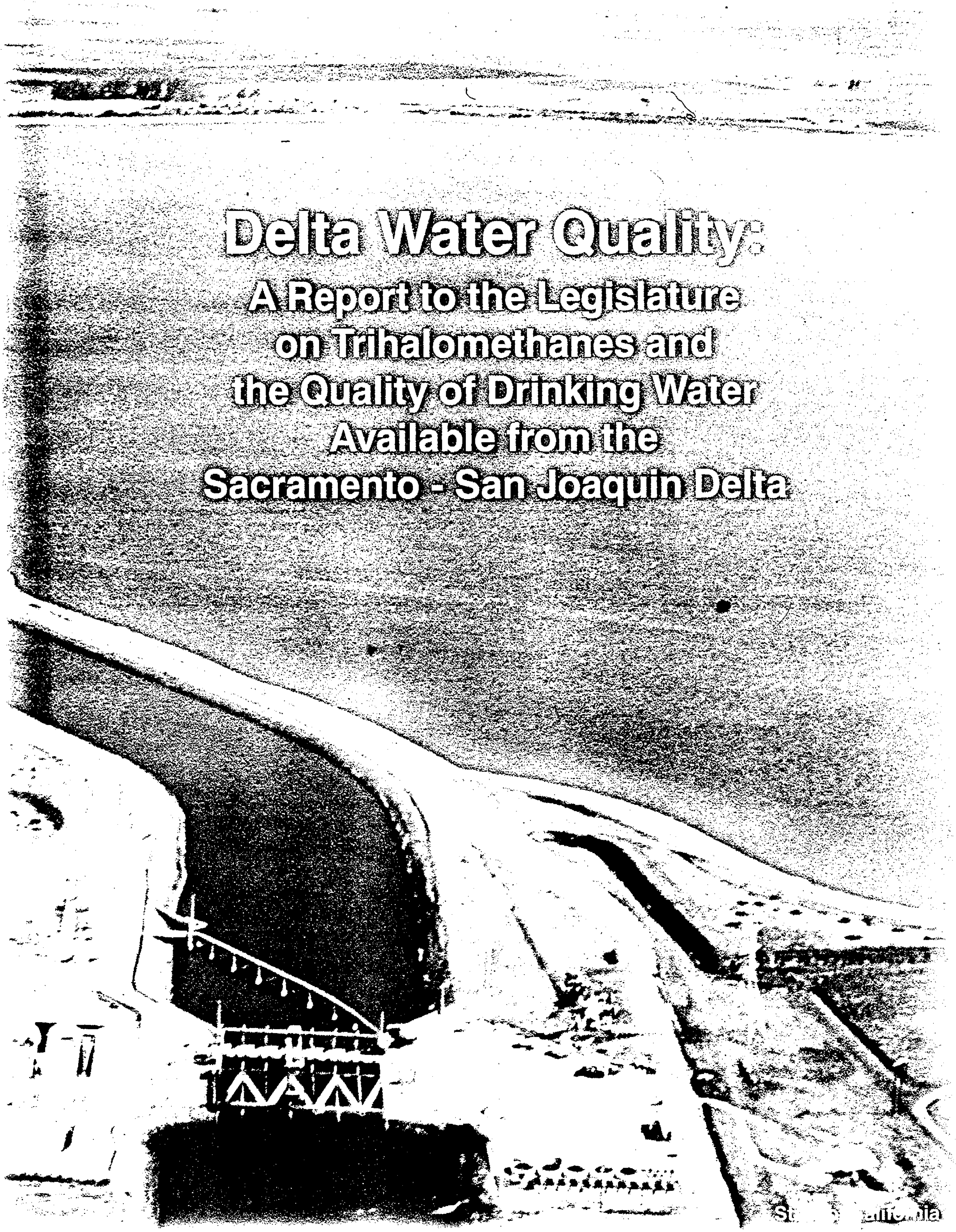


Delta Water Quality:

A Report to the Legislature on Trihalomethanes and the Quality of Drinking Water Available from the Sacramento - San Joaquin Delta

State of California

State of California

PETE WILSON, *Governor*

DELTA WATER QUALITY:
A Report to the Legislature on Trihalomethanes and the Quality of Drinking Water Available from the Sacramento-San Joaquin Delta

October 1991

Prepared by:

State Water Resources Control Board
Department of Health Services
Department of Water Resources

State of California

ACKNOWLEDGEMENTS

The accuracy and scope of this report would not have been possible without the generous assistance of citizens throughout California. Among numerous others, a special "Thank You" goes to:

Stuart Krasner,
Metropolitan Water District of Southern California

Gregory Gartrell,
Contra Costa Water District

John Gaston,
CH2M Hill

Lyle Hoag,
California Urban Water Agencies

Walter Wadlow,
Santa Clara Valley Water District

And not least, the authors of this report express their gratitude to these staff members and, through them, to all others who helped:

Leo Winternitz and Hugh Smith,
State Water Resources Control Board

Alexis Milea and John Andrew,
Department of Health Services

Bruce Agee and Mike Sutliff,
Department of Water Resources.

Finally, there are the secretaries, without whom there would have been no report at all: Thank you Lynne Bitnoff, Jody Guro and everyone else like you who helped out.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Conclusions:

Water quality in the Sacramento-San Joaquin Delta does not pose a serious health risk to California's population. It also does not pose a serious problem to the utilities charged with treating the water to meet current state and federal standards.

The quality of drinking water from the Delta does pose, however, a potentially serious problem to the utilities charged with treating the water to meet anticipated federal standards. Though it is uncertain when new standards may be promulgated, many water experts expect stricter standards for trihalomethanes (THMs) and new standards for other disinfection by-products (DBPs) within 3 to 5 years.

Although most regulated contaminants were not detected at utilities using the Delta as a chief source of drinking water, all utilities surveyed for this report consistently reported taste and odor concerns, elevated THM levels and, in many cases, turbidity.

In summary:

1. Given the Delta's current water quality, and,

2. Given the current state and federal regulations (for example, the Surface Water Treatment Rule (SWTR) which must be implemented by June 1993) which may preclude available options for controlling high trihalomethane levels, and,

3. Given the anticipated stricter standards for trihalomethanes and new standards for other disinfection by-products,

It is clear that water utilities charged with protecting the public health through treating drinking water from the Delta will face serious problems in meeting anticipated state and federal regulations.

Chapter 1 INTRODUCTION

California Senate Concurrent Resolution 55 (SCR55) requested a summary of the quality of the water available from the Sacramento-San Joaquin Delta.

Findings:

- The Sacramento-San Joaquin Delta is a source of drinking water for more than 20 million Californians.

- Disinfection of Delta water which contains organic precursors and bromide results in the formation of trihalomethanes and other disinfection by-products.

- Given the Delta's current water quality, the need to meet the provisions of the SWTR, and the possibility of stricter standards for THMs and other DBPs, it will be difficult for utilities to achieve compliance with the new maximum contaminant levels (MCLs).

Chapter 2 FACTORS AFFECTING DELTA WATER QUALITY

Findings:

- o Several factors can affect the drinking water quality of Delta water:

  - Tides, diversions and low river flows can allow intrusion of saline San Francisco Bay water into the Delta.

  - Wastewater from municipal, industrial and agricultural discharges upstream of, and in, the Delta can contain a variety of harmful constituents.

Chapter 3 DELTA DRINKING WATER QUALITY

Findings:

- o Most treated Delta water meets current drinking water standards, and most regulated organic contaminants are not detected. However, THMs are occasionally detected at levels at or above the current drinking water standard.

  - Treated Delta water meets current standards for microorganisms, clarity, inorganic chemicals (such as the metals), organic compounds (which include industrial and agricultural chemicals), and radioactivity. Most regulated contaminants were not detected at utilities using the Delta as a chief source of drinking water.

  - During low-flow periods (such as the current drought), sodium, chloride, and bromide concentrations typically increase.

  - Total dissolved solids (TDS) are generally high but within the recommended level of 500 mg/l.

- o Trihalomethanes are suspected human carcinogens. For this reason, EPA set the standard for THMs in treated drinking water at 0.10 milligrams per liter or 100 parts per billion (ppb).

- o EPA is currently reviewing the drinking water standard for trihalomethanes with the possible intent of replacing it with a stricter standard or individual standards for each of the THMs.

- o The implementation of the SWTR by June 1993 will require more stringent disinfection criteria for many utilities. This will make public drinking water safer against various diseases, but may also result in higher THM formation and reduce the number of treatment options for THM control available to water purveyors.

Chapter 4 THMs AND OTHER DBP PRECURSORS IN THE DELTA

Findings:

- o Total trihalomethane formation potential (TTHMFP) is an indicator of precursor levels in source water; it is used to judge the relative contribution of precursor materials from agricultural drains, tributary streams, and from entrained sea water.

- Source waters with high TTHMP generally result in high THMs after treatment.

- Located on nearly 60 islands and tracts in the Delta, 260 drainage pump stations return irrigation and seepage water to the surrounding island channels.

- During the recent drought, Delta island drainage contributed up to 45 percent of the organic THM precursors in Delta waters during the irrigation months of April to August (1988), and over 50 percent during the winter leaching period (1987-88).

- The TTHMFP concentrations (170 to 420 ug/l in 1990) in samples from the Sacramento River at Greenes Landing are significantly lower than downstream stations.

- The low TTHMFP concentrations in waste water effluents indicate that treated waste water is probably not a major TTHMFP loading source.

- Sea water intrusion is a major source of THM precursors, particularly bromide in the western Delta. Preliminary data from 1990 show that 84 to 98 percent of the bromide in the California Aqueduct came from sea water.

Chapter 5 SURVEY OF OPERATING EXPERIENCES OF USERS OF BAY-DELTA WATER SUPPLIES

Findings:

- A summary of operating experiences of the users of Delta water as required in SCR55 revealed that:

  - All agencies surveyed which use water pumped from the Delta (particularly southern Delta water) experience problems with THM formation.
  - Bromide levels, which may lead to higher THM concentrations, have increased in recent years due to the drought and have added to the difficulties in controlling THMs in the finished water.
  - Various agencies have converted, or are planning to convert to alternative disinfection processes in order to better control THM formation. However, these agencies anticipate that further modifications will be necessary if stricter EPA or state standards are established for THMs and other DBPs.
  - Taste-and-odor, turbidity, color, and total dissolved solids (TDS) are also common problems associated with Delta water. While these do not necessarily pose health risks, they at times degrade the quality of the water delivered to the consumer.
  - Most southern California agencies surveyed, when asked what could be done to improve raw water quality, responded that alternative Delta transfer facilities would provide the best possible drinking water quality. Most agencies that treat water from the California Aqueduct prefer an isolated Delta transfer facility to control organic THM precursors and bromide. Otherwise they believe that some mechanism to control or treat agricultural discharges in the Delta is needed.

Chapter 6 OPTIONS TO USING DELTA WATER AND MEETING DRINKING WATER STANDARDS

Findings:

- o To minimize THM formation, California water utilities currently have available ozone and chloramines as alternative disinfectants to chlorine. For many, the technology is new and requires extensive capital investment. In addition, there are regulatory concerns about the DBPs formed by alternative disinfectants. In particular, the use of ozone may be limited because of the formation of the DBP bromate when bromide is present.

- o Irrespective of the treatment strategy followed, minimizing or avoiding DBP precursors will result in lower concentrations of DBPs delivered to consumers of Delta water.

- o Numerous facilities have been proposed to improve the reliability and quality of source water:

  - North and South Delta Water Management Facilities
  - Through-Delta Water Facilities
  - Dual Water Transfer Facilities
  - The Peripheral Canal
  - Delta Agricultural Drainage Management
  - Sierra Source-To-User Alternative
  - Off-stream Storage (e.g., Los Vaqueros and Los Banos Grandes)

- o Best management practices to improve Delta water quality include possible:

  - Relocation of problem agricultural drains
  - Relocation of export pumps or points of diversion
  - Expanded monitoring programs to quantify sources of THMFPs, particularly from agricultural drains.

- o Monitoring of Delta water has been expanded in part because extensive cooperation has been achieved in gaining access to Delta islands.

- o Regulatory actions, such as waste discharge requirements on agricultural drains, may be needed to help resolve the problem of organic THM and DBP precursors in Delta source water.

Chapter 7 FINDINGS

This chapter contains a summary of the significant findings in this report.

