Chapter 4, part C. WATER QUALITY

CALFED PROGRAM GOALS AND OBJECTIVES

The CALFED Bay-Delta Program's goal for water quality is to improve the quality of water of the Sacramento-San Joaquin Delta Estuary for all beneficial uses; including domestic, industrial, agricultural, recreation, and aquatic habitat. Providing good water quality for agricultural and industrial uses includes lowering mineral, nutrient, and metal concentrations in water such that the water is nontoxic and can be reused. The goal for drinking water quality is to reduce pathogens, nutrients, turbidity, and toxic substances in source waters to the Delta through watershed protection measures. In addition, bromide and organic carbon levels would be low enough to meet drinking water regulations. Good water quality for recreational use involves reduction of disease-causing organisms in the water and reduction in nuisance algal blooms.

Because water quality is intrinsically linked to ecosystem health, this section of the monitoring plan also addresses the CALFED Ecosystem Restoration goal of rehabilitating the capacity of the Bay-Delta system to support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities in ways that favor native members of those communities. The CALFED Watershed Management Coordination Program goal, to help coordinate and integrate existing and future local watershed programs and to provide technical assistance and funding for watershed activities, will be partially addressed by the water-quality-monitoring program.

The water-quality-monitoring program scope includes baseline, trend, effectiveness, compliance/mitigation and operations monitoring. The program addresses the programmatic water-quality actions outlined in the CALFED Phase II Report (11/98) (Table 4-2).

GOALS AND OBJECTIVES OF THE MONITORING PLAN

The goal of the water-quality-monitoring plan is to monitor water quality and associated physical and environmental variables to document the effects of CALFED Stage 1 actions on water quality and on the ecosystem (Table 4-3). A monitoring network will be established to evaluate the success of proposed CALFED Water-Quality Program Plan actions, to address or verify identified water-quality problems, and to assess trends, loads, and sources of important water-quality constituents. The major question, "Is Delta water quality improving?", will be addressed through this monitoring program.

Monitoring Principles—The water-quality-monitoring plan is based on several monitoring principles. To maximize the efficiency and effectiveness of monitoring, the monitoring plans are based on conceptual models (For example, see *Appendix VII.B.4*: Disinfection Byproduct Precursors, and San Joaquin Basin Dormant Spray Pesticides). Also to maximize efficiency and effectiveness, the monitoring plan uses existing programs as much as possible (Table 4-6). For example, the proposed contaminant monitoring program is based on the Sacramento River Watershed Monitoring Program, the USGS National Water-Quality Assessment Program and special programs, the Interagency Ecological Program and the San Francisco Estuary Institute Regional Monitoring Program. The water-quality-monitoring plan is integrated with monitoring plans for the other common programs (see "Linkages" at the end of this chapter). To the extent possible, local and interagency cooperation and involvement is encouraged and has been received in some areas. The proposed program should be integrated with monitoring efforts by local watershed groups.

