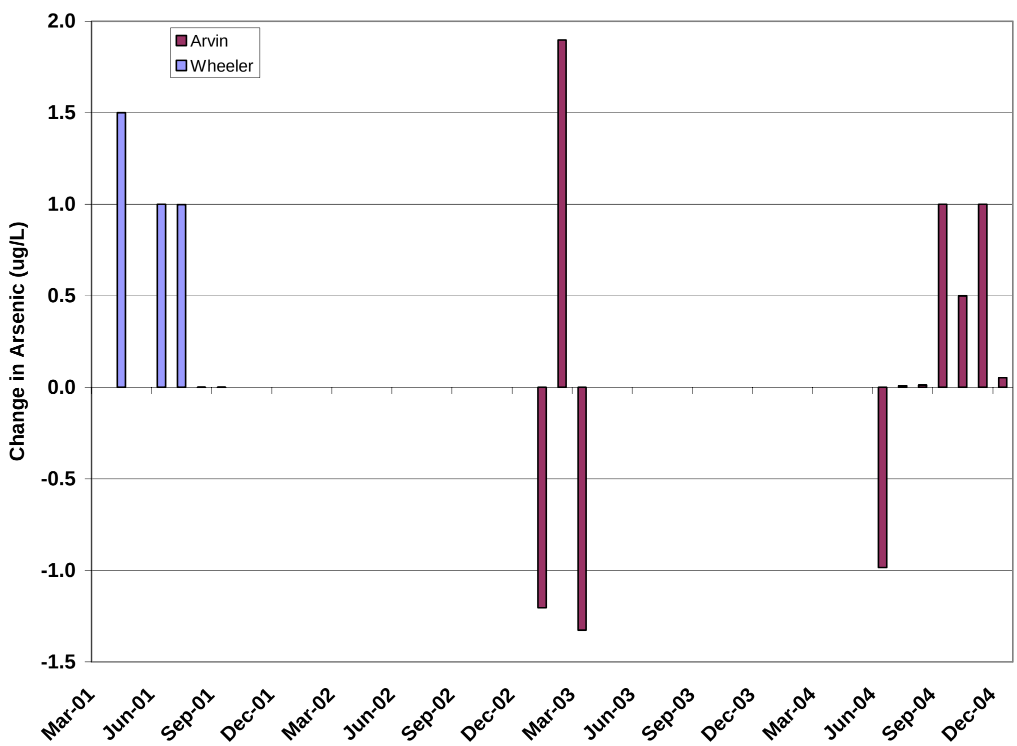


Figure 5-37. Arsenic, Predicted Changes from Inflows - Checks 29 to 41

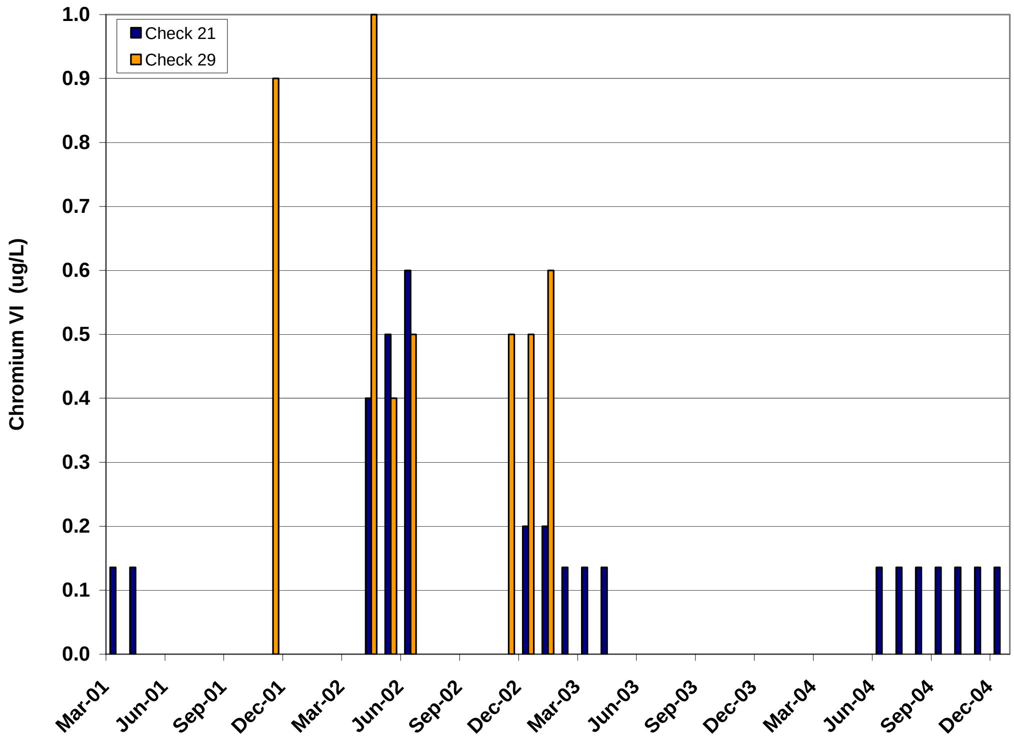


Chromium VI

Chromium VI causes acute gastritis and may be a human carcinogen. It is currently regulated in drinking water based on the 50 µg/L total chromium MCL. The Office of Environmental Health Hazard Assessment (OEHHA) is developing a PHG for chromium VI that may be as low as 0.2 µg/L, based on a 2005 "pre-release" draft. The average concentration in the aqueduct during the period of inflows ranged from 0.4 to 0.6 µg/L, whereas, the average concentrations in the inflows were much higher, ranging from less than 0.5 to 4.9 µg/L. The average concentrations of the four largest volume inflows all exceeded the aqueduct concentrations. Semitropic had an average concentration of 4.9 µg/L, substantially higher than the aqueduct concentrations.

Concentrations of chromium VI measured in the aqueduct at Checks 21 and 29 are displayed in **Figure 5-38**. No data were available for Checks 41 or 66. Most detections occurred at Check 21, at concentrations ranging from 0.1 µg/L to 0.6 µg/L. Concentrations measured at Check 29 were slightly higher, ranging from 0.4 µg/L to 1.0 µg/L, suggesting the possibility that inflows may have been responsible for measurable changes.

Figure 5-38. Chromium VI Changes Between Checks 21 and 29



Predicted versus measured differences in chromium VI concentrations between Checks 21 and 29 are shown in **Figure 5-39**. In the months when increases were detected, increases were predicted, even though the magnitude of the increases was larger than predicted. In a number of months during 2001 and 2004, increases were predicted but not observed. In two months during 2002, decreases were measured but not predicted. The month of November 2001 had the highest predicted and measured increase in chromium VI concentrations between Checks 21 and 29.

Figure 5-40 shows that the predicted increase in November 2001 was attributable to Semitropic inflows. During the other months in which the concentrations in the aqueduct actually increased, the inflows from Kern and CV were likely responsible.

Figure 5-39. Chromium VI, Predicted vs. Actual - Checks 21 to 29

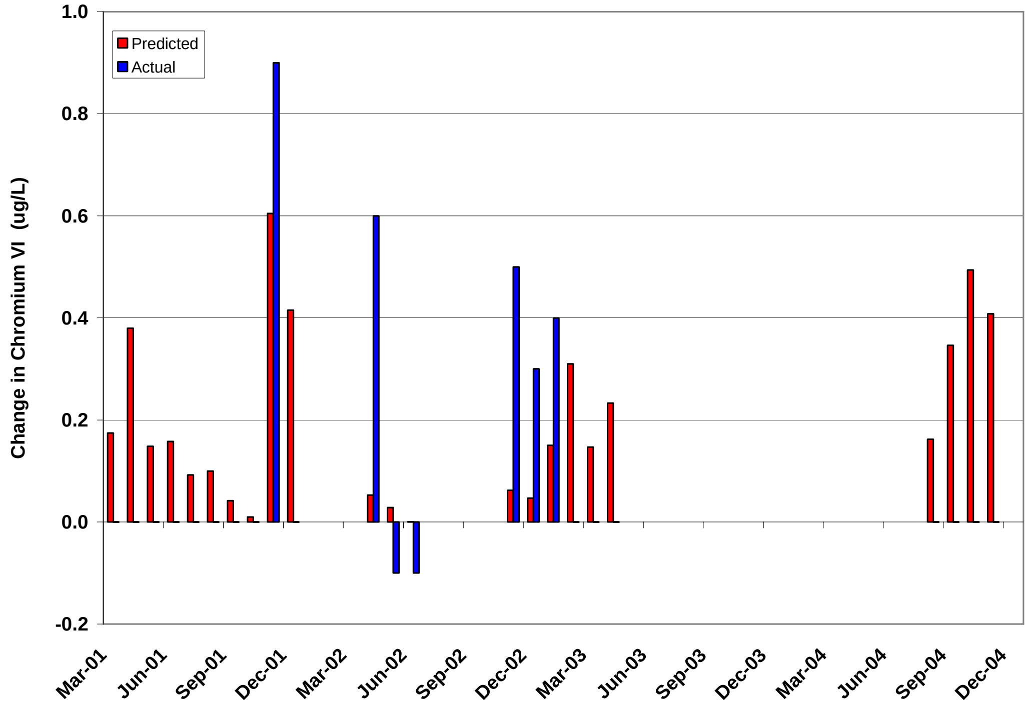
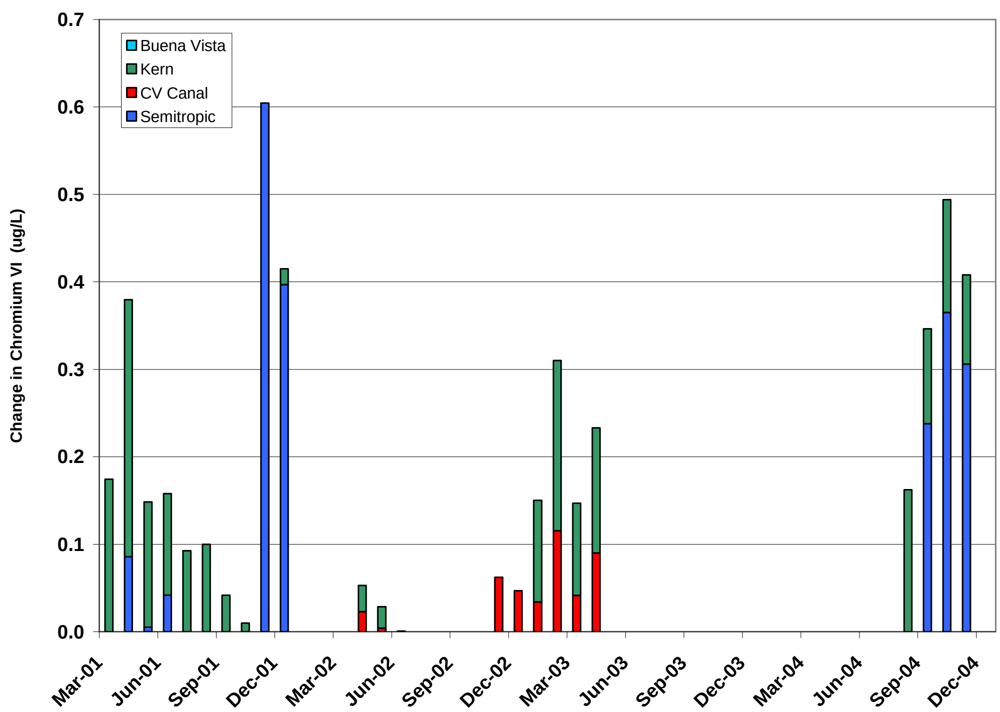


Figure 5-40. Chromium VI, Predicted Changes from Inflows – Checks 21 to 29



Sulfate

Sulfate occurs naturally in drinking water supplies and has a secondary MCL of 250 mg/L based on aesthetic effects. The average concentration in the aqueduct was 38 to 39 mg/L during the period of inflows. The average concentrations in the inflows ranged from 25 to 837 mg/L, with Arvin being the only inflow that was below aqueduct concentrations. The low volume Wheeler inflow was the only one that exceeded the secondary MCL.

Changes in sulfate concentrations in the aqueduct between Checks 21 and 41 are shown in **Figure 5-41.** During the period when inflows occurred, the secondary MCL for sulfate was never approached, with measured concentrations not exceeding 60 mg/L. No sulfate data are available for Check 66. The figure indicates that, in 6 of the 26 months inflows were permitted, sulfate concentrations increased progressively between Check 21, Check 29 and Check 41, as might be expected as a consequence of inflows containing elevated sulfate concentrations. This pattern did not hold for other months when various patterns were observed, including a progressive decrease during one month.

Figure 5-41. Sulfate Changes Between Checks 21 and 41

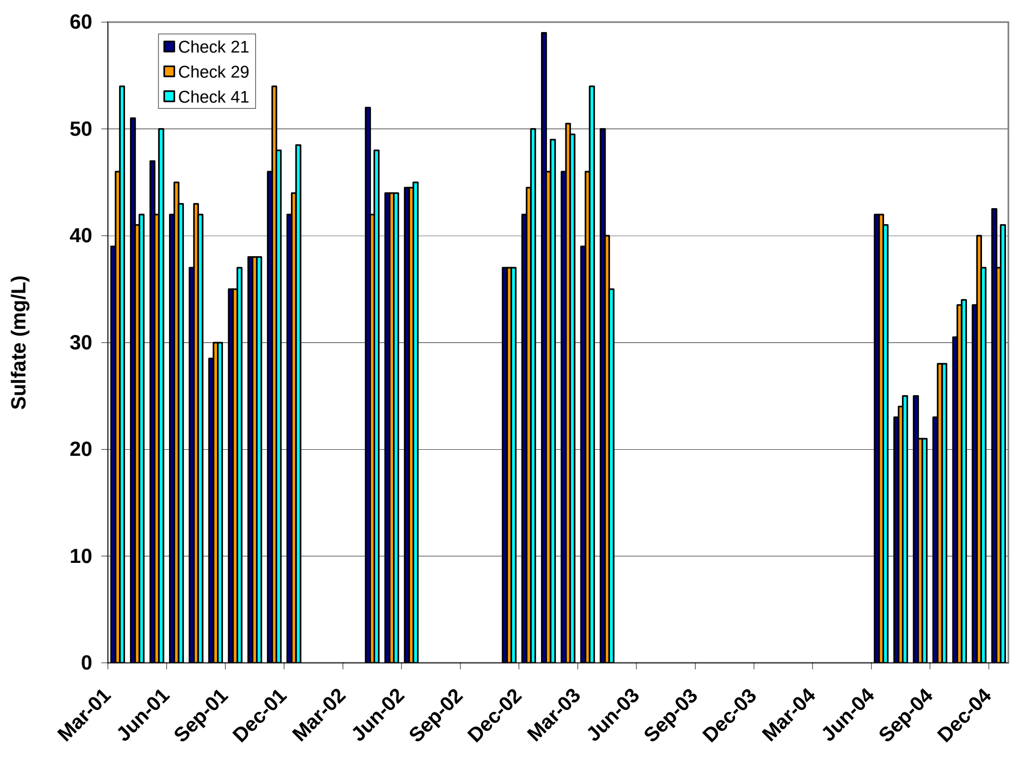


Figure 5-42 displays predicted versus measured sulfate concentrations in the aqueduct between Checks 21 and 29. Increases were most often predicted and observed, and predicted changes generally were associated with observed changes in the same direction, but of greater magnitude than predicted. Predicted changes were generally in the range of 0 to 5 mg/L in either direction,

whereas observed changes ranged from a decrease of 13 mg/L to an increase of 8 mg/L. As shown in **Figure 5-43**, the largest predicted increases were primarily due to Semitropic.

Figure 5-42. Sulfate, Predicted vs. Actual - Checks 21 to 29

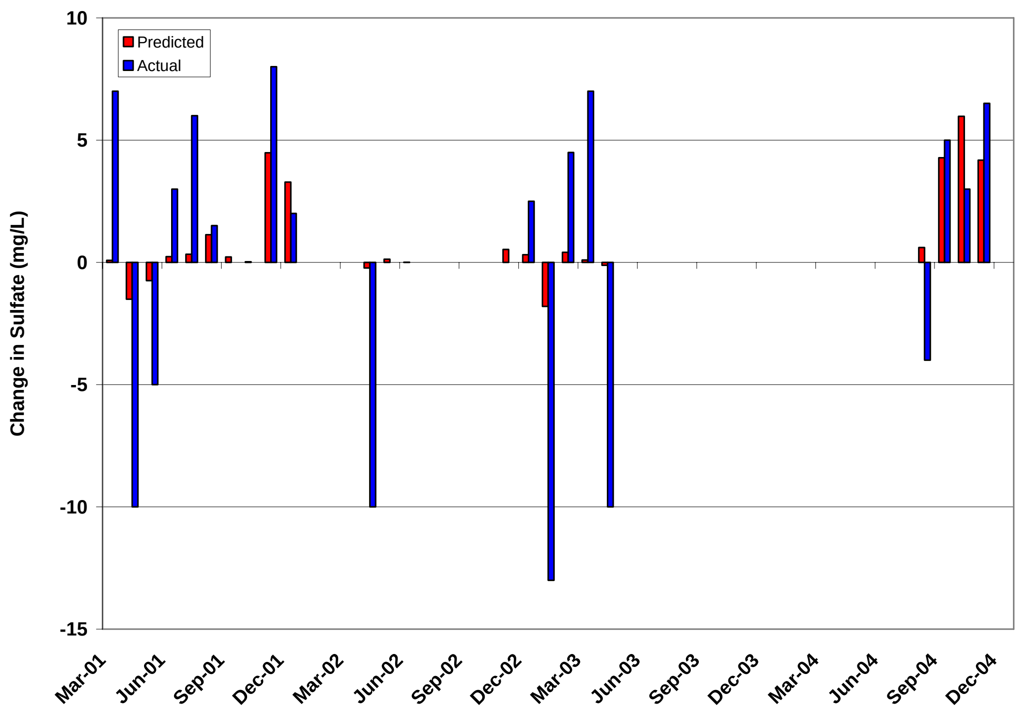
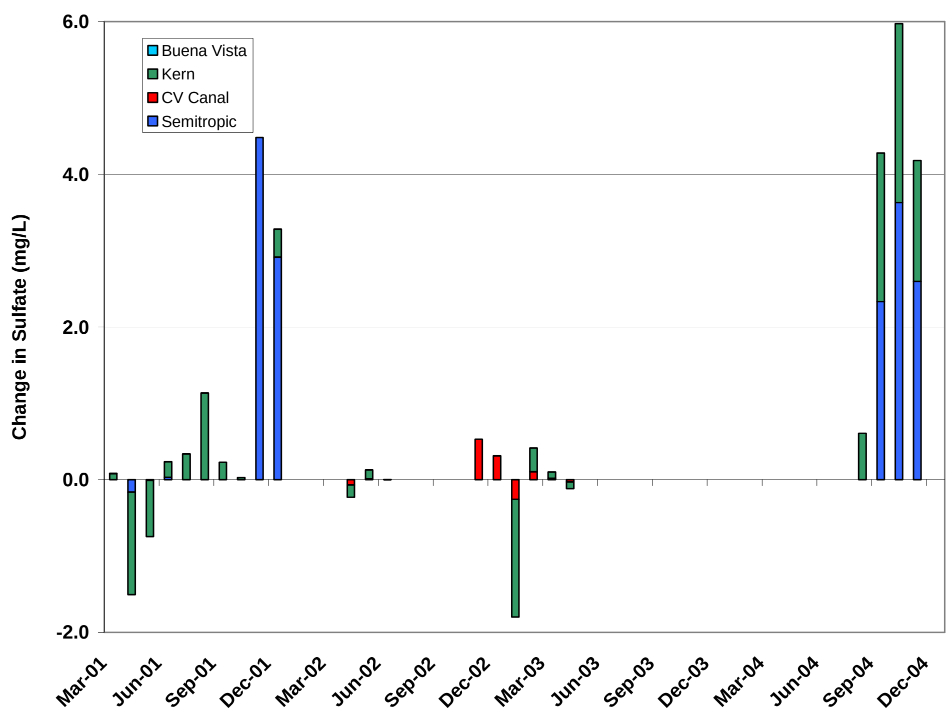


Figure 5-43. Sulfate, Predicted Changes from Inflows - Checks 21 to 29



Predicted versus measured changes between Check 29 and Check 41 are shown in **Figure 5-44**. The correspondence between predicted and observed changes appears to be relatively poor, with observed changes being in the opposite of the predicted direction in a number of months. Predicted changes ranged from a decrease of 2.5 mg/L to an increase of 0.9 mg/L, and measured differences ranged from a decrease of 3 mg/L to an increase of 8 mg/L. **Figure 5-45** indicates that the predicted increase during 2001 was attributable to Wheeler, while the predicted decrease in 2003 was due to inflows from Arvin.

Summary

The ability to use the California Aqueduct to convey non-Project inflows is a valuable water management tool. Inflows can represent a large percent of the water in the aqueduct so the water quality of the inflows must be evaluated when decisions are made to accept non-Project groundwater and surface water. The inflows that were conveyed in the California Aqueduct in the last five years varied tremendously in water quality. Of the four largest volume inflows, the Arvin inflow had lower TDS, bromide, and TOC concentrations than the aqueduct, but nitrate, chromium VI, and arsenic levels were higher than those in the aqueduct. While the Semitropic inflow had TOC concentrations lower than those in the aqueduct, all other constituents were considerably higher than aqueduct concentrations. The data that were available for this analysis were inadequate to accurately predict the impacts of inflows on aqueduct water quality. Predicted concentration changes for all constituents were generally much lower than actual measured concentration changes.

The SWP Contractors, who receive SWP water downstream of the inflow locations, must be able to adequately assess the impact of proposed inflows on aqueduct quality. DWR's Delta Simulation Model (DSM2) is being extended to include the California Aqueduct. While progress has been made, additional efforts are needed to improve monitoring, better coordinate and integrate the MWQI Program with other DWR water quality monitoring and forecasting activities, and develop a greater ability to forecast and analyze changes in water quality.

POTENTIAL ACTIONS

Improve Monitoring of Inflows and Aqueduct Water Quality

The SWP Contractors and DWR should develop a more comprehensive monitoring program to evaluate the impacts of inflows on aqueduct water quality. More frequent and more representative data should be collected from the inflows at the point of discharge to the aqueduct and at the checks on the aqueduct so the actual impact of inflows can be evaluated. Consideration should be given to installing analyzers that will gather real-time data on TOC, DOC, chloride, sulfate, fluoride, bromide, phosphate, and nitrate at Checks 21, 29, and 41. Arsenic and chromium VI samples should be collected at least weekly during the periods when inflows are occurring. The quality of groundwater inflows can vary depending upon which wells are pumping into the system. The inflow monitoring program should include provisions for monitoring at the point of discharge to the aqueduct so that the actual quality of water entering the aqueduct is monitored. The monitoring frequency should be tied to the frequency at which changes in wells pumping into the system are made.

Figure 5-44. Sulfate, Predicted vs. Actual - Checks 29 to 41

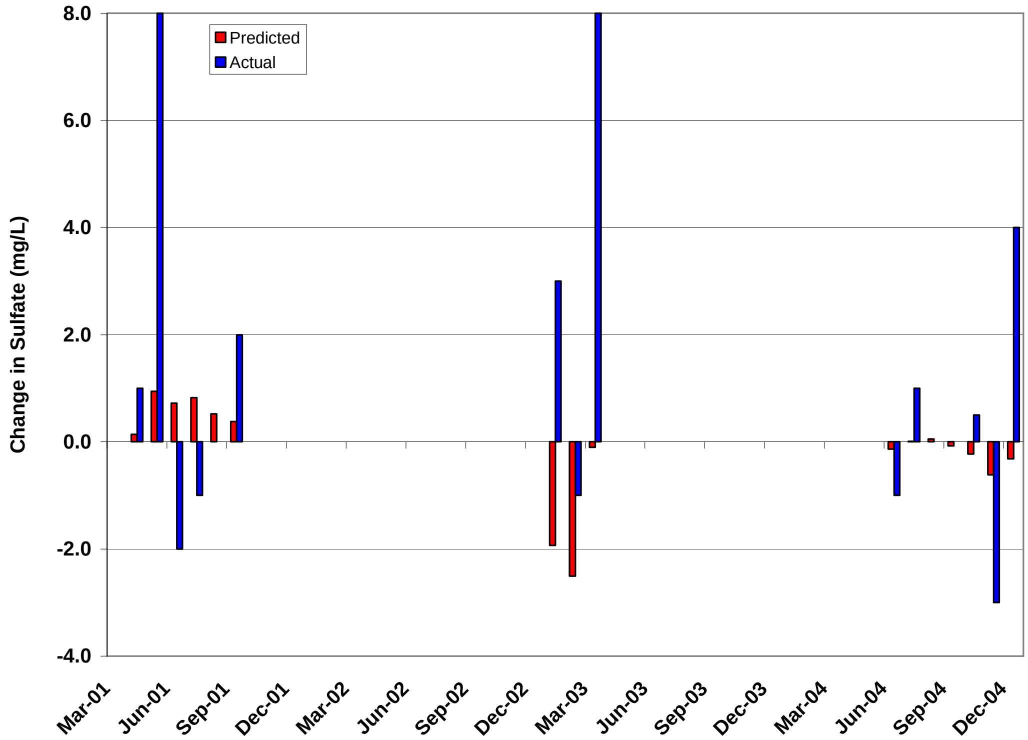
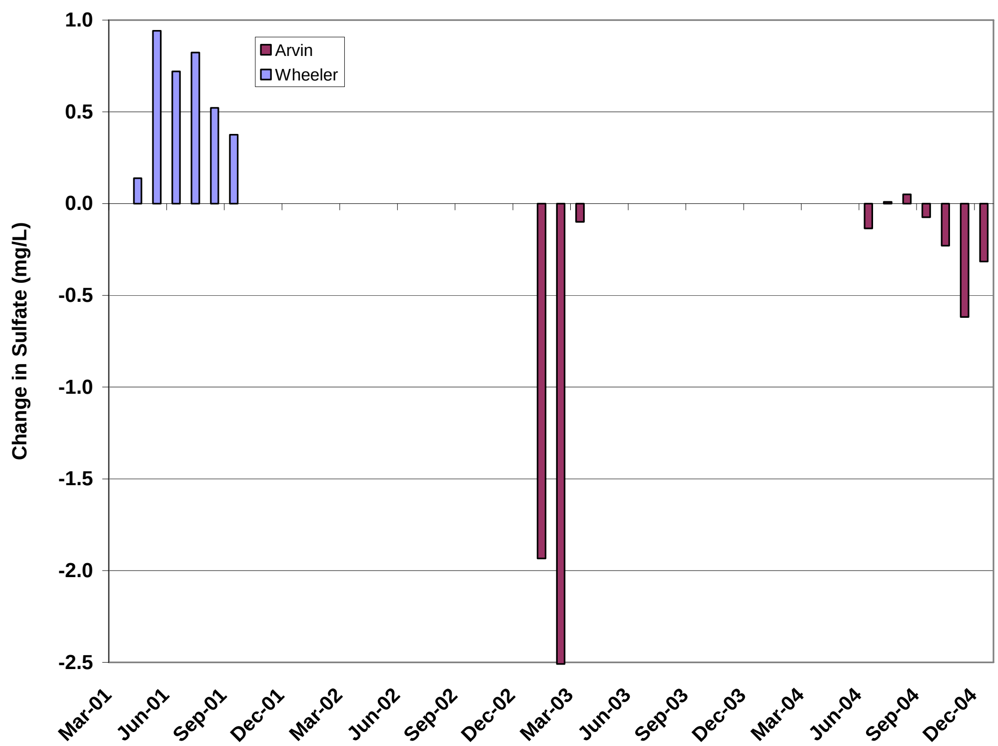


Figure 5-45. Sulfate, Predicted Changes from Inflows - Checks 29 to 41



Improving the accuracy of predictions of inflow effects will lead to improved ability to make decisions on inflow proposals and improved ability to mitigate any water quality degradation that may occur as a consequence of inflow operations. This improved decision making capability will allow maximum use of SWP facilities to convey non-Project waters and increase the efficiency of water management in California. A robust water quality monitoring and forecasting component is critical to achieving this end.

Investigate Inconsistencies in TDS/EC Data

TDS is conservative in the system so it should be a reliable constituent for detecting water quality changes due to inflows. EC recorders continuously monitor EC (a surrogate for TDS) at Checks 21, 29, 41, and 66. Although the data were not available for this analysis, there is some EC monitoring of inflows at the point that they discharge to the aqueduct. In this analysis, the actual changes in TDS as a result of inflows were always substantially greater than predicted changes. The inconsistency between predicted and measured differences suggests the need to more closely examine factors that could explain the discrepancies. Possible factors include travel time between measurement points, off-peak pumping causing variable dilution of inflow waters, possible non-representative sampling, the quality control protocol for maintaining and cross-calibrating the auto-recorders, frequency and quality control of aqueduct monitoring, and frequency and quality control of inflow flow and quality monitoring. The EC data should be more intensively analyzed and factors affecting EC should be studied to better understand how to evaluate the changes in EC due to inflows. This information is needed before additional real-time monitoring is conducted so that the additional data can be properly evaluated.

Add Phosphorus to the List of Constituents of Concern

Nutrient stimulation of algal growth has become a major concern in the SWP reservoirs and in the East Branch of the California Aqueduct. Phosphorus should be added to the constituents of concern list and included in the required monitoring for inflows and in the aqueduct.

Prepare Annual Reports

The Facilitation Group that evaluates inflow proposals and recommends their acceptance or rejection could be asked to perform annual assessments of water quality impacts of inflows, and to make recommendations to DWR for actions that would eliminate adverse water quality impacts or reduce such impacts to insignificance.

CASTAIC LAKE

Castaic Lake, located about 45 miles northwest of downtown Los Angeles, is the terminus reservoir of the West Branch of the California Aqueduct. Castaic Lake is supplied by the SWP from Pyramid Lake, and has a maximum storage of 323,700 acre-feet. Castaic Lake supplies water to Metropolitan Water District of Southern California (MWDSC), Castaic Lake Water Agency, and the Ventura County Flood Control District.

KEY CONCERNS

As identified in the previous sanitary survey, cattle grazing is a potentially contaminating activity in the Castaic Lake watershed. The presence of gulls roosting at Castaic Lake has been identified as a new potentially contaminating activity in the Castaic Lake watershed. In cooperation with DWR staff, MWDSC has spent considerable time and resources to understand the extent of the grazing problem and to find a solution. MWDSC has also spent considerable time and resources to understand and address gull roosting. This section describes the current status of grazing and gull roosting, and actions taken since the last sanitary survey.

Although the previous watershed sanitary survey documents other potential contaminating activities in the Castaic Lake watershed such as recreation, fires, spills, and oil pipelines, there have been no major changes or incidents impacting water quality from these activities.

ACTIONS TAKEN SINCE 2001 SANITARY SURVEY

Cattle Grazing

Cattle grazing was initially identified as a potential source of pathogens and indicator organisms in the Castaic Lake watershed.

Occurrence in the Watershed

Currently, there is one rancher in the Castaic Lake watershed. This is a family-owned and operated ranch, with approximately 150 head of cattle. The ranch is located just outside of the watershed, west of Elderberry Forebay.

Beginning in 1996, small groups of cattle (less than 20) were observed in the water by MWDSC staff near Elderberry Forebay. The presence of cattle in the watershed became more prevalent after the August 1996 Marple fire that burned several cattle exclusion fences. DWR and MWDSC staff do not track grazing specifically, but incidentally notice the presence of cattle during their normal work routines in the Castaic Lake area. In the spring of 2001, cattle in the Elderberry Forebay were noticed more frequently by DWR and MWDSC staff. By the fall of 2001, cattle droppings were prevalent along the main access road on the west side of Elderberry Forebay, confirming the increased presence of cattle.

Health Concern

Cattle fecal deposits are a known source of *Cryptosporidium parvum*, a fecal borne protozoan parasite carried by and causing gastrointestinal illness in humans, cattle, and wildlife. Since treatment processes are not 100 percent effective at removing/inactivating these protozoa, the presence of cattle in the Castaic Lake watershed is a public health hazard. Other enteric human pathogens frequently detected in cattle include *Salmonella* spp., *Campylobacter jejuni*, *Clostridium perfringens*, and *Listeria monocytogenes*. A single sick calf can produce up to 1×10^8 pathogenic bacteria per ml of feces and estimates of *Cryptosporidium parvum* environmental loading by cattle range from 3,900 to 2×10^8 oocysts per cow per day, indicating a very high potential for environmental contamination (Atwill et al., 2003; Atwill et al., 2006; Dorner et al., 2004).

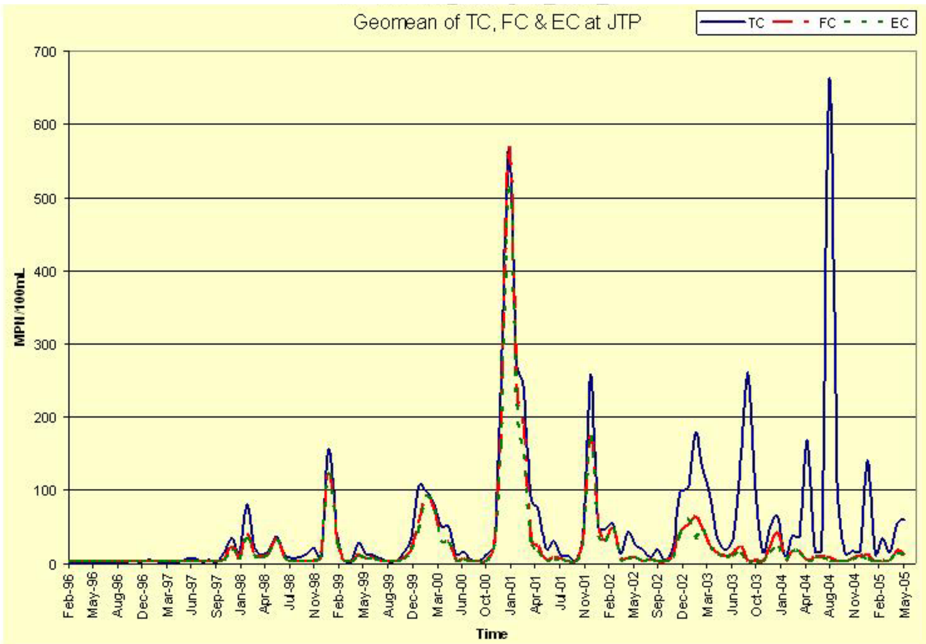
Three Contractors receive water from Castaic Lake via the Castaic Lake Outlet Tower, and then pipelines transport the water to the respective facilities/treatment plants. MWDSC routinely monitors for coliforms and *E. coli* at the Jensen WTP intake, which receives SWP water from Castaic Lake. Since coliforms and *E. coli* are often used as indicators for the presence of *Cryptosporidium parvum*, MWDSC became concerned when *E. coli* levels began increasing, particularly during the winter months, beginning in late 1997 to early 1998. **Figure 5-46** shows that peak levels of *E. coli* occurred during the winters of 2000 and 2001.

Best Management Practices

MWDSC originally brought this issue to DWR's attention in writing after the 1996 Marple Fire. When grazing activity increased again in 2001, several correspondences between MWDSC, DWR, and CDHS occurred in the spring and summer of 2001. CDHS also wrote a letter to the U.S. Department of Agriculture's Forest Service (U.S. Forest Service) to seek their assistance to control unauthorized grazing occurring on U.S. Forest Service land, as the U.S. Forest Service is the prime landowner in the Castaic Lake watershed. On September 5, 2001, these agencies and the Castaic Lake Water Agency met at Castaic Lake to discuss the current state of knowledge and tour the area of concern. After this meeting, DWR staff indicated that they would consider installing a fence to control cattle from entering the watershed.

In September 2001, DWR staff met with the rancher to explain the grazing problem and to seek assistance. The rancher expressed willingness to help, agreed to remove cattle whenever sighted in the watershed, and suggested fencing locations to prevent the cattle from accessing the lake. After subsequent meetings with the affected parties, it was agreed that 3.5 miles of new fence would be installed to protect the entire west side of Elderberry Forebay. The new fencing would supplement existing fencing owned by the rancher, as shown in **Figure 5-47.** The cost of the fencing was approximately $50,000 and the fence was completed in the summer of 2003.

Figure 5-46. Bacteria Levels at Jensen WTP



Source: Brown and Caldwell. 2006. Prepared for MWDSC
TC – Total Coliform, FC- Fecal Coliform, EC- *E. coli*

Figure 5-47. Fencing in the Castaic Lake Watershed

Results

In the fall of 2004, Metropolitan staff toured the access road on the west side of Elderberry Forebay. The access road did not have any new cattle droppings, and was much cleaner than in 2001. MWDSC staff contacted the rancher in fall of 2004, and both parties concurred that the cattle have not been able to access the lake since the new fence was installed. Additionally, the Los Angeles Department of Water and Power was contacted, as they operate the power plant located in the Elderberry Forebay, and they also indicated that the cattle have not been sighted in the watershed since the new fence was installed.

Additional Studies

Although cattle grazing is a primary concern, there could be other contaminant sources contributing to the high *E. coli* levels seen in the winter of 2000 and 2001. To further investigate the increasing levels of *E. coli*, MWDSC initiated a limited microbial source tracking study in 2001 to determine the relative contribution of cows, gulls, and tributary creeks to the seasonal *E. coli* contamination within Castaic Lake. MWDSC received Proposition 13 grant monies in 2002 to partially fund this study, and the portion of the study funded by grant monies began in 2004. A total of 427 *E. coli* isolates were collected over a non-sequential three year period (2001, 2002, and 2004), and were analyzed by a polymerase chain reaction (PCR) targeting repetitive DNA sequences. Isolate sources were Castaic Lake outlet tower (N = 175), other lake locations (N = 11), tributary creeks (N = 107; Castaic, Elizabeth, Elderberry, Fish, and Necktie Creeks), cow patties (N = 51), and gull fecal samples (N = 83).

Overall, the results demonstrated that 30 percent of lake isolates were the same as gull fecal isolates, compared to a 6 percent match between lake and cow fecal samples (MWDSC, 2006). Water samples at the Castaic Lake outlet tower were collected at various depths, beginning at the surface and throughout the various tier depths. There are nine tier depths that allow selective withdrawal of water from the Castaic outlet tower (tier 1 elevation = 1495’, tier 2 elevation = 1475’, tier 3 elevation = 1460’, tier 4 elevation = 1440’, tier 5 elevation = 1425’, tier 6 elevation = 1410’, tier 7 elevation = 1395’, tier 8 elevation = 1375’, tier 9 elevation = 1355’). Samples were also collected at the Castaic Lake lower tower, which is a nearby, but separate facility than the outlet tower. The lower tower withdraws water from the deepest area in Castaic Lake (1285 feet elevation). At the Castaic Lake outlet tower, 27 percent of surface water isolates and 29 percent of tier 6 isolates were the same as gull isolates, and 35 percent of lower tower isolates were the same as gull isolates. Only 4 to 7 percent of isolates from various depths matched cow isolates (MWDSC, 2006). Therefore, these results clearly demonstrated that gulls contributed more *E. coli* contamination to the lake than cows. Additional conclusions from the MWDSC study are:

- Although a less prevalent source, cattle were also contributing to the contamination. In addition, 8 percent of bovine isolates were identified as enterotoxigenic strains indicating the potential for contamination of the lake with pathogenic *E. coli*.
- The clear demonstration that both gull and bovine fecal material was impacting the lake, coupled with documented carriage of a wide variety of human pathogens by both types of

animals emphasizes the importance of source water protection plans to minimize the potential risks to public health.

- Intra-source fingerprint analysis showed that the population of *E. coli* isolated from birds was far more diverse than that observed from cows, as can be explained by the scavenging habit, more varied diet, and wide geographic range of gulls.
- Approximately 50 percent of outlet tower isolates could not be assigned to any of the potential sources investigated. This may be due to a potential limitation of the approach with a relatively small library of *E. coli* isolates, the broad heterogeneity of *E. coli* populations, the occurrence of other sources of contamination within the watershed, or environmental reservoirs of *E. coli* such as lake sediment.

Since gulls were identified as the dominant source of contamination, removal of birds from roosting on or near the outlet tower would likely reduce the severity of fecal contamination. Limiting the access of cows to the watershed, which was achieved with the additional fencing, will also reduce the potential for contamination with pathogens.

Gull Roosting

When DWR and MWDSC staff met in 2001 to discuss how to best address grazing, DWR staff indicated that an unusually high number of gulls were roosting on the lake at night, as well as in the year 2000. MWDSC decided to further investigate this issue.

Occurrence in the Watershed

MWDSC asked a local ornithologist to visit Castaic Lake. With his assistance, the majority of the gulls present at Castaic Lake were identified as Western gulls (*Larus occidentalis*). Based on his knowledge of Western gulls, he indicated that large numbers of Western gulls at sites distant from the coast were very unusual, which may indicate there is a readily available food source nearby.

Beginning in March 2002, MWDSC contracted with Dr. Richard Golightly, Humboldt State University, to begin tracking the number of gulls at Castaic Lake every 10 days. Surveys were conducted from March 2002 through July 2002 and from December 2002 through June 2003 to ascertain the number of gulls using the lake. During that study, the peak number of gulls was 8,000 (Golightly, 2003). There was a high variation in the number of gulls throughout the day, by day, and by season. Numbers of gulls were greatest in the winter and drastically declined by April 1. The general behavior pattern observed was gulls roosting on Castaic Lake at night and departing in the early morning to forage.

Health Concern

Gull roosting on water supply reservoirs can lead to contamination of those water supplies, and such problems have been experienced by water supply managers across the United States. Gulls may also serve as mechanical vectors of disease organisms that are picked up on their feet and/or feathers at landfills or sewage treatment plants. The most common problem associated with gull roosting on water supply reservoirs has been contamination with fecal bacteria. However, a wide variety of human pathogens has been detected in various species of gull. These include *Campylobacter* spp., *Listeria* spp., *Salmonella* spp., *Shigella* spp., *Yersinia* spp., *Vibrio cholerae*, *Vibrio parahemolyticus*, enterotoxigenic *E. coli*, and the protozoan parasite *Cryptosporidium* spp. (Buck, 1990; Cizek et al., 1994; Fenlon, 1983; Fenlon, 1985; Fricker and Metcalf, 1984; Monaghan et al., 1985; Moore et al., 2002; Ogg et al., 1989; Shayegani et al., 1986; Smith et al., 1993). Therefore, there are potentially serious public health consequences that could result from large populations of gulls congregating on lakes used as sources of drinking water, particularly around outlet towers.

Gull Surveys and Identification of Best Management Practices

As mentioned in the previous section, MWDSC received Proposition 13 grant monies to provide partial funding for a limited microbial source tracking study to determine the relative contribution of cows, gulls, and tributary creeks to the seasonal *E. coli* contamination within Castaic Lake. Results and conclusions from this study were presented previously.

Proposition 13 grant monies were also used to continue the gull survey work initiated in 2002. Fifteen ground counts of gulls were conducted from October 2004 through May 2005, and in January 2005 radio transmitters were attached to a sample of Western gulls to monitor their daily movements (Golightly, 2005a). Nine aerial surveys were conducted between January and May 2005 in an effort to determine locations of the radio-marked gulls when away from Castaic Lake (Golightly, 2005a). In addition to enumerating the gulls at Castaic Lake, radio telemetry was considered necessary to better understand gull movements when the gulls are away from the lake, so effective best management practices could be developed. Seven other water bodies near Castaic Lake were also surveyed for gulls.

Based on the study results, MWDSC requested that Dr. Golightly identify potential best management practices to reduce gull populations at Castaic Lake. Separate reports were prepared for the survey work and for management practices. The following is a list of major conclusions drawn from both the survey work and the management practices reports (Golightly, 2005a, Golightly, 2005b):

- The composition of identified gull species at Castaic Lake was 84 percent Western gulls, 16 percent California gulls, and very few Ring-billed gulls (less than 1 percent).

- Many of the Western gulls associated with Castaic Lake are probably also associated with the nesting colony at Anacapa Island in the Northern Channel Islands.

- Gull populations at Castaic Lake rapidly increased from October through November. Numbers of gulls at the lake then fluctuated from December through March, and then decreased again at the onset of breeding in March and April. In March, all radio marked gulls were at marine locations, specifically Anacapa Island.

- From October 2004 to May 2005, the peak number of gulls was approximately 7,000 which occurred on February 16, 2005. This is similar to the peak number of gulls from the March 2002 to June 2003 study, which was 8,000 gulls on January 3, 2003.

- During the time period in which numbers of gulls at Castaic Lake fluctuated (December through March), the surveys with the highest number of gulls occurred approximately 6 days after low-pressure weather events in the marine environment. Conversely, the surveys with the lowest abundances occurred 16 days after low-pressure events that occurred in the marine environment. It is speculated that during inclement weather in the marine environment, food access may be poorer. Thus, storm events at sea may result in significant number of gulls traveling inland to Castaic Lake.

- No gull used the Castaic Lake vicinity exclusively; all made periodic trips to the marine environment.

- Gulls were found at the Simi Valley landfill, the Chiquita Canyon landfill, and the Calabasas sanitary landfill. Foraging at landfills may be habitual, as individual gulls were found at landfills multiple times.

- Gulls at Castaic Lake may feed by day at sanitary landfills, out of local dumpsters, or from other anthropogenic food sources, until returning to the marine environment.

- Seven other lakes near Castaic Lake were surveyed; none of the lakes had gull abundances approaching those reported for Castaic Lake.

- Since Castaic Lake was the largest out of the lakes surveyed, the ratio of shoreline to total area is less than other lakes. It is speculated that this allowed roosting at significant and safe distances from shore, reducing any potential risk from shore disturbance or predators.

- To reduce roosting at the lake, nearby food sources must be eliminated and/or the lake made less attractive as a roost site.

- Control of food will also be effective for reducing gull numbers at Castaic Lake, and would be necessary at three levels: 1) at Castaic Lake and the Castaic Lagoon, 2) at the town of Castaic (restaurant dumpsters), and 3) at nearby landfills.

Best Management Practices

Based on the recommendations from Dr. Golightly, MWDSC has decided to proceed with best management practices to address the presence of gulls at Castaic Lake. Gull management practices will be implemented to discourage birds from roosting at Castaic Lake and will include educational pamphlets, food management within the local areas, and potentially more direct means of discouraging gulls from roosting at night near the Castaic Lake outlet tower. Pilot-scale best management practices to discourage gulls from roosting at night were implemented in January and February 2007 with limited success. Gulls were chased off the lake surface using a motorized boat for four consecutive nights. The percentage of gulls successfully managed from the system each night ranged from 15 to 64 percent.

Other best management practices considered for the future are: replacing trash cans at the Castaic Lake State Recreation Area (SRA) with new animal-proof trash cans, installing "Please Don't Feed Gulls" signs around the Castaic Lake SRA, working with the Los Angeles County Department of Public Health to educate local businesses about the importance of keeping dumpsters closed, and working with local landfills to discourage gull presence.

Results

MWDSC anticipates that gull management practices will be implemented at Castaic Lake in 2007.

POTENTIAL ACTIONS

Determine if Other Locations Along the SWP May Benefit from Gull Management Programs

The presence of gulls, or other waterfowl have proven to be a nuisance and health concern for a variety of water sources used for domestic supply. If there are other SWP Contractors who are experiencing similar problems, it is recommended that these SWP Contractors possibly collaborate on an experimental program designated to actively discourage gull roosting.

LAKE PERRIS

Lake Perris, the terminal reservoir of the East Branch of the California Aqueduct, is an artificial impoundment that was created by the construction of Perris Dam in the early 1970's. Lake Perris is located in western Riverside County, about 13 miles southeast of the City of Riverside. Lake Perris is supplied by the SWP from Silverwood Lake through the Santa Ana Valley Pipeline, and has a maximum storage of 131,450 acre-feet. It is a multi-use facility, providing water storage, recreation, and fish and wildlife habitat.

MWDSC is the only SWP Contractor requesting deliveries from Lake Perris. Lake Perris supplies water to MWDSC's Diamond Valley Lake, Lake Skinner, or directly to the Mills WTP. Historically, key water quality concerns associated with Lake Perris have limited MWDSC's ability to withdraw their full entitlement from the lake. Current water quality concerns are pathogens, T&O, algal toxins, and anoxia in the hypolimnion. Since the previous sanitary survey, MWDSC has embarked on various water quality studies and is in various planning stages for projects that are designed to address these concerns and enable MWDSC to use Lake Perris year-round.

The following sections describe key water quality concerns in further detail and actions taken over the last five years. This section also provides a description of the seismic hazard discovered in 2005, and how that has impacted water quality.

KEY CONCERNS

Recreational Usage

The Lake Perris SRA, which opened in 1974, fulfills the mandate that all SWP facilities provide recreational amenities and opportunities. Body-contact recreation includes swimming, water skiing, and personal watercraft riding. Nonbody-contact recreation at Lake Perris includes camping, picnicking, horseback riding, sail and power boating, fishing, hiking, bicycling, hunting, and rock climbing.

Of the four Southern California SWP reservoirs, Lake Perris receives the heaviest recreational use with an average of 1.1 million visitors each year (Lake Perris SRA website). According to the Lake Perris SRA, 2001/2002 attendance was about 612,063 people during the peak recreation season (May through September). It is estimated that 50 percent of the visitors during the peak recreation season are involved in body-contact recreation (Personal Communication, Ron Kruper, 2003, Lake Perris SRA).

Key water quality concerns associated with recreation are pathogens and methyl tert butyl ether (MTBE). MTBE is no longer a concern since the State of California ordered a ban of MTBE in gasoline effective January 2004. MTBE in gasoline blends in California were voluntarily reduced in January 2003. Additionally, Lake Perris SRA began providing MTBE-free fuel at its marina beginning in May 2003. These changes have led to a significant reduction in MTBE levels, as MTBE levels at Lake Perris have been nondetectable (less than 0.5 µg/L) since July 2003 (See Chapter 3). The previous sanitary survey reported levels ranging from ND to 45 µg/L.

Pathogens continue to be a key water quality concern at Lake Perris. Since the 1980's, there has been a history of bacteriological and pathogen contamination at the swimming beaches. During the recreation season (Memorial Day through Labor Day), Lake Perris SRA staff collects samples on either Saturdays or Sundays along the heavy-recreational beaches and coves. When a fecal coliform sample exceeds 400 MPN/100mL, the beach is closed until subsequent samples show fecal coliform levels below the trigger level.

Lake Perris SRA staff has taken numerous measures to reduce the coliform counts (installation of two circulation pumps, installation of additional restrooms closer to the shoreline, public education, closure of Moreno Beach), and these measures have reduced the number of beach closures. However, beach closures still occur. There were seven beach closures at Lake Perris from 2001 to 2004.

The presence of fecal coliforms or *E. coli* is a concern for Lake Perris as a drinking water reservoir since it is an indication that fecal contamination is occurring. Enteric pathogens may be shed into reservoir waters during body-contact recreation from residual fecal material and from accidental fecal releases. These inputs increase pathogen concentrations in the reservoir, water treatment costs, as well as gastrointestinal illness risks for swimmers.

Anoxic Hypolimnion

Thermal stratification occurs as a natural process at Lake Perris beginning in April and lasting to November. Lake Perris stratifies as sunlight heats the upper layers of the water, making this water less dense than the colder water on the bottom. In a stratified reservoir, the cooler, denser layer is the hypolimnion, and the warmer, less dense upper layer is the epiliminion. The layer where temperature changes rapidly with depth is known as the metalimnion. The hypolimnion is typically isolated from wind mixing and often becomes oxygen-depleted because of its isolation from the oxygenated upper layers. Additionally, when algal blooms in the epilimnion die, their biomass begins to decompose and sink. The hypolimnion becomes anaerobic, and eventually anoxic, due to the decomposition of algae and other organic matter.

During thermal stratification, Lake Perris has two recurring problems; algal produced T&O in the epilimnion and hypolimnetic anaerobic conditions. As these two conditions can occur simultaneously during the stratified period, there are times when the entire lake is unacceptable as a source of drinking water, hindering MWDSC's ability to obtain full access to its allotment stored in Lake Perris.

The most commonly reported T&O compounds associated with algal blooms in the epilimnion are geosmin and MIB. Anoxic conditions at the sediment-water interface can result in the release of nutrients and metals compounds, such as manganese and iron, from the sediments into the water column. Unfavorable taste and odor compounds such as sulfides, ammonia, and methane can develop under anaerobic or anoxic conditions. Hydrogen sulfide, polysulfides, and organosulfides are the most problematic, as they produce strong objectionable odors and have high oxidant (disinfectant) demand.

Seismic Hazard

DWR released a seismic study of Perris Dam in June 2005. It was determined that a portion of the foundation is potentially susceptible to liquefaction and severe loss of strength during a large earthquake event. This risk has led to the temporary lowering of Lake Perris by 25 feet below the spillway level, to elevation 1563 feet, to mitigate the seismic risk while a permanent solution is being determined by DWR.

Water quality is a key concern if the current elevation of Lake Perris were to be altered permanently from its previous normal elevation of 1588 feet. Changing the lake elevation will affect thermal structure and the proportional volumes of water in each of the layers of the lake (hypolimnion, metalimnion, and epilimnion). A reduced lake elevation leads to a reduced hypolimnetic volume, which means that there is less oxygen mass, and the hypolimnion will become anoxic much quicker. This will reduce operational flexibility if water cannot be drawn from the hypolimnion.

As further explained below**,** there has been an increase in T&O problems from benthic algae since the lake was lowered. The most severe T&O problems caused by benthic algae at Lake Perris occurred in 2006.

ACTIONS TAKEN SINCE 2001 SANITARY SURVEY

Evaluation of Body Contact Recreation at Lake Perris

As discussed earlier, MWDSC has embarked on various water quality studies since the previous sanitary survey to address microbial contamination from body-contact recreation occurring at Lake Perris. The studies undertaken by MWDSC were a multi-pronged approach to determine the potential impact of swimming on Lake Perris water quality (MWDSC, 2005). The multi-pronged approach consisted of: 1) fecal coliform and *E. coli* sampling at eleven locations and at multiple lake depths for a period of 18 months; 2) fingerprinting analysis by repetitive- PCR of *E. coli* isolates from the beaches and the outlet tower; 3) hydraulic modeling of Lake Perris under five different scenarios of body-contact recreational use and lake conditions; and 4) risk assessment modeling to determine impacts to downstream consumers of water from Lake Perris using a well-established dose response model.

The goals of the studies were to: 1) further understand the fate and transport of fecal coliforms in Lake Perris, 2) characterize fecal coliform and *E. coli* levels at various locations and depths throughout the lake, 3) determine if any relationships exist between *E. coli* found at the swimming beaches and at the outlet tower where water is withdrawn for municipal supply, and 4) predict pathogen concentrations and consumer risk levels at Lake Perris due to current levels of body-contact recreation.

This section provides a brief summary of findings from each of the reports. For further details, the reader is referred to the State Water Board as funding for these reports have been provided through an agreement with the State Water Board pursuant to the Costa-Machado Water Act of 2000 (Proposition 13).

Current Pathogen/Bacterial Quality

No pathogen data have been collected to date by MWDSC at Lake Perris. There are no other known pathogen monitoring programs at Lake Perris. Therefore, the following discussion will focus on bacteriological quality.

During the recreation season (Memorial Day through Labor Day), Lake Perris SRA staff collects samples on either Saturdays or Sundays along the heavy-recreational beaches and coves. When a fecal coliform sample exceeds 400 MPN/100mL, the beach is closed until subsequent samples show fecal coliform levels below the trigger level. There were seven beach closures at Lake Perris from 2001 to 2004.

From April 2003 to September 2004, MWDSC conducted a water quality study where a total of 619 samples were collected and analyzed for fecal coliforms and *E. coli.* Eleven sampling sites, three of which were sampled at multiple lake depths, were selected to reflect the spatial relationships between the public beaches and boat launch facilities, and the outlet structure through which water is delivered to MWDSC's water treatment plants. **Figure 5-48** is a map of sampling locations**.** It should be noted that the swimming areas at Lake Perris are Perris Beach Towers 1, 3, and 5, as well as Moreno Beach Tower 8. These areas are collectively referred to as the "beach" sites. Sail Cove, Power Cove, and Launch Ramp 2 are not swimming areas, but are designated areas used to launch sailboat, personal watercraft, and motor boats, respectively. These areas are collectively referred to as the near "shoreline" sites.

Lake Perris water samples were collected from sites at Perris Beach buoyline, Moreno Beach buoyline, center of the lake, and the outlet tower. *E. coli* levels were evaluated and assessed based on the following ratings:

- ≤ 10 MPN/100mL *E. coli* – Low
- > 10 – 100 MPN/100mL *E. coli* – Moderate to Moderately High
- > 100 – 1000 MPN/100mL *E. coli* – High
- > 1000 MPN/100mL *E. coli* – Very High

Figure 5-48. Lake Perris Sampling Location Sites for MWDSC Study

Base Map Source: Google

Major conclusions from this study (MWDSC, 2005) were:

- During the 18-month study, *E. coli* levels at the beaches and near shoreline sites ranged from less than 2 to 17,000 MPN/100mL. The occurrence of high to very high levels of *E. coli* were prevalent among the swimming beach sites (Perris Beach Towers 1, 3, and 5, and Moreno Beach Tower 8), ranging from 26 to 45 percent occurrence. In comparison, the percent occurrence of high *E. coli* levels from Sail Cove, Power Cove, and the Launch Ramp ranged from six to ten percent.

- For the main swimming beach (Perris Beach), there appeared to be three peaks where *E. coli* levels were greater than 100 MPN/100mL. The first peak occurred from May through September 2003, the second peak during January 2004, and the third peak from April to June 2004.

- The percent occurrence of swim beach samples with *E. coli* levels greater than 100 MPN/100mL indicate that high to very high levels of *E. coli* occurred at approximately the same frequency during the non-rainy season as during the rainy season.

- The lake sites were one or more logs lower in *E. coli* levels than the beach sites. Sixty percent of the lake samples had non-detectable *E. coli* levels and only one percent were greater than 100 MPN/100mL.

- At most lake sites, *E. coli* levels peaked in January 2004 to levels between 10 and 250 MPN/100mL. *E. coli* levels at the lake sites were highest during the rainy season.

- Overall, the highest level of percent positive *E. coli* samples was found at the beaches, then at the near shoreline sites, next the lake center, and next the buoylines. The lowest values were found at the outlet tower.

In conclusion, the study confirmed that both body-contact recreation and runoff from the watershed during the rainy season can be equally important as sources of fecal contamination to Lake Perris. However, recreation may be easier to manage as a potential contaminant source than runoff.

In addition to bacteriological monitoring, fingerprinting analysis was conducted as a means to determine the potential impact of fecal contamination from the beaches on the outlet tower. A total of 403 *E. coli* and 28 non-*E. coli* isolates were fingerprinted by the repetitive-PCR method (MWDSC, 2005). Banding patterns resulting from rep-PCR were compared from beach isolates to outlet tower isolates, and a small subgroup of isolates from other locations throughout the lake. A similarity threshold of 95 percent was established for this study based on the intensity of banding patterns from the duplicate isolates. Thus, isolates displaying 95 percent similarity or greater were considered to be the same.

Out of 179 *E. coli* beach isolates, 65 beach isolates (36 percent) displayed relatedness to outlet tower isolates at the 95 percent similarity threshold. This suggests that *E. coli* from the swim areas can impact the outlet tower.

<u>Hydraulic Modeling Findings</u>

The objective of the hydrodynamic modeling component was to assess the impact of fecal coliforms from various types of recreation activities and under various lake conditions. The Estuary and Lake Computer Model (ELCOM) was used by FlowScience to perform a series of three-dimensional hydrodynamic simulations of Lake Perris (FlowScience, 2004).

Five scenarios with different loading levels and lake operating conditions were modeled. The scenarios modeled were:

1) Scenario 1 - Calibration or Base Case: Use 2003 measured inflow, outflow, meteorological data, and estimated recreator pathogen loading data to calibrate the model for 2003.

2) Scenario 2 - No Swimmers: Similar to Scenario 1, except that all swimmers and their associated loadings were removed from the model.

3) Scenario 3 - Non-Body Contact Boaters Only: Similar to Scenario 2, except that all skiers and personal water craft users are also removed from the model. Non-body contact boating activities such as fishing remained in the model.

4) Scenario 4 - Drought Conditions: Similar to Scenario 1, except that the flow conditions are altered so that there are no inflows. Outflows are also set to zero, except for a two month period during summer in which 30,000 acre-feet of water is released (an operational worst case or minimal lake volume simulation).

5) Scenario 5 – Destratified: Similar to the calibration or base case, except that the reservoir is mixed by means of an air bubbler so that the thermal stratification is reduced.

The ELCOM model was able to predict fecal concentrations during the calibration scenario that correlated reasonably well with measured epiliminion concentrations when based on seasonal averages. Based on the results from the scenarios evaluated, these conclusions can be drawn with regard to fecal coliform concentrations at Lake Perris:

- The lowest fecal coliform concentrations at the outlet tower occurred when non-body contact boaters (Scenario 3) were the only recreators allowed on the lake.
- The fecal coliforms at the outlet tower were nearly identical regardless of whether or not the swimmers are allowed at the beaches. This outcome is probably due to the decay rate of fecal coliforms on the surface of the lake. Nonetheless, it is widely known that pathogens survive longer than fecal coliforms.
- The concentration of fecal coliforms increases when shallower outlet tiers are used. Overall, fecal coliforms tend to stay above the thermocline if introduced at the surface of the lake.
- The concentrations of fecal coliforms decrease as the outflow of water from Lake Perris increases. Greater outflows lead to increased mixing of the lake.
- Most of the loading at the beaches is from swimmers.
- The loading from boaters, skiers, and personal water craft users do not contribute substantially to the fecal coliforms at the beaches.
- Mixing by an air bubbler will result in increased fecal coliform concentrations in the hypoliminion, and thus, at the deeper tiers of the outlet tower.

Pathogen and Risk Assessment

Although over 100 different enteric and potentially waterborne pathogens can be shed by recreators, previous studies have shown that *Cryptosporidium* is the pathogen of greatest threat to consumer public health in most recreationally impacted surface waters. *Cryptosporidium* concentrations and consumer risk levels resulting from body-contact recreation in Lake Perris were calculated for several recreational scenarios using a probabilistic pathogen fate model coupled with consumer risk calculations (Anderson, 2004).

The modeling results by Dr. Michael Anderson indicate that body-contact recreation represents a significant threat to the microbial water quality in Lake Perris, with the model predicting elevated *Cryptosporidium* at the outlet. Based on the model and calculations used by Dr. Anderson, there is a 10 percent probability that the annual average daily risk of infection to water consumers will exceed the USEPA target maximum risk of infection of 2.47×10^{-7} infections/person/day when water is drawn from the epilimnion of the lake. Daily risks of infection during the summer were about two times higher than the annual average value. Removal of swimming from the main body of the lake was predicted to reduce the probability of exceeding the USEPA maximum risk level by one-half, to about a 5 percent probability.

Alternatives to Limit Body Contact Recreation

As summarized above, the collective findings of the bacteriological monitoring, fingerprinting analyses, hydraulic modeling, and the pathogen risk assessment have demonstrated that:

- Body-contact recreation is a source of fecal contamination.
- Fecal contamination occurring at the swim beaches can be transported to the outlet tower and therefore to downstream consumers.
- The lowest fecal coliform concentrations at the outlet tower occur when non-body contact boaters (Scenario 3) are the only recreators allowed on the lake.
- Most of the loading at the beaches is from swimmers.
- Boaters, skiers, and personal water craft users do not contribute substantially to the fecal coliforms at the beaches.
- Removal of swimming from the main body of the lake was predicted to reduce the probability of exceeding the USEPA maximum risk level by one-half, to about a 5 percent probability.

The results of these studies were presented in March 2003 to a CALFED Science Panel, which concurred with the report's main findings. The findings from these studies have provided the basis for solutions currently being pursued by MWDSC.

To reduce the risk of waterborne pathogens at Lake Perris, MWDSC is proposing voluntary swimming alternatives (i.e. swim lagoons, water play areas and other water features) to swimming in the reservoir. Solutions under consideration are pending approval by MWDSC management and its Board. Final selection and location of recreational facilities will be based on close coordination with Lake Perris SRA staff.

To proceed with the proposed alternatives, MWDSC issued a Draft Environmental Impact Report (EIR) in March 2006 for the voluntary swimming alternatives, as well as the hypolimnetic oxygenation system. The MWDSC Board certified the Final EIR in July 2006. Currently, design is underway for the voluntary swimming alternatives and hypolimnetic oxygenation system. Details on the hypolimnetic oxygenation system are presented in the following sections.

Projected Water Quality Improvements

Since the swim lagoons will be a voluntary alternative to swimming in Lake Perris, projected water quality improvements can only be estimated. Assuming that 100 percent of the current swimmers in Lake Perris were transferred to the swim lagoons, the risk assessment modeling predicts that the probability of exceeding the USEPA maximum risk level would be reduced by 50 percent, to about a 5 percent probability (Anderson, 2004). This is a significant water quality improvement, as it reduces the health risk to downstream consumers by 50 percent.

Evaluation of Hypolimnetic Aeration

Need for Hypolimnetic Aeration

As discussed earlier, the hypolimnion becomes depleted of oxygen during thermal stratification, primarily due to the decomposition of algae and other organic matter. When the hypolimnion becomes anoxic, T&O compounds, nutrients, and metals can be released into the water column from the sediments.

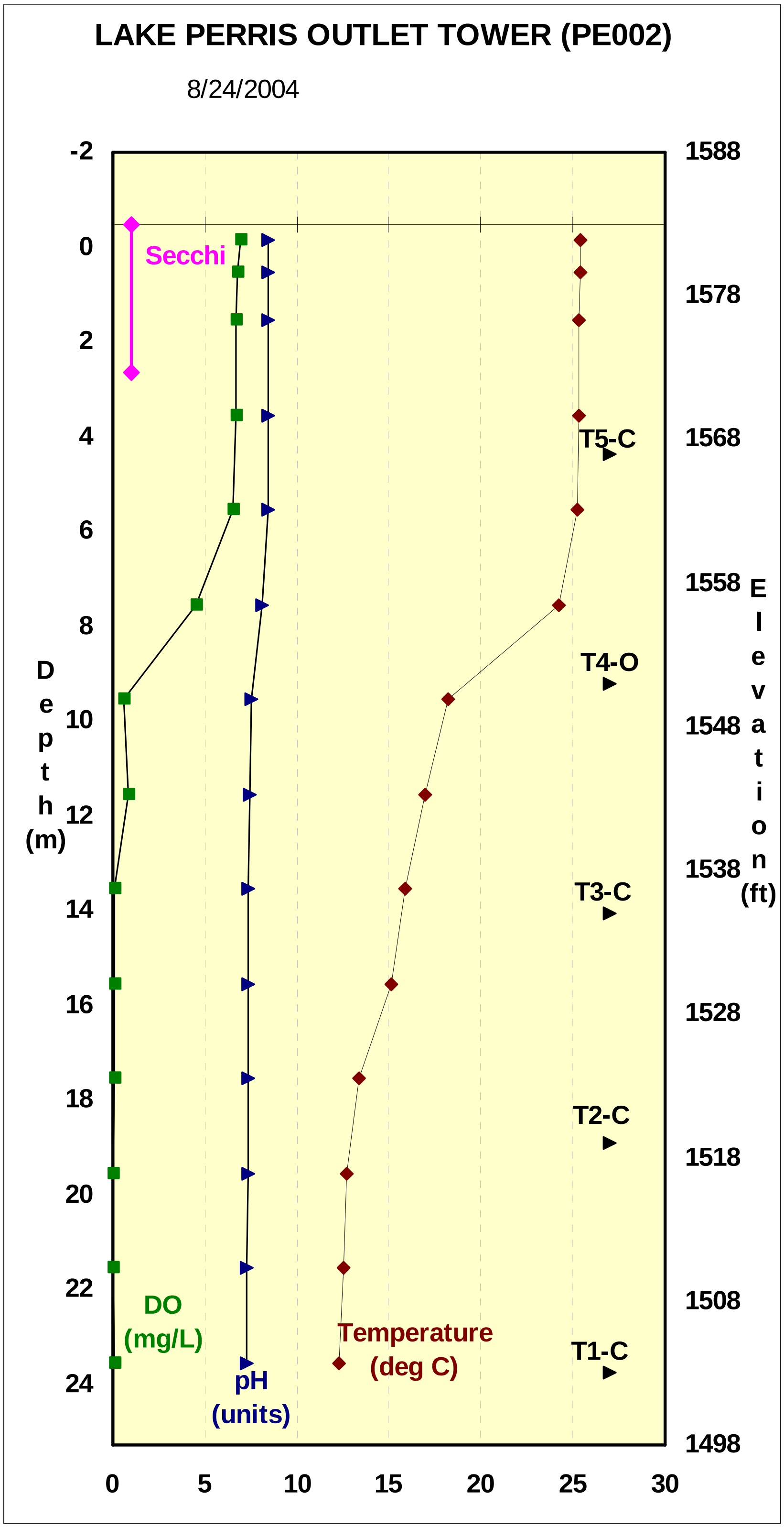
Oxygen profile data for the years 1994 through 2003 show that 29 to 55 percent of the lake volume becomes anaerobic (MWDSC, 2003). **Figure 5-49** shows a typical lake profile during the stratified period when the hypolimnion is anoxic.

Between 1986 and 2004, the depth of the reservoir varied from 97.3 to 107.9 feet; the measured thickness of the hypolimnion varied from 16.4 to 29.5 ft, and the volume of the hypolimnion varied from 50,500 to 91,900 acre-feet. To make the hypolimnion usable as a source of drinking water in the summer, oxygenation of 80,000 acre-feet of water in the hypolimnion has been proposed (FlowScience, 2005).

Alternatives Evaluated

To prevent low oxygen levels in the hypolimnion and the resulting water quality degradation, two methods have been traditionally used: 1) hypolimnetic oxygenation and 2) artificial reservoir destratification. Hypolimnetic oxygenation is a method of adding dissolved oxygen to the hypolimnion while maintaining the natural thermal destratification. In artificial destratification, the reservoir's seasonal thermocline is purposely disrupted by physically mixing the reservoir. This allows oxygen that penetrates the water surface to be mixed throughout the entire water column.

Figure 5-49. Lake Perris Outlet Tower Profile – 8/24/04



Source: MWDSC

On behalf of MWDSC, FlowScience completed an initial review of hypolimnetic oxygenation and destratification alternatives (FlowScience, 2005). The following three alternatives were determined to be the most feasible, or preferred alternatives:

- Diffused oxygen input (using pure oxygen)
- Speece Cone oxygenation (using pure oxygen)
- Bubble plume destratification (using compressed air)

The diffused oxygen input and the Speece Cone oxygenation are hypolimnetic oxygenation alternatives, and the Bubble Plume destratification is considered an artificial reservoir destratification alternative.

Diffused oxygen input is a method in which oxygen is bubbled into a reservoir at depth. Oxygen is delivered or generated on-site and then conveyed to the hypolimnion via on-grade and submerged supply lines. It is then diffused into the hypolimnion either through porous pipes or special diffuser structures. As the bubbles rise, oxygen is dissolved into the water with an oxygen transfer rate that is dependent upon the bubble size and the dissolved oxygen concentration of the overlying water.

Hypolimnetic oxygenation using a Speece Cone is a method whereby oxygen is introduced into the hypolimnion via a submerged Speece Cone that rests at the bottom of the reservoir. Oxygen and electrical power are conveyed to the Speece Cone via on-grade and submerged supply lines. A submersible pump supplies hypolimnetic water to the adjacent Speece Cone, where water is exposed to the oxygen and oxygen transfer occurs. The oxygenated water is then returned to the hypolimnion through a diffuser.

Destratification using a bubble plume system was also evaluated as a method to increase oxygen levels in the hypolimnion of Lake Perris. The concept behind a bubble plume destratification system is to introduce kinetic energy into the hypolimnion, thus allowing the energized hypolimnetic water to rise and entrain warmer epilimnetic water. This entrainment results in mixing of the hypolimnion with the epilimnion and, increases the temperature and oxygen content of the hypolimnetic waters.

FlowScience compared the alternatives based on the following criteria: 1) design complexity and ease of installation, 2) track record, 3) safety considerations, 4) reliability, 5) environmental impacts, 6) secondary water quality impacts, 7) installation and initial capital costs, 8) annual operating and maintenance costs, 9) extent of oxygenation, 10) maintenance requirements, and 11) flexibility.

Bubble destratification is the least expensive alternative, but the physical effects are significant. Bubble destratification eliminates anoxia and the presence of highly reduced compounds, but this process also spreads T&O compounds throughout the entire water column, eliminating the ability to selectively withdraw water.

FlowScience concluded that between the two hypolimnetic oxygenation alternatives, the diffused oxygen input system would be a better choice for Lake Perris than the Speece Cone system, primarily due to costs, track record, and ability to oxygenate a larger volume of the hypolimnion without the need for additional mixing equipment.

Based on the FlowScience report, MWDSC is moving forward with plans for the diffused oxygenation system, or hypolimnetic oxygenation system. MWDSC's Board approved funding for final design and construction of the diffused oxygenation system. MWDSC has also received grant funding to assist with a portion of the project cost. Currently, the diffused oxygenation system is scheduled to be on-line by March 2008.

Projected Water Quality Improvements

The use of a hypolimnetic oxygenation system in Lake Perris will keep the hypolimnion acceptable as a source independent of algal blooms occurring in the epilimnion. It will provide oxygen to the hypolimnion without breaking up the stratification that normally occurs each year, unlike the bubble plume destratification system. Subsequently, hypolimnetic oxygenation will reduce the occurrence of T&O events resulting from anoxic conditions in the hypolimnion. Other benefits include oxidizing odor-producing substances such as ammonia, hydrogen sulfide, and methane to nitrate, sulfate, and carbon dioxide. Other improvements include oxygenating the sediments which will reduce phosphorus and nitrogen recycling (Beutel, 2006), which in turn will reduce the occurrence of algal blooms and subsequent T&O events.

The proposed diffused oxygenation system using pure oxygen will increase the availability of good quality water, and will increase operational flexibility. In turn, this allows water stored in Lake Perris to be withdrawn more frequently, particularly during episodes of high bromide or TOC from Lake Silverwood.

Drawdown of Lake Perris

Need for Drawdown

Perris Dam is a zoned earthfill embankment containing approximately 25 million cubic yards of compacted fill. It is approximately 11,600 feet long, with a maximum structural height of 128 feet. The normal maximum operating level is 1,588 feet, 108 feet above the reservoir bottom. The spillway crest is at 1,590 feet, and the dam crest elevation is 1,600 feet.

DWR released a seismic study of Perris Dam in June 2005. It was determined that a portion of the embankment and foundation is underlain by thin layers of low-plasticity and clayey sands that are potentially susceptible to liquefaction and severe loss of strength during a large earthquake event. This risk has led to the temporary lowering of Lake Perris by 25 feet below the spillway level, to elevation 1,563 feet, to mitigate the seismic risk while a permanent solution is being determined. **Figure 5-50** shows Lake Perris at this lowered level in 2005.

Figure 5-50. Lake Perris at Lowered Level

Impacts on Water Quality Since the Lowering of Lake Perris

Due to concerns regarding the seismic stability of the dam discussed earlier, the water elevation of Lake Perris was reduced from elevation 1,588 feet to 1,563 feet. Lowering the lake has impacted water quality, as the most severe T&O event caused by benthic algae on record occurred in 2006.

Nutrient rich sediments at the lake bottom are exposed to more sunlight when the lake is lowered. Nutrients are then much more readily available to the surface, causing an increase in algal growth. In August 2006, the entire shoreline of Lake Perris was impacted by a benthic algae *(Oscillatoria curviceps)* bloom. This particular benthic algae was extremely unusual, as it caused MIB levels to increase from less than 10 ng/L to over 200 ng/L within a two week period (Personal Communication, William Taylor, MWDSC, November 2006). Although copper sulfate treatments were conducted to control the benthic algal bloom, peak MIB concentrations at the outlet tower reached 292 ng/L. As a result, delivery of water from Lake Perris was curtailed until MIB levels decreased. MWDSC staff expects T&O problems will continue from macrophytes and benthic algae, as long as the lake is lowered.

Lowering the lake also constrains the depths at which lake water can be withdrawn. For example, when Lake Perris has full storage at elevation 1,588 feet, all five tier depths at the outlet tower can be utilized. When the lake elevation is lowered to 1,563 feet, only the bottom four tier depths are available.

Alternatives to Address Seismic Hazard

As requested by the State Water Contractors (SWC), DWR is currently evaluating future options for Lake Perris, beyond remediating the dam. Due to the significant impacts and costs of remediating Perris Dam, the SWC requested that DWR perform a study to evaluate alternatives for permanently lowering, maintaining the existing lake level, or raising the normal maximum operating level of the reservoir (DWR, 2006).

The eight reservoir options studied included a range from permanently emptying the reservoir to increasing the normal reservoir level to 1,814 feet for a total volume of 1,000,000 acre-feet. Intermediate steps included lake elevations of 1,563 feet, 1,588 feet (as designed normal operating condition), 1,640 feet, 1,706 feet, and 1,752 feet. The eighth option considers using the lake for recreational use only, with an approximate 40,000 acre-feet capacity. The elevation for this option was not specified.

Each of the reservoir options will have multiple impacts, including various short-term construction impacts, construction magnitude, water storage benefits, recreation in the Lake Perris SRA, environment, property, water quality, and others. Thirteen impacts were identified in all. A weighted evaluation was performed, and each issue was given a rating ranging from -5 to 5 to reflect the severity of the negative or positive impact, respectively. The existing 1,588 feet elevation was given a rating of 0 in all cases. The evaluation for each of the reservoir options showed the 1,588 feet elevation as-designed condition as most highly rated, with a value of 0, the 1,640 feet elevation reservoir as second with a value of -0.18, and the 1,706 feet elevation reservoir as third with a value of -0.39. These compare with the least favorable option, the recreation only 40,000 acre-feet reservoir with a value of -1.62.

The evaluation recommended that a further benefit/cost analysis be conducted on the two most highly ranked reservoir options, those with reservoir levels at 1,588 ft and 1,640 feet. DWR has done extensive study of the option to remediate the dam to return it to the normal maximum water level of 1,588 feet. Additional studies, including preliminary designs to estimate construction and modification costs, as well as recreation and environmental mitigation costs are needed for the two preferred options. It is expected that the cost analysis will be completed in 2007. It is expected that design work, environmental documentation and permitting will take approximately two to three years, followed by construction work.

POTENTIAL ACTIONS

Lobby and/or Seek Funding to Construct Alternative Swimming Solutions

Recreational facilities are financed according to legislation enacted by the Davis-Dolwig Act (1961), Assembly Bill 12 (1966), and Assembly Bill 1441 (1989). The Davis-Dolwig Act declared that providing for the enhancement of fish and wildlife and for recreation in connection with the SWP benefits all the people of California and that the costs attributable to such enhancement should be borne by them. The act also provided a procedure through which DWR was to be reimbursed for those project costs allocated to recreation and fish and wildlife enhancement and for costs of acquiring property for recreation development.

Currently, the financial cost of developing preliminary and final design for alternative swimming solutions has been borne by MWDSC, and Proposition 13 grant funding which MWDSC received in 2002. However, the SWP Contractors could assist in seeking or lobbying additional sources of funding which will be needed for the project construction and possibly, operation.

Conduct Additional Water Quality Monitoring if Size of Lake Perris is Changed

If the current elevation of Lake Perris is altered permanently from its previous normal elevation of 1,588 feet, modifications to DWR's current water quality monitoring program will be required. It is recommended that DWR and MWDSC collaborate on needed changes to the current monitoring program. This monitoring will be needed to understand the "new" lake, and to assist in developing new management strategies to ensure good water quality.

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CHAPTER 6
Incidents and Emergency Response Measures

CALIFORNIA STATE WATER PROJECT
WATERSHED SANITARY SURVEY
2006 UPDATE

CHAPTER 6
INCIDENTS AND EMERGENCY RESPONSE MEASURES

In the past five years there have been a number of incidents that could potentially adversely affect water quality in the Sacramento-San Joaquin Delta (Delta) and the State Water Project (SWP). This chapter contains a description of the following incidents:

- Jones Tract Levee Failure – A portion of the west levee on Upper Jones Tract failed in June 2004 resulting in flooding of both Upper and Lower Jones tracts.
- Wastewater Spills in the Delta – There have been numerous spills of untreated and partially treated wastewater in the Delta.
- Wastewater Spills in Silverwood Lake – In 2005, there were three wastewater spills impacting Silverwood Lake.
- High Runoff and Turbidity in Silverwood and Castaic lakes – Water quality has been impacted at Silverwood and Castaic lakes due to heavy winter rainfall and wildfires.
- Oil Spill in Pyramid Lake – Due to heavy rainfall, a landslide broke a pressurized oil pipeline in the Pyramid Lake watershed on March 23, 2005.