Chapter 1

INTRODUCTION

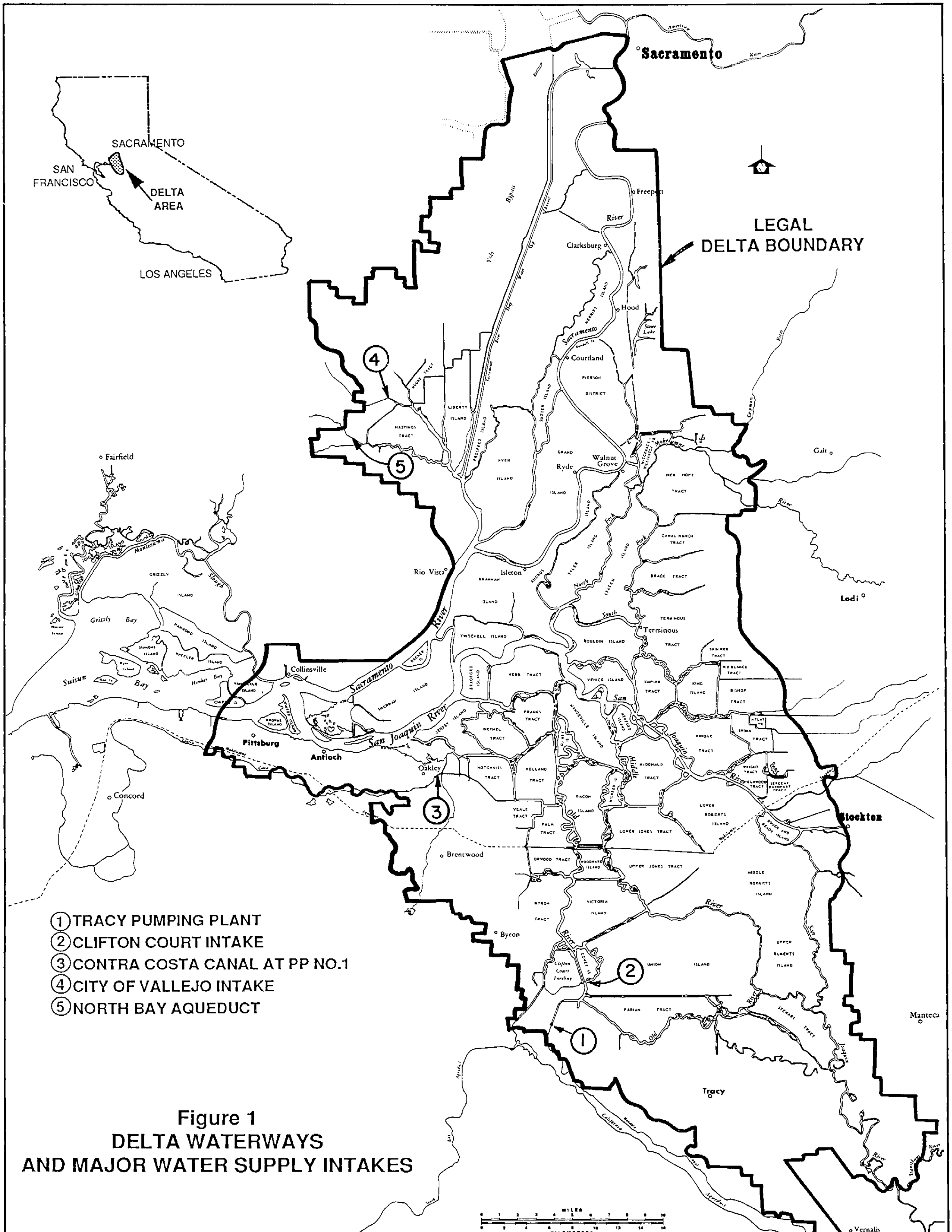
California Senate Concurrent Resolution Number 55 requested information on the quality of water taken from the Sacramento-San Joaquin Delta, with a special emphasis on the effects of trihalomethanes and other disinfection by-products and their precursors on the quality of drinking water. This report summarizes information on these effects from existing sources.

The Sacramento-San Joaquin Delta (Figure 1) is a source of drinking water for 20 million Californians. Water flowing into the Delta from the Sacramento, San Joaquin and other river systems is used for urban and agricultural use, recreation, navigation, and to support wildlife and fisheries. Part of the water is exported from the Delta by the State Water Project, by the federal Central Valley Project, and by numerous municipalities. Water flowing through the Delta is also removed by western Delta industries and over 1,800 agriculture points of diversion. Fresh water not used in the Delta or not exported from the Delta flows out to the Pacific Ocean through the Suisun, San Pablo and San Francisco bays, helping to support wildlife and fisheries. Fresh water outflows also prevent saline water from encroaching into the Delta and degrading water quality.

There are several factors that affect the quality of Delta water. Intrusion of saline water into the San Francisco Bay-Delta is a result of the interaction of the tides, freshwater outflow and diversions and atmospheric conditions. Levee failures can also reduce the ability of water suppliers to control salinity intrusion. Wastewater from municipal, industrial and agricultural discharges upstream of the Delta may contain a variety of harmful chemicals which can degrade water quality. Organic compounds from soils, especially peat soils, also increase the formation of trihalomethanes (THMs) and other disinfection by-products (DBPs) upon treatment of the water. This summary focuses on the last of these factors affecting the Sacramento-San Joaquin Delta water quality, i.e., the formation of trihalomethanes and other disinfection by-products.

Trihalomethanes and other disinfection by-products are formed when certain substances containing dissolved organics and bromide combine with the chlorine or other disinfectants used to disinfect drinking water to make it microbiologically safe for drinking. Figure 2, a brief outline of trihalomethane formation, shows that when disinfectants are added to water containing trihalomethane precursors, trihalomethanes and other disinfection by-products are formed. Trihalomethanes formed during chlorination include chloroform, dichlorobromomethane, dibromochloromethane, and bromoform; other DBPs and other disinfectants of regulatory concern are listed in Figure 2 also.

Water containing higher concentrations of trihalomethane precursors generally produce higher concentrations of trihalomethanes upon treatment with chlorine and other disinfectants. Trihalomethane precursors include humic and fulvic acids derived from the decomposition of organic substances found in Delta peat soils and levee materials, and from the growth of algae. Bromide contributed by seawater or estuarine water is another trihalomethane precursor.



①TRACY PUMPING PLANT
②CLIFTON COURT INTAKE
③CONTRA COSTA CANAL AT PP NO.1
④CITY OF VALLEJO INTAKE
⑤NORTH BAY AQUEDUCT

Figure 1
DELTA WATERWAYS AND MAJOR WATER SUPPLY INTAKES

Figure 2
OUTLINE OF TRIHALOMETHANE FORMATION

(Water Containing) Trihalomethane Precursors	+	Disinfectants	→	(Treated Water with) Disinfection By-Products
Examples:		Examples:		Examples:
Humic acids Fulvic acids Bromide		Chlorine Chlorine Dioxide Chloramine Ozone		Trihalomethanes: Chloroform Bromoform Bromodichloromethane Dibromochloromethane Other disinfection by-products: Chlorinated Acetic Acids/ Brominated Acetic Acids Chlorinated Alcohols Chlorinated Aldehydes Chlorinated Ketones Chlorite and Chlorate Haloacetonitriles Chlorophenols Chloropicrin Cyanogen Chloride Iodate Bromate MX

Note: Some disinfectants and disinfection by-products are being considered by EPA for development of MCLs.

Because of evidence from animal studies linking chloroform, a THM, to cancer formation, the Environmental Protection Agency (EPA) in 1979 set the standard for trihalomethanes in treated drinking water at 0.10 milligrams per liter or 100 parts per billion (ppb). One ppb would be the equivalent of two drops in a large backyard swimming pool (25,000 gallons).

Currently, utilities treating Delta water are meeting the present maximum contaminant level (MCL) of 100 ppb for trihalomethanes, although there have been occasional violations and some utilities are close to the standards. New regulations promulgated by EPA and the state (for example, the Surface Water Treatment Rule (SWTR)) set more stringent disinfection criteria which must be met by June 1993. In addition, EPA is currently reviewing the standard for trihalomethanes with the intent of replacing it with a stricter standard and is considering the establishment of standards for other DBPs.

In summary: Given the Delta's current water quality, the need to meet the provisions of the SWTR, and the possibility of stricter standard for THMs and new standards for other DBPs, it will be difficult for utilities to achieve compliance with the new maximum contaminent levels.

Chapter 2

FACTORS AFFECTING DELTA WATER QUALITY

The amount and/or type of treatment required to make water meet drinking water standards depends on the quality of the source water. The major factors affecting the quality of water flowing through the Sacramento-San Joaquin Delta are flow and quality conditions as influenced by Delta inflow, floods, tides, evaporation, diversions, municipal, industrial, and agricultural uses, and wastewater discharge.

Flow Conditions

Figure 3 shows a water balance schematic for the Delta. Water flowing through the Delta primarily comes from the Central Valley's Sacramento and San Joaquin rivers and their tributaries. Inflows vary seasonally, depending on precipitation, but they are also influenced by federal and state water project releases and other upstream reservoir releases.

Floods and high tides can also affect Delta water quality. Flood protection is provided by an extensive levee network. However, Delta levees are susceptible to failure due to their age, materials used in their construction, and other natural phenomena such as high wind, waves and, possibly, earthquakes. Levee failure can result in uncontrolled seawater intrusion into the Delta, increasing the salinity and the bromide content of Delta water. Such a failure ocurred in 1972 when Andrus Island flooded.

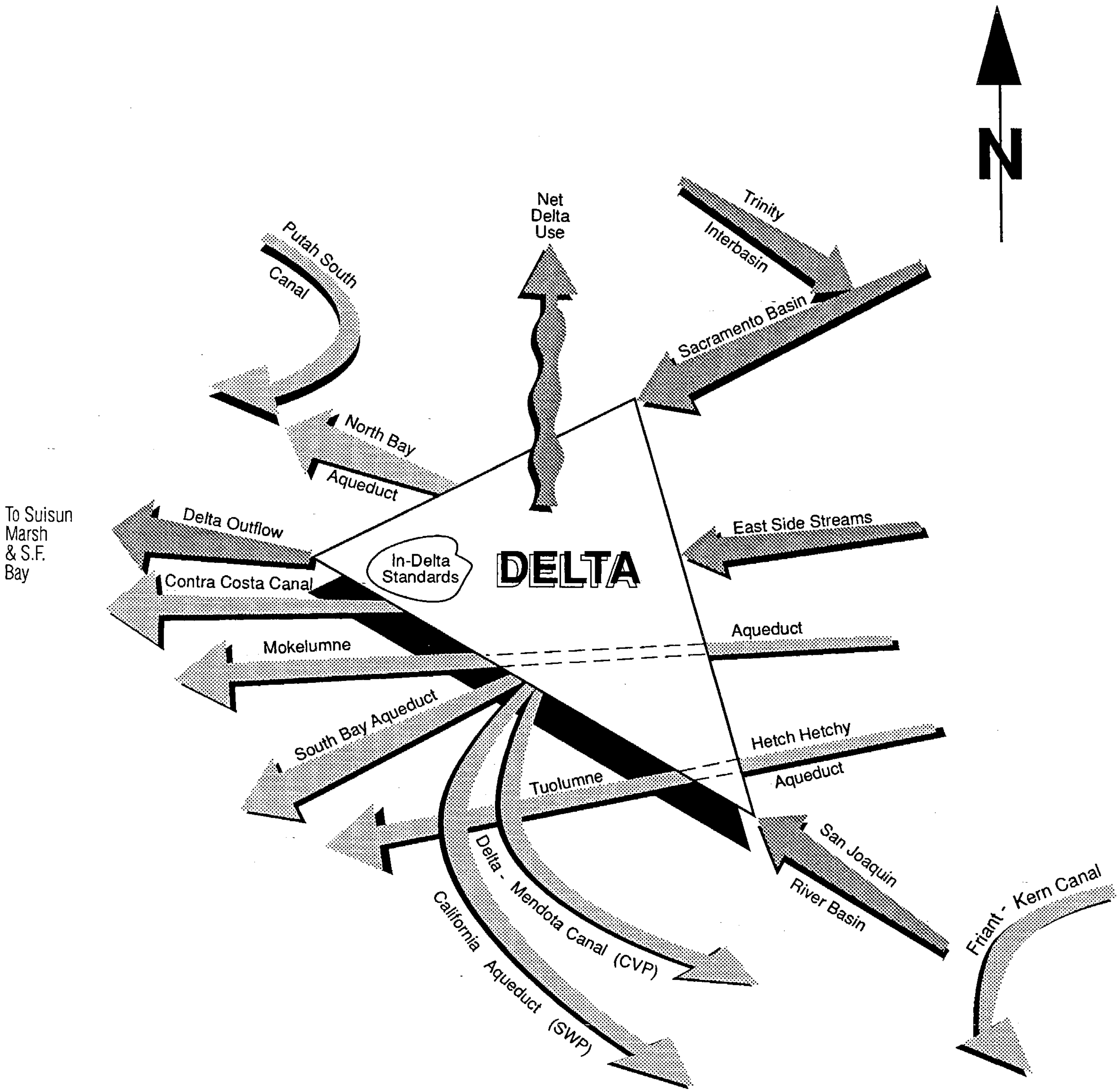
Agriculture Activities

Agricultural wastewater contains salts, trihalomethane precursors and some detectable levels of pesticides, all of which affect the quality of the water in the Delta. More than 520,000 acres, or 70 percent, of the land tributary to the Delta is used for agriculture. Certain agricultural practices intended to protect crop production and to manage soil salinity in the Delta produce drainage water which contains high amounts of salt and organic trihalomethane precursors, primarily from peat soils. Concentrations of salt in Delta channels can be elevated, especially under low flow conditions such as in the summer, when dilutions and dispersion are reduced, and in winter, when salt is leached from Delta islands. According to preliminary estimates by the Department of Water Resources (DWR), for example, Delta island drainage in 1987 contributed up to 45 percent of the organic THM precursors in Delta waters during the irrigation months April to August and over 50 percent during the winter leaching period (see Chapter 5, Delta Island Drainage).

Pesticides used on crops, irrigation ditches, channels and levees are another cause of concern. Pesticides and their breakdown products have been found to be toxic to fish and wildlife and can cause cancer and other health problems in humans. As a result, the use of pesticides is highly regulated.

Figure 3

DELTA HYDROLOGIC BALANCE



CHA0137R3

Domestic and Industrial Activities

The water quality of the Delta is affected by municipal and industrial activities both within and upstream of the Delta. Discharges from sewage and wastewater treatment plants and industrial sites often contain small amounts of hazardous trace elements and organic chemicals. Surface runoff from cities and some rural areas contains solvents, pesticides, herbicides and other organic chemicals as well as trace elements that are undesirable for drinking water.

Chapter 3

DELTA DRINKING WATER QUALITY

The Standards

Under the federal Safe Drinking Water Act, EPA sets maximum contaminant levels (MCLs) for numerous contaminants of drinking water. In 1978, EPA granted the California Department of Health Services (DHS) primary authority for the regulation of public water supplies in California. Under state law and conditions of primary authority, DHS must adopt standards at least as stringent as EPA's.

There are two types of drinking water standards. Primary MCLs are set for substances, such as bacteria and THMs, which pose a possible threat to human health when they are above certain levels in drinking water; these standards are based upon comprehensive health risk assessments, cost and technical feasibility of water treatment, analytical detection methods, monitoring costs, and levels of population exposure. Secondary MCLs are set for aesthetic water quality, such as taste, odor, and appearance, which may affect consumer acceptance of tap water. The MCLs are listed in the Domestic Water Quality and Monitoring Regulations, Title 22 of the California Code of Regulations (CCR) (see Table 1 for Primary and Secondary Standards).

Data Collection and Review

DHS reviewed the water quality data routinely reported to its Office of Drinking Water (ODW) and collected directly from utilities using the Delta for all or most of their water supply. The water systems reviewed were those under DHS jurisdiction, i.e., those systems with 200 service connections or more. Water utilities with fewer than 200 service connections fall under the jurisdiction of the local health officer. A list of the systems reviewed that use the Delta as their chief source of drinking water is in Table 2.

