JUNE 2002

Sacramento River Watershed Program

Annual Monitoring Report: 2000-2001

SACRAMENTO RIVER WATERSHED PROGRAM

Report Review Process

The review process and schedule for the 2000-2001 Annual Monitoring Report of the Sacramento River Watershed Program (SRWP) is outlined in the table below. This process includes internal reviews by the SRWP Monitoring, Toxics, and Public Outreach and Education Sub-Committees, and review by the all SRWP stakeholders and other interested public. The Public Draft report and the Final report will be available from the SRWP website,

http://www.sacriver.org.

Comments received for the Administrative Draft Annual Monitoring Report are available on the SRWP website. Comments received for the Public Draft Annual Monitoring Report were compiled and are responded to in Appendix E of this document.

SRWP Annual Monitoring Report (AMR) Review and Submittal Schedule

	Date	Review Milestones
✓	2-27-2002	AMR Administrative Draft submitted to Monitoring Sub-committee
✓	3-22-2002	Written Comments on Administrative Draft Due from Monitoring Sub-committee
✓	3-27-2002	Review and approve proposed responses to Monitoring Sub-committee comments at Monitoring Sub-committee meeting
✓	4-17-2002	Public draft released for stakeholder and peer review
✓	5-15-2002	Written comments on Public Draft due from all reviewers
✓	5-21-2002	E-mail comments on Public Draft received from peer reviewers
	5-22-2002	Review and approve proposed responses to Public Draft Comments at Monitoring Sub-committee meeting
✓	6-17-2002	Proposed responses to Peer Reviewer comments on Public Draft submitted to Monitoring Sub-Committee by e-mail
✓	6-28-2002	Submit Final AMR to SRCSD, Monitoring Sub-committee and USEPA

Acknowledgements

The Sacramento River Watershed Program Monitoring Program and the Annual Monitoring Report are products of the efforts of many people. A great deal of effort has been expended in field, laboratory, and office work to collect and analyze samples, to manage, summarize data, and to interpret the results of the Sacramento River Watershed Program monitoring effort. While the names of all of the individuals involved in the SRWP monitoring program are too numerous to list here, we would like to gratefully acknowledge the assistance of all of the participating members of the Monitoring Sub-Committee, the Toxics Sub-Committee, the Biological and Habitat Sub-Committee, and the Public Outreach and Education Sub-Committee. The members of these committees have provided invaluable assistance and advice in developing the monitoring program and in preparing and reviewing this document. We are also grateful for the efforts of the Peer Reviewers of this report. Their insightful comments and recommendations resulted in substantial improvements to this document.

In additional to the participating SRWP committee members, the following agencies and contractors have been instrumental in implementing the SRWP monitoring program.

U. S. Environmental Protection Agency

Sacramento Regional County Sanitation District

Central Valley Regional Water Quality Control Board

San Francisco Estuary Institute

California Department of Water Resources

U. S. Geological Survey

California Department of Fish and Game

University of California Aquatic Toxicology Laboratory

Moss Landing Marine Lab

Sierra Environmental Services

Sequoia Analytical Laboratories

BioVir Laboratories

Pacific EcoRisk

Larry Walker Associates

Acronyms and abbreviations Used in this Document

BMIs	Benthic Macroinvertebrates
CDFG	California Department of Fish and Game
CSBP	California Stream Bioassessment Procedure
CTR	California Toxics Rule
D/DB-P	Disinfection/Disinfection By-Product Rule
DDTs	Dichlorodiphenylethane compounds
DHS	California Department of Health Services
DOC	Dissolved Organic Carbon
DWR	California Department of Water Resources
EPT Index	Ephemera/Plecoptera/Tricoptera Index
FFGs	Functional Feeding Groups
FPOM	Fine Particulate Organic Matter
IBI	Index of Biotic Integrity
ICR	Information Collection Rule
MCLs	Maximum Contaminant Levels
μg/L	micrograms per liter
mg/L	milligrams per liter
MPN/100 mL	Most Probable Number of Bacteria per 100 mL
MWQI	Municipal Water Quality Investigations Program
NAWQA	National Water Quality Assessment Program
ng/L	nanograms per liter
NPDES	National Pollutant Discharge Elimination System
NTR	National Toxics Rule
NTU	Nephelometric Turbidity units
PCBs	Polychlorinated Biphenyls
RWQCB	Regional Water Quality Control Board

SRCSD	Sacramento Regional County Sanitation District
TIE	Toxicity Identification Evaluation
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon

Executive Summary

What is in this Report?

This is the third Annual Monitoring Report for Sacramento River Watershed Program (SRWP). This document provides a review of the Sacramento River Watershed Program (SRWP) monitoring effort and the data generated by the SRWP and other collaborating water quality monitoring programs (USGS NAWQA, Sacramento River Coordinated Monitoring Program, City of Redding NPDES Monitoring, Department of Water Resources intensive tributary monitoring program). This report describes data collected from 1998–2001 by the SRWP and from varying periods for programs coordinating with the SRWP. These water chemistry, aquatic toxicity, fish tissue, and bioassessment data are used to evaluate the attainment of beneficial uses and potential impairment in surface waters of the Sacramento River watershed, to assess spatial and temporal distributions of a variety of important water quality characteristics, and to compare the relative contributions of different inputs to the Sacramento-San Joaquin Delta of selected parameters.

The categories of water quality data considered in this review are mercury (in water and fish tissue), drinking water parameters of concern, aquatic toxicity, organochlorine pesticides and PCBs in fish tissue, and bioassessment parameters (based on physical habitat and benthic macroinvertebrate community data). Locations discussed in this executive summary are illustrated in Figure 1 (page 11) and in the individual sections of the Data Review beginning on page The preliminary conclusions of this review of SRWP and other monitoring data are summarized below.

Mercury

Mercury concentrations in fish tissue collected from 1997 to 2000 from the mainstem Sacramento River below Shasta Reservoir and major tributaries to this section of the river were higher than several of the human health-based and wildlife-based advisory and screening values. Frequent exceedances of the tissue-based water quality criterion for mercury recently developed by the USEPA (0.3 mg/kg; USEPA 2001) and adopted by the California Office of Health Hazard Assessment (OEHHA), and less frequent exceedance of the previous USEPA screening value of 0.6 mg/kg, indicate that there are human health concerns associated with consumption of some fish species from surface waters of the lower Sacramento River watershed. The current water quality USEPA criterion of 0.3 mg/kg is based on a fish consumption rate of 17.5 g/day (equivalent to 4 quarter-pound servings per month). There is some disagreement whether the available data are adequate to warrant issuing fish consumption advisories, and OEHHA has not issued advisories for these waters. However, the Central Valley Regional Water Quality Control Board has recommended addition of a number of waterbodies to California's 303(d) list based on much less information than evaluated in this document. Interim Public Health Notices have also been issued by Placer, Yuba, and Nevada counties for eight Sierra foothill waterbodies based on the same data used by the Regional Board. Although there is substantial uncertainty about the actual level of risk posed by these concentrations of mercury in fish, there is agreement that the risks are greatest for small children and pregnant women, and that the risks increase with greater consumption of fish. General consumption guidelines are provided by OEHHA on their web page (http://www.oehha.org), in addition to consumption advisories for specific waterbodies. Concerns over mercury in fish from the lower Sacramento River watershed are being addressed with more focused monitoring being performed for 2000-2002 (Years 3 and 4). This shift in focus is in large part a result of coordination and consultation with OEHHA, which has been an active participant in the SRWP, and has provided the SRWP with guidance regarding data needs and study design for evaluation of human health risks related to fish consumption.

Consumption-weighted average mercury concentrations[1] in tissues of fish collected from the Sacramento River mainstem from Keswick to the Delta, and in smaller tributaries were lower than USEPA human health-based criterion of 0.3 mg/kg. However, in almost all trophic level 4 species collected throughout the watershed, average mercury concentrations were higher than the 0.3 mg/kg criterion, and were frequently two to three times higher than this criterion.

Consumption-weighted average mercury concentrations in fish tissue collected from the lower American River and Feather River, and in three agricultural drains were higher than USEPA human health-based criterion of 0.3 mg/kg. Exceedance of the criterion indicates that there are potential human health risks associated with consumption of fish from these waterbodies.

Total water column mercury concentrations in the Sacramento River from Keswick to River Mile 44 rarely exceeded the CTR mercury criterion of 50 ng/L (USEPA 2000). Total mercury concentrations exceeded the 50 ng/L limit in 30% of Cache Creek samples and 46% of samples from the upper Mill Creek watershed. The Feather and Yuba rivers are significant sources of mercury loads, but concentrations of total mercury and methylmercury were not elevated compared to the Sacramento River mainstem in 2000-2001. However, relatively high concentrations of mercury in fish from the lower Feather River and American River suggest that these watersheds may have been significantly elevated sources of bioavailable methylmercury in previous years, or alternatively that fish may be accumulating mercury from other locations. Spring Creek in the upper Sacramento River watershed, Deer Creek, Big Chico Creek, and the American River did not appear to be major sources of total mercury—concentrations were low compared to the Sacramento River and were never observed to exceed the 50 ng/L CTR criterion at these sites. With the exceptions of Mill Creek and Cache Creek, total mercury concentrations rarely exceeded the 50 ng/L CTR criterion at any site.

[1] The consumption-weighted average is an estimate of the average concentration of mercury for the total of freshwater and estuarine fish consumed, assuming that a combination of trophic level 3 and trophic level 4 fish are consumed. The approach is consistent with the development of the methylmercury criterion (USEPA 2001), which also assumes that fish consumed consist of a mix of different trophic level species. The consumption-weighted average (*CWA*) mercury concentration is calculated as follows:
CWA = (56.6% x *Trophic Level 3 avg. mg/kg*) + (43.4% x *Trophic Level 4 avg. mg/kg*).

Methylmercury concentrations in water column samples exceeded the Great Lakes human health-based criterion of 0.24 ng/L most frequently in samples from Arcade Creek (67% of samples) and from two agricultural drain sites (25% and 35% of samples). Methylmercury concentrations exceeded the Great Lakes wildlife-based criterion of 0.05 ng/L in nearly every sample collected from mainstem location below Hamilton City, and in all other tributaries and agricultural drains sampled.

The Sacramento River watershed drainage is a major source of mercury to the Delta. This watershed contributes approximately 90% of the total mercury loads to the Delta. Within the Sacramento River watershed, the Cache Creek drainage is the single largest source area for total mercury. The Delta Tributaries Mercury Council of the SRWP is currently evaluating additional controllable mercury sources within the Sacramento River watershed as part of its Strategic Plan to control mercury in the watershed.

Aquatic Toxicity

Samples collected from Arcade Creek at Norwood Avenue continue to exhibit a much higher frequency and severity of toxicity than all other tributaries and mainstem Sacramento River sites sampled in 2000-2001 monitoring. This pattern was also exhibited in limited sampling of two other locations in the Arcade Creek urban watershed.

The results of the 2000-2001 monitoring and of previous aquatic toxicity monitoring efforts have confirmed that significant toxicity to test organisms occurs in surface waters monitored by the SRWP throughout the watershed. *Ceriodaphnia dubia* toxicity attributable to organophosphate pesticides in agricultural runoff and urban runoff has been definitively shown by SRWP monitoring and other studies.

Regularly scheduled monitoring conducted from 1998–2000 was valuable in evaluating the overall frequency and distribution of observed water column toxicity, and for identifying or confirming the causes of some of the observed toxicity. However, significant questions remain regarding the sources, severity, persistence, and ecological significance of periodic toxicity in the Sacramento River watershed surface waters. To address these questions, the SRWP aquatic toxicity monitoring effort in 2000-2001 focused primarily on monitoring specific episodic events (e.g. agricultural dormant spray season, runoff events, high flow events). This strategy resulted in observation of much more frequent and severe toxicity in the Arcade Creek urban watershed, but did not result in greater frequency of observed toxicity for other locations. However, winter of 2000-2001 was a below-average rainfall year and this may have affected the frequency of episodic toxicity throughout the watershed. Episodic monitoring of toxicity was continued in the 2001-2002 monitoring season.

Organophosphate, Carbamate, and Triazine Pesticides

The results of SRWP and other monitoring programs continue to support the focus of the SRWP and of both state and federal regulatory agencies on the management of organophosphate pesticides in surface waters. Diazinon and chlorpyrifos appear to have the greatest potential for impacts on aquatic life, with other monitored pesticides appearing to have relatively low to minimal risk of impacts on aquatic life or human health. The potential impacts on beneficial uses from diazinon and chlorpyrifos are being addressed through the Water Quality Management Strategy developed by the Organophosphate Pesticide Focus Group (SRWP 2001), and by the TMDL being developed by the Central Valley Regional Water Quality Control Board.

There are still few data are available for the many minor tributaries in the Sacramento River watershed. For smaller tributary watersheds with a substantial proportion of agricultural land use, there may a significant potential for pesticide concentrations to occasionally reach concentrations of concern. However, no pesticides were detected in limited SRWP monitoring of several smaller tributary watersheds in 2000-2001. Additional pesticide monitoring data (e.g. from DWR) should be evaluated for these watersheds when they become available, to better characterize the potential risks from pesticides in these watersheds.

The shift from use of organophosphate and carbamate pesticides to other pesticides, such as pyrethroids and pyrethrins, indicates the need to increase monitoring for these pesticides. The University of California at Davis Aquatic Toxicology Laboratory is currently performing research to develop new sampling and analytical techniques to adequately identify and measure toxic concentrations of these pesticides in water, sediment, and tissue.

Drinking Water Parameters of Concern

The Sacramento River and major tributaries provide water supplies for municipal, industrial and agricultural use in the Sacramento River Basin and downstream in the Sacramento-San Joaquin Delta. In addition, the Sacramento River is the primary source of flow to the Sacramento-San Joaquin Delta and the source of drinking water for an additional 20 million people in the Bay Area, Central Coast, and Southern California. The Sacramento River and its major tributaries are generally considered high quality drinking water sources. Although the quality of the Sacramento River is changed as it moves downstream and into the Delta, data collected to date for the best available indicators demonstrate that drinking water beneficial uses are substantially realized in the Sacramento River watershed. Water supply agencies treating Sacramento River and Delta water are currently able to meet drinking water standards and provide safe drinking water to millions of consumers throughout California. However, anticipated future drinking water regulations *may* require agencies treating Delta water to implement additional treatment (at increased costs). Drinking water parameters of potential concern included in the SRWP monitoring program include organic carbon, total dissolved solids, pathogens, turbidity, and nutrients. Organic carbon is of concern primarily due to its role in the creation of carcinogenic trihalomethanes (THMs) and other disinfection by-products during disinfection of source water. Total dissolved solids (TDS) can have an important effect on the taste and palatability of drinking water, and at very high levels, may cause health problems in sensitive individuals. The presence of high levels of TDS may also be objectionable to consumers owing to excessive scaling in water pipes and fixtures, heaters, boilers, and household appliances. TDS concentrations are also a factor limiting use of Delta waters for groundwater recharge, particularly in the Southern San Joaquin Valley. Pathogens such as *Cryptosporidium* and *Giardia* are of concern due to their potential to cause adverse human health effects. The primary concern associated with turbidity is its effect on disinfection processes, because high levels have been shown to protect microorganisms from the action of disinfectants and to increase the levels of chlorine and oxygen needed during treatment. Elevated nutrient concentrations may promote excessive algal growth and consequently contribute to taste and odor problems associated with some species of algae.

The mainstem Sacramento River, and major tributaries (the Yuba, Feather, and American rivers) consistently meet water quality goals and objectives for drinking water-related parameters, suggesting that these waterbodies achieve their designated beneficial uses as sources of municipal and agricultural supply water and recreation:

There was a general trend for concentrations of several parameters (TDS, organic carbon, nutrients) to increase in the mainstem Sacramento River from the upper watershed to the lower watershed. This trend can generally be attributed to a combination of natural and anthropogenic sources, and is moderated by high quality Sierra tributary inflows.

The Basin Plan limit for median fecal coliform numbers (200 MPN/100mL) was not exceeded at any site, and the maximum limit for single samples (400 MPN/100 mL) was exceeded infrequently in the Sacramento River, the American River, and Cache Slough.

TOC concentrations measured in the Sacramento River at Colusa, Verona, and Freeport often exceed the Stage 1 Disinfectant/Disinfection By-Product (D/DBP) Rule treatment threshold of 2.0 mg/l. The 2.0 mg/L threshold is significant because exceedance of this threshold may require utilities to remove up to 35% percent of TOC in their source water. It is not clear that the observed levels of organic carbon will result in a requirement for municipal drinking water suppliers to remove *additional* TOC in source water. The Stage 1 D/DBP Rule does not require such treatment if certain treatment technology requirements used, or if other water quality requirements are met in influent or treated water. Additionally, treatment technologies currently in use by many utilities are already able to remove ≥35% of source water TOC from Sacramento River water. Even if additional TOC removal is necessary, this requirement would not limit the water supply use.

Giardia cysts were detected in 41% to 75% of samples collected from the mainstem Sacramento River and major tributaries, and in one of five Cache Slough samples. *Cryptosporidium* öocysts were detected in 12 of 116 samples from the mainstem Sacramento River. Although the analytical method used for *Giardia* and *Cryptosporidium* is much improved (compared to the ICR method used previously), there remains a high degree of uncertainty associated with data for these pathogens. This monitoring has been suspended by the SRWP Monitoring Sub-committee due primarily to funding limitations.

The parameters of greatest concern for drinking water quality (TOC, TDS, nutrients, and pathogens) are still largely unregulated by the Regional Water Quality Control Board (RWQCB) and the Water Quality Control Plan (Basin Plan). The combination of existing and future land use changes, and the resulting increases in point source and nonpoint source discharges in the Sacramento River watershed, has the potential to increase loadings of these largely unregulated parameters of concern. The RWQCB is currently implementing a work plan for the development of an effective drinking water policy. This policy is expected to specifically address these parameters and establish water quality objectives for eventual inclusion in the Basin Plan.

PCBs and Organochlorine Pesticides in Fish Tissue

Based on comparisons to screening values for organochlorine pesticides and PCBs in fish tissue, consumers who eat a variety of fish from different locations appear to be at relatively low risk from these compounds in fish tissue. However, potential risks increase for people selectively consuming a limited number of higher trophic level species (e.g. white catfish, largemouth bass, striped bass), and for individuals consuming more fish than the 30 g/day (eight quarter-pound servings per month) on which the screening values were based.

Consumption-weighted average concentrations of DDTs and dieldrin in fish from agricultural drains, and of PCBs in fish from Delta locations exceeded USEPA screening values for these compounds. However, these results were dependent on very limited data for trophic level 3 species, and additional data are needed to adequately assess the potential risks for these waterbodies. Monitoring of organochlorine pesticides and PCBs in fish tissue has been continued in 2001-2002 to help address these questions.

Evaluation of consumption-weighted average concentrations suggests the need to re-evaluate several of the waterbodies cited on the1998 303(d) for impairment due to organochlorine pesticides and PCBs. The results also support the Regional Board’s recommendation to remove the lower American River from the updated 2002 303(d) list.

Fish from smaller tributaries throughout the watershed tended to have lower concentrations of most organochlorines than other waterbodies evaluated (the Sacramento River mainstem, the Delta, the American and Feather rivers, and several agricultural drains). There was little evidence of other distinct spatial trends in organochlorine concentrations in fish tissue.

Bioassessment

Available data indicate that the beneficial uses evaluated by bioassessment monitoring (i.e. aquatic life uses and habitat) are achieved to a fairly high degree in the Sacramento River mainstem, major tributaries, and in all of the smaller tributaries assessed to date (Deer Creek, Big Chico Creek, Mill Creek, Butte Creek). However, because appropriate sampling techniques and reference conditions are in the process of being developed for assessing biological communities in non-wadable river systems, these results should not be considered conclusive (particularly for the mainstem Sacramento River).

There was a strong correlation between elevation and physical habitat and aquatic life metrics. Lower elevation sites were more impacted by sedimentation and had much lower diversity and less complex community structure.

The majority of sites evaluated had similar physical habitat characteristics and were considered to be in good to excellent condition. However, it is important to note that there are no comparable physical habitat measures for the non-wadable sites and that these appear to be the most physically impacted sites.

Macroinvertebrate communities at most sites were described as complex with a wide range of taxa represented. Macroinvertebrate communities were dominated by sensitive taxa at almost all sites. Because reference conditions and biocriteria have not been developed for the Sacramento River watershed, it is not clear how the sampled stream and river reaches compare to other systems and ecoregions. However, the dataset for the complete 1997-2000 sampling effort provides a baseline of biological information that will contribute to developing an Index of Biotic Integrity (IBI) for the Sacramento River watershed, and the focus of future bioassessment efforts have shifted to developing a process for defining reference conditions for the watershed, beginning in the Sierra foothill ecoregion.

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I. Program Overview

Organization and Funding

The Sacramento River Watershed Program (SRWP) is an association of stakeholders in the Sacramento River watershed. These stakeholders include representatives of local municipalities and districts, state and federal agencies, agriculture, industry, landowners, environmental organizations, universities, technical consultants, and watershed conservancies. The SRWP was formed in 1996 and has functioned through a series of stakeholder meetings.

Formation of the SRWP was facilitated by the Sacramento River Toxic Pollutant Control Program (SRTPCP), a locally initiated effort led by Sacramento County and the Sacramento Regional County Sanitation District (SRCSD). The SRTPCP is a watershed-based approach to the management of potentially toxic pollutants in surface waters of the Sacramento River watershed.

Funding for the SRTPCP is provided primarily by the federal government and is administered by USEPA Region IX. Local matching funds are provided by the Sacramento Regional County Sanitation District, and in-kind services are provided by several participating stakeholders. Additionally, significant public and private support of the program is being provided through the active participation of numerous representatives on the SRWP sub-committees. A portion of the SRTPCP funding was specifically designated to assist in the formation of the broader watershed program.

Program Goals and Objectives

The goal statement developed by the participating stakeholders for the SRWP in 1996 is as follows:

> ***SRWP Goal Statement***: *"To ensure that current and potential uses of the watershed's resources are sustained, restored and, where possible, enhanced while promoting the long-term social and economic vitality of the region."*

One of the primary tasks of the SRTPCP and the SRWP is the design and implementation of a water quality monitoring program for the watershed. In early stakeholder meetings, a Monitoring Sub-committee was formed to lead the development of the water quality monitoring program.

Monitoring Program Goals

The Monitoring Sub-committee established the following long-term goal for the SRWP water quality monitoring program:

> *"In coordination with other sub-committees and the larger stakeholder group, develop a cost-efficient and well-coordinated long term monitoring program within the watershed to identify the causes, effects and extent of constituents of concern that affect the beneficial uses of water and to measure progress as control strategies are implemented."*

The SRWP water quality monitoring program is envisioned by the sub-committee to be a long-term (e.g. 20 year) effort that provides information to promote the understanding of conditions in surface waters of the watershed and to assess the health of these waters. The monitoring program is a dynamic activity that changes as information is accumulated and new information needs are identified. It is projected that the water quality program will be integrated with other resource monitoring activities, including biological communities, habitat, land use, etc. More in-depth descriptions of the monitoring program are provided in the Phase 1 Monitoring Plan (LWA 1998a), and the Quality Assurance Project Plans for monitoring conducted from 1998 through 2001 (LWA1998b, 1999, and 2000).

The Monitoring Sub-committee established the following goal for the first year of the monitoring program, and retained this goal for the second year of monitoring:

> *"To assess conditions in the mainstem of the Sacramento River through the collection of baseline information, with an emphasis on examining the degree to which beneficial uses are attained or potentially impaired."*

The SRWP has made substantial progress towards meeting both the long-term and short-term goals for the monitoring program. The monitoring program developed by the SRWP through the stakeholder process is currently coordinating with a number of ongoing monitoring programs managed by federal, state, and regional public agencies. The collection and evaluation of baseline information for water quality parameters of interest to the SRWP is being accomplished directly through SRWP monitoring, and through cooperative data sharing with other monitoring programs conducted by the Department of Water Resources, the Central Valley Regional Water Quality Control Board, the U.S Geological Survey, the Sacramento River Coordinated Monitoring Program, and the City of Redding. Additionally, the program also compiles and reports water quality data generated prior to the initiation of SRWP monitoring in 1998. Evaluating the available information and identifying gaps in the data needed to assess the degree to which beneficial uses are achieved or potentially impaired in the watershed was (and continues to be) an integral part of the development of the monitoring program. The evaluation of water quality monitoring information documented herein is an extension of this ongoing process.

Objectives

The Monitoring Sub-committee also adopted long-term and short-term objectives. The long-term objectives include:

- Identification of available monitoring program elements that will provide information needed to understand the condition of surface waters of the watershed (i.e. to inventory the characteristics of the watershed).
- Identification of an approach for determining the relative health of the watershed (i.e. a means to assess and evaluate the meaning of the above information).

The short-term objectives developed by the sub-committee include:

- Identification of the monitoring goals and future uses for the data being collected, including: *water quality characterization, biological assessment, long-term trend analysis, and compliance with applicable water quality regulations*

Identification of data needs and data quality objectives (i.e. to ensure that data collected will be useful, understandable, accessible, manageable, and scientifically valid).

Coordination with other sub-committees of the SRWP (e.g. Toxics, Biological and Habitat, Education and Outreach).

Assessment of Beneficial Uses and Compliance with Water Quality Objectives

As stated above, the initial goal for the SWRP monitoring effort includes examining the degree to which beneficial uses are attained or potentially impaired. The existing and potential beneficial uses for the Sacramento River watershed are outlined in the water quality control plan (Basin Plan) for the Central Valley Region. The following are existing beneficial uses in the Sacramento River watershed, as defined in the Central Valley Region Basin Plan (CVRWQCB 1995):

municipal and domestic water supply	*agriculture (irrigation and stock watering)*
industry (process, service supply, power)	*contact recreation*
non-contact recreation	*freshwater habitat*
migration	*spawning*
wildlife habitat	*navigation*

Another purpose of the SRWP monitoring program is the comparison of observed ambient concentrations with adopted water quality objectives and criteria[2]. Numeric and narrative objectives have also been adopted in the Basin Plan (CVRWQCB 1995) for surface waters of the Sacramento River watershed for selected toxic pollutants in California. Water quality criteria for toxic pollutants are also included in the California Toxics Rule (CTR) (USEPA 2000). The CTR criteria are largely the same as the current USEPA recommended national ambient water quality criteria (USEPA 1999).

The Regional Water Quality Control Boards for the Central Valley and San Francisco Bay have developed lists of impaired waters which will not meet water quality objectives after implementation of technology-based controls for point sources and best management practices for non-point sources. These lists are required under Section 303(d) of the Clean Water Act. The portions of the lists that address the Sacramento River and its tributaries and the Sacramento-San Joaquin Delta are provided in individual data review sections. Management plans that establish Total Maximum Daily Loads (TMDLs) for listed pollutants must be prepared for all waters contained on the 303(d) lists, and the regulations state that TMDLs must lead to compliance with adopted water quality objectives.

[2] The SRWP's review and evaluation of designated uses and the criteria developed to protect these uses is consistent with the Water Quality Standards program mandated by the Clean Water Act, wherein a Standard for a water body is defined by four elements: designated uses of the water body, water quality criteria to protect the designated uses, an antidegradation policy, and general implementation policies.

Monitoring Program Description

The 2000-2001 SRWP monitoring program includes chemical, physical, biological and toxicological monitoring elements. The proposed program augments and coordinates with a number of other monitoring efforts that are ongoing in the watershed, including the USGS National Water Quality Assessment Program (NAWQA), the Sacramento Coordinated Water Quality Monitoring Program (CMP), and monitoring efforts by the Department of Water Resources (DWR), Department of Pesticide Regulation (DPR), City of Sacramento, and City of Redding.

The SRWP Monitoring Program was developed through an interest-based, coordinated approach. Managers of major water quality monitoring activities in the watershed were identified and invited to participate on the Monitoring Sub-committee. Numerous Sub-committee meetings were held to discuss and evaluate considerations in the development of the first year SRWP monitoring program. Existing monitoring programs were described and opportunities for coordination and integration were identified. Parameters of interest, candidate monitoring locations, monitoring frequency, sample collection methods, appropriate analytical methods, quality assurance/quality control, and program costs were evaluated by the Sub-committee.

Several possible monitoring approaches were discussed and evaluated during development of the proposed program design, including:

1. Mainstem river emphasis, with most parameters monitored.
2. More stations sampled with limited set of parameters monitored, with emphasis on parameters that are currently monitored by existing major programs.
3. More parameters monitored at fewer sites, with emphasis on existing major program sites.
4. Selected stations, parameters, and analytical methods chosen to facilitate an initial evaluation of beneficial use attainment in the watershed, with mainstem and major tributary emphasis.

Ultimately, the fourth approach was selected by the Monitoring Sub-committee as the starting point for the SWRP monitoring program and the best available means to achieving SRWP monitoring goals. The emphasis on the mainstem Sacramento River was favored to provide a foundation to which other programs and future additions to the SRWP Monitoring Program could be connected. This approach was chosen to provide best achievable information using conventional monitoring tools that would be most immediately useful in evaluating beneficial use attainment and potential impairment, and in the identification of management issues. Monitoring parameters and methods were selected to provide information that best addressed these issues. Sites were chosen to complement and augment ongoing monitoring, to provide information at the mouths of major tributaries, and to coincide with flow monitoring stations.

The sites monitored, parameters measured, and sampling schedule for the SRWP monitoring program are discussed in the following sections.

Sampling Sites

Site selection criteria were developed by the Monitoring Sub-committee to determine the monitoring locations for the SWRP monitoring program. Criteria used for the initial selection of sites included the following:

existing sampling station	*site access constraints*
flow gauging station	*sampling access constraints*
magnitude of streamflow	*available water quality data*
critical habitat area	*in existing watershed program*
predominant land use (e.g. agriculture, municipal, industrial, mining, etc.)	*potential water quality impairment, including 303(d) listed waterbodies*

After an initial screening using the criteria listed above, the selection was narrowed to include sites along the mainstem of the Sacramento River and at the mouths of major tributaries. Major tributaries were identified using existing streamflow data. Mainstem sites were selected to facilitate coordination with existing programs and to provide information below major reservoirs. Major tributaries were selected based on the magnitude of flow into the mainstem. The three major tributaries into Lake Shasta were included to capture these inputs and large tributary areas.

In addition to the mainstem monitoring, three smaller Sierra Nevada tributaries (Mill Creek, Big Chico Creek, and Deer Creek) were selected for special studies for 1998-2000 monitoring. The Sub-committee included these tributaries on a demonstration basis to encourage monitoring in these areas and to coordinate with the monitoring activities of the Department of Water Resources, Northern District.

The SRWP monitoring program for 2000-2001 implemented several significant changes to the monitoring program. Note that changes made in the monitoring program were always prioritized by considering the goals of the program and the overall approach, even when those changes were required by decreases in the monitoring budget. The specific changes to the monitoring program are documented in the Quality Assurance Project Plan (QAPP) (SRWP 2000). Significant revisions to the program included:

The overall monitoring contract was awarded to a new prime contractor, Pacific EcoRisk of Martinez, California. As a result of awarding the monitoring contract to Pacific EcoRisk, there were also several changes in other contractors performing sampling and analysis for the SRWP in 2000-2001.

Bioassessment monitoring was initiated in three new tributary watersheds (Cow Creek, Battle Creek, and Stony Creek), and discontinued or reduced in four tributary watersheds (McCloud River, Mill Creek, Deer Creek, Big and Chico Creek). The changes in bioassessment monitoring locations were simply the implementation of the existing strategy to rotate monitoring into new tributary watersheds on a two year cycle.

Monitoring for mercury and methylmercury was conducted at one additional new location (Sacramento River at Greene's Landing). This site was added to SRWP monitoring to coordinate with a CALFED-funded study of mercury loading in the Sacramento River. Fish tissue monitoring was also added at Stony Creek because it is considered to have the potential for high mercury concentrations.

The basic monitoring frequency was changed from monthly to 9 events per year. This change was primarily a response to budget constraints. Additionally, the basis for monitoring pesticides and aquatic toxicity was changed from regularly scheduled sampling to an episodic basis.

Monitoring for nutrients, minerals, turbidity, and trace metals in water (except for mercury), sediment toxicity, and algal bioassessment was discontinued. Organic carbon, TDS, and TSS monitoring were also discontinued at upper watershed sites. All of these elements were discontinued in part as a result of budget constraints and prioritization of the remaining available monitoring budget.

Analysis for methylmercury in water was added to the monitoring program. Methylmercury is the most bioavailable form of mercury, and monitoring this parameter has been identified as an important step in understanding potential human health risks due to mercury pollution in the Sacramento River watershed.

The 2000-2001 SRWP monitoring program includes monitoring at 52 locations in the Sacramento River watershed. Eight of these sites are located on the mainstem of the Sacramento River, ranging from the Sacramento River below Keswick Reservoir to the Sacramento River at Greene's Landing. The remaining 44 sites are located on tributaries to the Sacramento River, including 4 sites on major tributaries, 3 agricultural drains, one urban creek, and 36 sites on 10 smaller tributary watershed. The proposed sites cover over 300 miles of the Sacramento River system and represent a drainage area of over 23,000 square miles. Table 1 lists the sampling sites for the SWRP 2000-2001 monitoring program with a description of the location and the type of site. The site locations are illustrated in Figure 1.

Nine scheduled or episodic water column monitoring events will be conducted at 14 of the above sites. One annual monitoring event will be conducted at 37 bioassessment monitoring sites and at 17 fish tissue monitoring sites.

Monitoring Parameters

Specific individual parameters measured by the SRWP 2000-2001 monitoring effort are listed in Table 2. The rationales for monitoring environmental parameters included in the SRWP monitoring program are discussed below.

Mercury, PCBs, and chlorinated pesticides in fish tissue

Mercury and certain organic contaminants (including DDT and PCBs) are readily accumulated directly from water or through the food web from low levels in water, resulting in concentrations in fish tissue which may be of concern to humans and wildlife. Monitoring levels of these pollutants in fish provides an effective way to assess potential human health hazards due to contamination of the Sacramento River system. Because fish accumulate contaminants throughout their life span and their habitat, measurements of contaminant concentrations in fish tissue provide an indication of average conditions over space and time. Fish tissue data can be useful in the determination of long term levels and trends of bioaccumulative contaminants (such as mercury, DDT and PCBs) in the watershed. This long-term data set can be used to measure the effectiveness of activities to control these pollutants.

Mercury in water

As stated above, low concentrations of mercury and methylmercury in water are of potential concern to human health. Several programs are currently planned or under way in the Sacramento River watershed to monitor mercury concentrations at various locations, including the Sacramento Coordinated Water Quality Program, the USGS National Water Quality Assessment for the Sacramento River, and CALFED. SRWP mercury monitoring supplements existing data, and planned and ongoing monitoring efforts, with information for eleven locations. Data obtained will be used to quantify ambient concentrations of mercury and methylmercury in surface waters of the Sacramento River watershed and to study whether these concentrations are causing or contributing to potential human health risks or otherwise adversely affecting beneficial uses.

Pesticides in water

Low concentrations of pesticides in water can affect the growth, reproduction and/or survival of sensitive aquatic species. The SRWP currently monitors organophosphate (OP), carbamate, and triazine pesticides. These classes of pesticides have been identified as being of potential concern to aquatic life in the Sacramento River system and are responsible for the presence of several Sacramento River watershed waterbodies on the 303(d) list of impaired waterbodies. Several programs are currently under way in the Sacramento River watershed to monitor pesticides at various locations in the Sacramento River watershed, including programs administered by the California Department of Pesticide Regulation (DPR), the California Regional Water Quality Control Board, and the USGS National Water Quality Assessment for the Sacramento River. SRWP pesticide monitoring will supplement the existing data with information for 10 additional locations. Specific pesticides analyses and locations for monitoring were selected on the basis of documented use of these pesticides upstream from the locations monitored, on pesticide-caused toxicity detected at these streams/rivers, and on inclusion for pesticides on the 303(d) list of impaired water bodies. Data obtained are used to quantify ambient concentrations of pesticides in surface waters of the Sacramento River watershed and to assess whether these concentrations are potentially adversely affecting uses. It should be noted that numerous other pesticides of potential concern to aquatic life and human health (including pyrethroids and legacy organochlorine pesticides) are not being monitored by the SRWP.

Toxicity in water

Ambient samples of water and sediment can be tested in the laboratory for toxicity to provide an indication of the conditions that exist in the natural environment. Standard test species and test procedures are used to provide reliable and comparable results. Toxicity is deemed to occur when test species are significantly affected by exposure to ambient water or sediment as compared to laboratory controls. Toxic effects measured for the

SRWP in 2000-2001 include reduced reproduction and increased mortality of *Ceriodaphnia dubia*. Effects may occur rapidly over a period of hours to four days (acute toxicity) or may occur over a longer period (chronic toxicity). For the SRWP monitoring program, the results of toxicity testing are also used to trigger further investigations to determine the cause of observed toxicity. These toxicity identification investigations include the consideration of a number of factors, including contributing watershed characteristics, chemical characteristics of the water, biology, and additional toxicity testing wherein classes of toxicants are selectively removed or rendered non-toxic. Results from these weight-of-evidence investigations are useful in identifying potential water quality problems in the watershed. Sites for aquatic toxicity monitoring were selected to provide an overall survey of the distribution of toxicity in the watershed, and to coordinate with existing monitoring programs.

Pathogens and pathogen indicators

Pathogens are disease-producing organisms (protozoa, bacteria, and viruses) which adversely affect the quality of drinking water and/or may pose human health risks for water contact recreation. Two pathogens of particular concern are *Giardia lamblia* and *Cryptosporidium parvum*. Water treatment agencies are currently required to remove or inactivate at least 99.9% of *Giardia* and effective December 2001, are required to remove 99% of *Cryptosporidium* (Interim Enhanced Surface Water Treatment Rule, USEPA 1998). Although most facilities utilizing conventional or direct filtration remove at least 2 logs of *Cryptosporidium* (*ibid.)*, this organism is resistant to disinfection with chlorine, and high numbers of *Cryptosporidium* in source waters may require water supply agencies to switch to ozone or other disinfectants. Although data sets exist for the Sacramento River near Redding and in the Sacramento River below Sacramento, data on the numbers of these pathogens are otherwise lacking for most of the Sacramento River system. Monitoring efforts by the Department of Water Resources, and the Metropolitan Water District in the lower end of the watershed near Sacramento to assess numbers of *Cryptosporidium*, *Giardia*, and coliform organisms (indicators of fecal contamination) were completed in April, 1998, but no final report is expected to be released. The results of a second DWR study conducted in 2000 have yet not been released. The SRWP pathogen monitoring effort extends monitoring for these specific parameters to several additional upstream locations in the Sacramento River watershed. Coliform bacteria are monitored primarily as indicators of other pathogenic organisms, and are monitored at the same locations as *Cryptosporidium* and *Giardia*. It was anticipated that SRWP data would be used primarily to determine the magnitude and extent of numbers of these pathogens in the mainstem of the river below major dams.

Organic carbon in water

The organic content of water (measured as total and dissolved organic carbon) is a parameter important to drinking water suppliers. High concentrations of organic compounds in source waters contributes to the production of disinfection by-products (trihalomethanes and halo-acetic acids) as a result of conventional water treatment. Some of these by-products are carcinogenic and pose human health problems at relatively low concentrations. Additionally, the Stage 1 Disinfectants and Disinfection By-Product Rule (effective January 2002) requires drinking water systems serving at least 10,000 people to meet specified total organic carbon (TOC) removals dependant on source water TOC concentrations. For these reasons, baseline data on typical organic carbon concentrations and seasonal variability of those concentrations in the Sacramento River system are important to the assessment of drinking water uses. SRWP monitoring for organic carbon augments fairly extensive monitoring already being performed by the USGS NAWQA program, the City of Sacramento and the Department of Water Resources.

General constituents (suspended and dissolved solids, turbidity, alkalinity, hardness) in water

These "conventional" water quality characteristics are important to the evaluation of the attainment of a variety of uses, including drinking water supply, recreation, aesthetics, aquatic habitat, and agricultural supply. Data for these parameters are available from a number of programs, including USGS NAWQA, the Sacramento Coordinating Monitoring Program and the Department of Water Resources. SRWP monitoring augments the ongoing data collection efforts for some of these constituents.

Benthic invertebrates and habitat characterization

Benthic invertebrates are the aquatic insects and other organisms that live along the bottom of streams, lakes, and other waterbodies. Procedures have been developed and recently refined to standardize the assessment of biological habitat and benthic communities for use as a monitoring tool (Plafkin et al. 1989, CDFG 1996, DWR 1997). Ideally, information on invertebrate diversity, abundance, species richness, and other community metrics collected at specific sites is compared against expected conditions (or reference stream conditions) to evaluate the relative health of the biological community at that location. This information is used in combination with chemical concentration and toxicity data to assess ecosystem conditions at various locations. Different procedures are used depending on the characteristics of the stream (i.e. wadable versus non-wadable). This monitoring tool can be effectively used by citizen monitoring groups in smaller tributary watersheds. The Department of Water Resources and Department of Fish and Game are working actively with a number of tributary watershed groups to provide education and training regarding the assessment methods. Data from the SRWP monitoring program is intended to supplement and integrate results from projected tributary efforts.

Sampling Frequency and Schedule

Monitoring frequency varied by location and the parameter to be tested, as summarized below:

Basic water quality monitoring—for mercury, pathogens, organic carbon, and general constituents in water, there were 9 scheduled sample events at all sites monitored. Two "event-based" sample events planned for Greene's Landing on the lower Sacramento River mainstem were not conducted. These two events were to be conducted during periods of high Sacramento River flows conditions which did not occur in the 2000-2001 monitoring period.

Pesticides in water and chronic water column toxicity—sampling was generally "event-based", with a total of 9 sampling events. 5 of these events were coordinated with scheduled basic water quality sampling events. Event-based sample events were planned to coincide with conditions expected to result in higher pesticide concentrations (e.g. during seasonal pesticide applications, expected periods of agricultural or urban runoff), or conditions that match a previously observed pattern of toxicity. The exact timing and nature of these events were determined by the Toxicity Focus Group of the SRWP and the sampling contractor (Pacific EcoRisk).

Fish tissue—sampling will be conducted once annually for all sites to be monitored.

Bioassessment—biota sampling and physical habitat assessment will be conducted once annually for all sites to be monitored.

The scheduled sample events were conducted beginning on the third Tuesday of each month, and were typically conducted over a period of two or three days. No scheduled events were conducted in June, August, or December. (Descriptions and dates for specific episodic and scheduled events are described later in the *Pesticides* and *Aquatic Toxicity* Data Review sections of this report.) A breakdown of sampling sites, sampling frequency, and parameters to be analyzed are provided in Table 3.

Table 1. SRWP 2000-2001 Monitoring Sites

Site description	SRWP Site ID(1)	Site Type
Sacramento River above Lake Shasta	SRSHA	tributary
Sacramento River below Keswick Reservoir	SRBKR	mainstem
Cow Creek watershed (5 sites)	CW###	tributary
Battle Creek watershed (5 sites)	BA###	tributary
Sacramento River at Bend Bridge near Red Bluff	SRABB	mainstem
Mill Creek at Mouth	MCMOU	tributary
Deer Creek watershed (4 sites)	DC###	tributary
Stony Creek watershed (7 sites)	ST###	tributary
Big Chico Creek watershed (4 sites)	CH###	tributary
Sacramento River near Hamilton City	SRHAM	mainstem
Sacramento River at Colusa	SRCOL	mainstem
Butte Creek watershed (6 sites)	BC###	tributary
Sacramento Slough	SACSL	agricultural drain
Colusa Basin Drain	COLDR	agricultural drain
Yuba River at Marysville	YRMRY	tributary
Feather River near Nicolaus	FRNIC	tributary
Sacramento River at Veterans Bridge	SRVET	mainstem
Arcade Creek	ARCNW	urban creek
Natomas East Main Drain	NEMDR	agricultural drain
American River at J Street	ARJST	tributary
American River at Discovery Park	ARDPK	tributary
Sacramento River at Freeport	SRFPT	mainstem
Sacramento River at River Mile 44	SRRMF	mainstem
Sacramento River at Greene's Landing	SRGRN	mainstem
Putah Creek	PUTAH	tributary
Upper Putah Creek	PUTAU	tributary
Cache Slough near Ryers Island Ferry	CCHSL	tributary

(1) ### indicates multiple site IDs for this drainage.

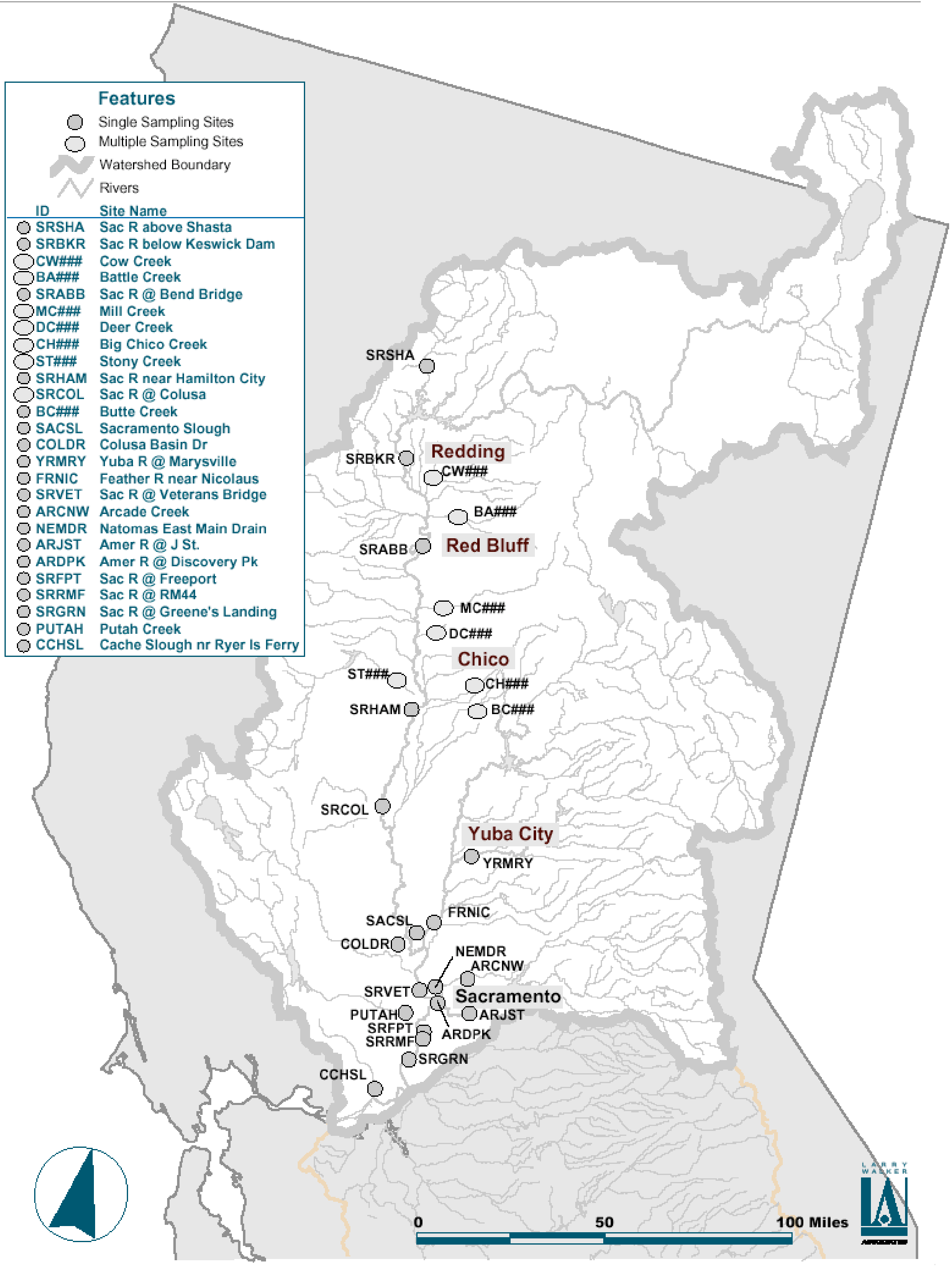


Figure 1. SRWP Monitoring Program Sampling Sites

Table 2. Parameters Measured for the SRWP 2000-2001 Monitoring Program

Chemical and Physical Water Quality Characteristics	
Mercury	*General Constituents*
Total Mercury, unfiltered	Alkalinity
Total Mercury, filtered	Total Suspended Solids
Methylmercury, unfiltered	Hardness
Methylmercury, filtered	Turbidity
	Total Dissolved Solids
	Dissolved Organic Carbon
	Total Organic Carbon
Field Parameters	
Temperature	*Pesticides*
pH	Organophosphate Pesticides
Dissolved Oxygen	Carbamate Pesticides
Conductivity	Triazine Pesticides
Microbiological Water Quality Characteristics	
Cryptosporidium parvans	Total coliform bacteria
Giardia lamblia	Fecal coliform bacteria
Aquatic Toxicity	
Ceriodaphnia reproduction	*Ceriodaphnia* mortality
Biota	
Fish Tissue	*Benthic Invertebrates*
Mercury	Community abundance and diversity metrics
Chlorinated pesticides	Physical Habitat measures
PCBs	

Table 3. Summary of Sampling Sites, Sampling Frequency, and Parameters.

MONITORING PLANNED FOR 2000-2001
Sacramento River Watershed Program

	Water Chemistry											Path-ogens		Aquatic Toxicity		Fish Tissue		Bioassess-ment (b)	
Location	**Hg (filtered and unfiltered)**	**MeHg (filtered and unfiltered)**	**TSS**	**Hardness**	**Alkalinity**	**TOC**	**DOC**	**TDS**	**OP pesticides**	**carbamate pesticides**	**triazines**	**Giardia/Crypto**	**Total, Fecal Coliforms**	**Ceriodaphnia**	**WC Tox Followup (a)**	**Mercury**	**PCBs & chlor. pest.**	**Benthic Invertebrates**	**Habitat Assessment**
Sac. R. above Shasta															E				
Sac. R. below Keswick	5	5												9 E	E	2	2		
Cow Creek																		5	5
Battle Creek																		5	5
Sac. R. at Bend Bridge	9	9	9			9	9	9				9	9	9 E	E	2	2		
Mill Creek at Mouth	9	9	9						3 E							4	4		
Deer Creek									3 E									4	4
Stony Creek																4	4	7	7
Big Chico Creek									3 E									4	4
Sac. R. near Hamilton City	9	9	9	9		9	9	9	9 E							2	2	1	1
Sac. R. @ Colusa	9	9	9			9	9	9	9 E			9	9	9 E	E	2	2	1	1
Butte Creek																		6	6
Sac. Slough	9	9	9			9	9	9	9 E	9 E				9 E	E	2	2		
Colusa Basin Dr	9	9	9			9	9	9	9 E	9 E				9 E	E	2	2		
Yuba R. at Marysville	9	9	9			9	9	9										1	1
Feather R. near Nicolaus	9	9	9			9	9	9	9 E		4 E			9 E	E	2	2	1	1
Sac. R. at Veterans Br.	AMP		AMP	AMP		AMP	AMP	9	9 E		4 E	9	AMP			2	2		
Arcade Creek	9	9							9 E	9 E	9 E			9 E	E			1	1
Natomas East Main Drain						DWR	DWR	DWR								2	2		
Amer R @ Fairbairn WTP				SAC		SAC	DWR	SAC				SAC	SAC						
American R. at J St.																2	2	1	1
American R. at Discovery Pk	AMP		AMP	AMP									AMP	9 E	E	2	2		
Sac. R. at Freeport	NAQ AMP	NAQ	NAQ	AMP	NAQ	NAQ AMP	NAQ AMP	9	NAQ	NAQ	NAQ	6	AMP	9 E	E				
Sac. R. at RM44	AMP		AMP	AMP	9	9	9	9				6	AMP			4	4		
Sac. R. at Greene's Lndg (c)	21 E	21 E	21 E																
Putah Creek																2	2		
Upper Putah Creek																2	2		
Yolo Bypass	GS	GS	GS	GS		GS	GS	GS	GS	GS	GS								
Cache Creek at Rumsey			GS	GS		GS	GS	GS											
Cache Sl. near Ryers Ferry																2	2		

Table Notes: Numerical values indicate number of environmental samples collected annually. Additional samples may be collected for Quality Assurance. Values appended with "E" indicate that some or all of the monitoring will be "event-based" or episodic in nature.
Text entries indicate data or samples collected by primary coordinating programs: AMP = Sacramento River Ambient Program; NAQ = USGS NAWQA; CF = CALFED; GS = USGS
(a) A fixed budget is allocated for Toxicity follow-up consisting of chemistry, TIE testing, and episodic monitoring with no pre-determined sample frequency.
(b) Bioassessment monitoring includes both physical habitat and biological assessments. Sites are monitored once peryear, and values indicate number of sites in each watershed.
(c) Includes 9 scheduled events, plus two episodic events consising of 6 samples each.

II. Data Review

The purpose of this data review is to present the results of monitoring performed by the SRWP and coordinating programs, and to present the conclusions of evaluation of these data. This review utilizes data compiled for the period 1994 through 2001, but focuses on SRWP monitoring conducted in 2000-2001. The primary data considered and presented for this review were generated by the following programs:

- The Sacramento River Watershed Program (SRWP) (http://www.sacriver.org)
- The Sacramento River Coordinated Monitoring Program (CMP) (LWA 2001),
- The City of Redding NPDES monitoring program,
- USGS National Assessment of Water Quality (NAWQA) for the Sacramento River (http://water.wr.usgs.gov/sac_nawqa/index.html),
- Department of Water Resources (Northern District) Intensive Tributary Monitoring Program (http://wwwdpla.water.ca.gov/nd/index.html),

The data from the coordinating programs are collected using similar sampling and analytical methods, and were therefore considered compatible with SRWP data. Data from these programs were pooled for subsequent evaluations, presentation of summary data (e.g. summary statistics), and plots of data, unless stated otherwise. For parameters with concentrations reported below analytical detection limits, summary statistics presented in this report were estimated using the robust method of Helsel and Cohn (1988), which uses probabilities adjusted for the proportion of data below detection to calculate unbiased estimates of the typical parametric statistics (mean, standard deviation, etc.). Additionally, selected results were also considered and evaluated from a number of other monitoring studies referenced in following data review sections.

The review of data for parameters measured for the 2000-2001 SRWP monitoring effort is organized into the following general categories:

- Mercury in water and fish tissue
- Pesticides in water
- Aquatic toxicity
- Drinking water parameters of concern (organic carbon, dissolved and suspended solids, pathogens)
- Organochlorine pesticides and PCBs in fish tissue
- Bioassessment

Process for Data Evaluation

Each evaluation is preceded by an overview of relevant monitoring information. The evaluations presented within each data review category were designed to address specific goals of the SRWP monitoring program. Monitoring data were evaluated for evidence that beneficial uses are attained or impaired, and if these evaluations indicated potential impairment due to a specific monitoring parameter, temporal and spatial trends in water quality were also evaluated and discussed. If the evaluations indicated that a particular parameter is probably not causing impairment, spatial and temporal trends were not evaluated for that parameter. Descriptions of the specific methods used to evaluate attainment of beneficial uses and spatial and temporal trends follow.

Evaluation of Attainment and Potential Impairment of Beneficial Uses

Comparisons with applicable water quality criteria, objectives, and other advisory criteria were performed as a preliminary evaluation of the degree to which beneficial uses of the Sacramento River watershed are attained or potentially impaired. Concentrations in water are compared to California Toxics Rule (CTR) criteria, USEPA Maximum Contaminant Levels (MCLs) for drinking water, and Central Valley Basin Plan objectives (which incorporate California Department of Health Services (DHS) Maximum Contaminant Levels (MCLs) for drinking water by reference). Concentrations of mercury and organic compounds in fish tissue were compared to various screening values developed by several different state and federal regulatory agencies. As a rule, these regulatory criteria and other limits define what are believed to be "safe levels", rather than thresholds of adverse effects. Because these limits are conservative by design, individual exceedances are not necessarily predictive of actual impairments of beneficial uses. For the purpose of these evaluations, concentrations that exceed these regulatory limits in water or tissue are considered indicators of *potential* impairment of beneficial uses. Cases where concentrations clearly do not exceed regulatory limits indicate that beneficial uses are not being impaired by a specific constituent, but do not provide unequivocal evidence that a specific beneficial use is being fully attained. The results of these comparisons to regulatory criteria and other limits were also evaluated for consistency with the State Water Resources Control Board's 303(d) list of waterbodies which the State considers to be impaired and not attaining beneficial uses.

Spatial and Temporal Trends

For parameters determined to have the potential to impair beneficial uses, evaluations of spatial and temporal trends were also performed. Evaluation of these trends support the SRWP goal of collecting and evaluating water quality data for the purpose of characterizing baseline conditions in the watershed, and also provide information relevant to identifying sources of pollutants or causes of potential impairment. Due to the limitations of the currently available data (e.g. only a few years of data for most parameters, different monitoring periods for different programs, high percentages of data below detection for some parameters and programs, and very few data for some sites and parameters), formal statistical analysis of the spatial and temporal trends would be resource-intensive and would provide little additional useful information for the SRWP. The discussions of general trends are qualitative and descriptive and are not characterized as statistically significant. Summary statistics and time series plots of chemical physical, and microbiological water quality characteristics were also prepared and are provided in Appendix A and Appendix B, respectively. If appropriate for the specific data category, a semi-quantitative assessment was performed of the relative importance of the loads of selected pollutants to the Delta.

Statement of Data Quality

Data presented in this report have been reviewed and validated as required by the Quality Assurance Project Plan (SRWP 2000). In general, data collected by the SRWP and cooperating programs are adequate for the purposes intended and the evaluations presented in this review. A detailed review of data quality is presented in Appendix D of this report.

A. Mercury Data Summary

Monitoring results for the Sacramento River Watershed Program (SRWP) for the period June 1998 through June 2001 and for primary coordinating programs (USGS NAWQA, Sacramento River Coordinated Monitoring Program, City of Redding NPDES monitoring, and Department of Water Resources) are presented and summarized in this section. Data are compared to adopted water quality objectives and advisory criteria to evaluate attainment and potential impairment of beneficial uses in the watershed. Data are evaluated for spatial and temporal trends, and summary statistics are also provided in Appendix A. Qualitative comparisons of mass loads from the Sacramento River watershed and other major Delta inputs are used to evaluate the relative contributions of mercury to the San Francisco Bay – Sacramento/San Joaquin Delta system.

i. Background and Available Data Overview

The sources of data utilized for this report are summarized in Table 4. The monitoring locations for the primary data considered for this report (USGS NAWQA, Sacramento River Coordinated Monitoring Program, City of Redding NPDES monitoring, the California Department of Water Resources, and the Sacramento River Watershed Program) are illustrated in Figure 2.

Table 4. Mercury monitoring programs (water column and fish tissue) in the Sacramento River Watershed

Program	Monitoring Period(s)	Parameters	# of locations & geographic reference
SRWP	6/98–6/01 6/00–6/01	▪ Total Hg in water, ▪ Total Hg in fish tissue ▪ Methylmercury in water	3 water column sites: 2 upper watershed, and 1 in lower watershed; 13 fish tissue sites on Sacramento River and major tributaries
SRWP Special Study (USGS)	1/19/00, 2/20/00	▪ TSS, total Hg, and methylmercury in water	Sac. R. at bend Bridge and Woodson Bridge, Antelope Creek, Elder Creek, and Mill Creek
SRWP Special Study (CDFG)	3/01–6/01	▪ TSS, total Hg, and methylmercury in water	11 Sacramento River sites from Hamilton City to Colusa
SRWP Special Study (PER)	4/01	▪ TSS, total Hg, and methylmercury in water	3 sites in Mill Creek drainage
Sacramento River Mercury Control Planning Project (LWA 1997)	3/95–2/96	▪ Total and filtered Hg and MeHg, and TSS in water ▪ Hg and MeHg in benthic invertebrates and fish	7 water column sites on Sacramento River, Feather River, and Yuba River. MeHg at selected sites. 55 benthic invertebrate and 25 fish sites on Sierra tributaries to the Sacramento River.
Sacramento River CMP (SRCSD)	12/92–6/01	▪ Total and dissolved Hg in water	5 sites on Sacramento and American rivers in Sacramento metropolitan area
USGS Mercury Transport Study (Roth et al. 1998)	6/96–5/97	▪ Total, dissolved, and colloidal Hg in water	6 sites on Sacramento River and 7 sites on selected tributaries.
Sacramento River Basin NAWQA (USGS)	2/96–4/98	▪ Total Hg and MeHg in water ▪ Total Hg in sediments	12 Hg sites (5 MeHg sites), distributed throughout watershed
USGS (Domagalski 1998)	2/96–2/97	▪ Total Hg and MeHg in water ▪ Total Hg in sediments	11 water column and 17 sediment sites on the Sacramento River and major tributaries.
CVRWQCB (Slotton et al. 1997)	Spring, 1996	▪ Hg in benthic invertebrates.	38 sites in the Cache Creek watershed
CVRWQCB (Foe and Croyle 1998)	10/93–4/95, 1996-1998	▪ Total and dissolved Hg, and TSS in water	22 sites in major Delta tributaries, and 10 additional sites in Cache Ck watershed
City of Redding	1/98–5/01	▪ Total Hg in water	1 site at Sacramento River below Keswick Dam
SF Estuary Regional Monitoring Program	1989–1997	▪ Total and dissolved Hg in water ▪ Total Hg in fish tissue	18 Bay-Delta sites, including Sacramento River and San Joaquin River at the Delta terminus
Special Tributary Program (DWR)	6/98–5/00	▪ Total Hg in water ▪ Total Hg in fish tissue	13 water column sites and 8 fish tissue sites on Mill Creek, Big Chico Creek, and Deer Creek

ii. Attainment of Beneficial Uses and Potential Impairment

One of the SRWP monitoring program's primary goals is to assess the degree to which beneficial uses are attained or potentially impaired in surface waters of the watershed. For the purpose of these evaluations, mercury concentrations in water and fish tissue were compared to various regulatory criteria and screening or advisory thresholds. Concentrations that exceed these regulatory limits in water or tissue are considered indicators of *potential* impairment of beneficial uses. Cases where concentrations clearly do not exceed regulatory limits indicate that beneficial uses are not being impaired by a specific constituent, but do not provide unequivocal evidence that a specific beneficial use is being fully attained. The results of these comparisons to regulatory criteria and other limits were also evaluated for consistency with the State Water Resources Control Board's 303(d) list of waterbodies which the State considers to be impaired and not attaining beneficial uses.

Water Column

Human Health Thresholds

Total mercury concentrations in water were compared with a variety of regulatory, screening, and advisory thresholds (Table 5). Adopted total mercury water quality objectives for the Sacramento River watershed include a human health-based water quality objective for drinking water of 2000 ng/L (the drinking water Maximum Contaminant Level or MCL) adopted in the Central Valley Basin Plan, and a human-health-based federal water quality criterion of 50 ng/L (30-day average) adopted in the May 2000 California Toxics Rule (CTR). The CTR criterion reflects the latest USEPA national water quality criterion for total mercury for protection of human health, which has superceded the 1985 USEPA national criterion value of 12 ng/L. The CTR criterion does not reflect the approach used in the Great Lakes Initiative, where an objective of 3.1 ng/L was adopted based on use of field-derived bioaccumulation factors (BAFs). The fish consumption-based human health criteria for mercury are intended to protect sensitive individuals (pregnant women, unborn children, infants) and are based on different assumptions of fish consumption rates and bioaccumulation rates.

It should be noted that USEPA has stated that it intends to re-evaluate and revise its 304(a) national criteria guidance for mercury criteria by the year 2002, and that new human health criteria could be proposed for California within a year of USEPA's 304(a) revisions. This new criterion may be promulgated as a fish tissue-based criterion.

Wildlife Thresholds

No wildlife-based water quality objectives have been adopted for mercury in California and USEPA has not issued national wildlife-based advisory criteria for mercury in water. A wildlife-protective standard of 1.3 ng/L total mercury has been adopted for the Great Lakes area, based on criteria developed by USEPA. USEPA revised these Great Lakes values for protection of wildlife species in its Mercury Report to Congress (USEPA 1997), an advisory document. Total mercury criterion values presented in the Mercury Report to Congress ranged from 0.6 ng/L to 1.8 ng/L, with an average of 0.9□g/L for the species considered. The Mercury Report to Congress also identified a methylmercury criterion of 0.05 ng/L in water for protection of wildlife.

Table 5. Regulatory Standards and Other Threshold Values for Mercury in Water.

Basis for Limit	Concentration in water, ng/L	Form of Hg	Reference
Human Health	2000	Total	Maximum Contaminant Level (MCL) in drinking water (USEPA, 1996)
Human Health	50[2]	Total	Federal water quality criterion per California Toxics Rule (May 2000), Recommended National Water Quality Criteria (USEPA 1999)
Human Health	0.24 3.1	Methyl Total	Specific to Great Lakes, federal water quality criterion for Great Lakes (USEPA 1995)
Wildlife[1]	0.05 0.641 0.91	Methyl Dissolved Total	Mercury Report to Congress, Vol. VI (USEPA 1997)
Wildlife	1.3	Total	Specific to Great Lakes, federal water quality criterion for Great Lakes (USEPA 1995)

(1) Lowest average criterion, based on the average for all mammalian wildlife species studied in Mercury Report to Congress.
(2) This value represents a 30-day average not to be exceeded more than once in three years.

Comparison with Water Column Threshold Values

Because the mercury objective for protection of human health for drinking water exposure is orders of magnitude higher than fish consumption-based limits, the remaining discussion will focus only on the fish consumption-based values. The percentage of data meeting specific regulatory or advisory thresholds are presented in Table 6.

Total mercury concentrations in the Sacramento River (from Keswick to River Mile 44) and in the major tributaries were rarely observed to exceed the CTR criterion for mercury (0.3%, or 2 of 600 total samples in the Sacramento River, and in no samples from the American, Feather, and Yuba rivers). Mercury concentrations in Cache Creek exceeded the 50 ng/L limit in 30% of samples. Based on data collected by DWR and SRWP, mercury concentrations in the Mill Creek exceeded the 50 ng/L limit in 13% of samples collected from the mouth of the creek. Higher concentrations and percent exceedances (46%) were observed in waters of the upper Mill Creek watershed, where the influence from geothermal activity (hot springs) is greatest. DWR data for Deer Creek and Big Chico Creek indicate that the CTR criterion was met in every sample collected in the Deer Creek watershed, and in all but one sample (of 86) collected in the Big Chico Creek watershed. Mercury concentrations did not exceed the CTR criterion in any samples from the two agricultural drains monitored (Sacramento Slough and Colusa Basin Drain). Mercury concentrations did not exceed 50 ng/L in any samples collected in 2000-2001.

In comparison with total mercury advisory criteria in the range from 2–5 ng/L (as indicated by USEPA Region IX staff) for human health protection, or at 1.3 ng/L concentrations (as has been adopted in the Great Lakes for wildlife protection), ambient water column concentrations of total mercury frequently exceed these values at all sites tested throughout the Sacramento River watershed. In comparison with the 3.1 ng/L Great Lakes criterion for the protection of human health, the Sacramento River above

Hamilton City exceeded this criterion in 35% of samples, while the 3.1 ng/L limit was exceeded in 94% of samples collected from the Sacramento River from Colusa to River Mile 44. The 3.1 ng/L limit was exceeded in fewer than 12% of samples from the Deer Creek watershed, in 17% of samples from the Big Chico Creek watershed, and in nearly every sample (86%) from Mill Creek.

The Great Lakes Initiative adopted a human health-based methylmercury criterion of 0.24 ng/L. Methylmercury concentrations measured by SRWP and USGS at eight mainstem Sacramento River sites exceeded 0.24 ng/L in 11% of samples, and methylmercury concentrations in the two agricultural drain sites (Colusa Drain and Sacramento Slough,1996-1998) exceeded 0.24 ng/L in 25% and 35% of samples. Arcade Creek (an urban creek) exhibited the highest percentage of exceedances of the 0.24 ng/L limit (67%, 2000-01 data). Methylmercury concentrations in Cache Creek exceeded 0.24 ng/L in 9% of samples collected. In comparisons with the 0.05 ng/l wildlife-based methylmercury advisory criterion identified in the Mercury Report to Congress by USEPA, methylmercury concentrations exceeded the limit in approximately 83% of the total samples collected at all sites.

Fish Tissue

Threshold Values

Mercury concentrations in composite and individual fish tissue samples were compared with several different advisory thresholds and criteria for mercury in fish tissue (all expressed as wet weight) (Table 6). Human health-based limits range from 1.0 mg/kg (the Food and Drug Administration (FDA) Action Level applicable to commercially-caught fish), to 0.30 mg/kg (national ambient water quality criterion for protection of human health; USEPA 2001), to 0.14 mg/kg (SFRWQCB 1995). USEPA fish tissue advisory criteria for protection of wildlife in the Great Lakes, as revised in the 1997 Mercury Report to Congress, range from 0.68 mg/kg to 0.028 mg/kg. These criteria and screening values are risk-based advisory values against which tissue concentrations can be compared to determine whether more intensive monitoring, evaluation, or risk management (e.g. consumption advisories) are warranted. Note that these risk-based values are based on assumed fish consumption rates for humans (6.5 g/day to 30 g/day) or for wildlife species. For individuals or populations consuming more or less fish than assumed for a specific limit or screening value, the risk of adverse health effects is correspondingly increased or decreased. Additionally, each criterion or screening value is calculated from a reference dose (RfD) based on a daily intake level estimated not to cause adverse effects, and a safety factor to account for uncertainties in the reference dose. The current USEPA human health-based reference dose incorporates a safety factor of 10, and reference doses for birds and mammalian wildlife range from 2 to 10. The consumption rate and reference dose associated with each limit are specified in Table 7.

Table 6. Comparisons With USEPA Total Mercury Water Quality Criteria for Human Health: Percent of Data meeting Criteria(1996-2000)

			% of data meeting USEPA criteria for protection of human health		
Location	Years monitored	Total number of samples	1997 USEPA 3.1 ng/L Great Lakes Standard	1985 USEPA 12 ng/L Criterion	1999 USEPA 50 ng/L Criterion(1)
Spring Creek PP Discharge to Keswick Res.	1998–2000	11	100.0%	100.0%	100.0%
Sacramento River below Keswick	1998–2001	53	93.5%	100.0%	100.0%
Sacramento River above Bend Bridge	1996–2001	48	63.9%	97.2%	100.0%
Mill Creek at Mouth	1998–2001	28	19.7%	54.6%	87.2%
Mill Creek at Highway 99	2001	4	1.6%	100.0%	100.0%
Mill Creek at Black Rock	1998–2001	19	14.1%	46.2%	82.6%
Mill Creek at Highway 36	1998–2000	19	4.3%	20.2%	54.0%
Sacramento River near Hamilton City	1999–2001	20	59.5%	94.8%	100.0%
Deer Creek at Mouth	1998–2000	14	94.3%	100.0%	100.0%
Deer Creek at Upper Diversion Dam	1998–2000	20	78.7%	100.0%	100.0%
Deer Creek at Ponderosa Way	1998–1999	12	97.7%	100.0%	100.0%
Deer Creek below Childs Meadows	1998–2000	19	93.6%	100.0%	100.0%
Big Chico Creek above Mud Creek	1998–2000	21	78.1%	100.0%	100.0%
Mud Creek above Big Chico Creek	1998–2000	11	58.5%	85.8%	97.6%
Big Chico Creek at Chico (Rose Ave.)	1998–2000	19	92.0%	100.0%	100.0%
Big Chico Creek above Salmon Hole	1998–2000	16	88.5%	100.0%	100.0%
Big Chico Creek at Hwy 32	1998–2000	19	95.8%	100.0%	100.0%
Sacramento River at Colusa(2)	1996–2001	54	28.5%	86.1%	99.8%
Sacramento Slough(2)	1996–2001	43	2.8%	80.6%	100.0%
Colusa Basin Drain	1996–2001	46	5.4%	84.5%	100.0%
Yuba River at Marysville	1996–2001	46	47.5%	93.7%	100.0%
Feather River near Nicolaus(2)	1996–2001	47	22.8%	89.3%	100.0%
Sacramento River at Verona(2)	1996–1998	28	11.3%	80.3%	100.0%
Sacramento River at Veterans Bridge(2)	1994–2001	109	3.9%	77.2%	100.0%
Arcade Creek at Norwood Ave.	1996–2001	46	14.9%	72.9%	99.1%
American River at Discovery Park(2)	1994–2001	106	59.3%	98.6%	100.0%
Sacramento River at Freeport(2)	1994–2001	159	11.8%	80.5%	100.0%
Sacramento River at River Mile 44(2)	1994–2001	103	10.6%	74.5%	99.6%
Sacramento River at Greene's Landing(2)	2000–2001	26	33.2%	97.6%	100.0%
Cache Creek at Rumsey(2)	1996–1999	47	13.2%	37.7%	70.3%
Cache Slough near Ryers Ferry(2)	1998–2000	11	5.2%	77.9%	100.0%
Yolo Bypass near Woodland	1997–1998	10	0.1%	8.8%	69.9%

(1) 50 ng/L is also the human health-based mercury objective adopted in the May 2000 California Toxics Rule

(2) Included on California 1998 303(d) list of impaired waterbodies

Comparison with Fish Tissue Threshold Values

Fish tissue data from the SRWP monitoring effort at various locations were compared with fish tissue advisory values[3]. The concentrations of mercury accumulated in fish are known to be species specific, with predatory upper trophic level fish (e.g. Trophic Levels 3 and 4) having higher mercury concentrations. Additionally, concentrations of mercury are size- and age-dependent within a given species, with older, larger fish typically having higher mercury concentrations. (The process which produces these conditions is termed "biomagnification".) To control for these species-, age-, and size-dependent effects, SRWP fish tissue monitoring focused on mercury concentrations in individual fish and composite samples comprised of fish of similar legal catchable size. Where there were sufficient numbers of a particular species, tissue concentrations were plotted against length to illustrate this relationship (Figures 3 and 4, for largemouth bass and white catfish, respectively). Figure 5 presents data for individual samples for other species.

Average mercury concentrations are presented for each species and location in Table 8a. Average mercury concentrations are also summarized by waterbody type, species, and trophic level[4] in Table 8b, and the consumption-weighted average is provided for each waterbody type. The consumption-weighted average is an estimate of the average concentration of mercury for the total freshwater and estuarine fish consumed, and assumes that a combination of trophic level 3 and trophic level 4 fish are consumed. While the approach has not been adopted as official policy, USEPA Region 4 used this method for a TMDL developed for the Savannah River in Georgia, in which the consumption-weighted average was compared directly to the fish tissue-based water quality criterion for methylmercury (0.3 mg/kg) to evaluate whether a waterbody should be considered impaired (USEPA 2001b). The approach is also consistent with the development of the methylmercury criterion (USEPA 2001), which also assumes that fish consumed consist of a mix of different trophic level species. The consumption-weighted average mercury concentration is calculated as follows:

Consumption-Weighted Average = (57% x *Trophic Level 3 avg.*) + (43% x *Trophic Level 4 avg.*).

The percentages used for trophic levels 3 and 4 (TL3 and TL4) in this equation are based on assumptions used by USEPA in development of the methylmercury criterion, which assumed consumption of TL2, TL3, and TL4 species in proportions of 21.7%, 45.7%, and 32.6%, respectively (USEPA 2001). For the purpose of this analysis for the SRWP, it was assumed that no TL2 species were consumed and the TL2 percentage was apportioned equally between TL3 and TL4 species. It should be noted that the USEPA default consumption rates and TL3 and TL4 percentages may not be appropriate for

[3] All SRWP fish tissue data presented are for edible fillets with skin off.

[4] "Trophic level" describes the position of a species in the food chain, determined by the number of energy-transfer steps to that level. Trophic level 3 fish consume primarily zooplankton and benthic invertebrates. Trophic level 4 fish preferentially consume trophic level 3 and lower trophic level fish species, as well as benthic invertebrates. Larger individuals of some primarily trophic level 3 species (e.g. trout) may be piscivorous and function at trophic level 4.

consumers in the Sacramento River watershed, and should ideally be adjusted based on site-specific consumption information. Fish consumption patterns for the Sacramento River watershed are currently being investigated by the Delta Tributaries Mercury Council of the SRWP. Additionally, although the consumption-weighted average should ideally be calculated separately for each waterbody, there were insufficient data to perform these calculations for each location and waterbody. However, species average concentrations were similar within each defined waterbody category, so grouping the locations within these broad waterbody categories appeared to provide characterizations that were also reasonable for the individual waterbodies.

Comparisons of tissue mercury concentrations to fish tissue advisory values are summarized below.

A total of fourteen fish species are represented in the data set, including seven trophic level 3 species and seven trophic level 4 species (Tables 8a and 8b). The average mercury concentrations for combined trophic level 3 species (0.10–0.18 mg/kg) were lower than the 0.3 mg/kg criterion for all waterbody categories sampled (Ag drains, tributaries, major tributaries, the Sacramento River from Keswick to the I Street Bridge, and Delta sites including Cache Slough and the Sacramento River at Mile 44 below I Street Bridge. Average mercury concentrations calculated individually for each of the seven trophic level 3 species (48 total samples) were also below 0.3 mg/kg for all locations and waterbody categories.

The average mercury concentrations for combined trophic level 4 species (0.30–0.88 mg/kg) were equal to or greater than the 0.3 mg/kg criterion for every waterbody category sampled. Average mercury concentrations calculated individually for each of the seven trophic level 4 species (204 total samples) were greater than 0.3 mg/kg for most locations and waterbody categories, with the following exceptions: Sacramento pikeminnow in the Sacramento River mainstem from Bend Bridge to River Mile 44, white catfish in Colusa Basin Drain, Natomas East Main Drain, and Putah Creek, and smallmouth bass in Chico Creek and Deer Creek all had average mercury concentrations lower than 0.3 mg/kg.

Average mercury concentrations in fish tissue exceeded the USEPA criterion (0.3 mg/kg) in largemouth bass from all waterbody types and locations sampled, and average concentrations in white catfish exceeded the USEPA criterion in six of nine sites sampled (Table 8, Figures 3 and 4). These two species were collected from lower Sacramento River and Delta sites, agricultural drains, and major and lesser tributaries from Keswick to Cache Slough.

Most largemouth bass collected also exceeded the USEPA 1996 Screening Value (0.6 mg/kg), and a number of individual largemouth bass collected from the American River, Feather River, the Sacramento River at River Mile 44, and from Cache Slough exceeded the FDA Action Level of 1.0 mg/kg (Figure 4).

All striped bass sampled (n = 8) exceeded the 0.3 mg/kg criterion (Figure 5). Striped bass exhibited the highest average mercury concentration (1.2 mg/kg) for any species sampled, and included the highest mercury concentration of any sample (3.5 mg/kg) for a single large individual fish (~33 inches long) collected from the Feather River at Nicolaus.

Consumption-weighted average mercury concentrations were highest (0.48 mg/kg) for the two major tributaries sampled (American River and Feather River), and also exceeded the 0.3 mg/kg criterion for the two agricultural drains (Colusa Basin Drain and Sacramento Slough). Consumption-weighted averages were lower than the 0.3 mg/kg criterion for tributaries (0.20 mg/kg), the Sacramento River from Keswick to the "I" Street Bridge (0.25 mg/kg), and the two Delta locations sampled (0.25 mg/kg, Sacramento River at Mile 44 and Cache Slough).

Table 7. Criteria and Screening Values for Mercury in Fish Tissue

Basis for limit	Criterion or Screening Value[1], mg/kg	RfD (µg/kg/day)	Body Weight (kg)	Consumption Rate (kg/day)	Reference
Human Health	1.0	0.47	60	0.0284	FDA Action Level[2] (vm.cfsan.fda.gov/~dms/)
	1.0	0.3	60	0.018	ATSDR 1999 (www.atsdr.cdc/gov/press/ma990419.html)
	0.6	0.06	60	0.065	USEPA Screening Value (USEPA 1995)
	0.33	0.1	60	0.018	Mercury Report to Congress, Vol. VI (USEPA 1997)
	0.14	0.06	70	0.030	SFRWQCB Screening Value (SFRWQCB 1995)
	0.23	0.1	70	0.030	OEHHA and SFEI Screening Value (OEHHA 1999, SFEI 1999)
	0.3	0.1	70	0.0175	Ambient Water Quality Criterion for Human Health (USEPA 2001)
Wildlife[4]	0.08 0.34	Hg criterion in trophic level 3 fish Hg criterion in trophic level 4 fish (See USEPA 1997 for calculations)			Mercury Report to Congress, Vol. VI (USEPA 1997)

(1) Expressed as mg/kg wet weight Values are calculated as (RfD x Body Weight) ÷ Consumption Rate.
(2) The FDA Action Level is intended to apply only to commercially caught fish, and not to locally-caught or sport fish.
(3) The USEPA 2001 criterion also assumes that a specific proportion of 3 trophic levels of fish are consumed—.0038 kg/day Trophic Level 2 (21.7%), .0080 mg/day Trophic Level 3 (45.7%), and .0057 kg/day Trophic Level 4 fish (32.6%).
(4) Lowest average criterion, based on the average for all mammalian wildlife species studied in Mercury Report to Congress.

Table 8a. Mercury in Fish Tissue, Average Species Concentrations by Location

			Hg concentrations in fish tissue, mg/kg, wet weight		
Waterbody Type	Location	Species	Count	Mean	Std. Dev.
Ag Drains	Colusa Basin Drain	Carp	2	0.142	0.052
		White Catfish	2	0.258	0.066
	Natomas East Main Drain	Largemouth Bass	3	0.645	0.041
		Striped Bass	1	0.808	•
		White Catfish	2	0.248	0.053
	Sacramento Slough	Largemouth Bass	3	0.480	0.034
		White Catfish	3	0.506	0.115
Delta (below I Street Bridge)	Cache Slough	Carp	1	0.107	•
		Crappie	1	0.315	•
		Largemouth Bass	18	0.708	0.290
		Sacramento Sucker	1	0.107	•
		White Catfish	21	0.497	0.193
	Sacramento R. at Mile 44	Bluegill	1	0.103	•
		Largemouth Bass	27	0.869	0.303
		Pike Minnow	1	0.115	•
		Sacramento Sucker	1	0.221	•
		Striped Bass	1	0.343	•
		White Catfish	30	0.404	0.240
Lower Sac. R. Mainstem	Sacramento R. above Bend Bridge	Pike Minnow	1	0.119	•
		Rainbow Trout	2	0.037	0.008
		Sacramento Sucker	1	0.103	•
	Sacramento R. at Colusa	Carp	1	0.186	•
		Pike Minnow	2	0.224	0.108
		Sacramento Sucker	1	0.059	•
		Striped Bass	1	0.303	•
	Sacramento R. at Veterans Br	Largemouth Bass	2	0.888	0.099
		Pike Minnow	1	0.251	•
		Sacramento Sucker	1	0.098	•
		White Catfish	2	0.384	0.239
	Sacramento R. below Keswick	Rainbow Trout	3	0.035	0.002
	Sacramento R. near Hamilton City	Pike Minnow	2	0.253	0.052
		Sacramento Sucker	1	0.030	•

Table continues on following page…

Table 8a. Mercury in Fish Tissue, Average Species Concentrations by Location

(Continued from previous page)

Waterbody Type	Location	Species	Hg concentrations in fish tissue, mg/kg, wet weight Count	Mean	Std. Dev.
Major Tributaries	American R. at Discovery Park	Largemouth Bass	3	1.198	0.301
		Pike Minnow	2	0.419	0.002
		Redear Sunfish	1	0.302	•
		Sacramento Sucker	1	0.247	•
		White Catfish	2	0.393	0.185
	American R. at J Street	Largemouth Bass	1	0.659	•
		Pike Minnow	2	0.485	0.084
		Sacramento Sucker	2	0.092	0.010
	Feather R. near Nicolaus	Bluegill	1	0.121	•
		Channel Catfish	1	0.729	•
		Largemouth Bass	29	0.812	0.496
		Pike Minnow	2	0.887	0.442
		Redear Sunfish	1	0.220	•
		Striped Bass	5	1.595	1.172
		White Catfish	10	0.702	0.315
Tributaries	Big Chico Ck @ Hwy 32	Rainbow Trout	2	0.042	0.002
	Big Chico Ck @ Hwy 99	Riffle sculpin	1	0.146	•
		Smallmouth bass	1	0.231	•
	Big Chico Ck near mouth	Largemouth Bass	1	0.331	•
		Pike Minnow	1	0.484	•
	Clear Ck @ Hwy 273	Riffle sculpin	1	0.241	•
	Clear Ck @ Reading Bar	Rainbow Trout	1	0.046	•
		Riffle sculpin	1	0.160	•
	Clear Ck above Whiskeytown	Rainbow Trout	1	0.050	•
		Riffle sculpin	2	0.102	0.008
	Clear Creek at Mouth	Largemouth Bass	1	0.452	•
		Rainbow Trout	1	0.046	•
	Deer Ck @ Hwy 99	Riffle sculpin	1	0.082	•
		Smallmouth bass	1	0.075	•
	Deer Ck below Childs Meadow	Riffle sculpin	1	0.034	•
	McCloud R. above Shasta	Rainbow Trout	1	0.053	•
	Mill Ck at Black Rock	Riffle sculpin	1	0.327	•
	Mill Ck at Hwy 99	Riffle sculpin	1	0.279	•
	Pit R. above Shasta	Rainbow Trout	1	0.047	•
	Putah Creek	Bluegill	6	0.118	0.037
		Largemouth Bass	17	0.433	0.187
		Sacramento Sucker	1	0.185	•
		White Catfish	1	0.146	•
	Sacramento R. above Shasta	Rainbow Trout	2	0.060	0.004
	Upper Putah Creek	Brown Trout	1	0.056	•

Table 8b. Mercury in Fish Tissue,
Summarized by Waterbody Category and Trophic Level

Site Category	Species	Trophic Level(1)	Count	Hg concentrations in fish tissue, mg/kg, wet weight: Mean	Std. Dev.	Species-weighted trophic level averages(2)	Consumption-weighted Avg(3)
Ag drains (Sacramento Slough, Colusa Drain, Natomas East Main Drain)	Carp	3	2	0.14	0.052	0.14	0.33
	Largemouth bass	4	6	0.56	0.096	0.58	
	Striped bass	4	1	0.81	•		
	White catfish	4	7	0.36	0.155		
Tributaries (Sac. R. above Shasta, Pit River, McCloud River, Clear Ck, Mill Ck, Deer Ck, Big Chico Ck, Putah Ck,)	Bluegill	3	6	0.12	0.037	0.11	0.20
	Brown trout	3	1	0.06	•		
	Rainbow trout	3	9	0.05	0.007		
	Riffle sculpin	3	9	0.16	0.098		
	Sacramento sucker	3	1	0.19	•		
	Largemouth bass	4	19	0.43	0.178	0.30	
	Pikeminnow	4	1	0.48	•		
	Smallmouth bass	4	2	0.15	0.11		
	White catfish	4	1	0.15	•		
Major tributaries (Feather River and American River)	Bluegill	3	1	0.12	•	0.18	0.48
	Redear sunfish	3	2	0.26	0.058		
	Sacramento sucker	3	3	0.14	0.09		
	Channel catfish	4	1	0.73	•	0.88	
	Largemouth bass	4	33	0.84	0.484		
	Pikeminnow	4	6	0.60	0.303		
	Striped bass	4	5	1.60	1.172		
	White catfish	4	12	0.65	0.314		
Lower Sac. R. Mainstem (Keswick to "I" Street Bridge)	Carp	3	1	0.19	•	0.10	0.25
	Rainbow trout	3	5	0.04	0.004		
	Sacramento sucker	3	4	0.07	0.034		
	Largemouth bass	4	2	0.89	0.099	0.45	
	Pikeminnow	4	6	0.22	0.074		
	Striped bass	4	1	0.30	•		
	White catfish	4	2	0.38	0.239		
Delta (Sac. River below "I" Street Bridge, and Cache Slough)	Bluegill	3	1	0.10	•	0.12	0.25
	Carp	3	1	0.11	•		
	Sacramento sucker	3	2	0.16	0.081		
	Crappie	4	1	0.32	•	0.40	
	Largemouth bass	4	45	0.80	0.305		
	Pikeminnow	4	1	0.12	•		
	Striped bass	4	1	0.34	•		
	White catfish	4	51	0.44	0.224		

(1) Trophic level 3 fish consume primarily zooplankton and benthic invertebrates. Trophic level 4 fish preferentially consume trophic level 3 and lower trophic level fish species, as well as benthic invertebrates. Larger individuals of some primarily trophic level 3 species (e.g. trout) may be piscivorous and function at trophic level 4.

(2) The average mercury concentration for each trophic level, calculated as the average of mercury concentrations for each species in the trophic level.

(3) The average mercury concentration for total freshwater and estuarine fish consumed, as described in the Total Maximum Daily Load (TMDL) for Total Mercury in Fish Tissue Residue in Lake Bennett (USEPA 2001b). The consumption-weighted average is calculated as follows: *Consumption-Weighted Average* = (56.6% x *Trophic Level 3 avg.*) + (43.4% x *Trophic Level 4 avg.*).

What do the results say about attainment of beneficial uses and potential impairment, and how does this compare with any relevant 303(d) listings for parameter and sites?

The beneficial uses at greatest potential risk from elevated mercury concentrations are wildlife protection and human health protection related to the consumption of fish, and therefore fish tissue concentrations are considered the best available indicator of potential impairment. An interim sport fish consumption advisory is currently in effect for the San Francisco Bay and Delta Region for elevated concentrations of mercury and other chemicals. Sport fish consumption advisories are also in effect for elevated mercury concentrations in fish in Clear Lake and Lake Berryessa, and more fish consumption advisories have been issued at the County Health Department level for foothill reservoirs on both sides of the watershed. The California Office of Environmental Health and Hazard Assessment (OEHHA) has also issued an interim advisory and consumption guidance for Black Butte Reservoir, in the Stony Creek Watershed. Based on these advisories (which recommend limiting consumption of specific sizes and species of fish), the local sportfishing beneficial use has been described by the Regional Board and SWRCB as impaired in the Bay, in the Delta, and in Clear Lake and Lake Berryessa.

A number of both mainstem and tributary reaches in the Sacramento River watershed are included for mercury on the California 1998 303(d) list (Table 9). The Central Valley Regional Water Quality Control Board (CVRWQCB) has also recommended the addition of ten new waterbodies for the 2002 update to the 303(d) list (CVRWQCB 2001), including Black Butte Reservoir and five reservoirs in the Sierra Nevada foothills. It should be noted that the CVRWQCB used a more conservative approach to determine impairment than used by USEPA to develop the methylmercury criterion or the Savannah River TMDL (USEPA 2001, 2001b). The CVRWQCB compared average concentrations only in trophic level 4 species with the 0.3 mg/kg USEPA criterion, and considered trophic level 3 species only when there were “limited” data for trophic level 4 fish. With only one exception, all of the current and recommended 303(d) listings for mercury are based on elevated concentrations of mercury in fish tissue, and mining activity (resource extraction) is cited as the major source of mercury.

With the exception of Cache Creek, the waterbodies included on the 303(d) list had a fairly high frequency of compliance with the CTR criterion of 50 ng/L (97-100%) and the USEPA 1985 criterion of 12 ng/L (>70%) for total mercury concentrations in water. Conversely, with the exceptions of the Sacramento River at Hamilton City and the American River at Discovery Park, 303(d)-listed waterbodies had very low rates of compliance (less than 25%) with the Great Lakes 3.1 ng/L human health objective for mercury in water. Fish tissue data indicated that concentrations of mercury in trophic level 4 species (particularly largemouth bass, white catfish, and striped bass) frequently exceed screening values at a number of locations in the lower watershed. Based on comparisons of consumption-weighted average tissue mercury concentrations to the recently-adopted 0.3 mg/kg USEPA criterion, SRWP fish tissue data generally support the need for fish consumption advisories already in effect for the lower American River, the lower Feather River, and Sacramento Slough, and indicate that advisories should be evaluated for two additional agricultural drains (Colusa Basin Drain and Natomas East Main Drain). These same data also indicate that potential health risks are lower for the

Sacramento River mainstem from Keswick to River Mile 44 (which is technically in the Delta) and for most smaller tributaries throughout the watershed, for consumers of a mix of trophic level 3 and 4 fish. Potential health risks are of course higher for individuals consuming higher than average amounts of fish, or for those consuming primarily trophic level 4 species (especially largemouth bass, white catfish, or striped bass[5]). However, because the USEPA criterion for methylmercury includes substantial margins of safety, moderate differences in the rates of consumption and percentages of TL3 and TL4 species would not result in greatly increased risks. Potential risks will also vary for specific waterbodies within each waterbody category, but these differences are expected to be relatively small since mercury concentrations were generally similar in fish from the different locations monitored within each category.

Based on guidance from OEHHA, the available fish tissue data from the SRWP are not yet sufficient to support additional consumption advice from OEHHA in the Sacramento River watershed. However, SRWP fish tissue data for the lower Sacramento River watershed and the recommended addition of ten waterbodies to the 303(d) list for mercury in fish tissue by the Regional Board clearly indicate a need to further evaluate potential human health and wildlife concerns in these waterbodies. The SRWP is continuing to investigate these concerns with fish tissue monitoring performed in the fall of 2001. Additionally, agencies participating in the SRWP are also applying for CALFED funds to perform extensive fish tissue monitoring in the Sacramento River watershed for this purpose.

[5] The current fish consumption advisory for San Francisco Bay and Delta waterways is specifically for mercury concentrations in striped bass.

Table 9. Waterbodies Listed For Mercury On the California 1998 303(d) List or Recommended for Addition or Revision for the 2002 303(d) List

Waterbody	Listed Source of Mercury	Area Affected		Fish Advisory	303(d) List
Delta Waterways	Resource Extraction	480000	Acres	Yes	1998
Berryessa Lake	Resource Extraction	20700	Acres	Yes	1998
Clear Lake	Resource Extraction	43000	Acres	Yes	1998
Davis Creek Reservoir	Resource Extraction	290	Acres	No	1998
Marsh Creek Reservoir	Resource Extraction	375	Acres	No	1998
American River, Lower	Resource Extraction	23	Miles	No	1998
Cache Creek	Resource Extraction	35	Miles	No	1998
Feather River, Lower	Resource Extraction	60	Miles	No	1998
Harley Gulch	Resource Extraction	8	Miles	No	1998
Humbug Creek	Resource Extraction	9	Miles	No	1998
James Creek	Resource Extraction	6	Miles	No	1998
Sacramento River (Red Bluff To Delta)	Resource Extraction	30	Miles	No	1998
Sacramento Slough	Source Unknown	1	Miles	No	1998
Sulfur Creek	Resource Extraction	7	Miles	No	1998
Bear Creek	Resource Extraction	28	Miles	No	2002(3)
Upper Bear River	Resource Extraction	8	Miles	IPHN(1)	2002(3)
Black Butte Reservoir	Resource Extraction	4,500	Acres	Yes(2)	2002(3)
Camp Far West Reservoir	Resource Extraction	2,002	Acres	IPHN(1)	2002(3)
Lake Combie	Resource Extraction	360	Acres	IPHN(1)	2002(3)
Lake Englebright	Resource Extraction	815	Acres	IPHN(1)	2002(3)
Little Deer Creek	Resource Extraction	4	Miles	IPHN(1)	2002(3)
Lower Putah Creek	Resource Extraction	24	Miles	No	2002(3)
Rollins Reservoir	Resource Extraction	840	Acres	IPHN(1)	2002(3)
Scotts Flat Reservoir	Resource Extraction	725	Acres	IPHN(1)	2002(3)
Humbug Creek	Resource Extraction	3	Miles	IPHN(1)	2002(3)
James Creek	Resource Extraction	8.5	Miles	No	2002(3)

(1) Interim Public Health Notification issued by Placer, Nevada, and Yuba counties.
(2) Draft Advisory issued by OEHHA, 2000.
(3) Recommended for addition or revision for California 303(d) 2002 list update by the Central Valley Regional Board (CVRWQCB 2001)

iii. Spatial Distributions & Patterns

This evaluation is based on water quality data for the 2000-2001 monitoring period. Previous annual reports considered data for monitoring periods that varied for individual sites, e.g. one location may have data for 1996 through 2000, while another location may have data only for 1998-2000. The complete data set and specific monitoring periods for each location are summarized in Appendix A (Summary Statistics). Fish tissue data reviewed in this section are also presented in Appendix A.

Water Column

Water column total mercury concentrations in the mainstem Sacramento River generally increased with distance downstream from the Keswick Reservoir discharge (Figure 6). A significant proportion of the increase occurred between Keswick and Colusa, with approximately a four-fold increase in median concentrations (from 0.72 ng/L to 3.1 ng/L) measured for the 2000-2001 monitoring period. Median total mercury concentrations in the mainstem below Colusa increased more moderately to the Sacramento below the confluence with the Feather River (by about 40%), and decreased slightly below the American River confluence. In the Sacramento River below the American River confluence, there was no apparent trend in total mercury concentrations (Sacramento River at Freeport, River Mile 44, and Greene's Landing).

Total mercury concentrations for the Feather River system were similar to those in the Sacramento River at Colusa, while concentrations in the Yuba and American rivers were much lower. Total mercury concentrations in Mill Creek, Arcade Creek, and the two agricultural drains monitored were all substantially higher than concentrations anywhere in the mainstem Sacramento River. SRWP special studies conducted in 2000 by USGS (Domagalski 2000) and in 2001 by Pacific Ecorisk to identify potential sources of the observed increase in mercury between Red Bluff and Colusa confirmed that Mill Creek was a significant source of mercury during some storm events. The USGS study concluded that there were also other significant sources of mercury in this stretch of the river. It was determined that Elder Creek (on the West side of the valley) and Antelope Creek (on the East side of the valley) were probably not significant sources. Thomes Creek was not monitored by this study, but was identified as a potentially significant source of mercury, and has been added to the SRWP monitoring program for 2001-2002.

Total methylmercury concentrations measured by SRWP in 2000-2001 exhibit a similar spatial distribution pattern to that for total mercury (compare Figures 6 and 7). Median unfiltered methylmercury concentrations in the mainstem Sacramento River also exhibited a dramatic (more than six-fold) increase from less than 0.02 ng/L below Keswick to 1.3 ng/L at Veterans Bridge. An interesting deviation from the pattern observed for total mercury was observed in the Sacramento River below the American River confluence. A similar decrease was observed below the American River confluence for the Sacramento River at Freeport, but methylmercury concentrations appeared to increase substantially at River Mile 44, and then decrease again at Greene's Landing to below concentrations at Freeport. While the influence of the Sacramento Regional Wastewater Treatment Plant below Freeport may explain some of the increase in methylmercury at River Mile 44, there is no obvious explanation for the observed decrease at Greene's Landing.

Because methylmercury is a non-conservative pollutant (i.e. mass is not necessarily conserved in the form of methylmercury due to methylation and demethylation processes), source assessments based on apparent differences in concentration must be made with caution. However, it is interesting to note that nearly all of the increase observed in Sacramento River mainstem methylmercury concentrations occurs before confluences with the major tributaries. Additionally, methylmercury concentrations observed in the Feather and Yuba Rivers were not high enough to account for increases below the confluence with the Feather River. Methylmercury concentrations in the Feather River and American River were slightly lower than observed in the Sacramento River mainstem from Colusa to River Mile 44, and methylmercury concentrations in the Yuba River were similar to those in the Sacramento River mainstem. Methylmercury concentrations were higher in Mill Creek, Sacramento Slough, and Colusa Basin Drain (concentrations approximately twice those measured in the mainstem), and may account for at least some of the increase in mainstem concentrations. However, the flows from these sources are relatively small compared to the mainstem, and the increases in methylmercury concentrations observed are likely at least partially due methylation of instream mercury sources in the mainstem Sacramento River.

Fish Tissue

Fish tissue samples (typically consisting of composites of five fish each) were collected from 28 locations ranging from the three tributaries above Lake Shasta to Cache Slough (near Rio Vista) in the Delta (Figure 5). Fish were collected during the months of September and October from 1997 to 2000. A total of 14 fish species have been sampled, including seven trophic level 3 species and seven trophic level 4 species. It should be noted that mercury concentrations in fish tissue are dependent not only on water column concentrations of bioavailable mercury, but also on the productivity of the waterbody (e.g. oligotrophic vs. eutrophic) and the trophic level, feeding patterns, and age of the fish. For this reason, mercury concentrations in trophic level 3 species (e.g. rainbow trout), should not be directly compared with concentrations in trophic level 4 species (e.g. largemouth bass) as a means of inferring spatial differences in levels of bioavailable mercury. However, examination of the average tissue mercury concentrations for each trophic level (Table 8) provides a less biased view of regional patterns in fish tissue concentrations.

Spatial patterns in average mercury concentrations for each trophic level are generally similar to the patterns discussed previously for consumption-weighted averages. The average tissue mercury concentrations for both trophic level 3 and 4 species was highest for the two major tributaries (Feather River and American River). Average tissue mercury concentrations in trophic level 3 species were generally similar at all of the other locations (agricultural drains, smaller tributaries, Sacramento River mainstem, and the two Delta locations). Average tissue mercury concentrations in trophic level 4 species were highest in the major tributaries and agricultural drains, and lowest in smaller tributaries. Average tissue mercury concentrations in trophic level 4 species were similar in the lower Sacramento River mainstem (from Keswick to the "I" Street Bridge) and the two Delta sites (Sacramento River at Mile 44 and Cache Slough).

This pattern in fish tissue concentrations exhibits at least one interesting contrast with the spatial pattern observed for the water column mercury and methylmercury concentrations—in 2000-2001 mercury and methylmercury concentrations in the Feather and American rivers were generally lower than or similar to concentrations observed in the mainstem, while average fish tissue mercury concentrations were approximately twice as high in the two tributary locations as in the mainstem Sacramento River. Because the mercury concentrations in fish tissue integrate bioavailable mercury concentrations in water over a period of several years, these results suggest that the pattern observed in water column concentrations of total mercury and methylmercury in 2000-2001 may not be representative of typical conditions over a longer period. Although most of the fish species sampled were selected because they are not highly migratory, an alternative hypothesis that can not be ruled out based on these results is that the fish or their prey accumulated high mercury concentrations from locations other than where they were caught.

iv. Temporal Distribution & Patterns

Unfiltered total mercury concentrations in the water column exhibit strong seasonal patterns in the mainstem Sacramento River and major tributaries. Concentrations of total mercury typically peak following early wet season precipitation and with increased river flows of the early wet season (typically in November-December), and then decrease steadily through the remainder of the year. In general, this pattern is consistent with the seasonal mobilization of fine-grained particulates in river sediments and runoff deposited during the dry season and during lower stream flows. Mercury tends to adsorb to fine grained sediments, leading to the close correlation between sediment transport and mercury transport phenomena. This pattern appears to be consistent at all the mainstem Sacramento River sites monitored between Redding and River Mile 44, and in the major tributaries in the lower watershed (the Feather River, Yuba River, and American River). This pattern is less distinct for total mercury concentrations in the agricultural drainage-dominated Colusa Basin Drain and Sacramento Slough.

Methylmercury concentrations exhibited a less distinct and more variable seasonal pattern throughout the watershed in 2000-2001 (Figure 8). At most locations, water column concentrations of unfiltered methylmercury exhibited only a moderate increase during the early wet season (Fall 2000), with higher peaks observed in the late wet season (early Spring 2001) for many sites. The most consistent temporal trend observed for 2000-2001 data was the gradual increase in methylmercury that was observed for all three major tributary locations, but most dramatically for the Feather and Yuba rivers. Longer-term patterns in methylmercury concentrations in the Sacramento River at Freeport exhibit a more consistent pattern of increased concentrations in the early wet season, followed by a general decline through the remainder of the year (Figure 9). Probable causes of temporal variations in Sacramento River methylmercury include seasonal mobilization of total mercury, increased methylation due to seasonal water temperature changes, or increased inflows of methylmercury from tributaries. Continuing methylmercury monitoring by the SRWP monitoring program and several CALFED-funded projects are expected to provide additional information to address this question.

Seasonal variation in unfiltered methylmercury concentrations are illustrated in Figure 8 for selected SRWP locations monitored 2000-2001. Longer-term patterns in seasonal variation in unfiltered total mercury and methylmercury concentrations are illustrated for the Sacramento River at Freeport in Figure 9 for 1996 through 2001. Time series plots of water column mercury and methylmercury concentrations are also presented in Appendix B of this report.

v. Mass Load Comparisons

Evaluations of mass load sources within the Sacramento River watershed and from other major Delta tributaries are currently being performed as part of the Strategic Plan being developed by the Delta Tributaries Mercury Council (DTMC) for management of mercury in the Delta and Sacramento River. This information is vital to development of pollutant management strategies and Total Maximum Daily Loads (TMDLs). It should be noted that mass loads are not direct indicators of water quality or predictors of instantaneous concentrations of mercury in water or in fish tissue.

For annual average estimates, average annual loads from the Sacramento River at River Mile 44, the Yolo Bypass, the San Joaquin River, and the Mokelumne River were calculated as the long-term annual average flow (USGS Water Resources Data, 1996) multiplied by the average concentration value for the available data for each major input. The resulting estimates are intended only to provide a semi-quantitative comparison of the relative magnitude of the major Delta inputs, and are not intended to be definitive estimates of actual loads. Because these estimates are based on limited data and long-term average flows, they do not fully account for the seasonal spikes in mass loadings that typically occur during peak streamflow events, and may therefore underestimate total mercury loads to the Delta. It should also be noted that estimates of mass loads of *total* mercury provide little direct information regarding causes of excessive mercury bioaccumulation in the Delta, primarily because total mercury concentrations are not closely related to concentrations of bioavailable mercury.

