

# **Study of Drinking Water Quality in Delta Tributaries**

## **Executive Summary**

**California Urban Water Agencies  
May 1995**

**BROWN AND CALDWELL**

Archibald & Wallberg Consultants  
Marvin Jung & Associates  
McGuire Environmental Consultants, Inc.

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## FOREWORD

California Urban Water Agencies (CUWA) is an organization of the largest urban water providers in California, which serve water to metropolitan areas encompassing about two-thirds of the state's 32 million population and three-fourths of its \$800 billion annual economy. CUWA was formed to work on statewide water supply issues. Among these concerns is the quality of waters which are the principal sources of California's drinking water.

The largest of California's drinking water sources is the Sacramento-San Joaquin Delta (Delta) and its tributaries. This water is provided to 22 million people. Delta water poses some significant drinking water quality concerns which mount as more stringent drinking water regulations come on line.

In 1989, CUWA sponsored the Delta Drinking Water Quality Study. It collated and focused the Delta drinking water quality information available at that time, and stimulated further scientific discussion of this problem and some excellent subsequent work by state water resource agencies and others. This Study of Drinking Water Quality in Delta Tributaries is intended to help fill the gap in our knowledge of drinking water quality problems in waters upstream of the Delta in its major tributary streams.

There are numerous point and diffuse sources of drinking water contaminants in the Delta tributary watersheds. Additional and better data are needed to support development of a comprehensive source control program for the Delta tributaries. This study identifies some specific needs:

- o Pathogen data are particularly lacking. Much better monitoring is needed for key pathogens such as *Giardia* and *Cryptosporidium*.
- o Sources of the load of organic carbon in Sacramento River water were largely unidentified in this study. Additional data should be collected on Sacramento urban runoff and combined sewer overflows and Sacramento basin agricultural drainage to determine how much they contribute to the unidentified load of organic carbon.
- o Mine drainage from the Yuba and Bear rivers watershed is a significant source of arsenic. If the arsenic maximum contaminant level is established at the lower end of the range currently being considered by the U.S. Environmental Protection Agency (2 to 20 micrograms per liter), treatment/management alternatives for reducing arsenic in drinking water supplies should be further investigated.
- o Mud and Salt sloughs contribute substantial loads of organic carbon and mineral salts to the San Joaquin River. Additional data should be collected on contaminant loads from these sloughs.

## EXECUTIVE SUMMARY

The Study of Drinking Water Quality in Delta Tributaries was undertaken to evaluate loadings of key drinking water contaminants to the Sacramento-San Joaquin Delta (Delta) tributaries and to determine if there are contaminant source control measures which, if implemented, would improve drinking water quality in the Delta tributaries and at the Delta pumping plants. The first phase of the study, which is the subject of this report, entailed a quantitative evaluation of the concentrations and loads of key contaminants at various locations in the tributary watersheds.

The objective of this phase of the work was to determine if control of certain contaminant sources in the tributary watersheds would result in improvements in the drinking water quality at specified benchmark locations in the tributaries and the Delta. A second phase of work would then evaluate management alternatives for the significant contaminant sources in more detail. Work on the first phase was, to a large extent, dictated by the amount of data available for the evaluation. Limited available data resulted in a selection of subsets of the key contaminants, period of record, and monitoring locations for an initial evaluation. Although constrained from the originally envisioned scope, the results of this evaluation provide, with the exception of pathogens, an indication of the significance of the contaminant sources in the watershed with respect to contaminants of most concern to drinking water quality.

The study area consisted of the watersheds of the Sacramento and San Joaquin rivers, the two major riverine sources to the Delta. The Sacramento River provides about 85 to 90 percent of the freshwater flow to the Delta and the San Joaquin River provides most of the remainder. The several small eastside tributaries (Calaveras, Mokelumne, and Cosumnes rivers) provide less than one percent of the freshwater flow. Within the Delta, there are other sources of water (precipitation and seawater intrusion) and contaminants (Delta agricultural drainage and seawater). These in-Delta sources were not evaluated in this study but are discussed in this report where relevant. For example, seawater is a much more significant source of bromide than either of the tributaries, and Delta agricultural drainage adds significant disinfection by-product precursor material between the Sacramento River and the Delta pumping plants.

### Parameters Selected for Evaluation

The first part of the study involved the selection of parameters for evaluation. These parameters included contaminants of concern, contaminant sources, and in-stream benchmark locations. Preliminary management alternatives were identified to aid in the selection of benchmark locations and contaminant sources. Table ES-1 shows the relationship of these parameters to the management alternatives. The study area, locations of the benchmark locations, and contaminant source discharge locations are shown on Figure ES-1.