Treated Delta water meets current standards for microorganisms, clarity, inorganic chemicals (such as the metals), organic compounds (which include industrial and agricultural chemicals), and radioactivity. In fact, most regulated contaminants were not detected at utilities using the Delta as a chief source of drinking water. A few inorganic chemicals, including nitrate, aluminum, arsenic, selenium, flouride and barium, are present at trace levels. Low levels of radioactivity are also detected. Other Delta constituents of traditional concern, such as sulfate (a secondary standard) and sodium (unregulated), are present at levels less than 100 mg/l (milligrams per liter). It should be noted here that during low flow periods (such as the current drought), sodium, chloride, and bromide concentrations typically increase. Total dissolved solids (TDS) are generally high but within the recommended level of 500 mg/l.

Compliance with the current THM standard of 100 ug/l (micrograms per liter) is based on a running annual average of a utility's quarterly averages. The quarterly average in turn is an average of samples collected throughout the water distribution system. For the systems reviewed in this report, all had detectable levels of THMs, and many had quarterly averages or single samples

Table 1

State of California
Department of Health Services

Primary Standards
Maximum Contaminant Levels
For Contaminants in Drinking Water

February 1991

California Code of Regulations, Title 22

(All values in milligrams per liter (mg/l) unless otherwise noted)

Constituent	MCL
Inorganic	mg/l
Aluminum	1
Arsenic	0.05
Barium	1
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate *(as NO_3)*	45
Selenium	0.01
Silver	0.05
Fluoride	1.4-2.4*
Radioactivity	pCi/l**
Combined Radium-226 and Radium-228	5
Gross Alpha particle activity (including Radium-226, but excluding Radon and Uranium)	15
Tritium	20,000
Strontium-90	8
Gross Beta particle activity	50
Uranium	20
Organic	mg/l
Chlorinated Hydrocarbons	
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005

*MCL dependent upon air temperature.

**Pico Curies per Liter

Maximum Contaminant Levels (continued)
Page 2

Chlorophenoxys	
2,4-D	0.1
2,4,5-TP Silvex	0.01
Synthetics	
Atrazine	0.003
Bentazon	0.018
Benzene	0.001
Carbon Tetrachloride	0.0005
Carbofuran	0.018
Chlordane	0.0001
1,2-Dibromo-3-chloropropane	0.0002
1,4-Dichlorobenzene	0.005
1,1-dichloroethane	0.005
1,2-Dichloroethane	0.0005
cis-1,2-Dichloroethylene	0.006
trans-1,2-dichloroethylene	0.01
1,1-Dichloroethylene	0.006
1,2-Dichloropropane	0.005
1,3-Dichloropropene	0.0005
Di(2-ethylhexyl) phthalate	0.004
Ethylbenzene	0.680
Ethylene Dibromide	0.00002
Glyphosate	0.7
Heptachlor	0.00001
Heptachlor Epoxide	0.00001
Molinate	0.02
Monochlorobenzene	0.030
Simazine	0.01
1,1,2,2-Tetrachloroethane	0.001
Tetrachloroethylene	0.005
Thiobencarb	0.07
1,1,1-Trichloroethane	0.200
1,1,2-Trichloroethane	0.032
Trichloroethylene	0.005
Trichlorofluoromethane	0.15
1,1,2-Trichloro-1,2,2-Trifluoroethane	1.2
Vinyl Chloride	0.0005
* Xylenes	1.750
Total Trihalomethanes	0.10

*MCL is for either single isomer or the sum of the isomers.

Secondary Standards
Aesthetic Standards Established by the State of California Department of Health Services

Parameters	Units	MCL
Chloride	mg/l	250
Color	units	15
Copper	mg/l	1.0
Corrosivity		Relatively Low
Foaming Agents (MBAS)	mg/l	0.5
Iron	mg/l	0.3
Manganese	mg/l	0.05
Odor-Threshold	units	3
Specific Conductance	micromhos	900
Sulfate	mg/l	250
Thiobencarb*	mg/l	0.001
Total Dissolved Solids	mg/l	500
Turbidity	units	5
Zinc	mg/l	5.0

*Also listed as a Primary Drinking Water Standard with MCL of 0.07 mg/l.

Table 2

SYSTEMS REVIEWED WHICH USE THE DELTA AS A SOURCE OF DRINKING WATER[1/]

- Santa Rosa District
  American Canyon Water District, American Canyon (SWP--North Bay Aqueduct)

- San Francisco District
  Alameda County Flood Control and Water Conservation District, Zone #7 (SWP--South Bay Aqueduct)
  California Cities Water Company, West Pittsburg (CVP--Contra Costa Canal)
  City of Antioch (CVP--Contra Costa Canal, and San Joaquin River)
  City of Benicia (SWP--North Bay Aqueduct)
  City of Martinez and Pittsburg (CVP--Contra Costa Canal)
  Contra Costa Water District, Concord (CVP--Conta Costa Canal)
  Oakley County Water District, Oakley (CVP--Contra Costa Canal)

- Monterey District
  Santa Clara Valley Water District, San Jose (SWP--South Bay Aqueduct and CVP--San Felipe Unit)

- Stockton District
  Little Potato Slough Mutual Water Company, Terminous (Delta)

- Merced District
  City of Avenal (CVP--San Luis Canal)
  City of Coalinga (CVP--Coalinga Canal)
  City of Dos Palos (CVP--Delta-Mendota Canal)
  City of Huron (CVP--San Luis Canal)
  Lemoore Naval Air Station (CVP--San Luis Canal)
  Santa Nella County Water District (CVP--San Luis Canal)

- Santa Barbara District
  Calleguas Municipal Water District (SWP, via The Metropolitan Water District of Southern California, Los Angeles, Jensen Water Treatment Plant)

- Los Angeles District
  The Metropolitan Water District of Southern California, Los Angeles (SWP--California Aqueduct) (There are 23 member agencies covering a 6 county service area, including Los Angeles, Orange, San Bernardino, Riverside, Ventura, and San Diego counties.)

- San Bernardino District
  Crestline-Lake Arrowhead Water Agency, Crestline (SWP--Silverwood Lake)

1/ Listed North to South By Office of Drinking Water (ODW) District.
CVP is the federal Central Valley Project; SWP is California's State Water Project.
The source of the South Bay Aqueduct, San Luis Canal/California Aqueduct, Coalinga Canal, and the Delta-Mendota Canal is the Old River near Byron; Rock Slough, near Knightsen, is the source of the Contra Costa Canal; the source of the North Bay Aqueduct is Barker Slough near Rio Vista.
The City of San Francisco has an emergency, or standby, turnout from the South Bay Aqueduct; the East Bay Municipal Utility District has an emergency pumping plant at Bixler in the central Delta.

exceeding 100 ug/l. At these systems, however, the running annual average, on which compliance with the MCL is based, usually met the standard. Table 3 shows the various levels of THMs found statewide in treated Delta drinking water; those plants using chloramines as a primary disinfectant have been marked with an asterisk. Some utilities may be precluded by the Surface Water Treatment Rule (SWTR) from using chloramines only.

Adopted by EPA in 1979, the current standard for THMs is based on the potential carcinogenicity to humans of one of the THMs, chloroform. Recent information suggests that the other THMs are also potential human carcinogens; one, bromodichloromethane, has been found to be more potent than chloroform in animal studies. Besides the THMs, chlorine and most alternate disinfectants, including chloramines, ozone, and PEROXONE (combination of ozone and hydrogen peroxide), form a number of DBPs. Presently, THMs are the only DBPs for which monitoring is required. While health effects data on other DBPs are limited, EPA believes it has sufficient data to regulate haloacetic acids and bromate.

The risk associated with the current MCL for THMs is equivalent to four additional cancer cases above the background in a population of 10,000 people. EPA's policy for regulating a carcinogen at a 1-in-1 million risk level is the basis for their considering the revision of the current THM standard. The current MCL attempts to establish a balance between protecting the consumer against the potential risk of cancer and against the transmission of infectious disease. The current THM standard applies only to systems with populations of 10,000 or more which use a disinfectant in their water treatment. EPA chose not to apply the MCL to systems serving less than 10,000 people because, based on studies in 1979, the benefits in risk reduction did not outweigh the excessive cost of THM monitoring and treatment for smaller communities. However, in the future, EPA may extend the THM standard to smaller water systems.

Anticipated EPA Standards

EPA is reviewing the THM standard and expects to propose new standards in June, 1993. Currently EPA is discussing a new THM standard in the range of 50-100 ug/l, rather than the 25-50 ug/l range considered earlier. This is because the Agency is now looking more at balancing the theoretical risks of THMs with the established benefits of disinfection for inactivation of pathogenic microorganisms. EPA may also regulate the individual THMs. For example, bromodichloromethane appears to have the greatest relative risk to human health of the four THMs; it is formed preferentially in the presence of bromide ions resulting from sea water intrusion in the Delta. EPA may propose MCLs for other DBPs such as bromate, an ozonation DBP, and the haloacetic acids. Further, unlike the current THM standard, these new MCLs may affect all utilities, not just those with populations greater than 10,000. If this occurs, small utilities may not have the economic and technical capability to meet even the current standard, although variances may be available in these cases. Additionally, the SWTR, which went into effect on December 31, 1990, mandates that utilities improve their disinfection practices by June 1993. This may inadvertently cause more THM and other DBP problems in the future because the longer disinfectant contact time required by the SWTR tends to increase DBP formation.

Table 3

A SURVEY OF TRIHALOMETHANE LEVELS IN TREATED DELTA DRINKING WATER

The following are average 1989 trihalomethane (THM) levels, listed in micrograms per liter, or parts per billion. The THM regulation applies only to water systems which serve 10,000 people or more and use a disinfectant in their water treatment. Utilities which buy treated Delta water from wholesale agencies, such as the Crestline-Lake Arrowhead Water Agency, may have higher THM values (due to the use of chlorine only and the longer residence time of the water in the distribution system), or lower values (due to blending of treated Delta water with local surface water or well water).

Utility	THM Level/ug/l
Crestline-Lake Arrowhead Water Agency	176
California Cities Water Company	98
American Canyon Water District	91
Santa Clara Valley Water District, Rinconada Water Treatment Plant	90
Santa Clara Valley Water District, Santa Teresa Water Treatment Plant	87
Alameda County Flood Control and Water Conservation District, Zone #7	71
Santa Clara Valley Water District, Penitencia Water Treatment Plant	68
Contra Costa Water District	63
City of Benicia	61
Metropolitan Water District, Jensen Water treatment Plant	58
City of Martinez	49
Metropolitan Water District, Mills Water Treatment Plant *	26
City of Pittsburg *	17
City of Antioch *	10

* These plant use chloramines as the primary means of disinfection.

California Recommended Public Health Levels

In 1992, DHS will begin to establish recommended public health levels (RPHLs) for drinking water pursuant to Section 4023 of Assembly Bill 21, the California Safe Drinking Water Act. RPHLs will be solely health-based standards and will only affect utilities with more than 10,000 service connections. As they are strictly health-based, the RPHLs may be lower than the MCL for a particular contaminant. An RPHL for THMs will require that utilities treating Delta water consider all feasible measures which can help reduce the level of the contaminant to as close to the RPHL as possible. DHS will then order the utility to implement those measures which are deemed to be reasonable. Because of the potential significant changes which may occur in the MCL for THMs in the near future, the adoption of an RPHL for this group of contaminants will be deferred for now.

Chapter 4

THMs AND OTHER DBP PRECURSORS IN THE DELTA

Sources

The Department of Water Resources (DWR) has studied the sources of THM precursors, organic matter and bromide in the Delta since 1981. DWR studies have focused on several sources of THM precursors including, stream inflows, island drainage and seawater influence. To a lesser extent, other potential sources, including discharges from waste water treatment plants, have been examined.

In these studies, bromide and naturally occurring dissolved organic matter, such as humic and fulvic acids, or humic substances, have been extensively documented as total THM formation potential precursors (TTHMFPs). These substances are present in natural waters primarily as a result of the decomposition of plant matter. Bromide is found in the natural salts of sea water and is introduced into fresh water in the Delta as the water mixes with diluted sea water. The presence of bromide in the water contributes to the formation of bromine-containing THMs and DBPs during the treatment of drinking water.

TTHMFPs are indicators of precursor levels in source water; they are used to judge the relative contribution of precursor materials from agricultural drains and river waters. Unique relationships between TTHMFPs and THMs have not been established because any relationship will vary with the treatment used, the method of measuring the TTHMFPs, the bromide concentration and organic content of the source water. However, source waters with high TTHMFPs generally result in high THMs after treatment.

DWR is currently developing a model of THM precursors for use in its Delta Simulation Model used for hydrology, water quality, and planning studies. When the model is completed and calibrated, it will be possible to test theories about the relative contribution of THM precursors in the Delta. The model will provide capability to estimate the effects of Delta physical or operational modifications on concentrations of THM and other DBP precursor compounds.

Delta Island Drainage

Much of the Delta was once a vast tule marsh. Thick layers of peat were formed from the decay of the marsh vegetation, especially the great bulrush or tule, Scirpus lacustris. Islands in the central Delta tend to have the thickest layers of peat, over 30 feet at some locations. Nearly half of the Delta is covered with peat soils 10 or more feet deep. Islands located along the periphery of the Delta have a mixture of peat and mineral soils.

Located on nearly 60 islands and tracts in the Delta, 260 drainage pump stations (see Figure 4) return irrigation and seepage water to the surrounding island channels to prevent island flooding. Preliminary DWR estimates indicate that, during recent drought conditions, Delta island drainage contributed 40 to 45 percent of the organic THM precursors in Delta waters during the irrigation months April to August (1988), and 38 to 52 percent during November to February (1987-88) of the winter leaching period. The water quality impact of Delta island drainage during drought years is expected to be markedly greater than during normal years, but data for normal years are not available.

Various scientific studies of the characteristics of organic THM precursor materials show distinct differences between drain and river water samples taken from the Delta. Drain water samples have about four times greater TTHMFP[1/] and ten or more times greater overall potential for forming DBPs than river water. In addition, drain water contains heavier and larger sized humic molecules than river water samples. The characteristics of organic THM precursors found in drain and river samples are distinct enough to indicate that THM precursor compounds in drainage are predominantly from Delta island peat soils and not primarily a result of the concentrating effects from evaporation of irrigation water applied to Delta fields.