JONES TRACT LEVEE FAILURE

Eleven hundred miles of levees are needed to protect Delta land uses, including farmland, state highways, railroad, natural gas, and electric transmission facilities, and thousands of acres of habitat. Levees also protect the quality of water pumped from the Delta for drinking water supplies. In the last 100 years there have been 162 levee failures in the Delta (DWR et al, 2005a). When a levee fails, salt water from the Bay can inundate land that is below sea level and seriously affect Delta water supplies for months. In June 2004, a levee failed on Upper Jones Tract. The Jones Tract levee failure is described, the actions taken to protect drinking water quality are assessed, and efforts to stabilize and improve the levee system in the Delta are discussed in this section.

SUMMARY OF THE INCIDENT

A portion of the west levee of Upper Jones Tract, located in the southern Delta, failed at about 8:00 a.m. on the morning of June 3, 2004. **Figure 6-1** shows the location of the levee break, and **Figure 6-2** shows the break. Upper Jones Tract immediately began to flood, and the flooding soon spread to adjacent Lower Jones Tract through the railroad trestle that divides the two properties (**Figure 6-3**).

Figure 6-1. Location of Levee Break

Figure 6-2. Levee Break on Upper Jones Tract

Source: DWR

Figure 6-3. Flooding of Lower Jones Tract from Upper Jones Tract

Source: DWR

Within an hour, the State-Federal Flood Operations Center (FOC) was activated, and an Incident Command Post (ICP) was established by the San Joaquin County Sheriff's Office on the east side of Upper Jones Tract near Highway 4. Evacuation of Upper Jones Tract and Lower Jones Tract (referred to as Jones Tract in the following paragraphs) began immediately and, as a result, there was no loss of human life. The California Department of Water Resources (DWR) established the following objectives for the emergency response:

- Protect Highway 4.
- Minimize salt water intrusion into the Delta.
- Prevent the failure of Jones Tract perimeter levees and adjacent islands' levees.
- Close the levee breach.

An immediate concern was intrusion of salt water into the Delta caused by flooding of the two tracts. Accordingly, DWR and the U.S. Bureau of Reclamation (USBR) increased upstream reservoir releases and curtailed project diversions from the South Delta. As a consequence of these actions, salinity intrusion was successfully controlled, though not eliminated.

Resources were required to meet the objectives of protecting Highway 4, Jones Tract perimeter levees and adjacent islands' levees, and to close the levee breach. By the evening of June 4, the Governor had declared a State of Emergency that made state resources available to meet the emergency. Federal resources were sought through an emergency request under Public Law 84-99. The U.S. Army Corps of Engineers (USACE) were asked to provide funding to raise the Trapper Slough levee, located on the southern border of Upper Jones Tract, and to close the breach. The Trapper Slough levee protects Highway 4, and was not sufficiently high to protect the highway from the flooding that was underway.

Early response to the emergency was inhibited by various problems, including:

- USACE approved funding for raising the Trapper Slough levee, but not for armoring the levee or closing the breach, as USACE management believed they lacked authority to authorize expenditures to perform these tasks.

- Because the failure was on a non-project levee, DWR had no clear jurisdiction for instituting repairs, nor immediate access to emergency funding.

- Telecommunications equipment did not function reliably, reducing the ability to communicate among field personnel, and between the ICP and FOC. Also, there was some early confusion about the location of the DWR emergency response facilities at the site.

By June 5, a Unified Command, including San Joaquin County, DWR, and the California Department of Transportation (Caltrans) representatives, was established at the site, and a contractor was hired to close the breach. On June 8, DWR assumed control over the incident, and on that same day, raising of the Trapper Slough levee was completed. Also on that day, local Reclamation Districts 2038 and 2039 requested that DWR institute a flood fight to protect the interior levees of the two tracts. A flood fight is conducted by employing crews and materials such as sand bags, rocks, and plastic sheeting to control leaks and levee overtopping that can lead to levee failure. The Jones Tract flood fight resulted in 16 miles of levee being armored with rock and plastic sheeting. By June 30, the breach had been closed and protection of the interior levees completed. Also on June 30, a Presidential Declaration of Emergency was issued. This declaration authorized the Federal Emergency Management Agency (FEMA) to reimburse the state agencies for the cost of responding to the emergency.

The DWR contractor began to dewater the island on July 12 with four 42-inch pumps. Subsequently, an additional four 42-inch pumps and two 30-inch pumps began operation on July 26. Pump locations are shown in **Figure 6-1**. Collectively, these pumps produced a maximum flow rate of 350,000 gallons per minute (780 cubic feet per second [cfs]). The incident was closed by the Office of Emergency Services (OES) on July 12, 2004, although pump-out of the island and water quality monitoring continued until December 18 when most of the water had been removed. Removal of the remaining water subsequently became the responsibility of the local reclamation districts. The total volume of water pumped from Jones Tract by the time responsibility was turned over to the local agencies was estimated at 140,000 acre-feet.

California law requires any agency responding to an emergency declared by the Governor to prepare an After Action Report (AAR) of its activities. Accordingly, DWR produced an AAR (DWR, 2004a). The OES likewise prepared an AAR (OES, 2005). The two AARs are directed primarily at describing the chronology and processes by which various agencies became involved in the incident, what activities were performed by the entities, and how they interacted. The AARs also include assessments of the adequacy of the emergency response, along with recommendations to improve response for future emergencies of like kind. The AARs are included as **Appendix D**.

In addition to the Red Cross and San Joaquin County Sheriff, some 13 state agencies and at least four federal agencies became involved in the incident response. Despite the complexity of the incident, the number of involved entities, the lack of clear jurisdiction over the failed non-project levee, and early problems with communications and coordination, the incident was successfully brought to a close without loss of human life or serious injury. Also, the DWR objectives of minimizing salt water intrusion into the Delta, protecting the Jones Tract levees from further damage, and repairing the breached levee were attained in a timely manner. From this perspective, response to the emergency would be characterized as a qualified success. Costs attributable to the incident are estimated at nearly $100 million (DWR, 2005a).

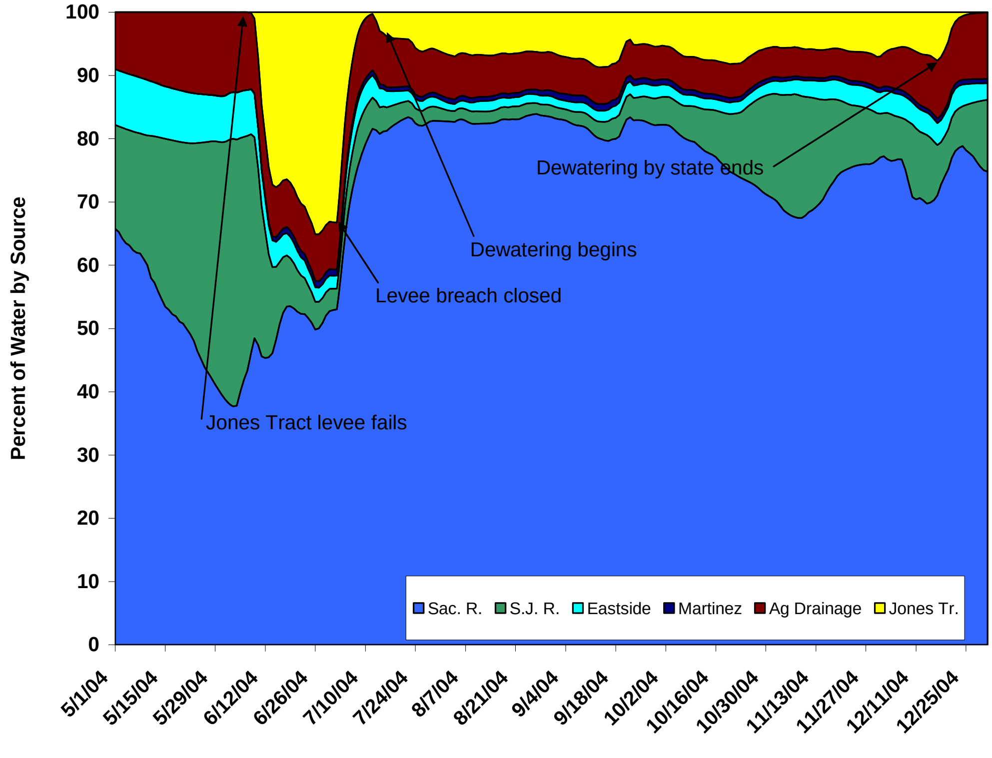
A significant component missing in the overall management of the incident was protection of water quality. The following discussion addresses the water quality consequences of the incident and identifies areas where improvements with respect to water quality protection are needed.

WATER QUALITY CONSEQUENCES OF THE JONES TRACT LEVEE FAILURE

During the course of the incident, from June through mid-December 2004, when removal of flood waters from Jones Tract was completed, DWR staff collected water quality samples of channel and flood waters, and analyzed them for constituents of concern to drinking water purveyors, such as organic carbon, bromide, nutrients, chlorophyll, salinity, turbidity, hydrocarbons, and synthetic organic pollutants such as pesticides. Staff of DWR's Municipal Water Quality Investigations (MWQI) Program are preparing a report documenting the water quality consequences of the levee break. The discussion of water quality impacts is based largely on information provided by MWQI staff (Personal Communication, Cindy Messer, DWR).

DWR developed a historical Delta Simulation Model (DSM2) volumetric fingerprinting simulation to assist in understanding the impact of the Jones Tract levee failure on water quality at Clifton Court Forebay (DWR, 2005b). **Figure 6-4** shows the sources of water at Clifton Court Forebay during the period May through December 2004, including the contribution from Jones Tract. The simulation model predicted that water from Jones Tract began reaching Clifton Court on June 7, the proportion rising as high as 35 percent of the water in Clifton Court on June 26 and 27, then began tapering slowly. Jones Tract volume contributions to Clifton Court began falling rapidly after the levee break was closed on June 30. Between the time dewatering of Jones Tract began on July 12 until the state turned the project over to the local reclamation districts on December 18, the contribution of Jones Tract water to Clifton Court was estimated to have ranged from less than 1 percent to about 9 percent, and averaged 6 percent.

Figure 6-4. Contribution of Jones Tract to Water Volume at Clifton Court



Seawater Intrusion and Salinity

Because the ground surface elevations of most Delta islands are below sea level, the islands tend to flood when levee breaks occur. During such times, large quantities of water rush from Delta channels into the island, causing a flow of saline water into the Delta from Suisun Bay. Depending on flow, wind, and tidal conditions existing at the time of the levee failure, salinity intrusion can be serious and the quality of water diverted from the Delta significantly degraded. Once salinity intrusion penetrates into freshwater channels of the southern Delta, it can be difficult or infeasible to expel the salty water, and it must be used for Delta agriculture and diverted from the Delta through the SWP and Central Valley Project (CVP) pumping plants.

The Jones Tract levee break resulted in 12,000 acres flooding. After three days, about 150,000 to 200,000 acre-feet of water had entered Jones Tract. This amounted to about 35 percent of the fresh water volume in Delta channels, and about ten times the volume of fresh water in the channels of the South Delta. Water flowed in and out of the breach with the tides, exchanging with Middle River, at an estimated volume of 30,000 cfs (Personal Communication, Cindy Messer, DWR).

The flooding and subsequent pump-out of Jones Tract had the potential to adversely impact water quality at the Harvey O. Banks Delta Pumping Plant (Banks) initially due to seawater intrusion when the islands were flooding (June 3 to June 30) and then due to pumping the water off the islands into Delta channels (July 12 to December 18). The effects of salinity intrusion experienced at Banks were moderated by the increases in upstream reservoir releases and curtailed pumping at the SWP and CVP pumping plants. **Figure 6-5** compares daily average electrical conductance (EC) readings from the continuous recorder at Banks during 2004 to the average daily EC for 2001, 2002, 2003, and 2005 combined. This figure reveals that EC during the early months of 2004 was running below average for the other years, until May 16 when the EC equaled the average of the other years. Although 2004 was classified as a below normal water year, flows were high on the Sacramento and San Joaquin rivers in late February through March 2004. However, Sacramento River flows were fairly low in May and San Joaquin River flows dropped in mid-May when Vernalis Adaptive Management Program (VAMP) flows were discontinued. **Figure 6-6** depicts Sacramento and San Joaquin River flows, along with SWP and CVP diversions during 2004. This figure shows that SWP and CVP diversions corresponded with Sacramento River flows during this period, and that San Joaquin River flows remained low all year. As shown in **Figure 6-5**, from May 16 until July 29, 2004 EC exceeded the average of the other years, then fell generally lower for the remainder of the year. At least some of the May to July rise is probably attributable to salinity intrusion due to the levee failure. By June 27, 2004, EC was 46 percent higher than the average of the other years (398 µS/cm vs. 217 µS/cm). The difference decreased from that point, suggesting a diminishing influence of salinity intrusion with time.

Figure 6-5. Electrical Conductance at Banks

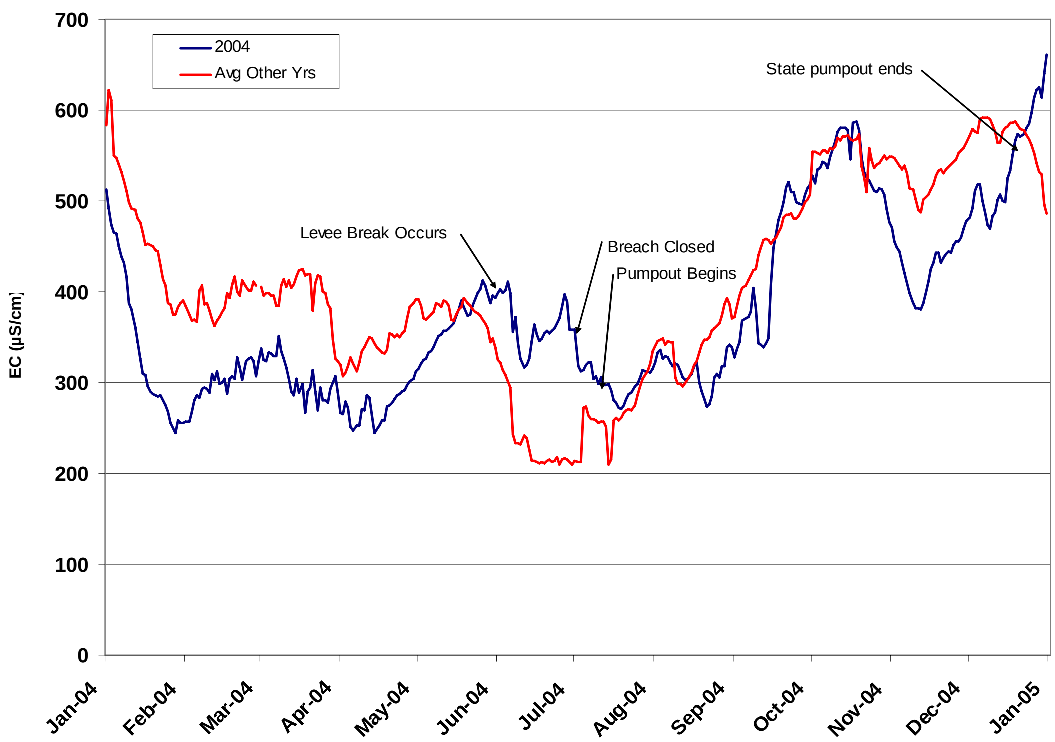
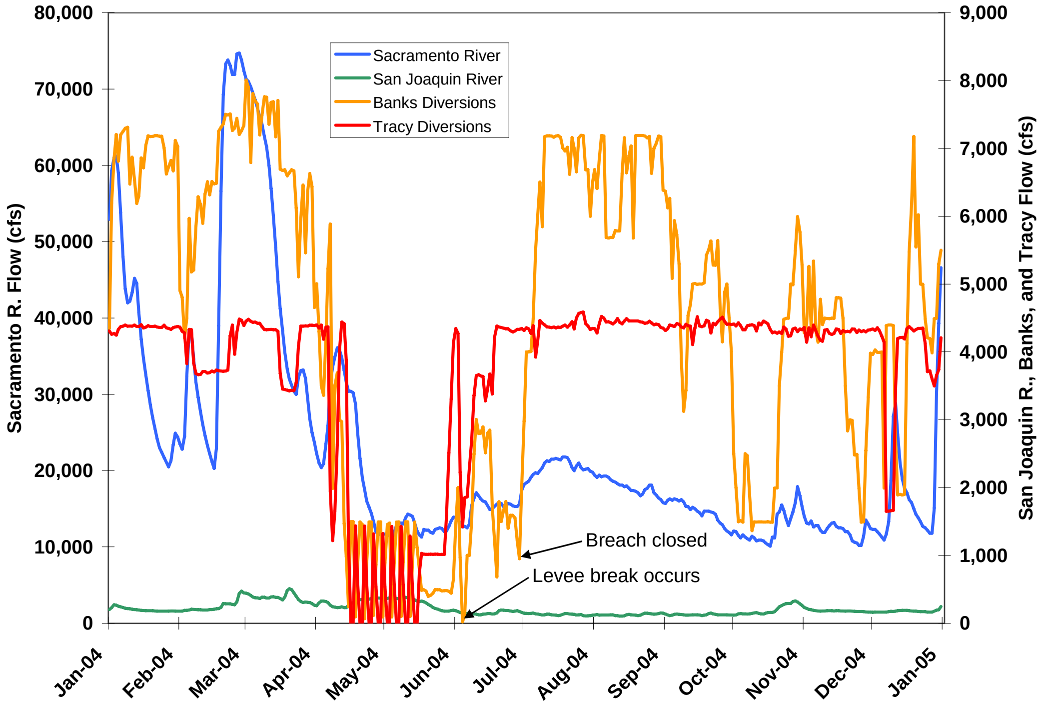


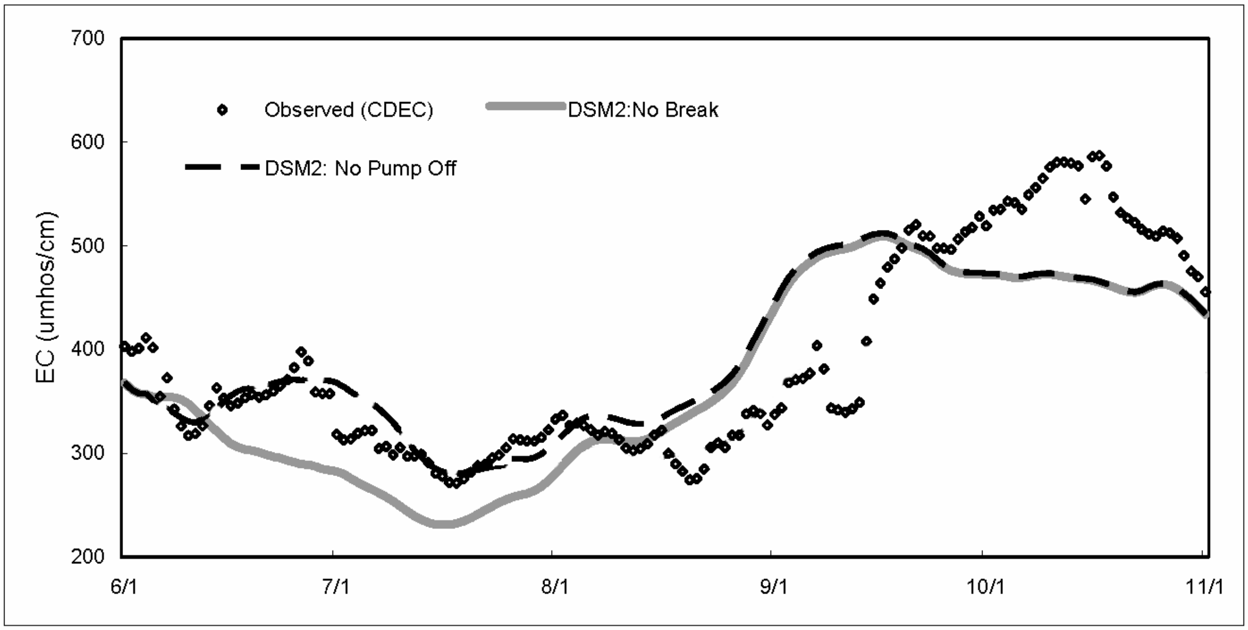
Figure 6-6. Sacramento and San Joaquin River Flows, SWP and CVP Diversions in 2004



DWR's DSM2 model was used to simulate EC at Clifton Court during the period of the Jones Tract levee break (DWR, 2005b). The purpose of the simulation was to use available water quality data from the flooded islands to validate the ability of the model to simulate hydrodynamics during a levee break and water quality impacts associated with the flooding of an organic carbon-rich Delta island. The results, illustrated in **Figure 6-7**, show EC actually measured at Clifton Court, the simulated EC that would have been expected had there been no levee break, and EC that would have been expected had a break occurred, but water impounded on Jones Tract had not been pumped back into Delta channels. The figure indicates that from shortly after the break until the first week in August, observed EC was up to 100 µS/cm (µmhos/cm) higher than would have been expected if the break had not occurred. The pump-out began on July 12, so it appears from the simulation that salinity intrusion was largely responsible for the observed EC increase prior to that date. From July 12 until the first week in August, the difference between actual and observed EC did not increase overall, suggesting water pumped off the islands did not further increase EC.

Between early August and mid-September, the model predicted higher EC at Clifton Court than was observed. The simulation suggests the water pumped off the islands did not worsen, and may have actually contributed to improving salinity at Clifton Court. From mid-September to November, the prediction was for lower EC than was observed at Clifton Court. The simulation assumed EC of the impounded water stayed essentially constant over the period while pumping occurred. In actuality, after the levee breach was sealed, average EC of the impounded water on Jones Tract continued to increase from about 300 µS/cm initially to about 500 µS/cm by mid-November when the pump-out operation was nearly complete. This erroneous assumption may have contributed to the under-prediction of EC at Clifton Court during the mid-September to November period. Another possible explanation of overpredictions and underpredictions of EC at Clifton Court could be incorrect estimates of the quality and/or quantity of agricultural drainage into the system during the time period of interest.

Figure 6-7. Results of EC Simulation for Clifton Court



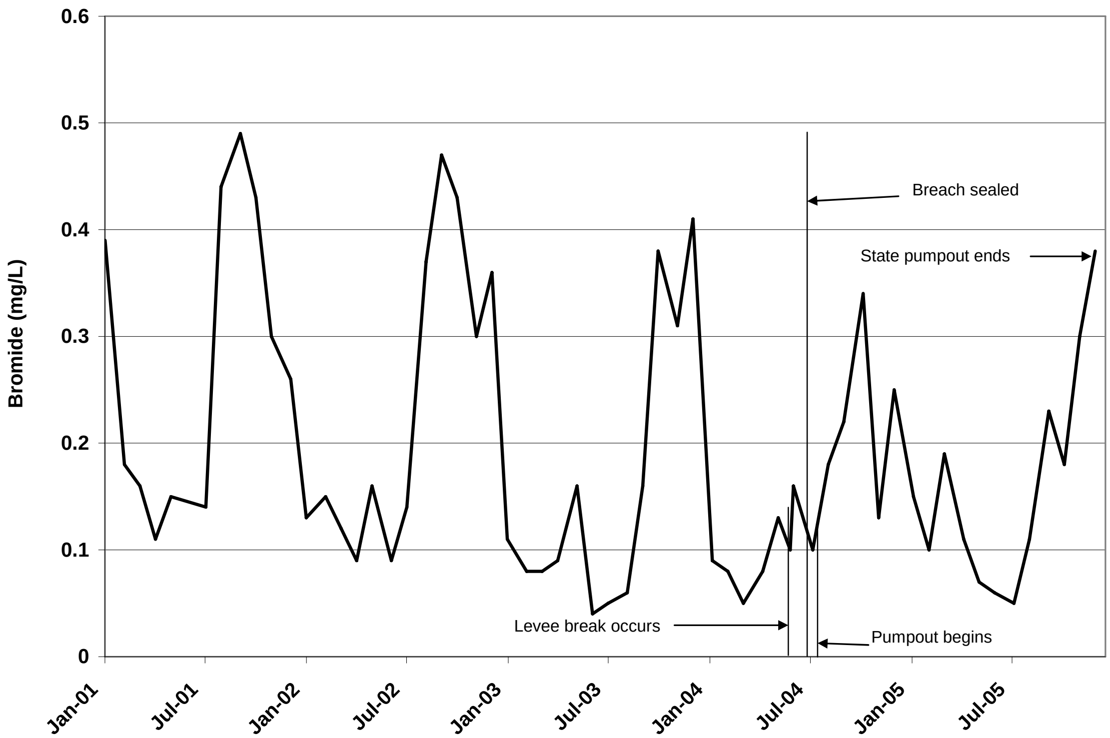
Source: DWR, 2005b. Modified by removal of "Historical" curve for clarity.

The levee break occurred at a time when upstream reservoirs were at or near capacity so releases of freshwater could be made to repel seawater intrusion. The impacts of a levee break during drought conditions, when reservoir releases could not repel seawater intrusion, could potentially have far more adverse impacts on EC at the Delta pumping plants.

Bromide

Because bromide is a component of seawater, salinity intrusion resulting from the levee break could potentially increase bromide concentrations at the Delta pumping plants. **Figure 6-8** displays bromide concentrations measured in discrete samples collected during the period 2001 through 2005. No unusual increase is apparent during the time of the levee breach, nor for the remainder of 2004. In fact, bromide concentrations following the June 3 levee break through the end of the year were lower than had been experienced in the previous three years.

Figure 6-8. Bromide Concentrations at Banks



Organic Carbon

Pumping water from Jones Tract into Middle River could adversely impact organic carbon concentrations at Banks. Jones Tract is in the south central Delta area, and is classified as having peat soil with high concentrations of dissolved organic carbon (DOC) in drainage waters (Jung and Tran, 1999). When Jones Tract flooded, there was concern that organic carbon stored in the peat soils would leach into the overlying water and then be discharged to Middle River when the water was pumped off. MWQI monitoring showed that total organic carbon (TOC) concentrations in waters sampled from Jones Tract averaged about 5 mg/L initially and increased to about 25 mg/L by the time most of the water had been pumped off. This represented about a 1 mg/L per week increase in TOC.

Figure 6-9 compares TOC measured by the continuous recorder at Banks to the combined inflows of the Sacramento and San Joaquin rivers. Organic carbon concentrations are clearly related to inflow. As has been previously established through the MWQI Program, TOC and DOC concentrations in Delta inflows, Delta channels, and in water diverted from the South Delta increase when surface runoff containing decaying organic matter enters these water bodies. This appears to be responsible for the sharp organic carbon seasonal increase associated with the wet season. **Figure 6-9** shows that, on June 10 there was a concentration spike of 4.0 mg/L and on June 22 a spike of 3.2 mg/L. These measurements were made during the period the Jones Tract levee breach was open and water flowed tidally in and out of the island, and may be attributable, at least in part, to contributions from Jones Tract. On July 1, a 3.8 mg/L TOC spike was observed at Banks just after the breach was closed. TOC at Banks declined until the pumpout began, and generally increased thereafter until year end.

Figure 6-9. TOC at Banks vs. Inflows

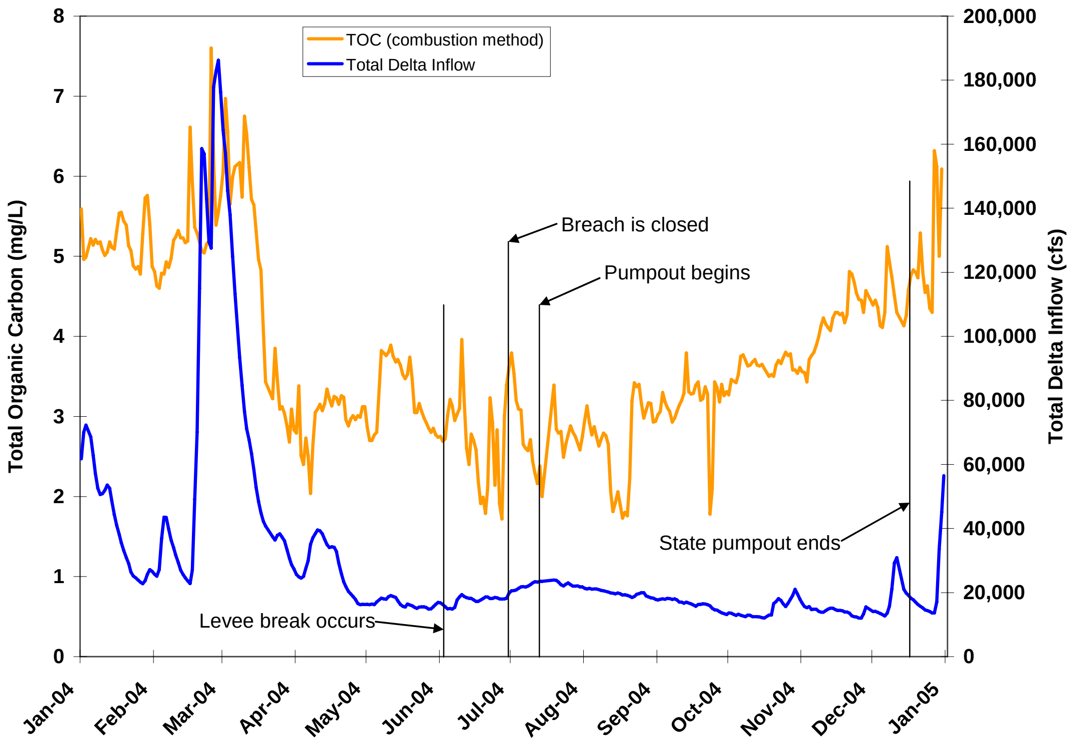
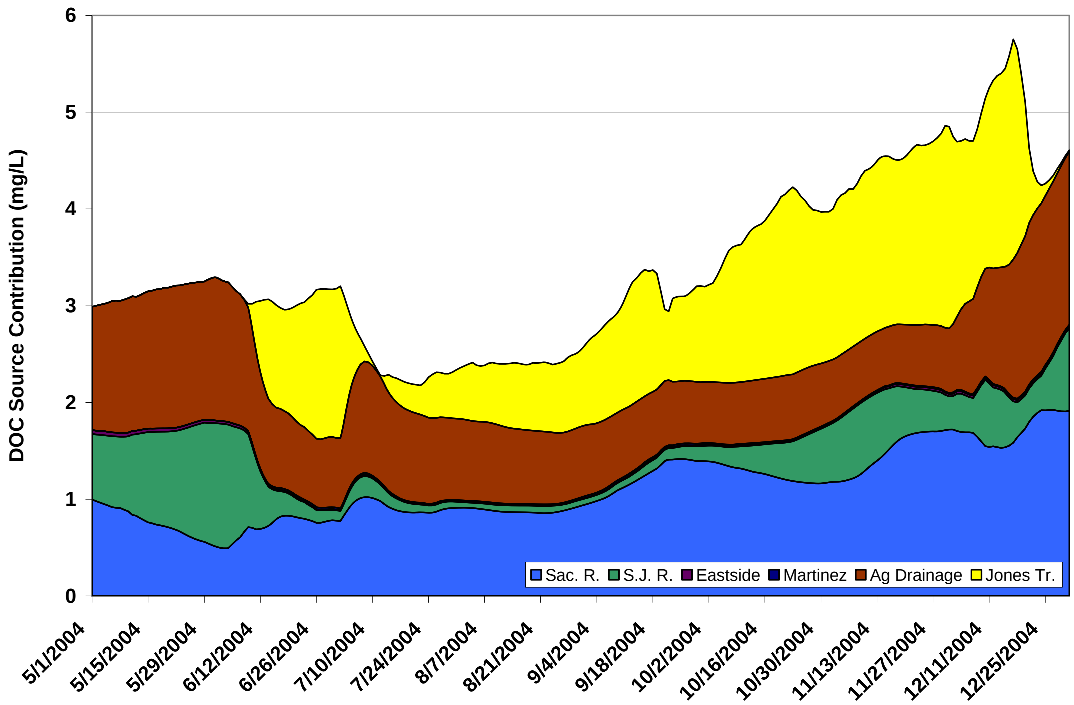


Figure 6-10 is a DSM2 fingerprint that estimates the impact of the Jones Tract levee failure on DOC concentrations at Clifton Court. The model results suggest that DOC concentrations at Clifton Court increased by 1 to 2 mg/L during the period that water was being pumped off of Jones Tract, and is generally consistent with the pattern of TOC concentrations shown in **Figure 6-9**. MWQI staff compared DOC concentrations observed at Banks following the levee break in 2004 to analyses of discrete samples collected between 1986 through 2003. These researchers estimated that, between July and December 2004, water from Jones Tract contributed 0.5 mg/l to 1.0 mg/l additional DOC at Banks (Personal Communication, Cindy Messer, DWR). Although it's not possible to clearly determine the impact of Jones Tract on DOC at the pumping plants, it appears from the modeling studies and comparison to historical data that Jones Tract resulted in at least a 0.5 mg/L increase in DOC and possibly an increase of as much as 2 mg/L at the pumping plants.

To provide some perspective for the amount of DOC that was pumped off of Jones Tract, DWR estimated that removing all agricultural drainage from the Delta would result in a decrease in DOC of about 1 mg/L at Banks (DWR, 2003). Fortunately, the TOC concentrations at Banks were in the 3 to 4 mg/L range during many of the months that water was pumped off of Jones Tract. As discussed in Chapter 2, the SWP Contractors are required to remove additional TOC from their influent water when TOC exceeds 4 mg/L based on the running annual average of quarterly average concentrations. TOC concentrations were between 4 and 6 mg/L during most of the fall of 2004. If the levee break had occurred during the wet season when TOC concentrations are higher in the Delta, an additional 0.5 to 1.0 mg/L of DOC from Jones Tract would have been more significant.

Figure 6-10. Modeled DOC Fingerprint in Clifton Court Forebay



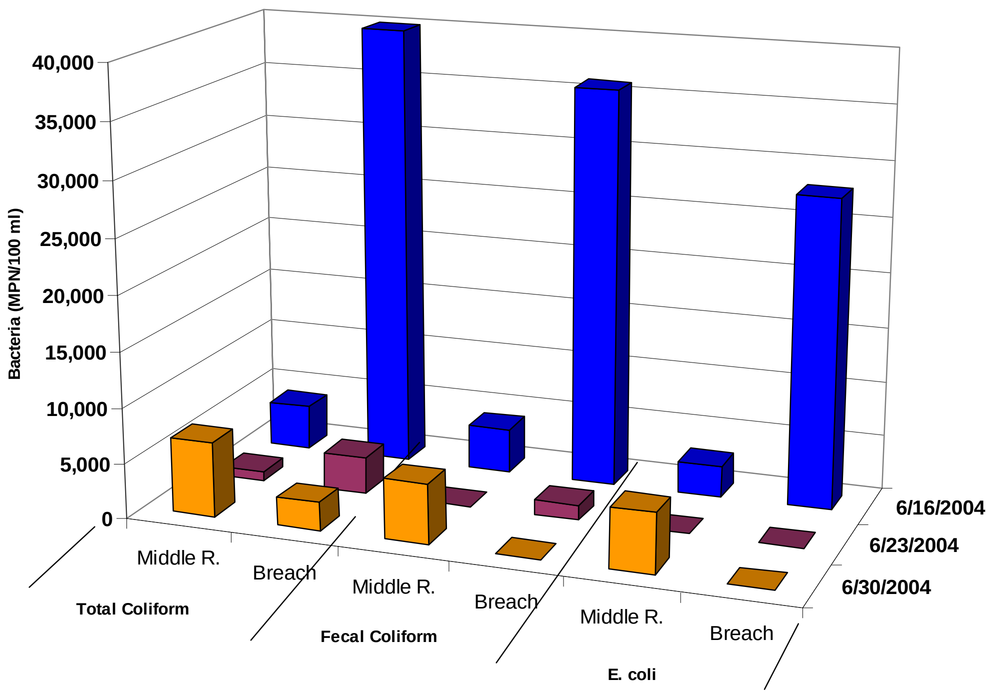
Algae and T&O Compounds

Samples were collected from Jones Tract and analyzed for methyl isoborneol (MIB) and geosmin. MIB reached 1000 ng/L in samples collected while water was being pumped off of the island. At that time, Jones Tract was contributing about 5 to 10 percent of the water at Banks and is thought to be responsible for the elevated MIB levels (70 ng/L) at Banks. The organism responsible for the MIB production on Jones Tract was a planktonic cyanobacterium, *Planktothrix perornata*. As a result of the levee break, this organism has been introduced into southern California reservoirs (Personal Communication, Rich Losee, MWDSC).

Bacteria

Samples were collected from Jones Tract and from Middle River near the levee breach on June 16, 23, and 30, 2004. Samples were analyzed for total coliform, fecal coliform, and *Escherichia coli* (*E. coli*). **Figure 6-11** indicates bacterial densities on the flooded island were high initially, and their influence appears to have been felt in Middle River. One week later, densities of all three types of organisms had decreased both in island and river water. By the third sampling the data suggest densities in the river were not due to Jones Tract, as river densities were higher than densities in Jones Tract water. By the end of the month, the breach had been closed. No data were available to determine the bacteriological effect of pumping the water from the flooded island to Middle River that began on July 12 and continued to late December.

Figure 6-11. Bacteriological Monitoring Results



Other Water Quality Constituents

Samples of water on Jones Tract were collected and analyzed for other water quality constituents, including petroleum hydrocarbons, pesticides, pathogens, nutrients, trace elements, and chlorophyll. The report being prepared by MWQI staff will contain a thorough discussion of the water quality conditions accompanying the levee break (Personal Communication, Cindy Messer, DWR).

ADEQUACY OF JONES TRACT EMERGENCY RESPONSE WITH RESPECT TO WATER QUALITY

As previously stated, the emergency response to the Jones Tract levee failure by DWR and other agencies resulted in attainment of DWR's objectives, which were to minimize physical damage to the levee system, repair the levee, and minimize sea water intrusion. Although there was disorganization and equipment malfunction often associated with emergency situations, life and property were protected and, as evidenced by the foregoing discussion, water quality impacts of the emergency were modest and short-lived. This may not have been the case had hydrologic and other conditions been less favorable. In view of the prospect for more serious future emergencies, the SWP Contractors and the California Department of Health Services (CDHS) are interested in determining if the response to this emergency was fully adequate to protect drinking water quality.

Although emergency management staff from DWR were brought onto the scene immediately after the levee failure, DWR water quality specialists were not involved until about two weeks after the failure, at which time they were charged with collecting samples of the waters impounded on Jones Tract. The data collected by DWR were analyzed to determine the water quality impacts at Banks from pumping water from Jones Tract into Middle River. Likewise, after some delay, DWR modeling staff was enlisted to run simulations predicting hydrologic and water quality consequences of the event. The reports resulting from these efforts provide a valuable retrospective on the emergency, and will guide future efforts to react to water quality conditions resulting from similar emergencies. However, the delay in commencing this work arguably may have deprived the incident management team of opportunities to take action to protect water quality during the incident.

The OES AAR acknowledged work by CDHS in directing the planning and implementation of a water quality monitoring plan, and identified salt water intrusion as a concern associated with the emergency. This report did not identify any need for improvements in the water quality response, nor did it contain any recommendations for improving the emergency response directed at water quality protection.

The DWR AAR acknowledges that DWR staff was responsible for collecting water quality samples. The report also contains a set of recommended actions to be taken in advance of a similar future emergency. One identified priority, directed to "Environmental Issues and Health/Safety" is:

> "*Be proactive and aware of the role/responsibility of DWR with respect to environmental/health/safety issues such as water quality and toxics. Be aware of other responding agencies roles and verify that necessary actions are being performed regardless of responsibility.*"

The DWR report is silent on whether, and to what extent, SWP Contractors were kept apprised and involved in managing the emergency. There is, consequently, no information in the report to indicate whether the SWP Contractors were given adequate notice of the potential for adverse water quality changes, or whether ongoing communications with drinking water suppliers were adequate. Evidence does exist to suggest there was a lack of water quality expertise in the management of the emergency, and that involvement of water quality specialists was delayed.

The contract for pumping out Jones Tract had no provisions for protection of water quality. In the latter months when the water on Jones Tract contained elevated concentrations of salts and organic carbon, it may have been useful to modify the pumping schedule to minimize the water quality impacts on drinking water suppliers, but that was not possible in the absence of a contractual clause permitting such an alteration.

Although the water quality consequences of the Jones Tract levee failure were evidently relatively mild, that may not have been the case had good fortune not accompanied the event. Providing adequate protection of the health of millions of Californians relies on strong protection of drinking water sources. An adequate level of protection will be attained only if water quality expertise is incorporated in emergency response decisions, and timely, effective, and ongoing communications occur between DWR and the SWP Contractors during emergencies. The low priority treatment of water quality concerns in the DWR AAR and the lack of provision for water quality expertise in the Jones Tract emergency management team suggest the need for a reappraisal of the role of water quality in DWR flood emergency management.

DWR EMERGENCY RESPONSE PLAN

The DWR Emergency Response Plan (ERP) is the master planning document for emergency response related to the SWP (DWR, 2004b). It does not, however, address Delta levee failures, which are handled by the Division of Flood Management under DWR's statutory authorization to inspect and evaluate the maintenance of all of the State's federally designated project levees and channels, and to engage in flood fighting in the event of levee failures. The ERP is discussed here, however, because it seems the most appropriate place for policies to appear related to protection of drinking water supplies conveyed through the SWP. Such policies appear nowhere else in DWR's emergency preparedness and response documents.

The ERP delegates responsibility for emergency response to DWR's five Field Divisions, under each Field Division's Emergency Action Plan (EAP). Each Field Division's EAP, in turn, details the procedures whereby emergencies are identified, resources mobilized, and response initiated within that Field Division. Envisioned emergencies include earthquakes, fires, bomb threats, explosions, flood emergencies, including dam and aqueduct failures, hazardous spills, civil disorder, general emergencies, and those unique to individual Field Divisions. DWR also has a master Business Recovery Plan (BRP), along with Recovery Action Plans (RAPs) for each Field Division. Among other things, the RAPs establish guidelines for decision making, and emergency notification during declared emergencies. The Field Division EAPs and RAPs are intended to be used together to meet emergency situations.

DWR's emergency planning documentation is vague on water quality issues, with the exception of hazardous spills. In the case of toxic, radiological, or pathogenic spills, each Field Division has specific procedures that must be followed, including notification of SWP drinking water Contractors as appropriate. The existing body of emergency planning documentation for the SWP does not:

- Specifically define DWR's responsibilities for protecting the drinking water source for two-thirds of California's population.
- Include Delta levee failures in the scope of its activities.
- Establish a priority for protection of drinking water quality.
- Establish mechanisms for assuring water quality expertise is brought to bear on emergencies that could affect SWP drinking water quality, particularly with regard to involvement in decision making.
- Require ongoing communications between DWR emergency management teams and SWP drinking water Contractors as emergency situations unfold.

ACTIONS TAKEN TO IMPROVE LEVEE SYSTEM INTEGRITY

CALFED Delta Levee Integrity Program

In its 2000 Record of Decision, the California Bay-Delta Program (CALFED) included actions to preserve and improve the integrity of Delta levees (CALFED, 2000). There are five components to the Levee System Integrity Program (Levee Program).

- Base Level Protection – Improve and maintain existing Delta levee system stability to meet the USACE Public Law 84-99 levee standard.
- Special Improvement Projects – Enhance flood protection for key islands that provide statewide benefits to the ecosystem, water supply, water quality, economics, and infrastructure.
- Levee Subsidence Control Plan – Develop best management practices to control and reverse subsidence and work with local districts and property owners to implement cost-effective measures.
- Emergency Management and Response Plan – Enhance the ability of local, State, and Federal agencies to rapidly respond to levee emergencies.
- Levee Risk Assessment – Perform a risk assessment to quantify the major risks to Delta resources from floods, seepage, subsidence, and earthquakes, evaluate the consequences, and develop recommendations to manage the risk.

The first major Levee Program action was development of a Memorandum of Understanding (MOU) between DWR and USACE in July 2001. The purpose of the MOU was to establish a framework for implementing the Levee Program. Progress on the Levee Program was obtained from the Levee System Integrity Program Multi-Year Program Plan (Years 6-9) (CALFED, 2005) and various other documents prepared for the Levee Program

Base Level Protection

The Levee Program has improved more than 43 miles of levees in the Delta. Significant projects were undertaken on Sherman, Bradford, and Jersey Islands and at Webb Tract. Levees have been maintained throughout the Delta with Levee Program funds. However, considering there is a total of some 1100 miles of levees in the Delta, only 165 miles of which are designated as Project Levees, there is substantial work remaining to be accomplished.

Special Improvement Projects

DWR has completed no projects to enhance flood protection for critical islands and is currently giving a high priority to funding projects that raise deficient levees on critical islands to more modest standards.

Subsidence

There is a loss of 35,000 cubic yards of peat soils each day in the Delta. Subsidence and the methods leading to its reversal are being studied by the U.S. Geological Survey (USGS) on Twitchell Island under grants from the Levee Program. These studies have shown that it is possible to stop subsidence by shallow flooding and that it is possible to begin reversing its effects by growing aquatic plants. Additional studies in-progress show promise for further increases in land surface elevation through dispersing silts and soils over the fallen aquatic plants.

Emergency Response

DWR staff is working with local agencies and Delta counties to make sure all agencies have Standardized Emergency Management System (SEMS) compatible emergency response plans. DWR provides funding and assistance to respond to emergencies, such as the Jones Tract levee failure.

Levee Risk Assessment

A preliminary risk analysis was conducted to estimate Delta water quality (salinity), export disruption, and economic consequences of multiple seismically initiated Delta levee failures (Jack R. Benjamin & Associates, Inc. et al, 2005). Under the conditions modeled in this study, Bay water would rush into the Delta and it would take almost one year for total dissolved solids (TDS) concentrations to return to 500 mg/L at the Delta pumping plants. Assumptions included in this analysis are that there would be no pumping from the Delta until the TDS concentrations reach 500 mg/L and all water that would have been pumped would be released from upstream reservoirs to flush the saline water out of the Delta.

Recognizing that an earthquake is only one of multiple threats facing the Delta, DWR, in conjunction with USACE, the Department of Fish and Game (DFG), and the California Bay-Delta Authority (CBDA), is currently conducting the Delta Risk Management Strategy (DRMS). DRMS is a multi-year, multi-million dollar assessment of major risks to the Delta from floods, climate change, subsidence, and earthquakes. DRMS will also evaluate the consequences and develop recommendations to manage the risk. A final report is due by January 2008. Phase 1 involves construction of a Risk Analysis Framework to evaluate the economic and environmental consequences of levee breaks. Phase 2 involves detailed evaluation of risk reduction strategies. This study will help establish priorities for near-term and long-term actions that will reduce the risk associated with levee failures in the Delta.

In September 2006 DWR released a series of Initial Technical Framework (ITF) documents that describe the methodologies that will be used to evaluate each element of the DRMS. The Hydrodynamics/Water Quality ITF describes the modeling framework that will be used to assess salinity impacts and the screening level analysis that will be used for other constituents such as TOC and DOC (URS et al, 2006). The approach to be used to estimate TOC and DOC impacts is presented in the following paragraph:

> *"Simplified simulations of TOC/DOC may be performed for a limited number of scenarios. These simulations would consider TOC/DOC as a conservative tracer and treat islands as sources of TOC/DOC. These assumptions are not realistic because TOC/DOC is not conservative and the islands will not be constant sources. Furthermore, the source rates from the islands are uncertain. The purpose of these screening level simulations is to evaluate whether TOC/DOC is an issue that merits more detailed analysis. For example if predicted TOC/DOC exceeds standards while predicted salinity is low enough for export for a number of likely scenarios, this issue should be analyzed in more detail in future studies."*

The ITF includes provision for technical review and guidance through a Hydrodynamic/Water Quality Modeling Review Team that is to be established. This team will include knowledgeable independent experts who will be asked to consider such issues as whether the approach addresses the most important water quality issues, whether the conceptual basis for the work is scientifically sound, and whether important uncertainties are adequately addressed.

Funding for Delta Levee Improvements

Significant state funding has recently been made available for repairs and improvements to levees, some of which can be spent for Delta levees. The Legislature appropriated $500 million from the General Fund in July 2006 for levees on the Sacramento River system and the voters approved bonds for a broader spectrum of levees in November 2006. The Governor, as part of his 2007-08 budget proposal, intends to revert $200 million of the original $500 million appropriation to the General Fund now that bond funding is available. Proposition 84 provides $275 million specifically for Delta flood control projects, including improved emergency response, levee maintenance, and levee improvements. Additional funding in Proposition 84 ($315 million) and Proposition 1E ($3 billion) is allocated for Central Valley flood control. Some of these funds could be spent on Delta projects.

POTENTIAL ACTIONS

Reassess Water Quality Impacts of Jones Tract Levee Failure

DWR estimated the volume of water impounded and subsequently pumped off of Jones Tract using historical information on the size and elevation of the island. DWR is currently planning to conduct a topographic survey of the Delta. Data from the topographic survey of Jones Tract should be used to refine the estimates of the volume of water that was impounded on Jones Tract after the levee was repaired. If the revised estimate is substantially different than the current estimate of 140,000 acre-feet, DWR should reevaluate the water quality impacts.

Encourage DWR to Establish a Policy on Protecting Source Water Quality

As part of its emergency planning documentation, DWR should acknowledge that, as supplier of the source water for about two-thirds of California's population, it has significant responsibility for assuring the waters of the SWP are suitable for production of drinking water. Events that cause rapid changes in the quality of SWP waters threaten the ability of drinking water treatment plants to reliably produce safe drinking water. Accordingly, the SWC should encourage DWR to establish a policy that drinking water source protection is a priority second only to protection of life and the physical integrity of the Delta and SWP. This policy should be embodied in DWR's ERP and BRP, and into the EAPs and RAPs of the individual Field Divisions, as well as into the guidance documents of the DWR Division of Flood Management. Implementation of this policy will require development of adequate real-time water quality monitoring and forecasting infrastructure. Implementation of the policy will also necessitate incorporation of water quality expertise in operational decision making during incidents, such as levee failures, having the capacity to affect source water quality protection.

Broaden Scope of Levee Risk Assessments

Until the present, water quality risk analysis has focused only on salinity, whereas the water quality concerns of drinking water purveyors go considerably beyond salinity, and certainly include bromide, organic carbon, pathogens, nutrients that cause taste and odor (T&O) incidents, and toxic substances. Broadening risk assessments to include these water quality constituents would greatly improve the ability of decision makers to protect the health of consumers receiving drinking water supplies taken from the Delta.

Request DWR Include Water Quality Staff in Emergency Response Teams

In concert with its identified water quality responsibilities, DWR should make a determination that all flood emergencies have the potential of causing failures in drinking water production facilities and endangering the public. Consistent with this finding, the SWC should request that DWR routinely include water quality staff participation in emergency response management teams, and that participation should begin with the initial reporting of an incident. Water quality participants should be at a decision-making organizational level, such as the Chief of the Office of Water Quality.

The water quality expert(s) appointed to serve as members of the emergency response management team should act as liaison to the SWP Contractors, and should be responsible for providing advance warning of impending quality changes, ongoing communications as emergency response progresses, and a communications link between the SWP Contractors and the emergency management team. The water quality expert(s) appointed to serve as members of the emergency response management team should also assume responsibility for liaison and communications with CDHS, the State Water Resources Control Board (State Water Board) and Regional Water Quality Control Boards (Regional Water Boards), the U.S. Environmental Protection Agency (USEPA) and other entities having a drinking water quality role.

Request DWR Revise Emergency Planning and Response Documents to Better Address Water Quality Concerns

DWR should revise its emergency planning and response documentation to include specific provisions for addressing foreseeable water quality emergencies. DWR water quality managers should be involved in this development, and SWC representatives should be invited to participate, at least with regard to establishing communications protocols. Even though levee failures would continue to be managed by DWR's Division of Flood Management, policies set forth in the EAP and subsidiary documents relating to drinking water quality protection would be applicable to Delta levee emergencies.

Revision of DWR's emergency planning and response and flood management policy documents should include provisions such as a requirement for all proposed contracts to be reviewed by water quality experts to identify any need for contractual clauses to protect water quality, and a requirement for immediate creation and implementation of a water quality monitoring plan, as appropriate to the emergency at hand.

Participate in DRMS Project

The DRMS Project water quality focus is primarily on salinity, with less emphasis being placed on other water quality constituents. The SWC should meet with the DWR Project Manager to request that DWR water quality staff, the CALFED Water Quality Program Manager, and water quality staff from SWP Contractors are involved in establishing CALFED policies for protecting the quality of drinking water supplies associated with failures of Delta levees. Specifically, water quality staff should participate on the Hydrodynamic/Water Quality Modeling Review Team with a primary focus of assisting in developing linkage between water quality assessments and emergency management actions. SWP Contractors should review the draft report and provide any comments needed to ensure that other water quality constituents are adequately addressed.

WASTEWATER SPILLS IN THE DELTA WATERSHED

Spills of raw or partially treated wastewater occur from collection systems and from wastewater treatment plants. A sanitary sewer overflow (SSO) is any overflow, spill, release, discharge, or diversion of untreated or partially treated wastewater from a sanitary sewer system. Major causes of SSOs include grease, root, and debris blockages; sewer line flood damage; manhole structure failures; vandalism; pump station mechanical failures; power outages; excessive storm or groundwater inflow/infiltration; improper construction; lack of proper operation and maintenance; insufficient capacity; and contractor-caused damage. Spills of raw or partially treated wastewater occur due to equipment malfunctions or operator errors at wastewater treatment plants. Spills also occur during storm events when stormwater infiltrates a wastewater collection system and the capacity of the wastewater treatment plant is exceeded.

OCCURRENCE IN THE WATERSHED

Due to staffing constraints, the Central Valley Regional Water Board does not have a database that tracks historic spills from wastewater treatment plants and SSOs (Personal Communication, Patricia Leary, Central Valley Regional Water Board). Information was obtained on spills that had been included in the Executive Officer's Reports prepared for each meeting of the Central Valley Regional Water Board. Although these reports do not contain a list of all spills in the region, the larger spills and spills from agencies that have a history of multiple spills are generally discussed in the reports. Executive Officer's Reports were available from September 2001 through January 2007 on the Central Valley Regional Water Board's website. **Table 6-1** contains a summary of spills exceeding 10,000 gallons that occurred downstream of the major reservoirs and reached surface waters. Spills occurring upstream of reservoirs such as Shasta, Oroville, and Folsom in the Sacramento Basin and New Melones, New Don Pedro, and Millerton in the San Joaquin Basin would not impact Delta water quality due to the dilution of the spill in the reservoir. During the last two weeks of December 2005 there was heavy rainfall throughout the Sacramento and San Joaquin watersheds. Rainfall totals for the two weeks ranged from 4.8 inches at Friant Dam to 22.75 inches at Shasta Dam. The heaviest rains fell on December 30 and 31 (New Year's Storm). During that time there were multiple spills of raw and partially treated wastewater in the watershed. **Table 6-2** lists the spills downstream of the major reservoirs that occurred during the New Year's Storm.

Table 6-1 indicates that there have been a number of spills in the Sacramento and San Joaquin watersheds. Although some spills occur as a result of storm events that overload the system, a number of spills have occurred during dry weather conditions. The spills of raw wastewater from the cities of Stockton, Lathrop, and Isleton and Sacramento County Sanitation District 1 (CSD-1) into Delta waterways are of most concern due to the proximity to drinking water intakes.

Table 6-1. Wastewater Spills in the SWP Watershed, 2001-2006

Discharger	Spill Date	Type of Spill	Volume (gallons)	Receiving Water
Spills in the Delta				
City of Stockton	11/26/01	Raw wastewater	10,080	Deep Water Ship Channel, San Joaquin R.
	04/03/05	Raw wastewater	12,000	Quail Lake
	1/13/06	Raw wastewater	9,750	Calaveras R.
	1/25/06	Raw wastewater	22,000	Walker Slough
	1/28/06	Raw wastewater	13,800	McLeod Lake
	06/16/06	Undisinfected secondary effluent	8,750,000	San Joaquin R.
	8/23/06	Raw wastewater	45,000	Smith Canal, San Joaquin R.
City of Lathrop	06/11/04	Raw wastewater	300,000 to 400,000	South San Joaquin Irrigation Canal, San Joaquin R.
	4/17-19/02	Raw wastewater	100,000	South San Joaquin Irrigation Canal, San Joaquin R.
Sacramento County Sanitation District -1	09/20/06	Raw wastewater	200,000	Sacramento R.
City of Isleton	01/07/02	Raw wastewater	60,000	Georgiana Slough
City of Manteca	10/06/03	Undisinfected tertiary effluent	10,000	South San Joaquin Irrigation Canal, San Joaquin R.
	10/13/03	Undisinfected tertiary effluent	10,000	South San Joaquin Irrigation Canal, San Joaquin R.
City of Vacaville	04/03/06	Partially treated industrial wastewater	231,000 to 730,480	Gibson Canyon Creek
Spills in the Sacramento River Basin				
Sacramento County Sanitation District -1	05/27/01	Raw wastewater	200,000	Cherry Cr.
	07/14/02	Raw wastewater	446,000	San Juan Cr.
	11/20/02	Raw wastewater	36,000, possibly significantly more	Chicago Creek, American R.
	12/08/02	Raw wastewater	9,000	Minnesota Cr., American R.
	08/21/03	Raw wastewater	40,000 to 54,000	Chicken Ranch Slough, American R.
	03/11/04	Raw wastewater	28,000	Arcade Cr., Sacramento R.
	09/15/06	Raw wastewater	39,000	Arcade Cr., Sacramento R.
City of Auburn	04/05/06	Blend of tertiary and disinfected, filtered primary effluent	6,000,000	Auburn Ravine
Grass Valley	9/18-19/03	Undisinfected tertiary effluent	650,000 to 750,000	Wolf Cr., Bear R.
City of Winters	12/03/06	Raw wastewater	26,000 to 45,000	Putah Cr., Yolo Bypass
Shasta County Service Area - 8	01/01-31/03	Raw wastewater	15,000	Cow Cr., Sacramento R.
Folsom Prison	09/24/02	Raw wastewater	5,000 to 10,000	Lake Natoma, American R.

Table 6-1. Wastewater Spills in the SWP Watershed, 2001-2006, Continued

Discharger	Spill Date	Type of Spill	Volume (gallons)	Receiving Water
Spills in the San Joaquin Basin				
Town of Livingston	07/24/01	Undisinfected secondary effluent	2,400,000	Merced R.
City of Modesto	10/13/04	Raw wastewater	1,200,000	Dry Cr., Tuolumne R.
California Department of Corrections, Sierra Conservation WWTP	05/17/05	Undisinfected secondary effluent	274,000	Shotgun Cr.
Jamestown Sanitary District	04/04/06	Raw wastewater	23,400	Woods Cr.
City of Fresno	12/15/04	Raw wastewater	15,000	San Joaquin R.

City of Stockton

The City of Stockton has had a number of large spills, including an 8.75 million gallon spill of undisinfected secondary wastewater on June 16, 2006. OMI Thames Water, the contract operator of the collection system and the Stockton Regional Wastewater Control Facility, bypassed a portion of the wastewater around the tertiary treatment units and the disinfection system due to operational errors. For about 10 hours the undisinfected secondary effluent was discharged to the San Joaquin River along with fully treated effluent. This spill occurred during dry weather conditions when flow in the San Joaquin River at Vernalis was quite high (16,525 cfs). This spill was notable because OMI Thames Water reported to OES that drinking water was not impacted. CDHS and downstream water agencies were made aware of the spill from newspaper reports. In September 2006, the CDHS District Engineer for Stockton requested information on the spills of raw and partially treated wastewater for the past five years. OMI Thames Water responded by providing information for January 1, 2001 through September 22, 2006. OMI Thames Water reported 57 collection system spills ranging in volume from 1 to 45,000 gallons that have reached Delta waterways. The only spill from the wastewater treatment plant was the June 2006 spill.

After the June 2006 spill, California Urban Water Agencies (CUWA) expressed concern to the Central Valley Regional Water Board over the lack of notification to downstream water agencies. The Central Valley Regional Water Board staff asked Stockton to include water agencies on the list of agencies to be notified in the event of a spill. CUWA, Contra Costa Water District (CCWD), and Alameda County Water District are now notified via telephone call or fax when spills occur in Stockton. CUWA notifies all of its members, including a number of SWP Contractors.

Table 6-2. 2005-2006 New Year's Storm Wastewater Spills

Discharger	Volume (gallons)	Description
Raw Wastewater		
Sacramento Regional County Sanitation District	10,077,000	Raw wastewater discharged to American River.
	560,000	Raw wastewater discharged to Morrison Cr.
City of Roseville	3,800,000	Raw wastewater discharged to Dry Cr.
City of Grass Valley	1,000,000	Raw wastewater discharged to Wolf Cr. when primary clarifiers overflowed.
City of Redding	699,390	Raw wastewater spilled from collection system.
Sacramento County Sanitation District 1	250,000	Raw wastewater discharged from manhole to unnamed creek.
City of Auburn	70,800	Raw wastewater discharged from collection system to Auburn Ravine.
Nevada County Sanitation District	3,000	Raw wastewater discharged into Little Deer Cr. from collection system.
Placer County Sewer Maintenance District 1	Unknown	Raw wastewater discharged from manholes.
City of Galt	Unknown	Raw wastewater discharged to storm drain when pump station failed.
City of Jackson	Unknown	Raw wastewater discharged to Jackson Cr. from collection system.
Partially Treated Wastewater		
Sacramento Regional County Sanitation District	~590,000,000	Influent flows to SRWTP reached 550 mgd, which exceed peak wet weather capacity by almost 200 mgd. A blend of fully and partially treated effluent was discharged to the Sacramento R. for over 36 hours.
City of Redding	60,000,000 to 100,000,000	Blended raw wastewater and primary effluent discharged to the Sacramento R for three to seven days.
City of Auburn	14,930,000	Blend of tertiary and filtered, disinfected primary effluent discharged to Auburn Ravine
Nevada County Sanitation District	258,000	Blend of filtered and unfiltered secondary effluent discharged to Gas Canyon Cr.
Nevada County Sanitation District	120,000	Bypassed filtration and discharged secondary effluent to Deer Cr.
Placer County Sewer Maintenance District 1	13,500	Blend of primary and secondary wastewater discharged to Rock Cr.
City of Nevada City	Unknown	Blended secondary and tertiary wastewater discharged.
Placer County Sewer Maintenance District 3	Unknown	Bypassed filtration and discharged secondary effluent to Miners Ravine.
Blended Wastewater and Stormwater		
City of Marysville	11,000,000	Treated wastewater ponds, located in Feather R. floodplain, were inundated with river water.
City of Wheatland	72,000	Wastewater infiltration beds inundated by Bear R.
Yuba City	Unknown	Treated wastewater ponds, located in Feather R. floodplain, were inundated with river water. Ponds were reported to be empty when storm began.
Linda County Water District	Unknown	Treated wastewater ponds, located in Feather R. floodplain were inundated.
Placer County Sewer Maintenance District 3	Unknown	Sludge drying beds flooded and overflowed into Miners Ravine.

City of Lathrop

The City of Lathrop reported that a corroded air release valve on the City's force main that carries raw wastewater to the Manteca Wastewater Control Facility broke off and resulted in a spill of about 100,000 gallons into the South San Joaquin Irrigation District Canal. The City estimates that the spill started on April 17, 2002. The spill was discovered on April 19, 2002 and remedial measures were taken; however, most of the spill was released to the Delta. San Joaquin River flow at Vernalis was 2,990 cfs when this spill occurred.

On June 11, 2004, the City's force main burst and spilled 300,000 to 400,000 gallons of raw wastewater into the South San Joaquin Irrigation District Canal. An unknown amount of the wastewater flowed into French Camp Slough in the Delta. The flow in the San Joaquin River at Vernalis was only 1,110 cfs when this spill occurred. The Executive Officer's Report for September 2004 reported that this was the fourth significant spill from Lathrop's force main in four years, these spills could have been avoided with improved operations and maintenance, and Lathrop's spill response plan was inadequate. Information was not available on the other spills.

Sacramento CSD-1

Sacramento Regional County Sanitation District (SRCSD) provides wastewater treatment at the Sacramento Regional Wastewater Treatment Plant (SRWTP) for the urbanized portion of Sacramento County. Sacramento CSD-1 operates the collection system for most unincorporated areas of Sacramento County, the cities of Citrus Heights, Elk Grove, and Rancho Cordova, one third of the City of Sacramento, and a small portion of the City of Folsom. Sacramento CSD-1 also operates two small wastewater treatment plants in rural areas of Sacramento County.

Sacramento CSD-1 has had a number of spills to creeks that drain to the American River and a major spill in the Sacramento River in the Delta. On September 20, 2006 Sacramento CSD-1 reported that the force main crossing under the Sacramento River in Walnut Grove was broken and spilled 200,000 gallons of raw wastewater to the Sacramento River. Sacramento CSD-1 responded to the spill by turning off the lift station upstream of the break and hauling wastewater from the line to the Walnut Grove Wastewater Treatment Facility until the force main was repaired. The cause of the force main break is unknown but it was noted in the report to the Central Valley Regional Water Board that barges had been in the river. This spill occurred during dry weather conditions when flow in the Sacramento River was 20,500 cfs.

City of Isleton

On January 7, 2002 the City of Isleton discovered that their force main was broken and raw wastewater was entering a ditch that flows to a lift station, where it was pumped into Georgiana Slough. The total amount of the spill was estimated to be 90,000 gallons. The City estimated that they were able to recover 30,000 gallons. This spill occurred when flow in the Sacramento River at Freeport was 64,500 cfs.

New Year's Storm Spills

On December 30 and 31, 2005 record amounts of rainfall fell in the Sacramento and San Joaquin watersheds. Numerous dischargers reported problems with collections systems and overloaded wastewater treatment plants. **Table 6-2** lists the major spills in the Sacramento and San Joaquin valleys downstream of the large dams on the rivers. There were spills of raw wastewater, partially treated wastewater, and instances of rivers overflowing and inundating wastewater ponds. When these spills occurred the flow in the Sacramento River was about 92,000 cfs and the flow in the San Joaquin River was 12,000 cfs. In addition, an estimated 250,000 cfs was flowing through the Yolo Bypass, indicating that spills upstream of the Sacramento urban area were likely routed down the bypass. More detail is provided on a few of the larger spills near the Delta.

Sacramento

On December 30 and 31, 2005 over three inches of rain fell in the Sacramento region in a 24 hour period. As a result of this storm, the SRCSD had five SSOs reported within its system of large diameter interceptors that carry wastewater to the SRWTP (SRCSD, 2006). Two of these spills reached surface waters. Over ten million gallons of raw wastewater overflowed from the outlet of a triple-barrel siphon structure, entered the storm drain system, and was subsequently pumped into the American River. Approximately 560,000 gallons of raw wastewater was spilled from a pipeline construction site when a plug was dislodged due to surcharging of the system downstream of the construction site. The spill reached Morrison Creek, which flows into the Delta.

SRCSD also experienced problems at the SRWTP when an interceptor construction site was flooded by an adjacent creek and contributed significant flows to the plant starting on December 31, 2005. The SRWTP is permitted to treat up to 392 million gallons per day (mgd) of wet-weather flow. During this storm, influent flows peaked at 550 mgd. Initially the flows in excess of the plant capacity were diverted to onsite emergency storage basins where some settling of solids was achieved. By early in the morning of January 2, the emergency storage basins were full so SRCSD started releasing water from the basins, blending it with treated water, and discharging it to the river. The blended wastewater was discharged to the Sacramento River until the evening of January 3 when SRCSD was able to correct the problem at the construction site. The estimated volume of approximately 590 million gallons discharged was calculated by multiplying the peak wet weather flow of 392 mgd by 1.5 days of discharging in excess of this amount. At the time that SRWTP was discharging partially treated wastewater, the City of Sacramento was discharging combined wastewater and stormwater that had received only partial treatment. The City's discharge was due in part to the need to limit flows to the SRWTP due to the inflow from the construction site.

Marysville/Yuba City Area

The cities of Marysville and Yuba City and the Linda County Water District currently discharge their secondary treated wastewater to infiltration ponds that are in the floodplain of the Feather River. The City of Wheatland discharges its treated wastewater to ponds that are in the floodplain of the Bear River, a tributary to the Feather River. During the New Year's Storm the rivers flooded the ponds and treated wastewater that is normally not discharged to the rivers entered the rivers. Some of this wastewater was likely diverted into the Yolo Bypass at the Sacramento Weir.

WATER QUALITY IMPACTS

The impacts of a wastewater spill on water quality at the Delta pumping plants depends upon the location and volume of the spill, the type of spill (raw wastewater or partially treated wastewater), and the hydrologic conditions in the rivers and Delta at the time of the spill. **Table 6-3** presents information on the quality of untreated wastewater taken from a textbook (Metcalf & Eddy, Inc., 1992). Untreated wastewater contains high concentrations of organic carbon, nutrients, and pathogenic organisms and it may contain any number of pharmaceuticals and endocrine disrupting compounds. Additional data from the 10 million gallon spill into the American River during the New Year's Storm are presented in **Table 6-4**. SRCSD described this spill as diluted wastewater due to the amount of stormwater that had infiltrated the wastewater collection system during the storm event (SRCSD, 2006). This diluted wastewater contained 13,000,000 MPN/100 ml of total coliforms and 3,000,000 MPN/100 ml of fecal coliforms and resulted in increases of two to three orders of magnitude in the American River. Samples were not analyzed for *Giardia* and *Cryptosporidium*.

Table 6-3. Water Quality Characteristics of Untreated Wastewater

Constituent	Concentration Range
Total suspended solids (mg/L)	100 - 350
Biochemical oxygen demand (mg/L)	110 - 400
Total dissolved solids (mg/L)	250 - 850
Total organic carbon (mg/L)	80 - 290
Total nitrogen (mg/L as N)	20 - 85
Total phosphorus (mg/L as P)	4 - 15
Total coliform (MPN/100 ml)	10^6 - 10^9
Fecal coliform (MPN/100 ml)	10^5 - 10^6
Giardia cysts (cysts/L)	100 – 100,000
Cryptosporidium (oocysts/L)	100 – 10,000
Enteric viruses (No./L)	10,000 - 100,000

Source: Metcalf & Eddy, Inc. 1992. Wastewater Engineering Treatment, Disposal, and Reuse. Third Edition.

Table 6-4. Total and Fecal Coliform Densities During Spill to American River

Monitoring Location	Total Coliform (MPN/100 ml)	Fecal Coliform (MPN/100 ml)
Spill Site	13,000,000	3,000,000
Outfall to American R.	8,000,000	5,000,000
American R. Upstream	2,200	800
American R. Entry Point	13,000,000	3,000,000
American R. Downstream	700,000	500,000

Source: SRCSD, 2006. Interceptor SSO Report – 12/31/2005 Events.

CCWD has set up a procedure to model the impacts of spills from the Stockton and Sacramento areas at their intakes and at Clifton Court Forebay. CCWD has run a DSM2 historical simulation that covers a variety of hydrologic and operational conditions. When a spill occurs, CCWD staff obtains river flows, export volumes, barrier conditions, the position of the Delta Cross Channel, and other factors affecting Delta operations, as well as information on the location, volume, and duration of the spill. The model then uses a day from the historical simulation that is most similar to the conditions occurring during the storm event. The model predicts the percent of wastewater mixed with Delta water showing up at the intakes over a number of days. CCWD also runs the model each week based on forecasted hydrologic conditions. The weekly model runs are used by CCWD staff to determine what size spill would warrant water quality monitoring or other actions at their treatment plants.

REGULATORY SETTING AND NOTIFICATION REQUIREMENTS

Regulatory Setting

National Pollutant Discharge Elimination System (NPDES) Permits issued by the Central Valley Regional Water Board for wastewater treatment plant discharges contain standard provisions that prohibit the discharge of wastewater that has not been treated to the level required by the permit. The standard provisions also require that the discharger provide safeguards, such as alternate power supplies and emergency storage basins, to prevent discharges of untreated or partially treated wastewater in the event of an electrical power failure. Upon request of the Central Valley Regional Water Board, a discharger must file a report on the measures in place to prevent and cleanup spills.

To provide a consistent, statewide regulatory approach to address SSOs, the State Water Board adopted Statewide General Waste Discharge Requirements (WDRs) for Sanitary Sewer Systems, Water Quality Order No. 2006-03 (Sanitary Sewer Order) on May 2, 2006. The Sanitary Sewer Order requires public agencies that own or operate sanitary sewer systems to develop and implement sewer system management plans (SSMPs) and report all SSOs to the State Water Board's online SSO database. Key deadlines in the Sanitary Sewer Order are listed in **Table 6-5.**

Table 6-5. Sanitary Sewer Order Requirements

Requirement	Explanation	Deadline
Submit Notice of Intent	Application for coverage under the Sanitary Sewer Order.	11/2/06
Report SSOs in SSO Database	SSOs must be entered into the State Water Board's online database: http://ciwqs.waterboards.ca.gov	9/2/07 for Central Valley Region
Emergency Response Program	Plan that includes measures to contain a spill, notification procedures, and monitoring to determine nature and impact of discharge.	5/2/08 – 8/2/09 depending on population served
Final SSMP	SSMP incorporating all requirements in the Sanitary Sewer Order.	5/2/09 – 4/2/11 depending on population served

The Sanitary Sewer Order requires the owners and operators of sanitary sewer systems to take all feasible steps to eliminate SSOs and to develop and implement a system-specific SSMP. SSMPs must include provisions to provide proper operation and maintenance while considering risk management and cost. The SSMP must contain a spill response plan that establishes standard procedures for immediate response to an SSO in a manner designed to minimize water quality impacts and potential nuisance conditions. The SSMPs must be updated every five years.

Notification Requirements

When a spill of untreated or partially treated wastewater occurs, the owner or operator of the collection system or wastewater treatment plant is required to provide notice of the spill to the Central Valley Regional Water Board, the local health officer, and OES when certain criteria are met. The Sanitary Sewer Order and NPDES permits contain the most stringent reporting requirements. Wastewater spills greater than 1,000 gallons, all wastewater spills that enter waters of the state (surface and groundwater), and spills that occur where public contact is likely, regardless of the volume, must be reported to the Central Valley Regional Water Board by telephone as soon as notification is possible and will not substantially impede cleanup or other emergency measures. The notification must occur within 24 hours of detection of the spill. In addition to oral notification, a written report must be submitted to the Central Valley Regional Water Board within five days of the spill.

A key requirement of the Sanitary Sewer Order is that SSOs must be entered into the State Water Board's SSO online database. The Los Angeles, Santa Ana, and San Diego regions were required to start reporting on January 2, 2007; the North Coast, San Francisco Bay, and Central Coast regions must start reporting by May 2, 2007; and the Central Valley, Lahontan, and Colorado River Basin regions must start reporting by September 2, 2007. Wastewater spills greater than 1,000 gallons, all wastewater spills that enter waters of the state, and spills that occur where public contact is likely, regardless of the volume are classified as Category 1 SSOs. Category 1 SSOs must be reported to the SSO database as soon as possible but no later than three business days after the SSO is detected. The Sanitary Sewer Order contains other requirements for reporting of SSOs that do not reach surface waters and for monthly reporting if no SSOs occurred.

Health and Safety Code section 5411.5 requires that the local health officer be notified immediately if any untreated or partially treated waste is discharged to waters of the State or discharged in a manner where it may reach waters of the State. There is no minimum amount of wastewater stipulated. California Water Code section 13271 requires notification of OES if a spill greater than 1000 gallons is discharged to waters of the State or discharged in a manner where it may reach waters of the State. OES is then required to notify the appropriate Central Valley Regional Water Board, the local health officer, and the administrator of environmental health. The Central Valley Regional Water Board determines whether the State Water Board should also be notified. The local health officer and the administrator of environmental health determine if public notification is needed.

ACTIONS TAKEN SINCE 2001 SANITARY SURVEY

Notification of Water Agencies

As discussed previously, CUWA requested that the Central Valley Regional Water Board include a provision in NPDES permits requiring that downstream drinking water suppliers be notified of spills at wastewater treatment plants. Central Valley Regional Water Board staff are now requiring dischargers to notify water suppliers who request to be notified when spills occur in the Delta.

Sewage Spills Work Group

A Sewage Spills Work Group consisting of CUWA members and staff from DWR and CDHS has recently been formed. SWP Contractors who are not members of CUWA were invited to join the Work Group. The Work Group will initially focus on developing criteria for when water agencies should be notified of spills, a process for notification, and a plan to respond to spills when notification is received by the water agencies. The Work Group will be considering long-term actions to work with the wastewater industry and regulatory agencies to reduce the frequency and magnitude of spills in the Delta.

POTENTIAL ACTIONS

SWP Contractors Should Participate in Sewage Spills Work Group

Several SWP Contractors who are CUWA members are participating in the Sewage Spills Work Group. All SWP Contractors that provide drinking water have been invited to join the Work Group. When this Work Group develops recommendations for notification and response measures and long-term actions, the SWP Contractors should consider these recommendations and determine if it is appropriate to include them in the Action Plan. At that time the SWP Contractors can determine how they can best support the efforts of the Work Group to implement their recommendations.

WASTEWATER SPILLS IN SILVERWOOD LAKE

Wastewater generated in the small communities in the Silverwood Lake watershed and in the State Recreation Area (SRA) near the lake shore is treated and transported out of the watershed so there are no permitted discharges to the lake or its tributary streams. During 2005 there were three wastewater spills into Silverwood Lake which will be discussed in chronological order.

Silverwood Lake, approximately 30 highway miles north of the city of San Bernardino, is the first reservoir on the East Branch of the California Aqueduct and is located in the San Bernardino National Forest. Water from the SWP flows into the lake through the Mojave Siphon Power plant and flows out of the lake and into the San Bernardino Tunnel, which leads to the Devil Canyon Powerplant. The reservoir has a storage capacity of about 74,970 acre-feet, and provides regulatory and emergency storage, recreation, wildlife habitat, and insures a continuous flow through the Devil Canyon Powerplant.

The SWP Contractors who may be impacted by a wastewater spill in Silverwood Lake are listed in **Table 6-6**, as these contractors request deliveries from either Silverwood Lake or downstream.

Table 6-6. State Water Contractors Requesting Delivery from Silverwood Lake or Downstream

State Water Contractor	Turnout Location (Milepost)
Mojave Water Agency	401.10
Crestline Lake Arrowhead Water Agency	407.65 (Silverwood Lake)
Metropolitan Water District of Southern California (MWDSC)	412.88 (Devil Canyon Afterbay)
Desert Water Agency	412.88 (Devil Canyon Afterbay)
San Gabriel Valley Municipal Water District	412.88 (Devil Canyon Afterbay)
Coachella Valley Water District	412.88 (Devil Canyon Afterbay)
San Bernardino Valley Municipal Water District	412.88 (Devil Canyon Afterbay)
San Gorgonio Pass Water Agency	412.88 (Devil Canyon Afterbay)
MWDSC	440.05 (Santa Ana Valley Pipeline)
MWDSC	443.44 (Lake Perris)

SECONDARY EFFLUENT SPILL, JANUARY 9 and 10, 2005

Description of Event

The Crestline Sanitation District's (CSD) effluent outfall line transports chlorine-disinfected secondary treated wastewater effluent from all three of CSD's wastewater treatment plants (Cleghorn, Seely, and Houston WWTPs) to the Los Flores Ranch, located just outside the Silverwood watershed. Portions of the effluent outfall line are located near the shoreline of the lake. The effluent outfall system terminates at a receiving channel and flood-irrigates a pasture area in Los Flores Ranch.