The results of previous assessments of mass load contributions to the Delta (SRWP 2000, 2001) highlighted the dominance of the Sacramento River watershed with respect to total riverine flows and mercury inputs to the Delta—approximately 90% of estimated total average total mercury loads are from the Sacramento River and Yolo Bypass. In years with relatively high annual flows, such as 1998, loads from the Yolo Bypass and the Cache Creek watershed are estimated to exceed the loads from the rest of the Sacramento River watershed. Although the available data for the San Joaquin River and the Mokelumne River are still very limited, the low annual flows (in comparison to the Sacramento River flows) and moderate mercury concentrations in these rivers suggest that these inputs are responsible for a relatively low percentage of total mercury inputs to the Delta (less than 10% for the San Joaquin River and Mokelumne River, combined).

As part of the Strategic Plan for mercury controls, the DTMC is analyzing a variety of data sources in addition to mercury concentration and flow data to develop load models for the Sacramento River watershed. The DTMC is evaluating land use characteristics, density of mercury and gold mines, and several other measures of geographical features that may be useful in relating load estimates for specific sources and tributary watersheds to loads in the Sacramento River mainstem. The goal of this process is to estimate known background loads and source loads, and to compute discrete contributions from controllable sources. Preliminary results of the DTMC evaluations indicate that total mercury loads double (approximately) in the mainstem between Hamilton City and Colusa, and double again between Colusa and the Sacramento River below the confluence with the Feather River. The largest increase in methylmercury load in the mainstem Sacramento River is estimated to occur between Hamilton City and Veterans Bridge, increasing the load approximately six-fold in this reach. The Feather River is estimated to represent approximately one-fifth of the methylmercury load at Veterans Bridge. The results of the DTMC evaluations don't indicate any single outstanding source of mercury or methylmercury loads to the Sacramento River, but instead suggest that loads in mainstem increase throughout the river's length. This preliminary assessment is consistent with the patterns described for spatial variability of total mercury and methylmercury water column concentrations. Potential sources of total mercury and methylmercury loads include natural soil erosion and geothermal springs, which appear to represent significant proportions of the total loads, in addition to anthropogenic sources such as mines and urban runoff. The Strategic Plan and DTMC evaluations of mercury sources in the Sacramento River watershed are scheduled to be released late in 2002.

vi. Conclusions and Recommendations

Mercury concentrations in fish tissue collected from 1997 to 2000 from the mainstem Sacramento River below Shasta Reservoir and major tributaries to this section of the river were higher than several of the human health-based and wildlife-based advisory and screening values. Frequent exceedances of the tissue-based water quality criterion for mercury recently developed by the USEPA (0.3 mg/kg) and adopted by the California Office of Health Hazard Assessment (OEHHA), and less frequent exceedance of the previous USEPA screening value of 0.6 mg/kg, indicate that there are human health concerns associated with consumption of some fish species from the lower Sacramento River watershed. The current water quality USEPA criterion of 0.3 mg/kg is based on a fish consumption rate of 17.5 g/day (equivalent to 4 quarter-pound servings per month). There is some disagreement whether the available data are adequate to warrant issuing fish consumption advisories, based on the fact that OEHHA has not issued advisories for these waters, while the Central Valley Regional Water Quality Control Board has recommended addition of a number of waterbodies to California's 303(d) list based on the available data. Interim Public Health Notices have also been issued by Placer, Yuba, and Nevada counties for eight Sierra foothill waterbodies based on the same data used by the Regional Board. Although there is substantial uncertainty regarding the level of risk posed by these concentrations of mercury in fish, there is agreement that the risks are greatest for small children and pregnant women, and that the risks increase with greater consumption of fish. General consumption guidelines are provided by OEHHA on their web page (http://www.oehha.org), in addition to consumption advisories for specific waterbodies. Concerns over mercury in fish from the lower Sacramento River watershed are being addressed with more focused monitoring being performed for 2000-2002 (Years 3 and 4). This shift in focus is in large part a result of coordination and consultation with OEHHA, which has been an active participant in the SRWP, and has provided the SRWP with guidance regarding data needs and study design for evaluation of human health risks related to fish consumption.

Other conclusions of this review of mercury monitoring data can be summarized as follows:

Consumption-weighted average mercury concentrations in tissues of fish collected from the Sacramento River mainstem from Keswick to the Delta, and in smaller tributaries were lower than USEPA human health-based criterion of 0.3 mg/kg. However, in almost all trophic level 4 species collected throughout the watershed, average mercury concentrations were higher than the 0.3 mg/kg criterion, and were frequently two to three times higher than this criterion.

Consumption-weighted average mercury concentrations in fish tissue collected from the lower American River and Feather River, and in three agricultural drains were higher than USEPA human health-based criterion of 0.3 mg/kg. Exceedance of the criterion indicates that there are potential human health risks associated with consumption of fish from these waterbodies.

Total water column mercury concentrations in the Sacramento River from Keswick to River Mile 44 rarely exceeded the CTR mercury criterion of 50 ng/L(USEPA 2000). Total mercury concentrations exceeded the 50 ng/L limit in 30% of Cache Creek samples and 46% of samples from the upper Mill Creek watershed. The Feather and Yuba rivers are significant sources of mercury loads, but concentrations of total mercury and methylmercury were not elevated compared to the Sacramento River mainstem in 2000-2001. However, relatively high concentrations of mercury in fish from the lower Feather River and American River suggest that these watersheds may have been significantly elevated sources of bioavailable methylmercury in previous years, or alternatively that fish may be accumulating mercury from other locations. Spring Creek in the upper Sacramento River watershed, Deer Creek, Big Chico Creek, and the American River did not appear to be major sources of total mercury—concentrations were low compared to the Sacramento River and were never observed to exceed the 50 ng/L CTR criterion at these sites. With the exceptions of Mill Creek and Cache Creek, total mercury concentrations rarely exceeded the 50 ng/L CTR criterion at any site.

Methylmercury concentrations in water column samples exceeded the Great Lakes human health-based criterion of 0.24 ng/L most frequently in samples from Arcade Creek (67% of samples) and from two agricultural drain sites (25% and 35% of samples). Methylmercury concentrations exceeded the Great Lakes wildlife-based criterion of 0.05 ng/L in nearly every sample collected from mainstem location below Hamilton City, and in all other tributaries and agricultural drains sampled.

The Sacramento River watershed is the major source of total mercury to the Delta. This watershed contributes approximately 90% of the total mercury loads to the Delta. Within the Sacramento River watershed, the Cache Creek drainage is the single largest source area for total mercury. The Delta Tributaries Mercury council of the

SRWP is currently evaluating additional controllable mercury sources within the Sacramento River watershed as part of its Strategic Plan to control mercury in the watershed.

MAP KEY

Site ID	Location
SRSHA	Sac. R. above Shasta
MRSHA	McCloud R. above Shasta
PRSHA	Pit R. above Shasta
SCKPP	Spring Ck Power Plant discharge
SRBKR	Sac. R. below Keswick Res.
SRABB	Sac. R. above Bend Bridge
MC###	Mill Creek sites
DC###	Deer Creek sites
SRHAM	Sac. R. at Hamilton City
MUDCH	Mud Creek
CH###	Big Chico Creek sites
SRCOL	Sac. R. at Colusa
FRNIC	Feather R. near Nicolaus
COLDR	Colusa Basin Drain
SACSL	Sacramento Slough
SRVON	Sac. R. at Verona
SRVET	Sac. R. at Veterans Bridge
NEMDR	Natomas East Main Drain
ARCNW	Arcade Cr. at Norwwod Av.
ARJST	American R. at J Street
ARDPK	American R. at Discov. Pk.
SRFPT	Sac. R. at Freeport
SRRMF	Sac. R. at Mile 44
SRRMF	Sac. R. at Greene's Landing
CCHCK	Cache Creek at Rumsey
PUTAH	Putah Creek
PUTAU	Upper Putah Creek
YOLOB	Yolo Bypass
CCHSL	Cache Slough

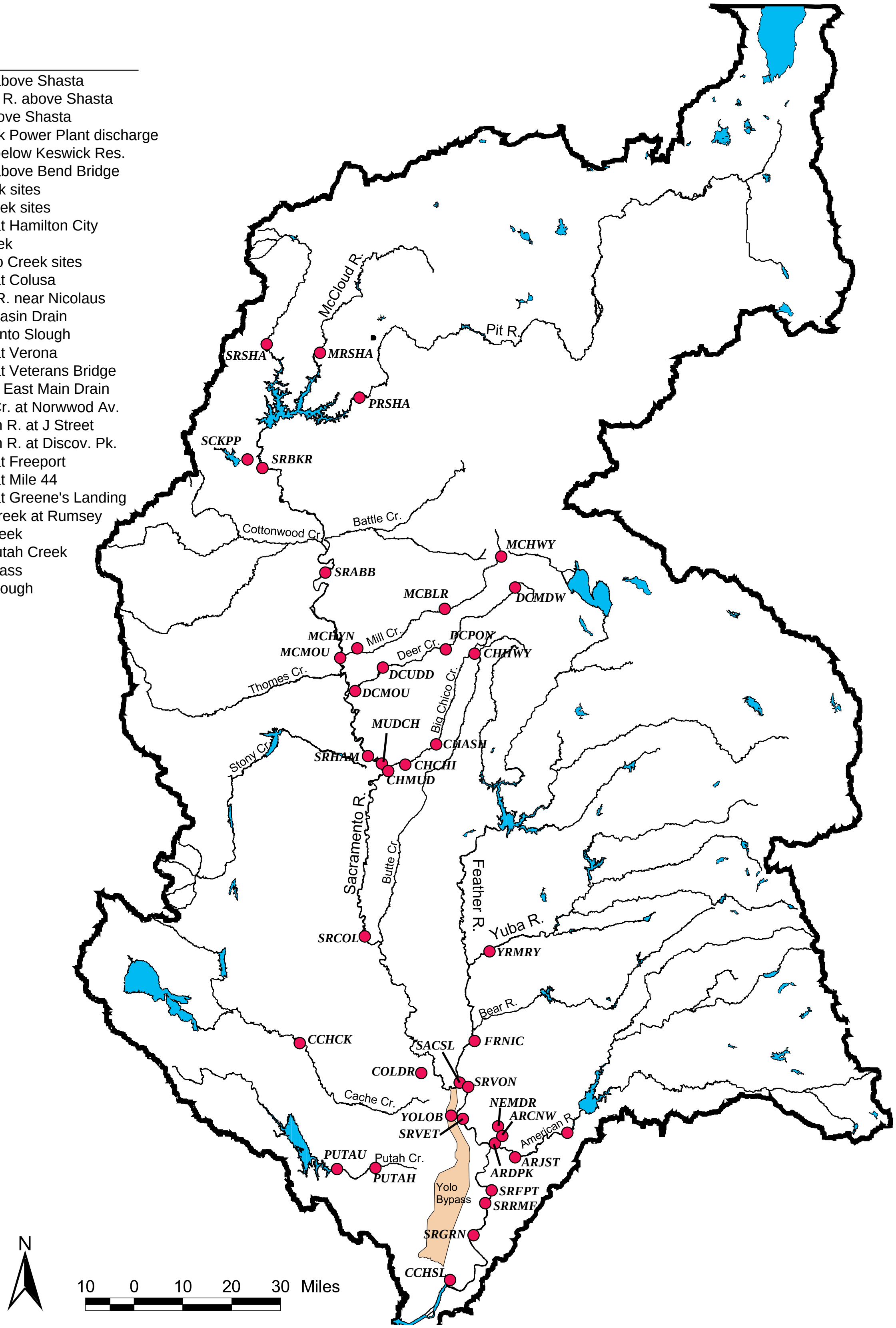


Figure 2. Mercury Monitoring Sites for the Sacramento River Watershed Program: USGS NAWQA, City of Redding, Sacramento River CMP, and SRWP

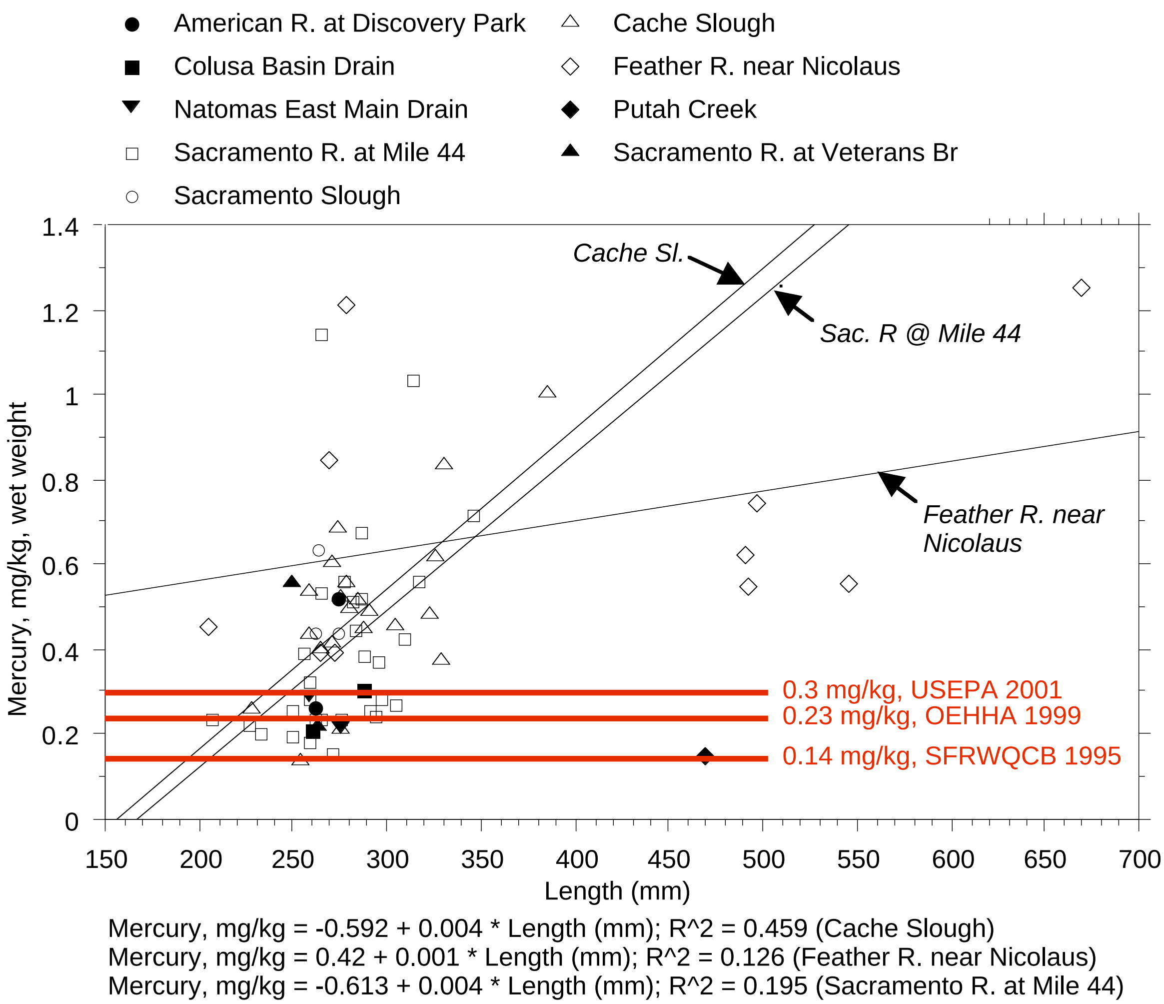
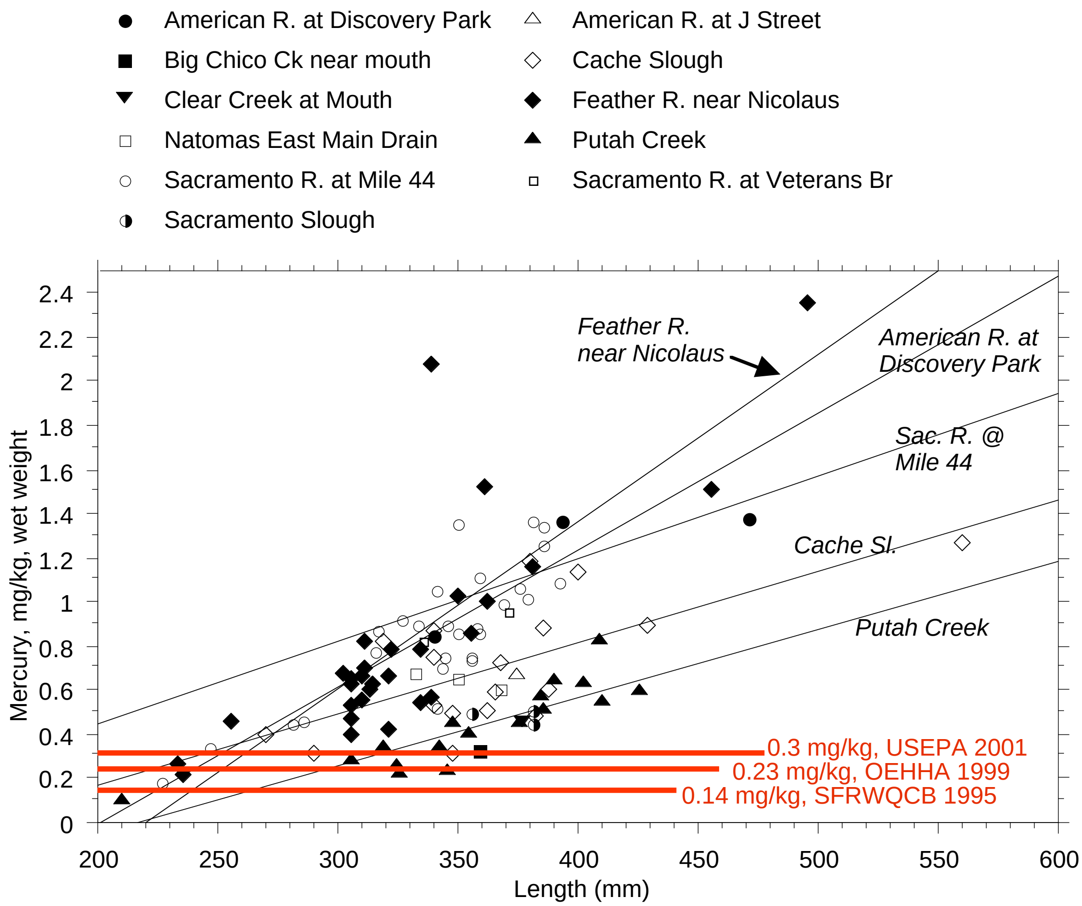


Figure 3. Mercury in White Catfish in the Sacramento River Watershed: SRWP Data, 1997-2000



Mercury, mg/kg = -0.309 + 0.0038 * Length (mm); R^2 = 0.6728 (American R. at Discovery Park)
Mercury, mg/kg = -0.4743 + 0.0032 * Length (mm); R^2 = 0.4616 (Cache Slough)
Mercury, mg/kg = -1.6657 + 0.0076 * Length (mm); R^2 = 0.6563 (Feather R. near Nicolaus)
Mercury, mg/kg = 1.4398 - 0.0023 * Length (mm); R^2 = 0.9442 (Natomas East Main Drain)
Mercury, mg/kg = -0.6721 + 0.0031 * Length (mm); R^2 = 0.7473 (Putah Creek)
Mercury, mg/kg = -1.2482 + 0.0062 * Length (mm); R^2 = 0.698 (Sacramento R. at Mile 44)

Figure 4. Mercury in Largemouth Bass in the Sacramento River Watershed: SRWP Data, 1997-2000

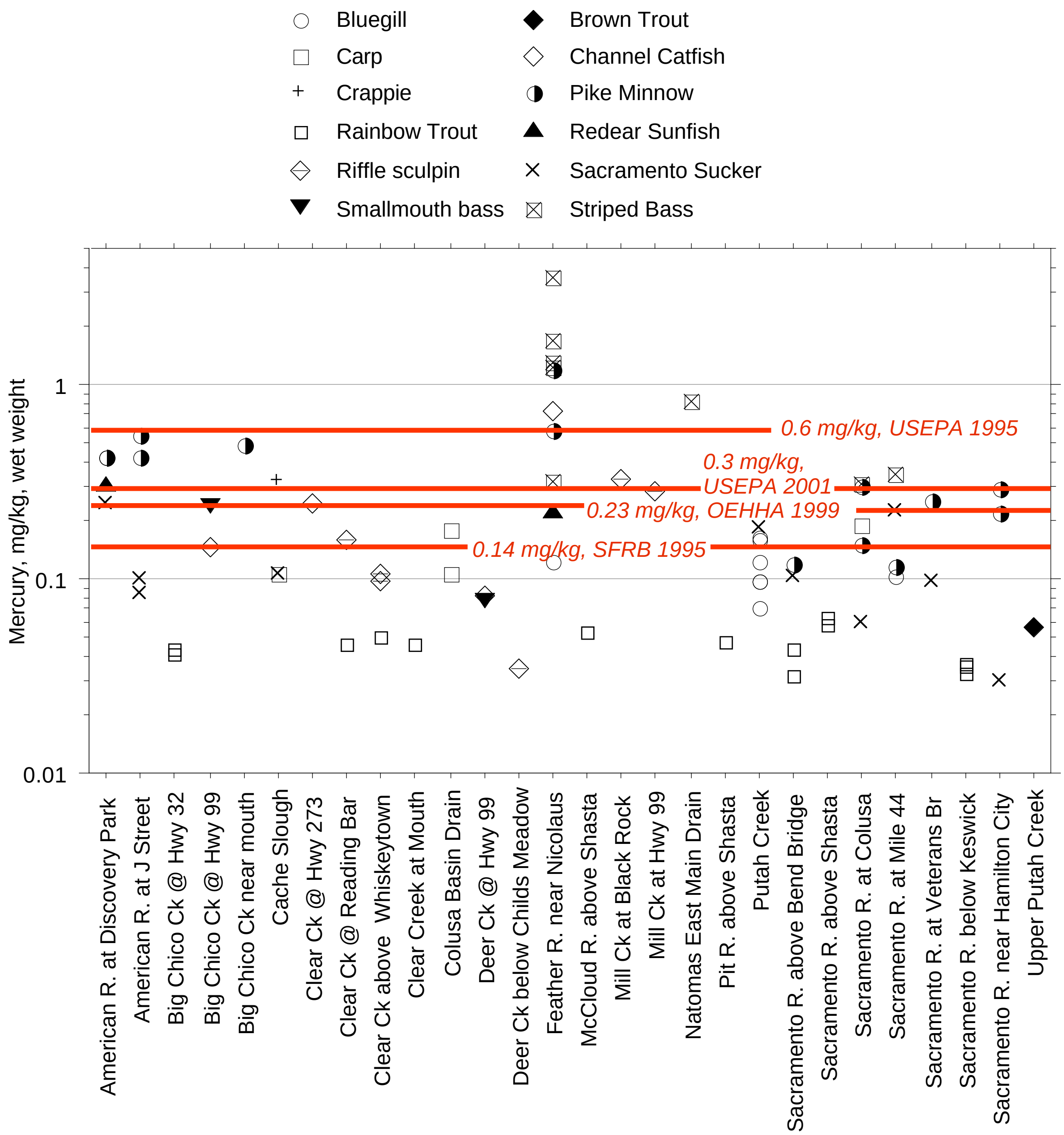


Figure 5. Mercury in Other Fish Species in the Sacramento River Watershed: SRWP Data, 1997–2000, and DWR Data, 1999

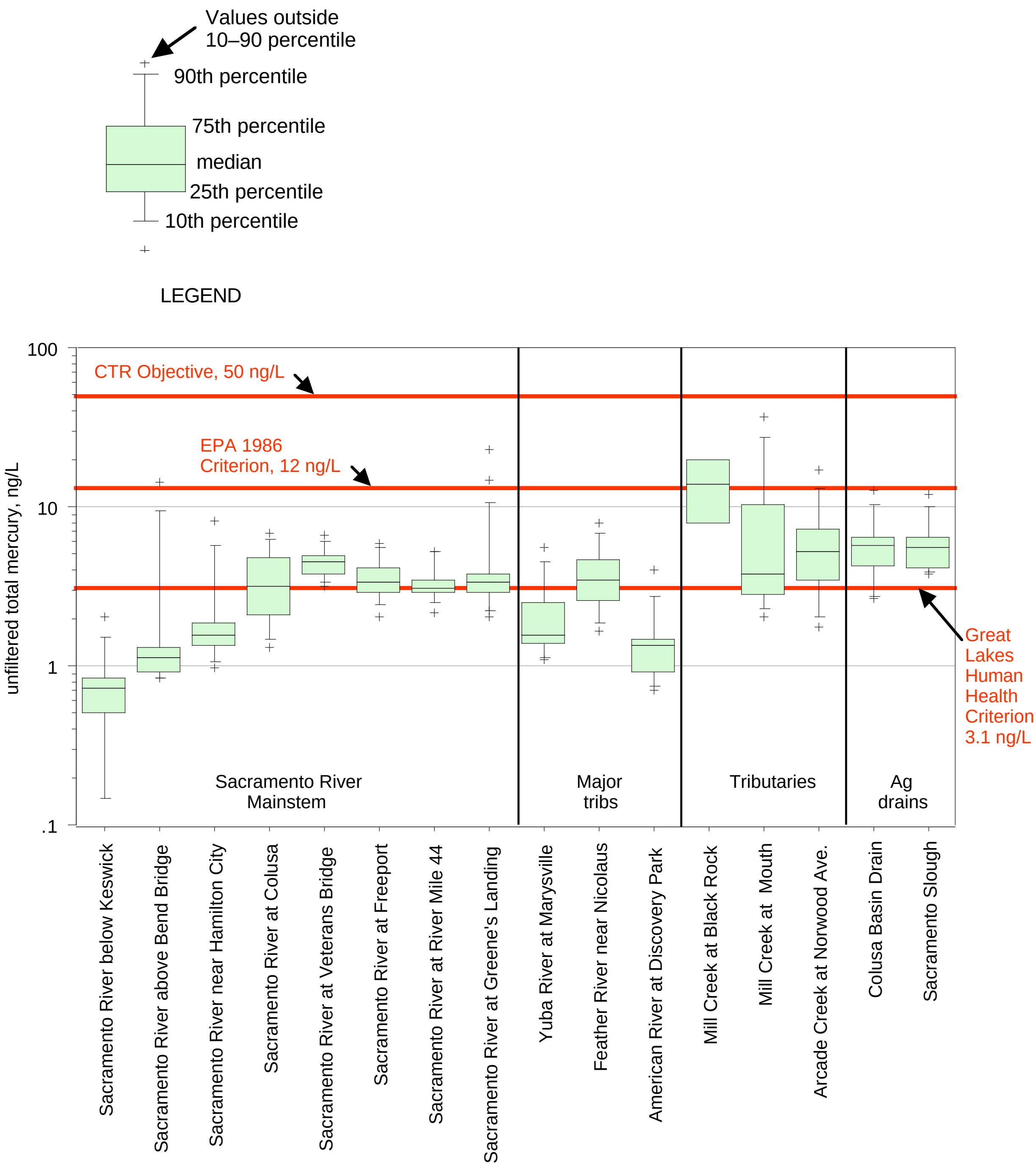
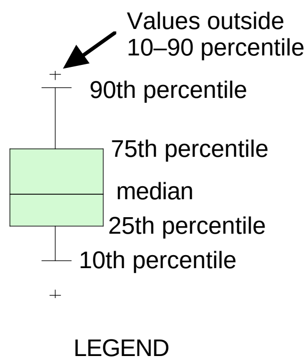


Figure 6. Mercury in the Sacramento River Watershed, Unfiltered Total Mercury Concentrations in Water, 2000-2001 data



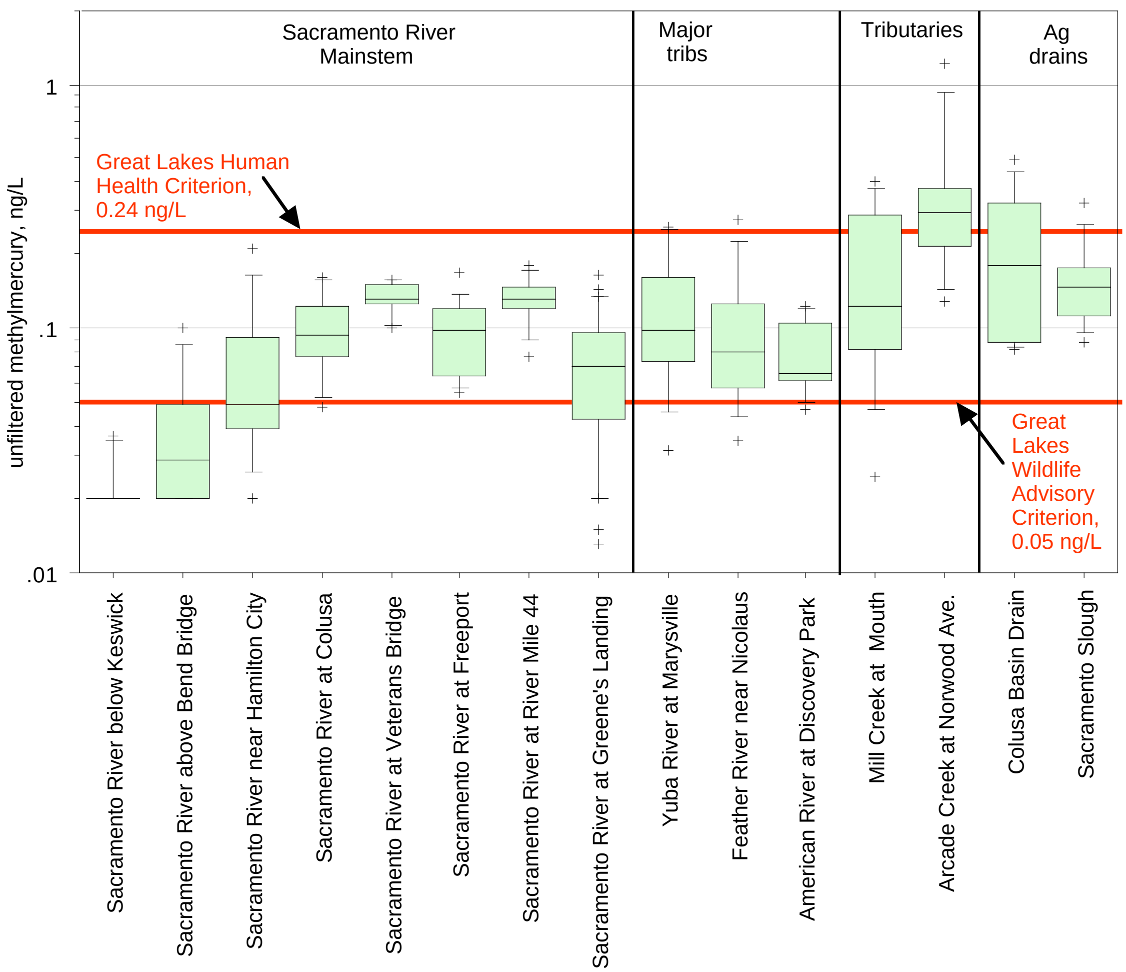


Figure 7. Methylmercury in the Sacramento River Watershed: Unfiltered Methylmercury Concentrations in Water (SRWP data, 2000-2001)

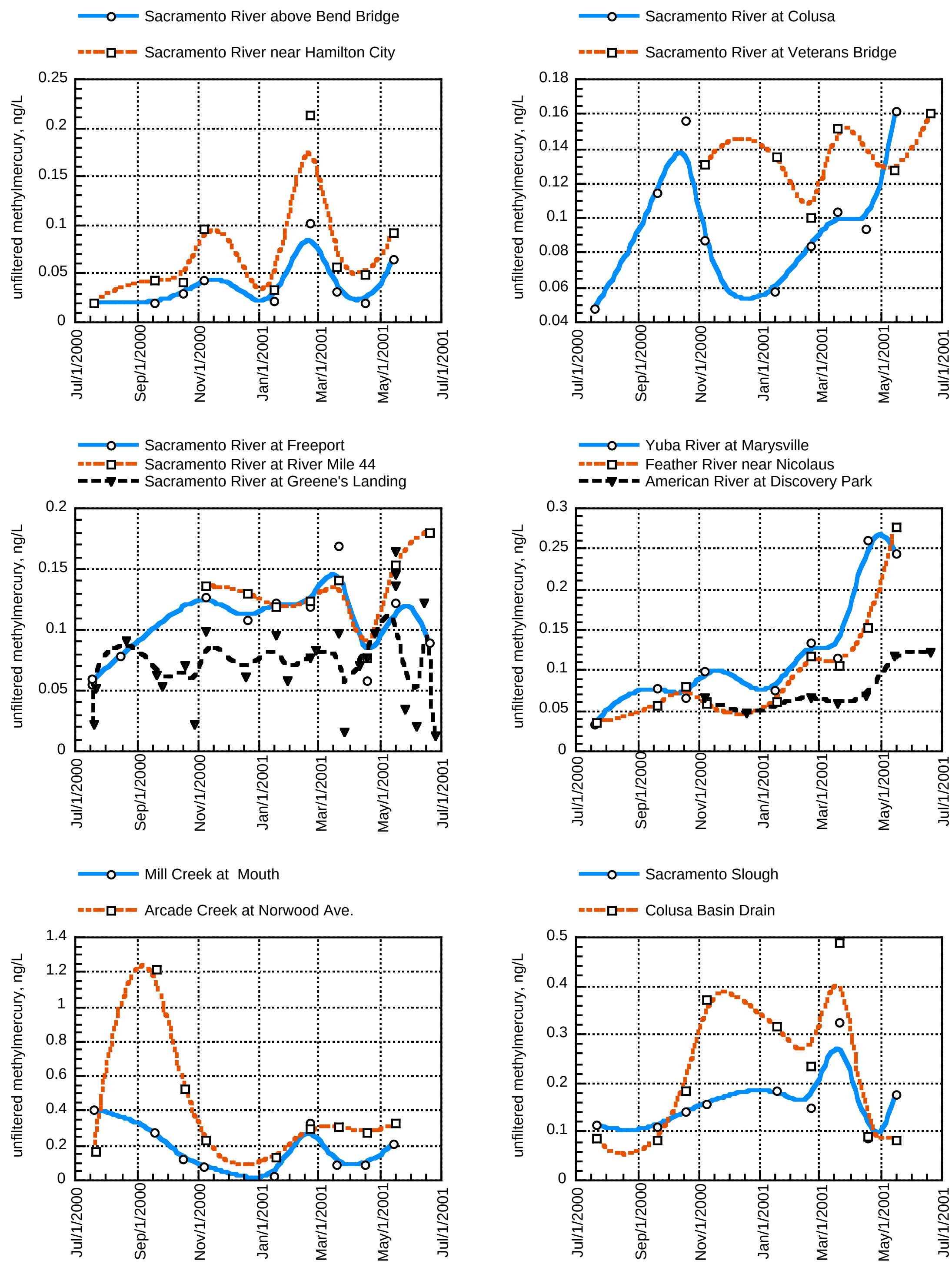


Figure 8. Unfiltered Methylmercury Concentration Time Series, 2000-2001 Data
Smoothed line fits are shown to illustrate general temporal trends observed in 2000-2001 SRWP, USGS, and CMP monitoring data.

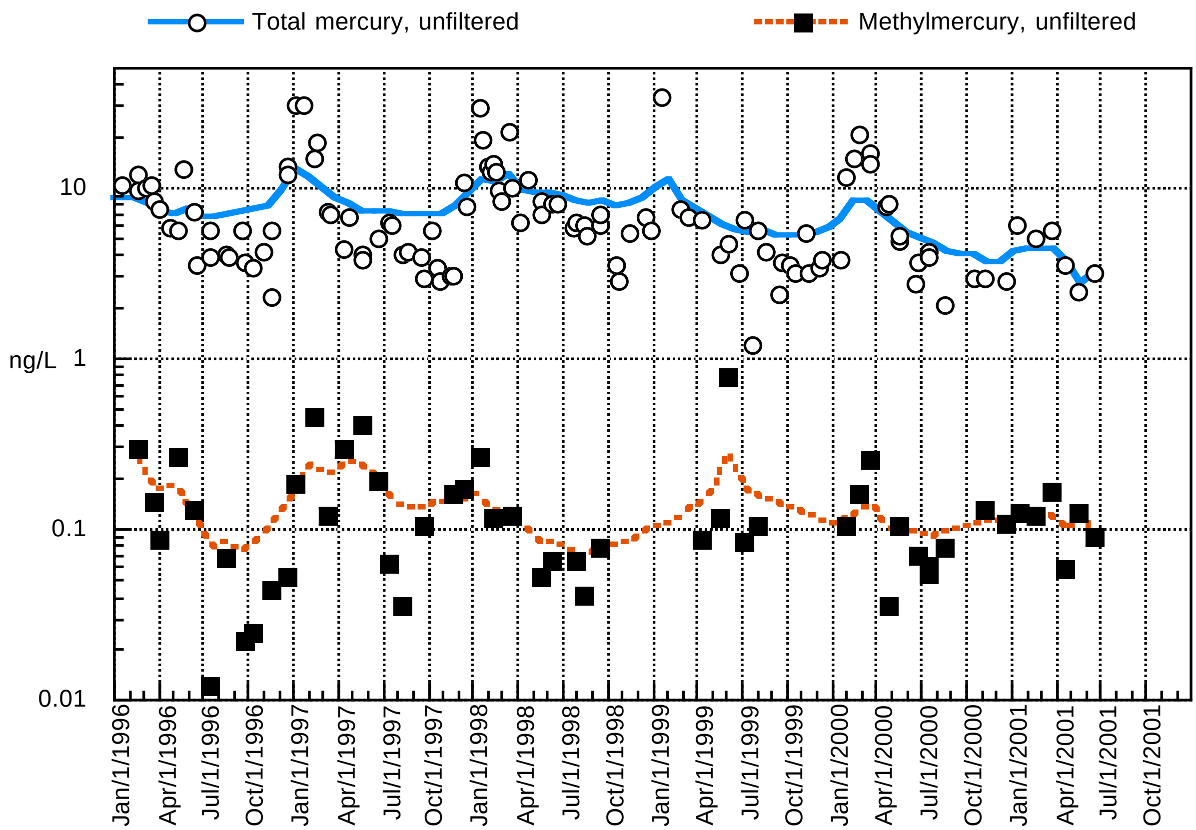


Figure 9. Unfiltered Total Mercury and Methyl Mercury in Water: Sacramento River at Freeport (USGS NAWQA data, 1996-2000, and Sacramento River CMP data, 1996-2001)

B. Pesticide Data Summary

Monitoring results for the Sacramento River Watershed Program (SRWP) and for primary coordinating programs (USGS NAWQA, Sacramento River Coordinated Monitoring Program, City of Redding NPDES monitoring, and Department of Water Resources) are presented and summarized in this section. Data were compared to relevant water quality objectives and toxicity thresholds to evaluate attainment of beneficial uses and potential impairment of these uses in surface waters of the watershed. It should be noted that these evaluations are limited to the pesticides monitored by SRWP, and do not include many other pesticides that have potential to affect beneficial uses. Data were evaluated for spatial and temporal trends if evidence of potential impairment was found. Summary statistics for pesticides detected in 1999-2001 monitoring are provided in Appendix A.

i. Background and Available Data Overview

The sources of data utilized for this report are summarized in Table 10a. The majority of non-SRWP data discussed in this report were obtained from the Department of Pesticide Regulation Surface Water Database (July 15, 2000). The monitoring locations for the primary data considered for this report (USGS NAWQA, California, the Sacramento River Coordinated Monitoring Program, California Department of Pesticide Regulation, and the Sacramento River Watershed Program) are illustrated in Figure 10.

The majority of the pesticide monitoring performed in surface waters of the Sacramento River watershed has been focused on pesticides used in rice cultivation and orchard dormant spray applications, and pesticides commonly found in urban runoff. Of these, the SRWP monitoring program has focused primarily on organophosphate and carbamate pesticides, with triazine pesticides also monitored at selected locations (Table 10a). “Legacy” organochlorine pesticides (including DDT, aldrin, dieldrin, endrin, heptachlors, chlordanes, endosulfans, toxaphene, and hexachlorocyclohexanes) were not monitored in water. All samples were collected as instantaneous grab samples.

As discussed previously in this document, SRWP monitoring for pesticides was performed partially on an episodic basis in 2000-2001. A total of 9 events, including 4 episodic events and 5 scheduled events, were monitored at 10 locations. SRWP monitoring in 2000-2001 included both dry weather and wet weather episodic events. Wet weather episodic events included the first significant watershed-wide storm event of the 2000-2001 wet season (late October 2000), the organophosphate pesticide dormant spray application period (late January 2001), and a late wet season rainfall event (April 2001). The single dry weather “episodic” event was scheduled to coincide with the highest probability for detecting rice herbicides (late May 2001). The other events consisted of 4 scheduled dry season events and one dry weather event scheduled to coordinate with the Regional Monitoring Program monitoring conducted in February 2001. These events are summarized in Table 10b.

Table 10a. Pesticide monitoring programs in the Sacramento River Watershed

Program	Monitoring Period(s)	Parameters	# of locations & geographic reference
SRWP	6/99–5/01	▪ Organophosphate, carbamate, and triazine pesticides in water	6 sites: 3 Sac. River sites (OPs), 2 Ag. Drain sites (OPs, carbamates), and 1 urban runoff-dominated site (all parameters)
Sacramento River CMP (SRCSD)	12/92–12/01	▪ Diazinon and chlorpyrifos in water	5 sites on Sacramento and American rivers in Sacramento metropolitan area
Sacramento River Basin NAWQA (USGS)	2/96–4/98	▪ Wide range of pesticides, including OPs, carbamates,	5 sites: 1 Sac. River site, 2 Ag. Drainage dominated sites, 1 urban runoff-dominated site, and Yolo Bypass
USGS (Domagalski 1998)	5/98–9/00	▪ Wide range of pesticides, including OPs, carbamates,	Continuation of NAQWA monitoring at Sac. River at Freeport
Department of Pesticide Regulation	1996–2000 (wet season episodic sampling)	▪ Organophosphate, carbamate, and triazine pesticides in water	3 sites: Sacramento River at Veterans Bridge (Alamar) and Sutter Bypass near Karnak, and Wadsworth cnal
Department of Pesticide Regulation	1995–2000	▪ Rice Pesticides	3 sites: Sacramento River at Village Marina, Butte Slough, and Colusa Basin Drain
CVRWQCB	1/94–3/94	▪ Organophosphate, carbamate, and triazine pesticides in water	21 sites: Sacramento River, Feather River, Yuba River, and multiple ag. drainage-affected sites
Sacramento NPDES Stormwater Monitoring Program	1990–2000	▪ Organophosphate and carbamate pesticides in water	13 Sacramento area urban runoff and river sites
SF Estuary Regional Monitoring Program	1989–1998	▪ Pesticides in water	18 Bay-Delta sites, including Sacramento River and San Joaquin River at the Delta terminus
Special Tributary Program (DWR)	6/98–5/00	▪ Pesticides in water	13 water column sites on Mill Creek, Big Chico Creek, and Deer Creek
Offstream Storage Study (DWR)	1999 to 2001	▪ Pesticides in water	42 sites: 7 Sac. River sites and 32 tributary sites between Keswick and Colusa, and 3 reservoir sites. *Data not available*

Table 10b. SRWP Pesticide Monitoring, 2000-2001: Events and locations.

Events		Locations and Pesticides Monitored[1]									
Dates	Description	Mill Creek	Deer Creek	Big Chico Creek	Sac. R at Hamilton City	Sac. R. at Colusa	Sacramento Slough	Colusa Basin Drain	Feather R. near Nicolaus	Sac. R. at Veterans Br.	Arcade Creek at Norwood Av
July 18-21, '00	Scheduled dry weather event	—	—	—	o	o	o/c	o/c	o	o	o/c/t
Sept 19-20 '00	Scheduled dry weather event	—	—	—	o	o	o/c	o/c	o	o	o/c/t
Oct 17-20, '00	Scheduled dry weather event	—	—	—	o	o	o/c	o/c	o	o	o/c/t
Oct 30-31, '00	First significant storm event (10/25-30) of the wet season (e.g. "first flush"),	—	—	—	o	o	o/c	o/c	o/t	o/t	o/c/t
Jan 26-27, '01	Rainfall event (1/25-26) following OP pesticide dormant spray application	o	o	o	o	o	o/c	o/c	o/t	o/t	o/c/t
Feb 7-8, '01	Coordination with Regional Monitoring Program sampling (dry weather event)	o	o	o	o	o	o/c	o/c	o/t	o/t	o/c/t
April 8-9, '01	Late wet season storm event, (4/6-8)	o	o	o	o	o	o/c	o/c	o/t	o/t	o/c/t
May 29-31, '01	Rice pesticide application and discharge season (dry weather "episodic" event)	o	o	o	o	o	o/c	o/c	o	o	o/c/t
June 21-22, '01	Scheduled dry weather event	—	—	—	o	o	o/c	o/c	o	o	o/c/t

(1) "o" = organophosphate pesticides by EPA Method 8141a
"c" = carbamate pesticides by EPA Method 8321
"t" = triazine pesticides by EPA Method 619
"—" indicates site not monitored for the event

ii. Attainment of Beneficial Uses and Potential Impairment

Pesticides monitored by the SRWP include organophosphate and phenoxyurea pesticides, carbamate pesticides, and triazine pesticides (analyzed by USEPA methods 8141, 8321, and 619, respectively). Individual pesticides and their respective reporting limits are presented in Table 11. Nine of these pesticides were detected in SRWP monitoring in 2000-2001. An additional five pesticides detected in 1999-2000 monitoring, but not detected in 2000-2001 (aldicarb, carbofuran, propazine, prowl, and tebuthiuron), were discussed in the 1999-2000 Annual Monitoring Report and are not evaluated again in this document. The concentrations of pesticide detected in 2000-2001 were compared with a variety of regulatory and toxicity thresholds (Table 12) to evaluate potential risks to human health and aquatic life. The regulatory thresholds considered included USEPA aquatic life criteria, USEPA's Maximum Contaminant Levels (MCL) for drinking water, reference doses for drinking water from USEPA's IRIS database, and minimum toxic thresholds from USEPA's Office of Pesticide Programs (OPP) Ecotoxicity database. Also considered were recommended aquatic life criteria developed by the California Department of Fish and Game for diazinon and chlorpyrifos (CDFG 2000). There are no criteria in the adopted California Toxics Rule for any of the pesticides detected in SRWP monitoring. Of the pesticides detected in SRWP monitoring, only chlorpyrifos, diazinon, and malathion have aquatic life criteria developed using USEPA methodology. None of the pesticides detected in 2000-2001 have an adopted Drinking Water MCL. No relevant regulatory limits are available for other detected pesticides (bromacil, carbaryl, diuron, EPTC, methomyl, and prometon). The results of these comparisons provide some perspective regarding potential impacts on beneficial uses. However, these results do not provide definitive or conclusive information regarding such impacts.

Comparisons with water quality criteria and toxicity thresholds

Chlorpyrifos was detected at greater than DFG's recommended Continuous Concentration Criterion (CCC) of 0.014 μg/L in only one SRWP sample in 2000-2001 (0.7 μg/L at Colusa Basin Drain), and was previously detected in only one sample from Arcade Creek in 1999-2000. Toxicity thresholds for crustacean species (which includes *Ceriodaphnia dubia*) are as low as 0.01–0.035 μg/L. In other studies, chlorpyrifos has been documented at much higher concentrations than these thresholds in urban creeks and urban runoff, and has been shown to contribute to significant mortality in tests with *Ceriodaphnia dubia* (LWA 1999, Katznelson and Mumley 1997, Bailey *et al*. 1997). Data in DPR's Surface Water Database indicate that these concentrations have been occasionally exceeded in agricultural drainage-affected waterways, urban runoff, and urban creeks, and sometimes by more than an order of magnitude. Based on SRWP and USGS NAWQA monitoring and data reported by other studies in DPR's Surface Water Database, concentrations have not been observed to exceed these thresholds in the Sacramento River and major tributaries.

Diazinon was detected at greater than DFG's recommended Continuous Concentration Criterion (CCC) of 0.050 μg/L in six of nine samples collected from Arcade Creek in 2000-2001. Aquatic toxicity testing at this site indicates that metabolically activated toxicants are often the cause of significant mortality and/or reproductive toxicity frequently observed at this site—a pattern that is consistent with diazinon toxicity. Although diazinon was not detected at greater than the recommended CCC at any other SRWP-monitored site, data in the DPR Surface Water database indicate that diazinon concentrations have commonly exceeded this value at nearly every location monitored, including the Sacramento River mainstem, and major and minor tributaries. The greatest magnitude and most frequent exceedances of the recommended CCC have been observed in the numerous waterways most directly affected by agricultural drainage or urban runoff. Based on the data in the DPR Surface Water database, diazinon concentrations in agricultural drainage-dominated waterways commonly exceed 0.2 μg/L, the lowest LC_{50} (for crustacea) recorded in the USEPA's OPP Ecotoxicity database. Although it appears that this concentration is not frequently exceeded in the Sacramento River or major tributaries, other studies have documented cases of significant reproductive effects and mortality to *Ceriodaphnia dubia* due to diazinon, or have observed diazinon concentrations high enough to cause toxicity (Foe and Sheipline 1993, Larsen *et al.*

1998a and b, Holmes *et al.* 1998). Concentrations many times higher than DFG's recommended CCC and other toxicity thresholds have been documented in urban creeks and agricultural drains by numerous researchers and monitoring programs (Ogle and Cooke 2000).

Malathion was detected above USEPA's Instantaneous Maximum concentration criterion (USEPA 1986) of 0.1 μg/L in one sample from Colusa Basin Drain (0.24 μg/L). The criterion is equal to the lowest toxicity threshold (LOEC, crustacean species) in USEPA's OPP Ecotoxicity database (USEPA 2000, July 2000 version). Data in DPR's Surface Water Database indicate that these concentrations have been infrequently exceeded in agricultural drainage-affected waterways and urban runoff, although sometimes by as much as an order of magnitude. Based on SRWP and USGS NAWQA monitoring and data reported by other studies in DPR's Surface Water Database, concentrations have not been observed to exceed these thresholds in the Sacramento River and major tributaries.

EPTC was not detected at concentrations exceeding or approaching the lowest toxic threshold reported in USEPA's OPP Ecotoxicity Database (630 μg/L, crustacean species), either in SRWP monitoring or data reported in DPR's Surface Water Database.

Methomyl was not detected at concentrations exceeding or approaching the lowest toxic threshold reported in USEPA's OPP Ecotoxicity Database (0.8 μg/L, LOEC for crustacean species), either in SRWP monitoring or data reported in DPR's Surface Water Database.

Bromacil was not detected at concentrations exceeding or approaching the lowest toxic threshold reported in USEPA's OPP Ecotoxicity Database (6.8 μg/L, aquatic plant species EC_{50}), either in SRWP monitoring or data reported in DPR's Surface Water Database.

Carbaryl was not detected at concentrations exceeding or approaching the lowest toxic threshold reported in USEPA's OPP Ecotoxicity Database (1.5 μg/L, crustacean species), either in SRWP monitoring or data reported in DPR's Surface Water Database.

Diuron was not detected in 2000-2001 at concentrations greater than the minimum toxicity threshold in USEPA's OPP Ecotoxicity Database (2.4 μg/L, aquatic plant species EC_{50}), but has been detected at concentrations greater than this threshold in Arcade Creek in 1999-2000. Data reported in DPR's Surface Water Database indicate that this threshold was exceeded occasionally in agricultural drainage, urban runoff, and urban creeks, sometimes by more than an order of magnitude. It was not exceeded in any samples reported for the Sacramento River.

Prometon was not detected at concentrations exceeding or approaching the lowest toxic threshold reported in USEPA's OPP Ecotoxicity Database (98 μg/L, aquatic plant species EC_{50}), either in SRWP monitoring or data reported in DPR's Surface Water Database.

No pesticides were detected at concentrations exceeding or approaching drinking water reference doses (RfD) reported in USEPA's IRIS database.

Table 11. Pesticides monitored by the Sacramento River Watershed Program.

Analyte	**RL, µg/L[1]**	**Analyte**	**RL[1]**
Organophosphate pesticides by EPA Method 8141a			
Azinphosmethyl	1.0	Fenthion	0.10
Bolstar	0.10	Malathion	0.10
Chlorpyrifos	0.05	Merphos	0.10
Coumaphos	0.20	Mevinphos	0.70
Def	0.10	Naled	0.50
Demeton-S	0.20	Parathion, ethyl	0.10
Diazinon	0.05	Parathion, methyl	0.10
Dichlorovos	0.20	Phorate	0.10
Dimethoate	0.10	Prowl	0.10
Disulfoton	0.10	Ronnel	0.10
EPN	0.10	Stirophos	0.10
EPTC	0.10	Tokuthion	0.10
Ethion	0.10	Trichloronate	0.10
Ethoprop	0.10	Trifluralin	0.10
Fensulfotion	0.50		
Carbamate pesticides by EPA Method 8321			
Aldicarb	0.8	Linuron	0.8
Aminocarb	0.8	Methiocarb	0.8
Barban	7.0	Methomyl	7.0
Benomyl (Carbendazim)	0.8	Mexacarbate	0.8
Bromacil	0.8	Monuron	0.8
Carbaryl	0.14	Neburon	0.8
Carbofuran	0.14	Oxamyl	7.0
Chloropropham	7.0	Propachlor	7.0
Chloroxuron	0.8	Propoxur	0.8
Diuron	0.8	Siduron	0.8
Fenuron	0.8	Tebuthiuron	0.8
Fluometuron	0.8		
Triazine pesticides by EPA Method 619			
Ametryn	0.5	Propazine	0.5
Atraton	0.5	Simetryn	0.5
Atrazine	0.5	Simazine	0.5
Cyanazine	0.5	Terbuthylazine	0.5
Prometon	0.5	Terbutryn	0.5
Prometryn	0.5		

(1) Reporting Limit

Table 12. Advisory Criteria and Other Threshold Values for Pesticides Detected in SRWP Monitoring (2000–2001).

	Units = µg/L			
Pesticide	Aquatic Life Criterion	MCL	IRIS RFd	Minimum Toxicity Thresholds [3] (threshold type, taxonomic class)
Bromacil	—	—	—	6.8 (minimum EC_{50}, aquatic plants)
Carbaryl	—	—	700	1.5 (minimum LC_{50}, crustacea)
Chlorpyrifos	0.014 [1] 0.041 [2]	—	21	0.035 (minimum LC_{50}, crustacea) 0.01 (LOEC, crustacea)
Diazinon	0.05 [4]	—	—	0.2 (minimum LC_{50}, crustacea)
Diuron	—	—	14	2.4 (minimum EC_{50}, aquatic plants)
EPTC	—	—	180	630 (LC_{50}, crustacea) 1360 (EC_{50}, aquatic plants)
Malathion	0.1	—	140	0.1 (LOEC, crustacea) 0.5 (minimum LC_{50}, crustacea)
Methomyl	—	—	175	7.6 (EC_{50}, crustacea) 0.8 (LOEC, crustacea)
Prometon	—	—	100	98 (minimum EC_{50}, aquatic plants)

(1) CDFG recommended criterion continuous concentration (CCC)
(2) CDFG recommended criterion maximum concentration (CMC)
(3) From USEPA's Environmental Fate and Effects Division Office of Pesticide Programs Pesticide Ecotoxicity Database (USEPA 2000)
(1) CDFG recommended criterion continuous concentration (CCC). Note that this value is incorrectly rounded to one significant digit by CDFG, and should be expressed as 0.053 µg/L, according to USEPA procedures for calculating aquatic life criteria.

What do these results say about attainment of beneficial uses and potential impairment, and how does this compare with any relevant 303(d) listings for parameter and sites?

Waterbodies in the Sacramento River watershed that are included on the California 1998 303(d) list due to elevated pesticide concentrations are presented in Table 13. Table 13 also summarizes waterbodies recommended for addition to the 2002 303(d) list by the Regional Water Quality Control Board.

As stated previously, it should be noted that comparisons with advisory criteria and toxicity thresholds do not provide conclusive evidence of attainment or impairment of beneficial uses. However, for the purpose of these evaluations, repeated significant exceedances of these values are considered as an indication of potential impairment of beneficial uses. In general, regulatory agency advisory criteria (e.g. USEPA aquatic life criteria or drinking water MCLs) are given the most weight in these evaluations. However, because most of the pesticides detected do not have any adopted regulatory limits, detected concentrations were compared to available toxicity threshold data as a coarse screen for potential impairment of beneficial uses. These were considered the best available indicators of potential impairment. As previously noted, these evaluations are limited to the pesticides monitored by SRWP, and do not include many other pesticides that have the potential to affect beneficial uses.

The beneficial uses at greatest potential risk from elevated pesticide concentrations in surface water are "Cold Freshwater and Estuarine Habitat" and "Commercial and Sport Fishing" (as defined in the Central Valley Region Basin Plan, CVRWQCB 1995). The most direct effects are likely to be on aquatic plants and crustacea, taxonomic groups which include the species most sensitive to the most widely used insecticides and herbicides. Based on data from the SRWP and other monitoring efforts, there may be significant potential for localized impacts on these beneficial uses due to elevated concentrations of some pesticides in some surface waters of the Sacramento River watershed. Based on findings of elevated concentrations and documented toxicity in surface waters ranging from small urban creeks and agricultural drains to the Sacramento River mainstem and Delta waterways, diazinon appears to pose the greatest and most extensive risks. The Central Valley Regional Board has concluded that beneficial uses are impaired by diazinon, and has cited diazinon as the primary reason for including numerous waterbodies on the 1998 303(d) list and recommended 2002 update of the 303(d) list of impaired waterbodies (Table 13). Direct effects of elevated diazinon concentrations are likely to be limited to sensitive zooplankton species. These invertebrate species are also important food sources for higher trophic level organisms in the ecosystem, and reduction of zooplankton populations during critical periods could impact populations of higher trophic level organisms (e.g. fish) (Ogle and Cooke 2000).

Although less frequently detected at toxic concentrations in the mainstem Sacramento River, elevated chlorpyrifos concentrations appear to pose similar risks. Because of its toxic mode of action is the same as diazinon, chlorpyrifos will also contribute to organophosphate toxicity even at concentrations below its single-chemical toxicity threshold (Bailey *et al.* 1996). The available pesticide concentration data agree well with the California 303(d) list of impaired waterbodies. Chlorpyrifos and diazinon are responsible for the greatest number of the individual listings on the California 303(d) List of impaired waterbodies, with diazinon alone responsible for the listing of 30 Sacramento River miles, 60 Feather River miles, 48,000 acres in the Delta, 265,000 acres in the San Francisco Bay Estuary. Diazinon is also responsible for numerous listings in urban creeks in the Sacramento metropolitan area, as well as in other urban area in California. Diazinon is also cited as a cause of impairment for all five new waterbodies recommended for addition to the 2002 303(d) list (CVRWQCB 2001). Based on a weight of evidence approach, it appears clear that these two organophosphate pesticides have a high potential for impairment of aquatic life and related beneficial uses in surface waters of the Sacramento River watershed.

There appears to be some potential for localized impacts on aquatic life in specific waters in the watershed due to occasionally elevated concentrations of malathion and carbofuran, primarily in waterways dominated by agricultural drainage. As with diazinon and chlorpyrifos, direct toxic effects of these insecticides are likely to be limited to sensitive aquatic invertebrate species. There appears to be little risk of beneficial use impairment from these pesticides in the Sacramento River and larger tributaries, however. The available data appear to support the single 303(d) listing for malathion in the Sacramento River watershed (Colusa Basin Drain), although the number of detections and potential impacts of both carbofuran and malathion have been substantially reduced in recent years by changes in rice farming practices. There are no 303(d) listings in the Sacramento River watershed due specifically to carbofuran.

There appears to be some potential for localized impacts on aquatic life due to occasionally elevated concentrations of diuron, primarily in urban creeks and waterways dominated by agricultural drainage. There appears to be little risk of beneficial use impairment in the Sacramento River and larger tributaries from this herbicide. Direct toxic effects of this pesticide are probably limited to sensitive aquatic plant species. There are no 303(d) listings due specifically to diuron.

For the locations monitored, there appears to be little to no significant potential for impairment of aquatic life uses due to elevated concentrations of other pesticides monitored by the SRWP. Although the potential certainly exists for impairment due to synergistic effects from exposure to multiple pesticides, based on the available data there is yet little evidence of this phenomenon at the locations monitored, with the specific exception of organophosphate pesticides (discussed previously). Beneficial uses related to human health concerns (drinking water supply, and contact and non-contact recreational use) do not appear to be at risk from any of the pesticides monitored by the SRWP.

Table 13. Waterbodies in the Sacramento River watershed listed for pesticides on the California 1998 303(d) List or recommended for addition to the 303(d) List

Pesticide	**Waterbody**	**Area Affected**	**Cited Sources**
Chlorpyrifos	Delta Waterways	48,000 Acres	Agriculture; Urban Runoff
	Arcade Creek	10 Miles	Urban Runoff
	Elder Creek	10 Miles	Urban Runoff
	Chicken Ranch Slough	5 Miles	Urban Runoff
	Strong Ranch Slough	5 Miles	Urban Runoff
Diazinon	Delta Waterways	48,000 Acres	Agriculture; Urban Runoff
	Feather River, Lower	60 Miles	Agriculture; Urban Runoff
	Sac. R. (Red Bluff To Delta)	30 Miles	Agriculture
	Morrison Creek	20 Miles	Agriculture; Urban Runoff
	Arcade Creek	10 Miles	Agriculture; Urban Runoff
	Elder Creek	10 Miles	Agriculture; Urban Runoff
	Chicken Ranch Slough	5 Miles	Agriculture; Urban Runoff
	Strong Ranch Slough	5 Miles	Agriculture; Urban Runoff
	Natomas E. Main Drain	5 Miles	Agriculture; Urban Runoff
	Elk Grove Creek	5 Miles	Agriculture
	Sacramento Slough	1 Miles	Agriculture; Urban Runoff
	SF Bay/Delta Estuary	265,460 Acres	Nonpoint Source
Group A Pesticides (aldrin, dieldrin, endrin, heptachlor, heptachlor epoxide, chlordanes, endosulfans, toxaphene, and hexachlorocyclohexanes)	Delta Waterways	48,000 Acres	Agriculture
	Colusa Drain	70 Miles	Agriculture
	Feather River, Lower	60 Miles	Agriculture
	American River, Lower[(1)]	23 Miles	Urban Runoff
Malathion, Methyl Parathion	Colusa Drain	70 Miles	Agriculture
DDT	Delta Waterways	48,000 Acres	Agriculture
Dieldrin, Chlordane	SF Bay/Delta Estuary	292,520 Acres	Nonpoint Source
	Recommended additions to the 2002 303(d) List		
Azinphos-methyl, diazinon, molinate	Colusa Drain	70 Miles	Agriculture
Diazinon	Lower Bear River	18 Miles	Agriculture
Diazinon	Jack Slough	13 Miles	Agriculture
Diazinon, Molinate	Butte Slough	7.5 Miles	Agriculture
Diazinon	Sutter Bypass	25 Miles	Agriculture

(1) Recommended for removal from 303(d) list in 2002 (CVRWQCB 2001)

iii. Spatial Distributions & Patterns

Spatial distributions and patterns of detection were evaluated for pesticides determined to have a reasonable potential to cause impairment of beneficial uses (chlorpyrifos, diazinon, malathion, and diuron). As with other pollutants, the ability to evaluate spatial distribution patterns is highly dependent on the sites selected for monitoring. SRWP monitoring was performed at sites selected to complement monitoring performed by USGS NAWQA and the Department of Pesticide Regulation. Most of the data available are from monitoring performed in water bodies dominated by agricultural drainage or urban runoff, and for the mainstem Sacramento River. There are relatively few data available for the major tributaries to the Sacramento River (Feather River, Yuba River, and American River), and even fewer currently available for the greater number of minor tributaries to the Sacramento River. Within these limitations, there are still a number of general patterns discernible in the available data.

General patterns

As expected, the frequency of detection and maximum concentrations detected are generally highest in waterbodies dominated by agricultural drainage or urban runoff, and lowest in the mainstem Sacramento River and tributaries.

In the Sacramento River, the frequency of detection and maximum values are generally lower upstream of the major agricultural production areas in the watershed. As an example, in SRWP monitoring, no organophosphate pesticides were detected in any samples collected from the Sacramento River near Hamilton City and Colusa sites, or from several smaller tributaries (Mill Creek, Deer Creek, and Big Chico Creek), which are above the region of the most intensive agricultural use of organophosphate pesticides for dormant spray applications. No pesticides were detected in 9 samples collected in 2000-2001 from the Feather River, and there were few detections in the lower American River.

In SRWP monitoring, the greatest number of different pesticides (nine of 14 pesticides detected, 1999-2001) and the most frequent detections were observed at Arcade Creek. This pattern is consistent with results of USGS NAWQA monitoring performed 1996-1998.

Organophosphate pesticides

Organophosphate pesticides have been monitored at 13 locations by the SRWP. Of the 29 pesticides analyzed in the organophosphate pesticide scan (EPA Method 8141), five were detected in SRWP monitoring conducted 1999-2001. These were chlorpyrifos, diazinon, EPTC, malathion, and prowl.

Diazinon is a widely used organophosphate insecticide. Its pattern of detection reflects its use in a variety of agricultural and urban/residential settings. In SRWP monitoring, it was the most frequently detected organophosphate pesticide, detected at six of thirteen sites monitored (Colusa Basin Drain, Sacramento Slough, Sacramento River at Veteran Bridge, Arcade Creek, American River, and the Sacramento River at Freeport). Of these SRWP sites, diazinon was detected most frequently (17 of 21 samples) in Arcade Creek, an urban creek affected by both urban runoff and aerial deposition from nearby agricultural areas. In studies contained in the DPR Surface Water database, diazinon was frequently detected (and concentrations were highest) in both urban runoff and waterways dominated by agricultural runoff. Diazinon was less frequently detected in the Sacramento River mainstem and tributaries monitored. Reporting limits for most of the data ranged from 0.002 μg/L for the USGS NAWQA program, to 0.01-0.05 μg/L for most of the other studies in the DPR Surface Water database.

In the ten studies contained in the DPR Surface Water database, chlorpyrifos was most frequently detected in urban runoff. It was never detected in the Sacramento River mainstem and was rarely detected in other water bodies. Chlorpyrifos was detected in two SRWP samples (on each from Arcade Creek and Colusa Basin Drain). Reporting limits for most of the data ranged from 0.004 μg/L for the USGS NAWQA program, to 0.03-0.05 μg/L for most of the other studies in the DPR Surface Water database.

Malathion was detected in only one SRWP sample, from Sacramento Slough. In studies contained in the DPR Surface Water database, malathion was most frequently detected in waterways dominated by agricultural drainage, and it has been less frequently detected in urban runoff and urban creeks. Malathion was not reported at detectable concentrations for any of the hundreds of results reported for the Sacramento River in the DPR Surface Water database. Reporting limits for most of the data ranged from 0.005 μg/L for the USGS NAWQA program, to 0.03-0.1 μg/L for most of the other studies in the DPR Surface Water database.

Carbamate pesticides

Carbamate pesticides were monitored at seven locations by the SRWP (one urban creek, two agricultural drainage dominated waterways, the American River, and three Sacramento River sites). Pesticides analyzed in the carbamate pesticide scan (EPA Method 8321) includes both herbicides and insecticides, seven of which were detected in SRWP monitoring conducted in 1999-2001. Of the pesticides detected, only diuron appeared to have a significant potential to impair beneficial uses, and potential impacts from diuron appear limited to urban creeks and agricultural drains.

Diuron is an herbicide commonly used for weed control on public rights of way and for landscape maintenance, with significant amounts also used for alfalfa and citrus crops. In SRWP monitoring, diuron was detected in Arcade Creek and Colusa Basin Drain. In DPR's Surface Water database, diuron was commonly detected at nearly every location monitored, including the Sacramento River mainstem, urban creeks, urban runoff, and in many waterways dominated by agricultural drainage. The highest concentrations were reported in smaller agricultural drains. Concentrations approaching toxic levels were not reported in the mainstem and major tributaries. Reporting limits for most of these studies ranged from 0.003–0.07 μg/L.

Triazine pesticides

Triazine pesticides were monitored by the SRWP in Arcade Creek, the Feather River, and the Sacramento River at Veterans Bridge. Of the pesticides analyzed in the triazine pesticide scan (EPA Method 619), only prometon and propazine were detected in SRWP monitoring conducted 1999-2001. Neither of these two pesticides were considered to have significant potential for beneficial use impairment.

Pesticides detected in SRWP 2000-2001 monitoring are listed in Table 14, along with their primary uses and pounds reported applied in 2000 in the Sacramento River watershed. Summary statistics for pesticides detected in SRWP monitoring (1999-2001) are presented in Appendix A.

iv. Temporal Distribution & Patterns

Most of the available monitoring data are focused on the periods of greatest use of particular pesticides or categories of pesticides (e.g. rice pesticide monitoring in late spring and organophosphate pesticide monitoring during the dormant spray application season). Although the episodic monitoring conducted by the SRWP in 2000-2001 is intended to monitor conditions most likely to result in pesticide detections, pesticides were infrequently detected at any location other than Arcade Creek. It should be noted that this first year of monitoring represents only a single sample for each specific type of episodic "event", and therefore no definitive conclusions regarding temporal patterns can be reached based solely on SRWP monitoring. Additionally, this focused approach to monitoring provides relatively little information about other periods or seasons. However, in combination with the available data from other programs, these results generally confirm that the pattern of detections and greatest concentrations reflects patterns of pesticide use. Specific examples include:

- The highest concentrations of diazinon were detected in the months of January and February throughout the watershed. This period coincides with the dormant spray application season.
- The highest concentrations of carbofuran, malathion, and molinate have been observed in May and June, coincident with the release of water from rice fields.
- The percent detections reported for carbofuran in DPR's Surface Water Database decreased from approximately 85% in 1994, to 0% in 2000, and carbofuran was not detected in SRWP 2000-2001 monitoring. A similar pattern was observed for malathion. These decreases correspond to changes made by the rice farming industry to pesticide application practices and in holding times for irrigation water after pesticide application. Granular formulations of carbofuran were also banned in 1994 to protect wildlife.

Overall use of cholinesterase-inhibiting organophosphate and carbamate insecticides has declined over the last several years (DPR 2000a). In contrast, over the same period, the total number of acres planted in fruit and vegetable crops and the total pounds of all varieties of pesticides applied has increased in California (*ibid.*). This suggests that there may be a general shift from organophosphate and carbamate insecticides to other categories of pesticides, possibly in response to economic, patterns of pest pressures, and pesticide resistance. It has been suggested that pyrethroid pesticides are increasingly being used in place of organophosphate and carbamate pesticides for many crops, and the Department of Pesticide Regulation documented an increase in the number of pyrethroid applications from 1991 to 1996 and a corresponding decrease in the number of organophosphate pesticide applications during this period (DPR 1999). However, reported applications of the five pyrethroids accounting for 93% of the total pyrethroid use in California in 1999 (bifenthrin, cyfluthrin, cypermethrin, esfenvalerate, and permethrin) appear to have stabilized in counties in the Sacramento River watershed, with no substantial increases from 1995 to 2000 (based on published pesticide use reports from DPR). This suggests that pesticides other than pyrethroids may be replacing organophosphate and carbamate pesticides. Other means of pest control, including biopesticides (e.g. bacteria, naturally-occurring compounds, and pheromones), reduced-risk pesticides, and non-chemical pest management practices have also increased dramatically since 1995 (*ibid.*). Given the extremely low toxicity thresholds of some of these pesticides (e.g. pyrethrins and pyrethroids, Table 15), the lack of monitoring data has been recognized as significant information gap. In response to this need, the University of California Department of Entomology is currently developing new analytical and monitoring methods for monitoring pyrethroid pesticides, and USGS has also been funded by CALFED to develop analytical methods.

The Department of Pesticide Regulation has also documented an increase in the number of detections of thiobencarb in Colusa Basin Drain (1994-2000) and the number of exceedances of the performance goal of 1.5 μg/L and the USEPA criterion of 6.2 μg/L (Newhart 2000). The increasing number and magnitude of detected concentrations are due in part to the increased use of thiobencarb. Increased use of this rice pesticide is attributed to an increase in acreage planted in rice in Glenn and Colusa counties, the geographical spread of rice weeds, and the development of herbicide resistance in rice weeds.

There were generally insufficient detected SRWP pesticide data to generate meaningful time series plots.

v. Mass Load Comparisons

Average mass loads of pesticides to the Delta can not be reliably estimated from the available data, due primarily to relatively infrequent monitoring and even less frequent detection of pesticides in most waterbodies monitored.

vi. Conclusions and Recommendations

Conclusions of this review of pesticide monitoring data can be summarized as follows:

The results of SRWP and other monitoring programs continue to support the focus of the SRWP and of both state and federal regulatory agencies on the management of organophosphate pesticides in surface waters. Diazinon and chlorpyrifos appear to have the greatest potential for impacts on aquatic life uses, with other monitored pesticides appearing to have relatively low to minimal risk of impacts on aquatic life or human health. The potential impacts on beneficial uses from diazinon and chlorpyrifos are being addressed through the Water Quality Management Strategy developed by the Organophosphate Pesticide Focus Group (SRWP 2001), and by the TMDL being developed by the Central Valley Regional Water Quality Control Board.

There are still few data available for the many minor tributaries to the Sacramento River watershed. For smaller tributary watersheds with a substantial proportion of agricultural land use, there may be a significant potential for pesticides to occasionally reach concentrations of concern in surface waters. Although no pesticides were detected in the limited SRWP monitoring of several smaller tributary watersheds in 2000-2001, the available monitoring data are far too limited to make any reliable assessments regarding the potential impacts of pesticides for these and other tributaries. Additional pesticide monitoring data (e.g. from DWR) should be evaluated for these watersheds when they become available, to better characterize the potential risks from pesticides in these watersheds, and additional monitoring should also be considered.

The shift from use of organophosphate and carbamate pesticides to other pesticides (including but not limited to pyrethroids and pyrethrins) indicates the need to increase monitoring for these pesticides. The University of California at Davis Department of Entomology is currently performing research to develop new sampling and analytical techniques to adequately identify and measure toxic concentrations of these pyrethroid pesticides in water, sediment, and tissue.

Table 14. Most frequently monitored pesticides (DPR Surface Water Database, July 2000) and pesticides detected in SRWP Monitoring, 2000-2001: Major uses and total watershed applications.

Pesticide	Use category	Top uses (lbs applied x 1,000)[1]	Total use reported for Sac. River watershed[4] (lbs x 1000) 1999	2000	Detection by SRWP, 2000-01[5]
Atrazine	Herbicide	Forest trees (28), corn (16), sudan grass (15)	18	14	ND
Bromacil	Herbicide	Citrus crops (53), rights of way (16), landscape maintenance (3)	4.6	5.4	Detected
Carbaryl	Insecticide	Citrus crops (60), nut crops (56), stonefruit[2] (51), apples (31), tomatoes (31), landscape maintenance (9)	37	58	Detected
Chlorpyrifos	Insecticide	Pest control[3] (526), Almonds (203), cotton (275), landscape maintenance (158), walnuts (146), alfalfa (188), broccoli (76), stonefruit[2] (71)	156	136	Detected
Carbofuran	Insecticide	Alfalfa (64), rice (29), grapes (18)	33	19	ND
Diazinon	Insecticide	Pest control[3] (346), Almonds (124), lettuce (115), walnuts (146), stonefruit[2] (110)	99	93	Detected
Diuron	Herbicide	Rights of way (497), citrus crops (233), alfalfa (216), landscape maintenance (39),	96	112	Detected
EPTC	Herbicide	Alfalfa (178), corn (85), sugarbeets (44), potatoes (40), tomatoes (30)	39	34	Detected
Fonofos	Insecticide	Broccoli (6), beans (5), tomatoes (5)	0.68	.20	NM
Malathion	Insecticide	Alfalfa (246), oranges (71), strawberries (76), pest control[3] (58), lettuce (46),	47	27	Detected
Methyl parathion	Insecticide	Walnut (60), stonefruit[2] (45), pears (23), apples (13)	39	10	ND
Methomyl	Insecticide	Lettuce (131), alfalfa (70), tomatoes (51), corn (45, sugarbeets (43), grapes (38)	30	29	Detected
Molinate	Herbicide	Rice (913)	851	951	NM
Prometon	Herbicide	landscape maintenance (0.0021), indoor and greenhouse-grown plants (0.0017)	0	2.5	Detected
Simazine	Herbicide	Oranges (214), grapes (166), almonds (56), walnuts (37)	29	40	ND
Thiobencarb	Herbicide	Rice (734)	703	993	NM

(1) Total lbs used in California in 1999 (DPR 2000). The DPR Pesticide Use database available for this report was characterized as “preliminary” by DPR.
(2) apricot, nectarines, peaches, plums, prunes
(3) public health and structural pest control
(4) Total pounds of active ingredient applications reported for major agricultural counties in Sacramento River watershed (Butte, Sutter, Colusa, Yolo, Yuba, Glenn, Sacramento, and Tehama)
(5) Indicates whether detected in 2000-01 monitoring. “ND” = Not Detected; “NM” = Not Monitored.

Table 15. Total Pounds Applied (1999 and 2000) and Toxicity Threshold Values for the Five Pyrethroid Pesticides Most-Used in the Sacramento River Watershed

	Total use reported for Sacramento River watershed[1], lbs x 1000			
Pesticide	1999	2000	IRIS RFd	Minimum Toxicity Thresholds, µg/L (threshold type, taxonomic class)[2]
Bifenthrin	2.0	2.2	—[3]	0.004 (EC_{50}, crustacea)
Cyfluthrin	1.1	1.5	180	250,000 (LC_{50}, aves)
Cypermethrin	14.1	14.5	70	0.0047 (LC_{50}, crustacea) 0.0006 (LOEC, crustacea)
Esfenvalerate	6.8	5.6	—	0.15 (EC_{50}, crustacea) 0.07 (LC_{50}, fishes)
Permethrin	25.2	23.4	350	0.018 (minimum EC_{50}, crustacea)

(1) Total pounds of active ingredient applications reported for major agricultural counties in Sacramento River watershed (Butte, Sutter, Colusa, Yolo, Yuba, Glenn, Sacramento, and Tehama)
(2) From U.S. EPA's Environmental Fate and Effects Division of the Office of Pesticide Programs Pesticide Ecotoxicity Database, (USEPA 2000).
(3) "—" indicates no value reported.

MAP KEY

Site ID	Location
MCMOU	Mill Creek at Mouth
DCMOU	Deer Creek at Mouth
SRHAM	Sac. R. at Hamilton City
CHMOU	Big Chico Creek at Mouth
SRCOL	Sac. R. at Colusa
FRNIC	Feather R. near Nicolaus
COLDR	Colusa Basin Drain
SACSL	Sacramento Slough
SRVET	SAc. R. at Veterans Bridge
ARCNW	Arcade Cr. at Norwwod Av.
ARDPK	American R. at Discov. Pk.
SRFPT	Sac. R. at Freeport
SRRMF	Sac. R. at Mile 44

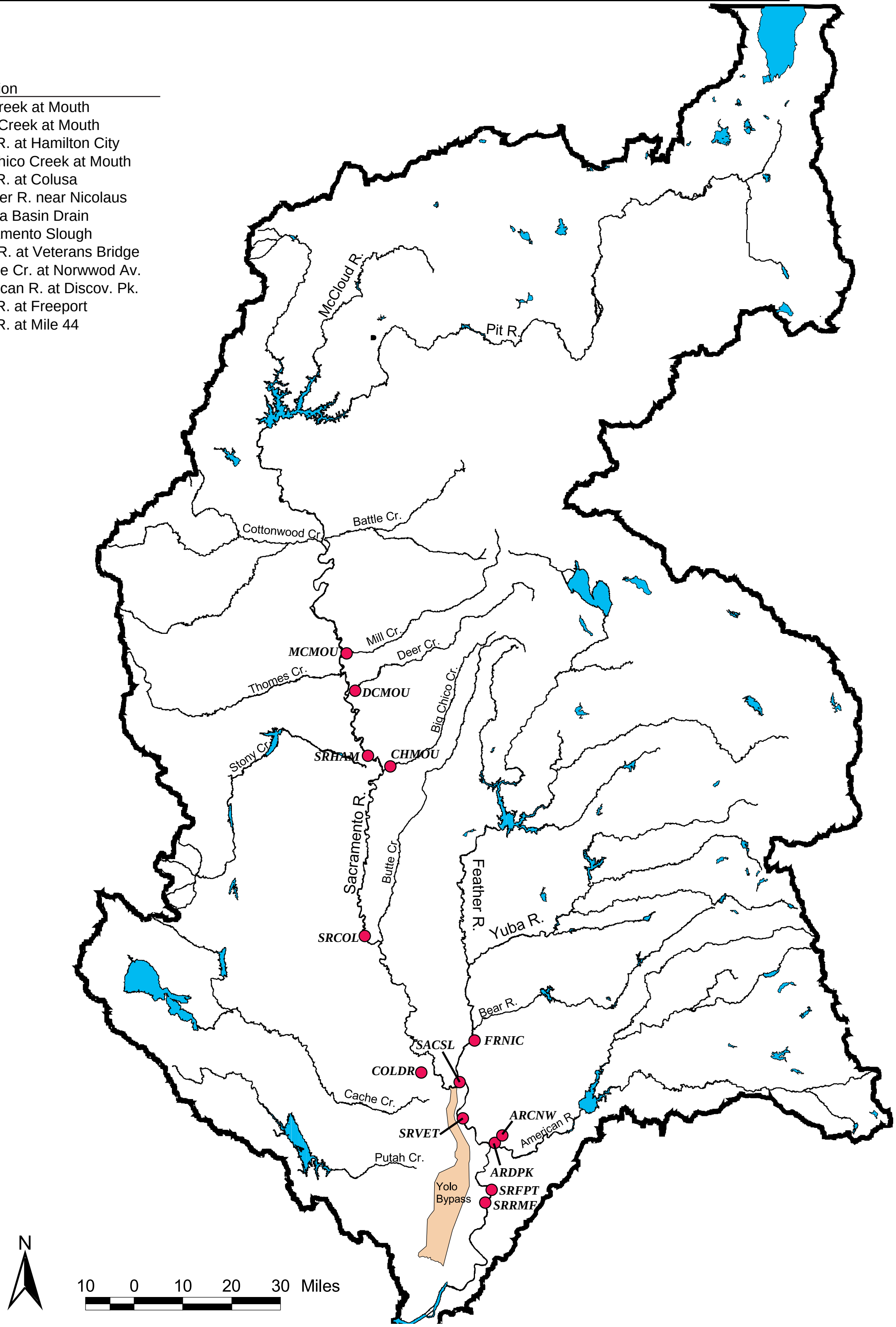


Figure 10. Pesticide Monitoring for the Sacramento River Watershed Program, 2000–2001 Monitoring Locations

C. Aquatic Toxicity

i. Background and Overview of Available Data

Aquatic toxicity monitoring in the mainstem Sacramento River and its tributaries was undertaken by the SRWP to characterize the spatial and temporal distribution of toxicity in surface waters of the watershed, and to identify potential sources and causes of toxicity. Laboratory toxicity tests were performed using USEPA procedures and the standard freshwater test organism, *Ceriodaphnia dubia* (water flea), seven-day reproduction and survival test to assess water quality. Tests using the Fathead minnow (*Pimephales*) and the algae *Selenastrum capricornutum* were performed in previous monitoring years and are not reported in this document. Determination of significant toxicity for each test endpoint was accomplished using hypothesis testing statistical procedures as specified in the method documents for the specific tests. Toxicity Identification Evaluations (TIEs) (USEPA 1991, 1992, 1993) were performed on selected samples to attempt to identify the toxicants responsible for repeated adverse effects in toxicity tests. The toxicity monitoring program (implemented in 1996 and continuing to present) was designed to assess the success of implemented pollution control programs (e.g. for rice pesticides), as well as to identify toxicity concerns in the study area.

Aquatic toxicity monitoring conducted in 2000–2001 was performed at ten locations throughout the watershed. Sites monitored for aquatic toxicity monitoring were selected to provide an overall survey of the distribution of toxicity in the watershed, and to coordinate with existing monitoring programs, and were located on the Sacramento mainstem, two major tributaries, two agricultural drainage-dominated sites, and one urban runoff-dominated site. In previous years, monitoring was also performed on eight smaller tributaries (Sacramento River above Shasta, McCloud River, Pit River, Mill Creek, Deer Creek, Big Chico Creek, Clear Creek, and Butte Creek). The locations of the 2000-2001 monitoring sites are illustrated in Figure 11.

A total of nine events, including four episodic events and five scheduled events, were monitored at the10 locations. SRWP monitoring in 2000-2001 included both dry weather and wet weather episodic events. Wet weather episodic events included the first significant watershed-wide storm event of the 2000-2001 wet season (late October 2000), the organophosphate pesticide dormant spray application period (late January 2001), and a late wet season rainfall event (April 2001). The single dry weather “episodic” event was scheduled to coincide with the highest probability for detecting rice herbicides (late May 2001). The other events consisted of four scheduled dry season events and one dry weather event scheduled to coordinate with the Regional Monitoring Program monitoring conducted in February 2001. (Note: These events are also summarized in Table 10b in the previous section.) An additional four “follow-up” events were conducted at three additional sites in the Arcade Creek watershed (Natomas East Main Drainage Canal, at the mouth of Arcade Creek, and at Arcade Creek at Auburn Avenue) to investigate the sources of the frequent significant toxicity observed in this urban drainage.

A summary of a number of other relevant studies of aquatic toxicity in the Sacramento River watershed is provided in Table 16 (and are also summarized in more detail in de Vlaming *et al*. 2000). The critical results of these studies can be briefly summarized as follows:

Foe 1998—This study identified diazinon as the responsible toxicant in each of ten samples (out of 33) exhibiting toxicity from Orestimba Creek, San Joaquin River at Vernalis, and Sacramento Slough. Samples from the Sacramento River at Greene's Landing were not toxic to *Ceriodaphnia* (three samples, January 1997). Samples were collected following precipitation events of 0.5 inches or more.

DPR (Nordmark et al. 1998-2000, Gill 2002)—This five-year study by the Department of Pesticide Regulation is focused on the occurrence of toxicity attributable to detections of dormant-spray pesticides in a small agricultural drainage (Wadsworth Canal), the Sutter Bypass, and in the Sacramento River. Preliminary results reported from this ongoing study indicate that significant chronic toxicity was rarely observed in samples from the Sacramento River (one sample in 1998-99 monitoring, and one sample in 1999-00 monitoring). At the Sutter Bypass location, only acute toxicity to *Ceriodaphnia* was monitored, and no significant toxicity was observed (1996-1998). Acute toxicity monitoring was changed to the Wadsworth Canal location for 1998-99 monitoring, and multiple occurrences of acute toxicity to Ceriodaphnia were observed in 1998-99 and 1999-00 monitoring. The authors stated that occurrences of acute toxicity generally corresponded with diazinon concentrations of approximately 0.2 μg/L. Diazinon and methidathion were the most commonly detected pesticides, with occasional detections of carbaryl, diuron, simazine, bromacil, and hexazinone also reported. The highest concentrations and most frequent detections were reported for Wadsworth Canal. Results from monitoring in winter 2000-2001 were not available in time for inclusion in this report.

SFEI 1998—The Regional Monitoring Program for Trace Substances aquatic toxicity results for the Sacramento River: one of two samples caused significant toxicity to *Mysidopsis bahia* (shrimp), zero of two samples caused significant toxicity to *Mytilus edulis* (mussel) larvae.

DPR 1998—Studies performed by the Department of Pesticide Regulation have concluded that aquatic toxicity attributed to pesticides in rice field drainage has been greatly reduced, due to changes in farming practices and extended holding times for applied pesticides.

CVRWQCB 2000—Sacramento River Watershed Program aquatic toxicity data for 1998-1999 have also been compiled and reported in a separate report prepared by the Central Valley Regional Water Quality Control Board.

Table 16. Selected Aquatic Toxicity Monitoring Programs in the Sacramento River Watershed

Program	Monitoring Period and (frequency)	Parameters	# of sampling locations & geographic reference
SRWP	8/96–5/01 (monthly)	▪ 7-day *Ceriodaphnia* toxicity tests ▪ 4-day *Selenastrum* toxicity tests ▪ 7-day *Pimephales* toxicity tests ▪ Toxicity Identification Evaluations	21 sampling sites throughout the Sacramento River watershed (*Selenastrum* testing limited to 3 sites after 5/98; *Pimephales* testing discontinued after 5/99)
Regional Board/CalFed	6/99–5/00 (monthly)	▪ 7-day *Pimephales* toxicity tests	24 sampling sites throughout the Sacramento River watershed
CUWA	2/98–3/99 (monthly)	▪ *Pimephales* toxicity tests with SRWP samples split with UCD Aquatic Toxicology Lab	6 SRWP sites: 5 mainstem Sacramento River sites and one Feather River site
DWR Special Tributary Monitoring	6/98–5/00 (monthly)	▪ 7-day *Ceriodaphnia* and 10-day*Pimephales* toxicity tests ▪ Toxicity Identification Evaluations	27 (*Cerio.*) sampling sites in Sac River tributaries (Clear Ck, Mill Ck, Deer Ck, Big Chico Ck)
SF Bay Regional Monitoring Program (SFEI 1997)	1994–1997 (episodic storm events)	▪ 48-hour *Mytilus* and *Crassostrea* toxicity tests, and 7-day *Mysidopsis* bahia toxicity tests ▪ Dissolved and particulate diazinon and chlorpyrifos in water	10-13 Bay-Delta sampling sites, including the Sacramento River and San Joaquin River at the Delta terminus
CVRWQCB (Foe *et al*. 1998)	1996 and 1997 wet seasons	▪ 7-day *Ceriodaphnia* toxicity tests ▪ Toxicity Identification Evaluations ▪ Dormant-spray pesticides in water	4 sampling sites: Sac Slough and Sac River at Greene's Landing; Orestimba Ck, and San Joaquin River at Vernalis
DPR (Nordmark *et al*. 1998-00)	1996–00, weekly during dormant spray season	▪ 96-hour and 7-day *Ceriodaphnia* toxicity tests ▪ Dormant-spray pesticides, herbicides in water	2 Sutter Bypass sampling sites, Wadsworth Canal, 1 sampling site at Sacramento River at Bryte *or* Alamar
Rice Pesticide Monitoring (DPR 1995-98)	1995-1999 (episodic discharge events)	▪ 96-hour *Ceriodaphnia* toxicity tests ▪ Rice pesticides in water	4 sampling sites: Colusa Basin Drain, Butte Slough, and Sacramento River at Village Marina and near Bryte
CVRWQCB, CALFED	9/00–8/01	▪ 4-day *Selenastrum* toxicity tests	8 sites in the Sacramento River watershed *(data not available for review)*

ii. Attainment of Beneficial Uses and Potential Impairment

Comparisons with water quality criteria and 303(d) listings: What do the data say about attainment of beneficial uses and potential impairment? Toxicity to aquatic organisms in surface waters outside designated mixing zones[6] is prohibited by the Basin Plan's enforceable narrative water quality objective:

> *"All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life. This objective applies regardless of whether the toxicity is caused by a single substance or the interactive effect of multiple substances. Compliance with this objective will be determined by analyses of indicator organisms, species diversity, population density, growth anomalies, and biotoxicity tests of appropriate duration or other methods as specified by the Regional Water Board."*

The results of SRWP monitoring and other studies have documented that water collected from different streams and rivers throughout the watershed have episodically caused toxicity to zooplankton, fish larvae, and algal test organisms (*Ceriodaphnia*, *Pimephale*s, and *Selenastrum*, respectively*)*. The magnitude of statistically significant effects observed on test organisms ranged from small decreases in growth or reproduction to 100% mortality of the test organisms. However, whether such observed toxicity to test organisms indicates non-attainment of specific designated beneficial uses remains open to interpretation. Observed toxicity to test organisms may be of ecological significance, e.g. if it translates to significant decreases in instream populations of resident species. Although the link between significant effects in laboratory toxicity tests and ecosystem impairment has not been definitively established, some studies have established that there is a statistically significant relationship between laboratory results and ecosystem effects, most clearly for highly toxic point source discharges (de Vlaming *et al*. 2000). For the purpose of the evaluations performed herein, it is assumed that toxicity to test organisms is an indication of potential impairment to aquatic species and ecosystems.

As stated previously, toxicity in surface waters is prohibited by the Basin Plan, and violations of this prohibition have resulted in waterbodies being included on the 303(d) List of impaired waterbodies. A number of sites have been included on California's 1998 303(d) list of impaired waterbodies for toxicity of unknown cause and for organophosphate pesticides (Table 17), which have been identified as causes of observed toxicity in the watershed. The observed toxicity attributed to diazinon and chlorpyrifos in Arcade Creek samples is consistent with the 303(d) listings of this and several other waterbodies for toxicity due to these pesticides. The Sacramento River mainstem from Shasta to the Delta, the lower Feather River, and the American River are all listed for toxicity of unknown causes(s), and some samples from each of these reaches were toxic to test organisms in previous monitoring years. The causes of observed toxicity at these

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[6] The Central Valley Basin Plan states that mixing zones *may* be allowed and that objectives *may* not apply within designated mixing zones, but will apply at the edge of designated mixing zones (CVRWQCB 1995). If granted, mixing zones are generally designated in NPDES permits for specific point source discharges. None of the locations monitored by the SRWP are within designated mixing zones.

locations has not yet been determined. The Toxicity Focus Group of the SRWP has developed a strategy to address toxicity of unknown causes and has applied for funding from CALFED to begin implementing the strategy.

Table 17. Waterbodies cited for unknown toxicity and organophosphate pesticides on California 1998 303(d) list or Recommended for Addition to the 2002 303(d) List

Waterbody	Cause for Listing	Source	Area Affected	Units
	1998 303(d)-listed waterbodies			
Delta Waterways	Unknown Toxicity(1)	Source Unknown	48,000	Acres
Delta Waterways	Chlorpyrifos, Diazinon	Agriculture, Urban Runoff	48,000	Acres
American River, Lower	Unknown Toxicity	Source Unknown	23	Miles
Arcade Creek	Chlorpyrifos, Diazinon	Agriculture, Urban Runoff	10	Miles
Cache Creek	Unknown Toxicity	Source Unknown	35	Miles
Chicken Ranch Slough	Chlorpyrifos, Diazinon	Agriculture, Urban Runoff	5	Miles
Colusa Basin Drain	Unknown Toxicity	Agriculture	70	Miles
Elder Creek	Chlorpyrifos	Urban Runoff	10	Miles
Elder Creek	Diazinon	Agriculture, Urban Runoff	10	Miles
Elk Grove Creek	Diazinon	Agriculture, Urban Runoff	5	Miles
Feather River, Lower	Unknown Toxicity	Source Unknown	60	Miles
Feather River, Lower	Diazinon	Agriculture, Urban Runoff	60	Miles
Morrison Creek	Diazinon	Agriculture, Urban Runoff	20	Miles
Natomas East Main Drain	Diazinon	Agriculture, Urban Runoff	5	Miles
Sacramento River (Red Bluff To Delta)	Unknown Toxicity	Source Unknown	185	Miles
Sacramento River (Red Bluff To Delta)	Diazinon	Agriculture	30	Miles
Sacramento River (Shasta Dam To Red Bluff)	Unknown Toxicity	Source Unknown	50	Miles
Sacramento Slough	Diazinon	Agriculture, Urban Runoff	1	Miles
Strong Ranch Slough	Diazinon	Agriculture, Urban Runoff	5	Miles
	Waterbodies recommended for addition to the 2002 303(d) List			
Lower Putah Creek	Unknown Toxicity	Source Unknown	36	Miles
Upper Putah Creek	Unknown Toxicity	Source Unknown	27	Miles

(1) "Unknown Toxicity" is the term used in the 303(d) List to indicate toxicity of unknown cause(s).

iii. Spatial and Temporal Patterns

Toxicity testing results from 2000–2001 monitoring are summarized in Tables 18 and 19. It should be noted that the spatial and temporal coverage of the watershed by SRWP and other monitoring efforts are not yet adequate to completely characterize and evaluate the incidence and significance of aquatic toxicity throughout the watershed. However, the results available so far have demonstrated some consistent temporal and spatial patterns discussed below.

Results from the 2000–2001 survey confirm general spatial patterns of toxicity observed in previous surveys. The results of 2000–2001 aquatic toxicity monitoring can be summarized as follows:

Mortality

Twenty-one of 97 samples collected (22%) caused significant mortality[7] to *Ceriodaphnia*. Of these 21 samples, 16 samples (76%) were collected in the Arcade Creek urban watershed. Samples collected from Natomas East Main Drain (which receives agricultural runoff and less urban runoff than Arcade creek) during this same period did not cause significant mortality. The remaining five samples causing mortality were collected from three mainstem Sacramento River sites (four samples) and from the Feather River (one sample).

No significant mortality was observed in samples from the two agricultural drainage-dominated sites (Colusa Basin Drain and Sacramento Slough) in monitoring conducted 2000-2001, as well as in the previous monitoring period (1999-2000). Monitoring performed prior to 1996 reported 100% *Ceriodaphnia* mortality in samples collected from these sites during the spring, when rice field runoff was present in surface waters (Connor *et al.* 1993). In 2000-2001 monitoring, four of nine samples from Colusa Basin Drain and one of nine samples from Sacramento Slough caused significant adverse reproductive effects. The long-term decrease in toxicity at these locations is attributed largely to the effectiveness of changes in pesticide application practices and longer holding times implemented by the rice farming industry for rice flood water to allow for degradation of pesticides.

All samples collected from October 2000 through May 2001 from Arcade Creek at Norwood Avenue caused severe mortality (100%) and reproductive toxicity to *Ceriodaphnia* (nine of 13 total samples). The observed toxicity during this period was more frequent and severe than observed in previous SRWP monitoring because specific episodic event were targeted when toxicity was expected to occur. Six toxic Arcade Creek samples were treated with piperonyl butoxide (PBO), which prevents metabolic activation of organophosphate pesticides. PBO completely eliminated significantly mortality in all of six treated samples, indicating that some or all of the toxicity was due to a metabolically activated toxicant such as diazinon or chlorpyrifos. Outside of the Arcade Creek watershed, there were no distinct temporal

[7] Significant mortality is defined as ≥20% mortality that is significantly different from controls at a 95% statistical confidence level.

trends in mortality, except that relatively few samples were significantly toxic to *Ceriodaphnia* from April 2001 through June 2001.

Reproductive toxicity

Significant adverse reproductive effects to *Ceriodaphnia* have been observed at nearly every location monitored in the Sacramento River watershed during the past four years. In 2000–2001 monitoring, 14 of 36 samples (39%) collected from four Sacramento River mainstem sites from Redding to Freeport caused significant decreases in reproduction. A few samples collected from the major tributary sites (American River and Feather River) also caused adverse reproductive effects. Most of the samples causing reproductive effects were collected between July 2000 and February 2001. In all of these cases, the specific causes of observed reproductive toxicity have not been determined.

Of the six toxic Arcade Creek samples treated with PBO, the treatment did not remove all significant reproductive effects. However, it can't be determined from the test results whether the remaining reproductive toxicity was due to the presence of another toxicant or to the need to better optimize the dose of PBO.

The watershed-wide pattern of reproductive toxicity to *Ceriodaphnia* observed in the months of January and February of 1997-2000 was not observed in 2001. This period typically coincides with seasonal high flows and application of dormant-spray pesticide applications. However, 2000-2001 was a relatively low rainfall year in the watershed with below-normal precipitation in January and February, and normal seasonal high flows did not occur in the Sacramento River mainstem or in the major tributaries. Although there were no strong seasonal patterns observed in the incidence of significant toxicity to *Ceriodaphnia* in 2000-2001 monitoring (Figures 12 and 13), the results of the SRWP and other monitoring programs support the conclusion that significant adverse effects on test organisms (at most locations) tend to be associated with episodic events. The episodic events most commonly associated with observed toxicity are the application and subsequent runoff of dormant-spray pesticides from agricultural areas, and seasonal hydrologic events such as first-flush storms in areas affected by urban runoff.

iv. Conclusions and Recommendations

Samples collected from Arcade Creek at Norwood Avenue continue to exhibit a much higher frequency and severity of toxicity than all other tributaries and mainstem Sacramento River sites sampled. In 2000-2001 monitoring. This pattern was also exhibited in limited sampling of two other locations in the Arcade Creek urban watershed.

The results of the 2000-2001 monitoring and of previous aquatic toxicity monitoring efforts have confirmed that significant toxicity to test organisms occurs in surface waters throughout the watershed. *Ceriodaphnia dubia* toxicity attributable to organophosphate pesticides in agricultural runoff and urban runoff has been definitively shown by SRWP monitoring and other studies.

Regularly scheduled monitoring conducted from 1998–2000 was valuable in beginning to evaluate the overall frequency and distribution of observed water column toxicity, and for identifying or confirming the causes of some of the observed toxicity. However, spatial and temporal coverage of the watershed by SRWP and other programs is far from comprehensive, and significant questions remain regarding the sources, severity, persistence, and ecological significance of periodic toxicity in surface waters of the Sacramento River watershed. It is clear that definitively addressing all of these questions will require monitoring and studies of much greater scope (and cost) than the current efforts by SRWP and other programs. To address some of these questions, the SRWP aquatic toxicity monitoring effort in 2000-2001 focused primarily on monitoring specific episodic events (e.g. agricultural dormant spray season, runoff events, high flow events). This strategy resulted in observation of much more frequent and severe toxicity in the Arcade Creek urban watershed, but did not result in a notably greater frequency of observed toxicity for other locations. However, winter of 2000-2001 was a below-average rainfall year and fewer rainfall events may have reduced the frequency of episodic aquatic toxicity observed throughout the watershed. Additionally, interpretation of this single season of monitoring a few episodic events must be cautious because the causes and timing of significant episodic toxicity events may differ greatly in different waterbodies, and the likelihood of missing a particular toxic event is high. Although even a single toxic event of sufficient severity has the potential to have significant adverse ecosystem impacts if key species are affected, there is currently insufficient evidence to either support or rule out such a hypothetical event. Episodic monitoring of aquatic toxicity was continued in the 2001-2002 monitoring season.

Table 18. Summary of 2000-2001 Aquatic Toxicity Monitoring Survey Results: Samples Exhibiting Significant Toxicity to *Ceriodaphnia dubia*

		Samples Exhibiting Significant Toxicity(1)			
	total samples collected	Significant reduction in reproduction		Significant Mortality (>20%)	
Monitoring Location	n	n	%	n	%
Sacramento River below Keswick Reservoir	9	3	33%	1	11%
Sacramento River above Bend Bridge	9	4	44%	1	11%
Sacramento River at Colusa	9	3	33%	0	0%
Sacramento Slough	9	1	11%	0	0%
Colusa Basin Drain	9	4	44%	0	0%
Feather River at Nicolaus	9	3	33%	1	11%
Natomas East Main Drain	4	2	50%	0	0%
Arcade Creek at Norwood Ave.	13	9	69%	9	69%
Arcade Creek at Mouth	4	4	100%	4	100%
Arcade Creek at Auburn Ave.	4	3	75%	3	75%
American River at Discovery Park	9	2	22%	0	0%
Sacramento River at Freeport	9	4	44%	2	22%

(1) Significant toxicity is defined as increased mortality and/or decreased reproduction that is significantly different from controls at a 95% statistical confidence level.

Table 19. SRWP 2000–2001 Toxicity Test Results, Reproduction and Mortality in *Ceriodaphnia*

Toxicity testing endpoints[2]: Reproduction (average neonates/adult)
% Mortality (days to 100% mortality)

Sample Dates:

Site	18-23 Jul 2000	19-30 Sept 2000	17-20 Oct 2000	30-31 Oct 2000	26-28 Jan 2001	5-6 Feb 2001	7-9 Feb 2001	15-16 Feb 2001	8-10 Apr 2001	17 Apr 2001	29-31 May 2001	6-7 Jun 2001	21-22 Jun 2001
Laboratory Control[1]	26.7-35.0	25.6-38.4	21.4-27.2	29.7-37.2	24.1-29.6	30.7	22.5-25.0	17.1	16.8-29.4	34.6	27.5-29.3	29.3	24.4
	0	*0-10*	*0-10*	*0-10*	*0-20*	*0*	*0*	*20*	*0*	*0*	*0-10*	*30*	*0*
Sacramento River below Keswick	16.7	24.8	32.6	1.4	21.0		13.4		29.4		27.5		18.8
	10	*0*	*0*	*70*	*0*		*10*		*0*		*10*		*30*
Sacramento River above Bend Bridge	27.7	9.5	34.9	16.8	14.4		13.0		23.5		33.1		31.1
	0	*100 (7)*	*0*	*0*	*30*		*11*		*10*		*0*		*0*
Sacramento River at Colusa	25.9	18.2	27.3	27.6	15.6		24.8		31.9		33.2		16.2
	0	*10*	*0*	*0*	*20*		*20*		*0*		*10*		*30*
Sacramento Slough	27.3	29.1	27.0	35.8	34.3		20.1		29.7		24.0		21.0
	20	*10*	*10*	*0*	*0*		*0*		*10*		*30*		*10*
Colusa Basin Drain	25.5	19.9	21.7	38.2	24.5		16.8		23.8		31.1		25.2
	10	*10*	*0*	*0*	*0*		*10*		*0*		*0*		*10*
Feather River near Nicolaus	28.0	26.5	27.5	29.4	33.5		18.9		0.0		26.3		20.8
	0	*10*	*0*	*0*	*0*		*0*		*100 (1)*		*20*		*10*
American River at Discovery Park	28.2	21.9	22.5	20.9	27.8		16.3		33.5		25.9		28.1
	10	*0*	*0*	*10*	*0*		*11*		*0*		*0*		*0*
Sacramento River at Freeport	16.1	21.2	25.3	22.7	26.8		22.1		28		26.4		6.4
	10	*10*	*10*	*30*	*0*		*15*		*0*		*0*		*90*
Arcade Creek at Norwood Avenue	30.4	23.8	0.0	2.6	4.0	14.0	0.0	3.9	0.0	5.5	0.0	21.3	24.5
	10	*10*	*100 (7)*	*100 (6)*	*100 (6)*	*100 (6)*	*100 (7)*	*100 (7)*	*100 (1)*	*100 (5)*	*100 (8)*	*30*	*10*
Arcade Ck at Norwwod + 50 ppb PBO									24.3				
									20				
Arcade Ck at Norwwod + 100 ppb PBO			7.7	7.4	27.4		6.4		0.0		0.1		
			0	*0*	*0*		*0*		*30*		10		
Arcade Ck at Norwwod + 200 ppb PBO					0.0		0.0						
					100		*20*						
Arcade Creek at Auburn Boulevard						32.9		7.0		0.0		7.8	
						0		*70*		*100 (2)*		*100 (5)*	
Arcade Creek at Mouth						9.6		5.5		14.7		16.0	
						80		*100 (7)*		*100 (6)*		*80*	
Natomas East Main Drain						22.4		9.3		38.6		27.7	
						10		*20*		*0*		*20*	

Table Notes:

(1) The laboratory controls met all EPA criteria for test acceptability.
Ceriodaphnia tests for different locations were set up on separate days. Range of data for separate controls is shown.