**Table ES-1. Preliminary Management Alternatives**

Alternative	Contaminant source	Contaminants of concern	Discharge locations	Primary downstream benchmark location
Rerouting Sacramento River Agricultural Drainage	Agricultural drainage	DBP-precursors, microbiological contaminants, nutrients, arsenic, total dissolved solids, pesticides	Colusa Basin Drain, Sacramento Slough	Sacramento River at Verona and Greene's Landing, Barker Slough Pumping Plant, Banks Pumping Plant
Eliminating Combined Sewer Overflows from the City of Sacramento	Wastewater and urban runoff	Microbiological contaminants, total dissolved solids, DBP-precursors, nutrients, arsenic	Combined Wastewater Treatment Plant, Sump 2, Pioneer Reservoir	Sacramento River at Greene's Landing, Barker Slough Pumping Plant, Banks Pumping Plant
Improving Sacramento Urban Runoff Quality through Best Management Practices	Urban runoff	Microbiological contaminants, nutrients, total dissolved solids, arsenic, DBP-precursors	Forty-four (44) discharge locations on the American and Sacramento rivers	Sacramento River at Greene's Landing, Barker Slough Pumping Plant, Banks Pumping Plant
Diverting the SRWTP Effluent	Wastewater	DBP-precursors, microbiological contaminants, nutrients, arsenic, total dissolved solids	Freeport on the Sacramento River	Sacramento River at Greene's Landing, Barker Slough Pumping Plant, Banks Pumping Plant
Eliminating Subsurface Agricultural Drainage from the San Joaquin River	Agricultural drainage	Total dissolved solids, DBP-precursors, microbiological contaminants, nutrients, arsenic, pesticides	Mud Slough, Salt Slough	San Joaquin River at Vernalis, Tracy Pumping Plant

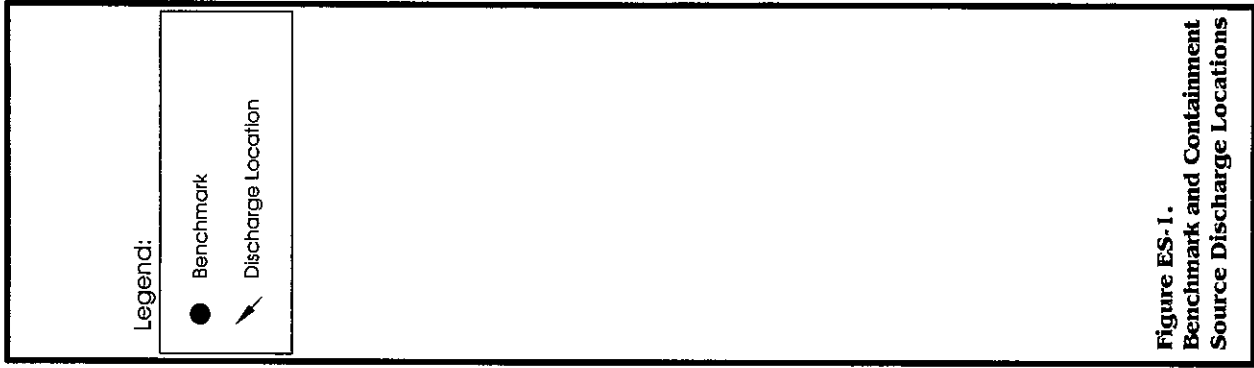
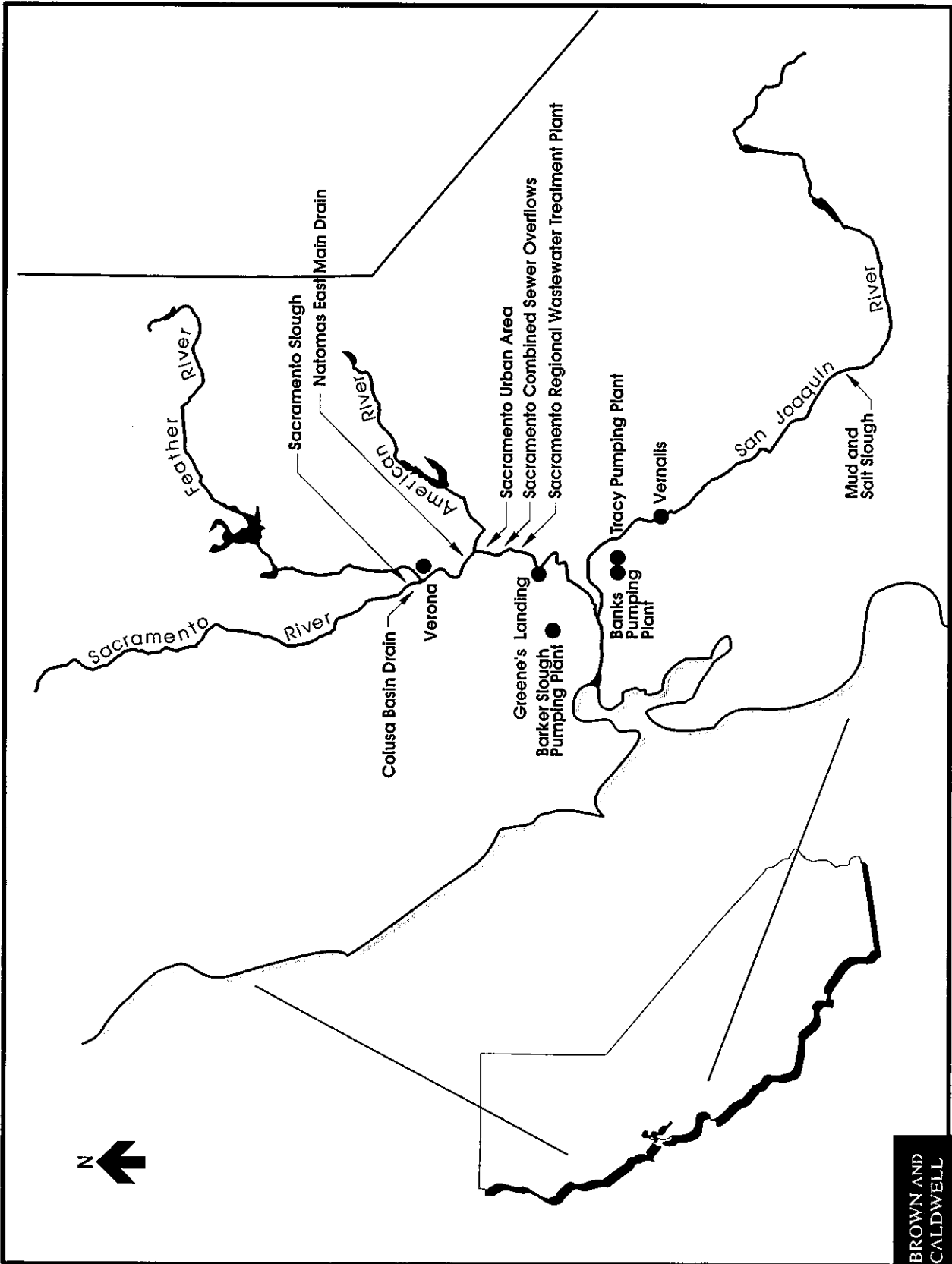