On January 9 and January 10, 2005 the CSD effluent outfall line was damaged in two locations due to extremely heavy rain and the high water level in the lake. The Silverwood area received approximately 24 inches of rain during the five day period from January 6 to January 11, 2005. The first pipeline break was detected when a low flow alarm was received from Los Flores Ranch on January 9, 2005 at approximately 6 pm. Due to inclement weather during the night, the location of the break was not identified until the morning of January 10, 2005. A 30 foot section of the 19-inch pipe was damaged from the high water level of the lake, wind-generated heavy wave action, and stormwater runoff which undermined the shore, exposing the pipe under the bank. The undermining caused the pipe to drop and separate. The approximate location of the first pipeline break is shown in **Figure 6-12.**

The second pipeline break occurred on January 10, 2005 at approximately 2:50 pm when a 110 foot section of the Seeley Creek WWTP outfall was washed away. The discharge point of this break was approximately 1,800 feet upstream of Silverwood Lake and flowed into the East Fork West Fork Mohave River (or Miller Canyon Creek) before entering the lake. The approximate location of the second pipeline break is shown in **Figure 6-12.**

CSD notified Metropolitan Water District of Southern California (MWDSC), Crestline Lake Arrowhead Water Agency (CLAWA), and DWR staff on January 10. CSD estimated that 9.2 million gallons of treated chlorinated wastewater was released into the Silverwood watershed as a result of the first pipeline break, and an additional 2.1 million gallons as a result of the second pipeline break.

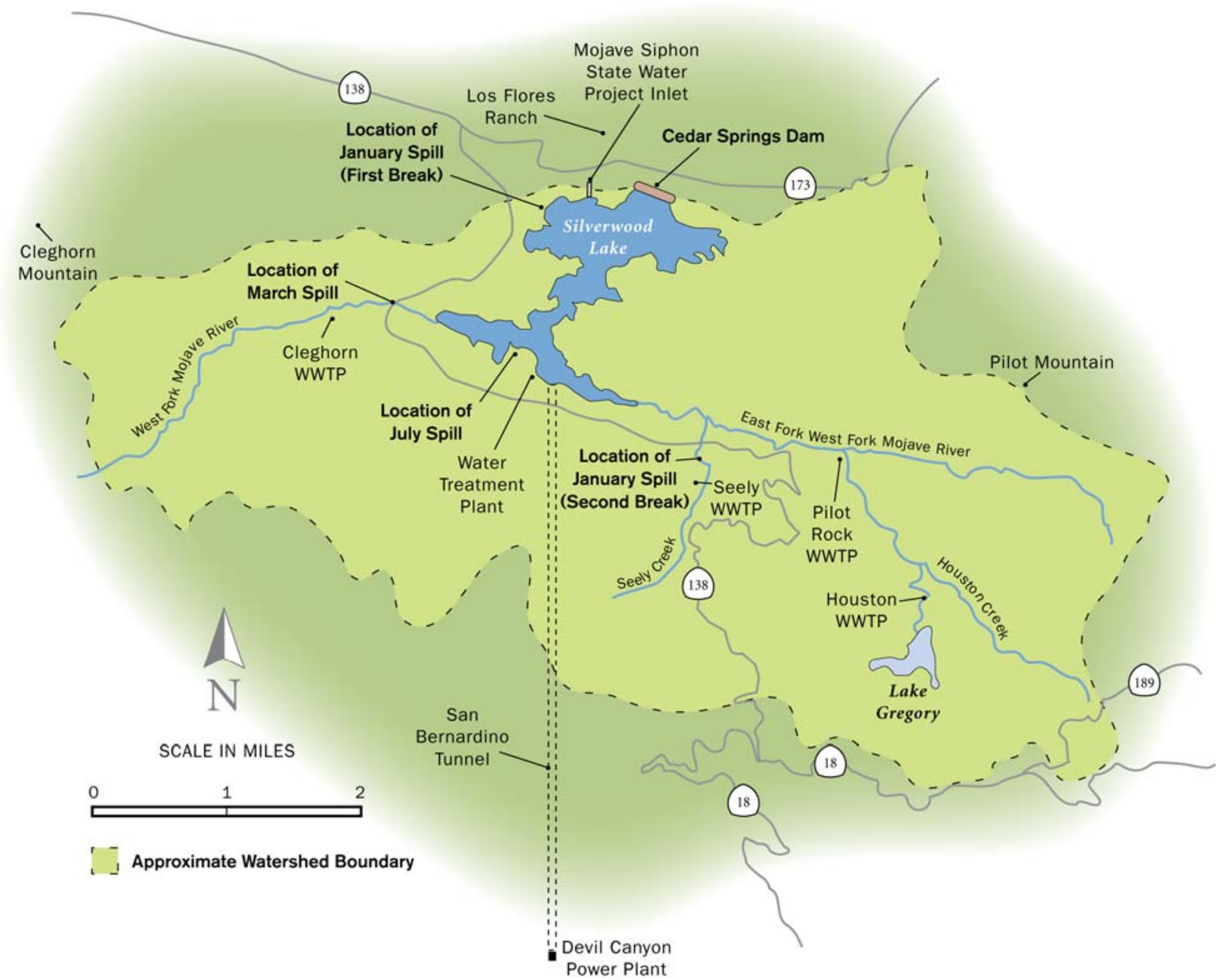
Water Quality Impacts

For the first pipeline break, CSD collected daily lake samples from January 10 through January 17 approximately 100 feet upstream of the discharge, at the point of discharge, and approximately 100 feet downstream of the discharge. For the second pipeline break, CSD collected daily samples from January 12 through 17. The data were requested but not obtained.

In response to the first pipeline break, MWDSC initiated a monitoring program for coliforms, *Cryptosporidium,* and *Giardia* at Silverwood Lake and Devil Canyon Afterbay, as well as the Mills Water Treatment Plant (WTP), which normally receives water from Silverwood Lake via the Santa Ana Valley Pipeline. Over 200 liters of raw water and 2,800 liters of treated Mills

WTP water were analyzed in the immediate aftermath of the spill and during the eight-week follow-up period. DWR assisted in collecting samples for MWDSC immediately after the spill.

Figure 6-12. Approximate Location of Wastewater Spills in Silverwood Lake Watershed



In response to the spill, CLAWA collected additional bacteriological samples at the raw water to their WTP influent. Normally, coliforms are collected and analyzed once a week for raw water, but coliform monitoring was increased after the spill. Monitoring results are shown in **Table 6-7.**

Table 6-7. Coliform Monitoring Results for January 2005 Storm Season and Secondary Treated Sewage Line Break- Crestline Lake Arrowhead Water Agency WTP Influent

Location	Date	Total Coliforms (MPN/100mL)	Fecal Coliforms (MPN/100mL)
CLAWA WTP Influent	01/12/05	900	80
CLAWA WTP Influent	01/13/05 @ 9:15am	> 1,600	280
CLAWA WTP Influent	01/13/05 @ 2pm	> 1,600	500
CLAWA WTP Influent	01/14/05	900	80
CLAWA WTP Influent	01/17/05	170	4

Source: Crestline Arrowhead Lake Water Agency

The results of the MWDSC monitoring program are presented in **Tables 6-8, 6-9 and 6-10**. **Table 6-8** shows pathogen monitoring results at Silverwood Lake and its tributaries, in the spilled secondary effluent from the first pipeline break, and in Devil Canyon Afterbay. Samples of the spilled effluent were not collected by MWDSC for the second pipeline break. **Table 6-9** shows pathogen monitoring results from the Mills WTP influent and treated water. The Mills WTP was sampled for five consecutive workdays during the period January 11 through 18, 2005, and sampling continued on a weekly basis in February and March 2005.

Table 6-8. Protozoa Monitoring Results for January-March 2005 Storm Season- Silverwood Lake

Location	Date	Turbidity (NTU)	*Giardia* (cysts/10 L)	*Cryptosporidium* (oocysts/10 L)
Silverwood Lake[a]	01/03/05	12.1	0	0
Spilled Secondary Effluent from First Pipeline Break	01/10/05	NA[b]	**3,896**	**24**
Devil Canyon Afterbay	01/10/05	350	**5**	**3**
Devil Canyon Afterbay	01/10/05	350	**13**	**2**
Devil Canyon Afterbay	01/11/05	283	**8**	**2**
Devil Canyon Afterbay	01/13/05	193	**5**[c]	**1**[c]
Miller Creek	01/24/05	3.0	0	0
Cleghorn Creek	01/24/05	4.1	0	0
Devil Canyon Afterbay	02/07/05	5.5	0	0
Devil Canyon Afterbay	03/09/05	5.0	0	0

[a] Prior to contamination event.
[b] Data not collected.
[c] Only 8 L of sample analyzed (by CHDiagnostics).

Table 6-9. Protozoa Monitoring Results for January-March 2005 Storm Season- Mills Water Treatment Plant

	Mills Influent (10 L analyzed)			Mills Treated Water (200 L analyzed)		
Date	**Turbidity (NTU)**	***Giardia* (cysts)**	***Cryptosporidium* (oocysts)**	**Turbidity (NTU)**	***Giardia* (cysts)**	***Cryptosporidium* (oocysts)**
01/05/05	6.3	0	0	0.07	0	0
01/11/05[a]	201	**5**	0	0.07	0	0
01/12/05	232	**6**	**2**	0.13	0	0
01/13/05	203	**16**	**3**	0.12	0	0
01/14/05	182	**1**	0	0.07	0	0
01/18/05	40	**1**	0	0.06	0	0
01/20/05	25	**2**	**1**	0.05	0	0
01/24/05	13.1	0	0	0.06	0	0
02/02/05[b]	-	-	-	-	-	-
02/10/05	5.5	0	0	0.05	0	0
02/16/05	7.0	0	0	0.05	0	0
02/23/05	19.1	**1**	**1**	0.07	0	0
03/02/05	6.7	0	0	0.07	0	0
03/08/05	5.2	**1**	0	0.06	0	0
03/15/05	4.2	0	0	0.06	0	0

[a] Sewage pipe break occurred January 9/10.
[b] Plant shutdown.

In summary, *Cryptosporidium* and *Giardia* were detected in an effluent sample collected directly from the first pipeline break (flow rate at time of collection was approximately 1 cfs), in untreated source water samples (Devil Canyon Afterbay and Mills WTP influent), but not in Mills WTP treated water. Based on these results it was estimated that approximately 8×10^9 *Giardia* cysts and 5×10^7 *Cryptosporidium* oocysts were released into Silverwood Lake as a result of the first pipeline break. Average concentrations were eight *Giardia* cysts and two *Cryptosporidium* oocysts per 10 L at Devil Canyon Afterbay, and five cysts and one oocyst per 10 L in Mills WTP influent (average for all samples that were positive for at least one organism). These detections are considered significant when compared to historical *Cryptosporidium* and *Giardia* data at Mills WTP influent, as there were only two positive *Cryptosporidium* detects (both at one oocyst per 10 L) and no *Giardia* detects over a six year period, from January 2000 to December 2005.

Although *Giardia* and *Cryptosporidium* were detected in the first pipeline break, it could not be determined whether the cysts and oocysts detected in Devil Canyon Afterbay and Mills WTP influent originated in the treated wastewater effluent or in storm-induced run-off within the watershed. As discussed previously, the Southern California area experienced heavy rainfall during this time period, resulting in very high turbidities at Devil Canyon. Water quality at Silverwood Lake was likely impacted by both the wastewater spill and increased runoff due to the heavy storms.

Table 6-10 shows MWDSC coliform monitoring results for the spilled secondary effluent from the first pipeline break, Devil Canyon Afterbay, and the Mills WTP Influent. It is important to note that no fecal coliform or *E. coli* was detected in the spilled secondary effluent from the first pipeline break, but *Giardia* and *Cryptosporidium* were detected.

Table 6-10 compares spill-impacted waters to historical coliform levels at the Mills WTP Influent (January monthly medians 2000 to 2004). **Table 6-10** shows elevated total coliform levels at the Mills WTP influent beginning on January 10th, with fecal coliform and *E. coli* levels becoming elevated on January 11th. Elevated levels of coliforms continued at the Mills WTP Influent until January 19, 2005, nine days after the spill. As discussed earlier, water quality at the Mills WTP influent was likely impacted by both the wastewater spill and increased runoff due to the heavy storms.

Table 6-10. Coliform Monitoring Results for January 2005 Storm Season and Secondary Treated Sewage Line Break- Silverwood Lake and Mills WTP Influent

Location	Date	Total Coliforms (MPN/100mL)	Fecal Coliforms (MPN/100mL)	*E. coli* (MPN/100mL)
Spill Impacted Data				
Spilled Secondary Effluent from First Pipeline Break	01/10/05	2	<2	<2
Devil Canyon Afterbay	01/10/05	24,000	130	130
Devil Canyon Afterbay	01/11/05	7,000	170	170
Devil Canyon Afterbay	01/13/05	8,000	110	110
Mills WTP Influent	01/10/05	> 1,600	4	4
Mills WTP Influent	01/11/05	> 1,600	130	80
Mills WTP Influent	01/12/05	2,200	80	80
Mills WTP Influent	01/13/05	1,100	170	110
Mills WTP Influent	01/18/05	300	23	8
Mills WTP Influent	01/19/05	27	11	4
Mills WTP Influent	01/20/05	500	30	30
Historical Data (January monthly medians 2000-2004)				
Mills WTP Influent		4-26	2-8	2-6

Source: MWDSC
Samples analyzed by Multiple Tube-Fermentation method (SM9221)
MPN – Most Probable Number method

Existing Emergency Response Provisions

A contractor was brought on-site to the first pipeline break location the morning of January 10, 2005, and site preparation began that afternoon. Repairs began the afternoon of January 11, and were completed by 11:30 am on January 12, 2005. For the second pipeline break, repairs began on January 11 and were completed by January 13 at 8 pm. In February 2005, the CSD and the Lahontan Regional Water Board discussed technologies that could be used to protect the effluent outfall in the future. In order to protect the effluent outfall at critical points along the lake shoreline, the CSD installed a buried K-rail along the embankment where the first pipeline break occurred and rip rap to protect the embankment.

Due to the wastewater spill, MWDSC increased coagulant and polymer doses, as well as target contact time and ozone dose at the plant influent for the Mills WTP. Similarly, CLAWA increased their coagulant, polymer, and disinfectant dose.

In this instance, DWR was not required to respond to the wastewater spill as the responsible party was the CSD. However, DWR's Southern Field Division has an EAP which is designed to provide guidance to DWR staff responding to various emergencies (DWR, 2004b). The EAP has specific emergency response procedures for fire, floods, death or injury, emergency evacuation, and hazardous spills. The emphasis of hazardous spill management is to minimize contamination by containing the spill as quickly as possible. Clean-up of the spill occurs after the spill is contained. The method of clean-up is dependent upon the material involved, and the capability of the DWR Southern Field Division to safely and properly handle it.

RAW WASTEWATER AND SECONDARY EFFLUENT SPILLS, MARCH 26 and APRIL 1, 2005

Description of Event

On March 26, 2005 raw wastewater was observed leaking up from cracks in Highway 138, near the intersection of Highway 138 and Cleghorn Road. The California State Parks' sewer main carries wastewater from the Silverwood Lake SRA to CSD's Cleghorn WWTP. An estimated 250 gallons of raw wastewater entered Cleghorn Creek, approximately ¼ mile upstream of the lake. The approximate site of the spill is shown in **Figure 6-12**. The sewer main broke as a result of earth movement caused by flooding.

The sewer line was shut down and temporary sanitation facilities were put in place for the general public. The spill was stopped and contained within 3½ hours. Repairs were initiated for the Cleghorn roadway and sewer main. On April 1, 2005, while the contractor was trying to locate the California State Parks' sewer main, the CSD's forcemain carrying chlorinated secondary effluent from the Cleghorn WWTP was punctured. This led to the release of approximately 300 gallons of chlorinated secondary effluent to Cleghorn Creek. Repairs were made to both pipelines by April 2, 2005.

Water Quality Impacts

Water quality samples were taken by the CSD from March 27 to April 6, 2005. Samples were collected from two locations: 1) Cleghorn Creek, 50 feet upstream from the sewer main break, and 2) Cleghorn Creek, 50 feet downstream from the sewer main break. Sample results are shown in **Table 6-11**. Clearly, the downstream samples on 3/28/05 and 3/31/05 are evident of contamination as a result of the raw wastewater spill.

Table 6-11. Crestline Sanitation District Sampling for March 26, 2005 Sewer Main Break and April 1, 2005 Effluent Forcemain Break

Sample Location & Date	Date & Time	Fecal Coliform (MPN/100ml)	Fecal Streptococcus (MPN/100ml)	Total Coliform (MPN/100ml)
Cleghorn Creek – 50 feet Upstream	3/27/05	< 2	4.0	4.0
	3/28/05	< 2	22	40
	3/29/05 10:00	< 2	< 2	30
	3/29/05 13:30	< 2	7	2
	3/30/05	< 2	4.0	< 2
	3/31/05	< 2	11	< 2
	4/1/05	< 2	11	11
	4/2/05	140	90	500
	4/3/05	< 2	8	< 2
	4/4/05	< 2	17	13
	4/5/05	< 2	8	11
	4/6/05	< 2	8	50
Cleghorn Creek – 50 feet Downstream	3/27/05	< 2	4.0	50
	3/28/05	1,600	1,600	> 1,600
	3/29/05 10:00	2	< 2	50
	3/29/05 13:00	< 2	23	11
	3/30/05	< 2	13	< 2
	3/31/05	500	170	> 1,600
	4/1/05	< 2	< 2	50
	4/2/05	< 2	8	30
	4/3/05	< 2	17	22
	4/4/05	< 2	13	30
	4/5/05	< 2	13	30
	4/6/05	< 2	13	170

As shown in **Table 6-12**, the MWDSC conducted follow-up sampling for pathogens on March 28, 2005. Samples were collected for protozoan pathogen analysis at Devil Canyon, Silverwood Lake Outlet Tower (0.4 m), and from two lake surface sites (0.4 m) between the Silverwood Lake Outlet tower and the mouth of Cleghorn Creek. Samples were also collected from the influent and treated water of the Mills WTP. *Cryptosporidium* was not detected in any samples, and *Giardia* was only detected in the Silverwood Lake Outlet Tower sample.

Table 6-12. Pathogen Monitoring at Silverwood Lake Following March 2005 Wastewater Spill

Location	Date	Volume (L)	Turbidity (NTU)	*Giardia*[a]	*Cryptosporidium*[a]
Silverwood Lake Outlet Tower, 0.4 m	03/28/05	10	1.2	**1**	0
Devil Canyon	03/28/05	10	2.06	0	0
Cleghorn Arm, 0.4 m	03/28/05	10	1.58	0	0
Marina, 0.4 m	03/28/05	10	1.41	0	0
Mills WTP Influent	03/28/05	10	-	0	0
Mills WTP Treated Water	03/28/05	200	-	0	0

[a]Limit of detection is 1 cyst/oocyst per 10 L for untreated water and 1 cyst/oocyst per 200 L for finished water.

As shown in **Table 6-13**, the MWDSC conducted follow-up sampling for coliforms on March 26 and March 28, 2005. Coliform samples were collected from the same locations as the pathogen sampling discussed above. **Table 6-13** compares the spill-impacted waters to historical coliform levels at the Mills WTP Influent (March monthly medians 2000 to 2004). **Table 6-13** shows that *E. coli* levels after the spill are within historical levels, indicating no water quality impact. However, total and fecal coliform samples collected at the Cleghorn Arm and the Marina are greater than historical levels, indicating an impact from the spill, particularly for samples collected on the same day as the spill (March 26, 2005). CLAWA's WTP was not in operation during this time period and was not impacted by this spill.

Existing Emergency Response Provisions

According to California State Parks, there is a response plan for wastewater spills (Personal Communication, Rick Reisenhofer). Typically, the first step is to turn off water sources to prevent further volumes of water from being generated, make appropriate repairs, and ensure proper notifications are made to DWR, OES, DFG, CDHS, Lahontan Regional Water Board, San Bernardino County Department of Environmental Health Services, and CLAWA. To prevent sewer main breaks in the future, the California State Parks rerouted the path of Cleghorn Creek to its original path before the flood. This effort is expected to prevent further earth movement and subsequent sewer main breaks.

Table 6-13. Coliform Monitoring at Silverwood Lake and Mills WTP Influent Following March 2005 Wastewater Spill

Location	Date	Total Coliforms (MPN/100mL)	Fecal Coliforms (MPN/100mL)	*E. coli* (MPN/100mL)
Spill Impacted Data				
Cleghorn Arm, 0.4 m	03/26/05	17,000	50	7
Cleghorn Arm, 0.4 m	03/28/05	170	4	4
Silverwood Lake Outlet Tower, 0.4 m	03/28/05	11	2	2
Devil Canyon	03/28/05	23	4	4
Marina, 0.4 m	03/28/05	300	4	2
Mills WTP Influent	03/28/05	30	7	7
Historical Data (March monthly medians 2000-2004)				
Mills WTP Influent		4-27	2-17	2-17

Source: MWDSC
Samples analyzed by Multiple Tube-Fermentation method
MPN – Most Probable Number method

RAW WASTEWATER SPILL, JULY 27, 2005

Description of Event

On July 27, 2005 a wastewater lift station maintained by the California State Parks for the Silverwood Lake SRA failed. This caused a backup of wastewater from a restroom (restroom building number five) located right behind Sawpit Beach, spilling about 50 to 100 gallons into the lake before it was stopped (**see Figure 6-12**). The wastewater backup was caused by an electrical transformer switch failure; the transformer and switch controlling the station overheated and burned out.

The restroom building was immediately shut down and bleach was added to the wastewater coming from the building. The lift station was pumped out, as well as all standing sewer water. All visitors were evacuated from the water at Sawpit Beach and directed to the Cleghorn swim area. The electrical system for the lift station was repaired and all other transformer switches were inspected to prevent reoccurrence at other lift stations.

Water Quality Impacts

As shown in **Table 6-14**, samples were collected by MWDSC on the same day at the site of the spill (Sawpit Beach) and at the Silverwood Lake Outlet Tower for pathogens. The next day, samples were taken again at these same sites, as well as at Devil Canyon Afterbay and the Mills WTP. Additional samples were taken five to six days after the spill at the Mills WTP, the Weymouth WTP, and Live Oak Reservoir. *Cryptosporidium* was detected only at the site of the spill.

Table 6-14. Pathogen Monitoring at Silverwood Lake Following July 2005 Wastewater Spill

Location	Date	Turbidity (NTU)	*Giardia*[a]	*Cryptosporidium*[a]
Silverwood Lake, Sawpit Beach	07/27/05	2.73	0	0
	07/28/05	2.42	0	**2**
Silverwood Lake Outlet Tower	07/27/05	2.93	0	0
	07/28/05	2.37	0	0
Devil Canyon	07/28/05	2.56	0	0
Mills WTP Influent	07/28/05	2.50	0	0
	08/02/05	2.50	0	0
Mills WTP Treated Water	07/28/05	0.06	0	0
	08/02/05	0.06	0	0
Weymouth WTP Influent	07/28/05	2.25	0	0
	08/01/05	1.30	0	0
Weymouth WTP Treated Water	07/28/05	0.08	0	0
	08/01/05	0.07	0	0
Live Oak Reservoir	08/02/05	2.10	0	0

a Limit of detection is 1 cyst/oocyst per 10 L for untreated water and 1 cyst/oocyst per 200 L for finished water.

Coliform samples were also collected by MWDSC as shown in **Table 6-15**. **Table 6-15** compares the spill impacted waters to historical coliform levels at the Mills WTP influent (July monthly medians 2000 to 2004). **Table 6-15** shows fecal coliform samples collected the same day as the spill at the Sawpit Beach and Outlet Tower are elevated compared to historical Mills WTP influent levels. Only one *E. coli* sample at the Outlet Tower collected on the same day of the spill appears to be elevated. Total coliform levels also appear to be elevated as a result of the spill. However, elevated coliform levels may also be attributed to body-contact activity in Silverwood Lake during this summer time period.

Existing Emergency Response Provisions

Please see discussion of Raw Wastewater and Secondary Effluent Spills, March 26 and April 1, 2005.

Table 6-15. Coliform Monitoring at Silverwood Lake and Mills WTP Influent Following July 2005 Wastewater Spill

Location	Date	Total Coliforms (MPN/100mL)	Fecal Coliforms (MPN/100mL)	*E. coli* (MPN/100mL)
Spill Impacted Data				
Silverwood Lake, Sawpit Beach	07/27/05	1,300	80	2
Silverwood Lake, Sawpit Beach	07/28/05	500	4	<2
Silverwood Lake Outlet Tower	07/27/05	500	80	14
Silverwood Lake Outlet Tower	07/28/05	140	2	<2
Devil Canyon	07/28/05	700	50	4
Mills WTP Influent	08/01/05	8	2	2
Historical Data (July monthly medians 2000-2004)		2-22	<2 -1	<2-1

Source: MWDSC
Samples analyzed by Multiple Tube-Fermentation method (SM9221)
MPN – Most Probable Number method

POTENTIAL ACTIONS

Recommend that DWR Develop Emergency Wastewater Spill Procedure

The SWP Contractors should recommend that DWR develop a separate emergency response procedure for wastewater spills in the Field Divisions' EAPs. Wastewater spills are different than a general hazardous spill response in terms of containment and clean-up.

Request DWR to Provide a Summary Report to Impacted Contractors

The SWP Contractors should request that DWR provide a summary report for events such as wastewater spills or hazardous waste spills. The report should include a description of the event, description of the response, list of agencies involved and their roles, water quality data, data analysis, recommendations to prevent event in the future, evaluation of response and related recommendations. The report should be submitted to the SWC and all impacted SWP Contractors.

Track Crestline Sanitation District's Future Plans for Wastewater Facilities in the Watershed

Currently there are four WWTPs employing secondary treatment in the Silverwood watershed; three are owned by the CSD. CSD is currently considering upgrading their three WWTPs to tertiary treatment. Due to limited funding, there are plans to upgrade only one of the plants. If all plants could be upgraded to tertiary treatment, the tertiary treated effluent water could be used locally, and the effluent outfall pipeline which transports treated wastewater effluent could be eliminated. This would eliminate a potential source of contamination in the Silverwood watershed, particularly in light of the January 2005 wastewater spill from the effluent outfall.

SWP Contractors Should Clarify Support Roles with DWR

The SWP Contractors and DWR should clarify the needed resources to respond to a wastewater spill, and what supporting roles the SWP Contractors could provide. For example, if DWR staff could commit resources for sample collection, the SWP Contractors might be able to provide laboratory analysis support.

HIGH RUNOFF AND TURBIDITY IN SILVERWOOD AND CASTAIC LAKES

Silverwood and Castaic lakes were both temporarily impacted by high runoff in the winter of 2004 to 2005, which increased turbidity and possibly pathogens and/or pathogen indicators in the lakes. The Silverwood watershed was also impacted by a major wildfire in 2003.

Silverwood Lake and its watershed were described in the previous section. The SWP Contractors who may be impacted by high runoff into Silverwood Lake were listed previously in **Table 6-6** as these contractors request deliveries from either Silverwood Lake or downstream.

Castaic Lake, located about 45 miles northwest of downtown Los Angeles, is the terminal reservoir of the West Branch of the California Aqueduct. Castaic Lake is supplied water from the SWP from Pyramid Lake, and has a maximum storage of 323,700 acre-feet. Castaic Lake supplies water to MWDSC, the Castaic Lake Water Agency (CLWA), and the Ventura County Flood Control District.

SILVERWOOD LAKE

Description of Event

There are two main tributaries which contribute natural runoff to Silverwood Lake, the West Fork Mojave River (or Cleghorn Creek) and the East Fork West Fork Mojave River (or Miller Canyon Creek). **Table 6-16** shows annual inflows to Silverwood from 1996 to 2005.

Over the 2001 through 2005 reporting period, the highest amount of natural inflow occurred in 2005. The amount of natural inflow in 2005 almost equaled the storage capacity of the lake.

The Silverwood Lake watershed experienced heavy rain throughout the winter season of 2005. Rain gauge data is collected by DWR on a daily basis. Monthly rainfall totals from 2001 through 2005 are shown in **Figure 6-13.** The highest monthly rainfall was 27.89 inches in January 2005. Natural runoff into Silverwood Lake also peaked in January 2005 as shown in **Figure 6-14. Figure 6-14** clearly shows that natural runoff into the lake increases during the wet season, and that turbidity at Devil Canyon is affected as natural runoff into the lake increases.

Table 6-16. Inflows to Silverwood Lake

Year	Natural Inflow (acre-feet)
1996	11,714
1997	8,890
1998	41,685
1999	2,291
2000	4,621
2001	5,694
2002	330
2003	7,429
2004	15,060
2005	70,252

Figure 6-13. Monthly Rainfall Totals at Silverwood Lake, 2001-2005

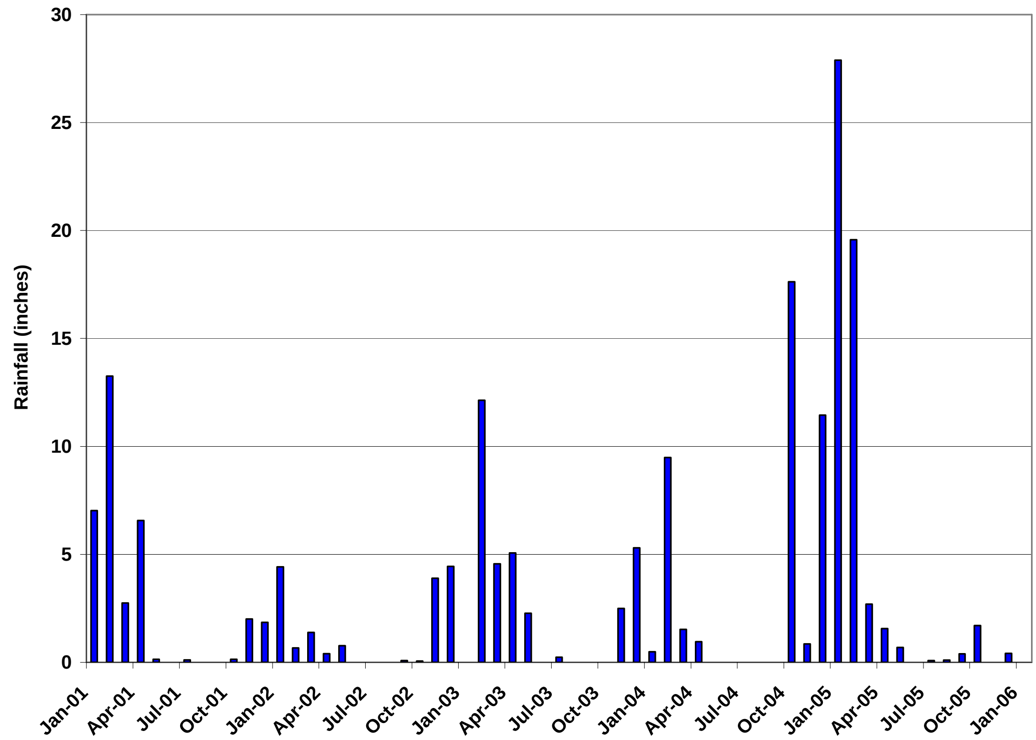
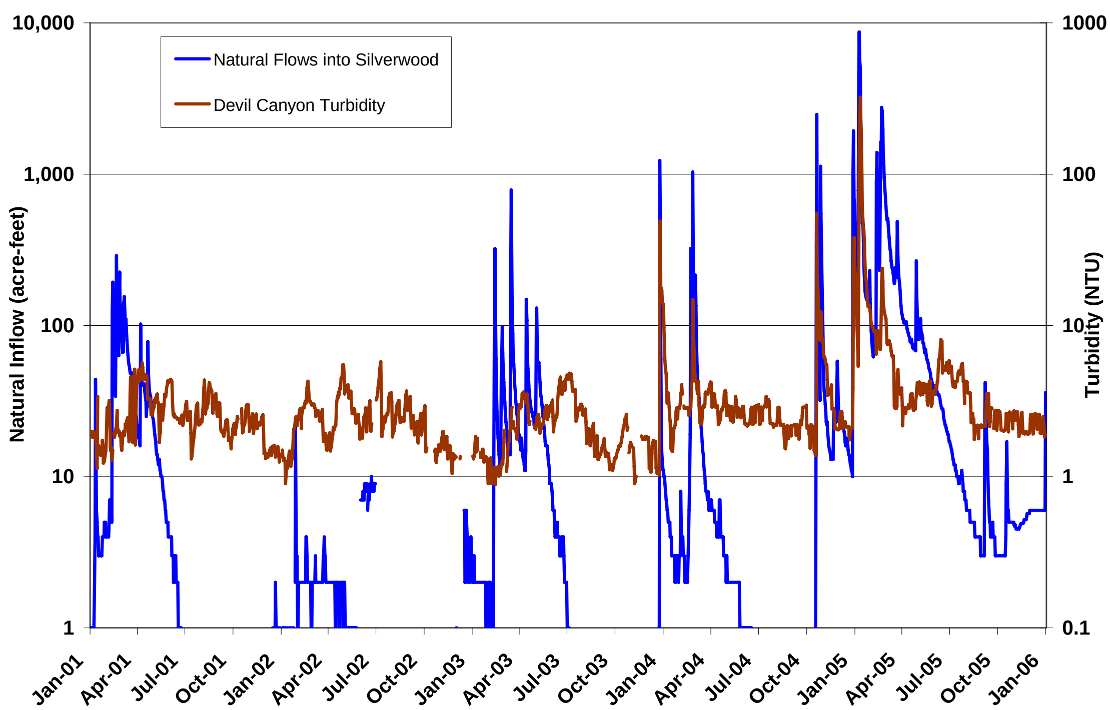
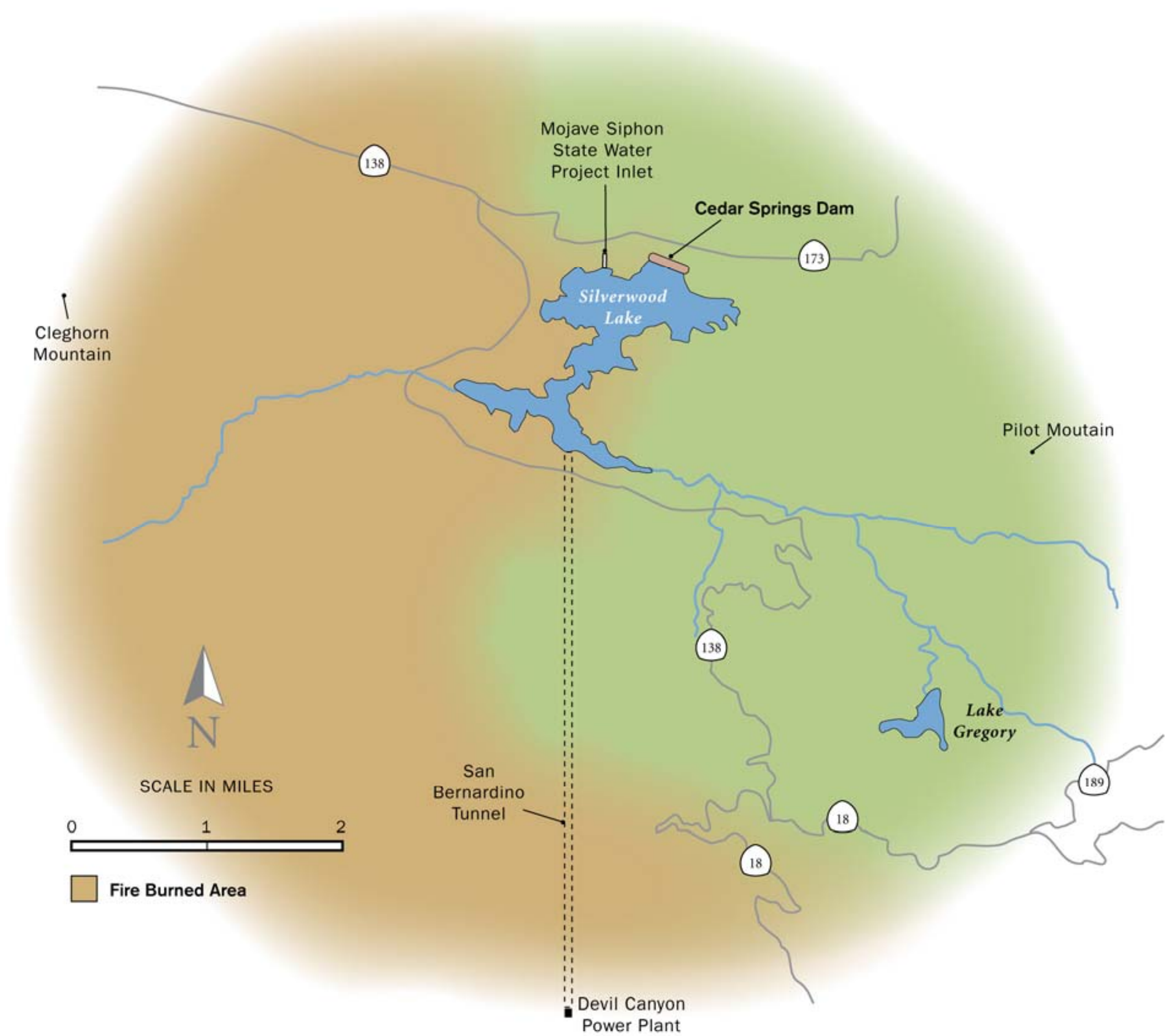


Figure 6-14. Daily Runoff and Turbidity at Silverwood Lake, 2001-2005



In addition to heavy rains, the Silverwood watershed was also impacted by the Old Fire in October 2003 as shown in **Figure 6-15.** Approximately 8,900 acres of the burn area was within the watershed, representing about 40 percent of the Silverwood Lake watershed. The main burn area occurred in Cleghorn Canyon, located on the western side of Silverwood Lake.

Figure 6-15. Map of Old Fire Burn Area, October 2003



Adapted from Mountain Area Safety Task Force figure.

A Burn Area Emergency Rehabilitation (BAER) Team was formed to recommend watershed restoration and stabilization treatments for the burn area. The BAER report indicated that the hydrophobic condition of the soil and the lack of cover will cause increased erosion; 17 to 30 times the normal level of sediment for the first year post burn storm season. The BAER team also classified the burn intensities for the watershed area; ten percent of the watershed burned low, eight percent burned moderately, 24 percent burned high, and 58 percent was not burned.

Water Quality Impacts

Due to the hydrophobic soil conditions and lack of vegetation, there was potential for increased amounts of sediment, silt, suspended solids, ash, and other debris to enter the lake as a result of the fire. Increased solids loading into the lake would then increase turbidity, nutrients, metals, and possibly pathogen loading.

On December 25, 2003, the Silverwood watershed received over five inches of rain within a 24-hour period, causing mudslides and high runoff within the watershed. This was the first heavy rain since the October 2003 fire, and large amounts of debris entered the lake, as shown in **Figures 6-16 and 6-17**. **Figure 6-14** indicates that the daily average turbidity at Devil Canyon on December 26, 2003 was 49 NTU, but separate examination of hourly data shows that the turbidity peaked at 236 NTU. In an attempt to characterize the post-fire impact to source water quality, MWDSC staff collected water samples on December 26, 2003, first from Devil Canyon Afterbay and then from the Silverwood Lake Outlet Tower. **Table 6-17** shows key drinking water constituents which were elevated as a result of the recent fire and high runoff. To better illustrate how elevated certain constituents became, **Table 6-17** also provides the yearly 2003 average at Devil Canyon. In summary, most of the metals regulated for drinking water were elevated. Additionally, the Silverwood Lake Outlet Tower showed slightly lower measurements than the Devil Canyon Afterbay, indicating the magnitude of the impact may have been fairly short-lived and was starting to decrease. However, additional water quality samples would be needed to fully characterize the timing and release of fire-impacted water from Silverwood Lake.

Table 6-17. Key Constituents Impacted by the 2003 Fire in Silverwood Lake Watershed

Constituent	Devil Canyon Afterbay	Silverwood Outlet Tower @ 3 meters	2003 Yearly Average at Devil Canyon
Aluminum (µg/L)	8,500	1,100	58
Iron (µg/L)	6,600	840	124
Manganese (µg/L)	248	48	22
TOC (mg/L)	4.61	3.12	3.7
Total Phosphorus (mg/L)	0.486	0.145	0.08

Source: MWDSC

CLAWA's WTP was also impacted by the October 2003 fire and subsequent storms. CLAWA did not collect any special samples at their plant influent in December 2003 when fire-impacted runoff entered Silverwood Lake. However, CLAWA provided daily turbidity data sampled at their WTP influent, which showed the peak daily turbidity was 65 NTU on December 26, 2003. CLAWA staff indicated that their plant remained in operation, but flows were reduced.

Figure 6-16. View of Cleghorn Arm, Silverwood Lake - December 26, 2003

Figure 6-17. View of Sawpit Beach, Silverwood Lake – December 26, 2003

Although Silverwood Lake supplies SWP water to the Mills WTP, the Skinner WTP, the Diemer WTP, and the Weymouth WTP, only the Mills WTP receives 100 percent SWP water. The other three plants can blend SWP water with Colorado River water, thus diminishing the impact of post-fire runoff at these WTPs. Fortunately, the Mills WTP was shutdown during this time period, due to maintenance of the Santa Ana Valley pipeline. High turbidities did reach the Weymouth and Diemer WTPs one day after the storm, but the WTPs remained in compliance with all drinking water regulations by increasing chemical dosage and increasing Colorado River blends. Although all state and federal water quality regulations were met, the main impact to the Diemer and Weymouth WTPs was taste and odor related, as flavor profile analysis deemed the water unacceptable with a burnt wood and ashy taste.

Water quality was also impacted during the winter of 2004 to 2005, due to high runoff. **Figure 6-14** indicates a direct relationship between runoff and turbidity during this time period. Turbidities at Devil Canyon Afterbay remained above 20 NTU for one month, from the end of December 2004 to the end of January 2005, peaking at 322 NTU on January 11, 2005. The peak turbidity occurred two days after the peak daily inflow, which was 8,701 acre-feet on January 9, 2005.

Turbidity data was also provided by CLAWA for their WTP influent during this time period. As shown in **Figure 6-18**, turbidity reached as high as 239 NTU on January 10, 2005 and remained above 20 NTU for over ten days. Again, the CLAWA WTP remained in operation.

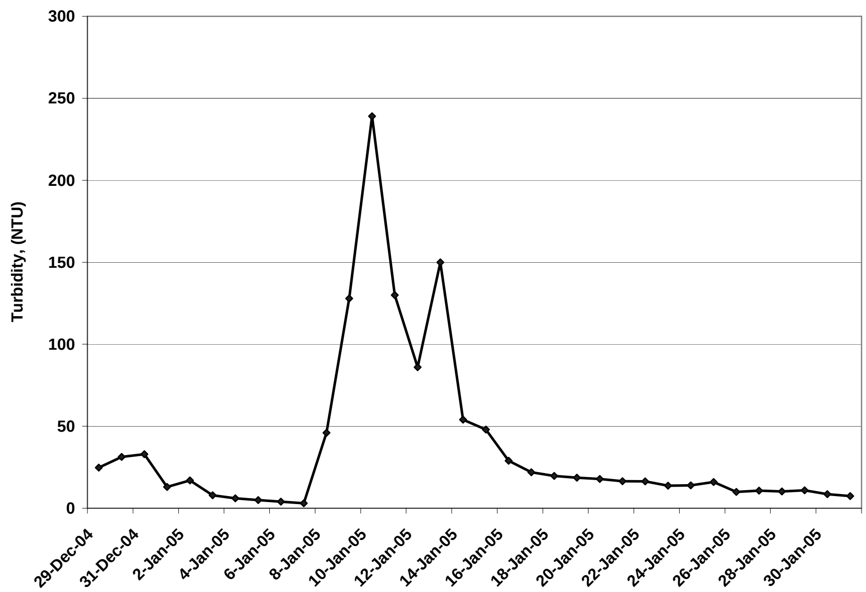
As discussed previously, water quality was also secondarily impacted by high runoff when heavy erosion occurred around a 19-inch wastewater trunk line owned by CSD, causing it to break, spilling chlorine-disinfected secondary treated wastewater into Silverwood Lake on January 9, 2005.

Actions Taken

The National Resources Conservation Service (NRCS), California State Parks, DWR, and MWDSC met to identify post-fire concerns and resources. The BAER Team issued their final report on November 17, 2003 which recommended an 800-acre area within the watershed for aerial straw mulching to protect water quality. Although the burn area was much larger than this, treatments are not recommended on slopes steeper than 55 percent, or for moderately burned areas. Since 660 of the 800 acres were lands owned by the U.S. Forest Service, the U.S. Forest Service helimulched 660 acres by the end of November 2003.

The NRCS conducted a separate watershed assessment in early December 2003. This assessment recommended helimulching of the remaining 140 acres and placement of additional sandbags around CSD's Cleghorn WWTP. DWR helimulched the remaining 140 acres in early January 2004.

Figure 6-18. Influent Turbidities at CLAWA's WTP During Period of High Runoff into Silverwood Lake



CASTAIC LAKE

Description of Event

There are two main tributaries which contribute natural runoff to Castaic Lake, Castaic Creek on the northwest arm and Elizabeth Creek on the northeast arm. **Table 6-18** shows annual inflows to Castaic Lake from 1996 to 2005. Over the 2001 through 2005 reporting period, the highest amount of natural inflow occurred in 2005. The amount of natural inflow in 2005 equaled approximately 41 percent of the lake storage capacity.

The Castaic Lake watershed experienced heavy rain throughout the winter season of 2004 to 2005. Rain gauge data is collected by DWR on a daily basis. Monthly rainfall totals from 1999 through 2005 are shown in **Figure 6-19.** The highest monthly rainfall was 13.5 inches in January 2005. As expected, the tributaries leading to Castaic Lake and Elderberry Forebay also experienced increased flow, as shown in **Figure 6-20.** Over the 2001 through 2005 reporting period, natural daily inflows were always less than 1,000 acre-feet, except in early 2005 when daily inflows into Elderberry Forebay peaked at 11,577 acre-feet on January 9, 2005 as well as 13,672 acre-feet into Castaic Lake.

Table 6-18. Inflows to Castaic Lake

Year	Natural Inflow (acre-feet)
1996	8,934
1997	9,475
1998	97,229
1999	6,439
2000	8,303
2001	13,772
2002	675
2003	4,303
2004	5,429
2005	132,948

Figure 6-19. Monthly Rainfall Totals at Castaic Lake, 1999-2005

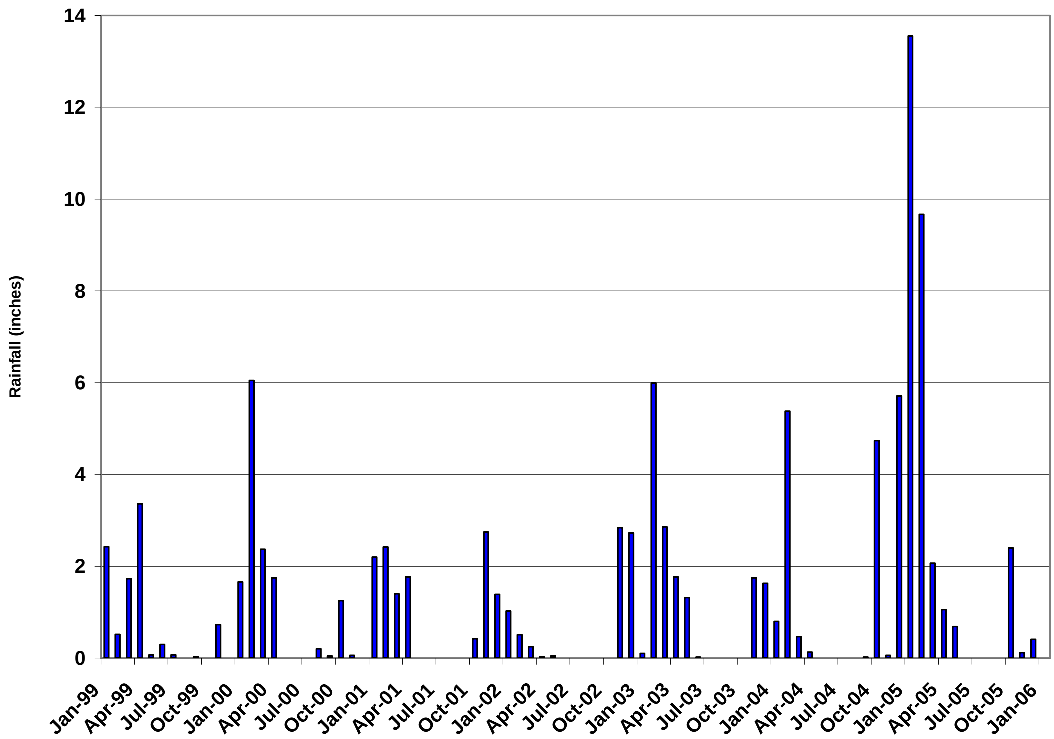
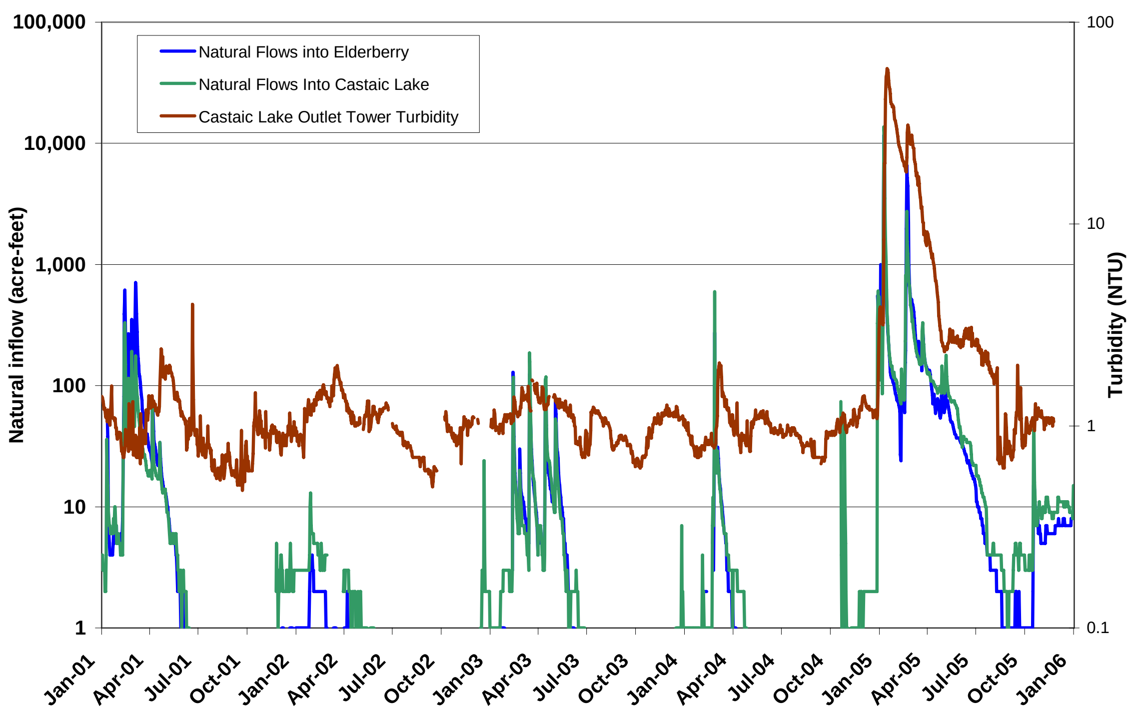


Figure 6-20. Daily Runoff and Turbidity at Castaic Lake, 2001-2005



Water Quality Impacts

Figure 6-20 shows daily turbidity measured at the Castaic Lake Outlet Tower and natural inflow into Castaic Lake. Daily turbidities at the Castaic Lake Outlet Tower were less than 1 to 2 NTU over the entire reporting period, except in early 2005. From January through April 2005, turbidities remained over 2 NTU for four months due to heavy rains and high runoff into both Elderberry Forebay and Castaic Lake. **Figure 6-20** also shows that turbidities at the Castaic Lake Outlet Tower were elevated from mid-January to mid-February 2005, ranging from 20 to 58 NTU, and peaking at 58 NTU on January 15, 2005. **Figure 6-21** shows an aerial picture of Castaic Lake during this time. **Figure 6-22** shows influent turbidity at MWDSC's Jensen WTP in relation to runoff occurring into Castaic Lake. The Jensen WTP receives 100 percent SWP from Castaic Lake. The peak influent turbidity at the Jensen WTP was 93 NTU. **Figure 6-22** shows the three day time lag between the peak runoff measured at both Elderberry Forebay and Castaic Lake, and the peak turbidity at the Jensen WTP. Although plant influent turbidities were higher than normal, the treatment processes were able to keep the plant effluent turbidities in compliance. It is difficult to provide an analysis for other constituents besides turbidity, as these constituents are monitored less frequently than the duration of this incident.

Figure 6-21. Castaic Lake, 2005

CLWA was also impacted by high runoff in the Castaic Lake watershed, as CLWA operates the Rio Vista WTP and the Earl Schmidt WTP, which both treat 100 percent SWP water. **Figure 6-23** shows plant influent turbidities for both WTPs during this time period. Similarly to the MWDSC's Jensen WTP, peak turbidity at CLWA's Rio Vista WTP was 105 NTU on January 12, 2005.

Actions Taken

During this time, increased costs were incurred by MWDSC for increased chemical and sludge disposal costs (Personal Communication, Dr. Sun Liang, MWDSC). Similarly, CLWA increased coagulant, coagulant aid, and filter aid to treat the elevated turbidity in the raw water. CLWA also reported that backwashing of filters occurred more frequently (Personal Communication, Jim Leserman, CLWA).

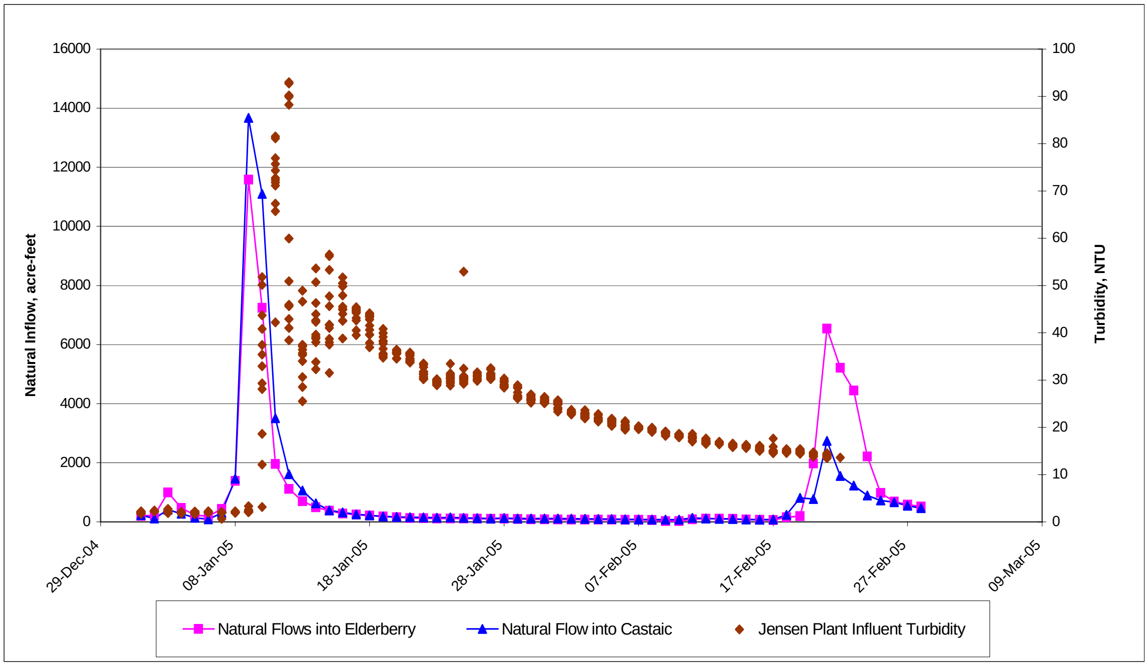
POTENTIAL ACTIONS

Periods of high runoff and associated turbidity occur infrequently in the Castaic and Silverwood watersheds. During periods of heavy rain and runoff, water treatment plant operators should continue the current practice of optimizing treatment. Source control actions to reduce runoff and turbidity are not warranted, unless there is a fire in the watershed due to the infrequency of these events and normal settling in the lakes.

DWR to Assess Fire-Impacted Watersheds and Determine if Further Actions Needed to Protect Water Quality

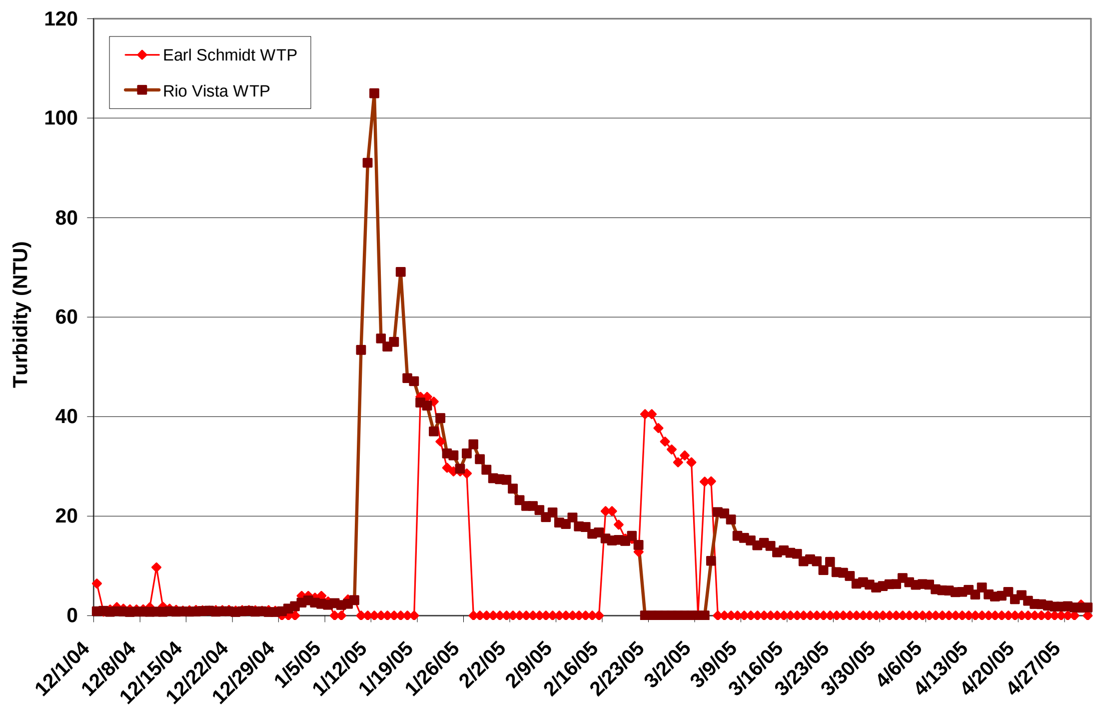
The Contractors should request that DWR play an active role whenever there is a fire within the watersheds of the SWP. Although DWR may not have the specific expertise to assess a fire-burned watershed, DWR can work with agencies such as the NRCS or the various BAER teams when they are assembled to assess watershed conditions. A summary report showing the watershed, the burn area, and watershed assessment should be compiled and provided to the impacted Contractors. If there are any proactive measures which can be taken to lessen erosion and protect water quality, these measures should be presented to the impacted Contractors for consideration.

Figure 6-22. Influent Turbidities at Jensen WTP During Period of High Runoff



Graph provided by MWDSC

Figure 6-23. CLWA Treatment Plant Maximum Daily Influent Turbidities



OIL SPILL IN PYRAMID LAKE

Pyramid Lake is the first reservoir on the West Branch of the California Aqueduct. Pyramid Lake is located in the Angeles and Los Padres National Forests, about 60 miles northwest of downtown Los Angeles. Water from the SWP flows into the lake at the end of the Peace Valley Pipeline at Mile 14.07 of the West Branch of the California Aqueduct. The reservoir has a storage capacity of about 171,200 acre-feet, and provides regulatory storage for the Castaic Powerplant, normal regulatory storage for water deliveries from the SWP West Branch, emergency storage in the event of a shutdown of the SWP to the north, recreation opportunities, and incidental flood protection.

Pyramid Lake water flows to the Castaic Powerplant via the Angeles Tunnel and into Elderberry Forebay and Castaic Lake. Water is pumped back into Pyramid Lake during off-peak power usage periods so that power can be generated during peak power usage periods. Due to the Castaic Powerplant, water is frequently exchanged between Pyramid and Castaic Lake. There are no Contractors receiving water directly from Pyramid Lake. As discussed previously, Castaic Lake supplies water to MWDSC, Castaic Lake Water Agency, and the Ventura County Flood Control District.

Although this section focuses on an oil spill in the Pyramid Lake watershed, the presence of one oil pipeline in the Castaic Lake watershed was documented in the previous 2001 Sanitary Survey Update (DWR, 2001). According to the 2001 Sanitary Survey, the pipeline is approximately one mile away from the lake area and presents a low threat to Castaic Lake. There have been no reported oil spills in the Castaic Lake watershed over the reporting period.

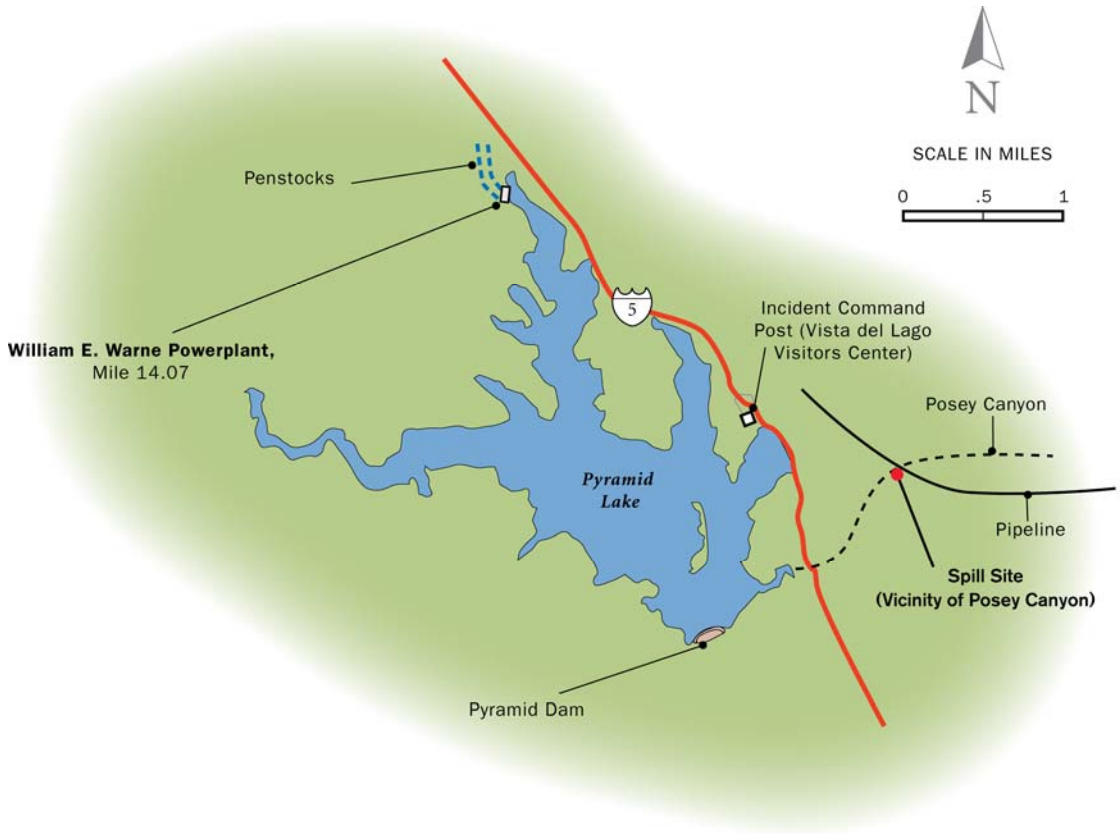
DESCRIPTION OF EVENT

On March 23, 2005, at approximately 1:00 p.m., an estimated 126,000 gallons of oil spilled into Posey Canyon, approximately 1.3 miles upstream from Pyramid Lake Due to heavy rainfall, a landslide broke the pressurized 14-inch pipeline as it was moving light crude oil from the southern San Joaquin Valley to Los Angeles area refineries. The pipeline is owned by Pipeline System LLC, a wholly owned subsidiary of Pacific Energy. **Figure 6-24** shows the location of the spill. **Figure 6-25** shows the spill was somewhat naturally contained in a cove of the lake.

WATER QUALITY IMPACTS

Samples were collected by DWR beginning March 24, 2005 (day after the spill) through approximately April 5, 2005. Samples were analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds, total extractable petroleum hydrocarbons, oil and grease, gasoline range organics, diesel range organics, and oil range organics. A cursory review of this data shows that the majority of samples were non-detectable. However, there were a few low level detections of toluene, total xylenes, methyl tert butyl ether (MTBE), and ethylbenzene. There was one detection of bis(2-ethylhexyl)phthalate at 6.7 μg/L, which was above the maximum contaminant level of 4.0 μg/L.

Figure 6-24. Location of Pyramid Oil Spill



Samples were collected by MWDSC from March 26 through April 7, 2005 at Pyramid Lake center, the Pyramid Outlet Tower, and the Piru Creek release point. Samples were analyzed for VOCs and flavor profile analysis at MWDSC's Water Quality Laboratory. No target VOCs were detected at or above the MWDSC laboratory's minimum reporting levels in any of the samples. However, in many of the samples there was evidence of oil/petroleum contamination as indicated by very low level detections (below the minimum reporting levels) of some of the target analytes [benzene, toluene, ethylbenzene, xylenes (BTEX)], as well as the presence of many non-target analytes (e.g., alkyl-benzenes). In regard to flavor profile analysis, the samples collected from Pyramid Lake exhibited strong petroleum odors at depths above 10 meters, with the intensity decreasing through the water column. In summary, strong evidence of oil contamination was observed through analytical and olfactory techniques in the upper layers of the water in samples collected five days after the spill. Although very low level detections decreased over the 13-day sampling period, strong petroleum odors persisted in the upper 10 meters of the lake.

Figure 6-25. Pyramid Oil Spill, Posey Canyon, March 2005

Figure 6-26. Clean-up Efforts Underway for Pyramid Oil Spill, March 2005

There was no immediate water quality threat to SWP Contactors, as MWDSC and CLWA receive water from Castaic Lake, and not directly from Pyramid. Water was not exchanged between Pyramid and Elderberry Forebay until oil contamination had diminished greatly at Pyramid. Additionally, water is withdrawn deep from both the Pyramid and Castaic Outlet Towers, which remained unaffected by the oil spill.

EXISTING EMERGENCY RESPONSE PROVISIONS

Response activities were directed by the unified command consisting of USEPA, DFG's Office of Spill Prevention and Response (OSPR), and Pacific Energy Partners. A command center was set-up at the Vista Del Lago Visitors Center.

The pipeline was immediately shut down and a culvert was bulldozed to minimize the flow to Pyramid Lake. Primary and secondary containment booms were placed across the mouth of Posey Canyon cove to isolate and contain the oil, vacuum trucks were sent to the site to vacuum up the oil from the water, and skimmers were used to remove surface oil. Oily debris (mostly twigs, sticks, and other vegetation) were removed from the lake and shore. **Figure 6-26** shows clean-up efforts underway on March 26, 2005. Crews also removed oil from capture pools created by underflow dams in the canyon leading to the cove. An underflow dam is one in which drain pipes are installed at the bottom of the dam, allowing clean water to flow into the lake, while keeping the oil in the pool behind the dam.

DWR and MWDSC were involved to determine when the water could be moved from Pyramid Lake to Elderberry Forebay. As mentioned earlier, both agencies collected water quality samples. DWR's Southern Field Division has an EAP which is designed to provide guidance to DWR staff responding to an emergency. The EAP has specific emergency response procedures for fire, floods, death or injury, emergency evacuation, and hazardous spills. However, USEPA and DFG's OSPR were in charge of this clean-up effort.

POTENTIAL ACTIONS

Request DWR to Provide a Summary Report to Impacted Contractors

The SWP Contractors should request that DWR provide a summary report for events such as wastewater spills or hazardous waste spills. The report should include a description of the event, description of the response, list of agencies involved and their roles, water quality data, data analysis, recommendations to prevent event in the future, evaluation of response and related recommendations. The report should be submitted to the SWC and all impacted SWP Contractors.

DWR to Seek Containment Equipment from Oil Companies to be Placed Near Reservoir

To better protect source water supplies from future oil pipeline breaks, it is critical that the containment of spilled oil be expedited. DWR or the SWC should request that the oil companies whose lines are located in the Pyramid watershed store spill contaminant equipment close to Pyramid reservoir.

Coordinate Emergency Response Drills with Oil Companies

Oil companies normally conduct practice emergency response drills for pipeline breaks. DWR and downstream SWP Contractors could coordinate with the oil companies to ensure that drills are being conducted. DWR and appropriate SWC staff may wish to consider participating in such drills with the oil companies.

Encourage Devices to Prevent or Reduce Oil Spill Volume When New Pipelines Installed

In the event a new oil pipeline is installed in any of the SWP watersheds, DWR should encourage oil companies to include devices, such as valves, in the design of the new pipeline. These devices can prevent continued spillage of oil if a pipeline break occurs. Additionally, devices which can improve detection of breaks in the pipeline should be considered.

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CHAPTER 7

Concerns with System Operation and Maintenance

CALIFORNIA STATE WATER PROJECT
WATERSHED SANITARY SURVEY
2006 UPDATE

CHAPTER 7
CONCERNS WITH SYSTEM OPERATION AND MAINTENANCE

The State Water Project (SWP) is a complex system that provides irrigation and drinking water to most regions of the state. As with any complex system, operation and maintenance problems are a continuous challenge. The SWP Contractors and the California Department of Water Resources (DWR) work cooperatively to address these issues. With a system as large as the SWP, many issues arise during a five-year period; however, the Technical Review Committee for the 2006 Update identified the following key issues for discussion and analysis as part of this sanitary survey:

- Clifton Court Forebay Sedimentation – The potential role sedimentation in Clifton Court Forebay (Clifton Court) plays in stimulating taste and odor (T&O) producing algae in the South Bay Aqueduct (SBA).

- Forebay and Storage Tank Maintenance on Coastal Branch – The potential impacts of sedimentation in forebays and storage tanks on T&O episodes in the Coastal Branch.

- Hesperia Master Drainage Plan – Efforts to remove urban runoff from the East Branch of the California Aqueduct (East Branch).

- Water Quality Changes Due to Demand Pattern Changes – The impacts of increased SWP deliveries and shifts in the timing of those deliveries on water quality in the East Branch

CLIFTON COURT FOREBAY SEDIMENTATION

KEY CONCERNS

Alameda County Flood Control and Water Conservation District, Zone 7 Water Agency (Zone7 Water Agency), Alameda County Water District (ACWD) and Santa Clara Valley Water District (SCVWD) treat water taken from the SBA and are collectively referred to as the SBA Contractors. The SBA Contractors have expressed concern that sedimentation of Clifton Court has resulted in a shallow water body that encourages algal and vascular plant growth that result in T&O problems. Biological growths in the Delta and/or Clifton Court have created T&O compounds that have passed rapidly through the SBA and have resulted in consumer complaints of T&O in treated drinking water produced from this source. Sudden changes in water quality, particularly those involving T&O compounds, are a key concern of the SBA Contractors.

While the close proximity of Clifton Court to the SBA creates immediate T&O concerns for SBA Contractors, other SWP Contractors, including those as far away as Southern California, are interested in conditions that create T&O incidents in the Sacramento-San Joaquin Delta (Delta), Clifton Court, the California Aqueduct, and other SWP reservoirs. For example, following the Jones Tract levee break in the Delta, a bloom of cyanobacteria (commonly known as blue-green algae) is believed to have been responsible for introducing *Planktothrix* into the SWP, affecting SWP Contractors as far south as Metropolitan Water District of Southern California (MWDSC). This event is described in further detail in Chapter 6.

Information is presented in this section on the amount of sediment potentially accumulating in Clifton Court. In addition, the available data are reviewed to determine if it is possible to relate current water quality measurements to known algal blooms and actual T&O incidents. As the focus of the 2006 Update is on developing an action plan for improving water quality, this analysis is directed toward evaluating available tools for their potential to provide early warning of impending T&O problems, and to identify measures that could reduce the extent of the T&O problems and the ability to provide early warning to SBA Contractors in the future.

Description of Clifton Court Forebay

Clifton Court, located in the southern Delta, is the forebay to H.O. Banks Delta Pumping Plant (Banks). Its intake structure on Old River is the point where water is drawn from Delta channels into the conveyance and storage facilities of the SWP south of the Delta. **Figure 7-1** is a location map of the facility. Water is taken into Clifton Court through radial gates located on the southeast side of the reservoir. The intake gates are generally opened during high tides when water can flow freely into the reservoir. During low tides the intake gates are closed to maintain the surface water elevation of the reservoir. The maximum flow rate through Clifton Court is presently 12,000 cubic feet per second (cfs) due to operational constraints, though plans exist for improvements that would permit a capacity increase. If the reservoir were at its design capacity, the currently permitted maximum flow would result in the reservoir volume being exchanged in about 32 hours. Clifton Court operating constraints include requirements to preserve water levels in southern Delta channels, and to protect Delta channels from scouring caused by excessive flow velocities. The SWP must also be operated in compliance with terms of the water quality provisions embodied in the water rights permit issued by the State Water Resources Control Board (State Water Board).

After passing through fish screens, water flows through an intake channel connecting the west side of Clifton Court to Banks. The distance from Clifton Court intake to Banks is about three miles. Water is then pumped into the California Aqueduct. Like most of the pumping facilities of the SWP, Banks is generally operated during the night time hours, or “off peak”, when energy demands and power costs are lower. From Banks, water flows through 1.2 miles of the California Aqueduct to Bethany Forebay, where it is pumped into the SBA by the South Bay Pumping Plant. Del Valle Check 7 (DV Check 7) is located at SBA Mile 16.32, and the aqueduct ends at the Santa Clara Terminal Reservoir (Terminal Tank), at Mile 42.18. Thus, the distance from Clifton Court to the end of the SBA is about 50 miles. The key features of the SBA were shown previously in **Figure 3-3**. The close proximity of the Delta and Clifton Court to the intakes of the SBA Contractors means that water quality conditions in the Delta and Clifton Court are quickly transported to their water treatment plant intakes, often with little warning.

Figure 7-1. Clifton Court Forebay

Base Map Source: Google

Travel Time Along SBA

The design capacity of most of the SBA is 300 cfs, and the wetted cross-section of the open aqueduct is about 65 square feet at design depth. Computation of velocity and distance indicates that, at design flow, water could travel from the South Bay Pumping Plant to DV Check 7 in about five hours and to the Terminal Tank in about 13 hours. Electrical conductance (EC) data were analyzed to estimate travel times through the SBA during high and low flow conditions. EC has been measured continuously at Clifton Court intake, Banks, DV Check 7 and the Terminal Tank, however monitoring at the latter location was discontinued in 2002. These measurements provide a marker that is useful for tracking water as it flows through the SBA. During the years 2001 through 2004, diversions into the SBA for the high demand months of May through August averaged 215 cfs. During the same years, diversions for the low demand months of November through February averaged 76 cfs. Daily mean EC data for the two time periods were used for the analysis. For Clifton Court intake, Banks, and DV Check 7, EC data for 2001 to 2004 were used, and available data for 2001 to 2002 were used for the Terminal Tank. Daily EC for pairs of monitoring stations were compared and regression coefficients computed. Then, the data for the upstream station were shifted forward in one-day increments (as if all the measurements at the upstream station were made one day later) and compared

statistically. The best correlation coefficient indicates the best EC match, which should provide an indication of how long water generally takes to flow from one station to another.
Results of this analysis are shown in **Figure 7-2.** An r^2 of 1.0 indicates a perfect match, whereas 0 means there is no linear relationship between the two sets of numbers being compared. During the high demand months of May through August, water flowed from Clifton Court intake to Banks in about three days, from Banks to DV Check 7 in one day, and reached the Terminal Tank on the same day it arrived at DV Check 7. During the low demand months of November through February, water flowed from Clifton Court intake to Banks in one day, from Banks to DV Check 7 in three days, and from DV Check 7 to the Terminal Tank in four days. Therefore, estimated travel time from Clifton Court intake to the Terminal Tank was about four days in the May through August period and eight days during the November through February period. Algal blooms and other Delta water quality problems quickly become problems for the SBA Contractors due to the short travel times in the SBA. Early warning of Delta water quality problems would assist the SBA Contractors in adjusting water treatment operations.

Sedimentation of Clifton Court Forebay

The maximum surface area of Clifton Court is 2,180 acres. At the time of its construction in the late 1960's, its design capacity was 31,260 acre-feet and it had an average depth of 14.3 feet. Since that time, the reservoir has retained sediments that have been removed periodically to maintain reservoir capacity. The reservoir was last dredged in 1992, when approximately 400,000 cubic yards of sediments were removed (Roger Foote Associates, 1993). Its current capacity is unknown.

The velocity of water slows after it enters Clifton Court and sediment entrained in the water column settles out. This has been particularly noticeable in the vicinity of the intake structure, which is the location from which accumulated material was last removed in 1992. Sedimentation patterns are affected by the velocity of the water passing through the reservoir, with higher velocities causing higher sediment loads to stay in suspension. Because the Delta is characteristically windy, and because of the relatively shallow depths of the reservoir, wind action can stir bottom sediments, causing pronounced increases in turbidity within Clifton Court.

Figure 7-3 depicts the relationship between turbidity and wind speed measured at Banks from 1992 through 2002 (Janik, 2002). According to this figure, turbidity at Banks appears to be significantly affected by wind, with highest turbidities coinciding with highest average and maximum wind speeds. As Clifton Court Forebay has become shallower in places since dredging last occurred in 1992, there is a concern that bottom sediments can be more readily disturbed, causing turbidity problems to increase. **Figure 7-4** is a plot of median annual turbidity at Banks over the period 1992 through 2005. While this figure depicts substantial swings, it appears 1993 was similar to 2004 and 2005, and 1994 was similar to 2003. This depiction fails to demonstrate a consistent pattern of worsening turbidity problems.