(2) Outlined cells indicate a significant reduction in reproduction or increase in mortality (>20%) compared to the laboratory control.
The reproduction endpoint was analyzed with Dunnett's test and the mortality endpoint was analyzed with Fisher's exact test (p<.05).

(3) Piperonyl butoxide (PBO) prevents toxic action of metabolically activated organophosphate pesticides.

MAP KEY

Site ID	Location
SRBKR	Sac. R. below Keswick Res.
SRABB	Sac. R. above Bend Bridge
SRCOL	Sac. R. at Colusa
FRNIC	Feather R. near Nicolaus
COLDR	Colusa Basin Drain
SACSL	Sacramento Slough
NEMDR	Natomas East Main Drain
ARCMO	Arcade Cr. at Mouth
ARCAB	Arcade Cr. above NEMDR
ARCNW	Arcade Cr. at Norwwod Av.
ARDPK	American R. at Discov. Pk.
SRFPT	Sac. R. at Freeport

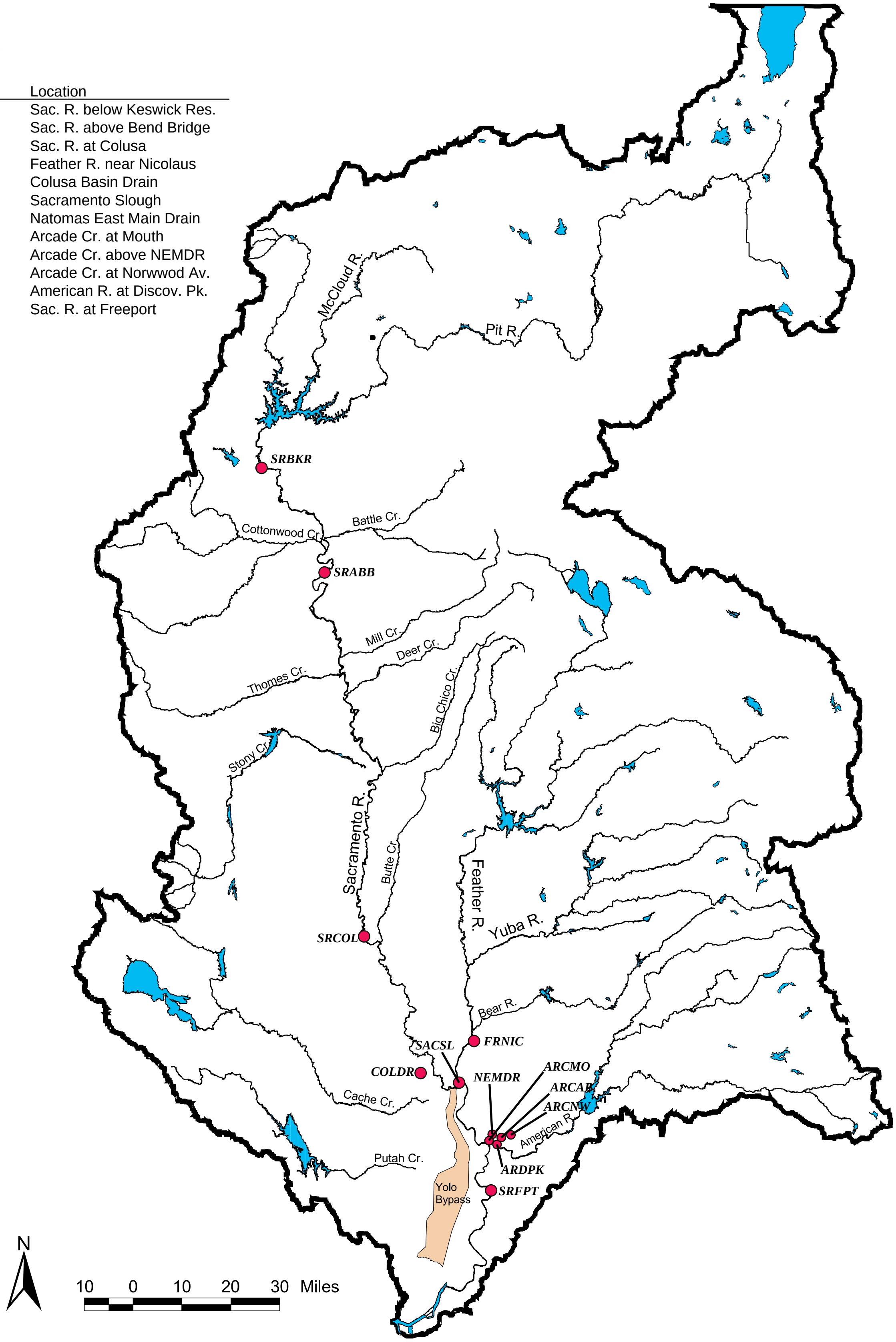
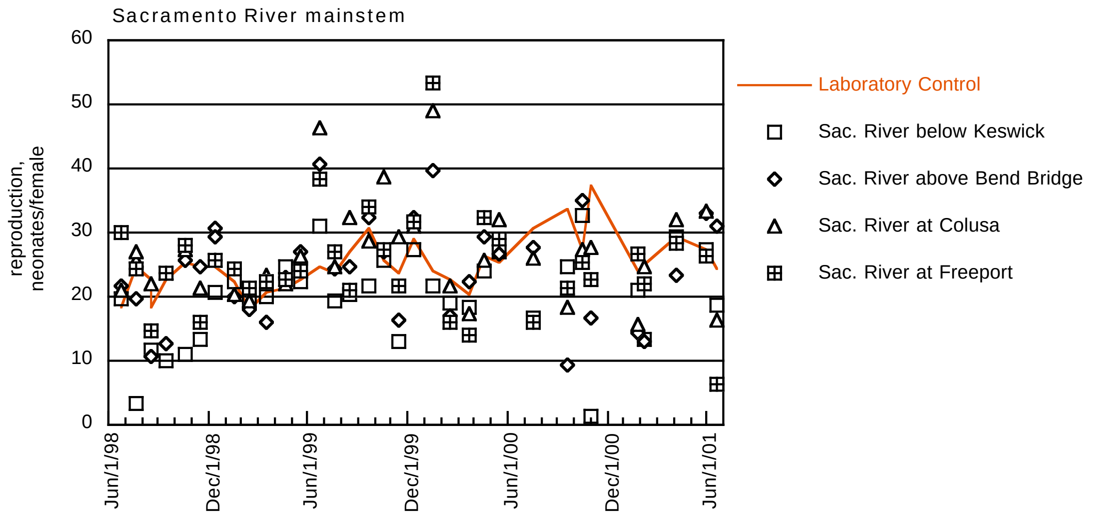


Figure 11. Aquatic Toxicity Monitoring for the Sacramento River Watershed Program, 1999-2000 Monitoring Locations



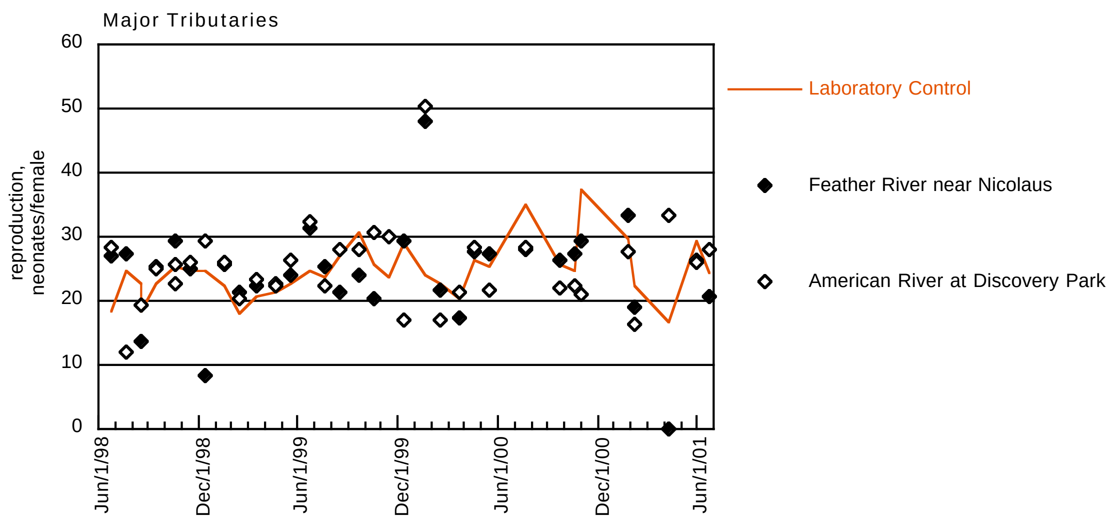


Figure 12. Ceriodaphnia Reproduction in Samples from the Mainstem Sacramento River and Major Tributaries

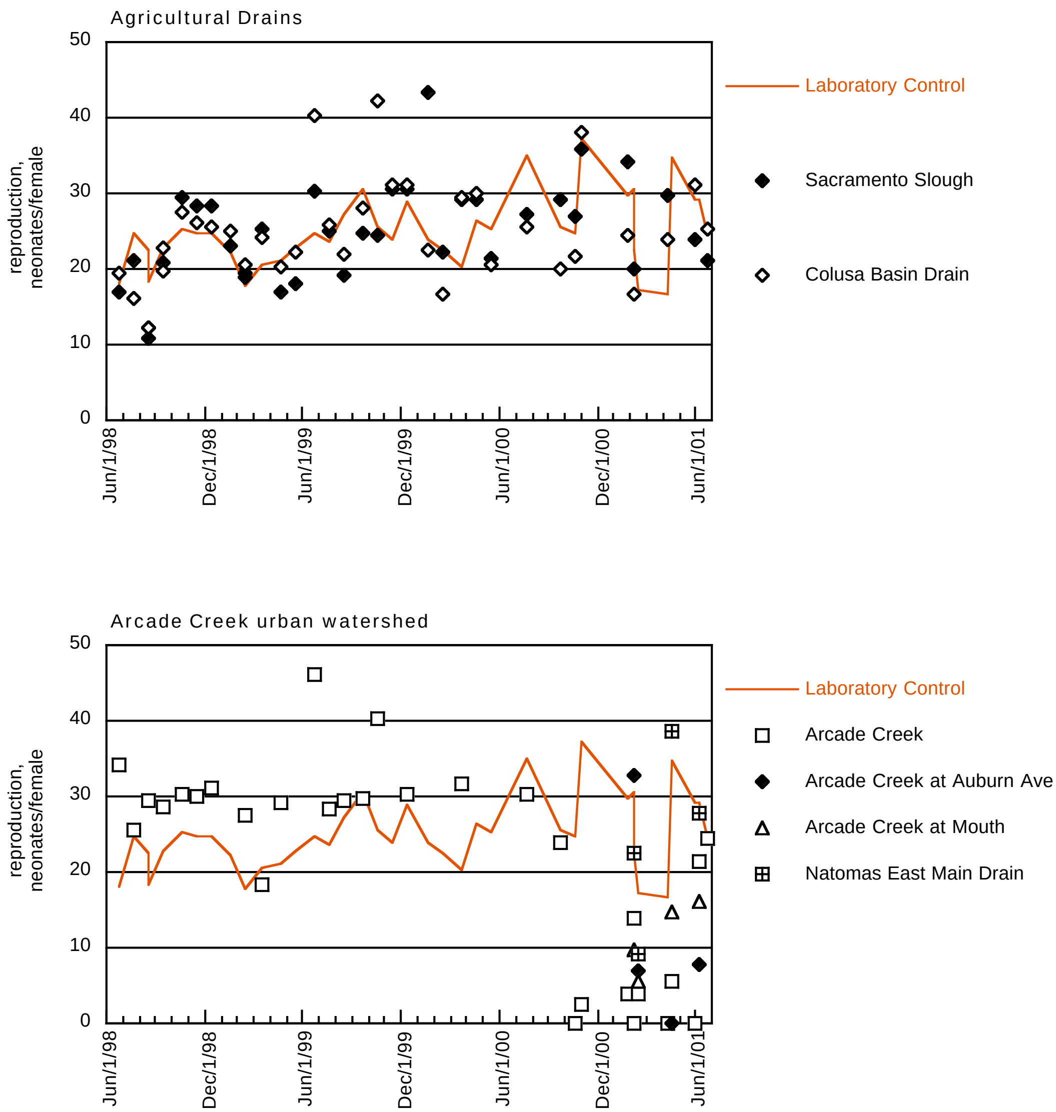


Figure 13. Ceriodaphnia Reproduction in Samples from Agricultural Drains and the Arcade Creek Urban Watershed

D. Drinking Water Parameters of Concern

i. Background and Available Data Overview

For the purposes of this analysis, drinking water parameters are grouped into three categories: total dissolved solids, total and dissolved organic carbon, and pathogens. Nutrients, minerals, turbidity, and taste effects of some rice pesticides are also considered parameters relevant to drinking water beneficial uses, but were not monitored in 2000-2001. The parameters included within each category are discussed below in terms of their attainment of beneficial uses, and spatial and temporal distributions, if additional evaluation was warranted. For selected parameters, relative contribution to mass loads within the Sacramento-San Joaquin Delta are also discussed. General spatial distribution patterns, when considered, are described in terms of mean or median concentrations, as appropriate. Summary statistics for all parameters discussed are provided in Appendix A.

The sources of data utilized for this report are summarized in Table 20. The monitoring locations for the primary data considered for this report (USGS NAWQA, Sacramento River Coordinated Monitoring Program, City of Redding NPDES monitoring, the California Department of Water Resources, and the Sacramento River Watershed Program) are illustrated in Figure 14.

Table 20. Selected Drinking Water Monitoring Programs in the Sacramento River Watershed

Program	Monitoring Period(s)	Parameters	# of sampling locations & geographic reference
NAWQA (USGS)	2/96–4/98 (through 2000 for Sacramento River at Freeport)	▪ Total Dissolved Solids in water ▪ Total and Dissolved Organic Carbon in water ▪ Nutrients in water: nitrite as N; nitrate as N; ammonia as N organic nitrogen as N; dissolved orthophosphate as P; total phosphorus as P ▪ General Minerals in water: total alkalinity; sodium; chloride; sulfate; calcium; dissolved magnesium, manganese, potassium, iron, silica as SiO_2	12 sampling sites distributed throughout the Sacramento River watershed
SRWP	6/98–6/01	▪ Total Dissolved Solids in water ▪ Nutrients in water: nitrite as N nitrate as N; ammonia as N dissolved orthophosphate as P total phosphorus as P ▪ General Minerals in water: Total Alkalinity; Sodium; Chloride; Sulfate; Calcium; Total Magnesium, Manganese, Potassium, Iron Total and Fecal Coliform in water ▪ *Giardia* and *Cryptosporidium* in water	12 sampling sites on Sacramento River and major tributaries
MWQIP (DWR)	3/86–3/98 (1/96–3/98 considered for present analysis)	▪ Total Dissolved Solids in water ▪ Dissolved Organic Carbon in water ▪ Nutrients in water: Nitrate as N; Ammonia as N ▪ General Minerals in water: Total Alkalinity; Sodium; Chloride; Sulfate; Calcium; Dissolved Magnesium, Potassium ▪ Fecal Coliform in water	19 sampling sites distributed throughout the Sacramento-San Joaquin Delta (5 sites considered for present analysis)
CMP (SRCSD)	12/92–6/01 (10/96–6/01 considered for present analysis)	▪ Total and Fecal Coliform in water	5 sites on Sacramento and American rivers in Sacramento metropolitan area
City of Redding	1/98–5/01	▪ Total Dissolved Solids in water	1 site at Sacramento River below Keswick Dam

ii. Attainment of Beneficial Uses and Potential Impairment

Comparisons with Relevant Water Quality Objectives

The Central Valley Basin Plan has adopted by reference California Title 22 of the California Code of Regulations Maximum Contaminant Levels (MCLs) for drinking water, as Basin Plan objectives. Specifically, the Basin Plan states:

> *"At a minimum, water designated for use as domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the maximum contaminant levels (MCLs) specified in the following provisions of Title 22 of the California Code of Regulations, which are incorporated by reference into this plan: Tables 64431-A (Inorganic Chemicals) and 64431-B. "*

Note that these drinking water MCLs are originally intended to apply to finished tap water, rather than to untreated sources of drinking water. Comparisons of surface water characteristics with MCLs clearly indicate that there is no impairment due to a specific parameter when the MCL for that parameter is not exceeded. Exceedances of MCLs in untreated source water indicate that there is some potential for increased treatment costs or for exceedances of the MCL in the treated drinking water, but are not definitive evidence that the use is impaired. For the purpose of these evaluations, it is assumed that waters that comply with MCLs are achieving the designated use as sources of drinking water, and that exceedance of MCLs indicate potential impairment of this use.

Existing applicable water quality objectives and goals for the parameters included within three drinking water categories (TDS, TOC and DOC, and pathogens) are listed in Table 22. Median concentrations of drinking water-related parameters monitored in 2000-2001 are presented in Table 23. The results of comparisons with these numeric thresholds can be summarized as follows:

Total dissolved solids concentrations in surface waters monitored in the Sacramento River watershed were not observed to exceed DHS and USEPA's Secondary Drinking Water Standard Maximum Contaminant Level (MCL) of 500 mg/L.

Total organic carbon concentrations were compared to the 2.0 mg/L TOC treatment threshold included in the Stage 1 Disinfectants/Disinfection By-products (D/DBP) Rule. This regulation is designed to limit precursors to disinfection byproducts such as trihalomethanes, which are human carcinogens. In cases where the running annual average TOC in source water (measured at water treatment plant intakes) is 2.0–4.0 mg/L, water utilities may be required to remove up to 35% of the TOC (depending on source water alkalinity) unless they meet other specific quality or treatment technology requirements[8]. If the running average source water TOC is greater than 4.0 mg/L, water utilities may be required to remove up to 45% of the TOC in their

[8] Utilities would not have to meet these removal requirements if they meet one of several possible conditions, including: (1) average TOC in their treated water less than 2.0 mg/L; (2) average levels of haloacetic acids and trihalomethanes below 30 μg/L and 40 μg/L, respectively, or a clear commitment to implement treatment to meet these levels by June 2005; or (3) average Specific UV Absorbance (SUVA) less than 2.0 L/mg-m in source water or treated water.

influent. Total organic carbon concentrations occasionally exceeded the D/DBP goal at all sites evaluated (Table 22). TOC concentrations measured in Sacramento Slough and the Colusa Basin Drain exceeded the 2 mg/L D/DBP treatment threshold in almost every sample analyzed, and exceeded the 4.0 mg/L threshold in more than 50% of samples collected. The percentage of TOC concentrations in the mainstem Sacramento River exceeding the 2 mg/L D/DBP threshold value increased in a downstream direction from Keswick to Veterans Bridge. The Yuba, Feather, and American rivers also occasionally have TOC concentrations above the relevant drinking water quality threshold value, with percent exceedances ranging from 14% (in the Yuba River at Marysville) to 47% (in the Feather River near Nicolaus). Long-term average TOC concentrations were greater than 2.0 mg/L at most locations monitored, with the exception of the Yuba River, The American River, the Sacramento River above Bend Bridge, and several smaller tributaries.

Limits for *Giardia*, and *Cryptosporidium* in surface waters have not yet been adopted by regulatory agencies. *Giardia* and *Cryptosporidium* concentrations were evaluated using only data from sites monitored by the Sacramento River Watershed Program (SRWP data 1999-2001), and all of the results cited for *Giardia* and *Cryptosporidium* are for total immunofluorescent antibody-positive cysts. Median numbers of *Giardia* cysts detected in the four mainstem Sacramento River sites ranged from <0.1—0.2 cysts/L, with no apparent spatial trend. *Giardia* were detected in 41% to 75% of samples collected from mainstem Sacramento River sites, again with no apparent trend. The median *Giardia* numbers were <0.1 cysts/L in samples from the Feather River near Nicolaus and Cache Slough near Ryer Island Ferry, with percent detections of 42% and 20%, respectively. The maximum number of *Giardia* cysts detected in any sample was 1.2 cysts/L (12 cysts in a 10 liter sample) from the Sacramento River above Bend Bridge. Nearly all samples evaluated for *Cryptosporidium* were below the detection limit of 0.1 öcyst/L, and the maximum number of *Cryptosporidium* oöcysts detected in any sample was 0.8 cysts/L (8 cysts in a 10 liter sample) from the Sacramento River at Colusa. Although the method (EPA 1623) used for analysis of Giardia and Cryptosporidium in 1999-2001 monitoring is significantly improved compared to the ICR method, there are still significant concerns regarding the recoveries and reliability of the method (particularly in turbid samples). Average recoveries for matrix spikes of SRWP samples was approximately 50%. There remains a high degree of uncertainty associated with data for these pathogens, due to the lack of meaningful thresholds or guidelines for comparison, the lack of information about infectivity, and the probable under-reporting of true pathogen numbers by current analytical methods.

Fecal coliform numbers were evaluated in comparison to the Basin Plan water quality objective of 200 Most Probable Number (MPN) per 100 milliliters (ml) as a geometric mean value and a maximum value of 400 MPN/100 ml. Geometric mean fecal coliform numbers did not exceed the 200 MPN/100 ml objective at any site. Maximum fecal coliform numbers were observed to exceed the 400 MPN/100 ml objective infrequently in the Sacramento River (in 9 of 205 total samples from the mainstem) and in the American River (in 3 of 53 samples), and in Cache Slough (in 3 of 12 samples). Numbers of other pathogens monitored in the Sacramento River watershed are not directly comparable with drinking water quality objectives.

Total and fecal coliform data are also relevant to another important beneficial use, contact recreation. Although USEPA has identified as a priority the transition to using *E. coli* and *Enterococcus* bacteria (instead of total and fecal coliform bacteria) as indicators of microbial contamination (Action Plan for Beaches and Recreational Waters; EPA/600/R-98/079, March 1999), in this same document, USEPA reaffirmed commitment to the limits established in the 1986 criteria document (*Ambient Water Criteria for Bacteria—1986*), which include specific limits for total and fecal coliform bacteria. The 1986 criteria document is also referenced in USEPA's *National Recommended Water Quality Criteria* (USEPA 1999). The California Department of Health Services (DHS) *Guidance for Freshwater Beaches* (Draft, February 11, 2000) recommends limits and testing for total and fecal coliform bacteria, as well as *E. coli* or Enterococcus. The non-regulatory DHS *Guidance* also cites the numbers of bacteria at which closing and posting beaches is recommended. These recommended limits are identical to the limits cited by USEPA in the 1986 criteria document (*Ambient Water Criteria for Bacteria—1986*).

For the purpose of evaluating achievement and potential impairment of contact recreational uses, total and fecal coliform data were compared to the limits recommended by USEPA and DHS. The recommended limits for total coliform are 1,000 MPN/100 mL as a geometric mean and 10,000 MPN/100 mL as a single sample maximum. These limits for total coliform bacteria were exceeded in two of 53 samples collected from the American River at Discovery Park, and in one of 54 sample from the Sacramento River at Veterans Bridge. The limits for fecal coliform bacteria are essentially the same values adopted in the Central Valley Basin Plan (200 MPN/100 mL as a geometric mean and 400 MPN/100 mL as a single sample maximum). Comparisons to fecal coliform limits are provided in the previous paragraph.

Table 21. Water Quality Objectives Relevant to Drinking Water Parameters(1)

Parameter	Units	Threshold Value	Basis
TDS	mg/L	500	DHS and USEPA Secondary Drinking Water Standard MCL
TOC	mg/L	2	Disinfectants/Disinfection By-products Rule Treatment Threshold
Sulfate	mg/L	250	DHS and USEPA Secondary Drinking Water Standard MCL
Fecal coliforms	MPN/100 mL	200 (median) 400 (maximum)	CVRWQCB Basin Plan Objective, DHS Recommended Limits (CDHS 2000), and USEPA Recommended Criteria (USEPA 1999)
Total coliforms	MPN/100 mL	1,000 (median) 10,000 (maximum)	DHS Recommended Limits for freshwater beaches (CDHS 2000), and USEPA Recommended Criteria (USEPA 1999)

(1) Primary and Secondary Drinking Water Standard MCLs have been adopted by reference in the Central Valley Basin Plan.

Table 22. Comparisons with Total Organic Carbon Water Quality Goals

Location	% of Data Meeting Water Quality Goals[1]	
	2 mg/L	4 mg/L
Pit River above Shasta	88%	100%
McCloud River above Shasta	100%	100%
Sacramento River above Shasta	100%	100%
Spring Creek PP Discharge to Keswick Res.	100%	100%
Sacramento River below Keswick	100%	100%
Clear Creek near Mouth	97%	100%
Sacramento River above Bend Bridge	66%	99%
Mill Creek at Mouth	66%	91%
Sacramento River near Hamilton City	52%	89%
Deer Creek at Mouth	95%	100%
Big Chico Creek above Mud Creek	83%	99%
Mud Creek above Big Chico Creek	33%	84%
Sacramento River at Colusa	51%	97%
Sacramento Slough	2%	38%
Colusa Basin Drain	0%	3%
Yuba River at Marysville	86%	100%
Feather River near Nicolaus	53%	99%
Sacramento River at Verona	37%	97%
Sacramento River at Veterans Bridge	42%	89%
Natomas East Main Drain	0%	11%
Arcade Creek at Norwood Ave.	0%	2%
American River at J Street	56%	98%
American River at Discovery Park	69%	100%
Sacramento River at Freeport	40%	97%
Sacramento River at River Mile 44	21%	91%
Cache Slough near Ryers Ferry	33%	67%

(1) Disinfectants/Disinfection Byproduct Rule treatment threshold for DBP precursor removal. If average source water TOC is >2 mg/L and ≤4 mg/L, water utilities may be required to remove up to 35% of the TOC in their influent. If average source water TOC is >4 mg/L and ≤8 mg/L, water utilities may be required to remove up to 45% of the TOC in their influent. TOC removal depends on source water alkalinity and treatment technologies used, and is not required when the running annual average TOC in source water or treated water is less than 2.0 mg/L, or if other specific D/DBP conditions are met.

Although water from the Sacramento River from Hood and upstream is considered to be of high quality for drinking water supply, the quality of water in the Central and Southern Sacramento-San Joaquin Delta is often marginal for drinking water supply and compliance with increasingly stringent drinking water objectives is becoming more difficult. The Sacramento River alone provides up to 75% of the water entering the Delta, including a large portion of seasonal organic carbon and TDS mass loads. Although the Sacramento River therefore has a substantial effect on the quality of Delta drinking water supply source water, there are also significant internal sources of TOC and TDS within the Delta. As stated previously, the parameters of primary concern for drinking water quality—TOC, TDS, and pathogens—are currently largely unregulated by the RWQCB and the Water Quality Control Plan (Basin Plan). Expected changes in Sacramento River watershed land uses (e.g. increased urbanization and development) have the potential to increase regulated point source discharges and (relatively) unregulated non-point source discharges, and therefore to increase loads of TOC, TDS, and pathogens to the Delta., The RWQCB is currently evaluating its priorities for development of an effective drinking water policy to address these and other drinking water concerns. This policy would be implemented by development of a work plan to address these parameters and to establish water quality objectives for eventual inclusion in the revised Basin Plan.

What do these results say about attainment of beneficial uses and potential impairment, and how does this compare with any relevant 303(d) listings for parameter and sites?

The California 1998 303(d) list does not consider all of the contaminants of concern to drinking water supply, and few waterbodies in the Sacramento River watershed are cited on the 303(d) list for pollutants relevant to drinking water concerns (Table 24). Delta waterways, the Pit River, Clear Lake, and Whiskeytown Reservoir are listed for impairment due to electrical conductivity, nutrients, organic enrichment, and coliform bacteria. No waterbodies are listed for Giardia or Cryptosporidium. The Regional Board has also recommended addition of three creeks in the Sacramento River watershed to the 2002 303(d) list for impairments due to fecal coliform. It is clear however, that the Sacramento River and major tributaries generally provide water that is of very high quality for municipal and agricultural supply. Comparisons of drinking water parameters with relevant water quality goals and objectives for the Sacramento River watershed show that the mainstem Sacramento River, and major tributaries (the Yuba, Feather, and American rivers) consistently meet water quality goals and objectives, suggesting that these waterbodies achieve their beneficial uses as sources of municipal and agricultural supply water and contact recreation, as designated by the Central Valley Region Basin Plan (CVRWQCB 1995). Although the TOC concentrations measured in the Sacramento River from Bend Bridge to the Delta often exceed the 2.0 mg/l goal, it is not clear that these concentrations of organic carbon will result in a requirement for additional treatment for municipal drinking water suppliers to remove additional TOC in source water. The Stage 1 D/DBP Rule does not require such treatment if certain treatment technologies are used, or if other water quality requirements are met (e.g. for specific ultraviolet absorbance in source or treated water, TOC <2.0 mg/L in treated water, or trihalomethanes and haloacetic acids less than specified concentrations in treated water). Additionally, treatment technologies currently in use by many utilities are already able to remove ≥35% of TOC from Sacramento River water. Even if additional TOC removal is necessary, this requirement would not limit the water supply use, but would increase treatment costs. Additionally, comparisons of coliform bacteria data to limits recommended by USEPA and California Department of Health Services indicate that these limits are infrequently exceeded and suggest that recreational uses protected by these limits are generally well-supported in the mainstem Sacramento River and its major tributaries.

Table 23. Median Concentrations of Selected Drinking Water Parameters

Location	TDS, mg/L	TOC, mg/L	DOC, mg/L	Total Coliform MPN/ 100mL	Fecal Coliform MPN/ 100 mL	*Giardia*(a), cysts/L	*Cryptosporidium*(a), oöcysts/L
Pit R. above Shasta	93	1.4	1.3	—(c)	—	—	—
McCloud R. above Shasta	62	0.7	0.6	—	—	—	—
Sac. R. above Shasta	60	1.5	1.4	—	—	—	—
Spring Ck Power Plant	52	1.3	1.2	—	—	—	—
Sac R. below Keswick	76	1.1	1.0	8	<2	—	—
Sac R. above Bend Br.	83	1.7	1.5	112	25	0.16	<0.1
Mill Creek at Mouth	101	1.5	—	—	4	—	—
Deer Creek at Mouth	98	1.3	—	—	7.5	—	—
Big Chico Ck in Chico	104	1.2	—	—	72	—	—
Sac R. at Hamilton City	94	2.0	1.7	168	59	0.13	<0.1
Sac R. at Colusa	91	2.0	1.6	138	31	0.20	<0.1
Sacramento Slough	190	4.6	3.8	—	—	—	—
Colusa Basin Drain	335	7.2	5.8	—	—	—	—
Yuba R. at Marysville	54	1.3	1.1	—	—	—	—
Feather R. nr Nicolaus	63	2.0	1.5	114	16	<0.1	<0.1
Sac R. at Verona	90	2.2	1.8	—	—	—	—
Sac R. at Veterans Br.	103	2.2	2.1	438	30	<0.1	<0.1
Natomas East Main Drain	200	6.2	5.7	—	295	—	—
Arcade Ck at Norwood	165	8.1	7.2	—	—	—	—
American R. at J St	39	1.9	1.6	—	—	—	—
American R. at Discovery Pk	35	1.8	1.7	305	48	—	—
Sac. R. at Freeport	82	2..2	1.7	390	34	0.14	<0.1
Sac. R. at Mile 44	98	2..6	2.3	297	18	0.20	—
Cache Creek	173	3.6	3.0	—	—	—	—
Cache Slough	140	2.2	2.6	154	32	<0.1	<0.1
Greene's Landing[b]	99[b]	2.4[b]	2.5[b]	—	10	—	—
Barker Slough[b]	176[b]	6.3[b]	5.2[b]	—	123(d)	—	—
Banks Pumping Plant[b]	254[b]	3.6[b]	3.9[b]	—	—	—	—
San Joaquin R. at Vernalis[b]	361[b]	3.2[b]	3.3[b]	—	—	—	—

Note: Table lists median values for available data from 1994-2001, except for mean data from Woodard (2000) which are generally based on longer periods of record.
(a) *Giarda* cysts per liter and *Cryptosporidium* öocysts per liter
(b) Mean data reported from Woodard (2000).
(c) "—" indicates parameter not evaluated at this location.
(d) Median data from MWQI data base (DWR 1999)

Table 24. Waterbodies cited for drinking water-related parameters on California 1998 303(d) list or recommended for addition to the 2002 303(d) List.

Waterbody	Cause for Listing	Source	Area Affected	Units
		1998 303(d)-listed waterbodies		
Delta Waterways	Electrical Conductivity	Agriculture	16,000	Acres
Delta Waterways	Organic Enrichment, Low DO	Municipal point sources, sewers	75	Acres
Whiskeytown reservoir	Coliform bacteria	Septage disposal	100	Acres
Clear Lake	Nutrients	Unknown	43,000	Acres
Pit River	Nutrients, Organic Enrichment, Low DO	Agriculture, Grazing	100	Miles
		Waterbodies recommended for addition to the 2002 303(d) List		
Clover Creek	Fecal coliform	Human and livestock sources	10.5	Miles
South Cow Creek	Fecal coliform	Human and livestock sources	7	Miles
Wolf Creek	Fecal coliform	Urban runoff, recreation, agriculture	14.5	Miles

iii. Spatial and Temporal Distribution Patterns and Mass Loads

Because drinking water and recreational beneficial uses generally appear to be adequately supported for the Sacramento River watershed locations monitored by the SRWP, and the parameters monitored were not considered likely to impair these uses, spatial and temporal distributions were not evaluated for any of the drinking water-related parameters monitored in 2000-2001. Based on the same criterion, mass loads were also not evaluated for these parameters. Spatial and temporal trends and mass loading have been considered in previous Annual Monitoring Reports (SRWP 2000, 2001) for results of SRWP monitoring conducted 1998-2000 and from other major monitoring efforts.

iv. Conclusions and Recommendations

The mainstem Sacramento River, and major tributaries (the Yuba, Feather, and American rivers) consistently meet water quality goals and objectives for drinking water-related parameters. Based on the best available indicators, these results suggest that designated beneficial uses as sources of municipal and agricultural supply water and recreational uses are generally being achieved:

There was a general trend for concentrations of several parameters (TDS, organic carbon, nutrients) to increase in the mainstem Sacramento River from the upper watershed to the lower watershed. This trend can generally be attributed to a combination of natural and anthropogenic sources, and is moderated by high quality Sierra tributary inflows.

The Basin Plan limit for median fecal coliform numbers (200 MPN/100mL) was not exceeded at any site, and the maximum limit for single samples (400 MPN/100 mL) was exceeded infrequently in the Sacramento River, the American River, and Cache Slough.

TOC concentrations measured in the Sacramento River at Colusa, Verona, and Freeport often exceed the Stage 1 Disinfectant/Disinfection By-Product (D/DBP) Rule treatment threshold of 2.0 mg/l. The 2.0 mg/L threshold is significant because exceedance of this threshold may require utilities to remove up to 35% percent of TOC in their source water. It is not clear that the observed concentrations of organic carbon will result in a requirement for municipal drinking water suppliers to remove *additional* TOC in source water. The Stage 1 D/DBP Rule does not require such treatment if certain treatment technology requirements used, or if other water quality requirements are met in influent or treated water. Additionally, treatment technologies currently in use by many utilities are already able to remove ≥35% of source water TOC from Sacramento River water. Even if additional TOC removal is necessary, this requirement would not limit the water supply use.

Giardia cysts were detected in 41% to 75% of samples collected from the mainstem Sacramento River and major tributaries, and in one of five Cache Slough samples. *Cryptosporidium* öocysts were detected in 12 of 116 samples from the mainstem Sacramento River. Although the analytical method used for *Giardia* and *Cryptosporidium* is much improved (compared to the ICR method used previously), there remains a high degree of uncertainty associated with data for these pathogens. This monitoring has been suspended by the SRWP Monitoring Sub-committee due primarily to funding limitations.

Although water from the Sacramento River from Hood and upstream is considered to be of high quality for drinking water supply, the quality of water in the Central and Southern Sacramento-San Joaquin Delta is often marginal for drinking water supply and compliance with increasingly stringent drinking water objectives is becoming more difficult. The Sacramento River alone provides up to 75% of the water entering the Delta, including a large portion of seasonal organic carbon and TDS mass loads. Although the Sacramento River therefore has a substantial effect on the quality of Delta drinking water supply source water, there are also significant internal sources of TOC and TDS within the Delta. As stated previously, the parameters of primary concern for drinking water quality—TOC, TDS, and pathogens—are currently largely unregulated by the RWQCB and the Water Quality Control Plan (Basin Plan). Expected changes in Sacramento River watershed land uses (e.g. increased urbanization and development) have the potential to increase regulated point source discharges and (relatively) unregulated non-point source discharges, and therefore to increase loads of TOC, TDS, and pathogens to the Delta. In order to address these and other drinking water concerns, the RWQCB is implementing a work plan for the development of an effective drinking water policy. This policy is expected to address these parameters and to establish water quality objectives for eventual inclusion in the revised Basin Plan.

MAP KEY

Site ID	Location
SRSHA	Sac. R. above Shasta
MRSHA	McCloud R. above Shasta
PRSHA	Pit R. above Shasta
SCKPP	Spring Ck Power Plant discharge
SRBKR	Sac. R. below Keswick Res.
SRABB	Sac. R. above Bend Bridge
MC###	Mill Creek sites
DC###	Deer Creek sites
SRHAM	Sac. R. at Hamilton City
MUDCH	Mud Creek
CH###	Big Chico Creek sites
SRCOL	Sac. R. at Colusa
FRNIC	Feather R. near Nicolaus
COLDR	Colusa Basin Drain
SACSL	Sacramento Slough
SRVON	Sac. R. at Verona
SRVET	Sac. R. at Veterans Bridge
NEMDR	Natomas East Main Drain
ARCNW	Arcade Cr. at Norwood Av.
ARJST	American R. at J Street
ARDPK	American R. at Discov. Pk.
SRFPT	Sac. R. at Freeport
SRRMF	Sac. R. at Mile 44
SRRMF	Sac. R. at Greene's Landing
CCHCK	Cache Creek at Rumsey
YOLOB	Yolo Bypass
CCHSL	Cache Slough

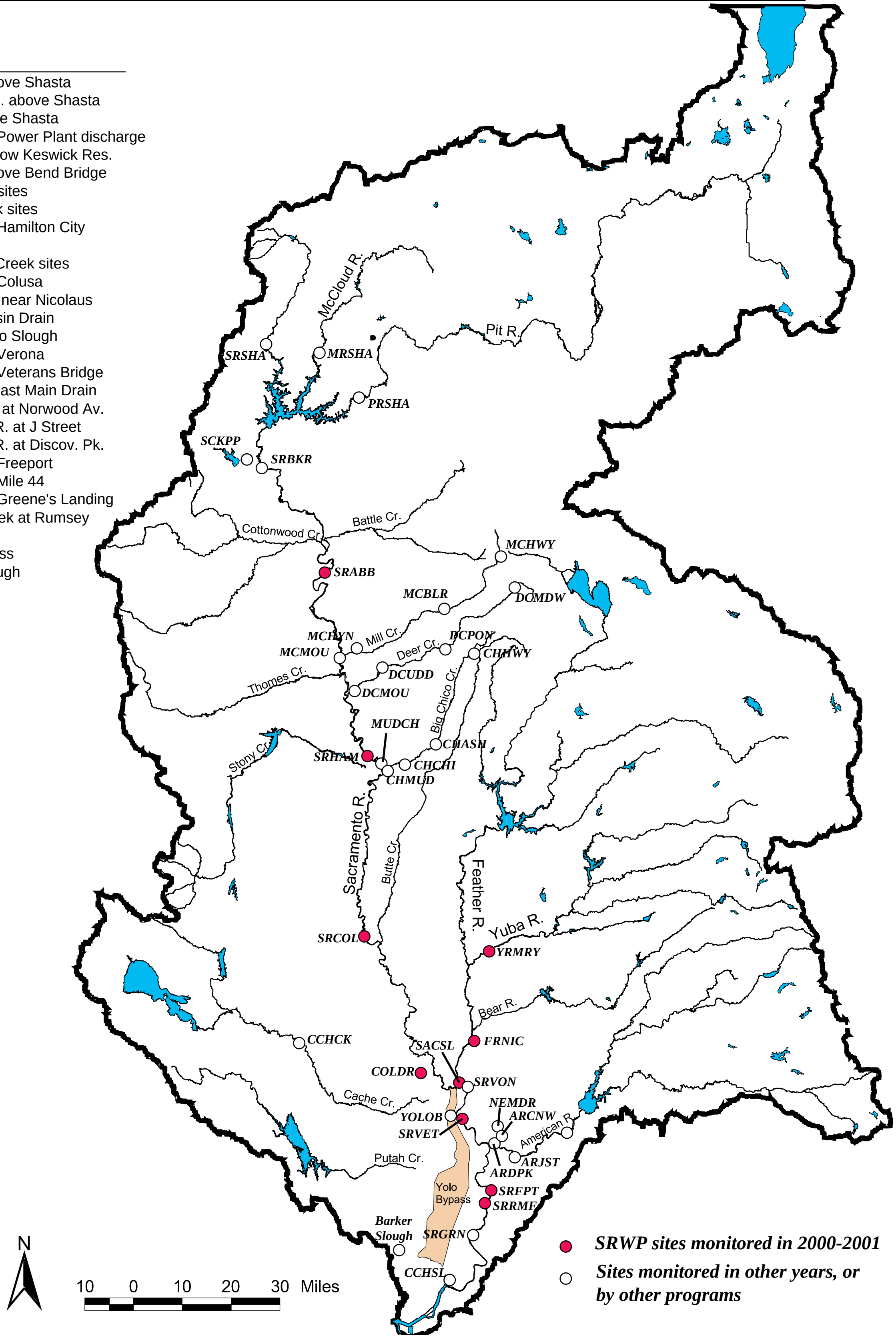


Figure 14. Drinking Water Constituent Monitoring in the Sacramento River Watershed, USGS NAWQA, Sacramento River CMP, City of Redding, DWR MWQI, and SRWP

E. Organochlorine Pesticides and PCBs in Fish Tissue

i. Background and Available Data Overview

In September and October of 1997-2000, the SRWP monitoring program collected fish from 17 locations and analyzed tissue for concentrations of organochlorine pesticides (DDTs, chlordanes, aldrin, dieldrin, endrin, hexachlorocyclohexanes, hexachlorobenzene, endosulfans, methoxychlor, mirex, and oxadiazinon) and PCB compounds. Monitoring in the Sacramento River watershed for these compounds in fish tissue has been performed previously by the Toxic Substances Monitoring Program (administered by the State Water Resources Control Board) between 1977 and 1996. Organochlorine pesticides and PCBs have also been analyzed in fish collected as part of DWR's tributary monitoring program (1999). Studies of these pollutants in fish tissue were also performed in San Francisco Bay in 1994 and 1997 (Table 25).

The locations of sites monitored in 1997–2000 by the SRWP are illustrated in Figure 15.

Table 25. Fish Contamination Monitoring programs in the Sacramento River Watershed

Program	Monitoring Period	Parameters	Total # of locations & geographic reference
SRWP	Sep-Oct '97, Sep-Oct '98, Sep-Oct '99 Sep-Oct '99	Organochlorine pesticides and PCBs in edible fish tissue	17 fish tissue sites, distributed throughout the watershed
TSMP (SWRCB)	1977–1996	metals, organics, and pesticides in fish	Many sites distributed throughout the watershed
SFBRWQCB	1994	mercury and organochlorines in fish	San Francisco Bay
SF Estuary RMP (SFEI)	1997	mercury and organochlorines in fish	San Francisco Bay
DWR	1999	Organochlorine pesticides and PCBs in edible fish tissue	Deer Creek, Mill Creek, Big Chico Creek, and Clear Creek watersheds

ii. Attainment of Beneficial Uses and Potential Impairment

Comparisons with fish tissue screening values and 303(d) listings: What do the data say about attainment of beneficial uses and potential impairment? Concentrations of organochlorine pesticides and PCBs in fish tissue were compared primarily to USEPA national screening values (SFRWQCB *et al*. 1995, USEPA 1995, USEPA 1998) adjusted for a fish consumption rate of 30 g/day and an updated PCB cancer slope factor (SFEI 1999), and to California Office of Environmental Health Hazard Assessment screening values (OEHHA 1999; SFEI 1998). Exceedance of screening values is considered an indication that more intensive site-specific monitoring or evaluation of human health risks should be conducted (SFEI 1998, 1999). Note that these risk-based human health limits are based on assumptions of specific fish consumption rates that are typically averages for the general population. For individuals or populations (e.g. sport fisherman or some ethnic populations) consuming more fish than assumed for a specific limit or screening value, the risk of adverse health effects is increased.

Consumption-weighted average organochlorine concentrations were also calculated by waterbody category in Table 28. The consumption-weighted average is an estimate of the average concentration in tissue for the total freshwater and estuarine fish consumed, and assumes that a combination of trophic level 3 and trophic level 4 fish are consumed. Although not adopted as official policy, USEPA Region 4 used this approach in a TMDL developed in Georgia, and compared the consumption-weighted average directly to the fish tissue-based water quality criterion for methylmercury to evaluate whether a waterbody should be considered impaired (USEPA 2001b). The approach is also consistent with the development of the fish tissue-based criterion for methylmercury (USEPA 2001), which assumes that fish consumed consist of a mix of different trophic level species. The consumption-weighted average concentration is calculated as:

CWA = (56.6% x *Trophic Level 3 avg.*) + (43.4% x *Trophic Level 4 avg.*).

Consumption-weighted averages, and averages for individual species and trophic levels were all compared to screening values. In all cases where concentrations were below detection, the average concentration was calculated with the tissue concentration set equal to one half the detection limit. The possible range for the average was also calculated by substituting zero and the detection limit for data below detection. Comparisons with screening values were made using the “best estimate” average values (based on the one half detection limit substitution) for the entire data set and for waterbodies grouped by the following categories:

Lower Sacramento River mainstem, from Keswick to the “I” Street Bridge in Sacramento),

Delta locations (Sacramento River below “I” Street Bridge, and Cache Slough),

Major tributaries (Feather River and American River),

Smaller tributaries, from above Shasta to Putah Creek,

Agricultural drains (Colusa Basin Drain, Sacramento Slough, and Natomas East Main Drain).

Based on comparisons to updated USEPA screening values, the overall risks from organochlorine pesticides in fish tissue appear to be low. However, some individual samples and some species averages exceeded screening values. PCB concentrations in striped bass (34 ng/g, n=1) white catfish (26 ng/g, n=19) were greater than the 23 ng/g screening value. In carp (n=3), average concentrations of DDTs (344 ng/g) and dieldrin (8.3 ng/g) exceeded screening values (69 ng/g, and 1.5 ng/g, respectively), but two of the three samples for this species were from one ag drain location (Colusa Basin Drain). Consumption-weighted averages also exceeded screening values for DDTs and dieldrin in fish from agricultural drains, but these exceedances were also strongly influenced by the average for one trophic level 3 species (carp in Colusa Basin Drain) with very high concentrations of these pesticides. Consumption-weighted averages also exceeded screening values for PCBs in fish from Delta locations, but this exceedance was also strongly influenced by the single sample for the one trophic level 3 species caught for this Delta locations (Sacramento sucker from Sacramento River at Mile 44). Review of the maximum ranges for consumption-weighted averages (based on substitution of zero and the detection limit for concentrations below detection) revealed that evaluations for dieldrin are the most sensitive to the substitution method used. Approximately 85% of the dieldrin results were below the reporting limit of 2.0 ng/g, and the reporting limit is greater than the USEPA screening value for this pesticide (1.5 ng/g). Based on the low percentage of concentrations detected above 2 ng/g, it is unlikely that average concentrations exceed the screening except in fish from agricultural drains.

Summaries of these evaluations are provided in Tables 26 and 27. Consumption-weighted averages are summarized in Table 28, and results for individual samples and trophic level 3 and 4 species are illustrated in Figures 16 and 17. The data set used for these evaluations is also presented in Appendix A.

There are several waterbodies included on the 1998 California 303(d) list for impairment due to organochlorine pesticides and PCBs (Table 29). Evaluation of consumption-weighted average concentrations suggests the need to re-evaluate several of these 303(d) listings. Consumption-weighted average concentrations of dieldrin and chlordane in SRWP fish samples from the Feather River and American River suggest that concentrations of these chemicals may not be sufficiently high in fish tissue to warrant 303(d) listing at these sites for Group A pesticides, and the Central Valley Regional Board has recommended removing the lower American River from the 2002 303(d) list. Consumption-weighted average concentrations of PCBs in fish from agricultural drains suggest that the 303(d) listing for PCBs in Natomas East Main Drain should also be re-evaluated. Additional data are also needed to evaluate the high consumption-weighted average concentrations of DDT and dieldrin estimated for agricultural drains. Results from the monitoring conducted in 2001 and planned for 2002 will provide additional data needed to adequately evaluate these results. This monitoring has been designed in concert with OEHHA to provide the more complete data needed to evaluate attainment of beneficial uses and the need for fish consumption advisories in the lower Sacramento River watershed.

iii. Spatial and Temporal Distribution & Patterns

Concentrations of organochlorines accumulated in fish tissue are dependent on a number of factors in addition to exposure to these compounds, including species and trophic level, age, size, and tissue lipid concentrations. The species and size of fish analyzed for this study varied by location, and it is difficult to describe purely spatial variation independent of these factors. For this reason, concentrations in trophic level 3 species (e.g. rainbow trout), should not be directly compared with concentrations in trophic level 4 species (e.g. largemouth bass) as a means of inferring spatial differences in concentrations of bioavailable mercury. However, examination of the consumption-weighted average organochlorine concentrations for each waterbody category (Table 28) provides a relatively unbiased biased view of broad regional patterns in fish tissue concentrations. These results suggest that concentrations of organochlorines are generally low in fish from smaller tributaries. Although consumption-weighted average PCBs were highest in the Delta locations, and DDTs and dieldrin were highest in the fish from agricultral drains, these values were very dependent on high concentrations in a very limited number of samples or species. Considering only the two species collected from the most sites (white catfish and largemouth bass), there were no distinct or consistent differences in average concentrations for different waterbody categories.

Consumption weighted averages of organochlorine concentrations in fish tissue are summarized in Table 28 by waterbody category. Concentrations in individual species are illustrated for each location sampled in Figures 18 and 19.

There are currently insufficient data available to assess seasonal or long-term temporal trends in the concentrations of organochlorines in fish tissue.

vi. Conclusions and Recommendations

Consumption-weighted average concentrations of DDTs and dieldrin in fish from agricultural drains, and of PCBs in fish from Delta locations exceeded screening values, but these results were dependent on very limited data for trophic level 3 species. Additional data are needed to adequately assess the potential risks for these waterbodies.

Based on comparisons to screening values for organochlorines in fish tissue, consumers who eat a variety of fish from different locations appear to be at relatively low risk from organochlorines in fish tissue. However, potential risks increase for people selectively consuming a limited number of higher trophic level species (e.g. white catfish, largemouth bass, striped bass), and for individuals consuming more fish than the 30 g/day (eight quarter-pound servings per month) on which the screening values were based.

Evaluation of consumption-weighted average concentrations suggests the need to re-evaluate several of the waterbodies cited on the1998 303(d) for impairment due to organochlorine pesticides and PCBs. The results also support the Regional Board’s recommendation to remove the lower American River from the updated 2002 303(d) list.

Smaller tributaries throughout the watershed tended to have lower concentrations of most organochlorines than other waterbodies. There was little evidence of other distinct spatial trends in organochlorine concentrations in fish tissue.

Monitoring of organochlorine pesticides and PCBs in fish tissue has been continued for 2000-2001 monitoring.

Table 26. Organochlorines in Fish Tissue: Regulatory Limits, Screening Values, and Summary of SRWP Data (1997-2000)

	PCBs (as Aroclors)	Sum of Chlordanes	Sum Of DDTs	Dieldrin
Updated USEPA Screening Values(1) (SFRWQCB *et al.* 1995)	23 ng/g	18 ng/g	69 ng/g	1.5 ng/g
OEHHA Screening Values(2) (OEHHA 1999, SFEI 1998)	20 ng/g	30 ng/g	100 ng/g	2 ng/g
FDA Action Levels(3)	2000 ng/g	300 ng/g	5000 ng/g	300 ng/g
Total number of samples analyzed (1997 – 1999)	98	98	98	98
Number of samples exceeding USEPA screening value	18	1	7	9
Percent of samples exceeding USEPA screening value	18%	1%	7%	9%
Species(4) exceeding screening values	RT, WC, LMB, SB, PM, SS	PM	CP, WC, SS, LMB	WC, PM, LMB, CP
Sites(5) exceeding screening values	SACSL SRBKR SRCOL SRVET SRRMF NEMDR ARDPK ARJST	ARDPK	COLDR PUTAH SRVET SRRMF	COLDR SACSL ARDPK SRRMF CCHSL
Sites exceeding no screening values	SRABB, SRHAM, FRNIC			

(1) Screening value is based on a consumption rate of 30 g/day.
(2) Screening value is based on a consumption rate of 21 g/day.
(3) FDA Action Level is based on a consumption rate of 6.5 g/day.
(4) BT–Brown trout, CP–Carp, RT–Rainbow trout, LMB–Largemouth bass, PM–Sacramento pikeminnow, RS–Riffle sculpin, SB–Striped bass, SMB–Smallmouth bass, SS–Sacramento sucker, WC–White catfish
(5) Sites in downstream order: SRBKR–Sac. River below Keswick; SRABB–Sac. River at Bend Bridge; SRHAM–Sac. River at Hamilton City; SRCOL–Sac. River at Colusa; SRVET–Sac. River at Vets Bridge; COLDR–Colusa Basin Drain; SACSL–Sacramento Slough; Feather River near Nicolaus; ARJST–Amercian River at J Street; NEMDR–Natomas East Main Drain; ARDPK–American River at Discovery Park; PUTAH–Putah Creek; SRRMF–Sac. River at Mile 44; CCHSL–Cache Slough near Ryers Ferry.

Table 27. Comparisons to screening values for organochlorine pesticides

PCBs as Sum of Aroclors (USEPA Screening Value[1] = 23 ng/g)	
Species averages	Overall species averages for striped bass (n=1) and white catfish (n=19) exceeded the Screening Value (SV). Species average concentrations were above the SV in white catfish and striped bass (n=1) for the lower Sacramento River mainstem, in white catfish and Sacramento sucker (n=1) for Delta locations, and in white catfish for major tributaries All species averages for smaller tributaries and ag drains were below the SV.
Trophic Level (TL) averages	Overall TL3 and TL4 average concentrations were lower than the SV. Trophic level 3 average was above the SV for the Delta locations, but based on only one species and one sample. Trophic Level 4 average was above the SV for major tributaries.
Consumption-weighted avg (CWA)	CWA above Screening Value for Delta locations, but result dependent on single high Sacramento sucker sample CWA below Screening Value for all other waterbody categories.
Summary of potential risks	Potential risk is highest at Delta locations (Sac. River at Mile 44 and Cache Slough), and low at other locations.
Sum of Chlordanes (Screening Value = 18 ng/g)	
Species averages	All species averages were below the SV.
Trophic Level (TL) avg.	All were below the SV.
Consumption-weighted avg (CWA)	Below the SV for all waterbody categories
Summary of potential risks	Risk appears to be very low for all waterbody categories sampled (Lower Sac. River mainstem, Delta, major tributaries, smaller tribs, and ag drains).
Sum of DDTs (Screening Value = 69 ng/g)	
Species averages	The overall average (n=3) and the ag drain average (n=2) for Carp exceeded the SV. Species average concentration was above the SV in Sacramento sucker (n=1) for smaller tributaries, but was based on only one sample for this species. All other overall species averages were below the SV.
Trophic Level (TL) averages	Three of 35 TL3 samples and 4 of 63 TL4 samples were above the SV. Overall Trophic Level 3 and 4 average concentrations were lower than the SV. Trophic level 3 average was above the SV for Ag drains, but based on only one species (Carp, n=2).
Consumption-weighted avg (CWA)	CWA was above the SV for Ag drains, but based on only one TL3 species (Carp, n=2). CWA was below the SV for all other waterbody categories.
Summary of potential risks	Some potential risks for fish from ag drains, but risk may be overestimated due to reliance on single TL3 species. Overall risk appears low .
Dieldrin (Screening Value = 1.5 ng/g)	
Species averages	The overall average (n=3) and the ag drain average (n=2) for Carp exceeded the SV. Other overall and waterbody category averages were below the SV.
Trophic Level (TL) averages	Two of 35 TL3 samples and 8 of 63 TL4 samples were above the SV. Overall TL3 average was above SV, but influenced by one very high Carp sample. Overall TL4 average was below the SV
Consumption-weighted avg (CWA)	CWA was above the SV for Ag drains, but based on only one TL3 species (Carp, n=2). CWA was below the SV for all other waterbody categories.
Summary of potential risks	There may be some potential risks for fish from ag drains, but risk may be overestimated due to reliance on single TL3 species. Overall risks appear low .

(1) Updated USEPA screening value based on a consumption rate of 30 g/day (SFRWQCB *et al.* 1995)

Table 28. Consumption-weighted average organochlorine concentrations in fish

				Consumption-weighted Avg[2], ng/g			
Site Category	Species	Trophic Level[1]	Count	Aroclors	Chlordanes	DDTs	Dieldrin
Lower Sac. R. Mainstem (Keswick to "I" Street Bridge)	Carp	3	1	**11.0** (10.5–11.5) *55% detects*	**1.4** (0.8–2.0) *41% detects*	**31.4** (31.3–31.4) *95% detects*	**1.0** (0–1.9) *9% detects*
	Rainbow trout	3	5				
	Sacramento sucker	3	5				
	Largemouth bass	4	2				
	Pikeminnow	4	6				
	Striped bass	4	1				
	White catfish	4	2				
Delta (Sac. River below "I" Street Bridge, and Cache Slough)	Sacramento sucker	3	1	**28.7** (28.5–29.0) *70% detects*	**2.1** (0.8–2.4) *70% detects*	**46.9** *100% detected*	**1.1** (0.2–2.0) *25% detects*
	Largemouth bass	4	8				
	Pikeminnow	4	1				
	White catfish	4	10				
Major tributaries (Feather River and American River)	Sacramento sucker	3	3	**13.0** (12.5–13.5) *67% detects*	**2.5** (2.1–3.0) *61% detects*	**17.1** *100% detected*	**1.1** (0.2–1.9) *17% detects*
	Largemouth bass	4	6				
	Pikeminnow	4	6				
	White catfish	4	3				
Tributaries (Sac. R. above Shasta, Pit River, McCloud River, Clear Ck, Mill Ck, Deer Ck, Big Chico Ck, Putah Ck)	Brown trout	3	1	**3.7** (2.9–4.6) *8% detects*	**1.1** (0.4–1.8) *8% detects*	**18.1** (17.4–18.1) *42% detects*	**1.0** (0–2.0) *0% detects*
	Rainbow trout	3	8				
	Riffle sculpin	3	8				
	Sacramento sucker	3	1				
	Largemouth bass	4	4				
	Pikeminnow	4	1				
	Smallmouth bass	4	3				
Ag drains (Sacramento Sl., Colusa Drain, Natomas East Main Drain)	Carp	3	2	**7.2** (6.7–7.7) *50% detects*	**1.6** (1.1–2.1) *58% detects*	**288** *100% detects*	**7.4** (7.0–7.4) *42% detects*
	Largemouth bass	4	6				
	White catfish	4	4				
	USEPA Screening Values			*23 ng/g*	*18 ng/g*	*69 ng/g*	*1.5 ng/g*

(1) Trophic level 3 fish consume primarily zooplankton and benthic invertebrates. Trophic level 4 fish preferentially consume trophic level 3 and lower trophic level fish species, as well as benthic invertebrates. Larger individuals of some primarily trophic level 3 species (e.g. trout) may be piscivorous and function at trophic level 4.

(2) The average concentration for total fish consumed, as described USEPA 2001b. The consumption-weighted average is calculated as: (56.6% x *Trophic Level 3 avg.*) + (43.4% x *Trophic Level 4 avg.*). Averages are calculated by substituting 1/2 the reporting limit for concentrations below detection. Maximum ranges for averages based on substitution of zero and the reporting limit are presented in parentheses. Percent detected concentrations are shown in italics.

Table 29. Waterbodies cited on California's 1998 303(D) List for PCBs and organochlorine pesticides.

Water Body	Cause for 303(d) Listing	Source of Pollution	Size Affected	Unit
Delta Waterways	DDT	Agriculture	48,000	Acres
Delta Waterways	Group A Pesticides[1]	Agriculture	48,000	Acres
American River, Lower[2]	Group A Pesticides	Urban Runoff	23	Miles
Colusa Basin Drain	Group A Pesticides	Agriculture	70	Miles
Feather River, Lower	Group A Pesticides	Agriculture	60	Miles
Natomas East Main Drain	PCBs	Industrial Point Source	12	Miles
Natomas East Main Drain	PCBs	Urban Runoff	12	Miles

(1) Group A pesticides: aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexanes (including lindane), endosulfan, and toxaphene

(2) Recommended for removal from 2002 303(d) by Regional Board (CVRWQCB 2001)

MAP KEY

Site ID	Location
SRSHA	Sac. R. above Shasta
MRSHA	McCloud R. above Shasta
PRSHA	Pit R. above Shasta
CCWHI	Clear Creek above Whiskeytown Res.
CCIGO	Clear Creek near Igo
CCMOU	Clear Creek at mouth
SRBKR	Sac. R. below Keswick Res.
SRABB	Sac. R. above Bend Bridge
MC###	Mill Creek sites
DC###	Deer Creek sites
SCORL	Stony Creek near Orland
SRHAM	Sac. R. at Hamilton City
MUDCH	Mud Creek
CH###	Big Chico Creek sites
SRCOL	Sac. R. at Colusa
FRNIC	Feather R. near Nicolaus
COLDR	Colusa Basin Drain
SACSL	Sacramento Slough
SRVET	Sac. R. at Veterans Bridge
NEMDR	Natomas East Main Drain
ARCNW	Arcade Cr. at Norwood Av.
ARJST	American R. at J Street
ARDPK	American R. at Discov. Pk.
SRRMF	Sac. R. at Mile 44
PUTAH	Putah Creek
PUTAU	Upper Putah Creek
YOLOB	Yolo Bypass
CCHSL	Cache Slough

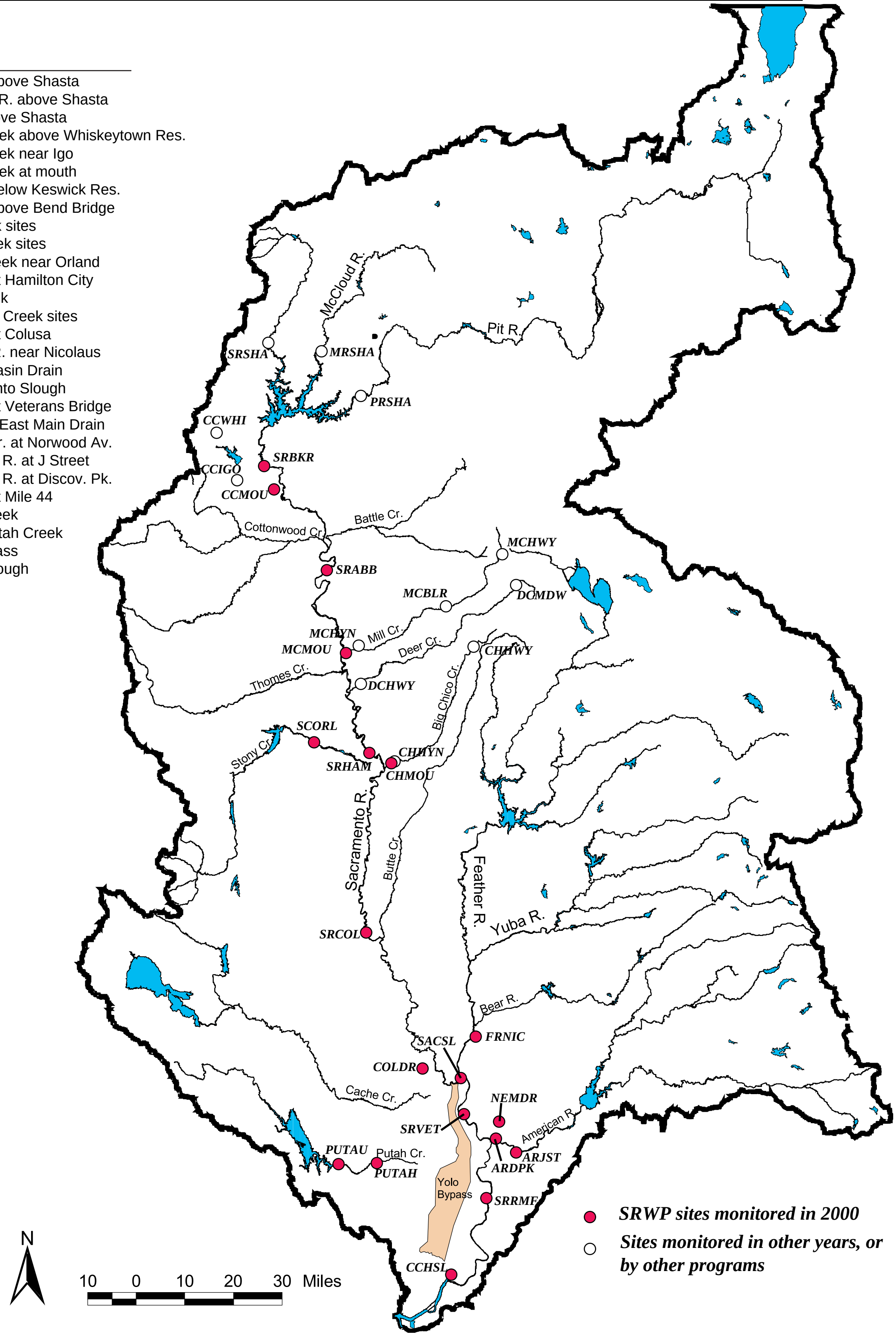


Figure 15. SRWP monitoring for organochlorines in fish tissue: 1997 - 2000 monitoring locations

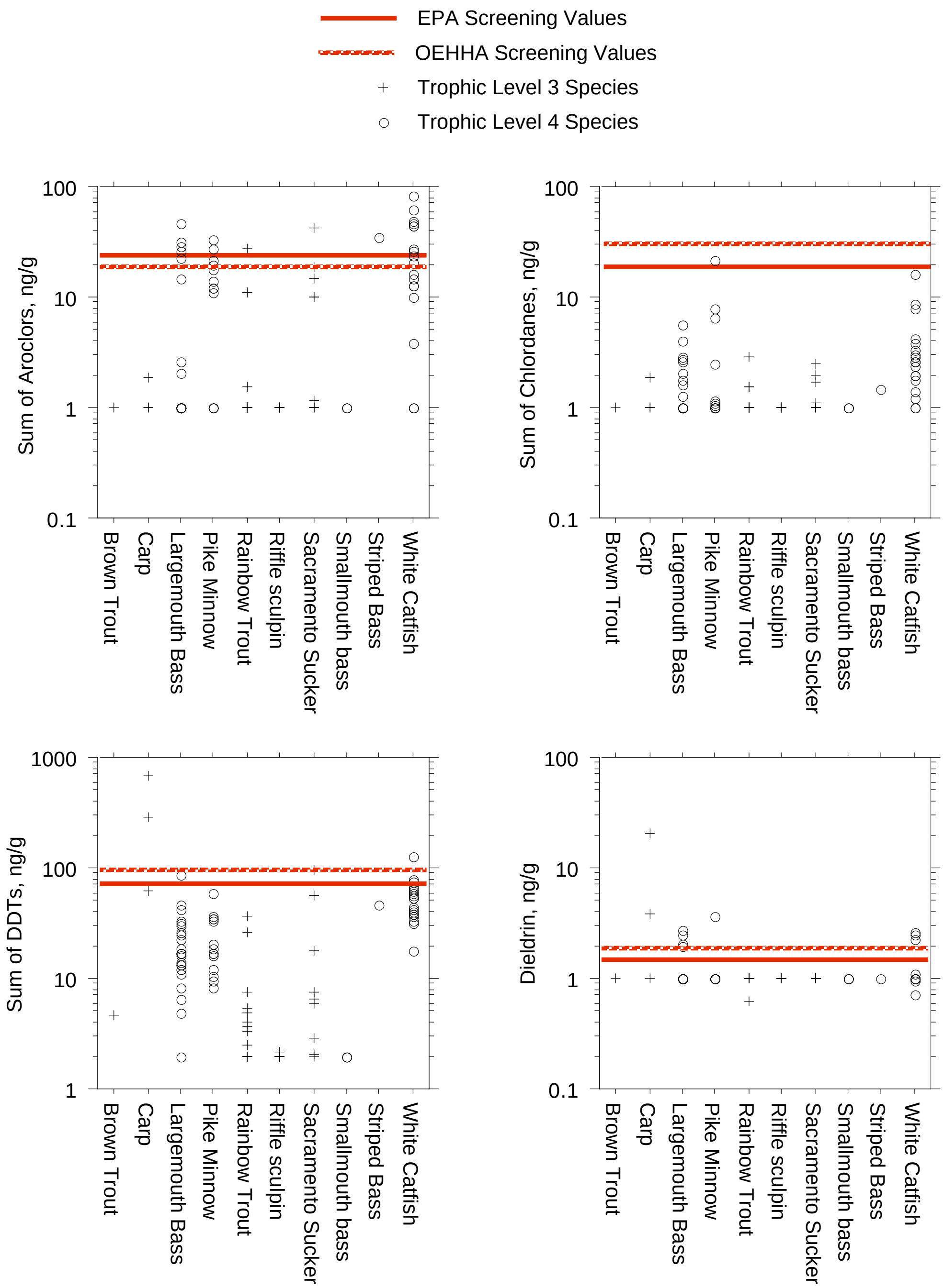


Figure 16. Organochlorine pesticides in fish tissue, summarized by species

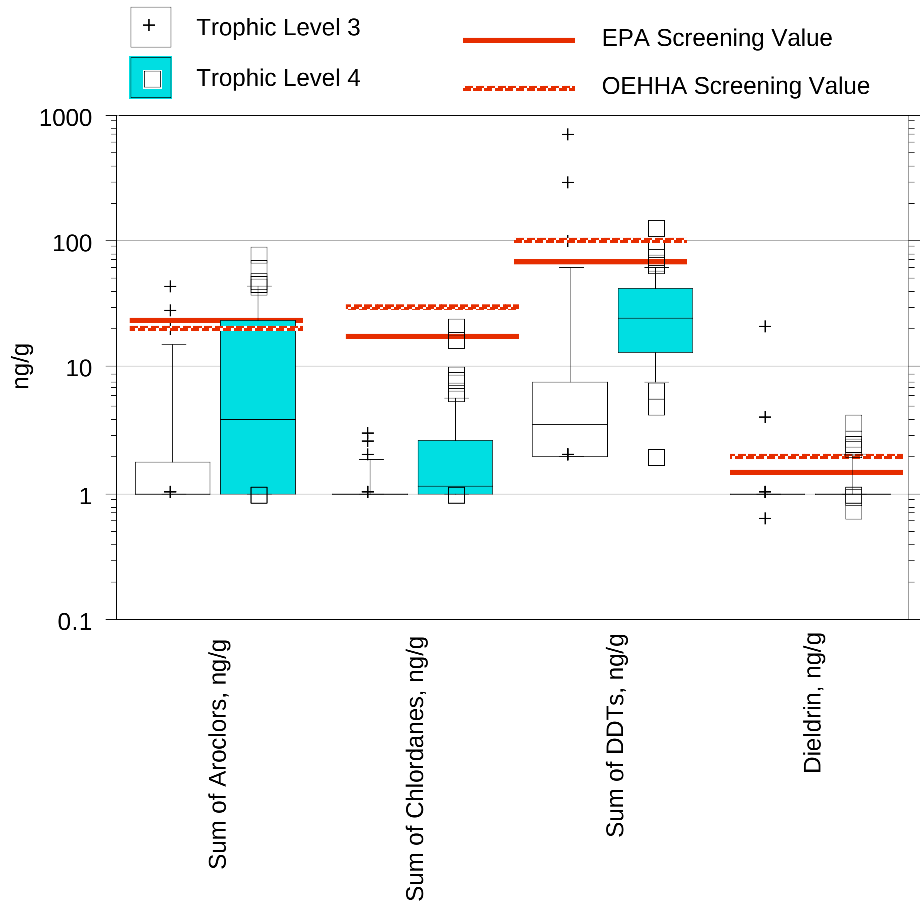


Figure 17. Organochlorine pesticides in fish tissue, summarized by trophic level
Trophic Level 3 species include largemouth bass, Sacramento pikeminnow, striped bass, white catfish, and smallmouth bass. Trophic Level 4 species include carp, rainbow and brown trout, riffle sculpin, and Sacramento sucker.

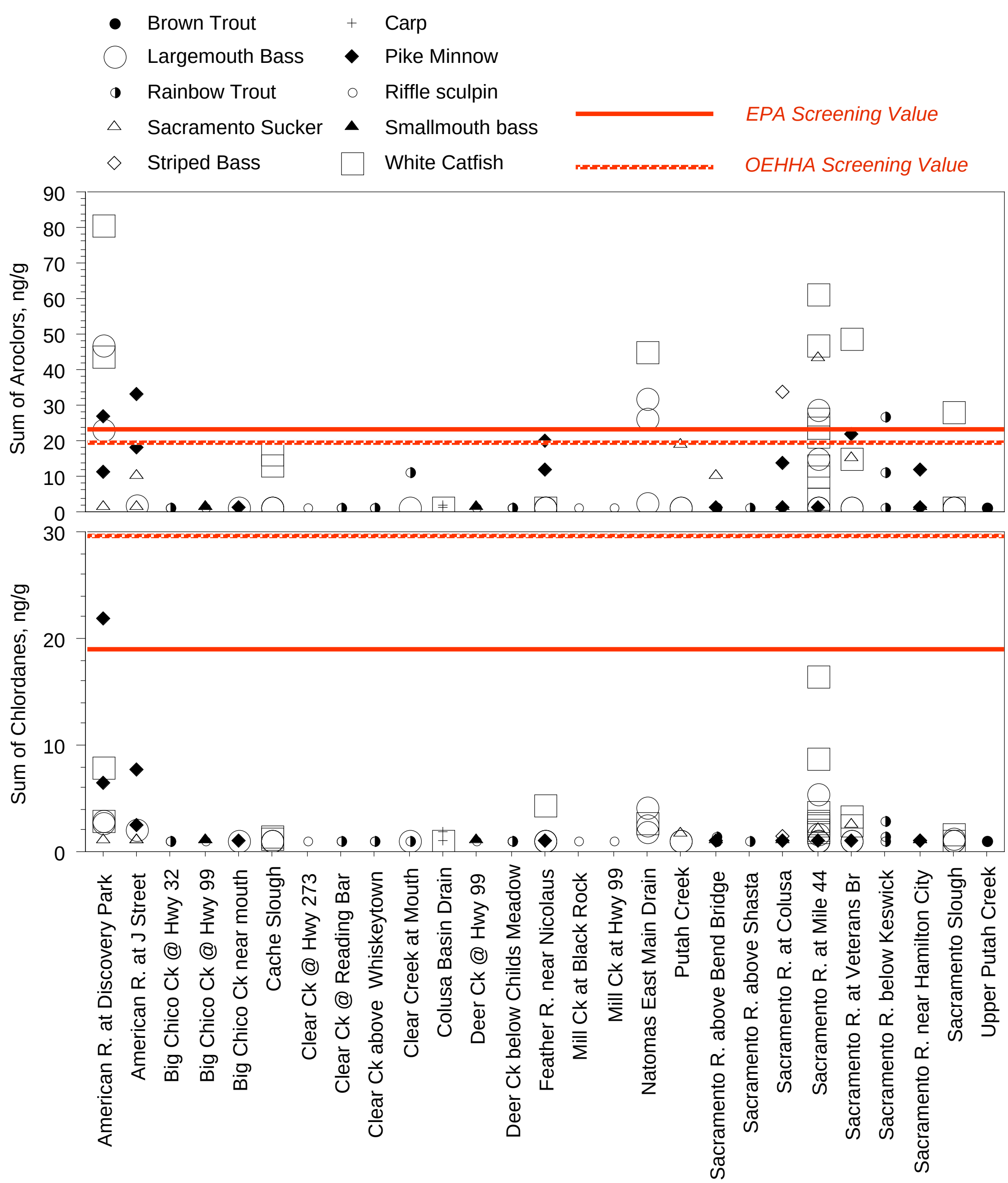


Figure 18. PCBs and Chlordanes in fish tissue: SRWP 1997 - 2000 data

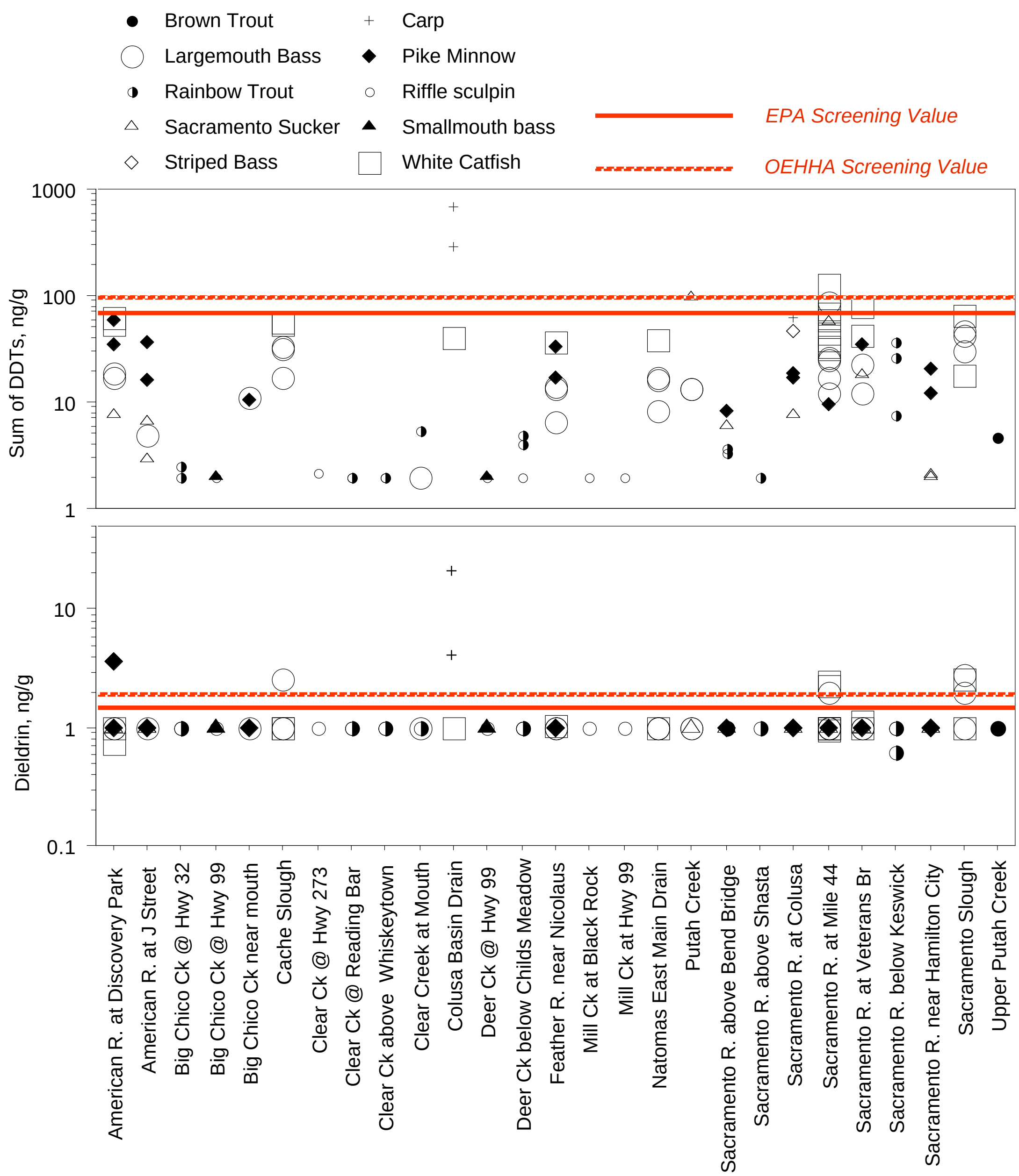


Figure 19. DDTs and Dieldrin in fish tissue: SRWP 1997 - 2000 data

F. Bioassessment

i. Background

The overall objectives of SRWP bioassessment monitoring effort has been to provide baseline data useful in evaluating the health of aquatic communities in the watershed, and to supplement and integrate with monitoring efforts being performed in tributary watersheds. The information generated will provide data needed to develop biocriteria for the Sacramento River watershed, which will eventually allow more direct evaluations of the degree to which specific beneficial uses are achieved or impaired (e.g. the warm and cold freshwater beneficial uses designated in the Central Valley Basin Plan).

As part of a multi-agency program to evaluate water quality in the Sacramento River watershed, macroinvertebrate samples were collected from wadable and non-wadable sites in the mainstem Sacramento River and eleven tributary watersheds to assess their biological condition. Bioassessment monitoring locations were selected based on a strategy to rotate monitoring into new tributary watersheds on a two year cycle. This strategy was developed as a compromise between the need to provide baseline information in tributaries throughout the watershed, and the need to provide longer term and more in-depth monitoring data for individual tributary watersheds. Selection of specific tributary watersheds was also coordinated with other bioassessment monitoring performed by DWR and USGS. The specific locations within each tributary watershed were selected to provide the broadest coverage, and specific stream reaches and transects were selected as specified in the California Stream Bioassessment Procedure (CDFG 1999). The California Stream Bioassessment Procedure (CSBP), developed by the California Department of Fish and Game (DFG), was used to evaluate the benthic macroinvertebrate communities at each site (Harrington 1996). The CSBP is a regional adaptation of the U.S. Environmental Protection Agency (USEPA) Rapid Bioassessment Protocols (Barbour *et al.* 1997) and is recognized by the USEPA as California's standardized bioassessment procedure (Davis *et al.* 1996). Additional samples were collected by the United States Geological Survey (USGS) at five non-wadable sites using their National Water Quality Assessment (NAWQA) procedures. Macroinvertebrate samples have been collected during four fall sampling periods between 1997 and 2000 by DFG, USGS, and the California Department of Water Resources (DWR).

Bioassessment is a general term that may include assessment of fish, amphibian, algal or other communities, or single indicator species. The CSBP utilizes measures of the stream's benthic macroinvertebrate (BMI) community and its physical/ habitat structure to assess the biotic health of a site. BMIs can have a diverse community structure, with individual species residing within the stream for a period of months to several years. They are also sensitive, in varying degrees, to temperature, dissolved oxygen, sedimentation, scouring, nutrient enrichment and chemical and organic pollution (Resh and Jackson 1993). Together, biological and physical assessments integrate the effects of water quality over time, are sensitive to multiple aspects of water and habitat quality, and provide the public with more familiar expressions of ecological health (Gibson 1996).

ii. Attainment of Beneficial Uses and Potential Impairment

Physical Habitat Quality Assessment and Benthic Macroinvertebrate Data Analysis

Physical habitat quality was assessed for the monitoring reaches using U.S. Environmental Protection Agency (USEPA) Rapid Bioassessment Protocols (RBPs) (Plafkin *et al*. 1989). Habitat quality assessments were recorded for each monitoring reach during each sampling event. Figure 20 illustrates sites monitored by SRWP in Year 3 (2000). The list of benthic macroinvertebrates taxa identified from the samples was used to calculate and summarize macroinvertebrate community-based metric values. Descriptions of the metric values used to describe the benthic macroinvertebrate communities are provided in Table 30.

Each of the monitoring reaches was given a relative BMI Ranking Score based on 6 of the BMI metric values (Table 30; metrics 1,2,4,6,8 and 9) selected to provide a composite measure of abundance, diversity, and tolerance to disturbance. The specific metrics were selected to provide a composite index that best differentiates between impaired and non-impaired sites through different measures of community structure and function. The composite BMI ranking scores were computed as follows:

$$Score = \sum \left(\frac{x_i - \bar{x}}{sem_i} \right)$$

where: x_i = site value for the *i*-th metric;
$\bar{x}$ = overall mean for the *i*-th metric;
sem_i = standard error of the mean for the *i*-th metric.
Note: An overall score of “0" is the average relative score.

Results for individual metrics and stream reaches and transects are presented in Appendix C. A complete list of macroinvertebrates identified from samples collected in 2000 is available on request. Taxa identified in other monitoring years are documented in previous Annual Monitoring Reports.

Physical Habitat Quality Assessment

Physical habitat was assessed only for “wadable” sites due to limitations of the methodology in assessing physical habitat for deep water (“non-wadable”) sites. The majority of wadable sites had similar physical habitat characteristics and were in very good condition. All sites scored in the low end of the “excellent” category or in the high end of the “good” category. The only major physical habitat problem noted for the wadable sites was sedimentation. Some sites had fairly good riparian protection and bank vegetation, but had moderate amounts of sediment deposition and low substrate diversity. In general, sites farther downstream in a particular watershed or tributary tended to have a higher degree of sedimentation.

BMI Ranking Scores

Average BMI ranking scores for each tributary watershed are illustrated in Figure 21. BMI ranking scores for individual sites are also presented in Figure 22. Most of the wadable sites had similar BMI ranking scores. In general, the tributary streams (Butte

Creek, Big Chico Creek and Deer Creek) ranked higher than larger river sites, except at the most downstream sites on these tributary. The non-wadable sites from which riffle samples were collected (Feather River near Nicolaus, American River at Harrington Bar, Yuba River at Marysville) had scores similar to the other large river sites (Sacramento River at Lamoine, McCloud River at the Nature Conservancy), while the sites sampled using snag sampling methodology scored lower than all other sites. It should be noted that the difference in sampling methodology for the snag samples precludes a strict comparison between these sites and the riffle samples.

There was a poor relationship between physical habitat scores and overall site rankings based on the bioassessment metrics (illustrated with 1997-1999 data in Figure 22a). As discussed previously, all wadable sites were considered to be in “good” to “excellent” physical condition, and this habitat score range provided limited ability to differentiate between sites based on habitat quality. Physical habitat quality is only one of the variables that affect biological condition and most of the biological variation was not explained by variation in physical habitat conditions at sites of higher physical quality.

What do the data say about attainment of beneficial uses and potential impairment? Because of the absence of reference condition information for the Sacramento River watershed, it is not yet feasible to make a definitive assessment of the degree to which beneficial uses in the watershed are attainment or potentially impaired. However, there are some subjective assessments that can be made based on the results of the benthic invertebrate data and physical habitat assessments:

For the majority of sites, taxonomic richness and community diversity are described as high (relative to the possible range for these measures).

Sensitive taxa were generally abundant at most sites. Sensitive taxa were less abundant at lower elevation tributary sites and at all the non-wadable sites except the Yuba River site. Extreme dominance of a community by one or a few taxa was rare—only the Arcade Creek site was characterized by dominance of one tolerant taxon (63% percent *Chironomini*).

Measures of tolerance to disturbance indicated that most of the communities in this dataset were intolerant to disturbance, with the exceptions of the lowest elevation sites on Big Chico Creek and Deer Creek, and all of the non-wadable sites except the Yuba River site. The level of community tolerance was generally higher in the lower elevation sites, both within a watershed and at the individual non-wadable sites. Taxa intolerant of disturbances were abundant at the higher elevation tributary sites and much less common at the lower elevation sites. There were very few tolerant taxa overall. Of the non-wadable sites, the Yuba River and American River sites had tolerance measures comparable to the upstream tributary sites.

All of the functional feeding groups were represented in the SRWP data, but shredders were encountered only rarely and at only a few sites. Grazing taxa were fairly common in the dataset, a reflection of the high abundance of sensitive mayfly and caddisfly taxa, which are often algae-scraping organisms. Although there were many predator taxa, these represented a small proportion of the community. Most of the remaining organisms were either collector-gatherers or filtering collectors, both of which feed on fine particulate organic matter (FPOM). The relative proportion of collector-gatherer taxa to filterer taxa varied considerably in wadable sites while collector-gatherers were dominant in the non-wadable sites.

Abundance of organisms varied from a low value of 600 organisms per sample to 4200 organisms per sample in the wadable sites. Abundance was somewhat less variable in the non-wadable sites, ranging between 2200 and 4800 organisms in the non-wadable sites. Note that because of differences in sampling method, abundance is not directly comparable for wadable and non-wadable sites.

The majority of sites evaluated had similar physical habitat characteristics and were considered to be in good to excellent condition. However, it is important to note that there are no comparable physical habitat measures for the non-wadable sites and that these appear to be the most physically impacted sites.

iii. Spatial and Temporal Patterns

There were several spatial trends that were observed consistently through the 1997-2000 monitoring period.

Most of the upper tributary sites sampled were in good to excellent physical and biological condition. Sites farthest downstream on each tributary had consistently lower biological metric scores than upstream sites. The differences among the upper watershed sites were minimal.

The larger river sites typically had lower scores than the upper tributary sites and exhibited lower community diversity typical of more impacted wadable streams.

As is typical within high-gradient watersheds, there was a strong elevation gradient in biological quality for most tributary watersheds (Deer Creek, Butte Creek, Big Chico Creek, and Stony Creek). There was an overall trend of decreased diversity at lower elevation sites and an increase in tolerant taxa at lower elevation sites, when compared to higher elevation sites within the same watershed. The elevational component observed is typical of studies of ecosystem health. However, it should be noted that there are several potential sources of this pattern. Downstream sites integrate water quality impacts from a larger area, tend to have a higher level of physical habitat impairment, and also tend to be in different ecoregions than upstream sites, making it difficult to distinguish the effects of water quality and physical habitat impairment from ecosystem effects. The relationship between elevation and relative BMI scores is summarized in Figure 22a for 1997-1999 data.

Arcade Creek—the waterbody with the most highly urbanized watershed—received the lowest relative BMI score in each of the four years monitored. This is consistent with the high frequency of mortality observed in aquatic toxicity tests with *Ceriodaphnia* at this site, and provides additional evidence that this waterbody is impaired.

The only discernible temporal trend was that BMI scores for each site were generally consistent from year to year. There were no other temporal trends or year-to-year differences apparent in the relative BMI ranking scores for the 1997-2000 monitoring period.

iv. Conclusions and Recommendations

In general, macroinvertebrate communities at most sites were described as complex with a wide range of taxa represented. Macroinvertebrate communities were dominated by sensitive taxa at almost all sites. Overall, the available data suggest that the beneficial uses evaluated by bioassessment monitoring (i.e. aquatic life uses and habitat) are achieved to a fairly high degree in the Sacramento River mainstem, major tributaries, and in all of the smaller tributaries assessed to date (Deer Creek, Big Chico Creek, Mill Creek, Butte Creek, Stony Creek, Cow Creek, and Battle Creek). However, because of the absence of reference condition information for the Sacramento River watershed, it is not yet feasible to make a definitive assessment of the degree to which beneficial uses are attained or potentially impaired in surface waters of the watershed. Note also that although the tributaries monitored were selected to include a range of tributary watershed types, they are not necessarily representative of the entire watershed.

Identification of reference sites and reference conditions within the Sacramento River watershed is needed to objectively assess the biological integrity of surface waters in the watershed. To address this need, the SRWP Biological and Physical Habitat Assessment Sub-Committee have shifted its focus toward developing the process for identifying reference conditions. The Biological and Physical Habitat Assessment Sub-Committee have estimated that this information can be developed fairly quickly and will be invaluable to future bioassessment work in the watershed. The process to identify and select reference conditions is currently being developed for the Sierra foothills ecoregion, and is expected to be applicable to other ecoregions in the watershed (and throughout the state) with relatively little modification. The Sierra foothill ecoregion was selected for initial development of this process because this area will be experiencing dramatic growth in the next 10 to 20 years. The increased development and changes in land use are expected to increasingly influence the water quality and biological integrity of the Sacramento River watershed. Although the work done by the SRWP to date has provided a strong foundation of information for aquatic invertebrate communities in the Sacramento River watershed as a whole, there is still a need for more sites within the Sierra Nevada Foothills ecoregion to characterize the range of natural variation in aquatic macroinvertebrate communities. Sampling for the reference condition project (funded by the Central Valley RWQCB and the SRWP) has already begun in the Sierra Foothill region, and development of the framework for selecting reference sites in the valley floor of the Sacramento River watershed is also underway (also funded by the Central Valley RWQCB and the SRWP).

Table 30. Bioassessment metrics used to describe characteristics of the benthic macroinvertebrate (BMI) community

BMI Metric	Description	Response to Impairment[1]
	Richness Measures	
1. Taxa Richness	Total number of individual taxa	decrease
2. EPT Taxa	Number of taxa in the Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) insect orders	decrease
	Composition Measures	
3. EPT Index	Percent composition of mayfly, stonefly and caddisfly larvae	decrease
4. Sensitive EPT Index	Percent composition of mayfly, stonefly and caddisfly larvae with tolerance values between 0 and 3	decrease
5. Shannon Diversity Index	General measure of sample diversity that incorporates richness and evenness (Shannon and Weaver 1963)	decrease
	Tolerance/Intolerance Measures	
6. Tolerance Value	Value between 0 and 10 weighted for abundance of individuals designated as pollution tolerant (higher values) or intolerant (lower values)	increase
7. Percent Intolerant Organisms	Percent of organisms in sample that are highly intolerant to impairment as indicated by a tolerance value of 0, 1 or 2	decrease
8. Percent Tolerant Organisms	Percent of organisms in sample that are highly tolerant to impairment as indicated by a tolerance value of 8, 9 or 10	increase
9. Percent Dominant Taxa	Percent composition of the single most abundant taxon	increase
	Functional Feeding Groups (FFG)	
10. Percent Collectors	Percent of macrobenthos that collect or gather fine particulate matter	increase
11. Percent Filterers	Percent of macrobenthos that filter fine particulate matter	increase
12. Percent Grazers	Percent of macrobenthos that graze upon periphyton	variable
13. Percent Predators	Percent of macrobenthos that feed on other organisms	variable
14. Percent Shredders	Percent of macrobenthos that shreds coarse particulate matter	decrease
	Abundance Measures	
15. Estimated Abundance	Estimated number of macroinvertebrates in sample calculated by extrapolating from the proportion of organisms counted in the subsample	variable

(1) Metrics that increase in response to impairment are assigned a negative value.

Table 31. Summary of Bioassessment Monitoring Results for 2000.

			Physical Habitat Scores				BMI Ranking Scores			
Watershed	Location Description	Site ID	'97	'98	'99	'00	'97	'98	'99	'00
Stony Creek	5 riffles downstream of road crossing on Middle Fork of Stony Creek	MFSC-MC	ns	ns	ns	170	ns	ns	ns	52.5
Stony Creek	5 riffles immediately upstream and downstream of Rd. 306 bridge	SC-306	ns	ns	ns	124	ns	ns	ns	28.8
Stony Creek	5 riffles 300 meters upstream of Road 303 bridge	SC-401	ns	ns	ns	159	ns	ns	ns	-0.6
Stony Creek	5 riffles approximately 1 km south of Alder Springs Road crossing	SC-ASR	ns	ns	ns	129	ns	ns	ns	-28.7
Stony Creek	5 riffles approximately 600m downstream of old bridge crossing	SC-R	ns	ns	ns	150	ns	ns	ns	13.2
Stony Creek	5 riffles immediately upstream and downstream of Rd. 200-A crossing	SC-200A	ns	ns	ns	134	ns	ns	ns	-56.5
Stony Creek	5 riffles 350 m north of Olive Road	SC-OR	ns	ns	ns	132	ns	ns	ns	-57.1
Cow Creek	5 riffles immediately upstream and downstream of Ponderosa Way on South Cow Creek	SCC-PW	ns	ns	ns	175	ns	ns	ns	78.8
Cow Creek	5 riffles immediately upstream and downstream of Whitmore Road crossing on Old Cow Creek	OCC-WR	ns	ns	ns	159	ns	ns	ns	81.9
Cow Creek	5 riffles immediately upstream and downstream of Oak Run crossing on Little Cow Creek	LCC-OR	ns	ns	ns	150	ns	ns	ns	-34.0
Cow Creek	5 riffles downstream of Coronado Mine	CC-CM	ns	ns	ns	174	ns	ns	ns	-19.4
Cow Creek	5 riffles upstream and downstream of Milleville Plains Road	CC-MPR	ns	ns	ns	160	ns	ns	ns	-6.3
Battle Creek	5 riffles upstream of Highway 44 on North Fork of Battle Creek	NFBC-44	ns	ns	ns	172	ns	ns	ns	38.0
Battle Creek	5 riffles upstream of Wilson Hill Road bridge on North Fork of Battle Creek	NFBC-WHR	ns	ns	ns	179	ns	ns	ns	64.3
Battle Creek	5 riffled upstream of Manton Rd. crossing on North Fork of Battle Creek	NFBC-MR	ns	ns	ns	176	ns	ns	ns	39.1
Battle Creek	5 riffles adjacent to the diversion channel fish screen	BTC-FS	ns	ns	ns	160	ns	ns	ns	1.5
Battle Creek	5 riffles immediately upstream and downstream of Gover Rd. bridge	BTC-GR	ns	ns	ns	168	ns	ns	ns	21.9
Deer Creek	5 riffles upstream of Potato Patch Camp	DC-PPC	162	161	159	159	59.8	61.9	72.0	34.3
Deer Creek	5 riffles in the Ishii Wilderness downstream of Ponderosa Way	DC-PW	158	168	157	155	27.3	30.9	34.0	25.7
Deer Creek	5 riffles upstream and downstream of the Deer Creek Fish Screen	DC-FS	156	168	143	141	-5.1	-4.6	7.1	-9.0

(Continues on following page)

Table 31. Summary of Bioassessment Monitoring Results (continued from previous page).

Watershed	Location Description	Site ID	Physical Habitat Scores '97	'98	'99	'00	BMI Ranking Scores '97	'98	'99	'00
Deer Creek	5 riffles downstream of railroad crossing at the Clairveaux Monastery	DC-M	156	153	132	126	-15.8	-14.8	-25.6	-48.3
Big Chico Creek	5 riffles upstream of Highway 32 crossing	BCC-H32	150	160	153	152	68.2	29.4	65.0	80.2
Big Chico Creek	5 riffles in the vicinity of Forest Ranch	BCC-FR	170	164	165	149	49.7	35.5	52.9	32.4
Big Chico Creek	5 riffles within Upper Bidwell Park	BCC-BP	172	159	143	162	-19.6	-21.5	-53.0	-15.1
Big Chico Creek	5 riffles downstream of Rose Avenue	BCC-RA	149	ns	ns	113	-5.9	ns	ns	-36.6
Butte Creek	5 riffles upstream of Cherry Hill Campground	BC-CHC	155	152	146	149	48.1	42.7	58.2	83.0
Butte Creek	5 riffles upstream of Doe Mill Road	BC-DMR	157	163	148	154	54.0	29.4	63.5	34.5
Butte Creek	5 riffles immediately upstream and downstream of Richbar Road crossing	BC-RR	ns	ns	ns	167	ns	ns	ns	23.6
Butte Creek	5 riffles down-stream of Honey Run Covered Bridge	BC-HR	153	135	137	146	-7.1	30.8	6.0	20.1
Butte Creek	5 riffles upstream of Skyway Road crossing on Little Butte Creek	LBC-S	ns	ns	ns	162	ns	ns	ns	38.2
Butte Creek	5 riffles upstream and downstream of Haut Coulteanc Road on Little Butte Creek	LBC-HCR	ns	ns	ns	153	ns	ns	ns	88.3
Sacramento River	5 riffles downstream of the Lamoine exit off Interstate-5	SR-L	ns	136	129	ns	ns	-3.4	7.5	ns
McCloud River	5 riffles downstream of Ladybug Creek at The Nature Conservancy Property	MR-TNC	178	176	165	ns	-12.4	11.4	17.3	ns
McCloud River	5 riffles upstream of Stout=s Road Bridge	MR-SR	ns	171	150	ns	ns	-24.1	66.3	ns
Deepwater sites										
Yuba River	DFG collected three riffle samples upstream of Marysville at Smartsville Road	YR-M	-	-	-	-	-25.3	-33.7	-14.5	-12.3
Feather River	DFG collected three snag samples just upstream of the Sacramento River confluence	FR-EN	-	-	-	-	-59.6	5.1	-52.1	-42.2
Sacramento River	DFG collected three snag samples upstream of Highway 32	SR-HAM	-	-	-	-	ns	ns	ns	-98.8
Sacramento River	DFG collected three snag samples downstream of Sacramento State Park near Colusa	SR-SSP	-	-	-	-	-90.0	-61.7	-95.9	-100
Arcade Creek	DFG collected three snag samples within the boundaries of Del Paso Park	AC-DPP	-	-	-	-	-95.2	-78.4	-148	-124
American River	DFG collected three riffle samples near Harrington Bar	AR-HB	-	-	-	-	-67.7	-28.0	-110	-53.3

Table Notes: "ns" indicates that site was not sampled in that year. Physical Habitat scores range from 1-200; 1-50 indicates poor physical habitat, 51-100 indicates fair habitat, 101-150 indicates good habitat and 151-200 indicates excellent habitat. Physical habitat was not quantified at Deepwater Sites. BMI Ranking Scores represent a weighted sum of 7 bioassessment metrics (Cumulative Taxonomic Richness, EPT Richness, Percent Dominant Taxon, Shannon diversity, Sensitive EPT Index, Percent Intolerant Organisms and Percent Tolerant Organisms); score values are only relative to other sites in this project

MAP KEY

Site ID	Location
SCC-PW	South Cow Ck at Ponderosa Way
OCC-WR	Old Cow Ck at Whitmore Road
LCC-OR	Little Cow Ck at Oak Run
CC-CM	Cow Ck below Coronado Mine
CC-MPR	Cow Ck at Milleville Plains Rd
NFBC-44	North Fk Battle Ck above Hwy 44
NFBC-WHR	North Fk Battle Ck above Wilson Hill Rd Br.
NFBC-MR	North Fk Battle Ck above Manton Rd.
BTC-FS	Battle Ck near diversion channel fish screen
BTC-GR	Battle Ck at Gover Rd. bridge
DC-PPC	Deer Ck above Potato Patch Camp
DC-PW	Deer Ck below Ponderosa Way
DC-FS	Deer Ck at Fish Screen
DC-M	Deer Ck at Clairveaux Monastery
MFSC-MC	Middle Fork of Stony Ck
SC-306	Stony Ck below Rd. 306 Bridge
SC-401	Stony Ck above Road 303 bridge
SC-ASR	Stony Ck near Alder Springs Rd
SC-R	Stony Ck below old bridge
SC-200A	Stony Ck below Rd. 200-A
SC-OR	Stony Ck near Olive Road
BCC-H32	Big Chico Ck above Hwy 32
BCC-FR	Big Chico Ck near Forest Ranch
BCC-BP	Big Chico Ck in Upper Bidwell Park
BCC-RA	Big Chico Ck below Rose Av.
BC-CHC	Butte Ck above Cherry Hill Cmpgrd
BC-DMR	Butte Ck above Doe Mill Road
BC-RR	Butte Ck at Richbar Road
BC-HR	Butte Ck below Honey Run Br.
LBC-S	Little Butte Ck above Skyway Rd
LBC-HCR	Little Butte Ck at Haut Coulteanc Rd
Deepwater sites	
YR-M	Yuba River at Smartsville Road
FR-EN	Feather River at Nicolaus
SR-HAM	Sac. R. at Hamilton City
SR-SSP	Sac. R. at Colusa
AC-DPP	Arcade Ck in Del Paso Park
AR-HB	American R. near Harrington Bar

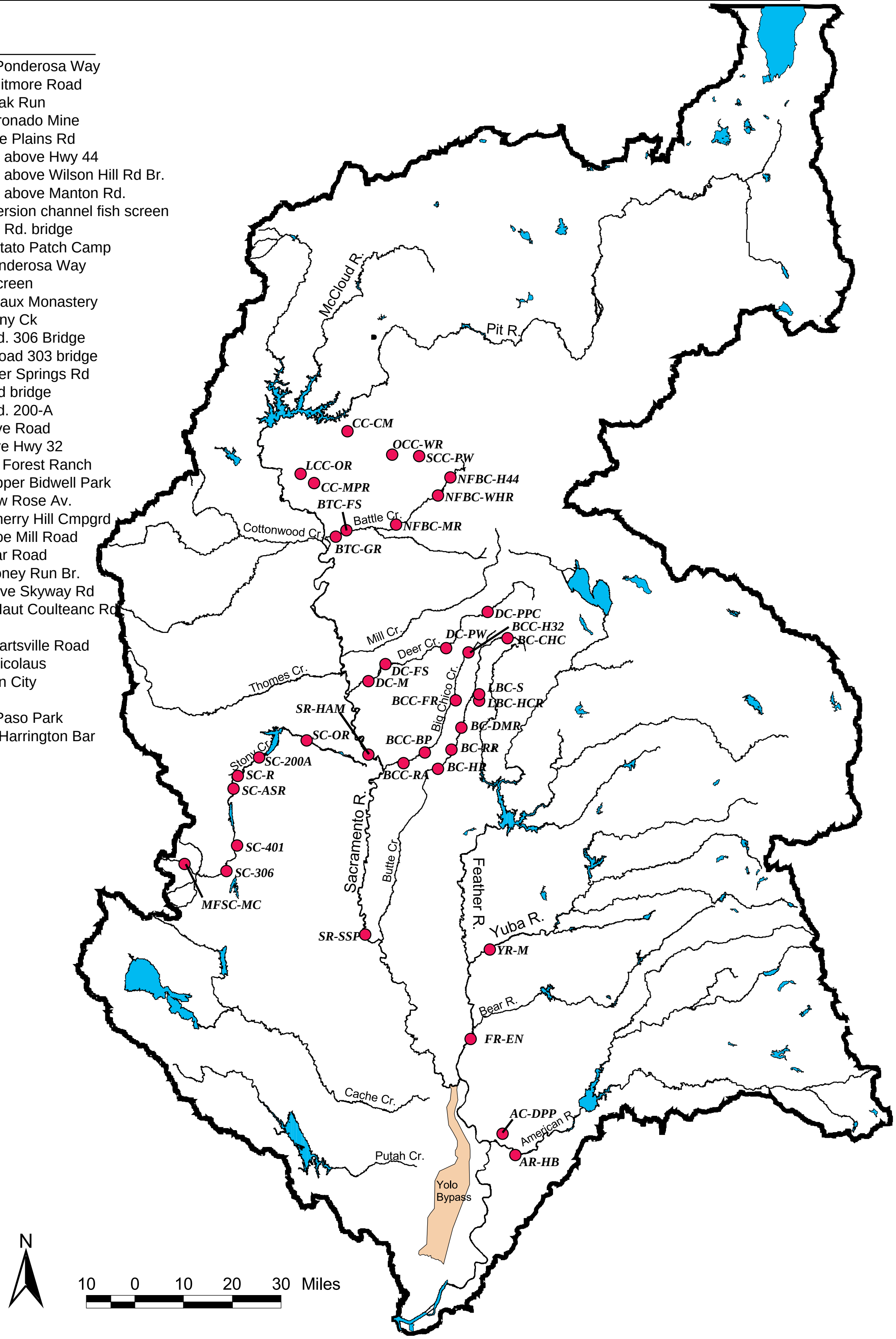


Figure 20. SRWP bioassessment monitoring in the Sacramento River watershed: Year 3 (2000) monitoring locations

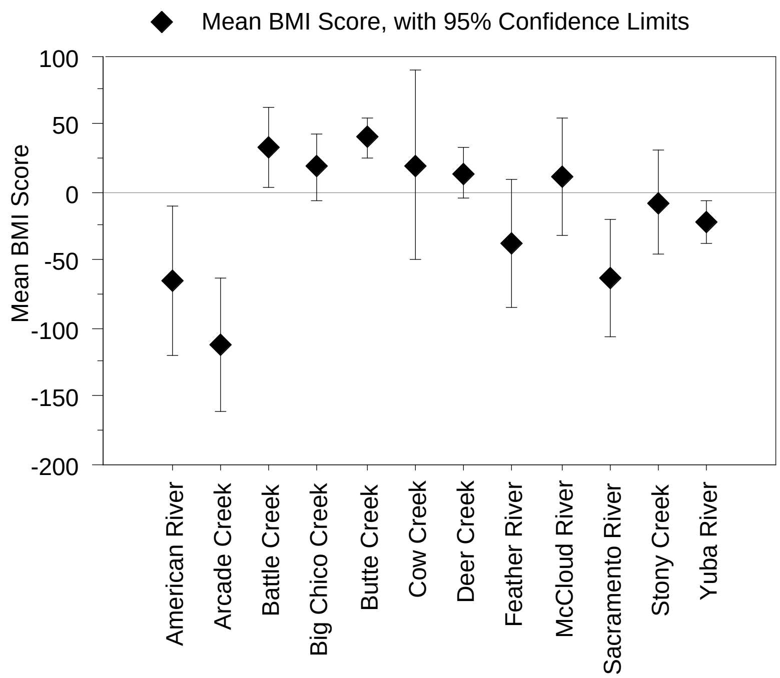


Figure 21. Relative ranking scores for watersheds sampled in 1997 through 2000

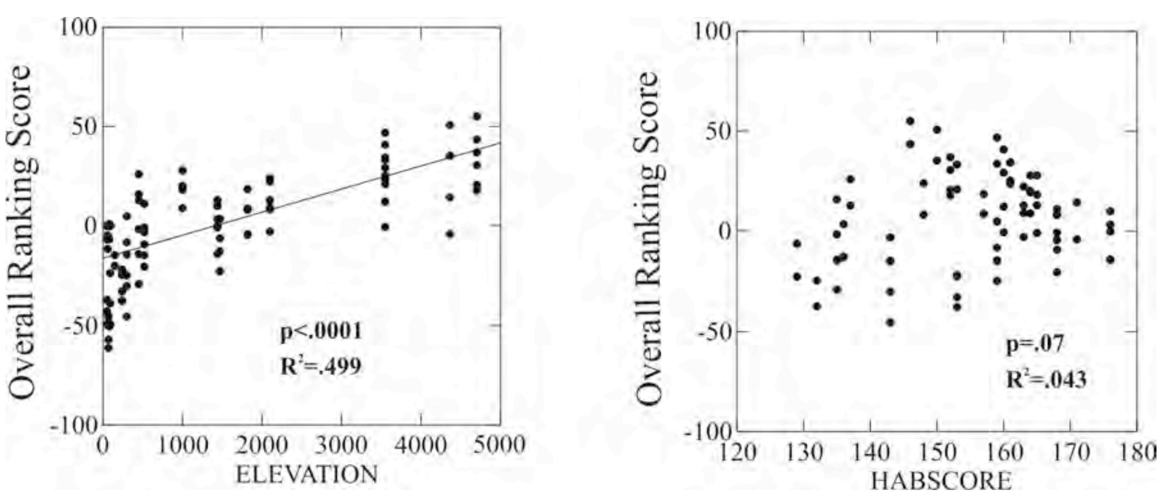


Figure 22. Relationships Between Biological Ranking Score and (a) Elevation, and (b) Physical Habitat Score, 1997-1999.