Figure ES-1.  
Benchmark and Containment  
Source Discharge Locations



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The identification and selection of contaminants of concern was based on issues related to treating and managing Delta source water to meet drinking water requirements of the U.S. Environmental Protection Agency (EPA) including the Disinfectants/Disinfection By-Products Rule, the Surface Water Treatment Rule, the Enhanced Surface Water Treatment Rule, and a potentially more stringent Maximum Contaminant Level (MCL) for arsenic. Therefore, disinfection by-product precursors, microbiological contaminants, and arsenic were selected for evaluation. In addition, nutrients were included because nutrients can cause algal blooms in Delta source water resulting in greater disinfection by-product precursor loads and taste and odor problems. Total dissolved solids (TDS), objectionable in drinking water because of possible physiological effects, unpalatable mineral tastes, and corrosion effects, was also included. Pesticides were included on the list of contaminants of concern but were investigated separately and reported on in a technical memorandum (Appendix C).

The principal contaminant sources in the Sacramento River watershed were identified as agricultural drainage, urban runoff from the Sacramento metropolitan area, combined sewage discharges from the Sacramento combined sewer system, wastewater discharges from the Sacramento Regional Wastewater Treatment Plant (SRWTP), and mine drainage. Approximately 80 percent of the rice field drainage from the entire watershed discharges to the rivers from Colusa Basin Drain and Sacramento Slough. Therefore, these two drains were selected as representative of the impact of the rice drainage on the river. Sacramento urban runoff discharges from 44 sumps along the American and Sacramento rivers. Four of these sumps have been monitored since 1990 and are thought to be representative of the entire urban area. The Sacramento combined sewage system discharges to the Sacramento River at three locations. The SRWTP discharges to the Sacramento River at Freeport. Mine drainage was treated separately (see discussion below).

In the San Joaquin Basin, the principal contaminant source was identified as subsurface agricultural drainage from the west side of the watershed. This drainage consists of imported Delta water and some groundwater which, after application to agricultural crops, percolates through marine soils, picking up salts and trace elements before discharge to the San Joaquin River. Mud and Salt sloughs are the two major waterways that convey this drainage to the San Joaquin River.

The benchmark locations were selected principally as (1) sites on the Sacramento and San Joaquin rivers where it was expected there would be considerable water quality data, and (2) the Delta pumping plants. The Sacramento River at Greene's Landing and the San Joaquin River at Vernalis, the two major monitoring locations on the rivers before they enter the Delta, were selected as benchmark locations. The Sacramento River at Verona was also selected as an upstream benchmark location. Three of the Delta pumping plants were selected as benchmark locations. The Banks Pumping Plant and Tracy Pumping Plant in the south Delta are the major export locations. Barker Slough Pumping Plant was added because a number of the possible Sacramento River watershed management alternatives might improve water quality in the south Delta and perhaps simultaneously degrade water quality in the north Delta.