Figure 7-2. Estimated Travel Time from Clifton Court Intake to SBA Terminal Tank

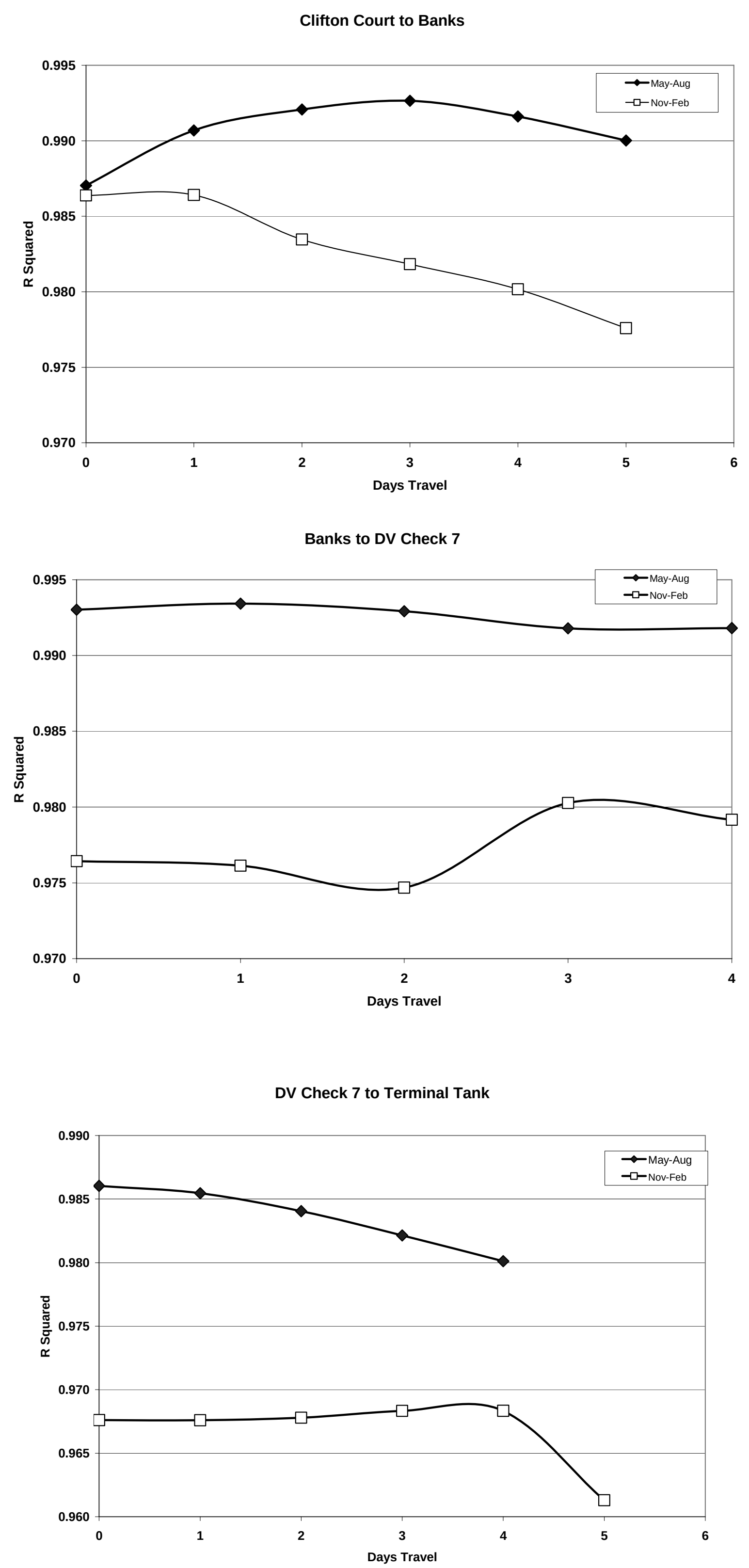


Figure 7-3 Relationship of Turbidity to Wind at Banks

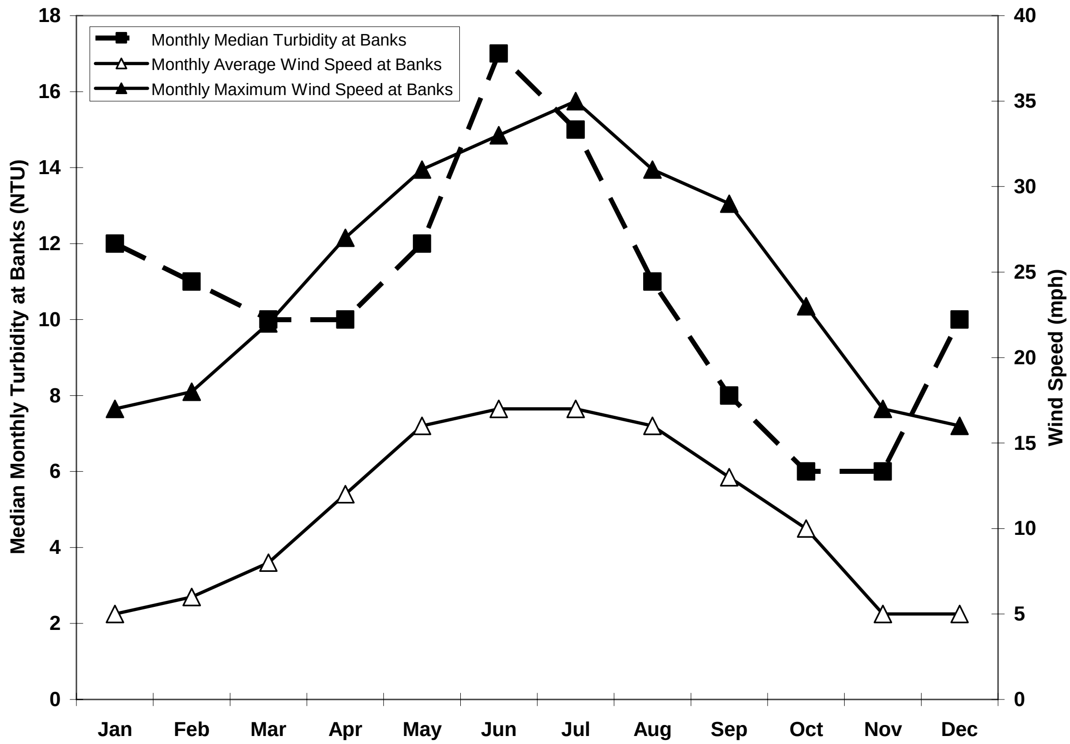
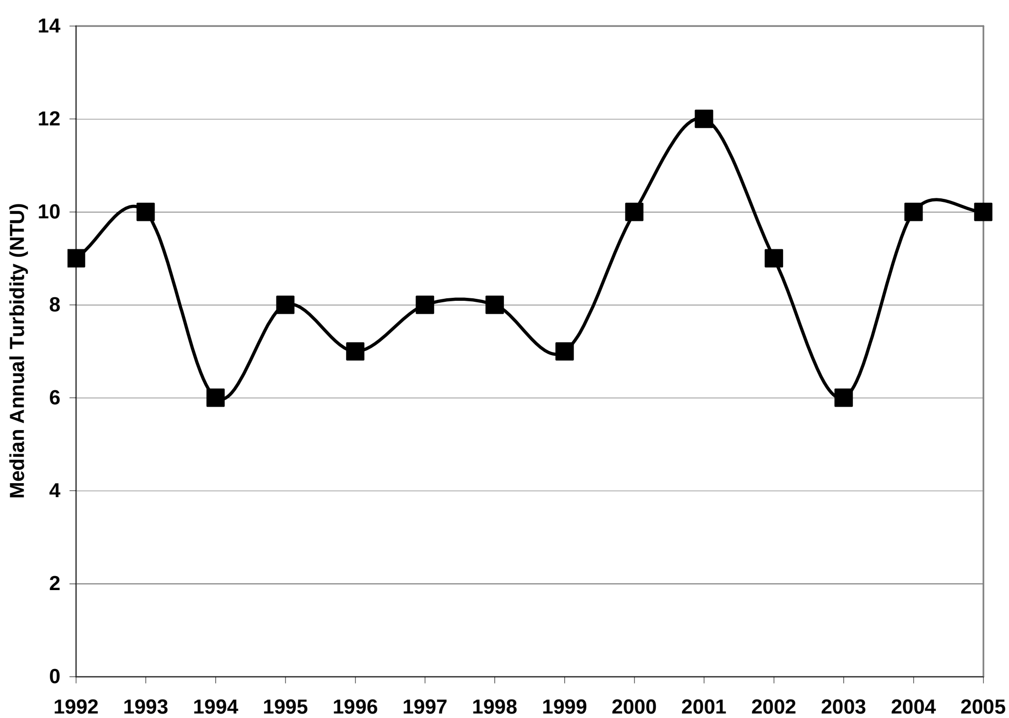


Figure 7-4 Annual Median Turbidity at Banks



The reservoir is operated on a tidal cycle basis, with the gates being opened during high tides, allowing water to flow in from Old River. The complexities associated with operation of the forebay, along with wind effects, greatly complicate the patterns of sedimentation and sediment re-suspension in Clifton Court, as seen in **Figure 7-5.** This figure presents grab sample data for total suspended solids (TSS) on the same days at Clifton Court intake and at Banks. The period of October 2003 to July 2006 was selected because samples were collected from both locations on the same days. While there is general correspondence in the pattern of TSS concentrations found at both locations, concentrations at Banks can be higher than at Clifton Court, indicating there are times when there is net sediment removal from the forebay. However, using the entire data record between July 2000 and June 2006 when samples were collected on the same day at both locations yields an average TSS at Clifton Court intake of 13.2 mg/L, and an average at Banks of 9.7 mg/L. This indicates there is, overall, a net sediment accumulation in the forebay. Based on the suspended solids data, 9.5 pounds of sediment would accumulate for every acre-foot of water flowing through Clifton Court. This calculation suffers, however, from a relatively small amount of data (46 samples collected same day at each location), and relies on the assumption that observed turbidity is due exclusively to inorganic matter and not to phytoplankton.

To determine the reasonableness of the sedimentation rate estimate, the total amount of sediment that would have accumulated in Clifton Court between 1993 and the end of 2005, based on the 9.5 pounds per acre-foot rate, was calculated to be about 80,000 cubic yards. **Table 7-1** provides the basis for the calculations. This computation suggests the sedimentation rate estimate may be in the correct order of magnitude.

Further insight into suspended sediments in Clifton Court may be gained by comparing turbidity measurements made at Clifton Court and at Banks by automated monitoring equipment that takes measurements at both locations with high frequency. **Figure 7-6** and **Figure 7-7** are frequency histograms of daily average daily turbidity measurements from continuous recorders during the period 1995 through 2005 at Clifton Court intake and Banks, respectively. The most commonly observed turbidities at Clifton Court were between 10 and 15 NTU, with about 30 percent of the values falling within that range. By contrast, the highest frequency turbidity range at Banks was 5 to 10 NTU, with about 40 percent of observed values falling within that range. Turbidities averaged 16 NTU at Clifton Court intake and 11 NTU at Banks. The 95 percent confidence interval about both means was 0.3 NTU, indicating that the observed difference is statistically significant. Unfortunately, there is not a means of translating turbidity measurements into mass loads. The suspended solids data indicated that about 27 percent of the sediment load entering Clifton Court is deposited there as the water passes through (mean 13.2 mg/L compared to 9.7 mg/L). Turbidity at Banks averaged 31 percent lower than at the intake to Clifton Court. If the turbidity difference was entirely due to sediment deposition in the forebay, this number compares favorably to the deposition estimate made by interpreting suspended solids data.

Figure 7-5. Comparison of Suspended Solids Concentrations

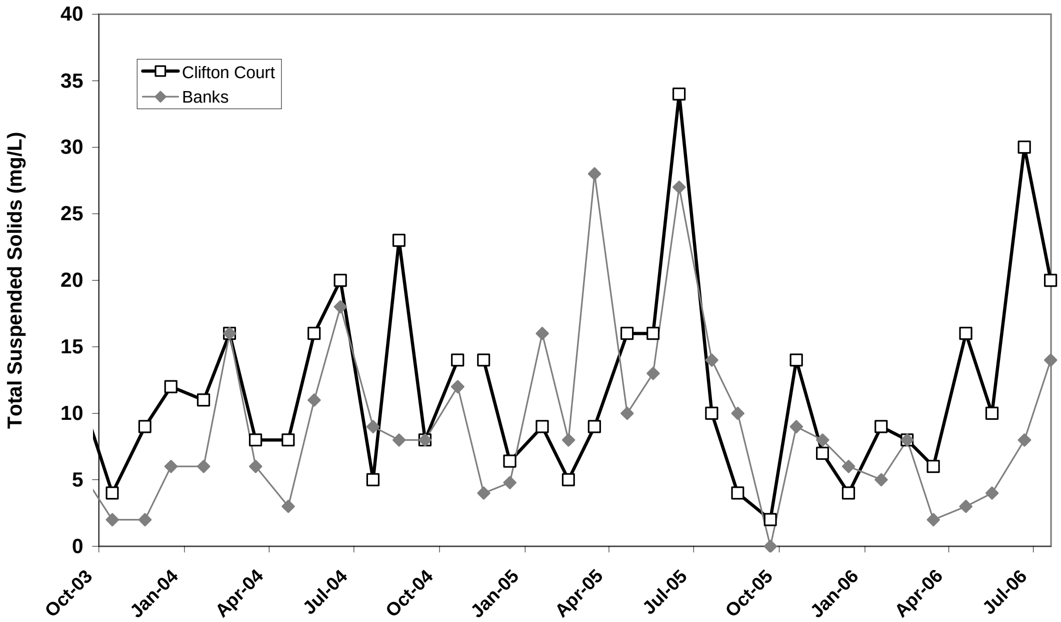


Table 7-1. Computations of Sediment Accumulation in Clifton Court 1993-2005

1. Average flow through Banks during the period 1993-2005: 3878 cfs or 7692 acre-feet/day.
2. 7692 acre-feet/day for 13 years (4748 days) = 3.652×10^7 acre-feet.
3. Assuming sediment specific gravity is 2.7 (specific gravity of continents from The Handbook of Chemistry and Physics), sediments weigh 4365 lb/cubic yard.
4. Assuming sediment accumulation rate is 9.5 lb/acre-foot flow through Clifton Court, 9.5 lb/acre-foot * 3.652×10^7 acre-feet = 3.470×10^8 lbs sediment.
5. 3.470×10^8 lbs / 4365 lb/cubic yard = 79480 cubic yards of sediment accumulation during 1993-2005.

Figure 7-6. Frequency Histogram of Daily Average Turbidity Measurements at Clifton Court Intake

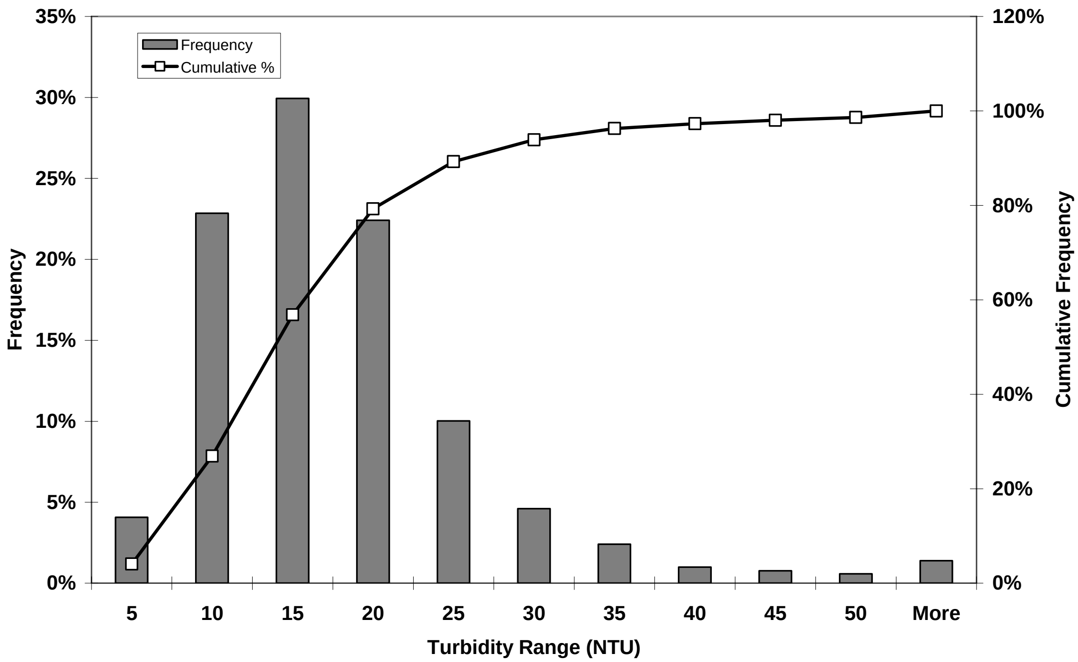
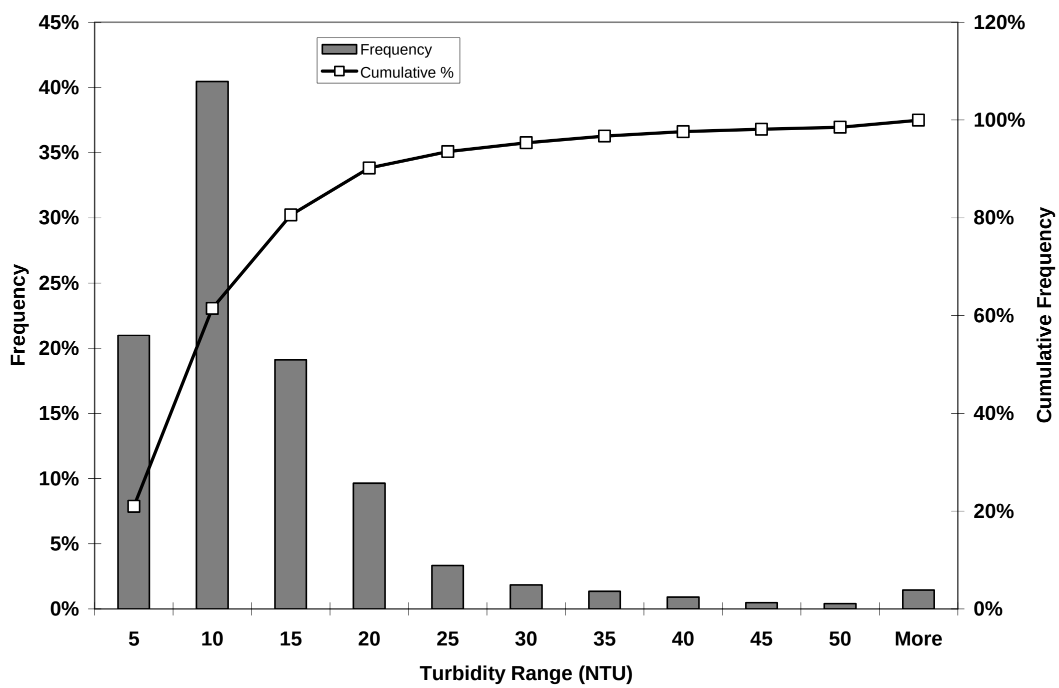


Figure 7-7. Frequency Histogram of Daily Average Turbidity Measurements at Banks



Algal Production in Clifton Court and Delta

Nutrients, algal blooms, and T&O problems throughout the SWP were described in Chapter 3. Chapter 5 contains a discussion of the algal and T&O problems faced by the SBA Contractors. Benthic cyanobacteria produce methyl isoborneol (MIB) and geosmin and result in T&O problems for the SBA Contractors. As described in Chapter 5, DWR's copper sulfate program has been effective in reducing blooms in the SBA but there is uncertainty over the future use of copper sulfate to control algal blooms. Although benthic cyanobacteria grow in the SBA, the most severe T&O incidents appear to be related to blooms of benthic cyanobacteria in Clifton Court.

The focus of this section is on the detection of benthic cyanobacteria blooms in Clifton Court. It has proven more difficult to control cyanobacteria and algae in the forebay than in the aqueduct, and a major challenge has been to understand the dynamics of growth in the forebay well enough to know where and when to take control actions. Although cyanobacteria are technically not algae, they are commonly called blue-green algae and the term "algal blooms" is used in this section to include both cyanobacteria and algae.

Monitoring Methods

Data from continuous turbidity, fluorescence, and pH recorders, along with laboratory and field analyses of discrete samples were used to analyze conditions in Clifton Court. Because the presence of problem-causing algae and cyanobacteria must be detected by use of instrumentation, it is necessary to discuss population dynamics in terms of the instruments and techniques that are used to provide insight into their life cycles, and the limitations these tools have.

Turbidity

Turbidity measurements are made by automated, continuous recording equipment installed at Clifton Court intake and at Banks. Turbidity is measured by passing light through a sample and quantifying the proportion of the incident light that can pass unobstructed through the sample. As such, any particulate matter capable of deflecting the light beam will be recorded as turbidity, whether the material is inorganic sediment, living matter such as algae and zooplankton, or non-living organic matter such as decaying vegetation. Therefore, while turbidity measurements are useful, they have this limitation. For example, if there was a phytoplankton (free floating algae) bloom in Clifton Court, turbidity measurements made at the intake could be higher than those at Banks suggesting a loss of sediment from the forebay while, in actuality, the increased turbidity would be due to the presence of large numbers of algae in the water column of the forebay.

Fluorescence

Photosynthesizing organisms, such as algae and vascular plants, derive energy from absorbing light at a short wavelength, converting some of the energy, and emitting (or fluorescing) light at a longer wavelength. Instruments are capable of measuring fluorescence on a continual basis, and the readings are an indication of photosynthetic activity. Automated fluorometers are installed at Clifton Court intake and Banks, and the data produced by these instruments may provide a clue to algal population dynamics in the Delta and Clifton Court.

pH Measurements

Continuous recording of pH is made at Clifton Court intake and Banks. pH can, potentially, be useful for detecting algal blooms, as the photosynthesis process tends to drive pH up during the daylight hours.

Discrete (Grab) Sampling Data

Water quality samples are regularly taken from Clifton Court intake and from Banks and analyzed for numerous constituents, including total and volatile suspended solids. Samples taken from Delta channels through the Interagency Ecological Program (IEP) are analyzed for chlorophyll *a* and pheophyton *a*, and phytoplankton samples are identified and enumerated, and phytoplankton biomass estimated.

Dissolved Oxygen

Dissolved oxygen (DO) measurements can be useful for detecting the presence of large algal populations, because high photosynthetic activity during daylight hours and algal respiration during night time hours can cause wide swings in DO. A well aerated water sample can contain DO concentrations approaching its saturation point, which depends on atmospheric pressure and temperature. When algae photosynthesize, they produce oxygen that can dissolve in the water and raise the DO concentration up to and beyond the saturation point. Super-saturation occurs when DO levels exceed the concentration at which saturation naturally occurs at a given temperature and atmospheric pressure. Typically, waters with high concentrations of healthy algae will cause the DO level in the water to steadily increase to super-saturation as the day progresses, and then fall to low levels that are sometimes harmful, or fatal, to fish and other aquatic organisms as the algae cease photosynthesizing and consume oxygen during the night time hours.

Detection of Problematic Algal Blooms

Because human ability to detect tastes and odors varies, T&O thresholds are a somewhat subjective measurement. Also, agencies differ in their approaches to managing T&O, so there is no single number that reflects an acceptable level of MIB, nor of geosmin. While 10 ng/L is generally accepted as the concentration that begins to result in customer complaints, the SBA Contractors have developed the thresholds shown in **Table 7-2.**

Table 7-2. SBA Contractor Thresholds

SBA Contractor	MIB (ng/L)	Geosmin (ng/L)
Zone 7 Water Agency	9	4
ACWD	5	5
SCVWD	8	10

Figures 7-8 and 7-9 show the MIB and geosmin concentrations measured at Banks between 2001 and 2005. As indicated on **Figure 7-8**, MIB concentrations have greatly exceeded the lowest threshold of 5 ng/L set by ACWD during the summer months in 2003, 2004, and 2005. **Figure 7-9** shows that geosmin concentrations have exceeded the lowest threshold of 4 ng/L set by Zone 7 Water Agency much more frequently. During 2001 and 2002, the peak concentrations occurred in the fall, whereas in 2003 to 2005, the peak concentrations occurred in July and August.

Figure 7-8. MIB Concentrations at Banks

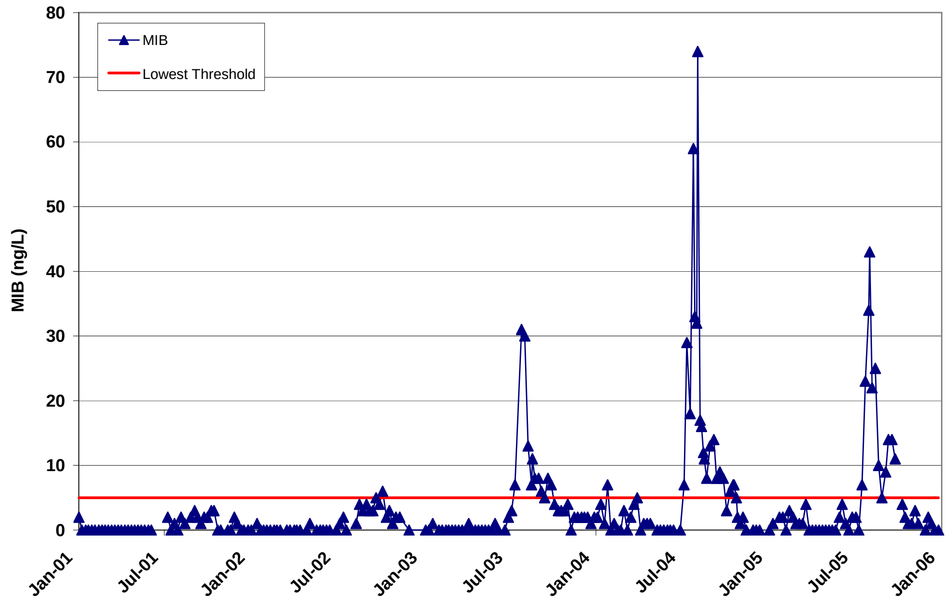
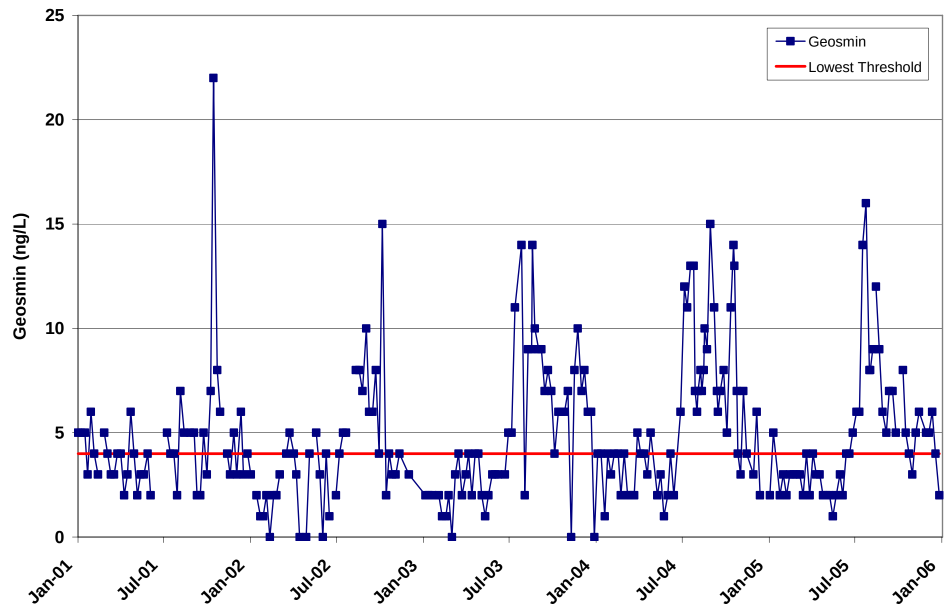


Figure 7-9. Geosmin Concentrations at Banks



Water quality data were examined for several significant T&O incidents that created difficulties for the SBA Contractors. These data were evaluated to determine if it is possible to provide early warning of incidents in the future. **Table 7-3** is a summary of incidents during the 2001-2005 period of this study, as recorded in monthly water quality summary reports prepared by the DWR Division of Operations and Maintenance. The following three periods were selected for analysis:

- August 2003 - A bloom of benthic cyanobacteria occurred in Clifton Court during August 2003. This bloom was associated with the highest MIB concentration (30 ng/L) detected to that date in Clifton Court since monitoring for this compound began in 2000. Geosmin concentrations were also elevated (14 ng/L).

- July and August 2004 - During the last week of July and first week of August 2004, high concentrations of MIB (up to 55 ng/L) and geosmin (up to 12 ng/L) were observed at Clifton Court intake. The source was believed to be benthic cyanobacteria. During this period, a levee break on Jones Tract in the Delta resulted in MIB concentrations of up to 1000 ng/L entering Delta waters.

- August 2005 - On August 3, 2005, MIB at Clifton Court intake reached 78 ng/L while Banks had a concentration of 43 ng/L, indicating the algal bloom originated in the Delta and traveled through Clifton Court. Geosmin concentrations were also elevated.

These periods correspond with elevated MIB and geosmin levels in the SBA, as discussed in Chapter 5.

These incidents are believed to have been caused by benthic cyanobacteria in the Delta and Clifton Court. Because benthic cyanobacteria and algae are not free floating in the water, measurements of turbidity, fluorescence and suspended solids may not be sensitive to their presence. However, T&O incidents are known to sometimes be associated with periods when benthic growths are decomposing, breaking free, and spilling their cellular contents into the water. Therefore, these measurements have the potential to provide useful information even on blooms of benthic algae. Dissolved oxygen and pH measurements are indicators of photosynthesis and respiration so they can be expected to be sensitive to the presence of both benthic and planktonic algae.

<u>Fluorescence</u>

Figure 7-10 is a time series plot of fluorometric measurements at Clifton Court intake and at Banks made during the 2001 through 2005 period of this study. This figure indicates that there is a general correspondence between fluorometric measurements at the two locations, but there are also periods when large differences are observed. Fluorometers are relatively delicate and, like other unattended monitoring instruments, are capable of giving erroneous data. Therefore, without validation by separate means, fluorescence spikes have the potential to be artifacts. That caution in mind, during the early months of 2001 fluorescence at Clifton Court intake was much higher than at Banks. Between 2001 and 2004 there were a number of months when fluorescence

at Banks was higher than at Clifton Court, possibly indicating algal activity in Clifton Court that did not originate in the Delta.

Table 7-3. Summary of Algal Bloom and Taste and Odor Incidents Affecting Clifton Court

Month/Year	Comment
August 2003	A taste and odor episode began in late July in Clifton Court Forebay with MIB exceeding 30 ng/L, the highest values since monitoring began in fall 2000. Elevated levels of MIB were produced by benthic cyanobacteria (blue-green algae) and resulted in a large number of complaints from customers served by South Bay Aqueduct water. Copper sulfate was applied to the Forebay on 8/13/03 and MIB levels declined to less than 10 ng/L.
September 2003	Taste and odor values have been relatively low since the last report. They remain in the range of 5 to 10 ng/L. Copper sulfate treatment at Clifton Court Forebay was effective in reducing the production of MIB.
October 2003	The taste and odor compound MIB, was high in Lake Del Valle and Clifton Court Forebay. Selective release from the lower valves in Lake Del Valle reduced MIB in the South Bay Aqueduct.
April 2004	MIB and geosmin continued to be low project wide. However, geosmin has been increasing at the Clifton Court Forebay Inlet during the past month.
July 2004	High levels of geosmin (≈ 20 ng/L) have been identified at Clifton Court Intake.
August 2004	MIB and geosmin in Clifton Court Forebay Inlet were similar to last week at 5 ng/L and 8 ng/L, respectively. MIB at Banks Pumping Plant was higher than the Inlet at 12 ng/L. Dramatic reductions in MIB levels were recorded at Jones Tract. The concentration declined from over 1000 ng/L on July 28 to 9 and 16 ng/L on August 16, 2004 in Upper and Lower Jones Tract discharge, respectively.
September 2004	In Clifton Court Forebay Inlet, MIB remained at 10 ng/L this week while the compound decreased in Jones Tract to 19 ng/L (UJDC) and 9 ng/L (LTDC).
August 2005	Clifton Court inlet MIB and geosmin were 38 and 7 ng/L, respectively, while at the outlet MIB concentration was 109 ng/L[a].

Source: SWP Monthly Water Quality Summaries – available online at http://wwwomwq.water.ca.gov/MonthlyReportsPage/index.cfm

[a] Note: The 109 ng/L MIB concentration was subsequently removed from the O&M database.

Figure 7-10. Fluorescence at Clifton Court and Banks

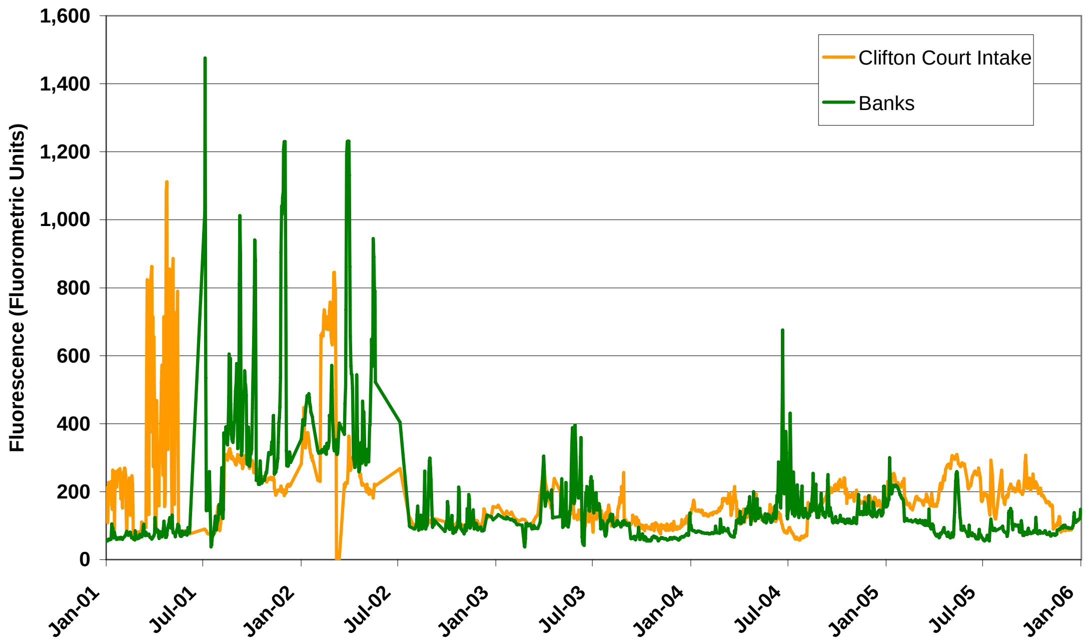
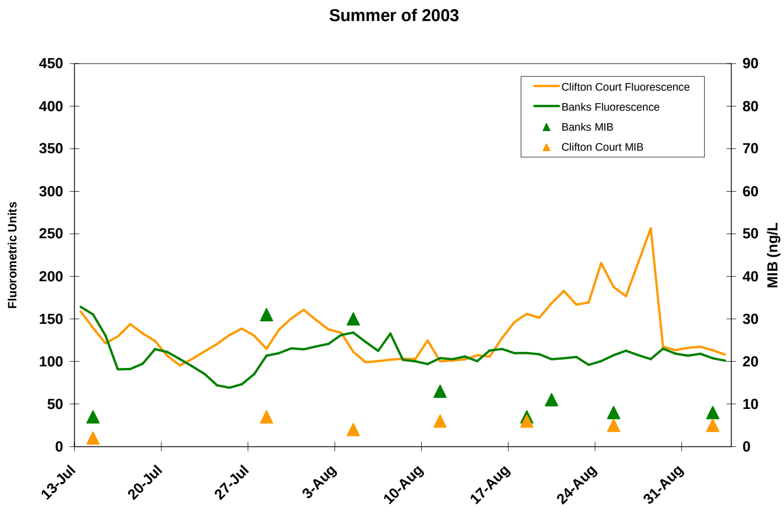
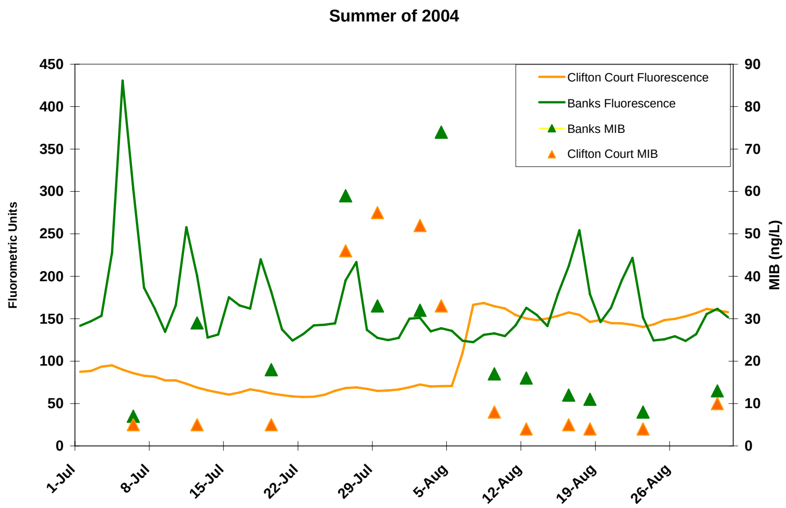
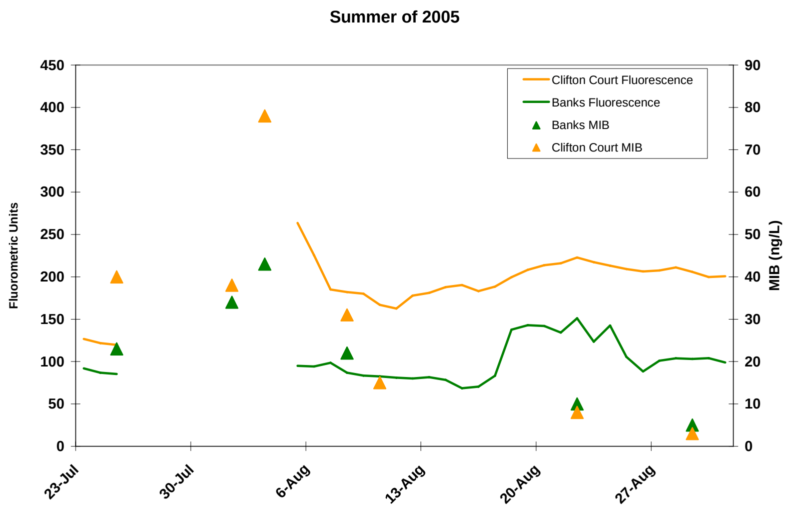


Figure 7-11 shows mean daily fluorescence readings taken at Clifton Court intake and Banks and MIB concentrations during the periods of algal blooms in the summers of 2003, 2004, and 2005. These data do not show a relationship between fluorescence readings and MIB concentrations at either location. The fluorescence readings during the summer of 2003 provide no indication that an algal bloom was occurring in Clifton Court during August, and were not sensitive to the effects of a copper sulfate treatment on August 13. During the summer of 2004, a levee break on Jones Tract in the Delta resulted in MIB concentrations of up to 1000 ng/L entering Delta waters. The spike in MIB concentrations at Clifton Court and Banks is clearly seen in the plot for 2004. Interestingly, fluorescence at Banks declined during the period of peak MIB concentrations and remained flat at Clifton Court. Fluorescence increased at Clifton Court after the MIB concentrations dropped. The Clifton Court fluorometer may have been malfunctioning in July and early August 2004 but the Banks fluorescence readings also did not correspond with the peak. During the summer of 2005 the fluorometers were not functioning for about ten days during which there were peak MIB concentrations at both Banks and Clifton Court intake. The MIB data indicate that this bloom originated in the Delta and traveled through Clifton Court to Banks. Over the five year period 2001 to 2005, fluorescence at Clifton Court intake averaged 188 fluorometric units (FU), with a standard deviation of 126 FU. Mean fluorescence at Banks was 168 FU with a standard deviation of 166 FU. Given the high variability of the data, and the inconsistent responsiveness of fluorometric measurements during known periods of algal blooms and presence of T&O compounds, fluorescence measurements do not reliably predict algal blooms and can not reliably be used as an indication that T&O events are occurring in the Delta or Clifton Court.

Figure 7-11. Fluorescence at Clifton Court and Banks During Algal Blooms







pH Measurements

Diurnal swings in pH are often associated with algal blooms. The hourly pH readings recorded at Banks during the peak algal blooms in the summers of 2003, 2004, and 2005 are presented in **Figure 7-12.** Daily pH fluctuations are apparent, with maxima generally occurring late at night and minima usually occurring in the morning, but there is considerable variability in the data. Daily pH excursions were generally small, about 0.2 to 0.5 pH units. In 2003, differences among blocks of time are evident in the pH data, but it is unclear whether the data are accurate or whether the equipment was operating well during a substantial part of the period of interest. There may have been a pH instrument response beginning on July 15 and continuing until July 27, possibly presaging the 30 ng/L MIB reading that was made on July 28. On the other hand, the instrument appears not to have been functioning well prior to July 15. The plots for 2004 and 2005 indicate that there is not a consistent relationship between pH and the T&O compounds. The seemingly erratic behavior of the instrument suggests that, if it were to produce information that could be used to predict T&O incidents, improvements would be needed in the equipment and/or maintenance. pH measurements show daily fluctuations that should, at least in part, be attributable to photosynthetic and respiratory activity in the system; however, the instrumentation appears to be insensitive to conditions under which T&O compounds are formed.

Turbidity

Mean daily turbidity readings taken from automated recorders at Clifton Court intake and Banks are shown in **Figure 7-13.** An interesting turbidity spike occurred at Banks on August 3, 2003 that corresponded with high levels of MIB. Unfortunately, the instrument was out of service for the ten days prior to the spike so it is unclear whether this apparent increase actually occurred, or was a false reading. A second spike occurred on August 7 at both locations, with the Clifton Court spike being the greater of the two, which would be expected if suspended material entered Clifton Court and settled before reaching Banks. Since there is no time lag between the spikes, a more likely explanation might be windy conditions that stirred up sediments. The data for 2004 and 2005 are plotted on the same scale as for 2003 so the three years can be compared. There is no apparent relationship between turbidity and MIB concentrations during these two years. Turbidity readings would not be likely to reflect the presence of benthic algae, but might indicate the results of treatment if decomposing material entered the water column. No corroborative evidence was seen, however. Turbidity measurements made by unattended autosampling equipment tend to be fairly reliable, but turbidity measurements do not distinguish between living and non-living suspended matter.

Figure 7-12. pH at Banks During Algal Blooms

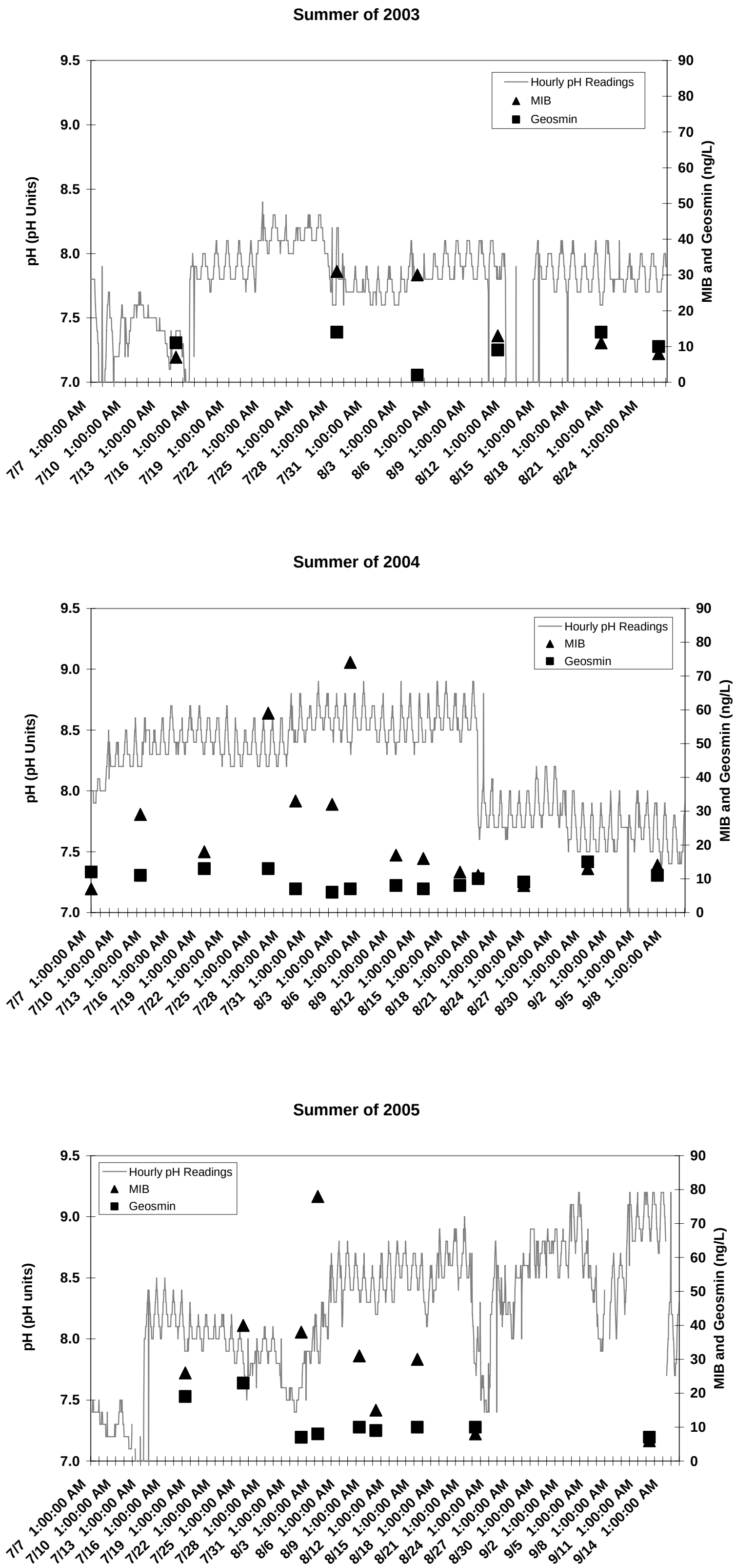
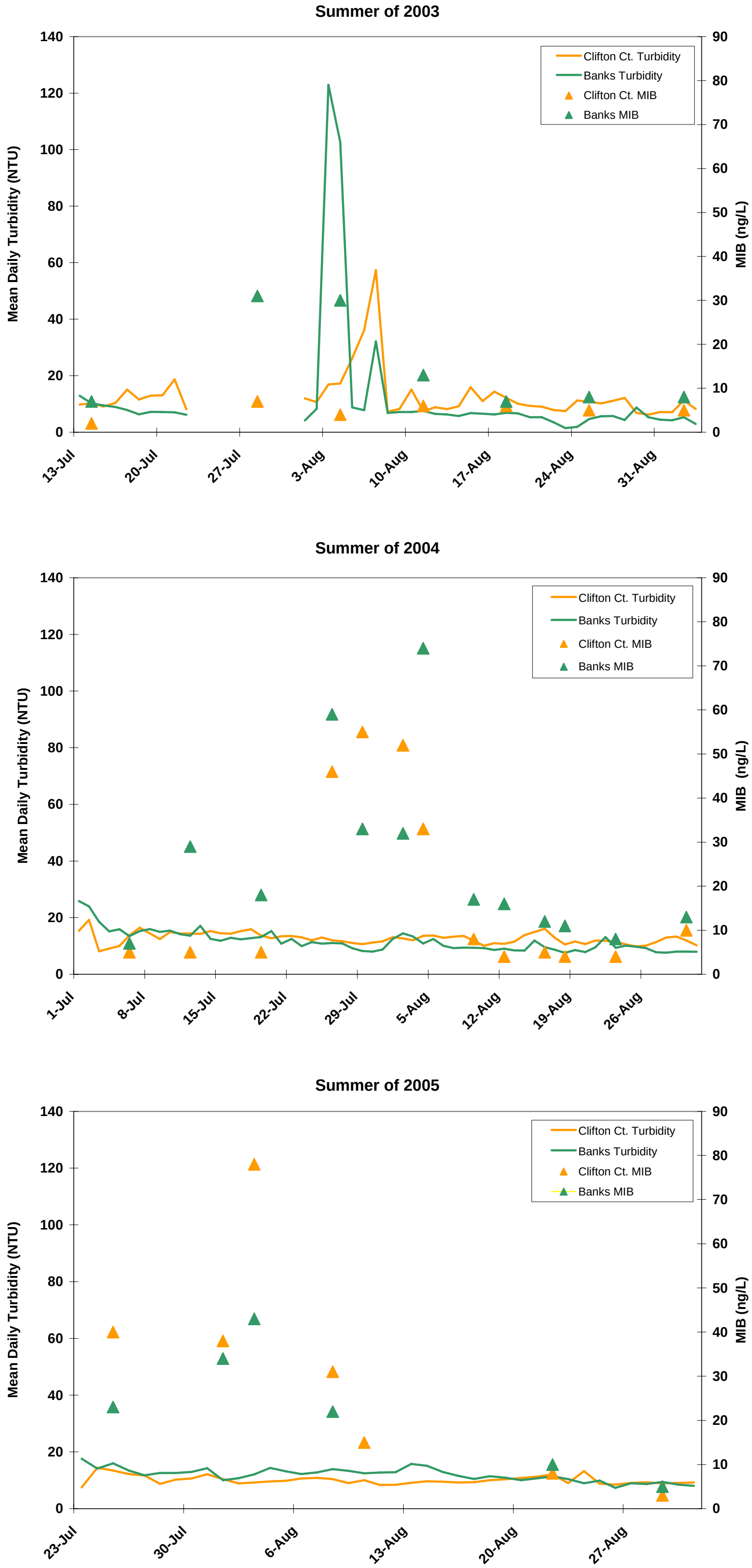


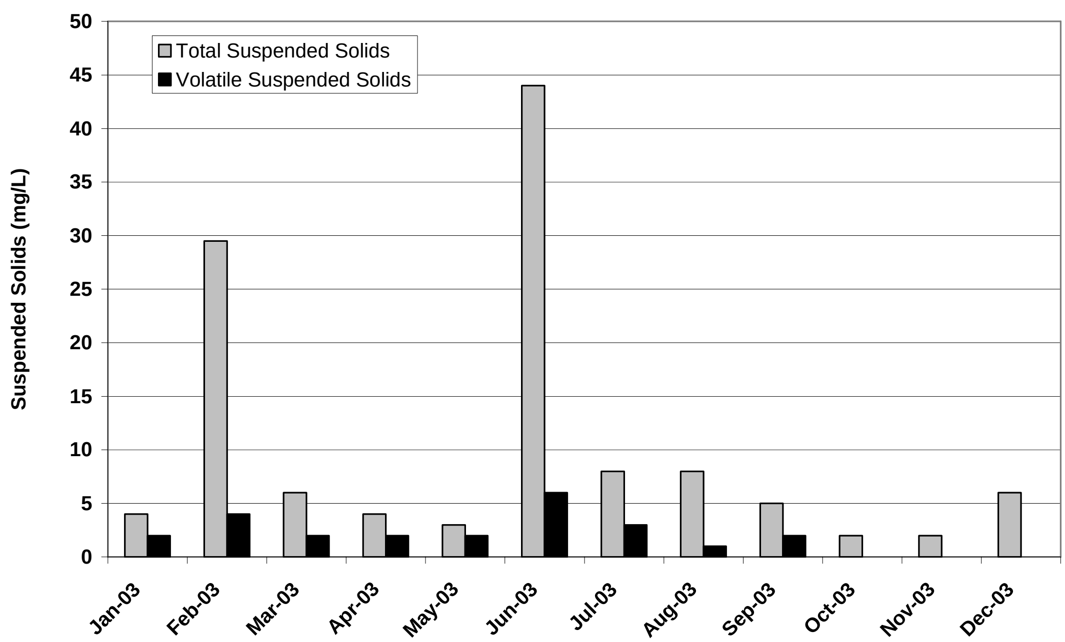
Figure 7-13. Turbidity at Clifton Court Intake and Banks During Algal Blooms



Total and Volatile Suspended Solids

Figure 7-14 depicts results of total and volatile suspended solids analyses of discrete samples taken from Banks during 2003. The presence of algae in the water column might be expected to increase the proportion of volatile suspended solids in relation to total suspended solids. On August 20, when samples were taken from Banks, volatile suspended solids were reduced compared to the July and September samples. This may, potentially, be an indication of reduced algal productivity in the reservoir related to the copper sulfate treatment that was applied on August 13. However, it is likely that the change would reflect reduced populations of phytoplankton, compared to the benthic algae that were producing MIB in the forebay at that time. Discrete samples of total and volatile suspended solids can provide information that is generally better quality-controlled, but samples are currently collected monthly and are not useful for tracking algal blooms.

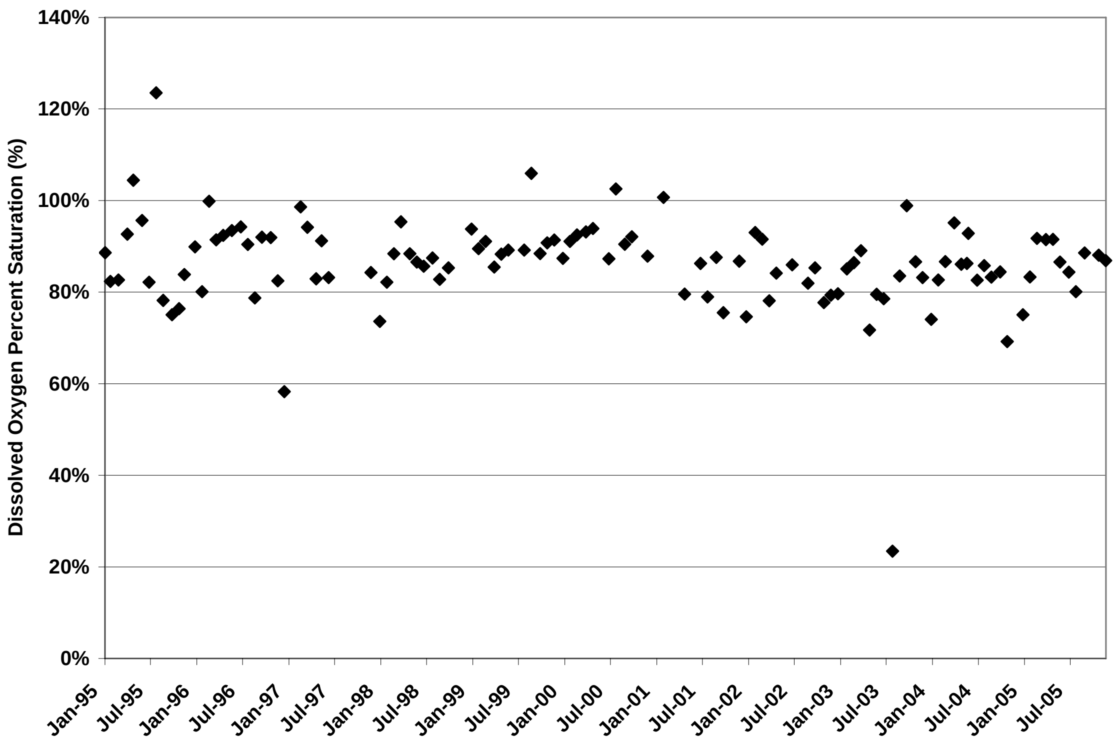
Figure 7-14. Suspended Solids at Banks During 2003



Dissolved Oxygen

Dissolved oxygen has been measured monthly at Banks since 1995. These data were evaluated and percent DO saturation computed and depicted in **Figure 7-15**. These data indicate that there is considerable variability in DO saturation. On August 20, 2003 at 8:10 in the morning DO was 2.0 mg/L which, at the ambient temperature and atmospheric pressure, would correspond to about 23 percent saturation, a record low for the study period. This occurred about two weeks after MIB concentrations peaked at 30 ng/L at Banks and one week after a copper sulfate application. As shown previously on **Figure 7-11**, MIB concentrations declined to less than 10 ng/L following the treatment. The DO sag suggests that there was an oxygen demand due to a large scale die-off of algae following the copper sulfate treatment. Another possible explanation is that the DO sag was due to respiration during an algal bloom but the MIB and geosmin data indicate that at least T&O producing algae had been reduced. Data were not available to determine whether DO recovered that day or, perhaps, went to super-saturation, indicating an ongoing algal bloom. If the data for this day are correct, this is an indication of an oxygen sag that would have nearly depleted oxygen in the forebay during the dark hours of August 19. Low DO in the reservoir could result in anaerobic conditions that trigger chemical reactions that produce T&O compounds, in addition to being fatal to aquatic organisms. Sags in DO were not seen during the algal blooms of 2004 and 2005; however monthly samples are not adequate to detect the impacts of algal blooms on DO concentrations.

Figure 7-15. Percent Dissolved Oxygen Saturation at Banks



Conclusions on Ability to Detect Algal Blooms

The foregoing discussion has cast doubt on the ability of currently available instruments and monitoring techniques to reliably detect and provide early warning of impending T&O problems. The limited available data are not conclusive in demonstrating whether DO measurements may be a useful tool for monitoring the presence of algae in Clifton Court, but this form of measurement has possible advantages. DO can be monitored continuously and relatively inexpensively by available automated instrumentation. Because DO fluctuates as a result of respiration and photosynthesis, it should be sensitive to algal population dynamics, whether the algae in question are planktonic or benthic. Also, oxygen fluctuations due to phytoplankton populations should be relatively insensitive to the distribution of organisms throughout the water column, so that floating algae, such as *Microcystis aeruginosa,* should be detectable. Oxygen fluctuations may also provide a means of quantifying algal biomass.

Fluorescence, pH, and turbidity measurements at Clifton Court and Banks, along with other information, are of some value in interpreting algal conditions, but appear to lack the sensitivity to provide unambiguous early warning of impending algal blooms and consequent T&O incidents. Analysis of discrete samples for total and volatile suspended solids can provide useful insights, but are generally not definitive due to the limited data that can be produced, particularly since algal blooms and the production of T&O compounds can change quickly.

Available monitoring data have failed to provide unequivocal evidence of algal blooms during periods when elevated concentrations of T&O compounds have been measured in the Delta, and caused problems for SBA Contractors. The difficulty of sensing the presence of algae is compounded in the case of organisms such as *Microcystis aeruginosa* that are not evenly distributed through the water column and are less likely to be detected by continuous monitoring equipment or collection of water samples at the usual one-meter sampling depth. The inability to reliably detect and quantify algal blooms entering the SWP from the Delta is a serious obstacle to reliable early warning of T&O events.

Vascular Plant Growth in Clifton Court

Aquatic vascular plants, or rooted weeds, grow in Clifton Court and other Delta water bodies when temperatures are suitable and light penetration in the water is sufficient for plants to take root and grow. Clifton Court and O'Neill Forebay are examples of shallow water bodies within the SWP that host vascular plant growths sufficient to cause problems such as facilities obstruction and biomass removal and disposal. Water depth and clarity are critical for aquatic vascular plant growth and it follows that sedimentation, such as occurs in Clifton Court, is directly related to the ability of aquatic vascular plants to grow in the forebay.

Control of aquatic vascular plant growth in Clifton Court has been accomplished through mechanical means (harvesting), and by chemical treatment with Komeen®, and Nautique®, both of which are copper based aquatic herbicides. **Table 7-4** lists the history of herbicide treatments in Clifton Court that have occurred during the relevant time period. It seems reasonable to assume that aquatic vascular plants would be most likely to contribute T&O compounds during die-off and decomposition. This occurs seasonally in the fall as water temperatures drop, and can be expected to occur following herbicide treatments.

Figures 7-8 and 7-9 depict occasions when geosmin and MIB concentrations in samples collected at Banks exceeded the lowest thresholds established by the SBA Contractors. MIB and geosmin maxima tend to occur during the summer months when aquatic vascular plants are generally healthy, and are probably related to algal growth. There have, however, been a few instances when MIB concentrations were elevated during the fall and geosmin concentrations have exceeded the 4 ng/L threshold during the fall months of recent years, when vascular plants would have been degenerating.

Table 7-4. History of Aquatic Herbicide Treatment in Clifton Court Forebay

Year	Date	Acres Treated	Herbicide	Method
1995	May 15-17	300	Komeen	Boat
	Aug 21-23	600	Komeen	Aerial
1996	Jun 10	250	Komeen	Aerial
	Sep 9	600	Komeen	Aerial
1997	May 22	680	Komeen	Aerial
	Jul 14 -15	546	Komeen	Aerial
1998	Jul 12	750	Komeen	Aerial
1999	Jun 10	796	Komeen	Aerial
2000	Jul 30	700	Komeen	Aerial
2001	Jun 28	700	*Nautique*	Aerial
2002	Jun 23	700	Komeen	Aerial
2003	May 11	700	*Nautique*	Aerial
2004	Jun 2	700+	Komeen	Boat
2005	May 2	770	Komeen	Boat
2005	Jun 20	770	Komeen	Boat

Source: Jeffrey Janik, DWR Division of O&M, Water Quality Section

The record of MIB and geosmin analyses of Banks waters was compared to the record of herbicide treatments to determine whether there is any apparent correspondence between treatments and spikes of these T&O compounds. None of the elevated MIB concentrations occurred shortly following an herbicide treatment. On June 20, 2005, geosmin was at 4 ng/L and then rose to 5 ng/L a week later. None of the other herbicide treatments corresponded with increases in geosmin concentrations. The data are too limited for firm conclusions, but it appears unlikely that deteriorating aquatic vascular plants are responsible for the peak MIB and geosmin concentrations but may be responsible for the fall geosmin concentrations that exceed the threshold.

As discussed in Chapter 2, the future use of copper formulations for algae or aquatic vascular plant control is uncertain. An alternate means of controlling these growths is mechanical harvesting, which DWR has employed in SWP facilities with mixed success.

Impact of Clifton Court Sedimentation on Benthic Algal Growth

Evidence has been presented in this chapter to demonstrate there are occasions when algal blooms in the Delta are transported into, and through, Clifton Court and into the California Aqueduct. There is also evidence that benthic cyanobacteria growing in Clifton Court Forebay are responsible for some of the T&O problems that have been experienced by the SBA Contractors. Algacide treatments of the forebay have evidently succeeded in controlling blooms of benthic cyanobacteria, resulting in reductions in T&O compound concentrations. If benthic cyanobacteria in the forebay are assumed to be, at least in part, responsible for T&O problems, then it follows that sedimentation of the forebay will reduce its depth, increase the area where light penetrates to the bottom, and thus encourage production of benthic cyanobacteria and T&O compounds.

Benthic algae require light penetration to the bottom surface of a water body to survive and grow. Light penetration in water is affected by the concentration of suspended solids in the water column. As depth increases, less of the incident light is available. The depth at which the energy algae can produce by photosynthesis is equal to the energy they must consume in respiration is termed the "compensation depth." Typically the compensation depth is in the region where only about one percent of the incident light remains. Algae cannot survive at depths greater than the compensation depth. A shallow water body that permits light penetration to the bottom will have a greater surface area to support growths of benthic algae than will a deeper water body. Therefore, to the extent sedimentation in Clifton Court has increased the surface area where light can penetrate to the bottom, it could potentially worsen the T&O problem.

Secchi depth measurements are a gauge of water clarity. A circular disk is lowered into the water until it can no longer be seen by the observer and that depth recorded. Light generally penetrates water to a depth of 1.7 times Secchi depth (Michaud, 1991). Secchi depth measurements are somewhat subjective, depending on the eyesight of the person performing the analysis and other factors, but are generally repeatable within a few centimeters. Secchi depth data for Clifton Court were sparse (only 15 measurements made during the period 1998-2001), but were sufficient to demonstrate that the water is relatively turbid. Secchi depths ranged from 1.0 to 3.6 feet, with a median of 2.0 feet, indicating that light would penetrate to depths of 1.7 to 6.1 feet.

Based on these data, increasing the water depth even a foot or two in shallow areas would be expected to greatly reduce the ability of benthic algae to grow. Dredging shallow areas where light penetrates to the bottom would be expected to produce benefits proportional to the surface area being dredged. During the fall of 1992, about 400,000 cubic yards of sediment were removed from Clifton Court in the vicinity of the intake structure, deepening the forebay by an average 4 feet. This would have amounted to about 62 acres of bottom surface area, or about 3 percent of the total surface area of the forebay (2,180 acres).

POTENTIAL ACTIONS

Investigate Current Equipment Capabilities

Before a final determination is made on the usefulness of measuring fluorescence, pH, and turbidity at Clifton Court and Banks for early detection of algal blooms and T&O incidents, it would be desirable to eliminate instrument error as a confounding factor. Maintenance of unattended water quality monitoring equipment is a real challenge and, given limited resources, there may be practical limits on how much attention a given instrument can receive. It would be useful to perform an experiment in which Banks and/or Clifton Court monitoring equipment receives very frequent maintenance and calibration, with associated discrete sample collection and analysis of relevant constituents such as MIB, geosmin, chlorophyll *a*, and pheophyton *a*. The purposes of this experiment would be to assess the instruments' capabilities at their best, and to develop improved understanding of the level of attention that is required to assure high quality data.

Consider Continuous Measurement of Dissolved Oxygen

Continuous measurements of DO appear to have the potential to provide early warning of impending T&O problems. One potential action would be to continuously measure DO in Clifton Court and quantify the daytime versus night time changes in DO concentrations and oxygen saturation as a way of sensing significant changes in algal population dynamics. To assess whether such an equipment investment is warranted, frequent discrete sampling and analysis for DO could be performed in the field during July to September. This is the period that was associated with benthic cyanobacteria blooms in Clifton Court during 2003, 2004, and 2005.

Support Interagency Ecological Program Grant Application

New phytoplankton sensing technology is being investigated by IEP staff. At present, fluid imaging technology is being investigated for its potential to identify and quantify the presence of organisms that are not distributed evenly in water columns. A grant application has been submitted to the California Bay-Delta Program (CALFED) for purchase of fluid imaging instruments. A potential action is to support the grant proposal and/or consider experimentation with similar technology for detection of algal blooms in Clifton Court.

Investigate Alternatives for Controlling Nutrient Loading to Clifton Court

There are currently few regulatory controls on nutrients in the source waters to the Delta. The CALFED Water Quality Program is investigating possible regulatory control mechanisms for nutrients as part of the technical studies needed to support development of a drinking water policy for the Central Valley. The SWP Contractors should stay apprised of that process and, if requested, provide evidence of the impacts nutrients have on treatment of Delta water supplies.

FOREBAY AND STORAGE TANK MAINTENANCE ON COASTAL BRANCH

KEY CONCERNS

The Coastal Branch Aqueduct junction with the California Aqueduct is about 12 miles south of Check 21, near Kettleman City. The key features of the Coastal Branch were previously shown in Figure 3-5. The open aqueduct of the Coastal Branch ends at Mile 14.82, at the Forebay to the Devil's Den Pumping Plant. The remaining 143 miles is pipeline, the first 101 miles of which is part of the SWP, and the remaining 42 miles belongs to the Central Coast Water Authority (CCWA). The Coastal Branch is designed to supply about 48,000 acre-feet of water annually to CCWA, and that agency serves drinking water to San Luis Obispo and Santa Barbara counties.

Five pumping plants lift water to the CCWA system, and each has a forebay that serves as the pool from which water is pumped. The forebays of the downstream three pumping plants, Devil's Den Pumping Plant (Mile 14.82), Bluestone Pumping Plant (Mile 19.02), and Polonio Pass Pumping Plant (Mile 26.51) are structured so that water is pumped from the sides of the forebays. Sediment accumulation has been experienced in these forebays, but not in the forebays of the two upstream plants, Las Perillas Pumping Plant and Badger Hill Pumping Plant, that are designed for straight flow-through. CCWA staff theorizes that sedimentation of the downstream forebays may be related to their "sidedraft" design.

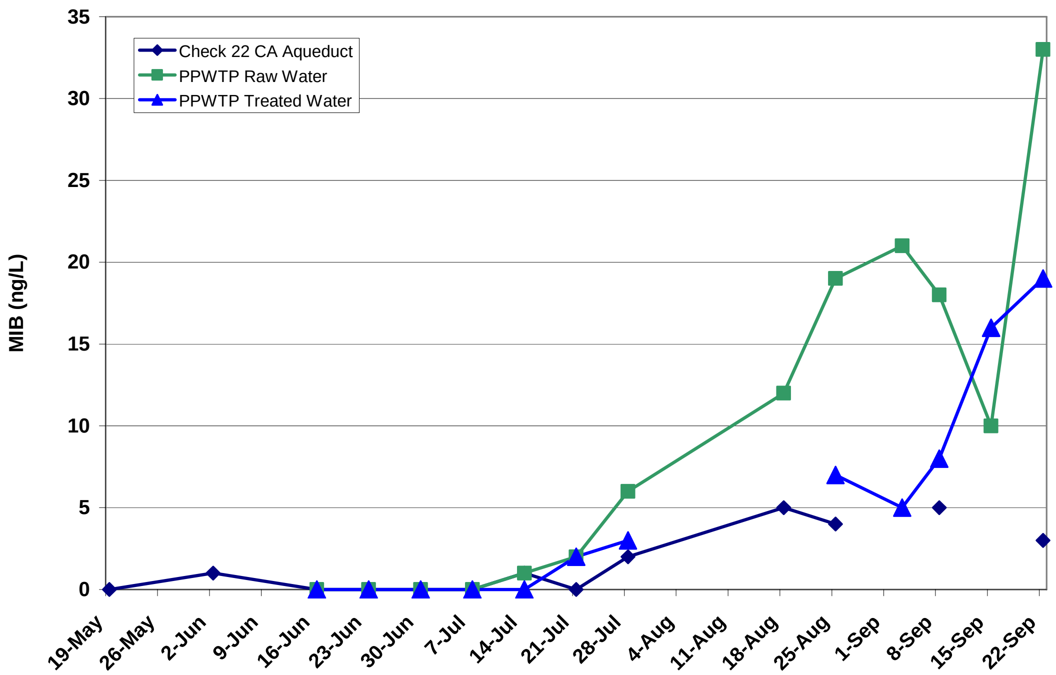
Polonio Pass Water Treatment Plant (PPWTP), owned and operated by CCWA, is located at Mile 27.82. Three raw water storage tanks owned by DWR are located just upstream of the PPWTP at Mile 27.70. Like the forebays of Devil's Den, Bluestone, and Polonio Pass pumping plants, these tanks act as settling basins and accumulate sediments. Sediment accumulation in the forebays and storage tanks of the Coastal Branch presents water quality concerns because sediments can support biological growths that can be a source of T&O compounds in treated drinking water.

Increased Taste and Odor Incidents

The portion of the Coastal Branch serving CCWA was completed in 1997. Since October 1999, CCWA has experienced periodic episodes of T&O that have generally not coincided with T&O incidents in other parts of the SWP system. Geosmin and MIB are produced as a result of biological activity, and are frequently responsible for T&O in treated drinking water supplies. CCWA reports that customer complaints are generally received when concentrations of either compound reach 10 ng/L; however sensitive individuals can detect these compounds at concentrations as low as 5 ng/L.

In 2003 CCWA experienced a serious T&O incident that resulted in numerous customer complaints. Water samples from various points in the system were collected and analyzed for geosmin and MIB. MIB concentrations in the California Aqueduct at Check 22 and in the Coastal Branch are shown in **Figure 7-16.** Check 22 is located just downstream of the Coastal Branch junction with the California Aqueduct. MIB concentrations in the influent to PPWTP were far higher than measured at upstream locations, (samples low in MIB were taken at several points along the Coastal Branch upstream of the treatment plant), and peaked on September 22, 2003 at 33 ng/L. Samples were also collected from PPWTP treated water. While treatment generally reduced MIB concentrations, many customer complaints were received because concentrations in treated water were still high enough to be detected (16 ng/L on 9/15/03 and 19 ng/L on 9/22/03). On 9/15/03, the treated water MIB concentration (16 ng/L) was actually higher than the concentration measured in the influent water (10 ng/L). This may be an indication of a concentration spike that had passed through the plant at the time of sampling.

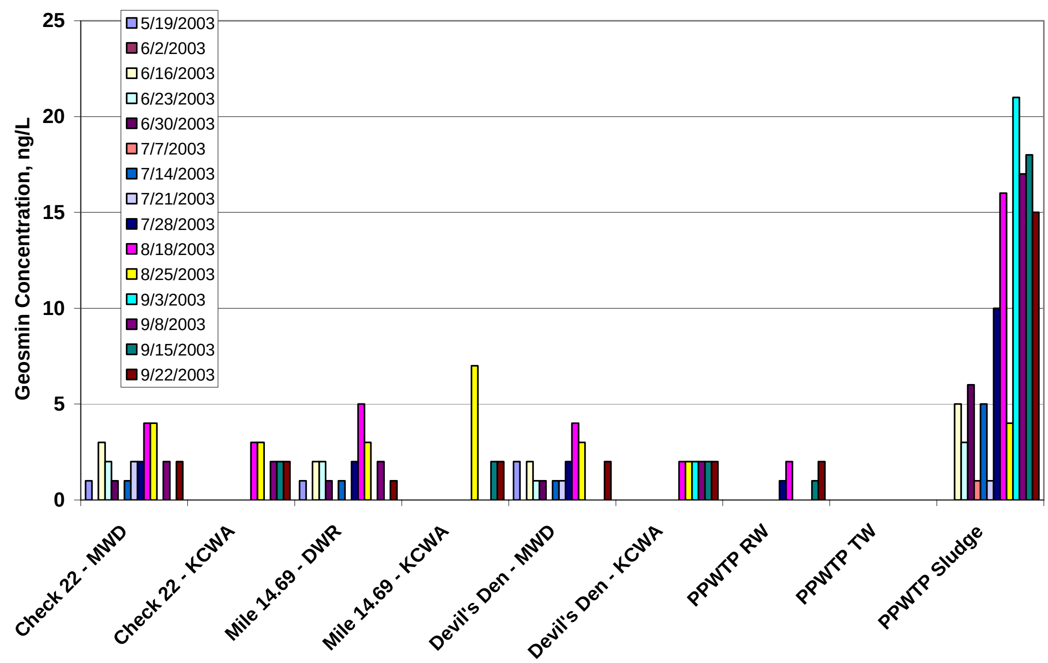
Figure 7-16. MIB Concentrations in California Aqueduct and Coastal Branch in 2003



Monitoring results for geosmin samples collected in 2003 are depicted in **Figure 7-17.** Geosmin concentrations in the influent to PPWTP were non-detectable until September, then only moderate (1-2 ng/L), and concentrations in the treated water were consistently undetectable. Geosmin was regularly detected, however, in sludge from the plant's sludge lagoons, and at concentrations as high as 21 ng/L.

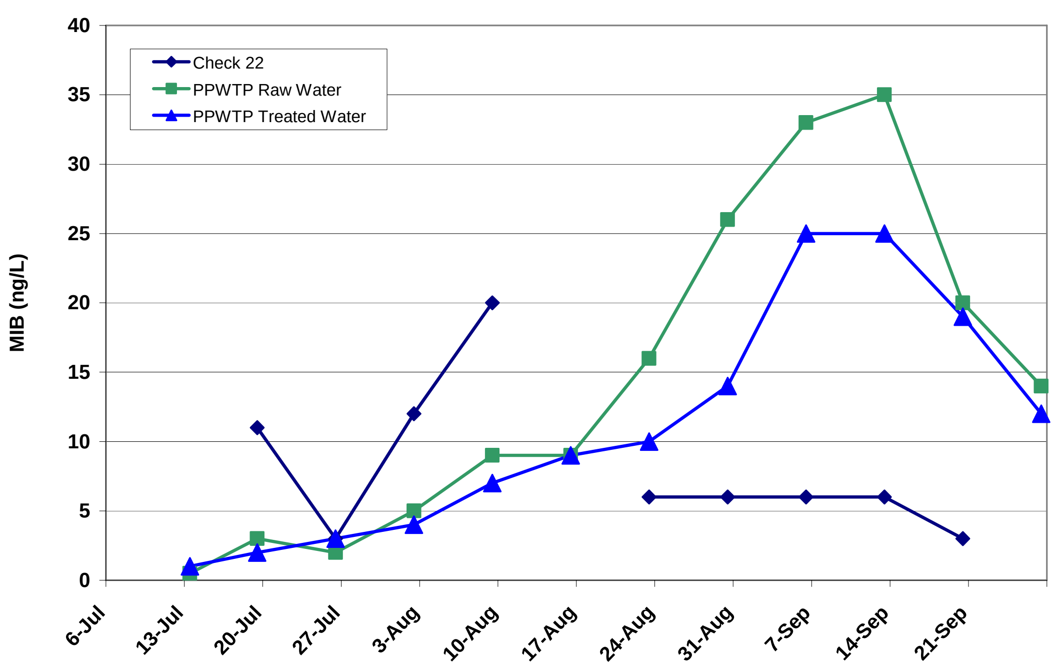
During late August 2004 MIB concentrations rose sharply as shown in **Figure 7-18.** Samples collected from the California Aqueduct at Check 22, showed elevated concentrations as high as 20 ng/L in July and early August, but these did not coincide with concentrations observed at PPWTP, indicating the sources were not the same. MIB was not effectively removed by PPWTP, entered the distribution system, and resulted in customer complaints. Samples collected in 2004 were also analyzed for geosmin, but concentrations did not exceed 3 ng/L.

Figure 7-17. Geosmin Concentrations in California Aqueduct and Coastal Branch in 2003



Note: PPWTP samples are analyzed by KCWA. As of 7/1/03, their detection limit is 2 ng/L. Non-detect samples are charted as 0.

Figure 7-18. MIB Concentrations in California Aqueduct and Coastal Branch in 2004



Sediment Accumulation in Forebays and Storage Tanks

Based on data collected during 2003 and 2004, CCWA staff suspected the source of MIB and geosmin was in the Coastal Branch system. High concentrations of geosmin were detected in PPWTP sludge lagoons in 2003, as shown previously in **Figure 7-17.** This was an indication that T&O compounds could be associated with sediment, and the forebays of the Devil's Den, Bluestone, and Polonio Pass pumping plants were known to retain sediments. Therefore, during the summer of 2005, CCWA staff decided to survey sediment loads, beginning with Polonio Pass Pumping Plant forebay, located about 1.3 miles upstream of PPWTP.

Figure 7-19 is a bathymetric map displaying a grid upon which the depths of sediments on the bottom of Polonio Pass Pumping Plant forebay are color coded and plotted according to sediment depth. The point of view is overhead, looking down on the forebay bottom. Sediment depths ranged from 1 to over 7 feet, and averaged 3.4 feet. Sediments were removed from the forebay during the summer of 2005. **Figure 7-20** is a bathymetric map depicting the condition of the forebay after sediment removal when the depth ranged from 0 to about 3 feet, and averaged 1.2 feet. **Figure 7-21** shows the results of MIB testing during the summer and early fall of 2005. The maximum concentration detected in the raw water influent to PPWTP was 11 ng/L, and MIB concentrations in the treated water did not exceed 9 ng/L. Customer T&O complaints diminished to insignificant levels during this period. Three samples taken from the California Aqueduct at Check 22 were all at or below 4 ng/L, indicating the MIB present in the system is generated within the Coastal Branch.

These data formed the basis for a hypothesis on the part of CCWA staff that an association exists between sediments in the Coastal Branch system and T&O incidents that have been experienced. This association has not, as yet, been proven with scientific certainty, and further work is underway to confirm, or disprove, the hypothesis.

Experiment to Minimize Sedimentation

The experience of CCWA has suggested the need to minimize sediment deposition in the Coastal Branch system, including the forebays to the pumping plants and the storage tanks. If water in the forebays could be kept in circulation, sedimentation would be reduced or eliminated. CCWA staff decided to install a SolarBee®, which is a solar powered reservoir circulator, in Polonio Pass Pumping Plant forebay. **Figure 7-22** is a photograph of the SolarBee® in the forebay. As shown in **Figure 7-23**, sediment levels in the forebay did not accumulate to a large degree during the period of the experiment, (average 1.3 feet depth) and appear to indicate a positive effect of the SolarBee®. Experimentation continued in 2006, with a re-survey of the forebay on March 30, 2006 indicating average sediment depth was 0.9 feet. However, experimentation with this equipment continues and, to date, no conclusions as to its effectiveness have been drawn.