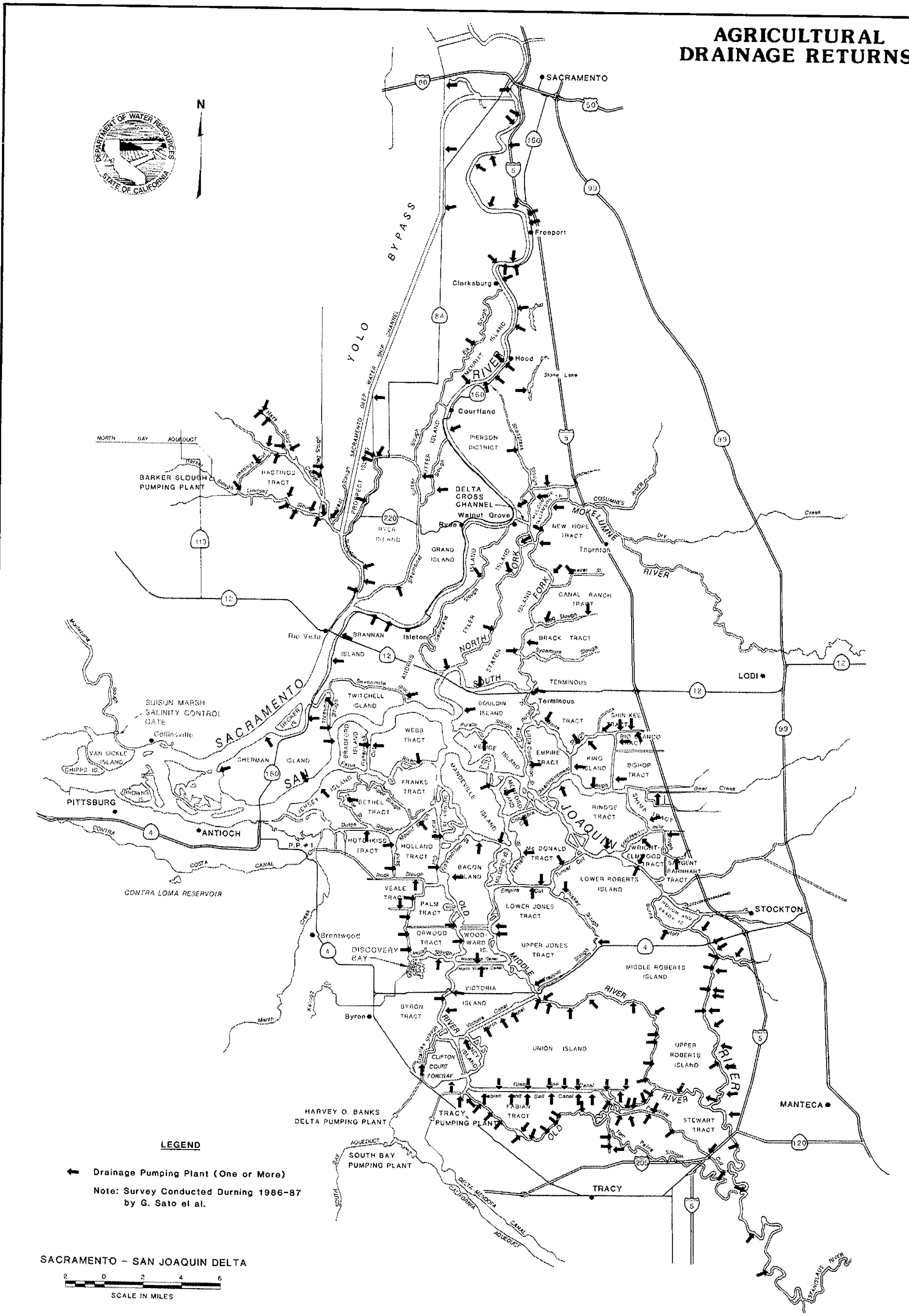
The volume of drainage discharges corresponds to seasonal agricultural activities on the islands. There is a summer peak of drainage flow, typically in July and August, corresponding to increased irrigation during that period. There is also a winter peak, typically observed in December and January, resulting from rain runoff and the flooding of fields to leach out salts accumulated in the soil. In general, the concentrations of island drainage water TTHMFP are correlated with island soil type. For example, August maximum TTHMFP concentrations were higher (2000 to 4000 ug/l) on islands with the greatest amounts of peat soils and lower (under 1000 ug/l) on islands with mineral soils. Similar patterns are observed during the winter drainage peak. DWR tests of Delta soil extracts have shown that peat soils have a higher capacity to produce TTHMFP (61,000 ug TTHMFP/kg) than mineral soils (27,000 ug TTHMFP/kg).

Rivers

The Sacramento River is the largest source of fresh water flowing into the Delta. The TTHMFP concentrations (170 to 420 ug/l in 1990) in samples from the Sacramento River at Greenes Landing are significantly lower than downstream stations. During the drought, the Sacramento River has been virtually the only source of fresh water exported through the Harvey O. Banks Delta Pumping Plant (Banks Pumping Plant) and North Bay Pumping Plant of the State Water Project, and the only source pumped into the Contra Costa Canal by Contra Costa Water District.

1/ *DWR modified EPA's "total trihalomethane formation potential" (TTHMFP) assay to compare the THM precursor content of source water supplies.*

Figure 4


AGRICULTURAL
DRAINAGE RETURNS
SACRAMENTO
Freeport
Clarksburg
Hood
Courtland
YOLO
BYPASS
PIERSON
DISTRICT
BARKER SLOUGH
PUMPING PLANT
HASTINGS
TRACT
DELTA
CROSS
CHANNEL
Walnut Grove
RYER
ISLAND
GRAND
ISLAND
NEW HOPE
TRACT
Thornton
CANAL RANCH
TRACT
BRACK TRACT
Rio Vista
BRANNAN
ISLAND
Isleton
TERMINOUS
Terminous
LODI
SUISUN MARSH
SALINITY CONTROL
GATE
Collinsville
VAN SICKLE
ISLAND
CHIPPS IS.
SACRAMENTO
TWITCHELL
ISLAND
SHERMAN
ISLAND
BOULDIN
ISLAND
WEBB
TRACT
FRANKS
TRACT
BETHEL
TRACT
HOTCHKISS
TRACT
HOLLAND
TRACT
BACON
ISLAND
VENICE
ISLAND
EMPIRE
TRACT
KING
ISLAND
BISHOP
TRACT
RINDGE
TRACT
MANDEVILLE
ISLAND
McDONALD
TRACT
LOWER ROBERTS
ISLAND
WRIGHT-
ELMWOOD
TRACT
SARGENT
BARNHART
TRACT
PITTSBURG
ANTIOCH
CONTRA
COSTA
CANAL
CONTRA LOMA RESERVOIR
Brentwood
DISCOVERY
BAY
VEALE
TRACT
PALM
TRACT
ORWOOD
TRACT
WOOD-
WARD
IS.
LOWER JONES
TRACT
UPPER JONES
TRACT
STOCKTON
MIDDLE ROBERTS
ISLAND
VICTORIA
ISLAND
BYRON
TRACT
Byron
UNION ISLAND
UPPER
ROBERTS
ISLAND
CLIFTON
COURT
FOREBAY
FABIAN
TRACT
STEWART
TRACT
MANTECA
HARVEY O. BANKS
DELTA PUMPING PLANT
TRACY
PUMPING PLANT
SOUTH BAY
PUMPING PLANT
TRACY
DELTA MENDOTA
CANAL
CALIFORNIA
AQUEDUCT
LEGEND
Drainage Pumping Plant (One or More)
Note: Survey Conducted Durning 1986-87
by G. Sato el al.
SACRAMENTO - SAN JOAQUIN DELTA
SCALE IN MILES
DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA

Water flowing into the Delta from the San Joaquin River near Vernalis is a mixture of Central Valley agricultural drainage and fresh water. TTHMFP concentrations in the San Joaquin River (270 to 650 ug/l at Vernalis in 1990) are higher than in the Sacramento River; however, as previously mentioned, virtually none of the San Joaquin River flow reaches the Banks Pumping Plant during low flow conditions. Some San Joaquin River water diverted at the Delta Mendota Canal does mix with State Water Project water at San Luis Reservoir south of the Delta. During normal and wet years, the proportion of San Joaquin River water exported from the southern Delta is larger than during low flow periods. In high flow conditions, the majority of water exported from the southern Delta can be of San Joaquin River origin; during these times, the quality of the San Joaquin River improves, and TTHMFP concentrations are typically in the same range observed in the Sacramento River during similar hydrologic conditions.

Sources of THM precursors in the rivers tributary to the Delta include upstream agricultural discharges, treated waste water effluents, surface and urban runoff, and instream sources (algae and the soils of the river bottoms).

Waste Water Discharges

DWR measured TTHMFP in the effluents of the Sacramento Main Waste Water Treatment Plant, Stockton East, and City of Vacaville Waste Water Treatment Plant as part of a limited study conducted in 1981. TTHMFP in the filtered effluents ranged from low to moderate (110 ug/l to 320 ug/l). By comparison, the 1983 to 1990 average TTHMFP in the Sacramento River at Greenes Landing is 290 ug/l; the American River average is 220 ug/l. The low TTHMFP concentrations in waste water effluents, combined with small relative flows as compared to the receiving waters, indicates that treated waste water is probably not a major TTHMFP loading source.

In-Channel Delta Contributions

Other sources of THM precursors may be found in the Delta itself. Decaying plant materials in the channels and phytoplankton blooms (algae) contribute to the THM precursor loading of the Delta, as may the soils of the river channels. Currently, there is no direct means of determining the relative contribution from these in-channel sources.

The Effect of Sea Water Intrusion

Sea water intrusion is a major source of THM precursors, particularly bromide in the western Delta; this is especially true when Delta outflow is insufficient to control salinity in the Delta. Pumping from the southern Delta by the Central Valley Project and State Water Project, low river inflows, and flood tides have the potential to cause reversal of the direction of natural river flows in the southern Delta. When reverse flow conditions occur, saline Bay water is blended with the river water flowing toward the state and federal pumps. Since sea water has high amounts of bromide, intrusion significantly affects the quality of Delta water withdrawn at the Contra Costa Water District, State Water Project, and Central Valley Project intakes.

The relative contribution of bromide from sea water intrusion is substantial. Preliminary data from 1990 show that 84 to 98 percent of the bromide in the California Aqueduct probably came from seawater. During that year, bromide in the Sacramento River measured at Greenes Landing ranged from 10 to 44 ug/l (parts per billion). Bromide concentrations measured at Banks Pumping Plant (State Water Project) ranged from 250 to 580 ug/l in some months, up to 58 times the concentration found in the Sacramento River.

Bromide exacerbates the problem of meeting the THM maximum contaminant level for drinking water in that the presence of bromide complicates treatment and affects the range of effective treatment options. Because THM compounds containing bromine atoms (brominated methanes) are heavier than their chlorinated counterparts, fewer molecules are required to exceed the THM MCL, as compared to chloroform, the THM which contains only chlorine.

Chapter 5

SURVEY OF OPERATING EXPERIENCES OF USERS OF BAY-DELTA WATER SUPPLIES

This chapter summarizes the operating experiences of the users of Delta water. A questionnaire was developed (See Appendix, Treatment Plant Questionnaire) and forwarded to thirteen water agencies which use water taken from the Sacramento-San Joaquin Delta. These agencies are:

Alameda County Water District
Alameda County Flood Control and Water Conservation District (Zone 7)
Antelope Valley-East Kern Water Agency (AVEK)
Contra Costa Water District
Crestline-Lake Arrowhead Water Agency
Los Angeles Department of Water and Power (LADWP)
Napa County Flood Control and Water Conservation District
Palmdale Water District
San Bernardino Valley Municipal Water District (SBVMWD)
San Gabriel Valley Municipal Water Agency
Santa Clara Valley Water District
Solano County Flood Control and Water Conservation District
The Metropolitan Water District of Southern California (MWD)

(Figures 5 and 6 are maps showing the locations of these agencies in terms of the Delta or their relationship with the State Water Project).

Conducted in late March and early April 1991, follow-up visits by DWR staff to individual districts and agencies were also conducted to confer with the plant operators and/or superintendents; they were intended to gain additional insight concerning the operational issues addressed by the questionnaires. Tables 4 through 6 summarize responses to the questionnaire.