## **Data Evaluation**

The data collection effort and the development of the evaluation method was an iterative process. Data were identified and collected from a number of monitoring programs for the contaminants of concern at the benchmark locations and contaminant source discharges. A review of the available data narrowed the list of contaminants of concern which could be evaluated, forced the use of surrogate data and the mingling of data from different periods of record in order to proceed with the evaluation, and influenced the development of the evaluation method. The specific contaminants selected for evaluation were organic carbon, alkalinity, bromide, arsenic, ammonia, nitrate plus nitrite, total phosphorus, and TDS. Due to the lack of data, microbiological contaminants were not selected for analysis. Surrogate data from the Natomas East Main Drain were used to evaluate Colusa Basin Drain and Sacramento Slough. There are extensive data on Natomas East Main Drain and limited data for the Colusa Basin Drain and Sacramento Slough. Both drains carry rice drainage; however, Natomas East Main Drain also carries urban runoff. An examination of the limited data from Colusa Basin Drain and Sacramento Slough indicated this surrogate source was reasonable for a preliminary evaluation. In addition, older data were used to evaluate Mud and Salt sloughs; this was necessary because more current data were not identified.

Three techniques were used in evaluating the data: (1) a comparison of the ranges of concentration levels at the benchmark locations and contaminant source discharges; (2) the inspection of time series plots of precipitation, flow, concentration, and loads; and (3) a statistical treatment of mass loads which estimated the percent of the river loads contributed by the contaminant source discharges during wet and dry water years and wet and dry seasons. Most of the benchmark location data came from a single monitoring program, the California Department of Water Resources (DWR) Municipal Water Quality Investigation (MWQI) Program. The contaminant source data were assembled from a number of monitoring programs. The period 1990 to 1993 was selected for evaluation because this was the period with the greatest amount of overlap in the various data. All contaminant sources and three of the benchmark locations (Banks Pumping Plant, the Sacramento River at Greene's Landing, and the San Joaquin River at Vernalis) were evaluated.

## **Mine Drainage, Delta Agricultural Drainage, and Pesticides**

Mine drainage, Delta agricultural drainage, and pesticides were investigated separately to determine if they should be quantitatively evaluated in the study. Technical memoranda were prepared on each of these subjects. Mine drainage is considered to be a major source of metals (copper, zinc, and mercury) to the Sacramento River. These contaminants (copper, zinc, and mercury) are not of concern to drinking water supplies at the concentrations found in the Sacramento River. Recent work shows that high concentrations of arsenic are present in mine drainage from the Yuba and Bear rivers watershed. There were, however, insufficient data to include mine drainage as a source of arsenic in the evaluation effort.

Although not a source of contaminants to the Delta tributaries, Delta agricultural drainage is a significant source of disinfection by-product precursors. The past and ongoing work on Delta

agricultural drainage was reviewed to understand the relative importance of Delta agricultural drainage and other sources of disinfection by-product precursors in the Delta tributary watersheds. Recent work has shown that total organic carbon (TOC) concentrations increase, on average, by 1.1 milligrams per liter (mg/l) between the Sacramento River at Greene's Landing and several locations in the south Delta. This corresponds to an average TOC increase of 54 percent. A comparison of Greene's Landing and Banks TOC data shows an average 1.5 mg/l (74 percent) increase between these two locations. The maximum TOC increase between these two sites has been 5.1 mg/l (261 percent). Delta agricultural drainage is a significant source of this TOC.

Pesticides, as a group of contaminants, were originally selected as contaminants of concern due to recent intensive studies that show that pesticides in agricultural drainage are toxic to aquatic life in downstream waters. The pesticide monitoring programs generally consist of relatively few samples analyzed for a large number of compounds. Pesticide monitoring has largely been synoptic in nature, most pesticides are not detected in the tributaries, and concentrations detected in the rivers are well below drinking water standards. For these reasons, pesticides were not included in the evaluation. A long-term effort to reduce pesticide concentrations in agricultural drainage from rice fields has proven highly effective. More recent work is focusing on pesticides in runoff from other crops, such as orchards. The recent data confirm that pesticide concentrations, where detected, are well below drinking water standards.

### **Sacramento River Water Quality**

The sources of key drinking water contaminants to the Sacramento River at Greene's Landing are diffuse and not easily controlled. The contaminant sources evaluated in this study, agricultural drainage, Sacramento urban runoff, Sacramento combined sewer overflows, and the SRWTP discharge, did not account for the majority of the load of most drinking water contaminants at Greene's Landing. Individual contaminant sources contributed significant amounts of individual contaminants but no one source contributed significant loads of more than one contaminant or had a substantial impact on drinking water quality. This study has shown that a comprehensive source control program is needed to control drinking water contaminants in the Sacramento and San Joaquin watersheds. It will not be possible to improve drinking water quality by controlling a single source in the watershed.