Figure 7-19 Bathymetric Map of Polonio Pass Forebay Before Sediment Removal

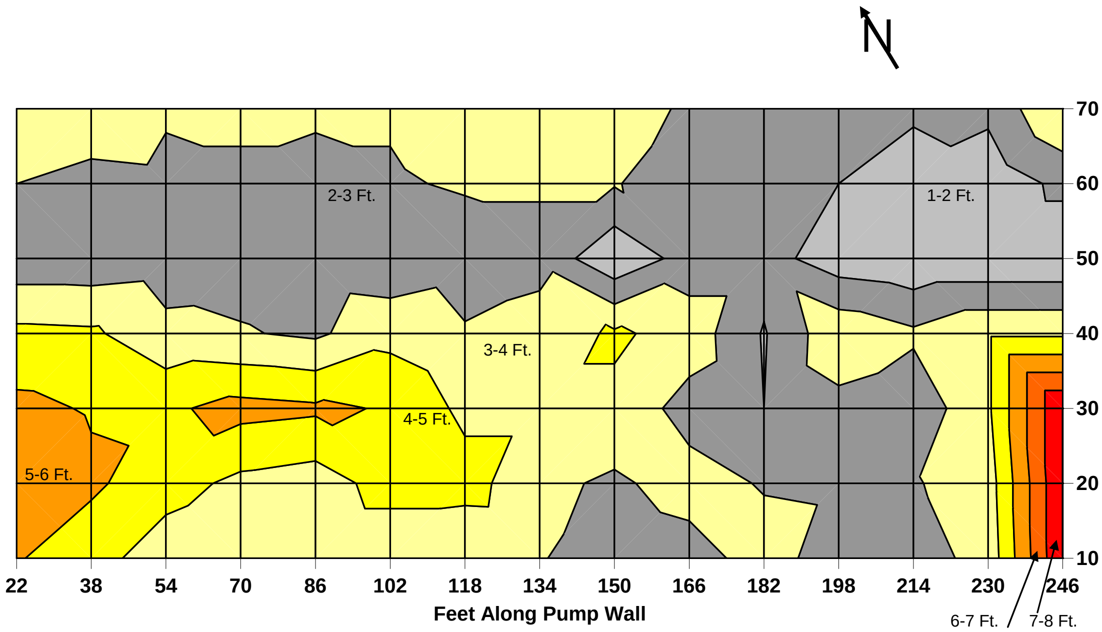


Figure 7-20. Bathymetric Map of Polonio Pass Forebay After Sediment Removal

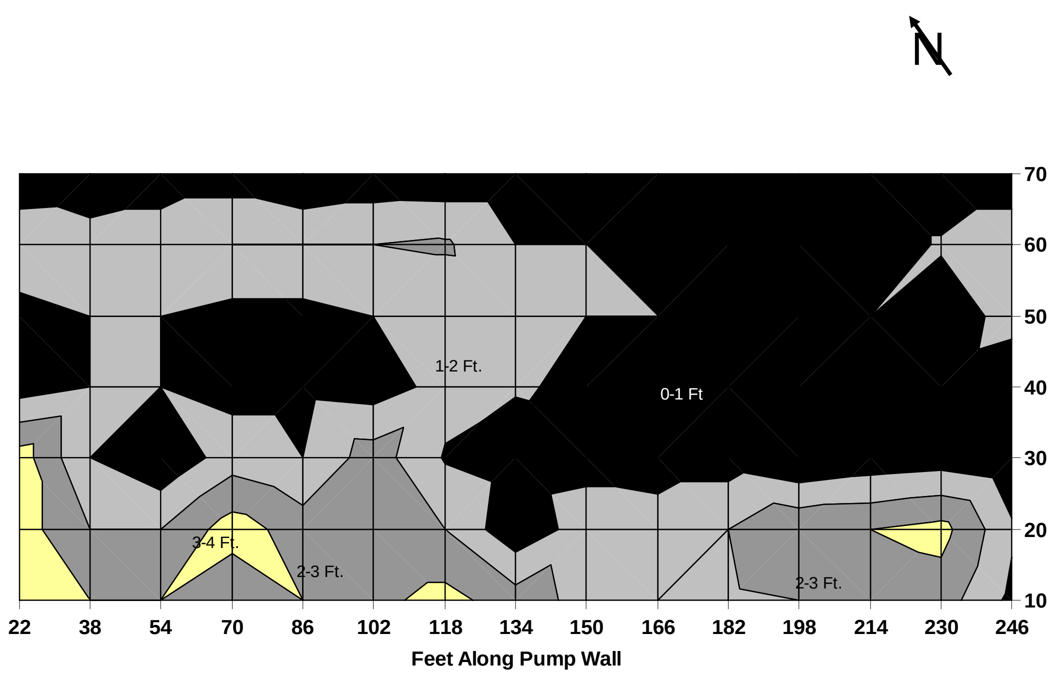


Figure 7-21. MIB Concentrations in California Aqueduct and Coastal Branch in 2005

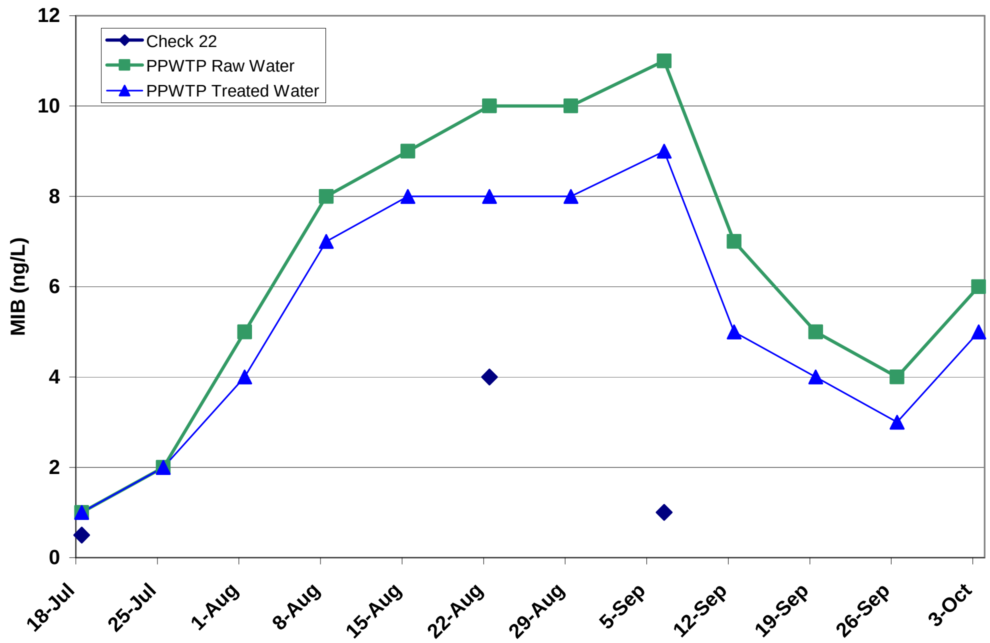
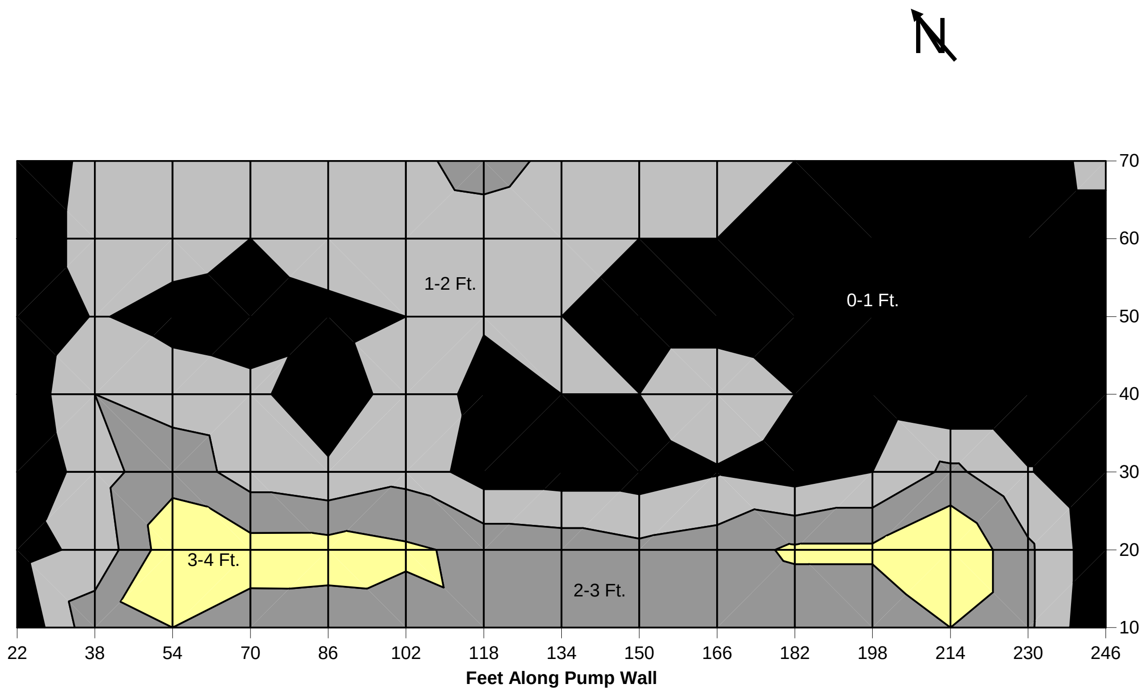


Figure 7-22. Installation of SolarBee® at Polonio Pass Pumping Plant Forebay

Figure 7-23. Bathymetric Map of Polonio Pass Pumping Plant After SolarBee® Experiment



CCWA staff identified an additional benefit they attribute to removal of sediments from pumping plant forebays. For two consecutive years prior to removal of sediment from the forebay in 2005, the PPWTP experienced three separate spikes in ammonia concentrations sufficiently high to necessitate reduction in plant treated water production to provide an acceptable level of disinfection. This problem occurred during plant startup after annual shutdowns. After Devil's Den forebay was cleaned, two ammonia spikes occurred, and after Polonio Pass forebay was cleaned only one spike occurred. Staff theorizes the remaining spike may have come from Bluestone because that forebay was not completely cleaned.

Maintenance to Minimize Sediment Accumulation

CCWA staff also recognized the need to maintain the three raw water storage tanks in the system so significant sediment beds were not allowed to accumulate. Operationally, loss of tank capacity due to sediment accumulation meant water levels in the tanks could not be drawn down more than about five feet without re-suspending bottom sediments that disrupted plant production. There was also concern that T&O compounds could be produced by biological activity in the sediments in the tanks.

Maintenance of the three raw water storage tanks belonging to DWR has been a challenge, as they are some distance from the headquarters of the San Joaquin Field Division. This challenge was addressed in an unusual and innovative manner by agreement between DWR and CCWA.

CCWA provided the necessary tank maintenance to assure sediment did not accumulate to levels that would cause operational difficulties or promote T&O problems. This coordinated effort was successful in maintaining the tanks, but responsibility for this maintenance has since shifted back to DWR, and the success of the current approach is still being evaluated. The managements of both entities are aware that satisfactory arrangements for assuring adequate maintenance of these storage facilities are necessary.

POTENTIAL ACTIONS

Continue SolarBee Experiment

While preliminary and, as yet unproven, the experience and data collected by CCWA appear to indicate water quality and treatment reliability improvements may be attained by sediment removal and/or prevention of sedimentation in the forebays of Devil's Den, Bluestone, and Polonio Pass pumping plants, and the three raw water storage tanks located at Mile 27.70 on the Coastal Branch. As the water quality effects of preventing sedimentation in the forebays have been studied only recently, it has not been demonstrated with scientific certainty that current efforts to prevent sediment deposition (SolarBee®) would be adequate under all hydrologic and operational conditions. Wet years, for example, could be associated with higher sediment loading. CCWA should consider continuing the experiment over a broader range of hydrologic conditions, and collect sediment deposition data, water quality samples, and plant operations data to assess its success and identify any undesirable treatment process impacts from the sediment load.

Prevent Sediment Accumulation with Proper Maintenance

If further study verifies the relationship between sediment control and T&O prevention, an important action to prevent or mitigate T&O incidents would be to ensure the forebays and raw water tanks in the system continue to be well maintained to prevent sediment accumulation.

HESPERIA MASTER DRAINAGE PLAN

KEY CONCERNS

The East Branch of the California Aqueduct traverses the incorporated City of Hesperia in San Bernardino County, as shown on **Figure 7-24**. Drainage in this area is in a northeasterly direction towards the Mojave River. When the East Branch was constructed, the natural drainage pattern was interrupted so overchutes and culverts were constructed to convey drainage over and under the aqueduct. There is a two mile stretch of the aqueduct beginning at Mile 397, where urban runoff is discharged into the aqueduct through 45 drop inlets. The inlets were installed to prevent flooding of the urban area adjacent to the aqueduct on the northeast side. **Figure 7-25** shows a drop inlet along the aqueduct. There are a number of SWP Contractors who have turnouts downstream of this area, as shown in **Table 7-5**. As the Hesperia watershed is becoming increasingly urbanized with residential and commercial developments, the amount of urban runoff into the aqueduct is expected to increase. **Table 7-5** indicates the approximate distance from the Hesperia drop inlets to the various downstream SWP Contractors in order to demonstrate the proximity of this potentially contaminating activity to water supplies used for drinking water.

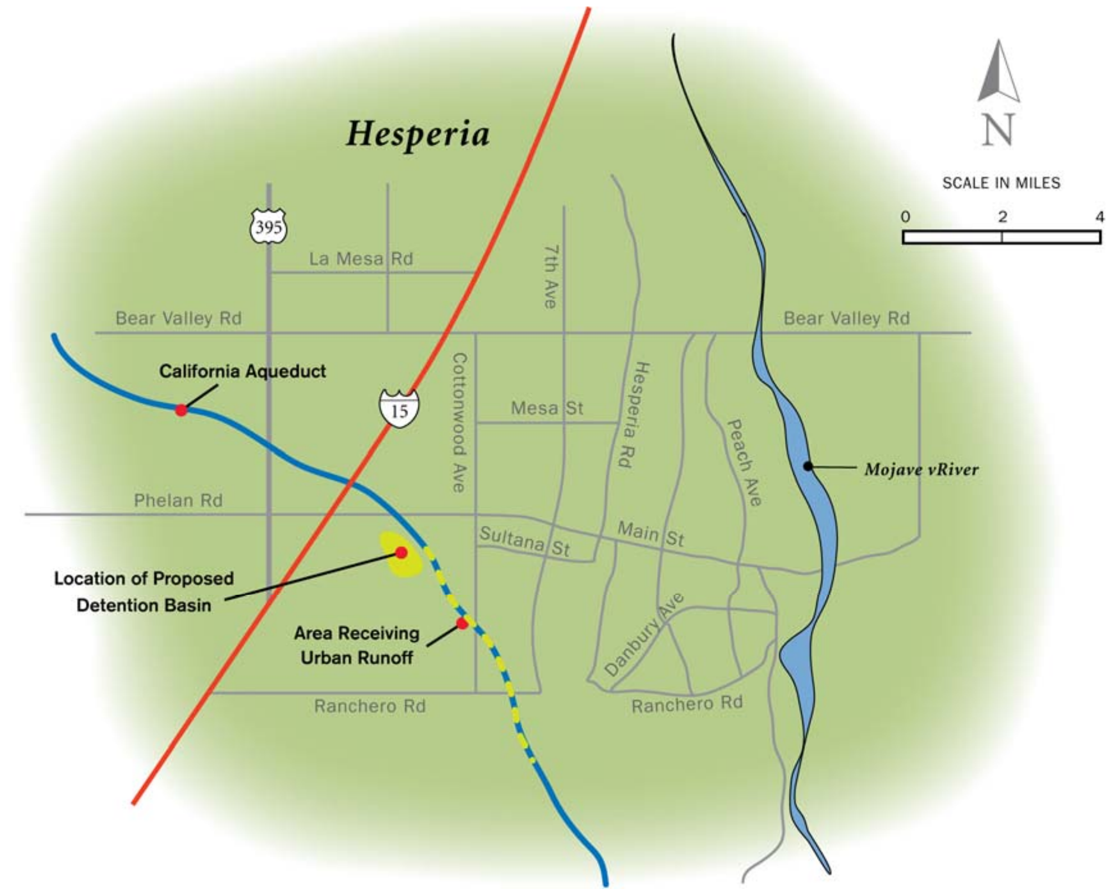
Table 7-5. Turnouts Downstream of Hesperia Drop Inlets

SWP Contractor	Turnout Location (Mile)	Approximate Distance from Hesperia Drop Inlets (miles)
Mojave Water Agency	401.10	4
Crestline Lake Arrowhead Water Agency	407.65 (Lake Silverwood)	11
MWDSC	412.88 (Devil Canyon Afterbay)	16
Desert Water Agency	412.88 (Devil Canyon Afterbay)	16
San Gabriel Valley Municipal Water District	412.88 (Devil Canyon Afterbay)	16
Coachella Valley Water District	412.88 (Devil Canyon Afterbay)	16
San Bernardino Valley Municipal Water District	412.88 (Devil Canyon Afterbay)	16
San Gorgonio Pass Water Agency	412.88 (Devil Canyon Afterbay)	16
MWDSC	440.05 (Santa Ana Valley Pipeline)	43
MWDSC	443.44 (Lake Perris)	46

The Mojave Water Agency, the San Gabriel Valley Water District, and the San Gorgonio Pass Water Agency use SWP deliveries for groundwater recharge. The Desert Water Agency and the Coachella Valley Water District do not receive water directly from the SWP, but participate in a wheeling exchange with MWDSC. Crestline Lake Arrowhead Water Agency, San Bernardino

Valley Municipal Water District, and MWDSC receive water from the SWP for subsequent treatment and delivery to their member agencies or consumers.

Figure 7-24. East Branch of California Aqueduct near the City of Hesperia



Potential Impact of Urban Runoff on Aqueduct Water Quality

Typical pollutants found in urban runoff are nutrients, suspended solids, organic carbon, bacteria, hydrocarbons, trace metals, and pesticides. Urban runoff occurs on a year-round basis and includes wet and dry weather discharges. Wet weather runoff results from seasonal storms, while dry weather runoff results from activities such as lawn irrigation and car washing. Wet weather runoff is of relatively short duration and can have highly variable pollutant concentrations. Typically, the highest wet weather pollutant load occurs after a first-flush event. The San Bernardino County Flood Control District (SBCFCD) has no data on the quality of the runoff water entering the aqueduct. DWR staff reports that one sample was taken in the winter of 1993. This sample contained elevated levels of suspended solids and organic carbon was measured at 11.9 mg/L. Concentrations of metals or minerals detected were not considered to be elevated

.

Figure 7-25. Drop Inlets Along the California Aqueduct in Hesperia

Note: This figure shows the end of a drop inlet pipeline leading into the California Aqueduct. The pipeline collects drainage from the other side of the embankment and discharges into the aqueduct.

The volume of runoff discharged to the aqueduct via the drop inlets is not measured. However, the magnitude of the flow can be estimated from the design criteria for the detention basin being considered to capture storm flows in lieu of the drop inlets (see Master Plan of Drainage below for more information). The inlet flow to the detention basin being designed is for a 24-hour, 100-year storm event, which is 5,010 cfs. The capacity of the California Aqueduct along the East Branch ranges from 2,630 to 2,880 cfs (DWR, 1999).

The City of Hesperia is experiencing growth; Hesperia's population has increased by an estimated 28.2 percent from 62,582 in 2000 to 80,268 in 2006. According to DWR staff, there are twenty-five home developments in some stage of planning or construction within one mile of the aqueduct in the Hesperia area (Personal Communication, Mark Herold, DWR). As land use in the Hesperia watershed becomes more urbanized, the amount of impervious surfaces will increase, and rainfall will no longer be able to soak into the ground. Consequently, more urban runoff will be discharged into the aqueduct. Since urban stormwater runoff contains various pollutants, downstream water users remain concerned about impacts to source water quality. Pollutant loads to the California Aqueduct from the drop inlets is unknown since information is not available on the quality or quantity of urban runoff discharged through the drop inlets.

Master Plan of Drainage

The SBCFCD developed a Master Plan of Drainage in May 1996 for the City of Hesperia to address the management of storm water flows in the watershed (SBCFCD, 1996). The SBCFCD has developed a variety of alternatives under the Master Plan of Drainage, and these alternatives have been revised and updated over the last ten years, as a result of on-going communication between the SBCFCD, DWR, and interested Contractors. The drainage plan proposes two infrastructure alternatives to control flows and convey runoff for a 100-year storm event – the South Community Alternative Plan and the Design 4 Plan.

The "South Community Alternative Plan" includes a small detention basin located near the aqueduct to temporarily detain storm flows, and assumes that urban runoff will continue to be conveyed to the aqueduct via the drop inlet structures. The "Design 4" Plan includes a larger detention basin and eliminates discharges into the aqueduct. Urban runoff will be redirected away from the drop inlets by interception channels and conveyed to the detention basin. Areas which are not redirected to the aqueduct are proposed to drain to impounding trenches adjacent to the aqueduct. It is planned that the "Design 4" detention basin will detain storm flows for no longer than a 24-hour period. The detention basin is meant to capture flows and release them through existing overchutes or new conveyance structures. The Design 4 Plan has higher costs than the South Community Alternative Plan due to: 1) a larger detention basin, 2) facilities needed to redirect the flows away from the drop inlets, and 3) construction of impounding trenches along the aqueduct. According to the most recent report prepared by the SBCFCD, the cost of the South Community Alternative Plan is $9.8 million in 2005 dollars and the estimated cost for the Design 4 alternative is $20.7 million (SBCFCD, 2006a). As shown in **Figure 7-24**, the approximate location for both detention basins is proposed to be just south of the California Aqueduct at DWR station 1890+00 (Mile 397.3), between Bandicoot Trail and the Edison easement, in the unincorporated area of San Bernardino County.

DWR has formally communicated to the SBCFCD that the continued use of the drop inlets is unacceptable (DWR, 2005). DWR maintains that the drop inlets were constructed in 1971 as temporary drainage measures until the SBCFCD completed its Hesperia Master Plan of Drainage. Additionally, DWR is conducting feasibility studies for the enlargement of the East Branch of the aqueduct, which will affect the drop inlets. The SBCFCD has repeatedly written letters to DWR stating that "the District is waiting on a commitment in cost sharing from the Department" and that the SBCFCD would be "agreeable to budget the funding needed to construct the larger basin, provided DWR agrees to cost share in the overall cost difference between the alternatives" (SBCFCD, 2006b). In other words, the SBCFCD will only move forward with the larger detention basin if DWR funds the $10.9 million difference between the two alternatives.

DWR and interested SWP Contractors have reviewed the Hesperia Basin Report (SBCFCD, 2006b). This report contains design criteria and preliminary design for the detention basin. DWR is in the process of submitting comments to the SBCFCD. As this project is still in the planning and design phase, it has not begun the permitting process related to the California Environmental Quality Act (CEQA).

POTENTIAL ACTIONS

Develop Coordinated Plan

There are eight SWP Contractors who have turnouts downstream of the Hesperia area. Of the eight, there are six SWP Contractors who take direct delivery from the SWP for either treatment or groundwater recharge. The SWP Contractors that treat the water are concerned about increasing contamination from urban runoff as the Hesperia area becomes more urbanized, and believe that urban runoff into the aqueduct should cease. It is not clear if all eight SWP Contractors are aware of this situation. Therefore, DWR should meet with the impacted SWP Contractors to determine the appropriate cost share between Hesperia and DWR to eliminate storm water runoff into the aqueduct.

Monitor Urban Runoff

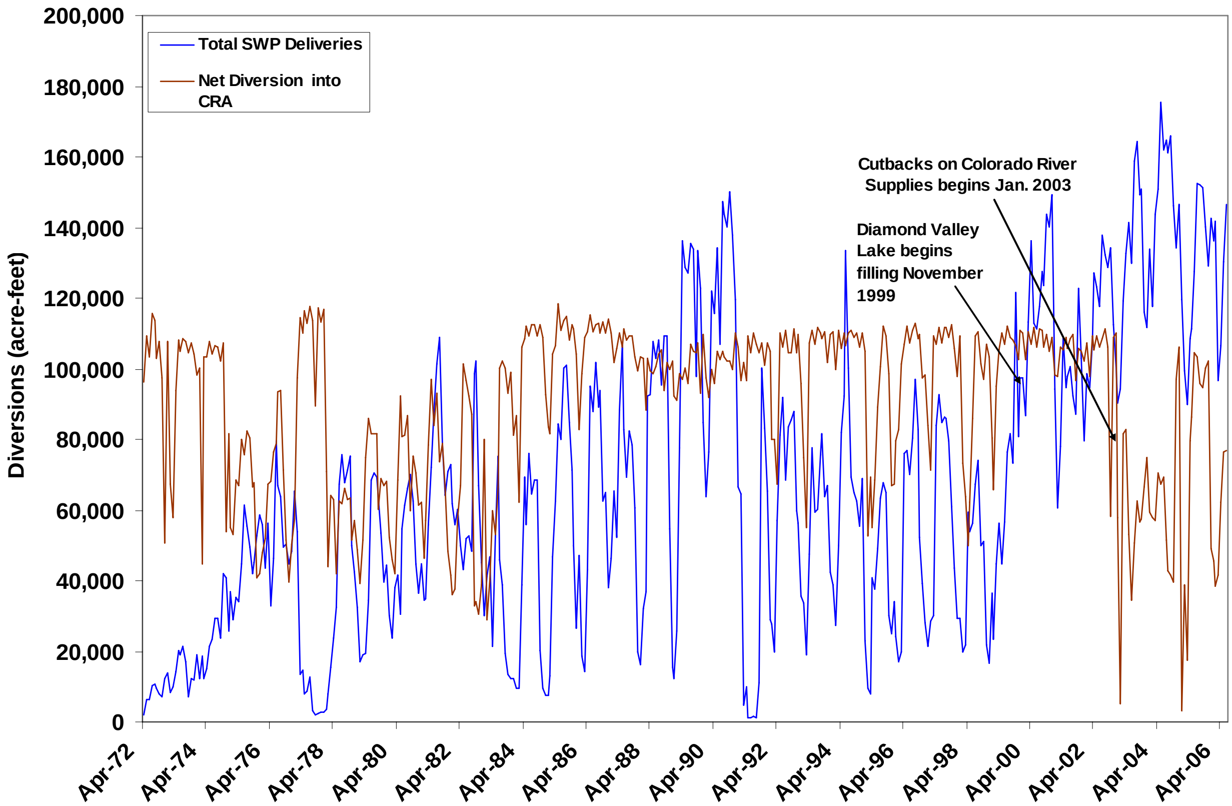
Since limited data exists to characterize the water quality of urban runoff entering the California Aqueduct, the SWP Contractors should work with DWR to determine the quantity and quality of the runoff flows.

WATER QUALITY CHANGES DUE TO DEMAND PATTERN CHANGES

KEY CONCERNS

MWDSC has experienced a dramatic increase in its reliance on SWP water since 1999 (**Figure 7-26**). Record volumes of SWP supplies were needed to fill MWDSC's newest reservoir, Diamond Valley Lake (DVL), when it became operational in late 1999, and to supplement cutbacks on Colorado River water supplies which began in 2003.

Figure 7-26. Total SWP Deliveries and Net Diversions from CRA to MWDSC, 1972-2006



Not only has the sheer volume of SWP delivery increased, but the timing of SWP delivery has also changed. For simplicity, the data are categorized into two groups: 1) "pre-DVL", from earliest record to 1999, and 2) "post-DVL" from 2000 to 2005. **Figure 7-27** shows average monthly deliveries for the pre-DVL and post-DVL time periods. When comparing the pre-DVL and post-DVL time periods, the overall increase in delivery volume is apparent, ranging from 85 to 207 percent for the respective months. The most dramatic change occurred in the months of January, February, and March, where deliveries increased approximately 200 percent, as shown in **Figure 7-28**. Historically, or pre-DVL, MWDSC has primarily taken deliveries from late spring to early fall, with a reduction in flows in winter. Within the last five years, this historical pattern has changed as high delivery volumes are beginning earlier in the year and occurring nearly year-round as shown in **Figure 7-28**.

Figure 7-27. Total SWP Deliveries to MWDSC – Monthly Averages 1972-2005

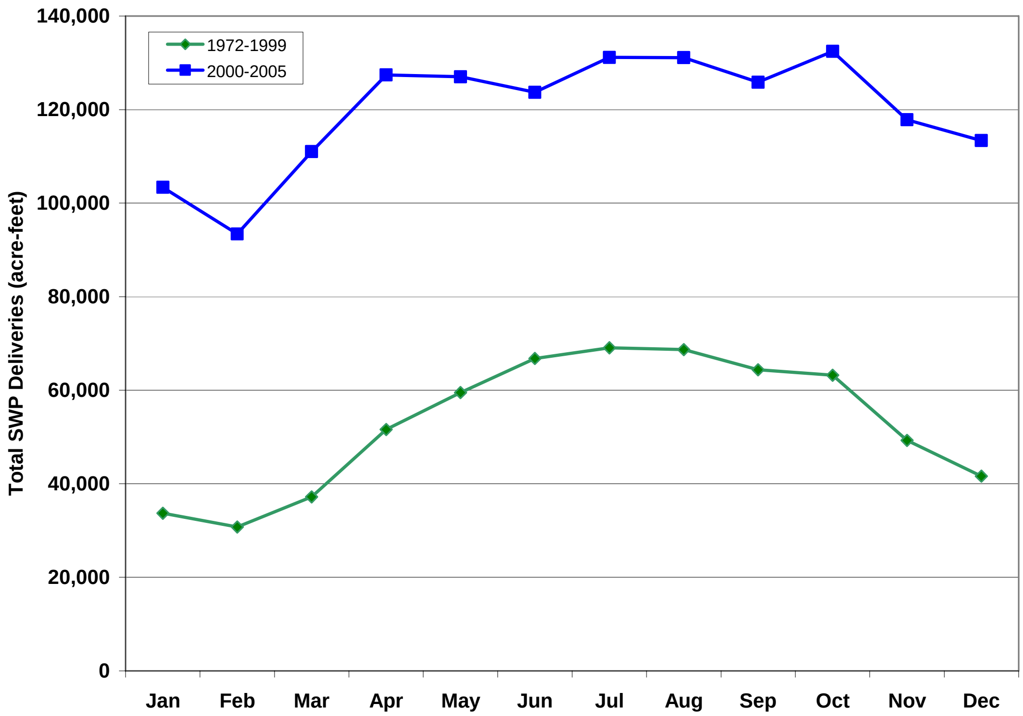
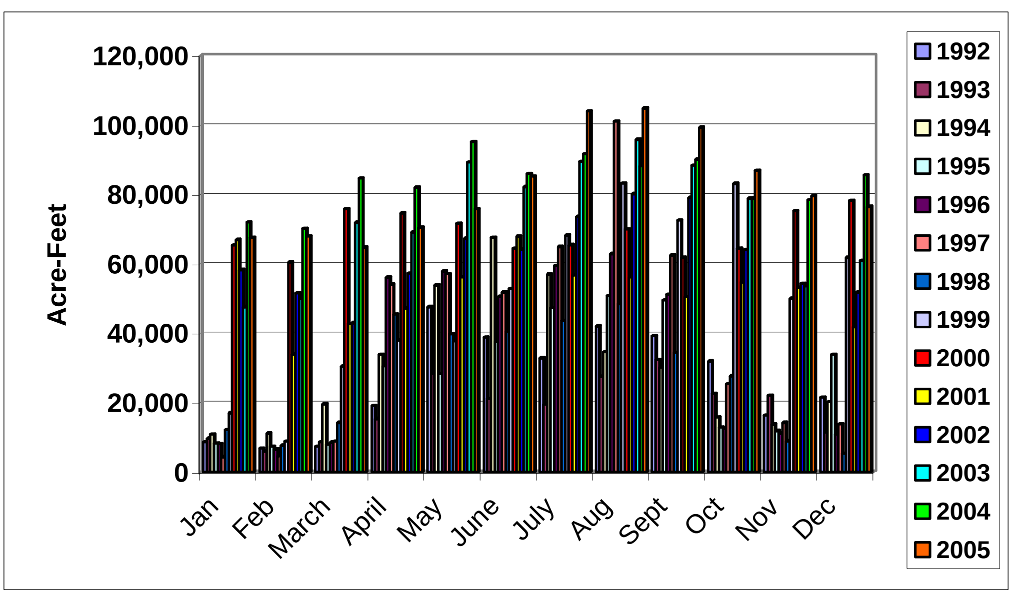


Figure 7-28. East Branch Deliveries, 1992 to 2005



The California Aqueduct bifurcates into the West Branch and East Branch immediately downstream of Check 41. The East Branch continues approximately another 100 miles to Silverwood Lake. Silverwood Lake storage is 74,970 acre-feet and the estimated residence time is 20 to 30 days (DWR, 2001). The West Branch continues to Pyramid and Castaic lakes, where the storage is 171,200 acre-feet and 323,700 acre-feet respectively. As residence time through Pyramid and Castaic Lakes is much longer than Silverwood Lake, the water quality impacts discussed in this section have not been as problematic for Contractors taking water from the West Branch compared to the East Branch.

SWP water is discharged from Silverwood Lake through the San Bernardino Tunnel, which leads to the Devil Canyon Powerplant. From Devil Canyon, water enters the Santa Ana pipeline, which conveys water with several delivery turnouts along the way to Lake Perris, the terminus of the East Branch of the California Aqueduct. The Mills Water Treatment Plant (WTP) receives water from the Santa Ana pipeline.

Source Water Quality Changes

Due to changes in East Branch source water quality within the last five years, MWDSC has experienced various treatment challenges in order to comply with drinking water regulations. Although all drinking water standards have been met, changes in source water quality have necessitated changes in operational procedures and MWDSC has incurred additional treatment costs.

Total organic carbon (TOC) and bromide have been selected for discussion as changes in these constituents have led to changes in operational procedures at Mills WTP. In addition to treatment challenges at the plant, MWDSC has also experienced an increase in algal blooms in their reservoirs storing SWP water. Therefore, changes in nutrients along the East Branch are also evaluated.

The data used in this evaluation were obtained from the DWR monthly reports, *State Water Project Operations Data*, from the DWR online Water Data Library, and from MWDSC.

Total Organic Carbon

TOC data collected at Banks and at Devil Canyon are depicted in **Figure 7-29**. For comparison between the pre-DVL and post-DVL time periods, **Table 7-6** contains a summary of statistical information for both Banks and Devil Canyon. The pre-DVL time period for Banks is from 1986 to 1999, and for Devil Canyon is 1981 to 1999 for. These periods were established based on the available data. Devil Canyon TOC data were obtained from MWDSC, and Banks TOC data were obtained from the DWR *State Water Project Operations Data* reports.

Figure 7-29. Total Organic Carbon at Banks and Devil Canyon

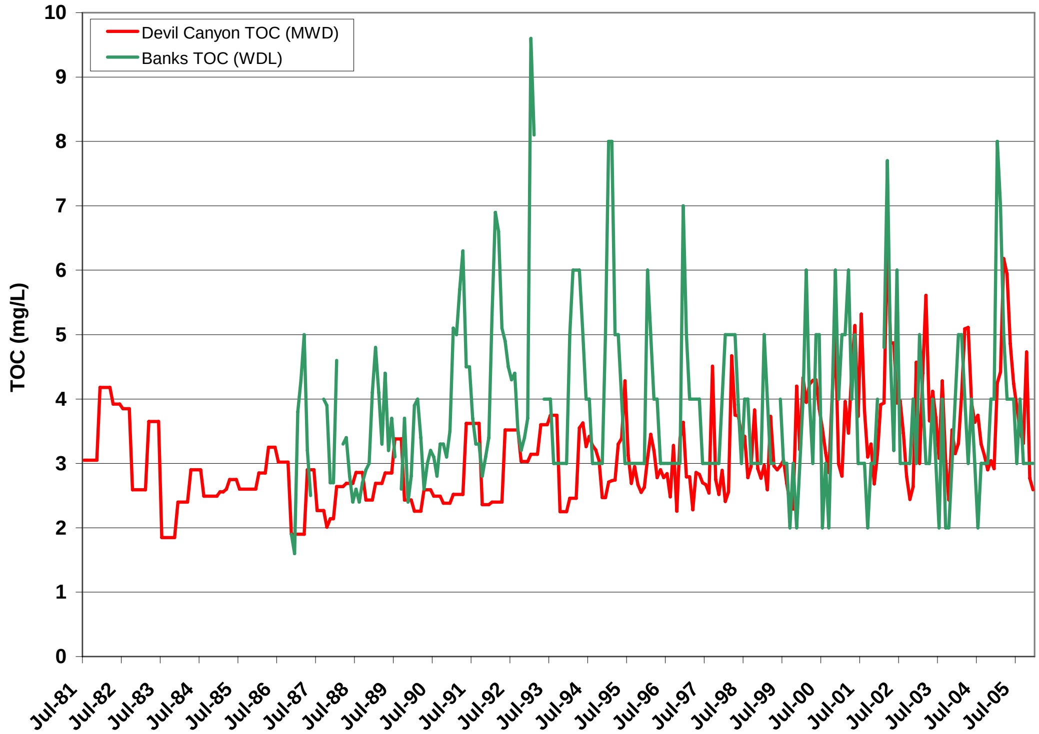


Table 7-6. Summary of TOC Statistical Information

Time Period	Banks (mg/L)	Devil Canyon (mg/L)
Mean ± std dev – pre-DVL	3.8 ± 1.3	2.9 ± 0.6
Mean ± std dev – post-DVL	3.8 ± 1.3	3.9 ± 0.9
Median – pre-DVL	3.4	2.8
Median – post-DVL	4.0	3.8
Max – pre-DVL	9.6	4.7
Max – post-DVL	8.0	6.5
Min – pre-DVL	1.6	1.9
Min – post-DVL	2.0	2.4

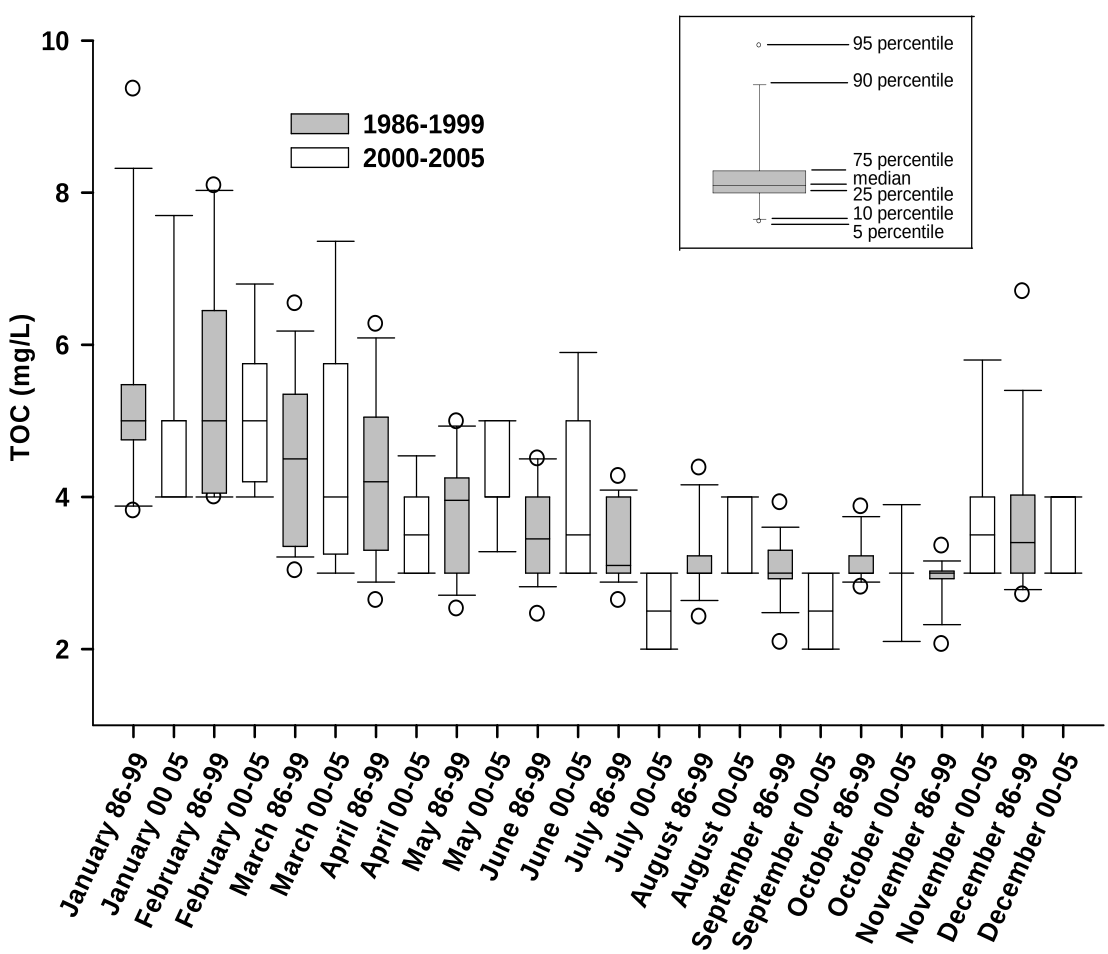
The mean and standard deviation at Banks have remained the same over the pre-DVL and post-DVL time periods. The median for TOC at Banks increased from 3.4 mg/L pre-DVL to 4.0 mg/L post-DVL. As shown in **Table 7-6**, the mean and standard deviation at Devil Canyon increased from the pre-DVL to the post-DVL time period. Notably, the mean increased from 2.9 mg/L to 3.9 mg/L, and the standard deviation increased approximately 0.3 mg/L over the last five years, indicating increased variability in TOC concentrations. The median for TOC at Devil

Canyon increased from 2.8 mg/L pre-DVL to 3.8 mg/L post-DVL. **Figure 7-29** clearly shows that during the post-DVL time period, there are many more instances where TOC is 4 mg/L or greater, compared to the pre-DVL time period (1981-1999).

Concentrations of TOC in Delta source waters increase as a result of runoff from natural, agricultural, and urban areas during the wet season. Accordingly, wetter years tend to be associated with higher TOC loads, and the early parts of wet seasons are generally characterized by significant spikes in TOC concentrations as surface runoff occurs. This phenomenon is probably the most important factor affecting TOC fluctuations in SWP waters, and may explain much of the apparent trends that are observed.

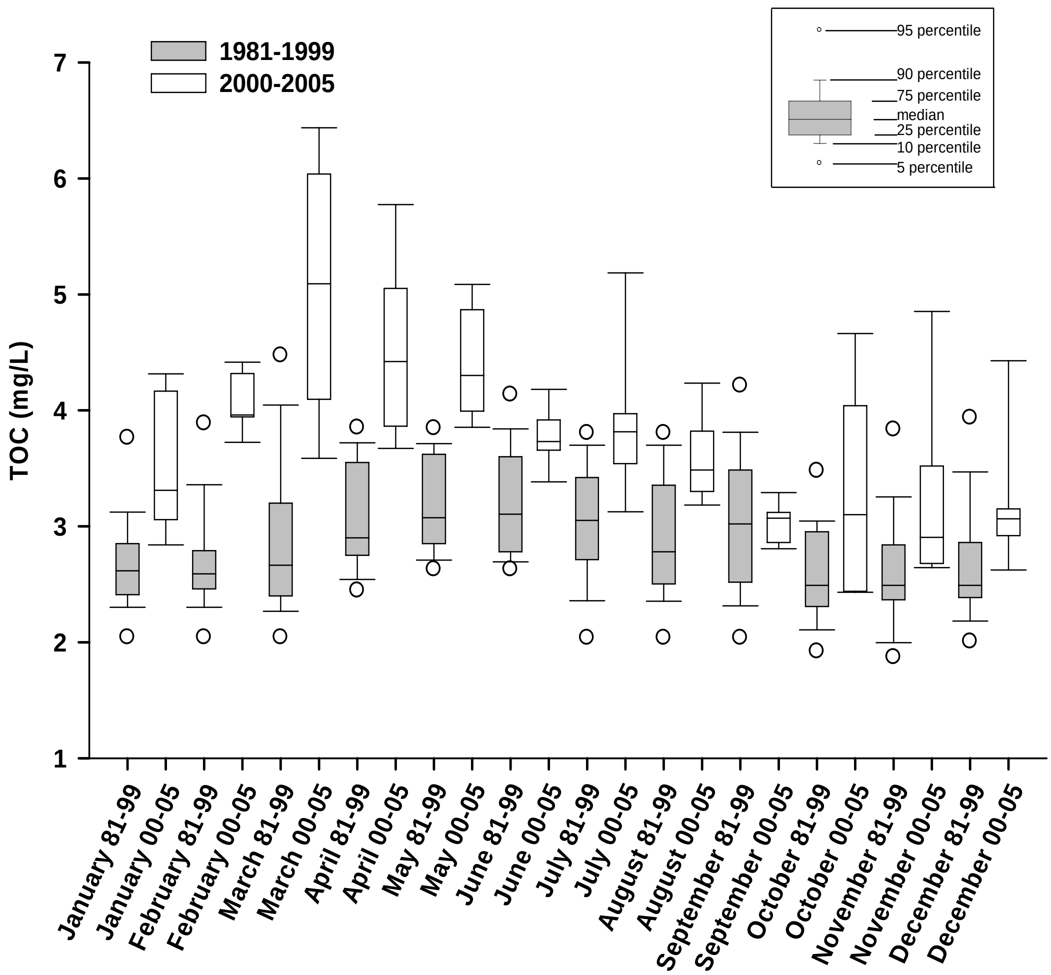
To further illustrate the statistics, **Figure 7-30** shows monthly trends from 1986-2005 at Banks, with the data broken into pre- and post-DVL time periods. Generally, monthly TOC medians are similar for the respective months in both time periods, with some months showing the median value being lower for the pre-DVL time period. Variability in the data are similar for the respective months in both time periods. TOC at Banks is normally highest in January and February.

Figure 7-30. Monthly Total Organic Carbon Trends at Banks, 1986-2005



To further illustrate the recent changes at Devil Canyon, **Figure 7-31** shows monthly trends from 1981-2005, with the data broken into pre- and post- DVL time periods. During the pre-DVL time period, monthly TOC medians were always 3.2 mg/L or less, but within the last five years, monthly TOC medians are 4 mg/L or greater 4 out of 12 months (February, March, April, May). The monthly TOC medians were higher during the post-DVL time period for all months, compared to pre-DVL. The monthly TOC 90th percentiles were higher during the post-DVL time period for all months except September, compared to pre-DVL. Additionally, **Figure 7-31** illustrates increased variability in the data during the post-DVL time period.

Figure 7-31. Monthly Total Organic Carbon Trends at Devil Canyon, 1981-2005

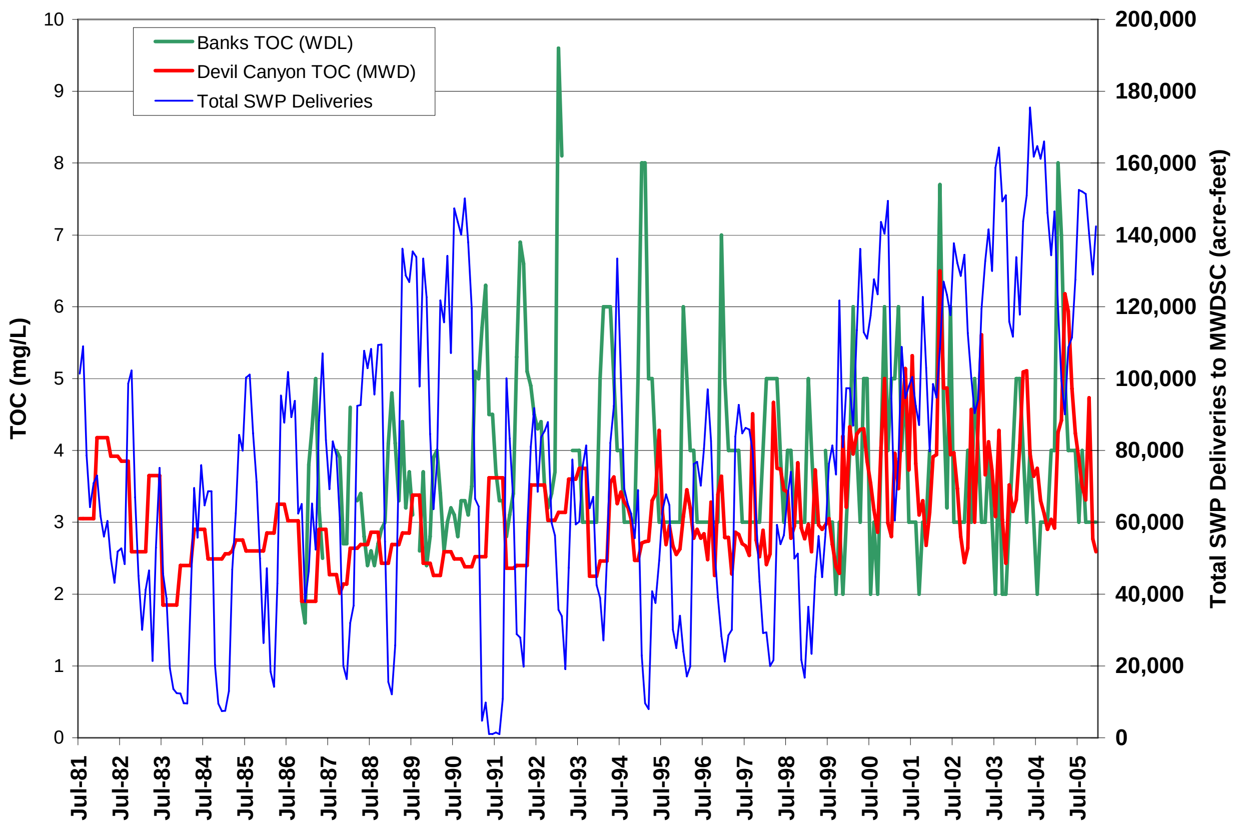


A variety of factors could explain the increase in TOC at Devil Canyon such as changes in upstream water quality, changes in sources of organic carbon, increased deliveries to MWDSC, and possibly, changes in the timing and delivery from San Luis reservoir, now that deliveries are high almost year-round.

Although there has been a dramatic increase in TOC levels at Devil Canyon in recent years, there only appears to be a slightly increasing trend in TOC levels at Banks. As stated earlier, the median increased from 3.4 to 4.0 mg/L, but the maximum decreased from 9.6 to 8.0 mg/L.

Figure 7-29 shows that the post-DVL TOC levels at Devil Canyon are closer to the TOC levels at Banks, compared to the pre-DVL time period. Since SWP pumping has dramatically increased since 1999 (**Figure 7-32**), this increase could partially explain why the TOC levels at Devil Canyon have increased. However, it is also likely that TOC levels at Devil Canyon have also increased due to changes in the timing of deliveries to MWDSC, rather than simply the increase in delivery volume. For example, **Figure 7-32** also shows a similar increasing trend in SWP deliveries to MWDSC from the mid-80's to 1990, yet during this time period TOC levels at Devil Canyon remained lower than at Banks. Perhaps TOC levels at Devil Canyon are now higher because TOC at Banks has increased slightly and more water is being exported to Southern California on a year-round basis. In short, the timing and volume of deliveries can result in water quality changes downstream.

Figure 7-32. Total Organic Carbon at Banks and Devil Canyon and Total SWP Deliveries to MWDSC

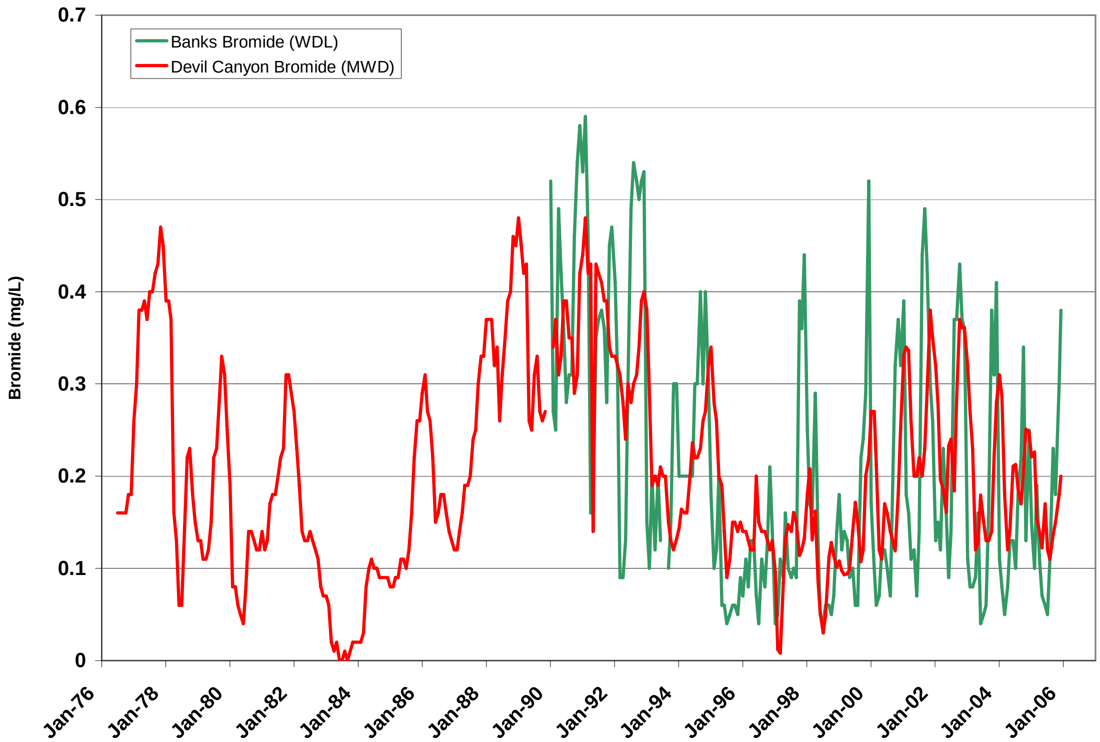


Chapter 3 - *Water Quality in the Watersheds and the State Water Project* contains an analysis of TOC changes in transit along the California Aqueduct. To briefly summarize, summary statistics were computed to verify whether TOC trends were significantly different at Banks and Check 41 over the 1997 to 2005 time period. This analysis failed to demonstrate there was a statistically significant difference in TOC concentrations between Banks and Check 41 for the study period.

Bromide

Bromide data collected at Banks and at Devil Canyon are presented in **Figure 7-33**. Bromide at both Banks and Devil Canyon generally peaks during the September-December time period. Bromide concentrations are typically elevated in the fall, due to seawater intrusion in the Delta. For comparison between the pre-DVL and post-DVL time periods, **Table 7-7** contains a summary of statistical information for both Banks and Devil Canyon. The pre-DVL time period for Banks is from 1990-1999, and for Devil Canyon is from 1976-1999.

Figure 7-33. Bromide at Banks and Devil Canyon (DWR data)



The median for bromide at Banks decreased from 0.18 mg/L pre-DVL to 0.15 mg/L post-DVL. The mean also decreased from 0.22 mg/L pre-DVL to 0.19 mg/L post-DVL, and the standard deviation decreased, indicating decreased variability. The median for bromide at Devil Canyon increased from 0.17 mg/L pre-DVL to 0.20 mg/L post-DVL, although the mean is similar for both time periods. The data do not indicate any clear change in trends between the pre- and post-DVL time periods. Bromide levels continue to increase during the late summer to fall months.

Table 7-7. Summary of Bromide Statistical Information

Time Period	Banks (mg/L)	Devil Canyon (mg/L)
Mean ± std dev – pre-DVL	0.22 ± 0.16	0.20 ± 0.12
Mean ± std dev – post-DVL	0.19 ± 0.12	0.21 ± 0.07
Median – pre-DVL	0.18	0.17
Median – post-DVL	0.15	0.20
Max – pre-DVL	0.59	0.48
Max - – post-DVL	0.49	0.38
Min – pre-DVL	0.04	0.01
Min – post-DVL	0.04	0.11

To further illustrate the statistics at Banks, **Figure 7-34** shows monthly trends from 1990-2005, with the data broken into pre- and post- DVL time periods. Bromide tends to be more problematic to SWP Contractors during the fall, when seawater intrusion into the Delta is more likely to occur due to reduced Delta outflow. Monthly bromide medians during the post-DVL time period are higher compared to the pre-DVL time period during these critical months (August-November). However, it must be noted that the 90^{th} percentile for the post-DVL data is never higher than the 90^{th} percentile for the pre-DVL time period. Therefore, the post-DVL data does not fall outside the historical data range.

To further illustrate the statistics at Devil Canyon, **Figure 7-35** shows monthly trends from 1976-2005, with the data broken into pre- and post- DVL time periods. During the pre-DVL time period, monthly bromide medians were always 0.2 mg/L or less, except for February. Within the last 5 years, monthly bromide medians were 0.2 mg/L or greater 4 out of 12 months. Similar to Banks, the increase in bromide levels within the last 5 years is most notable during the fall/early winter timeframe. Again, it must be noted that the 90^{th} percentile for the post-DVL data is never higher than the 90^{th} percentile for the pre-DVL time period. Therefore, the post-DVL data does not fall outside the historical data range.

The most significant factors affecting bromide levels in the SWP are Delta outflow, Delta diversions, and hydrology in relation to seawater/tidal flux. Average Delta outflow during the period 1/1/81 through 12/31/99 was 21,987 cfs, compared to 18,577 cfs for the period 1/1/2000 through 9/30/2005, a 15.5 percent reduction. This may account for the increase in bromide at Banks during the fall months of 2000-2005, compared to the historical record. Years 2001 through 2005 were also characterized by drier than normal hydrology in the Delta.

Figure 7-34. Monthly Bromide Trends at Banks, 1990-2005

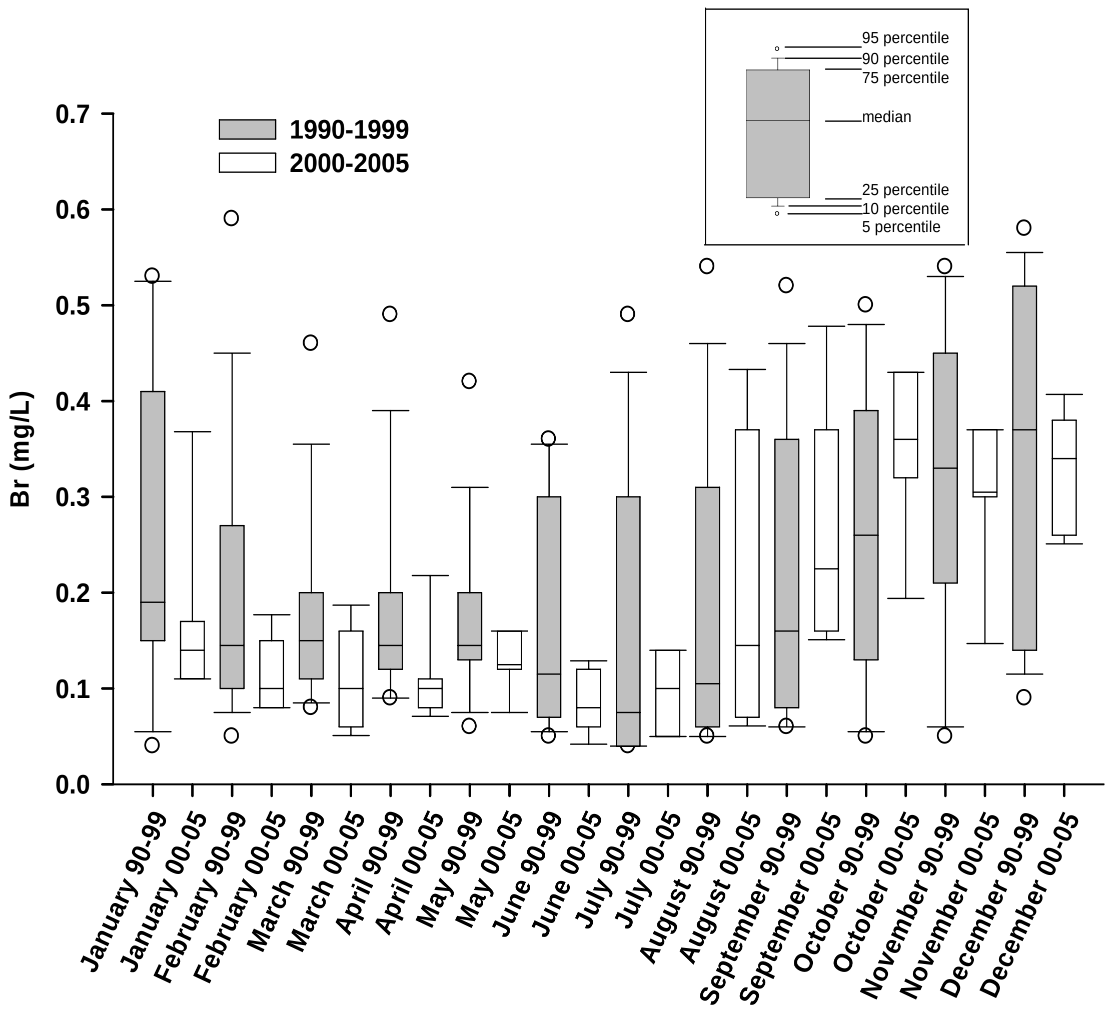
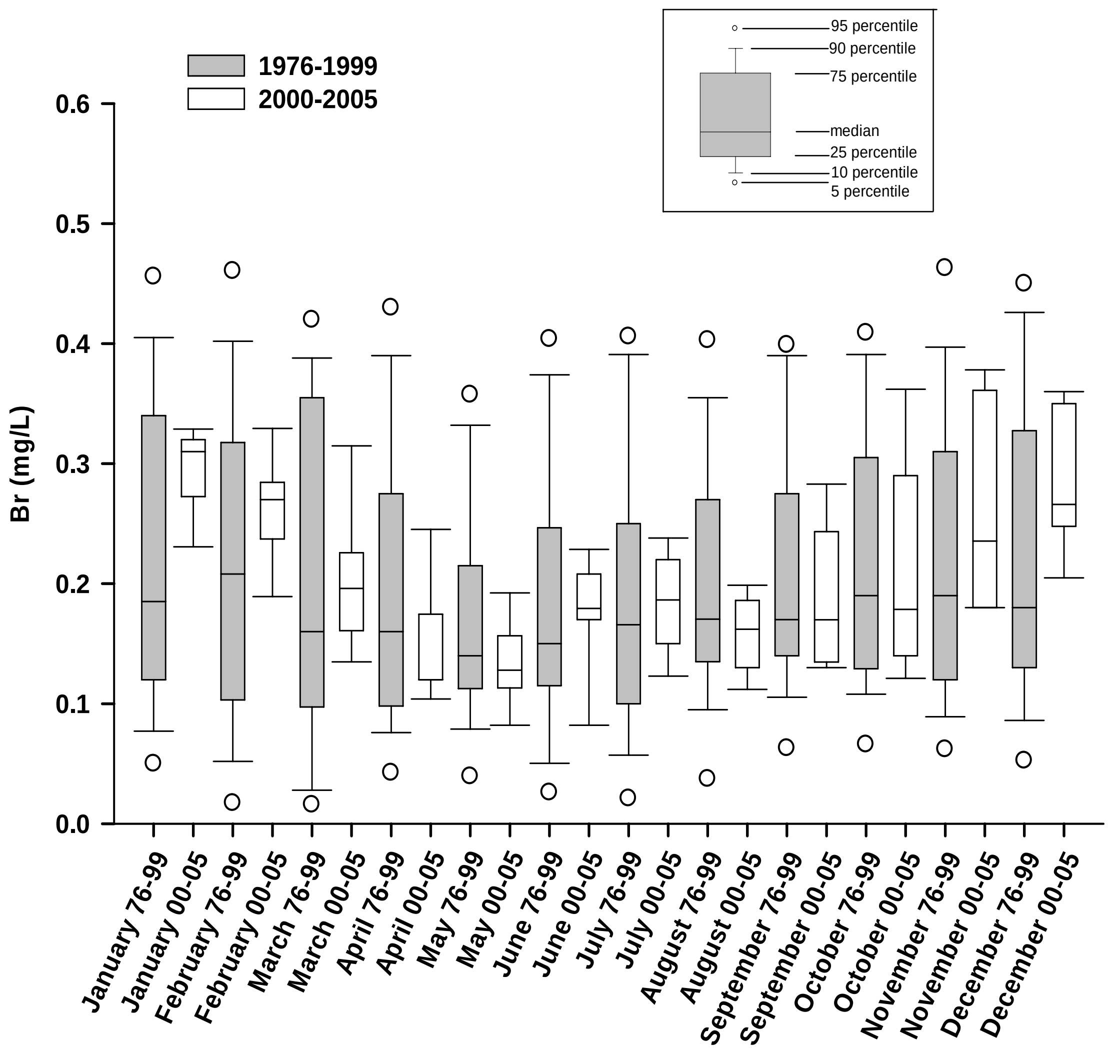


Figure 7-35. Monthly Bromide Trends at Devil Canyon, 1976-2005



Summary for Total Organic Carbon and Bromide

- TOC concentrations at Banks increased slightly from pre-DVL to post-DVL.
- TOC concentrations at Devil Canyon dramatically increased from pre-DVL to post-DVL.
- Monthly median bromide levels from pre-DVL to post-DVL increased at Banks over the last five years during the months of August to November. However, the post-DVL 90^{th} percentiles do not exceed the 90^{th} percentiles for the historical record.
- Monthly median bromide levels increased at Devil Canyon from pre-DVL to post-DVL during the months of November to March. However, the post-DVL 90^{th} percentiles do not exceed the 90^{th} percentiles for the historical record.

- TOC water quality changes over the last five years at Devil Canyon appear to be related to increase of deliveries, timing of deliveries, changes in upstream water quality, and hydrology.
- Bromide water quality changes over the last five years at Devil Canyon appear to be related to Delta outflows and hydrology.

Total Phosphorus

Total phosphorus data collected at Banks and at Devil Canyon from 1995 to 2005 are presented in **Figure 7-36.** Phosphorus does not appear to follow a seasonal pattern like bromide and organic carbon. For comparison between the pre-DVL (1995-1999) and post-DVL (2000-2005) time periods, **Table 7-8** contains a summary of statistical information for both Banks and Devil Canyon. The pre-DVL median for total phosphorus at Banks has decreased from 0.12 mg/L to 0.10 mg/L post-DVL. The median and mean for total phosphorus at Devil Canyon remained unchanged from pre-DVL to post-DVL. **Figure 7-36** shows that, with the exception of two data points, the levels remain below 0.15 mg/L.

Table 7-8. Summary of Total Phosphorus Statistical Information

Time Period	Banks (mg/L)	Devil Canyon (mg/L)
Mean ± std dev – pre-DVL	0.13 ± 0.04	0.09 ± 0.03
Mean ± std dev – post-DVL	0.11 ± 0.03	0.09 ± 0.05
Median – pre–DVL	0.12	0.09
Median - post-DVL	0.10	0.09
Max – pre-DVL	0.26	0.27
Max – post-DVL	0.28	0.46
Min – pre-DVL	0.07	0.02
Min – post-DVL	0.06	0.01

To further illustrate the historical trends, **Figure 7-37** shows monthly averages at Banks for each of the time periods. The higher levels of phosphorus at Banks during the pre-DVL time period occur throughout the year, and show no seasonal pattern.

Monthly averages at Devil Canyon appear to be similar over the pre-DVL and post-DVL time periods (**Figure 7-38**). The data suggest phosphorus is lost as water moves through the SWP to its terminus in Southern California. Most of the loss is probably due to settling of organic material in the reservoirs of the SWP.

Figure 7-36. Total Phosphorus at Banks and Devil Canyon, 1995-2005

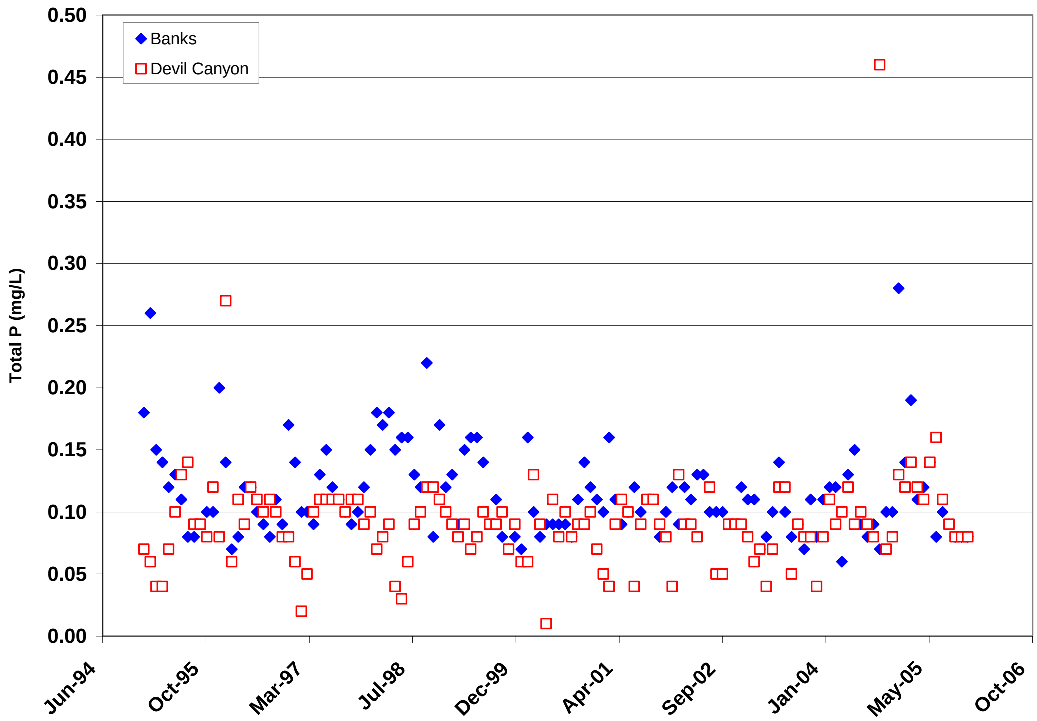


Figure 7-37. Monthly Averages for Total Phosphorus at Banks, 1995-2005

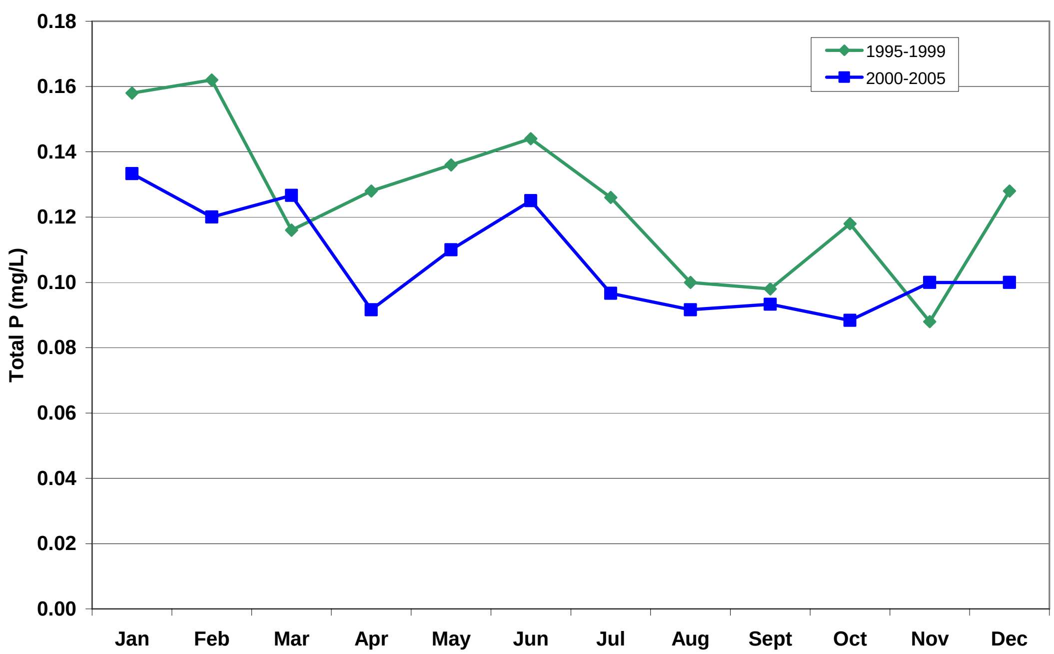
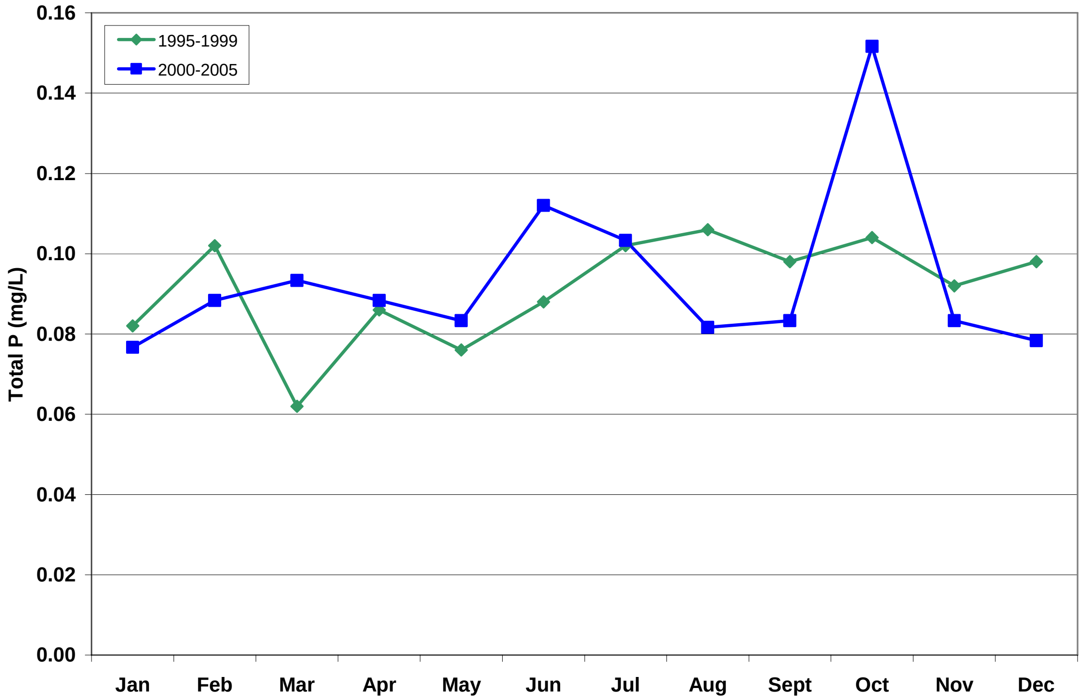


Figure 7-38. Monthly Averages for Total Phosphorus at Devil Canyon, 1995-2005



Total Nitrogen

Nitrogen in the aquatic environment can be present in several forms that are biochemically interconvertible. These are: organic nitrogen, ammonia, nitrite, nitrate, and gaseous nitrogen. Although gaseous nitrogen is actually part of the biochemical cycle, its relationship to the other nitrogen forms is complex. For purposes of simplicity, nitrogen is discussed here as the summation of the forms for which SWP waters are analyzed, which are those listed above with the exception of gaseous nitrogen. Total nitrogen, as used in this section, includes nitrate, nitrite and "Kjeldahl nitrogen" (organic nitrogen and ammonia).

Total nitrogen data collected at Check 41 and at Devil Canyon from 1998 to 2005 are presented in **Figure 7-39**. Nitrogen does not appear to follow a seasonal pattern like bromide and organic carbon. Unlike the previous constituents, statistics to compare pre-DVL and post-DVL time periods were not computed and compared, as there are only two years of data (1998 and 1999) which can be considered pre-DVL. Instead, statistics were computed for both check 41 and Devil Canyon over the entire 1998-2005 time period, as shown in **Table 7-9**. Overall, levels at Check 41 are higher than at Devil Canyon, and also have increased variability. It is difficult to evaluate how nitrogen has changed at Devil Canyon over the last five years, due to the limited data available before 1999. However, Devil Canyon nitrogen data as shown in **Figure 7-39** appear to be more variable in the last five years.

Figure 7-39. Total Nitrogen at Check 41 and Devil Canyon, 1998-2005

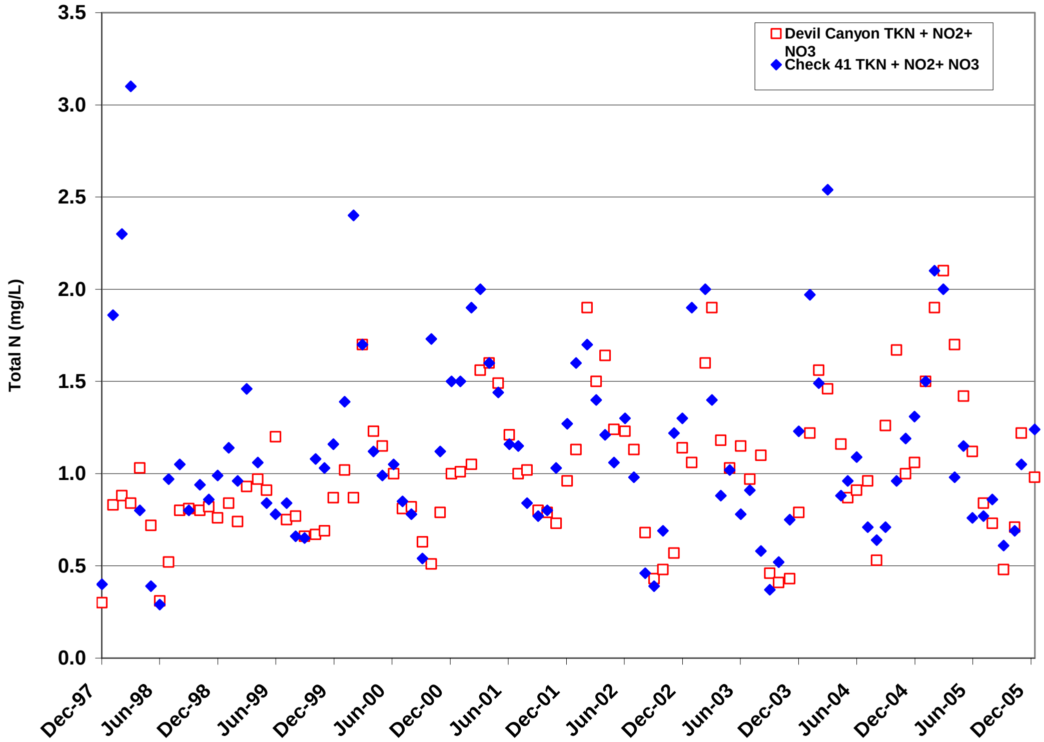


Table 7-9. Summary of Total Nitrogen Statistical Information

Time Period	Check 41 (mg/L)	Devil Canyon (mg/L)
1998-2005 mean ± std dev	1.14 ± 0.51	1.01 ± 0.38
1998-2005 median	1.05	0.97
1998-2005 max	3.1	2.1
1998-2005 min	0.29	0.3

Summary for Nutrients

- Phosphorus has remained the same at Devil Canyon for both time periods, and Banks has decreased slightly over the last five years.
- Both phosphorus and nitrogen are higher at upstream locations such as Banks and Check 41, compared to Devil Canyon.
- Nitrogen levels at Check 41 are more variable compared to Devil Canyon.
- Nitrogen levels at Devil Canyon appear to be more variable in the last five years.

Taste and Odor

The most commonly reported T&O compounds, geosmin and MIB, are produced in aquatic environments by cyanobacteria (blue-green algae) or mold-like, filamentous bacteria called actinomycetes. T&O compounds are released when these microbes die. The previous discussion on sedimentation in Clifton Court indicates that benthic cyanobacteria growing in Clifton Court Forebay may be responsible for some of the T&O problems affecting SBA Contractors. As described in Chapter 3, there is some evidence that MIB produced in the Delta is found as far south as Check 41, but at much lower concentrations. There is also a substantial amount of data indicating that MIB and geosmin are produced in the East Branch of the Aqueduct due to the growth of benthic algae.

To control or limit algal growth, DWR applies copper sulfate to the California Aqueduct and the SWP reservoirs. Both DWR and MWDSC staff agree that the number of taste and odor events increased in recent years. **Figure 7-40** shows that the number of copper sulfate treatments that have occurred during the period 1997-2005 increased along the East Branch. **Figure 7-41** shows the number of copper sulfate treatments that have occurred at Lake Skinner from 1997 to 2005. Although Lake Skinner receives both Colorado River water and SWP water, the percent of SWP water entering Lake Skinner has increased dramatically, which in turn, has been associated with increased numbers of copper sulfate treatments. **Figure 7-41** clearly shows that the delivery of SWP water to Lake Skinner has been year-round since 1999 (as indicated by percent SWP blend), where it used to be only from April through October.