Table 4-2. Water-Quality Program Actions

Drinking Water	Improve source-water quality to reduce potentially toxic and carcinogenic disinfection by-products by controlling TOC, pathogens, turbidity and bromide
Pesticides	Reduce impacts of pesticides through development and implementation of Best Management Practices, for both urban and agricultural uses, and support of pesticide studies and pilot projects for regulatory agencies while providing education and assistance in implementation of control strategies for the regulated pesticide users.
Organochlorine Pesticides	Reduce the load of organochlorine pesticides in the system, including residual DDT and Chlordane, by reducing runoff and erosion from agricultural lands through Best Management Practices. Sediment control will also protect valuable topsoil and prevent costly maintenance of drainage systems.
Trace Metals	Reduce impacts of trace metals such as copper, cadmium, and zinc in upper watershed areas, near abandoned mine sites. Reduce impacts of copper through urban stormwater programs and agricultural Best Management Practices. Study the ecological impacts of copper in the Delta. Determine the feasibility of copper reduction in the Delta.
Mercury	Reduce mercury in rivers and the estuary by source control at inactive and abandoned mine sites. Also study bioavailable mercury in the rivers and the estuary and its potential threat to human health.
Salinity	Reduce salinity through reduction of leaching of agricultural land via irrigation improvement, crop selection and changes in land use. Reduce imports of salt and study non-agricultural source contributions. Salinity reductions in the river would also incorporate real-time management of salt discharges. San Joaquin drainage problems have been evaluated in several studies over the past two decades. Complete resolution of the San Joaquin drainage problems is beyond the scope of the CALFED Bay-Delta Program.
Selenium	Reduce selenium, through irrigation control, crop selection, and possibly land fallowing or land retirement. Impacts of selenium will be further reduced by real-time management of selenium laden agricultural drain water released to the San Joaquin River to minimize concentrations in the river when selenium discharges occur.
Turbidity and Sedimentation	Reduce turbidity and sedimentation, which affect several hydraulic areas in the Bay/Delta and its tributaries, including treatment of drinking water sources. Study ecological impacts of sedimentation. Control sedimentation in several watersheds to protect spawning beds and maintain capacity of streams.
Low Dissolved Oxygen	Reduce impairment of rivers and the estuary caused by substances that exert excessive demand on dissolved oxygen. Oxygen-depleting substances are found in waste discharges, agricultural discharges, urban stormwater, sediment, and algae.
Toxicity of Unknown Origin	Through research and monitoring, identify parameters of concern in the water and sediment within the Delta, Bay, Sacramento River and San Joaquin River regions and implement actions to reduce their toxicity to aquatic organisms.

Table 4-3. Water-Quality Monitoring Objectives

1. Assess effects of CALFED activities (including Ecosystem Restoration, Storage and Conveyance, Water Transfers, Water Use Efficiency, Watershed Management Coordination, and Levee System Integrity Programs) on water quality
2. Determine sources, loads, and trends of water-quality constituents of concern
3. Assess system productivity of Bay/Delta waters
4. Monitor water and sediment quality as necessary to comply with CALFED actions
5. Provide continuing data on water-quality constituents of concern, such as bromide, that may indicate the need for further CALFED actions to improve water quality.
6. Assess ecological and human-health related to water and sediment quality, including monitoring contaminant concentrations in biota.

RECOMMENDED MONITORING

Five workgroups addressing different regional and constituent groups developed the recommended monitoring. The five groups are Sacramento Region, San Joaquin Region, Bay-Delta Region Contaminants, Bay-Delta Region Ecosystem Productivity, and Bay-Delta Region Drinking Water. Full reports from these workgroups are in Appendices *VII.B.1* through *VII.B.4*. The individual monitoring programs were integrated into the comprehensive program presented here. The water-quality-monitoring program is summarized for environmental contaminants, ecosystem productivity, and drinking water.

Environmental Contaminants

Contaminant monitoring is designed to monitor both human health and ecosystem effects of contaminants. This monitoring would address the CALFED actions to improve aquatic environments by reducing the concentration and loading of contaminants. The contaminants monitored are based on lists of contaminants developed by the CALFED Water-Quality Program, Regional Water-Quality Control Boards, the U.S. Environmental Protection Agency, and technical experts. These programs will be coordinated to provide information on the following classes of constituents:

- General water and sediment chemistry
- Nutrients
- Metals and trace elements
- Pesticides
- Turbidity and sedimentation
- Pathogens
- Water and sediment assays
- Bioaccumulation
- Ecological effects of contaminants

The list of contaminants will be amended if other contaminants, not now being regulated or considered for regulation, become important.

General Water and Sediment Chemistry

Measurements, such as temperature, specific conductance or electrical conductivity (EC), salinity, pH, total dissolved solids, dissolved oxygen (DO), are general indicators of water quality. Temperature and pH are critical in determining speciation of other water-quality constituents. This is important in determining the fate of constituents and, in some cases, bioavailability or toxicity of contaminants. EC, a measure of salinity, is often related to other constituents and can serve as a surrogate for other measurements. Salinity measurements are important because salinity criteria need to be met in the Bay-Delta estuary, according to Bay-Delta water rights agreements.