**Agricultural Drainage.** Sacramento Slough and Colusa Basin Drain constitute 80 percent of the total agricultural drainage discharged to the Sacramento River. These two drains are a significant source of TDS but do not appear to be a significant source of TOC, arsenic, and bromide. The two drains contribute approximately 30 percent of the TDS load to the Sacramento River at Greene's Landing. At this time it appears that rerouting this drainage to the Yolo Bypass or otherwise removing it from the river would likely reduce the TDS concentrations at Greene's Landing by about 30 percent. This would improve drinking water quality slightly. The DWR MWQI Program has initiated a study of TOC and trihalomethane formation potential (THMFP) in rice field drainage discharged to the Sacramento River from Sacramento Slough and the Colusa Basin Drain. At the conclusion of this study, more definitive conclusions will be drawn on the impact of rice field drainage on TOC loads in the Sacramento River.

**Sacramento Urban Runoff.** There were not sufficient flow data, or in some cases concentration data, to adequately assess the impacts of Sacramento urban runoff on the water quality of the Sacramento River at Greene's Landing. Based on data collected in the early 1980s on Fresno urban runoff, it appears that organic carbon concentrations in urban runoff can greatly exceed ambient river concentrations. The TOC concentrations found in the handful of samples collected on Sacramento urban runoff are substantially lower than the Fresno concentrations so conclusions can not be drawn in this study on the significance of Sacramento urban runoff. Over 70 percent of the load of organic carbon at Greene's Landing could not be explained by the contaminant sources evaluated in this study. It is likely that urban runoff accounts for some portion of this unidentified load. Although there were not sufficient data to assess the microbial contaminants of concern to drinking water, the high coliform counts present in urban runoff indicate that it may be a significant source of microbial contaminants at Greene's Landing.

**Sacramento Combined Sewer Overflows.** Based on limited data, Sacramento combined sewer overflows do not appear to be a significant source of TDS and arsenic. Although microbial contaminants could not be evaluated in this study, combined sewer overflows could be a significant source during the wet season. Raw wastewater and urban runoff have high concentrations of microbial contaminants, therefore it is likely that the combined sewer discharge does also.

**Sacramento Regional Wastewater Treatment Plant.** The SRWTP is the major source of ammonia and total phosphorus to the Sacramento River at Greene's Landing. Approximately 50 percent of the ammonia and 40 percent of the total phosphorus loads are discharged from the SRWTP. Removing the effluent discharge from the river would substantially reduce the ammonia and total phosphorus loads and there could be a reduction in inorganic nitrogen (ammonia, nitrate, and nitrite) in the river at Greene's Landing. Due to the relatively low concentrations of nutrients in the river, this would not substantially improve drinking water quality at Greene's Landing. Although microbial contaminants could not be adequately evaluated in this study, the SRWTP discharge may be a significant source of pathogenic microorganisms such as *Giardia* and *Cryptosporidium*. Metropolitan Water District of Southern California (MWD) conducted *Giardia* and *Cryptosporidium* sampling for the State Water Contractors. *Giardia* was detected in 42 percent of the Greene's Landing samples at an average concentration of 37 cysts per 100 liters (l). *Cryptosporidium* was detected in 50 percent of the Greene's Landing samples at an average concentration of 50 oocysts per 100 l. These limited data suggest there is a source of *Giardia* and *Cryptosporidium* upstream of Greene's Landing.

### **San Joaquin River Water Quality**

Agricultural drainage from Mud and Salt sloughs was the only contaminant source evaluated in the San Joaquin Basin. Unlike the Sacramento River, the San Joaquin River does not receive significant amounts of wastewater or urban runoff upstream of Vernalis. Stockton discharges wastewater and urban runoff to the river downstream of Vernalis. Agricultural drainage is by far the most significant discharge and source of contaminants to the river. Mud and Salt sloughs contribute most of the organic carbon and TDS loads to the San Joaquin River at Vernalis. It was not possible to evaluate the loads of other key drinking water contaminants.

The organic carbon load from Mud and Salt sloughs ranges from 30 percent during wet seasons of wet years to 100 percent during dry seasons of dry years. TDS loads range from 49 percent during dry seasons of wet years to 100 percent during dry seasons of dry years. Rerouting this drainage would substantially improve the water quality of the San Joaquin River at Vernalis; however, the substantial flow contribution from Mud and Salt sloughs is important to the flows in the upper reaches of the San Joaquin River.