Figure 7-40. Copper Sulfate Treatments along East Branch, 1997-2005

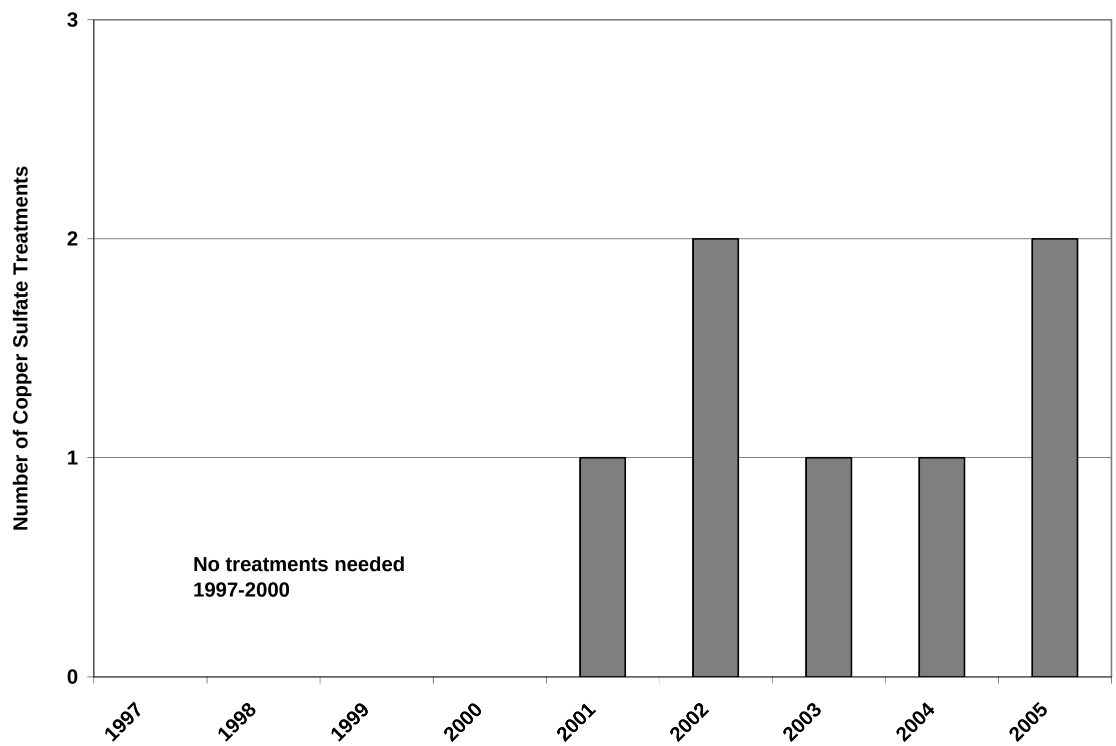
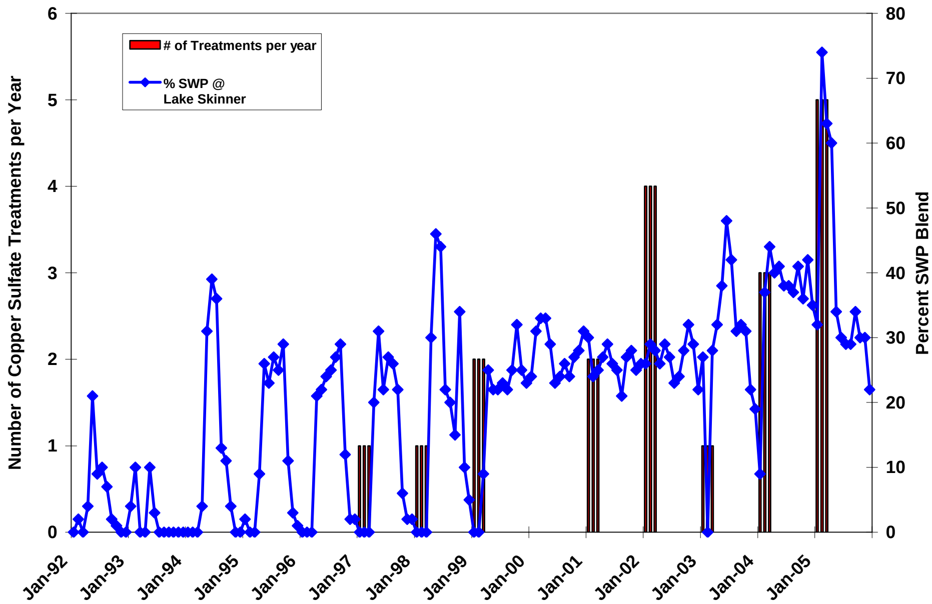
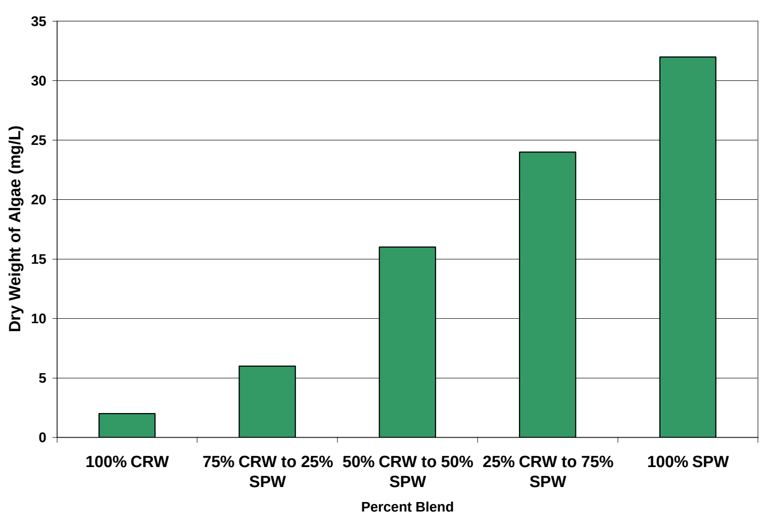


Figure 7-41. Copper Sulfate Treatments – Lake Skinner



The connection between increasing SWP water blends and increasing copper sulfate treatments is supported by previous studies conducted by MWDSC where algal production potential was measured with increasing blends of SWP water**.** As shown in **Figure 7-42**, these studies found that there was almost a linear relationship between algal production potential and percent blends of SWP water when added to Colorado River water. Specifically, the study concluded that SWP water has about 16 times the algal production potential of Colorado River water.

Figure 7-42. Algal Production Potential of SWP and Colorado River
Source: MWDSC



Summary for Taste and Odor

T&O events along the East Branch and at Lake Skinner have increased in recent years. Exact causes of increased T&O events along the East Branch are unknown. Previous studies conducted by MWDSC have linked increased algal production potential with increasing amounts of SWP water added to Colorado River water, which may explain the increase of T&O events at Lake Skinner.

Impacts on Water Treatment Plants

Total Organic Carbon

Since the TOC levels at Devil Canyon have been detected more frequently near 4.0 mg/L in recent years, the Mills WTP has been impacted dramatically. The Mills WTP became operational with ozone in October 2003, with the intention of falling under the "alternative compliance criteria" for the Stage 1 Disinfectants/Disinfection Byproducts (D/DBP) Rule, which would exempt the Mills WTP from the TOC removal requirement. However, this exemption no longer applies once the source water TOC running annual average is at 4.0 mg/L or greater. Therefore, whenever the source water TOC levels approach 4.0 mg/L, the Mills WTP is operating in the ozone and enhanced coagulation mode. MWDSC staff stated that they felt they were not getting the full benefit of implementing ozone since TOC levels have increased along the East Branch, which requires the plant to operate with both ozone and enhanced coagulation. Obviously, increasing levels of TOC in the source water equate to additional chemical and operational costs.

Total trihalomethane (TTHM) data from the Mills WTP was analyzed to determine if increased formation of TTHMs has occurred due to the increase in TOC levels at Devil Canyon. The average TTHMs in the Mills WTP treated water was 59.4 µg/L from 1994 to 1999, and the average was 50.5 µg/L from 2000 to 2005, indicating no compliance or health-related impacts.

Bromide

MWDSC's Mills and Jensen WTPs have needed to control bromate formation since ozone came on-line in October 2003 and July 2005, respectively. Bromate formation is managed through adjusting the pH, and the level of pH adjustment needed is dependent on the bromide levels in the source water. **Table 7-10** shows the operational changes which must be made at the various bromide levels in source waters. Similar to TOC, increasing levels of bromide in the source water equate to additional chemical and operational costs.

Table 7-10. MWDSC's Operational Strategy to Control Bromate Formation

Bromide Levels in Source Water	Mills WTP	Jensen WTP
< 0.2 mg/L	Adjust pH to 7.0	No pH adjustment needed
0.2-0.3 mg/L	Adjust pH to 6.5	Adjust pH to 7.0
> 0.3 mg/L	Adjust pH to 6.0	Adjust pH to 6.5

Taste and Odor

As discussed earlier, **Figures 7-40 and 7-41** show that the number of copper sulfate treatments have increased along the East Branch and at Lake Skinner from 1997 to 2005. Additional costs have been incurred by both DWR and MWDSC to manage and treat T&O events.

POTENTIAL ACTIONS

Study Operational Alternatives

Because the changes in TOC and bromide concentrations at MWDSC treatment plants appear to result from a combination of altered timing of deliveries in recent years, and possibly increased deliveries, actions that would affect TOC and bromide fluctuations would probably involve quantity and/or timing of deliveries. It is unclear whether it would be feasible to alter current SWP operations to accommodate TOC and bromide concerns but, as substantial treatment cost increases have been experienced, a study of operational alternatives to enhance water quality may be justified.

Study of Nutrient Loading to Terminal Reservoirs

This section offers only a preliminary analysis into what might be occurring for nutrients along the East Branch of the California Aqueduct and Silverwood Lake. Further study of the impact of nutrient loading on the terminal reservoirs in Southern California, and how that may vary seasonally, and as flows change, might shed additional light on the factors affecting nutrient fluctuations in the system and lead to options for addressing associated water quality problems.

Develop Tools for Better Real-Time Monitoring and Forecasting

As source water concentrations of TOC and bromide dictate daily operational modes for the SWP or MWDSC treatment plants, there is a definitive need for better real-time monitoring and forecasting. Computer models to provide short and medium forecasts of water quality at the treatment plants would be useful for providing advance warning of impending treatment challenges. Additional time to prepare for operational changes is valuable to the SWP Contractors, and may avoid unexpected treatment costs and increase the reliability of water treatment.

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APPENDICES

CALIFORNIA STATE WATER PROJECT
WATERSHED SANITARY SURVEY
2006 UPDATE

APPENDIX A

SUPPORTING INFORMATION FOR CHAPTER 3

DATA INDEX

MWQI Continuous Recorder Database

Station Name	Analyte	Begin Date	End Date
Hood	EC	12/22/98	12/31/05
Hood	Dissolved Organic Carbon (Combustion)	04/09/02	12/31/05
Hood	Total Organic Carbon (Combustion)	04/08/02	12/31/05
Hood	Total Organic Carbon (Ox)	04/05/02	12/31/05
Vernalis	Dissolved Organic Carbon (Combustion)	03/23/05	12/31/05
Vernalis	Total Organic Carbon (Combustion)	03/23/05	12/31/05
Banks	Dissolved Organic Carbon (Combustion)	09/14/01	12/31/05
Banks	Total Organic Carbon (Combustion)	09/14/01	12/31/05

MWQI Grab Sample Database

Station Name	Analyte	Begin Date	End Date
Hood	Total Organic Carbon (Ox)	01/12/98	12/05/05
Hood	Total Organic Carbon (Combustion)	10/30/00	12/05/05
Hood	Dissolved Bromide	01/11/96	12/05/05
Hood	Conductance (EC)	01/11/96	12/05/05
Hood	Total Nitrogen	11/04/02	12/05/05
Hood	Total Phosphorus	11/04/02	12/05/05
Hood	Turbidity	01/11/96	12/05/05
Vernalis	Total Organic Carbon (Combustion)	10/30/00	12/20/05
Vernalis	Total Organic Carbon (Ox)	09/02/98	12/20/05
Vernalis	Dissolved Bromide	07/18/96	12/20/05
Vernalis	Conductance (EC)	07/18/96	12/20/05
Vernalis	Total Nitrogen	11/06/02	12/20/05
Vernalis	Total Phosphorus	11/06/02	12/20/05
Vernalis	Turbidity	07/18/96	12/20/05

O&M WQ Continuous Recorder Database

Station Name	Analyte	Begin Date	End Date
Barker Slough	Electrical Conductance	01/01/96	12/31/05
Barker Slough	Temperature	01/01/96	12/31/05
Barker Slough	Turbidity	01/01/96	12/31/05
Cordelia	Electrical Conductance	01/01/01	12/31/05
Cordelia	Temperature	01/01/01	12/31/05
Cordelia	Turbidity	09/01/96	12/31/05
Clifton Court Intake	Electrical Conductance	01/01/96	12/31/05
Clifton Court Intake	Fluorometric Units	01/01/01	12/31/05
Clifton Court Intake	pH	01/01/01	11/18/05
Clifton Court Intake	Temperature	01/01/01	12/31/05
Clifton Court Intake	Turbidity	01/01/96	12/31/05
Banks	Electrical Conductance	01/01/96	12/31/05
Banks	Fluorometric Units	10/27/00	12/31/05
Banks	pH	10/27/00	12/31/05
Banks	Temperature	10/27/00	12/31/05

	O&M WQ Continuous Recorder Database (Continued)		
Station Name	Analyte	Begin Date	End Date
Banks	Turbidity	01/01/96	12/31/05
Banks	Ultraviolet Absorbance @254nM	10/27/00	12/31/05
DV Check 7	Electrical Conductance	01/01/96	12/31/05
DV Check 7	Fluorometric Units	01/01/01	12/31/05
DV Check 7	pH	01/01/01	12/31/05
DV Check 7	Temperature	01/01/01	12/31/05
DV Check 7	Turbidity	01/01/96	12/31/05
Vallecitos	Electrical Conductance	03/06/02	12/31/05
Vallecitos	Turbidity	03/06/02	12/31/05
Terminal Tank	Electrical Conductance	01/01/96	08/20/02
Terminal Tank	Fluorometric Units	01/01/96	08/20/02
Terminal Tank	Temperature	01/01/96	08/20/02
Terminal Tank	Turbidity	01/01/96	08/20/02
Pacheco	Electrical Conductance	01/01/96	12/31/05
Pacheco	Fluorometric Units	11/23/01	12/31/05
Pacheco	Temperature	01/01/01	12/31/05
Pacheco	Turbidity	01/01/96	12/31/05
Check 13	Electrical Conductance	01/01/96	12/31/05
Check 13	pH	01/01/00	12/31/05
Check 13	Temperature	01/01/00	12/31/05
Check 13	Turbidity	01/01/96	12/31/05
Check 13	Ultraviolet Absorbance @254nM	11/29/00	12/31/05
Check 21	Electrical Conductance	01/01/96	12/31/05
Check 21	Temperature	01/01/00	12/31/05
Check 21	Turbidity	01/01/96	12/31/05
Check 29	Electrical Conductance	01/01/96	12/31/05
Check 29	Temperature	01/01/00	12/31/05
Check 29	Turbidity	01/01/96	12/31/05
Check 41	Electrical Conductance	01/01/96	12/31/05
Check 41	pH	01/01/00	12/31/05
Check 41	Temperature	01/01/00	12/31/05
Check 41	Turbidity	01/01/96	12/31/05
Check 41	Ultraviolet Absorbance @254nM	12/12/02	12/13/04
Castaic Outlet	Electrical Conductance	01/01/96	12/31/05
Castaic Outlet	pH	01/01/01	12/31/05
Castaic Outlet	Temperature	01/01/01	12/31/05
Castaic Outlet	Turbidity	01/01/96	12/31/05
Check 66	Electrical Conductance	07/15/03	01/01/05
Check 66	Turbidity	07/15/03	01/01/05
Devil Canyon	Electrical Conductance	12/26/96	12/31/05
Devil Canyon	Turbidity	01/01/96	12/31/05

O&M WQ Discrete (Grab) Sample Database

Station Name	Analyte	Begin Date	End Date
Barker Slough	Conductance (EC)	12/17/97	12/31/05
Barker Slough	Dissolved Bromide	12/17/97	12/31/05
Barker Slough	Dissolved Nitrite + Nitrate	01/21/98	12/31/05
Barker Slough	Dissolved Ortho-phosphate	01/21/04	12/31/05
Barker Slough	Ortho-phosphate	05/19/04	05/19/04
Barker Slough	Ortho-phosphate	12/17/97	12/17/03
Barker Slough	Total Kjeldahl Nitrogen	12/17/97	12/31/05
Barker Slough	Total Organic Carbon (Combustion)	11/15/00	12/31/05
Barker Slough	Total Organic Carbon (Ox)	12/17/97	12/31/05
Barker Slough	Total Phosphorus	12/17/97	12/31/05
Barker Slough	Turbidity	12/17/97	12/31/05
Barker Slough	UV Absorbance @254nm	12/17/97	12/31/05
Barker Slough	Volatile Suspended Solids	12/17/97	12/31/05
Clifton Court Intake	Conductance (EC)	01/19/96	10/20/94
Clifton Court Intake	Conductance (EC)	02/18/98	12/31/05
Clifton Court Intake	Dissolved Bromide	01/19/96	12/31/05
Clifton Court Intake	Total Organic Carbon (Combustion)	11/15/00	12/31/05
Clifton Court Intake	Total Organic Carbon (Ox)	11/17/99	12/31/05
Clifton Court Intake	Turbidity	01/19/96	12/31/05
Clifton Court Intake	UV Absorbance @254nm	01/19/96	09/18/02
Clifton Court Intake	Volatile Suspended Solids	07/19/00	12/31/05
Banks	Conductance (EC)	01/12/96	07/02/97
Banks	Conductance (EC)	12/17/97	12/31/05
Banks	Dissolved Bromide	01/12/96	12/31/05
Banks	Dissolved Nitrite + Nitrate	06/22/96	09/14/95
Banks	Dissolved Nitrite + Nitrate	12/07/96	12/31/05
Banks	Dissolved Ortho-phosphate	01/21/04	12/31/05
Banks	Ortho-phosphate	03/17/04	06/10/04
Banks	Ortho-phosphate	12/17/97	12/17/03
Banks	Total Kjeldahl Nitrogen	12/17/97	12/31/05
Banks	Total Organic Carbon (Combustion)	11/15/00	12/31/05
Banks	Total Organic Carbon (Ox)	12/17/97	12/31/05
Banks	Total Phosphorus	12/17/97	12/31/05
Banks	Turbidity	01/12/96	12/31/05
Banks	Turbidity	07/18/96	07/02/97
Banks	UV Absorbance @254nm	01/12/96	12/31/05
Banks	Volatile Suspended Solids	12/17/97	12/31/05
DV Check 7	Conductance (EC)	12/17/97	12/31/05
DV Check 7	Dissolved Bromide	12/17/97	12/31/05
DV Check 7	Dissolved Nitrite + Nitrate	01/21/98	12/31/05
DV Check 7	Dissolved Ortho-phosphate	01/20/04	12/31/05
DV Check 7	Ortho-phosphate	03/15/04	05/19/04
DV Check 7	Ortho-phosphate	12/17/97	12/16/03

	O&M WQ Discrete (Grab) Sample Database (Continued)		
Station Name	Analyte	Begin Date	End Date
DV Check 7	Total Kjeldahl Nitrogen	12/17/97	12/31/05
DV Check 7	Total Organic Carbon (Combustion)	11/15/00	12/31/05
DV Check 7	Total Organic Carbon (Ox)	12/17/97	12/31/05
DV Check 7	Total Phosphorus	12/17/97	12/31/05
DV Check 7	Turbidity	12/17/97	12/31/05
DV Check 7	UV Absorbance @254nm	10/14/03	03/15/04
DV Check 7	Volatile Suspended Solids	12/17/97	12/31/05
Del Valle Outlet	Conductance (EC)	02/18/98	12/31/05
Del Valle Outlet	Dissolved Bromide	02/18/98	12/31/05
Del Valle Outlet	Dissolved Nitrite + Nitrate	02/18/98	12/31/05
Del Valle Outlet	Dissolved Ortho-phosphate	08/17/04	12/31/05
Del Valle Outlet	Ortho-phosphate	03/16/04	03/16/04
Del Valle Outlet	Ortho-phosphate	02/18/98	09/18/02
Del Valle Outlet	Total Kjeldahl Nitrogen	02/18/98	12/31/05
Del Valle Outlet	Total Organic Carbon (Combustion)	03/16/04	12/31/05
Del Valle Outlet	Total Organic Carbon (Ox)	10/20/99	12/31/05
Del Valle Outlet	Total Phosphorus	02/18/98	12/31/05
Del Valle Outlet	Turbidity	02/18/98	12/31/05
Del Valle Outlet	UV Absorbance @254nm	03/16/04	12/31/05
Del Valle Outlet	Volatile Suspended Solids	02/18/98	12/31/05
Terminal Tank	Conductance (EC)	02/18/98	12/31/05
Terminal Tank	Dissolved Bromide	02/18/98	12/31/05
Terminal Tank	Turbidity	02/18/98	12/31/05
Terminal Tank	Volatile Suspended Solids	05/19/99	12/31/05
DMC @McCabe Rd	Conductance (EC)	12/17/97	12/31/05
DMC @McCabe Rd	Dissolved Bromide	12/17/97	12/31/05
DMC @McCabe Rd	Total Organic Carbon (Combustion)	11/15/00	12/31/05
DMC @McCabe Rd	Total Organic Carbon (Ox)	12/17/97	12/31/05
DMC @McCabe Rd	Turbidity	12/17/97	12/31/05
DMC @McCabe Rd	UV Absorbance @254nm	03/17/99	09/15/99
DMC @McCabe Rd	Volatile Suspended Solids	03/17/99	09/18/02
Pacheco	Conductance (EC)	03/15/00	12/31/05
Pacheco	Dissolved Bromide	03/15/00	12/31/05
Pacheco	Dissolved Nitrite + Nitrate	03/15/00	12/31/05
Pacheco	Dissolved Ortho-phosphate	01/20/04	12/31/05
Pacheco	Ortho-phosphate	03/16/04	03/16/04
Pacheco	Ortho-phosphate	03/15/00	12/16/03
Pacheco	Total Kjeldahl Nitrogen	03/15/00	12/31/05
Pacheco	Total Organic Carbon (Combustion)	01/17/01	12/31/05

	O&M WQ Discrete (Grab) Sample Database (Continued)		
Station Name	Analyte	Begin Date	End Date
Pacheco	Total Organic Carbon (Ox)	04/19/00	12/31/05
Pacheco	Total Phosphorus	03/15/00	12/31/05
Pacheco	Turbidity	04/19/00	12/31/05
Pacheco	Volatile Suspended Solids	04/19/00	01/16/02
Check 13	Conductance (EC)	12/17/97	12/31/05
Check 13	Dissolved Bromide	12/17/97	12/31/05
Check 13	Dissolved Nitrite + Nitrate	07/15/98	12/31/05
Check 13	Dissolved Ortho-phosphate	07/21/04	12/31/05
Check 13	Ortho-phosphate	06/16/04	01/19/05
Check 13	Ortho-phosphate	07/15/98	07/15/98
Check 13	Total Kjeldahl Nitrogen	07/15/98	12/31/05
Check 13	Total Organic Carbon (Combustion)	11/15/00	12/31/05
Check 13	Total Organic Carbon (Ox)	12/17/97	12/31/05
Check 13	Total Phosphorus	07/15/98	12/31/05
Check 13	Turbidity	12/17/97	12/31/05
Check 13	UV Absorbance @254nm	03/17/99	12/31/05
Check 13	Volatile Suspended Solids	07/15/98	12/31/05
Check 21	Conductance (EC)	12/17/97	12/31/05
Check 21	Dissolved Bromide	02/18/98	12/31/05
Check 21	Dissolved Nitrite + Nitrate	04/18/00	12/31/05
Check 21	Dissolved Ortho-phosphate	01/20/04	12/31/05
Check 21	Ortho-phosphate	03/16/04	03/16/04
Check 21	Ortho-phosphate	04/18/00	12/16/03
Check 21	Total Kjeldahl Nitrogen	04/18/00	12/31/05
Check 21	Total Organic Carbon (Combustion)	11/14/00	12/31/05
Check 21	Total Organic Carbon (Ox)	02/18/98	12/31/05
Check 21	Total Phosphorus	04/18/00	12/31/05
Check 21	Turbidity	12/17/97	12/31/05
Check 21	Volatile Suspended Solids	12/17/97	12/31/05
Check 29	Conductance (EC)	05/20/98	12/31/05
Check 29	Dissolved Bromide	01/19/99	12/31/05
Check 29	Dissolved Nitrite + Nitrate	06/15/04	12/31/05
Check 29	Dissolved Ortho-phosphate	11/16/04	02/15/05
Check 29	Total Kjeldahl Nitrogen	06/15/04	12/31/05
Check 29	Total Organic Carbon (Combustion)	11/14/00	12/31/05
Check 29	Total Organic Carbon (Ox)	04/18/00	12/31/05
Check 29	Total Phosphorus	06/15/04	12/31/05
Check 29	Turbidity	05/20/98	12/31/05
Check 29	Volatile Suspended Solids	05/20/98	12/31/05
Check 41	Conductance (EC)	12/17/97	12/31/05
Check 41	Dissolved Bromide	12/17/97	12/31/05
Check 41	Dissolved Nitrite + Nitrate	01/21/98	12/31/05
Check 41	Dissolved Ortho-phosphate	05/14/03	12/31/05

Check 41	Ortho-phosphate	12/17/03	12/17/03
Check 41	Ortho-phosphate	12/17/97	11/19/03
	O&M WQ Discrete (Grab) Sample Database (Continued)		
Station Name	Analyte	Begin Date	End Date
Check 41	Total Kjeldahl Nitrogen	12/17/97	12/31/05
Check 41	Total Organic Carbon (Combustion)	11/15/00	12/31/05
Check 41	Total Organic Carbon (Ox)	12/17/97	12/31/05
Check 41	Total Phosphorus	12/17/97	12/31/05
Check 41	Turbidity	12/17/97	12/31/05
Check 41	UV Absorbance @254nm	01/21/98	12/31/05
Check 41	Volatile Suspended Solids	12/17/97	12/31/05
Castaic Outlet	Conductance (EC)	02/17/98	12/31/05
Castaic Outlet	Dissolved Bromide	11/16/98	12/31/05
Castaic Outlet	Dissolved Nitrite + Nitrate	01/20/98	12/31/05
Castaic Outlet	Dissolved Ortho-phosphate	05/12/03	12/31/05
Castaic Outlet	Ortho-phosphate	12/15/97	12/15/03
Castaic Outlet	Total Kjeldahl Nitrogen	12/15/97	12/31/05
Castaic Outlet	Total Organic Carbon (Combustion)	11/14/00	12/31/05
Castaic Outlet	Total Organic Carbon (Ox)	02/17/98	12/31/05
Castaic Outlet	Total Phosphorus	12/15/97	12/31/05
Castaic Outlet	Turbidity	02/17/98	12/31/05
Castaic Outlet	UV Absorbance @254nm	02/17/98	02/14/00
Check 66	Conductance (EC)	02/18/98	02/16/00
Check 66	Dissolved Bromide	02/17/99	02/16/00
Check 66	Dissolved Nitrite + Nitrate	01/21/98	12/31/05
Check 66	Dissolved Ortho-phosphate	01/21/04	12/31/05
Check 66	Ortho-phosphate	03/15/04	03/15/04
Check 66	Ortho-phosphate	12/16/97	12/17/03
Check 66	Total Kjeldahl Nitrogen	12/16/97	12/31/05
Check 66	Total Organic Carbon (Ox)	02/18/98	02/16/00
Check 66	Total Phosphorus	12/16/97	12/31/05
Check 66	Turbidity	02/18/98	02/16/00
Check 66	UV Absorbance @254nm	02/18/98	02/16/00
Silverwood Outlet	Conductance (EC)	02/17/98	12/31/05
Silverwood Outlet	Dissolved Bromide	02/16/99	12/31/05
Silverwood Outlet	Dissolved Nitrite + Nitrate	01/21/98	12/31/05
Silverwood Outlet	Dissolved Ortho-phosphate	01/20/04	12/31/05
Silverwood Outlet	Ortho-phosphate	03/15/04	03/15/04
Silverwood Outlet	Ortho-phosphate	12/15/97	12/15/03
Silverwood Outlet	Total Kjeldahl Nitrogen	12/15/97	12/31/05
Silverwood Outlet	Total Phosphorus	12/15/97	12/31/05
Silverwood Outlet	Turbidity	02/17/98	12/31/05
Devil Canyon	Conductance (EC)	12/17/97	12/31/05
Devil Canyon	Dissolved Bromide	12/17/97	12/31/05
Devil Canyon	Dissolved Nitrite + Nitrate	01/21/98	12/31/05
Devil Canyon	Dissolved Ortho-phosphate	01/21/04	12/31/05
Devil Canyon	Ortho-phosphate	03/17/04	03/17/04

Devil Canyon	Ortho-phosphate	12/17/97	01/07/04
Devil Canyon	Total Kjeldahl Nitrogen	12/17/97	12/31/05
	O&M WQ Discrete (Grab) Sample Database (Continued)		
Station Name	Analyte	Begin Date	End Date
Devil Canyon	Total Organic Carbon (Combustion)	11/15/00	12/31/05
Devil Canyon	Total Organic Carbon (Ox)	12/17/97	12/31/05
Devil Canyon	Total Phosphorus	12/17/97	12/31/05
Devil Canyon	Turbidity	12/17/97	12/31/05
Devil Canyon	UV Absorbance @254nm	12/17/97	12/31/05
Devil Canyon	Volatile Suspended Solids	02/18/98	12/31/05

ORGANICS MONITORING IN THE SWP

Parameter	Method
1,1,1,2-Tetrachloroethane	EPA 502.2
1,1,1-Trichloroethane	EPA 502.2
1,1,2,2-Tetrachloroethane	EPA 502.2
1,1,2-Trichloroethane	EPA 502.2
1,1-Dichloroethane	EPA 502.2
1,1-Dichloroethene	EPA 502.2
1,1-Dichloropropene	EPA 502.2
1,2,3-Trichlorobenzene	EPA 502.2
1,2,3-Trichloropropane	EPA 502.2
1,2,4-Trichlorobenzene	EPA 502.2
1,2,4-Trimethylbenzene	EPA 502.2
1,2-Dibromo-3-chloropropane (DBCP)	EPA 502.2
1,2-Dibromoethane (EDB)	EPA 502.2
1,2-Dichlorobenzene	EPA 502.2
1,2-Dichloroethane	EPA 502.2
1,2-Dichloropropane	EPA 502.2
1,3,5-Trimethylbenzene	EPA 502.2
1,3-Dichlorobenzene	EPA 502.2
1,3-Dichloropropane	EPA 502.2
1,4-Dichlorobenzene	EPA 502.2
2,2-Dichloropropane	EPA 502.2
2,4,5-T	EPA 615
2,4,5-TP (Silvex)	EPA 615
2,4-D	EPA 615
2,4-DB	EPA 615
2,4-Dichlorophenylacetic acid (DCAA)	EPA 615
2-Chlorotoluene	EPA 502.2
3-Hydroxycarbofuran	EPA 531.1
4-Chlorotoluene	EPA 502.2
4-Isopropyltoluene	EPA 502.2
Alachlor	EPA 608
Aldicarb	EPA 531.1
Aldicarb sulfone	EPA 531.1
Aldicarb sulfoxide	EPA 531.1
Aldrin	EPA 608
Aminomethylphosphonic Acid (AMPA)	EPA 547
Atrazine	EPA 608
Azinphos methyl (Guthion)	EPA 614
Benfluralin	EPA 614
Benzene	EPA 502.2
BHC-alpha	EPA 608
BHC-beta	EPA 608
BHC-delta	EPA 608
BHC-gamma (Lindane)	EPA 608
Bromacil	EPA 614

Parameter	Method
Bromobenzene	EPA 502.2
Bromochloromethane	EPA 502.2
Bromomethane	EPA 502.2
Captan	EPA 608
Carbaryl	EPA 531.1
Carbofuran	EPA 531.1
Carbon tetrachloride	EPA 502.2
Carbophenothion (Trithion)	EPA 614
Chlordane	EPA 608
Chlorobenzene	EPA 502.2
Chloroethane	EPA 502.2
Chloromethane	EPA 502.2
Chlorothalonil	EPA 608
Chlorpropham	EPA 608
Chlorpyrifos	EPA 608
Chlorpyrifos	EPA 614
cis-1,2-Dichloroethene	EPA 502.2
cis-1,3-Dichloropropene	EPA 502.2
Cyanazine	EPA 608 & 614
Dacthal (DCPA)	EPA 608 & 615
Demeton (Demeton O + Demeton S)	EPA 614
Diazinon	EPA 614
Dibromomethane	EPA 502.2
Dicamba	EPA 615
Dichloran	EPA 608
Dichlorodifluoromethane	EPA 502.2
Dichlorprop	EPA 615
Dicofol	EPA 608
Dieldrin	EPA 608
Dimethoate	EPA 614
Dinoseb (DNPB)	EPA 615
Disulfoton	EPA 614
Diuron	EPA 608
Endosulfan sulfate	EPA 608
Endosulfan-I	EPA 608
Endosulfan-II	EPA 608
Endrin	EPA 608
Endrin aldehyde	EPA 608
Esfenvalerate	EPA 614
Ethion	EPA 614
Ethylbenzene	EPA 502.2
Fluorobenzene	EPA 502.2
Formetanate hydrochloride	EPA 531.1
Glyphosate	EPA 547
Heptachlor	EPA 608
Heptachlor epoxide	EPA 608
Hexachlorobutadiene	EPA 502.2

Parameter	Method
Isopropylbenzene	EPA 502.2
m + p Xylene	EPA 502.2
Malathion	EPA 614
MCPA	EPA 615
MCPP	EPA 615
Methidathion	EPA 614
Methiocarb	EPA 531.1
Methomyl	EPA 531.1
Methoxychlor	EPA 608
Methyl tert-butyl ether (MTBE)	EPA 502.2
Methylene chloride	EPA 502.2
Metolachlor	EPA 608
Mevinphos	EPA 614
Molinate	EPA 614
Naled	EPA 614
Naphthalene	EPA 502.2
Napropamide	EPA 614
n-Butylbenzene	EPA 502.2
Norflurazon	EPA 614
n-Propylbenzene	EPA 502.2
o,p'-DDE	EPA 608
Oxamyl	EPA 531.1
Oxyfluorfen	EPA 608
o-Xylene	EPA 502.2
p,p'-DDD	EPA 608
p,p'-DDE	EPA 608
p,p'-DDT	EPA 608
Parathion, Ethyl	EPA 614
Parathion, Methyl	EPA 614
PCB-1016	EPA 608
PCB-1221	EPA 608
PCB-1232	EPA 608
PCB-1242	EPA 608
PCB-1248	EPA 608
PCB-1254	EPA 608
PCB-1260	EPA 608
Pendimethalin	EPA 614
Pentachloronitrobenzene (PCNB)	EPA 608
Pentachlorophenol (PCP)	EPA 615
Permethrin	EPA 608
Phorate	EPA 614
Phosalone	EPA 614
Phosmet	EPA 614
Picloram	EPA 615
Profenofos	EPA 614
Prometryn	EPA 614
Propargite	DWR Sulfur Pesticides

Parameter	Method
Propetamphos	EPA 614
Ronnel	EPA 608 & 614
s,s,s-Tributyl Phosphorotrithioate (DEF)	EPA 614
sec-Butylbenzene	EPA 502.2
Simazine	EPA 608
Styrene	EPA 502.2
tert-Butylbenzene	EPA 502.2
Tetrachloroethene	EPA 502.2
Thiobencarb	EPA 608 & 614
Toluene	EPA 502.2
Toxaphene	EPA 608
trans-1,2-Dichloroethene	EPA 502.2
trans-1,3-Dichloropropene	EPA 502.2
Trichloroethene	EPA 502.2
Trichlorofluoromethane	EPA 502.2
Triclopyr	EPA 615
Trifluralin	EPA 614
s,s,s-Tributyl Phosphorotrithioate (DEF)	EPA 614
sec-Butylbenzene	EPA 502.2
Simazine	EPA 608
Styrene	EPA 502.2
tert-Butylbenzene	EPA 502.2
Tetrachloroethene	EPA 502.2
Thiobencarb	EPA 608 & 614
Toluene	EPA 502.2
Toxaphene	EPA 608
trans-1,2-Dichloroethene	EPA 502.2
trans-1,3-Dichloropropene	EPA 502.2
Trichloroethene	EPA 502.2
Trichlorofluoromethane	EPA 502.2
Triclopyr	EPA 615
Trifluralin	EPA 614
Vinyl chloride	EPA 502.2

Appendix B

Supporting Information for Chapter 4

Major Wastewater Treatment Plants in the Sacramento and San Joaquin Watersheds

Facility/Service Area	ADWF, MGD	Design flow, MGD	Planned Expansion, MGD	Permit Renewal	Treatment Level and Processes	Receiving Water
Delta						
Sacramento Regional Wastewater Treatment Plant Urban areas of Sacramento County City of West Sacramento by 2007	160 annual average daily flow	207	218 by 2020	Regional Board staff expect to issue tentative permit in fall of 2007	Secondary - Primary clarifiers, pure oxygen activated sludge, secondary clarifiers, chlorination and dechlorination. Biosolids are stored and applied to land onsite.	Sacramento River
Stockton Regional Wastewater Control Facility City of Stockton	36.7	55		2007	Secondary/Tertiary - Primary sedimentation, followed by high rate trickling filters, and intermediate settling basins. Additional treatment by piping the wastewater under the San Joaquin River to the tertiary treatment facility with oxidation ponds, dissolved air flotation (DAF), filtration, chlorination and dechlorination. The DAF and filters operated July-Oct during peak algal production. The tertiary treatment facility discharges intermittently using ponds to store	San Joaquin River

Facility/Service Area	ADWF, MGD	Design flow, MGD	Planned Expansion, MGD	Permit Renewal	Treatment Level and Processes	Receiving Water
					wastewater. Biosolids disposed offsite.	
Delta Diablo Sanitation District Wastewater Treatment Plant	14.2				Tertiary	New York Slough, to San Joaquin River. Only 9.9 MGD discharged
Tracy Wastewater Treatment Plant City of Tracy	7.1 annual average daily flow	9	10.8 by 2008 16 by 2016	Regional Board staff recently issued revised tentative permit.	Secondary – Primary sedimentation, biofiltration, activated sludge, secondary sedimentation, chlorination and dechlorination. Biosolids disposed offsite. Tertiary – Filtration nitrification/denitrification will be completed by 2008.	Old River
Vacaville Easterly Wastewater Treatment Plant City of Vacaville and Elmira	6.9	10	15 Phase 1 17.5 by 2012 22 by 2020	2006	Secondary – Primary clarifiers, activated sludge reactors, secondary clarifiers, chlorination and dechlorination. Biosolids disposed offsite.	Old Alamo Creek to Alamo Creek, to Cache Slough, to Sacramento River
Manteca Wastewater Quality Control Facility Cities of Manteca and Lathrop	5.72 monthly average	6.95	9.87 by 2007	2009	Secondary - Biofiltration, activated sludge, secondary sedimentation, chlorination and dechlorination. Tertiary - Filtration, nitrification and denitrification, and UV	San Joaquin River Currently 2 mgd is applied to land and the rest is discharged to the river.

Facility/Service Area	ADWF, MGD	Design flow, MGD	Planned Expansion, MGD	Permit Renewal	Treatment Level and Processes	Receiving Water
					disinfection will be completed by 2007.	
West Sacramento Wastewater Treatment Plant City of West Sacramento	5.1	7.5		Will connect to SRWTP by 2007	Secondary – Primary clarifiers, aeration basins designed for nitrification and denitrification, secondary clarifiers, chlorination and dechlorination. Biosolids are disposed offsite.	Sacramento River
Brentwood Wastewater Treatment Plant City of Brentwood	2.2	4.5		2006	Tertiary – Oxidation, nitrification by extended aeration activated sludge, denitrification by anoxic basins, coagulation, filtration, chlorination and dechlorination. and a cascade aeration system to provide enough dissolved oxygen in the effluent prior to entering Marsh Creek	Marsh Creek, tributary to Dutch Slough and land application
Discovery Bay Wastewater Treatment Facility Town of Discovery	1.1	2.1		2008	Secondary - Oxidation ditches (operated to nitrify and denitrify), secondary clarifiers, and an ultraviolet (UV) disinfection system	Old River

Facility/Service Area	ADWF, MGD	Design flow, MGD	Planned Expansion, MGD	Permit Renewal	Treatment Level and Processes	Receiving Water
Bay						
Mountain House Community Services District Wastewater Treatment Facility Community of Mountain House	0.3	3.0	5.4	Regional Board staff expect to issue revised tentative permit 12/06.	Tertiary – Sequencing batch reactors for biological treatment including nitrification and denitrification, filtration, and UV disinfection.	Current discharge is to land. New permit will allow discharge to Old River
Sacramento Basin						
Dry Creek Wastewater Treatment Plant City of Roseville and unincorporated areas of Placer County	13	18		Regional Board staff expect to issue tentative permit 12/06	Tertiary - Primary clarification, secondary treatment through denitrification, aeration, and clarification, tertiary treatment through chemical coagulation, filtration, chlorination anddechlorination, pH adjustment and aeration. Ponds for emergency storage Biosolids disposed in landfill	Dry Creek, tributary to Sacramento River
Chico Water Pollution Control Plant City of Chico	6.5	9		2008	Secondary – Primary clarification, activated sludge, secondary clarification, chlorination and dechlorination. Biosolids disposed at	Sacramento River

Facility/Service Area	ADWF, MGD	Design flow, MGD	Planned Expansion, MGD	Permit Renewal	Treatment Level and Processes	Receiving Water
					sanitary landfill.	
Clear Creek Wastewater Treatment Plant City of Redding	6.5	8.8		2008	Advanced Secondary – Activated sludge, secondary clarifiers, filtration, chlorination and dechlorination. Biosolids disposed in landfill.	Sacramento River
Pleasant Grove Wastewater Treatment Plant City of Roseville	6	12	20.7	Regional Board staff expect to issue tentative permit 12/06.	Tertiary- Activated sludge oxidation ditches with nitrification and denitrification, and secondary clarification. Tertiary treatment is provided by chemical coagulation using rapid mix flocculation, followed by continuous backwash filtration, disinfection with hypochlorite, dechlorination, and final polishing over a cascade. Biosolids disposed offsite.	Pleasant Grove Creek, tributary to Sacramento River
Woodland Water Pollution Control Facility City of Woodland	6	7.8	10.4	2008	Tertiary – Activated sludge oxidation ditches, secondary clarifiers, filtration and UV disinfection. Ponds for treatment of biosolids and storage of excess wastewater.	Tule Canal, tributary to Yolo Bypass

Facility/Service Area	ADWF, MGD	Design flow, MGD	Planned Expansion, MGD	Permit Renewal	Treatment Level and Processes	Receiving Water
Yuba City Wastewater Treatment Facility Yuba City Receives septage from unsewered areas of Yuba and Sutter counties	6 average daily flow	7	10.5	2008	Secondary – Primary sedimentation, chlorination, dechlorination and pH adjustment. Biosolids disposed offsite and used as landfill cover material.	Currently discharged to ponds in Feather River floodplain
Davis Water Pollution Control Plant	5.5	7.5		Regional Board staff expect to issue tentative permit in 3/07	Secondary -Primary sedimentation, aerated ponds, lemna and oxidation ponds, overland flow and chlorination and dechlorination. Stormwater lagoon in the wetlands used in winter to treat runoff. Biosolids applied to overland flow fields, wetlands or disposed off-site at landfill	Willow Slough Bypass and Conoway Ranch Toe Drain, tributaries to Yolo Bypass
Oroville Sewerage Commission City of Oroville and surrounding areas	3.2	6.5		2010	Tertiary – Primary clarification, activated sludge treatment, secondary clarification, filtration, chlorination and dechlorination. Biosolids disposed at a sanitary landfill.	Feather River
Redding Stillwater	2.8	4.0	Expansion	2006	Tertiary - Activated sludge,	Sacramento River

Facility/Service Area	ADWF, MGD	Design flow, MGD	Planned Expansion, MGD	Permit Renewal	Treatment Level and Processes	Receiving Water
			to 8 by 2010		secondary clarification, filtration, chlorination and dechlorination. Biosolids to discharger property or sanitary landfill.	
Lincoln Wastewater Treatment and Reclamation Facility City of Lincoln	2.4	3.3	12	Regional Board staff expect to issue a tentative permit in June 2007	Tertiary – Activated sludge oxidation ditches with nitrification, denitrification basins, secondary clarification, dissolved air flotation, chemical coagulation, flocculation, filtration, UV disinfection and effluent aeration.	Land disposal and Auburn Ravine, tributary to Sacramento River
Hangtown Creek Wastewater Treatment Plant City of Placerville	2.3	3		Regional Board staff expect to issue a tentative permit in early 2007	Tertiary – primary clarifiers, trickling filter, anoxic selector, aeration basins, secondary clarifiers, ponds, filters, chlorination and dechlorination. Biosolids disposed offsite.	Hangtown Creek, tributary to South Fork of American River.
Grass Valley Wastewater Treatment Plant City of Grass Valley	2.1 average daily flow	2.78		2008	Tertiary - Primary sedimentation, activated sludge, nitrification, denitrification, secondary sedimentation, filtration, chlorination and dechlorination. Biosolids are	Wolf Creek, tributary to Bear River

Facility/Service Area	ADWF, MGD	Design flow, MGD	Planned Expansion, MGD	Permit Renewal	Treatment Level and Processes	Receiving Water
					applied to land.	
University of California Davis Wastewater Treatment Plant U.C. Davis Campus	1.5 monthly average dry weather	2.7		2008	Tertiary – Oxidation ditch operated for nitrification and denitrification, secondary clarifiers, filtration, UV disinfection. Biosolids are transported to a landfill.	South and North Forks of Putah Creek, tributary to the Yolo Bypass
Red Bluff Wastewater Reclamation Plant City of Red Bluff	1.4	2.5		Regional Board staff expect to issue a tentative permit in 5/07	Tertiary – Primary sedimentation, activated sludge with secondary clarification, filtration, and chlorination/dechlorination.	Sacramento River
Auburn Wastewater Treatment Plant City of Auburn	1.34, average daily flow	1.67		2010	Tertiary - Biological oxidation in an oxidation ditch and aerated ponds, including nitrification, secondary sedimentation, coagulation, and filtration, chlorine disinfection and dechlorination	Auburn Ravine, tributary to Sacramento River
Linda County Water District Wastewater Treatment Plant Community of Linda and unincorporated parts of south Yuba	1.24	1.8	5.0 by 2008	Regional Board staff expect to issue a tentative permit by	Secondary - Primary clarification, trickling filter, secondary clarification, chlorination and dechlorination. Tertiary facilities will be completed by 2008.	Feather River

Facility/Service Area	ADWF, MGD	Design flow, MGD	Planned Expansion, MGD	Permit Renewal	Treatment Level and Processes	Receiving Water
County				9/06.		
Live Oak Wastewater Treatment Plant City of Live Oak	0.51	1.4		2008	Secondary – Aeration lagoons, oxidation ponds, chlorination and dechlorination. Tertiary facilities will be completed by 2009	Reclamation District 777 Lateral Drain 1, tributary to Sutter Bypass
Marysville Wastewater Treatment and Reclamation Facility City of Marysville						Currently discharges to ponds that overflow to Feather River. Considering regional plant with Yuba City and Linda County.
Anderson Water Pollution Control Plant City of Anderson	1.4	2.0		2006	Tertiary – Activated sludge, secondary clarification, filtration, chlorination and dechlorination. Biosolids disposed on site.	Sacramento River
Olivehurst Public Utility District Wastewater Treatment Plant Community of Olivehurst	1.8 estimate	1.8	3.0 by 2006, 5.1 by 2008	2008	Secondary – Primary clarification, aeration, secondary clarification, chlorination and dechlorination Tertiary facilities consisting of filtration and UV disinfection will be completed by 12/06.	Western Pacific Interceptor Drainage Canal, tributary to Bear River
Placer Co Sewer	1.67	2.18	Possible	2010	Tertiary – Primary	Rock Creek,

Facility/Service Area	ADWF, MGD	Design flow, MGD	Planned Expansion, MGD	Permit Renewal	Treatment Level and Processes	Receiving Water
Maintenance District No. 1 Wastewater Treatment Plant Unincorporated area of north Auburn in Placer County			future connection to Lincoln Regional Plant		clarification, rotating biological contactors, trickling filters, secondary clarifiers, filtration, chlorine disinfection and dechlorination. Biosolids disposed at landfill.	tributary to Sacramento River. Water also diverted to Bear River.
Willows Wastewater Treatment Plant City of Willows and unincorporated areas	1.22 average monthly	1.12	1.2 2007	2011	Secondary – Primary aeration ponds, stabilization ponds, disinfection. Tertiary facilities consisting of extended aeration activated sludge, secondary clarification, filtration, chlorination and dechlorination will be completed by 2007.	Agricultural Drain C, Colusa Basin Drain, tributary to Sacramento River
Corning Wastewater Treatment Plant City of Corning	1.0	1.4		2008	Secondary – Oxidation ditch, clarifiers, chlorination and dechlorination.	Sacramento River
San Joaquin Basin						
City of Modesto Water Quality Control Facility City of Modesto, part of City of Ceres, and Empire Sanitary District	25	70		Regional Board staff expect to issue a tentative permit by 12/06.	Secondary - Primary clarifiers, biological treatment with fixed film reactors, facultative ponds, chlorination and dechlorination. Biosolids are disposed offsite.	San Joaquin River Land disposal – Jun to Sept. Water not used for irrigation is discharged to San Joaquin River Oct thru May. Can only discharge if 20 to 1

Facility/Service Area	ADWF, MGD	Design flow, MGD	Planned Expansion, MGD	Permit Renewal	Treatment Level and Processes	Receiving Water
						dilution ratio.
Turlock Water Quality Control Facility City of Turlock, communities of Denair and Keyes	12	20		2006	Secondary - Primary settling, biotowers, activated sludge basins, secondary settling, chlorination, and dechlorination. Tertiary filters should be in place by April 2006	Currently Harding Drain, tributary to San Joaquin River Petition to SWRCB to discharge to San Joaquin River.
Merced Wastewater Treatment Facility City of Merced	7.4	10		Regional Board staff expect to issue a tentative permit by 3/07.	Secondary – Primary clarifiers, activated sludge aeration, secondary clarifiers, chlorination and dechlorination. Biosolids disposed on site in sludge drying beds.	Hartley Slough, tributary to the San Joaquin River – 80 % of effluent discharged but most is used for agricultural irrigation Land disposal of 20% of effluent
White Slough Water Pollution Control Plant City of Lodi and urbanized unincorporated parts of San Joaquin County	5.9	7.0	11.6	Regional Board staff expect to issue a tentative permit by 3/07.	Tertiary - Primary sedimentation tanks, anaerobic digesters, activated sludge reactors, secondary sedimentation tanks, tertiary filters, UV disinfection, and equalization ponds. Biosolids disposed on farms.	Dredger Cut, tributary to White Slough – Sep to May Land disposal – June to August

Facility/Service Area	ADWF, MGD	Design flow, MGD	Planned Expansion, MGD	Permit Renewal	Treatment Level and Processes	Receiving Water
					Industrial wastewater from food processors is screened, and when necessary, blended with undisinfected secondary municipal wastewater, and applied to City-owned irrigation fields.	
El Dorado Irrigation District Deer Creek Wastewater Treatment Plant Cameron Park and unincorporated areas of El Dorado County	2.86 monthly average	3.6		2007	Tertiary – Primary clarification, aeration, secondary clarification, filtration, chlorine disinfection and dechlorination. Biosolids disposed on farmland or local landfill.	Deer Creek, tributary to Cosumnes River
Galt Wastewater Treatment Plant and Reclamation Facility Community of Galt	1.83 Average daily flow	3		2009	Secondary – Extended aeration oxidation ditches, secondary clarification, chlorine disinfection and dechlorination Tertiary facilities must be constructed by 11/09.	Laguna Creek, tributary to Cosumnes River Nov to Apr Disposal to land - May to Oct
El Dorado Irrigation District El Dorado Hills Wastewater Treatment Plant El Dorado Hills and adjacent areas	1.8	3.0		Regional Board staff expect to issue a tentative permit by	Tertiary - Primary clarifiers, activated sludge basins, secondary clarifiers, dissolved air floatation basin for activated sludge thickening, dissolved air floatation basin for algae	Carson Creek, tributary to Cosumnes River

Facility/Service Area	ADWF, MGD	Design flow, MGD	Planned Expansion, MGD	Permit Renewal	Treatment Level and Processes	Receiving Water
				3/07.	removal prior to filtration, tertiary filters, chlorination and dechlorination. Biosolids are disposed off-site.	

Appendix C – Supporting Information for Chapter 5

INTERIM
DEPARTMENT OF WATER RESOURCES WATER QUALITY CRITERIA FOR ACCEPTANCE OF NON-PROJECT WATER INTO THE STATE WATER PROJECT
MARCH 1, 2001

In accordance with the Water Code, non-project water may be conveyed, wheeled, or transferred in the State Water Project provided that water quality is protected.

GENERAL PROVISIONS

The proponent of any non-project water input proposal shall demonstrate that the water is of consistent, predictable, and acceptable quality.

The Department of Water Resources shall consider all non-project water input proposals based upon the criteria established in this document.

DWR will consult with State Water Project contractors and the Department of Health Services on drinking water quality issues relating to non-project water as needed to assure the protection of SWP water quality.

Nothing in this document shall be considered as authorizing the objectives of Article 19 of the water supply contracts or drinking water maximum contaminant levels to be exceeded.

These criteria shall not constrain DWR's ability to operate the SWP for its intended purposes or to protect its integrity during emergencies. There shall not be any adverse impacts to SWP water deliveries, operations or facilities.

DWR will use a two-tier approach for accepting non-project water into the California Aqueduct. Tier 1 programs have a "no adverse impact" criteria and shall be tied to historical water quality levels in the California Aqueduct. Programs meeting Tier 1 critieria shall be approved by DWR. Tier 2 programs, have water quality levels that exceed the historical water quality levels in the California Aqueduct and have the potential to cause adverse impacts to state water contractors. Tier 2 programs shall be referred to a state water contractor facilitation group for review. The facilitation group would review the program and if needed make recommendations to DWR to use during consideration of the project.

SPECIFIC PROVISIONS

Tier 1

Under Tier 1, all constituents of non-project water shall not exceed the historical water quality levels measured at the O'neill Forebay Outlet (formerly Check 13) on the SWP as measured by DWR's water quality monitoring program (Table 1).

Blending of multiple water sources prior to inflow into the SWP is acceptable. As part of a non-project water proposal, water may be introduced into the aqueduct that by itself might cause the ambient baseline to be exceeded, provided that the sum total of all introduced waters from a defined project do not exceed the historical baseline for the Aqueduct on an instantaneous flow weighted basis. Blending (mixing) within the aqueduct must be between and cannot overlap any active municipal and industrial delivery locations, without approval of DWR. The proponent shall demonstrate by model or an approach acceptable to DWR and the state water contractor facilitation group, that the water is adequately mixed before reaching the first M&I customer.

Non-project water proposals meeting Tier 1 water quality standards shall be approved by DWR without further review by other agencies except as is required by law.. However, upon approval by DWR of any pumpin under Tier 1, the state water contractor facilitation group will be notified by DWR of the action.

Tier 2

Non-project water exceeding Tier 1 standards or contributing to aqueduct levels that exceed the historical water quality baseline may be considered for input into the SWP on a case-by-case basis by the SWP contractors and DWR. Proposals that would impact SWP water quality delivered to downstream state water contractors will be reviewed by state water contractors. The intent is that proposals that produce an overall net water quality benefit will be approved.

A state water contractor non-project inflow ***facilitation group*** will be established and will review all requests for non-project inflow that do not meet the Tier 1 water quality criteria. This group will consist of representatives from each state water contractor, that chooses to participate. DWR may participate as an observer. The group will consider the merits, impacts, mitigation, cost/benefits or other issues of each Tier 2 non-project water proposal(s) and provide recommendations to DWR. The DWR will consider the ***facilitation group*** and any individual SWP contractor recommendations in reviewing the proposal. DWR will make the final decision to approve, modify or deny the non-project water proposal. Any decision must be in compliance with law and existing contracts.

The **facilitation group** would consider the range of potential impacts along with potential benefits, mitigation, and other issues associated with the program.

A consensus recommendation from the facilitation group would be sought regarding a potential exceedance of the historical water quality levels. In the absence of consensus from the **facilitation group**, DWR will base its decision on the merits of the program and its ability to provide overall benefits to the state water project.

WATER QUALITY CHANGES

Once a program for delivery of non-project water to the Aqueduct has been approved, an annual review of the program with the state water contractors will occur.

As needed, DWR, DHS or state water contractors may recommend changes or additions to these water quality criteria governing non-project water proposals. Proposed changes or additions will be reviewed by the ***facilitation group*** prior to consideration by DWR.

MONITORING

Non-project inflow proponents are responsible for monitoring the quality of the water at the point of introduction into the Aqueduct for the duration of the program.

IMPLEMENTATION

DWR will develop procedures to implement these criteria.

Table 1 HISTORICAL WATER QUALITY CONDITIONS 1988-2001 AT O'NEILL FOREBAY OUTLET (mg/L)

Metals, Minerals and others					
	Mean	Min	Max	Stand Dev	Count
Aluminum	0.029	0.004	0.527	0.050	137
Antimony	0.005*	0.005*	0.005*	0.000	10
Arsenic	0.002	0.001*	0.004	0.000	215
Barium	0.050*	0.037	0.068	0.002	139
Beryllium	0.001*	0.001*	0.001*	0.000	11
Bromide	0.21	0.05	0.54	0.11	121
Cadmium	0.004	0.001*	0.005	0.002	139
Chromium	0.005*	0.005*	0.011	0.001	189
Copper	0.005	0.001*	0.028	0.003	214
Fluoride	0.09	0.01*	0.40	0.05	225
Iron	0.049	0.005*	0.416	0.058	214
Manganese	0.007	0.003	0.06	0.004	17
Mercury	0.0008	0.0002*	0.0010	0.0004	163
Nickel	0.002	0.001*	0.004	0.001	11
Nitrate	3.5	0.6	9.6	1.8	192
Nitrate-Nitrite	0.6	0.1	1.2	0.3	22
Nitrite	0.5	0.3	1.1	0.2	21
Selenium	0.001*	0.001*	0.001*	0	208
Silver	0.004	0.001*	0.005	0.002	139
Sulfate	43	16	99	15	228
Total Organic Carbon	4	3	10	2	131
Zinc	0.009	0.005*	0.210	0.016	206

* These values represent reporting limits, actual values would be lower.

Pesticides, herbicides and synthetic organic chemicals are not detected in water samples at this location. Therefore, historical conditions are considered to be represented by less than detection levels for these compounds.

Salinity Criteria 1979-2000 (specific conductance, us/cm)

Year Type*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	454	401	393	363	355	351	338	340	299	302	350	343
Near Normal*	474	430	511	302	415	520	462	371	430	474	528	623
Dry	566	510	472	469	403	424	441	486	613	498	715	495
Critical	673	728	642	578	548	597	586	609	648	668	604	756

* Year type is based on water year classification, below normal and above normal have been combined into one designation as near normal.

Implementation Procedures for the Review of Water Quality from Non-Project Water Introduced into the State Water Project
March 14,2001

This document describes the approval and implementation procedures, as well as, responsibilities of the various parties involved in the introduction of Non-Project water into the State Water Project under the ***Department of water Resources Water Quality Criteria for Acceptance of Non-Project Water into the State Water Project.***

This document does not in anyway affect, modify or have any bearing upon any provisions of law, contract, policy or procedure governing water resources or the State Water Project other than stated above. Non-project inflow shall not constrain the ability of DWR to operate the SWP for its intended purposes or to protect the SWP integrity during emergencies and it shall not adversely impact SWP operations, deliveries, existing contracts or any other agreements.

DWR shall consider all non-project water input proposals based upon the approved water quality ***Criteria*** and the procedures established in this document. This document describes the procedures and responsibilities of the Project Proponent, Department of Water Resources, and the Facilitation Group as identified in the ***Criteria***.

Project Proponent

The proponent of a program that will introduce Non-Project water into the SWP will submit a complete detailed proposal to the Department of Water Resources for purposes of evaluating the water quality impacts . The proponent shall demonstrate that the non-project water is of consistent, predictable and reliable quality.

The Proponent is responsible for preparation of and compliance with any and all contracts, environmental documents, permits or licenses that are necessary consistent with applicable laws, regulations, agreements, procedures, or policies external to this document.

Project Description

The proponent will submit to DWR a document describing the proposed program, identifying the water source(s), planned operation, characterizing the inflow water quality and any anticipated impacts to SWP water quality and/or operations. The proposal will at a minimum include:

- Identify names, locations, addresses, and contact person(s) for all participants.
- Detailed information including maps identifying all sources of water, point of inflow to the SWP and ultimate fate of the introduced water.
- All terms and conditions of inflow, timing, rates and volumes of inflow, pumping, conveyance and storage requirements will be described.
- All construction details adjacent to SWP facilities will be described including valves, meters, pumps and piping size, location, etc.
- All potential impacts and/or benefits to downstream users will be identified
- Detailed water quality data will be provided for all sources of water and any blend of sources that will be introduced into the SWP.
- Describe anticipated water quality changes within the SWP.
- Identify other relevant environmental issues such as subsidence, ground water overdraft or, presence of endangered species.

Water Quality Monitoring
In order to demonstrate that the source(s) of water are of consistent, predictable, and acceptable quality the Proponent will monitor water quality. The proponent is responsible for all costs associated with characterizing and monitoring water quality up to and including the point of discharge into the SWP for the duration of the program. The proponent will, for the duration of the program, regularly report on operations as they affect water quality, monitoring data and water quality changes. One of three water quality monitoring schedules will be used and all information will be submitted to DWR on a regular basis (within 30 days of sampling).

Projects proponents shall select one of the testing options below and perform and provide all water quality testing described therein.

Option 1 - *Baseline tests*: Title 22 tests of record are required for all wells (sources), but a post inflow Title 22 test is allowed for any well near a similar well with a Title 22 test of record. *Periodic tests*: Constituents of Concern tests are required upon startup and quarterly for each discharge point.

Option 2 - *Baseline tests*: Constituents of Concern tests of record are required for all wells (sources) and Title 22 tests of record are required for representative wells comprising a subset of all wells. Representative wells shall be identified on a case-by-case basis to be representative of the manifold area; proximity, water levels, and agricultural water tests are significant for this purpose. The proponent shall identify representative wells subject to approval. *Start up tests in any year*: Title 22 tests are required for all discharge points upon startup. Constituents of Concern tests are required for all wells within two weeks of inflow startup. *Periodic tests*: Constituents of Concern tests are required monthly for each discharge point.

Option 3 – A project proponent may propose a monitoring schedule that is fully protective of water quality and consistent with the *Criteria*. The proposed monitoring schedule will be submitted to the Facilitation Group for review and approval.

Under any of the three testing options all Title 22 tests will be repeated every three years or as otherwise acceptable to the Department of Health Services to be compliant with Title 22. Sampling for pathogens (including giardia and cryptosporidium) may be required for any waters under the influence of surface water at the discretion of DWR and/or the Facilitation Group

Flow Measurements
The proponent will provide flow measurements and analytical data for all sources and discharges into the SWP to demonstrate compliance with the *Criteria*.

- The proponent will maintain current, accurate records of production rate and volume from each source, as well as, each point of discharge into the SWP.
- Meters will be properly calibrated and maintained.
- All flow measurements will be regularly submitted to DWR.

Reconsideration
If a proponent disagrees with the DWR decision of compliance with the Non-Project inflow *criteria* or feels that there is overriding benefit of the proposal, the proponent may seek review from the Facilitation Group.

- The SWC Facilitation Group may recommend to DWR that a proposal has some overriding benefit(s) and DWR may reconsider the proposal.
- Reconsideration by DWR will be on a case-by-case basis and DWR may waive or modify the inflow *criteria* for specific proposals if conditions warrant.

<u>DWR</u>

DWR, in consultation with the State Water Contractors, DHS, and other appropriate parties, will develop the ***Department of water Resources Water Quality Criteria for Acceptance of Non-Project Water into the State Water Project and Implementation Procedures for the Review of Water Quality from Non-Project Water Introduced into the State Water Project***. The *criteria* and *procedures* will be reviewed annually and revised as needed to protect SWP water quality.

DWR will seek, as needed DHS or State Water Contractor recommendations on changes or additions to the *criteria* and *procedures* documents governing Non-Project water inflow proposals. The Facilitation Group will review proposed changes or additions prior to implementation by DWR.

DWR will have ultimate responsibility for approving the water quality of all non-project inflow, as well as, the oversight of monitoring and tracking the water quality of operating programs.

Project Proposal
Upon receipt of a proposal for Non-Project water inflow DWR will review the proposal for adequacy. DWR shall consider all non-project water inflow proposals based upon the approved *Criteria*. If necessary, DWR will convene timely meetings with the Facilitation Group during the review of a proposal. At the minimum the review will include

- Examination of all documents and data for completeness of the submittal.
- Affected Field Divisions, the Facilitation group and all affected downstream users will be immediately notified of the submittal.
- Comments from all parties may be considered by DWR before the final decision.
- Upon completion of the review, DWR will notify the proponent and downstream users of the acceptance of the proposal, the need for modification of a proposal, or explain the reason(s) for rejecting the proposal.
- DWR may reconsider a decision on a proposal based upon a recommendation from the Facilitation Group. Reconsideration by DWR will be on a case-by-case basis and DWR may waive or modify the *Criteria* for specific proposals if conditions warrant

Annual Review
Once a program for delivery of non-Project water to the Aqueduct has been approved, an annual review of the program will occur with input from the Facilitation Group. As part of the review, program proponents will provide the following information:

- Summary of deliveries to the Aqueduct.
- Water quality monitoring results.
- Proposed changes in the program operation.

The review may result in changes in program operations, monitoring and testing required of the program proponent as a result of;

- New constituents being added to the EPA /DHS list of primary drinking water standards.
- Changes in the maximum contaminant levels for the EPA/DHS list of primary drinking water standards.
- Identification of new constituents of concern
- Changes in the water quality provided by the program.
- Changes in concentrations in the California Aqueduct.

This procedure shall recognize emerging contaminants as they are identified by the regulatory agencies and shall set appropriate standards for introduction based upon ambient levels in the California Aqueduct or State Action Levels, which ever is lower. Emerging contaminants are those that may pose significant risk to public health, but as yet do not have an MCL. Currently the Office of Environmental Health Hazard Assessment and the Department of Health Services establish Public Health Goals and Action Levels, respectively. These levels, though not regulated, do provide health-based guidance to water utilities and can require public notification if exceeded.

Water Quality Review
For operating projects DWR will track and annually report on water quality impacts to the SWP from Non-Project water inflow.

- DWR will review analyze and maintain records of water quality testing conducted by the proponent of the well(s), source(s) and discharge(s) into the SWP.
- DWR will determine what additional water quality monitoring, if any, is necessary within the SWP to assure compliance with the Criteria. DWR will conduct all water quality monitoring within the SWP
- DWR will prepare an annual report of water quality impacts in the SWP from Non-Project water and make all water quality data available to interested parties.

On-site Surveillance
The appropriate Field Division within DWR will be responsible for review and approval of all construction activities within the SWP right-of-way. Plans showing the discharge system piping, valves, sampling point, meters and locations must be submitted and approved prior to any construction. In addition, the appropriate Field Division will be responsible for confirmation of all meter readings and water quality monitoring conducted by the proponent.

- Field division staff may visit, inspect, calibrate meters and measure flow conditions at each source or point of discharge into the SWP.
- Flow meters, sampling ports and anti-siphon valves must be conveniently located near the SWP right-of-way.
- Field division staff may collect water samples at each source or point of discharge into the SWP.
- The appropriate Field Division will conduct additional water quality monitoring within the SWP, if deemed necessary, to assure compliance with the Non-Project Inflow Criteria.

SWC Facilitation Group

Upon initial review of a Non-project water inflow proposal, DWR shall notify the State Water Contractors of its receipt, its contents, and the possible need for a Facilitation Group. The State Water Contractors may form a Facilitation Group to advise DWR on any or all proposals for introduction of Non-Project water into the SWP.

- It is the responsibility of the State Water Contractors to form and coordinate the activities of the Facilitation Group. DWR will assist in coordination of Facilitation Group activities as requested.
- The SWC Facilitation Group can consult with State Water Contractors, DWR, the project proponent, other state or federal agencies, private consultants or other interested parties as needed to fully evaluate a Non-project Inflow Proposal.

The Facilitation Group is an advisory body that will review the *criteria* and *Procedures* for approval of water quality for Non-project inflow. The Facilitation Group will review and recommend action on Proposals that could degrade SWP water quality. Also, if a proponent proposes a monitoring Schedule under Option 3, above, the Facilitation Group will review the proposal and make appropriate monitoring recommendations.

Recommendations of the Facilitation Group

The Facilitation Group will consider the merits, impacts, mitigation, cost/benefits or other issues, in addition water quality, in an effort to develop a consensus recommendation for action on Non- Project Inflow Proposals.

- State Water Contractors will make all decisions on the direction and actions of Facilitation Group activities or development of a recommendation on any proposal.
- The facilitation group may provide comment or recommendations to DWR at any time, on any aspect, of any proposal. The facilitation group can also provide comment or recommendations to DWR on the *Criteria* or *Procedures* at any time.
- The Facilitation Group will provide DWR recommendations for formal approval, disapproval or modification of each individual Non-Project Inflow Project submitted for consideration. The recommendation shall include an explanation of the reasons for the recommendation.
- If consensus among State Water Contractors is not possible the Facilitation Group may submit both majority and minority opinions and recommendations.

DRAFT March, 2005

DEPARTMENT OF WATER RESOURCES
WATER QUALITY POLICY FOR ACCEPTANCE OF NON-PROJECT WATER INTO THE STATE WATER PROJECT

It is the policy of the Department of Water Resources to protect the water quality of the State Water Project and to minimize degradation of water quality by non-Project inflow programs.

GENERAL CRITERIA and PROVISIONS

The Department of Water Resources shall consider all non-Project water input proposals based upon the criteria established in this document.

The proponent of any non-Project water input proposal shall demonstrate that the water is of consistent, predictable, and acceptable quality.

DWR will consult with State Water Contractors and the Department of Health Services (DHS) on drinking water quality issues relating to non-Project water as needed to assure the protection of SWP water quality.

Nothing in this document shall be considered as authorizing the objectives of Article 19 of the water supply contracts or drinking water maximum contaminant levels to be exceeded.

These criteria shall not constrain the ability of DWR to operate the SWP for its intended purposes or to protect its integrity during emergencies. There shall not be any adverse impacts to SWP water deliveries, operations or facilities.

SPECIFIC CRITERIA and PROVISIONS

DWR will use a two-tier approach for accepting non-Project water into the California Aqueduct. Tier 1 programs have a “no adverse impact” criteria and shall be tied to historical water quality levels in the California Aqueduct. Programs meeting Tier 1 criteria shall be approved by DWR. Tier 2 programs, have water quality levels that exceed the historical water quality levels in the California Aqueduct and/or have the potential to cause adverse impacts to state water contractors. Tier 2 programs shall be referred to a State Water Contractor Facilitation Group for review. The Facilitation Group would review the program and if needed make recommendations to DWR to use during consideration of the project.

Tier 1

Under Tier 1, no constituents of non-Project water shall exceed the historical water quality at the O’Neill Forebay Outlet (formerly Check 13) on the SWP as measured by the DWR water quality monitoring program (Tables 1-4).

Blending of multiple water sources prior to inflow into the SWP is acceptable. As part of a non-Project water proposal, water may be introduced into the aqueduct that by itself might cause the ambient baseline to be exceeded, provided that the sum total of all introduced waters from a defined proposal do not exceed the historical baseline for the Aqueduct on an instantaneous flow weighted basis. Blending (mixing) within the aqueduct must be between and cannot overlap any active municipal and industrial (M&I) delivery locations, without approval of DWR. The proponent shall demonstrate by model or an approach acceptable to DWR and the State Water Contractor Facilitation Group that the water is adequately mixed before reaching the first M&I customer.

Non-Project water proposals meeting Tier 1 water quality standards shall be approved by DWR without further review by other agencies except as is required by law. However, upon approval by DWR of any pump-in under Tier 1, the State Water Contractor Facilitation Group will be notified by DWR of the action.

Table1 HISTORICAL WATER QUALITY CONDITIONS 1988 TO 2004 AT O'NEILL FOREBAY OUTLET (mg/L)

	Mean	Min	Max	Stand Dev
Aluminum	0.030	0.004	0.527	0.05
Antimony	0.003	0.001	0.005	0.002
Arsenic	0.002	0.001	0.004	0.0005
Barium	0.050	0.037	0.068	0.002
Beryllium	0.001*	0.001*	0.001*	0.000
Bromide	0.21	0.05	0.54	0.11
Cadmium	0.004	0.001	0.005	0.002
Chromium	0.005	0.001	0.011	0.0013
Copper	0.005	0.002	0.028	0.003
Fluoride	0.11	0.01	0.55	0.05
Iron	0.047	0.005	0.416	0.06
Manganese	0.010	0.003	0.06	0.008
Mercury	0.0008	0.0002	0.001	0.0004
Nickel	0.001	0.001	0.004	0.0006
Nitrate	3.5	0.6	9.6	1.8
Selenium	0.001	0.001	0.002	0.0001
Silver	0.004	0.001	0.005	0.002
Sulfate	43	17	99	15
Total Organic Carbon	4	2.1	9.3	1.33
Zinc	0.009	0.005	0.21	0.02

* These values represent reporting limits, actual values would be lower.

Table 2 O'Neill Forebay Outlet Salinity Criteria by Water Year Classification, 1979-2004 (Conductivity, μS/cm)

Year Type*	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wet	367	448	490	419	389	380	355	340	326	316	326	289
Near Normal	510	489	559	430	401	399	439	443	431	363	345	387
Dry	443	482	495	503	541	489	444	444	489	456	485	620
Critical	542	606	699	667	646	583	550	510	601	601	620	615

* Year type is based on water year classification, below normal and above normal have been combined into one designation as near normal

Table 3 O'Neill Forebay Outlet Bromide Criteria by Water Year Classification, 1993-2004 (Bromide, mg\L)

Year Type*	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wet	0.13	0.21	0.26	0.16	0.10	0.13	0.14	0.16	0.12	0.13	0.14	0.10
Near Normal	0.27	0.24	0.31	0.17	0.12	0.13	0.16	0.20	0.16	0.13	0.14	0.15
Dry	0.31	0.33	0.33	0.29	0.17	0.17	0.18	0.23	0.24	0.17	0.30	0.44
Critical	0.34	0.40	0.41	0.37	0.37	0.28	0.20	0.21	0.29	0.30	0.33	0.39

* Year type is based on water year classification, below normal and above normal have been combined into one designation as near normal

Table 4 O'Neill Forebay Outlet Total Organic Carbon Criteria by Water Year Classification, 1990-2004 (TOC, mg\L)

Year Type*	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wet	2.80	2.80	3.90	5.78	5.20	3.88	3.72	3.30	3.15	3.10	3.10	2.87
Near Normal	3.51	4.10	4.11	6.48	6.29	5.38	4.08	4.57	3.90	3.37	3.82	3.13
Dry	3.20	2.93	3.50	8.08	4.99	6.06	5.30	3.68	3.88	3.10	2.63	2.51
Critical	3.60	3.50	4.05	5.33	5.57	6.20	5.13	4.33	4.08	4.17	4.30	3.43

* Year type is based on water year classification, below normal and above normal have been combined into one designation as near normal

Tier 2

Non-Project water exceeding Tier 1 standards or contributing to aqueduct levels that exceed the historical water quality baseline may be considered for input into the SWP on a case-by-base basis by the State Water Contractor Facilitation Group and DWR. Proposals that would impact SWP water quality delivered to downstream State Water Contractors will be reviewed by State Water Contractor Facilitation Group. The intent is that proposals that produce an overall net water quality benefit will be approved.

A State Water Contractor Non-Project Inflow Facilitation Group will be established and will review all requests for non-Project inflow that do not meet Tier 1 water quality criteria. This group will consist of representatives from each State Water Contractor that chooses to participate. DWR may participate as an observer. The group will consider the merits, impacts, mitigation, cost/benefits or other issues of each Tier 2 non-Project water proposal (s) and provide recommendations to DWR. DWR will consider the Facilitation Group and any individual SWP Contractor recommendations in reviewing the proposal. DWR will make the final decision to approve, modify or deny the non-Project water proposal. Any decision must be in compliance with law and existing contracts.

The Facilitation Group would consider the range of potential impacts along with potential benefits, mitigation, and other issues associated with the program.

A consensus recommendation from the Facilitation Group would be sought regarding a potential exceedance of the monthly ambient or historical water quality levels. In the absence of consensus from the Facilitation Group, DWR will base its decision on the merits of the program and its ability to provide overall benefits to the State Water Project and the State of California.

Planning and Implementation Procedures

DWR shall consider all non-project water input proposals based upon the approved water quality *Criteria* and the procedures described below. The procedures and responsibilities of the Project Proponent, Department of Water Resources, and the Facilitation Group are described as per the *Criteria*.

Project Proponent

The proponent of a program that will introduce non-Project water into the SWP will submit a complete detailed proposal to the Department of Water Resources for purposes of evaluating the water quality impacts. The proponent shall demonstrate that the non-Project water is of consistent, predictable and reliable quality.

The Proponent is responsible for preparation of and compliance with any and all contracts, environmental documents, permits or licenses that are necessary consistent with applicable laws, regulations, agreements, procedures, or policies external to this document.

Project Description

The proponent will submit to DWR a document describing the proposed program, identifying the water source(s), planned operation, characterizing the inflow water quality and any anticipated impacts to SWP water quality and/or operations. The proposal must be submitted at least one month prior to proposed start up to allow for DWR and Facilitator Group review. The proposal will at a minimum include:

- Identify names, locations, addresses, and contact person(s) for all participants.
- Detailed information including maps identifying all sources of water, point of inflow to the SWP and ultimate fate of the introduced water.
- All terms and conditions of inflow, timing, rates and volumes of inflow, pumping, conveyance and storage requirements will be described.
- All construction details adjacent to SWP facilities will be described including valves, meters, pumps and piping size, location, etc.
- All potential impacts and/or benefits to downstream users will be identified
- Detailed water quality data will be provided for all sources of water and any blend of sources that will be introduced into the SWP.
- Describe anticipated water quality changes within the SWP.
- Identify other relevant environmental issues such as subsidence, ground water overdraft or, presents of endangered species.
- Performance measures and remedial actions that will be taken in the event projected water quality conditions are not met.

Water Quality Monitoring

In order to demonstrate that the source(s) of water are of consistent, predictable, and acceptable quality the Proponent will monitor water quality. The proponent is responsible for all costs associated with characterizing and monitoring the quality of water up to and including the point of discharge into the SWP for the duration of the program. The proponent will, for the duration of the program, regularly report on operations as they affect water quality, monitoring data and water quality changes. Non-Project inflow proponents are responsible for monitoring the quality of the water at the point of introduction into the Aqueduct for the duration of the program and reporting the data in a timely manner. One of three water quality monitoring schedules will be used and all information will be submitted to DWR in a timely manner.

Projects proponents shall select one of the testing options below and perform and provide all water quality testing described therein.

Option 1 - *Baseline tests*: Title 22 tests of record are required for all wells (sources), but a post inflow Title 22 test is allowed for any well near a similar well with a Title 22 test of record. *Start up tests in any year*: Constituents of Concern (COC) tests are required for all discharge locations (to the SWP) at start up and for all wells within two weeks of inflow startup. Analytical results for the initial discharge samples' COC tests shall be distributed to DWR and Facilitation Group within one week of start up. New programs or those with constituents that may potentially degrade the SWP shall conduct weekly COC sampling of all discharge locations until the proponent demonstrates that the non-project water is of consistent, predictable and reliable quality. *Periodic tests*: Once the nature of the discharge has been clearly established, the COC tests are required quarterly for each discharge point.

Option 2 - *Baseline tests*: Constituents of Concern tests of record are required for all wells (sources) and Title 22 tests of record are required for representative wells comprising a subset of all wells. Representative wells shall be identified on a case-by-case basis to be representative of the manifold area; proximity, water levels, and agricultural water tests are significant for this purpose. The proponent shall identify representative wells subject to approval. *Start up tests in any year*: Title 22 tests are required for all discharge points upon startup. Analytical results for the initial discharge COCs shall be distributed to DWR and Facilitation Group within one week of start up. COC tests are required for all wells within two weeks of inflow startup. New programs or those with constituents that may potentially degrade the SWP shall conduct weekly COC sampling of all discharge locations until the proponent demonstrates that the non-Project water is of consistent, predictable and reliable quality. *Periodic tests*: Once the nature of the discharge has been clearly established, the COC tests are required monthly for each discharge point.

Option 3 – A project proponent may propose a monitoring schedule that is fully protective of water quality and consistent with the *Criteria*. The proposed monitoring schedule will be submitted to the Facilitation Group for review and seeking a recommendation of approval. The monitoring must Constituents of Concern (COC) tests for all discharge locations (to the SWP) at start up. Analytical results for the initial discharge samples' COC tests shall be distributed to DWR and Facilitation Group within one week of start up. New programs or those with constituents that may potentially degrade the SWP shall conduct weekly COC sampling of all discharge locations until the proponent demonstrates that the non-project water is of consistent, predictable and reliable quality.

Under any of the three testing option all Title 22 tests will be repeated every three years.

Analytical Methods
Analytical laboratories used by non-Project inflow proponents will be DHS Certified. For COC analysis all laboratories will uses EPA prescribed methods that are compatible with and allow comparison to analytical results from DWR Bryte Chemical Laboratory. The table below lists the current methods used by DWR Bryte Chemical Laboratory.

Bryte Chemical Laboratory Analytical Methods for Constituents of Concern

Analyte	Method	Code	Reporting Limit	
Dissolved Arsenic	ICP/MS Trace elements (Dissolved)	EPA 200.8(D)	0.001	mg/L
Dissolved Bromide	IC Inorganic Anions 28d Hold	EPA 300.0 28d Hold	0.01	mg/L
Dissolved Nitrate	IC Inorganic Anions (Nitrate) 48hr Hold	EPA 300.0 48hr (NO3, OP)	0.1	mg/L
Dissolved Sulfate	IC Inorganic Anions 28d Hold	EPA 300.0 28d Hold	1	mg/L
Dissolved Organic Carbon	Organic Carbon (Dissolved) by Wet Oxidation	EPA 415.1 (D) Ox	0.1	mg/L as C
Total Organic Carbon	Organic Carbon (Total) by Wet Oxidation	EPA 415.1 (T) Ox	0.1	mg/L as C
Total Organic Carbon	Organic Carbon (Total) by Combustion	EPA 415.1 (T) Cmbst	0.5	mg/L as C
Total dissolved Solids	Total dissolved Solids (TDS)	Standard Method 2540-C	1	mg/L

Flow Measurements
The proponent will provide flow measurements and analytical data for all sources and discharges into the SWP to demonstrate compliance with the *Criteria*.