III. Year 4 and 5 Monitoring Plan

A number of significant changes were implemented by the Monitoring Sub-Committee for the Year 3 monitoring effort. These changes were implemented to meet the following objectives:

- To provide more focus on the water quality issues of greatest concern (mercury and organophosphate pesticides);
- To provide additional support for development of Water Quality Management Strategies for these pollutants;
- To shift more funding to special studies designed to follow-up on identified water quality problems or to fill identified data gaps;
- To provide more funding to tributary watershed groups for monitoring and other projects.

In order to meet these monitoring and funding objectives for Year 3, the Monitoring Sub-Committee conducted a thorough evaluation and reprioritization of monitoring needs for Year 3, based on criteria designed to support the objectives outlined above.

The Year 4 monitoring effort was planned to be largely a continuation of the monitoring performed in Year 3, with a primary focus on supporting development of the management strategies for mercury and organophosphate pesticides. Monitoring will be conducted primarily on an event-based schedule, and will include elements in the following categories:

- Mercury and methylmercury in water;
- Organophosphate, carbamate, and triazine pesticides in water;
- Parameters related to drinking water uses and issues, including nitrogen and phosphorous compounds, coliform bacteria, organic carbon, and selected "conventional" parameters in water;
- Causes and sources of aquatic toxicity (*Ceriodaphnia* toxicity testing and Toxicity Identification Evaluations)
- Mercury and organochlorine pesticides and PCBs in fish tissue;
- Bioassessment (identification of reference conditions in the Sierra Nevada foothill ecoregion);
- Continued funding of selected "Special Tributary Monitoring" projects;
- Selected special studies for mercury.

The frequency of monitoring was reduced to 6 events for Year 4 (due to budget cuts for the program), and all events were conducted on an "episodic" basis. The Year 4 monitoring plan approved by the SRWP Monitoring Sub-Committee is summarized in Table 32. The scope of the Year 5 monitoring program planned to be implemented 2002–2003 is nearly identical to the Year 4 monitoring plan, with additional reductions in monitoring frequency and planned special studies.

Table 32. SRWP Monitoring for 2001-2002: Locations, Analytes, and Numbers of Annual Sample Events

	Chemical Characteristics															Aquatic Toxicity		Fish Tissue		Bioassess-ment[b]	
Monitoring Locations	Hg and MeHg (filtered and unfiltered)	TSS	Hardness	Alkalinity	TOC	DOC	UVA 254	TDS	Nitrogen and Phosphorus compounds	OP pesticides	carbamate pesticides	triazines	*E. coli*	*Enterococcus*	Total, Fecal Coliforms	Ceriodaphnia	WC Tox Followup (a)	Mercury	PCBs & chlor. pest.	Benthic Invertebrates	Habitat Assessment
Pit R. above Shasta			atox	atox												6 E	E			RB	
McCloud R. above Shasta																				(b)	
Sac. R. above Shasta																	E			(b)	
Spring Ck. PP Discharge																				(b)	
Sac. R. below Keswick	5 E	5 E	atox	atox				RED		DWR	DWR					6 E	E	2	2		
Clear Creek	DWR	DWR	DWR							DWR	DWR									(b)	
Cow Creek at Mouth	DWR	DWR	DWR							DWR	DWR									(b)	
Cow Creek (multiple sites)																				(b)	
Cottonwood Ck at mouth	DWR	DWR	atox	atox						DWR	DWR					6 E	E				
Cottonwood Creek (3 sites)	12 E	12 E																			
Battle Creek at mouth	DWR	DWR	DWR							DWR	DWR									(b)	
Battle Creek (3 sites)	12 E	12 E																			
Sac. R. at Bend Br	5 E	5 E	atox	atox	6 E	6 E	6 E	6 E	6 E	DWR	DWR		6 E	6 E	6 E	6 E	E				
Paynes Ck	DWR	DWR	DWR							DWR	DWR									(b)	
Reeds Ck	DWR	DWR	DWR							DWR	DWR									TEH	
Red Bank Ck	DWR	DWR	DWR							DWR	DWR									TEH	
Elder Ck	DWR	DWR	DWR							DWR	DWR									(b)	
Antelope Ck	DWR	DWR	DWR							DWR	DWR									(b)	
Mill Creek @ Los Molinos	DWR	DWR	DWR							3 E											
Mill Creek (multiple sites)																				(b)	
Deer Creek	DWR	DWR	DWR							3 E											
Thomes Ck	DWR	DWR	DWR							DWR	DWR									(b)	
Thomes Creek (3 sites)	12 E	12 E																			
Coast Range reservoirs (3)	DWR	DWR	DWR							DWR	DWR									(b)	
Stony Creek	DWR	DWR	DWR							DWR	DWR									(b)	
Stony Creek (multiple sites)																				(b)	
Dry Creek (trib to Little Chico Ck)	4 E	4 E																			
Little Chico Creek	4 E	4 E																			
Big Chico Creek at Mouth	DWR	DWR	DWR							3 E											
Sac. R. near Hamilton City	5 E	5 E	atox	atox	6 E	6 E	6 E	6 E	6 E	6 E			6 E	6 E	6 E	6 E	E				
Sac. R. @ Colusa	5 E	5 E	atox	atox	6 E	6 E	6 E	6 E	6 E	6 E			6 E	6 E	6 E	6 E	E				
Butte Creek										DPR						DWR				(b)	
Sutter Bypass										DPR	DPR	DPR				DPR				(b)	
Ag Drains (Sutter, Colusa, Tehama Co.)																				RB	
Sac. Slough	4 E	4 E	atox	atox	6 E	6 E	6 E	6 E	6 E	6 E	6 E		6 E	6 E	6 E	6 E	E				
Colusa Basin Dr	4 E	4 E	atox	atox	6 E	6 E	6 E	6 E	6 E	6 E	6 E		6 E	6 E	6 E	6 E	E	2	3		
Bear River	GS									DPR						DPR				(b)	
Bear River reservoirs																		GS		(b)	
Other Yuba River sites										DPR	DPR									(b)	
Yuba R. at Marysville	5 E	5 E	atox	atox	6 E	6 E	6 E	6 E	6 E	6 E	6 E		6 E	6 E	6 E	6 E	E				
South Yuba River sites	GS																	GS		(b)	
Feather R. (multiple reference sites)																				RB	
Feather R. between Yuba and Bear R.																		2	2		
Feather R. near Nicolaus	5 E	5 E	atox	atox	6 E	6 E	6 E	6 E	6 E	6 E		4 E	6 E	6 E	6 E	6 E	E	2	2		
Sac. R. at Veterans Br.	CMP	CMP	CMP	6	CMP	CMP	6	6	6	6 E		4 E	CMP	6	CMP						
Coon Ck/Auburn Ravine																				RB	
Arcade Creek	4 E	4 E	atox	atox						6 E	6 E	6 E				6 E	E				
Natomas East Main Drain			DWR	DWR	DWR	DWR	DWR	DWR	6				6 E	6 E	6 E						
American R. above J St.																		2	2		
American R. at Discovery Pk	CMP	CMP	atox	atox	CMP	CMP	6	CMP	6	CMP			CMP	6	CMP	6 E	E	2	2		
Sac. R. at Freeport	CMP, GS	CMP	atox	atox	CMP	CMP	6	CMP	6	GS	GS	GS	CMP	6	CMP	6 E	E				
Sac. R. at RM44	CMP	CMP	CMP	6	CMP	CMP	6	CMP	6	CMP			CMP	6	CMP			4	4		
Sac. R. at Greene's Landing																				(b)	
Yolo Bypass	GS	GS	GS		GS	GS	GS	GS		GS	GS	GS								(b)	
Cache Creek at Rumsey		CF	atox	atox	CF	CF	CF	CF								6 E	E	2	2		
Prospect Slough																		2	2		
Cache Sl. near Ryers Ferry																				(b)	
Number Sites Monitored by SRWP	20	14	14	16	7	7	11	8	12	11	4	3	8	12	8	14	(c)	9	9	(b)	(b)
Number of Regular Analyses	86	86	0	12	42	42	66	48	72	57	24	14	48	72	48	84	(a)	20	21	(b)	(b)
Additional QC Analyses	12	9	0	0	12	12	12	6	12	12	12	12	6	6	6	12	(a)	2	2	(b)	(b)

Table Notes: Values indicate number of environmental samples collected annually. Additional samples are collected for Quality Assurance. Values appended with "E" indicate that monitoring will be "event-based". "atox" indicates parameter will be measured as part of aquatic toxicity monitoring effort. Other text entries indicate data or samples collected by primary coordinating programs: CMP = Sacramento River Coordinated Monitoring Program; GS = USGS; CF = CALFED; RB =Central Valley Regional Board; DWR = Dept of Water Resources; TEH = Tehama County RCD

(a) A fixed budget of $60,000 is allocated for Toxicity follow-up consisting of chemistry, TIE testing, and additional sampling that has no fixed frequency.

(b) Bioassessment monitoring includes physical habitat and biological assessments. Monitoring in 2001-2002 will consist primarily of identifying potential reference sites.

IV. Database and Data Access

Larry Walker Associates (LWA) is responsible for both data management and database development for the Sacramento River Watershed Program. All data collected by the SRWP is currently stored in a normalized, relational database (Microsoft Access) specifically designed by LWA and the Department of Water Resources (Interagency Ecological Program) to house water chemistry and toxicity test data. The sampling crews and laboratories contracted to collect and analyze the Program's monitoring data provide the data manager (LWA) with electronic and hard copy data that are then imported into the SRWP Database. These data are then validated and qualified according to the protocols described in the SRWP QAPP. In addition to the results reported in SRWP Annual Monitoring Reports, final qualified data will be made available to all interested users on the SRWP website (http://www.sacriver.org) as text and excel files.

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APPENDIX A

Summary Statistics for Monitoring Data: SRWP, USGS NAWQA, Sacramento River CMP, and City of Redding

Summary Statistics: Mercury Data

Mercury, total, filtered

Units = ng/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
SRBKR	Sacramento River below Keswick	7/19/00	4/17/01	6	5	83.3%	0.35	0.67	0.44	0.17	0.41	0.26	0.20
SRABB	Sacramento River above Bend Bridge	7/19/00	5/15/01	9	8	88.9%	0.36	2.67	0.66	1.04	0.49	0.50	0.20
MCMOU	Mill Creek at Mouth	7/19/00	5/15/01	9	9	100%	0.59	2.24	1.40	0.55	1.30	0.90	NR
MCHYN	Mill Creek at Highway 99	4/6/01	4/7/01	4	4	100%	1.13	5.34	3.08	2.24	2.41	3.78	NR
SRHAM	Sacramento River near Hamilton City	7/20/00	5/15/01	9	8	88.9%	0.43	2.15	0.71	0.70	0.59	0.55	0.20
SRCOL	Sacramento River at Colusa	7/20/00	5/16/01	9	9	100%	0.22	1.24	0.64	0.31	0.58	0.46	NR
SACSL	Sacramento Slough	7/21/00	5/16/01	9	9	100%	0.28	2.14	0.80	0.64	0.66	0.69	NR
COLDR	Colusa Basin Drain	7/21/00	5/16/01	9	8	88.9%	0.48	1.33	0.72	0.38	0.65	0.49	0.20
YRMRY	Yuba River at Marysville	7/20/00	5/16/01	9	9	100%	0.44	3.12	1.18	0.94	0.97	1.03	NR
FRNIC	Feather River near Nicolaus	7/21/00	5/16/01	9	9	100%	0.22	1.05	0.67	0.26	0.62	0.41	NR
SRVET	Sacramento River at Veterans Bridge	1/18/94	6/20/01	109	108	99%	0.47	7.96	1.81	1.25	1.49	1.30	0.50
ARCNW	Arcade Creek at Norwood Ave.	7/21/00	5/17/01	9	9	100%	1.23	4.02	2.03	0.98	1.88	1.22	NR
ARDPK	American River at Discovery Park	1/18/94	6/19/01	103	97	94.2%	0.07	3.89	1.37	0.90	1.09	1.12	0.41
SRFPT	Sacramento River at Freeport	2/15/94	6/19/01	106	105	99%	0.30	14.92	1.86	1.81	1.45	1.39	0.50
SRRMF	Sacramento River at River Mile 44	1/18/94	6/19/01	101	100	99%	0.46	11.10	1.84	1.51	1.47	1.38	0.50
SRGRN	Sacramento River at Greene's Landing	1/1/00	10/1/01	27	27	100%	0.15	2.56	0.88	0.66	0.71	0.71	NR

Mercury, total, unfiltered

Units = ng/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
SCKPP	Spring Creek PP Discharge to Keswick Res.	6/24/98	4/18/00	11	11	100%	0.51	1.65	1.15	0.38	1.09	0.62	NR
SRBKR	Sacramento River below Keswick	1/20/98	4/17/01	53	52	98.1%	0.19	10.4	1.44	1.62	1.14	1.05	0.03
SRABB	Sacramento River above Bend Bridge	2/13/96	5/15/01	48	48	100%	0.75	32.6	3.62	5.67	2.27	2.83	NR
MCMOU	Mill Creek at Mouth	6/23/98	5/15/01	28	28	100%	2.04	485	34.3	115	10.2	22.2	NR
MCHYN	Mill Creek at Highway 99	4/6/01	4/7/01	4	4	100%	4.38	7.55	6.20	1.50	6.08	2.59	NR
MCBLR	Mill Creek at Black Rock	6/23/98	4/6/01	19	19	100%	2.00	110	26.9	33.3	13.7	29.3	NR
MCHWY	Mill Creek at Highway 36	6/23/98	4/17/00	19	19	100%	4.38	1910	155	581	42.8	104	NR
SRHAM	Sacramento River near Hamilton City	6/23/99	5/15/01	20	20	100%	0.87	32.4	4.70	8.54	2.45	3.47	NR
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	14	14	100%	0.32	6.0	1.19	1.78	0.83	0.98	NR
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	4/17/00	20	20	100%	0.22	10.3	2.34	3.34	1.00	2.22	NR
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	12	12	100%	0.15	5.0	0.84	1.74	0.50	0.65	NR
DCMDW	Deer Creek below Childs Meadows	6/24/98	4/17/00	19	19	100%	0.16	7.0	1.16	1.80	0.74	1.00	NR
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	21	20	95.2%	0.33	10.1	2.16	2.73	1.16	2.24	0.2
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	11	11	100%	0.40	57.7	7.38	22.7	2.21	5.64	NR
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	19	19	100%	0.23	10.0	1.39	2.66	0.78	1.11	NR
CHASH	Big Chico Creek above Salmon Hole	6/23/98	2/14/00	16	15	93.8%	0.20	6.40	1.44	1.91	0.81	1.34	3
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	19	18	94.7%	0.18	4.90	0.91	1.23	0.62	0.83	3
SRCOL	Sacramento River at Colusa	2/28/96	5/16/01	54	54	100%	1.30	105	8.11	17.3	4.93	5.74	NR
SACSL	Sacramento Slough	2/12/96	5/16/01	43	43	100%	3.78	30.8	8.85	5.21	7.87	5.27	NR
COLDR	Colusa Basin Drain	3/6/96	5/16/01	46	46	100%	1.59	19.3	7.95	3.85	7.11	5.04	NR
YRMRY	Yuba River at Marysville	2/27/96	5/16/01	46	46	100%	1.09	46.7	5.37	8.64	3.27	3.95	NR
FRNIC	Feather River near Nicolaus	2/23/96	5/16/01	47	47	100%	1.65	46.2	6.90	8.11	5.15	4.90	NR
SRVON	Sacramento River at Verona	2/22/96	5/20/98	28	28	100%	2.46	39.8	8.57	8.17	6.86	6.26	NR
SRVET	Sacramento River at Veterans Bridge	1/18/94	6/20/01	109	109	100%	3.19	34.9	9.29	5.56	8.02	5.97	NR
ARCNW	Arcade Creek at Norwood Ave.	3/5/96	5/17/01	46	46	100%	1.06	54.3	10.3	11.0	7.28	8.45	NR
ARDPK	American River at Discovery Park	1/18/94	6/19/01	106	106	100%	0.56	13.3	3.30	2.46	2.64	2.54	NR
SRFPT	Sacramento River at Freeport	2/15/94	6/19/01	159	159	100%	1.20	36.2	8.46	6.45	6.79	6.26	NR
SRRMF	Sacramento River at River Mile 44	1/18/94	6/19/01	103	103	100%	2.13	73.4	9.87	9.68	7.52	7.48	NR
SRGRN	Sacramento River at Greene's Landing	1/1/00	10/1/01	26	26	100%	2.06	22.9	4.87	4.89	3.96	3.07	NR
CCHCK	Cache Creek at Rumsey	2/9/96	8/18/99	47	47	100%	2.68	2247.6	115	408	20.4	56.9	NR
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	11	11	100%	3.09	18.2	8.62	4.43	7.77	6.07	NR
YOLOB	Yolo Bypass near Woodland	1/31/97	4/30/98	10	10	100%	17.9	224	48.2	82.9	33.6	36.1	NR

Summary Statistics: Mercury Data

Methylmercury, filtered

Units = ng/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
SRBKR	Sacramento River below Keswick	7/19/00	4/17/01	6	1	16.7%	0.022	0.022	ID	ID	ID	ID	0.020
SRABB	Sacramento River above Bend Bridge	7/19/00	5/15/01	9	2	22.2%	0.032	0.046	ID	ID	ID	ID	0.020
MCMOU	Mill Creek at Mouth	7/19/00	5/15/01	9	9	100%	0.029	0.315	0.108	0.102	0.079	0.110	NR
MCHYN	Mill Creek at Highway 99	4/6/01	4/7/01	4	4	100%	0.025	0.045	0.033	0.010	0.032	0.015	NR
SRHAM	Sacramento River near Hamilton City	7/20/00	5/15/01	9	5	55.6%	0.02	0.045	0.020	0.013	0.016	0.017	0.020
SRCOL	Sacramento River at Colusa	7/20/00	5/16/01	9	8	88.9%	0.021	0.081	0.038	0.021	0.034	0.027	0.020
SACSL	Sacramento Slough	7/21/00	5/16/01	9	9	100%	0.021	0.114	0.059	0.032	0.052	0.046	NR
COLDR	Colusa Basin Drain	7/21/00	5/16/01	9	9	100%	0.024	0.229	0.089	0.074	0.067	0.093	NR
YRMRY	Yuba River at Marysville	7/20/00	5/16/01	9	8	88.9%	0.037	0.145	0.072	0.043	0.062	0.061	0.020
FRNIC	Feather River near Nicolaus	7/21/00	5/16/01	9	8	88.9%	0.03	0.196	0.062	0.064	0.048	0.057	0.020
SRVET	Sacramento River at Veterans Bridge	10/17/00	6/20/01	8	7	87.5%	0.038	0.077	0.051	0.015	0.050	0.022	0.029
ARCNW	Arcade Creek at Norwood Ave.	7/21/00	5/17/01	9	9	100%	0.071	1.183	0.247	0.461	0.151	0.203	NR
ARDPK	American River at Discovery Park	10/17/00	6/19/01	8	7	87.5%	0.028	0.064	0.038	0.014	0.036	0.019	0.027
SRFPT	Sacramento River at Freeport	10/18/00	6/19/01	9	8	88.9%	0.028	0.077	0.046	0.016	0.044	0.022	0.029
SRRMF	Sacramento River at River Mile 44	10/18/00	6/19/01	9	8	88.9%	0.038	0.752	0.140	0.302	0.068	0.129	0.029
SRGRN	Sacramento River at Greene's Landing	1/1/00	10/1/01	27	27	100%	0.02	0.336	0.093	0.072	0.0744	0.078	NR

Methylmercury, unfiltered

Units = ng/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
SRBKR	Sacramento River below Keswick	7/19/00	4/17/01	6	1	16.7%	0.036	0.036	ID	ID	ID	ID	0.02
SRABB	Sacramento River above Bend Bridge	7/19/00	5/15/01	9	6	66.7%	0.022	0.101	0.0357	0.033	0.026	0.039	0.02
MCMOU	Mill Creek at Mouth	7/19/00	5/15/01	9	9	100%	0.025	0.403	0.180	0.133	0.135	0.204	NR
MCHYN	Mill Creek at Highway 99	4/6/01	4/7/01	4	4	100%	0.030	0.067	0.0558	0.022	0.053	0.033	NR
SRHAM	Sacramento River near Hamilton City	7/20/00	5/15/01	9	8	88.9%	0.034	0.213	0.071	0.068	0.056	0.066	0.02
SRCOL	Sacramento River at Colusa	2/28/96	5/16/01	38	37	97.4%	0.046	1.265	0.1725	0.238	0.120	0.132	0.025
SACSL	Sacramento Slough	2/12/96	5/16/01	32	32	100%	0.057	1.180	0.2293	0.241	0.171	0.180	NR
COLDR	Colusa Basin Drain	3/6/96	5/16/01	34	34	100%	0.021	0.888	0.2224	0.172	0.174	0.194	NR
YRMRY	Yuba River at Marysville	7/20/00	5/16/01	9	9	100%	0.032	0.260	0.1224	0.082	0.102	0.112	NR
FRNIC	Feather River near Nicolaus	7/21/00	5/16/01	9	9	100%	0.035	0.277	0.1049	0.082	0.087	0.091	NR
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	27	100%	0.006	1.977	0.2216	0.450	0.122	0.195	NR
SRVET	Sacramento River at Veterans Bridge	11/7/00	6/20/01	6	6	100%	0.100	0.160	0.1342	0.022	0.133	0.037	NR
ARCNW	Arcade Creek at Norwood Ave.	7/21/00	5/17/01	9	9	100%	0.130	1.213	0.3851	0.393	0.309	0.325	NR
ARDPK	American River at Discovery Park	11/7/00	6/19/01	7	7	100%	0.047	0.123	0.078	0.031	0.074	0.042	NR
SRFPT	Sacramento River at Freeport	2/20/96	6/19/01	52	51	98.1%	0.012	0.780	0.1369	0.135	0.101	0.117	0.025
SRRMF	Sacramento River at River Mile 44	11/8/00	6/19/01	8	8	100%	0.077	0.180	0.1324	0.031	0.129	0.050	NR
SRGRN	Sacramento River at Greene's Landing	1/1/00	10/1/01	33	33	100%	0.013	0.164	0.0656	0.041	0.053	0.056	NR
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	0.035	0.395	0.1562	0.107	0.128	0.147	NR

Summary Statistics Table Notes:
monitoring period start and end — Dates of first and last reported data.
n — Total number of data reported.
n det — Total number of data above reporting limits.
% det — Percent of data above reporting limits.
min det — Minimum value for data detected above reporting limits.
max det — Maximum value of data detected above reporting limits.
mean — Arithmetic mean value. "ID" if insufficient data to calculate.
SD — Standard Deviation. "ID" if insufficient data to calculate.
median — 50th percentile value. "ID" if insufficient data to calculate.
IQR — Interquartile range. "ID" if insufficient data to calculate.
min RL — Lowest reporting limit for data below detection. "NR" indicates there were no data below reporting limits.

Summary Statistics: Data for Pesticides Detected in SRWP Monitoring

Aldicarb

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
SACSL	Sacramento Slough	6/22/99	6/21/01	21	0	0%	ND	ND	ID	ID	ID	ID	0.40
COLDR	Colusa Basin Drain	6/23/99	6/22/01	22	1	4.5%	0.70	0.70	ID	ID	ID	ID	0.40
SRVET	Sacramento River at Veterans Bridge	9/19/00	6/20/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.40
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	6/22/01	21	0	0%	ND	ND	ID	ID	ID	ID	0.40
ARDPK	American River at Discovery Park	9/19/00	6/19/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.40
SRFPT	Sacramento River at Freeport	9/20/00	6/19/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.40
SRRMF	Sacramento River at River Mile 44	9/20/00	6/19/01	3	0	0%	ND	ND	ID	ID	ID	ID	0.40

Bromacil

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
SACSL	Sacramento Slough	6/22/99	6/21/01	21	0	0%	ND	ND	ID	ID	ID	ID	0.4
COLDR	Colusa Basin Drain	6/23/99	6/22/01	21	4	19%	0.4	0.5	ID	ID	ID	ID	0.4
SRVET	Sacramento River at Veterans Bridge	9/19/00	6/20/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.4
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	6/22/01	21	3	14%	0.4	1	ID	ID	ID	ID	0.4
ARDPK	American River at Discovery Park	9/19/00	6/19/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.4
SRFPT	Sacramento River at Freeport	9/20/00	6/19/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.4
SRRMF	Sacramento River at River Mile 44	9/20/00	6/19/01	3	0	0%	ND	ND	ID	ID	ID	ID	0.4

Carbaryl

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
SACSL	Sacramento Slough	6/22/99	6/21/01	21	1	5%	0.14	0.14	ID	ID	ID	ID	0.07
COLDR	Colusa Basin Drain	6/23/99	6/22/01	21	0	0%	ND	ND	ID	ID	ID	ID	0.07
SRVET	Sacramento River at Veterans Bridge	9/19/00	6/20/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.07
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	6/22/01	21	4	19%	0.1	0.3	ID	ID	ID	ID	0.07
ARDPK	American River at Discovery Park	9/19/00	6/19/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.07
SRFPT	Sacramento River at Freeport	9/20/00	6/19/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.07
SRRMF	Sacramento River at River Mile 44	9/20/00	6/19/01	3	0	0%	ND	ND	ID	ID	ID	ID	0.1

Carbofuran

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
SACSL	Sacramento Slough	6/22/99	6/21/01	20	1	5%	0.11	0.11	ID	ID	ID	ID	0.07
COLDR	Colusa Basin Drain	6/23/99	6/22/01	21	2	10%	0.07	0.4	ID	ID	ID	ID	0.07
SRVET	Sacramento River at Veterans Bridge	9/19/00	6/20/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.07
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	6/22/01	21	0	0%	ND	ND	ID	ID	ID	ID	0.07
ARDPK	American River at Discovery Park	9/19/00	6/19/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.07
SRFPT	Sacramento River at Freeport	9/20/00	6/19/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.07
SRRMF	Sacramento River at River Mile 44	9/20/00	6/19/01	3	0	0%	ND	ND	ID	ID	ID	ID	0.1

Chlorpyrifos

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
MCMOU	Mill Creek at Mouth	1/26/01	5/29/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.05
SRHAM	Sacramento River near Hamilton City	6/23/99	6/21/01	20	0	0.0%	ND	ND	ID	ID	ID	ID	0.05
DCMOU	Deer Creek at Mouth	1/26/01	5/29/01	4	0	0.0%	ND	ND	ID	ID	ID	ID	0.05
CHMOU	Big Chico Creek at Mouth	1/26/01	5/29/01	4	0	0.0%	ND	ND	ID	ID	ID	ID	0.05
SRCOL	Sacramento River at Colusa	6/24/99	6/21/01	22	0	0.0%	ND	ND	ID	ID	ID	ID	0.05
SACSL	Sacramento Slough	6/22/99	6/21/01	20	0	0.0%	ND	ND	ID	ID	ID	ID	0.05
COLDR	Colusa Basin Drain	6/23/99	6/22/01	21	1	4.8%	0.7	0.7	ID	ID	ID	ID	0.05
FRNIC	Feather River near Nicolaus	7/21/00	6/22/01	9	0	0.0%	ND	ND	ID	ID	ID	ID	0.05
SRVET	Sacramento River at Veterans Bridge	7/20/99	6/22/01	29	0	0.0%	ND	ND	ID	ID	ID	ID	0.05
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	6/22/01	21	1	4.8%	0.05	0.05	ID	ID	ID	ID	0.05
ARDPK	American River at Discovery Park	9/19/00	6/19/01	8	0	0.0%	ND	ND	ID	ID	ID	ID	0.05
SRFPT	Sacramento River at Freeport	9/20/00	6/19/01	8	0	0.0%	ND	ND	ID	ID	ID	ID	0.05
SRRMF	Sacramento River at River Mile 44	9/20/00	6/19/01	7	0	0.0%	ND	ND	ID	ID	ID	ID	0.05

Summary Statistics: Data for Pesticides Detected in SRWP Monitoring

Diazinon

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
MCMOU	Mill Creek at Mouth	1/26/01	5/29/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.05
SRHAM	Sacramento River near Hamilton City	6/23/99	6/21/01	20	0	0.0%	ND	ND	ID	ID	ID	ID	0.05
DCMOU	Deer Creek at Mouth	1/26/01	5/29/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.05
CHMOU	Big Chico Creek at Mouth	1/26/01	5/29/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.05
SRCOL	Sacramento River at Colusa	6/24/99	6/21/01	22	0	0%	ND	ND	ID	ID	ID	ID	0.05
SACSL	Sacramento Slough	6/22/99	6/21/01	21	1	5%	0.05	0.05	ID	ID	ID	ID	0.05
COLDR	Colusa Basin Drain	6/23/99	6/22/01	21	1	5%	0.1	0.10	ID	ID	ID	ID	0.05
FRNIC	Feather River near Nicolaus	7/21/00	6/22/01	9	0	0%	ND	ND	ID	ID	ID	ID	0.05
SRVET	Sacramento River at Veterans Bridge	7/20/99	6/22/01	30	2	7%	0.04	0.05	ID	ID	ID	ID	0.05
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	6/22/01	21	17	81%	0.06	0.83	0.22	0.20	0.16	0.21	0.05
ARDPK	American River at Discovery Park	9/19/00	6/19/01	8	2	25%	0.05	0.05	ID	ID	ID	ID	0.05
SRFPT	Sacramento River at Freeport	9/20/00	6/19/01	8	1	13%	0.05	0.05	ID	ID	ID	ID	0.05
SRRMF	Sacramento River at River Mile 44	9/20/00	6/19/01	7	0	0%	ND	ND	ID	ID	ID	ID	0.05

Diuron

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
SACSL	Sacramento Slough	6/22/99	6/21/01	20	1	5%	0.7	0.7	ID	ID	ID	ID	0.4
COLDR	Colusa Basin Drain	6/23/99	6/22/01	21	5	23.8%	0.4	0.9	0.26	0.23	0.19	0.26	0.4
SRVET	Sacramento River at Veterans Bridge	9/19/00	6/20/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.4
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	6/22/01	21	6	28.6%	0.7	6.3	0.60	1.82	0.20	0.49	0.4
ARDPK	American River at Discovery Park	9/19/00	6/19/01	4	1	25.0%	0.6	0.6	ID	ID	ID	ID	0.4
SRFPT	Sacramento River at Freeport	9/20/00	6/19/01	4	1	25.0%	0.4	0.4	ID	ID	ID	ID	0.4
SRRMF	Sacramento River at River Mile 44	9/20/00	6/19/01	3	0	0.0%	ND	ND	ID	ID	ID	ID	0.4

EPTC

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
MCMOU	Mill Creek at Mouth	1/26/01	5/29/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.1
SRHAM	Sacramento River near Hamilton City	4/18/00	6/21/01	10	1	10%	0.12	0.12	ID	ID	ID	ID	0.1
DCMOU	Deer Creek at Mouth	1/26/01	5/29/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.1
CHMOU	Big Chico Creek at Mouth	1/26/01	5/29/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.1
SRCOL	Sacramento River at Colusa	5/16/00	6/21/01	11	0	0%	ND	ND	ID	ID	ID	ID	0.1
SACSL	Sacramento Slough	4/18/00	6/21/01	11	0	0%	ND	ND	ID	ID	ID	ID	0.1
COLDR	Colusa Basin Drain	4/18/00	6/22/01	11	0	0%	ND	ND	ID	ID	ID	ID	0.1
FRNIC	Feather River near Nicolaus	7/21/00	6/22/01	9	0	0%	ND	ND	ID	ID	ID	ID	0.1
SRVET	Sacramento River at Veterans Bridge	5/16/00	6/22/01	9	0	0%	ND	ND	ID	ID	ID	ID	0.1
ARCNW	Arcade Creek at Norwood Ave.	4/19/00	6/22/01	12	0	0%	ND	ND	ID	ID	ID	ID	0.1

Malathion

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
MCMOU	Mill Creek at Mouth	1/26/01	5/29/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.1
SRHAM	Sacramento River near Hamilton City	6/23/99	6/21/01	20	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
DCMOU	Deer Creek at Mouth	1/26/01	5/29/01	4	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
CHMOU	Big Chico Creek at Mouth	1/26/01	5/29/01	4	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
SRCOL	Sacramento River at Colusa	6/24/99	6/21/01	22	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
SACSL	Sacramento Slough	6/22/99	6/21/01	20	1	5.0%	0.1	0.1	ID	ID	ID	ID	0.1
COLDR	Colusa Basin Drain	6/23/99	6/22/01	21	1	4.8%	0.24	0.24	ID	ID	ID	ID	0.1
FRNIC	Feather River near Nicolaus	7/21/00	6/22/01	9	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
SRVET	Sacramento River at Veterans Bridge	7/20/99	6/22/01	29	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	6/22/01	21	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
ARDPK	American River at Discovery Park	9/19/00	6/19/01	8	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
SRFPT	Sacramento River at Freeport	9/20/00	6/19/01	8	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
SRRMF	Sacramento River at River Mile 44	9/20/00	6/19/01	7	0	0.0%	ND	ND	ID	ID	ID	ID	0.1

Summary Statistics: Data for Pesticides Detected in SRWP Monitoring

Methomyl

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
SACSL	Sacramento Slough	6/22/99	6/21/01	21	0	0%	ND	ND	ID	ID	ID	ID	0.07
COLDR	Colusa Basin Drain	6/23/99	6/22/01	22	1	4.5%	0.19	0.19	ID	ID	ID	ID	0.07
SRVET	Sacramento River at Veterans Bridge	3/21/00	6/20/01	5	0	0%	ND	ND	ID	ID	ID	ID	0.07
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	6/22/01	22	0	0.0%	ND	ND	ID	ID	ID	ID	0.07
ARDPK	American River at Discovery Park	9/21/99	6/19/01	5	0	0.0%	ND	ND	ID	ID	ID	ID	0.07
SRFPT	Sacramento River at Freeport	5/17/00	6/19/01	5	0	0.0%	ND	ND	ID	ID	ID	ID	0.07
SRRMF	Sacramento River at River Mile 44	9/20/00	6/19/01	3	0	0.0%	ND	ND	ID	ID	ID	ID	0.1

Prometon

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
MCMOU	Mill Creek at Mouth	1/26/01	5/29/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.1
SRHAM	Sacramento River near Hamilton City	6/23/99	6/21/01	20	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
DCMOU	Deer Creek at Mouth	1/26/01	5/29/01	4	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
CHMOU	Big Chico Creek at Mouth	1/26/01	5/29/01	4	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
SRCOL	Sacramento River at Colusa	6/24/99	6/21/01	22	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
SACSL	Sacramento Slough	6/22/99	6/21/01	21	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
COLDR	Colusa Basin Drain	6/23/99	6/22/01	21	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
FRNIC	Feather River near Nicolaus	7/21/00	6/22/01	9	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
SRVET	Sacramento River at Veterans Bridge	7/20/99	6/22/01	19	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	6/22/01	21	4	19.0%	0.1	0.21	ID	ID	ID	ID	0.1

Propazine

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
FRNIC	Feather River near Nicolaus	10/31/00	4/9/01	4	0	0.0%	ND	ND	ID	ID	ID	ID	0.5
SRVET	Sacramento River at Veterans Bridge	10/31/00	4/9/01	4	0	0.0%	ND	ND	ID	ID	ID	ID	0.5
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	6/22/01	20	2	10.0%	1.1	2.0	ID	ID	ID	ID	0.5

Prowl

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
MCMOU	Mill Creek at Mouth	1/26/01	5/29/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.1
SRHAM	Sacramento River near Hamilton City	6/23/99	6/21/01	21	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
DCMOU	Deer Creek at Mouth	1/26/01	5/29/01	4	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
CHMOU	Big Chico Creek at Mouth	1/26/01	5/29/01	4	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
SRCOL	Sacramento River at Colusa	6/24/99	6/21/01	21	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
SACSL	Sacramento Slough	6/22/99	6/21/01	20	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
COLDR	Colusa Basin Drain	6/23/99	6/22/01	21	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
FRNIC	Feather River near Nicolaus	7/21/00	6/22/01	9	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
SRVET	Sacramento River at Veterans Bridge	7/20/99	6/22/01	21	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	6/22/01	21	2	9.5%	0.1	0.47	ID	ID	ID	ID	0.1
ARDPK	American River at Discovery Park	9/19/00	6/19/01	8	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
SRFPT	Sacramento River at Freeport	9/19/00	6/19/01	8	0	0.0%	ND	ND	ID	ID	ID	ID	0.1
SRRMF	Sacramento River at River Mile 44	9/20/00	6/19/01	7	0	0.0%	ND	ND	ID	ID	ID	ID	0.1

Summary Statistics: Data for Pesticides Detected in SRWP Monitoring

Tebuthiuron

Units = µg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
SACSL	Sacramento Slough	6/22/99	6/21/01	21	0	0%	ND	ND	ID	ID	ID	ID	0.4
COLDR	Colusa Basin Drain	6/23/99	6/22/01	21	0	0.0%	ND	ND	ID	ID	ID	ID	0.4
SRVET	Sacramento River at Veterans Bridge	9/19/00	6/20/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.4
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	6/22/01	21	3	14%	0.4	3.0	ID	ID	ID	ID	0.4
ARDPK	American River at Discovery Park	9/19/00	6/19/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.4
SRFPT	Sacramento River at Freeport	9/20/00	6/19/01	4	0	0%	ND	ND	ID	ID	ID	ID	0.4
SRRMF	Sacramento River at River Mile 44	9/20/00	6/19/01	3	0	0%	ND	ND	ID	ID	ID	ID	0.4

Summary Statistics Table Notes:
monitoring period start and end — Dates of first and last reported data.
n — Total number of data reported.
n det — Total number of data above reporting limits.
% det — Percent of data above reporting limits.
min det — Minimum value for data detected above reporting limits.
max det — Maximum value of data detected above reporting limits.
mean — Arithmetic mean value. "ID" if insufficient data to calculate.
SD — Standard Deviation. "ID" if insufficient data to calculate.
median — 50th percentile value. "ID" if insufficient data to calculate.
IQR — Interquartile range. "ID" if insufficient data to calculate.
min RL — Lowest reporting limit for data below detection. "NR" indicates there were no data below reporting limits.

Summary Statistics: Drinking Water Parameters

Organic Carbon, dissolved

Units = mg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
PRSHA	Pit River above Shasta	11/15/99	5/16/00	4	4	100%	0.9	1.7	1.3	0.4	1.2	0.6	NR
MRSHA	McCloud River above Shasta	11/15/99	5/16/00	4	4	100%	0.5	0.8	0.7	0.1	0.6	0.2	NR
SRSHA	Sacramento River above Shasta	11/15/99	5/16/00	4	4	100%	0.9	1.4	ID	ID	ID	ID	NR
SCKPP	Spring Creek PP Discharge to Keswick Res.	10/20/99	4/18/00	4	4	100%	1.1	1.2	ID	ID	ID	ID	NR
SRBKR	Sacramento River below Keswick	10/20/99	5/16/00	8	8	100%	0.9	1.2	1.0	0.1	1.0	0.2	NR
SRABB	Sacramento River above Bend Bridge	2/13/96	5/15/01	44	44	100%	0.9	4.3	1.6	0.7	1.5	0.6	NR
SRHAM	Sacramento River near Hamilton City	9/22/99	5/15/01	17	17	100%	1.1	5.8	1.9	1.3	1.7	0.9	NR
SRCOL	Sacramento River at Colusa	2/28/96	5/16/01	36	36	100%	1.1	6.4	1.7	1.1	1.6	0.7	NR
SACSL	Sacramento Slough	2/12/96	5/16/01	41	41	100%	1.4	9.0	4.1	1.6	3.8	2.3	NR
COLDR	Colusa Basin Drain	2/7/96	5/16/01	47	47	100%	2.5	12.0	6.1	2.0	5.8	2.7	NR
YRMRY	Yuba River at Marysville	2/27/96	5/16/01	45	45	100%	0.7	3.3	1.2	0.5	1.1	0.5	NR
FRNIC	Feather River near Nicolaus	2/23/96	5/16/01	42	42	100%	1.2	4.2	1.8	0.7	1.7	0.7	NR
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	27	100%	1.3	3.6	1.9	0.6	1.8	0.7	NR
SRVET	Sacramento River at Veterans Bridge	8/15/00	6/20/01	10	10	100%	1.6	3.3	2.2	0.7	2.1	0.9	NR
NEMDR	Natomas East Mian Drain	11/13/97	3/5/01	49	49	100%	3.1	10.4	5.9	1.6	5.7	2.1	NR
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	5/17/00	46	46	100%	1.2	18.0	7.6	2.6	7.2	3.1	NR
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	1.1	6.4	1.7	1.2	1.6	0.7	NR
ARDPK	American River at Discovery Park	8/15/00	6/19/01	9	9	100%	1.2	2.8	1.8	0.5	1.7	0.7	NR
SRFPT	Sacramento River at Freeport	2/20/96	6/19/01	67	67	100%	0.3	3.7	1.8	0.6	1.7	0.8	NR
SRRMF	Sacramento River at River Mile 44	9/22/99	6/19/01	22	21	95.5%	1.5	4.1	2.3	0.7	2.3	0.9	2
CCHSL	Cache Slough near Ryers Ferry	10/20/99	2/16/00	3	3	100%	1.7	4.9	2.9	2.3	2.6	2.8	NR

Organic Carbon, total

Units = mg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
PRSHA	Pit River above Shasta	11/15/99	5/16/00	4	4	100%	1.0	1.8	1.4	0.4	1.3	0.6	NR
MRSHA	McCloud River above Shasta	11/15/99	5/16/00	4	4	100%	0.6	0.9	0.8	0.1	0.7	0.2	NR
SRSHA	Sacramento River above Shasta	11/15/99	5/16/00	4	4	100%	1.0	1.5	ID	ID	ID	ID	NR
SCKPP	Spring Creek PP Discharge to Keswick Res.	10/20/99	4/18/00	4	4	100%	1.2	1.3	ID	ID	ID	ID	NR
SRBKR	Sacramento River below Keswick	10/20/99	5/16/00	8	8	100%	1.0	1.3	1.1	0.1	1.1	0.2	NR
CCMOU	Clear Creek near Mouth	11/17/98	8/17/99	6	6	100%	1.2	1.8	1.4	0.2	1.4	0.4	NR
SRABB	Sacramento River above Bend Bridge	2/13/96	5/15/01	44	44	100%	0.9	6.5	1.9	1.0	1.7	0.8	NR
MCMOU	Mill Creek at Mouth	8/19/98	4/17/00	16	16	100%	0.7	8.2	2.0	2.1	1.5	1.5	NR
SRHAM	Sacramento River near Hamilton City	9/22/99	5/15/01	17	17	100%	0.9	8.9	2.4	2.2	1.9	1.6	NR
DCMOU	Deer Creek at Mouth	8/18/98	4/17/00	9	9	100%	0.9	1.8	1.3	0.3	1.3	0.5	NR
CHMUD	Big Chico Creek above Mud Creek	8/18/98	4/17/00	15	15	100%	0.6	3.1	1.4	0.8	1.2	0.9	NR
MUDCH	Mud Creek above Big Chico Creek	12/15/98	4/17/00	8	8	100%	1.3	3.7	2.6	1.0	2.5	1.6	NR
SRCOL	Sacramento River at Colusa	2/28/96	5/16/01	34	34	100%	1.1	6.8	2.2	1.3	2.0	1.0	NR
SACSL	Sacramento Slough	2/12/96	5/16/01	40	40	100%	1.8	12.4	4.9	2.0	4.6	2.6	NR
COLDR	Colusa Basin Drain	2/7/96	5/16/01	46	46	100%	3.9	14.0	7.4	2.1	7.2	2.9	NR
YRMRY	Yuba River at Marysville	2/27/96	5/16/01	45	45	100%	0.8	3.5	1.4	0.6	1.3	0.7	NR
FRNIC	Feather River near Nicolaus	2/23/96	5/16/01	40	40	100%	1.2	4.8	2.1	0.8	2.0	0.8	NR
SRVON	Sacramento River at Verona	2/22/96	4/22/98	24	24	100%	1.5	4.4	2.3	0.8	2.2	0.9	NR
SRVET	Sacramento River at Veterans Bridge	8/15/00	6/20/01	11	10	91%	1.3	4.3	2.4	1.1	2.2	1.5	0.2
NEMDR	Natomas East Main Drain	9/1/98	3/5/01	39	39	100%	3.1	11.6	6.5	2.3	6.2	3.0	NR
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	5/17/00	46	46	100%	2.0	22.2	8.7	3.5	8.1	3.7	NR
ARJST	American River at J Street	2/21/96	4/16/98	26	26	100%	1.2	8.1	2.1	1.6	1.9	0.9	NR
ARDPK	American River at Discovery Park	8/15/00	6/19/01	10	10	100%	1.2	2.5	1.8	0.4	1.8	0.6	NR
SRFPT	Sacramento River at Freeport	2/20/96	6/19/01	66	66	100%	0.8	4.7	2.3	0.8	2.2	0.9	NR
SRRMF	Sacramento River at River Mile 44	9/22/99	6/19/01	22	22	100%	1.8	6.4	2.7	1.1	2.6	1.1	NR
CCHSL	Cache Slough near Ryers Ferry	10/20/99	2/16/00	3	3	100%	1.9	5.4	3.2	2.5	2.8	3.1	NR

Summary Statistics: Drinking Water Parameters

Total Dissolved Solids

Units = mg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
PRSHA	Pit River above Shasta	7/22/98	5/16/00	11	11	100%	78.0	125	93.5	14.3	92.7	18.7	NR
MRSHA	McCloud River above Shasta	7/22/98	5/16/00	10	10	100%	55.0	83.0	63.1	10.4	62.4	14.1	NR
SRSHA	Sacramento River above Shasta	7/22/98	5/16/00	10	10	100%	39.0	91.0	61.8	16.0	60.0	24.6	NR
SCKPP	Spring Creek PP Discharge to Keswick Res.	6/24/98	4/18/00	13	13	100%	43.0	59.0	52.3	4.4	52.1	6.7	NR
SRBKR	Sacramento River below Keswick	1/20/98	12/19/00	55	55	100%	51.5	97.5	76.4	11.1	75.6	16.1	NR
CCMOU	Clear Creek near Mouth	10/20/98	8/17/99	10	10	100%	50.0	74	59.6	8.3	59.1	12.7	NR
SRABB	Sacramento River above Bend Bridge	7/22/98	5/15/01	31	31	100%	52.5	149	84.5	19.4	82.6	25.4	NR
MCMOU	Mill Creek at Mouth	8/19/98	2/14/00	14	14	100%	64.0	154	104.7	28.7	101.3	42.2	NR
MCHWY	Mill Creek at Highway 36	10/28/99	2/14/00	3	3	100%	60.0	294	181.7	131.2	149.9	264.1	NR
SRHAM	Sacramento River near Hamilton City	8/18/99	5/15/01	10	10	100%	50.0	123	96.9	22.4	94.3	36.1	NR
DCMOU	Deer Creek at Mouth	8/18/98	4/17/00	9	9	100%	73.0	132	99.9	21.7	97.9	34.5	NR
CHMUD	Big Chico Creek above Mud Creek	6/22/99	2/14/00	4	4	100%	58.0	134	108.8	43.2	103.5	65.7	NR
MUDCH	Mud Creek above Big Chico Creek	12/15/98	2/14/00	7	7	100%	1.6	133	78.4	44.0	50.1	111.9	NR
SRCOL	Sacramento River at Colusa	2/28/96	5/16/01	60	60	100%	17.0	159	93.8	19.0	91.2	28.0	NR
SACSL	Sacramento Slough	2/12/96	5/16/01	35	35	100%	84.0	662	204.9	104.3	190.1	100.2	NR
COLDR	Colusa Basin Drain	2/7/96	5/16/01	42	42	100%	33.0	509	355.8	91.1	335.3	156.8	NR
YRMRY	Yuba River at Marysville	2/27/96	5/16/01	36	36	100%	20.0	88	55.3	13.1	53.7	19.0	NR
FRNIC	Feather River near Nicolaus	2/23/96	5/16/01	59	59	100%	22.0	137	64.9	18.0	62.7	22.3	NR
SRVON	Sacramento River at Verona	2/22/96	4/22/98	26	26	100%	53.0	126	90.9	15.4	89.6	22.7	NR
SRVET	Sacramento River at Veterans Bridge	6/24/98	6/20/01	42	42	100%	50.0	193	106	28	103	39	NR
NEMDR	Natomas East Main Drain	11/13/97	3/5/01	48	48	100%	58.0	338	210	58.6	200	92	NR
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	6/22/99	39	39	100%	58.0	237	174	50.3	165	79	NR
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	24.0	52.0	39.6	6.7	39.0	9.9	NR
ARDPK	American River at Discovery Park	9/21/99	6/19/01	13	13	100%	16.0	88	41.3	24.3	35.1	33.7	NR
SRFPT	Sacramento River at Freeport	2/20/96	6/19/01	32	32	100%	37.0	111	83.5	16.0	81.8	23.9	NR
SRRMF	Sacramento River at River Mile 44	6/23/98	6/19/01	43	43	100%	42.0	151	101	25.4	97.6	36.9	NR
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	79.0	94	87	4.6	87.3	7.2	NR
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	13	13	100%	108	198	143	28.9	140	42.9	NR

Turbidity

Units = NTU

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
PRSHA	Pit River above Shasta	7/22/98	5/16/00	10	10	100%	1.95	23.9	6.85	7.68	4.82	6.66	NR
MRSHA	McCloud River above Shasta	7/22/98	5/16/00	10	10	100%	0.54	6.34	2.26	2.09	1.58	2.42	NR
SRSHA	Sacramento River above Shasta	7/22/98	5/16/00	10	10	100%	0.81	8.35	2.46	2.71	1.70	2.25	NR
SCKPP	Spring Creek PP Discharge to Keswick Res.	6/24/98	4/18/00	12	12	100%	0.42	1.94	1.09	0.57	0.95	0.84	NR
SRBKR	Sacramento River below Keswick	1/20/98	12/19/00	55	55	100%	0.90	36.1	4.34	5.74	3.40	2.65	NR
CCMOU	Clear Creek near Mouth	8/5/98	8/17/99	13	13	100%	1.00	16.0	2.92	5.07	1.95	1.99	NR
SRABB	Sacramento River above Bend Bridge	6/24/98	5/17/00	23	23	100%	2.12	48.2	9.52	12.2	5.79	7.92	NR
MCMOU	Mill Creek at Mouth	6/23/98	1/19/00	17	17	100%	1.40	53.0	8.36	14.7	4.50	7.29	NR
MCBLR	Mill Creek at Black Rock	6/23/98	2/14/00	17	17	100%	0.60	25.0	4.94	6.61	2.99	5.19	NR
MCHWY	Mill Creek at Highway 36	6/23/98	2/10/00	22	22	100%	1.50	62.0	9.35	15.0	5.85	8.13	NR
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	11	11	100%	2.04	140	26.0	49.6	7.94	21.0	NR
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	13	13	100%	0.40	6.10	1.43	1.80	1.10	1.13	NR
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	6/6/00	21	21	100%	0.20	35.0	2.62	10.29	0.87	1.52	NR
DCPON	Deer Creek at Ponderosa Way	6/24/98	6/6/00	12	12	100%	0.20	1.90	0.73	0.62	0.55	0.70	NR
DCMDW	Deer Creek below Childs Meadows	6/24/98	5/8/00	21	20	95%	0.60	26.0	2.58	7.20	1.30	1.90	0.5
CHMUD	Big Chico Creek above Mud Creek	6/23/98	8/17/99	15	15	100%	0.30	4.60	1.03	1.27	0.74	0.82	NR
MUDCH	Mud Creek above Big Chico Creek	6/23/98	5/20/99	8	8	100%	1.40	7.40	3.48	2.22	2.97	3.01	NR
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	8/17/99	15	15	100%	0.30	3.20	0.84	0.91	0.62	0.68	NR
CHASH	Big Chico Creek above Salmon Hole	6/23/98	8/17/99	15	15	100%	0.20	2.30	0.60	0.68	0.44	0.46	NR
CHHWY	Big Chico Creek at Hwy 32	6/23/98	8/17/99	14	14	100%	0.20	1.20	0.51	0.28	0.45	0.34	NR
SRCOL	Sacramento River at Colusa	6/24/98	5/16/00	23	23	100%	2.87	261	32.3	64.3	18.3	29.2	NR
FRNIC	Feather River near Nicolaus	6/23/98	5/16/00	23	23	100%	1.13	57.0	8.94	13.6	5.66	7.80	NR
SRVET	Sacramento River at Veterans Bridge	6/24/98	5/16/00	23	23	100%	3.75	81.2	25.9	17.1	21.6	20.8	NR
SRFPT	Sacramento River at Freeport	6/23/98	5/17/00	23	23	100%	6.43	65.5	23.8	16.8	19.2	19.9	NR
SRRMF	Sacramento River at River Mile 44	6/23/98	5/17/00	23	23	100%	5.10	58.1	24.0	16.3	19.3	20.7	NR
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	11	11	100%	2.67	89.3	33.6	27.5	23.5	40.1	NR

Summary Statistics Table Notes:
monitoring period start and end — Dates of first and last reported data.
n — Total number of data reported.
n det — Total number of data above reporting limits.
% det — Percent of data above reporting limits.
min det — Minimum value for data detected above reporting limits.
max det — Maximum value of data detected above reporting limits.
mean — Arithmetic mean value. "ID" if insufficient data to calculate.
SD — Standard Deviation. "ID" if insufficient data to calculate.
median — 50th percentile value. "ID" if insufficient data to calculate.
IQR — Interquartile range. "ID" if insufficient data to calculate.
min RL — Lowest reporting limit for data below detection. "NR" indicates there were no data below reporting limits.

Summary Statistics: Pathogens Data

Cryptosporidium

Units = öocysts/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
SRABB	Sacramento River above Bend Bridge	7/21/99	5/15/01	20	4	20.0%	0.10	0.20	ID	ID	ID	ID	0.1
SRHAM	Sacramento River near Hamilton City	6/24/99	5/17/00	12	2	16.7%	0.30	0.50	ID	ID	ID	ID	0.1
SRCOL	Sacramento River at Colusa	7/21/99	5/16/01	20	2	10.0%	0.10	0.80	ID	ID	ID	ID	0.1
FRNIC	Feather River near Nicolaus	6/22/99	5/16/00	12	0	0.0%	ND	ND	ID	ID	ID	ID	0.08
SRVET	Sacramento River at Veterans Bridge	7/20/99	5/15/01	20	2	10.0%	0.20	0.30	ID	ID	ID	ID	0.1
SRFPT	Sacramento River at Freeport	6/23/99	5/15/01	34	1	2.9%	0.10	0.10	ID	ID	ID	ID	0.1
SRRMF	Sacramento River at River Mile 44	7/19/00	5/15/01	10	1	10.0%	0.30	0.30	ID	ID	ID	ID	0.1
CCHSL	Cache Slough near Ryers Ferry	6/22/99	2/16/00	5	1	20.0%	0.20	0.20	ID	ID	ID	ID	0.1

Giardia

Units = cysts/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
SRABB	Sacramento River above Bend Bridge	7/21/99	5/15/01	20	15	75.0%	0.10	1.20	0.22	0.30	0.16	0.20	0.1
SRHAM	Sacramento River near Hamilton City	6/24/99	5/17/00	12	8	66.7%	0.10	0.60	0.19	0.19	0.13	0.20	0.1
SRCOL	Sacramento River at Colusa	7/21/99	5/16/01	20	13	65.0%	0.10	0.70	0.26	0.19	0.20	0.26	0.1
FRNIC	Feather River near Nicolaus	6/22/99	5/16/00	12	5	41.7%	0.08	0.20	ID	ID	ID	ID	0.1
SRVET	Sacramento River at Veterans Bridge	7/20/99	5/15/01	22	9	40.9%	0.10	0.60	0.12	0.16	0.06	0.13	0.1
SRFPT	Sacramento River at Freeport	6/23/99	5/15/01	34	24	70.6%	0.10	0.80	0.22	0.21	0.14	0.22	0.1
SRRMF	Sacramento River at River Mile 44	7/19/00	5/15/01	10	6	60.0%	0.10	1.10	0.38	0.43	0.20	0.46	0.1
CCHSL	Cache Slough near Ryers Ferry	6/22/99	2/16/00	5	1	20.0%	0.30	0.30	ID	ID	ID	ID	0.1

Coliform, total

Units = MPN/100 mL

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
SRBKR	Sacramento River below Keswick	7/22/98	5/16/00	20	19	95.0%	1	62	15	16	8	18	1
SRABB	Sacramento River above Bend Bridge	6/24/98	5/15/01	31	31	100%	1	1700	298	477	112	313	NR
SRHAM	Sacramento River near Hamilton City	6/24/99	5/17/00	10	10	100%	17	2400	519	849	168	591	NR
SRCOL	Sacramento River at Colusa	6/24/98	5/16/01	31	31	100%	11	2200	329	526	138	318	NR
FRNIC	Feather River near Nicolaus	6/23/98	5/16/00	23	23	100%	3	1600	359	502	114	395	NR
SRVET	Sacramento River at Veterans Bridge	10/29/96	6/20/01	54	54	100%	17	16000	1046	2664	438	881	NR
ARDPK	American River at Discovery Park	10/29/96	6/19/01	53	53	100%	17	50000	2018	8626	305	812	NR
SRFPT	Sacramento River at Freeport	10/29/96	6/19/01	53	53	100%	13	9000	970	1813	390	862	NR
SRRMF	Sacramento River at River Mile 44	5/20/99	12/14/99	6	6	100%	130	900	372	323	297	389	NR
CCHSL	Cache Slough near Ryers Ferry	6/23/98	2/16/00	12	12	100%	30	1600	345	511	154	385	NR

Summary Statistics: Pathogens Data

Coliform, fecal

Units = MPN/100 mL

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
SRBKR	Sacramento River below Keswick	7/22/98	5/16/00	20	8	40.0%	1	9	1	3	1	1	1
CCMOU	Clear Creek near Mouth	8/20/98	8/17/99	9	9	100%	2	85	16	33	8	16	NR
SRABB	Sacramento River above Bend Bridge	6/24/98	5/15/01	32	28	87.5%	4	1100	93	236	25	68	2
MCMOU	Mill Creek at Mouth	6/23/98	5/19/99	12	12	100%	1	46	10	17	4	10	NR
MCBLR	Mill Creek at Black Rock	6/23/98	5/19/99	11	7	63.6%	1	10	3	3	1	3	1
MCHWY	Mill Creek at Highway 36	6/23/98	5/19/99	12	9	75.0%	1	33	5	12	2	5	1
SRHAM	Sacramento River near Hamilton City	6/24/99	5/17/00	10	10	100%	4	1000	210	354	59	253	NR
DCMOU	Deer Creek at Mouth	6/24/98	5/17/99	9	9	100%	2	224	31	101	7	20	NR
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	5/17/99	11	7	63.6%	1	14	2	5	1	3	1
DCPON	Deer Creek at Ponderosa Way	6/24/98	5/18/99	8	2	25.0%	1	2	ID	ID	ID	ID	1
DCMDW	Deer Creek below Childs Meadows	6/24/98	5/17/99	11	10	90.9%	1	41	11	13	5	14	1
CHMUD	Big Chico Creek above Mud Creek	6/23/98	5/20/99	12	12	100%	10	1119	169	388	72	160	NR
MUDCH	Mud Creek above Big Chico Creek	6/23/98	5/20/99	7	7	100%	16	162	46	69	34	38	NR
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	5/20/99	11	10	90.9%	8	233	62	75	37	72	1
CHASH	Big Chico Creek above Salmon Hole	6/23/98	5/20/99	12	11	91.7%	1	20	6	6	3	6	1
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/20/99	11	9	81.8%	2	22	5	7	3	5	1
SRCOL	Sacramento River at Colusa	6/24/98	5/16/01	31	30	96.8%	4	1600	157	388	31	97	2
FRNIC	Feather River near Nicolaus	6/23/98	5/16/00	23	22	95.7%	2	500	66	145	16	46	20
SRVET	Sacramento River at Veterans Bridge	10/29/96	6/20/01	54	53	98.1%	2	2400	98	426	30	64	2
NEMDR	Natomas East Main Drain	4/6/98	10/2/00	29	29	100%	52	12000	919	2750	295	660	NR
ARDPK	American River at Discovery Park	10/29/96	6/19/01	53	53	100%	2	3000	169	514	48	110	NR
SRFPT	Sacramento River at Freeport	10/29/96	6/19/01	52	52	100%	4	8000	237	1503	34	87	NR
SRRMF	Sacramento River at River Mile 44	6/24/99	12/14/99	6	6	100%	4	50	24	17	18	30	NR
CCHSL	Cache Slough near Ryers Ferry	6/23/98	2/16/00	12	12	100%	6	1600	258	551	32	120	NR

Summary Statistics Table Notes:
monitoring period start and end — Dates of first and last reported data.
n — Total number of data reported.
n det — Total number of data above reporting limits.
% det — Percent of data above reporting limits.
min det — Minimum value for data detected above reporting limits.
max det — Maximum value of data detected above reporting limits.
mean — Arithmetic mean value. "ID" if insufficient data to calculate.
SD — Standard Deviation. "ID" if insufficient data to calculate.
median — 50th percentile value. "ID" if insufficient data to calculate.
IQR — Interquartile range. "ID" if insufficient data to calculate.
min RL — Lowest reporting limit for data below detection. "NR" indicates there were no data below reporting limits.

Summary Statistics: Other Conventional Water Chemistry Parameters

Alkalinity, total

Units = mg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
PRSHA	Pit River above Shasta	7/22/98	5/16/00	13	13	100%	60.0	220	81.1	53.4	74.9	32.3	NR
MRSHA	McCloud River above Shasta	7/22/98	5/16/00	17	17	100%	36.0	130	56.7	24.1	54.1	22.4	NR
SRSHA	Sacramento River above Shasta	7/22/98	5/16/00	12	12	100%	39.0	64.0	52.4	9.48	51.6	14.4	NR
SCKPP	Spring Creek PP Discharge to Keswick Res.	6/24/98	4/18/00	13	13	100%	24.0	78.0	42.4	13.9	41.0	15.7	NR
SRBKR	Sacramento River below Keswick	7/22/98	6/21/01	32	32	100%	30.0	62.0	50.3	6.97	49.8	10.2	NR
CCWHI	Clear Creek above Whiskeytown	6/22/99	8/17/99	3	3	100%	24.0	42.0	34.0	10.5	33.1	18.8	NR
CCMOU	Clear Creek near Mouth	6/22/99	8/17/99	3	3	100%	24.0	44.0	36.0	12.9	34.8	21.4	NR
SRABB	Sacramento River above Bend Bridge	2/13/96	6/21/01	61	61	100%	30.0	62.0	50.2	6.21	49.8	8.83	NR
MCMOU	Mill Creek at Mouth	6/22/99	4/17/00	8	8	100%	24.0	51.0	38.4	9.79	37.3	15.8	NR
MCGGE	Mill Creek at USGS gage	10/28/99	1/19/00	3	3	100%	38.0	51.0	43.3	8.16	43.0	12.7	NR
MCBLR	Mill Creek at Black Rock	6/22/99	4/17/00	6	6	100%	24.0	46.0	35.0	7.90	34.3	12.9	NR
SRHAM	Sacramento River near Hamilton City	6/23/99	5/17/00	13	13	100%	31.0	66.0	56.2	9.67	55.4	12.9	NR
DCHWY	Deer Creek at Highway 99	6/23/99	4/17/00	5	5	100%	32.0	84.0	55.8	22.7	52.4	37.2	NR
DCPON	Deer Creek at Ponderosa Way	6/23/99	11/8/99	4	4	100%	35.0	60.0	52.8	15.8	51.6	20.6	NR
DCALN	Deer Creek at A Line Road	1/20/00	4/17/00	3	3	100%	24.0	40.0	33.3	9.90	32.6	16.8	NR
CHMUD	Big Chico Creek above Mud Creek	6/22/99	4/17/00	9	9	100%	28.0	89.0	69.7	24.1	65.1	40.4	NR
MUDCH	Mud Creek above Big Chico Creek	1/19/00	4/17/00	3	3	100%	38.0	62.0	49.7	13.4	48.7	24.1	NR
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/22/99	4/17/00	7	7	100%	30.0	90.0	60.7	26.8	55.3	44.0	NR
CHAGC	Big Chico Creek above Golf Course	9/14/99	4/17/00	7	7	100%	29.0	90.0	70.0	24.8	65.5	43.3	NR
CHASH	Big Chico Creek above Salmon Hole	6/22/99	8/17/99	3	3	100%	48.0	88.0	74.0	29.9	71.4	43.9	NR
CHHWY	Big Chico Creek at Hwy 32	10/28/99	1/19/00	3	3	100%	61.0	75.0	69.0	8.43	68.7	14.2	NR
LCSTL	Little Chico Creek at Stilson Cyn	9/14/99	1/19/00	4	4	100%	57.0	92.0	82.3	22.8	80.7	28.5	NR
LCTEN	Little Chico Creek at Ten Mile	10/28/99	1/19/00	3	3	100%	49.0	79.0	64.7	16.8	63.5	30.6	NR
SRCOL	Sacramento River at Colusa	2/28/96	6/21/01	88	88	100%	37.0	72.0	56.2	7.07	55.7	10.0	NR
BCGGE	Butte Creek at USGS gage	6/23/99	4/19/00	6	6	100%	34.0	64.0	48.7	13.0	47.2	21.6	NR
BCHWY	Butte Creek at Colusa Highway	6/23/99	4/19/00	8	8	100%	43.0	110	86.6	27.8	82.1	46.3	NR
BCPLF	Butte Creek below Pool Four	9/14/99	1/19/00	4	4	100%	36.0	55.0	44.3	9.27	43.6	15.9	NR
BCOKD	Butte Creek above Okie Dam	9/14/99	1/19/00	4	4	100%	43.0	59.0	53.0	8.25	52.6	12.7	NR
SACSL	Sacramento Slough	2/12/96	6/22/01	73	73	100%	50.0	206	134	38.0	127	57.8	NR
COLDR	Colusa Basin Drain	2/7/96	6/22/01	82	82	100%	60.0	480	196	62.4	186	84.6	NR
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	27	100%	16.0	36.0	28.4	4.87	28.0	7.32	NR
FRNIC	Feather River near Nicolaus	2/23/96	6/22/01	61	61	100%	22.0	51.0	38.2	5.72	37.8	8.08	NR
SRVON	Sacramento River at Verona	3/19/96	4/22/98	26	26	100%	24.0	73.0	53.9	9.86	52.9	14.5	NR
SRVET	Sacramento River at Veterans Bridge	6/24/98	5/17/00	34	34	100%	34.0	84.0	64.3	11.1	63.3	16.5	NR
NEMDR	Natomas East Main Drain	11/13/97	3/5/01	45	45	100%	28.0	169	85.5	33.6	79.3	45.8	NR
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	6/22/01	93	93	100%	18.5	130	69.5	29.1	62.8	41.8	NR
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	16.0	27.0	19.7	2.78	19.6	3.89	NR
ARDPK	American River at Discovery Park	6/23/98	6/21/01	34	34	100%	15.0	74.0	24.7	11.2	23.6	8.08	NR
SRFPT	Sacramento River at Freeport	2/20/96	6/22/01	91	91	100%	21.0	82.0	53.5	10.6	52.4	15.0	NR
SRRMF	Sacramento River at River Mile 44	6/23/98	5/15/01	38	38	100%	36.1	130	58.3	16.5	56.8	17.7	NR
CCHSL	Cache Slough near Ryers Ferry	6/23/98	4/18/00	25	25	100%	40.0	128	71.8	17.0	70.2	20.4	NR

Summary Statistics: Other Conventional Water Chemistry Parameters

Total Suspended Solids

Units = mg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
PRSHA	Pit River above Shasta	7/22/98	5/16/00	10	3	30.0%	6.00	12.0	3.82	4.30	2.61	3.95	5.0
MRSHA	McCloud River above Shasta	7/22/98	5/16/00	10	1	10.0%	10.0	10.0	ID	ID	ID	ID	5.0
SRSHA	Sacramento River above Shasta	7/22/98	5/16/00	10	1	10.0%	11.0	11.0	ID	ID	ID	ID	5.0
SCKPP	Spring Creek PP Discharge to Keswick Res.	6/24/98	4/18/00	12	1	8.33%	5.00	5.00	ID	ID	ID	ID	5.0
SRBKR	Sacramento River below Keswick	4/21/98	2/20/01	55	32	58.2%	0.05	13.0	1.63	2.19	0.99	1.59	0.10
CCMOU	Clear Creek near Mouth	9/15/98	8/17/99	11	11	100%	0.20	11.6	2.76	3.72	1.47	3.48	NR
SRABB	Sacramento River above Bend Bridge	3/8/96	5/15/01	46	34	73.9%	3.00	355	26.8	63.7	10.3	22.7	5.0
MCMOU	Mill Creek at Mouth	6/23/98	5/15/01	23	18	78.3%	0.80	754	54.3	195	7.74	23.1	5.0
MCHYN	Mill Creek at Highway 99	4/6/01	4/7/01	4	0	0.0%	ND	ND	ID	ID	ID	ID	5.0
MCBLR	Mill Creek at Black Rock	6/23/98	4/6/01	12	11	91.7%	0.20	53.8	14.2	20.6	3.87	14.9	5.0
MCHWY	Mill Creek at Highway 36	6/23/98	2/14/00	16	16	100%	0.80	130.0	30.2	43.3	10.7	34.6	NR
SRHAM	Sacramento River near Hamilton City	6/23/99	5/15/01	20	13	65.0%	5.20	218	28.9	63.4	4.97	19.7	5.0
DCMOU	Deer Creek at Mouth	6/24/98	11/18/99	12	12	100%	0.40	14.0	2.54	4.58	1.36	2.22	NR
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	2/14/00	17	17	100%	0.30	145	10.2	48.7	1.23	3.08	NR
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	10	10	100%	0.20	5.00	1.05	1.76	0.607	1.03	NR
DCMDW	Deer Creek below Childs Meadows	6/24/98	2/14/00	16	16	100%	0.20	93.0	7.08	32.7	1.29	2.91	NR
CHMUD	Big Chico Creek above Mud Creek	6/23/98	2/14/00	15	15	100%	0.20	97.0	10.7	30.7	2.34	8.21	NR
MUDCH	Mud Creek above Big Chico Creek	6/23/98	2/14/00	9	9	100%	0.40	32.8	7.22	12.1	3.23	8.91	NR
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	2/14/00	15	15	100%	0.20	122	12.0	39.8	1.99	7.17	NR
CHASH	Big Chico Creek above Salmon Hole	6/23/98	2/14/00	15	15	100%	0.20	91.0	9.48	28.9	1.73	5.43	NR
CHHWY	Big Chico Creek at Hwy 32	6/23/98	2/14/00	14	14	100%	0.20	46.0	6.81	15.1	1.68	5.07	NR
SRCOL	Sacramento River at Colusa	2/28/96	5/16/01	37	37	100%	10.5	579	86.4	132	48.7	73.4	NR
SACSL	Sacramento Slough	2/12/96	5/16/01	42	42	100%	30.0	182	68.1	35.9	61.3	39.3	NR
COLDR	Colusa Basin Drain	2/7/96	5/16/01	50	50	100%	21.0	373	121	69.1	104	85.3	NR
YRMRY	Yuba River at Marysville	2/27/96	5/16/01	47	28	59.6%	1.00	153	18.4	34.8	5.39	15.0	5.0
FRNIC	Feather River near Nicolaus	2/23/96	5/16/01	47	43	91.5%	5.00	123	26.0	28.5	16.2	24.0	5.0
SRVON	Sacramento River at Verona	2/22/96	3/25/98	25	25	100%	24.0	117	59.0	29.6	52.7	38.3	NR
SRVET	Sacramento River at Veterans Bridge	1/4/94	6/20/01	94	94	100%	4.00	200	37.2	26.9	30.8	27.4	NR
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	5/17/00	48	48	100%	5.00	656	69.1	121.4	35.5	56.2	NR
ARJST	American River at J Street	2/21/96	4/16/98	26	26	100%	2.00	116	13.9	27.2	6.67	10.8	NR
ARDPK	American River at Discovery Park	1/4/94	6/19/01	92	64	69.6%	1.00	41.0	5.65	7.87	2.90	5.29	1.0
SRFPT	Sacramento River at Freeport	1/4/94	6/19/01	125	124	99.2%	2.00	368	38.3	46.0	26.4	32.4	1.0
SRRMF	Sacramento River at River Mile 44	1/18/94	6/19/01	86	85	98.8%	2.00	230	35.9	38.5	24.8	31.9	1.0
SRGRN	Sacramento River at Greene's Landing	1/1/00	10/1/01	27	27	100%	8.20	167	26.9	35.9	20.5	17.5	NR
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	9.00	607	130	202	59.7	149	NR
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	8	8	100%	8.00	43.0	22.5	14.2	18.8	21.1	NR

Summary Statistics: Other Conventional Water Chemistry Parameters

Hardness

Units = mg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
PRSHA	Pit River above Shasta	7/22/98	5/16/00	13	13	100%	14.0	68.0	47.7	13.3	45.4	20.6	NR
MRSHA	McCloud River above Shasta	7/22/98	5/16/00	16	16	100%	32.0	94.0	49.4	15.6	47.8	17.6	NR
SRSHA	Sacramento River above Shasta	7/22/98	5/16/00	12	12	100%	32.0	76.0	46.0	12.4	44.9	15.1	NR
SCKPP	Spring Ck PP Discharge to Keswick Res.	6/24/98	4/18/00	12	12	100%	28.0	64.0	39.2	10.0	38.4	10.9	NR
SRBKR	Sacramento River below Keswick	2/18/98	6/21/01	63	63	100%	36.0	82.0	45.0	6.51	44.6	6.56	NR
CCWHI	Clear Ck above Whiskeytown	6/22/99	8/17/99	3	3	100%	16.0	52.0	36.0	21.0	32.2	40.1	NR
CCMOU	Clear Ck near Mouth	6/22/99	8/17/99	3	3	100%	40.0	44.0	ID	ID	ID	ID	NR
SRABB	Sacramento River above Bend Bridge	2/13/96	6/21/01	61	61	100%	27.0	128	48.0	13.5	47.0	11.1	NR
MCMOU	Mill Ck at Mouth	6/22/99	4/17/00	8	8	100%	24.0	72.0	44.5	16.1	42.2	24.8	NR
MCGGE	Mill Ck at USGS gage	10/28/99	1/19/00	3	3	100%	36.0	52.0	45.3	9.90	44.8	16.6	NR
MCBLR	Mill Ck at Black Rock	6/22/99	4/17/00	6	6	100%	28.0	48.0	38.0	7.05	37.5	11.1	NR
SRHAM	Sacramento River near Hamilton City	6/23/99	5/15/01	21	21	100%	41.0	68.0	52.8	7.10	52.4	10.1	NR
DCHWY	Deer Ck at Highway 99	6/23/99	4/17/00	5	5	100%	28.0	72.0	46.0	19.7	43.0	31.3	NR
DCUDD	Deer Ck at Upper Diversion Dam	6/24/98	5/18/99	10	10	100%	27.0	52.0	37.2	9.1	36.3	12.8	NR
DCPON	Deer Ck at Ponderosa Way	6/23/99	11/8/99	4	4	100%	48.0	56.0	52.0	3.60	51.9	5.88	NR
DCALN	Deer Ck at A Line Road	1/20/00	4/17/00	3	3	100%	20.0	30.0	26.0	6.45	25.6	10.5	NR
DCMDW	Deer Ck below Childs Meadows	6/24/98	5/18/99	10	10	100%	12.0	25.0	18.8	3.50	18.5	4.97	NR
CHMUD	Big Chico Ck above Mud Ck	6/22/99	4/17/00	9	9	100%	24.0	78.0	54.7	19.2	51.3	31.7	NR
MUDCH	Mud Ck above Big Chico Ck	1/19/00	4/17/00	3	3	100%	32.0	58.0	44.0	14.8	42.7	25.8	NR
CHCHI	Big Chico Ck at Chico (Rose Ave.)	6/22/99	4/17/00	7	7	100%	20.0	88.0	60.9	24.9	55.4	45.4	NR
CHAGC	Big Chico Ck above Golf Course	9/14/99	4/17/00	7	7	100%	24.0	76.0	61.7	21.2	58.0	35.2	NR
CHASH	Big Chico Ck above Salmon Hole	6/22/99	8/17/99	3	3	100%	68.0	76.0	72.0	4.46	71.9	8.00	NR
CHHWY	Big Chico Ck at Hwy 32	10/28/99	1/19/00	3	3	100%	52.0	64.0	57.3	7.0	57.1	11.9	NR
LCSTL	Little Chico Ck at Stilson Cyn	9/14/99	1/19/00	4	4	100%	52.0	88.0	75.0	19.2	73.6	28.6	NR
LCTEN	Little Chico Ck at Ten Mile	10/28/99	1/19/00	3	3	100%	44.0	74.0	62.0	19.3	60.5	31.8	NR
SRCOL	Sacramento River at Colusa	2/28/96	6/21/01	59	59	100%	36.0	104	55.0	10.7	54.1	12.9	NR
BCGGE	Butte Ck at USGS gage	6/23/99	4/19/00	6	6	100%	28.0	84.0	50.7	22.5	47.0	34.7	NR
BCHWY	Butte Ck at Colusa Highway	6/23/99	4/19/00	6	6	100%	44.0	132.0	83.0	34.6	77.2	57.8	NR
BCPLF	Butte Ck below Pool Four	9/14/99	1/19/00	4	4	100%	32.0	56.0	45.5	11.4	44.5	20.6	NR
BCOKD	Butte Ck above Okie Dam	9/14/99	1/19/00	4	4	100%	40.0	60.0	49.0	9.4	48.4	16.3	NR
SACSL	Sacramento Slough	2/12/96	6/22/01	60	60	100%	52.0	232	122.3	35.6	116.3	52.3	NR
COLDR	Colusa Basin Drain	2/7/96	6/22/01	66	66	100%	48.0	372	180.9	46.3	174.5	64.9	NR
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	27	100%	18.0	45.0	31.4	6.50	30.8	9.55	NR
FRNIC	Feather River near Nicolaus	2/23/96	6/22/01	60	60	100%	22.0	84.0	40.4	12.4	39.0	13.4	NR
SRVON	Sacramento River at Verona	2/22/96	4/22/98	26	26	100%	24.0	69.0	51.6	10.2	50.5	15.5	NR
SRVET	Sacramento River at Veterans Bridge	1/4/94	6/20/01	100	100	100%	28.0	97.1	60.2	12.9	58.8	17.8	NR
NEMDR	Natomas East Main Drain	11/13/97	3/5/01	45	45	100%	27.0	165	95.9	31.3	90.2	47.4	NR
ARCNW	Arcade Ck at Norwood Ave.	2/6/96	6/22/01	76	76	100%	23.0	132	77.9	26.7	72.4	40.5	NR
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	16.0	28.0	20.2	3.05	20.0	4.17	NR
ARDPK	American River at Discovery Park	1/18/94	6/21/01	107	107	100%	14.0	103.0	26.0	11.16	24.6	10.33	NR
SRFPT	Sacramento River at Freeport	1/4/94	6/22/01	139	139	100%	19.0	94.0	54.5	13.3	52.9	18.1	NR
SRRMF	Sacramento River at River Mile 44	2/1/94	6/19/01	84	84	100%	24.0	94.0	57.7	14.4	55.8	20.4	NR
CCHSL	Cache Slough near Ryers Ferry	6/23/98	4/18/00	18	18	100%	58.5	116	74.4	16.7	72.9	21.5	NR

Summary Statistics Table Notes:
monitoring period start and end — Dates of first and last reported data.
n — Total number of data reported.
n det — Total number of data above reporting limits.
% det — Percent of data above reporting limits.
min det — Minimum value for data detected above reporting limits.
max det — Maximum value of data detected above reporting limits.
mean — Arithmetic mean value. "ID" if insufficient data to calculate.
SD — Standard Deviation. "ID" if insufficient data to calculate.
median — 50th percentile value. "ID" if insufficient data to calculate.
IQR — Interquartile range. "ID" if insufficient data to calculate.
min RL — Lowest reporting limit for data below detection. "NR" indicates there were no data below reporting limits.

Summary Statistics: Field Data

Dissolved Oxygen

Units = mg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
PRSHA	Pit River above Shasta	7/22/98	5/16/00	9	9	100%	9.90	13.0	11.4	0.94	11.3	1.45	NR
MRSHA	McCloud River above Shasta	7/22/98	5/16/00	9	9	100%	8.30	11.7	10.6	1.36	10.5	2.01	NR
SRSHA	Sacramento River above Shasta	7/22/98	5/16/00	9	9	100%	9.80	12.8	11.0	0.97	11.0	1.49	NR
SCKPP	Spring Creek PP Discharge to Keswick Res.	6/24/98	4/18/00	12	12	100%	8.80	11.7	10.3	0.83	10.2	1.27	NR
SRBKR	Sacramento River below Keswick	6/24/98	4/17/01	27	27	100%	9.40	13.8	10.9	1.15	10.9	1.53	NR
CCMOU	Clear Creek near Mouth	8/20/98	8/17/99	14	14	100%	9.20	11.9	10.9	0.74	10.9	1.09	NR
SRABB	Sacramento River above Bend Bridge	2/13/96	5/15/01	59	59	100%	7.85	12.9	10.7	0.99	10.6	1.39	NR
MCMOU	Mill Creek at Mouth	6/23/98	5/29/01	34	34	100%	6.10	17.4	10.4	1.99	10.3	2.65	NR
MCHYN	Mill Creek at Highway 99	4/6/01	4/7/01	4	4	100%	8.10	12.1	10.4	2.06	10.3	3.62	NR
MCBLR	Mill Creek at Black Rock	6/23/98	4/6/01	19	19	100%	9.40	12.0	10.8	0.85	10.7	1.26	NR
MCHWY	Mill Creek at Highway 36	6/23/98	6/7/00	29	29	100%	7.90	13.6	10.4	1.18	10.3	1.66	NR
SRHAM	Sacramento River near Hamilton City	6/23/99	6/21/01	35	35	100%	7.60	14.7	10.4	1.65	10.2	2.24	NR
CHMOU	Big Chico Creek at Mouth	1/26/01	5/29/01	4	4	100%	9.50	16.6	12.0	3.75	11.7	5.39	NR
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	18	18	100%	8.80	11.8	10.5	0.86	10.5	1.28	NR
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	10	10	100%	7.80	13.7	10.6	1.73	10.5	2.65	NR
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	18	18	100%	8.80	11.6	10.2	0.90	10.2	1.34	NR
CHASH	Big Chico Creek above Salmon Hole	6/23/98	2/14/00	16	16	100%	8.90	12.4	10.6	1.31	10.5	1.93	NR
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	17	17	100%	9.30	11.6	10.6	0.71	10.5	1.06	NR
SRCOL	Sacramento River at Colusa	2/28/96	6/21/01	87	87	100%	7.70	16.1	10.3	1.14	10.2	1.44	NR
SACSL	Sacramento Slough	2/12/96	6/22/01	50	50	100%	5.10	13.8	8.53	2.02	8.31	2.77	NR
COLDR	Colusa Basin Drain	2/7/96	6/22/01	53	53	100%	5.00	12.6	8.27	2.00	8.04	2.79	NR
YRMRY	Yuba River at Marysville	2/27/96	5/16/01	45	45	100%	6.51	15.9	10.9	1.63	10.8	2.28	NR
FRNIC	Feather River near Nicolaus	2/23/96	6/22/01	65	65	100%	7.54	15.7	10.3	1.44	10.2	1.90	NR
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	27	100%	7.30	12.8	9.75	1.22	9.68	1.75	NR
SRVET	Sacramento River at Veterans Bridge	1/18/94	6/22/01	120	120	100%	6.60	14.2	9.78	1.27	9.70	1.71	NR
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	6/22/01	26	26	100%	1.80	14.4	7.51	3.69	6.48	5.73	NR
ARJST	American River at J Street	2/21/96	4/16/98	26	26	100%	8.20	12.8	10.4	1.27	10.3	1.86	NR
ARDPK	American River at Discovery Park	1/4/94	6/19/01	102	102	100%	6.18	15.2	9.92	1.51	9.81	2.07	NR
SRFPT	Sacramento River at Freeport	2/20/96	6/19/01	97	97	100%	6.10	14.2	9.53	1.33	9.44	1.81	NR
SRRMF	Sacramento River at River Mile 44	1/18/94	6/19/01	110	110	100%	6.70	12.2	9.34	1.20	9.26	1.64	NR
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	10	10	100%	8.30	11.9	10.7	1.12	10.7	1.62	NR
CCHSL	Cache Slough near Ryers Ferry	6/23/98	2/16/00	15	15	100%	6.95	11.0	9.15	1.32	9.06	2.02	NR

Summary Statistics: Field Data

Temperature

Units = °C

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
PRSHA	Pit River above Shasta	7/22/98	5/16/00	16	16	100%	7.0	20.1	12.5	4.3	11.8	6.4	NR
MRSHA	McCloud River above Shasta	7/22/98	5/16/00	20	20	100%	5.3	27.1	11.1	5.2	10.3	5.5	NR
SRSHA	Sacramento River above Shasta	7/22/98	5/16/00	15	15	100%	7.3	19.7	11.0	4.3	10.3	5.3	NR
SCKPP	Spring Creek PP Discharge to Keswick Res.	6/24/98	4/18/00	19	19	100%	7.6	13.5	11.1	1.8	11.0	2.7	NR
SRBKR	Sacramento River below Keswick	1/20/98	4/17/01	72	72	100%	8.2	14.5	11.3	1.4	11.2	2.0	NR
CCWHI	Clear Creek above Whiskeytown	6/22/99	8/17/99	3	3	100%	17.7	19.6	18.5	1.2	18.5	1.9	NR
CCMOU	Clear Creek near Mouth	8/5/98	5/29/01	25	25	100%	6.2	23.2	13.4	5.7	12.3	7.6	NR
SRABB	Sacramento River above Bend Bridge	2/13/96	5/15/01	75	75	100%	7.7	14.1	11.6	1.5	11.5	2.1	NR
MCMOU	Mill Creek at Mouth	6/22/99	5/29/01	21	21	100%	4.7	32.9	15.2	8.8	13.1	11.3	NR
MCHYN	Mill Creek at Highway 99	4/6/01	4/7/01	4	4	100%	8.2	10.2	9.2	0.9	9.2	1.5	NR
MCGGE	Mill Creek at USGS gage	10/28/99	1/19/00	3	3	100%	10.7	13.0	11.8	1.3	11.7	2.3	NR
MCBLR	Mill Creek at Black Rock	6/22/99	4/6/01	7	7	100%	5.7	16.2	10.7	4.2	10.0	6.7	NR
SRHAM	Sacramento River near Hamilton City	6/23/99	6/21/01	51	51	100%	6.4	18.2	12.9	2.9	12.5	4.3	NR
DCMOU	Deer Creek at Mouth	8/18/99	5/29/01	6	6	100%	6.0	27.0	14.6	8.6	12.6	13.5	NR
DCHWY	Deer Creek at Highway 99	6/23/99	4/17/00	5	5	100%	10.0	28.4	17.6	9.7	15.6	13.9	NR
DCPON	Deer Creek at Ponderosa Way	6/23/99	11/8/99	4	4	100%	9.5	18.8	15.1	4.6	14.6	7.7	NR
DCALN	Deer Creek at A Line Road	1/20/00	4/17/00	3	3	100%	4.1	6.60	5.4	1.4	5.3	2.5	NR
CHMUD	Big Chico Creek above Mud Creek	10/28/99	1/19/00	3	3	100%	6.4	8.90	7.6	1.4	7.6	2.5	NR
MUDCH	Mud Creek above Big Chico Creek	1/19/00	4/17/00	3	3	100%	11.1	13.2	12.1	1.2	12.1	2.1	NR
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/22/99	4/17/00	7	7	100%	9.9	23.5	16.5	6.3	15.4	9.7	NR
CHAGC	Big Chico Creek above Golf Course	9/14/99	4/17/00	7	7	100%	8.6	20.8	12.4	4.7	11.9	5.7	NR
CHASH	Big Chico Creek above Salmon Hole	6/22/99	8/17/99	3	3	100%	19.1	20.1	19.6	0.6	19.6	1.0	NR
CHHWY	Big Chico Creek at Hwy 32	10/28/99	1/19/00	3	3	100%	6.4	8.90	7.6	1.4	7.6	2.5	NR
LCSTL	Little Chico Creek at Stilson Cyn	9/14/99	1/19/00	4	4	100%	10.6	22.0	15.7	5.3	15.1	8.5	NR
LCTEN	Little Chico Creek at Ten Mile	10/28/99	1/19/00	3	3	100%	10.2	13.2	11.8	1.7	11.7	3.0	NR
SRCOL	Sacramento River at Colusa	2/28/96	6/21/01	108	108	100%	7.2	24.0	14.8	3.9	14.2	5.4	NR
BCGGE	Butte Creek at USGS gage	6/23/99	4/19/00	6	6	100%	7.3	19.4	13.4	4.9	12.6	8.4	NR
BCHWY	Butte Creek at Colusa Highway	6/23/99	4/19/00	7	7	100%	9.8	27.4	15.7	7.0	14.6	9.8	NR
BCPLF	Butte Creek below Pool Four	9/14/99	1/19/00	4	4	100%	8.4	18.1	11.9	5.2	11.4	6.8	NR
BCOKD	Butte Creek above Okie Dam	9/14/99	1/19/00	4	4	100%	9.5	18.1	13.1	4.1	12.7	6.2	NR
SACSL	Sacramento Slough	2/12/96	6/22/01	64	64	100%	7.0	30.5	17.5	6.1	16.4	8.6	NR
COLDR	Colusa Basin Drain	2/7/96	6/22/01	71	71	100%	3.7	30.9	17.2	6.4	15.9	9.4	NR
YRMRY	Yuba River at Marysville	2/27/96	5/16/01	47	47	100%	8.1	21.4	12.6	3.3	12.2	4.4	NR
FRNIC	Feather River near Nicolaus	2/23/96	6/22/01	80	80	100%	6.7	29.7	15.4	5.0	14.5	6.8	NR
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	27	100%	8.7	22.5	15.4	4.5	14.7	6.6	NR
SRVET	Sacramento River at Veterans Bridge	1/18/94	6/22/01	136	136	100%	7.6	24.1	15.2	4.5	14.5	6.2	NR
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	6/22/01	40	40	100%	6.1	28.0	16.7	6.3	15.4	9.3	NR
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	8.4	19.7	13.7	3.8	13.2	5.4	NR
ARDPK	American River at Discovery Park	1/4/94	6/19/01	101	101	100%	7.6	24.4	14.4	4.3	13.8	5.7	NR
SRFPT	Sacramento River at Freeport	2/20/96	6/19/01	122	122	100%	7.1	22.6	15.8	4.4	15.1	6.2	NR
SRRMF	Sacramento River at River Mile 44	1/18/94	6/19/01	113	113	100%	7.9	22.9	15.5	4.5	14.9	6.2	NR
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	10	10	100%	7.1	22.6	14.7	6.1	13.5	9.3	NR
CCHSL	Cache Slough near Ryers Ferry	6/23/98	4/18/00	23	23	100%	8.4	22.6	15.3	4.9	14.5	7.2	NR

Summary Statistics: Field Data

pH Units = standard units

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
PRSHA	Pit River above Shasta	7/22/98	5/16/00	15	15	100%	7.3	8.5	8.0	0.4	8.0	0.5	NR
MRSHA	McCloud River above Shasta	7/22/98	5/16/00	18	18	100%	7.1	8.5	7.9	0.4	7.9	0.5	NR
SRSHA	Sacramento River above Shasta	7/22/98	5/16/00	14	14	100%	7.4	8.9	8.0	0.4	8.0	0.6	NR
SCKPP	Spring Creek PP Discharge to Keswick Res.	6/24/98	4/18/00	18	18	100%	6.8	8.3	7.5	0.5	7.5	0.6	NR
SRBKR	Sacramento River below Keswick	1/20/98	4/17/01	71	71	100%	6.7	8.6	7.7	0.4	7.7	0.6	NR
CCWHI	Clear Creek above Whiskeytown	6/22/99	8/17/99	3	3	100%	8.1	8.6	ID	ID	ID	ID	NR
CCMOU	Clear Creek near Mouth	8/5/98	8/17/99	21	21	100%	7.1	8.0	7.4	0.2	7.4	0.3	NR
SRABB	Sacramento River above Bend Bridge	2/13/96	5/15/01	72	72	100%	7.0	8.5	7.7	0.3	7.7	0.4	NR
MCMOU	Mill Creek at Mouth	6/22/99	5/29/01	20	20	100%	7.4	9.2	8.0	0.5	8.0	0.7	NR
MCHYN	Mill Creek at Highway 99	4/6/01	4/7/01	4	4	100%	7.3	7.8	7.5	0.2	7.5	0.4	NR
MCGGE	Mill Creek at USGS gage	10/28/99	1/19/00	3	3	100%	7.3	7.6	7.4	0.2	7.4	0.3	NR
MCBLR	Mill Creek at Black Rock	6/22/99	4/6/01	7	7	100%	7.3	7.6	7.5	0.1	7.5	0.2	NR
SRHAM	Sacramento River near Hamilton City	6/23/99	6/21/01	49	49	100%	6.0	8.5	7.6	0.6	7.6	0.9	NR
DCMOU	Deer Creek at Mouth	8/18/99	5/29/01	5	5	100%	7.1	8.8	7.8	0.7	7.8	1.2	NR
DCHWY	Deer Creek at Highway 99	6/23/99	4/17/00	5	5	100%	7.6	8.4	7.9	0.4	7.9	0.5	NR
DCPON	Deer Creek at Ponderosa Way	6/23/99	11/8/99	4	4	100%	7.5	8.0	7.8	0.3	7.8	0.4	NR
DCALN	Deer Creek at A Line Road	1/20/00	4/17/00	3	3	100%	7.3	7.8	7.6	0.3	7.6	0.5	NR
CHMOU	Big Chico Creek at Mouth	1/26/01	5/29/01	3	3	100%	7.4	7.9	7.7	0.3	7.7	0.5	NR
CHMUD	Big Chico Creek above Mud Creek	6/22/99	4/17/00	8	8	100%	7.4	8.4	7.9	0.4	7.9	0.7	NR
MUDCH	Mud Creek above Big Chico Creek	1/19/00	4/17/00	3	3	100%	7.2	7.4	7.3	0.1	7.3	0.2	NR
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/22/99	4/17/00	7	7	100%	7.3	8.3	7.9	0.4	7.9	0.6	NR
CHAGC	Big Chico Creek above Golf Course	9/14/99	4/17/00	6	6	100%	7.5	8.2	7.9	0.3	7.9	0.5	NR
CHASH	Big Chico Creek above Salmon Hole	6/22/99	8/17/99	3	3	100%	8.0	8.1	ID	ID	ID	ID	NR
CHHWY	Big Chico Creek at Hwy 32	10/28/99	1/19/00	3	3	100%	7.5	7.9	ID	ID	ID	ID	NR
LCSTL	Little Chico Creek at Stilson Cyn	9/14/99	1/19/00	4	4	100%	7.3	8.3	7.8	0.5	7.8	0.9	NR
LCTEN	Little Chico Creek at Ten Mile	10/28/99	1/19/00	3	3	100%	7.2	8.0	7.5	0.5	7.5	0.8	NR
SRCOL	Sacramento River at Colusa	2/28/96	6/21/01	107	107	100%	6.9	8.6	7.8	0.3	7.8	0.4	NR
BCGGE	Butte Creek at USGS gage	6/23/99	4/19/00	6	6	100%	6.5	8.7	8.1	0.9	8.0	1.4	NR
BCHWY	Butte Creek at Colusa Highway	6/23/99	4/19/00	7	7	100%	6.6	8.5	7.9	0.8	7.8	1.3	NR
BCPLF	Butte Creek below Pool Four	9/14/99	1/19/00	4	4	100%	7.3	7.9	7.6	0.3	7.6	0.6	NR
BCOKD	Butte Creek above Okie Dam	9/14/99	1/19/00	4	4	100%	7.3	8.2	7.7	0.4	7.7	0.8	NR
SACSL	Sacramento Slough	2/12/96	6/22/01	62	62	100%	6.7	8.7	7.8	0.4	7.7	0.5	NR
COLDR	Colusa Basin Drain	2/7/96	6/22/01	69	69	100%	6.7	8.6	7.9	0.4	7.8	0.6	NR
YRMRY	Yuba River at Marysville	2/27/96	5/16/01	47	47	100%	6.4	8.7	7.5	0.4	7.5	0.6	NR
FRNIC	Feather River near Nicolaus	2/23/96	6/22/01	78	78	100%	6.6	8.7	7.7	0.3	7.7	0.5	NR
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	27	100%	7.5	8.1	7.8	0.2	7.8	0.2	NR
SRVET	Sacramento River at Veterans Bridge	1/4/94	6/22/01	135	135	100%	6.8	8.9	7.7	0.4	7.6	0.6	NR
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	6/22/01	38	38	100%	5.9	8.6	7.2	0.7	7.1	1.0	NR
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	7.0	7.7	7.4	0.2	7.4	0.2	NR
ARDPK	American River at Discovery Park	1/4/94	6/19/01	101	101	100%	6.4	8.6	7.4	0.5	7.3	0.7	NR
SRFPT	Sacramento River at Freeport	2/20/96	6/19/01	113	113	100%	6.9	8.8	7.7	0.3	7.7	0.4	NR
SRRMF	Sacramento River at River Mile 44	1/18/94	6/19/01	114	114	100%	6.1	8.8	7.5	0.5	7.5	0.6	NR
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	8.1	8.7	8.3	0.2	8.3	0.3	NR
CCHSL	Cache Slough near Ryers Ferry	6/23/98	4/18/00	23	23	100%	6.9	8.5	7.5	0.4	7.4	0.6	NR

Specific Conductance

Units = μmhos/cm at 25˚C

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	mean	SD	median	IQR	min RL
PRSHA	Pit River above Shasta	7/22/98	5/16/00	16	16	100%	121	194	137	23	136	23	NR
MRSHA	McCloud River above Shasta	7/22/98	5/16/00	18	18	100%	77	184	115	27	112	33	NR
SRSHA	Sacramento River above Shasta	7/22/98	5/16/00	15	15	100%	76	146	111	27	108	39	NR
SCKPP	Spring Creek PP Discharge to Keswick Res.	6/24/98	4/18/00	19	19	100%	69	85	76	5	76	7	NR
SRBKR	Sacramento River below Keswick	1/20/98	4/17/01	71	71	100%	74	208	113	22	111	26	NR
CCWHI	Clear Creek above Whiskeytown	6/22/99	8/17/99	3	3	100%	109	169	139	33	137	61	NR
CCMOU	Clear Creek near Mouth	8/20/98	8/17/99	15	15	100%	80	106	91	7	91	11	NR
SRABB	Sacramento River above Bend Bridge	2/13/96	5/15/01	74	74	100%	85	272	126	29	124	33	NR
MCMOU	Mill Creek at Mouth	6/22/99	5/29/01	21	21	100%	65	335	168	65	158	86	NR
MCHYN	Mill Creek at Highway 99	4/6/01	4/7/01	4	4	100%	30	144	113	75	96	116	NR
MCGGE	Mill Creek at USGS gage	10/28/99	1/19/00	3	3	100%	111	194	157	48	153	86	NR
MCBLR	Mill Creek at Black Rock	6/22/99	4/6/01	7	7	100%	23	234	122	68	103	119	NR
SRHAM	Sacramento River near Hamilton City	6/23/99	6/21/01	50	50	100%	84	259	150	39	145	54	NR
DCMOU	Deer Creek at Mouth	8/18/99	5/29/01	6	6	100%	86	203	148	47	142	81	NR
DCHWY	Deer Creek at Highway 99	6/23/99	4/17/00	5	5	100%	58	168	109	48	101	80	NR
DCPON	Deer Creek at Ponderosa Way	6/23/99	11/8/99	4	4	100%	102	117	112	8	112	12	NR
DCALN	Deer Creek at A Line Road	1/20/00	4/17/00	3	3	100%	43	70	57	15	56	28	NR
CHMOU	Big Chico Creek at Mouth	1/26/01	5/29/01	4	4	100%	108	352	187	141	168	151	NR
CHMUD	Big Chico Creek above Mud Creek	7/20/99	4/17/00	7	7	100%	59	200	146	60	134	103	NR
MUDCH	Mud Creek above Big Chico Creek	1/19/00	4/17/00	3	3	100%	79	176	126	54	120	99	NR
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/22/99	4/17/00	7	7	100%	61	202	152	56	141	98	NR
CHAGC	Big Chico Creek above Golf Course	9/14/99	4/17/00	7	7	100%	60	209	146	56	136	98	NR
CHASH	Big Chico Creek above Salmon Hole	6/22/99	8/17/99	3	3	100%	180	196	189	9	189	16	NR
CHHWY	Big Chico Creek at Hwy 32	10/28/99	1/19/00	3	3	100%	77	140	111	36	107	65	NR
LCSTL	Little Chico Creek at Stilson Cyn	9/14/99	1/19/00	4	4	100%	121	190	166	38	163	55	NR
LCTEN	Little Chico Creek at Ten Mile	10/28/99	1/19/00	3	3	100%	104	152	133	31	131	50	NR
SRCOL	Sacramento River at Colusa	2/28/96	6/21/01	106	106	100%	95	252	141	25	139	31	NR
BCGGE	Butte Creek at USGS gage	6/23/99	4/19/00	6	6	100%	89	132	106	18	105	29	NR
BCHWY	Butte Creek at Colusa Highway	6/23/99	4/19/00	7	7	100%	128	227	183	43	179	69	NR
BCPLF	Butte Creek below Pool Four	9/14/99	1/19/00	4	4	100%	81	111	99	15	98	26	NR
BCOKD	Butte Creek above Okie Dam	9/14/99	1/19/00	4	4	100%	72	111	95	19	94	34	NR
SACSL	Sacramento Slough	2/12/96	6/22/01	63	63	100%	76	785	349	132	323	186	NR
COLDR	Colusa Basin Drain	2/7/96	6/22/01	71	71	100%	129	1283	625	215	587	288	NR
YRMRY	Yuba River at Marysville	2/27/96	5/16/01	47	47	100%	22	166	77	26	73	33	NR
FRNIC	Feather River near Nicolaus	2/23/96	6/22/01	80	80	100%	28	146	89	17	87	25	NR
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	27	100%	62	186	131	28	128	43	NR
SRVET	Sacramento River at Veterans Bridge	1/4/94	6/22/01	137	137	100%	21	243	150	38	145	55	NR
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	6/22/01	40	40	100%	92	513	258	121	230	168	NR
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	40	68	51	7	51	9	NR
ARDPK	American River at Discovery Park	1/4/94	6/19/01	101	101	100%	28	80	53	11	52	15	NR
SRFPT	Sacramento River at Freeport	2/20/96	6/19/01	112	112	100%	51	214	139	31	136	43	NR
SRRMF	Sacramento River at River Mile 44	1/18/94	6/19/01	116	116	100%	62	234	141	39	135	54	NR
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	262	382	320	41	318	64	NR
CCHSL	Cache Slough near Ryers Ferry	6/23/98	4/18/00	18	18	100%	106	313	203	57	196	84	NR

Summary Statistics Table Notes:
monitoring period start and end — Dates of first and last reported data.
n — Total number of data reported.
n det — Total number of data above reporting limits.
% det — Percent of data above reporting limits.
min det — Minimum value for data detected above reporting limits.
max det — Maximum value of data detected above reporting limits.
mean — Arithmetic mean value. "ID" if insufficient data to calculate.
SD — Standard Deviation. "ID" if insufficient data to calculate.
median — 50th percentile value. "ID" if insufficient data to calculate.
IQR — Interquartile range. "ID" if insufficient data to calculate.
min RL — Lowest reporting limit for data below detection. "NR" indicates there were no data below reporting limits.