Sediment characteristics such as grain-size, total organic carbon (TOC), ammonia and sulfides are recommended to assess the condition of the benthic habitats.
Many of these general chemical measurements have ecosystem effects. Elevated temperatures and low dissolved oxygen levels may adversely affect migration and spawning of salmon and steelhead, for example.

Nutrients
Nutrient concentrations can indicate the potential for algal blooms, which can cause problems in drinking water taste and odor and for ecosystem effects such as eutrophication. Algal blooms can also contribute to disinfection by-product production, a drinking water concern. Monitoring of nutrient concentrations is useful to determine possible sources of nonpoint-source pollution such as from agriculture, dairies and livestock operations and from urban runoff.

Metals and Trace Elements
High concentrations of metals and trace elements can be toxic to humans and aquatic organisms. Some trace elements such as selenium, bioaccumulate and can pose a threat to wildlife even though dissolved selenium concentrations may be relatively low. Monitoring of metals and trace elements will focus on particular contaminants of concern in different watersheds. In the Sacramento watershed, metals such as mercury, cadmium, chromium, copper, and zinc are released from abandoned mines. Mercury buried in hydraulic mining debris throughout the estuary, delta and watershed may be available for biological uptake. In the San Joaquin watershed, trace elements of most concern are selenium, boron, and molybdenum. Monitoring and special studies in the Bay-Delta to identify sources and effects of mercury and selenium to the Bay-Delta are proposed.

Pesticides
Pesticides will be selected for monitoring based on the quantity of pesticide used in a particular location, the pesticide's potential to cause toxicity to aquatic organisms, the timing of application, the physical properties of the pesticide, and its demonstrated capacity to mobilize in the environment. Certain pesticides that are no longer used but are persistent in the environment (DDT, toxaphene, dieldrin, and chlordane) are proposed for monitoring as well.

Turbidity and Sedimentation
Turbidity and sedimentation are of concern for contaminant, drinking water and ecosystem effects. Contaminants, such as organochlorine pesticides, metals, and other inorganic constituents such as phosphorus, can be transported with sediments. Turbidity and sedimentation will be monitored to assess how they affect water quality and water treatment (see 2. Drinking Water, below). Ecosystem effects include smothering of spawning gravels and effects on ecosystem productivity, transport of contaminants, and benthic effects. Salmon emigration may be affected by precipitation-induced increases in turbidity in rivers and streams. Positive effects of turbidity and sedimentation may include sediment recruitment for habitat and decreased light infiltration that reduces algal blooms in the Delta.

Pathogens
Pathogens such as *Giardia* and *Cryptosprodium* are proposed for monitoring in both the Sacramento and San Joaquin watersheds. However, better analytical test methods are needed to assess the viability and actual human health risks associated with existing pathogen levels in the system (See 2. Drinking Water, below for more detail).

Water and Sediment Bioassays
Water and sediment bioassays will be used to monitor toxicity to biological organisms. Toxicity monitoring is essential because toxicity may result from an unknown

contaminant or from a combination of contaminants, that may not be detected by analysis of individual contaminant levels. Toxicity identification evaluations (TIEs) are proposed to analyze the source of detected toxicity. Samples will be taken in sufficient numbers so that there can be statistical evaluation of toxicity.

Bioaccumulation
Bioaccumulation monitoring is essential for assessing ecosystem and human health effects of contaminants that concentrate in the food chain. Bioaccumulation information will be used to determine the potential for ecological damage due to contaminant body burdens and to assess human health risks from ingestion of fish and shellfish. Examples of proposed bioaccumulation monitoring are determining concentrations of persistent contaminants such as mercury, PCBs, dioxins and organochlorine pesticides in bivalves like *Potamocorbula*, fish and bird tissues.

Ecological Effects of Contaminants
Ecological effects of contaminants should be monitored in close coordination with restoration monitoring. Many ecological response indicators can be used to monitor contaminant effects. For example, the number of benthic species per sample is a commonly used indicator of benthic response to contaminants. However, to evaluate whether numbers of benthic species are affected by contaminated sediments or other factors, a suite of "habitat" and "stressor" measurements must be monitored synoptically with the benthos. Monitoring selected indicators of phytoplankton, zooplankton, benthic invertebrates, and several fish species for potential contaminant effects is recommended. Measurements of production, growth, mortality, or reproductive capacity are also recommended.