- The proponent will maintain current, accurate records of production rate and volume from each source, as well as, each point of discharge into the SWP.
- All flow measurements will be submitted to DWR regularly.

Reconsideration
If a proponent disagrees with the DWR decision of compliance with the *Criteria* or feels that there is overriding benefit of the proposal, the proponent may seek review from the Facilitation Group.

- The SWC Facilitation Group may recommend to DWR that a proposal has some overriding benefit(s) and DWR may reconsider the proposal.
- Reconsideration by DWR will be on a case-by-case basis and DWR may waive or modify the Criteria for specific proposals if conditions warrant.

Ongoing Program
Any Project Proponent who has established a non-Project inflow program my reinitiate the program by notifying DWR at least ten days before inflow is scheduled to begin and provide the following information: 1) water quality data or updated modeling that accurately reflects the quality of water to be put into the SWP, 2) Turn-in location, and 3) expected duration of inflow. DWR will notify the facilitation group of this reinitiating of inflow. The proponent must reinitiate water quality monitoring for the constituents of concern and verify within one week after inflow begins that the water quality is as forecast by the proponent.

Long Range Planning
Future non-Project inflow programs should be planned and designed considering the following items.

1. DWR will be reluctant to approve projects involving water quality exceeding primary drinking water standards unless the proponent can show that the water will be treated or blended before it enters the SWP to prevent water quality impacts.
2. The project proponent of a Tier 2 project should clearly identify and establish that water inflow will be managed and operated such that poor quality water will be blended with better quality water so that SWP water quality will not be degraded.
3. If a significant water supply deficiency exists and it is recommended by the facilitation group that raw water quality criteria be set aside to assure adequate supply, such action will be subject to approval by the Department of Health Services.
4. The proponent of a non-Project inflow program which degrades SWP water quality must establish adequate mitigation and/or compensation to downstream water contractors for water quality impacts associated with increased water supply or treatment costs.

DWR

DWR will seek, as needed, DHS or State Water Contractor recommendations on changes or additions to this document governing the water quality of non-Project water proposals. The Facilitation Group will review proposed changes or additions prior to implementation by DWR, as needed.

DWR will have ultimate responsibility for approving the water quality of all non-project inflow, as well as, the oversight of monitoring and tracking the water quality of operating programs.

DWR will have ultimate responsibility for ensuring that the proponent of any non-Project inflow perform according to their proposal, and will take appropriate action in the event of non-conformance.

Project Proposal
Upon receipt of a proposal for Non-Project water inflow DWR will review the proposal for adequacy. DWR shall consider all non-project water inflow proposals based upon the approved *Criteria*. Review will take no more than one month after receiving a complete program proposal. If necessary, DWR will convene timely meetings with the Facilitation Group during the review. At the minimum the review will include

- Examination of all documents and data for completeness of the submittal.
- Affected Field Divisions, the Facilitation group and all affected downstream users will be immediately notified of the submittal.
- Comments from all parties may be considered by DWR before the final decision.
- Upon completion of the review DWR will notify the proponent, and downstream users, of the acceptance of the proposal or explain the reason(s) for rejecting the proposal.
- DWR may reconsider a decision on a proposal based upon a recommendation from the Facilitation Group. Reconsideration by DWR will be on a case-by-case basis and DWR may waive or modify the *Criteria* for specific proposals if conditions warrant

Annual Review
Once a program for delivery of non-Project water to the Aqueduct has been approved, an annual review of the program will occur with input from the Facilitation Group. As part of the review, program proponents will provide the following information:

- Summary of deliveries to the Aqueduct.
- Water quality monitoring results.
- Proposed changes in the program operation.

The review may result in changes in monitoring and testing required of the program proponent as a result of;

- New constituents being added to the EPA /DHS list of primary drinking water standards.
- Changes in the maximum contaminant levels for the EPA/DHS list of primary drinking water standards.
- Identification of new constituents of concern
- Changes in the water quality provided by the program.
- Changes in Background level in the California Aqueduct.

This procedure shall recognize emerging contaminants as they are identified by the regulatory agencies and shall set appropriate standards for introduction based upon ambient levels in the California Aqueduct or State Action Levels, which ever is lower. Emerging contaminants are those that may pose significant risk to public health, but as yet do not have an MCL. Currently the Office of Environmental Health Hazard Assessment and the Department of Health Services establish Public Health Goals and Action Levels, respectively. These levels, though not regulated, do provide health-based guidance to water utilities and can require public notification if exceeded.

Water Quality Review

For operating projects DWR will track and annually report on water quality impacts to the SWP from non-Project water inflow.

- DWR will review analyze and maintain all records of water quality testing conducted by the proponent of the well(s), source(s) and discharge(s) into the SWP.
- DWR will determine what additional water quality monitoring, if any, is necessary within the SWP to assure compliance with the *Criteria*. DWR will conduct all water quality monitoring within the SWP
- DWR will prepare an annual report of water quality impacts in the SWP from non-Project water and make all water quality data available to interested parties.

On-site Surveillance

The appropriate Field Division within DWR will be responsible for review and approval of all construction activities within the SWP right-of-way. Plans showing the discharge system piping, valves, sampling point, meters and locations must be submitted and approved prior to any construction. In addition, the appropriate Field Division will be responsible for confirmation of all meter readings and water quality monitoring conducted by the proponent.

- Field division staff may visit, inspect, calibrate meters and measure flow conditions at each source or point of discharge into the SWP.
- Flow meters, sampling ports and anti-siphon valves must be conveniently located near the SWP right-of-way.
- Field division staff may collect water samples at each source or point of discharge into the SWP.
- The appropriate Field Division will conduct additional water quality monitoring within the SWP, if deemed necessary, to assure compliance with the Non-Project Inflow Criteria.
- DWR will monitor Aqueduct water quality and analyze several “split samples” of the water at the point of introduction into the Aqueduct to ensure consistent analytical results

SWC Facilitation Group

Upon initial review of a non-Project water inflow proposal, DWR shall notify the State Water Contractors of its receipt, its contents, and the possible need for a Facilitation Group review. The State Water Contractors may form a Facilitation Group to advise DWR on any or all proposals for introduction of non-Project water into the SWP.

- It is the responsibility of the State Water Contractors to form and coordinate the activities of the Facilitation Group. DWR will assist in coordination of Facilitation Group activities as requested.
- The SWC Facilitation Group can consist of State Water Contractors, DWR, the project proponent, other state or federal agencies, consultants or other interested parties as needed to fully evaluate a non-Project inflow proposal.

The Facilitation Group is an advisory body that will review the *Criteria* and *Implementation Procedures* for approval of water quality for non-Project inflow. The Facilitation Group will review and recommend action on programs with water quality that could degrade SWP water quality. Also, if a proponent proposes a monitoring schedule under Option 3, above, the Facilitation Group will review the proposal and make appropriate monitoring recommendations.

Recommendations of the Facilitation Group
The Facilitation Group will consider the merits, impacts, mitigation, cost/benefits or other issues, in addition to water quality, in an effort to develop a consensus recommendation for action on non-Project inflow proposals.

- Only State Water Contractors will have a vote in the direction of Facilitation Group activities or development of a recommendation on any proposal.
- The Facilitation Group can provide comment or recommendations to DWR at any time, on any aspect, of any proposal or pump-in program. The Facilitation Group can also provide comment or recommendations to DWR on the *Criteria* or *Implementation Procedures* at any time.
- The Facilitation Group will provide DWR with written recommendations for formal approval, disapproval or modification of each individual non-Project inflow proposal submitted for consideration. The recommendation shall explain the reasons for the recommendation.
- If consensus is not possible the Facilitation Group may submit both majority and minority opinions and recommendations.

DEPARTMENT OF WATER RESOURCES
WATER QUALITY POLICY FOR ACCEPTANCE OF NON-PROJECT WATER INTO THE STATE WATER PROJECT

POLICY APROVAL

Approval Recommended
Date _______________

____
Steven Kashiwada
Chief, Division of Operations and Maintenance
Department of Water Resources

Approval Recommended
Date _______________

____
Tom Glover
Deputy Director
Department of Water Resources

Approved
Date _______________

____
Lester Snow
Director
Department of Water Resources

Appendix D – Supporting Information for Chapter 6

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Division of Flood Management

After Action Report

2004 Jones Tract Flood Incident

<u>Memorandum Report</u>

December 2004

State of California | The Resources Agency

M e m o r a n d u m

Date:

To: 1. Gary Bardini
2. Leslie F. Harder, Jr.

From: Jay Punia, Chief
Flood Operations Branch
Department of Water Resources

Subject: After Action Report, 2004 Jones Tract Incident

This report presents a comprehensive review and analysis of the Department of Water Resources' (DWR) emergency response to the June 2004 levee breach at the Jones Tract, and serves as a planning document to improve DWR's flood emergency response readiness. Specifically, the report:

- Provides a summary of the incident including a chronology
- Describes the post-flood debriefing process
- Identifies successes and areas of improvement with DWR's emergency response
- Analyzes the effectiveness of the Standardized Emergency Management System (SEMS) implementation for this incident
- Makes recommendations for implementing improvements

According to the California Code of Regulations, Title 19, Section 2450, any State agency responding to an emergency for which the Governor proclaims a State of Emergency must complete and transmit an After Action Report to the Governor's Office of Emergency Services. This report meets this requirement.

If you have any questions, please contact me at (916) 574-2611.

SURNAME DWR 155 (Rev 4/02)	/s/			

STATE OF CALIFORNIA
Arnold Schwarzenegger, Governor

THE RESOURCES AGENCY
Mike Chrisman, Secretary for Resources

DEPARTMENT OF WATER RESOURCES
Lester A. Snow, Director

Joseph Grindstaff
Chief Deputy Director

Brian White
Assistant Director for Legislation

Tom Glover Deputy Director	Stephen W. Verigin Acting Deputy Director	Gerald E. Johns Deputy Director
Susan Sims Assistant Director, Public Affairs	Pete S. Garris Deputy Director	Nancy Saracino Chief Counsel

DIVISION OF FLOOD MANAGEMENT

Leslie F. Harder, Jr..Chief
Gary B. Bardini...Chief, Hydrology and Flood Operations Office

This report was prepared under the direction of

Jay S. Punia...Chief, Flood Operations Branch

by

Terri Wegener .... Senior Engineer, WR

With the assistance of

Brian Smith...Supervising Engineer, WR
Eric Butler.. Senior Engineer, WR
Kevin Elcock.. Senior Engineer, WR
Sherry Constancio..Engineer, WR
Sonny Fong..Emergency Preparedness and Security Manager

Table of Contents

Executive Summary

Purpose and Scope

This After Action Report (AAR) covers the Department of Water Resources (DWR) emergency response actions, application of the Standardized Emergency Management System (SEMS), and recommends modifications to plans and procedures and training and exercise needs. An AAR serves to provide a source for documentation of response activities, identification of successes and problems during emergency operations, analysis of the effectiveness of the SEMS implementation and to provide a plan of action to improve emergency operations.

Specifically, this report is a review and analysis of DWR's emergency response to the 2004 Jones Track Flood Incident. This report includes a set of recommendations for improving DWR's response to a flood emergency for the upcoming 2004-2005 winter season and for future flood seasons. The following activities were carried out to develop this report:

- Two after action debriefings and several meetings were held with staff from the Flood Operations Center (FOC), the Incident Command Team (ICT) and DWR management, and participating DWR divisions
- Issues requiring further attention, improvement or corrections were identified

California Code of Regulations, Title 19, Section 2450, requires, in part, that any State agency responding to an emergency, for which the Governor proclaims a State of Emergency, must submit an AAR to the Governor's Office of Emergency Services (OES). This report meets that requirement.

History of Event

On June 3, 2004, at approximately 7:50 a.m. a levee breach occurred on the west levee of the Upper Jones Tract in the southern region of the Delta in San Joaquin County. As the flooding began, State, federal and local agencies began mobilizing.

By 9:00 a.m., the State Federal Flood Operations Center had activated, implemented the "Delta Levee Failure Incident" response protocol, and begun coordinating with numerous State, federal and local agencies.

The San Joaquin Sheriffs Office established a command post on the eastern side of Upper Jones Tract adjacent to State Highway 4.

Evacuation of Upper Jones Tract and Lower Jones Tract began. DWR and other agencies determined that the Trapper Slough levee on the southern border of Upper Jones Tract was not at a high enough elevation to protect State Highway 4.

DWR established the following objectives for protecting lives and property:

- Protect Highway 4 from failure by Trapper Slough
- Prevent the failure of Jones Tract perimeter levees and adjacent levee islands
- Close the levee breach
- Minimize saltwater intrusion into the Delta

DWR and the U.S. Bureau of Reclamation (USBR) immediately took steps to try to protect water quality by restricting the flow of water exported south from their respective pumping plants and by releasing water from upstream reservoirs.

By the evening of June 4, 2004 an emergency request under Public Law 84-99 was made to the U.S. Army Corps of Engineers (Corps) to raise and armor the Trapper Slough Levee to protect State Highway 4 and to close the breach. Ultimately the Corps agreed to raise the Trapper Slough levee (with assistance from the California Department of Transportation (Caltrans) and materials provided by DWR), but denied the request for armoring the Trapper Slough levee and the closing of the breach. Governor Arnold Schwarzenegger declared a State of Emergency.

On June 5, 2004 a Unified Command had been established at the site of the Sheriff's command post. Sharing the command were staff from San Joaquin County, DWR, and Caltrans. Governor Arnold Schwarzenegger visited the flooded island. That same day an agreement was reached with Dutra Construction to close the breach.

On June 6, 2004 DWR established a command post at the site of the Unified Command and on June 8, 2004 took over control of the incident.

Raising of the Trapper Slough levee was completed on June 8, 2004 and, at the request of the Reclamation Districts 2038 and 2039, DWR began a flood fight to protect the island interior levees. Approximately 16 miles of levee were eventually lined with visquine or armored with rock to protect the inside of the island. California Department of Forestry (CDF) and California Conservation Corps (CCC) crews were deployed to carry out the flood fight to protect the island's interior.

Both the breach closure and protection of the interior levee slopes were completed on June 30, 2004. As a result there were no further problems due to high tides or winds.

On June 24, 2004 DWR awarded a contract for the dewatering of the island, and on July 12, 2004 operation of four 42-inch pumps began at a pump station constructed on Upper Jones Tract. By July 26th construction of another pump station was completed north of the Burlington Northern – Santa Fe Railroad (BNSF) line, and all 10 pumps (eight 42-inch and two 30-inch) were in operation. The maximum flow rate was approximately 350,000 gallons per minute (780 cubic feet per second).

On June 30, 2004 a Presidential Declaration of Emergency was declared which authorized the Federal Emergency Management Agency (FEMA) to reimburse the costs of responding to this emergency.

On July 12, 2004 the incident was officially closed by OES. Pumpout of the island and monitoring for potential future failures continued. As of December 14, 2004, dewatering of the Upper Jones Tract was essentially finished but pumping was expected to continue for a couple of days at Lower Jones Tract. An estimated 140,000 acre-feet of water had been removed from the island. The remaining water in drainage ditches and low-lying areas will be pumped by Reclamation District's pumps.

Debrief Process

The debrief process was conducted in several steps. On August 10, 2004 DWR Director Lester Snow briefed the Senate Committee on Agriculture and Water Resources on the incident. On August 23, 2004 a debrief meeting was held at State OES headquarters for all DWR staff that participated in the incident. On September 1, 2004 a second debrief meeting included State, local, and federal agencies that participated in the Jones Tract incident. In addition, a questionnaire was distributed to all DWR staff members who participated in the incident. The results of these three debrief meetings and the responses to the questionnaires are reflected in this AAR.

Summary of Response—Successes and Issues

DWR successfully met the objectives set at the outset of the breach for protecting lives and property. These four objectives were:

- Protect Highway 4 from failure by Trapper Slough
- Prevent the failure of Jones Tract perimeter levees and adjacent levee islands
- Close the levee breach
- Minimize saltwater intrusion into the Delta

DWR accomplished these objectives in spite of the fact that this levee breach occurred with no warning on a non-project levee outside of the normal flood season. Interagency cooperation was laudable during this event with a number of agencies, departments, and divisions working to meet the unusual demands of the emergency.

An objective to dewater the island was determined during the course of the event and was essentially completed on Upper Jones Tract by December 14, 2004. Pumping continued for a couple more days at Lower Jones Tract.

A number of issues had the potential to affect the quality and nature of DWR's flood response. Prime among these is the lack of clear direction and funding when a levee not constructed under the Corps' auspices (a non-project levee) fails. Until the Governor provided clear direction to DWR to respond to the flood fight the State's role in the flood fight and flood response was unclear. The source of funds available to conduct the response and the State's role in flood recovery were also unclear. Other significant issues are included in the table below along with recommendations. In addition, minor issues are addressed in the text of this report.

Table EX 1: Recommended Pre-Event Flood Emergency Actions

Issue	Category/Sub	Title	Recommended Action	Response
A1	Policy 1	DWR Responsibility for Flood Fight on Non-project Levees	Develop a clear policy and plan specifying DWR's ***flood fight responsibility*** on non-project levees. The policy should provide a funding mechanism for any specified flood response.	L – Exec S – DFM
A2	Policy 2	Repair of Flood Damage from Non-project Levee Failure	Develop a clear policy specifying DWR's authority to ***repair flood damage and assist in the recovery*** of flood damaged areas (including dewatering of flooded areas) from non-project levees. The policy should provide a funding mechanism for any repair and recovery work.	L – Exec S – DFM
A3	Staffing 1	Annual Staff Assignments	Organize 2004-2005 Department-wide, cross-division, flood response teams for both the FOC and Regional ICTs. Annually update DWR flood emergency response assignments for both the FOC and ICT, clearing the assignments with managers and supervisors.	L – EPM S – DFM
A4	Equipment 1	Emergency Voice / Data Telecommunications Plan	Develop and annually review an emergency telecommunications plan. Execute an annual or multi-year services contract to provide rapid, effective telecommunications in remote areas in the event normal telecommunications services are inadequate.	L – DFM, DTS
A5	Training 1	SEMS Specific Duties	Annually conduct SEMS, FOCIS, and section-specific training for flood response teams in the FOC and ICP. The training will be for flood response teams and for DWR managers and personnel likely to have a flood response role. Conclude annual training/briefings with an emergency management exercise.	L – EPM S – Training Office, DFM
A6	Policy 3	Authorize Flood Management Emergency Expenditures	Authorize the Division of Flood Management to expend funds during major flood emergencies for the necessary contracts and equipment required to respond quickly and institute corresponding emergency business practices.	L – DMS S – DFS, Exec, DFM

Issue: Recommended actions in order of priority (A1, A2, A3 etc.)
Category/Sub: The four categories are Policy, Staffing, Equipment and Training. Category items are subcategorized in order of priority (Policy 1, Policy 2, etc.)
Response: Responsible parties listed by L (Lead) and S (Support)

Table EX 1: Recommended Pre-Event Flood Emergency Actions (continued)

Issue	Category/Sub	Title	Recommended Action	Response
A7	Policy 4	Interagency Agreements	Execute and update as needed interagency agreements with all applicable agencies to enable immediate flood fight response. Annually review existing agreements.	L – Exec S – DFM
A8	Policy 5	Compensation	Institute a method to fairly compensate applicable managers and supervisors who work extended flood (and other disasters) response hours.	L – DMS S – Exec
A9	Equipment 2	Flood Fight Materials	Restock and expand flood fight materials expended during the flood fight. Provide mechanisms to reimburse DFM for stockpiled materials utilized in the flood fight.	L – DFM S – DMS
A10	Policy 6	DWR Business Processes	Establish streamlined or specialized business processes to use in a flood emergency. Streamline normal business processes such as Travel Expense Claims and invoice payment. Train line staff and managers in applicable Divisions in SEMS and emergency response roles and responsibilities.	L – DMS S – DFS, Exec, DFM
A11	Equipment 3	DWR Incident Command Post	Provide an adequately supplied mobile emergency response office(s) to enable rapid setup of an easily recognized DWR ICP. Trailers equipped with computers, office equipment and supplies are needed for an effective initial field response--and if necessary a larger incident command post by DWR.	L – DMS S – DFM
A12	Training 2	Interagency Coordination	Build upon key relationships with CDF, CCC, OES, locals, and other agencies by annually conducting discussions with key personnel.	L – DFM
A13	Policy 7	Mission Tasking by OES	Follow pre-established OES mission tasking procedures unless otherwise directed by the Governor’s Office or designee. Train DWR managers in mission tasking.	L – DFM

Issue: Recommended actions in order of priority (A1, A2, A3 etc.)
Category/Sub: The four categories are Policy, Staffing, Equipment and Training. Category items are subcategorized in order of priority (Policy 1, Policy 2, etc.)
Response: Responsible parties listed by L (Lead) and S (Support)

Table EX 2: Recommended Actions During Flood Emergencies

Issue	Category/Sub	Title	Recommended Action	Response
E1	Staffing 2	Emergency Staff Assignments	Direct all personnel assignments during an event from the FOC. Assign an individual to deploy staff at both the FOC and ICP.	L – DFM
E2	Staffing 3	SEMS Reports	Each section will designate an individual whose entire function is to keep a real time log of the information flow in their section. This real time log will allow the quick and accurate writing of official SEMS reports in FOCIS. Provide annual FOCIS training.	L – DFM
E3	Staffing 4	Numbers of Staff Assigned	Notify key staff in all affected divisions of any potential event. Provide sufficient numbers of staff early in a major flood event. Continue staffing at sufficient levels to ensure adequate flood emergency response. Conduct an emergency meeting of all DFM staff to notify of major event and review staffing assignments. Distribute Flood Alert and Mobilization Memoranda via email to all DWR staff.	L – DFM
E4	Training 3	Communication Between FOC and ICP	Encourage peer-to-peer communications during events within sections and between section chiefs at the FOC and ICPs. Daily assign a messenger to transport materials from ICP(s) to FOC.	L – DFM
E5	Equipment 4	Workspace Assignments	Provide an assigned workspace in the FOC for Incident Command Personnel.	L – DFM S – DMS
E6	Policy 8	CDF Transition Team	Request CDF assistance to assist in initial setup of an ICP.	L – DFM S – EPM
E7	Staffing 5	Staffing Rotation and Duration	Rotate teams on an eight day sequence, providing a one day overlap between teams.	L – DFM S – Exec
E8	Staffing 6	Public Information Officers (PIO) at the FOC and ICP	Have PIO coverage at both the FOC and ICP at all times. Train and utilize PIOs from various Divisions to allow for adequate coverage without putting undue burden on the PAO.	L – DFM S – PAO
E9	Policy 9	Environmental Issues and Health/Safety	Be proactive and aware of the role/responsibility of DWR with respect to environmental/health/safety issues such as water quality and toxics. Be aware of other responding agencies roles and verify that necessary actions are being performed regardless of responsibility.	L – DFM S – DES

Issue: Recommended actions in order of priority (A1, A2, A3 etc.)
Category/Sub: The four categories are Policy, Staffing, Equipment and Training. Category items are subcategorized in order of priority (Policy 1, Policy 2, etc.)
Response: Responsible parties listed by L (Lead) and S (Support)

Chapter One – Introduction

1.1 Purpose and Scope

This AAR covers DWR emergency response actions, application of the SEMS, modifications to plans and procedures and training and exercise needs. An AAR serves to provide a source for documentation of response activities, identification of successes and problems during emergency operations, analysis of the effectiveness of the SEMS implementation and to provide a plan of action to improve emergency operations.

Specifically, this report is a review and analysis of the DWR emergency response to the 2004 Jones Tract Flood Incident. This report includes a set of recommendations for improving DWR's response to flood emergencies. The following activities were carried out to develop this report:

- Two after action debriefings and several meetings were held with staff from the FOC, the Incident Command Team and DWR management, and participating DWR divisions
- Issues requiring further attention, improvement or corrections were identified

California Code of Regulations, Title 19, Section 2450, requires, in part, that any State agency responding to an emergency, for which the Governor proclaims a State of Emergency, must submit an AAR to the Governor's OES. This report meets this requirement.

1.2 History of Event

On June 3, 2004, at approximately 7:50 a.m. a levee breach occurred on the west levee of the Upper Jones Tract in the southern region of the Delta in San Joaquin County. The break occurred approximately 1/4 mile north of the Woodward Island ferry exposing the tract to flooding from Middle River. As the flooding began, State, federal and local agencies began mobilizing.

By 9:00 a.m. the State Federal Flood Operations Center had activated, implemented the "Delta Levee Failure Incident" response protocol and begun coordinating with numerous State, federal and local agencies.

The San Joaquin Sheriffs Office established a command post on the eastern side of Upper Jones Tract adjacent to State Highway 4.

Evacuation of Upper Jones Tract and Lower Jones Tract began. DWR and other agencies determined that the Trapper Slough levee on the southern border of Upper Jones Tract was not at a high enough elevation to protect State Highway 4. Other immediate concerns were the BNSF embankment that acted as the barrier between Upper Jones Tract and Lower Jones Tract, the Mokelumne River Aqueduct operated by

East Bay Municipal Utility District (EBMUD), and the Kinder-Morgan gasoline pipeline. All three facilities crossed the Jones Tract in approximately the same location.

DWR established the following objectives for protecting lives and property at Jones Tract:

- Protect Highway 4 from failure by Trapper Slough
- Prevent the failure of Jones Tract perimeter levees and adjacent levee islands
- Close the levee breach
- Minimize saltwater intrusion into the Delta

DWR and the USBR immediately took steps to try to protect water quality in the southern Delta and their pumping plants. Additional water was released from upstream reservoirs. Export pumping was reduced at the Bureau's Tracy Pumping plant. DWR ceased pumping from the Harvey O. Banks Delta Pumping Plant.

By the evening of June 4, 2004 an emergency request under Public Law 84-99 was made to the Corps to raise and armor the Trapper Slough Levee to protect State Highway 4 and to close the breach. Ultimately the Corps agreed to raise the Trapper Slough levee (with assistance from Caltrans and materials provided by DWR), but denied the request for armoring the Trapper Slough levee and the closing of the levee breach. Governor Arnold Schwarzenegger declared a State of Emergency.

On June 5, 2004 a Unified Command had been established at the site of the Sheriff's command post. Sharing the command were staff from San Joaquin County, DWR, and Caltrans. Governor Arnold Schwarzenegger visited the flooded island. That same day an agreement was reached with Dutra Construction to close the breach.

On June 6, 2004 DWR established a command post at the site of the Unified Command and on June 8, 2004 took over control of the incident. San Joaquin County and the California Highway Patrol (CHP) remained in support of the incident. Staff from the Division of Flood Management, Bay-Delta Office and other DWR divisions eventually made up the ICT until July 15, 2004 when the ICP closed. Members of the Department of Boating and Waterways, CDF and Caltrans were also integrated into the command as agency representatives. Liaison efforts with surrounding growers and agencies were taking place and flood fight materials and other resources began to arrive at the site. CDF and CCC hand crews were deployed to carry out the flood fight to protect the island's interior.

Raising of the Trapper Slough Levee was completed on June 8, 2004 and, at the request of the Reclamation Districts 2038 and 2039, DWR began a flood fight to protect the inside of the island from the rising flood waters. Approximately 16 miles of levee were eventually lined with visquine or armored with rock to protect the island interior levees.

Dutra Construction completed closing the breach on June 30, 2004, approximately 20 days ahead of schedule. This occurred on the same day as the completion of protecting the island's interior levees. The closure occurred several days before an astronomical high tide was due. This high tide would have resulted in a rise of the island water surface elevation to its highest level since the day of the breach. As a result of the closure and completion of the protection efforts, there were no problems due to the high tidal period or winds.

Following negotiations with local agencies on June 24, 2004, DWR opened bids and awarded a contract for the dewatering of the island. That effort began on July 12, 2004 with the startup of four 42-inch pumps at a pump station constructed on Upper Jones Tract just south of the BNSF railroad line. By July 26, 2004 another pump station had been constructed north of the BNSF line and all 10 pumps (eight 42-inch and two 30-inch) were in operation. The maximum flow rate was approximately 350,000 gallons per minute (approximately 780 cubic feet per second). By July 26, 2004 the water level had been reduced by about 18 inches.

On June 30, 2004 a Presidential Declaration of Emergency was declared which authorized the FEMA to reimburse the costs of responding to this emergency.

On July 12, 2004 the incident was officially closed by OES. Pumpout of the island and monitoring for potential future failures continued. As of December 14, 2004, dewatering of the Upper Jones Tract was essentially finished but pumping was expected to continue for a couple of days at Lower Jones Tract. An estimated 140,000 acre-feet of water had been removed from the island. The remaining water in drainage ditches and low-lying areas will be pumped by District pumps.

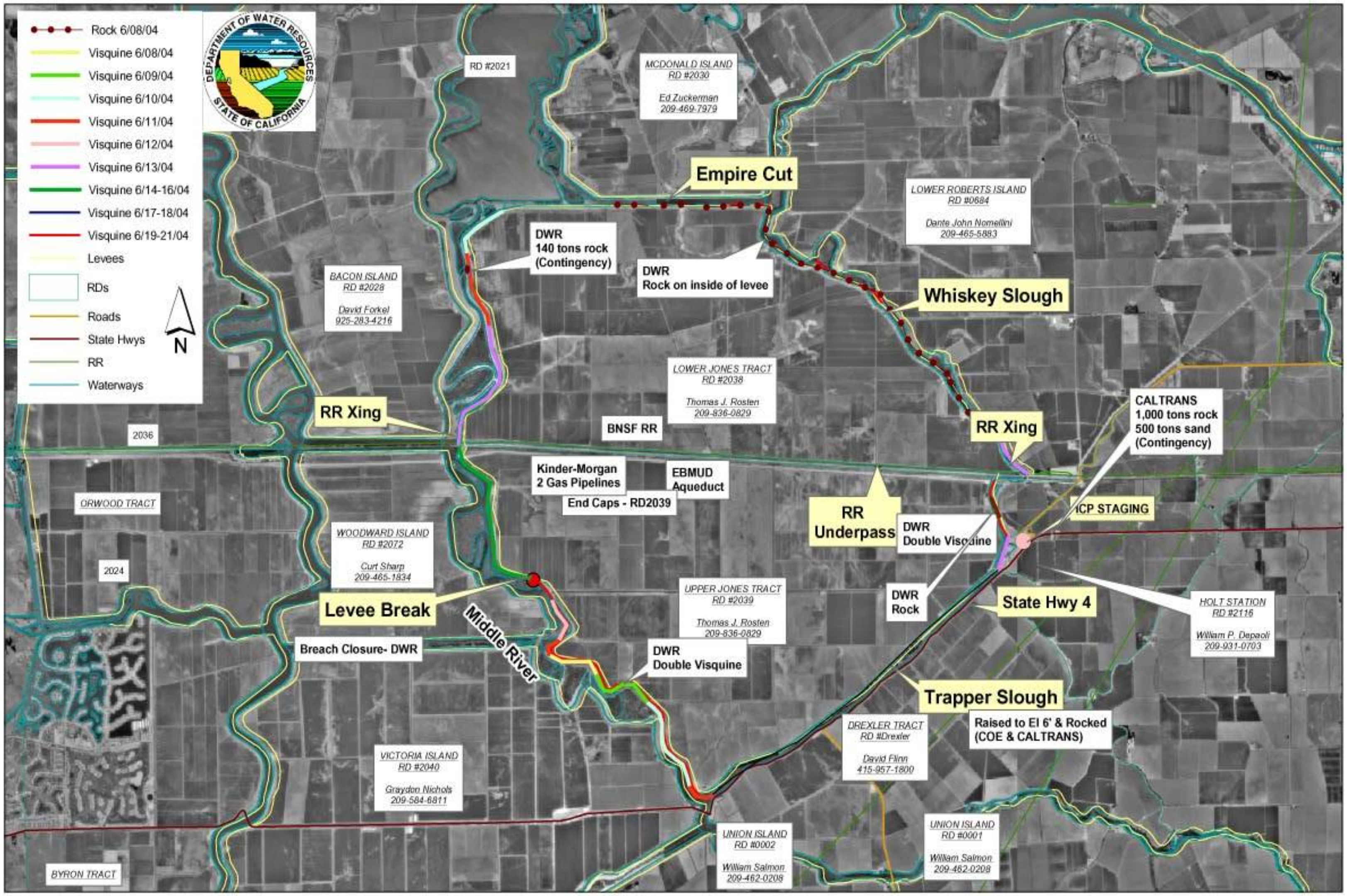
1.3 Date/Time of Proclamations/Declarations

Almost immediately after the levee was breached on June 3, 2004, San Joaquin County declared a State of Emergency. On June 4, 2004, the DWR Director declared the Department to be under an emergency and mobilized. The Governor followed with the proclamation of a State of Emergency on June 4, 2004. On June 30, 2004 the President proclaimed a State of Emergency at the federal level. The Presidential proclamation allowed the State to submit claims for federal reimbursement of emergency costs by FEMA.

The four declarations are listed in bullet form below. Copies of the declarations are included in Appendix A of this report.

- June 3, 2004 – San Joaquin County proclaims a State of Emergency
- June 4, 2004 – Flood Mobilization Memorandum
- June 4, 2004 – Governor proclaims a State of Emergency
- June 30, 2004 – President proclaims a State of Emergency

Figure 1: Jones Tract Levee Failure Emergency Response Map



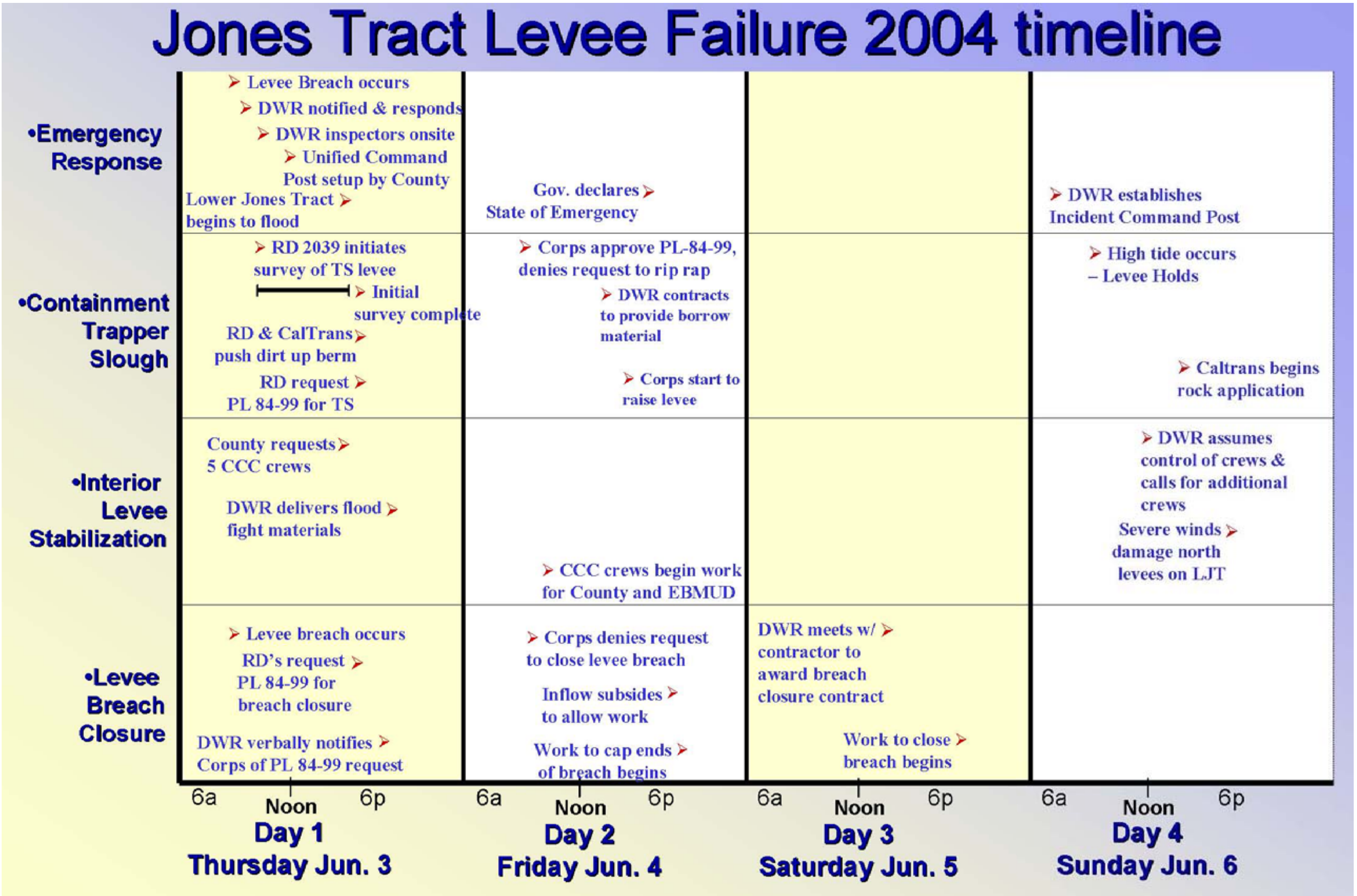


Figure 2: Jones Tract Graphical Timeline June 3-6, 2004

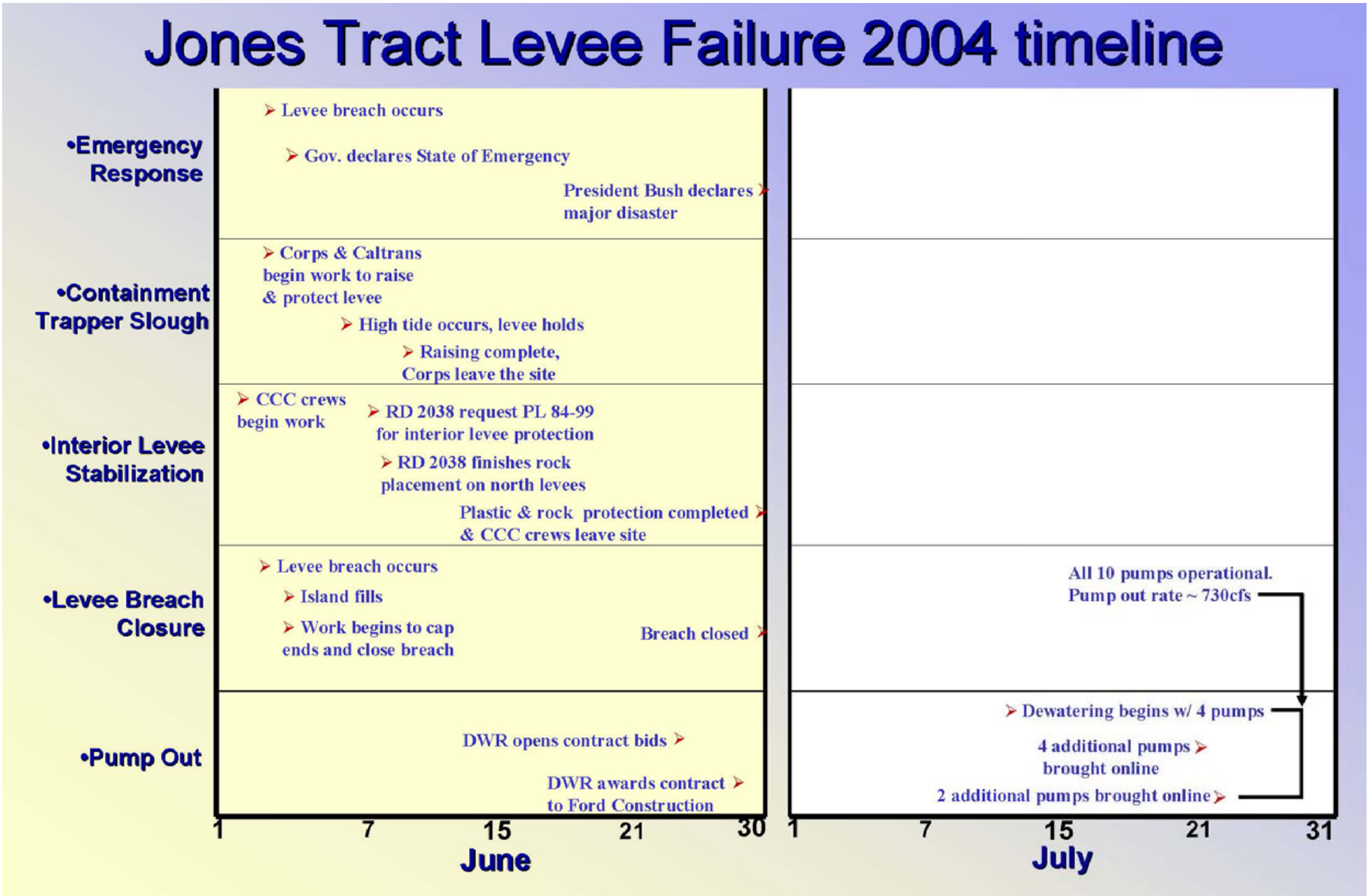


Figure 3: Jones Tract Graphical Timeline June -July, 2004

Chapter Two – Discussion of Response at Designated SEMS Levels

The following is a summary of the response, conclusions on the response, and recommendations for improvement at designated SEMS levels.

2.1 Incident Command Team

Initially, DWR was part of a Unified Command established on June 5, 2004 by San Joaquin County, DWR, and Caltrans. A DWR ICT was established at the site on June 6, 2004 and took over sole command of the incident on June 8, 2004.

At the beginning the ICT was composed of staff from the Bay-Delta Office and the Division of Flood Management. By the end of the first week, a number of the original ICT personnel were recalled by their parent organizations and new staff had to be recruited. Initially there was the expectation that the inside slopes of the levees surrounding Upper Jones Tract and Lower Jones Tract would not require wave wash protection. By June 10, 2004, changing site and weather conditions necessitated slope protection and extended the need for a full ICT.

The ICT and the FOC began to assign/recruit replacement and additional staff for the ICT's general staff. Eventually staff was assigned to the ICT primarily from the Bay-Delta Office, Division of Flood Management, Division of Engineering (DOE), Division of Operations & Maintenance and the San Joaquin District. The Divisions of Fiscal Services, Environmental Services and Safety of Dams, along with the Public Affairs Office and Central District, also provided staff.

The ICT was in the field from June 6, 2004 to July 15, 2004. Staff rotation became a problem by the end of June. Although the proximity of the incident to Sacramento allowed for periodic breaks by assigned staff, coordination difficulties in assigning staff and consistency remained a problem.

The primary missions of the ICT were to install wave wash protection on the land side of the interior levees, maintain the crest elevation of Trapper Slough and close the breach. DOE staff assigned to the Operations Section of the ICT were responsible for the latter and generally the ICT was not directly involved.

2.2 Flood Operations Center

The FOC activated immediately upon notification of the breach. The FOC initiated the "Delta Levee Failure Incident" protocol and mobilized to support the incident. Because the levee failed so quickly the FOC did not issue a Flood Alert letter but immediately issued a Flood Mobilization letter. A request for assistance under Public Law 84-99 was prepared and submitted to the Corps. Many of the pre-established FOC Emergency Response Team members were immediately activated, and personnel from many divisions with varying levels of SEMS training were also recruited to staff the FOC and assume assigned SEMS roles throughout the event. Several FOC Team members were assigned to the ICP.

2.3 FOC Management/DWR Executive

The FOC Management Section worked closely with DWR Executive providing information and recommendations. The FOC Management was the direct liaison to the Governor's OES and the Corps, while DWR Executive worked directly with the Department of Finance, Resources Agency, Governor's Office and the Legislature.

The FOC Management convened daily conference calls with the responding State, federal and local agencies, including the ICT at Jones Tract. The ICT briefed FOC Management frequently throughout the day, depending upon the level of activity.

2.4 Local Agencies

DWR dealt with a number of local agencies during the response, especially with Reclamation Districts 2038 and 2039. These districts had jurisdictional responsibilities for the levees surrounding Upper Jones Tract and Lower Jones Tract.

2.5 Operational Area

The primary Operational Area (OA) involved was San Joaquin County. From the beginning, the OA provided vital support to the incident, including command post facilities. The ICT stayed in close contact with the San Joaquin County OES and related agencies. The San Joaquin County Sheriff's Office, with assistance from the CHP, provided traffic control and security in the area of the incident. Although not the primary OA, Contra Costa County provided additional support in the form of boat patrols on Middle River and helicopter reconnaissance flyovers.

2.6 Regional Emergency Operations Center (REOC)

The Governor's Office of Emergency Services State Operations Center (SOC) and the Inland Region (REOC) supported the incident by requesting federal assistance, coordinating State resources and providing assistance to the San Joaquin County Operational Area. OES provided an agency representative to the FOC as well as field support to the ICP, including staff and critical communications equipment.

2.7 Other State Agencies

Numerous State agencies participated in or supported the incident response. A summary of their response roles is given below:

- Caltrans: Assisted the Corps of Engineers in raising the Trapper Slough levee by providing rock for wave wash protection and performing surveys to install vertical controls for the levee raising operation.

- CDF: Provided labor crews to install wave wash protection and provided a Command Team to advise and assist in the organization and startup of DWR's ICT. The Department of Corrections was also involved in the provision and oversight of crews.
- CCC: Provided labor crews to work in the staging area, install wave wash protection and install a sandbag wall on Trapper Slough.
- CHP: Provided traffic control and security in the incident area in cooperation with the San Joaquin County Sheriff's Office. The CHP also assisted in reconnaissance efforts by conducting numerous flyovers of the incident area.
- Department of Boating and Waterways: Provided an air boat and crew for use on the inside of the island, providing a method for flood fight staff and others to assess the status of levees and the installation of wave wash protection.
- Central Valley Regional Water Quality Control Board: Provided regulatory guidance and assistance during recovery efforts, particularly regarding the pump out phase.
- The Department of Fish and Game: Supplied air boats for use inside the island, patrolled the area for illegal fishing activity, and conducted assessments for fish loss.
- California Department of Health Services: Provided support in conducting water quality monitoring.

2.8 Federal Agencies

The Corps, upon request by the State for assistance under Public Law 84-99, issued an emergency contract to raise the elevation of the Trapper Slough Levee. The USBR coordinated with DWR on water releases from upstream reservoirs and restricting export pumping from the southern Delta to protect water quality. The National Weather Service provided monitoring equipment, and localized tide, wind and weather forecasts and warnings. The U.S. Coast Guard was involved due to waterway issues in the Delta and surrounding Jones Tract. The Environmental Protection Agency and the U.S. Geological Survey were involved in water quality issues regarding the water that flooded the island.

Chapter Three – Debrief Process

3.1 Introduction

DWR participated in an informational hearing conducted by the Senate Committee on Agriculture and Water Resources and conducted two debriefing sessions. In addition, a questionnaire was distributed to determine which parts of the system responded successfully to the emergency and which parts of the system can be improved upon for future flood emergencies the State responds to.

The comments received were compiled for this AAR. The results and recommended actions are included in Chapters Four and Chapter Five of this report.

3.2 Legislative Hearing

The Senate Committee on Agriculture and Water Resources held an informational public hearing on August 10, 2004 at the State Capitol regarding the Jones Tract Levee Incident. The purpose of the hearing was to find out what impediments or constraints occurred between federal, State, and local agencies responding to the June 3, 2004 emergency and what steps should be taken now to address these issues before another levee breach happens with more drastic results. Presentations were made by the DWR Director, San Joaquin County, the Corps, OES, and Reclamation Districts 2038 and 2039 representatives.

It was expressed by various individuals that within the existing structure of emergency response and funding options, the emergency response to the Jones Tract Levee breach was effective and accomplished its primary goal of protecting adjoining islands from flooding. Various local, State and federal agencies worked together and provided a very timely and effective response. It was acknowledged that there is no clear policy for closing a breach on non-project levees, repairing damaged non-project levees, and for dewatering flooded islands. Legislation or a policy clarifying the role of State, federal and local agencies in repairing damage to non-project levees would expedite the response in the future.

DWR Director Lester Snow explained that there were no material delays in responding to the emergency situation. The objectives of the response were met. The Trapper Slough levee was raised protecting Highway 4; the inside of the island was protected thereby preventing damage to adjacent islands; the breach was closed; and pumping of the island was underway. These objectives were achieved by the efforts of numerous State, federal and local agencies working as a team, each bringing their particular skills to the event.

The local reclamation district representatives made it very clear that the levee breach repair work, dewatering of the flooded island and repair of the damaged levee was beyond their capacity to fund.

The committee concluded that there are policy issues related to the repair of non-project levees and dewatering of flooded islands that needs to be resolved by either legislation or policy clarification.

3.3 DWR Debriefs

On August 23, 2004, DWR and OES held an After Action Debriefing in Sacramento. All DWR employees who participated in the response were invited to attend this debrief. In addition, several meetings were conducted with key ICP staff involved in the response.

3.4 Local Agency Debrief

Another debriefing session was held on September 1, 2004 in Stockton with local, State, and federal agencies involved in emergency operations. Attending were representatives of DWR, OES, the Corps, Reclamation Districts 2038 and 2039, San Joaquin County OES and Sheriff's Department, Caltrans, CDF, and CCC. A facilitated discussion allowed each group attending to present successes and items to be improved upon.

3.5 Questionnaire

A questionnaire was distributed to all DWR employees who participated in the flood incident. These employees were from multiple divisions, including the Division of Flood Management, Division of Planning and Local assistance, Division of Environmental Services, Division of Engineering, Division of Management Services and Division of Fiscal Services. The questionnaire asked "What went well?" and "What could have been improved?" in eight separate categories. These categories were: staffing and support, communications and information, overall FOC Operations, overall ICP Operations, how could your specific role and functions be improved, relationships and interagency coordination, training and preparedness, and other. A copy of the questionnaire is located in Appendix C of this report.

Chapter Four – Recommendations Table

The principal findings and recommendations of this report are presented in two summary tables. Table 1 presents those items that should be accomplished in advance of the next flood emergency. Table 2 presents those items that should be carried out during the next flood emergency. These measures, if carried out, will enable DWR to respond quickly and effectively during the next flood emergency.

Within each table, recommendations are ranked in order of urgency or importance to accomplish the recommended activity. Table 1 presents actions that must be accomplished in advance of the event, ranked in order of importance (A-1, A-2, A-3, etc.). Table 2 presents those actions that must be taken during the event, ranked in order of priority (E-1, E-2, E-3, etc).

In addition, recommendations are broken into four category types: Policy, Equipment, Staffing and Training. All of the recommendations within a specific category are also numbered.

Table 1: Recommended Pre-Event Flood Emergency Actions

Issue	Category/Sub	Title	Recommended Action	Response
A1	Policy 1	DWR Responsibility for Flood Fight on Non-project Levees	Develop a clear policy and plan specifying DWR's ***flood fight responsibility*** on non-project levees. The policy should provide a funding mechanism for any specified flood response.	L – Exec S – DFM
A2	Policy 2	Repair of Flood Damage from Non-project Levee Failure	Develop a clear policy specifying DWR's authority to ***repair flood damage and assist in the recovery*** of flood damaged areas (including dewatering of flooded areas) from non-project levees. The policy should provide a funding mechanism for any repair and recovery work.	L – Exec S – DFM
A3	Staffing 1	Annual Staff Assignments	Organize 2004-2005 Department-wide, cross-division, flood response teams for both the FOC and Regional ICTs. Annually update DWR flood emergency response assignments for both the FOC and ICT, clearing the assignments with managers and supervisors.	L – EPM S – DFM
A4	Equipment 1	Emergency Voice / Data Telecommunications Plan	Develop and annually review an emergency telecommunications plan. Execute an annual or multi-year services contract to provide rapid, effective telecommunications in remote areas in the event normal telecommunications services are inadequate.	L – DFM, DTS
A5	Training 1	SEMS Specific Duties	Annually conduct SEMS, FOCIS, and section-specific training for flood response teams in the FOC and ICP. The training will be for flood response teams and for DWR managers and personnel likely to have a flood response role. Conclude annual training/briefings with an emergency management exercise.	L – EPM S – Training Office, DFM
A6	Policy 3	Authorize Flood Management Emergency Expenditures	Authorize the Division of Flood Management to expend funds during major flood emergencies for the necessary contracts and equipment required to respond quickly and institute corresponding emergency business practices.	L – DMS S – DFS, Exec, DFM

Issue: Recommended actions in order of priority (A1, A2, A3 etc.)
Category/Sub: The four categories are Policy, Staffing, Equipment and Training. Category items are subcategorized in order of priority (Policy 1, Policy 2, etc.)
Response: Responsible parties listed by L (Lead) and S (Support)

Table 1: Recommended Pre-Event Flood Emergency Actions (continued)

Issue	Category/Sub	Title	Recommended Action	Response
A7	Policy 4	Interagency Agreements	Execute and update as needed interagency agreements with all applicable agencies to enable immediate flood fight response. Annually review existing agreements.	L – Exec S – DFM
A8	Policy 5	Compensation	Institute a method to fairly compensate applicable managers and supervisors who work extended flood (and other disasters) response hours.	L – DMS S – Exec
A9	Equipment 2	Flood Fight Materials	Restock and expand flood fight materials expended during the flood fight. Provide mechanisms to reimburse DFM for stockpiled materials utilized in the flood fight.	L – DFM S – DMS
A10	Policy 6	DWR Business Processes	Establish streamlined or specialized business processes to use in a flood emergency. Streamline normal business processes such as Travel Expense Claims and invoice payment. Train line staff and managers in applicable Divisions in SEMS and emergency response roles and responsibilities.	L – DMS S – DFS, Exec, DFM
A11	Equipment 3	DWR Incident Command Post	Provide an adequately supplied mobile emergency response office(s) to enable rapid setup of an easily recognized DWR ICP. Trailers equipped with computers, office equipment and supplies are needed for an effective initial field response--and if necessary a larger incident command post by DWR.	L – DMS S – DFM
A12	Training 2	Interagency Coordination	Build upon key relationships with CDF, CCC, OES, locals, and other agencies by annually conducting discussions with key personnel.	L – DFM
A13	Policy 7	Mission Tasking by OES	Follow pre-established OES mission tasking procedures unless otherwise directed by the Governor’s Office or designee. Train DWR managers in mission tasking.	L – DFM

Issue: Recommended actions in order of priority (A1, A2, A3 etc.)
Category/Sub: The four categories are Policy, Staffing, Equipment and Training. Category items are subcategorized in order of priority (Policy 1, Policy 2, etc.)
Response: Responsible parties listed by L (Lead) and S (Support)

Table 2: Recommended Actions During Flood Emergencies

Issue	Category/Sub	Title	Recommended Action	Response
E1	Staffing 2	Emergency Staff Assignments	Direct all personnel assignments during an event from the FOC. Assign an individual to deploy staff at both the FOC and ICP.	L – DFM
E2	Staffing 3	SEMS Reports	Each section will designate an individual whose entire function is to keep a real time log of the information flow in their section. This real time log will allow the quick and accurate writing of official SEMS reports in FOCIS. Provide annual FOCIS training.	L – DFM
E3	Staffing 4	Numbers of Staff Assigned	Notify key staff in all affected divisions of any potential event. Provide sufficient numbers of staff early in a major flood event. Continue staffing at sufficient levels to ensure adequate flood emergency response. Conduct an emergency meeting of all DFM staff to notify of major event and review staffing assignments. Distribute Flood Alert and Mobilization Memoranda via email to all DWR staff.	L – DFM
E4	Training 3	Communication Between FOC and ICP	Encourage peer-to-peer communications during events within sections and between section chiefs at the FOC and ICPs. Daily assign a messenger to transport materials from ICP(s) to FOC.	L – DFM
E5	Equipment 4	Workspace Assignments	Provide an assigned workspace in the FOC for Incident Command Personnel.	L – DFM S – DMS
E6	Policy 8	CDF Transition Team	Request CDF assistance to assist in initial setup of an ICP.	L – DFM S – EPM
E7	Staffing 5	Staffing Rotation and Duration	Rotate teams on an eight day sequence, providing a one day overlap between teams.	L – DFM S – Exec
E8	Staffing 6	Public Information Officers (PIO) at the FOC and ICP	Have PIO coverage at both the FOC and ICP at all times. Train and utilize PIOs from various Divisions to allow for adequate coverage without putting undue burden on the PAO.	L – DFM S – PAO
E9	Policy 9	Environmental Issues and Health/Safety	Be proactive and aware of the role/responsibility of DWR with respect to environmental/health/safety issues such as water quality and toxics. Be aware of other responding agencies roles and verify that necessary actions are being performed regardless of responsibility.	L – DFM S – DES

Issue: Recommended actions in order of priority (A1, A2, A3 etc.)
Category/Sub: The four categories are Policy, Staffing, Equipment and Training. Category items are subcategorized in order of priority (Policy 1, Policy 2, etc.)
Response: Responsible parties listed by L (Lead) and S (Support)

Chapter Five – Issues and Recommendations

Issues and recommendations resulting from the debriefing process are presented on the following sheets. The issues are numbered in the following way:

Items to be accomplished in advance of the next flood emergency, numbered in order of priority (A1, A2, A3, etc.)

Items to be accomplished during flood emergencies, numbered in order of priority (Equipment 1, Equipment 2, Equipment 3, etc.)

Items are presented according to category. The four categories are policy, equipment, staffing, and training. Within each category, items are ranked. For example, policy items are numbered Policy 1, Policy 2, Policy 3, etc.

Responsible parties are listed, showing those parties that have lead responsibility for completing the task, and those that are a party to the tasks' completion.

The discussion presents the major comments received according to the issue and the resulting recommendations.

ISSUE NUMBER: A1

ISSUE TITLE: DWR Responsibility for Flood Fight on Non-project Levees

Category: Policy 1

Discussion: A clear policy specifying DWR's flood fight authority on non-project levees is needed. A State plan and policies are needed for responding to non-federal levee failures in the Delta and for allocating responsibilities. Lack of such a plan and policies affected decision-making during the initial flood fight.

Recommendations: Develop a clear policy and plan specifying DWR's flood fight responsibility on non-project levees. The policy should provide a funding mechanism for any specified flood response.

Responsible Parties: Lead: DWR Executive
Support: DFM

ISSUE NUMBER: A2

ISSUE TITLE: Repair of Flood Damage from Non-project Levee Failure

Category: Policy 2

Discussion: A clear policy specifying DWR's authority to repair flood damage (including dewatering of flooded areas) from non-project levees is needed.

Recommendations: Develop a clear policy specifying DWR's authority to repair flood damage and assist in the recovery of flood damaged areas (including dewatering of flooded areas) from non-project levees. The policy should provide a funding mechanism for any repair.

Responsible Parties: **Lead:** DWR Executive
Support: DFM

ISSUE NUMBER: A3

ISSUE TITLE: Annual Staff Assignments

Category: Staffing 1

Discussion: The FOC and the ICP scrambled to locate personnel to assign to the event and needed to obtain approval from sometimes reluctant supervisors leading to confusion, understaffing, and competition for individuals.

Recommendations: Organize 2004-2005 flood response teams for both the FOC and ICP. Annually update DWR flood emergency response assignments for both the FOC and ICT, clearing the assignments with managers and supervisors.

Responsible Parties: **Lead:** Emergency Preparedness Manager
Support: DFM

ISSUE NUMBER: A4

ISSUE TITLE: Emergency Voice / Data Telecommunications Plan

Category: Equipment 1

Discussion: Poor cellular phone coverage and lack of computer/Internet access led to confusing and inefficient communications, and prevented the ICP from receiving or sending electronic documents. Of prime concern was the inability to communicate from the field by phone and to submit and read FOCIS reports from the ICP due to limited Internet access.

Recommendations: Develop and annually review an emergency telecommunications plan. Execute an annual or multi-year services contract to provide rapid, effective telecommunications in remote areas in the event normal telecommunications services are inadequate.

Responsible Parties: Lead: DFM, DTS

ISSUE NUMBER: A5

ISSUE TITLE: SEMS Specific Duties

Category: Training 1

Discussion: Personnel who either played a key role in flood response or were assigned to the ICP and the FOC were not trained in their SEMS specific duty leading to lack of communication.

Recommendations: Annually conduct SEMS, FOCIS, and section-specific training for flood response teams in the FOC and ICP. The training will be for flood response teams and for DWR managers and personnel likely to have a flood response role.

Responsible Parties: **Lead:** Emergency Preparedness Manager
Support: Training Office, DFM

ISSUE NUMBER: A6

ISSUE TITLE: Authorize Flood Management Emergency Expenditures

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Category: Policy 3

Discussion: Water Code Section 128 provides authority for DWR to carry out an emergency response, but there is no funding absent a Governor's decision. DWR did not have access to emergency funds to immediately cover the expenses of the response to the Jones Tract Flood Incident. This created uncertainty and complications in securing necessary contracts and assurance that costs incurred would be adequately covered. Without access to emergency funds in the future, DWR could face critical delays in executing an effective disaster response.

Recommendations: Authorize the Division of Flood Management to expend funds during major flood emergencies for the necessary contracts and equipment required to respond quickly. Work to establish an emergency funding mechanism with appropriate controls, possibly similar to the emergency fund utilized by CDF.

Responsible Parties: Lead: DMS
Support: DFS, DWR Executive, DFM

ISSUE NUMBER: A7

ISSUE TITLE: Interagency Agreements

Category: Policy 4

Discussion: Interagency agreement allowing immediate response needs to be formalized. Agreements with applicable agencies would have avoided a potential delay to the flood fight while contracts were being executed. Examples of agencies are: CDF, CCC, Boating and Waterways, and Caltrans.

Recommendations: During the 2004-2005 water year, execute interagency agreements with all applicable agencies to enable immediate flood fight response.

Responsible Parties: Lead: DWR Executive
Support: DFM

ISSUE NUMBER: A8

ISSUE TITLE: Compensation

Category: Policy 5

Discussion: Senior Engineers, Supervising Engineers and other applicable managers and supervisors who worked extensive hours (up to fourteen hours per day) for days or weeks at a time were not compensated for their effort. Rank-and-file staff is compensated at a rate of time and one half for their extraordinary effort, leading to a disparity between the supervisory/management classifications and support staff.

Recommendations: Institute a method to fairly compensate Senior Engineers, Supervising Engineers and other applicable managers and supervisors who work extended flood response hours.

Responsible Parties: Lead: DMS
Support: DWR Executive

ISSUE NUMBER: A9

ISSUE TITLE: Flood Fight Materials

Category: Equipment 2

Discussion: Pre-positioned flood materials were expended during the Jones Tract flood fight, leaving exposure for a future flood.

Recommendations: Restock and expand flood fight materials expended during the flood fight. Provide mechanisms to reimburse DFM for stockpiled materials utilized in the flood fight.

Responsible Parties: Lead: DFM
Support: DMS

ISSUE NUMBER: A10

ISSUE TITLE: DWR Business Processes

Category: Policy 6

Discussion: Business processes set up for the normal course of work were cumbersome and in some cases slowed down or hindered flood response.

Recommendations: Institute streamlined or specialized business processes to use in a flood emergency. Authorize the Division of Flood Management to expend funds during major flood emergencies for the necessary contracts and equipment required to respond quickly. Streamline normal business processes such as Travel Expense Claims, purchasing, contracting and bill payment. Train personnel in applicable Divisions in SEMS and emergency response.

Responsible Parties: **Lead:** DMS
Support: DFS, DWR Executive, DFM

ISSUE NUMBER: A11

ISSUE TITLE: DWR Incident Command Post

Category: Equipment 3

Discussion: It was difficult to physically locate DWR's ICP during the first days of the event. This difficulty added to the confusion onsite. The ICP lacked basic communication equipment such as facsimiles, copy machines and telephones.

Recommendations: Provide an adequately supplied mobile emergency response office to enable rapid setup of an easily recognized DWR ICP. Trailers equipped with computers, office equipment, and supplies and assigned locations for each SEMS section are needed for an effective initial field response by DWR.

Responsible Parties: **Lead:** DMS
Support: DFM

ISSUE NUMBER: A12

ISSUE TITLE: Interagency Coordination

Category: Training 2

Discussion: Lack of understanding of other agencies mission and roles led to inefficiencies.

Recommendations: Expand existing relationships with CDF, CCC, OES, and other agencies at the key staff level by annually conducting preseason startup meetings. Train DWR staff and management to understand these relationships.

Responsible Parties: Lead: DFM

ISSUE NUMBER: A13

ISSUE TITLE: Mission Tasking by OES

Category: Policy 7

Discussion: A change in mission tasking procedures was implemented with little notice during the event. This led to confusion and uncertainty about the process amongst staff and managers.

Recommendations: Follow pre-established OES mission tasking unless otherwise directed by the Governor's Office or designee. Train DWR staff and managers in mission tasking procedures.

Responsible Parties: Lead: DFM

ISSUE NUMBER: E1

ISSUE TITLE: Emergency Staff Assignments

Category: Staffing 2

Discussion: Staff assignments were confusing. Recruiting and retaining staff was unpredictable.

Recommendations: Direct all personnel assignments during an event from the FOC. Assign a specific position to execute staff assignments.

Responsible Parties: Lead: DFM

ISSUE NUMBER: E2

ISSUE TITLE: SEMS Reports

Category: Staffing 3

Discussion: Rapid pace, quick decisions, and volumes of information resulted in late or sketchy transmission of reports.

Recommendations: Each section will designate an individual whose entire function is to keep a real time log of the information flow in their section. This real time log will allow the quick and accurate writing of official SEMS reports in FOCIS. Annually train staff at all levels in the use of FOCIS. Applies to ICP(s) and FOC.

Responsible Parties: Lead: DFM

ISSUE NUMBER: E3

ISSUE TITLE: Numbers of Staff Assigned

Category: Staffing 4

Discussion: Inadequate numbers of pre-trained staff at the onset of the event led to confusion and some inefficiency.

Recommendations: Notify key staff in all affected divisions of any potential event. Provide sufficient numbers of staff early in a major flood event. Continue staffing at sufficient levels to insure adequate and consistent flood emergency response. Conduct an emergency meeting of all DFM staff to notify of major event and review staffing assignments. Distribute Flood Alert and Mobilization Memoranda via email to all DWR staff and post on Aquanet.

Responsible Parties: Lead: DFM

ISSUE NUMBER: E4

ISSUE TITLE: Communication Between FOC and ICP

Category: Training 3

Discussion: Lack of communication between the ICP and the FOC sections over policy, equipment, and personnel onsite led to confusion.

Recommendations: Institute periodic conversations during the event between section chiefs at the FOC and the ICP. Daily assign a messenger to transport materials between the ICP and the FOC

Responsible Parties: Lead: DFM

ISSUE NUMBER: E5

ISSUE TITLE: Workspace Assignments

Category: Equipment 4

Discussion: ICP personnel needed designated desk space in order to accomplish assigned tasks.

Recommendations: Provide assigned workspace for ICP personnel. This role will be carried out by the Logistics Section.

Responsible Parties: **Lead:** DFM
Support: DMS

ISSUE NUMBER: E6

ISSUE TITLE: CDF Transition Team

Category: Policy 8

Discussion: Although the goals and objectives of the disaster response were skillfully achieved, there was some level of confusion and delay in the establishment of a fully functional ICP. Given the extended length of time between flood events, DWR does not act as a first responder or maintain primary responsibility in disasters on a regular basis. With extensive experience and expertise in the SEMS/Incident Command System, CDF has offered its services to activate specialized strike teams to establish ICPs at the beginning of an event and to assist DWR with ongoing ICP operations as necessary. This will ensure immediate and efficient disaster response. CDF would remain at the ICP until such a time when DWR could effectively assume control, and possibly remain for an extended period in a support/mentoring role.

Recommendations: Request CDF assistance to assist in initial setup of an ICP.

Responsible Parties: **Lead:** DFM
Support: Emergency Preparedness Manager

ISSUE NUMBER: E7

ISSUE TITLE: Staffing Duration and Rotation

Category: Staffing 5

Discussion: Given the staffing difficulties experienced in the Jones Tract event, staff at the ICP and FOC were sometimes working for extended periods of time with little relief. Although it is important to keep experienced and knowledgeable individuals onsite, this can create situations of burnout. By having teams set up with the ability to rotate regularly, DWR would be able to ensure that there is capable, experienced staff on-hand and could provide much needed relief for everyone involved.

Recommendations: Rotate teams on an eight-day sequence, providing a one-day overlap for team transition and turnover.

Responsible Parties: Lead: DFM
Support: DWR Executive

ISSUE NUMBER: E8

ISSUE TITLE: Public information Officers (PIO) at the FOC and ICP

Category: Staffing 6

Discussion: During the early stages of the event there was a great need for PIO coverage at both the FOC and ICP. The number of PIO staff available was not sufficient to satisfy the demands for information and media attention. Although every attempt was made to accommodate the media at the flood site, it was largely a reactionary approach.

Recommendations: Have PIO coverage at both the FOC and ICP at all times. In many cases the Office of Public Affairs serves as the first point of contact with the news media and public so it is necessary to involve them immediately. Train and utilize PIOs from various divisions to allow for adequate coverage without putting undue burden on the Public Affairs Office. Consider taking a proactive approach with the media by anticipating their needs and planning accordingly so the PIOs do not have to continually react to media demands (create a predetermined media area, pre-establish time and place for daily media briefings, identify public/private property ahead of time to prevent issues with landowners, prepare a daily written update to provide to the media, prepare and update maps, etc.). Use the Internet to post updates directly to DWR’s Aquanet website.

Responsible Parties: **Lead:** DFM
Support: Public Affairs Office

ISSUE NUMBER: E9

ISSUE TITLE: Environmental Issues and Health/Safety

Category: Policy 9

Discussion: DWR encountered numerous environmental and regulatory issues during the course of the event (health and safety of staff working in and around floodwaters, water quality related to pump out, contaminants in the fill used to raise Trapper Slough, etc.). Given the number of initial responding agencies, there was some confusion regarding what actions were actually being taken and who was ultimately responsible for handling some of these issues.

Recommendations: Be proactive and aware of the role/responsibility of DWR with respect to environmental/health/safety issues such as water quality and toxics. Increase communications and be aware of other responding agencies roles to verify that necessary actions are being performed regardless of responsibility. Involve the Division of Environmental Services (DES) as necessary from the beginning of any event to ensure that environmental and regulatory issues are appropriately identified and addressed. The Safety Officer should be directly involved in communications with other agencies and DES to ensure procedures are followed. All pertinent information should be compiled and reported to the ICP and FOC for inclusion into status reports.

Responsible Parties: **Lead:** DFM
Support: DES

APPENDICES

Appendix A

Declarations—State and Federal Along with Flood Mobilization Memorandum

State of California

The Resources Agency

Memorandum

Date: June 4, 2004

To: Division/District Chiefs

From: **Department of Water Resources**

Subject: Flood Mobilization

Current flood conditions, forecasted high tides and winds on the Upper and Lower Jones Tract in San Joaquin County necessitate the mobilization of the Department to prepare river forecasts, manage flood-related information, provide technical assistance and fight floods on a time basis of up to 24 hours per day, as needed. In accordance with established procedures, as set forth in the Flood Emergency Operations Manual, I declare the Department to be under an emergency and mobilized as of June 4, 2004.

Personnel requested by the State-federal Flood Operations Center shall be available for duty in the Center or in the field as called upon, and are temporarily relieved of other duties until dismissed by the Flood Operations Center Director.

The Chief of the Division of Fiscal Services shall take steps to obtain the necessary funds for materials, emergency equipment, and for salaries of personnel who have been working and are continuing to work on flood operations.

Lester A. Snow
Director

cc: (See attached list.)

DWR 9045 (Rev. 4/02)

EXECUTIVE DEPARTMENT

STATE OF CALIFORNIA

PROCLAMATION
by the
Governor of the State of California

I, ARNOLD SCHWARZENEGGER, Governor of the State of California, find that conditions of extreme peril to the safety of persons and property exist within the County of San Joaquin, State of California, as a result of a levee break that occurred on June 3, 2004, and ongoing flooding. Upon the request of the Director of Emergency Services for the County of San Joaquin who has declared a local disaster, and because the magnitude of this disaster exceeds the capabilities of the services, personnel, and facilities of the county, I find the County of San Joaquin to be in a state of emergency, and under the authority of the California Emergency Services Act, set forth at Title 2, Division 1, Chapter 7 of the California Government Code, commencing with section 8550, I hereby proclaim that a State of Emergency exists within San Joaquin County.

Pursuant to this proclamation, I hereby direct all agencies of the state government, as necessary, to utilize and employ state personnel, equipment and facilities for the performance of any and all activities to alleviate this emergency including repairs to transportation facilities caused by flood damage and/or repair activities and, furthermore, direct the implementation of state disaster assistance programs in accordance with state law. Furthermore, I specifically authorize the State Director of Emergency Services to take all necessary action authorized by the Emergency Services Act (Government Code section 8550, et seq.) to alleviate this emergency.

I FURTHER DIRECT that as soon as hereafter possible, this proclamation be filed in the Office of the Secretary of State and that widespread publicity and notice be given to this proclamation.

IN WITNESS WHEREOF I have here unto set my hand and caused the Great Seal of the State of California to be affixed this the fourth day of June 2004.

/s/ Arnold Schwarzenegger

Governor of California

* * *

Federal Register Notice

Billing Code 9110-10-P

DEPARTMENT OF HOMELAND SECURITY

Federal Emergency Management Agency

[FEMA-1529-DR]

California; Major Disaster and Related Determinations

AGENCY: Federal Emergency Management Agency, Emergency Preparedness and Response Directorate, Department of Homeland Security.

ACTION: Notice.

SUMMARY: This is a notice of the Presidential declaration of a major disaster for the State of California (FEMA-1529-DR), dated June 30, 2004, and related determinations.

EFFECTIVE DATE: June 30, 2004.

FOR FURTHER INFORMATION CONTACT: Magda Ruiz, Recovery Division, Federal Emergency Management Agency, Washington,
DC 20472, (202) 646-2705.

SUPPLEMENTARY INFORMATION: Notice is hereby given that, in a letter dated June 30, 2004, the President declared a major disaster under the authority of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C. §§ 5121-5206 (the Stafford Act), as follows:

I have determined that the damage in certain areas of the State of California, resulting from flooding as a result of a levee break on June 3, 2004, and continuing, is of sufficient severity and magnitude to warrant a major disaster declaration under the Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C. §§ 5121-5206 (the Stafford Act). I, therefore, declare that such a major disaster exists in the State of California.

In order to provide Federal assistance, you are hereby authorized to allocate from funds available for these purposes, such amounts as you find necessary for Federal disaster assistance and administrative expenses.

You are authorized to provide Public Assistance and Hazard Mitigation in the designated areas and any other forms of assistance under the Stafford Act you may deem appropriate. Consistent with the requirement that Federal assistance be supplemental, any Federal funds provided under the Stafford Act for Public Assistance and Hazard Mitigation will be limited to 75 percent of the total eligible costs. If Other Needs Assistance under Section 408 of the Stafford Act is later requested and warranted, Federal funding under that program will also be limited to 75 percent of the total eligible costs.

Further, you are authorized to make changes to this declaration to the extent allowable under the Stafford Act.

The Federal Emergency Management Agency (FEMA) hereby gives notice that pursuant to the authority vested in the Under Secretary for Emergency Preparedness and Response, Department of Homeland Security, under Executive Order 12148, as amended, William L. Carwile, III, of FEMA is appointed to act as the Federal Coordinating Officer for this declared disaster.
I do hereby determine the following area of the State of California to have been affected adversely by this declared major disaster:

San Joaquin County for Public Assistance.

San Joaquin County within the State of California is eligible to apply for assistance under the Hazard Mitigation Grant Program.

(The following Catalog of Federal Domestic Assistance Numbers (CFDA) are to be used for reporting and drawing funds: 97.030, Community Disaster Loans; 97.031, Cora Brown Fund Program; 97.032, Crisis Counseling; 97.033, Disaster Legal Services Program; 97.034, Disaster Unemployment Assistance (DUA); 97.046, Fire Management Assistance; 97.048, Individual and Household Housing; 97.049, Individual and Household Disaster Housing Operations; 97.050 Individual and Household Program-Other Needs, 97.036, Public Assistance Grants; 97.039, Hazard Mitigation Grant Program.)

/s/

Michael D. Brown,
Under Secretary,
Emergency Preparedness and Response,
Department of Homeland Security.

Appendix B

Chronological Summary of Jones Tract Levee Failure Events

Chronological Summary of Jones Tract Levee Failure Events

Thursday, June 3, 2004

8:00 AM Levee breach occurs on the right (east) bank of the Middle River near Bacon Island Road.

9:00 AM FOC notified of break by OES. DWR flood fight specialist and inspectors immediately dispatched to site. FOC activated 24-hrs. FOC staff implemented the "Delta Levee Failure Incident" response and began coordinating with federal, State and local entities to gather and disseminate pertinent information.

AM Upper Jones Tract (Reclamation District 2039) floods (6,200 acres).

AM DWR and Corps inspectors arrive on site to determine scope and provide technical assistance.

AM Railroad and Reclamation District (RD) engineers are also onsite. Discussions begin regarding the viability of closing the opening in the railroad trestle between Upper Jones Tract and Lower Jones Tract.

AM Trapper Slough Levee determined to be at risk of overtopping, posing a threat to State Highway 4 and Roberts Island to the south.

AM Unified Command Post established onsite by San Joaquin County. DWR part of command structure.

10:00 AM DWR reduced and eventually ceased State Water Project exports south of Delta to minimize saltwater intrusion.

11:15 AM Verbal assurance provided by DWR to RD 2039 that assistance under AB 360 for flood fight activities would be pursued.

11:30 AM USBR Central Valley Project reduces exports to minimal levels and opens Delta Cross Channel gate.

1:00 PM DWR interagency conference call (including DWR, RD representatives, OES, Caltrans, Corps, and San Joaquin County): Results in proposal to (1) build dam at railroad trestle to prevent Lower Jones flooding; (2) close breach; (3) protect Hwy. 4; and (4) interior levee erosion protection.

PM Dutra Construction has been contracted by the RD to armor the ends of the breach to reduce further erosion.

PM Railroad still has not granted access.

3:30 PM Conference call: Results in firmed up plan, indication that the railroad has decided not to allow the blocking of the trestle opening, local contracts prepared to bring in rock, and up to 21 miles of plastic could be needed for wave protection. DWR prepares package for Governor's briefing. DWR responding to RD 2039 request for up to $50,000 in AB 360 subvention funds. RD 2039 president estimates rock to repair the breach and flood fight activities will start arriving by 17:00.

PM Lower Jones Tract (Reclamation District 2038) begins flooding as water passes under railroad trestle (5,800 acres).

7:00 PM Conference call: The railroad confirms that it will not allow the trestle to be closed. Locals and Caltrans will work through night to raise Trapper Slough Levee. DWR arranges to deliver heavy equipment and operators Friday morning. Dutra Construction will have to wait until the water stabilizes and flow through the breach significantly reduces prior to being able to start breach repair.

7:00 PM Reclamation District 2039 faxes letter to DWR requesting State and federal assistance. DWR verbally notifies Corps that an official request for PL84-99 assistance is being prepared.

9:00 PM DWR receives supplemental fax from RD clarifying help requested and Land, Easement, and Right of Way Agreement

11:20 PM DWR officially requests Corps PL 84-99 flood fight assistance for the Trapper Slough levee raising and erosion protection, and for emergency repairs to close the levee breach.

Friday, June 4, 2004

9:00 AM Corps approves the Trapper Slough levee raising and signs PL 84-99 agreement with DWR for emergency assistance to raise the Trapper Slough levee (Caltrans has agreed to rock the levee crown).

9:00 AM Corps denies request for emergency repairs to close the levee breach as not being under emergency operations authority (i.e.: flood has already occurred and the Trapper Slough levee raising will stabilize area).

PM DWR executes assurance and work agreements (through AB 360 Delta Levee Subventions Program) with RD 2039 and the Corps for the Trapper Slough levee raising to protect public benefits in the Delta.

2:30 PM DWR holds major media press conference at the FOC.

PM Governor proclaims State of Emergency directing all agencies of State government, as necessary, to utilize and employ State personnel, equipment and facilities for the performance of any and all activities to alleviate this emergency. Governor directs OES to ensure that all necessary State resources are brought to bear in both the response to and recovery from this emergency.

PM DWR executes contract to provide the Trapper Slough levee borrow material to the Corps.

PM DWR delivers flood fight materials to site.