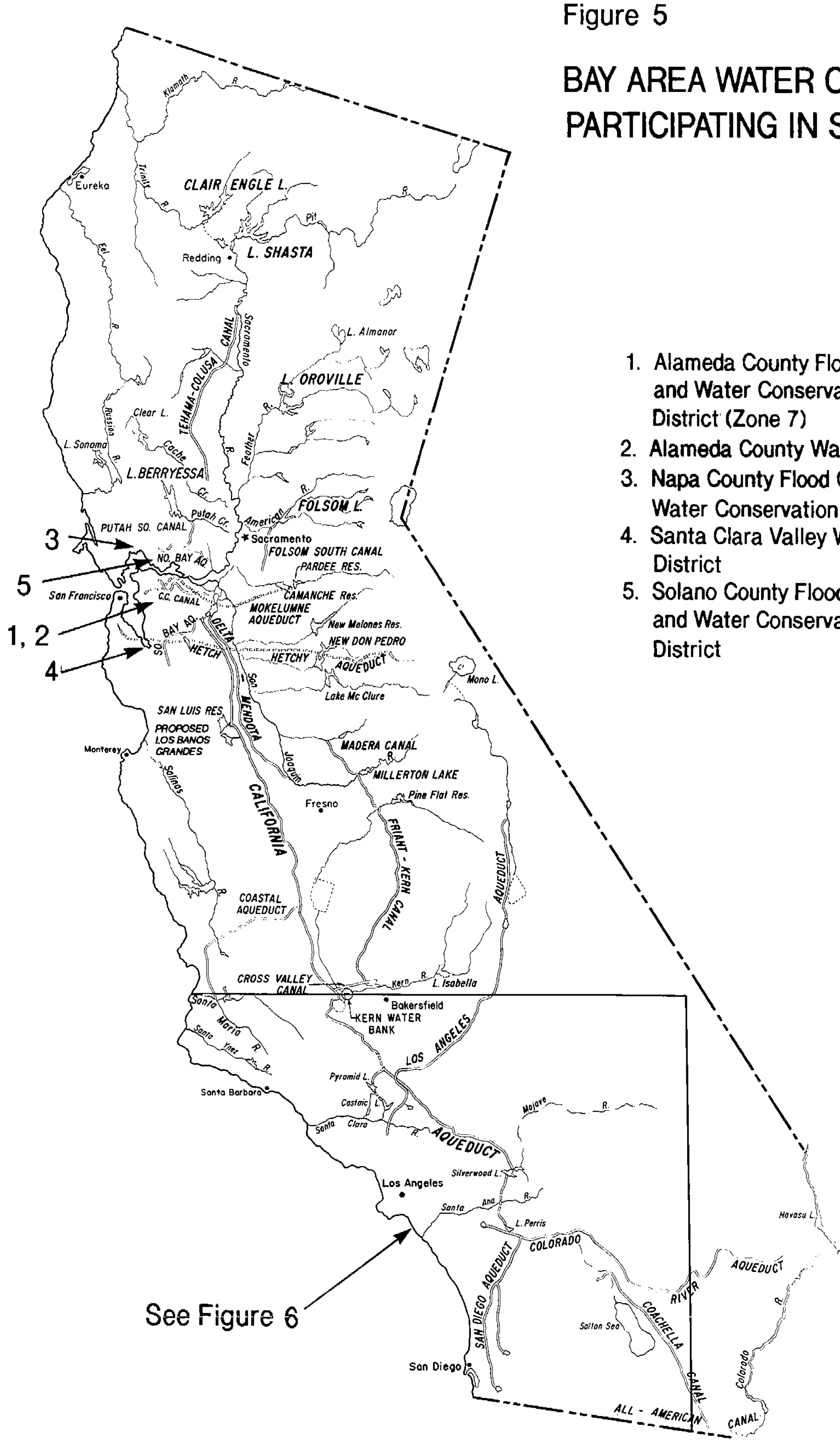
Alameda County Water District

Alameda County Water District's only facility is the Mission San Jose Water Treatment Plant. The plant, constructed in 1975 and modified in 1989, has a capacity of 10 mgd and serves a population of approximately 52,000; it uses 100 percent SWP water.

The problems that the District has experienced with SWP water are algal blooms, taste and odor, changes in turbidity, and high THMs. A public health notification has never been required but some consumer complaints concerning taste and odor have been registered. A modification for ozone treatment, which may cost about $7.2 million, is being studied. A new treatment plant with a capacity of 28 mgd is under construction which will also be served by the SWP. The plant, whose estimated construction cost is $40 million, will be of conventional design and will use ozone in the pre-disinfection process and chloramine in the post-disinfection process.

Figure 5

BAY AREA WATER CONTRACTORS PARTICIPATING IN SCR 55 SURVEY



1. Alameda County Flood Control and Water Conservation District (Zone 7)
2. Alameda County Water District
3. Napa County Flood Control and Water Conservation District
4. Santa Clara Valley Water District
5. Solano County Flood Control and Water Conservation District

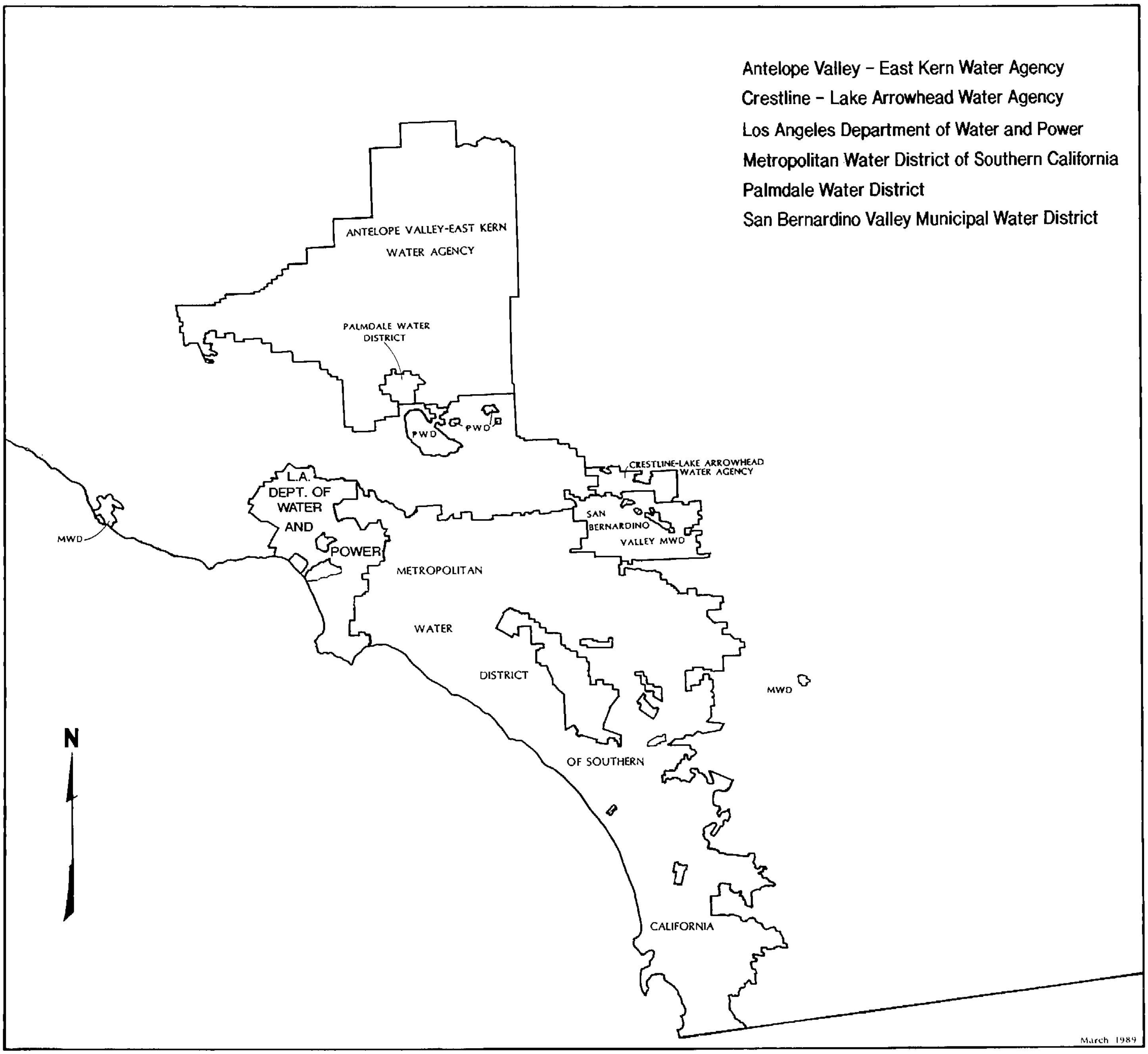


Figure 6

SOUTHERN CALIFORNIA WATER CONTRACTORS PARTICIPATING IN SCR 55 SURVEY

TABLE 4

WATER TREATMENT PLANT SURVEY
(FOR SCR 55)
GENERAL DATA

WATER AGENCY	PLANT NAME	LOCATION	YEAR BUILT	CAPACITY (mgd)	OUTPUT (mgd)	POPULATION SERVED BY DISTRICT
ALAMEDA CO WTR DIST	MISSION SAN JOSE WTP	FREMONT, CA	1975	10.	10.	52,000
AVEK	ROSAMOND	ROSAMOND, CA		14.	4.	
AVEK	EASTSIDE	PEARBLOSSOM, CA		10.	1.6	
AVEK	ACTON	ACTON, CA	1990	2.	1.6	
AVEK	QUARTZ HILL	6500 WEST AVE. N, QUARTZ HILL,	1978	55.	22.	90,000
CITY OF NAPA	JAMESON	NAPA, CALIFORNIA	1967	15.	15.	70,000
CONTRA COSTA	RALPH D. BOLLMAN	CLYDE, CA	1968	100.	35.	200,000
CRESTLINE	CRESTLINE TRTMNT PLT	SILVERWOOD LAKE	1973	10.	5.	50,000
LADWP	L.A. AQUEDUCT FILT	LOS ANGELES, CA	1987	600		
MWD	ROBERT B. DIEMER	3922 VALLEY VIEW, YORBA LINDA	1963	400.	299.	
MWD	HENRY J. MILLS	RIVERSIDE, CALIFORNIA	1978	150.	48.4	
MWD	WEYMOUTH	3201 WHEELER, LA VERNE, CA	1940	400.	200.	
MWD	ROBERT A. SKINNER	33740 BOREL RD., WINCHESTER	1976	320.	182.	
MWD	JENSEN	GRANADA HILLS	1972	400	200.	15,000,000
PALMDALE WATER DISTR	PALMDALE	700 E AVE. S, PALMDALE, CA	1987	12.	4.2	64,000
SAN BERNARDINO MWD	HORACE HINKLEY	1604 CROFTON AVE. MENTONE, CA	1987	12.	12.	
SAN BERNDARDINO MWD	HENRY TATE	3005 MILL CREEK RD.	1967	20.	12.	131,000
SANTA CLARA VLLY WD	RINCONADA WTP	LOS GATOS, CA	1967	75.	75.	
SANTA CLARA VLLY WD	SANTA TERESA WTP	SAN JOSE, CA	1989	100.	35.	
SANTA CLARA VLLY WD	PENITENCIA WTP	SAN JOSE, CA	1974	42.	42.	1,500,000
SOLANO CO. WA	BENICIA	LAKE HERMAN RD, BENICIA, CA	1971	12.	4.	25,000
ZONE 7	DELLE VALLE WTP	LIVERMORE, CA	1975	36.	22.	
ZONE 7	PATTERSON PASS	LIVERMORE, CA	1962	13.	13.	140,000

TABLE 5

WATER TREATMENT PLANT SURVEY
(FOR SCR 55)
WATER USAGE AND QUALITY PROBLEMS

WATER AGENCY	PLANT NAME	WATER SOURCE	PERCENT BLEND DELTA WATER	ALTERNATE WATER SOURCE	WQ PROBLEMS DELTA WATER	WQ PROBLEMS ALT SOURCE	WQ PROBLEMS DROUGHT
ALAMEDA CO WTR DIST	MISSION SAN JOSE WTP	DELTA	100		T&O, TURBIDITY, THMS		THMS DUE TO HIGH BROMIDES
AVEK	ROSAMOND						
AVEK	EASTSIDE						
AVEK	ACTON						
AVEK	QUARTZ HILL	DELTA	100	GROUND WATER	T&O, HIGH THM EXCEEDS THM CRITERIA		INCREASED BROMIDE LEVELS
CITY OF NAPA	JAMESON	DELTA	80		HIGH THMS, TASTE AND ODOR	TASTE AND ODOR	INCREASE IN COSTS
CONTRA COSTA	RALPH D. BOLLMAN	DELTA	100		HIGH THMS, TASTE AND ODOR		HIGH CHLORIDES,THMS,ORGANICS
CRESTLINE	CRESTLINE TRTMNT PLT	SWP	100		HIGH THMS, COLOR, TASTE AND ODOR		
LADWP	L.A. AQUEDUCT FILT.	OWENS VALLEY	0-75	MONO BASIN	VARYING THMS,CHLORIDE,BROMIDES		ELEVATED BROMIDES
MWD	ROBERT B. DIEMER	LAKE MATHEWS & SILVER-WOOD LAKE	26	COLORADO RIVER	HIGH THMS DUE TO INCREASED BROMIDES		ELEVATED BROMIDES DUE TO SEAWATER INTR.
MWD	HENRY J. MILLS	SILVERWOOD LAKE	100		HIGH THMS DUE TO INCREASED BROMIDES		ELEVATED BROMIDES DUE TO SEAWATER INTRUSION
MWD	WEYMOUTH	LAKE MATHEWS & SILVER-WOOD LAKE	31	COLORADO RIVER	HIGH THMS DUE TO INCREASED BROMIDES/T&O		ELEVATED BROMIDES DUE TO SEAWATER INTRUSION
MWD	ROBERT A. SKINNER	LAKE SKINNER	54	COLORADO RIVER	HIGH THMS DUE TO INCREASED BROMIDES		ELEVATED BROMIDES DUE TO SEAWATER INTRUSION
MWD	JENSEN	CASTAIC LAKE	100		HIGH THMS DUE TO INCREASED BROMIDES		ELEVATED BROMIDES DUE TO SEAWATER INTRUSION
PALMDALE WATER DISTR	PALMDALE	LOCAL SURFACE	43	GROUND WATER	VAR. IN TURBIDITY, T&O,THM		
SAN BERNARDINO MWD	HORACE HINKLEY	SANTA ANA RIVER	18	GROUND WATER	RED WATER	SAND,AIR	
SAN BERNDARDINO MWD	HENRY TATE	MILL CREEK	0	GROUND WATER			AIR, LOW CAPACITY WELLS
SANTA CLARA VLLY WD	RINCONADA WTP	SOUTH BAY AQUEDUCT	90	LOCAL RUNOFF	THMS, TASTE-AND-ODOR, TURBIDITY SPIKES		INCREASED BROMIDE LEVELS LEADING TO THMS
SANTA CLARA VLLY WD	SANTA TERESA WTP	S BAY AQ, SN LUIS RS	90	LOCAL RUNOFF	THMS, TASTE-AND-ODOR, TURBIDITY SPIKES		INCREASED BROMIDE LEVELS LEADING TO THMS
SANTA CLARA VLLY WD	PENITENCIA WTP	DELTA	90	LOCAL RUNOFF	THMS, TASTE-AND-ODOR, TURBIDITY SPIKES		INCREASED BROMIDE LEVELS LEADING TO THMS
SOLANO CO. WA	BENICIA	NORTH BAY	100		SLIGHTLY HIGHER TURB.&THM		
ZONE 7	DELLE VALLE WTP	DELTA	75		HIGH THMS		HIGHER THM PRECURSORS
ZONE 7	PATTERSON PASS	DELTA	100		HIGH THMS		HIGHER THM PRECURSORS