### **Banks Pumping Plant Water Quality**

Drinking water quality at Banks Pumping Plant would not be improved significantly by controlling Delta tributary contaminant sources evaluated in this study. Any improvements in water quality at Greene's Landing as a result of controlling the contaminant sources evaluated in this study would likely not result in significant improvements in drinking water quality at the Banks Pumping Plant. Improvements in water quality of the San Joaquin River at Vernalis would likely improve the drinking water quality of the Tracy Pumping Plant but would not improve drinking water quality at the Banks Pumping Plant due to the relatively small volume of San Joaquin River water that reaches the Banks Pumping Plant.

### **Conclusions and Recommendations**

Available data are inadequate to fully analyze all of the contaminants of concern identified at the beginning of this study at all of the benchmark locations.

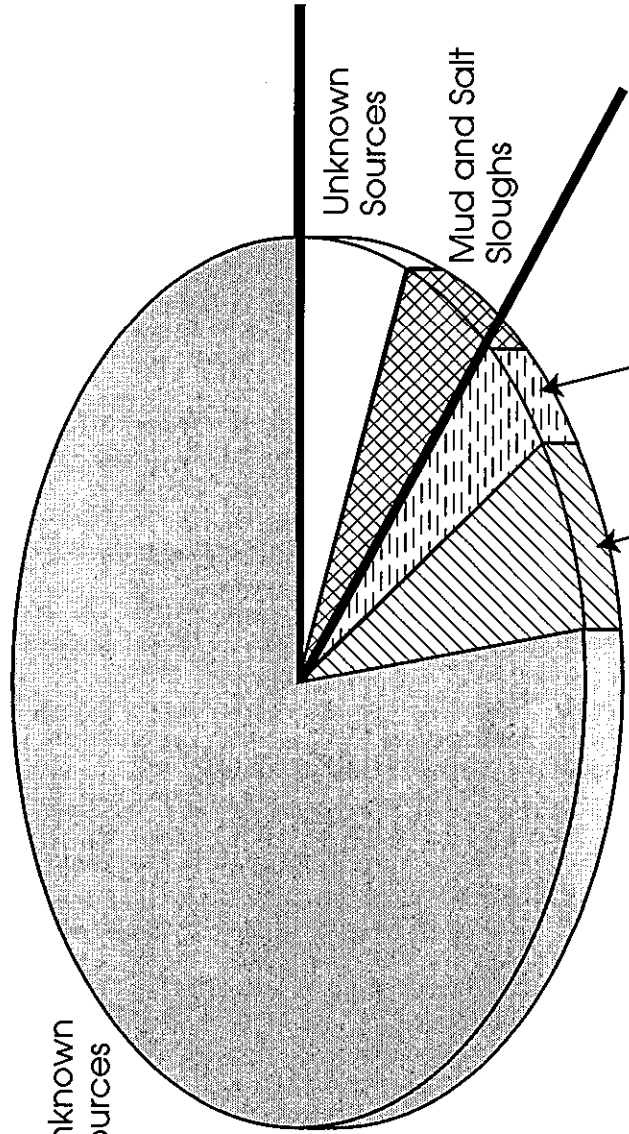
**Contaminants of Concern.** The key findings on contaminants of concern are evaluated in this section.

Disinfection By-Products. There were limited or no data on most of the disinfection by-product precursors, surrogates, and control parameters. Sufficient data on organic carbon allowed a mass loading analysis at Greene's Landing and Vernalis. The key finding was that the majority of the organic carbon load to the Sacramento River at Greene's Landing could not be attributed to the contaminant sources evaluated in this study. Mud and Salt sloughs contribute significant loads to the San Joaquin River. Figure ES-2 shows the relative proportions of organic carbon loading from the contaminant sources to the two rivers during the wet season of a dry year. The relative contribution during wet years and dry seasons is essentially the same.

Total Dissolved Solids. Control of Sacramento Basin agricultural drainage may result in lower TDS concentrations in the Sacramento River at Greene's Landing. However, due to Delta hydrology and the significant sources of TDS in Delta agricultural drainage and seawater that intrudes into the Delta, it is unlikely that Sacramento Basin controls would significantly improve water quality at the Banks Pumping Plant. Control of agricultural drainage from Mud and Salt sloughs would result in lower concentrations of TDS in the San Joaquin River at Vernalis. San Joaquin Basin controls would likely improve water quality at the Tracy Pumping Plant. TDS loads are shown on Figure ES-3.