Fish Tissue Data:
SRWP and DWR, 1997 - 2000

YEAR	STATION LOCATION	Site Category	Species	Tissue	Sample Type	Number of fish	Length (mm)	% Moisture	% Lipid	Mercury, mg/kg	Sum of PCB Congeners, µg/kg	Sum of Aroclors, µg/kg	Sum of Chlordanes, µg/kg	Sum of DDTs, µg/kg	Dieldrin, µg/kg
1997	Colusa Basin Drain	Ag Drain	White Catfish	fillet	Composite	5	288	78.8		0.304					
1997	Sacramento Slough	Ag Drain	White Catfish	fillet	Composite	5	274	77.6		0.438					
1997	Cache Slough	Delta	White Catfish	fillet	Composite	5	279	78.7		0.552					
1997	Cache Slough	Delta	White Catfish	fillet	Composite	5	271	79.1		0.415					
1997	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Composite	5	258	79.9	0.92	0.285	9.4	12.9	2.83	32.7	0.96
1997	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Composite	5	256	80.3	1.55	0.390	33.4	46.7	8.78	67.8	2.43
1997	Sacramento R. above Bend Bridge	Lower Sac. R. Mainstem	Rainbow Trout	fillet	Composite	5	313	75.3	2.54	0.032	7.3	ND	1.51	3.3	ND
1997	Sacramento R. below Keswick	Lower Sac. R. Mainstem	Rainbow Trout	fillet	Composite	5	366	72.4	3.99	0.032	23.8	27.0	2.88	26.4	0.62
1997	Sacramento R. at Veterans Br	Lower Sac. R. Mainstem	White Catfish	fillet	Composite	5	249	79.0	0.84	0.553	10.7	14.7	3.25	42.9	1.11
1997	American R. at Discovery Park	Major Tributary	White Catfish	fillet	Composite	4	274	80.4	0.49	0.524	58.8	80.6	7.97	62.0	0.72
1997	Feather R. near Nicolaus	Major Tributary	White Catfish	fillet	Composite	5	264	81.1	0.49	0.391	10.5	ND	4.29	36.4	1.01
1997	McCloud R. above Shasta	Tributary	Rainbow Trout	fillet	Composite	5	274	76.9		0.053					
1997	Pit R. above Shasta	Tributary	Rainbow Trout	fillet	Individual	1	332	86.0		0.047					
1997	Sacramento R. above Shasta	Tributary	Rainbow Trout	fillet	Composite	5	321	78.8		0.064					
1998	Colusa Basin Drain	Ag Drain	Carp	fillet	Composite	5	386	76.8	1.78	0.106	6.6	1.9	1.89	684.0	20.07
1998	Natomas East Main Drain	Ag Drain	Largemouth Bass	fillet	Composite	5	367	79.1	0.51	0.599	15.3	2.6	2.57	8.1	UJ
1998	Sacramento Slough	Ag Drain	Largemouth Bass	fillet	Composite	5	381	78.1	1.23	0.506	5.5	1.0	ND	41.3	2.79
1998	Cache Slough	Delta	Largemouth Bass	fillet	Composite	5	367	80.5	0.50	0.723	5.0	1.0	ND	32.7	2.53
1998	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Composite	5	345	77.0	0.86	0.748	6.2	1.0	ND	12.4	<2
1998	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Composite	5	334	76.6	0.90	0.895	116.9	1.0	1.01	25.0	2.01
1998	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Composite	5	286	80.5	1.67	0.518	46.5	3.8	3.78	75.9	2.28 J
1998	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Composite	5	250	80.0	1.94	0.258	57.1	10.0	16.40	129.5	<2
1998	Sacramento R. above Bend Bridge	Lower Sac. R. Mainstem	Pike Minnow	fillet	Composite	5	254	79.8	1.06	0.119	8.7	1.0	ND	8.4	<2
1998	Sacramento R. below Keswick	Lower Sac. R. Mainstem	Rainbow Trout	fillet	Composite	5	399	74.0	4.40	0.036	26.1	1.6	1.55	36.5	<2
1998	Sacramento R. at Colusa	Lower Sac. R. Mainstem	Carp	fillet	Composite	5	398	80.3	1.00	0.186	5.6	1.0	ND	62.7	<2
1998	Sacramento R. at Colusa	Lower Sac. R. Mainstem	Pike Minnow	fillet	Composite	5	278	80.6	0.76	0.301	7.0	1.0	ND	17.3	<2
1998	Sacramento R. near Hamilton City	Lower Sac. R. Mainstem	Pike Minnow	fillet	Composite	5	286	79.1	1.30	0.216	10.0	1.0	1.14	20.9	<2
1998	Sacramento R. near Hamilton City	Lower Sac. R. Mainstem	Sacramento Sucker	fillet	Composite	5	322	79.1	1.24	0.030	1.4	1.1	ND	2.1	<2
1998	Sacramento R. at Veterans Br	Lower Sac. R. Mainstem	Largemouth Bass	fillet	Composite	5	335	78.8	0.74	0.818	7.3	1.0	ND	22.5	<2
1998	American R. at Discovery Park	Major Tributary	Pike Minnow	fillet	Composite	5	283	75.0	4.02	0.418	35.7	11.0	21.78	58.2	3.67
1998	American R. at J Street	Major Tributary	Largemouth Bass	fillet	Composite	4	375	78.5	0.67	0.659	5.3	2.0	2.01	4.8	<2
1998	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Composite	5	382	79.1	0.72	1.154	8.2	1.0	ND	14.1	<2
1999	Natomas East Main Drain	Ag Drain	Largemouth Bass	fillet	Composite	5	332	79.2	0.7	0.680	35.1	26.0	4.08	16.1	<2
1999	Natomas East Main Drain	Ag Drain	White Catfish	fillet	Composite	5	258	80.7		0.286					
1999	Sacramento Slough	Ag Drain	White Catfish	fillet	Composite	5	263	79.1	0.4	0.639	1.2	ND	ND	17.9	<2
1999	Sacramento Slough	Ag Drain	Largemouth Bass	fillet	Composite	5	381	80.6	1.0	0.442	11.0	ND	1.27	45.9	2.00
1999	Cache Slough	Delta	White Catfish	fillet	Composite	5		81.8	0.6		15.5	16.0	1.40	56.4	<2
1999	Cache Slough	Delta	Largemouth Bass	fillet	Composite	5		79.6	0.4		6.5	ND	ND	17.0	<2
1999	Cache Slough	Delta	Largemouth Bass	fillet	Individual	1	385	76.6		0.877					
1999	Cache Slough	Delta	Largemouth Bass	fillet	Individual	1	340	78.3		0.747					
1999	Cache Slough	Delta	Largemouth Bass	fillet	Individual	1	340	78.6		0.872					
1999	Cache Slough	Delta	Carp	fillet	Composite	5	352	78.9		0.107					
1999	Cache Slough	Delta	Largemouth Bass	fillet	Individual	1	429	79.0		0.898					
1999	Cache Slough	Delta	Largemouth Bass	fillet	Individual	1	380	79.2		1.180					
1999	Cache Slough	Delta	White Catfish	fillet	Individual	1	270	79.3		0.602					
1999	Cache Slough	Delta	White Catfish	fillet	Individual	1	285	79.7		0.513					
1999	Cache Slough	Delta	White Catfish	fillet	Individual	1	280	81.2		0.497					
1999	Cache Slough	Delta	White Catfish	fillet	Individual	1	330	82.0		0.833					
1999	Cache Slough	Delta	White Catfish	fillet	Individual	1	274	83.3		0.680					
1999	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Composite	5		80.4	1.2		18.1	21.0	1.99	31.5	<2
1999	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Composite	5		79.8	2.0		24.8	24.0	2.67	58.8	<2
1999	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Composite	5		79.8	1.0		26.0	26.0	2.58	44.3	<2

YEAR	STATION LOCATION	Site Category	Species	Tissue	Sample Type	Number of fish	Length (mm)	% Moisture	% Lipid	Mercury, mg/kg	Sum of PCB Congeners, µg/kg	Sum of Aroclors, µg/kg	Sum of Chlordanes, µg/kg	Sum of DDTs, µg/kg	Dieldrin, µg/kg
1999	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Composite	5		72.2	3.9		36.6	29.0	5.50	88.6	<2
1999	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Composite	5		77.7	1.1		11.0	ND	1.58	26.4	<2
1999	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	250	58.9		0.197					
1999	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	283	69.3		0.448					
1999	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	379	76.7		1.010					
1999	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	385	76.7		1.340					
1999	Sacramento R. at Mile 44	Delta	Bluegill	fillet	Composite	5	185	76.9		0.103					
1999	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	341	76.9		1.050					
1999	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	355	77.1		0.750					
1999	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	315	77.2		0.775					
1999	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	341	77.2		0.524					
1999	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	317	77.6		0.867					
1999	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	358	78.1		0.883					
1999	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	350	78.4		1.350					
1999	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	259	78.5		0.327					
1999	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	265	78.9		0.536					
1999	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	277	78.9		0.563					
1999	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	309	78.9		0.426					
1999	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	286	78.9		0.673					
1999	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	295	78.9		0.375					
1999	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	261	80.3		0.238					
1999	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	305	80.4		0.271					
1999	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	290	80.5		0.256					
1999	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	265	81.1		1.140					
1999	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	275	81.3		0.237					
1999	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	281	82.3		0.515					
1999	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	233	82.6		0.204					
1999	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	381	82.8		1.370					
1999	Sacramento R. at Veterans Br	Lower Sac. R. Mainstem	Sacramento Sucker	fillet	Composite	5	318	79.6	1.37	0.098	19.0	15.0	2.44	18.2	<2
1999	American R. at Discovery Park	Major Tributary	Largemouth Bass	fillet	Composite	5	340	78.5	0.7	0.850	22.7	23.0	2.86	18.3	<2
1999	American R. at Discovery Park	Major Tributary	Sacramento Sucker	fillet	Composite	5	314	79.6	1.0	0.247	9.7	ND	1.10	7.6	<2
1999	American R. at J Street	Major Tributary	Pike Minnow	fillet	Composite	5	248	78.4	1.0	0.426	16.2	18.0	2.48	16.3	<2
1999	American R. at J Street	Major Tributary	Sacramento Sucker	fillet	Composite	5	266	77.5	1.1	0.099	2.5	ND	ND	2.9	<2
1999	Feather R. near Nicolaus	Major Tributary	Pike Minnow	fillet	Composite	5	287	80.5	0.7	1.200	19.0	20.0	ND	33.3	<2
1999	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Composite	5		76.7	0.9		7.4	ND	ND	13.3	<2
1999	Feather R. near Nicolaus	Major Tributary	Striped Bass	fillet	Individual	1	626	76.3		1.280					
1999	Feather R. near Nicolaus	Major Tributary	Striped Bass	fillet	Individual	1	645	76.5		0.320					
1999	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	339	76.7		2.080					
1999	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	361	77.7		1.520					
1999	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	321	77.8		0.667					
1999	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	495	77.8		2.350					
1999	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	305	77.9		0.649					
1999	Feather R. near Nicolaus	Major Tributary	White Catfish	fillet	Individual	1	497	77.9		0.745					
1999	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	314	77.9		0.633					
1999	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	310	78.0		0.555					
1999	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	310	78.0		0.667					
1999	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	322	78.1		0.787					
1999	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	456	78.1		1.510					
1999	Feather R. near Nicolaus	Major Tributary	Striped Bass	fillet	Individual	1	817	78.5		3.500					
1999	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	350	78.9		1.030					
1999	Feather R. near Nicolaus	Major Tributary	Bluegill	fillet	Composite	5	184	79.7		0.121					
1999	Feather R. near Nicolaus	Major Tributary	White Catfish	fillet	Individual	1	491	79.8		0.620					

YEAR	STATION LOCATION	Site Category	Species	Tissue	Sample Type	Number of fish	Length (mm)	% Moisture	% Lipid	Mercury, mg/kg	Sum of PCB Congeners, µg/kg	Sum of Aroclors, µg/kg	Sum of Chlordanes, µg/kg	Sum of DDTs, µg/kg	Dieldrin, µg/kg
1999	Clear Ck @ Hwy 273	Tributary	Riffle sculpin	fillet	Composite			79.3	1.13	0.241	2.7	ND	<RL	2.2	<2
1999	Clear Ck @ Reading Bar	Tributary	Riffle sculpin	fillet	Composite			80.0	0.83	0.160	<RL	ND	ND	<RL	<2
1999	Clear Ck @ Reading Bar	Tributary	Rainbow Trout	fillet	Composite			80.5	1.13	0.046	<RL	ND	ND	<RL	<2
1999	Clear Ck @ Reading Bar	Tributary	Riffle sculpin	liver	Composite			80.0	0.83	0.088					
1999	Clear Ck @ Reading Bar	Tributary	Rainbow Trout	liver	Composite			80.5	1.13	<.020					
1999	Clear Ck above Whiskeytown	Tributary	Rainbow Trout	fillet	Composite			78.1	1.96	0.050	0.9	ND	ND	<RL	<2
1999	Clear Ck above Whiskeytown	Tributary	Riffle sculpin	fillet	Composite			79.1	1.12	**0.107**	<RL	ND	ND	<RL	<2
1999	Clear Ck above Whiskeytown	Tributary	Rainbow Trout	liver	Composite			78.1	1.96	0.050					
1999	Clear Ck above Whiskeytown	Tributary	Riffle sculpin	fillet	Composite			79.1	1.12	**0.096**					
1999	Clear Ck above Whiskeytown	Tributary	Riffle sculpin	liver	Composite			79.1	1.12	0.213					
1999	Big Chico Ck @ Hwy 32	Tributary	Rainbow Trout	fillet	Composite			76.8	3.17	**0.041**	0.8	ND	ND	2.5	<2
1999	Big Chico Ck @ Hwy 32	Tributary	Rainbow Trout	fillet	Composite			76.8	3.17	**0.044**		ND	ND	<RL	<2
1999	Big Chico Ck @ Hwy 32	Tributary	Rainbow Trout	liver	Composite			76.8	3.17	0.037					
1999	Big Chico Ck @ Hwy 99	Tributary	Smallmouth bass	fillet	Composite			77.8	0.99	0.231	<RL	ND	<RL	<RL	<2
1999	Big Chico Ck @ Hwy 99	Tributary	Smallmouth bass	fillet	Composite			77.8	0.98		0.4	ND	ND	<RL	<2
1999	Big Chico Ck @ Hwy 99	Tributary	Riffle sculpin	fillet	Composite			79.6	0.61	0.146	<RL	ND	<RL	<RL	<2
1999	Big Chico Ck @ Hwy 99	Tributary	Smallmouth bass	liver	Composite			77.8	0.99	0.124					
1999	Big Chico Ck @ Hwy 99	Tributary	Riffle sculpin	liver	Composite			79.6	0.61	0.182					
1999	Deer Ck @ Hwy 99	Tributary	Riffle sculpin	fillet	Composite			77.2	2.84	0.082	0.4	ND	<RL	<RL	<2
1999	Deer Ck @ Hwy 99	Tributary	Smallmouth bass	fillet	Composite			79.2	0.93	0.075	<RL	ND	ND	<RL	<2
1999	Deer Ck @ Hwy 99	Tributary	Riffle sculpin	liver	Composite			77.2	2.84	0.043					
1999	Deer Ck @ Hwy 99	Tributary	Smallmouth bass	liver	Composite			79.2	0.93	0.044					
1999	Deer Ck below Childs Meadow	Tributary	Rainbow Trout	fillet	Composite			76.8	3.28	<.020	8.8	ND	<RL	4.9	<2
1999	Deer Ck below Childs Meadow	Tributary	Rainbow Trout	fillet	Composite			76.9	2.42		7.2	ND	<RL	4.0	<2
1999	Deer Ck below Childs Meadow	Tributary	Riffle sculpin	fillet	Composite			77.9	2.11	0.034	0.2	ND	ND	<RL	<2
1999	Deer Ck below Childs Meadow	Tributary	Rainbow Trout	liver	Composite			76.8	3.28	<.020					
1999	Deer Ck below Childs Meadow	Tributary	Riffle sculpin	liver	Composite			77.9	2.11	<.020					
1999	Mill Ck at Black Rock	Tributary	Riffle sculpin	fillet	Composite			79.1	0.73	0.327	<RL	ND	ND	<RL	<2
1999	Mill Ck at Black Rock	Tributary	Riffle sculpin	liver	Composite			79.1	0.73	0.353					
1999	Mill Ck at Hwy 99	Tributary	Riffle sculpin	fillet	Composite			79.7	1.01	0.279	0.2	ND	ND	<RL	<2
1999	Mill Ck at Hwy 99	Tributary	Riffle sculpin	liver	Composite			79.7	1.01	0.288					
1999	Putah Creek	Tributary	Sacramento Sucker	fillet	Composite	4	383	76.3	3.3	0.185	20.7	19.0	1.68	95.7	<2
1999	Putah Creek	Tributary	Largemouth Bass	fillet	Composite	5		77.9	0.6		3.9	ND	ND	13.2	<2
1999	Putah Creek	Tributary	White Catfish	fillet	Individual	1	470	73.3		0.146					
1999	Putah Creek	Tributary	Largemouth Bass	fillet	Individual	1	425	76.0		0.592					
1999	Putah Creek	Tributary	Largemouth Bass	fillet	Individual	1	354	76.7		0.396					
1999	Putah Creek	Tributary	Largemouth Bass	fillet	Individual	1	410	77.0		0.540					
1999	Putah Creek	Tributary	Largemouth Bass	fillet	Individual	1	345	77.1		0.231					
1999	Putah Creek	Tributary	Largemouth Bass	fillet	Individual	1	402	78.6		0.630					
1999	Putah Creek	Tributary	Bluegill	fillet	Composite	5	112	78.9		0.097					
1999	Putah Creek	Tributary	Bluegill	fillet	Composite	5	135	79.5		0.123					
2000	Colusa Basin Drain	Ag Drain	White Catfish	fillet	Composite	5	259.4	81.0	0.80	0.21	1.5	ND	ND	40.2	<RL
2000	Colusa Basin Drain	Ag Drain	Carp	fillet	Composite	5	371.6	78.3	1.25	0.18	3.6	ND	ND	284.8	3.88
2000	Natomas East Main Drain	Ag Drain	Largemouth Bass	fillet	Composite	5	350.4	76.8	0.74	0.65	23.4	32.0	1.82	17.2	<RL
2000	Natomas East Main Drain	Ag Drain	White Catfish	fillet	Composite	4	275.75	78.8	2.00	0.21	37.0	45.0	2.66	37.9	<RL
2000	Natomas East Main Drain	Ag Drain	Striped Bass	fillet	Individual	1	494	72.0		0.81					
2000	Sacramento Slough	Ag Drain	White Catfish	fillet	Composite	5	261.6	80.7	1.89	0.44	26.6	28.0	1.77	64.5	2.55
2000	Sacramento Slough	Ag Drain	Largemouth Bass	fillet	Composite	5	355	78.6	0.60	0.49	4.3	ND	ND	30.8	<RL
2000	Cache Slough	Delta	White Catfish	fillet	Composite	10	288.2	79.7	1.06	0.443096	9.7	13.0	1.21	54.7	<RL
2000	Cache Slough	Delta	Largemouth Bass	fillet	Composite	6	361.8	78.7	0.76	0.50	5.5	ND	ND	31.2	<RL
2000	Cache Slough	Delta	Sacramento Sucker	fillet	Composite	5	393.6	78.5		0.11					
2000	Cache Slough	Delta	Crappie	fillet	Composite	5	231.2	77.0		0.32					

Fish Tissue Data:
SRWP and DWR, 1997 - 2000

YEAR	STATION LOCATION	Site Category	Species	Tissue	Sample Type	Number of fish	Length (mm)	% Moisture	% Lipid	Mercury, mg/kg	Sum of PCB Congeners, µg/kg	Sum of Aroclors, µg/kg	Sum of Chlordanes, µg/kg	Sum of DDTs, µg/kg	Dieldrin, µg/kg
2000	Cache Slough	Delta	Largemouth Bass	fillet	Individual	1	400	78.6		1.14					
2000	Cache Slough	Delta	White Catfish	fillet	Individual	1	276	82.6		0.21					
2000	Cache Slough	Delta	Largemouth Bass	fillet	Individual	1	319	78.6		0.82					
2000	Cache Slough	Delta	White Catfish	fillet	Individual	1	254	81.3		0.14					
2000	Cache Slough	Delta	White Catfish	fillet	Individual	1	258	80.5		0.43					
2000	Cache Slough	Delta	White Catfish	fillet	Individual	1	259	80.7		0.53					
2000	Cache Slough	Delta	White Catfish	fillet	Individual	1	275	78.3		0.52					
2000	Cache Slough	Delta	White Catfish	fillet	Individual	1	290	82.3		0.49					
2000	Cache Slough	Delta	White Catfish	fillet	Individual	1	323	79.3		0.48					
2000	Cache Slough	Delta	White Catfish	fillet	Individual	1	325	78.6		0.62					
2000	Cache Slough	Delta	White Catfish	fillet	Individual	1	328	79.5		0.37					
2000	Cache Slough	Delta	White Catfish	fillet	Individual	1	305	79.9		0.45					
2000	Cache Slough	Delta	White Catfish	fillet	Individual	1	265	80.1		0.40					
2000	Cache Slough	Delta	White Catfish	fillet	Individual	1	228	80.1		0.25					
2000	Cache Slough	Delta	White Catfish	fillet	Individual	1	385	83.8		1.00					
2000	Cache Slough	Delta	Largemouth Bass	fillet	Individual	1	560	76.2		1.27					
2000	Cache Slough	Delta	Largemouth Bass	fillet	Individual	1	348	77.3		0.31					
2000	Cache Slough	Delta	Largemouth Bass	fillet	Individual	1	340	77.5		0.53					
2000	Cache Slough	Delta	Largemouth Bass	fillet	Individual	1	382	77.8		0.48					
2000	Cache Slough	Delta	Largemouth Bass	fillet	Individual	1	348	78.3		0.49					
2000	Cache Slough	Delta	Largemouth Bass	fillet	Individual	1	365	76.2		0.59					
2000	Cache Slough	Delta	Largemouth Bass	fillet	Individual	1	388	77.5		0.60					
2000	Cache Slough	Delta	Largemouth Bass	fillet	Individual	1	270	79.5		0.39					
2000	Cache Slough	Delta	Largemouth Bass	fillet	Individual	1	290	80.1		0.31					
2000	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Composite	6	368.7	77.5	1.12	0.99	13.2	15.0	ND	16.8	<RL
2000	Sacramento R. at Mile 44	Delta	Sacramento Sucker	fillet	Composite	5	452.2	76.1	3.83	0.22	24.3	43.0	2.00	57.4	<RL
2000	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Composite	7	287.86	79.6	1.46	0.386827	37.8	61.0	1.97	39.2	<RL
2000	Sacramento R. at Mile 44	Delta	Pike Minnow	fillet	Composite	5	252.2	81.7	0.96	0.11	5.0	ND	ND	9.7	<RL
2000	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	327	75.9		0.92					
2000	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	345	75.9		0.89					
2000	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	350	74.1		0.86					
2000	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	359	75.1		0.86					
2000	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Composite										
2000	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	343	74.4		0.70					
2000	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	392	74.8		1.08					
2000	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	386	74.2		1.26					
2000	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	376	73.5		1.06					
2000	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	359	76.0		1.11					
2000	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	356	74.0		0.74					
2000	Sacramento R. at Mile 44	Delta	Striped Bass	fillet	Individual	1	450	74.8		0.34					
2000	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	286	75.9		0.45					
2000	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	281	78.1		0.44					
2000	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	227	77.7		0.18					
2000	Sacramento R. at Mile 44	Delta	Largemouth Bass	fillet	Individual	1	247	76.6		0.34					
2000	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	317	80.6		0.56					
2000	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	314	81.3		1.04					
2000	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	259	77.3		0.18					
2000	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	296	72.0		0.29					
2000	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	294	79.2		0.25					

YEAR	STATION LOCATION	Site Category	Species	Tissue	Sample Type	Number of fish	Length (mm)	% Moisture	% Lipid	Mercury, mg/kg	Sum of PCB Congeners, µg/kg	Sum of Aroclors, µg/kg	Sum of Chlordanes, µg/kg	Sum of DDTs, µg/kg	Dieldrin, µg/kg
2000	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	270	79.0		0.16					
2000	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	265	77.1		0.24					
2000	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	227	76.2		0.22					
2000	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	207	75.9		0.24					
2000	Sacramento R. at Mile 44	Delta	White Catfish	fillet	Individual	1	345	79.4		0.72					
2000	Sacramento R. above Bend Bridge	Lower Sac. R. Mainstem	Sacramento Sucker	fillet	Composite	5	457	75.3	7.04	0.10	10.6	10.0	ND	5.9	<RL
2000	Sacramento R. above Bend Bridge	Lower Sac. R. Mainstem	Rainbow Trout	fillet	Composite	5	350	77.3	1.79	0.04	6.1	ND	ND	3.6	ND
2000	Sacramento R. below Keswick	Lower Sac. R. Mainstem	Rainbow Trout	fillet	Composite	4	422	73.9	5.32	0.04	11.3	11.0	ND	7.4	<RL
2000	Sacramento R. at Colusa	Lower Sac. R. Mainstem	Pike Minnow	fillet	Composite	5	275.2	78.7	1.36	0.15	10.8	14.0	ND	19.0	<RL
2000	Sacramento R. at Colusa	Lower Sac. R. Mainstem	Striped Bass	fillet	Individual	1	451	76.9	0.80	0.30	23.8	34.0	1.48	45.4	<RL
2000	Sacramento R. at Colusa	Lower Sac. R. Mainstem	Sacramento Sucker	fillet	Composite	5	290.4	79.7	0.86	0.06	3.8	ND	ND	7.5	ND
2000	Sacramento R. near Hamilton City	Lower Sac. R. Mainstem	Pike Minnow	fillet	Composite	5	298.2	79.0	1.05	0.29	9.1	12.0	ND	12.1	ND
2000	Sacramento R. near Hamilton City	Lower Sac. R. Mainstem	Sacramento Sucker	fillet	Composite	5	316.2	79.2	1.61	<.0314	0.6	ND	ND	ND	ND
2000	Sacramento R. at Veterans Br	Lower Sac. R. Mainstem	Pike Minnow	fillet	Composite	4	266	80.3	0.63	0.25	25.5	22.0	1.07	34.2	<RL
2000	Sacramento R. at Veterans Br	Lower Sac. R. Mainstem	White Catfish	fillet	Composite	5	263.6	78.4	3.04	0.21	40.5	49.0	2.40	77.0	<RL
2000	Sacramento R. at Veterans Br	Lower Sac. R. Mainstem	Largemouth Bass	fillet	Composite	5	371.2	77.9	0.78	0.96	4.2	ND	ND	11.9	<RL
2000	American R. at Discovery Park	Major Tributary	Pike Minnow	fillet	Composite	5	277.8	78.1	1.94	0.42	27.4	27.0	6.38	35.0	<RL
2000	American R. at Discovery Park	Major Tributary	White Catfish	fillet	Composite	5	261.8	78.7	1.96	0.26	41.4	44.0	3.00	54.0	<RL
2000	American R. at Discovery Park	Major Tributary	Largemouth Bass	fillet	Composite	5	393.4	78.3	0.86	1.37	29.8	47.0	2.71	17.1	<RL
2000	American R. at Discovery Park	Major Tributary	Largemouth Bass	fillet	Individual	1	471	77.1		1.38					
2000	American R. at Discovery Park	Major Tributary	Redear Sunfish	fillet	Composite	5	192.8	77.0		0.30					
2000	American R. at J Street	Major Tributary	Sacramento Sucker	fillet	Composite	5	249	79.6	1.32	0.08	7.6	10.0	ND	6.4	<RL
2000	American R. at J Street	Major Tributary	Pike Minnow	fillet	Composite	5	264.6	77.6	2.85	0.54	32.3	33.0	7.71	36.6	<RL
2000	Feather R. near Nicolaus	Major Tributary	Pike Minnow	fillet	Composite	5	300.8	79.8	0.74	0.57	9.1	12.0	ND	16.9	<RL
2000	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Composite	6	312.83	78.3	0.54	0.606581	5.7	ND	ND	6.5	ND
2000	Feather R. near Nicolaus	Major Tributary	Striped Bass	fillet	Individual	1	441	72.8		1.65					
2000	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	305	78.2		0.63					
2000	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	305	76.7		0.40					
2000	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	311	77.8		0.70					
2000	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	306	76.5		0.54					
2000	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	311	77.3		0.82					
2000	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	339	77.4		0.56					
2000	Feather R. near Nicolaus	Major Tributary	Redear Sunfish	fillet	Composite	5	153.6	76.8		0.22					
2000	Feather R. near Nicolaus	Major Tributary	Channel Catfish	fillet	Composite	5	478.6	72.2		0.73					
2000	Feather R. near Nicolaus	Major Tributary	White Catfish	fillet	Individual	1	272	80.5		0.39					
2000	Feather R. near Nicolaus	Major Tributary	White Catfish	fillet	Individual	1	269	79.4		0.85					
2000	Feather R. near Nicolaus	Major Tributary	White Catfish	fillet	Individual	1	545	69.2		0.55					
2000	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	305	75.6		0.47					
2000	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	334	75.8		0.79					
2000	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	362	76.9		1.00					
2000	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	236	77.7		0.21					
2000	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	233	78.6		0.27					
2000	Feather R. near Nicolaus	Major Tributary	Striped Bass	fillet	Individual	1	556	75.2		1.22					
2000	Feather R. near Nicolaus	Major Tributary	White Catfish	fillet	Individual	1	492	69.6		0.55					
2000	Feather R. near Nicolaus	Major Tributary	White Catfish	fillet	Individual	1	670	73.2		1.25					
2000	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	334	74.9		0.55					
2000	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	321	75.8		0.42					
2000	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	302	78.2		0.67					
2000	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	355	75.9		0.86					

Fish Tissue Data:
SRWP and DWR, 1997 - 2000

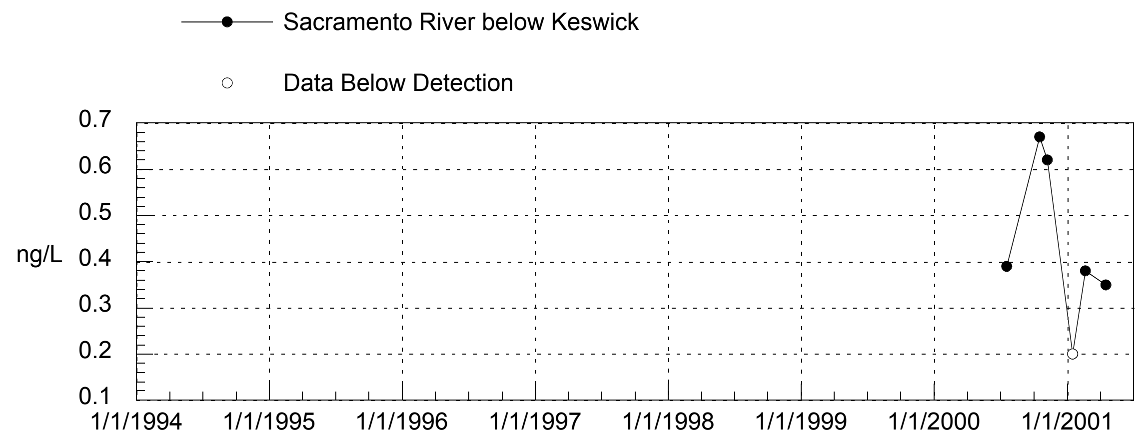
YEAR	STATION LOCATION	Site Category	Species	Tissue	Sample Type	Number of fish	Length (mm)	% Moisture	% Lipid	Mercury, mg/kg	Sum of PCB Congeners, µg/kg	Sum of Aroclors, µg/kg	Sum of Chlordanes, µg/kg	Sum of DDTs, µg/kg	Dieldrin, µg/kg
2000	Feather R. near Nicolaus	Major Tributary	Largemouth Bass	fillet	Individual	1	255	76.2		0.46					
2000	Feather R. near Nicolaus	Major Tributary	White Catfish	fillet	Individual	1	205	85.8		0.45					
2000	Feather R. near Nicolaus	Major Tributary	White Catfish	fillet	Individual	1	278	79.9		1.21					
2000	Clear Creek at Mouth	Tributary	Rainbow Trout	fillet	Composite	5	358.8	77.8	1.34	0.05	8.4	11.0	ND	5.3	ND
2000	Clear Creek at Mouth	Tributary	Largemouth Bass	fillet	Composite	5	376.4	80.0	0.50	0.45	4.0	ND	ND	ND	ND
2000	Big Chico Ck near mouth	Tributary	Pike Minnow	fillet	Composite	5	288.2	79.9	0.74	0.48	5.1	ND	1.11	10.4	ND
2000	Big Chico Ck near mouth	Tributary	Largemouth Bass	fillet	Composite	5	358.8	76.0	1.19	0.33	2.5	ND	ND	11.0	<RL
2000	Putah Creek	Tributary	Largemouth Bass	fillet	Composite	8	348	77.8	0.50	0.45	6.2	ND	ND	13.6	<RL
2000	Putah Creek	Tributary	Largemouth Bass	fillet	Individual	1	324	77.8		0.26					
2000	Putah Creek	Tributary	Largemouth Bass	fillet	Individual	1	376	78.2		0.45					
2000	Putah Creek	Tributary	Largemouth Bass	fillet	Individual	1	384	77.7		0.57					
2000	Putah Creek	Tributary	Largemouth Bass	fillet	Individual	1	409	77.3		0.82					
2000	Putah Creek	Tributary	Largemouth Bass	fillet	Individual	1	390	77.4		0.64					
2000	Putah Creek	Tributary	Largemouth Bass	fillet	Individual	1	306	77.8		0.28					
2000	Putah Creek	Tributary	Largemouth Bass	fillet	Individual	1	210	77.3		0.10					
2000	Putah Creek	Tributary	Largemouth Bass	fillet	Individual	1	385	74.3		0.50					
2000	Putah Creek	Tributary	Largemouth Bass	fillet	Individual	1	319	78.9		0.34					
2000	Putah Creek	Tributary	Largemouth Bass	fillet	Individual	1	342	78.5		0.34					
2000	Putah Creek	Tributary	Largemouth Bass	fillet	Individual	1	326	78.7		0.22					
2000	Putah Creek	Tributary	Bluegill	fillet	Composite	5	157a	79.8		0.16					
2000	Putah Creek	Tributary	Bluegill	fillet	Composite	5	147a	80.1		0.07					
2000	Putah Creek	Tributary	Bluegill	fillet	Composite	5	150a	78.2		0.16					
2000	Putah Creek	Tributary	Bluegill	fillet	Composite	5	148a	79.1		0.10					
2000	Upper Putah Creek	Tributary	Brown Trout	fillet	Composite	5	300.8	77.9	1.59	0.06	4.6	ND	ND	4.6	<RL
2000	Sacramento R. above Shasta	Tributary	Rainbow Trout	fillet	Composite	5	318	81.1	0.47	0.06	3.5	ND	ND	ND	ND

"<" indicates concentration not detected above specific reporting limit (for mercury and dieldrin)
"J" indicates the analyte was positively identified and the associated value is an estimated concentration
"ND" indicates "Not Detected"
"UJ" indicates that the analyte was not detected above the reported quantitation limit
<RL indicates not detected above reporting limits for individual compounds or congeners (for PCBs, aroclors, chlordanes, DDTs)
All tissue concentration data are provided on a "Wet Weight" basis
Blanks indicate data not reported or analyzed
Table Notes

APPENDIX B

Time Series Plots of Monitoring Data: SRWP, USGS NAWQA, Sacramento River CMP, and City of Redding

Time Series Plots of Monitoring Data: Mercury Data


Sacramento River below Keswick
Data Below Detection
ng/L
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1/1/1994
1/1/1995
1/1/1996
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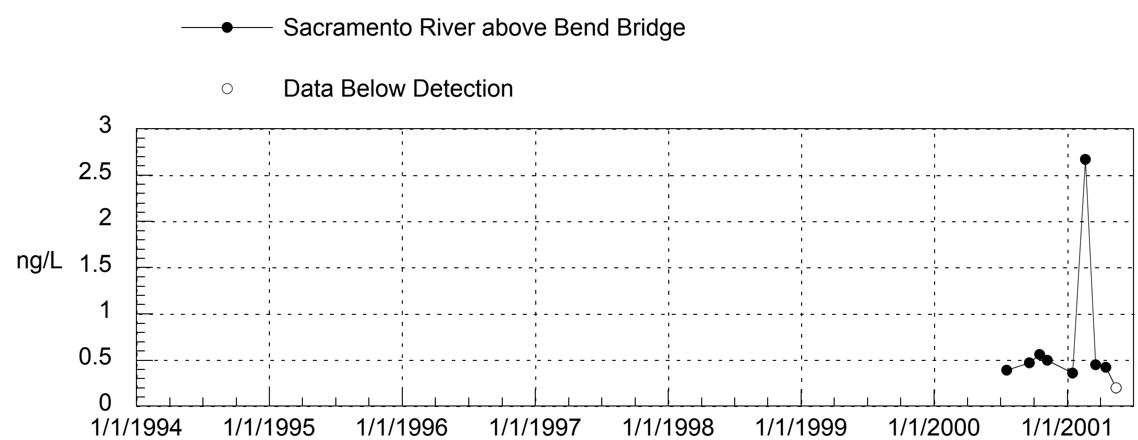
1/1/1999
1/1/2000
1/1/2001


Sacramento River above Bend Bridge
Data Below Detection
ng/L
3
2.5
2
1.5
1
0.5
0
1/1/1994
1/1/1995
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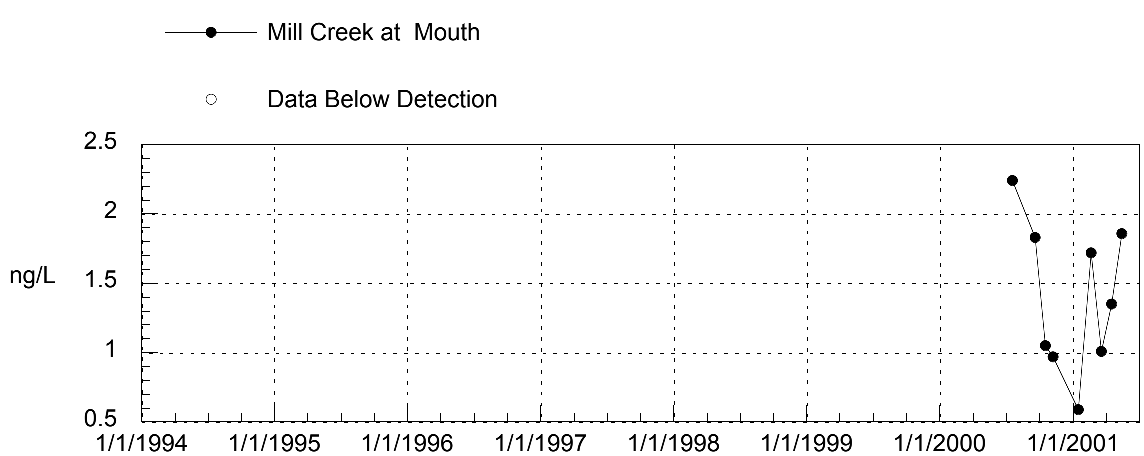
1/1/2000
1/1/2001


Mill Creek at Mouth
Data Below Detection
ng/L
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2
1.5
1
0.5
1/1/1994
1/1/1995
1/1/1996
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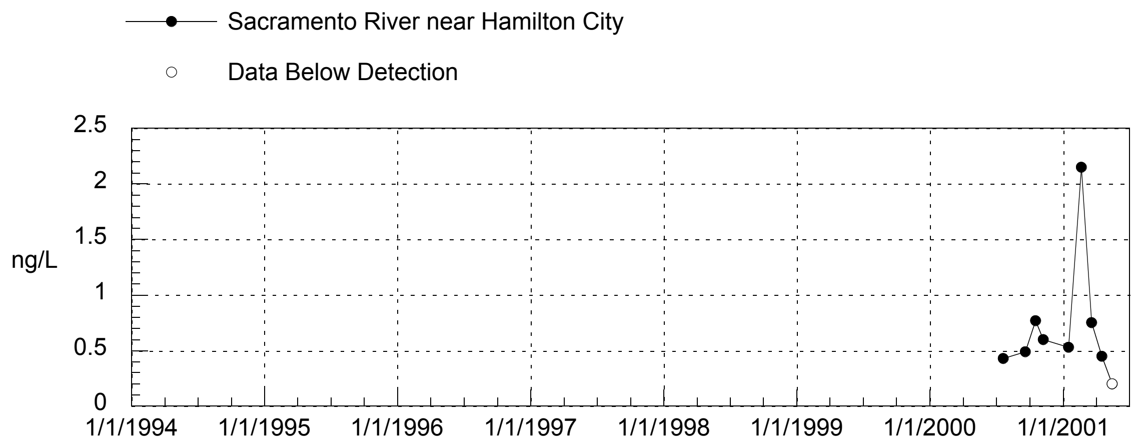
1/1/2000
1/1/2001


Sacramento River near Hamilton City
Data Below Detection
ng/L
2.5
2
1.5
1
0.5
0
1/1/1994
1/1/1995
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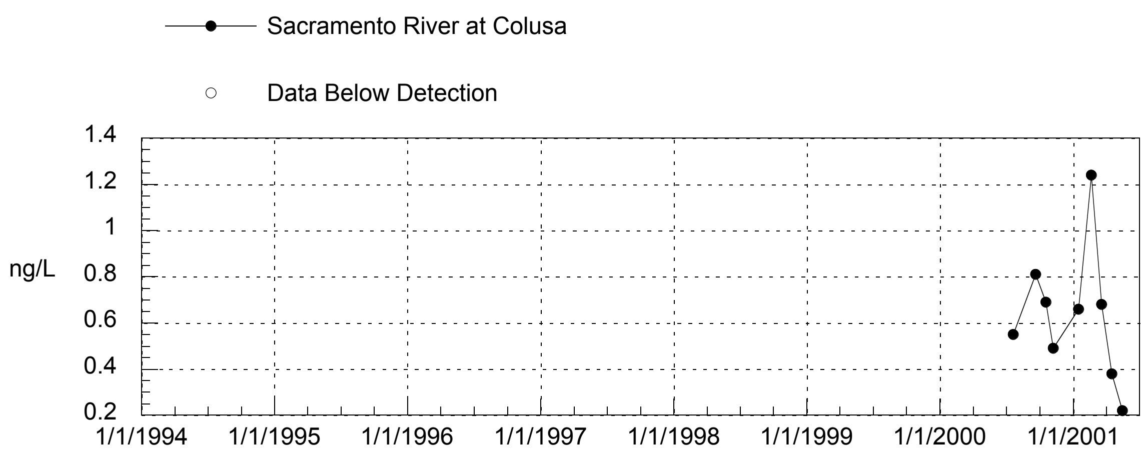
1/1/2000
1/1/2001


Sacramento River at Colusa
Data Below Detection
ng/L
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1.2
1
0.8
0.6
0.4
0.2
1/1/1994
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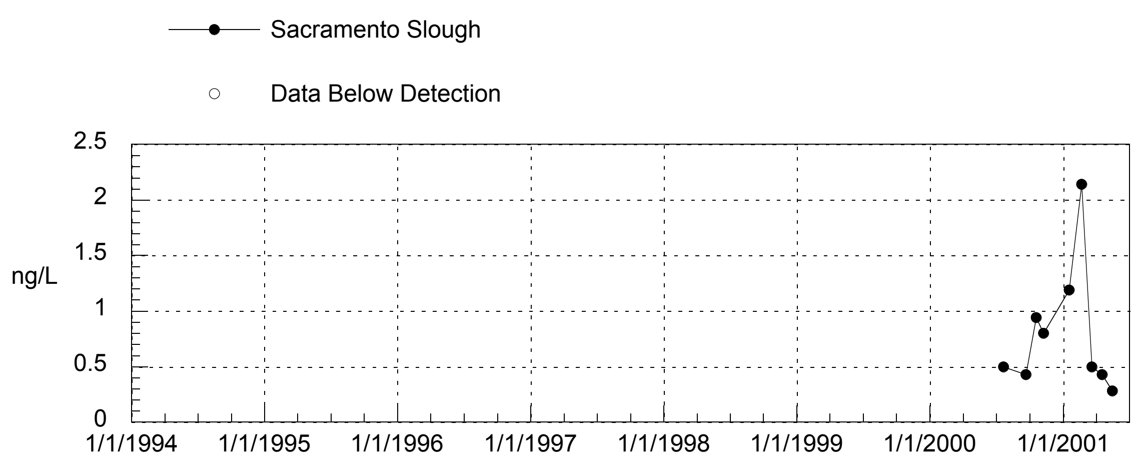
1/1/2000
1/1/2001


Sacramento Slough
Data Below Detection
ng/L
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2
1.5
1
0.5
0
1/1/1994
1/1/1995
1/1/1996
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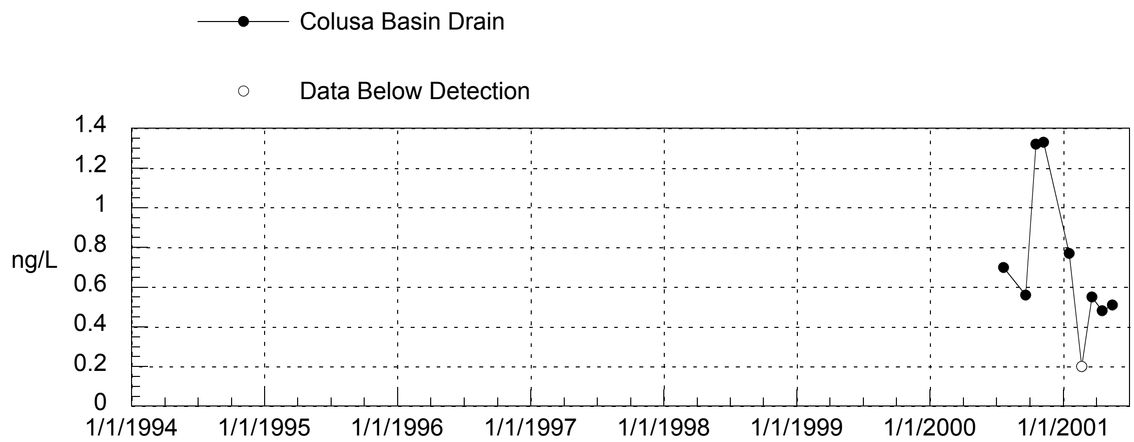
1/1/2000
1/1/2001



Colusa Basin Drain
Data Below Detection
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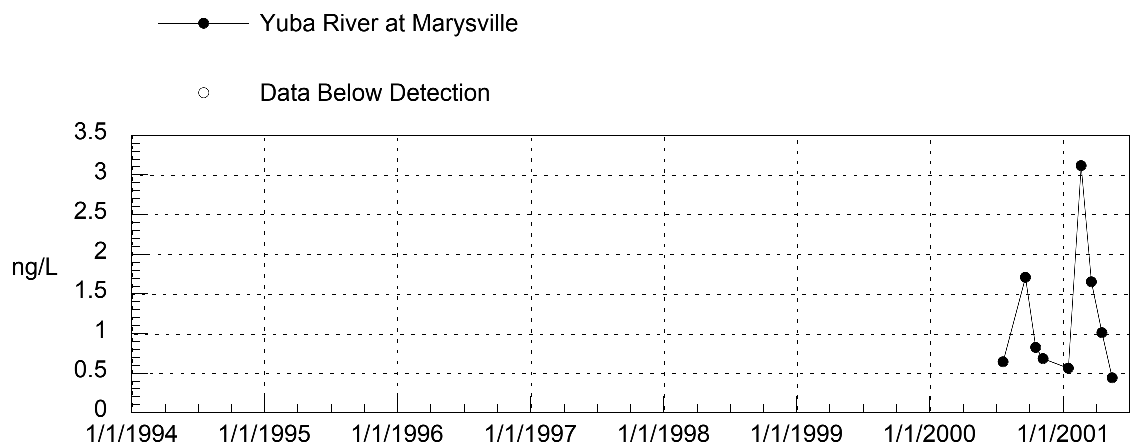
1.2
1
0.8
0.6
0.4
0.2
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001



Yuba River at Marysville
Data Below Detection
ng/L
3.5
3
2.5
2
1.5
1
0.5
0
1/1/1994
1/1/1995
1/1/1996
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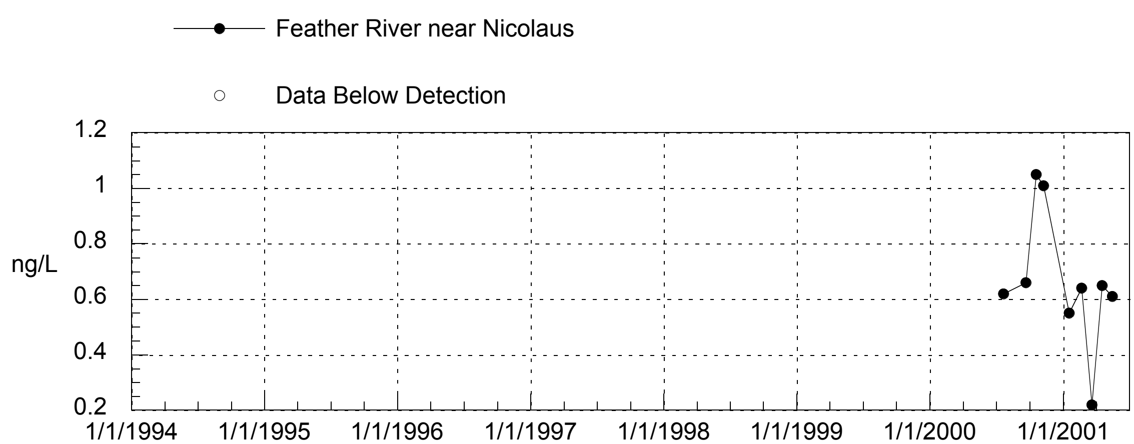
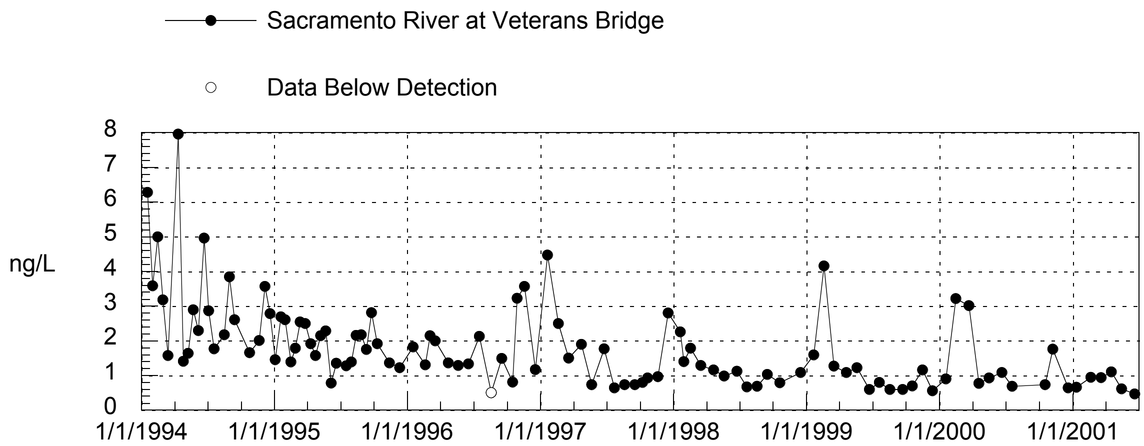
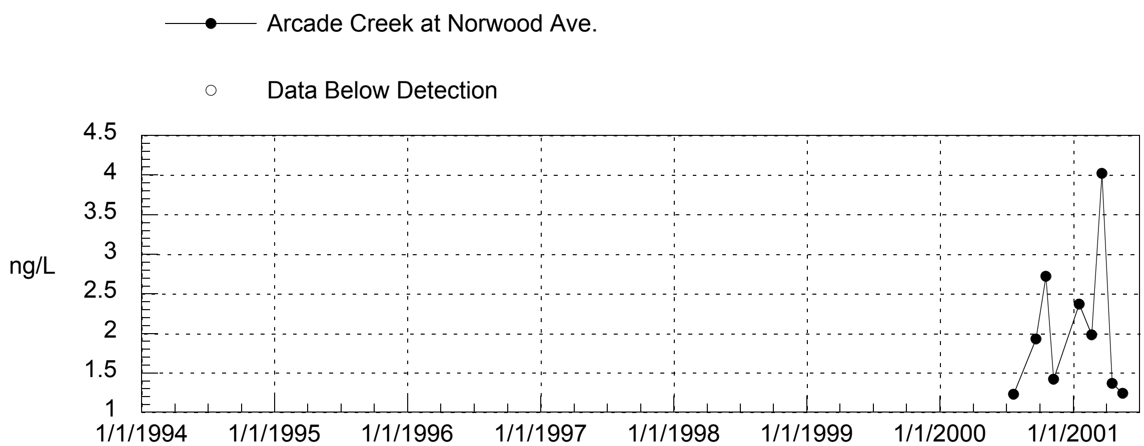
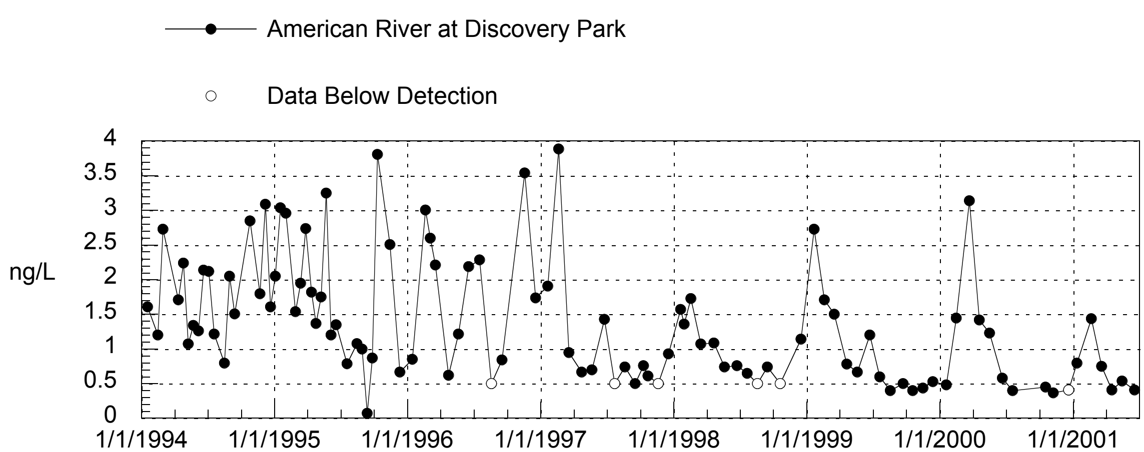
1/1/2000
1/1/2001

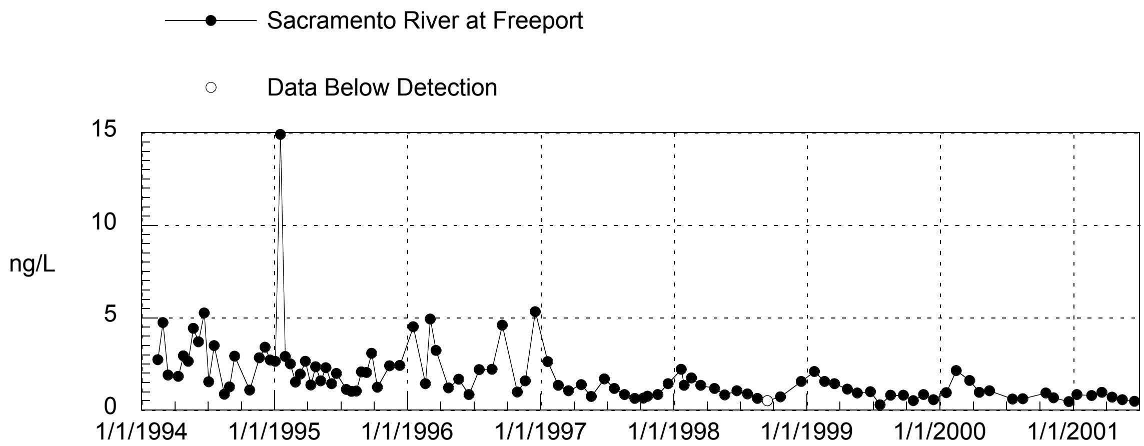


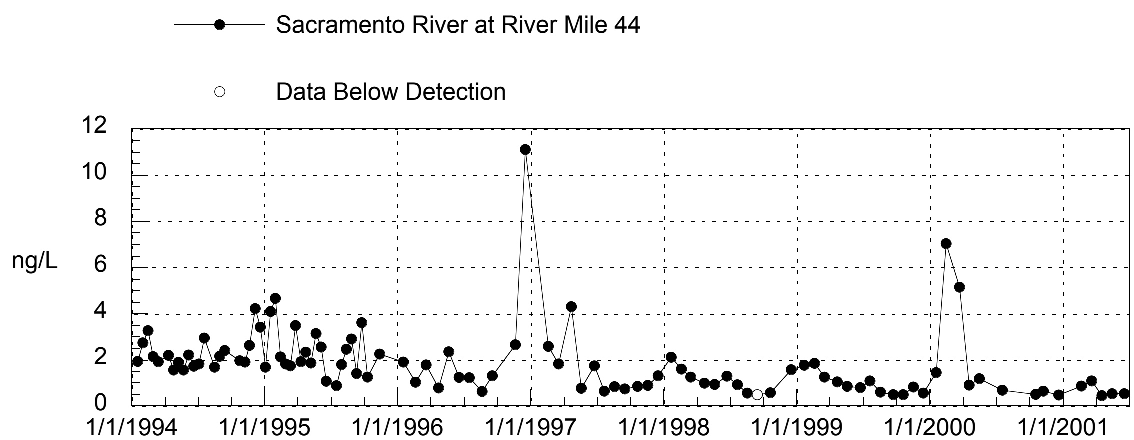
Feather River near Nicolaus
Data Below Detection
ng/L
1.2
1
0.8
0.6
0.4
0.2
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

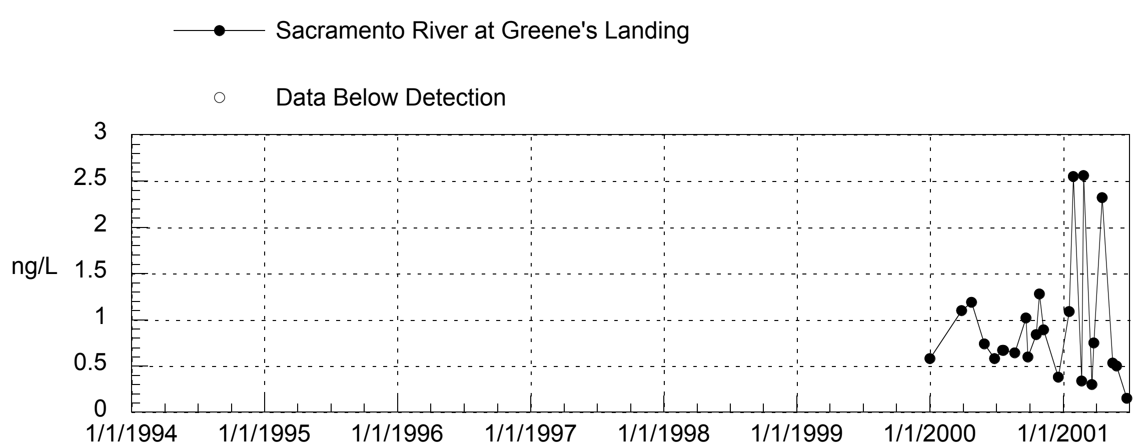

Sacramento River at Veterans Bridge
Data Below Detection
ng/L
0
1
2
3
4
5
6
7
8
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

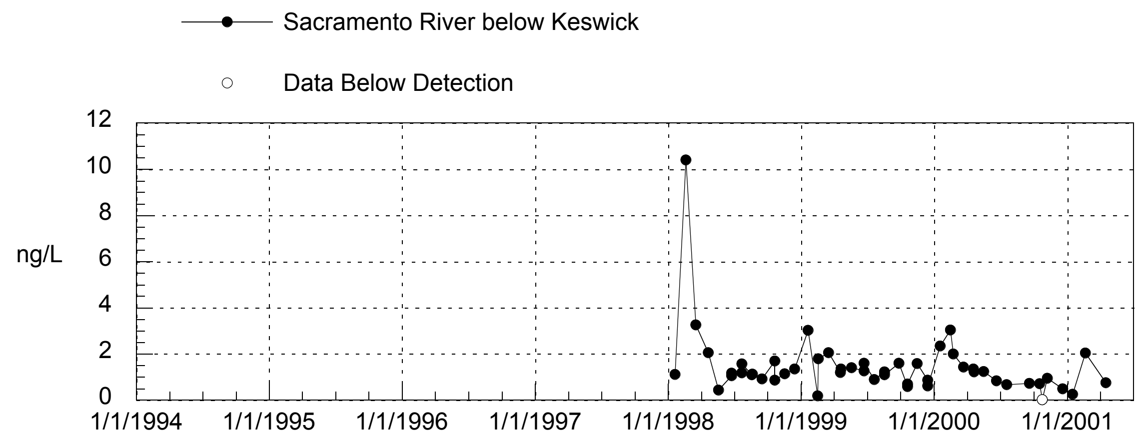

Arcade Creek at Norwood Ave.
Data Below Detection
ng/L
1
1.5
2
2.5
3
3.5
4
4.5
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

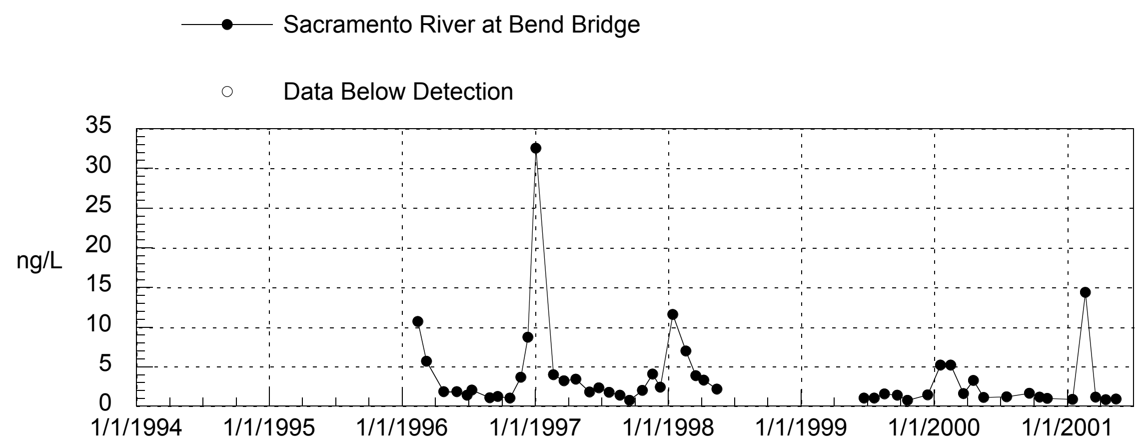

American River at Discovery Park
Data Below Detection
ng/L
0
0.5
1
1.5
2
2.5
3
3.5
4
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

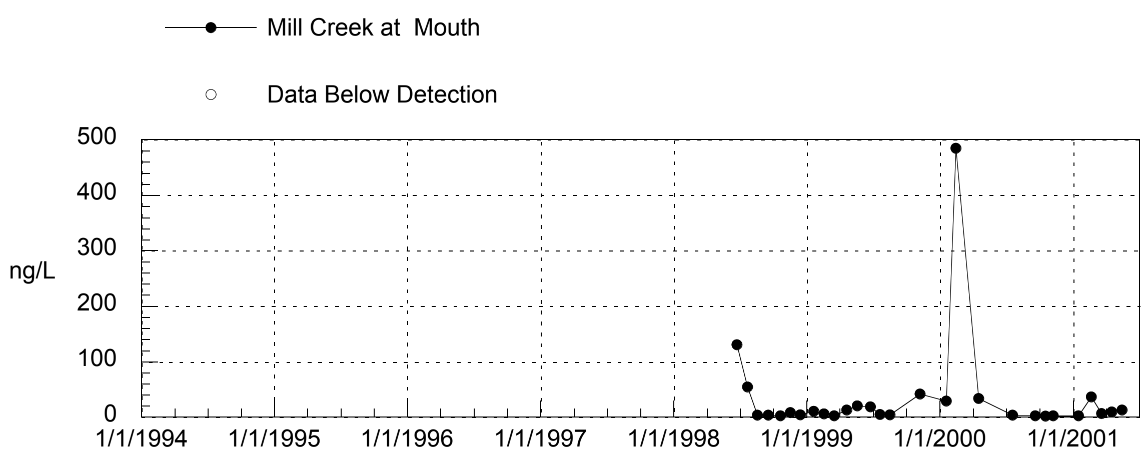

Sacramento River at Freeport
Data Below Detection
ng/L
15
10
5
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

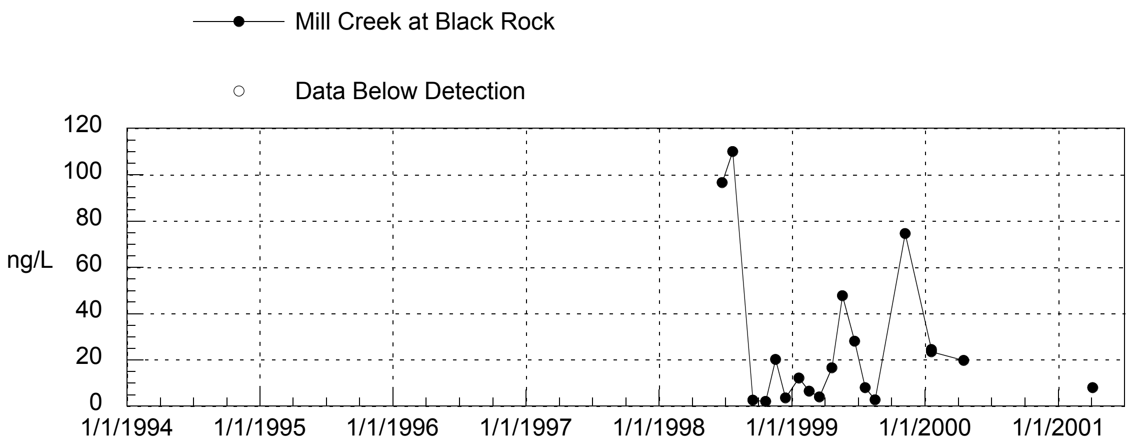

Sacramento River at River Mile 44
Data Below Detection
ng/L
12
10
8
6
4
2
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

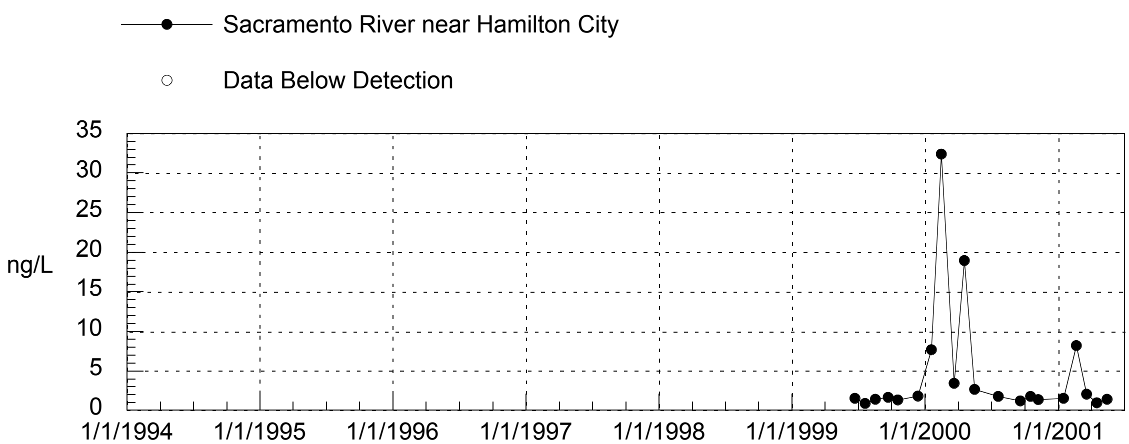

Sacramento River at Greene's Landing
Data Below Detection
ng/L
3
2.5
2
1.5
1
0.5
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

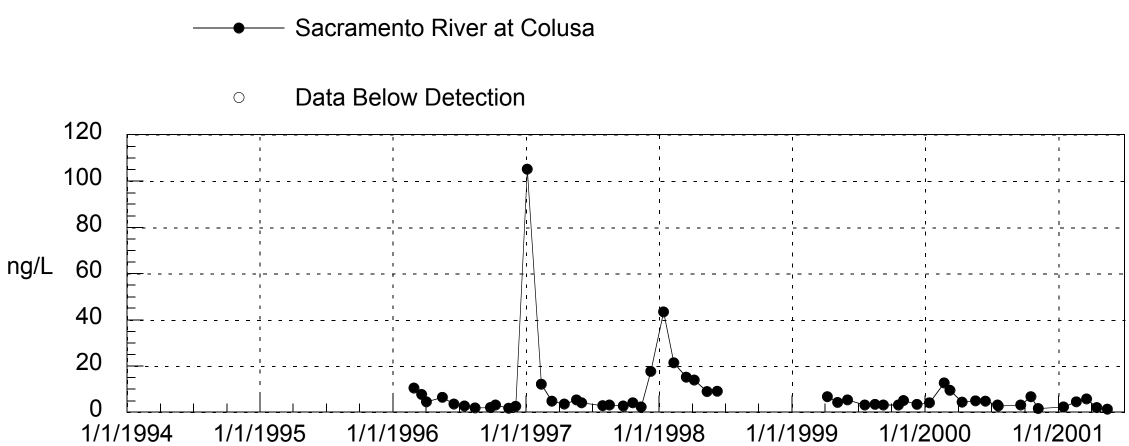

Sacramento River below Keswick
Data Below Detection
ng/L
12
10
8
6
4
2
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

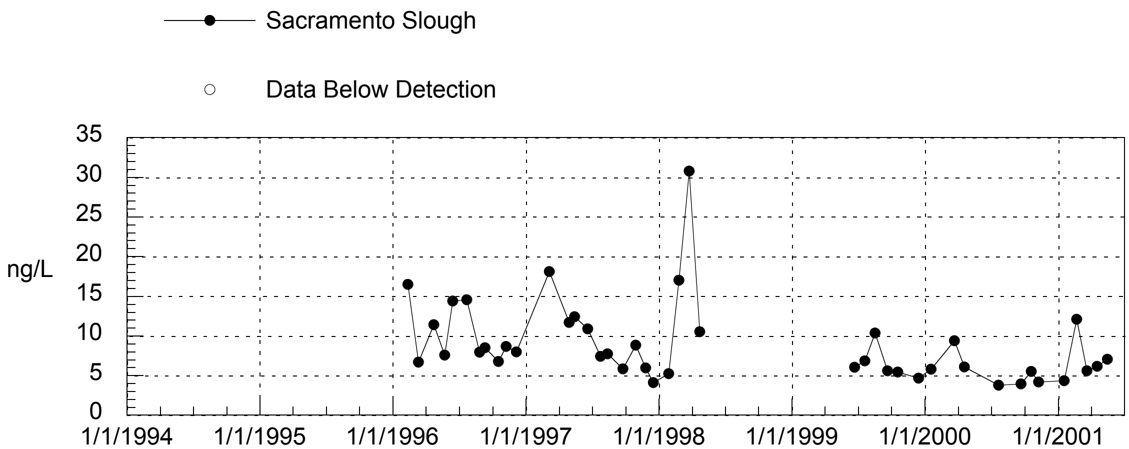

Sacramento River at Bend Bridge
Data Below Detection
ng/L
35
30
25
20
15
10
5
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

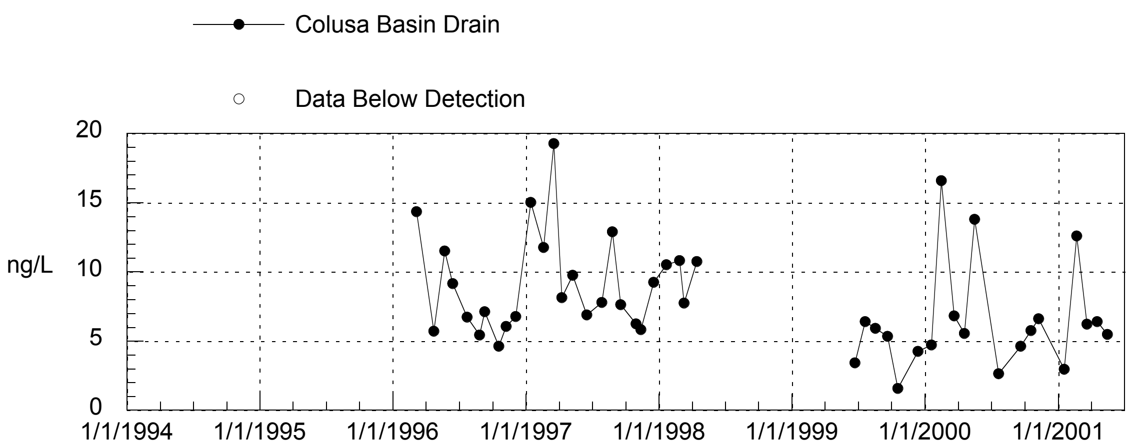

Mill Creek at Mouth
Data Below Detection
ng/L
500
400
300
200
100
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

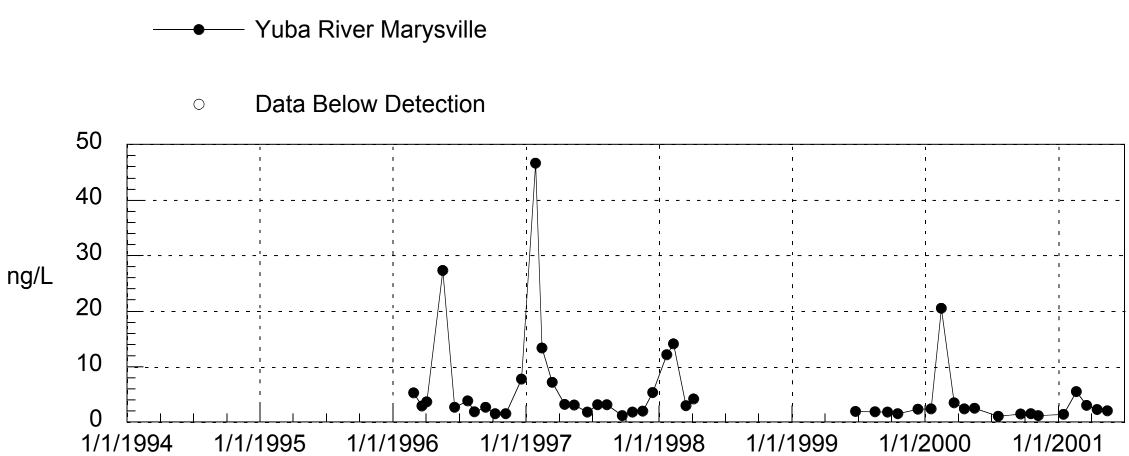

Mill Creek at Black Rock
Data Below Detection
ng/L
0
20
40
60
80
100
120
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

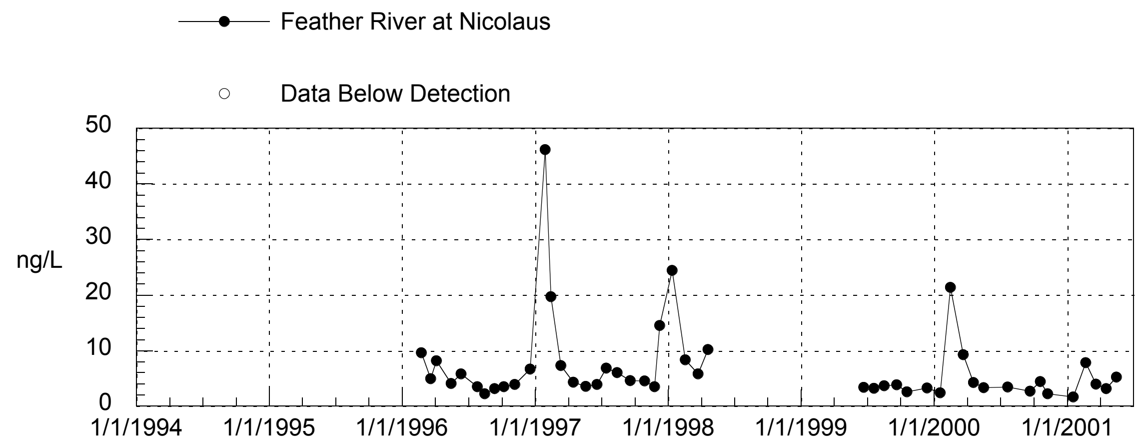

Sacramento River near Hamilton City
Data Below Detection
ng/L
0
5
10
15
20
25
30
35
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

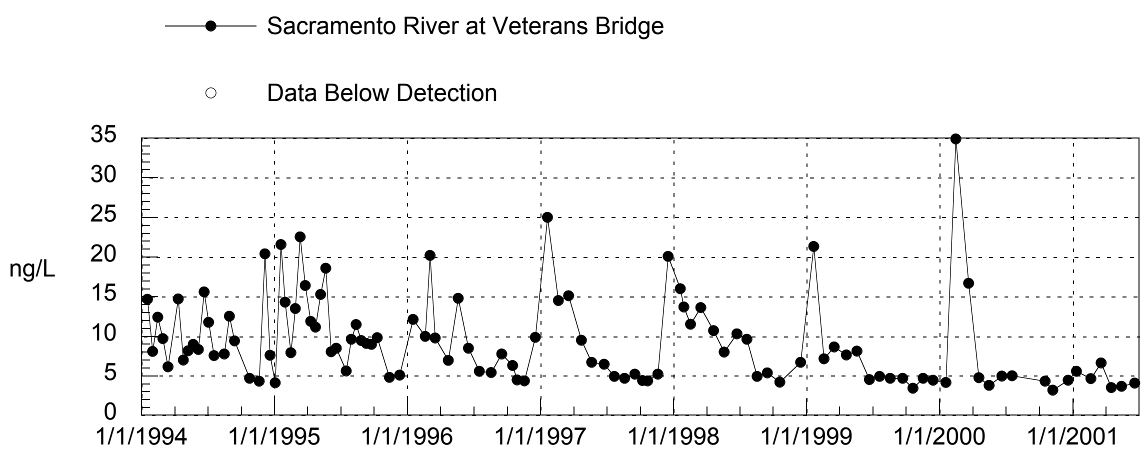

Sacramento River at Colusa
Data Below Detection
ng/L
0
20
40
60
80
100
120
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

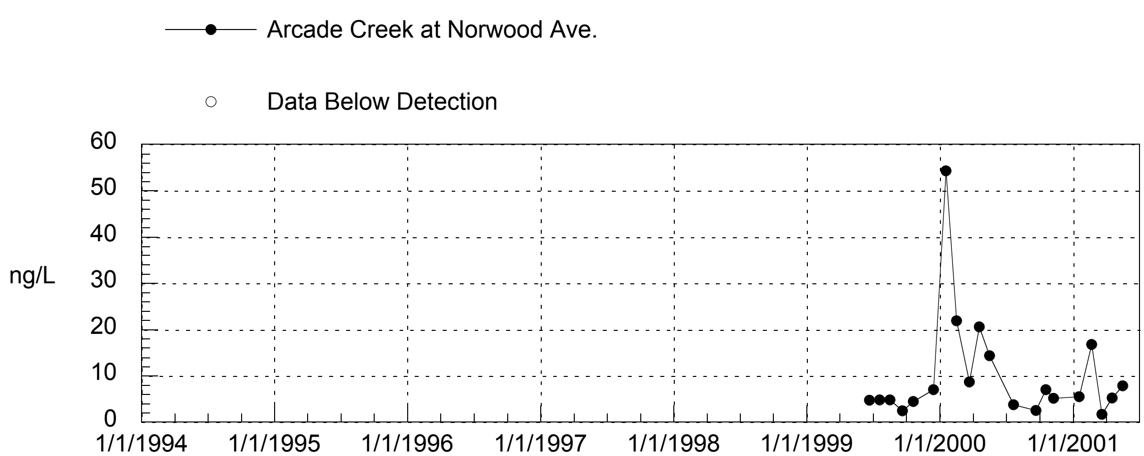

Sacramento Slough
Data Below Detection
ng/L
0
5
10
15
20
25
30
35
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

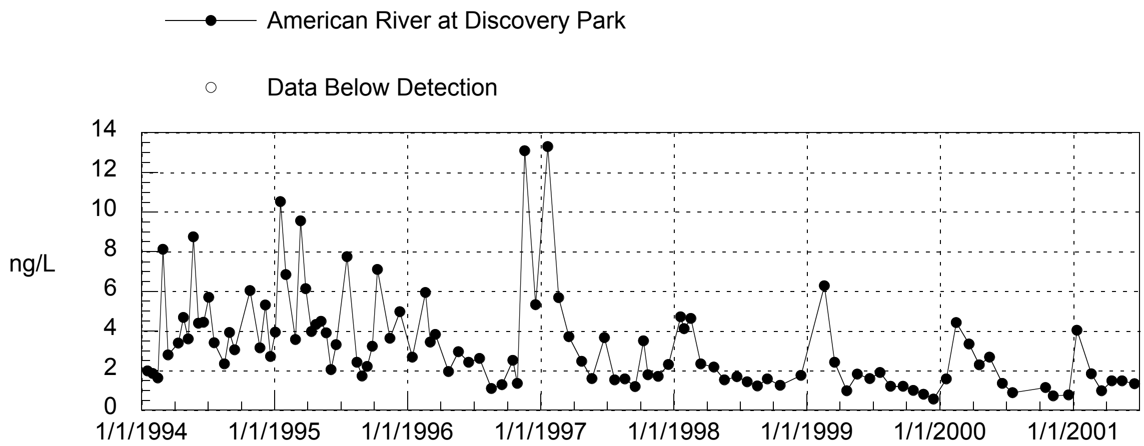

Colusa Basin Drain
Data Below Detection
ng/L
0
5
10
15
20
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

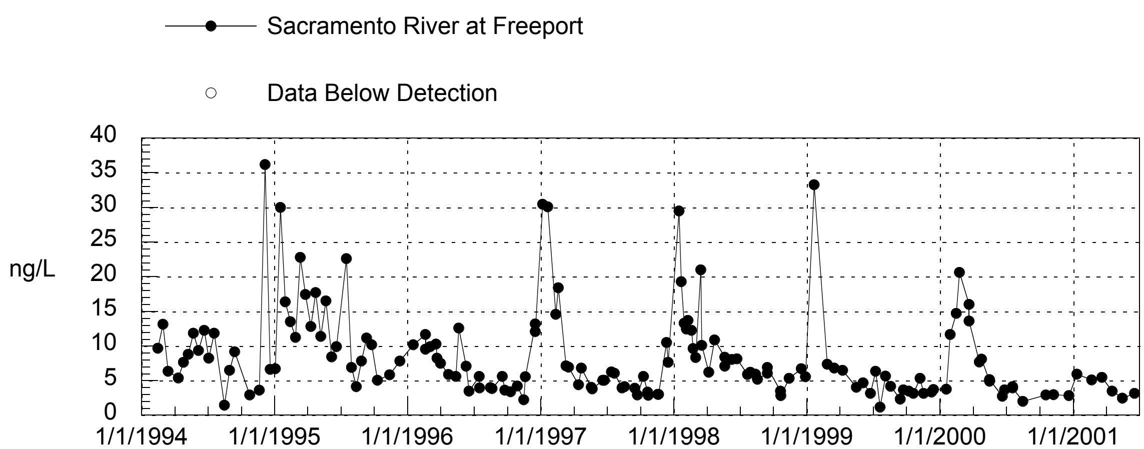

Yuba River Marysville
Data Below Detection
ng/L
0
10
20
30
40
50
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

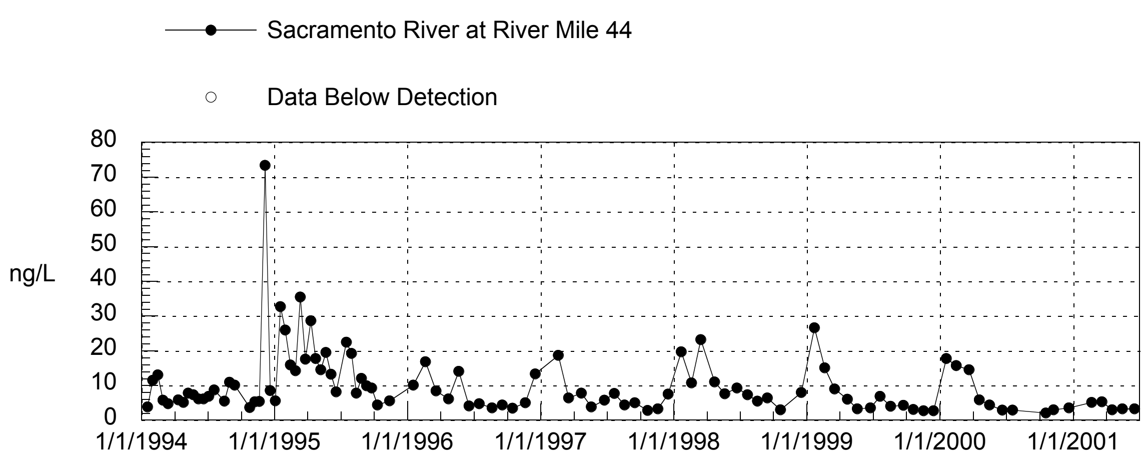

Feather River at Nicolaus
Data Below Detection
ng/L
50
40
30
20
10
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001


Sacramento River at Veterans Bridge
Data Below Detection
ng/L
35
30
25
20
15
10
5
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

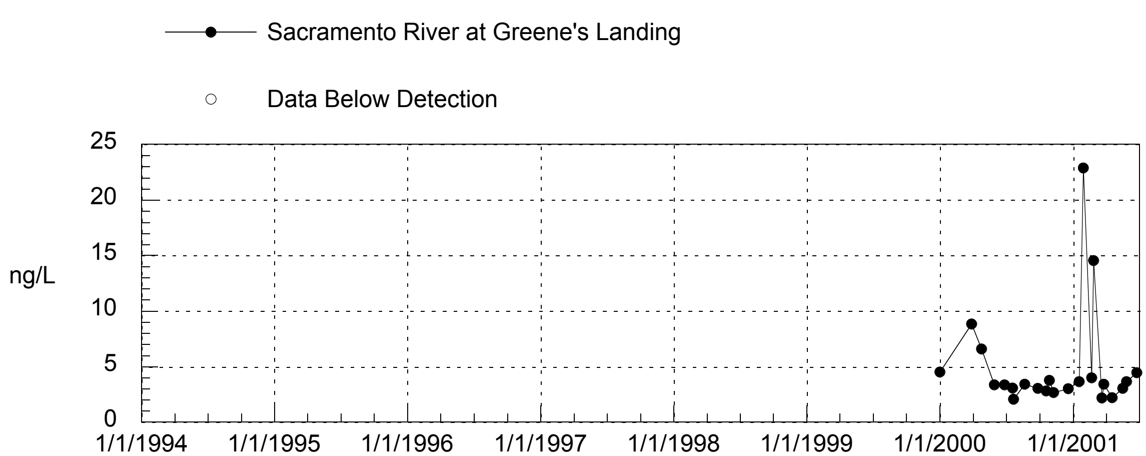

Arcade Creek at Norwood Ave.
Data Below Detection
ng/L
60
50
40
30
20
10
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

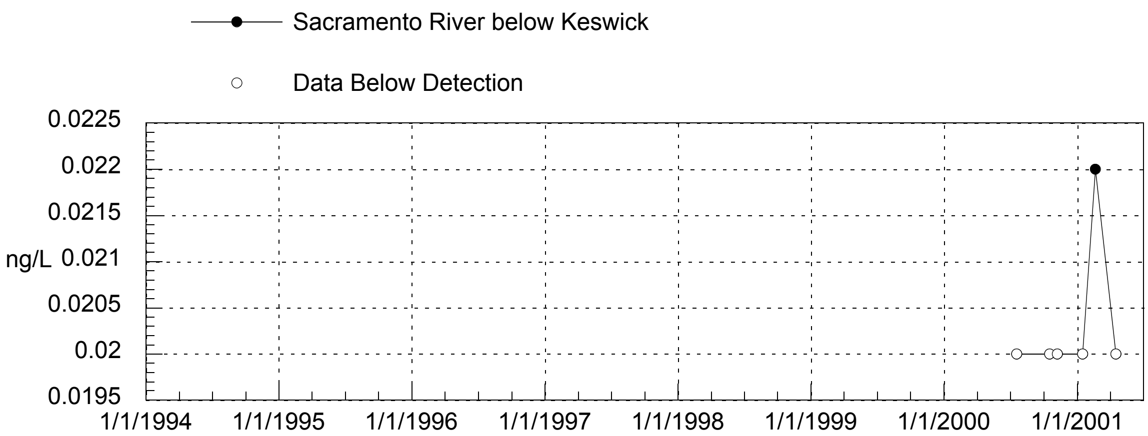

American River at Discovery Park
Data Below Detection
ng/L
0
2
4
6
8
10
12
14
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

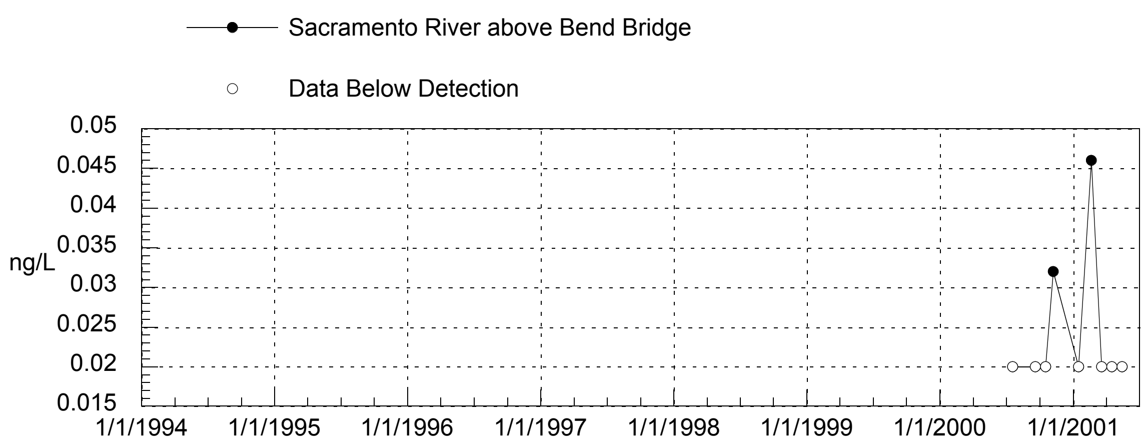

Sacramento River at Freeport
Data Below Detection
ng/L
0
5
10
15
20
25
30
35
40
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

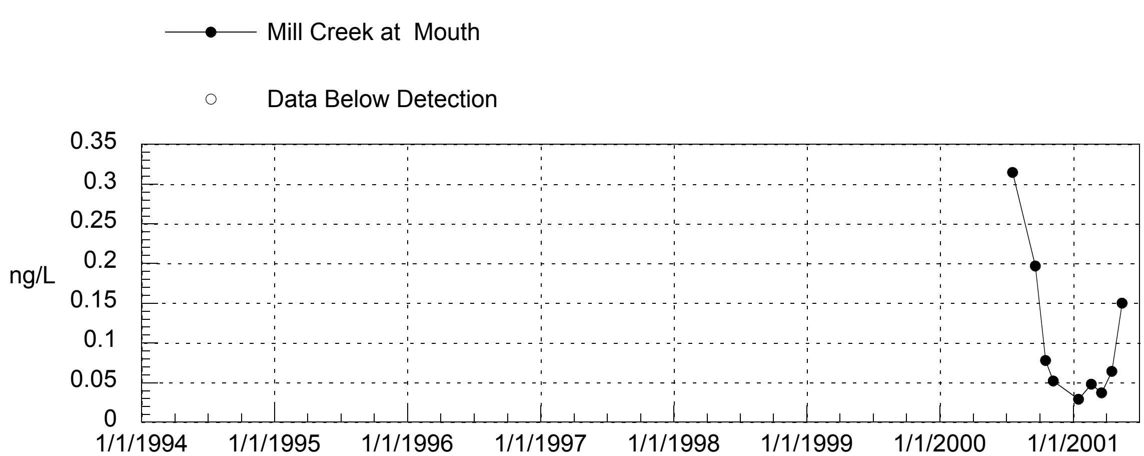

Sacramento River at River Mile 44
Data Below Detection
ng/L
0
10
20
30
40
50
60
70
80
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

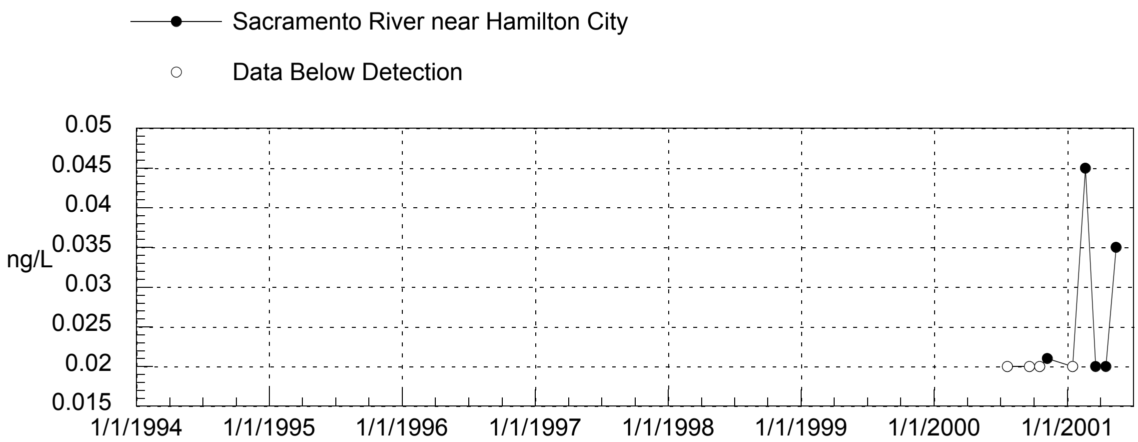
SPACE INTENTIONALLY BLANK

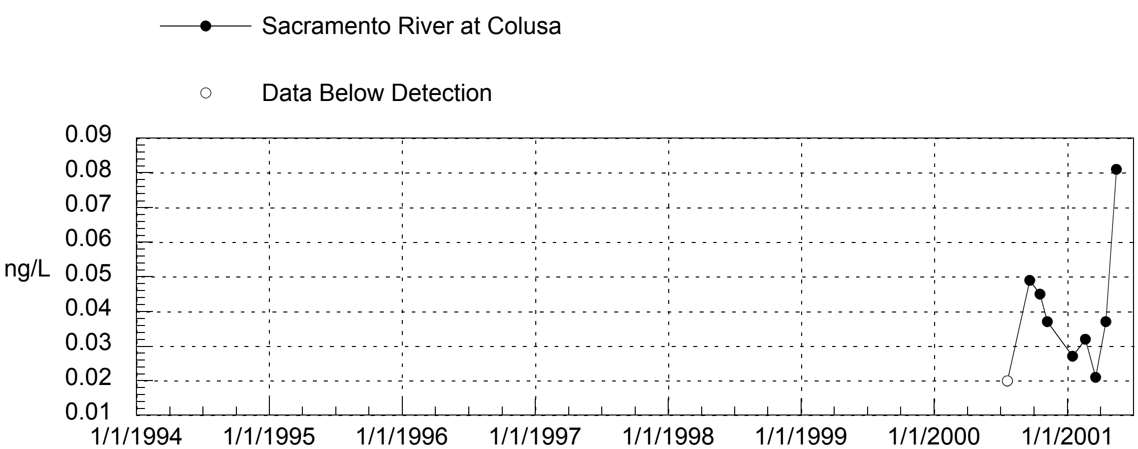


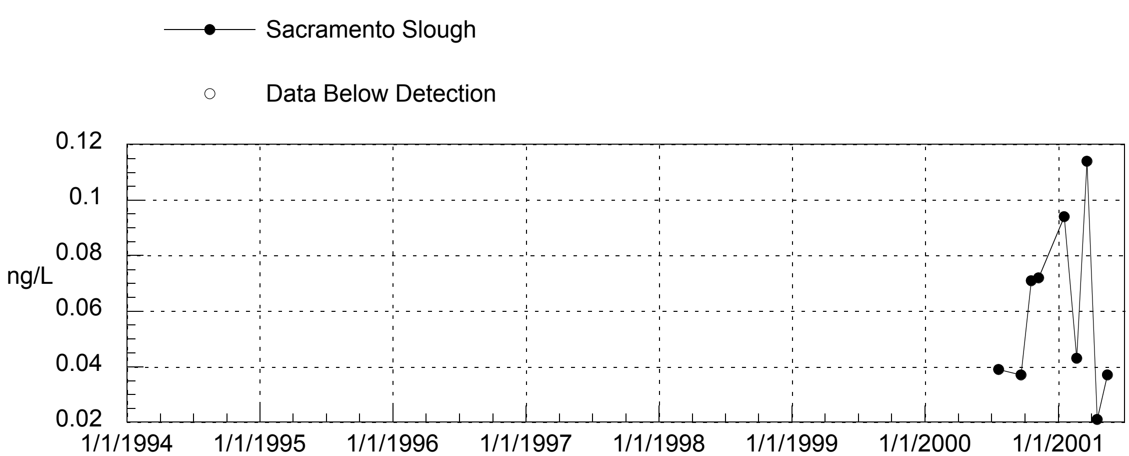

Sacramento River below Keswick
Data Below Detection
ng/L
0.0225
0.022
0.0215
0.021
0.0205
0.02
0.0195
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

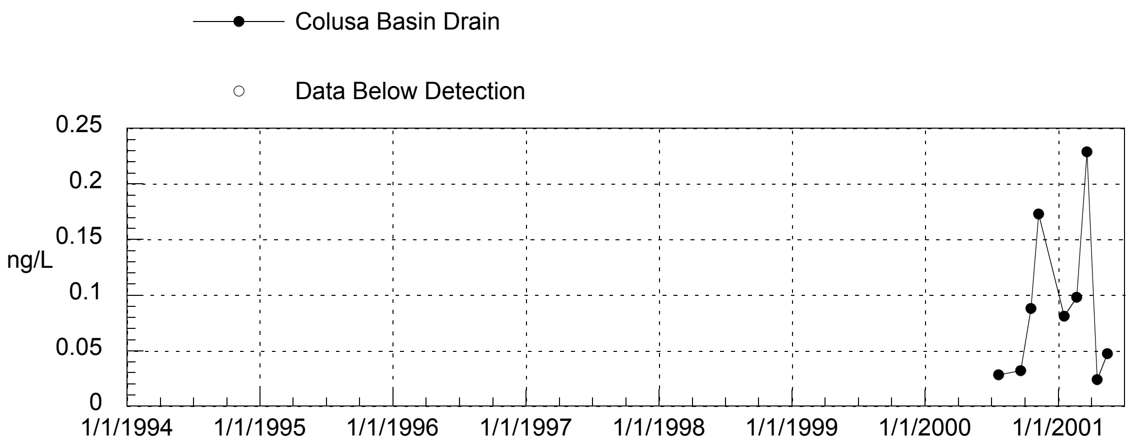

Sacramento River above Bend Bridge
Data Below Detection
ng/L
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

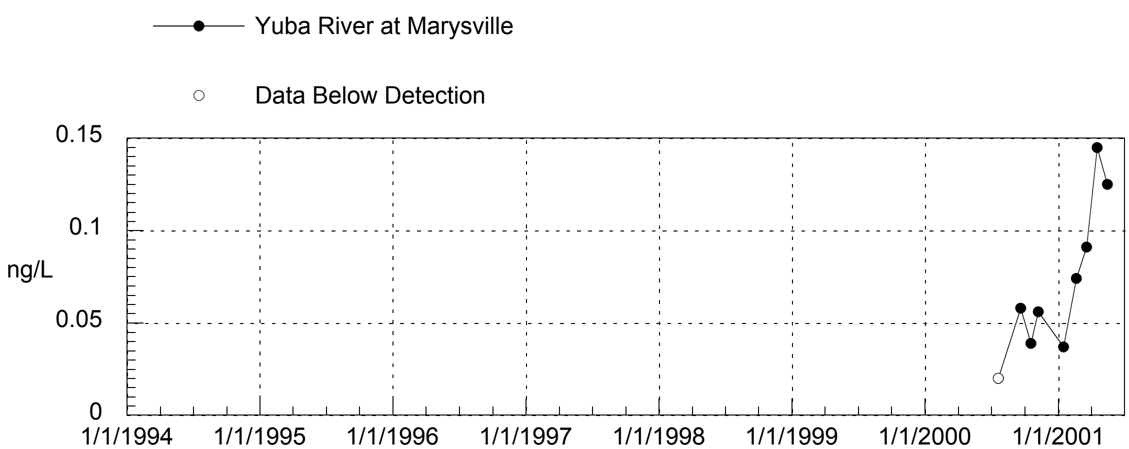

Mill Creek at Mouth
Data Below Detection
ng/L
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