Summary of Environmental Contaminant Monitoring
Environmental contaminants will be monitored for potential human health and ecosystem effects. This monitoring consists of the above general classes of contaminants, but will be focused spatially and temporally based upon existing information about these contaminants. Sufficient sampling should take place to assess statistical significance of toxicity or other effects found. For detailed information about specific monitoring proposed for each region and class of contaminants, see Appendices *VII.B.1* through *VII.B.4*.

Ecosystem Productivity
In addition to monitoring environmental contaminants, the water-quality-monitoring program consists of monitoring to determine the biological productivity of the water and sediment. System productivity is a measure of ecosystem health. Ecosystem productivity monitoring includes monitoring of physical processes, conventional water quality (not including contaminants or human health effects), and the status of lower trophic levels (microbes, phytoplankton, aquatic plants, and invertebrates, not including decapod shrimp or crabs). The following general classes of variables are proposed for monitoring:

- Basic physical variables
- Flow variables
- Chemical constituents
- Primary producers
- Microbial communities
- Zooplankton
- Sediment quality
- Benthic fauna

Basic physical variables
This includes climate, meteorological measures, salinity, temperature, suspended sediment/water clarity, and light attenuation. These variables affect the biological productivity of the system. Salinity, temperature and water clarity will be monitored for both ecosystem contaminants

(discussed in the previous section) and for ecosystem productivity.

Flow variables
Total daily inflow, diversion flows, tidal flows, and net (tidally-averaged) flows provide the essential underlying information defining the hydrologic environment of the Bay-Delta and thus for interpreting and analyzing data from the estuary.

Chemical constituents
Dissolved oxygen, pH, nutrients, organic nutrients and organic carbon along with physical factors such as light attenuation are important in assessing ecosystem productivity. Many of these constituents will be monitored for ecosystem productivity, environmental contaminant and drinking water purposes.

Primary producers
Primary producers are basic components of the food web, upon which the ecosystem depends. The biomass of phytoplankton is an indicator of the quantity of food energy (carbon) available at the base of the food web. Excessive phytoplankton biomass can suggest eutrophication. Primary production will be assessed by measuring the variables: phytoplankton biomass, phytoplankton primary production, phytoplankton species, benthic microalgae, and quantity and quality of submerged aquatic vegetation.

Microbial communities
Microbial communities, characterized by bacterial counts, biomass, and metabolic rate, are proposed for monitoring on a periodic, but infrequent basis, perhaps every quarter or in alternate years. Bacteria are an important part of the Bay's food web, but measurements are somewhat difficult and require specialized expertise.

Zooplankton
Zooplankton, a component in the food chain, will be assessed by monitoring mesozooplankton, macrozooplankton, microzooplankton, gelatinous zooplankton, and zooplankton secondary production. Assessing this step in the food chain is critical for ecosystem food-web analysis.

Sediment quality
Sediment quality is an important factor in assessing ecosystem health. Sediment contaminated with toxic substances may result in acute or chronic toxicity to benthic organisms and therefore affect ecosystem productivity. As described earlier (see Environmental Contaminants, Water and Sediment Chemistry), sediment characteristics will be monitored.

Benthic fauna
Benthos community composition can serve as an indicator of water quality and of changes in lower trophic level aquatic community structure and secondary productivity. Several reasons justify this monitoring:

- Benthic fauna are an important trophic step between living and detrital particulate organic matter and higher trophic levels including fish, birds, and people
- Benthic fauna contribute to the flux of dissolved and particulate material (including contaminants) between the sediment and the overlying water
- The types and abundance of benthic animals and their variation are commonly used as indicators of water quality
- The benthos of coastal aquatic systems is particularly susceptible to invasions of non-indigenous species released from ballast water. Because most benthic organisms do not move far after settlement, the benthic community provides a continuing record, through changes in species composition or abundance, of the effects of both short- and long-term changes in the environment.