**SACRAMENTO RIVER**

Unknown Sources



**SAN JOAQUIN RIVER**

Unknown Sources

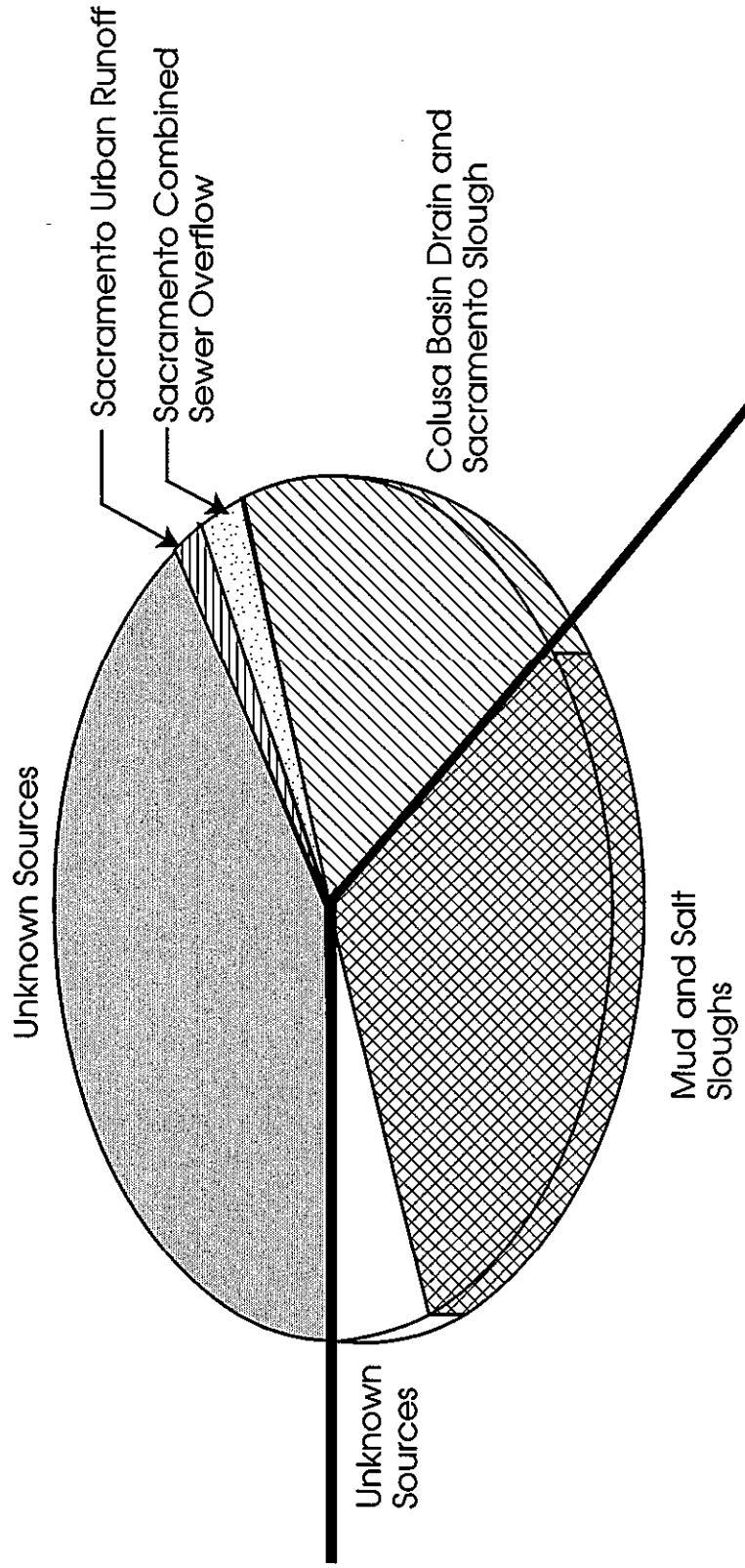
Mud and Salt Sloughs

Colusa Basin Drain and Sacramento Slough

Sacramento Regional Wastewater Treatment Plant

**Figure ES-2. Relative Mass Loading of Organic Carbon to the Delta**

**SACRAMENTO RIVER**



**SAN JOAQUIN RIVER**

**Figure ES-3. Mass Loading of Total Dissolved Solids to the Delta**

Arsenic. Arsenic concentrations in the Sacramento River at Greene's Landing and the Banks Pumping Plant will not be reduced by controlling any of the discharges evaluated. Additional monitoring of the Bear and Yuba rivers watersheds may indicate that controlling mine drainage in this region would reduce arsenic concentrations at Greene's Landing. It is uncertain, however, whether this would affect arsenic concentrations downstream of Greene's Landing. There were insufficient data to evaluate arsenic loads in the San Joaquin Basin, however, elevated arsenic concentrations in San Joaquin groundwater contribute to the arsenic load in the San Joaquin River.

Nutrients. A reduction in inorganic nitrogen and total phosphorus concentrations at Greene's Landing could likely be achieved through control of the SRWTP effluent discharge. It is unlikely that significant reductions in nutrient concentrations at the Banks Pumping Plant would be achieved.

Microbiological Contaminants. There were limited data on coliforms and no data on the pathogenic microorganisms of concern in drinking water. It was not possible to evaluate the microbiological contaminants in this study.