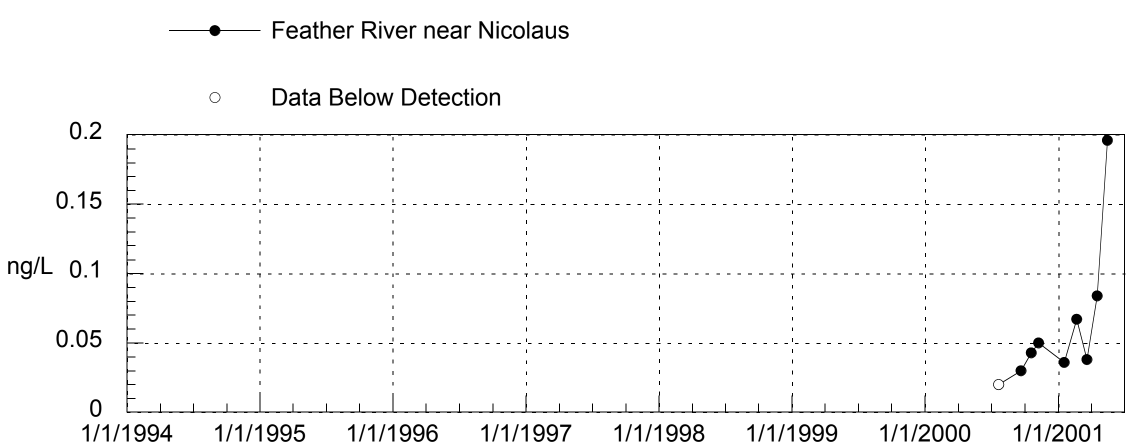

Sacramento River near Hamilton City
Data Below Detection
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
ng/L
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

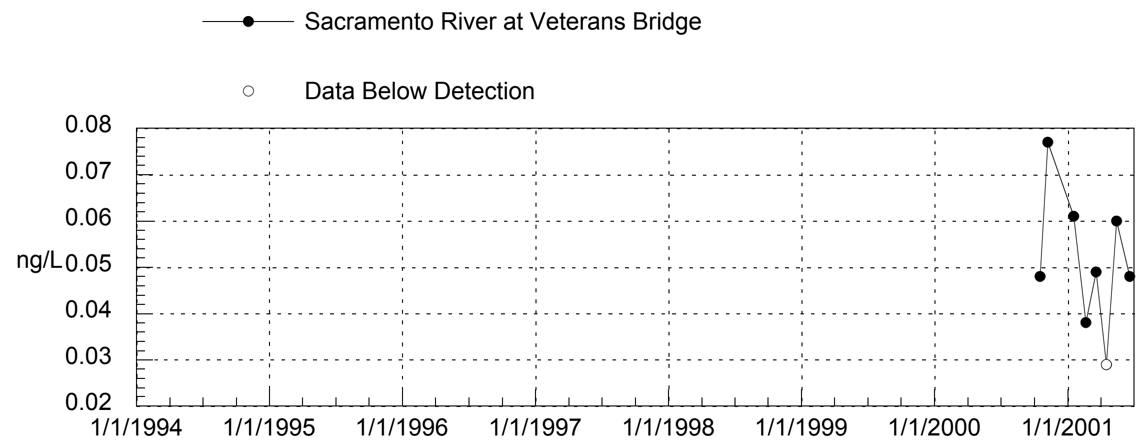

Sacramento River at Colusa
Data Below Detection
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
ng/L
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

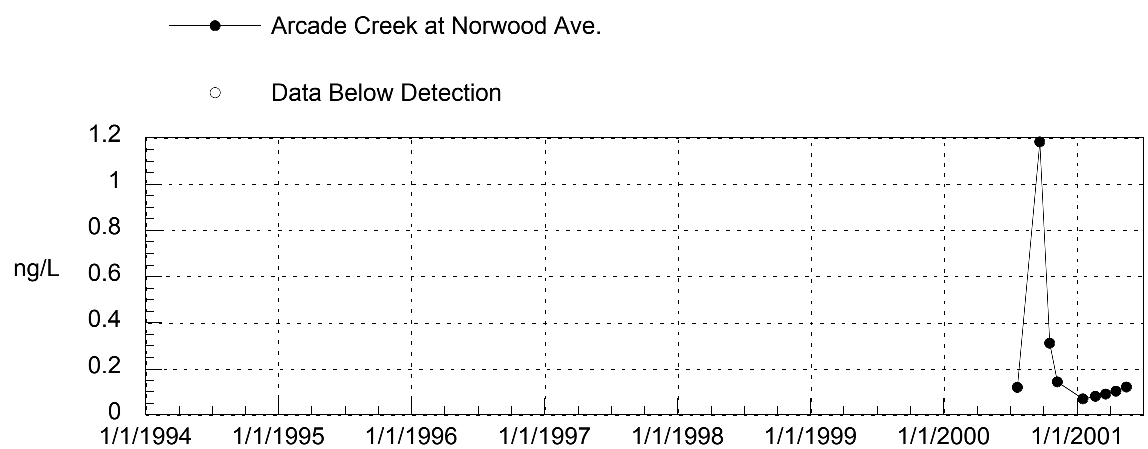

Sacramento Slough
Data Below Detection
0.12
0.1
0.08
0.06
0.04
0.02
ng/L
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

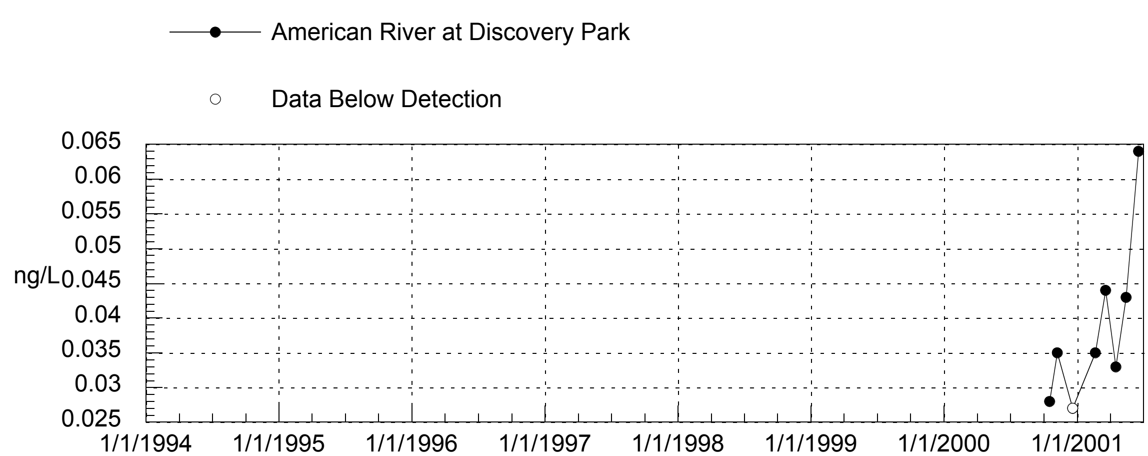

Colusa Basin Drain
Data Below Detection
ng/L
0.25
0.2
0.15
0.1
0.05
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

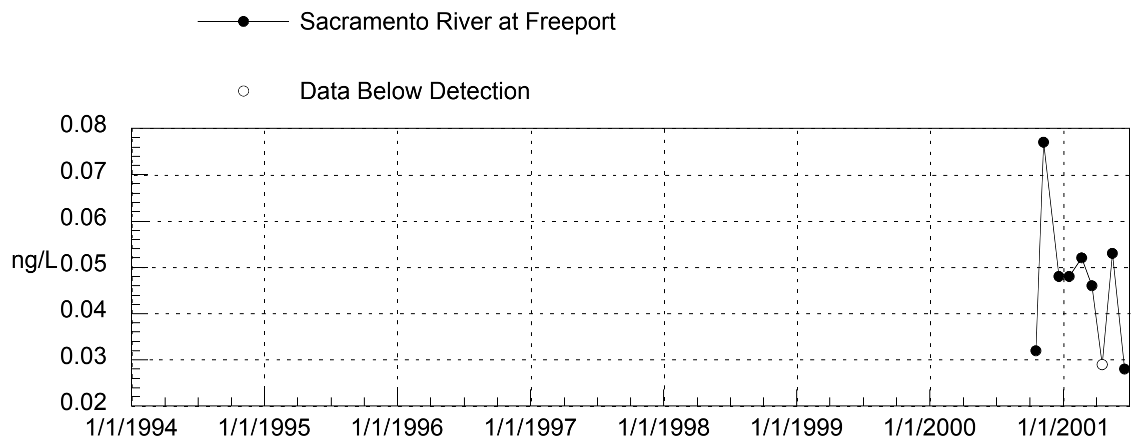

Yuba River at Marysville
Data Below Detection
ng/L
0.15
0.1
0.05
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

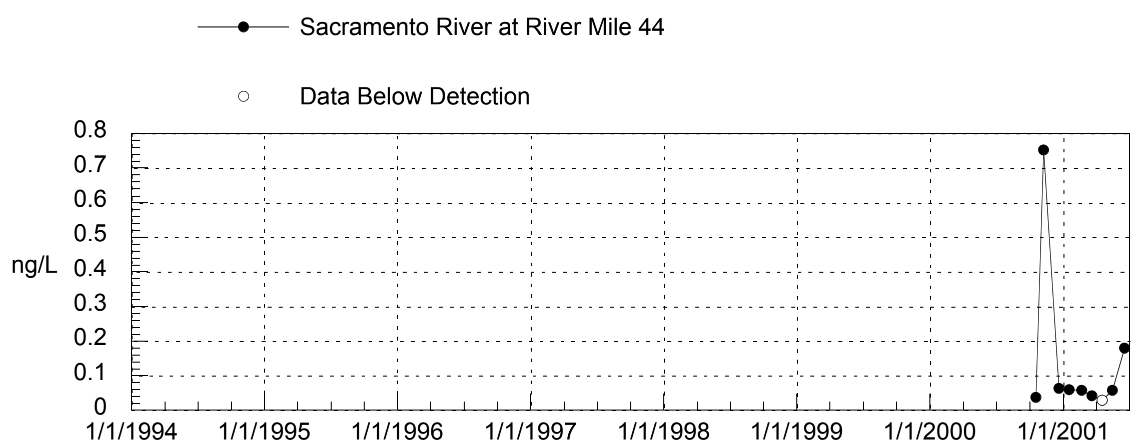

Feather River near Nicolaus
Data Below Detection
ng/L
0.2
0.15
0.1
0.05
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

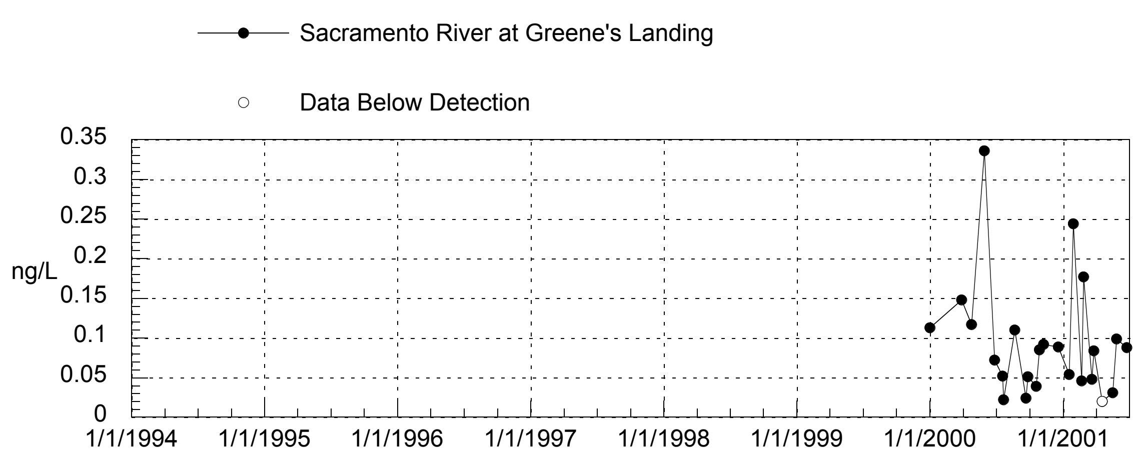

Sacramento River at Veterans Bridge
Data Below Detection
ng/L
0.08
0.07
0.06
0.05
0.04
0.03
0.02
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

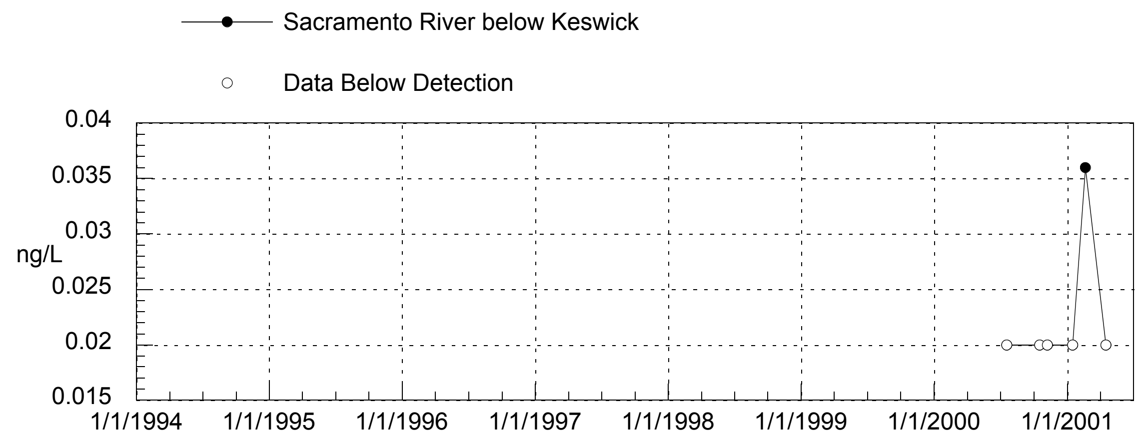

Arcade Creek at Norwood Ave.
Data Below Detection
ng/L
1.2
1
0.8
0.6
0.4
0.2
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

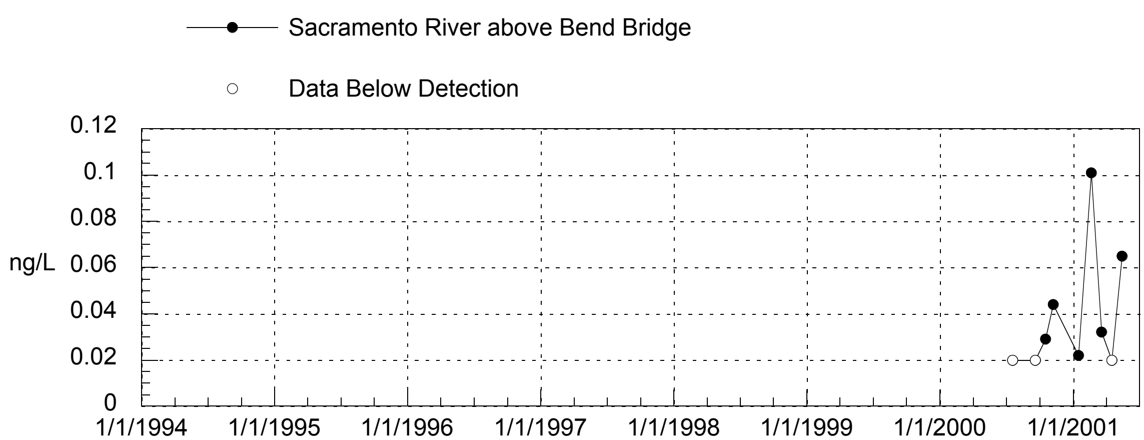

American River at Discovery Park
Data Below Detection
ng/L
0.065
0.06
0.055
0.05
0.045
0.04
0.035
0.03
0.025
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

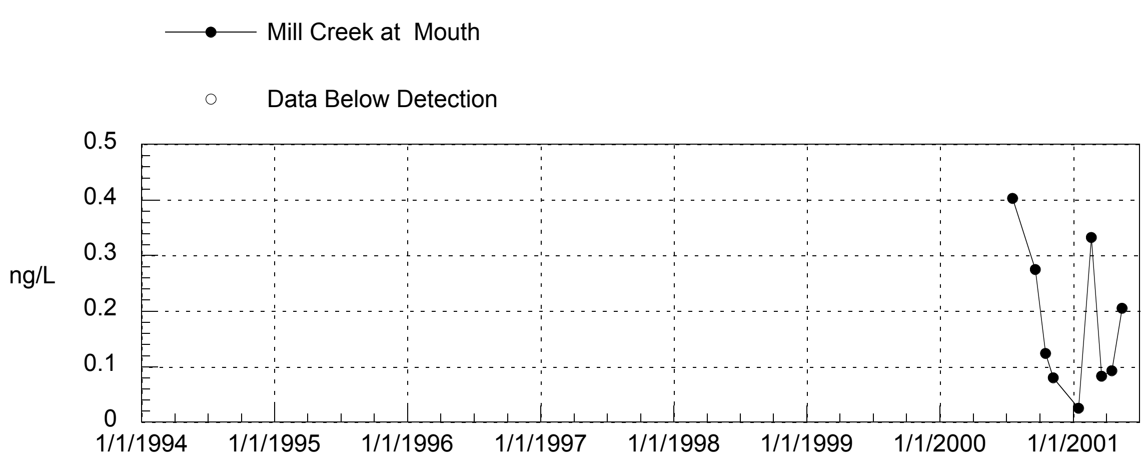

Sacramento River at Freeport
Data Below Detection
ng/L
0.08
0.07
0.06
0.05
0.04
0.03
0.02
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

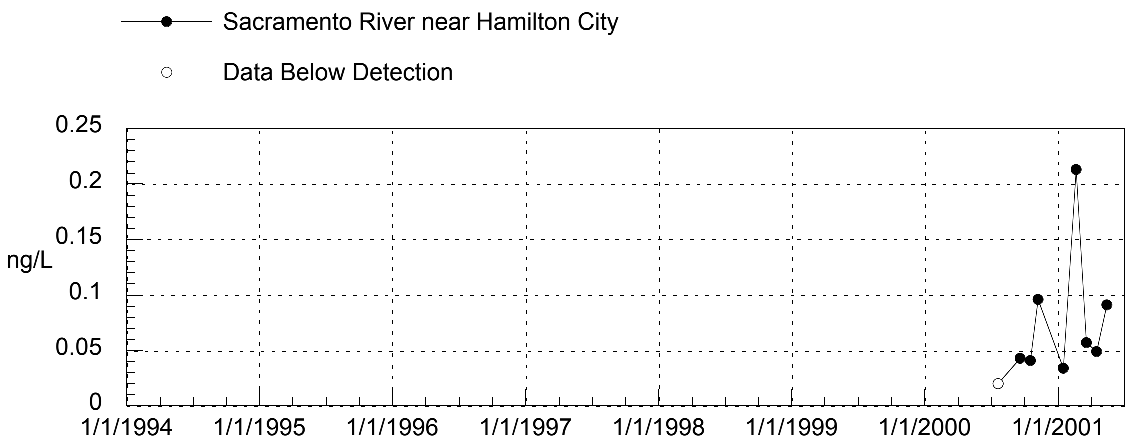

Sacramento River at River Mile 44
Data Below Detection
ng/L
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

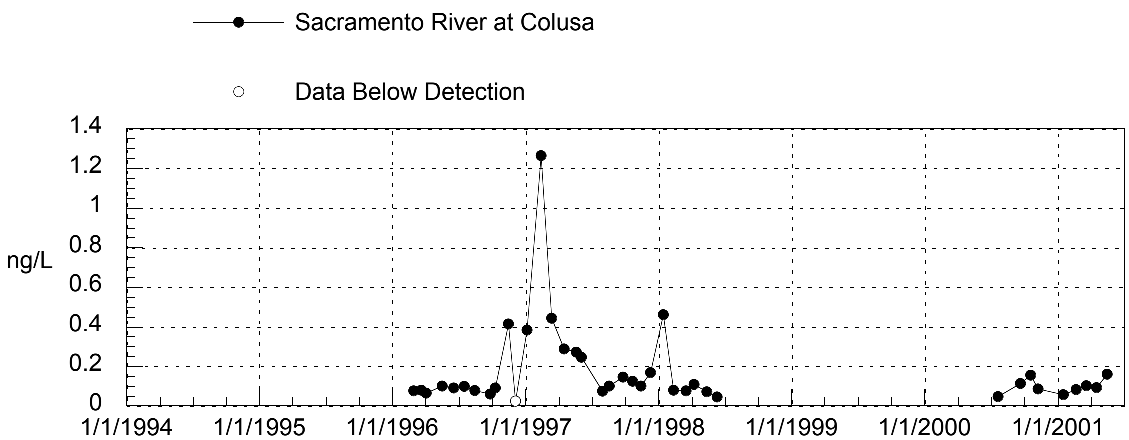

Sacramento River at Greene's Landing
Data Below Detection
ng/L
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

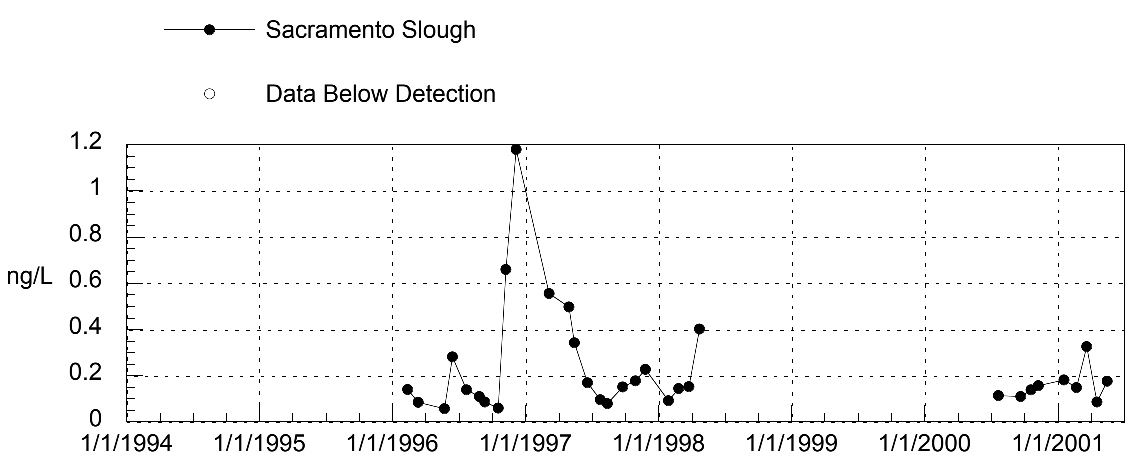

Sacramento River below Keswick
Data Below Detection
0.04
0.035
0.03
ng/L
0.025
0.02
0.015
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

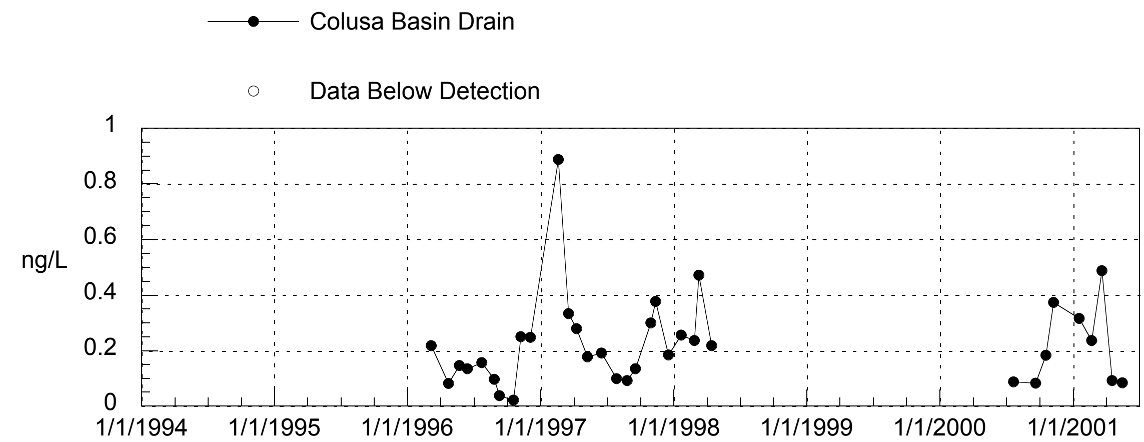

Sacramento River above Bend Bridge
Data Below Detection
0.12
0.1
0.08
ng/L
0.06
0.04
0.02
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

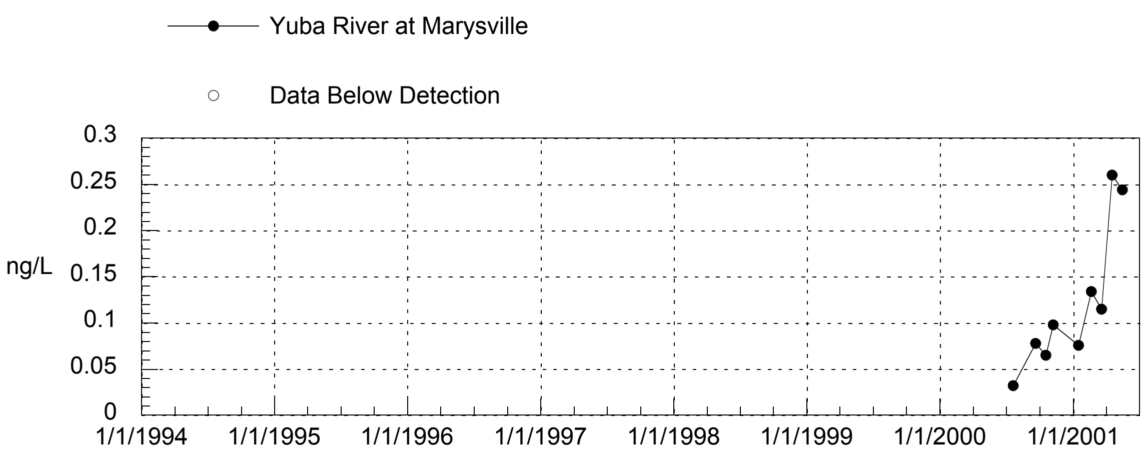

Mill Creek at Mouth
Data Below Detection
0.5
0.4
0.3
ng/L
0.2
0.1
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

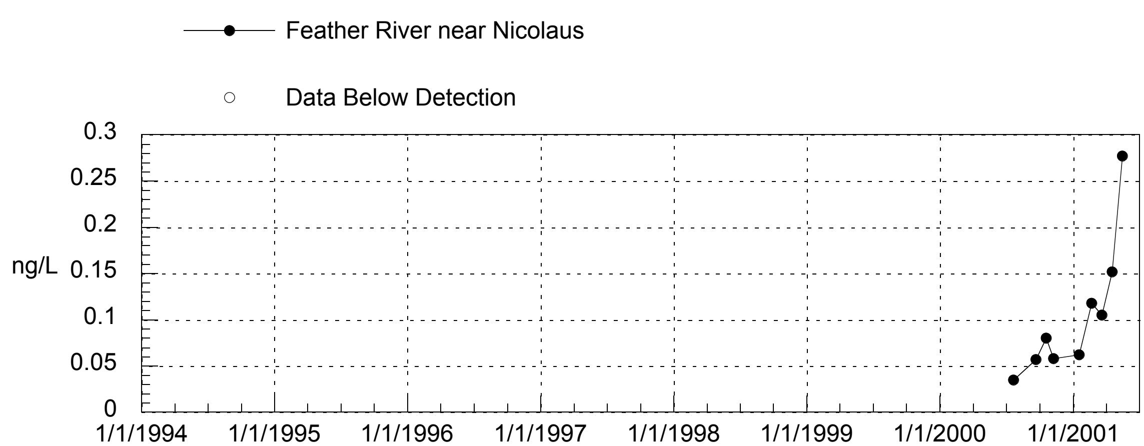

Sacramento River near Hamilton City
Data Below Detection
ng/L
0.25
0.2
0.15
0.1
0.05
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

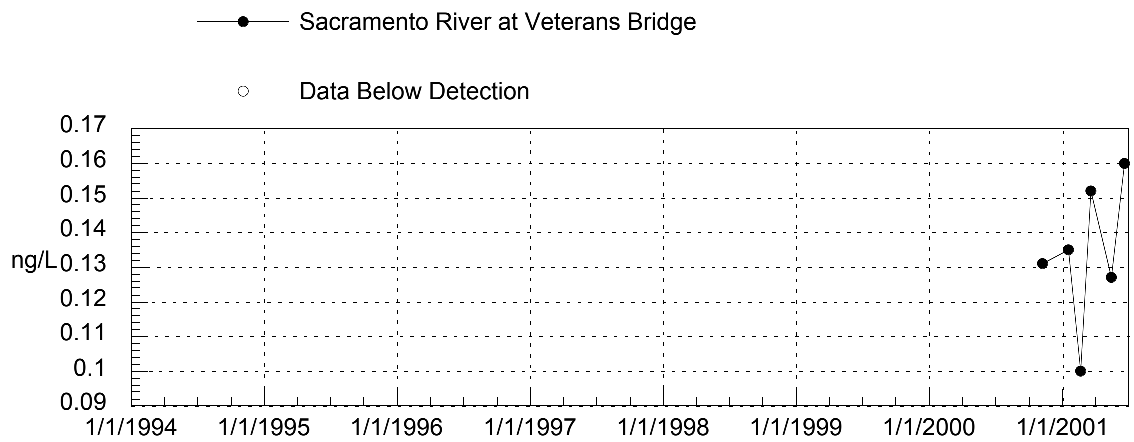

Sacramento River at Colusa
Data Below Detection
ng/L
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

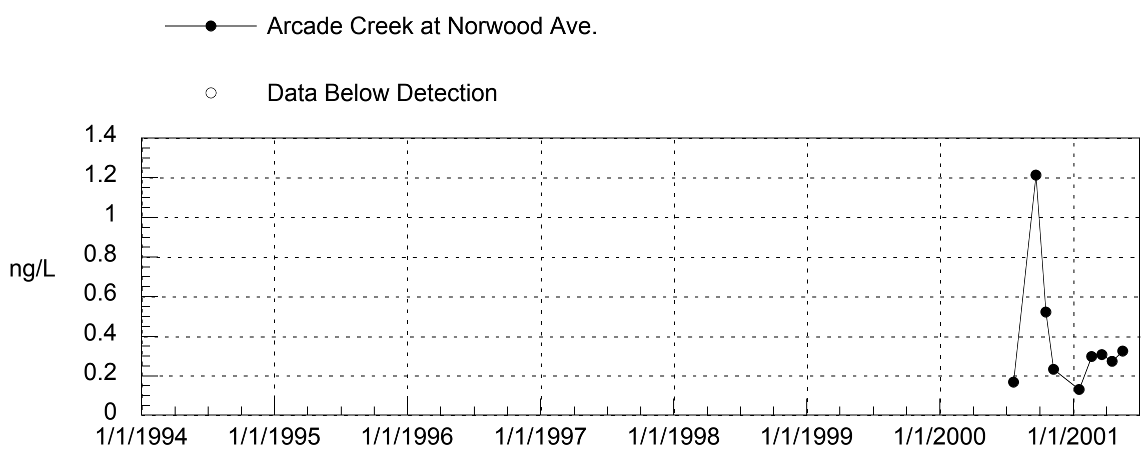

Sacramento Slough
Data Below Detection
ng/L
1.2
1
0.8
0.6
0.4
0.2
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

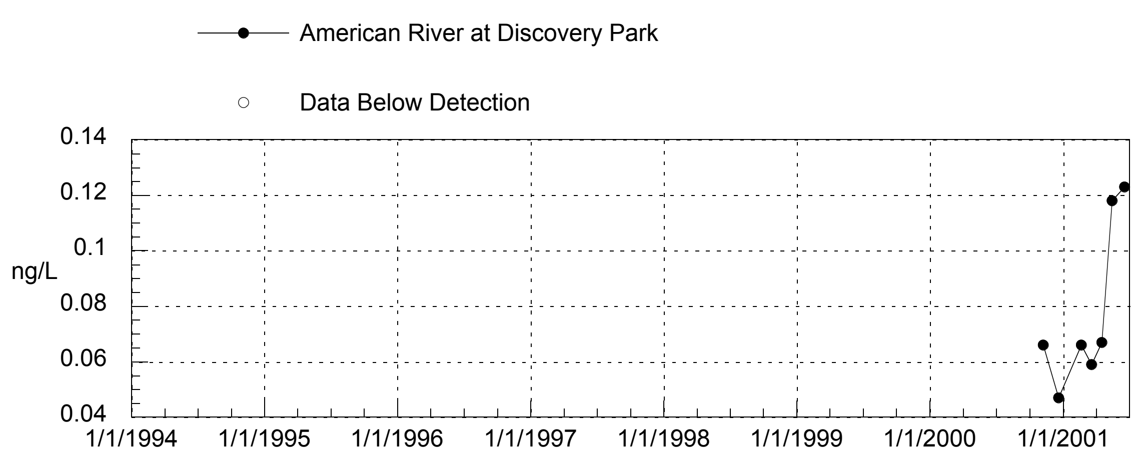

Colusa Basin Drain
Data Below Detection
ng/L
1
0.8
0.6
0.4
0.2
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

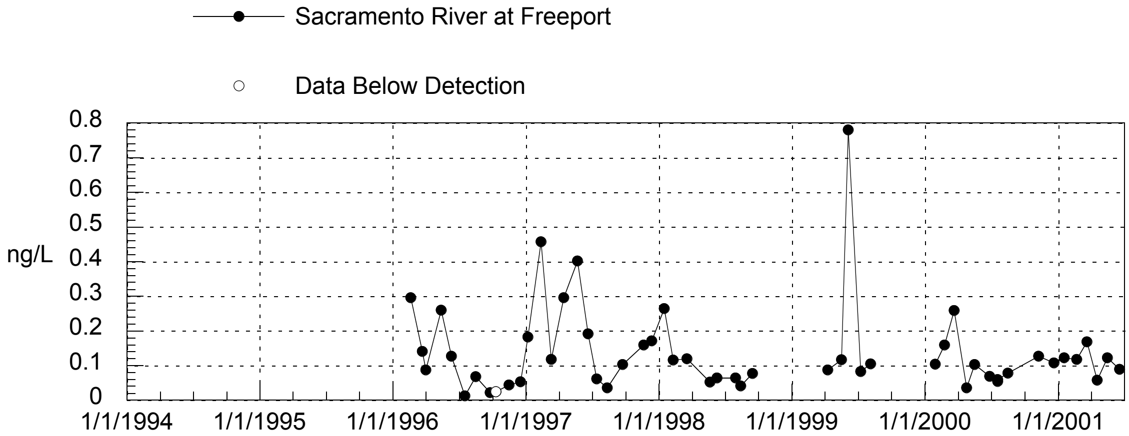

Yuba River at Marysville
Data Below Detection
ng/L
0.3
0.25
0.2
0.15
0.1
0.05
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

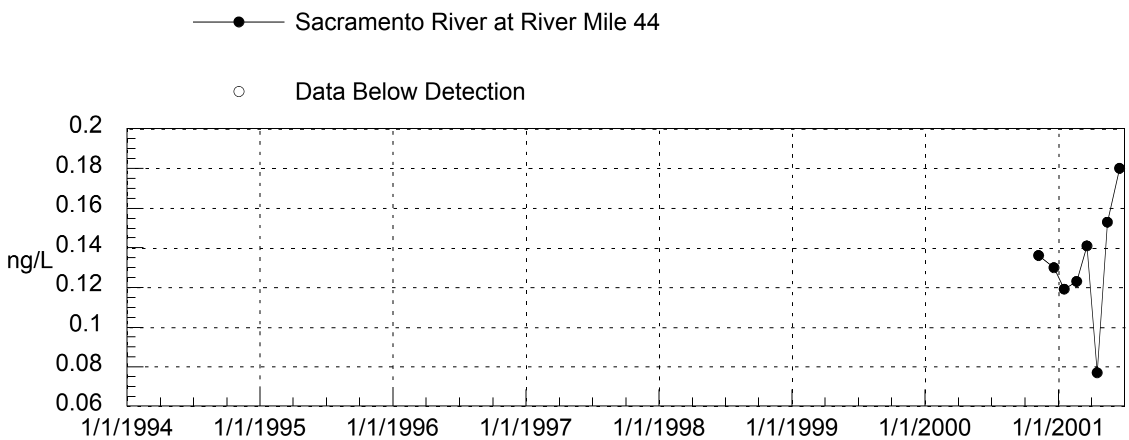

Feather River near Nicolaus
Data Below Detection
ng/L
0.3
0.25
0.2
0.15
0.1
0.05
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

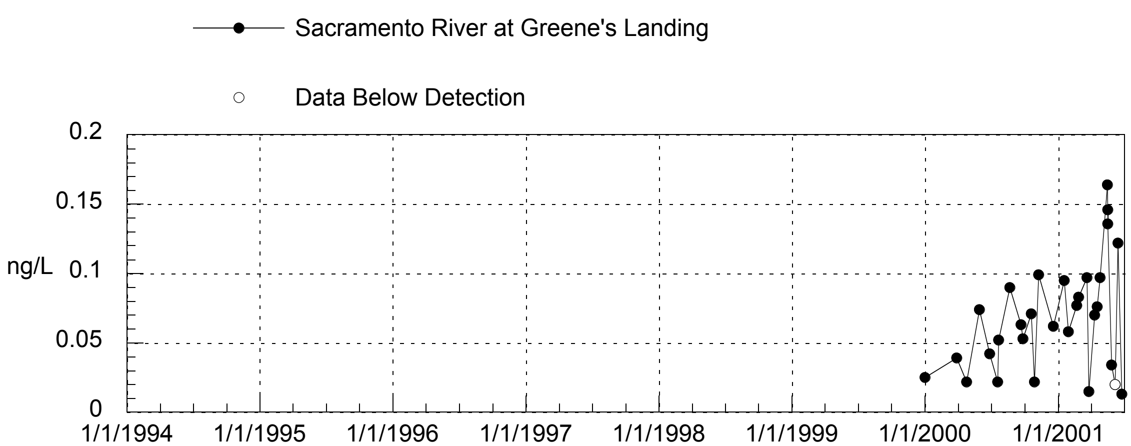

Sacramento River at Veterans Bridge
Data Below Detection
0.17
0.16
0.15
0.14
ng/L 0.13
0.12
0.11
0.1
0.09
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001


Arcade Creek at Norwood Ave.
Data Below Detection
1.4
1.2
1
0.8
ng/L
0.6
0.4
0.2
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001


American River at Discovery Park
Data Below Detection
0.14
0.12
0.1
ng/L
0.08
0.06
0.04
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

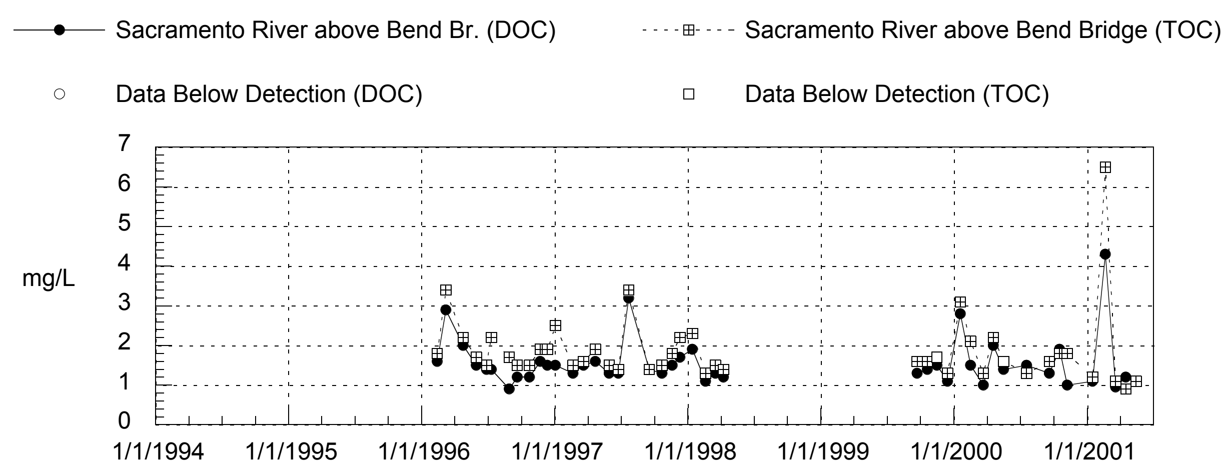

Sacramento River at Freeport
Data Below Detection
ng/L
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

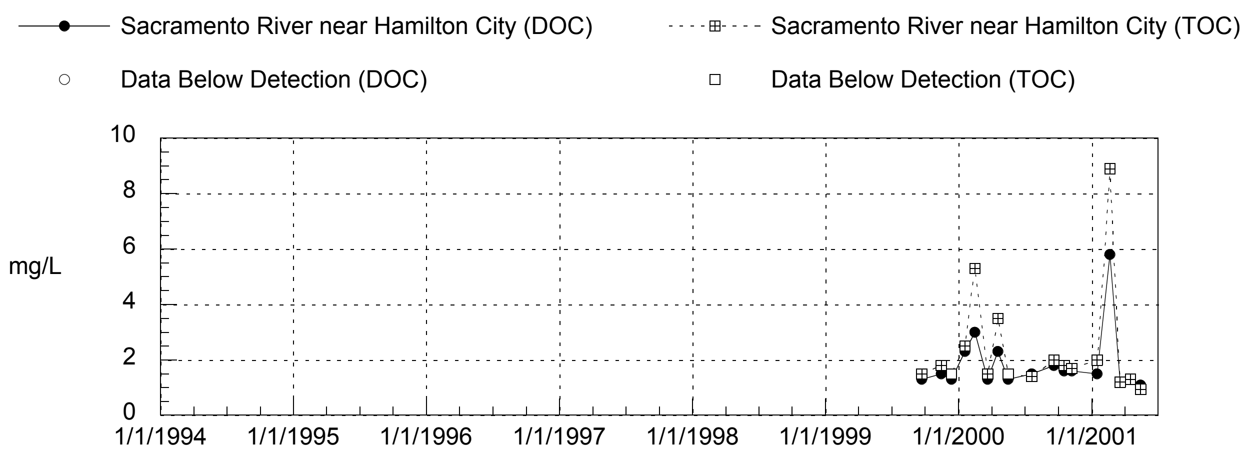

Sacramento River at River Mile 44
Data Below Detection
ng/L
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

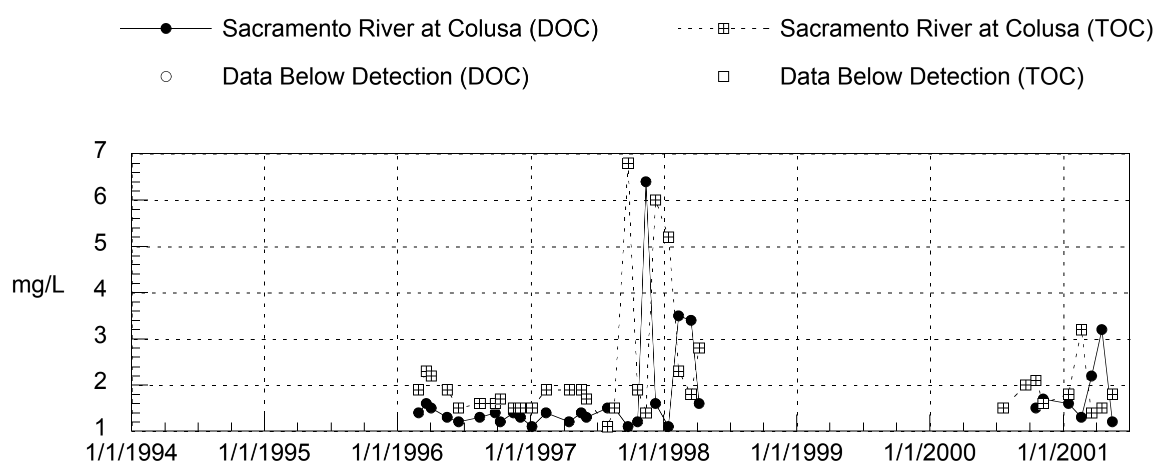

Sacramento River at Greene's Landing
Data Below Detection
ng/L
0.2
0.15
0.1
0.05
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

Time Series Plots of Monitoring Data: Drinking Water Parameters

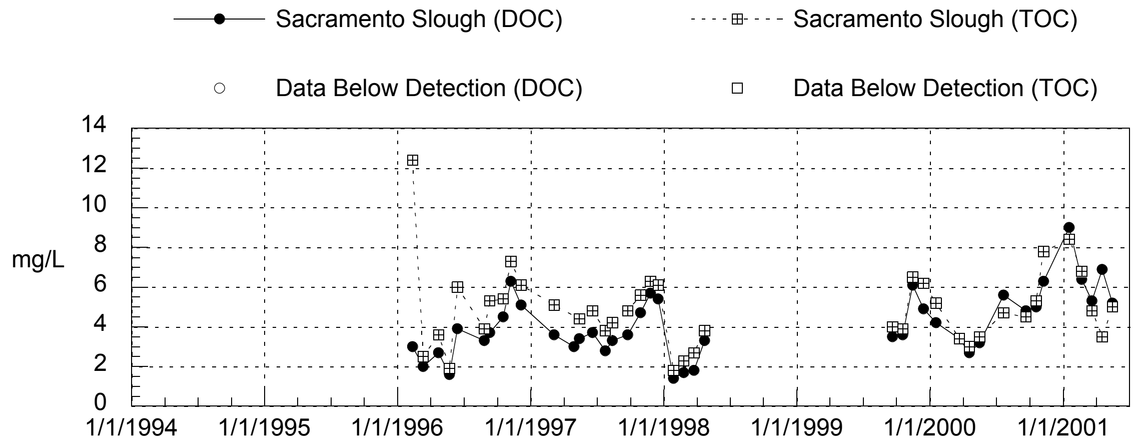
ORGANIC CARBON CONCENTRATIONS IN WATER

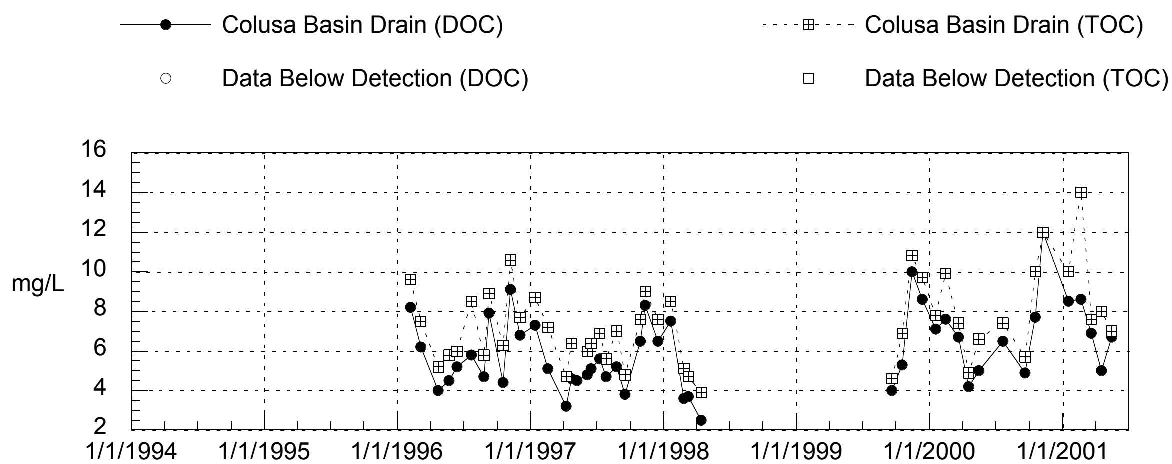


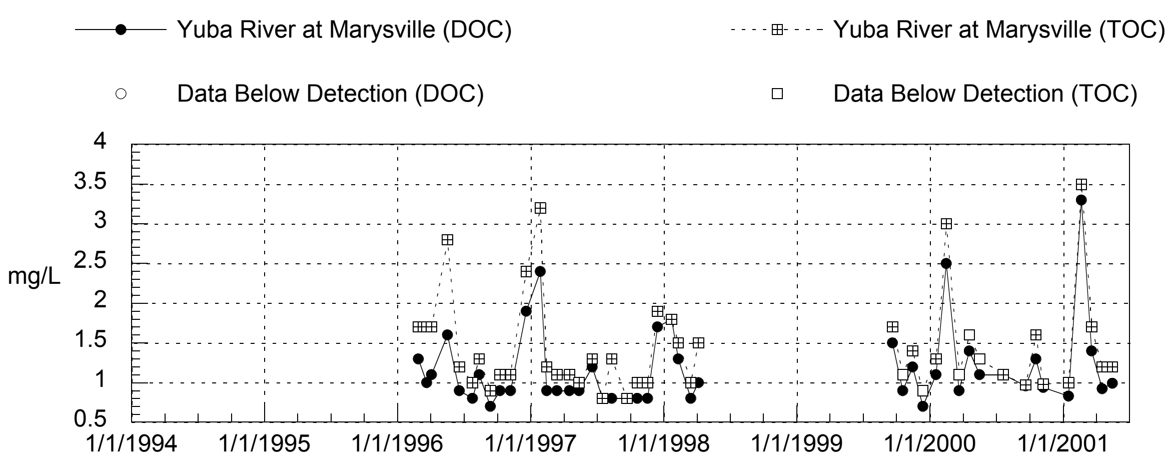




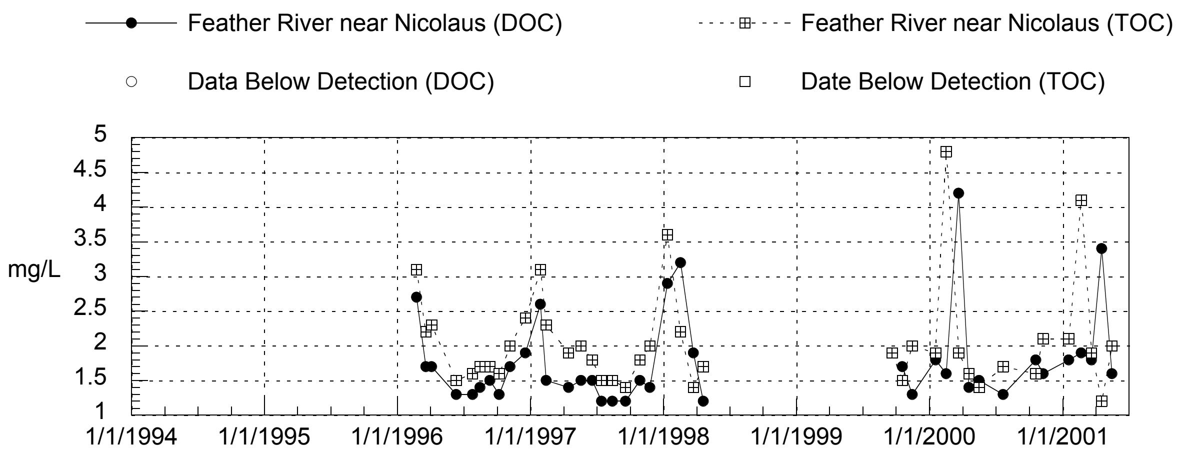
ORGANIC CARBON CONCENTRATIONS IN WATER

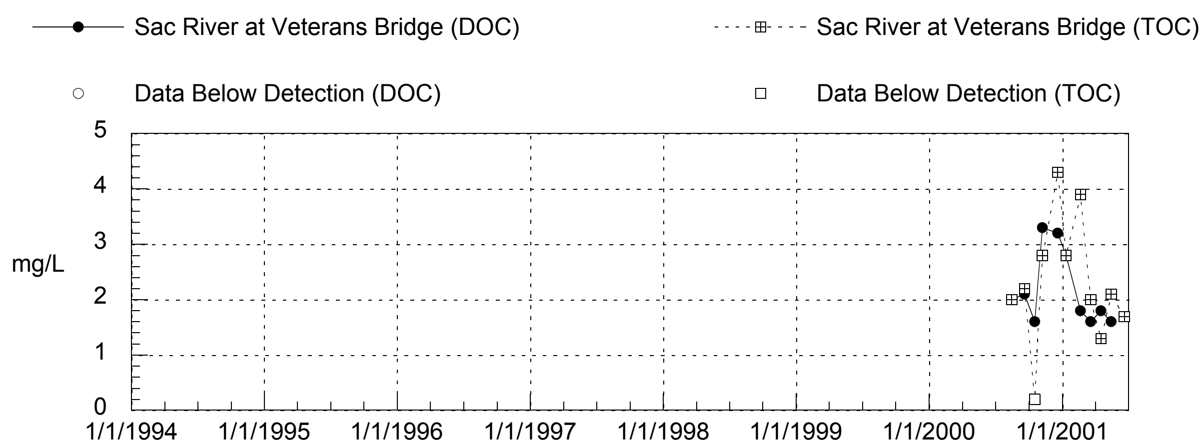


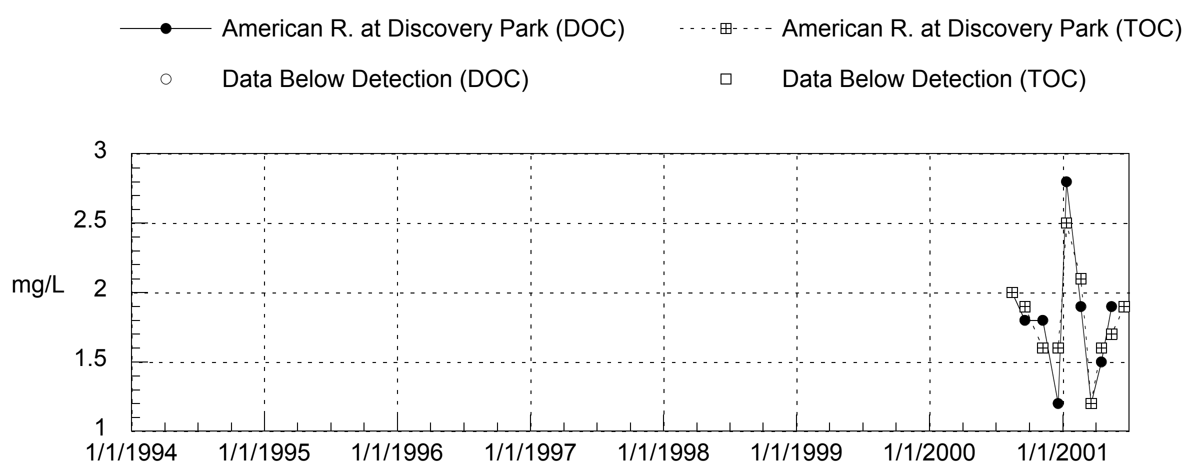




ORGANIC CARBON CONCENTRATIONS IN WATER







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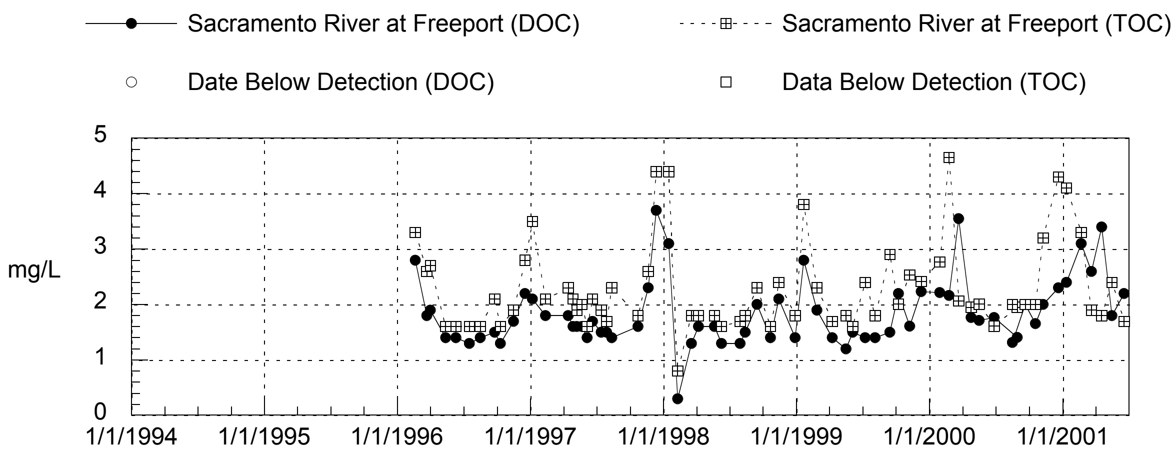
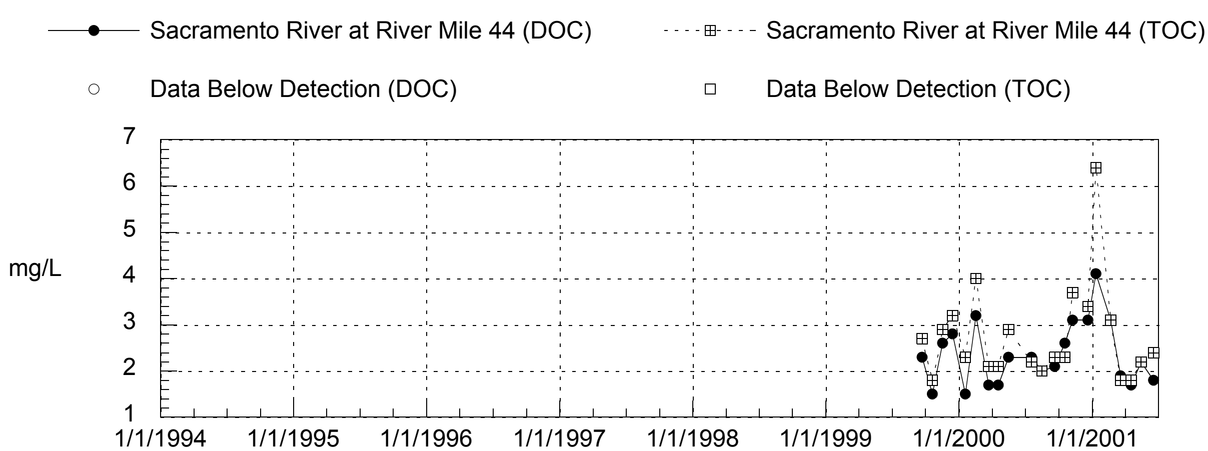
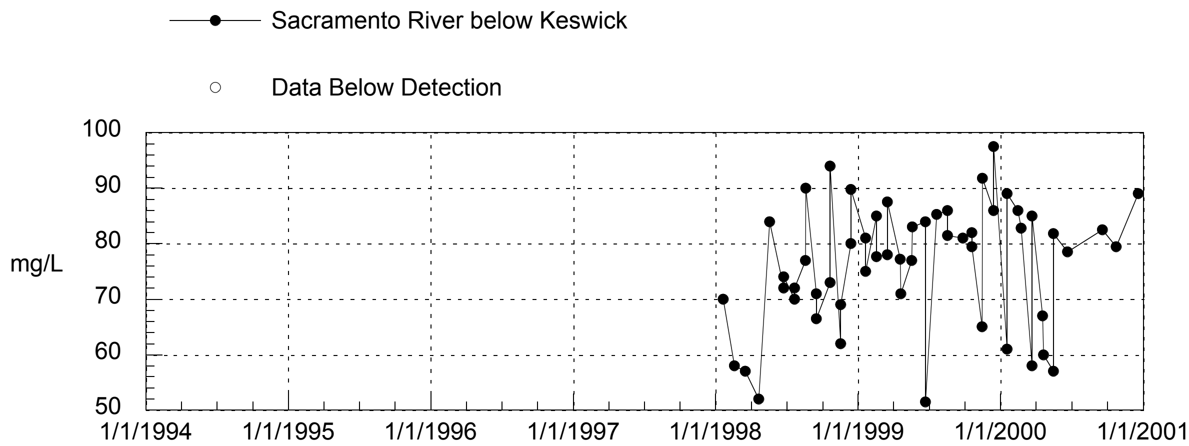
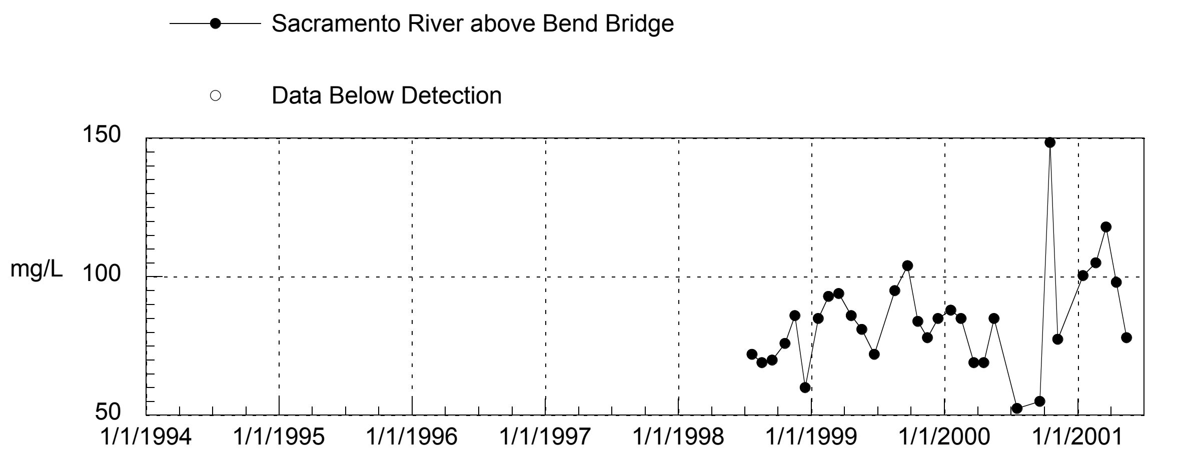
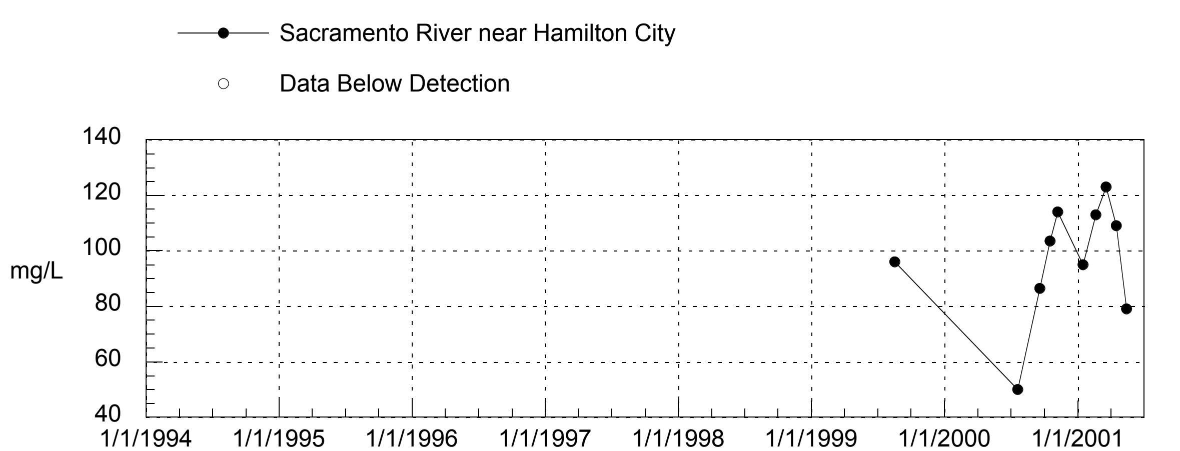




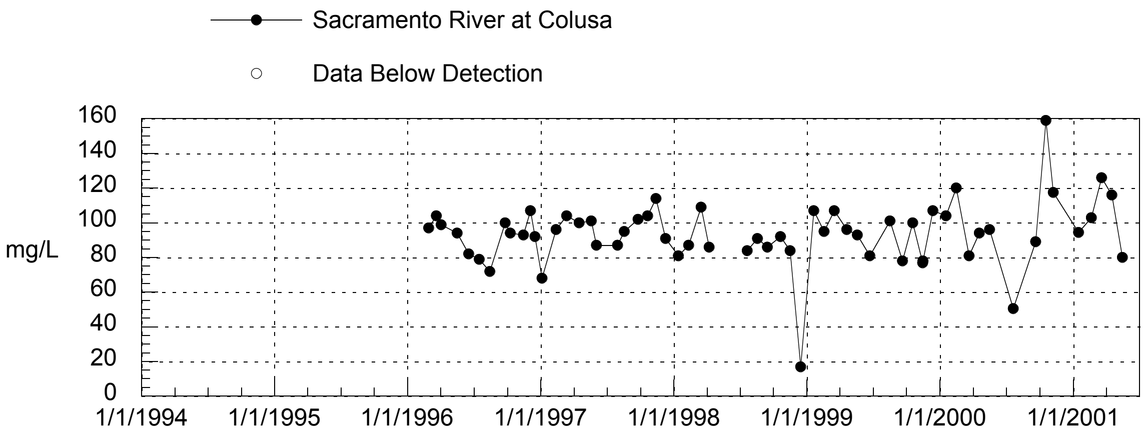
TOTAL DISSOLVED SOLIDS CONCENTRATIONS IN WATER

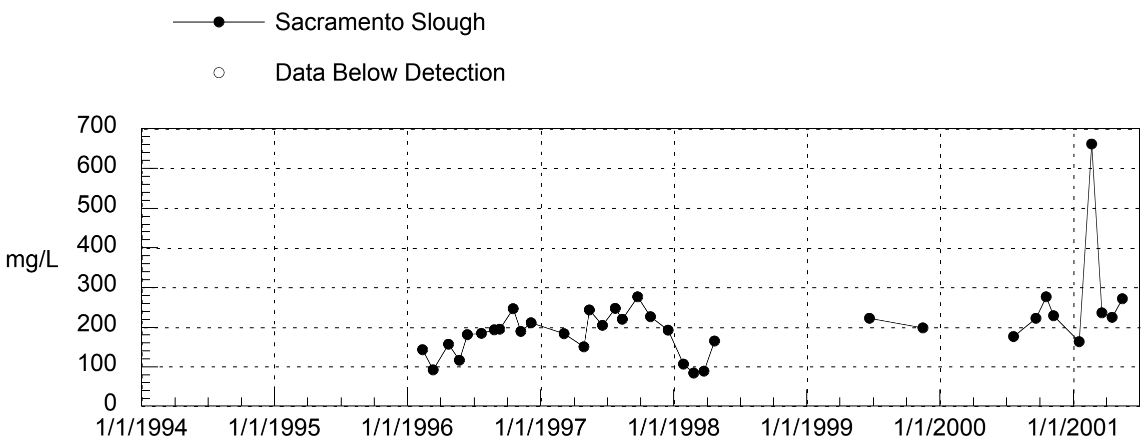


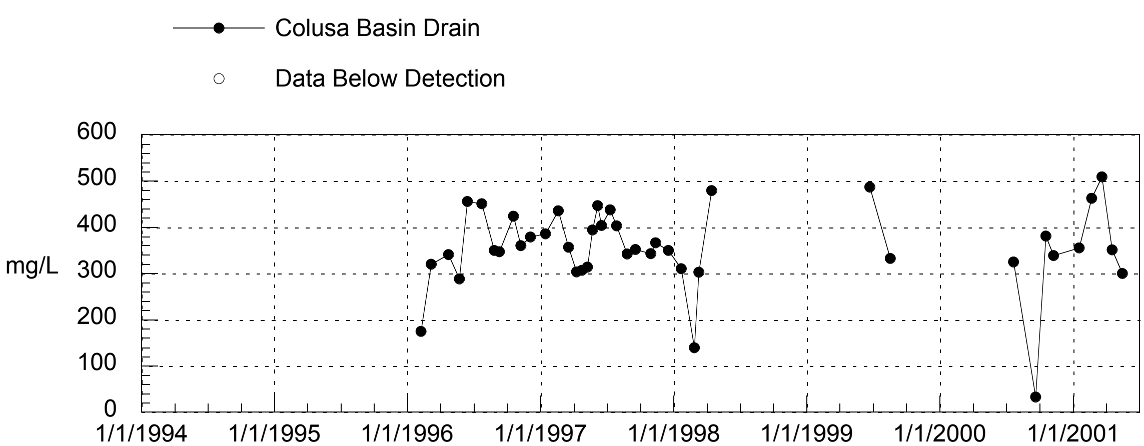




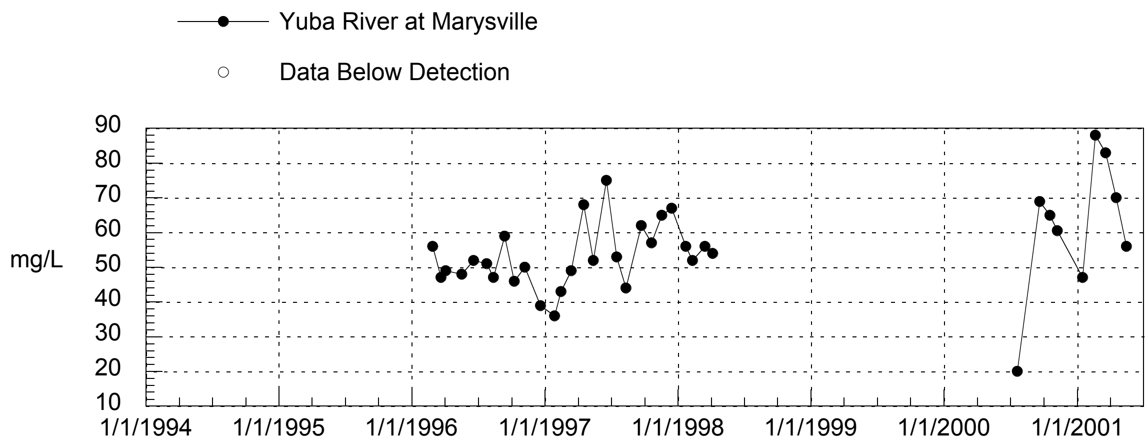
TOTAL DISSOLVED SOLIDS CONCENTRATIONS IN WATER

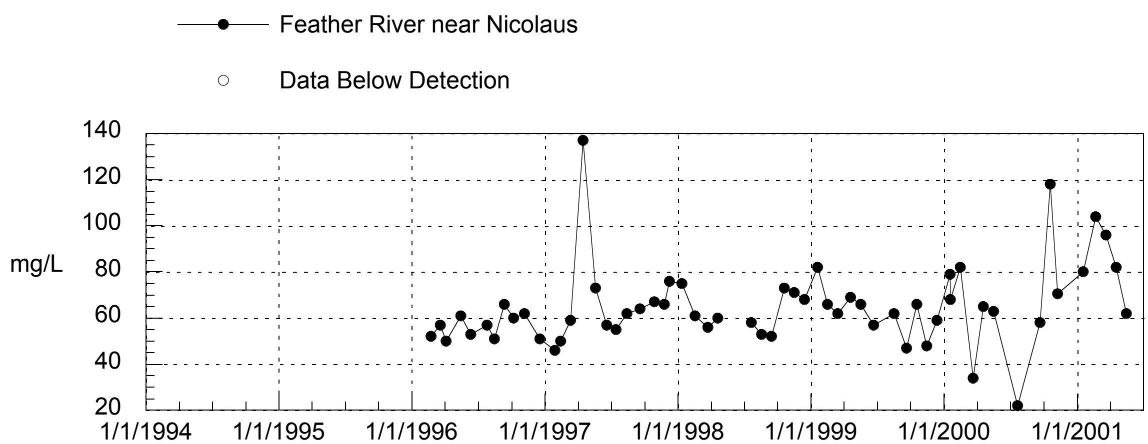


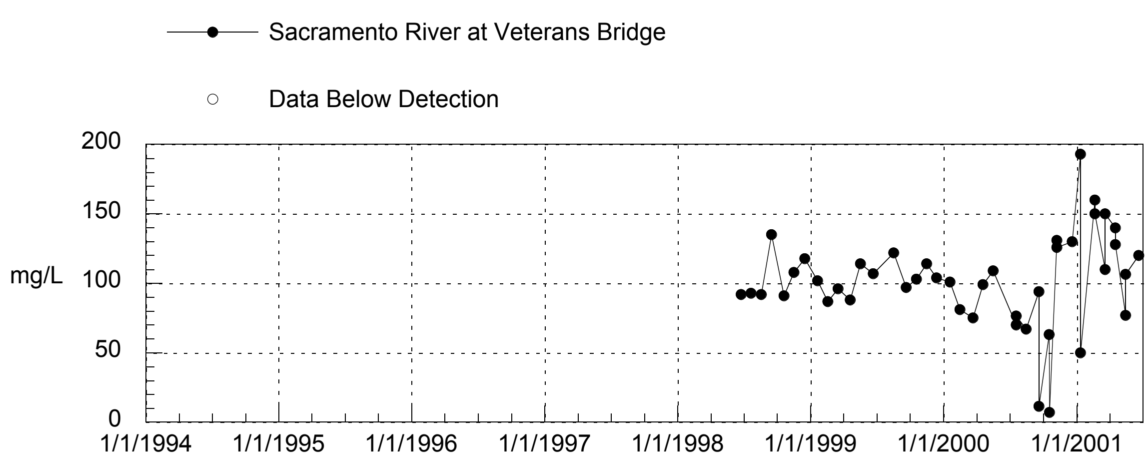




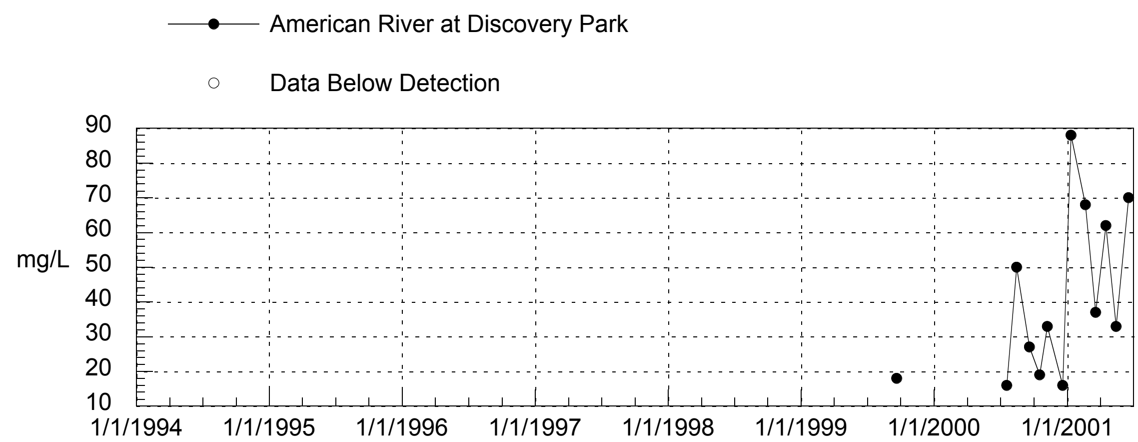
TOTAL DISSOLVED SOLIDS CONCENTRATIONS IN WATER

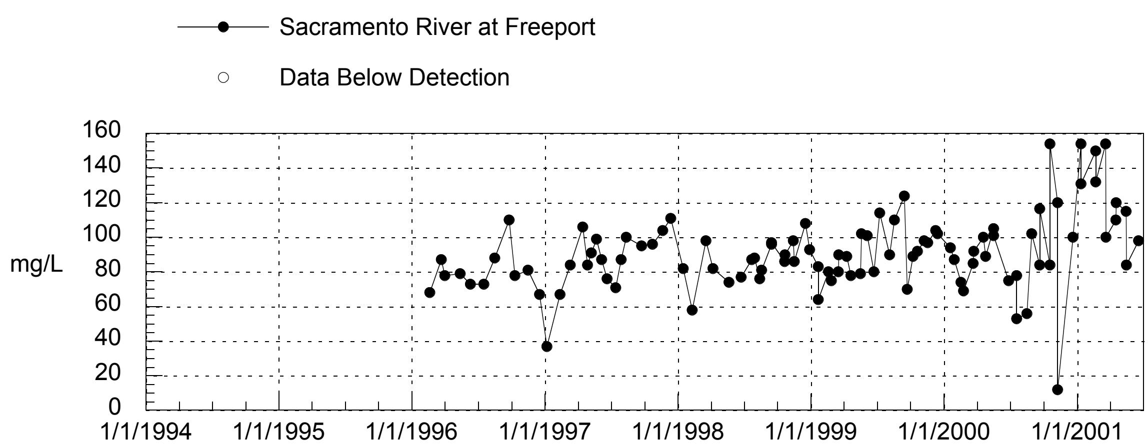


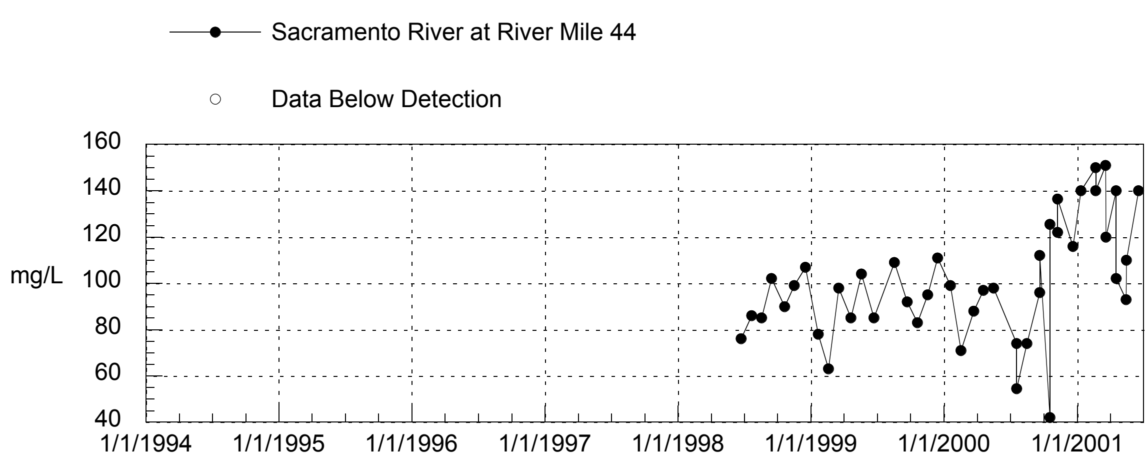




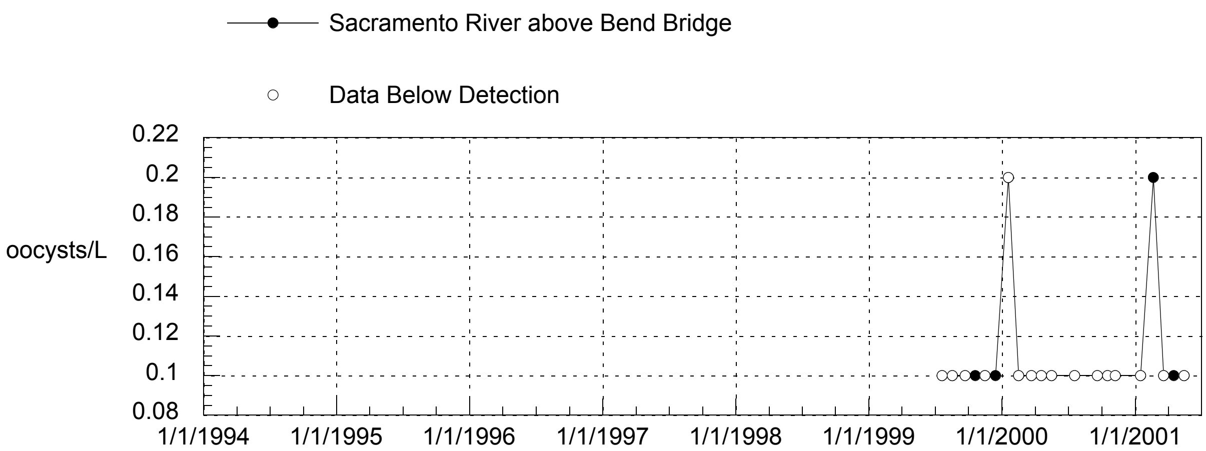
TOTAL DISSOLVED SOLIDS CONCENTRATIONS IN WATER

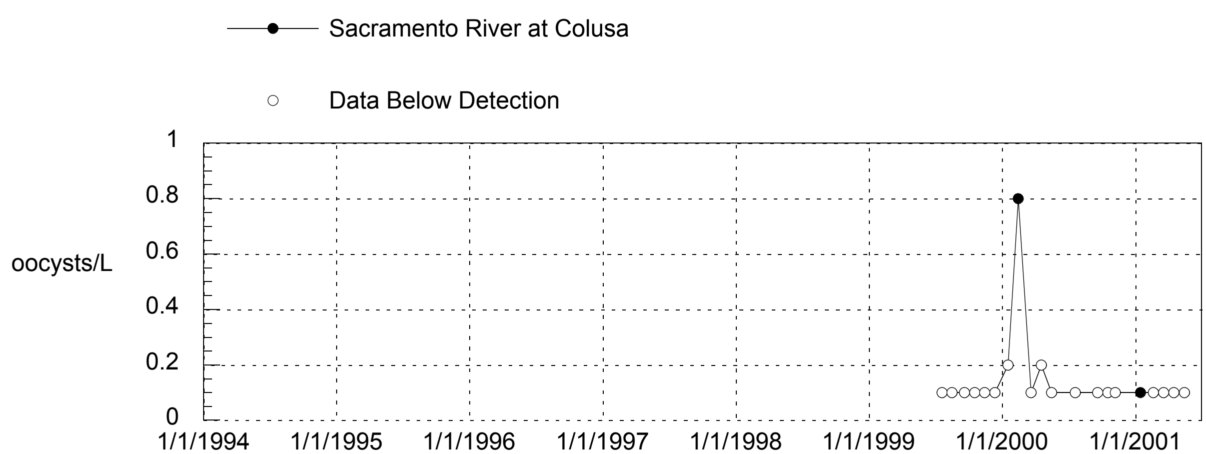


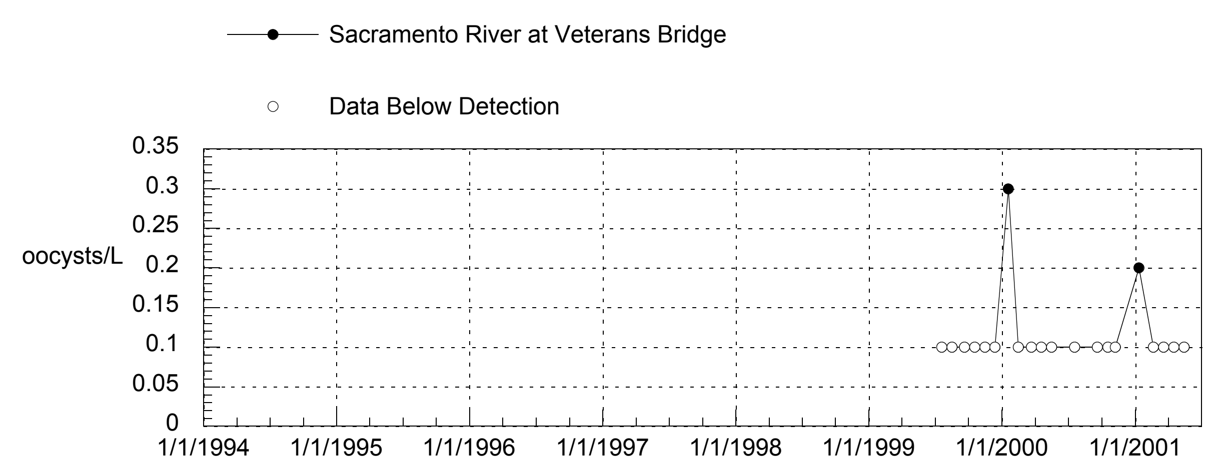




Time Series Plots of Monitoring Data: Pathogens


Sacramento River above Bend Bridge
Data Below Detection
oocysts/L
0.22
0.2
0.18
0.16
0.14
0.12
0.1
0.08
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001


Sacramento River at Colusa
Data Below Detection
oocysts/L
1
0.8
0.6
0.4
0.2
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001


Sacramento River at Veterans Bridge
Data Below Detection
oocysts/L
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

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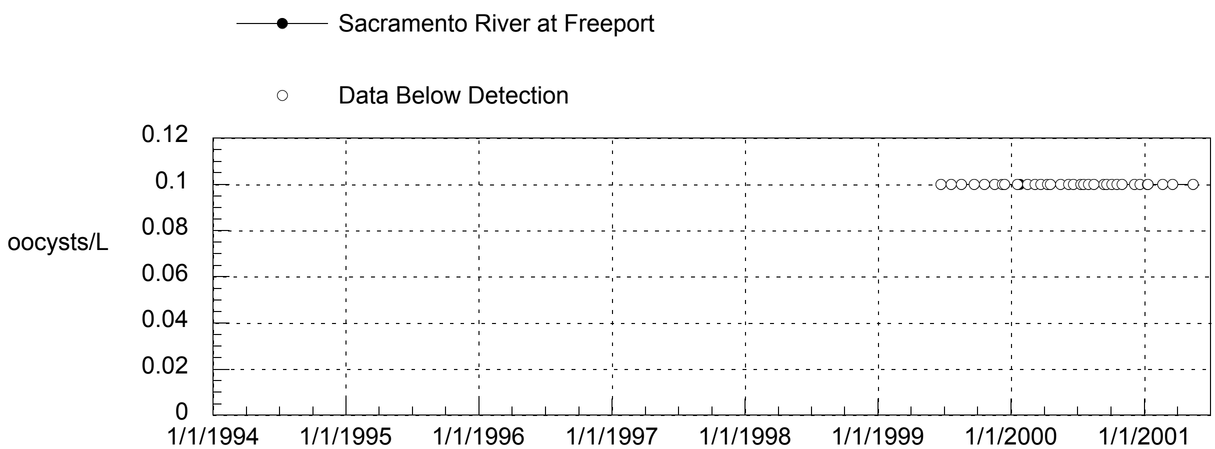
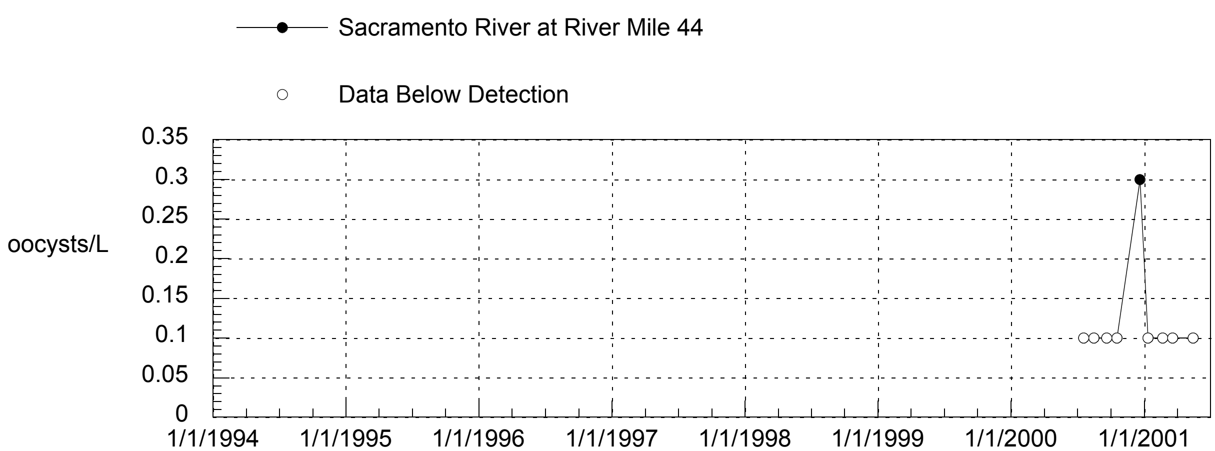
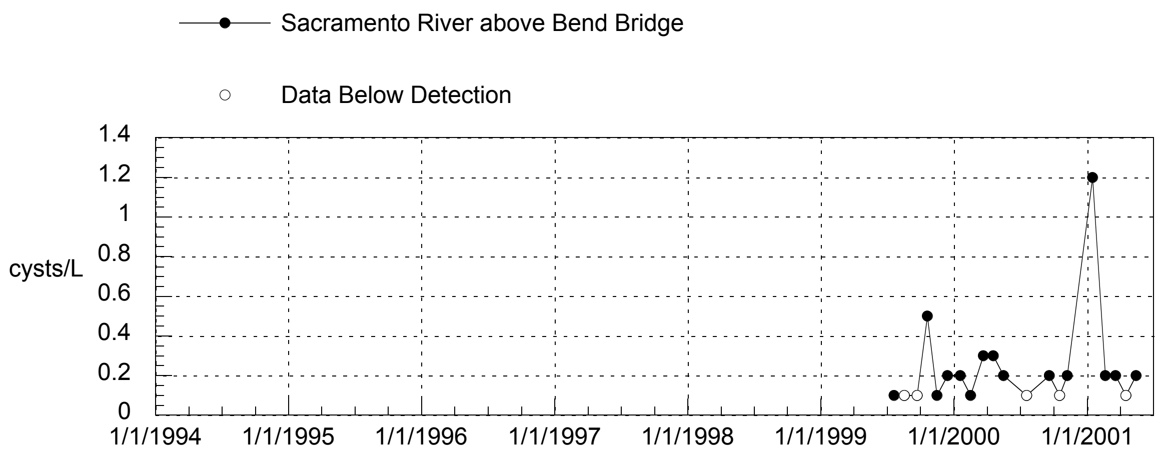
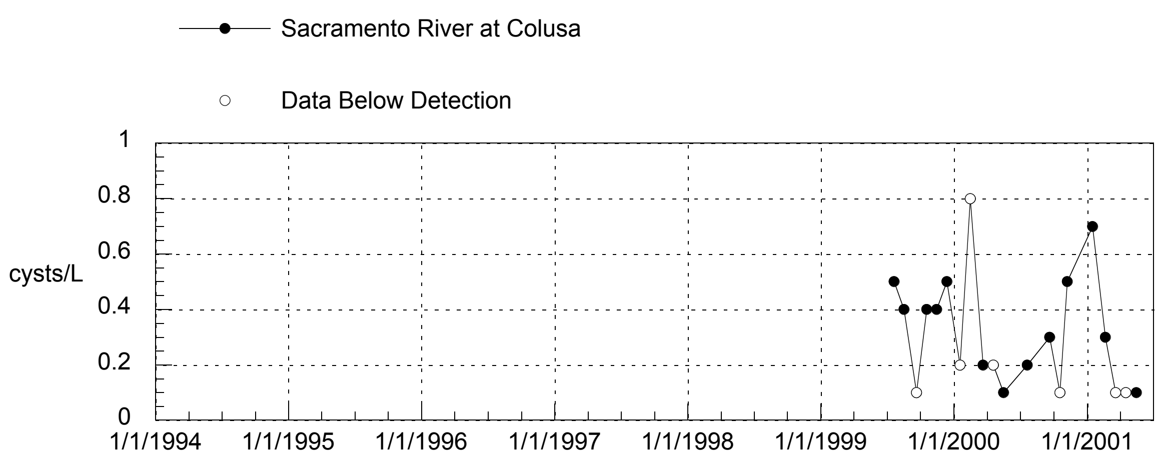
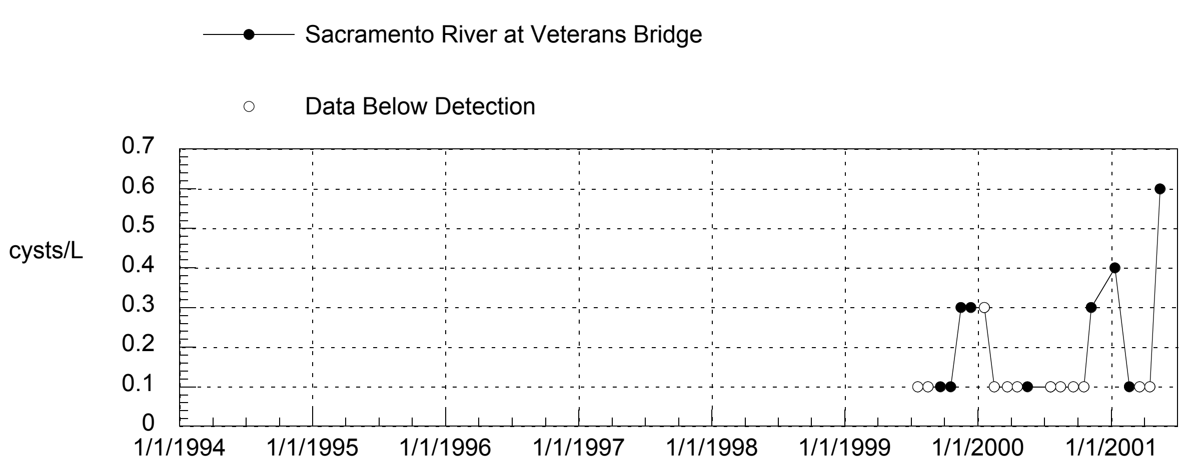
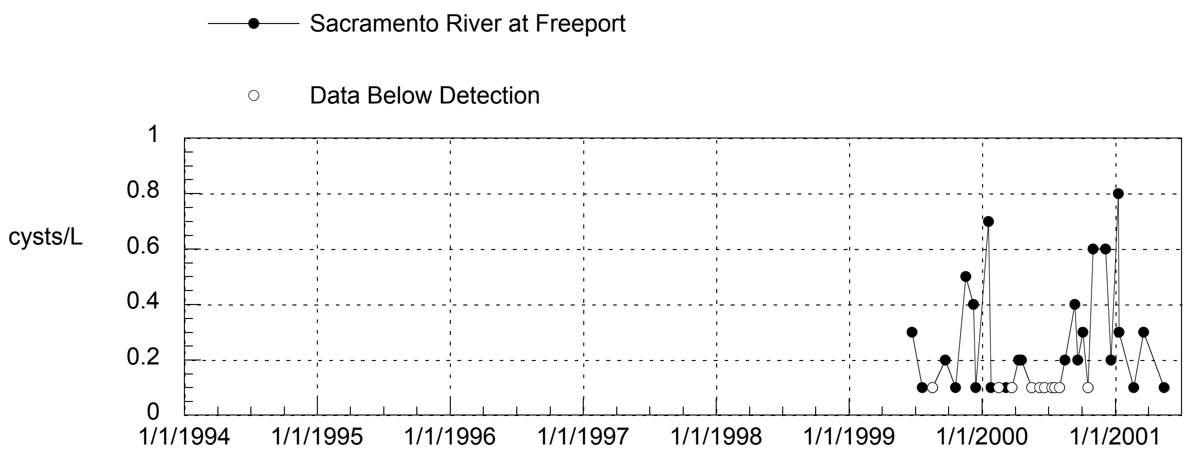


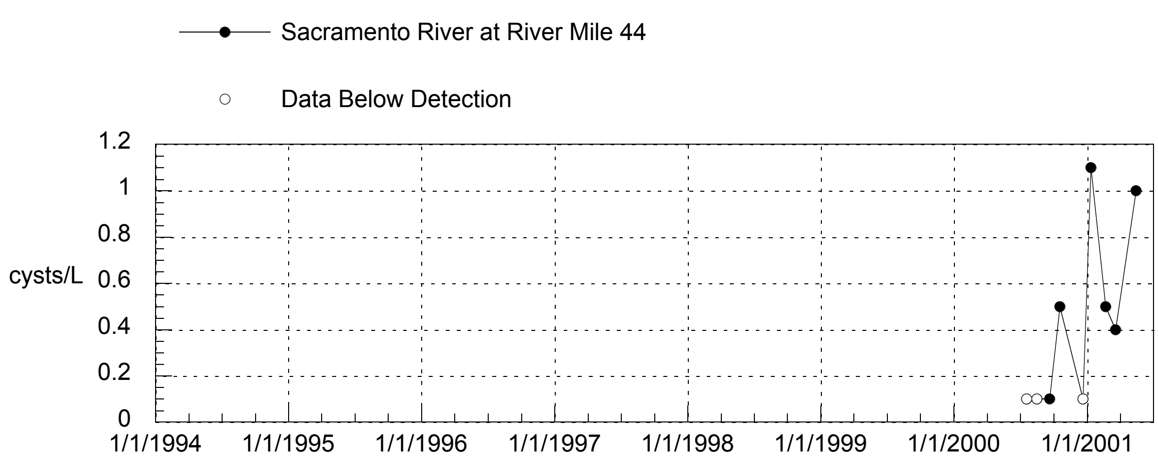


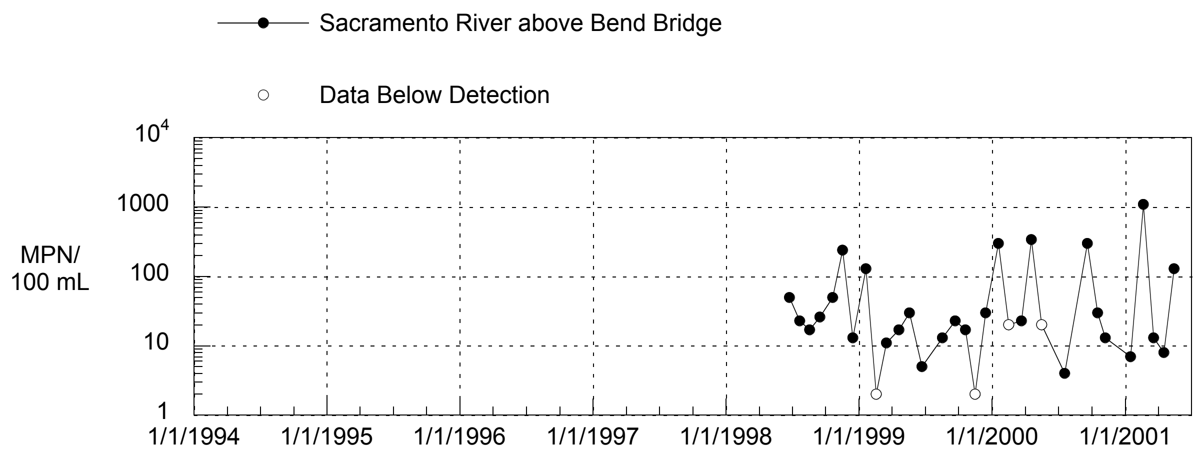

Sacramento River above Bend Bridge
Data Below Detection
cysts/L
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

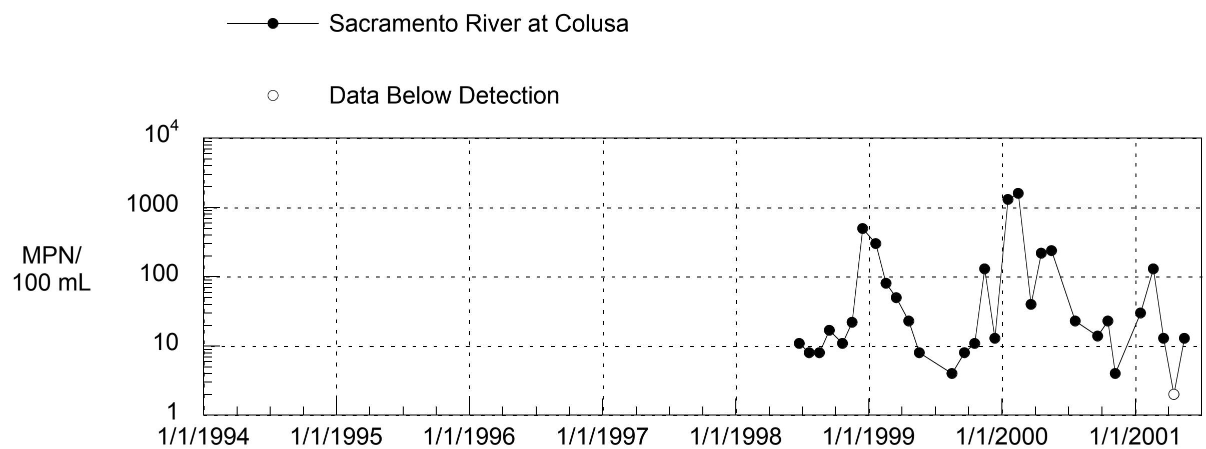

Sacramento River at Colusa
Data Below Detection
cysts/L
1
0.8
0.6
0.4
0.2
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

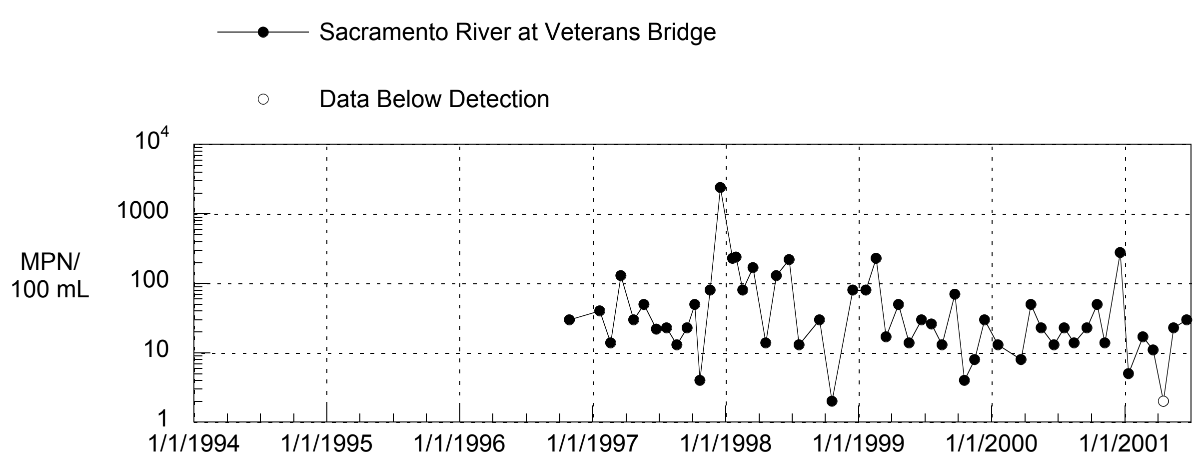

Sacramento River at Veterans Bridge
Data Below Detection
cysts/L
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001


Sacramento River at Freeport
Data Below Detection
cysts/L
0
0.2
0.4
0.6
0.8
1
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

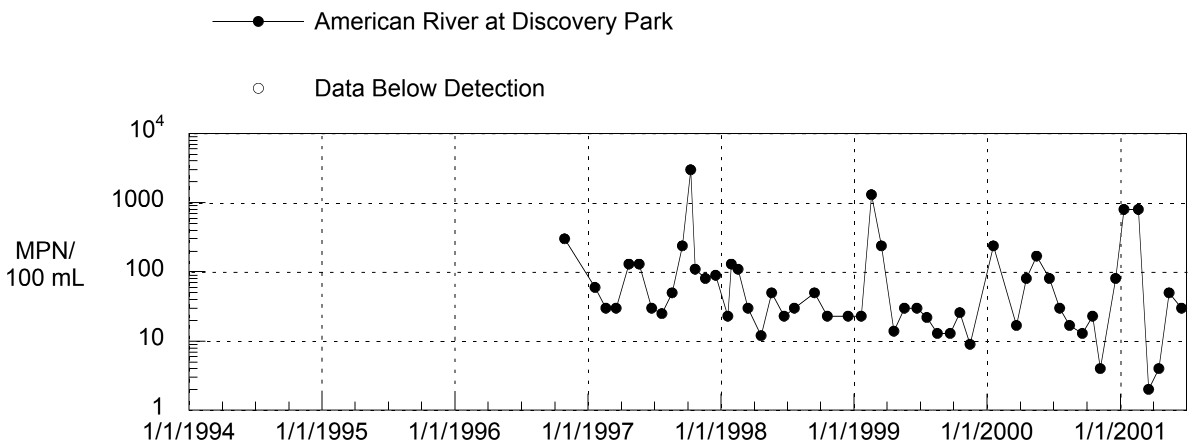

Sacramento River at River Mile 44
Data Below Detection
cysts/L
0
0.2
0.4
0.6
0.8
1
1.2
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

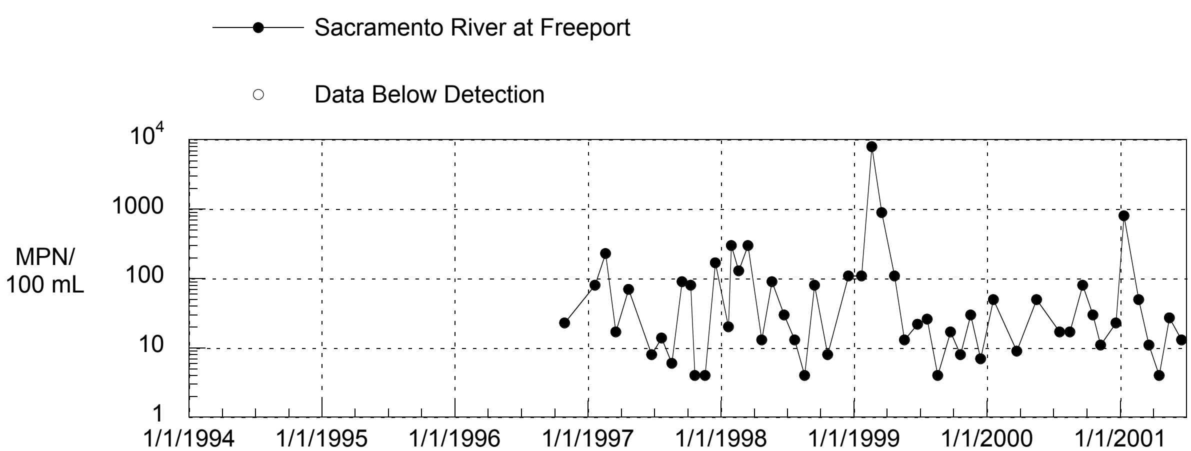

Sacramento River above Bend Bridge
Data Below Detection
10^4
1000
100
10
1
MPN/
100 mL
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