Summary of System Productivity Monitoring
By monitoring water quality and the lowest levels of the ecosystem food chain, changes

in the ecosystem as a result of CALFED actions may be documented. Many components of system productivity monitoring will also provide information to the other water-quality-monitoring program elements and to the ecosystem-monitoring program.

Drinking Water

Nearly 23 million people are dependent on the Sacramento-San Joaquin Delta for their drinking water supply. There are public health issues associated with providing good quality water from the Delta (see Table 4-4). Disinfection by-products (DBPs) are produced when source water containing organic matter and bromide are disinfected in drinking-water-treatment facilities. Example DBPs include trihalomethane (THM), haloacetic acid, and bromate (see Table 4-4). Although DBPs could be decreased by reducing the amount of disinfectant used, drinking water regulations enforced by the Department of Health Services require certain disinfectant concentrations and contact times. Reducing the amount of disinfection can result in greater quantities of disease-causing pathogens surviving the disinfection process. There are technological and cost limitations to treating pathogens and DBP precursors (DBPP) in drinking water. Therefore, it is critical that the Delta source water be closely monitored so that CALFED actions can be taken to produce the best quality source water possible.

Water utilities using Delta water as a source of drinking water face significant challenges in meeting federal drinking water standards on DBPs due to much higher levels of DBPPs in Delta water compared to the national averages. These utilities are able to meet current standards after considerable investment in drinking water treatment facilities.

Future drinking water regulations could become much more stringent if results from ongoing research indicate significant health risks of DBPs to humans. For example, the placeholder limits in Stage 2 of the Disinfectanct/DBP Rule, to be promulgated in 2002, would lower the Stage 1 limits on DBPs by 50%. Currently, Stage 1 of the Disinfectant/DBP Rule, promulgated December 1998, reduces the existing total THM limits by 20% and imposes a limit on the heretofore-unregulated DBP bromate. For utilities using ozone for disinfection, the new Stage 1 limit on bromate could be difficult to meet, especially during droughts when the bromide level in Delta water could be 10 or more times higher than that of the national average. Given the relatively few ozonation treatment plants using Delta water and their short histories of operation, it is too early to tell if the Stage 1 bromate limit could be met during drought conditions.

For the longer term, the potential combination of higher disinfection requirements and more stringent limits on DBPs could make it extremely difficult for Delta agencies using existing advanced treatment processes (ozonation and chlorination with enhanced coagulation) to comply with future regulatory standards unless Delta water quality is significantly improved, especially during droughts.

TOC, bromide, and pathogenic organisms in Delta waters need to be controlled so water utilities using Delta waters can meet current and new drinking water standards and provide drinking water that will not cause adverse health effects.

Table 4-4. Drinking Water Contaminants and Potential Health Effects

Drinking Water Contaminant	Potential Health Effects
Pathogenic organisms	Infections; illness; possible deaths
Trihalomethanes, haloacetic acids, and other disinfection by-products	Cancer; spontaneous abortions; liver; kidney, and nervous system toxicity
Bromate (a DBP)	Cancer

However, CALFED actions may increase the concentration of constituents of concern in Delta waters. In particular, creation of wetlands as part of the CALFED Ecosystem Restoration program will likely increase concentrations of particular forms of TOC with a high propensity to form DBPs. However, due to the land conversion from agriculture to wetlands, DBPPs that would have been produced under agriculture will not be formed. Also, the increased tidal exchange resulting from the wetlands may increase the concentration of bromide and Total Dissolved Solids (TDS) in Delta waters. Due to impending regulation, elevated bromide concentrations may indicate the need for further CALFED actions to improve water quality.

Subsidence of Delta islands may increase the loads of DBPPs in island drainage. Peat island drainage has been previously shown to contain higher concentrations of dissolved organic carbon (DOC), THMFP and other DBPPs than freshwater inputs to the Delta, the Sacramento and San Joaquin Rivers (Amy et al., 1990, DWR, 1990). Drainage on Delta islands will increase as peat islands continue to subside, thereby increasing the loads of DBPPs pumped off island. Therefore, if subsidence mitigation is not a CALFED priority, DBPP loads associated with continued subsidence will continue to increase.