**Management Alternatives Analysis.** A more detailed evaluation of the preliminary management alternatives identified in this study is not warranted at this time. Five preliminary management alternatives were identified to guide the data collection and evaluation effort. More detailed analysis is not recommended due to inadequacies in the available water quality data and to the lack of evidence that the contaminant sources evaluated in this study contribute to significant drinking water quality degradation at the benchmark locations. In the Sacramento Basin, the load of nutrients from the SRWTP could be reduced by removing the effluent discharge from the river but it is unlikely to result in any substantial water quality improvement. More data and a more detailed analysis of Mud and Salt sloughs are needed before removal of the drainage is warranted.

**Additional Water Quality Data Analysis.** Additional analysis of the existing water quality data is not recommended at this time. Load calculations and evaluations of data could be performed for a few additional contaminants (such as trihalomethane formation potential) and for additional benchmark locations (Tracy Pumping Plant and Barker Slough Pumping Plant). It is unlikely that this limited additional analysis of the existing data would change the conclusions of this study.

**Further Study of the Unidentified Load in the Sacramento Basin.** Additional data should be collected on Sacramento urban runoff and combined sewer overflows and Sacramento basin agricultural drainage to determine if they contribute to the largely unidentified load of organic carbon at Greene's Landing. TOC data could be collected as part of the Sacramento stormwater and combined sewer overflow monitoring programs. Data from the Natomas East Main Drain were used as a surrogate for Colusa Basin Drain and Sacramento Slough in this study. The MWQI rice field drainage study is collecting data that will help determine if the Natomas East Main Drain data are representative of these two major agricultural drains.



**Pathogen Monitoring.** Major contaminant sources in the Sacramento Basin should be monitored for microbial contaminants. As the Information Collection Rule (ICR) monitoring is conducted, valuable additional data will be collected on *Giardia*, *Cryptosporidium*, and viruses in raw drinking water. Corresponding data on major sources of contaminants should be collected to allow for a full evaluation of the sources of pathogenic microorganisms in the Sacramento River drinking water supplies. Microbiological data for Colusa Basin Drain and/or Sacramento Slough could be collected by the DWR Northern District or the MWQI program, provided that funds were available for this expensive monitoring. Pathogen monitoring of Sacramento urban runoff, combined sewer overflows, and the SRWTP effluent could be conducted as part of the routine monitoring conducted by the City and County of Sacramento. The California Regional Water Quality Control Board, Central Valley Region (Regional Board) has historically rejected suggestions that pathogen monitoring be included in National Pollutant Discharge Elimination System (NPDES) permits due to the expense and complexity of the monitoring. The California Urban Water Agencies (CUWA) should exert pressure on the Regional Board to include pathogen monitoring in NPDES permits, particularly since the EPA has deemed this monitoring to be feasible and necessary for drinking water supplies.

**Arsenic Studies.** Ongoing studies on arsenic in the Sacramento Basin should be tracked by CUWA. If the arsenic MCL is reduced to the lower end of the 2 to 20 µg/l range that EPA is considering, arsenic concentrations in the Delta and Delta tributaries will, at times, exceed the MCL. CUWA should track the U.S. Geological Survey (USGS) and the Regional Board monitoring of arsenic in mine drainage in the Yuba and Bear river watersheds. In addition, the USGS National Water Quality Assessment study of the Sacramento Basin will include the effects of mine drainage on Sacramento River water quality and aquatic life. If the arsenic MCL is established at the lower end of the range currently being considered by EPA, CUWA should study treatment/management alternatives for removing arsenic from drinking water supplies.

**San Joaquin Basin Agricultural Drainage.** Additional data should be collected on contaminants and contaminant loads from Mud and Salt sloughs. Based on the rough data evaluation conducted for this study, it appears that Mud and Salt sloughs contribute substantial loads of organic carbon and TDS to the San Joaquin River. These findings should be confirmed by concomitant monitoring of flow and key drinking water contaminants in the San Joaquin River and Mud and Salt sloughs. It is unlikely that the Mud and Salt Slough drainage will be removed from the river, but the additional data may be useful in recommending best management practices to improve the quality of the drainage water.

**Database Management.** This study has shown that there is a need for more cooperation and coordination between agencies conducting monitoring programs in the Delta tributary watersheds and the Delta. Better coordination of monitoring programs would produce more useful data as agencies adopt similar sampling and analytical methods and detection limits. CUWA should encourage agencies conducting monitoring programs to develop a plan for better coordination. CUWA should work with the agencies collecting data on the Sacramento and San Joaquin rivers to develop a common database management system. This would benefit everyone involved in studies on the Delta tributary watersheds. Inconsistencies in reporting data and the use of customized databases prevent researchers from taking full advantage of all of the available

data. CUWA should sponsor the development of a database manual, similar to the quality control manual prepared by DWR's MWQI program.