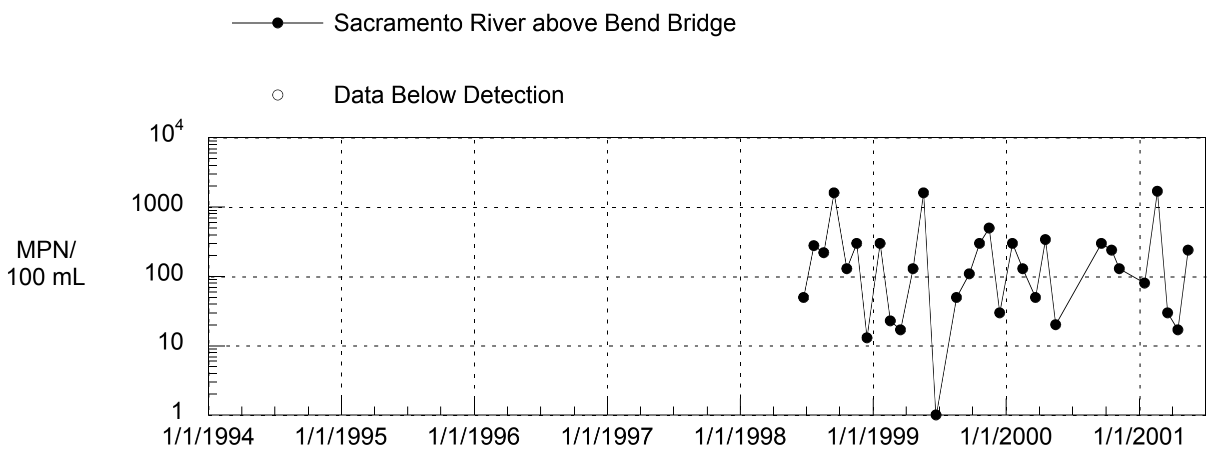

Sacramento River at Colusa
Data Below Detection
10^4
1000
100
10
1
MPN/
100 mL
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

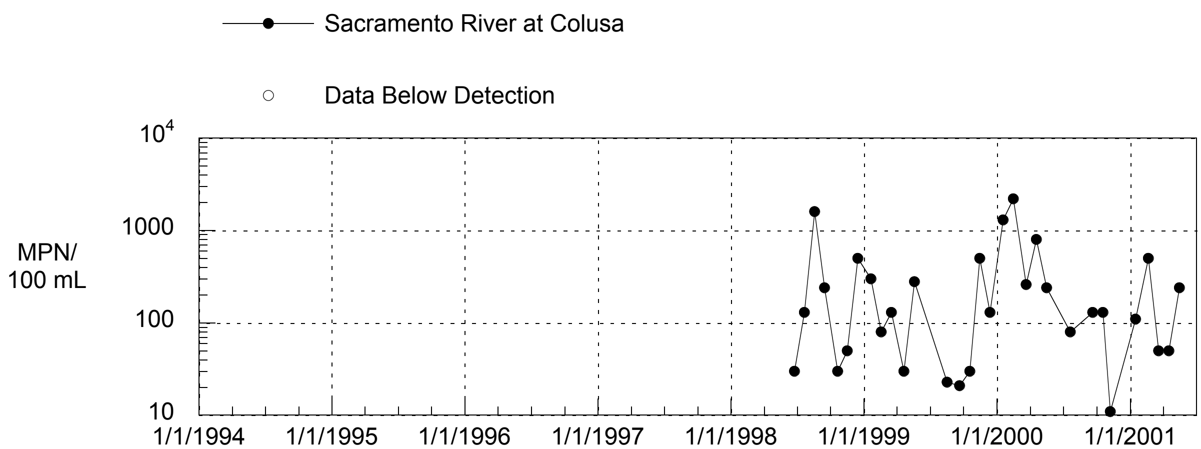

Sacramento River at Veterans Bridge
Data Below Detection
10^4
1000
100
10
1
MPN/
100 mL
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

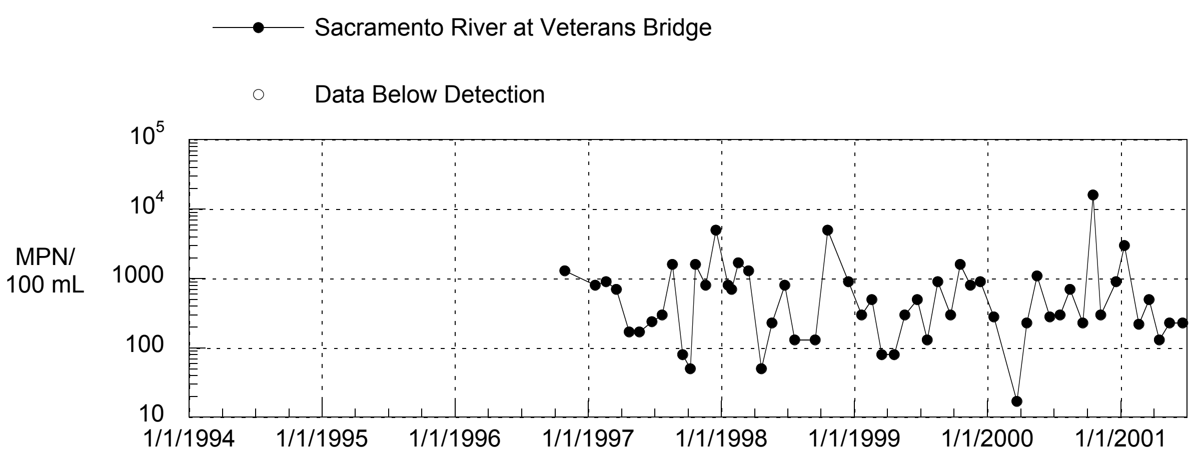
SPACE INTENTIONALLY BLANK






Sacramento River above Bend Bridge
Data Below Detection
MPN/
100 mL
10^4
1000
100
10
1
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001


Sacramento River at Colusa
Data Below Detection
MPN/
100 mL
10^4
1000
100
10
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001


Sacramento River at Veterans Bridge
Data Below Detection
MPN/
100 mL
10^5
10^4
1000
100
10
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

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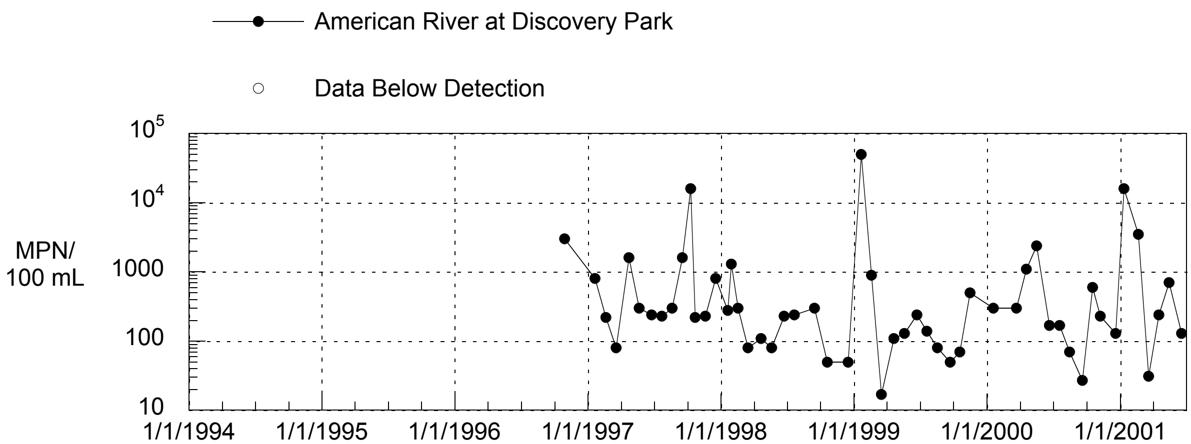
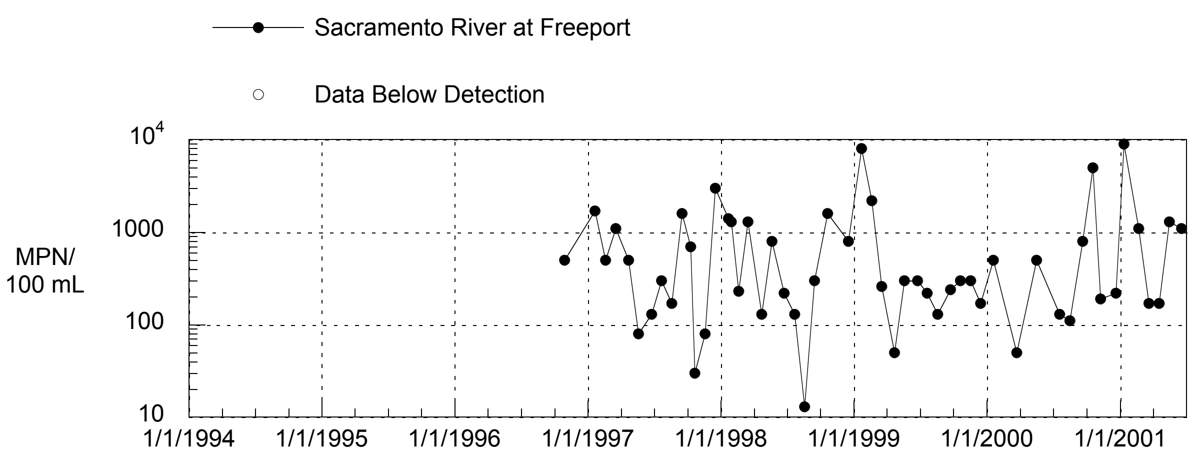
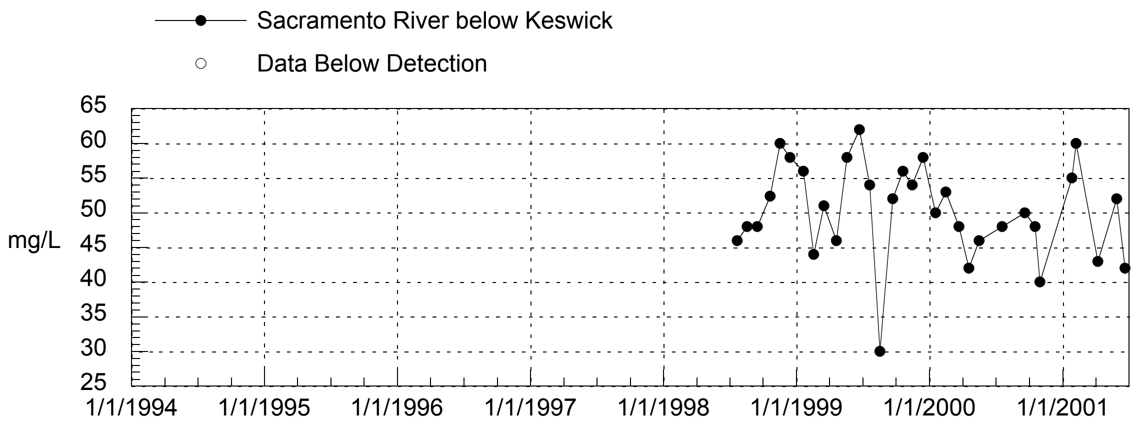
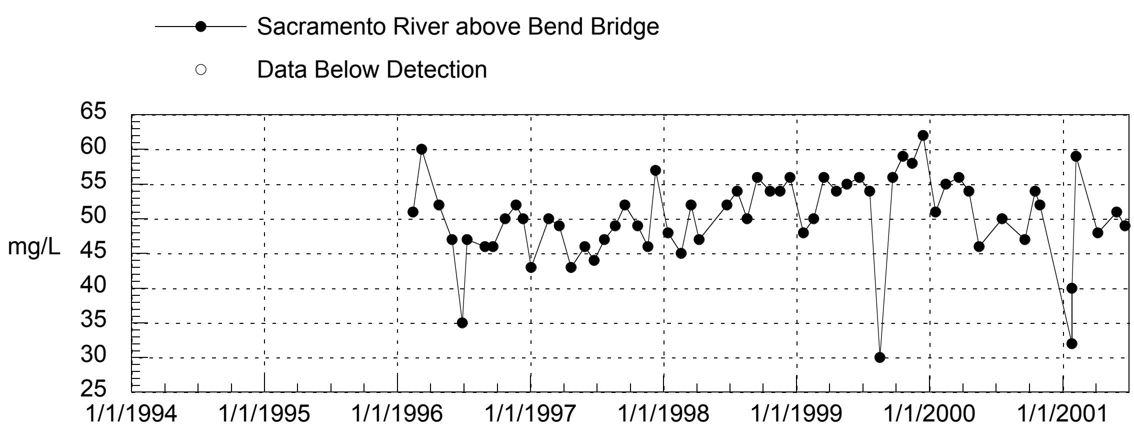
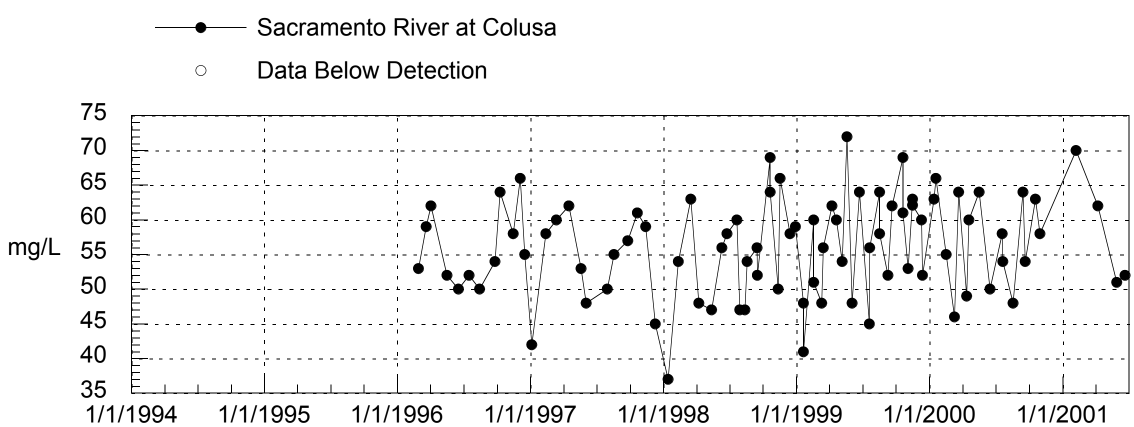


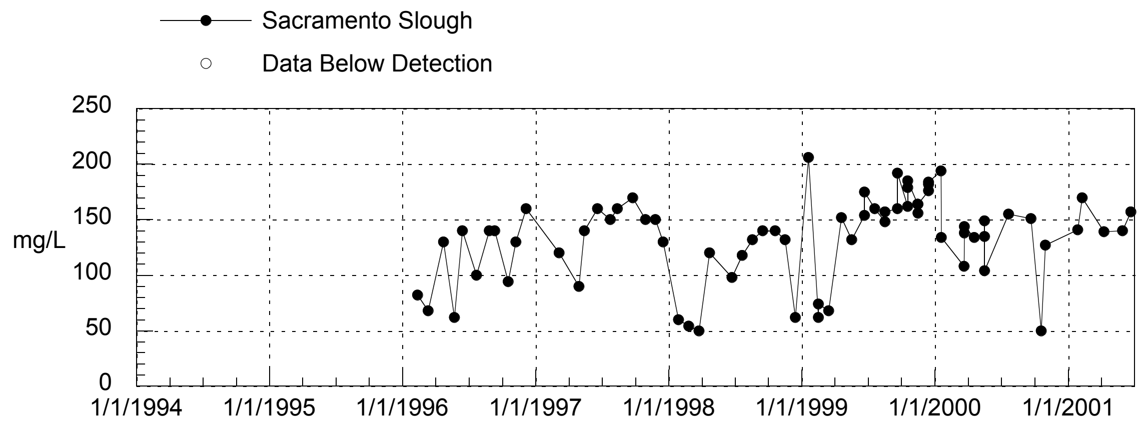


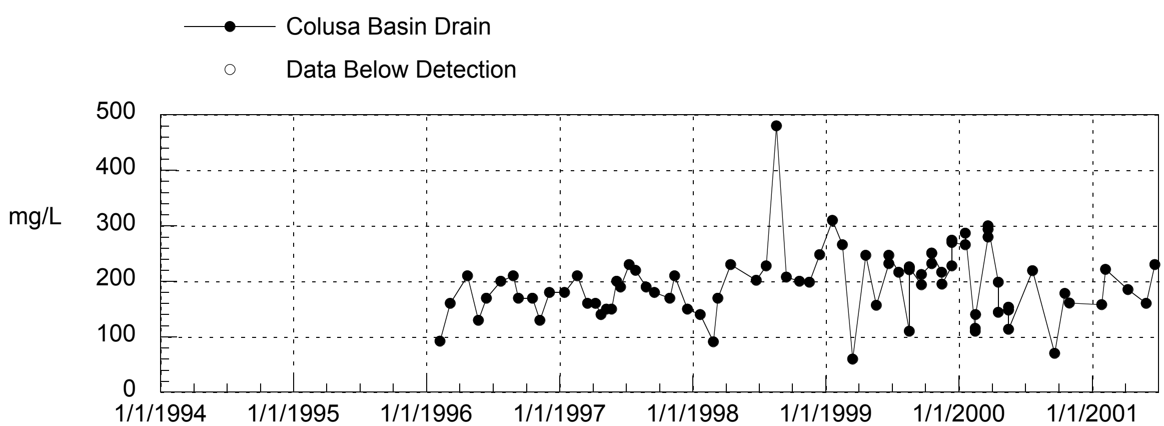
Time Series Plots of Monitoring Data: Other Conventional Water Chemistry Parameters

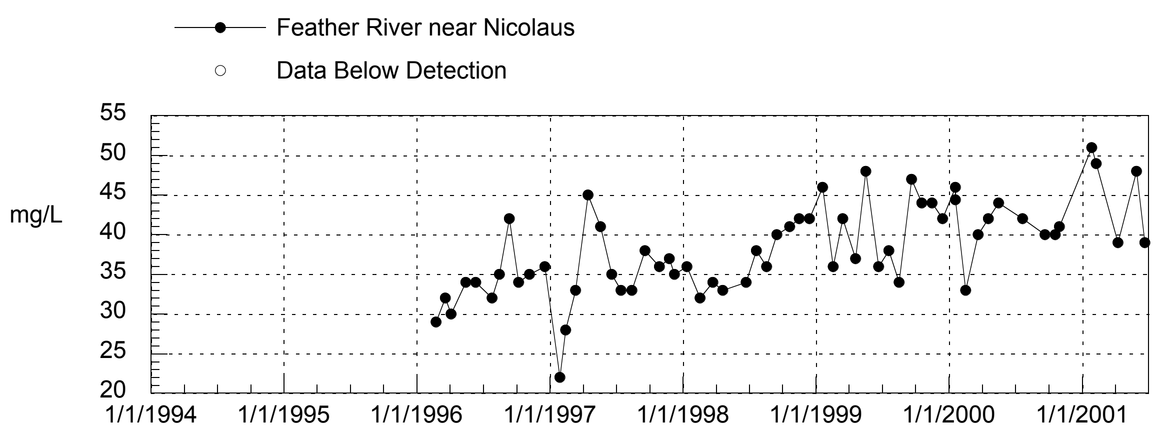

Sacramento River below Keswick
Data Below Detection
mg/L
65
60
55
50
45
40
35
30
25
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

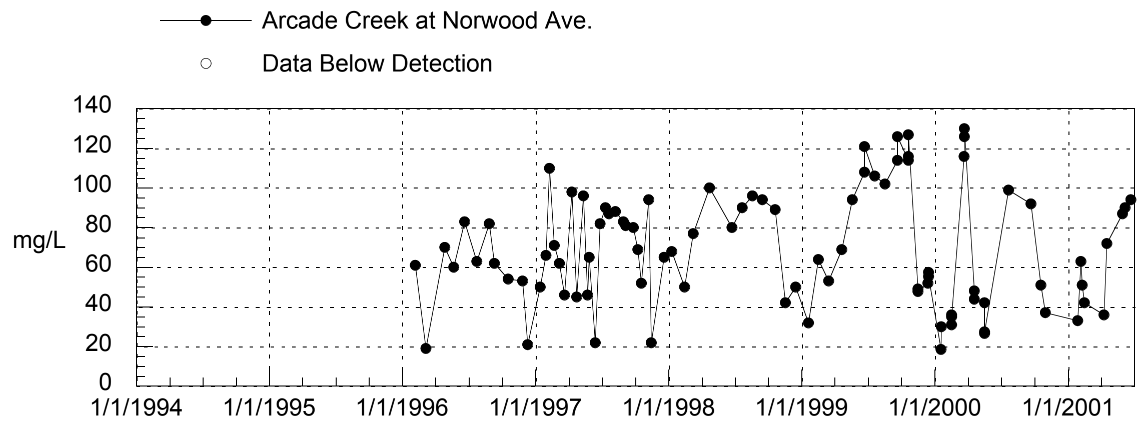

Sacramento River above Bend Bridge
Data Below Detection
mg/L
65
60
55
50
45
40
35
30
25
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

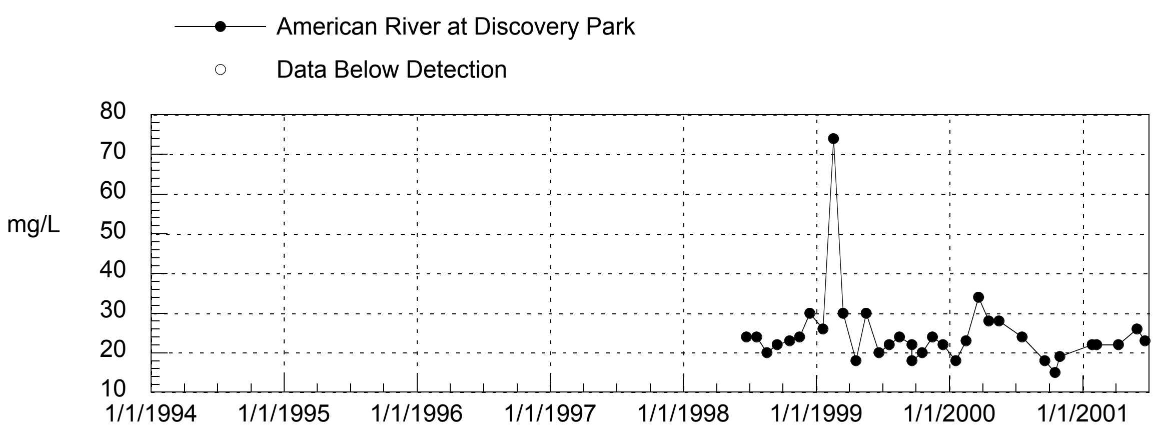

Sacramento River at Colusa
Data Below Detection
mg/L
75
70
65
60
55
50
45
40
35
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

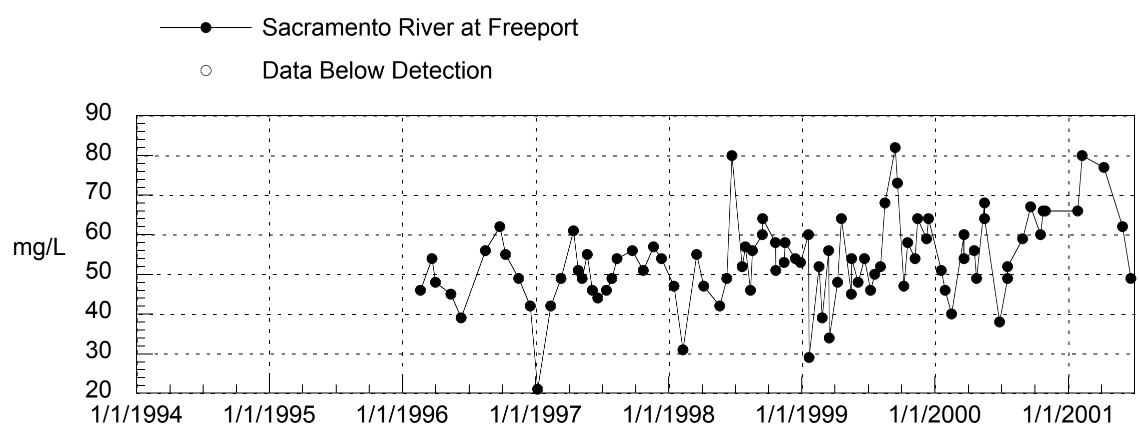

Sacramento Slough
Data Below Detection
mg/L
0
50
100
150
200
250
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001


Colusa Basin Drain
Data Below Detection
mg/L
0
100
200
300
400
500
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

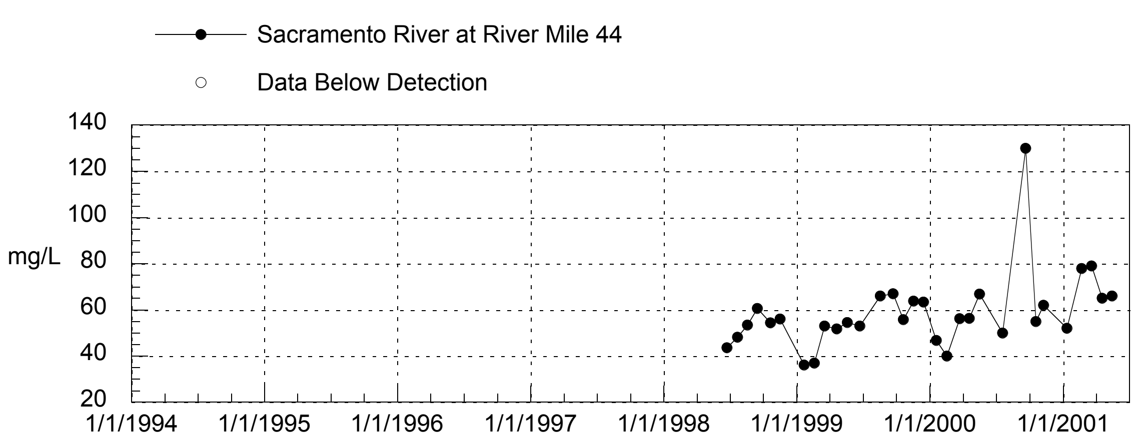

Feather River near Nicolaus
Data Below Detection
mg/L
20
25
30
35
40
45
50
55
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

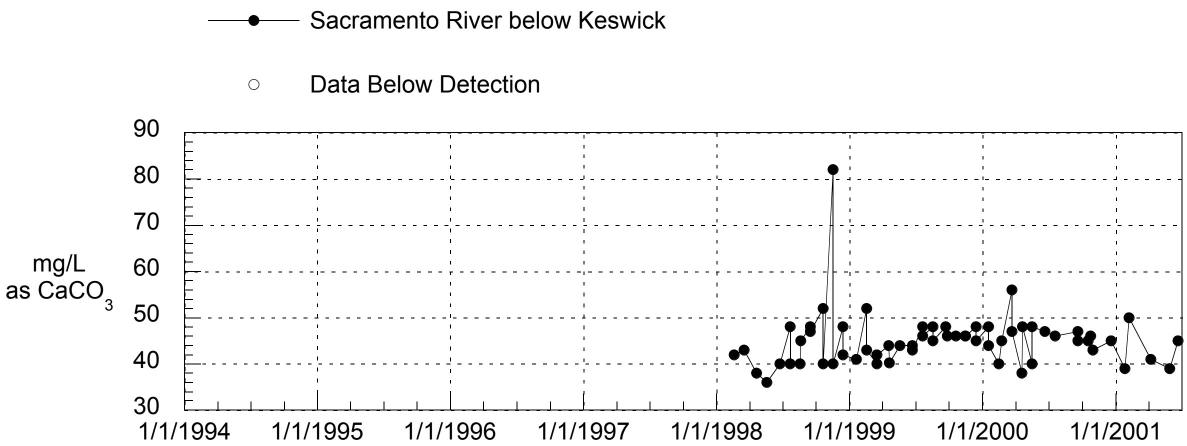

Arcade Creek at Norwood Ave.
Data Below Detection
mg/L
0
20
40
60
80
100
120
140
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001


American River at Discovery Park
Data Below Detection
mg/L
10
20
30
40
50
60
70
80
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

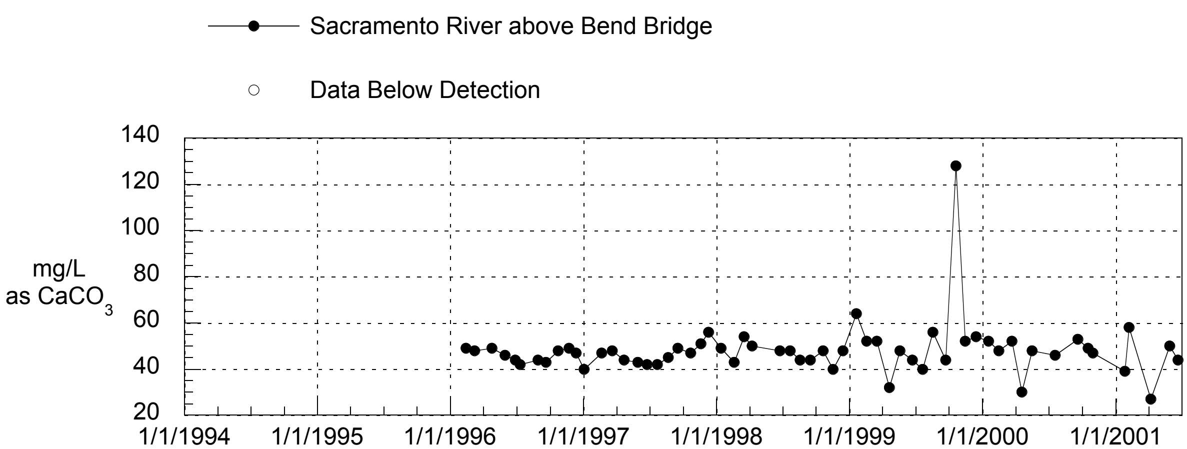

Sacramento River at Freeport
Data Below Detection
mg/L
20
30
40
50
60
70
80
90
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

SPACE INTENTIONALLY BLANK

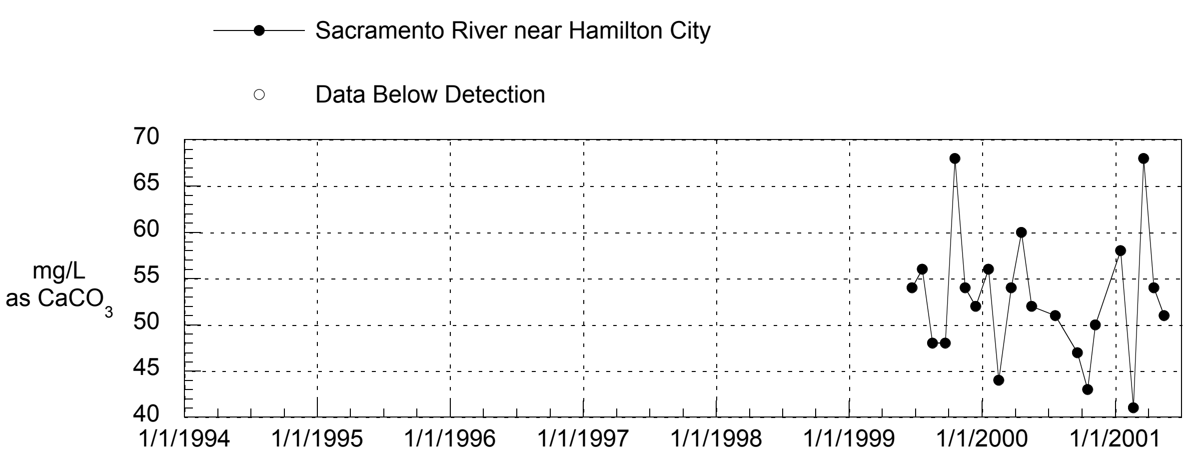




Sacramento River below Keswick
Data Below Detection
mg/L as $CaCO_3$
90
80
70
60
50
40
30
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

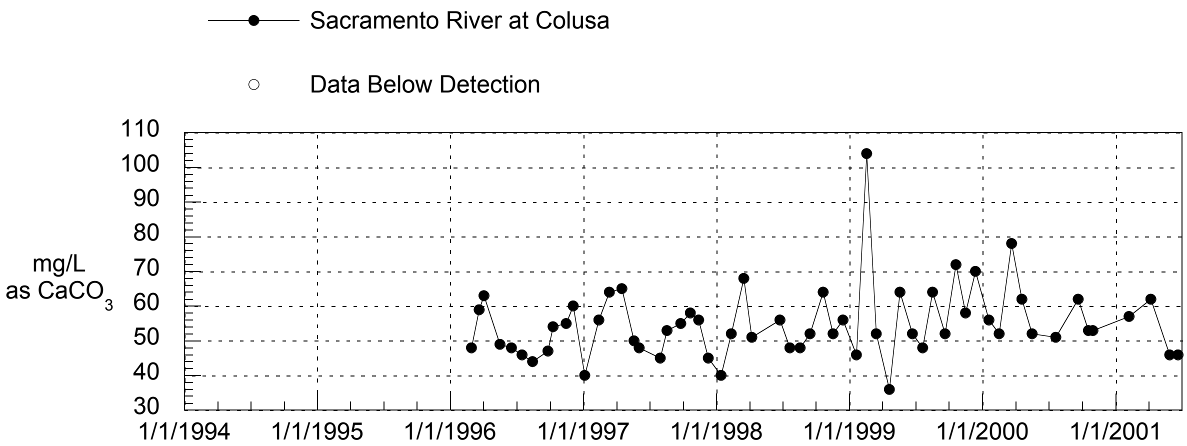


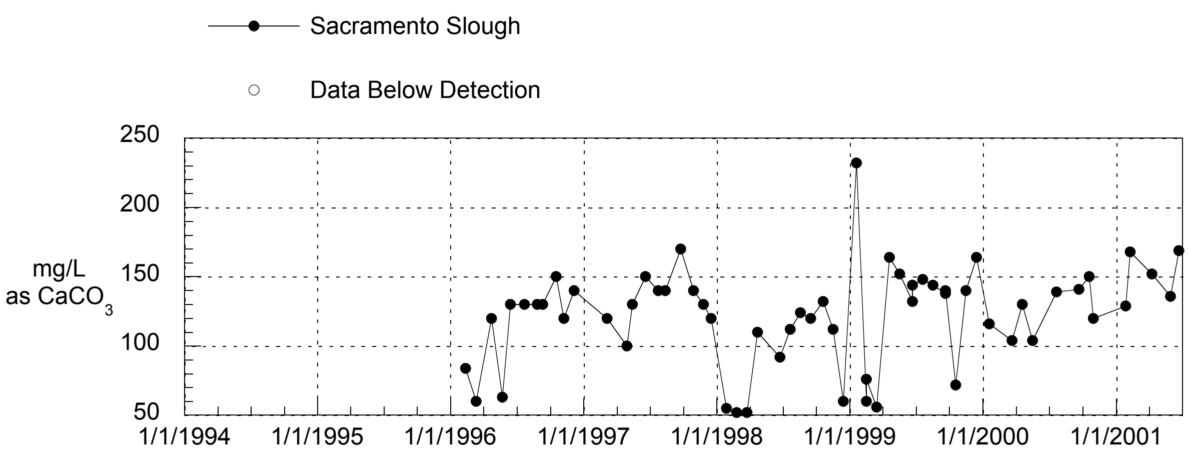
Sacramento River above Bend Bridge
Data Below Detection
mg/L as $CaCO_3$
140
120
100
80
60
40
20
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

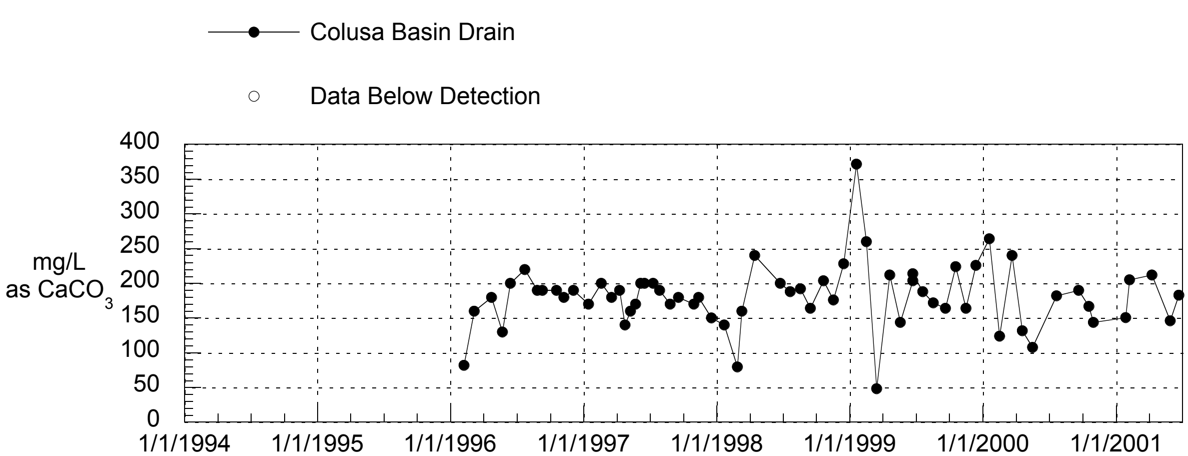


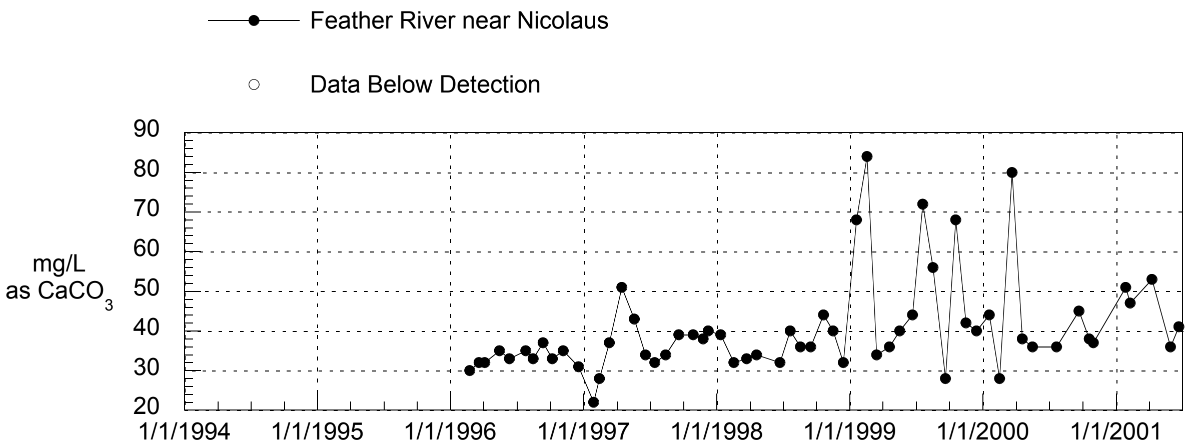
Sacramento River near Hamilton City
Data Below Detection
mg/L as $CaCO_3$
70
65
60
55
50
45
40
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

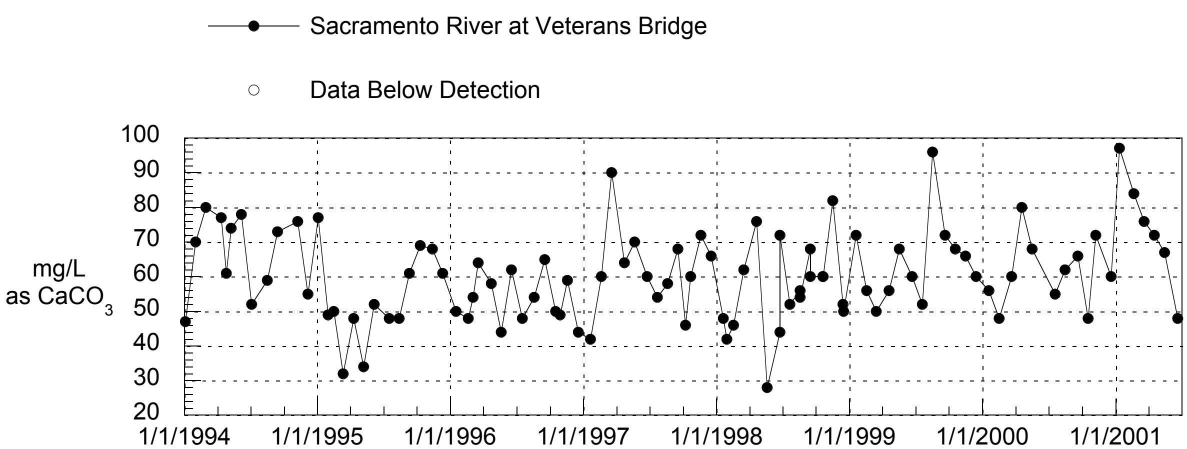
HARDNESS CONCENTRATIONS IN WATER

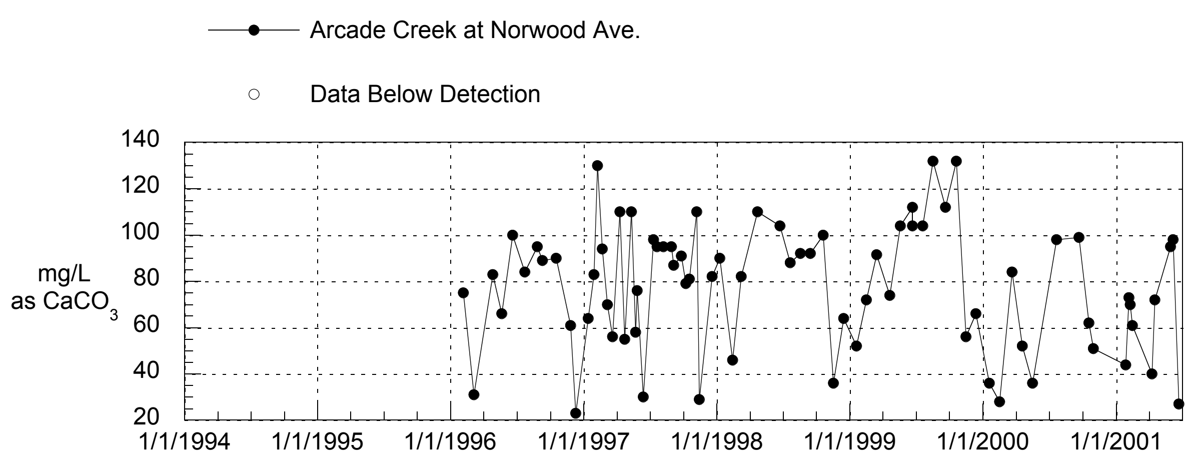


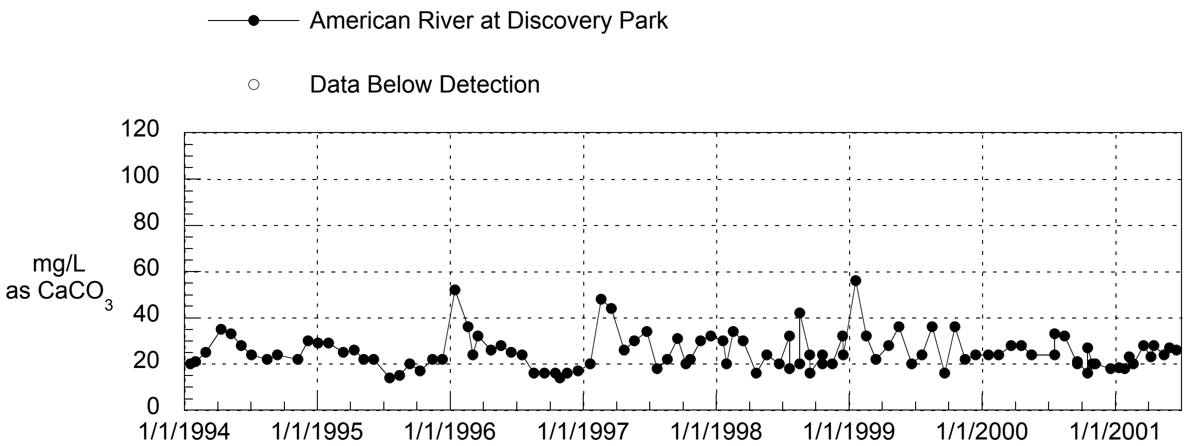


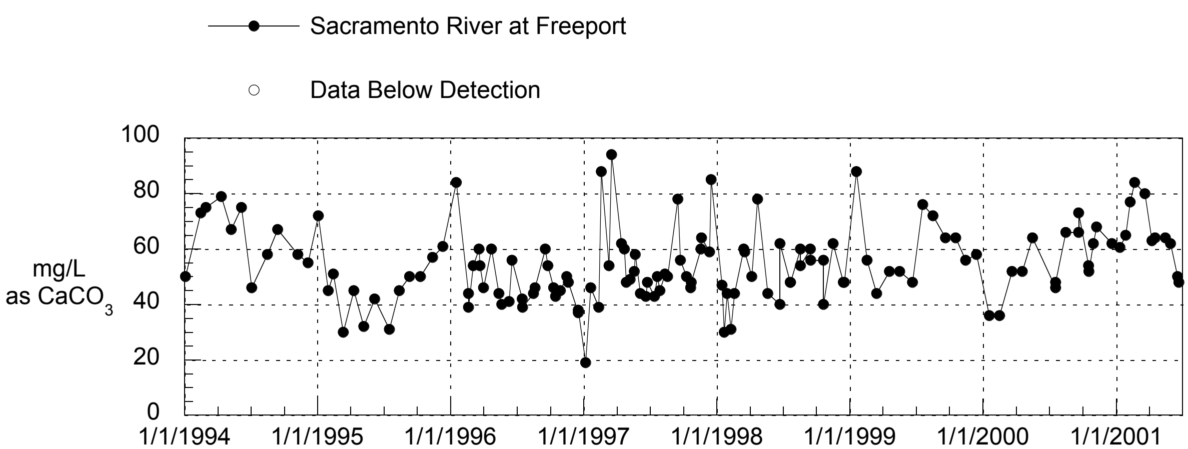


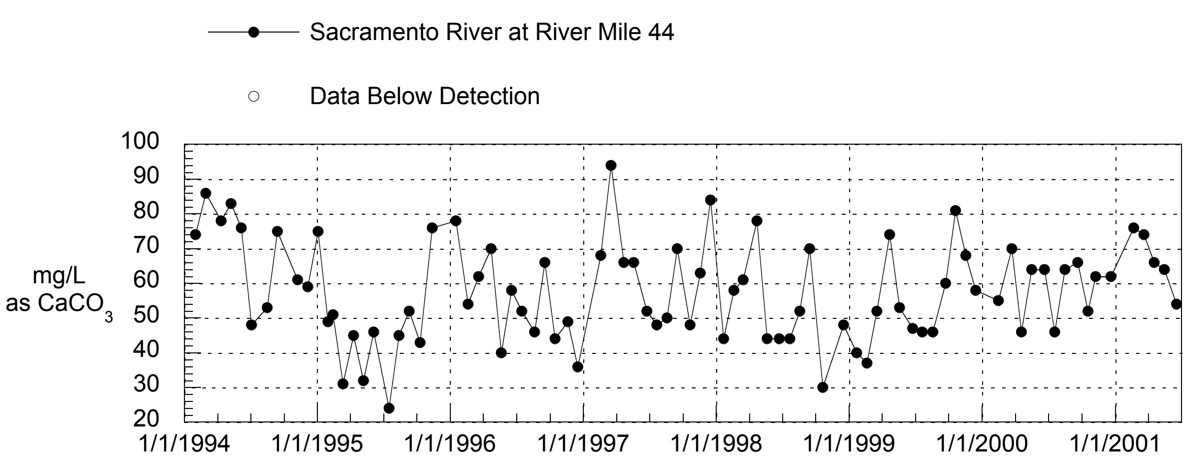

Feather River near Nicolaus
Data Below Detection
mg/L
as $CaCO_3$
90
80
70
60
50
40
30
20
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001


Sacramento River at Veterans Bridge
Data Below Detection
mg/L
as $CaCO_3$
100
90
80
70
60
50
40
30
20
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

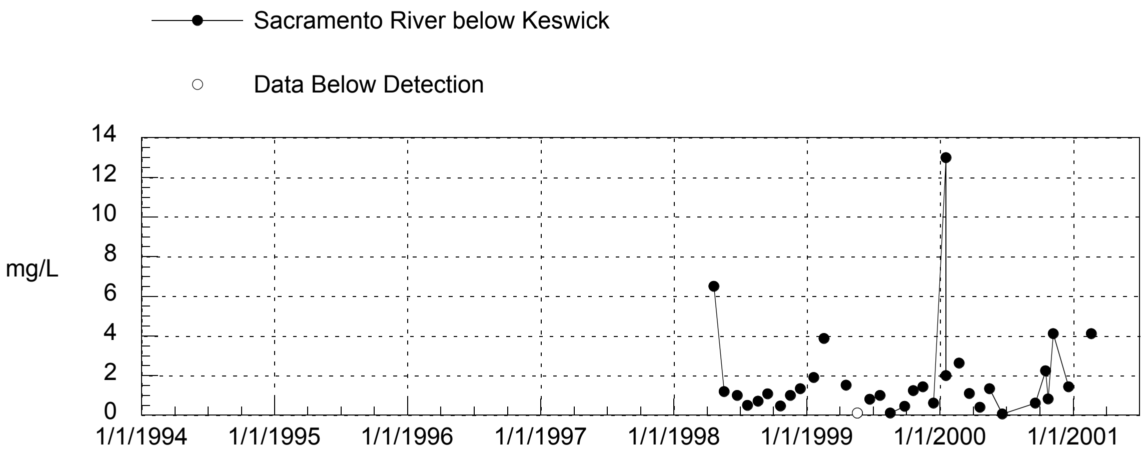

Arcade Creek at Norwood Ave.
Data Below Detection
mg/L
as $CaCO_3$
140
120
100
80
60
40
20
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

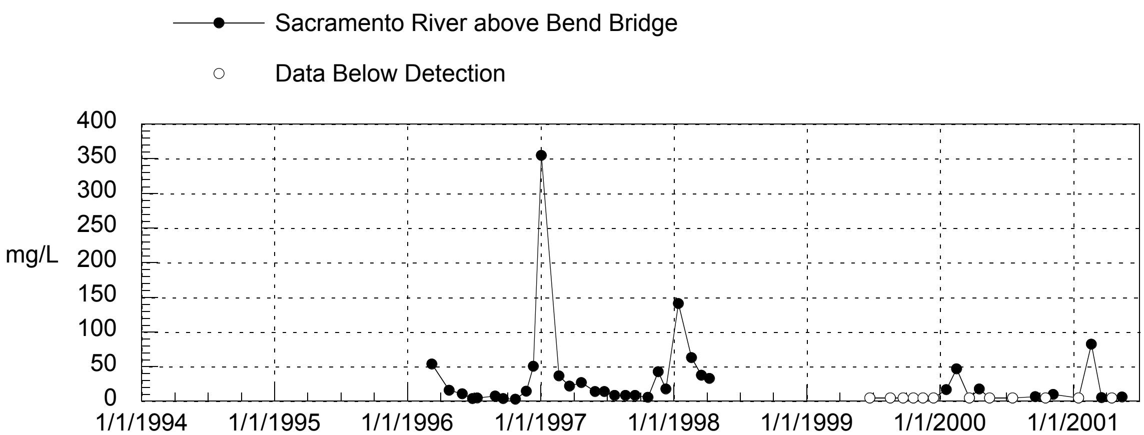

American River at Discovery Park
Data Below Detection
mg/L as $CaCO_3$
0
20
40
60
80
100
120
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

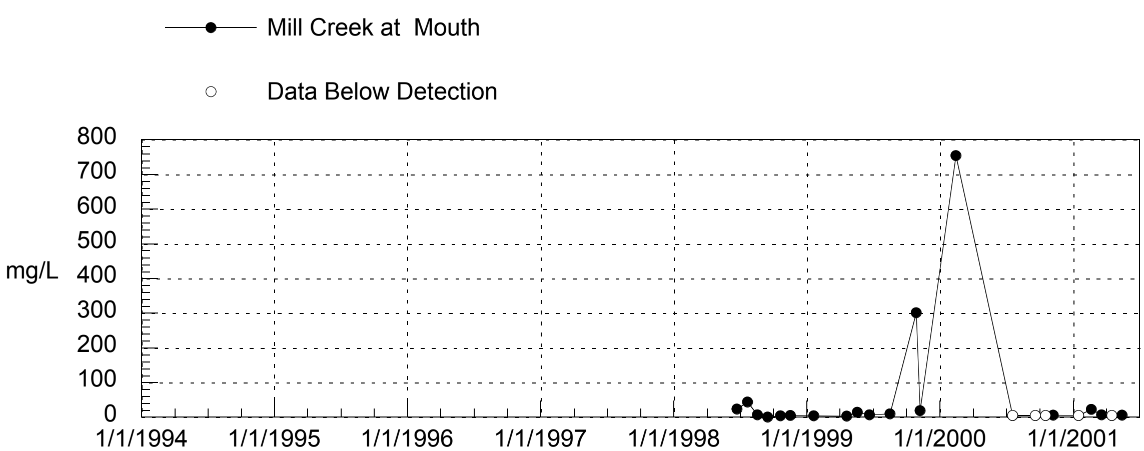

Sacramento River at Freeport
Data Below Detection
mg/L as $CaCO_3$
0
20
40
60
80
100
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001


Sacramento River at River Mile 44
Data Below Detection
mg/L as $CaCO_3$
20
30
40
50
60
70
80
90
100
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001

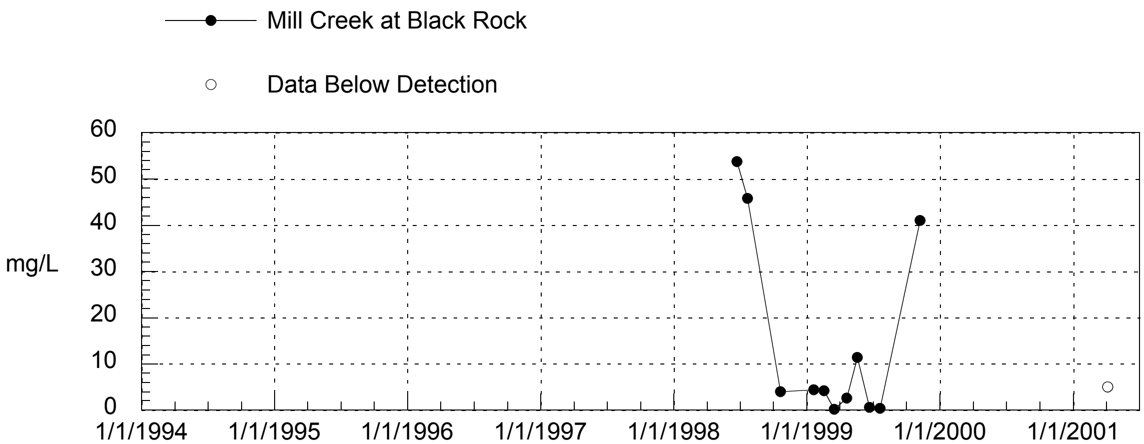
TOTAL SUSPENDED SOLIDS CONCENTRATIONS IN WATER

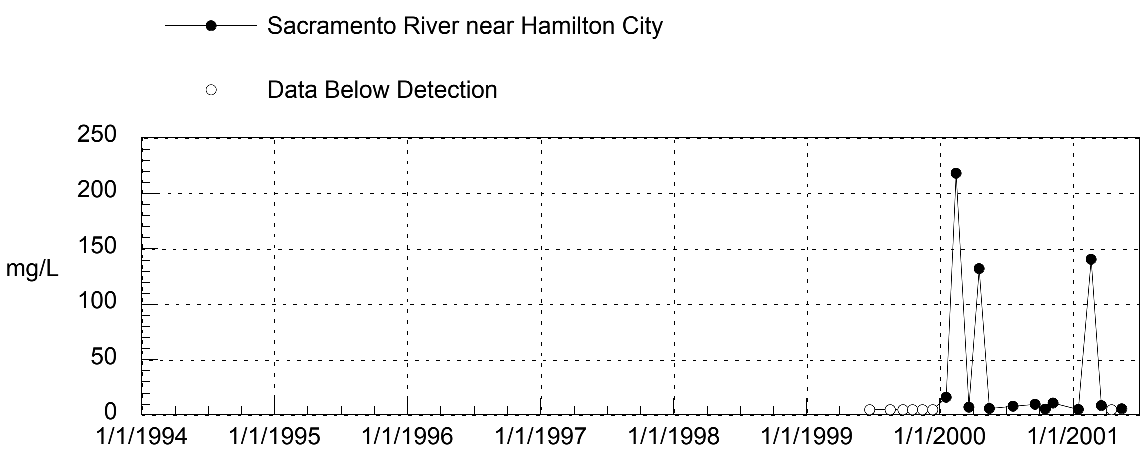


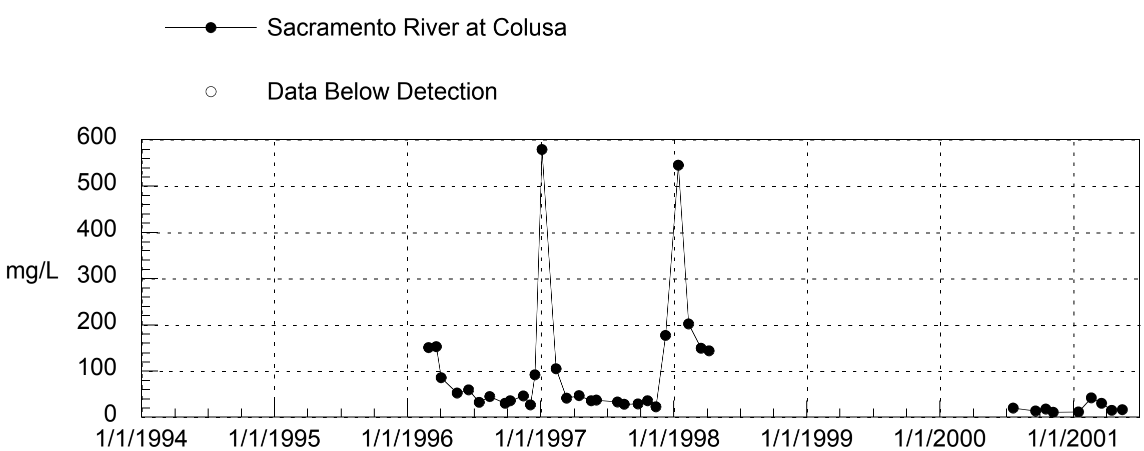




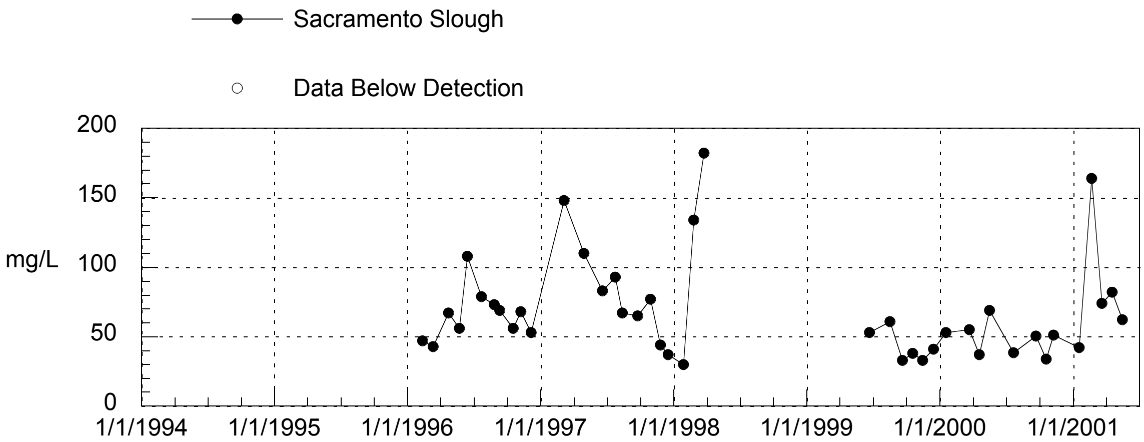
TOTAL SUSPENDED SOLIDS CONCENTRATIONS IN WATER

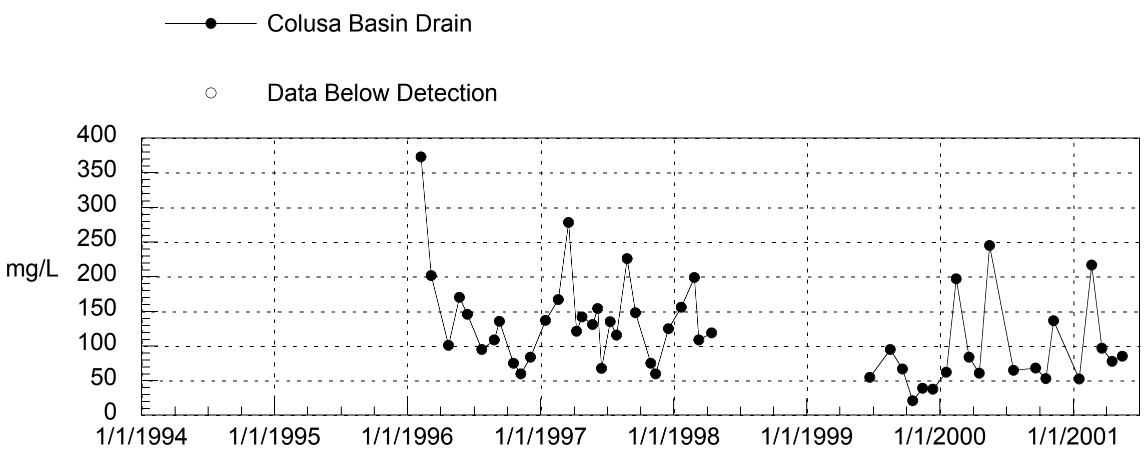


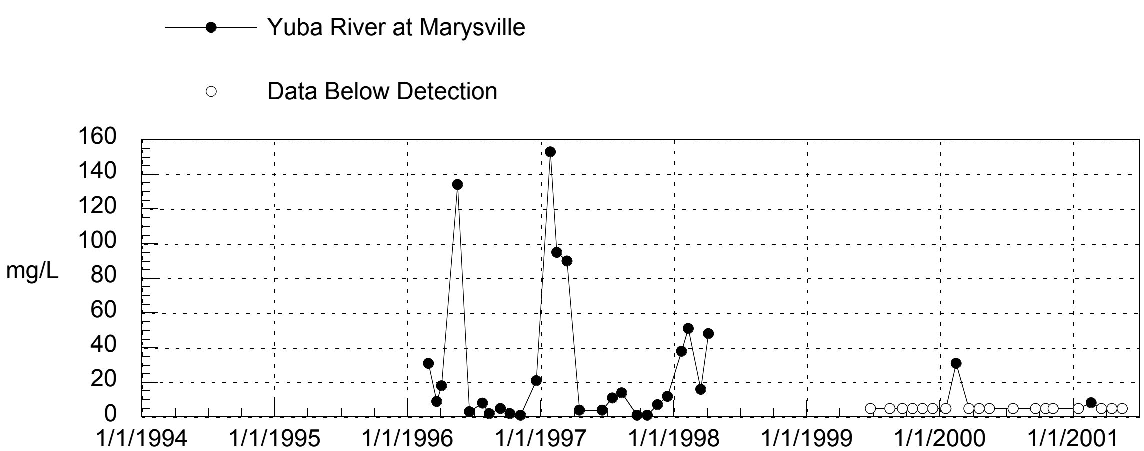




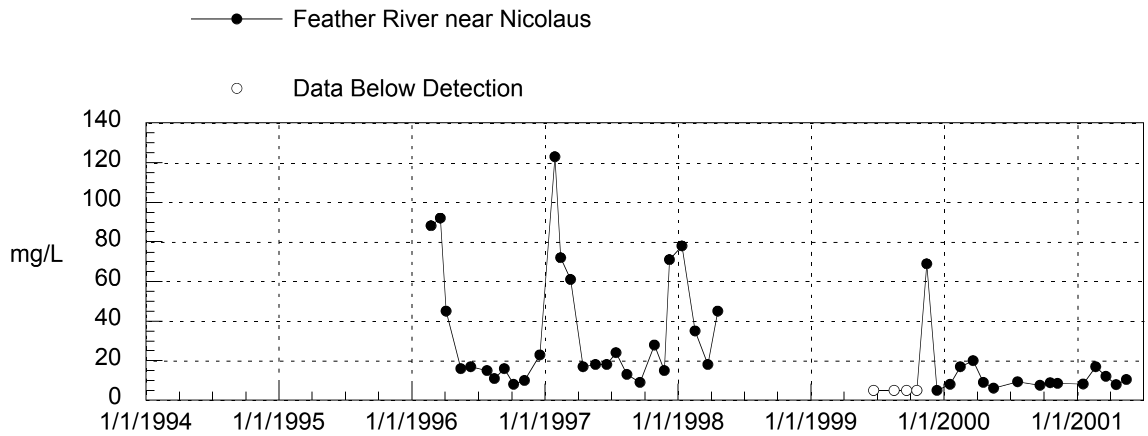
TOTAL SUSPENDED SOLIDS CONCENTRATIONS IN WATER

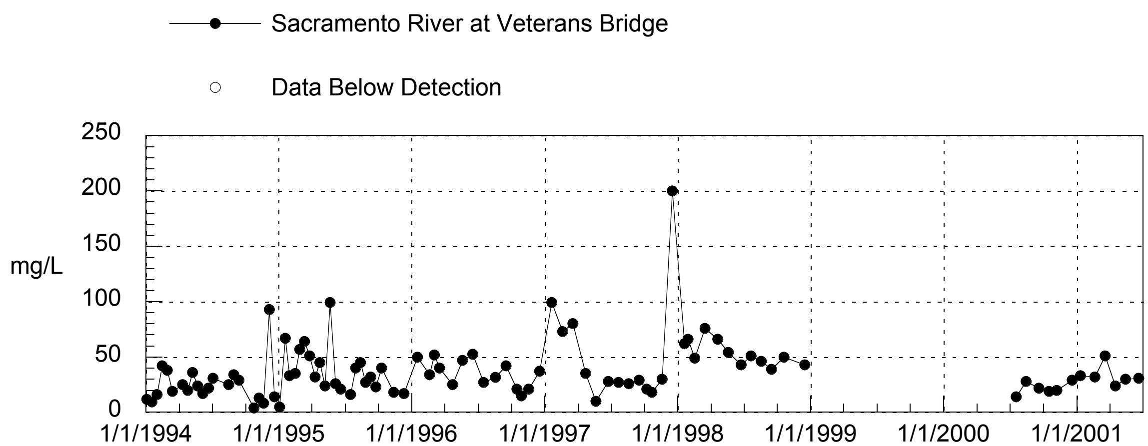


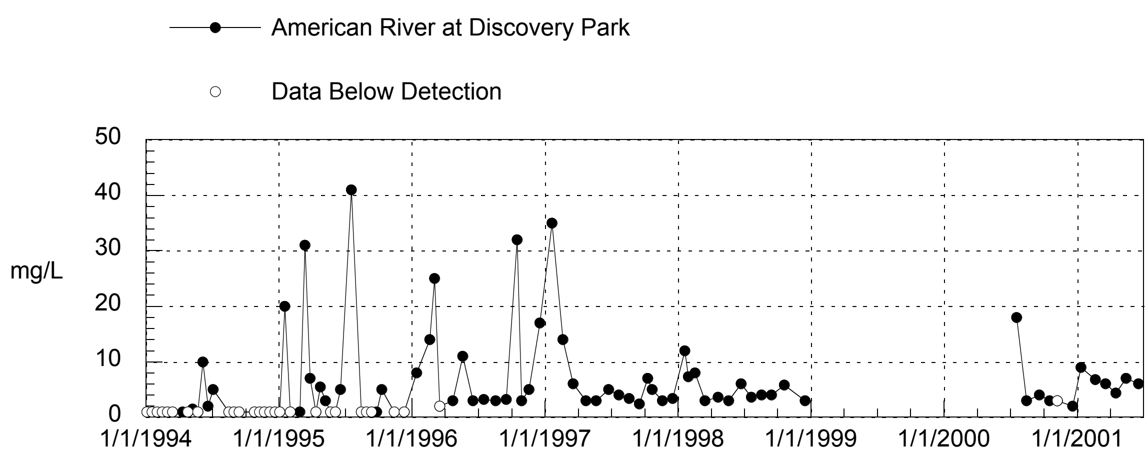




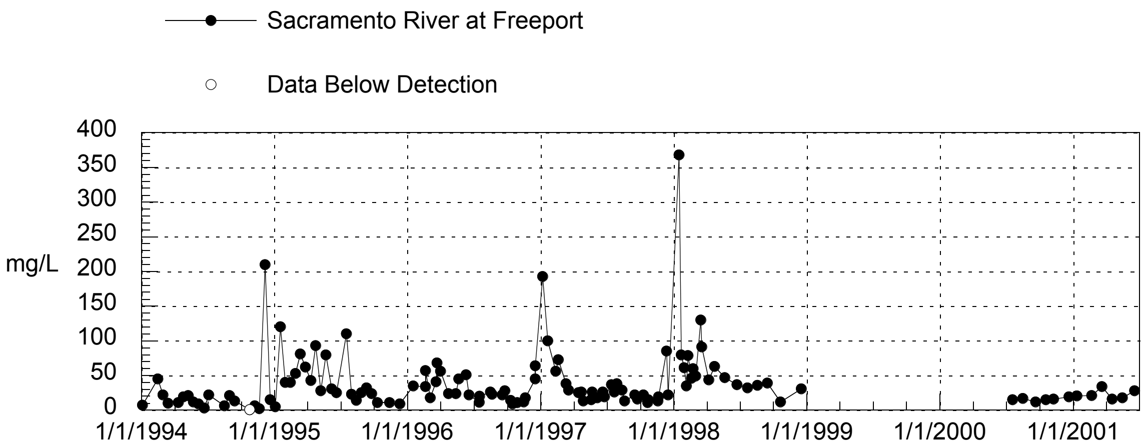
TOTAL SUSPENDED SOLIDS CONCENTRATIONS IN WATER

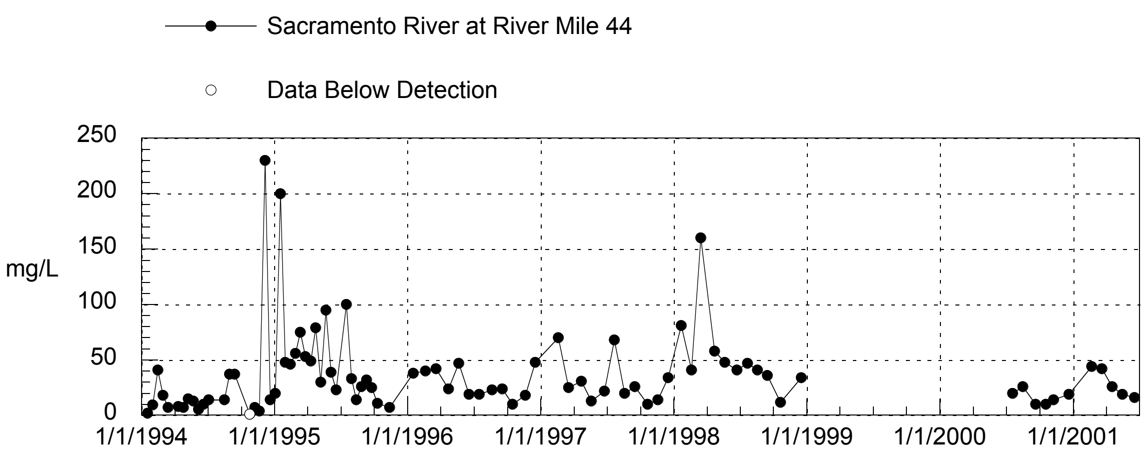


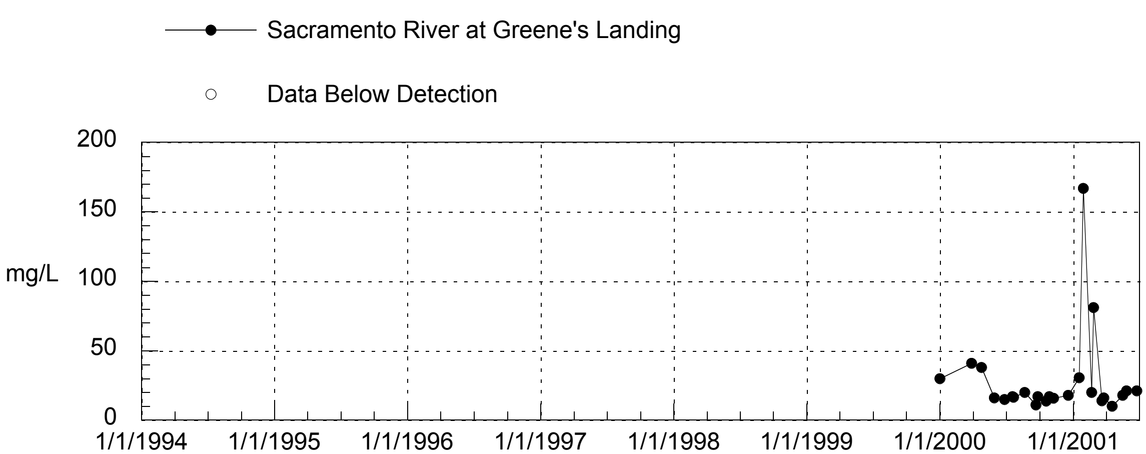




TOTAL SUSPENDED SOLIDS CONCENTRATIONS IN WATER







APPENDIX C

Bioassessment Data

Table 3. Dominant macroinvertebrate taxa (and their percent contribution) by reach from samples collected from sites within the Sacramento River watershed in Fall 2000.

	Dominant Taxon				
	1	2	3	4	5
STONY CREEK					
MFSC-MC	Orthocladinae (12)	*Rhithrogena* (12)	*Hydropsyche* (12)	*Baetis* (11)	*Serratella* (10)
SC-306	*Cheumatopsyche* (15)	*Tricorythodes* (11)	*Marilia* (11)	*Rhithrogena* (10)	*Psephenus* (8)
SC-401	Tanytarsini (26)	Orthocladiinae (8)	*Baetis* (7)	Tricorythodes (7)	*Ostracoda* (6)
SC-ASR	*Simulium* (16)	*Tanytarsini (15)*	*Tricorythodes (15)*	*Fallceon quilleri*	*Planaridae* (9)
SC-R	*Hydropsyche* (16)	Lymnaeiidae (9)	Planariidae (8)	*Microcylloepus* (6)	*Zaitzevia* (5)
SC-200A	*Hydropsyche* (45)	*Lymnaeidae* (8)	*Fossaria (8)*	*Optioservus* (7)	Orthocladinae (6)
SC-OR	*Hydropsyche* (39)	Planariidae (14)	*Baetis* (13)	Lymnaeidae (8)	Orthocladinae/ *Petrophila* (5/5)
COW CREEK					
SCC-PW	*Epeorus* (25)	*Lepidostoma* (17)	Chironomini (6)	*Micrasema* (6)	Tanytarsini (5)
OCC-WR	*Serratella* (19)	*Optioservus* (11)	*Baetis* (9)	*Epeorus* (9)	*Hydropsyche/ Lepidostoma* (9/9)
LCC-OR	*Baetis* (28)	Planariidae (15)	Philopotamidae (7)	Orthocladiinae (5)	*Hydropsyche* (4)
CC-CM	Orthocladinae (30)	*Baetis* (16)	*Prostoma* (13)	*Ophiogomphus* (5)	*Hydropsyche* (5)
CR-MPR	Orthocladinae (20)	*Baetis* (13)	*Tricorythodes* (13)	*Chimarra* (11)	Chironomini (7)
BATTLE CREEK					
NFBTC-44	*Optioservus* (18)	*Hydropsyche* (14)	*Heterlimnius* (12)	*Epeorus* (11)	*Baetis* (6)
NFBTC-WH	Orthocladiinae (19)	*Baetis* (11)	*Rhithrogena* (8)	*Hydropsyche* (7)	*Optioservus* (4)
NFBTC-MR	*Serratella* (23)	*Optioservus* (12)	Orthocladiinae (9)	*Baetis* (7)	*Hydropsyche* (6)

Table 3 (continued). Dominant macroinvertebrate taxa (and their percent contribution) by reach from samples collected from sites within the Sacramento River watershed in Fall 1999.

	Dominant Taxon				
	1	**2**	**3**	**4**	**5**
<u>BATTLE CREEK</u>					
BTC-FS	*Hydropsyche* (24)	*Cheumatopsyche* (12)	*Serratella* (8)	*Tricorythodes* (8)	*Baetis* (6)
BTC-GR	*Baetis* (13)	Planariidae (13)	Orthocladinae (11)	*Cheumatopsyche* (8)	*Chimarra*(8)
DEER CREEK					
DC-PPC	*Epeorus* (16)	Enchytraeidae (15)	*Baetis* (11)	*Serratella* (8)	*Hydropsyche* (8)
DC-PW	Orthocladiinae (22)	Naididae (17)	*Optioservus* (9)	*Serratella* (7)	*Isoperla* (5)
DC-FS	*Hydropsyche* (31)	*Baetis* (13)	Orthocladiinae (11)	*Cheumatopsyche* (11)	*Simulium* (3)
DC-M	*Simulium* (27)	*Baetis* (22)	Tanytarsini (15)	*Hydropsyche* (12)	Orthocladiina e (3)
BIG CHICO CREEK					
BCC-H32	*Hydropsyche* (13)	*Epeorus* (12)	*Orthocladiinae* (8)	*Serratella* (8)	*Ironodes* (8)
BCC-FR	Orthocladiinae (8)	*Baetis* (22)	*Optioservus* (9)	*Zaitzevia* (5)	*Sweltsa* (4)
BCC-BP	Lymnaeidae (25)	*Fossaria* (19)	*Tricorythodes* (10)	*Hydropsyche* (10)	Orthocladiina e(6)
BCC-RA	Planariidae (22)	*Optioservus* (20)	*Cheumatopsyche* (19))	Naididae (6)	Orthocladinae (5)
<u>BUTTE CREEK</u>					
BC-CHC	*Rhithrogena (19)*	*Baetis* (11)	*Heterlimnius* (8)	*Enchytraeidae* (8)	*Cinygmula/ Sweltsa* (6/6)
BC-DMR	*Baetis* (14)	*Epeorus* (13)	*Orthocladiinae* (8)	*Rhithrogena* (5)	*Hydropsyche* (5)

Table 3 (continued). Dominant macroinvertebrate taxa (and their percent contribution) by reach from samples collected from sites within the Sacramento River watershed in Fall 1999.

	Dominant Taxon				
	1	**2**	**3**	**4**	**5**
BUTTE CREEK					
BC-RR	*Serratella* (27)	*Baetis* (14)	*Hydropsyche* (8)	*Cheumatopsyche* (7)	Naididae (6)
BC-HR	*Serratella* (22)	*Baetis* (12)	*Cheumatopsyche* (10)	*Optioservus* (9)	*Hydropsyche* (9)
LBC-S	*Hydropsyche* (13)	*Heterlimnius* (10)	*Orthocladiinae* (8)	*Baetis* (7)	*Physa/Physella* (7)
LBC-HCR	Orthocladiinae (9)	*Ironodes* (9)	*Epeorus* (8)	*Hydropsyche* (7)	*Paraleptophlebia* (6)
NON-WADABLE SITES					
YR-M	*Hydropsyche* (19)	*Gammarus* (12)	*Baetis* (11)	*Serratella* (10)	Orthocladiinae (8)
FR-EN	Tanytarsini (26)	Orthocladiinae (15)	*Hydroptila* (11)	*Hydropsyche* (9)	Hygrobatidae/ Lebertidae (8/8)
SR-HAM	Orthocladiinae (35)	Naididae (17)	*Baetis* (12)	*Acentrella* (8)	*Hydropsyche* (7)
SR-SSP	Orthocladiinae (30)	Tanytarsini (17)	Naididae (17)	Enchytraeidae (10)	*Acentrella* (7)
AC-DPP	Chironomini (46)	Tanytarsini (16)	Orthocladiinae (9)	Oligochaeta (9)	*Tubificidae* (9)
AR-HB	*Tricorythodes* (16)	*Baetis* (15)	*Hydropsyche* (13)	Planariidae (13)	*Naididae* (11)

Table 4. Bioassessment metrics calculated from macroinvertebrate samples collected from riffles in the Sacramento River watershed between September 26 and November 7, 2000.

Stony Creek Watershed

	Middle Fork Stony Creek			**Stony Ck**			**Stony Ck**			**Stony Ck**			**Stony Ck**			**Stony Ck**			**Stony Ck**		
	Mill Creek			Road 306			Road 401			Alder Springs Rd.			Rancheria			Road 200A			Olive Road		
	MFSC-MC			SC-306			SC-401A			SC-ASR			SC-R			SC-200A			SC-OR		
Transect Number	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
ABL Laboratory Number	5161	5162	5163	5164	5165	5166	5167	5168	5169	5170	5171	5172	5173	5174	5175	5176	5177	5178	5179	5180	5181
Taxonomic Richness	30	38	28	29	31	30	34	30	27	28	27	21	34	33	43	24	24	29	25	18	20
Cumulative Taxa																					
Percent Dominant Taxon	26	17	20	17	22	20	12	28	38	26	30	42	14	17	17	46	28	60	41	40	36
Ephemeroptera Taxa	7	6	6	5	6	5	5	3	3	4	4	3	3	3	4	3	3	4	4	2	5
Plecoptera Taxa	4	4	5	3	3	1	0	0	0	1	0	1	0	1	2	0	0	0	0	0	0
Trichoptera Taxa	6	6	3	4	5	7	7	10	8	4	0	2	5	4	7	4	3	4	4	2	2
EPT Taxa	17	16	14	12	14	13	12	13	11	9	4	6	8	8	13	7	6	8	8	4	7
Cumulative EPT Taxa																					
EPT Index (%)	63	76	76	63	62	61	43	22	28	54	25	29	31	30	30	63	32	66	61	67	54
Sensitive EPT Index (%)	34	48	43	30	19	20	7	3	3	3	0	1	1	1	3	1	2	0	0	0	5
Shannon Diversity	2.6	2.9	2.6	2.7	2.7	2.7	3.0	2.4	2.4	2.5	2.5	2.1	3.0	3.0	3.1	2.1	2.3	1.8	2.1	1.9	2.1
Tolerance Value	3.5	2.9	3.3	3.3	3.7	3.7	4.5	5.7	5.1	4.5	4.9	5.2	4.5	4.7	4.7	4.6	4.9	4.4	4.6	4.6	4.4
Percent Intolerant Taxa (0-2)	34	49	43	30	21	21	11	2	4	3	7	1	5	9	8	0	1	0	0	0	5
Percent Tolerant Taxa (8-10)	0	4	10	0	2	1	1	18	0	2	2	2	11	7	7	4	4	1	4	3	3
Percent Collectors	53	32	51	32	39	19	40	54	28	56	41	38	26	34	21	22	16	8	23	35	17
Percent Filterers	14	19	8	20	17	31	32	31	54	21	33	54	26	25	27	47	29	62	45	44	38
Percent Grazers	15	29	25	27	21	27	14	7	11	5	3	1	31	33	29	24	45	24	15	10	27
Percent Predators	15	19	14	10	14	11	11	7	6	16	23	7	16	7	23	6	8	5	17	11	17
Percent Shredders	3	1	2	11	9	12	3	1	1	1	0	0	1	1	1	0	2	1	0	0	0
Abundance (#/ sample)	4877	1884	1875	3548	2879	3619	5215	4496	6479	4045	2419	4740	1572	2420	3474	3256	2887	1591	1927	3146	1961

Table 4. Bioassessment metrics calculated from macroinvertebrate samples collected from riffles in the Sacramento River watershed between September 26 and November 7, 2000.

	Cow Creek Watershed															Battle Creek Watershed								
	South Cow Ck			**Old Cow Ck**			**Little Cow Ck**			**Cow Creek**			**Cow Creek**			**NF Battle Ck**			**NF Battle Ck**			**NF Battle Ck**		
	Ponderosa Way			Whitmore Road			Oak Run			Coronado Mine			Milleville Planes			Hwy 44			Wilson Hill Road			Manton Road		
	SCC-PW			OCC-WR			LCC-OR			CC-CM			CC-MP			NFBTC-H44			NFBTC-WHR			NFBTC-MR		
Transect Number	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
ABL Laboratory Number	5182	5183	5184	5185	5186	5187	5188	5189	5190	5191	5192	5193	5194	5195	5196	5197	5198	5199	5200	5201	5202	5203	5204	5205
Taxonomic Richness	35	34	39	42	31	41	20	28	26	24	27	27	34	34	31	40	44	31	39	46	41	38	38	30
Cumulative Taxa																								
Percent Dominant Taxon	26	23	29	16	24	18	31	28	37	25	27	39	19	23	19	20	16	19	20	26	15	16	16	38
Ephemeroptera Taxa	6	7	7	7	6	9	4	4	3	2	2	2	4	4	5	8	6	6	8	8	9	6	7	6
Plecoptera Taxa	4	8	5	5	4	4	0	0	0	3	4	1	1	0	1	4	6	2	5	7	6	5	4	4
Trichoptera Taxa	6	6	7	8	6	9	5	4	5	3	5	4	7	6	6	6	6	5	6	6	6	4	7	2
EPT Taxa	16	21	19	20	16	22	9	8	8	8	11	7	12	10	12	18	19	13	19	21	21	15	18	12
Cumulative EPT Taxa																								
EPT Index (%)	72	77	79	68	74	76	50	43	49	36	38	19	53	45	49	46	43	43	57	48	68	55	51	54
Sensitive EPT Index (%)	62	61	56	45	57	54	7	1	3	5	3	2	3	1	1	21	21	14	32	26	40	37	33	47
Shannon Diversity	2.5	2.7	2.7	2.9	2.6	2.8	2.0	2.5	2.0	2.3	2.5	2.3	2.7	2.7	2.6	2.8	3.0	2.6	3.0	3.0	3.0	2.9	2.9	2.2
Tolerance Value	2.4	2.3	2.3	2.9	2.6	2.6	4.7	4.8	4.7	3.7	4.1	4.5	5.0	4.9	5.0	3.6	3.7	3.9	3.6	4.0	3.1	3.8	3.7	3.3
Percent Intolerant Taxa (0-2)	63	61	56	48	58	55	8	0	3	10	8	8	2	3	1	22	21	15	32	26	40	38	35	47
Percent Tolerant Taxa (8-10)	1	0	1	1	0	1	1	6	1	1	1	0	9	6	7	5	6	4	1	7	3	10	7	2
Percent Collectors	21	23	22	38	35	38	27	59	47	75	65	69	68	64	65	32	35	31	48	58	36	43	37	58
Percent Filterers	11	15	15	12	15	13	52	23	22	6	15	8	21	23	19	17	16	24	18	7	14	19	23	5
Percent Grazers	33	40	39	32	29	30	1	4	4	4	6	7	5	5	7	40	36	36	15	15	28	19	23	25
Percent Predators	8	7	10	14	8	10	14	14	25	14	13	17	6	8	8	10	12	7	11	15	18	17	17	12
Percent Shredders	27	14	13	4	13	9	7	0	2	1	0	0	0	0	1	3	1	1	9	5	4	1	1	0
Abundance (#/ sample)	3463	2253	1984	1317	3516	3459	3543	3781	3383	751	673	829	4632	5133	7096	5041	7723	4894	604	2497	1879	3003	3464	6336

Table 4. Bioassessment metrics calculated from macroinvertebrate samples collected from riffles in the Sacramento River watershed between September 26 and November 7, 2000.

	Battle Creek Watershed						**Deer Creek Watershed**											
	Battle Ck			**Battle Ck**			**Deer Creek**			**Deer Creek**			**Deer Creek**			**Deer Creek**		
	Fish Screen			Grover Road			Potato Patch Campground			Ponderosa Way			Fish Screen			Monastery		
	BTC-FS			BTC-GR			DC-PPC			DC-PW			DC-FS			DC-M		
Transect Number	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
ABL Laboratory Number	5206	5207	5208	5209	5210	5211	5212	5213	5214	5215	5216	5217	5218	5219	5220	5221	5222	5223
Taxonomic Richness	28	36	26	35	32	33	38	32	32	43	39	44	31	28	31	23	31	16
Cumulative Taxa																		
Percent Dominant Taxon	24	21	38	19	16	15	24	37	16	21	29	27	28	33	33	38	23	32
Ephemeroptera Taxa	6	4	3	7	6	4	9	8	9	9	7	8	6	4	7	4	4	3
Plecoptera Taxa	1	2	2	2	3	2	6	5	5	4	4	6	3	1	3	0	0	0
Trichoptera Taxa	8	6	6	8	6	7	7	6	1	8	6	9	5	7	6	3	4	2
EPT Taxa	15	12	11	17	15	13	22	19	15	21	17	23	14	12	16	7	8	5
Cumulative EPT Taxa																		
EPT Index (%)	72	61	78	62	49	39	70	45	74	38	19	30	58	80	72	40	53	25
Sensitive EPT Index (%)	18	7	13	12	10	7	55	29	36	26	16	22	7	8	8	0	0	0
Shannon Diversity	2.6	2.7	2.3	2.8	2.8	2.9	2.8	2.5	2.7	3.0	2.6	2.9	2.5	2.2	2.5	1.8	2.6	1.8
Tolerance Value	4.0	4.5	4.1	4.4	4.5	4.7	2.6	5.5	3.4	4.1	5.2	4.2	4.4	4.4	4.2	5.3	4.7	5.6
Percent Intolerant Taxa (0-2)	20	8	15	10	9	4	55	29	38	28	18	24	9	9	11	0	1	0
Percent Tolerant Taxa (8-10)	0	5	1	3	5	7	1	37	4	11	30	10	3	0	1	1	3	5
Percent Collectors	34	36	29	43	43	37	35	60	44	48	65	59	35	40	40	34	33	31
Percent Filterers	48	29	55	30	29	29	12	10	19	13	3	8	44	56	49	57	47	68
Percent Grazers	4	14	8	15	7	13	39	18	22	15	15	16	7	2	6	4	17	1
Percent Predators	14	20	7	13	19	19	10	9	11	23	16	16	13	2	5	5	3	1
Percent Shredders	0	1	0	0	1	1	5	4	4	1	0	1	0	0	0	0	0	0
Abundance (#/ sample)	6072	1718	4829	1534	4124	1490	2602	1310	2253	6141	4800	2941	4465	3217	4791	2976	5538	4378

Table 4. Bioassessment metrics calculated from macroinvertebrate samples collected from riffles in the Sacramento River watershed between September 26 and November 7, 2000.

	Big Chico Creek Watershed											
	Big Chico			**Big Chico**			**Big Chico**			**Big Chico**		
	Hwy 32			Forest Ranch			Bidwell Park			Rose Ave		
	BCC-H32			BCC-FR			BCC-BP			BCC-RA		
Transect Number	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
ABL Laboratory Number	5224	5225	5226	5227	5228	5229	5230	5231	5232	5233	5234	5235
Taxonomic Richness	43	43	31	34	37	47	25	29	28	26	21	25
Cumulative Taxa												
Percent Dominant Taxon	19	11	20	29	20	32	25	37	20	21	35	28
Ephemeroptera Taxa	7	10	9	7	6	8	2	4	3	1	1	1
Plecoptera Taxa	6	6	6	3	4	4	0	0	1	0	0	1
Trichoptera Taxa	10	8	1	4	3	8	4	8	4	8	1	2
EPT Taxa	24	24	16	14	13	20	6	12	8	9	2	4
Cumulative EPT Taxa												
EPT Index (%)	70	71	71	47	35	36	27	19	39	28	10	36
Sensitive EPT Index (%)	45	48	36	8	25	27	1	10	1	3	0	1
Shannon Diversity	3.0	3.2	2.9	2.4	2.9	2.9	2.4	2.2	2.6	2.4	2.1	2.2
Tolerance Value	2.9	2.8	3.2	4.7	4.0	4.1	5.3	5.2	5.1	4.4	4.8	4.5
Percent Intolerant Taxa (0-2)	45	47	37	8	26	24	1	10	1	3	0	2
Percent Tolerant Taxa (8-10)	3	0	2	1	6	6	4	5	4	7	13	1
Percent Collectors	34	36	36	64	54	54	29	12	21	21	30	13
Percent Filterers	19	14	22	15	5	2	8	6	28	30	16	33
Percent Grazers	34	29	21	16	19	21	47	72	40	24	13	30
Percent Predators	8	17	16	6	22	20	16	9	10	25	42	23
Percent Shredders	6	4	4	0	0	3	0	0	0	0	0	1
Abundance (#/ sample)	3545	3881	1429	1735	5968	1176	1675	5010	5039	1474	972	1087

Table 4. Bioassessment metrics calculated from macroinvertebrate samples collected from riffles in the Sacramento River watershed between September 26 and November 7, 2000.

Butte Creek Watershed

	Butte Creek			**Butte Creek**			**Butte Creek**			**Butte Creek**			**L. Butte Cr.**			**L. Butte Cr.**		
	Cherry Hill Camp.			Doe Mill Road			Rich Bar Road			Honey Run Bridge			Skyway			Hupp Coutolenc		
	BC-CHC			BC-DMR			BC-RBR			BC-HR			LBC-S			LBC-HCR		
Transect Number	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
ABL Laboratory Number	5236	5237	5238	5239	5240	5241	5242	5243	5244	5245	5246	5247	5248	5249	5250	5251	5252	5253
Taxonomic Richness	39	40	38	34	30	37	26	29	28	30	29	33	36	42	41	37	48	46
Cumulative Taxa																		
Percent Dominant Taxon	25	14	18	23	48	20	36	15	29	19	32	22	26	10	16	8	13	14
Ephemeroptera Taxa	8	9	8	8	6	9	6	6	7	6	8	7	5	7	8	9	8	6
Plecoptera Taxa	8	10	8	5	5	5	4	3	5	5	3	4	5	6	6	5	8	9
Trichoptera Taxa	7	8	8	7	5	7	4	4	6	4	4	5	5	4	6	6	8	8
EPT Taxa	23	27	24	20	16	21	14	13	18	15	15	16	16	17	21	21	25	24
Cumulative EPT Taxa																		
EPT Index (%)	76	74	66	71	41	56	85	64	81	71	74	70	61	46	46	70	76	56
Sensitive EPT Index (%)	59	46	44	54	18	33	52	37	46	21	43	32	28	22	26	51	40	36
Shannon Diversity	2.8	3.0	2.8	2.8	2.0	2.8	2.3	2.7	2.5	2.6	2.4	2.8	2.8	3.2	3.1	3.2	3.3	3.3
Tolerance Value	2.2	3.1	3.6	2.6	4.5	3.6	3.2	4.1	3.3	4.1	3.4	4.0	4.0	4.7	4.2	2.9	3.1	3.5
Percent Intolerant Taxa (0-2)	61	47	44	54	19	33	53	37	50	22	43	32	27	21	27	51	41	37
Percent Tolerant Taxa (8-10)	4	7	14	0	0	0	4	20	3	4	3	6	11	20	14	6	4	4
Percent Collectors	31	44	54	36	25	35	62	60	51	45	54	55	31	49	49	26	20	32
Percent Filterers	5	6	4	8	55	31	16	12	22	27	18	27	27	10	7	6	15	12
Percent Grazers	39	33	29	39	11	21	11	19	12	11	18	8	27	22	30	37	38	23
Percent Predators	20	12	9	10	6	11	11	10	14	17	10	9	10	13	12	17	18	22
Percent Shredders	4	5	4	7	3	2	0	0	0	0	0	0	5	6	3	14	9	10
Abundance (#/ sample)	1922	1619	852	1308	1005	3065	2562	4892	2591	3673	6087	2415	990	670	1005	1484	2342	1602

Table 4. Bioassessment metrics calculated from macroinvertebrate samples collected from riffles in the Sacramento River watershed between September 26 and November 7, 2000.

	Deepwater Sites																	
	Yuba River			**Feather R.**			**Sacramento R.**			**Sacramento R.**			**Arcade Creek**			**American River**		
	at Marysville			East Nicholas			Hamilton			Sacramento State Park			Del Paso Park			Harrington Bar		
	YR-M			FR-EN			SR-HAM			SR-SSP			AC-DPP			AR-HB		
Transect Number	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
ABL Laboratory Number	5254	5255	5256	5389	5390	5391	5386	5387	5388	5260	5261	5262	5257	5258	5259	5263	5384	5385
Taxonomic Richness	21	25	23	21	21	19	16	20	11	19	16	17	16	9	9	21	15	28
Cumulative Taxa																		
Percent Dominant Taxon	21	28	30	24	28	26	44	55	33	33	50	37	50	59	33	29	19	17
Ephemeroptera Taxa	5	6	5	5	5	5	1	3	3	5	2	3	1	0	0	5	3	5
Plecoptera Taxa	2	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera Taxa	3	3	3	2	2	2	2	2	1	3	2	2	1	0	1	1	1	2
EPT Taxa	10	11	10	7	8	7	3	5	4	8	4	5	2	0	1	6	4	7
Cumulative EPT Taxa																		
EPT Index (%)	72	33	66	38	29	35	3	4	77	19	25	6	1	0	0	49	44	44
Sensitive EPT Index (%)	22	13	15	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1
Shannon Diversity	2.5	2.4	2.4	2.4	2.3	2.1	1.6	1.6	1.8	2.0	1.7	1.8	1.5	1.1	1.7	2.2	2.2	2.6
Tolerance Value	3.8	4.3	4.0	4.8	4.8	5.4	6.2	5.9	4.7	5.5	5.2	7.7	6.6	6.5	6.8	5.7	5.4	5.4
Percent Intolerant Taxa (0-2)	21	12	15	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1
Percent Tolerant Taxa (8-10)	7	3	5	1	1	0	32	24	1	8	6	71	19	26	35	26	22	20
Percent Collectors	57	63	56	34	38	36	78	82	65	54	78	88	73	89	82	73	46	60
Percent Filterers	23	20	34	38	38	32	14	5	32	36	14	7	24	9	18	16	33	23
Percent Grazers	11	4	3	10	13	17	1	3	1	4	3	2	0	0	1	0	1	0
Percent Predators	10	13	7	18	11	15	6	7	2	6	2	4	3	1	0	11	20	16
Percent Shredders	0	1	0	0	0	0	1	3	0	0	3	0	0	0	0	0	0	1
Abundance (#/ sample)	1018	1565	2455	1112	1307	718	271	436	1207	1251	232	295	209	299	413	432	715	614

Table 5. Means and coefficients of variation calculated for bioassessment samples collected from macroinvertebrate samples collected from riffles in the Sacramento River watershed between September 26 and November 7, 2000.

Stony Creek Watershed

	Middle Fork Stony Creek		**Stony Ck**		**Stony Ck**		**Stony Ck**		**Stony Ck**		**Stony Ck**		**Stony Ck**	
	Mill Creek		Road 306		Road 401		Alder Springs Rd.		Rancheria		Road 200A		Olive Road	
	MFSC-MC		SC-306		SC-401A		SC-ASR		SC-R		SC-200A		SC-OR	
	Mean	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
Taxonomic Richness	32	17	30	3	30	12	25	15	37	15	26	11	21	17
Cumulative Taxa	52		47		50		43		54		39		30	
Percent Dominant Taxon	21	22	19	14	26	49	33	26	16	12	45	36	39	8
Ephemeroptera Taxa	6	9	5	11	4	31	4	16	3	17	3	17	4	42
Plecoptera Taxa	4	13	2	49	0	-	1	87	1	100	0	-	0	-
Trichoptera Taxa	5	35	5	29	8	18	2	100	5	29	4	16	3	43
EPT Taxa	16	10	13	8	12	8	6	40	10	30	7	14	6	33
Cumulative EPT Taxa	27		21		22		12		16		11		11	
EPT Index (%)	72	11	62	2	31	34	36	44	30	2	53	36	61	11
Sensitive EPT Index (%)	42	16	23	26	4	56	1	124	2	59	1	84	2	173
Shannon Diversity	2.7	6	2.7	1	2.6	13	2.4	10	3.0	2	2.0	13	2.0	4
Tolerance Value	3.2	10	3.6	7	5.1	13	4.9	7	4.6	2	4.7	5	4.5	2
Percent Intolerant Taxa (0-2)	42	18	24	23	6	78	3	93	7	30	0	173	2	173
Percent Tolerant Taxa (8-10)	4	105	1	61	6	159	2	9	9	30	3	57	3	23
Percent Collectors	45	26	30	34	41	32	45	22	27	24	16	45	25	37
Percent Filterers	13	42	23	33	39	34	36	46	26	4	46	36	42	9
Percent Grazers	23	33	25	13	10	35	3	58	31	7	31	40	17	52
Percent Predators	16	15	12	18	8	31	15	52	15	49	6	20	15	22
Percent Shredders	2	38	11	17	2	92	0	173	1	27	1	85	0	173
Abundance (#/ sample)	2879	60	3349	12	5397	19	3735	32	2489	38	2578	34	2345	30

Table 5. Means and coefficients of variation calculated for bioassessment samples collected from macroinvertebrate samples collected from riffles in the Sacramento River watershed between September 26 and November 7, 2000.

	Cow Creek Watershed										**Battle Creek Watershed**									
	South Cow Ck		**Old Cow Ck**		**Little Cow Ck**		**Cow Creek**		**Cow Creek**		**NF Battle Ck**		**NF Battle Ck**		**NF Battle Ck**		**Battle Ck**		**Battle Ck**	
	Ponderosa Way		Whitmore Road		Oak Run		Coronado Mine		Milleville Planes		Hwy 44		Wilson Hill Road		Manton Road		Fish Screen		Grover Road	
	SCC-PW		OCC-WR		LCC-OR		CC-CM		CC-MP		NFBTC-H44		NFBTC-WHR		NFBTC-MR		BTC-FS		BTC-GR	
	Mean	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
Taxonomic Richness	36	7	38	16	25	17	26	7	33	5	38	17	42	9	35	13	30	18	33	5
Cumulative Taxa	60		63		42		40		48		57		62		51		46		52	
Percent Dominant Taxon	26	11	19	20	32	14	30	25	21	12	18	13	20	26	23	55	28	33	16	12
Ephemeroptera Taxa	7	9	7	21	4	16	2	0	4	13	7	17	8	7	6	9	4	35	6	27
Plecoptera Taxa	6	37	4	13	0	-	3	57	1	87	4	50	6	17	4	13	2	35	2	25
Trichoptera Taxa	6	9	8	20	5	12	4	25	6	9	6	10	6	0	4	58	7	17	7	14
EPT Taxa	19	13	19	16	8	7	9	24	11	10	17	19	20	6	15	20	13	16	15	13
Cumulative EPT Taxa	31		29		11		15		16		25		30		22		18		22	
EPT Index (%)	76	5	72	6	47	8	31	33	49	8	44	4	58	18	53	4	70	13	50	23
Sensitive EPT Index (%)	60	5	52	12	3	94	3	46	2	72	19	22	33	21	39	19	13	44	10	27
Shannon Diversity	2.6	3	2.8	6	2.2	11	2.4	5	2.6	3	2.8	7	3.0	1	2.7	15	2.5	8	2.8	2
Tolerance Value	2.3	0	2.7	7	4.7	1	4.1	9	5.0	1	3.7	5	3.6	13	3.6	7	4.2	6	4.5	3
Percent Intolerant Taxa (0-2)	60	5	54	10	4	105	8	15	2	43	19	18	33	22	40	16	14	41	8	40
Percent Tolerant Taxa (8-10)	1	91	1	59	2	115	1	93	7	25	5	19	4	79	7	60	2	115	5	36
Percent Collectors	22	5	37	5	44	37	70	8	66	3	33	7	47	24	46	23	33	10	41	8
Percent Filterers	14	16	13	15	32	53	10	49	21	8	19	25	13	45	16	59	44	31	29	1
Percent Grazers	37	10	30	5	3	67	6	27	5	19	37	5	19	40	22	13	9	57	11	37
Percent Predators	8	18	11	29	18	37	15	14	7	15	10	26	15	25	15	20	14	46	17	23
Percent Shredders	18	42	9	49	3	119	0	173	0	110	2	49	6	38	1	56	0	173	1	57
Abundance (#/ sample)	2567	31	2764	45	3569	6	751	10	5621	23	5886	27	1660	58	4268	42	4207	53	2383	63

Table 5. Means and coefficients of variation calculated for bioassessment samples collected from macroinvertebrate samples collected from riffles in the Sacramento River watershed between September 26 and November 7, 2000.

	Deer Creek Watershed								Big Chico Creek Watershed							
	Deer Creek		**Deer Creek**		**Deer Creek**		**Deer Creek**		**Big Chico**		**Big Chico**		**Big Chico**		**Big Chico**	
	Potato Patch Campground		Ponderosa Way		Fish Screen		Monastery		Hwy 32		Forest Ranch		Bidwell Park		Rose Ave	
	DC-PPC		DC-PW		DC-FS		DC-M		BCC-H32		BCC-FR		BCC-BP		BCC-RA	
	Mean	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
Taxonomic Richness	34	10	42	6	30	6	23	32	39	18	39	17	27	8	24	11
Cumulative Taxa	52		58		46		36		59		63		45		41	
Percent Dominant Taxon	26	40	26	16	31	9	31	24	17	31	27	23	27	31	28	25
Ephemeroptera Taxa	9	7	8	13	6	27	4	16	9	18	7	14	3	33	1	0
Plecoptera Taxa	5	11	5	25	2	49	0	-	6	0	4	16	0	173	0	173
Trichoptera Taxa	5	69	8	20	6	17	3	33	6	75	5	53	5	43	4	103
EPT Taxa	19	19	20	15	14	14	7	23	21	22	16	24	9	35	5	72
Cumulative EPT Taxa	26		30		19		8		31		25		17		10	
EPT Index (%)	63	25	29	32	70	16	39	36	71	0	39	16	28	36	25	53
Sensitive EPT Index (%)	40	34	21	22	8	8	0	173	43	14	20	54	4	142	1	128
Shannon Diversity	2.7	6	2.8	7	2.4	8	2.0	22	3.0	6	2.8	10	2.4	7	2.3	7
Tolerance Value	3.9	39	4.5	13	4.3	2	5.2	9	3.0	8	4.3	9	5.2	1	4.5	5
Percent Intolerant Taxa (0-2)	41	33	23	22	9	14	0	173	43	13	19	51	4	128	2	78
Percent Tolerant Taxa (8-10)	14	140	17	65	2	84	3	64	2	92	5	62	4	11	7	82
Percent Collectors	46	27	57	16	38	6	32	5	35	4	57	10	21	40	21	40
Percent Filterers	13	35	8	60	49	12	57	18	18	22	7	88	14	87	26	36
Percent Grazers	26	44	15	5	5	48	7	118	28	23	19	15	53	32	22	39
Percent Predators	10	12	18	23	7	82	3	77	14	34	16	56	12	33	30	34
Percent Shredders	4	11	1	58	0	87	0	-	5	17	1	147	0	87	0	101
Abundance (#/ sample)	2055	33	4627	35	4158	20	4297	30	2952	45	2960	89	3908	49	1178	22

Table 5. Means and coefficients of variation calculated for bioassessment samples collected from macroinvertebrate samples collected from riffles in the Sacramento River watershed between September 26 and November 7, 2000.