TABLE 6

WATER TREATMENT PLANT SURVEY
(FOR SCR 55)
TREATMENT PROCESSES

WATER AGENCY	PLANT NAME	PREDISINFECTANT	PRIMARY COAGULANT	COAGULANT AID	SEDIMENTATION (Y/N)	FILTRATION MEDIA	POST DISINFECTION	COMMENTS
ALAMEDA CO WTR DIST	MISSION SAN JOSE WTP	CHLORINE	ALUM	POLYELECTROLYTE	Y		CL_2 & NH_3	
AVEK	ROSAMOND							
AVEK	EASTSIDE							
AVEK	ACTON							
AVEK	QUARTZ HILL							N. FEEDER 15 DAY DETENT. TIME RESULTS IN HIGHER THM CONCENTRATIONS
CITY OF NAPA	JAMESON							
CONTRA COSTA	RALPH D. BOLLMAN	CHLORINE	ALUM		Y	ANTH COAL,SAND,GRAVEL	CL_2 & NH3	
CRESTLINE	CRESTLINE TRTMNT PLT	CHLORINE	ALUM		Y		CHLORINE	HAS HAD PROBLEMS WITH THMS. QUARTERLY RUNNING ANNUAL AVGS HAVE VARIED BETWEEN 127 AND 198 ug/L
LADWP	L.A. AQUEDUCT FILT	OZONE					CHLORINE	MAY GO TO CHLORAMINES
MWD	ROBERT B. DIEMER	CHLORINE	ALUM	POLYMERS	Y	ANTH COAL,SAND,GRAVEL	CL_2 & NH_3	PRODUCING THMS AT MCL
MWD	HENRY J. MILLS	CHLORINE & AMMONIA	ALUM	POLYMERS	Y	ANTH COAL,SAND,GRAVEL	CL_2 & NH_3	WITH PRECHLORINATION
MWD	JENSEN	CHLORINE	ALUM	POLYMERS	Y	ANTH COAL,SAND,GRAVEL	CL_2 & NH_3	NOW ADD AMMONIA AT HEAD
MWD	WEYMOUTH	CHLORINE	ALUM	POLYMERS	Y	ANTH COAL,SAND,GRAVEL	CL_2 & NH_3	OF PLANT
MWD	ROBERT A. SKINNER	CHLORINE	ALUM	POLYMERS	Y	ANTH COAL,SAND,GRAVEL	CL_2 & NH_3	
PALMDALE WATER DISTR	PALMDALE							1990 4TH QTR THM = 107 ppb
SAN BERNARDINO MWD	HORACE HINKLEY	CHLORINE	ALUM		Y	ANTH COAL,SAND,GRAVEL	CHLORINE	
SAN BERNDARDINO MWD	HENRY TATE	CHLORINE	NALCO 8101	NALCO 8151	Y	ANTH COAL,SAND,GRAVEL	CHLORINE	
SANTA CLARA VLLY WD	RINCONADA WTP	CHLORINE	ALUM	CATIONIC POLYMER	Y	ANTH COAL,SAND,GRAVEL	CL_2 & NH_3	PRODUCING THMS AT MCL. MAY EXCEED WITH CONTINUED DROUGHT.
SANTA CLARA VLLY WD	SANTA TERESA WTP	CHLORINE	ALUM	CATIONIC POLYMER	Y	ANTH COAL,SAND,GRAVEL	CL_2 & NH_3	
SANTA CLARA VLLY WD	PENITENCIA WTP	CHLORINE	ALUM	CATIONIC POLYMER	Y	ANTH COAL,SAND,GRAVEL	CL_2 & NH_3	
SOLANO CO. WA	BENICIA	CHLORINE	ALUM		Y	ANTH COAL,SAND,GRAVEL		
ZONE 7	DELLE VALLE WTP	CHLORINE	ALUM	CATIONIC POLYMER	Y	ANTH COAL,SAND,GRAVEL	CL_2 & NH_3	
ZONE 7	PATTERSON PASS	CHLORINE	ALUM	CATIONIC POLYMER	Y	ANTH COAL,SAND,GRAVEL	CL_2 & NH_3	

NOTE: ANTH. COAL DENOTES ANTHRACITE COAL
CL_2 DENOTES CHLORINE
NH_3 DENOTES AMMONIA

Alameda County Flood Control and Water Conservation District (Zone 7)

Zone 7 has two facilities, the Del Valle Water Treatment Plant and the Patterson Pass Water Treatment Plant. The Patterson plant, constructed in 1962 with capacity of 9 mgd, was upgraded in 1986 to a capacity of 13 mgd; it uses 100 percent SWP water. The Del Valle plant, expanded to 36 mgd in 1990, uses approximately 75 percent SWP water. Both plants serve a combined population of 140,000 people.

The District has experienced problems with high turbidity, THMs, TDS and chlorides; it has also experienced taste and odor problems. The District attributes the high THM precursors to low inflows into the Sacramento-San Joaquin Delta and the high bromide levels to seawater intrusion. It has never issued a public health notification; however, one of its retailers, the City of Livermore, released notifications in the 2nd and 3rd quarters of 1984 because the running annual averages for THMs were above the 0.10 mg/l standard. Zone 7 has replaced chlorine with chloramines to lower THMs during disinfection; it is planning to construct an ozone facility to meet future drinking water standards.

Antelope Valley-East Kern Water Agency (AVEK)

AVEK, whose primary water source is the SWP, is serviced by Eastside, Rosamond, Acton and Quartz Hill Treatment Plants. Department staff visited Quartz Hill, the largest, and Acton, the newest. Completed this year, Acton is a relatively small, fully automated plant, with a capacity of 2 million gallons per day (mgd). Since the plant was not yet on-line, information concerning treatment problems was unavailable. Quartz Hill, the Agency's largest plant with a capacity of 55 mgd, was constructed in 1978 and was expanded in 1988.

Ground water may occasionally be used as an alternative water source. The area originally had a great abundance of ground water. As recent as 40 years ago, the ground water level was approximately 5 to 8 feet below the surface; presently, the level is at 300 to 340 feet below the surface. The Agency presently serves a population of 90,000. Since population in this area is growing constantly, future expansions are expected.

AVEK's main problems associated with SWP water are taste and odor (infrequently) and high THMs. AVEK has issued public health notifications for THMs and has had consumer complaints about taste and odor, THMs, and chlorine residual odors. AVEK feels that all these problems are related to the quality of SWP water. Increased bromide levels have been identified in their source water due to the drought. Presently, these problems are being corrected by blending treated water with ground water. This is only a temporary measure, and modifications to the plant will be necessary to meet future drinking water standards, especially THMs. AVEK experiences numerous problems because of its large geographical service area and small population. One problem in particular is the distribution system's feeder line in which water has a 15-day detention time and chlorine residuals form high levels of THMs.

Contra Costa Water District

Contra Costa has one treatment facility, the Ralph D. Bollman Water Treatment Plant which was constructed in 1968, with expansions and modifications in 1986. The plant, which uses 100 percent Delta water, has a capacity of 100 mgd and serves a population of 200,000.

The District is experiencing problems with taste and order, high THM readings, hardness, and high chloride and sodium levels. The District has never issued a public health notification, but has had consumer complaints concerning taste and odor, corrosion problems, and residue left on dishes. The District is constructing a new water treatment facility which will use ozone; it is also studying the possibility of constructing a reservoir on Kellogg Creek. The water from this site will mix higher quality water with Delta water to assist them with the control of THMs as well as reduce sodium and chloride levels. Contra Costa is also considering the possibility of a desalination plant and a new intake at Middle River in the Delta.

Crestline-Lake Arrowhead Water Agency

Crestline, with a capacity of 10 mgd, has one treatment plant which wholesales water to a number of utilities serving between 25,000 and 50,000 people. The plant was constructed in 1973 and has expanded with the addition of two more filters. Crestline uses 100 percent SWP water, with occasional local runoff from Houston Creek during wet years.

Crestline's major problem is high THMs, the running annual averages for each quarter of 1989 through 1990, respectively, being 176, 193, 198, 176, 162, 131, 128, 127 ug/l. Crestline stated that maintaining the required chlorine residual is contributing to the high THMs. The drinking water standard for utilities serving more than 10,000 people is 100 ug/l. Although no formal public health notification has been issued, the public has been informed through the annual water quality reports to customers that THM levels greater than the THM standard have occurred.

Color and taste and odor are also problems. Crestline has been authorized to design and construct an additional facility at the plant to recycle and pretreat waste water. Further improvements, when required, will include chloramination and/or ozone and will cost approximately $4 million, an amount which will greatly affect their future budget.

Los Angeles Department of Water and Power (LADWP)

The Department's Los Angeles Aqueduct Filtration Plant, constructed in 1987, has a capacity of 600 mgd and cost $146 million. LADWP uses ozone for pretreatment and stores the water in an open reservoir. The water is then chlorinated when it is pumped to the District's feeder stations. Most of its water comes from the Owens Valley and Mono Basin, but the Department has been increasing its consumption of SWP water. Since 1986, the percentage of SWP water has varied from 0 to 100 percent, and currently averages about 65 percent.

LADWP has experienced fluctuations in their THM levels attributable to the percentage of SWP water used. During periods when the Department increases the amount of SWP water from Metropolitan Water District, THM levels increase from approximately 30 ug/l in water containing no SWP supplies to approximately 70 ug/l in water containing 75 percent SWP supplies. Chloride and bromide levels also increased when SWP water usage is increased. LADWP has plans for a corrosion study using water from the Delta to evaluate corrosion rates for raw and treated water; it also has the option to convert to post chloramination should the Disinfection By-Product Rule changes require different post-chlorination procedures.

Napa County Flood Control and Water Conservation District

Napa has one treatment facility, the Jameson Canyon Water Treatment Plant. Constructed in 1967, with numerous improvements in 1988, it has a capacity of 15 mgd and serves a population of 70,000. Napa normally uses 50 percent SWP water, but during the drought has increased its usage to 80 percent.

Jameson has experienced problems with high THMs, taste and odor, and high turbidity. However, a public health notification has never been issued. Napa is controlling THMs by applying potassium permanganate as a pre-treatment. The main problem is an increase in treatment costs due to an increase in usage of SWP water.

Palmdale Water District

Palmdale Water District has one treatment plant, supplying a population of 64,000 and having a capacity of 12 mgd. It was constructed in 1987; an expansion to raise the capacity to 30 mgd is planned for the near future. Approximately 43 percent of Palmdale's water comes from the SWP, and the remainder from ground water sources.

Palmdale has experienced problems with fluctuating turbidity, THMs, and taste and odor. SWP water is blended with ground water to control THM problems. Palmdale Reservoir is used to store SWP water before treatment. Algal blooms in the reservoir have led to numerous taste and odor problems which have increased treatment costs. Palmdale is studying a proposal to construct a pipeline around the reservoir.

San Bernardino Valley Municipal Water District (SBVMWD)

SBVMWD has two treatment plants, the Horace Hinkley Water Filtration Plant and the Henry Tate Water Treatment Plant. The Tate Plant is the oldest facility, being constructed in 1967, with a plant capacity of 20 mgd. It uses no SWP water. Servicing a population of 66,000, the Tate plant has experienced problems directly related to the ground water supply (air, sand, etc.).

The Horace Hinkley Plant was built in 1987 and has a plant capacity of 12 mgd and a service population of 65,000. The plant uses between 4 to 18 percent SWP water, with other supply sources including ground water and the Santa Ana River. They have a supply canal that combines water from the SWP and water from other sources. During the visit, the plant was off-line due to a mud slide which damaged the canal downstream from the connection point.

The Hinkley plant has experienced problems with THMs and total dissolved solids (TDS). SBVMWD issued a public health notification in 1985 due to detectable levels of volatile organic compounds (VOCs). Lower than normal ground water levels have led to consumer complaints about sand and air in the water. They also have had a few complaints about "red water" which they attribute to SWP water. Both plants have plans for future modifications due to changes in federal and state surface water treatment, coliform, and ground water regulations. The District staff anticipate that DBPs and radon regulations will have major impacts on projected budgets and will cause major increases in water rates.

San Gabriel Valley Municipal Water Agency

San Gabriel Valley MWA uses SWP water for ground water recharge and currently does not operate any water treatment plants.

Santa Clara Valley Water District

The District serves a population of 1.5 million. Between 90 to 100 percent of the District's supply comes from the Delta through the South Bay Aqueduct and the San Felipe Division of the Central Valley Project. Santa Teresa, Rinconada, and Penitencia are the water treatment facilities operated by Santa Clara Valley Water District. Santa Teresa was constructed in 1989, with a plant capacity of 100 mgd; Rinconada was built in 1967, with a plant capacity of 75 mgd; and Penitencia, in 1974, with a plant capacity of 42 mgd.

Santa Clara Valley's main concerns are elevated THMs, occasional turbidity spikes, and taste and odor problems. The District has never been required to issue a public health notification to consumers, although some consumer complaints due to taste and odor have been received. The District has experienced elevated bromide levels. The Rinconada facility has been producing THMs at the MCL. The District believes that, with increased bromide levels, the MCL could be exceeded; it plans future improvements to their facilities to meet new drinking water standards. Improvements solely for the purpose of meeting new standards are estimated to cost between $60 to $200 million.

Solano County Flood Control and Water Conservation District

There are three water treatment facilities in Solano County: the North Bay Regional Water Treatment Plant, constructed in 1990; the Benicia Water Treatment Plant, constructed in 1971; and the Fleming Hill Treatment Plant, constructed in the mid-1950s. The North Bay plant, constructed as a joint venture between Fairfield and Vacaville, has a capacity of 40 mgd. The North Bay Plant is presently using 100 percent North Bay Aqueduct (NBA) water, but has the option of using Putah South Canal (PSC) water. Fleming Hill uses a 50-50 mix between NBA (Delta) and Lake Berryessa water. Future plans include increasing the amount of water from Lake Berryessa to control chronic taste and odor problems associated with organic matter in the NBA. Expanded in 1989, Benicia's plant has a capacity of 12 mgd and serves 25,000 people; it receives 100 percent of its water from the NBA.

NBA water causes problems with flocculation at the North Bay Regional Water Treatment Plant. Prior NBA/PSC mix required about 18 milligrams per liter (mg/l) alum. This spring an abrupt switch to 100 percent NBA water required alum dosages as high as 90 mg/l to control turbidity. Ozone is used for primary disinfection.