PM DWR Director declares a “Flood Mobilization” to provide ongoing FOC activation and to fund emergency operations.

PM DWR prepares Governors Action Request to request Corps’ Advance Measures assistance to fill Middle River breach.

PM Corps’ efforts to raise the Trapper Slough levee by the placement of dirt fill starts.

Saturday, June 5, 2004

7:00 AM Corps making good progress on raising the Trapper Slough levee since 6:00 p.m.

yesterday. Through DWR funding, RD 2038 and RD2039 contracted with Dutra to cap the levee breach.

AM FOC staff made phone contacts with surrounding RDs on levee status.

AM OES notifies DWR about availability of California Disaster Assistance Act for breach closure and flood fighting.

10:00 AM The Governor and DWR Director visit break site. Decision made to use OES California Disaster Assistance Funds to close the breach. Water is continuing to equalize across the breach.

10:30 AM DWR becomes part of Unified Command

AM DWR is notified that the Corps will raise Trapper Slough Levee one foot higher than originally planned and that another 15,000 cubic yards of earth fill are needed. DWR secured approval from the Port of Stockton shortly thereafter for the necessary earth fill.

11:30 AM Director and staff meet with Bill Dutra, CEO – Dutra Corporation, on site and enter into verbal contract to repair breach.

12:00 PM FOC is notified to start contracting process with Dutra Construction for levee closure. It was later determined that DOE would process the contract.

4:00 PM DWR Contracts Office and Dutra are contacted to initiate agreement. DWR construction inspectors from Division of Engineering are sent to inspect work that may begin as early as 7:00 p.m.

2:00 PM DWR staff at the site meets with Dutra to negotiate contract scope of work and unit costs.

5:00 PM In a conference call with the Corps, Caltrans, and DWR, it was agreed that the Corps should complete the additional 1-foot raise at the Trapper Slough levee due to high tide concerns expected in the morning.

7:00 PM FOC and OES conference call regarding mission task for incident. OES to create three mission tasks: 1) general flood fight, 2) repair levee breach, and 3) Trapper Slough Levee flood fight.

7:30 PM Dutra begins repairing the breach under the negotiated agreement with DWR.

Night As a precautionary measure, FOC and DWR field staff develops a levee visquine action plan for Upper Jones Tract and Lower Jones Tract.

<u>Sunday, June 6, 2004</u>

6:00 AM DWR establishes its own ICP to be co-located with the Unified Command Post.

AM Mission Task orders approved by OES.

AM Water levels in Upper Jones Tract and Lower Jones Tract have equalized.

Monday, June 7, 2004

PM Raising of the Trapper Slough levee with dirt fill is nearly completed. Caltrans is still in the process of armoring dirt fill with the placement of rock.

RD 2038 sends formal request for immediate DWR flood fight assistance to place rock and rip rap on Lower Jones Tracts' remaining interior levee slopes. RD 2039 sends a copy of AB 360 work agreement for RD 2039 emergency levee work for signature by DWR.

Tuesday, June 8, 2004

RD 2038 and 2039 formally request that DWR undertake the administration, contracting and payment to dewater Upper Jones Tract and Lower Jones Tract. The request states that each RD will contribute $400,000 to the dewatering efforts.

DWR ICP is fully operational and the San Joaquin County Unified Command Post is demobilized (sheriff and CHP remain onsite in support of ICP).

Corps' raising/fortification of the Trapper Slough levee is complete and its Emergency Operations Center is to be deactivated.

Wednesday, June 9, 2004

DWR Director sends formal PL 84-99 request to the Corps regarding the need for technical and direct assistance in repairing the breach and to pump inundated lands.

Friday, June 11, 2004

DWR Director acknowledges Corps assistance in raising the Trapper Slough levee and sends another formal PL 84-99 request to reaffirm need for further technical and direct assistance in repairing the breach.

Friday, June 18, 2004

Governor Schwarzenegger asks President George W. Bush to issue a major disaster declaration in San Joaquin County to make funds available to: (1) cover emergency response costs; (2) fund efforts to remove debris that threatens lives; (3) restore damaged infrastructure; (4) fund hazard mitigation programs; and (5) provide additional federal funding that may be appropriate.

Thursday, June 24, 2004

DWR opened contract bids to dewater Upper Jones Tract and Lower Jones Tract.

Monday, June 28, 2004

DWR awarded a contract to Ford Construction Company, Inc., of Lodi to dewater Upper Jones Tract and Lower Jones Tract after breach closure.

Wednesday, June 30, 2004

Middle River levee breach at Upper Jones Tract closed this morning well ahead of schedule. A "plug" was constructed in the closure to aid dewatering by allowing flow out of Jones Tract during low tidal cycles.

President George W. Bush declared a major disaster for the State of California under the Robert T. Stafford Disaster Relief and Emergency Assistance Act.

Monday, July 12, 2004

Manual dewatering began as pumping Units #1-4 (42-inch) were gradually brought online at approximately 50,000+ GPM each. Up to 10 total pumping units are expected to be gradually brought online.

Monday July 26, 2004

All 10 pumps, eight 42 inch and two 30 inch, were brought online. Pumping is at the rate of about 350,000 gallons per minute.

Summary of Pumpout

DATE	Estimated Total Drawdown (inches)	Estimated Total Volume Pumped (acre-ft)
8-1-04	2.34	27,819
8-14-04	4.11	49,395
9-1-04	6.36	63,161
9-10-04	7.47	74,211
10-14-04	10.36	103,161
10-25-04	11.12	110, 711
11-1-04	11.90	
11-15-04	13.97	
12-1-04	17.29	
12-14-04	18.66	140,000

Appendix C

Debriefing Questionnaire

2004 Jones Tract Levee Break After-Action Evaluation

Please complete this form return it via Email, inter-office mail, or FAX to the Flood Operations Center. Type directly onto this form, or print out. Use additional space, the back of the form or multiple sheets if necessary. Please call (916) 574-2619 if you have any questions.

DWR, Division of Flood Management
Flood Operations Center, Suite 200
P.O. Box 219000, 3310 El Camino Ave.
Sacramento, CA 95821

VOICE :(916) 574-2619
FAX: (916) 574-2798
Email: twegener@water.ca.gov

Name:
Job Title and Division:
Assigned Section (Management, P/I, Logistics, Finance, Operations):
Assigned Position/Role (Documentation, Flood Information Specialist, Plans Unit, etc):
Dates Assigned to Flood Incident:
Description of Emergency Duties:
EVALUATION—AREAS/SUBJECTS THAT WORKED WELL Please describe specific Areas/Subjects that worked well in each of the categories below:
Staffing and Support:
Communication and Information:
Overall FOC Operations:
Overall ICP Operations:
What went well with your Specific Role and Function:
Relationships and Inter-Agency Coordination:
Training and Preparedness:
Other:

2004 Jones Tract Levee Break After-Action Evaluation (Continued)

EVALUATION—AREAS/SUBJECTS THAT NEED IMPROVEMENT Please describe specific Areas/Subjects that need improvement in each of the categories below:
Staffing and Support:
Communication and Information:
Overall FOC Operations:
Overall ICP Operations:
How could your Specific Role and Function be improved:
Relationships and inter-Agency Coordination:
Training and Preparedness:
Other:

ADDITIONAL COMMENTS: Use the space below to provide additional comments and/or suggestions

Appendix D

Division/Office Response Detail

Division/Office Response Detail

Division/Office	Activities	Personnel	Equipment
Bay-Delta Office	Provided support to DWR Executive and staff to the ICT.	Approximately 23 staff for Headquarters and the ICT	Light vehicles and equipment for ICP; flood fight materials from SB 360 stockpile
DFM – Flood Operations Branch	Provided staff and management for the FOC; provided staff for the ICT.	Approximately 60 staff for the FOC and the ICP	A variety of light vehicles and heavy equipment for the ICP as well as equipment for the ICP trailers; flood fight materials from pre-positioned supplies (non-SB 360)
DFM – Hydrology Branch	Provided river, tide and weather forecasting to the FOC and ICT		
DFM – Floodplain Management Branch	Provided staff to the FOC and ICT		
DFM – Maintenance Branch	Provided staff to the ICT Operations Section		
DFM – Other	Supported the FOC and ICT		
DPLA – San Joaquin District	Provided staff for the ICT; provided staff and equipment to assist in water quality monitoring during pump out phase	7 staff for ICT and additional staff for pump-out water quality monitoring	Various light vehicles for the ICP and a boat, trailer, vehicle and water quality sampling and monitoring equipment.
DPLA-Central District	Provided staff for the ICT; provided staff and equipment to assist in water quality monitoring during pump out phase	2 staff for ICT and additional staff for pump-out water quality monitoring.	Various light vehicles for the ICP and a boat, trailer, vehicle and water quality sampling and monitoring equipment

Division/Office Response Detail

Division/Office	Activities	Personnel	Equipment
O&M-Delta Field Division & Delta MEO shop	Provided various staff and equipment to the ICT Operations and Logistics Sections; provided mobile equipment support to the ICT.		
DOE	Prepared, awarded and managed construction contracts to support incident response; provided staff to inspect and administer contracts to ICT; provided staff for ICT Operations as Strike Team Leader; conducted field survey work. San Joaquin Field Division provided support for emergency power generation at ICP.	11 staff for ICT to direct contracts plus additional staff in HQ to prepare, advertise, and administer contracts. One staff member used as ICT Operations Section Strike Team, Leader. Staff from geodetic Branch conducted field survey work. Electrical staff from San Joaquin Field Division was used to transport and support the emergency power generator.	Light vehicles and equipment for ICP; ICP facilities and support via contracts. Portable emergency generator used for onsite power at the ICP.
Division of Fiscal Services	Provided staff for ICT Finance/Admin Section and supported financial functions.	1 staff member of ICT’s Finance/Admin Section and various staff in HQ.	
Division of Safety of Dams	Provided staff for the ICT	1 person to P/I Section as technical specialist	Light vehicle

Division/Office Response Detail

Division/Office	Activities	Personnel	Equipment
Division of Management Services	Provided staff to ICT Logistics Section and supported logistical functions.	3 staff to support ICT in field or HQ	
Public Affairs Office (formerly Office of Water Education)	Provided staff for PIO function at ICT and FOC	2 staff to support ICT and HQ	
Division of Environmental Services	Supported collection of water quality data and regulatory issues, including public health, dewatering and the Trapper Slough levee fill concerns	4 staff to support the incident in HQ and the field	
The Reclamation Board	Provided management support to FOC	2 staff to support FOC	
Division of Technology Services	Provided communications and network support to incident	1 staff member to support incident	

Glossary

AAR – After Action Report
BDO – Bay-Delta Office
BNSF – Burlington Northern – Santa Fe Railroad
Caltrans – California Department of Transportation
CCC – California Conservation Corps
CDF – California Department of Forestry & Fire Protection
CHP – California Highway Patrol
Corps – U.S. Army Corps of Engineers
DFM – Division of Flood Management
DOE – Division of Engineering
DPLA – Division of Planning & Local Assistance
DWR – Department of Water Resources
EBMUD – East Bay Municipal Utility District
EPM – Emergency Preparedness Manager
F/A – Finance / Administration Section
FEMA – Federal Emergency Management Agency
FOC – Flood Operations Center
FOCIS – Flood Operations Center Information System
ICP – Incident Command Post
ICT – Incident Command Team
O&M – Division of Operations & Maintenance
OA – Operational Area
OES – Office of Emergency Services
PAO – Public Affairs Office
P/I – Planning / Intelligence Section
PIO – Public Information Officer
RD – Reclamation District
REOC – Regional Emergency Operations Center
SEMS – Standard Emergency Management System
SOC – State Operations Center
USBR – U.S. Bureau of Reclamation

Governor's Office of Emergency Services

UPPER JONES TRACT FLOOD

AFTER ACTION REPORT

July 15, 2005

Arnold Schwarzenegger
Governor

Henry R. Renteria
Director
Governor's Office of Emergency Services

DRAFT 8/25/06

UPPER JONES TRACT FLOOD 2004

After Action Report

July 15, 2005

Prepared by the OES Preparedness Branch
Branch Manager: Phyllis Cauley
Planning Section Manager: Sharron Leaon
Emergency Management Systems Unit Manager: Scott Davis
Project Lead: Judy Miller
Project Co-Lead: Deborah Vanderzanden
Project Research/Support: Glenn Cadman

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UPPER JONES FLOOD 2004
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EXECUTIVE SUMMARY

INTRODUCTION

In California, as part of the Standardized Emergency Management System (SEMS), statute requires the Governor's Office of Emergency Services (OES) to produce an After Action Report (AAR) within 120 days after the close of the incident period for each declared disaster. "This report shall review public safety response and disaster recovery activities." The supporting SEMS regulations require jurisdictions "declaring a local emergency for which the governor proclaims a state of emergency, and any state agency responding to that emergency" to complete and transmit an AAR to OES within ninety (90) days of the close of the incident period. The close of the incident period for the Upper Jones Flood 2004 was July 12, 2004. The purpose of this reporting requirement is to document response efforts, lessons learned, and any recommendations before critical data is lost due to the passage of time.

BACKGROUND

On June 3, 2004, a section of levee in the San Joaquin Delta failed, threatening the integrity of the delta levee system, the California State Water Project, Central Valley Project, public infrastructure and private property. The initial break occurred around 0800 hours on the Upper Jones Tract at Bacon Island Road, a sparsely populated agricultural land-use island located west of Stockton and north of Highway 4. San Joaquin County was notified of the levee failure at 0830 hours.

By the end of the first day, both the Upper and Lower Jones Tracts were flooded requiring the evacuation of both Tracts. Due to continual erosion caused by wind and wave action, the break in the levee expanded to almost 500 feet long. The levee also developed a 50-foot scour (a hole caused by water digging out the ground) at the base of the break. The San Joaquin Operational Area required extensive mutual aid to prevent further flooding.

The California Department of Water Resources (DWR), the California Department of Transportation (Caltrans), and the United States Army Corps of Engineers (USACE) worked together to raise the Trapper Slough levee to prevent additional flooding with assistance from other state and local agencies. Reclamation Districts 2038 and 2039 hired a local company to protect the ends of the levee to prevent the breach from enlarging. DWR executed a contract with a local company to close the breach. Caltrans initiated a contract with another local company to provide rock. DWR provided dirt purchased from the Port of Stockton, and the USACE provided the personnel and equipment to move the dirt and rocks into place. In addition, DWR contracted with the California Department of Forestry and Fire Protection (CDF) to provide the personnel and resources to patrol the levees, assist with sandbagging, and perform other flood fighting activities. (See Attachment C for a summary of responses provided by state agencies.)

Because the levee break/failure occurred with no warning on a non-project levee outside the normal flood season, there was some initial confusion regarding which agency was responsible for responding to and funding the repairs needed to close the levee breach. The DWR noted in its departmental After Action Report that there was a lack of clear direction and funding for repairing this levee because it was not constructed under the auspices of the USACE. Until the Governor directed the DWR to respond to the flood fight, the State's response role was unclear. The source of funds available to conduct the response and the State's role in recovery were also unclear. Despite these uncertainties, State agencies worked together to meet the unusual demands of this emergency. These issues are addressed in the Recommendations Section (Attachment B) of this report.

Due to the size of the levee break, the Incident Commander (IC) submitted a request through DWR to obtain assistance from the USACE. Extensive erosion compromised the Burlington Northern Santa Fe Railroad's track that runs along the levee. To resolve this situation, rail traffic was diverted through Stockton until the levee was repaired. In addition, water releases from Shasta, Oroville, and Folsom Lake Dams were increased to counter the salinity entering the Delta and the State Water Project. The flooding also endangered the East Bay Municipal Utility District's pipeline and could have compromised the Bay Area's water quality.

Once the islands were flooded and the levee breach was closed, pumping operations began to siphon the water out of Upper and Lower Jones Tracts. The pumping operations were completed by December 18, 2004. However, the Central Valley Region of the California Regional Water Quality Board ordered DWR and USACE crews to continue filling and shaping the interior side of the levee at the breach site and to reshape the Trapper Slough levee road to allow rainwater to flow to the inward side of that levee. DWR completed all of its identified repairs by April 30, 2005.

<u>Proclamations/Declarations</u>

- On June 3, 2004, San Joaquin County proclaimed a Local Emergency due to the extensive damage caused by the levee break and requested a Governor's State of Emergency Proclamation and a Presidential Declaration.
- On June 4, 2004, the Governor proclaimed a State of Emergency.
- On June 8, the Governor requested a Presidential Emergency Declaration.
- On June 14, it became evident that the situation warranted a Major Disaster Declaration. Therefore, the June 8th Emergency Declaration was withdrawn and the Governor requested a Major Disaster Declaration on June 17th.
- On June 30, 2004, President Bush declared the Upper Jones Flood 2004 to be a Major Disaster triggering the availability of federal public assistance funds.

SCOPE OF THE REPORT

The OES prepared this comprehensive statewide AAR on the Upper Jones Flood 2004 using information provided by participating state and local agencies. The AAR process provides critical feedback to OES for improving California's operational readiness. The AAR identifies specific improvements that may, upon validation, be included in subsequent plans and procedures within OES and the impacted Operational Areas (OAs). An OA is a critical component of the SEMS organization and is defined as a county and all the political subdivisions within the county. The OA is responsible for coordination between the state's (OES) emergency operations centers and the political subdivisions, including the cities, towns and special districts located within the county.

OES is responsible for collecting AAR from participating state agencies and OAs. The issues and recommendations presented in this AAR reflect the information provided on AARs received from participating agencies and do not necessarily represent OES' position on addressing the issues or recommendations identified in this AAR. OES did not evaluate or validate the identified issues or recommendations. It is the responsibility of the agency(ies) involved with the issue that must determine whether the issue merits corrective action and whether the recommendation will resolve the issue appropriately. This report identifies issues and their associated recommendations as they appear in various agencies' AARs.

RECOMMENDATIONS

The following issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' position on the issues. Before implementation, the recommendations must be further evaluated by the key agencies. The findings and recommendations are divided into the following broad categories:

1. Standardized Emergency Management System (SEMS): Most state agencies indicated that overall SEMS functioned well and helped them mount an effective response. Several agencies made specific recommendations to improve SEMS including: (1) conducting additional specialized training emphasizing how to establish an Incident Command Post or Unified Command and defining the role of state agency representatives who participate in the SOC to ensure all potential state agency responders have the appropriate training; (2) improving communication with the SOC/REOC to ensure any changes in procedures are explained to the appropriate SOC/REOC personnel, e.g., a change in the agency responsible for processing requests for additional resources; (3) developing a radio system with interoperability capability; and (4) establishing a dedicated emergency fund to facilitate timely and effective responses and eliminate or minimize funding issues.

2. Mutual Aid: The California Department of Forestry and Fire Prevention (CDF) suggests that local governments need to be informed of the availability of specialized state resources in order to expedite assistance; for example, CDF has mobile kitchens that may not be readily available from the public or private sector.

3. Hazard Mitigation: Several state agencies, including the Department of Water Resources, indicated that the State needs to establish an overall plan and policy for responding to nonfederal levees in the delta and for de-watering flooded areas.

ORGANIZATIONS CONTRIBUTING TO THIS REPORT:

State Agencies and Departments

California Conservation Corps
California Department of Boating and Waterways
California Department of Community Services and Development
California Department of Corrections
California Department of Fish and Game
California Department of Forestry and Fire Protection
California Department of Health Services
California Department of Social Services
California Department of Transportation
California Department of Water Resources
California Environmental Protection Agency
California Highway Patrol
Employment Development Department
Governor's Office of Emergency Services

Local Government/Operational Areas

San Joaquin County (Operational Area)

Introduction and Background

Introduction	This document provides response and recovery related information on the Upper Jones Flood 2004 disaster as required by state law. In California, as part of the Standardized Emergency Management System (SEMS), state statute requires the Governor's Office of Emergency Services (OES) to produce an After Action Report (AAR) after each declared disaster. "This report shall review public safety response and disaster recovery activities." The supporting SEMS regulations (Title 19, Division 2, Chapter 1, Article 8, Section 2450) require jurisdictions "declaring a local emergency for which the governor proclaims a state emergency, and any state agency responding to that emergency" to complete and transmit an AAR to OES within 90 (ninety) days of the close of the incident period. The close of the incident period for the Upper Jones Flood 2004 was July 12, 2004.
Type of Event	Flood
Locations	San Joaquin County
Incident Period	June 3, 2004 to July 12, 2004
Brief Description of Event	On June 3, 2004, a section of levee in the San Joaquin Delta failed, threatening the integrity of the delta levee system, the California State Water Project, the Central Valley Project, public infrastructure and private property. The initial levee break occurred around 0800 hours on a 250 foot section of the Upper Jones Tract at Bacon Island Road, an island located west of Stockton and north of Highway 4 in San Joaquin County. The levee break was reported to San Joaquin County at approximately 0830 hours. The County activated its Emergency Operations Center (EOC) and notified the California Warning Center at 0852 hours and the Department of Water Resources (DWR) immediately thereafter, triggering the immediate activation of the Inland Regional Emergency Operations Center (REOC) and the State Operations Center (SOC). The REOC immediately began to coordinate resource deployment to support the San Joaquin Operational Area (OA). DWR activated the State-Federal Flood Operations Center by 0900 hours. By the end of the first day, both the Upper and Lower Jones Tracts had flooded requiring the evacuation of both tracts. At 2045 hours on June 4, 2004, water had reached Trapper Slough,

but the flow was expected to stabilize and top off by the morning of June 5th. Due to continual erosion caused by high winds and wave action, the break in the levee expanded to almost 500 feet long. The levee also developed a 50-foot scour (a hole caused by water eroding out the ground) at the base of the break.

The San Joaquin OA required extensive mutual aid to prevent further flooding. Local Reclamation District 2039, using DWR Subventions funding (Assembly Bill 360), awarded a contract to a local company to provide barge-mounted cranes and rock to protect the exposed ends of the levee breach to keep the breach from enlarging. DWR awarded an emergency contract to a local company to close the levee breach section. The California Department of Transportation (Caltrans) initiated a contract with another local company to provide rock. DWR provided dirt purchased from the Port of Stockton, and the United States Army Corps of Engineers (USACE) provided the personnel and equipment to move the dirt and rocks into place. DWR contracted with the California Department of Forestry and Fire Protection (CDF) to provide personnel and resources to patrol the levees, assist with sandbagging, and perform other flood fighting activities.

The DWR, USACE, and Caltrans worked together to raise and armor the Trapper Slough levee to prevent additional flooding from affecting Highway 4 and other surrounding levees. In addition, many other state and local agencies provided mutual aid by providing the resources necessary to effectively respond to the flooding, including filling and placing sandbags and plastic sheeting on the levees. (See Attachment C for a summary of response activities performed by state agencies.)

Due to the size of the levee break and the severity of the flooding, the Incident Commander (IC) submitted a request through DWR to request assistance with closing the levee break from the USACE. In addition, shelters were established to provide services to 70 evacuees. To assist responding agencies with evacuations and to provide security to the area surrounding the levee break, the United States (U.S.) Coast Guard closed the river to normal river traffic on June 3rd. In coordination with the U.S. Coast Guard, the San Joaquin Sheriff's Office began patrolling the river with assistance from the Contra Costa Sheriff's Office that provided mutual aid by providing a boat to assist with evacuations and to control the "Lock out" area.

Extensive levee erosion caused by high winds and continuous wave action compromised the Burlington Northern Santa Fe Railroad's track that runs along the levee. To resolve this situation, on June 5, the Railroad suspended rail traffic over the levee. Approximately 58 trains per day (50 cargo and 8 passenger trains) were diverted through Stockton pending repair of the railroad track. Emergency repairs were completed in three days and cargo trains began using the track again. Passenger trains continued to be diverted for several more weeks until the Railroad was certain the tracks were safe for transporting passengers.

The continuous flooding of Upper and Lower Jones Tracts reduced the level of fresh water reaching the Delta and allowed the more saline waters from downstream to displace the freshwater rushing through the breach in the levee. This situation threatened the salinity levels in the Delta and the State Water Project. As a result, water releases from the State Water Project south of the Delta were temporarily discontinued to minimize saltwater intrusion. In addition, water releases from Shasta Lake, Lake Oroville and Folsom Lake Dams were temporarily increased to counter the salinity entering the Delta and the State Water Project. The flooding also endangered the East Bay Municipal Utility District's pipeline and could have compromised the Bay Area's water quality.

Once the islands were flooded and the levee breach was closed, DWR awarded a contract for de-watering the island and pumping operations began to siphon the water out of Upper and Lower Jones Tracts. The pumping operations were completed by December 18, 2004. However, the de-watering exposed unacceptable leakage at the breach closure that required additional work to stop it. As a result, DWR and USACE crews, by order of the California Regional Water Quality Control Board, Central Valley Region, continued to fill and shape the interior side of the levee at the breach site and work on the Trapper Slough levee to reshape the levee road to allow rainwater to flow to the inward side of that levee. DWR completed all its identified repairs.

Proclamations and Declarations

On June 3, 2004, San Joaquin County proclaimed a Local Emergency, requested a Governor's State of Emergency Proclamation and a Presidential Declaration.

On June 4, 2004, the Governor proclaimed a State of Emergency. On June 8, 2004, the Governor requested a Presidential Emergency Declaration.

On June 14, 2004, it became evident that a Major Disaster Declaration was warranted and the Emergency Declaration was withdrawn. The Governor requested a Major Disaster Declaration on June 17, 2004.

On June 30, 2004, President Bush declared the Upper Jones Tract 2004 incident to be a Major Disaster. The Presidential Declaration triggered the release of Federal "Public Assistance" (PA) Program grants to assist with the recovery process. The Declaration also activated the Hazard Mitigation Grant Program.

Public Assistance (PA) Program

Completed Preliminary Damage Assessments (PDAs) in San Joaquin County identified an estimated $14,670,600 in eligible PA damages incurred by local agencies and another $28,048,000 in eligible PA damages incurred by state agencies. These eligible PA damages were related to debris removal, emergency protective measures and permanent repairs to public buildings, roads and facilities.

Individual Assistance (IA) and Small Business Administration (SBA) Programs

The major disaster declaration by the President did not authorize the "Individual Assistance" (IA) or the Small Business Administration (SBA) programs due to the limited damage sustained by individual homes and businesses located in San Joaquin County. However, several other grants were made available to the displaced victims to assist with obtaining rental housing and immediate needs assistance.

The California Department of Community Services and Development (CSD) awarded $57,500 to San Joaquin County from its Community Services Block Grant. In addition, CSD directed discretionary funds to the San Joaquin County Department of Aging, Children's and Community Services to help 23 families cover the initial security deposit and first and last month rent needed to secure permanent rental housing.

SEMS Use and Function Evaluation:

Overview

SEMS is the emergency management system required by Government Code Section 8607(a) for managing response to multi-agency and multi-jurisdiction emergencies in California. The Response Information Management System (RIMS) is used to manage data, reports, and resources. Mutual Aid is an integral part of SEMS since the system revolves around the premise of neighbor helping neighbor as a means of responding to an emergency or disaster.

The following section discusses the application of SEMS, RIMS and Mutual Aid to the Upper Jones Tract Flood 2004. The identified issues and recommendations include cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' position on the issues. Before implementation of the recommendation, the issues must be further evaluated by the key agencies.

OES is responsible for collecting AAR from participating state agencies and OAs. The issues and recommendations presented in this AAR reflect the information provided on AARs received from participating agencies and do not necessarily represent OES' position on addressing the issues or recommendations identified in this AAR. OES did not evaluate or validate the identified issues or recommendations. It is the responsibility of the agency(ies) involved with the issue that must determine whether the issue merits corrective action and whether the recommendation will resolve the issue appropriately. This report identifies issues and their associated recommendations as they appear in an agency's AAR.

SEMS/RIMS Comments/Outcomes

Most agencies and organizations indicated that SEMS, in general, functioned very well and helped them respond effectively. Even though the response effort was very effective, some participating agencies indicated the following SEMS/RIMS and Mutual Aid areas could be improved using the following suggested recommendations:

Recommendations for Improvement

1) Standardized Emergency Management System (SEMS): Several agencies made specific recommendations to improve SEMS including: (1) conducting specialized training emphasizing how to establish an Incident Command Post or Unified Command and defining the role of state agency representatives who participate in the SOC to ensure all

potential state agency responders have the appropriate training; (2) improving communication between DWR's upper and middle management to prevent confusion related to who has responsibility for processing requests for additional resources; and (3) providing orientation to the SOC, including log-on procedures, to state agency representatives at the beginning of shifts.

2) Mutual Aid: The California Department of Forestry and Fire Prevention (CDF) suggests that local governments need to be informed of the availability of specialized state resources in

Summary of Other Recommended Improvements

Overview

Due to the nature of the disaster, the OA required extensive and specialized mutual aid to respond to and recover from the extensive flooding of both Upper and Lower Jones Tracts. In addition to the SEMS related issues discussed above, several participating agencies also identified other areas of concern related to problems they encountered while performing response or recovery activities during the Upper Jones Tract Flood 2004. A summary of some of the suggested recommendations for improving response and/or recovery is listed below by area of concern.

OES is responsible for collecting AAR from participating state agencies and OAs. The issues and recommendations presented in this AAR reflect the information provided on AARs received from participating agencies and do not necessarily represent OES' position on addressing the issues or recommendations identified in this AAR. OES did not evaluate or validate the identified issues or recommendations. It is the responsibility of the agency(ies) involved with the issue that must determine whether the issue merits corrective action and whether the recommendation will resolve the issue appropriately. This report identifies issues and their associated recommendations as they appear in an agency's AAR.

Areas of Concern/ Recommendations for Improvement

1) Communication: (1) OES needs to develop and implement a communication system with interoperability capability. (2) In general, interagency communication appeared to work well. However, management needs to improve communication down the chain of command to prevent confusion.
2) Federal/State Coordination: The Federal Highway Administration (FHWA) and Caltrans should establish agreed upon time frames for timely submittal of proposed restoration

projects and timely eligibility determination.

3) Funding/Financial: OES and the Department of Finance (DOF) should work together to establish a dedicated emergency fund to facilitate timely and effective responses and eliminate or minimize funding issues.
4) Hazard Mitigation: Several state agencies indicated that the State should establish an overall plan and policy for responding to nonfederal levees in the delta and for de-watering flooded areas.
5) Jurisdictional Issues: OES, DWR, Reclamation Districts and USACE should develop policies and procedures for handling non-federal levee failures, including de-watering flooded islands following a levee break.
6) Recovery: State agencies should inform OES of all their available resources, including grants that are available to meet the needs of the victims of disasters.
7) Resource Management: The State (DWR and OES) and local agencies should establish contracts for accessing specialized equipment with private industry to expedite flood responses.

Specific Recommendations

Recommendations Section

Specific areas of concern and their associated recommendations for improving SEMS, RIMS, response, and recovery activities are contained in the Recommendations Section (Attachment B) of this report.

- Recommendations are arranged by category in a series of matrices. Since many organizations had very similar recommendations, some of the recommendations represent a summarization of similar comments.
- The recommendations contained in the matrices are cross cutting, common, or system-wide and should be addressed by follow-up planning activities.

Federal Agencies

Federal agencies play a key role in emergency response and recovery efforts. This report, however, is intended to address state and local response and recovery activities associated with the Upper Jones Flood 2004 and its aftermath. Federal agencies are mentioned in connection with joint jurisdictional activities (federal/state/local) in both the response and recovery sections.

Response Activities

Operational Area

San Joaquin OA activated its EOC around 0830 hours on June 3, 2004 and notified OES' Warning Center of the situation at 0852 hours. The San Joaquin County Sheriff's Office established an Incident Command Post (ICP) immediately following the activation of the EOC. The OA and several state agencies indicated there were some problems related to establishing a Unified Command early in the response phase. The San Joaquin County Sheriff's Office was the first agency on the scene and set up an ICP near the levee break. The CDF set up its own ICP several miles away. For a while early in the response effort, each responding agency seemed to be operating independently rather than in a unified manner. However, this was resolved in a short time with the help of CDF.

On June 3, Caltrans responded with equipment and personnel and began shoring up the Trapper Slough levee.

On June 4, Reclamation District 2039 awarded a contract to a local company to furnish and install rock to protect the exposed ends of the levee breach. The OA coordinated efforts of local agencies and requested mutual aid from OES to ensure that Trapper Slough was raised to prevent flooding from Upper Jones Tract. This was a priority since flooding of Trapper Slough could severely impact Highway 4, Roberts Island, and Drexler Tract.

San Joaquin OA also coordinated with a variety of state agencies to manage the impact of the levee break. The OA coordinated with the Red Cross in order to assist the displaced farm workers. The Red Cross supplied hotel vouchers to five people and cared for ten displaced families and explored alternate shelters in case nearby Roberts Island sustained flooding. In addition, the OA organized the activities of local agencies such as deploying the County Sheriff's Office to patrol and secure the river near the breach and directing the County Health Service Department to assist with handling potential drinking water problems and arranging back-up water supplies.

State Agencies and Departments

Thirteen state agencies and departments reported assisting San Joaquin OA by providing a wide array of mutual aid, including the award and administration of a construction contract to close the breach, providing flood fighting resources to sandbag and raise a levee to prevent flooding into other areas, installing levee slope protection, water sampling and testing, floating debris removal, logistical operations, perimeter control, and evaluating buildings for structural safety.

State agencies and departments response activities are reflected in:

- The Response Summary Chart (Attachment C) that summarizes response activities for state agencies and departments.
- The Response Detail (Attachment D) that provides more detail on response activities for each participating agency/department.

Recovery Activities to October 31, 2004

General Background

Although President Bush declared the Upper Jones Tract 2004 incident to be a major disaster, San Joaquin County was only approved for the Federal PA and Hazard Mitigation Programs. The PA Program covered debris removal, emergency protective measures, and permanent restoration of public facilities. The Federal Declaration also activated the Hazard Mitigation Grant Program. The impact on individuals was limited so Federal IA funding was not authorized. However, the Red Cross provided temporary shelter, food and clothing to the displaced victims.

Specific elements of the recovery process are described below.

Disaster Field Office (DFO)

Due to the small number of people impacted by the disaster, no DFO was established. OES and other state agencies provided services to the impacted population both on-site and out of OES' headquarters. FEMA assigned a Federal Public Assistance Officer and a Deputy Public Assistance Coordinator and mission tasked an USACE representative to provide technical assistance on levees.

Disaster Recovery Center (DRC)

There was no need to establish a DRC due to the limited scope of the disaster.

Preliminary Damage Assessment (PDA)

OES staff assisted San Joaquin County with conducting damage assessments to determine the dollar amount of property damage caused by the flood. A PDA is a comprehensive report completed by the state in cooperation with local government and the private sector. The PDA is used to determine the level of state and/or federal assistance required. If federal assistance is requested, the PDA must be completed within 30 days of the occurrence. Based on the completed PDAs, the total estimated damage caused by the flooding was $41 million for damaged public entities, debris removal, emergency costs, and permanent restoration costs.

Public Assistance (PA) Program

The OES staff coordinated with FEMA to implement the PA Program for financial assistance to government agencies. Major activities conducted by OES staff included

- Providing technical assistance regarding program eligibility requirements to applicants;
- Conducting kick-off meetings and applicant briefings to inform potential government applicants of the state and federal assistance available;
- Conducting site inspections to determine the scope of work;
- Preparing project worksheets (PWs) to describe the scope of repair work and approved costs; and
- Helping generate the Lists of Projects spreadsheet for FEMA and OES to use to monitor the projects.

Individual Assistance (IA) Program

Due to the limited impact on individuals, no federal assistance was available through the Federal IA Program. However, other grant funding was made available through other state and federal agencies. See page 13 below under "State Agencies and Departments" for a brief description of contributions by state agencies. In addition, the U.S. Department of Agriculture (USDA) provided emergency loans for qualified farm, ranch, and aquaculture operations to assist with physical and crop production losses.

Hazard Mitigation Program

The Federal and State Public Assistance Officers decided that Section 406 Hazard Mitigation funding would be considered for all permanent work. 406 Hazard Mitigation funding is a federal program that makes funding available to victims of a federally declared disaster to make modifications to existing structures or terrain to prevent repetitive future damage to the same site.

To ensure that FEMA followed this agreed-upon policy, OES requested that every permanent PW include the scope of work for hazard mitigation to prevent repetitive damage at the site or include a comment that hazard mitigation was not feasible and why.

OES also requested that FEMA establish a 406 Hazard Mitigation tracking system in the National Emergency Management Information System for every large, permanent PW to ensure 406 Hazard Mitigation was always considered when preparing and approving PWs for these projects to prevent repetitive damage from future disasters.

OES Headquarters staff coordinated the Hazard Mitigation Program activities, including evaluating damage sites for potential hazard mitigation projects and ensuring that each permanent PW included the scope of work for the identified hazard mitigation work. This was possible due to:

- The small size of the disaster,
- Extensive website capabilities for access to program information, and
- Availability of online applications.

State Agencies and Departments

OES continued to coordinate recovery activities that were performed by other state agencies and departments. Several state agencies provided recovery-oriented services to the affected communities including:

- The California Department of Community Services and Development (CSD) provided grant funding to cover the first and last month's rent as well as the security deposit to meet the needs of the displaced farm workers who were unable to obtain housing.
- The local field office of the California Employment Development Department (EDD) assisted most of the displaced farm workers with obtaining other employment.
- The DWR managed de-watering of the Upper and Lower Jones Tracts and the removal of floating debris.

Additional details on state agencies and departments recovery activities are reflected in:

- The Recovery Summary Chart (Attachment E) summarizing recovery activities for state agencies and departments.
- The Recovery Detail (Attachment F) provides details on response activities for each participating agency/department.

ACRONYMS

LIST OF ACRONYMS

AAR	After Action Report
Caltrans	California Department of Transportation
CDBW	California Department of Boating and Waterways
CCC	California Conservation Corps
CDF	California Department of Forestry and Fire Protection
CDC	California Department of Corrections
CDFA	California Department of Food and Agriculture
CDHS	California Department of Health Services
CDSS	California Department of Social Services
CHP	California Highway Patrol
CSD	California Department of Community Services and Development
DAD	Disaster Assistance Division
DFO	Disaster Field Office
DOC	Department Operations Center
DFG	California Department of Fish and Game
DRC	Disaster Recovery Center
DSCO	Deputy State Coordinating Officer
DWR	Department of Water Resources
EDD	Employment Development Department
EOC	Emergency Operations Center
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
IA	Individual Assistance
IC	Incident Commander
ICP	Incident Command Post
ICT	Incident Command Team
IT	Information Technology
LAC	Local Assistance Center
OA	Operational Area
OES	Governor’s Office of Emergency Services
OSPR	Spill Prevention and Response
PA	Public Assistance
PDA	Preliminary Damage Assessment
REOC	Regional Emergency Operations Center
RIMS	Response Information Management System
SBA	Small Business Administration (United States)
SCO	State Coordinating Officer
SEMS	Standardized Emergency Management System
SOC	State Operations Center
US&R	Urban Search and Rescue

AAR RECOMMENDATIONS

The following tables display specific areas of concern and associated recommendations for improving statewide response and recovery activities as reported by the state and local agencies that completed an AAR. The identified issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not represent OES' position on the issues.

- The column "Key Agencies" identifies those state and local agencies that may need to be involved in resolving a particular issue.
- The Issues are arranged by category in a series of matrices.
- Since many organizations identified similar issues, some of the issues represent a summarization of similar comments.
- Similar recommendations for the same issue have also been consolidated; however, if different agencies identified alternate recommendations, the different recommendations were listed separately.
- The issues and recommended actions should be addressed by follow-up planning activities by the identified Key Agencies to improve future response and recovery activities.

ATTACHMENT B

UPPER JONES TRACT FLOOD 2004
AAR RECOMMENDATIONS

For easy reference, the issues are identified by area and category and can be found on the pages listed below:

The identified issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' policy or position on the issues.

AREA: SEMS

Recommended by	Problem Statement/Issue	Recommended Action	Key Agencies	Category
State Agency	Due to the type of emergency, flooding of a non-federal levee, there was some confusion as to which agency should be the "lead" responsible for responding to the incident during the initial stage of the response.	Several agencies stated that there is a need to provide specific training related to establishing an ICP and Unified Command to state and local agencies to ensure SEMS protocols are followed. Unified Command needs to be established early in the response system.	OES, DWR, CDF, OAs, Local jurisdictions	Management
State Agency	This disaster involved several different disciplines using Unified Command. Several agencies noted that the some of the responding agencies seemed to be working independently. These agencies noted that there was a lack of leadership and failure to enforce use of SEMS at the incident level during the initial stage of the response.	CDF can make personnel available from their Incident Command Team to assist with key command team positions for a short duration until the responsible state agencies have established control of the incident. OES should provide training related to how Unified Command works with multiple agency involvement.	OES, CDF, Other State Agencies with Response Responsibilities, Local Agencies	Management

The identified issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' policy or position on the issues.

AREA: SEMS

Recommended by	Problem Statement/Issue	Recommended Action	Key Agencies	Category
State Agency	There is an existing, but outdated, interagency agreement between DWR and OES regarding responses to levee failures. A few days into the disaster, the executive management of DWR and OES agreed to modify the usual resource ordering arrangements (through the SOC) to comply with a change in law (AB 360) which gives DWR permissive authority to handle its own resource ordering during a flood-related event. DWR received funding for response activities and took responsibility for ordering resources. However, this information was not shared with affected personnel in either department which made acquiring goods and services more complicated.	When departmental decisions are made that impact personnel supporting response activities, decisions should be immediately communicated to field personnel and state representatives of the impacted agencies. OES and DWR should develop a new interagency agreement to reflect existing law which allows DWR to handle resource ordering during flood-related events. Revise OES' standard operating procedures to include process authorized by AB 360.	OES, DWR, CDF	Management

The identified issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' policy or position on the issues.

AREA: SEMS

Recommended by	Problem Statement Statement/Issue	Recommended Action	Key Agencies	Category
State Agency	There is no state plan and policies for responding to non-federal levee failures in the Delta and for allocating responsibilities. The lack of such a plan and policies affected decision-making during the initial flood fight.	The State (DWR) needs to establish a policy and procedures for handling non-federal levee failures, including establishing the proper command structure during a flood related disaster. These procedures need to specify DWR's flood fight responsibilities on non-project levees and ensure pertinent information is shared throughout the response phase. In addition, the response plan should provide location-specific information that identifies resources and issues, including the following: infrastructure and levee information; short and long term water quality impacts; impacts of flooding on adjacent facilities; nearby sources of earth fill and riprap, appropriate staging areas, and the location of flood fight materials. Also list possible economic impacts and agencies that would be involved with response, recovery and mitigation measures.	OES, DWR, impacted OAs, Levee Maintenance Agencies	Management

AREA: SEMS

Recommended by	Problem Statement/Issue	Recommended Action	Key Agencies	Category
State Agency	See problem statement above	Legislation or policy clarifying the role of federal, state and local jurisdictions would expedite future flood responses.	OES, DWR, USACE, impacted OAs, Levee Maintenance Agencies	Management
State Agency	No Red Cross representative was included in the SOC to coordinate services for displaced residents.	Request American Red Cross to send a representative to the SOC when there is a risk of displacement of residents.	OES	Management
Operational Area	The OA did not receive OES' GIS Maps during the early stages of the disaster.	SOC staff should notify GIS staff immediately when a disaster occurs and request standard mapping configurations (these may have to be developed) at the onset of the disaster to expedite getting information to the OA.	OES, CDF, DWR	Planning/Intel
Operational Area	The OA did not receive OES' GIS Maps during the early stages of the disaster.	SOC staff should notify GIS staff immediately when a disaster occurs and request standard mapping configurations (these may have to be developed) at the onset of the disaster to expedite getting information to the OA.	OES, CDF, DWR	Planning/Intel

The identified issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' policy or position on the issues.

AREA: SEMS

Recommended by	Problem Statement/Issue	Recommended Action	Key Agencies	Category
State Agency	Due to the initial confusion related to who was responsible for commanding a non-federal levee failure, situation analysis was hampered due to the lack of information sharing. Some agencies thought DWR should have taken a stronger early role because they are the experts in flood analysis and flood control systems. This impeded sharing information among agencies.	OES and DWR procedures for establishing the proper command structure during a flood-related disaster should be established. These procedures need to include handling non-federal levee failures to avoid confusion and should ensure pertinent information is shared throughout the response phase.	OES, DWR	Plans/Management
State Agency	It was difficult for some state agencies to get cost codes from DWR so they could receive overtime pay for their activities	No recommendation from state agency. This may be a contract issue between DWR and the state agencies providing flood fighting assistance.	OES, DWR, and other State Agencies with lead responsibility for flood fighting	Finance/Admin

The identified issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' policy or position on the issues.

AREA: SEMS

Recommended by	Problem Statement/Issue	Recommended Action	Key Agencies	Category
State Agency	State supervisors/managers in public safety agencies should be compensated for the excess hours worked during a disaster. The current arduous pay compensation is not consistently applied in the different state agencies and is not equitable.	Inform state agencies about their ability to pay managers and supervisors for overtime when they are activated for a disaster.	OES, DPA, State Agencies with Response Responsibility	Finance/Admin
Operational Area	Responding agencies did not have an understanding of the need to document costs, agency record separation, and eligible costs.	Documentation, record keeping and eligible cost issues should be covered in the Logistics and the Finance/Administration sections. DAD PA staff should provide training to state agencies on how to document their costs.	OES, State Agencies with Response Responsibilities	Finance/Admin/Logistics

The identified issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' policy or position on the issues.

AREA: SEMS

Recommended by	Problem Statement/Issue	Recommended Action	Key Agencies	Category
State Agency	There was no information board at the ICP with a list of names and contact information for the various SEMS functions. Due to the large number of agencies involved in this incident, it was difficult to locate the PIO of Chief of Logistics unless you asked many different people.	An information board containing the names and contact information for the various SEMS functions should be posted at the ICP.	OES, State Agencies with Response Responsibilities, Local Agencies	Logistics
State Agency	Red Cross provided meals for staff assigned to the levee break. However, the number of responders was increased rapidly so that the vendor they used was no longer able to meet the needs of the responders. As a result, CDF/CDC Mobile Kitchen Units were assigned to furnish meals.	CDF suggests that local governments need to be informed of the availability of specialized state resources that can be used during disasters. For example, CDF has mobile kitchens that the public or private sector may not have readily available.	OES, DWR, CDF	Logistics

The identified issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' policy or position on the issues.

AREA: SEMS

Recommended by	Problem Statement/Issue	Recommended Action	Key Agencies	Category
State Agency	There were problems with the ordering process. At first OES issued missions and coordinated resource distribution, but several days into the event, DWR was given the responsibility for mission tasking. The change in resource ordering was not communicated to SOC/REOC or DWR staff causing delays in ordering equipment and supplies.	Establish more open communication between upper management of responding state agencies and SOC/REOC and field operations staff to ensure that all staff are aware of any changes in procedures. OES may want to provide additional resource ordering training to state/local agencies to ensure they are aware of the proper method for ordering supplies and mutual aid. OES has a resource ordering manual that provides additional information.	OES, DWR, Local Agencies, private contractors, State Agencies with Lead Responsibility for flood fighting	Logistics/Training
State Agency	Contractors' response: The vitally important response role of contractors in the all-risk environment continues to be problematic due to contractors' lack of understanding of SEMS, particularly ICS.	Develop a comprehensive outreach program that identifies key response contractors and/or organizations and provide them with a "nuts and bolts" orientation to working in an emergency environment under the ICS. CSTI has the ability to provide contractor related training for interested contractors.	OES, industry and labor representatives, ICS Technical Specialists, state agencies who used contractors in a prior emergency response, and Urban Search and Rescue members who provided liaison work for the World Trade Center contractors.	Training/Logistics

The identified issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' policy or position on the issues.

AREA: SEMS

Recommended by	Problem Statement/Issue	Recommended Action	Key Agencies	Category
State Agency	The ICP and CDF base were ten miles apart. The CDF base could have better supported the needs of the ICP had the two been co-located.	When possible, co-locate ICP and CDF base in future disaster response efforts.	CDF, OES, State Agencies with Response Responsibilities	Operations
State Agency	Migrant workers were hesitant to use mass care and shelter services.	Use a non-governmental organization to interface with the affected victims.	OES, DSS, Red Cross	Operations
State Agency	Some state agency staff assigned to the SOC and the ICP were not familiar with SEMS.	Provide additional SEMS training to state staff on a regular basis. SEMS policy guidelines and procedures should be readily available to staff in case of disaster. This guidance should include information related to establishing a Unified Command and Area Command.	OES, State Agencies with Response Responsibilities	Training

The identified issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' policy or position on the issues.

AREA:
SEMS

Recommended by	Problem Statement/Issue	Recommended Action	Key Agencies	Category
State Agency	Some state agency representatives assigned to the SOC experienced difficulty with logging onto RIMS. In addition, some of these agency representatives were confused about what they were responsible for doing while assigned to the SOC/REOC.	OES should provide orientation to agency representatives asked to serve in the SOC. This should include information on how to log into RIMS and what agency representatives are responsible for doing when assigned to the SOC/REOC. NOTE: Orientation should also be included in SEMS/NIMS procedures when they are developed. In addition, OES should provide additional staffing in the SOC/REOC from IT during the first few days of activation to assist with RIMS-related issues/problems.	OES, State Agencies with Response Responsibilities	Training/RIMS
State Agency	The RIMS AAR seems to ask for the same information that is already provided in other RIMS reports.	Revise RIMS forms to transfer information from one form to another. Note: Since the ARR is collected several months following the disaster, new issues may have been identified in the interim that should be included in the AAR.	OES	RIMS

The identified issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' policy or position on the issues.

AREA: SEMS

Recommended by	Problem Statement/Issue	Recommended Action	Key Agencies	Category
State Agency	Some state agency staff were unfamiliar with completing the RIMS AAR and the acronyms used in the report format.	Provide a legend of acronyms used in the RIMS forms, including the AAR**.** Revise the RIMS AAR to be more user-friendly.	OES	RIMS

The identified issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' policy or position on the issues.

AREA: MUTUAL AID

Recommended by	Problem Statement/Issue	Recommended Action	Key Agencies	Category
State agency	OES was able to access a Cost Unit Leader from CDF, but could not obtain a Finance Chief.	OES needs to access and request overhead personnel from other state agencies for non-fire events. CDF may be able to provide overhead teams to assist locals in the early response phase.	OES, State Agencies with Response Responsibilities	Logistics (Resource Management)
Operational Area	The OA indicated that state OES' "expert" staff appeared without advance notice or invitation.	The OA suggested that OES should provide advance notice to OAs when State staff is deployed to the incident.	OES, State Agencies with Response Responsibilities	Logistics/Operations

The identified issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' policy or position on the issues.

AREA: HAZARD MITIGATION

Recommended by	Problem Statement/Issue	Recommended Action	Key Agencies	Category
DWR	Delta waterways and levees are unique and failures require specialized labor and equipment that is not readily available.	The local entities and the State (DWR) should consider implementing contracts with contractors with this type of equipment. The contracts should be similar to the USACE's Indefinite Delivery Indefinite Quantity (IDIQ) contracts.	OES, DWR, Regional OES offices, USBR	Logistics (Resource Management)

The identified issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' policy or position on the issues.

AREA: COMMUNICATION

Recommended by	Problem Statement/Issue	Recommended Action	Key Agencies	Category
State Agency	OASIS communication systems used on-site were unreliable. Cell phones reception was very poor at the incident site. Better communication is needed for future incidents and radio communication interoperability issues need to be addressed.	Develop a communication system with interoperability capability.	OES	Logistics (Communication)

The identified issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' policy or position on the issues.

AREA: FINANCE

Recommend by	Problem Statement/Issue	Recommended Action	Key Agencies	Category
State Agency	Since the levee failure occurred to a non-federal levee, DWR could not assure its spending ability in a timely manner. DWR's permissive authorities to respond to levee incidents and flood emergencies are not funded. Current emergency contracting regulations do not allow for executing contracts immediately. There is no dedicated funding for costs incurred for emergency response, recovery and mitigation activities for any emergency/disaster. This impacts a department's ability to make a timely response. A dedicated fund could cover emergency expenditures. The lack of immediate funding requires contractors to incur expenses for emergency mitigation or response work without knowing if they will be reimbursed.	Possible solutions to this problem include the following suggestions: 1. Establish a dedicated emergency fund with a minimum amount of money ($20 to $30 million is recommended by CALFED's 1998 Emergency Response Committee) for the Legal Delta and/or for statewide disasters, administered by DWR or OES. This fund could facilitate a timely and effective response and eliminate or greatly minimize initial funding issues. This would probably require legislation to establish the fund. 2. Absent a dedicated fund, responding state agencies need the authority to advance monies for emergency repair work to ensure contractors are paid for services rendered. This could require legislation to authorize state agencies to fund emergency repair work pending the Governor's proclamation of an emergency.	DWR, OES, DOF, CALFED, CDF	Finance/Admin (Funding)

The identified issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' policy or position on the issues.

AREA: RECOVERY

Recommended by	Problem Statement/Issue	Recommended Action	Key Agencies	Category
State Agency	Responding agencies were not aware of assistance that was available to meet the needs of low-income victims causing requests for assistance to be delayed.	CSD has a grant available to meet the needs of low-income victims that will pay first and last month's rent and security deposits for displaced victims. This information should be filed in OES' library and on the resource database to allow these services to be used more quickly. This information should also be included in SEMS training classes.	CSD, OES	Recovery - Resource Management

The identified issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' policy or position on the issues.

AREA: FEDERAL/STATE COORDINATION

Recommended by	Problem Statement/Issue	Recommended Action	Key Agencies	Category
State Agency	No comprehensive database and tracking system exists for identifying Delta levees and their associated structural deficiencies.	Identify funding sources to allow DWR to survey all levees, identify responsible owners/agencies, explore technologies capable of identifying deficiencies and utilize appropriate technology, create and maintain database. This would assist early response efforts involving levee failures. NOTE: DWR and OES have initiated discussions and planning. OES, with concurrence from locals, may make HMGP funds available to DWR for this action.	DWR, OES, FEMA, USACE, State Reclamation Board agencies	Finance/Admin/IT
State Agency	There were long delays in requesting aid to repair damage to Highway 4 that was caused by heavy trucks delivering rocks to repair the levee. It took until October 19, 2004, for the Federal Highway Administration (FHWA) to make a determination. Repairs were delayed until the eligibility determination was made.	FHWA and Caltrans need to agree on time frames for timely submittal of proposed restoration projects and timely eligibility determinations.	FEMA, DWR, FHWA, Caltrans	Recovery Process

The identified issues and recommendations identify cross cutting, common, or system-wide issues as reported by the state and local agencies and do not necessarily represent OES' policy or position on the issues.

RESPONSE SUMMARY

July 15, 2005

RESPONSE SUMMARY

State agencies response activities chart

The following chart summarizes the wide array of activities that local and state agencies/departments performed during the Upper Jones Flood 2004. It reflects the various disciplines within the mutual aid system (fire and rescue, law enforcement, medical), as well as other state response capabilities. See Response Detail (Attachment D) for more information related to specific response activities by agency.

Note: Agencies and organizations were not asked to provide specific information on personnel and equipment deployment. If available, this information has been included in the matrix. N/A= data not available, not submitted.

Agency/Dept.	Activities	Personnel	Equipment
California Conservation Corps (CCC)	CCC crews assisted with sand bagging efforts and levee stabilization work.	335 hand crew members for 36,527.5 corpsmember hours	22 Vehicles
California Department of Boating and Waterways (CDBW)	Staff surveyed the levee and was on standby for possible rescue.	2 Aquatic Weed Specialists	1 Air boat 1 Pick-up Truck
California Department of Community Services and Development (CSD)	CSD provided a bi-lingual employee to coordinate services and respond to the needs of the displaced Hispanic farm workers.	1 Bi-lingual staff	N/A
California Department of Corrections (CDC)	Dispatched CDC inmate crews and CDC guards to assist with flood fighting efforts. CDC Mobile Kitchen Units were assigned to prepare meals for staff assigned to the incident.	74 personnel, includes CDC inmates and supervising guards	1 Mobile Kitchen Unit
California Department of Fish and Game (DFG), Office of Spill Prevention and Response (OSPR)	OSPR representative was dispatched to monitor potential hazardous materials issues. DFG provided airboats and pilots to provide swift water rescue capability and to accommodate media access.	7 OSPR staff	2 Air Boats 1 Warden Vehicle

Agency/Dept.	Activities	Personnel	Equipment
California Department of Forestry and Fire Protection (CDF)	CDF crews assisted with emergency work operations along the levee, particularly rock and visquine placement around the entire levee perimeter.	160 - 8 hand crews	1 Mobile Kitchen Unit
California Department of Health Services (CDHS)	CDHS coordinated with East Bay Municipal Utilities District on water contingencies. Staff analyzed water samples taken by the Regional Water Quality Control Board (RWQCB).	4 staff in SOC N/A Water Quality Control Staff	Water Sampling Equipment Laboratory Assay Equipment
California Department of Social Services (CDSS)	CDSS coordinated with San Joaquin County's Department of Social Services to assess impacts and identify assistance needed by the evacuees. Staff surveyed local food banks to determine whether there was a need for the Emergency Food Assistance Program.	3 staff in SOC	N/A
California Department of Transportation (Caltrans)	Representatives were dispatched to the incident. Coordinated with CHP on contingency plan for State Highway 4. Coordinated importing Caltrans equipment from several sources to assist with levee repair work. Secured a contract to provide over 30,000 tons of rock slope protection for Trapper Slough. Provided an OASIS trailer at the ICP. In coordination with DWR and USACE, facilitated emergency operations/inspections and maintenance of Trapper Slough, adjacent to Highway 4.	30 staff, including heavy equipment operators and engineers	Bulldozers, Mobile Command Unit, Portable Message Boards, Trucks OASIS trailer Water Tanker Grader

Agency/Dept.	Activities	Personnel	Equipment
California Department of Water Resources (DWR)	DWR activated its Flood Operations Center and dispatched a flood fight specialist and levee inspector and deployed a full ICT to the incident. DWR requested assistance from U.S. Army Corps of Engineers. Initiated contract with a local company for emergency repairs to the levee breach. Initiated other contracts with various contractors and material suppliers. Provided engineering and technical evaluations to the Levee Maintaining Agencies. Coordinated with outside agencies to facilitate emergency repairs to the levee.	140 staff (no classifications)	Various Pick-up trucks, Small dozers Front end loaders, Equipment transport vehicles Material storage containers
California Highway Patrol (CHP)	Mobilized patrol units to control entry and exit around the perimeter of the incident. Provided escort for repair materials transport to the incident. Provided assistance with security at the incident and roadways.	318 CHP officers	Patrol vehicles
Employment Development Department	Local EDD field staff was dispatched to the field to talk to growers and farm workers in order to link them with needed employment and unemployment insurance services.	1 staff in SOC 4 Field Staff	Office Computers
Governor's Office of Emergency Services (OES)	Administration Division Worked on time issues and overtime authorizations, and coordinated check-in of all SOC/REOC participants.	2 staff	None

Agency/Dept.	Activities	Personnel	Equipment
Governor's Office of Emergency Services (OES) - Continued	Inland Region Provided State Liaison to San Joaquin EOC. Regional Manager was the Senior OES Coordinator at the ICP.	1 Emergency Services Coordinator 1 Program Manager I	None
	Coastal Region Provided relief to the Inland State Liaison to San Joaquin EOC	1 Emergency Services Coordinator	None
	Fire and Rescue Branch Assisted San Joaquin EOC and DWR with ICS coordination, incident action planning (IAP), including IAP production, and trained all agencies in SEMS functions.	2 Assistant Chiefs 1 Senior Fire Coordinator	
	Law Enforcement Branch Reported to San Joaquin EOC immediately and provided evacuation coordination and control. Provided organizational assistance with ICS. Coordinated marine patrol units in the area throughout response phase.	1 Law Enforcement Coordinator	
	SOC/REOC Activated the Inland REOC/SOC in support of the Operational Area impacted by the flooding. Coordinated support activities with state agencies and departments.	38 OES Personnel	

RESPONSE DETAIL

OPERATIONAL AREA RESPONSE ACTIVITIES

San Joaquin Operational Area (OA)

Description:

San Joaquin County activated their EOC and notified OES' Warning Center at 0852 hour that a levee break occurred in the Upper Jones Tract on a 250 foot section of Bacon Island Road. The EOC established the IC objectives as protecting the public by evacuating the flooded Upper Jones Tract and securing the area from non-responders, protecting Trapper Slough from potentially flooding Highway 4, preventing or at least limiting further widening of the breach, and closing the breach as quickly as possible. The EOC coordinated requests for mutual aid with OES and the surrounding counties. The Upper Jones Reclamation District entered into a contract with a private construction company to cap the break in the levee.

San Joaquin County Sheriff's Office (SJCSO) initially set-up the IC and began patrolling the area, including the surrounding waterways. When it became necessary to evacuate Upper Jones Tract, the SJCSO requested and received mutual aid from the CHP and Contra Costa County Sheriff's Office to assist with evacuation and patrolling the waterways.

The County OES Director signed a contract with CCC to provide ten hours of labor by 32 corpsmembers to assist with raising the height of the Trapper Slough levee. This contract was dropped when CCC was mission tasked by OES. County OES continued to monitor the levee situation until the levee area was stabilized. Once the EOC was demobilized, county staff continued to monitor pumping activities

County OES declared a disaster on June 3, 2004 and received a Governor's proclamation on June 4, 2004. The County received a Presidential Declaration of a Major Disaster on June 30, 2004.

Period of SJ OA commitment: 06/03/04 to current (December 8, 2004)

Personnel: 3 County staff in EOC
County Sheriff 's Staff
3 Stockton Fire Department Staff

Equipment: Sheriff's patrol cars
Sheriff's patrol boats
Sheriff's Command Vehicle
Trailer for ICP

STATE AGENCY RESPONSE ACTIVITIES

California Conservation Corps (CCC)

Description:

The CCC deployed 335 hand crew members to support response efforts at the Upper and Lower Jones Tract levees. The CCC crews assisted with sand bagging efforts and levee stabilization work. The CCC opened their Emergency Operations Center to provide logistical assistance to the State Operations Center. The CCC used a new emergency management position for the first time. Due to the small size of the disaster, CCC combined EOC positions.

Period of CCC commitment: 06/03/2004 to 06/06/2004

Personnel: 335 hand crew members

Equipment: 22 vehicles

California Department of Boating and Waterways (CDBW)

Description:

Staff surveyed the levee and was on standby to rescue emergency workers in case a worker fell in the river.

Period of CDBW commitment: 06/03/2004 to 06/15/2004

Personnel: 2 Aquatic Weed Specialists

Equipment: 1 Air Boat
1 Pick-up Truck

California Department of Community Services and Development (CSD)

Description:

The CSD provided a bi-lingual staff member who spoke Spanish and had outreach training as well as knowledge of available funding within the department. CSD was able to respond to the needs of this vulnerable group through service providers already contracted through the department to provide food and shelter services in the area. Through this coordination and communication effort, CSD determined that the farm workers needed basic food, clothing and shelter services. CSD identified a need for permanent housing for 23 low-income families displaced by the flood.

In response, CSD awarded $57,500 to the county from its Community Service Block Grant. Discretionary funds were directed to the San Joaquin County Department of Aging, Children's and Community Services to help 23 families cover the initial first, last month and security deposit needed to secure permanent rental housing. The county also used the CSD funding to distribute food to the victims during the disaster.

The Campaign for Human Concerns, another agency receiving federal funds through CSD, coordinated employment, food and temporary housing for approximately 50 displaced farm workers.

Period of CSD commitment: 06/04/2004 to 10/12/2004

Personnel: 1 CSD staff

Equipment: None

California Department of Corrections (CDC)

Description:

The CDC deployed inmate hand crews and CDC guards to assist with sandbagging and levee stabilization. When the private caterer was unable to meet the needs of the flood fighting personnel, the CDC was tasked to set up a mobile kitchen unit near the levee.

Period of CDC commitment: 06/08/2004 to 06/25/2004

Personnel: 74 inmates and staff (unspecified classifications)

Equipment: One Mobile Kitchen Unit

<u>California Department of Fish and Game (DFG)</u>

Description:

DFG provided air boats and pilots to assist with patrolling the river around the levee break and to provide swift water rescue capability. DFG also accommodated media access to the levee break. In addition, DFG's Office of Spill Prevention and Response (OSPR) staff dispatched a representative to monitor potential hazardous materials issues.

Period of DFG commitment: 06/03/2004 to 07/15/2004

Personnel: 7 staff

Equipment: 2 Air Boats
1 Warden's Vehicle

California Department of Forestry and Fire Protection (CDF)

Description:

The CDF assisted with setting up the Incident Command Post to coordinate internal requests for mutual aid resources. CDF crews assisted with emergency work operations along the levee, particularly rock and visquine placement around the entire levee perimeter. In addition, after a private contractor could not meet the needs of feeding the hand crews, CDF manned a Mobile Kitchen Unit.

Period of CDF commitment: 06/05/2004 to 06/25/2004

Personnel: 160 personnel, including 8 Hand Crews

Equipment: 1 Mobile Kitchen Unit

California Department of Health Services (CDHS)

CDHS coordinated with East Bay Municipal Utilities District on water contingencies. CDHS was concerned with the quality of the drinking water for communities downstream of the levee break. Due to occurrence of a very low tide in which the water level in the flooded island was higher than the water level in the corresponding delta, this caused water to flow from the flooded island into the delta, carrying possible contaminants with it.

CDHS staff serving in the SOC were alerted to the low-low tide situation approximately 18 hours prior to its occurrence. CDHS staff convened conference calls with San Joaquin County officials, Contra Costa County Water District (the impacted water district), Regional Water Quality Control Board, CDHS Drinking Water Program, Department of Water Resources, and other water quality agencies. As a result, a water-sampling plan was developed, samples collected and assayed. This water sampling process was necessary to protect the communities downstream. CDHS staff analyzed water samples taken by the Regional Water Quality Control Board. Since the results of the water samples took several days, in the interim, the Contra Costa County Water District closed its water intake from the delta and used stored water to protect their customers. Assay results subsequently showed no risk to the public's health.

Period of CDHS commitment: 06/03/2004 to 06/25/2004

Personnel: 4 Staff in SOC
Several scientific assay staff

Equipment: Water Sampling Equipment
Laboratory Assay equipment

California Department of Social Services (CDSS)

Description:

CDSS coordinated with San Joaquin County's Department of Social Services to assess impacts and identify assistance needed by the evacuees. Staff surveyed local food banks to determine whether there was a need for the Emergency Food Assistance Program.

Period of CDSS commitment: 06/04/2004 to 06/08/2004

Personnel: 3 Staff in SOC

Equipment: None

California Department of Transportation (Caltrans)

Description:

Caltrans dispatched staff, including engineers and heavy equipment operators, to the incident within the first 24 hours of the incident and worked to shore up and raise the Trapper Slough levee to prevent flooding of Highway 4. They coordinated with CHP on a contingency plan for Highway 4 in case it became inundated by water flooding through the Trapper Slough portion of the levee adjacent to Highway 4. Caltrans, in conjunction with DWR, facilitated emergency operations, inspections and maintenance of Trapper Slough. Caltrans provided an OASIS trailer and a Mobile Operations Center (MOC) at the ICP. They provided a variety of equipment to assist with initial levee repair work. Caltrans also initiated a contract to provide over 30,000 tons of Rock Slope Protection (RSP) to further stabilize the levee. During emergency repair work, Caltrans provided staff to control traffic through the construction area.

Period of Caltrans commitment: 06/09/2004 to 07/16/2004

Personnel: 30 staff, including engineers and heavy equipment operators

Equipment: Bulldozers
Mobile Command Unit/Mobile Operations Center
OASIS Trailer
Grader
Water Tanker
Portable Message Boards for traffic control
Trucks

California Department of Water Resources (DWR)

Description:

DWR activated its Flood Operations Center and dispatched a flood fight specialist and levee inspector to the incident. The DWR Director issued a departmental "Flood Activation" letter to make DWR resources available for responding to the flood. DWR requested assistance from the U.S. Army Corps of Engineers (USACE). DWR established an on-site ICP and coordinated with San Joaquin's Emergency Operations Center.

DWR initiated contracts to (1) close the breach, (2) provide a source for fill material, (3) remove visible floating debris, (4) perform water quality sampling and testing, (5) dewater the flooded island, (6) coordinate with the United States Bureau of Reclamation and DWR's State Water Project pumping operations, and (7) release fresh water from upstream reservoirs to minimize salinity intrusion in to delta waterways.

DWR activated pre-established agreements with CDF and CCC to provide resources for levee protection work, relocated pre-deployment stockpiles of flood fighting materials to the site, provided engineering and technical evaluations to the affected Levee Maintaining Agencies, deployed a full ICT, coordinated with outside agencies to facilitate emergency repairs to the levee, provided AB 360 funds for protecting exposed ends of the levee breach, provided necessary heavy equipment and operators from DWR maintenance yards, and handled the media throughout the incident.

Period of DWR commitment: 06/03/2004 to April 4, 2005

Personnel: 140 staff

Equipment: Various pick-up trucks
Small bulldozers
Front-end loaders
Equipment transport vehicles
Material storage containers

California Highway Patrol (CHP)

Description:

The CHP responded immediately by mobilizing patrol units in the affected flood areas to control entry and exit around the perimeter of the failed levee. The CHP was responsible for protecting the public, patrolling evacuated areas to prevent looting, disseminating emergency information to the public and emergency response agencies, and in general, maintaining law and order. The CHP also provided an escort for trucks transporting repair materials to the incident site.

Period of CHP commitment: 06/03/2004 to 06/18/2004

Personnel: 318 CHP staff

Equipment: Patrol Vehicles

Employment Development Department (EDD)

Description:

The EDD dispatched their local field staff to the incident to talk to growers and farm workers as a means of linking them with needed employment and unemployment insurance services. Most services were provided during the recovery phase.

Period of EDD commitment: 06/04/2004 to 10/12/2004

Personnel: 1 Staff in SOC
4 Field Staff

Equipment: Office Computers

Governor's Office of Emergency Services (OES)

Description:

Several units within OES assisted with response efforts for this disaster. A summary of the response activities by participating OES units follows:

Response Activities:

Coastal Region
The Coastal Region deployed an Emergency Services Coordinator as relief for the Inland Field Representative at the San Joaquin OA EOC.

Inland Region/ State Operations Center (SOC)
The SOC and Inland Region Emergency Operations Center were activated to support local government, i.e., San Joaquin OA, and to coordinate state agency resources and response. The Emergency Services Coordinator for San Joaquin County was dispatched to the County Emergency Operations Center to assist with coordinating resource requests. One Inland Regional Manager was dispatched by OES' Chief Deputy to assist the Incident Commander as the Senior OES on-site liaison. The SOC issued state agency mission tasks to a variety of state agencies and coordinated mutual aid requests. The SOC/REOC de-activated on June 9th, but remained in close contact with the County and state agencies still participating in response and recovery activities.

Fire and Rescue Branch
The Fire and Rescue Branch dispatched one Senior Fire Coordinator and two Assistant Fire Chief to the site of the failed levee. Fire personnel developed the Incident Action Plan, including the IAP production, for this non-fire event.

Law Enforcement Branch
The Law Enforcement Branch dispatched one Law Coordinator to coordinate mutual aid assistance consisting of additional boat patrols in the river surrounding the impacted island.

Administration/Finance Branch
Administrative and Finance staff worked on time issues and overtime authorizations. Staff ensured that SOC and REOC participants logged in and out to document expenditures.

Executive Branch
Executive Branch coordinated with SOC/REOC to obtain necessary information for requesting a Governor's declaration and federal proclamation. The Public Information Officer ensured that up-to-date information was released to the media and coordinated the Governor's visit to the incident site. Telecommunications personnel set up the OASIS trailer at the ICP to assist with communications in the delta.

Period of OES commitment: 06/03/2004 –current date (12/08/2004)

Personnel:	Inland Region:	1 Program Manager I (Senior OES On-site Liaison)
		1 Emergency Services Coordinator (Field Representative)
	Fire and Rescue:	1 Senior Fire Coordinator
		2 Assistant Fire Chiefs/Coordinators
	Law Enforcement	1 Law Coordinator
	IT	1 Associate Information Systems Specialists
	Executive	1 Public Information Officer
		2 Telecommunications Specialists
	SOC/REOC	38 OES employees from several Branches

Equipment: Office equipment, including computers
1 OASIS trailer

RECOVERY SUMMARY

July 15, 2005

RECOVERY SUMMARY

State agency recovery activities chart

This chart summarizes recovery activities for state agencies and departments following the Upper Jones Tract Flood 2004. It reflects the various disciplines within the mutual aid system (fire and rescue, law enforcement, medical), as well as other state response capabilities. Note: Some of the activities performed during the recovery period were also performed during the agency's response activities. See Recovery Detail (Attachment F) for more information related to specific recovery activities by agency.

NOTE: Agencies and organizations were not asked to provide specific information on personnel and equipment deployment. If available, this information has been included in the matrix. N/A= data not available, not submitted.

Agency/Dept.	Activities	Personnel	Equipment
California Community Services and Development	Provided funding to assist displaced families with their initial first, and last month rents and the security deposit needed to secure permanent rental housing.	1 Bi-Lingual Staff	N/A
California Department of Transportation (Caltrans)	Caltrans prepared a proposed project for repairing Highway 4 and submitted the project to the FHWA. This project was denied approval.	N/A	N/A
Department of Water Resources	Managed de-watering of the inundated areas. Oversaw the contracted repairs to Trapper Slough levee and various water and soil monitoring activities.	N/A	N/A
Employment Development Department (EDD)	Provided outreach services. Provided unemployment insurance related information and directed affected individuals to the local EDD office.	3 Job Service staff 1 Unemployment Insurance staff	Computer with EDD Employment programs

Agency/Dept.	Activities	Personnel	Equipment
Governor's Office of Emergency Services (OES)	<u>Inland Region</u> OES staff continued to participate in weekly conference calls with DWR, USACE, and the Reclamation District engineers to discuss the status of pumping operations. Hazard Mitigation was included in each project worksheet. <u>Disaster Assistance Division</u> • OES coordinated with FEMA to assist San Joaquin County with preliminary damage assessments. • In coordination with FEMA, held applicant briefing, and processed Requests for Public Assistance (RPAs), • Conducted site inspections to determine scope of work, prepared project worksheets to describe scope of repair work and approved costs, and helped generate Lists of Projects spreadsheet for FEMA and OES to use. • Participated in daily, then weekly, conference call with DWR, USACE, and the Reclamation District Engineers to discuss status of pumping and other items relative to the levee repair operation.	1 Emergency Service Coordinator (ESC) 1 Program Manager I 1 Disaster Assistant Program Specialist II 3 Disaster Assistance Program Specialist I	Lap Top Computers

RECOVERY DETAIL

RECOVERY ACTIVITIES

California Department of Community Services and Development (CSD)

Description:

The CSD provided a Spanish-speaking bi-lingual staff with outreach training as well as knowledge of available funding. CSD was able to respond to the needs of this vulnerable group through service providers already contracted through the department to provide food and shelter services in the area. Through this coordination and communication effort, CSD determined that the farm workers needed basic food, clothing and shelter services. CSD identified a need for permanent housing for 23 low-income families displaced by the flood.

In response, CSD awarded $57,500 to San Joaquin County from its Community Service Block Grant. Discretionary funds were awarded to the San Joaquin County Department of Aging, Children's and Community Services to help 23 families cover the initial first, last month, and security deposit needed to secure permanent rental housing. The county also used the CSD funding to distribute food to the victims during the disaster.

The Campaign for Human Concerns, another agency receiving federal funds through CSD, coordinated employment, food, and temporary housing for approximately 50 displaced farm workers.

Period of CSD commitment: 06/04/2004 to 10/12/2004

Personnel: 1 CSD Bi-lingual staff

Equipment: None

California Department of Transportation (Caltrans)

Description:

Caltrans dispatched staff, including engineers and heavy equipment operators, to the incident within the first 24 hours of the incident and worked to shore up and raise the Trapper Slough levee to prevent flooding of Highway 4 and beyond. They coordinated with CHP on a contingency plan for Highway 4 in case it became inundated by water flooding through the Trapper Slough portion of the levee adjacent to Highway 4. Caltrans, in conjunction with DWR, facilitated emergency operations, inspections and maintenance of Trapper Slough. Caltrans provided an OASIS trailer and a Mobile Operations Center (MOC) at the ICP. They provided a variety of equipment to assist with initial levee repair work. Caltrans also initiated a contract to provide over 30,000 tons of Rock Slope Protection (RSP) to further stabilize the levee. During emergency repair work, Caltrans provided staff to control traffic through the construction area.

Period of Caltrans commitment: 06/09/2004 to 07/16/2004

Personnel: 30 staff, including engineers and heavy equipment operators

Equipment: Bulldozers
Mobile Command Unit/Mobile Operations Center
OASIS unit
Grader
Water Tanker
Portable Message Boards for traffic control
Trucks

California Department of Water Resources (DWR)

Description:

DWR initiated contracts to (1) close the breach, (2) provide a source for fill material, (3) remove visible floating debris, (4) perform water quality sampling and testing, (5) dewater the flooded island, (6) coordinate with the United States Bureau of Reclamation and DWR's State Water Project pumping operations, and (7) release fresh water from upstream reservoirs to minimize salinity intrusion in to delta waterways.

DWR activated pre-established agreements with CDF and CCC to provide resources for levee protection work, relocated pre-deployment stockpiles of flood fighting materials to the site, provided engineering and technical evaluations to the affected Levee Maintaining Agencies, coordinated with outside agencies to facilitate emergency repairs to the levee, provided AB 3360 funds for protecting exposed ends of the levee breach, provided necessary heavy equipment and operators from DWR maintenance yards, and handled the media throughout the incident.

During the recovery period, DWR continued to work with San Joaquin County to oversee the repairs to the levee on Trapper Slough. DWR completed the de-watering of Upper Jones tract in mid-December 2004. Repairs to Trapper Slough were finally completed in mid-February 2005. DWR received a conditional approval letter from the Regional Water Quality Control Board regarding the monitoring of the vadose zone through June 2005. A DWR contractor installed storm water run-off collection manifolds on the Trapper Slough levee to meet monitoring requirements. DWR also collected soil pH samples and surface water sampling as part of the monitoring requirements. DWR implemented several physical mitigation measures to reduce the potential for future erosion. DWR reduced seepage through the levee closure rockfill. In November 2004, DWR completed their departmental AAR and furnished a copy to the Governor's Office of Emergency Services.

Period of DWR commitment: 06/03/2004 to April 4, 2005

Personnel: 140 staff

Equipment: Various pick-up trucks
Small bulldozers
Front-end loaders
Equipment transport vehicles
Material storage containers

Employment Development Department (EDD)

Description:

EDD staff provided four staff (three Job Service staff and one Unemployment Insurance staff) to perform outreach activities in the community with other local workforce and social service agencies. They provided unemployment insurance and job services related information and directed affected people to the Red Cross or other services. EDD staff contacted major agricultural employers to assist in whatever way they could, such as filling jobs or helping their displaced field crews looking for available work.

Period of EDD commitment: 06/04/2004 to 10/12/2004

Personnel: 3 Job Services Staff
1 Unemployment Insurance staff

Equipment: Office Computers

Governor's Office of Emergency Services (OES)

Description:

Several units within OES assisted with the coordination of recovery efforts for this disaster. A summary of the recovery activities follows:

Recovery Activities:

Inland Region/ State Operations Center (SOC)
The SOC/REOC de-activated on June 9th, but remained in close contact with the County and state agencies that were still participating in response and recovery activities. OES staff participated in weekly conference call with DWR, USACE, and the Reclamation District (RD) engineers to discuss the status of pumping and other items related to the levee repair operation.

Disaster Assistance Division
Based on the Presidential proclamation of a major disaster, only public assistance and hazard mitigation funding were available to victims of the disaster. FEMA and OES formed a partnership whereby FEMA and OES representatives processed public assistance applications out of OES' Mather office. DAD staff held applicant briefings to inform potential applicants on how to apply for assistance. DAD processed the Requests for Public Assistance, conducted site inspections to determine the scope of work, and prepared project worksheets to describe the scope of repair work and the associated approved costs.

Hazard Mitigation:
Due to the small size of the disaster, the Hazard Mitigation program was primarily administered by OES Headquarters staff through the use of website capabilities and on-line applications.

Period of OES commitment: 06/03/2004 to 08/31/2004

Personnel: Inland
1 Emergency Services Coordinator

Disaster Assistance Division
1 Program Manager I
1 Disaster Assistant Program Specialist II
3 Disaster Assistance Program Specialists I

Equipment: Office equipment, including computers