Butte Creek Watershed

	Butte Creek		Butte Creek		Butte Creek		Butte Creek		L. Butte Cr.		L. Butte Cr.	
	Cherry Hill Camp.		Doe Mill Road		Rich Bar Road		Honey Run Bridge		Skyway		Hupp Coutolenc	
	BC-CHC		BC-DMR		BC-RBR		BC-HR		LBC-S		LBC-HCR	
	Mean	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
Taxonomic Richness	39	3	34	10	28	6	31	7	40	8	44	13
Cumulative Taxa	59		49		40		42		55		62	
Percent Dominant Taxon	19	29	30	50	27	40	24	28	17	44	12	27
Ephemeroptera Taxa	8	7	8	20	6	9	7	14	7	23	8	20
Plecoptera Taxa	9	13	5	0	4	25	4	25	6	10	7	28
Trichoptera Taxa	8	8	6	18	5	25	4	13	5	20	7	16
EPT Taxa	25	8	19	14	15	18	15	4	18	15	23	9
Cumulative EPT Taxa	39		27		20		18		26		30	
EPT Index (%)	72	7	56	26	77	14	72	2	51	17	67	15
Sensitive EPT Index (%)	50	16	35	51	45	17	32	34	25	12	42	19
Shannon Diversity	2.9	5	2.5	17	2.5	7	2.6	6	3.0	7	3.3	1
Tolerance Value	3.0	23	3.6	27	3.5	14	3.8	10	4.3	8	3.2	10
Percent Intolerant Taxa (0-2)	51	18	35	50	47	18	32	33	25	13	43	17
Percent Tolerant Taxa (8-10)	8	65	0	89	9	104	4	39	15	31	5	26
Percent Collectors	43	27	32	19	57	9	51	10	43	24	26	22
Percent Filterers	5	24	31	75	17	30	24	22	14	74	11	42
Percent Grazers	34	15	24	61	14	30	13	41	26	15	33	25
Percent Predators	14	42	9	30	11	20	12	35	12	13	19	15
Percent Shredders	4	20	4	60	0	173	0	87	4	36	11	24
Abundance (#/ sample)	1465	38	1793	62	3348	40	4058	46	888	21	1809	26

Table 5. Means and coefficients of variation calculated for bioassessment samples collected from macroinvertebrate samples collected from riffles in the Sacramento River watershed between September 26 and November 7, 2000.

Deepwater Sites

.	Yuba River		Feather R.		Sacramento R.		Sacramento R.		Arcade Creek		American R.	
	at Marysville		East Nicholas		Hamilton		Sacramento State Park		Del Paso Park		Harrington Bar	
	YR-M		FR-EN		SR-HAM		SR-SSP		AC-DPP		AR-HB	
	Mean	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
Taxonomic Richness	23	9	20	6	16	29	17	9	11	36	21	30
Cumulative Taxa	35		26		26		25		22		34	
Percent Dominant Taxon	26	19	26	7	44	25	40	23	47	28	21	31
Ephemeroptera Taxa	5	11	5	0	2	49	3	46	0	173	4	27
Plecoptera Taxa	2	0	0	173	0	-	0	-	0	-	0	-
Trichoptera Taxa	3	0	2	0	2	35	2	25	1	87	1	43
EPT Taxa	10	6	7	8	4	25	6	37	1	100	6	27
Cumulative EPT Taxa	15		8		7		8		3		8	
EPT Index (%)	57	37	34	14	28	153	17	58	1	132	46	7
Sensitive EPT Index (%)	17	30	1	32	0	173	0	173	0	-	1	85
Shannon Diversity	2.4	2	2.2	7	1.7	6	1.8	9	1.4	20	2.3	11
Tolerance Value	4.0	6	5.0	7	5.6	14	6.2	22	6.6	3	5.5	3
Percent Intolerant Taxa (0-2)	16	28	1	32	0	173	0	-	0	-	0	41
Percent Tolerant Taxa (8-10)	5	46	1	107	19	85	28	131	26	30	23	13
Percent Collectors	58	6	36	4	75	12	73	24	81	10	60	22
Percent Filterers	26	28	36	10	17	83	19	81	17	44	24	36
Percent Grazers	6	72	13	27	2	60	3	31	0	26	0	100
Percent Predators	10	28	15	23	5	55	4	49	1	102	16	30
Percent Shredders	0	173	0	-	2	103	1	173	0	-	0	173
Abundance (#/ sample)	1679	43	1046	29	638	78	593	96	307	33	587	24

Table 6. Physical habitat quality scores for sampling reaches within eight drainages within the Sacramento River watershed between September 26 and November 7, 2000. Scores for each habitat parameter range from 0 (poor) to 20 (excellent).

Habitat Parameter	STONY CREEK							COW CREEK				
	MFSC-MC	SC-306	SC-401	SC-ASR	SC-R	SC-200A	SC-OR	SCC-PW	OCC-WR	LCC-OR	CC-CM	CR-MPR
1. Instream Cover	18	14	13	14	13	13	12	17	14	14	17	17
2. Embeddedness	16	12	15	14	15	14	14	16	12	15	15	12
3. Velocity/ Depth Regimes	16	11	14	12	14	14	15	15	12	14	16	15
4. Sediment Deposition	16	13	18	13	14	14	13	16	14	15	16	12
5. Channel Flow	19	16	16	16	16	12	18	18	17	16	18	19
6. Channel Alteration	16	12	17	14	16	15	17	20	20	19	15	20
7. Riffle Frequency	17	14	17	16	16	16	16	17	17	13	15	15
8. Bank Vegetation	17	10	16	6	15	6	4	18	18	14	13	17
9. Bank Stability	17	6	16	8	13	10	6	18	18	12	15	16
10. Riparian Zone	18	16	17	16	18	20	17	20	17	18	18	17
TOTAL	**170**	**124**	**159**	**129**	**150**	**134**	**132**	**175**	**159**	**150**	**174**	**160**
Physical Condition	**Excellent**	**Good**	**Excellent**	**Good**	**Good**	**Good**	**Good**	**Excellent**	**Excellent**	**Good**	**Excellent**	**Excellent**

Table 6 (continued). Physical habitat quality scores for sampling reaches within eight watersheds within the Sacramento River watershed between September 26 and November 7, 2000. Scores for each habitat parameter range from 0 (poor) to 20 (excellent).

Habitat Parameter	BATTLE CREEK					DEER CREEK			
	NFBTC-H44	NFBTC-WH	NFBTC-MR	BTC-FS	BTC-GR	DC-PPC	DC-PW	DC-FS	DC-M
1. Instream Cover	18	17	17	15	16	15	15	14	14
2. Embeddedness	16	18	18	18	17	13	16	10	13
3. Velocity/ Depth Regimes	15	16	16	19	18	17	5	20	13
4. Sediment Deposition	16	17	16	17	17	14	14	8	15
5. Channel Flow	17	18	19	18	19	17	16	14	10
6. Channel Alteration	20	20	20	15	20	20	20	20	17
7. Riffle Frequency	17	17	16	14	14	13	18	7	8
8. Bank Vegetation	17	17	17	14	15	14	14	12	10
9. Bank Stability	16	19	17	13	15	17	17	17	13
10. Riparian Zone	20	20	20	17	17	19	20	19	13
TOTAL	**172**	**179**	**176**	**160**	**168**	**159**	**155**	**141**	**126**
Physical Condition	**Excellent**	**Excellent**	**Excellent**	**Excellent**	**Excellent**	**Excellent**	**Excellent**	**Good**	**Good**

Table 6 (continued). Physical habitat quality scores for sampling reaches within eight watersheds within the Sacramento River watershed between September 26 and November 7, 2000. Scores for each habitat parameter range from 0 (poor) to 20 (excellent).

Habitat Parameter	BIG CHICO CREEK				BUTTE CREEK					
	BCC-H32	BCC-FR	BCC-BP	BCC-RA	BC-CHC	BC-DMR	BC-RR	BC-HR	LBC-S	LBC-HCR
1. Instream Cover	17	15	17	8	16	16	17	17	16	16
2. Embeddedness	13	10	15	8	14	14	14	12	17	14
3. Velocity/ Depth Regimes	10	17	12	15	7	18	17	17	12	15
4. Sediment Deposition	14	8	16	8	14	14	15	13	16	14
5. Channel Flow	17	14	17	18	17	15	18	13	19	16
6. Channel Alteration	17	20	20	5	20	17	18	19	18	20
7. Riffle Frequency	18	13	12	12	19	12	17	4	17	7
8. Bank Vegetation	13	15	18	17	9	12	17	16	17	16
9. Bank Stability	16	18	18	17	14	18	17	17	14	16
10. Riparian Zone	17	19	17	5	19	18	17	18	16	19
TOTAL	**152**	**149**	**162**	**113**	**149**	**154**	**167**	**146**	**162**	**153**
Physical Condition	**Excellent**	**Good**	**Excellent**	**Good**	**Good**	**Excellent**	**Excellent**	**Good**	**Excellent**	**Excellent**

APPENDIX D

Review of Quality Assurance Data

Review of Quality Assurance Data

The Quality Assurance procedures for the 2000-2001 SRWP monitoring program are documented in the Quality Assurance Project Plan (QAPP) (LWA 2000). This appendix documents the types of quality control assessments used in the SRWP monitoring program (described below and summarized in Tables 1 through 6), and presents the results of those evaluation.. Detailed procedures for preparation and analysis of quality control samples are provided in the analytical method documents referenced in the QAPP.

Quality Assurance Procedures and Objectives

Qualitative Objectives

Comparability— Comparability of the data can be defined as the similarity of data generated by different monitoring programs. For the purpose of the SRWP Monitoring Program, this objective is addressed primarily by using standard sampling and analytical procedures where possible. Additionally, comparability of analytical data is addressed by analysis of standard reference materials (discussed subsequently in this document).

Representativeness—Representativeness can be defined as the degree to which the environmental data generated by the monitoring program accurately and precisely represent actual environmental conditions. For the SRWP, this objective is addressed by the overall design of the monitoring program. Specifically, assuring the representativeness of the data is addressed primarily by selecting appropriate locations, methods, times, and frequencies of sampling for each environmental parameter, and by maintaining the integrity of the sample after collection. Each of these elements of the quality assurance program are addressed elsewhere in this document.

Completeness

Data completeness is a measure of the amount of successfully collected and validated data relative to the amount of data planned to be collected for the project. Completeness is usually expressed as a percentage value. A project objective for percent completeness is typically based on the percentage of the data needed for the program or study to reach valid conclusions. Because the SRWP is intended to be a long term monitoring program, data that are not successfully collected for a specific sample event or site can typically be recollected at a later sampling event. For this reason, most of the data planned for collection can not be considered absolutely critical, and it is difficult to set an meaningful objective for data completeness. However, some reasonable objectives for data are desirable, if only to measure the effectiveness of the Monitoring Program. The following program goals for data completeness are based on the planned sampling frequency and a subjective determination of the relative importance of the monitoring element within the Monitoring Program:

Table 1. SRWP goals for data completeness.

Monitoring Element	Completeness Objective
Mercury	90%
Pesticides	90%
General Water Quality Constituents	90%
Pathogens	90%
Aquatic Toxicity	90%
Benthic Invertebrates	95%
Fish Tissue	85%

Field Procedures

For basic water quality analyses, quality control samples to be prepared in the field consisted of field blanks and field duplicates.

Field Blanks

The purpose of analyzing field blanks is to demonstrate that sampling procedures and equipment do not result in contamination of the environmental samples. Field blanks were generally prepared and analyzed for all analytes of interest at the rate of one per sample event, along with the associated environmental samples. Field blanks consisted of laboratory-prepared blank water processed through the sampling equipment using the same procedures used for environmental samples. If the concentration in the associated environmental samples was less than five times the value detected in the field blank, the results for the environmental samples may be affected by contamination and were qualified as *below detection* at the reported value.

Field Duplicates

The purpose of analyzing field duplicates is to demonstrate the precision of sampling and analytical processes. Field duplicates were prepared and analyzed at a rate of 1 per event for most analytes. Field duplicates consisted of two aliquots from the same composite sample, or of two grab samples collected in rapid succession. If the relative Percent Difference (RPD) of field duplicate results was greater than 25% and the absolute difference is greater than the RL, environmental results were qualified as *estimated*.

Laboratory Analyses

For basic water quality analyses, quality control samples prepared in the contract laboratory(s) will typically consist of equipment blanks, method blanks, standard reference materials, laboratory duplicates, matrix spikes, and matrix spike duplicates. Laboratory analyses for *Giardia* and *Cryptosporidium*, and coliform bacteria will include negative and positive quality control samples, as specified in the method documents.

Equipment Blanks

The purpose of analyzing equipment blanks is to demonstrate that sampling equipment is free from contamination. Prior to using sampling equipment for the collection of environmental samples, the laboratory responsible for cleaning and preparation of the equipment will prepare bottle blanks and sampler blanks. These were prepared and analyzed at the rate of one each per batch of bottles or sampling equipment. The blanks were analyzed using the same analytical methods specified for environmental samples.

Method Blanks

The purpose of analyzing method blanks is to demonstrate that the analytical procedures do not result in sample contamination. Method blanks were prepared and analyzed by the contract laboratory at a rate of at least one for each analytical batch. Method blanks consisted of laboratory-prepared blank water processed along with the batch of environmental samples. If the result for a single method blank was greater than the MDL, the source(s) of contamination should be corrected, and the associated samples should be reanalyzed. If reanalysis was not possible, the associated sample results were qualified as *below detection* at the reported value.

Laboratory Control Samples

The purpose of analyzing laboratory control samples is to demonstrate the accuracy of the analytical method. Laboratory control samples were analyzed at the rate of one per sample batch for most analytes. Laboratory control samples consisted of laboratory fortified method blanks. If recovery of any analyte is outside the acceptable range for accuracy, the analytical process is not being performed adequately for that analyte. In this case, the sample batch should be prepared again, and the laboratory control sample should be reanalyzed. If reanalysis was not possible, the associated sample results were qualified as *low or high biased*.

Laboratory Duplicates

The purpose of analyzing laboratory duplicates is to demonstrate the precision of the analytical method. Laboratory duplicates were analyzed at the rate of one pair per sample batch. Laboratory duplicates will consist of duplicate laboratory fortified method blanks. If the Relative Percent Difference (RPD) for any analyte is greater than the precision criterion *and* the absolute difference between duplicates is greater than the RL, the analytical process is not being performed adequately for that analyte. In this case, the sample batch should be prepared again, and laboratory duplicates should be reanalyzed. If reanalysis was not possible, the associated sample results were qualified as *not reproducible* due to analytical variability.

Matrix Spikes and Matrix Spike Duplicates

The purpose of analyzing matrix spikes and matrix spike duplicates is to demonstrate the performance of the analytical method in a particular sample matrix. Matrix spikes and matrix spike duplicates were typically analyzed at the rate of one pair per sample batch for most analytes. Each matrix spike and matrix spike duplicate consisted of an aliquot of laboratory-fortified environmental sample.

If matrix spike recovery of any analyte is outside the acceptable range, the results for that analyte have failed the acceptance criteria for that specific matrix. If recovery of laboratory control samples is acceptable, the analytical process is being performed adequately for that analyte, and the problem is attributable to the sample matrix. If the matrix problem can't be corrected, the results for that analyte were qualified as appropriate (*low or high biased*) due to matrix interference.

If matrix spike duplicate RPD for any analyte is greater than the precision criterion, the results for that analyte have failed the acceptance criteria for that specific matrix. If the RPD for laboratory duplicates is acceptable, the analytical process is being performed adequately for that analyte, and the problem is attributable to the sample matrix. If the matrix problem can't be corrected, the results for that analyte were qualified as *not reproducible*, due to matrix interference.

Aquatic and Sediment Toxicity Quality Control

For aquatic and sediment toxicity tests, the acceptability of test results was determined primarily by performance-based criteria for test organisms, culture and test conditions, and the results of control bioassays. Control bioassays included testing with reference toxicants, reference sediments, and negative and solvent controls. Test acceptability requirements are documented in the method documents for each bioassay method and in the QAPP.

In addition to the QA requirements for the toxicity testing methods, a total of twenty percent of the samples collected for aquatic toxicity testing were reserved for other QC analyses. Ten percent of aquatic toxicity samples were split and tested at the California Department of Fish and Game Laboratory at Elk Grove. An additional ten percent of analyses consisted of laboratory splits, spikes, and blanks. The results of duplicate and interlaboratory split analyses are considered acceptable if the results are not significantly different at the 95% confidence level *or* the RPD for the results is less than 30%. Acceptable results for tests with blanks are no significant toxicity. Although the laboratory has no formal limit of acceptability for analysis of spiked samples, the pattern and progress of toxic responses are evaluated subjectively for consistency with expected responses for the level of the spiked compound.

Benthic Invertebrates Processing and Analysis

Accuracy of identifications and precision of enumeration of benthic invertebrate collections was assessed by re-analysis of samples at the rate of one for every ten samples analyzed. This consisted of complete re-examination of the organisms in the archived original sample, including remnants from the sorting process. If any additional organisms are identified in the "remnant" fraction of the archived sample, the numbers of taxa and organisms was recorded. The total number of organisms and enumeration of individual taxa for the re-examined sample should be within 5% of the original total. Discrepancies in taxonomic identification or enumeration were resolved by consultation between taxonomic analysts.

Fish Tissue

Quality control requirements and assessment procedures for analysis of contaminants in fish tissue were generally similar to those for water quality samples (documented above). However, for analysis of PCBs and chlorinated pesticides, surrogate compounds (internal standards) were added to each sample to assess analytical accuracy of classes of similar compounds. The acceptable range for recovery of surrogate compounds was set by the analyzing laboratory. If surrogate recoveries were outside the defined range, the sample batch was prepared again and reanalyzed. If reanalysis was not possible, the associated environmental data for all analytes by the specific method was qualified as low or high biased, consistent with the surrogate recovery bias. If surrogate recovery bias is inconsistent for different surrogate compounds, the associated environmental data was qualified as biased due to indeterminate surrogate recovery bias.

Table 2a. Project Quality Control Requirements for Analysis of Water Quality Samples for Trace Metals, Organic Carbon, and General Water Quality Constituents.

QA Procedure	QA Parameter	Frequency	Criterion	Corrective Action
Equipment Blanks: • bottle blanks • sampler blanks	Contamination	1 per bottle or reagent batch.	< MDL	Identify contamination source. Reclean equipment. Reanalyze blank(s).
Field Blanks	Contamination	1 per event (trace metals and TOC)	< RL *or* < sample ÷ 5	Examine field log. Identify contamination source. Qualify data as needed.
Field Duplicate	Precision	1 per event	RPD ≤ 25% if |Difference| ≥ RL	Reanalyze both samples. Identify variability source. Qualify data as needed.
Method Blank	Contamination	≥1 per batch (trace metals and TOC)	< MDL *or*, if n≥3, avg ± 2 s.d. < RL	Identify contamination source. Reanalyze method blank and all samples in batch.
LCS or SRM	Accuracy	1 per batch	80-120% REC	Recalibrate and reanalyze LCS or SRM and samples
Lab Duplicate	Precision	1 per batch	RPD ≤ 20% if |Difference| ≥ RL	Recalibrate and reanalyze.
Matrix Spike	Accuracy	1 per batch	80-120% REC	Check SRM recovery. Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike Duplicate	Precision	1 per batch	RPD ≤ 20%	Check lab dup RPD. Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per planned sample event	90%	Reschedule sample events as necessary or appropriate.

MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

Table 2b. Project Quality Control Requirements for Analysis of Water Quality Samples: Requirements for Triazine Pesticide Analyses by EPA Method 619.

QA Procedure	QA Parameter	Frequency[1]	Criterion	Corrective Action
Equipment Blanks: • bottle blanks • sampler blanks	Contamination	1 per bottle or reagent lot	< MDL	Identify contamination source. Reclean equipment. Reanalyze blank(s).
Field Blanks	Contamination	1 per 3 events	< RL *or* < sample ÷ 5	Examine field log. Identify contamination source. Qualify data as needed.
Field Duplicate	Precision	1 per 6 events	RPD ≤ 25% if |Difference| ≥ RL	Reanalyze both samples. Identify variability source. Qualify data as needed.
Matrix Spike & LCS Atrazine Terbutryn Tributylphosphate Triphenlyphosphate	Accuracy	1 per batch	 28-163% REC 60-117% REC 60-150% REC 76-140% REC	Check SRM recovery. Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike & LCS Duplicates: Atrazine Terbutryn	Precision	1 per batch	 31% RPD 25% RPD	Check lab dup RPD. Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per event	90%	Reschedule sample events as necessary or appropriate.

Notes: MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

(1) The term “lot” refers to a set of bottles or reagents identifiable by a common production lot number, or to sampling equipment subjected to the same cleaning procedures as a set.
The term “batch”, as used in this document, refers to an uninterrupted series of analyses.

Table 2c. Project Quality Control Requirements for Analysis of Water Quality Samples: Requirements for Organophosphosphate Pesticide Analyses by EPA Method 8141A.

QA Procedure	QA Parameter	Frequency[1]	Criterion	Corrective Action
Equipment Blanks: • bottle blanks • sampler blanks	Contamination	1 per bottle or reagent lot	< MDL	Identify contamination source. Reclean equipment. Reanalyze blank(s).
Field Blanks	Contamination	1 per event	< RL or < sample ÷ 5	Examine field log. Identify contamination source. Qualify data as needed.
Field Duplicate	Precision	1 per 2 events	RPD ≤ 25% if |Difference| ≥ RL	Reanalyze both samples. Identify variability source. Qualify data as needed.
Matrix Spike & LCS Phorate Diazinon Disulfoton Methyl Parathion Stirophos Ethion Tributylphosphate Triphenlyphosphate	Accuracy	1 per batch	 22-96% REC 57-130% REC 47-117% REC 55-164% REC 68-128% REC 65-134% REC 60-150% REC 76-140% REC	Check SRM recovery. Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike & LCS Duplicates: Phorate Diazinon Disulfoton Methyl Parathion Stirophos Ethion	Precision	1 per batch	 24% RPD 21% RPD 22% RPD 24% RPD 25% RPD 20% RPD	Check lab dup RPD. Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per event	90%	Reschedule sample events as necessary or appropriate.

Notes: MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

(1) The term “lot” refers to a set of bottles or reagents identifiable by a common production lot number, or to sampling equipment subjected to the same cleaning procedures as a set.
The term “batch”, as used in this document, refers to an uninterrupted series of analyses.

Table 2d. Project Quality Control Requirements for Analysis of Water Quality Samples: Requirements for Carbamate Pesticide Analyses by EPA Method 8321.

QA Procedure	QA Parameter	Frequency1	Criterion	Corrective Action
Equipment Blanks: • bottle blanks • sampler blanks	Contamination	1 per bottle or reagent lot	< MDL	Identify contamination source. Reclean equipment. Reanalyze blank(s).
Field Blanks	Contamination	1 per 3 events	< RL or < sample ÷ 5	Examine field log. Identify contamination source. Qualify data as needed.
Field Duplicate	Precision	1 per 6 events	RPD ≤ 25% if |Difference| ≥ RL	Reanalyze both samples. Identify variability source. Qualify data as needed.
Matrix Spike & LCS Methomyl Bromacil Neburon Oryzalin	Accuracy	1 per batch	 37-113% REC 58-111% REC 55-132% REC 40-140% REC	Check SRM recovery. Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike & LCS Duplicates: Methomyl Bromacil Neburon	Precision	1 per batch	 25% RPD 25% RPD 25% RPD	Check lab dup RPD. Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per event	90%	Reschedule sample events as necessary or appropriate.

Notes: MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference;
RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample;
SRM = Standard Reference Material (=Certified Reference Material)

(1) The term “lot” refers to a set of bottles or reagents identifiable by a common production lot number, or to sampling equipment subjected to the same cleaning procedures as a set.
The term “batch”, as used in this document, refers to an uninterrupted series of analyses.

Table 3. Project Quality Control Requirements for Analysis of Water Quality Samples for Pathogens.

QA Procedure	Parameter	Frequency1	Criterion	Corrective Action
Coliform Bacteria Analyses				
Field Blanks	Contamination	1 per event	< RL or < sample ÷ 5	Examine field log. Identify contamination source. Qualify data as needed.
Method Blanks (Sterility Checks)	Contamination	1 per batch	< RL	Identify contamination source. Clean equipment and slides. Check reagents. Re-analyze blank.
Lab Duplicate	Precision2	1 per 10 samples, & at least 1 per batch	Rlog≤ 3.27•mean RLog	Recalibrate and reanalyze.
Cryptosporidium and Giardia Analyses				
Method Blanks	Contamination	1 per 20 samples	<1 cyst	Identify contamination source. Clean equipment and slides. Check reagents. Re-analyze blank.
Ongoing Precision and Recovery Samples	Precision	1 per 20 samples	56% RPD	Identify and correct problem. Re-examine OPR sample.
Ongoing Precision and Recovery Samples	Accuracy	1 per 20 samples	10-100% REC	Identify and correct problem. Re-examine OPR sample.
Matrix Spike	Accuracy	1 per 20 samples	11-100% REC	Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
All Pathogen Analyses				
Negative Control Samples	Contamination	1 per culture medium or reagent lot	< RL	Identify source. Clean equipment and prepare new media. Re-examine negative control
Negative Control Samples	Assay function	1 per culture medium or reagent lot	≥ RL	Identify and correct problem. Re-examine positive control.
Assess percent of data successfully collected	Data Completeness	1 per planned sample event	90%	Reschedule sample events as necessary or appropriate.

Notes: MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

(1) The method documentation defines an analytical batch as an “uninterrupted series of analyses”.

(2) Rlog is the absolute difference between logarithms of coliform counts for duplicate analyses. The mean Rlog is determined by performing duplicate analyses on the first 15 positive sample analyzed for each matrix type.

Table 4. Project Quality Control Requirements for Analysis of Benthic Invertebrates.

QA Procedure	Parameter	Frequency	Criterion	Corrective Action
Re-examination of sample	Accuracy Precision	1 per 10 benthic invertebrate samples	≤5% difference ≤5% difference	Resolve differences in identification and enumeration.
Assess percent of data successfully collected	Data Completeness	1 per planned sample event	100%	Reschedule sample events as necessary or appropriate.

Table 5. Project Quality Control Requirements for Analysis of Fish Tissue for Mercury.

QA Procedure	Parameter	Frequency	Criterion	Corrective Action
Method Blank (a.k.a. analytical blank or lab reagent blank)	Contamination	1 per batch	< MDL or < 10% of lowest sample	Identify contamination source. Reanalyze method blank and all samples in batch.
SRM (a.k.a. certified reference material)	Accuracy	1 per batch of 20 or fewer samples	Within 20% of the certified 95% confidence interval, or within 20% of the certified mean	Review raw data quantitation reports Check instrument response using calibration standard Recalibrate and reanalyze SRM and samples Repeat analysis until control limits are met
SRM (a.k.a. certified reference material)	Precision	1 per batch of 20 or fewer samples	RPD ≤ 35%, or RSD ≤ 30%	Recalibrate and reanalyze. If problem persists eliminate source of imprecision and reanalyze.
Field Duplicate (two aliquots from same composite sample: RMP calls this a lab duplicate)	Precision	1 per batch	RPD ≤ 35%	Recalibrate and reanalyze. If problem persists eliminate source of imprecision and reanalyze.
Matrix Spike	Accuracy	1 per batch	> 50% REC	Check SRM or LCS recovery. Review raw data quantitation reports Check instrument response using calibration standard Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike Duplicate	Precision	1 per batch	RPD ≤ 35%	Check lab duplicate RPD. Review raw data quantitation reports Check instrument response using calibration standard Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per planned sampling event	85%	Reschedule sampling as necessary or appropriate.

MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

Table 6. Project Quality Control Requirements for Analysis of Fish Tissue for Organochlorine Pesticides and PCBs.

QA Procedure	Parameter	Frequency	Criterion	Corrective Action
Method Blank (a.k.a. analytical blank or lab reagent blank)	Contamination	1 per batch	< MDL or < 10% of lowest sample	Identify contamination source. Reanalyze method blank and all samples in batch.
SRM (a.k.a. certified reference material)	Accuracy	1 per batch of 20 or fewer samples	As a group: 70% of the analytes within 35% of the 95% confidence interval Individually: No analyte >30% of 95% confidence interval for 2 consecutive analyses	Review chromatograms and raw data quantitation reports Check instrument response using calibration standard Recalibrate and reanalyze SRM and samples Repeat analysis until control limits are met
SRM (a.k.a. certified reference material)	Precision	1 per batch of 20 or fewer samples	RPD ≤ 35%, or RSD ≤ 30%	Recalibrate and reanalyze. If problem persists eliminate source of imprecision and reanalyze.
Field Duplicate (two aliquots from same composite sample: RMP calls this a lab duplicate)	Precision	1 per batch	RPD ≤ 35%	Recalibrate and reanalyze. If problem persists eliminate source of imprecision and reanalyze.
Matrix Spike	Accuracy	1 per batch	> 50% REC	Check SRM or LCS recovery. Review chromatograms and raw data quantitation reports Check instrument response using calibration standard Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike Duplicate	Precision	1 per batch	RPD ≤ 35%	Check lab duplicate RPD. Review raw data quantitation reports Check instrument response using calibration standard Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Surrogate Spike	Accuracy	1 per batch	set by analyzing laboratory	Check SRM or LCS recovery. Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per planned sampling event	85%	Reschedule sampling as necessary or appropriate.

MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

Summary of Quality Control Data

Aquatic Toxicity

For SRWP samples collected and analyzed in 2000-2001, aquatic toxicity tests met all performance criteria and all reported data were unqualified. The results for quality assurance analyses for aquatic toxicity testing are presented in monitoring data summaries produced by Pacific EcoRisk.

The overall completion rate was greater than the 90% objective for the program, and this monitoring element provided data that were adequate for the purposes of the SRWP.

Fish Tissue Monitoring

The results of Quality Assurance analyses performed for 2000 fish tissue monitoring are reported in "Quality Assurance/Quality Control Document for the Sacramento River Toxic Pollutant Control Program" prepared by the California Department of Fish and Game. All of the 2000-2001 results met data quality objectives. The overall completion rate was greater than the 85% objective for the program, and this monitoring element provided data that were adequate for the purposes of the SRWP.

Bioassessment

Quality assurance analyses for benthic macroinvertebrate analyses performed in 2000-2001 are reported in "Sacramento River Watershed Program: 2000 Biological Assessment Report prepared by the California Department of Fish and Game (CDFG). The overall completion rate for bioassessment monitoring was greater than the project target of 95%. Data produced by the Department of Fish and Game Aquatic Biology Lab resulted from procedures consistent with the SRWP QAPP, and are adequate for the purposes of this program.

Water Column Chemistry and Microbiology Monitoring

Quality control data for SRWP monitoring data collected from June 2000 through July 2001 are summarized below. Quality control data were evaluated using methods documented in the Quality Assurance Project Plan (QAPP) for the SRWP (LWA 2000). Sample results were reviewed for conformance with recommended allowable holding times for specific analyses and for compliance with SRWP Monitoring Program data quality objectives for laboratory and external QC results. Internal laboratory QC data reviewed include results for method blanks, laboratory control samples (standard reference materials), laboratory duplicates, matrix spikes, and matrix spike duplicates. Field and external laboratory QC data reviewed include results for field blanks and field duplicates. Program specifications for data quality are summarized in Tables 1-6 .

Holding Times

Data quality objectives for holding times generally conformed to EPA recommendations specified for the analytical methods used for individual parameters. Allowable holding times for the project ranged from 24 hours for microbiological analyses to 6 months for metals and hardness (after preservation). 94% of the total analyses were performed within acceptable holding times. Analyses performed outside of acceptable limits resulted in qualification of some analytical results for total dissolved solids, organic carbon, coliform bacteria, giardia, cryptosporidium, and organophosphate pesticides. Most of the qualified data were for individual OP pesticide analytes from only two samples analyzed just past the 40-day holding time. Coliform bacteria and organic carbon analyses were the most problematic, due to the short holding time and the logistics of getting samples to the lab from distant sampling locations. A summary of allowable holding times and compliance for individual analytes is presented in Table 7.

Laboratory Method and Filter Blanks

Laboratory method blanks and filter blanks were analyzed to evaluate the potential for contamination attributable to analytical reagents and sample processing. The project data quality objective for laboratory method and filter blanks was defined as below the project reporting limit. If detectable levels of an analyte were determined to be present in method or filter blanks, sample results were accepted without qualification if the associated environmental sample results were greater than five times the concentration detected in the blank. If detectable levels of an analyte were determined to be present in method or filter blanks and associated environmental sample results were less than five (5) times the concentration detected in the blank, the reported analytical results were qualified as an upper limit of the actual sample result.

For SRWP 2000-2001 monitoring results, mercury, methylmercury, TDS, and one organophosphate pesticide analyte were detected at greater than program reporting limits in laboratory method blanks in 10 of 1198 analyses. The overall success rate for analyses of laboratory method and filter blanks was 99%. Analytes detected in method blanks did not result in qualification of any analytical results. These results indicate that laboratory contamination of water quality samples is not a significant problem. Results for laboratory method blanks are summarized in Table 8.

Laboratory Control Sample Recoveries

Laboratory control samples were analyzed to evaluate analytical accuracy. If recoveries were outside the acceptable range for the analysis, associated samples results were qualified as “low- or high-biased” as indicated by the control sample recovery.

For SRWP 2000-2001 monitoring results, 12 of 795 laboratory control sample recoveries were outside project specifications (one each for methylmercury and DOC, and 10 pesticide analyte results). The overall success rate for analysis of laboratory control samples was 98.5%. These results indicate that analytical accuracy was adequate for analysis of water quality samples for the project. Results for laboratory control sample recoveries are summarized in Tables 9a–9d.

Laboratory Duplicates

Analyses of duplicate samples were conducted to evaluate analytical precision. If laboratory duplicate results were outside the project data quality objective, associated samples results were qualified as “estimated” (not reproducible) due to analytical variability. An RPD greater than the project data quality objective was not considered cause for qualification of analytical results if measured differences between replicates were less than the reporting limit, or if matrix spike duplicate results were acceptable.

For SRWP 2000-2001 monitoring results, 4 of 196 laboratory duplicate results were outside program specifications. The overall success rate for analyses of laboratory control sample duplicate RPDs was 98%. These results indicate that analytical precision was adequate to produce reliable data for the SRWP. Results for laboratory duplicate analyses are summarized in Table 10.

Matrix Spike Recoveries

Analyses of matrix spike samples (spiked environmental samples) were performed to evaluate the effect of water quality sample matrix on analytical accuracy. When a matrix spike recovery does not meet the project data quality objective, associated sample results are considered “low- or high-biased” due to matrix interference, as indicated by the recovery.

For SRWP 2000-2001 monitoring results, reported matrix spike recoveries exceeded program specifications for 13 of 354 total analyses. The overall success rates for analyses of matrix spike recoveries were 99% for pesticide analyses and 91% for all other analyses. Organic carbon analyses exceeded the project DQO most frequently, with 14% of the total recoveries outside of program specifications. In combination with the results for laboratory control samples, these results indicate that with the exception of organic carbon, matrix interference did not represent a significant problem and that analytical accuracy was adequate to produce reliable data for water quality samples for the SRWP. Results for matrix spike recoveries are summarized in Tables 11a and 11b.

Matrix Spike Duplicates

Analyses of matrix spike duplicate samples were performed to evaluate the effect of water quality sample matrix on analytical precision. If matrix spike duplicate results were outside this range, associated samples results were qualified as “estimated” (not reproducible) due to matrix variability.

For SRWP 2000-2001 monitoring results, nearly all matrix spike duplicate RPDs reported were within program specifications for all analytes. Matrix spike duplicate RPDs exceeded project objectives in a total of 6 of 164 analyses. The overall success rate for analyses of matrix spike duplicates was 96%. In combination with the results for laboratory duplicates, these results indicate that matrix interference did not represent a significant problem and that analytical precision was adequate to produce reliable water quality data for the SRWP. Results for matrix spike duplicate RPDs are summarized in Table 12.

Field Blanks

Field blanks were submitted and analyzed to evaluate the potential for sampling equipment and procedures to contaminate water quality samples. The project data quality objective for field and equipment blanks was defined as below the program reporting limit. If detectable levels of an analyte were determined to be present in field blanks, sample results were accepted without qualification if the environmental results were greater than five (5) times the concentrations detected in the blank. If detectable levels of an analyte were determined to be present in field or equipment blanks and sample results were less than five (5) times the concentrations detected in the blank, the reported results were qualified as an upper limit of the true sample concentration.

For SRWP 2000-2001 monitoring results, SRWP analytes were detected above reporting limits in 5 of 454 field blank analyses: 2 dissolved organic carbon analyses and 3 dissolved mercury analyses. The overall success rate for analysis of field blanks was 99%. Results of analyses of field blanks indicate that sampling procedures and equipment were generally adequate to prevent detectable or significant levels of contamination of samples collected for the SRWP. Results for field blank analyses are summarized in Table 13.

Field Duplicates

The purpose of analyzing duplicate field samples is to measure the reproducibility (i.e. precision) of analyte concentrations in field samples from replicate composite or grab samples. The results provide a measure of the variability attributable to sampling and sample handling procedures after sample collection. The project data quality objective for duplicates field samples was defined as a relative percent difference (RPD) of less than or equal to 25%. Duplicate RPDs outside this range resulted in the qualification of sample result data as “estimated” (not reproducible) due to sample variability. An RPD greater than 25% was not considered cause for qualification of data if measured differences between replicates were less than the reporting limit.

For SRWP 2000-2001 monitoring results, field duplicate RPDs exceeded program specifications for 7 of 532 pairs of analyses. The overall success rate for analysis of field duplicates was 99%. These results indicate that sampling and sample handling-generated variability was not excessive, and that sampling procedures were performed in a manner to provide adequate data for the SRWP. Results for field duplicates are summarized in Table 14.

Summary

From June 2000 through July 2001, the SRWP monitoring program successfully completed 3957 of 4001 planned water chemistry analyses for a completion rate of 98.9%. The primary controllable cause of uncompleted analyses was sample containers broken in shipping or in the laboratory. Of the 3957 completed analyses, data qualifications were required for 183 analytical results, leaving 3774 unqualified results for an overall analytical success rate of 94.3% for water chemistry and microbiology monitoring in Year 3. These results are summarized in Table 15.

The quality control results for 2000-2001 indicate that sampling and analytical methods for water chemistry and microbiology were generally adequate to produce reliable data for the SRWP.

Table 7. Summary of Compliance with Holding Times for SRWP Analyses, 2000-2001 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
Mercury - dissolved	6 months	118	0	100
Mercury - total	6 months	104	0	100
Methylmercury - dissolved	6 months	117	0	100
Methylmercury - total	6 months	114	0	100
total dissolved solids	7 days	100	4	96
total suspended solids	7 days	99	1	99
Hardness (atox)	6 months	108	0	100
Hardness (wc)	6 months	9	0	100
Organic carbon - dissolved	7 days	90	41	54
Organic carbon - total	7 days	80	24	70
Alkalinity - total (atox)	14 days	109	0	100
Alkalinity - total (wc)	14 days	9	1	89
Coliform - fecal	24 hours	23	3	87
Coliform - total	24 hours	22	2	91
Cryptosporidium	96 hours	37	3	92
Giardia	96 hours	37	3	92
Pesticides - EPA 619	40 days	20	0	100
Pesticides - EPA 8141A	40 days	90	2	98
Pesticides - EPA 8321A	40 days	31	0	100
	total for all parameters	1317	84	94%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 8. Summary of Compliance with Laboratory Method Blank Results for SRWP Analyses, 2000-2001 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
mercury - total	<RL or <S/5	14	4	71
methylmercury - total	<RL or <S/5	72	4	94
organic carbon - dissolved	<RL or <S/5	147	0	100
organic carbon - total	<RL or <S/5	173	0	100
total dissolved solids	<RL or <S/5	9	1	89
total suspended solids	<RL or <S/5	9	0	100
pesticides - EPA 619	<RL or <S/5	77	0	100
pesticides - EPA 8141A	<RL or <S/5	481	1	99.8
pesticides - EPA 8321A	<RL or <S/5	216	0	100
	total for all analyses	1198	10	99

(1) Data quality objectives (DQO) f are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 9a. Summary of Laboratory Control Sample and SRM Recoveries for SRWP Analyses, 2000-2001 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
mercury - total	80% - 120%	14	0	100
methylmercury - total	80% - 120%	23	1	95.7
organic carbon - dissolved	80% - 120%	153	1	99.3
organic carbon - total	80% - 120%	180	0	100
total dissolved solids	80% - 120%	8	0	100
total suspended solids	80% - 120%	8	0	100
	total for all analyses	386	2	99.5%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 9b. Summary of Laboratory Control Sample Recoveries for SRWP Organophosphate Pesticide Analyses, 2000-2001 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
azinphosmethyl	27% - 151%	13	0	100.0
bolstar	31% - 120%	13	0	100.0
chlorpyrifos	37% - 120%	13	0	100.0
coumaphos	46% - 134%	13	0	100.0
def	34% - 140%	13	0	100.0
demeton (total)	21% - 80%	8	2	75.0
demeton-s	7% - 71%	5	1	80.0
diazinon	57% - 130%	13	0	100.0
dichlorvos	13% - 145%	13	0	100.0
dimethoate	33% - 227%	13	1	92.3
disulfoton	47% - 117%	13	0	100.0
EPN	20% - 152%	13	0	100.0
EPTC	43% - 130%	6	0	100.0
ethion	47% - 118%	13	0	100.0
ethoprop	38% - 118%	13	0	100.0
fensulfothion	37% - 172%	13	1	92.3
fenthion	39% - 109%	13	0	100.0
malathion	54% - 121%	13	2	84.6
merphos	44% - 128%	13	0	100.0
mevinphos	30% - 192%	13	1	92.3
naled	16% - 285%	13	0	100.0
ethyl parathion	44% - 133%	13	0	100.0
methyl parathion	55% - 164%	13	0	100.0
phorate	22% - 96%	13	0	100.0
prowl	30% - 129%	13	0	100.0
ronnel	47% - 112%	13	0	100.0
stirophos	68% - 128%	13	1	92.3
sulfotepp	50% - 114%	13	0	100.0
tributylphosphate (surrogate)	60% - 150%	13	0	100.0
triphenylphosphate (surrogate)	76% - 140%	13	1	92.3
tokuthion	36% - 126%	13	0	100.0
trichloronate	36% - 115%	13	0	100.0
trifluralin	31% - 107%	13	0	100.0
total for EPA method 8141A		409	10	98%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 9c. Summary of Laboratory Control Sample Recoveries for SRWP Carbamate Pesticide Analyses, 2000-2001 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
benomyl	58% - 111%	1	0	100
bromacil	58% - 111%	2	0	100
carbaryl	40% - 131%	6	0	100
carbofuran	44% - 128%	1	0	100
diuron	57% - 133%	6	0	100
fluometuron	66% - 158%	1	0	100
methomyl	37% - 113%	5	0	100
monuron	55% - 134%	1	0	100
oryzalin (surrogate)	40% - 140%	8	0	100
tebuthiuron	67% - 109%	1	0	100
totals for EPA method 619		32	0	100%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO 2000-2001 Monitoring

Table 9d. Summary of Laboratory Control Sample Recoveries for SRWP Triazine Pesticide Analyses,

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
ametryn	54% - 173%	7	0	100
atraton	26% - 199%	7	0	100
atrazine	62% - 191%	7	0	100
cyanazine	30% - 232%	7	0	100
prometon	44% - 180%	7	0	100
prometryn	61% - 171%	7	0	100
propazine	56% - 180%	7	0	100
simazine	35% - 135%	7	0	100
simetryn	54% - 166%	7	0	100
tributylphosphate (surrogate)	60% - 150%	7	0	100
triphenylphosphate (surrogate)	76% - 140%	7	1	85.7
terbuthylazine	57% - 178%	7	0	100
terbutryn	61% - 169%	7	0	100
total for EPA method 8321A		91	1	99%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 10. Summary of Laboratory Duplicate Results for SRWP Analyses, 2000-2001 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
mercury - total	<=20% RPD	13	0	100.0
methylmercury - total	<=20% RPD	7	3	70
organic carbon - dissolved	<=20% RPD	89	0	100.0
organic carbon - total	<=20% RPD	87	1	99
	total for all analyses	196	4	98%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 11a. Summary of Matrix Spike Recoveries for SRWP Analyses, 2000-2001 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
mercury - dissolved	80% - 120%	4	0	100
mercury - total	80% - 120%	11	0	100
methylmercury - total	80% - 120%	16	2	88
total dissolved solids	80% - 120%	8	0	100
total suspended solids	80% - 120%	8	0	100
organic carbon - dissolved	80% - 120%	29	2	93
organic carbon - total	80% - 120%	26	6	77
cryptosporidium	11% - 100%	2	0	100
giardia	11% - 100%	2	0	100
	total for all analyses	106	10	91%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 11b. Summary of Matrix Spike Surrogate Recoveries for SRWP Pesticide Analyses, 2000-2001 Monitoring

Parameters	Method	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
tributylphosphate (surrogate)	EPA 619	60% - 150%	25	1	96
triphenylphosphate (surrogate)	EPA 619	76% - 140%	25	0	100
tributylphosphate (surrogate)	EPA 8141A	60% - 150%	84	1	99
triphenylphosphate (surrogate)	EPA 8141A	76% - 140%	84	1	99
oryzalin (surrogate)	EPA 8321A	40% - 140%	30	0	100
		total for all analyses	248	3	99

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 12. Summary of Matrix Spike Duplicate Results for SRWP Analyses, 2000-2001 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
mercury - dissolved	<=20% RPD	4	0	100
mercury - total	<=20% RPD	11	0	100
methylmercury - total	<=20% RPD	16	0	100
total dissolved solids	<=20% RPD	8	0	100
total suspended solids	<=20% RPD	8	1	88
organic carbon - dissolved	<=20% RPD	23	1	96
organic carbon - total	<=20% RPD	23	4	83
pesticides - EPA 619	<=20% RPD	11	0	100
pesticides - EPA 8141A	<=20% RPD	60	0	100
	total for all analyses	164	6	96%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 13. Summary of Field Blank Results for SRWP Analyses, 2000-2001 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
mercury - dissolved	<RL or <S/5	8	3	63
mercury - total	<RL or <S/5	2	0	100
methylmercury - dissolved	<RL or <S/5	8	0	100
methylmercury - total	<RL or <S/5	2	0	100
total suspended solids	<RL or <S/5	1	0	100
organic carbon - dissolved	<RL or <S/5	9	2	78
coliform - fecal	<RL or <S/5	5	0	100
coliform - total	<RL or <S/5	5	0	100
pesticides - EPA 619	<RL or <S/5	33	0	100
pesticides - EPA 8141A	<RL or <S/5	333	0	100
pesticides - EPA 8321A	<RL or <S/5	48	0	100
	total for all analyses	454	5	99%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 14. Summary of Field Duplicate Results for SRWP Analyses, 2000-2001 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
mercury - dissolved	<=25% RPD	11	2	82
mercury - total	<=25% RPD	4	0	100
methylmercury - dissolved	<=25% RPD	10	0	100
methylmercury - total	<=25% RPD	7	1	86
total dissolved solids	<=25% RPD	10	1	90
total suspended solids	<=25% RPD	11	0	100
hardness (atox)	<=25% RPD	11	0	100
organic carbon - dissolved	<=25% RPD	9	2	78
organic carbon - total	<=25% RPD	9	0	100
alkalinity - total (atox)	<=25% RPD	12	1	92
pesticides - EPA 619	<=25% RPD	33	0	100
pesticides - EPA 8141A	<=25% RPD	333	0	100
pesticides - EPA 8321A	<=25% RPD	72	0	100
	total for all analyses	532	7	99%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 15. Summary of Planned and Completed Environmental Analyses for SRWP Monitoring, 2000-2001 Monitoring

parameter	total analyses planned	analyses completed	percent completeness
Total mercury, filtered and unfiltered	220	201	91.4%
Methylmercury, filtered and unfiltered	220	208	94.5%
Total dissolved solids	90	90	100.0%
total suspended solids	105	97	92.4%
Hardness	106	106	100.0%
Organic carbon, dissolved and total	144	143	99.3%
Alkalinity - total	106	106	100.0%
Coliform - fecal	18	18	100.0%
Coliform - total	18	18	100.0%
Cryptosporidium	39	37	94.9%
Giardia	39	37	94.9%
Pesticides - EPA 619	187	187	100.0%
Pesticides - EPA 8141A	2088	2088	100.0%
Pesticides - EPA 8321A	621	621	100.0%
total for all analyses	4001	3957	98.90%
minus total qualified data		183	
total unqualified data		3774	94.33%
	% success averaged by parameter		97.7%

APPENDIX E

Response to Comments

RESPONSE TO COMMENTS

Responses to comments on the Public Draft of the SRWP Annual Monitoring Report (AMR) are presented below. The full text of comments from the three peer reviewers (Rainer Hoenicke, Revital Katznelson, and Andy Gunther) and from the Central Valley Regional Water Quality Control Board are presented with the responses immediately following each comment. Comments are numbered C-1 through C-127, and responses are in italics and preceded by an "*R*" .

Comments provided on the Administrative Draft SRWP AMR were received from the following agencies and individuals:

Regional Water Quality Control Board (resubmitted for Public Draft)

Mitch Maidrand, Sacramento Regional County Sanitation District

G. Fred Lee, G. Fred Lee Associates

Elaine Archibald, California Urban Water Agencies

Bill Crooks, Consultant to City of Sacramento

Responses to these comments were reviewed and approved by the SRWP Monitoring Sub-Committee. Copies of all original comment letters are available on request.

Rainer Hoenicke, California Legacy Project (Comments C1-C13)

C-1 Thank you for the opportunity to review the 2000-2001 Annual Report. It is well written and organized. Some of my comments relate to conceptual improvements that you might consider for future reports, while most comments pertain to more specific suggestions for improving the final version. I discovered a few typos that spell-check didn't catch, but I assume that the production team will do final proofing before the report is printed. Also, for some sections stylistic differences reveal different authorship and could be made less pronounced. For example, in most sections, the use of numbers between one and ten is correct, while in the tox. section, they are not spelled out as they should be. If you'd like my annotated copy, please let me know, and I'd be glad to send it.

R *These corrections were made as recommended.*

1. Conceptual improvement suggestions for future reports:

C-2 1.1 I like the section in the Exec. Summary explaining what's in the report. It would be a good idea to link the main objective statement ("to evaluate the attainment of beneficial uses and potential impairment...") with the types of indicators you chose for this evaluation and a brief description of why the indicators you did choose are appropriate for impairment assessment. The science framework could be strengthened that way. If you use the Pressure-State-Response model, you might find some surprises in the types of indicators that might emerge, and that might tell you a whole lot more than the predetermined chemicals of concern.

R *These suggestions will be brought to the attention of the monitoring sub-committee for consideration for future reports, as recommended.*

C-3 I also like your use of bioassessment techniques and the use of toxicity tests as integrative measures of potential impairment. Since pesticide use and the types of synthetic compounds used are changing rapidly, you may want to consider including in future monitoring plans and reports a clear separation of monitoring the environmental reflections of water quality improvement actions taken in the watershed, such as the likely outcomes of reduction of diazinon and chlropyrifos use, and the types of "surveillance" or pro-active monitoring suitable for detecting emerging problems and potential impairment by things other than legacy pollutants.

R *These suggestions will be brought to the attention of the monitoring sub-committee for consideration, as recommended.*

2. Specific suggestions for improving the 2000-01 report:

C-4 2.1 The program objectives are described only indirectly through the short-term and long-term objectives the Monitoring Subcommittee had adopted. While the goals of "identification of available monitoring program elements..." etc., are worth mentioning in the background section, the don't say much about the specific goals of the monitoring program. If the monitoring program was designed to 1) characterize water quality (based on what indicators?); 2) assess the biology; 3) assess long-term trends; and 4) compare results with compliance guidelines, then state so explicitly. The whole Objectives section is stated very awkwardly.

R *The Monitoring Sub-Committee is in the process of revising its goals and objectives. The referenced text in the Annual Monitoring Report will be updated when the revision process has been completed.*

C-5 2.2 The possible monitoring approaches outlined in the Monitoring Program Description are worth elaborating on, since the chosen mix may not be the optimal way of meeting the program objectives. For example, if you had very specific reasons to select a deterministic sampling design, then say so and elaborate. In most cases, the word "characterization" means that you'd like to use your sample set as a predictor for the watershed as a whole. Right now, you are only able to draw inferences about the individual sampling stations you picked, rather than the watershed. A paragraph or two briefly describing the rationale behind your choice of deterministic sampling in space and time (which makes a lot of sense in some cases and not in others) might be in order.

R *The monitoring approach used was selected as the best available means to achieving the SRWP's overall goals and objectives and also because it was the most compatible with the monitoring approaches used by other major programs in the watershed. This* *information will be added to the text. Note that sampling locations were selected to allow some reasonable inferences about the contributing drainages. However, the intent of this section isn't to document in detail the decision making process.*

C-6 2.3 Page 22, last paragraph: The imprecision inherent in the trophic level proportions doesn't justify stating the percentages as 21.7%. I'd round those numbers.

R *I agree, but rounding up those values results in a total of 101% for the three trophic levels, so the values were used as reported in the USEPA document referenced.*

C-7 2.4 Page 35. The OEHHA web site is www.oehha.ca.gov.

R *I checked the web site again, and www.oehha.org is correct. Going to the www.oehha.ca.gov address actually transfers you to the www.oehha.org web site.*

C-8 2.5 Page 65. Pesticide concentration data are used as an implied indicator of potential impairment. However, the toxicity data are not placed in the context of concentration data in the section of Attainment of Beneficial Uses and Potential Impairment. Although the co-occurrence of toxicity and concentrations of a particular compound or compound group above threshold levels doesn't show causality, it nevertheless deserves some discussion.

R *Coincident toxicity and frequency of elevated concentrations are very briefly discussed for Arcade Creek in the Aquatic Toxicity section. A recommendation to better integrate these elements in future reports will be provided to the Monitoring Sub-committee.*

C-9 2.6 Page 67. The grouping of mortality and reproductive effects in the Spatial and Temporal Patterns section is confusing. Subheadings of "Mortality" and "Reproductive Effects" might alleviate this problem.

R *This was addressed as recommended.*

C-10 2.7 Page 69. The Conclusions and Recommendations don't clearly outline alternative hypotheses to the reduced frequency of episodic aquatic toxicity. A table showing concentrations during and after runoff episodes in various years combined with total pesticide mass applied in the watershed and specific tributary watersheds may reveal that the lack of more frequent toxicity occurrences may not be related to total rainfall.

R *The analysis you suggest may result in some additional alternative hypotheses for consideration and possible testing. Unfortunately, the SRWP monitoring program was not designed to provide that level of detail for any specific monitoring event, and DPR's Pesticide Use data generally are not available until long after the analysis for the SRWP Annual Monitoring Report must be completed.*

C-11 2.8 Page 97. How were the sites for bioassessment sites selected? What criteria were applied?

R *Bioassessment monitoring locations were selected based on a strategy to rotate monitoring into new tributary watersheds on a two year cycle. This strategy was developed as a compromise between the need to provide baseline information in tributaries throughout the watershed, and the need to provide longer term and more in-depth monitoring data for individual tributary watersheds. Selection of specific tributary watersheds was also coordinated with other bioassessment monitoring performed by DWR and USGS. The specific locations within each tributary watershed were selected to provide the broadest coverage, and specific stream reaches and transects were selected as specified in the California Stream Bioassessment Procedure (CDFG 1999).*

C-12 2.9 Page 98. For the uninitiated, it might be useful to provide a bit more background on how habitat characteristics considered "normal" for different gradients and elevations relate to calculating the BMI score. I assume the score is normalized to substrate diversity and other factors considered normal for stream reaches at various elevations and gradients.

R *In fact, the habitat quality assessments and BMI scores presented are not normalized for different habitat characteristics such as elevation and gradient. This is essentially what the development of reference conditions and biocriteria is intended to provide, and why the SRWP is supporting their development. However, until those benchmarks are developed for the Sacramento River watershed, we can only calculate relative BMI and habitat scores that are not adjusted for specific habitat characteristics.*

C-13 2.10 Page 100. Conclusions and Recommendations: What about Arcade Creek? Was "potential impairment" derived from the lab tox tests with experimental animals confirmed with the BMI?

R *As stated in this section, we can't effectively determine impairment from the bioassessment data in the absence of reference conditions and criteria, but the low scores for Arcade Creek tend to support an assessment of "impaired" in combination with the toxicity and chemical data for this site. It was noted in the previous section ("Spatial and Temporal Patterns") that… "Arcade Creek (the waterbody with the most highly urbanized watershed) received the lowest relative BMI score in each of the four years monitored. This is consistent with the high frequency of mortality observed in aquatic toxicity tests with Ceriodaphnia at this site and the relative frequency of pesticide detections, and provides additional evidence that this waterbody is impaired."*

Revital Katznelson, State Water Resources Control Board (Comments C14-C16)

C-14 The report is well-written and comprehensive as far as the data interpretation is concerned. I was deeply impressed with the ability of the writer to convey the meaning of the findings and the caveats of using them directly for decision making.

R *Comment acknowledged.*

C-15 Based on the structure of the report, I assume that the major objective for creating it was to convey that discussion, rather than provide the information needed for result interpretation. I understand that it is in the nature of such vast monitoring efforts to provide statistics, rather than results, because there is no way of printing the entire database.

R *You are correct. However, the data are available on request, and will be made available via DWR's IEP database.*

C-16 However, there is no real "Results" section, and the way the data is presented in the Appendices is not always helpful for data interpretation. The organization of data works well for fish tissue sample results because the sampling conditions and actual timing do not affect the measured values. However, when one looks at the pooled results of water quality parameters that change during the day, without knowledge of the time of day they were collected or whether it rained that day, one's ability to interpret the data is limited."

R *Some of the parameters that the SRWP monitors are known have significant diurnal variations (e.g. methylmercury, temperature, pH, and dissolved oxygen). However, the program was designed to evaluate water quality over longer time scales and the data were not collected with the intention of analyzing diurnal variation (virtually all of the data have been collected during daylight hours). Nonetheless, for someone interested in pursuing this analysis, sampling times are available with the rest of the monitoring data. The program has begun to focus on the effects of rainfall events by shifting to a more event-driven monitoring strategy, and relevant information about rainfall events will be considered when analyzing data for future reports.*

Andy Gunther, Applied Marine Sciences (Comments C15-C63)

C-17 Per your request of April, 17, 2002, I have reviewed *The Sacramento River Watershed Program Annual Monitoring Report: 2000-2001*. This document clearly represents the work of many investigators and cooperation by many stakeholders, and all involved should be proud of their accomplishments. It is only through the gathering and analysis of monitoring information that we will be able to track the status and trends of important characteristics of the Sacramento River watershed.

I have divided my comments into general and specific comments. I hope these comments are useful as the SRWP continues its important work.

R *Comment acknowledged.*

General Comments

C-18 1. It is not apparent from the report whether the findings are considered a problem or not. For example, the conclusion from the pesticide monitoring that "…repeated significant exceedances of these values [advisory criteria and toxicity thresholds] are considered as an indication of potential impairment of beneficial uses" is rather ambiguous. Similarly, the report indicates concentrations of contaminants in fish tissue that exceed regulatory limits designed to protect human health are not an indicator of impaired beneficial use, but rather an indicator of "potential impairment." The difference between a potential and an actual impairment should be make explicit. It seems to me these waters are clearly not "fishable," and are thus impaired. It seems vital that the regulatory agencies (or the monitoring subcommittee) come to agreement on what constitutes a "real" impairment in order to provide guidance to the SRWP and meaning to the monitoring data. Is it the position of the USEPA and the Central Valley RWQCB that the presence of toxic compounds in fish at concentrations above criteria designed to protect human health is not a problem requiring remediation? If so, I think this needs to be carefully explained. Either comparing monitoring data to standards is meaningful to the public debate or it is not, and if the latter is true the SRWP should make more meaningful measurements.

R *This is a valid point and one that deserves more consideration by the Monitoring and Toxics Sub-Committees. The challenge here is in defining benchmarks of "actual impairment", in contrast to an exceedance of a specific regulatory limit. Currently, there is not even a well-defined regulatory process or policy for determining whether a waterbody is sufficiently impaired to be included on the 303(d) list of impaired waterbodies. The SRWP is confined to characterizing most waterbodies as "potentially impaired" with respect to beneficial uses (aquatic life, drinking water supply, sport fishing, recreation, etc.) because in most cases, it is in fact very difficult to establish whether an aquatic community is functionally impaired or whether water quality is limiting drinking water supplies, fishing, or recreational uses. Additionally,* *criteria and objectives are designed with a certain degree of "safety factor" so that occasional exceedances don't necessarily translate to actual impairment of a resource or beneficial use. That is why the SRWP treats exceedance of these regulatory limits as an indication of potential (rather than actual) impairment.*

C-19 2. The report mentions that the Central Valley RWQCB and the USEPA have listed many water bodies in the region. It is not clear if the listings (described on p. 3 and other places) have informed the selection of sampling sites or parameters. Given the goal of assessing "the degree to which beneficial uses are attained," it would seem imperative that the SRWP make measurements that provide definitive information that can be used to assess the validity of these listings over time.

R *The Monitoring Sub-Committee does consider whether and why water bodies are listed on the 303(d) list when selecting monitoring locations and parameters.*

C-20 3. In general, I found the document to be rather wordy and thus difficult to read. The authors frequently offer extraneous information that lengthens the discussion, and I suggest subsequent documents be more carefully edited. For example, the detailed description of the evolution of the monitoring sites and contractual responsibility (p. 5) are not really germane to the objectives of the report. This is an important public record, but could be part of an appendix. Another example is the discussion of monitoring results in the program overview section.

R *Comment acknowledged. These recommendations will be considered for future annual reports .*

C-21 4. There were many instances in which a statement on one page is inconsistent with a statement a page or two later, and I've highlighted these in my specific comments below. These instances are not necessarily contradictions, and may just need word-smithing to make the language more clear. However, as a reader I found them very confusing.

R *Comment acknowledged.*

C-22 5. The Executive Summary would be more effective with succinct statements of findings, rather than the lengthy descriptions in the present draft. Why include all the discussion on p. v about the disagreement regarding between agencies regarding the issuing of health advisories if you can make the statement on p. vi that "…there are potential human health risks associated with consumption of fish from these waterbodies." The Executive Summary also contains references to many place names that I was unfamiliar with, and it would have been helpful to at least include a reference to one of the map figures.

R *A reference to Figure 1 was added, as recommended. The level of discussion was retained in the Executive Summary at the request of a number of previous commentors who preferred more depth in the executive summary, rather than less.*

Your recommendation to simplify this section will be presented to the Monitoring Sub-committee for reconsideration.

C-23 6. The data review sections start with a presentation of available data that normally go back earlier in time than the 2000-2001 program, but these earlier data are frequently not discussed. There's no need to include them if they are not going to be discussed, and if they are going to be discussed the reader should be assured that the data are comparable (collected/analyzed by similar or intercalibrated methods).

R *Earlier data are included in the database and in summary statistics, even when not explicitly discussed. A statement was added explaining that data from other studies were considered comparable because they were collected using similar methods.*

C-24 7. It is great to see the QA data reported in Appendix D, and to see the QA/QC procedures summarized in Tables 2a-6. I did not see any mention of analysis of standard reference materials in order to determine measurement accuracy. This is a very important quality control sample that should be added to the program or reported.

R *Although some of the laboratories do analyze SRMs on a regular basis, those SRM results were not included in this QA review. We will request that SRM results are provided with future laboratory reports, for summary in the SRWP Annual Monitoring Report.*

Specific Comments

C-25 p. vii-viii The statement at the bottom of p. vii that OP pesticides have the greatest potential for impacts is somewhat at odds with the statement on p. viii that monitoring should be increased for pyrethroids, pyrethrins, and other pesticides, given that OP use is dropping.

R *I disagree. OP pesticides are still far more widely used than pyrethroids, etc., and have been demonstrated to be present in Sacramento River watershed surface waters at concentrations expected to cause toxicity to test organisms, and have been demonstrated to be the causative agent in samples causing toxicity to test organisms. Although the potential is there, I don't believe that the case for pyrethroids is nearly as strong or conclusive, thus the recommendation for increased monitoring and studies focused on these other pesticides.*

C-26 p. viii-ix The introductory discussion of parameters of concern does not mention coliform as an important measurement, but then results are reported. It is hard to determine from the discussion on p. ix if the SRWP thinks that the bacteriological measurements are indicative of problems or not. The strong statement that the data suggests "achievement of designated beneficial uses" is followed by much discussion about uncertainty. While such a discussion is valuable and honest, I think the report would be stronger if it included findings such as "based upon the best available indicators" beneficial uses are being achieved or they are not.

R *Coliform bacteria are considered to be in the "drinking water parameters of concern" group, based on their role as pathogen indicators. It is stated in the text that the locations monitored "… consistently meet water quality goals and objectives…", but it will be clarified that the numbers of coliform bacteria observed do not indicate impairment of drinking water or recreational uses. Your recommended language ("…based on best available indicators…") is an improvement and will be used where appropriate.*

C-27 p. 1 The first short-term objective, identification of the monitoring goals and future uses for the data being collected, seems backwards. Shouldn't you first identify the goals and uses for data before you spend money on collection and analysis? If not, it is easy to end up with a lot of valid scientific measurements that are not relevant to policy questions.

R *Identification of the monitoring goals and future uses for the data was done prior to designing the monitoring program and collecting data.*

C-28 p. 3 It might be worth using the concept of water quality standards here, which encompass both beneficial uses and water quality objectives.

R *Addressed as recommended.*

C-29 p. 3-4 In describing the monitoring approach, the programs goals and objectives are not mentioned. Instead, four alternate approaches are described and one is "ultimately" selected. While the selected approach seems most closely related to the programs goals as described earlier, this discussion would be much more compelling if the approach was derived from the goals and objectives.

R *It was clarified that the approach was selected as the best means of achieving the monitoring goals of the program.*

C-30 p. 5 The addition of "smaller tributaries" (Mill, Big Chico, Deer) and the bioassessment sites is not consistent the with approach from p. 4 of focusing on major tributaries.

R *This approach is described as the starting point and allows for expansion of the program to new locations and parameters.*

C-31 p. 6 The fact that many constituents and sites were discontinued due to "budget constraints" left me wondering how much I should rely upon the discussion of the approach previously presented. Clearly, there were many changes between Year 1 and 2000-2001 – were these all consistent with the approach? Did these changes allow the program to more effectively achieve its objectives ("adaptive" management)? I think in the future a more integrated description of how the program has evolved to more effectively achieve it's objectives, rather than a chronological recitation of changes, will make for a more useful presentation.

R *Changes made in the monitoring program were always prioritized by considering the goals of the program and the overall approach, even when those changes were required by decreases in the monitoring budget. Your recommendation will be provided to the Monitoring Sub-Committee for consideration for future annual monitoring reports.*

C-32 p. 7 The word "level" is not a synonym for concentration. Presentation of results (in toxicity section) should be avoided in the program overview.

R *"Level" will be changed to "concentration" throughout the document. No results were presented in this section, only discussion of measurements collected.*

C-33 p. 8 What is a "log of *Giardia*"? Are coliform not a standard considered by agencies?

R *"Log of Giardia" is the language used in the regulation cited. The term will be replaced with the appropriate percent removal in the report text for clarity. USEPA criteria and Basin Plan objectives for coliform bacteria are considered in the Drinking Water Parameters of Concern data review section.*

C-34 p. 14 At the top of the page the data review is described as being for 1994-2001, but in the middle of the page it is "review of data from the 2000-2001" program. Which is correct?

R *Summary statistics and data reviews consider data from 1994-2001, but the focus of the report is on the data measured during the 2000-2001 monitoring effort. This was specified in the text.*

C-35 p. 15 Concentrations above "safe levels" do not constitute impairment of the biological integrity of the water body? What's the purpose of the standards if they don't signal impairment? How do you decide when fish tissue concentrations are meaningful indicators of impairment?

R *As explained in the text, "safe levels" are not the same as "effect levels", i.e. exceedance of these thresholds (e.g. USEPA criteria and Basin Plan objectives) doesn't necessarily translate to adverse effects and use impairment. However, water and fish tissue concentrations below regulatory thresholds can clearly indicate that uses are not being adversely impacted by the specific parameter measured. Determining the precise fish tissue concentrations as meaningful indicators of impairment is an issue difficult to reach consensus on. The SRWP has not defined fish tissue concentrations that constitute impairment, and at this time, even the regulatory* *agencies involved (OEHHA and the Regional Board) don't necessarily agree on the amount of evidence needed to determine impairment for the 303(d) list or to issue fish consumption advisories. The best we can do at this time is recognize that fish tissue concentrations greater than specific screening values and criteria are an indication of potential human health risks, which are of course dependent on the frequency, amount and variety of fish eaten, as well as the location of capture. If the SRWP decides on more precise indicators and thresholds of impairment, these will be defined and used in the review of data.*

C-36 p. 15 The statement that a "high percentage of data [are] below detection" requires more discussion. Is this because the program has low detection limits and thus there appear to be low ambient concentrations, or is it because the program has high detection limits?

R *The statement is one of several general conditions limiting more rigorous statistical analysis of spatial and temporal trends. In general, analytical methods were selected to provide meaningful data for the program and data below detection indicate that ambient concentrations are low relative to concentrations of interest (such as regulatory limits).*

C-37 p. 15 *et seq*. I could not find a discussion of how the fish samples were analyzed. Were these whole fish, only muscle, with skin on or off? This is vital information for comparative purposes.

R *Information was added specifying that in all cases, values are for muscle tissue with skin off, as appropriate for comparison to screening values and criteria. The specific methods used to collect the data are documented in more detail in the SRWP QAPP referenced throughout the document.*

C-38 p. 23 A brief definition should be given of trophic level 3 and 4 in the text. I found this only in footnotes to Table 8b.

R *Comment addressed as recommended.*

C-39 p. 28, para 2 I note here the indication that the CVRWQCB used "a more conservative approach in determining impairment." Don't they set the standard for determining impairment? If there is another "less conservative" process for assessing impairment, it should be described.

R *"More conservative" is relative to approaches described previously in the same section. This was clarified in the text.*

C-40 Para 3 "….levels of potential concern." What does that mean? I note at the end (p. 29) a need for further evaluation is identified, so I assume that is what one does with "levels of potential concern." This conclusion should go up front in this section, and then the rationale for the conclusion is described.

R *"Levels of concern" was replaced with "…frequently exceeded screening values". I believe the conclusion is more appropriately left at the end of this section.*

C-41 p. 31 This presents a nice source assessment for mercury.

R *Comment acknowledged.*

C-42 p. 32 para 1 Be careful about making conservation of mass arguments for a nonconservative pollutant. I'd put the qualifying sentence up at the beginning of the paragraph.

R *Comment addressed as recommended.*

C-43 p. 33 para 1 An alternative explanation is that the fish accumulated mercury from another location. I don't see how that hypothesis is ruled out based on the information presented.

R *Your suggested alternate hypothesis was included as a potential explanation for the observed differences in fish tissue and water column mercury concentrations.*

C-44 p. 33 The discussion of methylmercury should include consideration of dissolved oxygen concentrations, as it is my understanding that methylation increases with decreasing DO.

R *Correlations between DO and methylmercury concentrations were not explicitly evaluated. While methylation in sediments does vary in response to DO concentrations, the DO concentrations in the water column generally are not expected to get low enough to significantly affect methylation in the surface waters monitored..*

C-45 p. 34 How were measurements below the limit of detection (mentioned on p. 15) dealt with when calculating average concentrations? Could the "massive spikes" account for the majority of loading? Has a "massive spike" every been quantified?

R *Concentrations of total unfiltered mercury in the waterbodies considered are virtually never below the detection limits for the analytical method used (EPA 1631 or equivalent). For parameters that do have concentrations below analytical detection limits, summary statistics presented in this report were estimated using the method of Helsel and Cohn (1988), which uses probabilities adjusted for the proportion of data below detection to calculate unbiased estimates of the typical parametric statistics (mean, standard deviation, etc.). This information will be added to the explanation of Data Review methods.*
Simultaneously occurring peak flows and high mercury concentrations ("massive spikes") probably do account for the majority of loading. Examples of these loading episodes have been quantified in the Sacramento River and tributaries by other studies, but characterization of those episodes is not the goal of the discussion.

C-46 p. 38-39 I don't see what the regression lines provide in the figures, other than to make them more difficult to understand. The relationships are not really used in the discussion, and no indication is give as to whether these relationships were statistically significant. Also, the standards should be presented with lines of much smaller weight on all graphs.

R *The regression lines are provided primarily to illustrate the consistent nature of the relationship between length and tissue mercury concentrations, as indicated on page 22, paragraph 1. Since the relationship between length (as a measure of age) and bioaccumulated mercury is well-established, no attempt was made to demonstrate statistical significance of the relationship. The line weights of criteria and screening values are purposely heavy to distinguish them from other features of the graphs.*

C-47 p. 45 "Evaluate predicted attainment of beneficial uses" – what does that mean?

R *"Predicted" is unnecessary and confusing here and was deleted.*

C-48 p. 45 I would put up front the statement that there are many pesticides not monitored (statement currently on p. 51)…indeed, isn't this an important reason the SRWP also performs toxicity testing?

R *Agreed. Comment addressed as recommended.*

C-49 p. 48 As was the case in earlier sections, the "available data" overview includes data that are not included in the analysis

R *Please refer to the response to comment C-23.*

C-50 p. 52 para 1 reference to Table 14 is to Table 13, I think.

R *You are correct. Text has been corrected.*

C-51 p. 53 top The statement about diuron seems to be inconsistent with the first paragraph under carbamate pesticides on p. 55. What about additive or synergistic effects among pesticides and their potential to impact beneficial uses in this manner?

R *The statement is not incorrect, but will be clarified.*

C-52 p. 57 para 1 I think the CALFED ERP is funding USGS to work on methods for pyrethroid pesticides as well.

R *Acknowledged.*

C-53 p. 58 para 2 "agricultural land use, there may <u>be</u> a significant potential…"

R *Corrected as recommended.*

C-54 p. 65 Is not a violation of a narrative water quality objective constitute an impairment? Table 17 indicates that waterbodies were listed due to toxicity of surface waters. Doesn't that mean that toxicity is considered an impairment, not a "potential" impairment?

R *As discussed earlier, there really isn't a specific regulatory (or SRWP) definition of what constitutes "impairment" of a waterbody, i.e. specifically what qualifies a waterbody for inclusion on (or removal from) the 303(d) list. The Regional Board and SRWP both use toxicity to test organisms as a reasonable surrogate for in situ toxicity to resident species in surface waters, but demonstration of toxicity under laboratory conditions is of itself not sufficient to demonstrate impairment of specific beneficial uses (e.g. support of aquatic life and ecosystems, sport fishing, etc.) under natural conditions. Occasional excursions above water quality objectives and infrequent toxicity are generally not considered adequate reason to characterize a water body as impaired, but exactly how bad is bad enough has not been defined. Until a more precise definition of "impaired" is developed, the Annual Report will continue to characterize these as evidence of potential impairment to beneficial uses.*

C-55 p. 67 first bullet Clarify what "significant" means in this context. I believe it is referring not just to statistical significance, but to a greater than 20% difference between control and treatment. The latter is a much more compelling standard for data interpretation.

R *Comment addressed as recommended.*

C-56 p. 68 para 2 The text says there was no watershed wide pattern of toxicity, yet p. 67 states that 39% of samples from Redding to Freeport caused reproductive toxicity. These two statements seem inconsistent.

R *The text on p.68 (first full paragraph) refers to a widespread temporal pattern of toxicity observed in the winter of the previous monitoring year that was not observed in 2000-2001. The discussion on p.67 (third bullet) refers to the overall frequency of toxicity observed at four specific mainstem sites in 2000-2001, and is not characterized as watershed-wide or as being any kind of a seasonal or other temporal pattern.*

C-57 p. 68 para 5 If the SRWP does not have the funds to determine if toxicity exists in waters of the State, isn't that the same this as saying we can't afford to determine if beneficial uses are being achieved? That is an important conclusion about the scale of the problem compared to the scale of resources provided.

R *Comment acknowledged.*

C-58 p. 76 para 2 "Potential impairment" is defined, but what about an actual impairment?

R *See responses to comments C-13, C-18, C-35, and C-54.*

C-59 p. 80 para 2 Here is a clear interpretation about whether beneficial uses are impaired or not. It is clear that it is much easier for the SRWP to make findings of no impairment than to make findings of impairment.

R *Comment acknowledged.*

C-60 p. 86 Setting concentrations below the limit of detection (LD) to one-half the LD for purposes of calculation is a standard method, but sensitivity of your calculated values to this assumption should be tested by setting the concentrations below the LD to the LD and to zero. This gives you a range that certainly includes the actual value.

R *Comment addressed as recommended.*

C-61 p. 87 para 3 Same comment as for p. 80 above.

R *Comment acknowledged.*

C-62 p. 98 How were the bioassessment sites selected. How does the SRWP know these are representative locations?

R *See response to comment C-11.*

C-63 p. 107 Why is the SRWP reducing monitoring to six events in Year 4? Won't this make it more difficult to separate "potential" impairments from actual impairments, and reduce the programs ability to detect trends? Is this due to the fact that there is less money available? This needs more explanation.

R *You are correct. Reduction in the number of monitoring events will make it more difficult to evaluate achievement and impairment of beneficial uses. This is simply a response to program budget cuts made at the federal level, and the SRWP is working to obtain other sources of funding. The reason for the reduction in monitoring will be included in the text.*

Central Valley Regional Water Quality Control Board (Comments C64-C127)

Executive Summary

C-64 In addition to the general background already provided, the Executive Summary should refer to the data that should be reported and portrayed in the sections of the report. Results for this year should be reported, compared, and contrasted with previous SRWP coordinated monitoring efforts.

R *It is too cumbersome and impractical to present all of the data within each data review section. All of the SRWP data are reported as summary statistics and time series plots in the report appendices. It is generally not the intent of the report to compare one year's data with the previous year's data.*

C-65 This section needs a paragraph describing the 9 monitoring events that were chosen for this year, and the rational for choosing those monitoring events. A brief description of the sites would also be useful (i.e. total number, mainstem vs. tributary, east vs. west, etc.).

R *Most reviewers felt that the Executive Summary section was already overly long and detailed. Details of the monitoring program are included in the Program Overview section and in the individual Data Review sections.*

C-66 **Page vi, par. 2:** It would be helpful to the reader to define "consumption-weighted average mercury concentration" in a footnote because this an unusual phrasing. (The reader is forced to go to a later section in the report to learn how a "consumption-weighted average" differs from an "average" concentration.)

R *Addressed as recommended.*

Table of Contents

C-67 Chapter II is missing a "B" section.

R *Sections were re-numbered.*

Program Overview

C-68 Page 4, first paragraph. Typo "havealso".

R *Addressed as recommended.*

C-69 **Page 3.** Delete last objective "Coordinate with pilot study…"

R *Addressed as recommended.*

C-70 **Page 6.** Typo – second bullet should be split into two separate bullets – one for bioassessment and one for mercury.

R *Addressed as recommended.*

C-71 **Page 6, par. 4:** Create a separate bullet for the description of the mercury monitoring changes.

R *Addressed as recommended.*

C-72 **Page 6, par. 8:** The location counts in this paragraph do not appear to correspond to Tables□ and 3.

R *Counts were corrected.*

C-73 **Page 9, bottom of page.** "Pesticides of concern to aquatic life in the Sacramento River system include organophosphate (OP), carbamate, and triazine pesticides" – wording should be changed to indicate that these are not the only pesticides of concern to aquatic life in the Sacramento River system. Rather these pesticides were selected to be monitored based upon earlier data that indicated a problem to aquatic life including 303d list, etc,. It should also be noted that there are many other pesticides (including pyrethroids) that are or are suspected of being of concern to aquatic life in Sacramento River system that we are not monitoring for as part of this program.

R *Addressed as recommended.*

C-74 **Page 13.** Describe the 9 events that were chosen for 2000-2001. Explain why they were chosen. Did the switch from monthly to event-based monitoring improve our understanding of the health of the Sacramento River watershed? How? For which parameters? Consideration of the 9 monitoring events should also appear in the parameter-specific discussions. Did we learn anything from monitoring during these events that we otherwise wouldn't have known?

R *Additional details of the monitoring schedule were added. The impact of switching to event-based monitoring is discussed in the appropriate Data Review sections (Pesticides and Aquatic Toxicity).*

C-75 **Page 13.** References to "monthly" sampling are inconsistent with the 9 events that were sampled in 2000-2001.

R *Text was corrected.*

Data Review

C-76 The data evaluations provided in the 2000-2001 SRWP Monitoring Report would be improved by a more comprehensive analysis. There should be a summarized representation of these data in each section available for the reader, within the text. The summary statistics in the appendices provide very little useful information for most parameters monitored and should not take the place of a more detailed representation and discussion of the data. We recommend that tables be included within the text containing the data in a summarized, but substantive manner. It is understandable that this is a difficult task given the relatively sparse data sets available and the many other issues related to methods, QA/QC, and other. Therefore, it would be more appropriate to report a lesser level of detail on previous studies not conducted in coordination with the SRWP. However, this is the third year of the SRWP monitoring report and the data collected and coordinated through SRWP for each of those monitoring seasons should be reported and discussed in high level of detail. This high level of detail is currently lacking from the report.

R *Comment acknowledged. See response to comment C-64. The level of detail currently included in the Annual Monitoring Report is considered appropriate for the objectives of the SRWP. Your recommendation for additional detail will be provided to the Monitoring Sub-Committee for consideration for future Annual Monitoring Reports.*

C-77 To improve consistency and readability, we recommend that each section within this chapter begin with:

- Table of SRWP sites, site codes and monitoring frequency for the parameter discussed.
- Map of (at least) the SRWP sites monitored for this parameter.
- Each section should start on a new page.

R *Maps of locations and site codes were provided in the sampling location figures immediately following the text of each section. Monitoring frequencies are provided earlier in the report and are not reiterated in each section. Each section now begins on a new page, as recommended.*

A. Mercury Data Summary

C-78 **Page 19, par. 3:** We recommend contacting Phil Woods to determine whether his comment dated 1999 regarding potential future human health criteria for mercury in water of 2-5µg/L reflects the current situation. USEPA may promulgate a fish tissue criterion for the CTR.

R *The Phill Woods reference was deleted. Discussion of the fish tissue criterion is included in the section.*

C-79 **Page 23, par. 2:** Indicate that Figures 3 and 4 present the largemouth bass and white catfish data tissue concentrations, and that Figure 5 presents data for other species – for individual samples rather than species averages (which are presented in Table 8).

R *Addressed as recommended.*

C-80 **Page 24, par. 1:** The authors must cite the source of their consumption-weighted average equation and note that the Trophic Level (TL) 3 and 4 percentages ultimately should be adjusted based on site-specific consumption information. This is critical because the inappropriate selection of TL proportions can either indicate an impairment where there is none, or conceal an existing impairment. For example, if we assume that people are eating 50% TL 4 species (which typically have higher levels of mercury) when they are actually eating 75% TL 4 species, we may conclude "no impairment" when there actually is an impairment. The authors used the TL 3 and 4 proportions used by the Lake Bennett (Georgia) TMDL (56.6% and 43.4%, respectively). However, as noted in Table□, the USEPA 2001 methylmercury criterion assumed TL 2, 3 and 4 proportions of 21.7%, 45.7%, and 32.6%, respectively. The USEPA 1995 Great Lakes criterion assumed TL 3 and 4 proportions of 25% and 75%, respectively, and the Clear Lake (California) TMDL criterion assumed TL 3 and 4 proportions of 30% and 70%, respectively.

R *Addressed as recommended.*

C-81 **Page 23-28, Table 8 and related text:** The authors state, "… in a TMDL developed in Georgia, USEPA Region 4 compared the consumption-weighted average directly to the fish tissue-based water quality criterion for methylmercury (0.3 mg/kg) to evaluate whether a waterbody should be considered impaired (USEPA 2001b)." However, as Table 8 indicates, SRWP water bodies were grouped into 5 categories by type (ag drains, major tributaries, <smaller> tributaries, Sacramento River from Keswick Dam to I Street, and Delta). This type of grouping is adequate for determining general similarities/differences between categories, but **not** adequate for determining whether a given waterbody is impaired because the "waterbody type average" calculations conceal the variability between the individual water bodies. To identify the potential level of impairment, average mercury concentrations and consumption-weighted averages should be calculated for each waterbody, and for large water bodies, physically and ecologically different segments should be evaluated independently. We recommend that the agricultural drains, tributaries, and Delta water bodies be evaluated independently rather than grouped, and that the lower Sacramento River be divided into at least two segments (e.g., (1) Keswick Dam to Hamilton City and (2) Colusa to I Street). The first two bullets on page 24 indicate that average mercury concentrations were calculated for each species from each water body, but that information does not appear to be included in Table 8 or elsewhere in the report. (Figures 3-5 present concentrations for individual samples, not species averages.)

R *The following text addressing these issues was added…*
" …although the consumption-weighted average should ideally be calculated separately for each waterbody, there were insufficient data to perform these calculations for each location and waterbody. However, species average concentrations were similar within each defined waterbody category, so grouping the locations within these broad waterbody categories appeared to provide characterizations that were also reasonable for the individual waterbodies."

Average concentrations for each waterbody were added in Table 8a, as recommended.

C-82 **Page 25, Table 7.** Please check the reference dose used to develop the USFDA Action Level of 1.0 mg/kg. In an article by Kate Mahaffey (USEPA, principal author of the Mercury Study Report to Congress), she states that the acceptable daily intake level used by USFDA was 0.4 micrograms/kg bwt/day (Public Health Reports 114:397-413, Sept/Oct 1999). If that is the case, the corresponding consumption rate used by USFDA would be around 24 g/day. The USFDA Action Level was issued when much less information was available regarding toxicity of methylmercury.

R *The RfD and consumption rates were corrected.*

C-83 **Page 27, par. 2:** The authors should note that the SWRCB/Regional Board used a slightly more conservative method to determine impairment using fish tissue concentrations. As described in the Central Valley Regional Board's *Final Staff Report on Recommended Changes to California's Clean Water Act Section 303(d) List* (Appendix A), "In evaluating mercury fish tissue data, staff compared the average concentrations in fish tissue samples of top trophic level fish (trophic level 4 fish – including mostly bass and catfish) to the US EPA human health criterion of 0.3 ppm. Concentrations of mercury in trophic level 3 fish (trout, suckers, carp, pikeminnow, etc.) were used when there were limited data on trophic level 4 fish. This approach is conservative since people may eat a mix of trophic level 3 and 4 fish. On the other hand, the US EPA default consumption rate may not be representative of fishing populations in Central Valley waters (i.e., consumption rates may be higher in the Central Valley). In calculating the average concentration, staff calculated a weighted average based on the number of fish in the composite sample analyzed." In addition, in general staff did not list water bodies if only one or two samples of a given species (e.g., Colusa Basin Drain and Natomas East Main Drain) were available at the time of the 303(d) List evaluation.

R *Addressed as recommended.*

C-84 **Page 27, par. 3:** The authors state, "These same data also indicate that potential health risks are lower for the Sacramento mainstem from Keswick to River Mile 44 … and for most smaller tributaries throughout the watershed, for consumers of a mix of trophic level 3 and 4 fish." Would the authors' observation change if (1) different TL 3 and 4 proportions were used in the consumption-weighted average calculations, or (2) the water bodies were evaluated independently rather than grouped?

R *Text was added to address these issues, as recommended.*

C-85 **Page 31, par. 3 line 6:** Methylmercury concentrations in fish tissue may also depend upon the eutrophic versus oligotrophic nature of the water body. For a reference, consider that oligotrophic lakes in the Canadian shield typically have much lower concentrations of total mercury in sediment and water but higher fish concentrations than in the west. Also see the recent Everglades study report (Stober et al. 2001, USEPA Region 4 Report 904-R-01-002).

R *Text was added to include oligotrophic and eutrophic characteristics as potentially significant factors influencing methylmercury in fish.*

C-86 **Page 34, par. 2:** The authors state in the middle of the second paragraph, "There is some disagreement whether the available data are adequate to warrant issuing fish consumption advisories, and OEHHA has not issued advisories for these <Sacramento River below Shasta Reservoir and major tributaries to this section of the river> waters. However, the Central Valley Regional Water Quality Control

Board has recommended addition of a number of water bodies to California's 303(d) list based on much less information than evaluated in this document. … Although there also continues to be substantial scientific disagreement about the actual level of risk posed by these concentrations of mercury in fish, there is … ." The authors did not describe any "disagreements" earlier in the report. Therefore, it is inappropriate to include any mention of "disagreements" in this "Conclusions and Recommendations" section. (Note, such unsubstantiated text was not included in the 1999-2000 report.) In addition, as noted above, Regional Board staff used a more conservative evaluation method than did the authors, and reviewed all available data to recommend additions to the 303(d) list. Also, please clarify the phrase "much less data". Regional Board staff evaluated data from water bodies individually for each potential listing. Is there that much more data in this report per water body than was used for evaluation of potential listings? (Note, the authors of this report did not release the SRWP 2000 fish tissue data when the Regional Board staff formally solicited information for the 2002 303(d) list update in February 2001and in later (e.g., March – September 2001) informal communications.)

R *There clearly is disagreement regarding what constitutes adequate data for advisories, based on the fact that the RWQCB has identified waterbodies as impaired for which OEHHA has not issued advisories. The phrase "much less information" was changed to "available data". As noted in your comment, there is in fact more data evaluated for this report than evaluated by the RWQCB to determine impairment due to fish tissue contamination.*

C. Pesticide Data Summary

C-87 There are many generalized statements made with reference to the pesticide monitoring data from 2000-2001 and how it relates to toxicity threshold significance and beneficial use impacts throughout the Sacramento River Watershed. Although there are no examples of the raw data to support these generalized statements. We recommend that data tables be added to the text to support such statements.

R *A table of pesticides monitored and reporting limits was added (Table 11). As stated previously, it is not practical to include a full list of the results in each section, and summary statistics are provided in the appendices.*

C-88 Episodic monitoring goal for 2000-2001 – Given that the 2000-2001 monitoring program for SRWP shifted its' focus to an episodic, or event based, approach the report lacks any discussion related to the episodes monitored. We recommend that the report include discussion describing the episodes that were monitored and likewise not monitored. In addition, this discussion should include sampling station locations and pesticide concentrations/loads with reference to the episodes (rainfall patterns, flow, etc.). What events were missed? Where were they? When? Timing, magnitude, frequency, and duration of episodes need to be described.

Likewise, non-episodic monitoring by SRWP needs to be addressed as such and discussed in more detail with data available for the reader to view.

R *Additional text and a table describing monitoring events was added (Table 10b). The types of events* <u>*not*</u> *monitored are essentially unlimited and are not discussed. Note that the great majority of results for pesticides were below detection and therefore do not support estimates of loads. Also, the type of monitoring conducted by the SRWP (single grab samples for each "event") do not support estimates of duration or timing. Magnitude and frequency of detected pesticide concentrations are discussed and documented in the summary statistics in the appendices.*

C-89 Beneficial uses and potential impairment - No reference is made to the number of aquatic life criterion exceedances for pesticides that have such criterion developed. Although, relating observed pesticide measurements to toxicological endpoint data is useful for interpreting results in the report, there are no tables that show such raw data in the text. We recommend that a table indicating the timing, magnitude, frequency, and duration of exceedances of aquatic life criteria or toxicological data (LC50, etc.) at each site be added and discussed.

R *See response to previous comment C-88.*

C-90 How do these pesticide data from 2000-2001 relate both spatially and temporally to other and past monitoring throughout the Sacramento River Watershed? – We recommend that a better evaluation of the distribution and trends of pesticides be discussed in this report. Again, tables or charts portraying the data would be useful. Given that this is the third monitoring report there should be plenty of available data for discussion. Many questions are unanswered with respect to how this year's data compares to previous monitoring by the SRWP and other studies. It is understandable to report data from other studies in a general fashion. However, monitoring data collected through the SRWP should be discussed and portrayed in more detail for each year collected.

R *Spatial and temporal trends are discussed to the degree supported by the data. As stated previously, the predominance of data below detection limit simply don't support the type of analysis suggested in your comment. Additionally, it is not currently an objective to perform year to year comparisons of the data. However, your recommendations will be provided to the Monitoring Sub-Committee for consideration for future reports and for planning future monitoring efforts.*

C-91 The laboratory reporting limits and expected percent recovery for the pesticide scans used should be included.

R *Reporting limits are provided, as recommended. Acceptable percent recoveries are documented in the program QAPP and are not reiterated in the AMR.*

C-92 The raw data compiled for this report should be included. At a minimum, the raw data collected by the SRWP should be included.

R *See response to comment C-64. All SRWP monitoring data are available on request (clauss@lwa.com) and will eventually be made available on DWR's IEP website.*

C-93 The sources and period of data considered for this report should be more clearly defined.

R *Addressed as recommended.*

C-94 Table 10 is referred to as the source of data for this report, but table 10 has studies from the early nineties that were not included in the summary statistics.

R *That's correct. As stated in the report, summary statistics are calculated for data from the SRWP and primary coordinating program (DWR, the City of Redding, and the Sacramento River Coordinated Monitoring Program) for the period 1994 to the present. Data from earlier monitoring efforts are considered and discussed when appropriate, but are generally too sparse to warrant inclusion in the data sets used for calculating summary statistics.*

C-95 Although the reports are yet unpublished, the data from the USGS/DPR dormant spray monitoring for 99-00 and 00-01 are available and should be included. These data would allow mass load calculations.

R *These data were not made available. Calculation of pesticide mass loads may be considered in future reports if supported by the available data and warranted by other analyses.*

C-96 In the discussion of attainment of beneficial uses, there should be some mention of the pesticides not monitored by SRWP, since these represent a potential threat to beneficial uses.

R *Addressed as recommended.*

C-97 The comparison with the CDFG criteria for diazinon and chlorpirifos is not complete. Comparison to the CCC should be made for samples representing four days continuous concentration. Comparison should also be made to the chronic criteria.

R *Data are for instantaneous grabs, not for 4-day averages. Results are compared to available chronic criteria (CCC). There is currently no recommended CCC for diazinon.*

C-98 Since the Chlorpirifos and Diazinon criteria are expressed as exceedences not to be exceeded more than once every three years, in order to use these criteria to assess impairment, more than one year's data should be used.

R *With the exception of diazinon at Arcade Creek, the SRWP pesticide data do not support more precise or meaningful estimations of percent exceedances, due to the* *predominance of data below detection limits. Note that all the SRWP data are considered in these evaluations.*

C-99 Monitoring Design Suggestion: The DWR Tributary Monitoring program does not collect samples during the dormant spray season. Given the land uses in the watersheds to those tributaries, pesticide sampling during the dormant spray season should be given a high priority in these tributaries.

R *This recommendation will be provided to the Monitoring Sub-Committee.*

C-100 **Page 45, Table 10** does not include the monitoring done by the USGS Toxic Substances Hydrology Program in the early nineties.

R *These data were not considered. As stated previously, the primary focus of the evaluation is on monitoring data conducted since 1994.*

C-101 **Page 46**, the CDFG CCC for diazinon is 50 ng/l, not 51 ng/l.

R *Corrected as recommended. Note that if CDFG had followed USEPA guidance, the CCC would be correctly expressed as 0.53 µg/L.*

C-102 **Page 48, Table 11 –** Under the uses of Diazinon and Chlorpyrifos why is there a category for "Pest Control" and one for "Stonefruit" that essentially indicate the same uses on apricots, nectarines, peaches, plums, and prunes? Either Pest Control or Stonefruit should be broken up into individual crops or everything should go under the Stonefruit category. (Understandable if this is how DPR reported the usage data)

R *An incorrectly attributed footnote was corrected to clarify.*

C-103 **Tables 11 (Page 48) and 14 (Page 55)** are duplicative and should be combined.

R *Addressed as recommended.*

C-104 **Page 51, last paragraph,** it should be noted that these conclusions only apply to the water bodies that were monitored.

R *Addressed as recommended.*

C-105 **Page 56, last paragraph**. "Overall use of cholinesterase-inhibiting organophosphate and carbamate insecticides has declined over the last several years (DPR 2000a). In contrast, over the same time period, the total number of acres planted in fruit and vegetable crops and the total pounds of pesticides applied has increased in California. This suggests that there may be a general shift from organophosphate and carbamate insecticides to other categories of pesticides, such as pyrethroids." – These are confusing sentences that do not necessarily directly relate to each other. For example, how can you indicate the shift is suggested to pyrethroids when a pyrethroid application is about 1/4 to 1/8 that of an OP application, when total acreage planted increased? These do not suggest pyrethroid use increasing but rather some other pesticide increasing. We recommend that these sentences be edited to be clearer so that a reader unfamiliar with the pesticide shift would understand that the shift is likely a result of economics and pest pressure/resistance.

R *Addressed as recommended.*

C-106 **Page 57.** Mass loads of pesticides – "Mass loads of pesticides can not be adequately estimated, due primarily to the infrequent detection of pesticides in most water bodies" – This is an incorrect and misleading statement. "Infrequent detection" needs to be distinguished from "infrequent monitoring", lack of funds, or failure to completely characterize an episodic event or other situation, which would be needed to calculate a pesticide load and accurately interpret the results.

R *Addressed as recommended. Note that average mass loads to the Delta were to be calculated only if relevant and possible and neither of these conditions were met. Also, note that it is not necessarily an SRWP objective to calculate instantaneous episodic loads for individual waterbodies.*

C-107 **Page 58** "However, no pesticides were detected in limited SRWP monitoring of several smaller tributary watersheds in 2000-2001" – This is a misleading statement. Raw data are not available to view in support of this statement. We recommend that more detail be given to reader to support such a statement including: description of the tributary sites monitored, how often and dates monitored, episodic or not, and most importantly - the general land use of the tributaries and their relative percent of drainage basin to the Sacramento River Watershed. The table that includes such data would be helpful. Which sites and when were non-detections of pesticides encountered in the watershed?

R *The text was modified to qualify the reliability of conclusions that can be reached based on the limited monitoring performed. Descriptions of SRWP monitoring events and locations monitored were added in Table 10b. It is not necessary to present the raw data to make a summary statement that no pesticides were detected. Information regarding general land use characteristics of drainages characterized by SRWP monitoring locations may potentially be useful, but these are not easily obtained, and collection of this type data is currently outside of the scope of the Annual Monitoring Report. However, your recommendation to include this level of information will be provided to the Monitoring Sub-Committee for consideration for future reports.*

C-108 Page 50, Paragraph 2, Sentence 2—This sentence hints at the additive nature of diazinon and chlorpyrifos. Bailey *et al.* (1996) provides evidence that diazinon and chlorpyrifos do act additively. That publication needs to be cited here.

R *Addressed as recommended.*

D. Aquatic Toxicity

C-109 Page 60, Paragraph 1. This background paragraph only lists *C. dubia* and *S. capricornutum* as test species employed during the SRWP toxicity monitoring program. The toxicity monitoring initiated in 1996 included the fathead minnow, so the minnow needs to be included in this discussion.

R *Fathead minnow and S. capricornutum toxicity were not monitored in 2000-2001 and are not discussed in this report. They are discussed in previous SRWP annual monitoring reports.*

C-110 Page 60, Paragraph 5. The Nordmark and Gill studies were conducted under the Department of Pesticide Regulation. These studies should be listed similarly to the rice pesticide study on page 61.

R *Addressed as recommended.*

C-111 Page 61, Paragraph 2. For clarification, add "shrimp" in parentheses after *M. bahia* and "mussel" in parentheses after *M. edulis*.

R *Addressed as recommended.*

C-112 Page 61, Paragraph 4. This section indicates that CVRWQCB 2000 summarizes "data discussed in this document". CVRWQCB 2000 summarizes data from the 98-99 monitoring, not the 00-01 monitoring.

R *Text was modified to clarify, as recommended.*

C-113 Page 62, Table 16. Add a row to include the following information:

Program	Monitoring Period	Parameters	# of sampling locations
Regional Board/CALFED	9/00 – 8/01 (monthly)	• 4-day *Selenastrum* toxicity tests	8 sites in the Sacramento River watershed

R *Addressed as recommended.*

C-114 Page 63, Paragraph 3. Closing parentheses are missing after the word "*Selenastrum*". Remove the word "small" from sentence 2. Only significant differences in growth or reproduction are considered toxic effects.

R *Closing parenthesis was added as recommended. Text was added to specify "statistically significant differences", which can include small decreases in growth and reproduction.*

C-115 Page 63, Paragraph 3, Last sentence . This sentence needs to be expanded, as the de Vlaming (2000) article was significant in identifying the relationship between toxicity test results and ecosystem impacts. This information is important and should be one of the cornerstones of why the SRWP continues to allocate funds for toxicity monitoring.

R *The text was modified to read… "Although the link between significant effects in laboratory toxicity tests and ecosystem impairment has not been definitively established, some studies have established that there is a statistically significant relationship between laboratory results and ecosystem effects, most clearly for highly toxic point source discharges (de Vlaming* et al. *2000). For the purpose of the* *evaluations performed herein, it is assumed that toxicity to test organisms is an indication of potential impairment to aquatic species and ecosystems."*

C-116 Page 63, Paragraph 4, Last sentence . This sentence should read "The Toxicity focus Group of the SRWP has developed a strategy to address toxicity of unknown causes and has applied for CALFED funding to begin implementing the strategy."

R *Addressed as recommended.*

E. Drinking Water Parameters of Concern

C-117 Another potential threat to the MUN beneficial use is the taste effects of rice pesticides.

R *Text added as recommended.*

F. Organochlorines and PCBs in Fish Tissue

C-118 **Pages 93 and 94**. Figures 18 and 19 are flawed and in need of repair.

R *Addressed as recommended.*

H. Bioassessment

C-119 How were individual sites and reaches chosen, and why were they chosen? – this needs to be discussed.

R *See response to comment C-11.*

C-120 Was variability detected within a given reach? – this needs to be reported as well as other method based evaluations.

R *Data for variability within each reach sampled was added to the bioassessment data in Appendix C.*

C-121 Many generalized statements are made in reference to aquatic communities in the Sacramento River Watershed. Data tables are needed to support these statements. These statements include but are not limited to: "For the majority of sites, taxonomic richness and community diversity are described as high (relative to the possible range for these measures)", "Sensitive taxa were generally abundant at most sites", "Measures of tolerance to disturbance indicated that most of the communities in this dataset were intolerant to disturbance, with the exceptions of…" "The majority of sites evaluated had similar physical habitat characteristics and were considered to be good to excellent condition".

R *Additional data tables were added to the report and to the bioassessment data in Appendix C.*

C-122 Statements need to be clarified when reporting the condition of the "Sacramento River Watershed and/or tributaries" – the sites monitored should be described in better detail related to the land use, and other available stressor data, within each basin. In addition, it should be clarified in better detail that the tributaries monitored are not representative of the entire watershed and do not necessarily reflect the biotic condition of the entire watershed. Please provide data tables with the text.

R *Detailed data on land use characteristics and potential stressors have not yet been compiled by the SRWP for the locations monitored, and this effort is not currently within the scope of the Annual Monitoring Report. However, it is anticipated that the extensive land use analysis being performed by the Department of Fish and Game as part of the development of protocols for selecting reference conditions will provide very useful data of this type. Your recommendation will be provided to the Monitoring Sub-Committee for consideration for future monitoring and reporting. Regarding your request to present additional data, please see also responses to the previous two comments.*

C-123 The discussion and references related to the development of reference conditions should include – The actual sampling for the reference condition project, which was funded through the Central Valley Regional Water Quality Control Board, has begun in foothill ecoregion. In addition, the development of the framework for selecting reference sites, also funded by the Regional Board, in the Valley floor of the Sacramento River watershed is also underway.

R *Addressed as recommended.*

C-124 **Page 95**. "Data collected at non-wadeable sites were used to evaluate methodologies for sampling in deepwater sites". This evaluation was not reported in this report. Was it part of another program? This sentence needs clarification.

R *This text refers to an evaluation discussed in previous reports. It was deleted.*

C-125 **Page 96.** BMI Ranking Score – It is indicated that values from metrics 1,2,4,6,8,9 from Table 30 were used to calculate a relative BMI Ranking Score for each site. Why were these metrics chosen out of the all the others?

R *These are the metrics specified in the California Stream Bioassessment Procedure (CDFG 1999) used by the SRWP. The specific metrics were selected to provide a composite index that best differentiates between impaired and non-impaired sites through different measures of community structure and function.*

C-126 Page 98 middle of page. Typo – "imapirment".

R *Text was corrected.*

C-127 **Page 103, last par.:** Shouldn't Year 5 monitoring begin in June 2002 (not 2001)?

R *Text was corrected.*