The Benicia Plant has encountered slightly elevated turbidity and THM values. Presently, no drought related problems are being experienced and no public health notifications have been issued. Only a few consumer complaints have been received, particularly when the Plant switched to NBA water which was "softer" than consumers had previously experienced. Fleming Hill has little capability for taste and odor control and has no THM treatment ability. The chemical feed portion of the plant is being upgraded, and a contractor has been hired to design an ozone facility.

The Metropolitan Water District of Southern California (MWD)

MWD treatment plants include Weymouth, Diemer, Jensen, Skinner and Mills. These plants serve a total population of 15 million. The oldest plant is Weymouth, with a capacity presently rated at 520 mgd; it was constructed in 1940, with expansions in 1950, 1960, and 1970. The plant is presently using approximately 24 percent SWP water, with the remainder coming from the Colorado River. MWD is constructing an ozone treatment demonstration plant at Weymouth, with a capacity of 5 mgd. The District's newest plant is Mills, constructed in 1978 and expanded in 1989, with a current capacity of 150 mgd. Mills and the Jensen plant use 100 percent SWP water; all other plants mix SWP water with Colorado River water.

MWD's main concern with SWP water is elevated bromide levels which, in turn, cause higher THM values. The agency stated that at times its approaches the 100 ug/l THM standard because of elevated bromide; it is also concerned about high organic precursors in SWP water from agricultural drainage. No public health notifications for THMs have been issued, but high levels of THMs have caused MWD to resort to the usage of chloramines only at the Mills plant. According to MWD, the SWTR will not allow chloramines only as an acceptable primary disinfectant at the Mills plant. The agency has minimal taste and odor problems due to algal activity in Castaic Lake and Lake Silverwood. However, extensive taste and odor problems in Lake Perris have periodically precluded its use as a water supply reservoir during the summer months. In the future, the agency foresees switching to ozone/PEROXONE as a primary disinfectant. The implementation of this type of treatment depends on the outcome of their ozone demonstration study at the Weymouth plant. However, MWD believes that the formation of bromate during ozonation of SWP water (due to bromide from sea water intrusion in the Delta) may impact the viability of ozone as an alternate disinfection strategy.

Chapter 6

OPTIONS TO USING DELTA WATER AND MEETING DRINKING WATER STANDARDS

Options include:

A. Alternatives to, or Modifications of Disinfection and/or other Treatment Plant Processes; and/or
B. Physical Facilities

Increasing concern about anticipated EPA standards for THMs has many California utilities reconsidering the traditional use of chlorination for disinfection and looking at alternatives to minimize THMs. Even with THM formation, chlorine is still the most widely used disinfectant in the United States because of its ease of use and low cost. There are two alternative disinfectants to chlorine currently available which can help minimize the formation of THMs: chloramine and ozone. Chlorine dioxide is another possible disinfectant whose use in California is precluded by DHS policy.

For utilities faced with high levels of THMs, there are limited treatment strategies:

A-1. Remove or reduce organic THM precursors (i.e., organic matter) prior to disinfection, that is, pre-treatment;

A-2. Modify or substitute disinfection practices;

A-3. Removing THMs after they have been formed, or post-treatment, is not an option. At this time, there is no post-treatment technology available to reduce THM levels effectively.

A-1. Pre-treatment

Many health officials believe that the best approach to avoid THMs is to reduce the precursor levels in the raw water that help produce them in the first place. One way this can be accomplished is by blending one water source which is high in organic matter with another which is low in precursors. Many California utilities already employ blending for control of THMs (and, incidentally, for reduction of nitrates in groundwater sources).

If a utility lacks an alternate water source, organic THM precursors can also be reduced with optimized conventional water treatment. Many utilities already do this. Coagulation/flocculation will help remove some organic THM precursors during the treatment process. Alternatively, granular activated carbon (GAC) an advanced drinking water technology, will remove many harmful organic chemicals, including THM precursors; however, the cost of pre-treatment using GAC is expensive. In addition, regeneration of GAC poses either problems with air quality or with transportation of hazardous wastes.

It should also be noted that at this time no technology has been explored for drinking water treatment that efficiently and practically can remove bromide from water. Reverse osmosis or distillation are costly and have not been demonstrated as practical or efficient for large-scale use.

A-2. Modify or Substitute Disinfection Practices

Chloramines

Chloramines are formed when ammonia is added to pre-chlorinated water during treatment. Chloramination reduces the formation of THMs, but is a weaker disinfectant and requires longer contact times than free chlorine; it is also less effective than free chlorine against viruses and Giardia cysts. This method may therefore not meet the requirements of the recently adopted Surface Water Treatment Rule (SWTR). Chloramination residuals are more stable and persist longer in the water distribution system than chlorine residuals, and, for this reason, chloramines are regularly used as a secondary disinfectant. However, the chloramine residual is dangerous to kidney dialysis patients in whom it can cause hemolytic anemia. In California, water utilities must notify dialysis centers in their service area prior to using chloramination.

Chlorine Dioxide

Chlorine dioxide is used primarily for taste and odor control in public water supplies. It is a strong oxidant and biocide, provides a good residual, and, unlike chlorine, is unaffected by higher pH. Chlorine dioxide does not react to the same extent with organic matter and therefore forms lower levels of THMs. However, chlorine dioxide and its oxychlorine by-products, chlorite and chlorate can cause methemoglobinemia and hemolytic anemia in humans. Patients on kidney dialysis are especially sensitive to these substances. Due to the potential adverse health effects, California has established action levels (ALs) for chlorine dioxide, chlorite and chlorate. Low ALs currently preclude the use of chlorine dioxide as a primary disinfectant in the state of California.

Ozone/PEROXONE

Ozone is widely used for water treatment in many parts of western Europe. It is the most powerful disinfectant commonly used in water treatment, requiring much shorter contact times compared to chlorine. However, it is extremely unstable, so it must be generated at the point of use. Although it appears to form fewer THMs than chlorine, ozonation does produce some brominated DBPs. This is a concern with Delta water because of the abundant bromide present from seawater intrusion. Since ozone does not persist as a residual, a secondary disinfectant must always be applied. Ozonation of Delta water also converts some of the bromide to bromate, a suspected human carcinogen which is expected to be regulated by EPA.

Ozone can also be combined with other agents to enhance the oxidation potential during the treatment process. The use of hydrogen peroxide with ozone (PEROXONE) results in a product which has far greater oxidizing power than ozone alone; PEROXONE may produce lower levels of brominated organic DBPs (for example, bromoform, a THM). However, it can produce higher levels of bromate.

There are other options common to the above alternate disinfectants. Each can be used to replace chlorine as the pre-oxidant in the water treatment train, with subsequent chlorination after filtration for maintenance of a residual. These disinfectants can also be used in combination with one another, such as the use of ozone as a primary disinfectant with chloramines added later for a system residual. Additionally, not only the type of disinfectant used but the point of its application in the water treatment train is important in minimizing THM formation. Most notable, however, is that very little is known about the reaction products of any of these alternative disinfectants.

A-3. Post-Treatment

Several technologies for post-treatment were considered, including GAC and air stripping. However, there is no post-treatment technology available today to reduce THM levels effectively.

B. Physical Facilities

Numerous facilities have been proposed over the years to improve the reliability and quality of the water in the California Aqueduct. Water quality degradation would be minimized, for instance, by:

- providing a more rapid and direct flow path across or around the Delta, thereby reducing both Delta and sea water influences;
- moving water around the Delta and avoiding these influences altogether; or
- storing high quality water off-stream.

The following is a summary of proposed alternative facilities as recently identified by the Department of Water Resources, California Urban Water Agencies, the State Water Contractors and the Contra Costa Water District. This list is intended to show the range of facilities being discussed by the water community at this time; possible improvements are included for each facility. Except for the DWR endorsement of the North and South Delta Water Management Facilities, the list does not constitute an endorsement by any of the agencies for the projects.

1. North and South Delta Water Management Facilities and Possible Improvements

The Department of Water Resources favors the construction of the proposed North and South Delta Water Management Facilities and is currently preparing environmental documentation for these projects.

1a. The South Delta Program would:

- Enlarge Clifton Court Forebay;
- Construct a siphon under Old River and a channel on the east side of Byron Tract;
- Construct two additional intakes into Clifton Court Forebay;
- Enlarge Middle River east of Woodward Island from North Victoria Island to Woodward Cut;
- Construct up to four barriers in the south Delta channels to improve water levels, circulation, water quality and flow conditions for migrating fish; and
- Shift some of the pumping at the Banks Pumping Plant from spring to winter months to decrease fish losses.

1b. The North Delta Program would:

- Enlarge the South and North forks of the Mokelumne River, adding additional gates to the Delta Cross Channel.
- Include, during later phases, partial tide gate barriers in the Sacramento River and adjoining sloughs, and additional connecting channels between the Sacramento River and the central Delta.

1c. Possible improvements provided by both North and South Delta Programs:

- Allow pumping capacity at the Harvey O. Banks Pumping Plant to be increase to 10,300 cubic feet per second (cfs);
- Reduce bromide to the extent reverse flow in the western Delta is reduced; and
- Might reduce organic THM precursors by providing a more direct flow path through the Delta.

2. The Through-Delta Facility and Possible Improvements

2a. The Through-Delta Water Transfer Facility would:

- Enlarge Victoria Canal and Middle River from its confluence with Victoria Canal to North Victoria Canal;
- Add an additional intake to the north side of Clifton Court Forebay on Old River;
- Construct a barrier at the head of Old River to reduce the number of salmon smolts diverted to the export pumps;
- Enlarge the North and South forks of the Mokelumne River;
- Construct a new channel from Hood on the Sacramento River to the upstream confluence of the North and South forks of the Mokelumne River with a capacity of 17,000 cfs;
- Construct a pumping plant and fish screen at the head of the new channel near Hood to provide this flow capacity and ensure that emigrating salmon smolts and shad would not be diverted into the new channel;
- Close the Delta Cross Channel gates permanently;
- Construct three permanent barriers at the head of Dutch Slough, False River, and Fisherman Cut;
- Change use of all Delta islands which are adding to the THM precursor problem through drainage; and
- Eliminate all agricultural drainage return flow discharged into the Delta Mendota Canal from Tracy Pumping Plant to the O'Neill Pumping Plant.

2b. Possible improvements resulting from these facilities:

- Allow pumping capacity at the Banks Pumping Plant to be increased to 10,300 cfs;
- Reduce bromide to extent reverse flow is reduced;
- Reduce agricultural drainage effects to the extent land use is changed.

3. Isolated Facilities or Canals and Possible Improvements

3a. The Dual Water Transfer Facility would:

- Construct a 10,300 cfs isolated canal to transfer SWP water from Hood on the Sacramento River to Clifton Court Forebay on the same alignment as the Peripheral Canal;
- Construct a fish screen and pumping plant near Hood;
- Construct siphons under the Mokelumne River flood channel, San Joaquin River, Old River and Disappointment Slough;
- Allow a 2,000 cfs release capability at the San Joaquin River;
- Allow the Delta Cross Channel gates to remain operational;
- Eliminate all agricultural drainage return flow discharges into the Delta Mendota Canal from Tracy Pumping Plant to the O'Neill Pumping Plant; and
- Transfer City of Tracy's water intake from the Delta Mendota Canal to the California Aqueduct.

3b. The Peripheral Canal would:

- Construct a 19,000 cfs isolated canal from Hood on the Sacramento River to Clifton Court Forebay on the same alignment as the original Peripheral Canal proposal, with pumping plant and fish screen near Hood, siphons and 4,000 cfs release capability;
- Eliminate all agricultural drainage return flow discharges into the Delta Mendota Canal from Tracy Pumping Plant to the O'Neill Pumping Plant; and
- Close the Delta Cross Channel gates permanently.

3c. Possible improvements provided by these facilities:

- Reduce significantly bromide and agricultural organic drainage impacts by by-passing the effects of the Delta.

4. Delta Agricultural Drainage Management and Possible Improvements

4a. Delta Agricultural Drainage Management would:

- Collect all or a major amount of the agricultural drainage from Delta Islands and treat it to reduce THM precursors, or discharge the drainage to another location.

4b. Possible improvements:

- Reduce the impacts of organics in Delta water.

5. The Sierra Source-to-User Alternative and Possible Improvements

5a. The Sierra Source-to-User Alternative would:

- Construct a new channel transferring water directly from the source (Feather and Sacramento rivers), bypassing the Delta, and delivering it directly to state and federal facilities for export.

5b. Possible improvements:

- Reduce significantly organic and bromide THM precursors.

6. Off-Stream Storage and Possible Improvements

6a. Off-Stream Storage would:

- Store high quality water during periods of surplus flows in such proposed facilities as Los Vaqueros and Los Banos Grandes reservoirs.

6b. Possible improvements resulting from these facilities:

- Allow reliable sources of high quality water when surplus flows are not available.

Best Management Practices

DWR estimates that during the 1988 irrigation season, April through August, agricultural drainage within the Delta contributed 40 to 45 percent of the organic carbon THM precursors in the water exported by the DWR in the California Aqueduct. During the winter leaching period, November through February, this drainage contributed 38 to 52 percent of that carbon. These analyses suggest two management strategies for drinking water: relocation of problem drains and export pumps or relocation of points of diversion. Other management strategies include blending of raw water supplies prior to treatment and improvements in the water treatment technologies.

Since little is known about the specific contribution of individual sources of THM precursors, best management practices for THM precursors would include expanded monitoring programs to quantify these sources (See regulatory action section). There should also be support and additional funding of the ongoing alternative water treatment technology research being conducted by various purveyors of treated Delta drinking water.

Alternative technology research for water treatment is being studied by many Delta users, including the following:

o Metropolitan Water District of Southern California (MWD) performed a 2-year pilot-plant study on the use of GAC for THM precursor removal. MWD is currently evaluating GAC regeneration issues and is planning to follow this with detailed siting studies should installation of GAC become necessary at its filtration plants.

- Contra Costa Water District (CCWD) has conducted a full-scale evaluation on the use of optimized alum coagulation for THM precursor removal.

- CCWD and East Bay Municipal Utility District (EBMUD) have evaluated membrane filtration for the removal of microbial pathogens. They are currently evaluating the use of membrane filtration for THM precursor removal.

- Most major users of Delta water have investigated and implemented the use of chloramines as an alternative disinfectant (usually for secondary disinfection and distribution system residual maintenance) to minimize THM formation.

- The use of ozone and/or PEROXONE as an alternative disinfectant--as well as its uses for taste and odor control and minimization of THM production--has been pilot-tested by Alameda County Water District (ACWD), Los Angeles Department of Water and Power (LADWP), CCWD, EBMUD, and MWD. LADWP has a full-scale ozone plant; CCWD and EBMUD will soon have full-scale ozone capability at some of their treatment plants. MWD is beginning a 2-year demonstration scale study to further evaluate the ozone and PEROXONE processes.

- MWD is performing bench-scale testing of ozone and PEROXONE for the production and control of brominated ozone by-products. Control options may include the addition of ammonia or acid prior to ozonation in order to alter the ozone/bromide chemistry and potentially minimize DBP production. ACWD and MWD have also partially investigated the use of ammonia addition in pilot-testing. LADWP and Santa Clara Valley Water District (SCVWD) will be conducting pilot tests evaluating pH depression and ammonia addition prior to ozonation for the control of brominated DBPs. SCVWD will be evaluating a variety of ozone application points along with GAC filtration. LADWP will also perform some bromide spiking experiments to study brominated DBP production.

Regulatory Actions

It is recognized that regulatory actions alone will not solve the problems posed by THMs and DBPs. However, taken together with other programs, regulatory actions could assist in bringing about a reasonable solution. Actions, for example, could include waste discharge requirements for precursors such as total organic carbon (TOC) discharged from urban wastewater treatment plants, urban and rural nonpoint sources, such as agricultural drainage points. Either the federal NPDES program or the California Water Code's waste discharge requirement program could be used in this effort.

Expanded monitoring programs by various state and federal agencies should be undertaken before such requirements are imposed.

As an example, the Department of Water Resources began studying THM precursors in the Delta beginning in 1983 as part of the Interagency Delta Health Aspects Monitoring Program (IDHAMP). The success of the study can be attributed, in part, to the cooperative spirit and participation of Delta landowners. Many landowners have viewed DWR efforts with skepticism, fearing that the study would not be conducted in a fair manner. However, the trust and cooperation of many landowners has been gained by striving to conduct the study in an equitable manner.

In 1987, the IDHAMP program was expanded to include numerous agricultural drains (Delta Island Drainage Investigation, or DIDI). DWR access to the drains was granted voluntarily by many Delta landowners. As the DIDI study progressed, it became clear that drainage from nearly all Delta islands should be evaluated. In 1990, requests for permission to access were again sent to Reclamation District boards and landowners. Access to the critical central portion of the Delta was granted at that time. Currently, the Municipal Water Quality Investigations (MWQI) program (formerly IDHAMP and DIDI) covers about 80 percent of the Delta (Figure 7). However, to complete the MWQI study, the Department will need access to key portions of the southern Delta.

Testimony presented at State Water Resources Control Board hearings indicates that some Reclamation Districts and property owners in the southern Delta still do not allow DWR access to their property for water quality studies. If necessary, the Central Valley Regional Water Quality Control Board has regulatory authority to issue Waste Discharge Requirements, which will allow the collection of the necessary data.

Bromide concentrations in drinking water supplies taken from the Delta could also be reduced by increasing Delta outflow to minimize seawater intrusion more effectively. Increased flow could be achieved by modifications of water rights. This issue and other issues will be considered in the Water Right Phase of the ongoing State Water Resources Control Board's Bay-Delta proceedings.

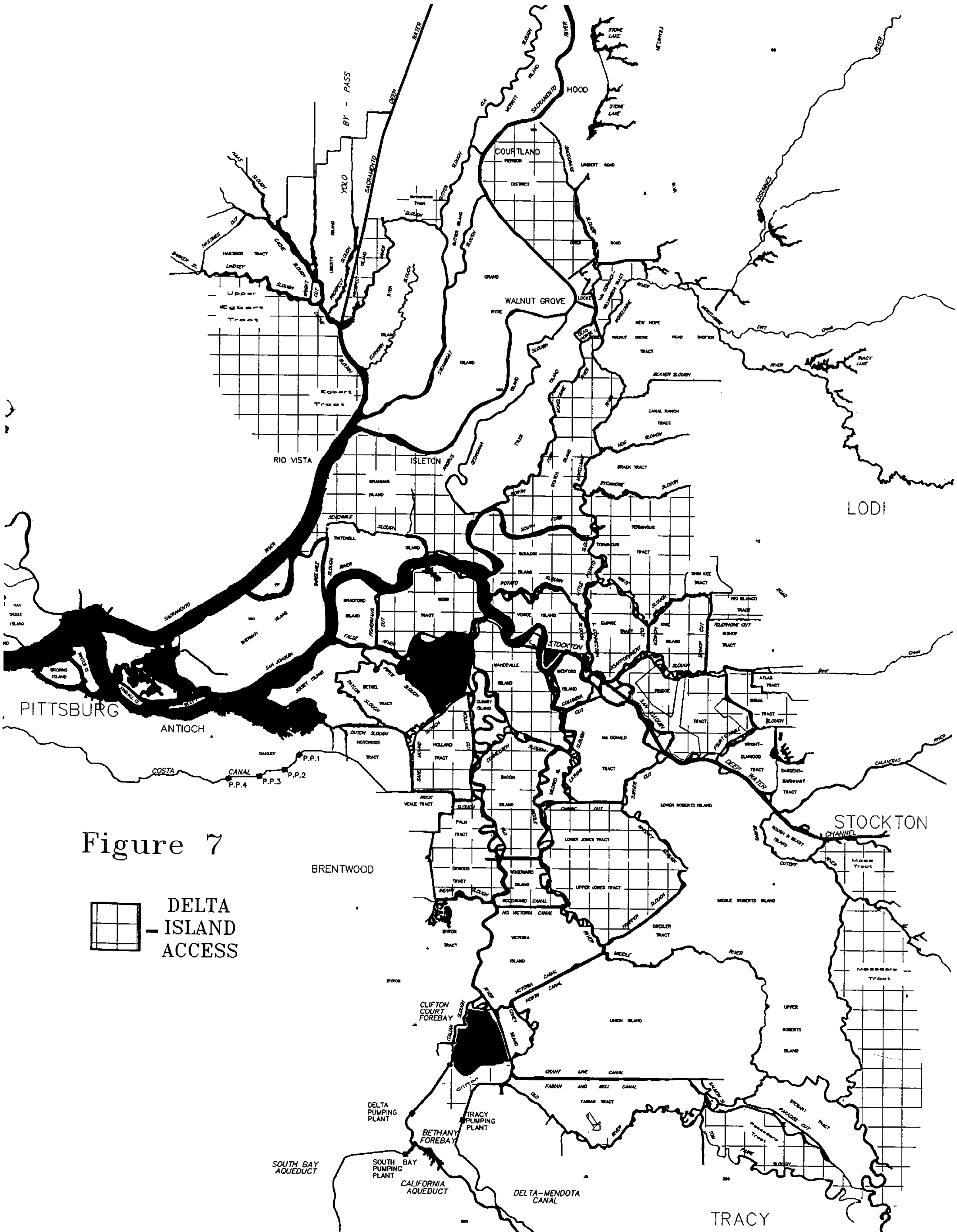

HOOD
COURTLAND
WALNUT GROVE
RIO VISTA
ISLETON
LODI
PITTSBURG
ANTIOCH
BRENTWOOD
STOCKTON
TRACY
YOLO BY - PASS
SACRAMENTO DEEP WATER
Upper Egbert Tract
Egbert Tract
CLIFTON COURT FOREBAY
DELTA PUMPING PLANT
TRACY PUMPING PLANT
BETHANY FOREBAY
SOUTH BAY AQUEDUCT
SOUTH BAY PUMPING PLANT
CALIFORNIA AQUEDUCT
DELTA-MENDOTA CANAL
COSTA CANAL
P.P.1
P.P.2
P.P.3
P.P.4
STOCKTON CHANNEL
DELTA - ISLAND ACCESS

Figure 7

Chapter 7

FINDINGS

- The Sacramento-San Joaquin Delta is a source of drinking water for more than 20 million Californians.

- Several factors can affect the drinking water quality of Delta water:

  - Tides, diversions, low river outflows and atmospheric conditions can allow intrusion of saline San Francisco Bay water into the Delta.
  - Wastewater from municipal, industrial and agricultural discharges upstream of and in the Delta can contain a variety of harmful chemicals.
  - Disinfection of Delta water which contains organic precursors and bromide results in the formation of trihalomethanes and other disinfection by-products.

- Trihalomethanes are suspected human carcinogens. For this reason, EPA set the standard for THMs in treated drinking water at 0.1 milligrams per liter or 100 parts per billion (ppb).

- Most treated Delta water meets current drinking water standards, and most regulated organic contaminants are not detected. However, THMs are occasionally detected at levels at or above the current drinking water standard.

- The implementation of the Surface Water Treatment Rule (SWTR) by June 1993 will require stringent disinfection criteria for many utilities.

- EPA is currently reviewing the standard for trihalomethanes with the possible intent of replacing it with a stricter standard or individual standards for each of the THMs.

- Given the Delta's current water quality, the need to meet the provisions of the Surface Water Treatment Rule, and the possibility of stricter standards for THMs and other DBPs, it will be difficult for utilities to achieve compliance with the new maximum contaminant levels.

- A summary of operating experiences of the users of Delta water as required in SCR 55 revealed that:

  - All agencies surveyed which use water pumped from the Delta (particularly southern Delta water) experience problems with THM formation.
  - Bromide levels, which lead to higher THM concentrations, have increased in recent years due to the drought and have added to the difficulties in controlling THMs in the finished water.
  - Various agencies have converted, or are planning to convert to alternative disinfection processes in order to better control THM formation. However, these agencies anticipate that further modifications will be necessary if new EPA or state standards are established for THMs and other DBPs.

- Taste and odor, turbidity, color and total dissolved solids (TDS) are common problems associated with Delta water. While these do not necessarily pose health risks, they at times degrade the quality of the water delivered to the consumer.
- Most southern California agencies surveyed, when asked what could be done to improve raw water quality, responded that alternate Delta transfer facilities would provide the best possible drinking water quality. Most agencies that treat water from the California Aqueduct prefer an isolated Delta transfer facility that would by-pass the Delta completely to control organic THM precursors and bromide. Otherwise, some mechanism to control organic THM precursors is needed for agricultural discharges in the Delta.

o To minimize THM formation, California water utilities currently have available ozone and chloramines as disinfectant alternatives to chlorine. For many, the technology is new and requires extensive capital investment. In addition, there are regulatory concerns about the DBPs formed by alternative disinfectants. In particular, the use of ozone may be limited because of the formation of the DBP bromate when bromide is present.

o Irrespective of the treatment strategy followed, minimizing or avoiding DBP precursors will result in lower concentrations of DBPs delivered to consumers of Delta water.

o Numerous facilities have been proposed to improve the reliability and quality of source water.

- North and South Delta Water Management Facilities
- Through-Delta Water Facilities
- Dual Water Transfer Facilities
- The Peripheral Canal
- Delta Agricultural Drainage Management
- Sierra Source-To-User Alternative
- Off-stream Storage (e.g., Los Vaqueros and Los Banos Grandes)

o Best management practices to improve Delta water quality include possible:

- Relocation of problem agricultural drains
- Relocation of export pumps or points of diversion
- Expanded monitoring programs to quantify sources of THMFPs, particularly from agricultural drains.

o Monitoring of Delta water has been expanded in part because extensive cooperation has been achieved in gaining access to Delta islands.

o Regulatory actions, such as waste discharge requirements on agricultural drains, may be needed to help resolve the problem of organic THM and DBP precursors in Delta source water.

Appendix

Treatment Plant Questionnaire

APPENDIX 1

TREATMENT PLANT QUESTIONNAIRE

History:

Name of Plant:
Location:
Year Built:
Improvements:

Current Plant:

Population served by Plant
Plant Capacity:
Current Output:

Plant Data Requested:

In addition to completing this questionnaire, please provide information generally available to the public (e.g. plant flow diagram, general description, types and quantities of chemicals used annually, chemical input points, sampling locations, etc.).

Operating Experiences

All of the following questions concern the quality of water which has been taken from the Delta, whether by the State Water Project, or other water suppliers. Please answer the questions as they relate to the Delta - source water only.

Approximately how much of your water supply comes through the Sacramento / San Joaquin Delta?

List and describe any water quality problems that you have encountered (e.g. high turbidity, taste and odor, high THMs, TDS, hardness, selenium, mercury, metals, pesticides, solvents, etc.) attributable to State Water Project (SWP) or Delta water.

Have you had any water quality problems related to the current drought? If so, please describe.

Do you have any problems meeting present drinking water standards? If so, what are these problems?

Have you ever issued a public health notification as a result of these difficulties? If so, when, and for what cause?

Have you had many consumer complaints about your water quality? What were the nature of the complaints?

Were any of these related to your raw water supply (particularly SWP water)?

What did you do to correct these problems? What are your plans to correct these problems?

Do you have any early warning systems to predict when problems may occur? (e.g. monitoring algal blooms in the Delta, measuring TDS in source waters, etc)

What has been the effect of water quality problems on your operating budget?

DWR Role in Water Quality

Do you feel the Department of Water Resources is doing all that it can to provide raw water of good quality. If not, what steps might the Department take to assure better raw water quality?

Future

Have you made, or are you planning, any changes in operations or facilities, to meet anticipated water quality regulations, including the Surface Water Treatment Rule, Coliform Rule, Ground Water Treatment Rule, and the anticipated Disinfection By Product and Radon Regulations? If so, please describe. How much will this affect your projected budget? Will these changes affect the individual rate payer?

Do your plans to meet new regulations depend on the quality of SWP water, or would they be necessary regardless of the source?

Will you be looking for alternative sources of water to meet the new or anticipated standards?

Role of other state agencies

Should state regulatory agencies assume a more active role in assuring the quality of the State's drinking water sources? If so please describe.

Name of Person Completing Questionnaire: ____________________

Title: ____________________

Address: ____________________

____

Phone: ____________________

Signature: ____________________ **Date:** ______________


Cover: Clifton Court Forebay, State Water Project
Courtesy of the Department of Water Resources