The key drinking-water-constituents of concern to be monitored are DBPP sources, concentrations and loads (TOC and bromide), pathogenic organisms (*Giardia*, *Cryptosporidium*, coliform bacteria, and viruses), the concentration of other chemical contaminants (pesticides, metals, and other organic compounds such as MTBE), TDS or salinity, nutrients, and turbidity (Table 4-5).

Summary of Drinking Water-Monitoring

CALFED, through the Water Quality Program Plan, proposes activities to improve water quality at an affordable cost. However, certain CALFED actions may significantly increase the concentration of drinking water contaminants in Delta waters, thereby exacerbating existing conditions, particularly in relation to formation of DBPs. CMARP will monitor changes in contaminant concentrations to ensure that water quality is not further degraded as a result of CALFED ecosystem actions. Drinking water-quality contaminants are undergoing increasingly stringent regulation. Further degradation of Delta source waters would increase the cost and decrease the effectiveness of water treatment.

Table 4-5. Drinking Water Constituents of Concern

Monitoring Constituent	**Significance to Drinking Water Quality**
TOC (DBP precursor)	Formation of disinfection by-products
Bromide (DBP precursor)	Formation of brominated disinfection by-products and bromate
Pathogenic organisms	Waterborne diseases
Chemical contaminants	Regulated drinking water-quality constituents
TDS or salinity	Taste and odor problems (salty taste), corrosion of infrastructure and appliances, effects on wastewater reclamation programs, groundwater conjunctive use programs and blending projects, health concerns (sodium)
Nutrients	Taste and odor problems (algae-geosmin and 2-methylisoborneol), effects on filtration (algae)
Turbidity	Effects on filtration and disinfection

RESEARCH NEEDS

Research needs for environmental contaminants, agricultural contaminants and drinking water contaminants are listed below. For detailed lists of research questions, see Appendices *VII.A.6, B.1, and B.2*).

Environmental Contaminants

- Determine causes of unknown water and sediment toxicity
- Develop toxicity testing with resident organisms
- Develop contaminant effects indicators in the estuary.
- Study bioaccumulation of contaminants
- Determine sources of mercury and other contaminants
- Determine fate and transport of mercury, selenium and other contaminants
- Estimate sediment loadings and predict changes in sediment loadings due to CALFED actions including ecosystem restoration projects and changes in storage and conveyance
- Research methods to manage urban stormwater drainage/urban runoff to minimize toxicity to resident organisms
- Research control methods of introduced aquatic weeds/species that minimize toxicity to nontarget organisms
- Develop Best Management Practices to reduce the transport of pesticides and other contaminants to water sources

System Productivity

- Reevaluate the flow-X2 relationship and update it (base the relationship on a larger dataset and make any changes in the relationship necessary)
- Develop carbon and nutrient budgets for the estuary and its sub-regions
- Develop models of phytoplankton dynamics for the estuary and its sub-regions
- Determine the relative importance of various organic carbon sources in the northern estuary
- Determine the fate of bacterial production in the northern estuary
- Continue and expand work on retention mechanisms in the Low-Salinity Zone and seaward
- Assess the role of benthic microalgae in the estuarine food web
- Model studies of the food web
- Study the role of introduced zooplankton species in the food web
- Continue studies of the influence of *Potamocorbula amurensis* on estuarine food webs
- Anticipate the role in the food web of additional introductions of non-indigenous species
- Determine the roles of benthic invertebrates and various size classes of zooplankton in the food web leading to species targeted for restoration
- Sediment studies to estimate loadings of sediment from the mainstem rivers into the Bay and Delta
- Sediment studies to determine deposition rates, residence times, and burial rates for sediment in representative habitat types in the Bay-Delta
- Determine benthic production in each major habitat
- Determine the effects of shallow water restoration projects on primary production
- Determine the importance of sediment and nutrients to production of phytoplankton and aquatic plants
- Determine factors that control higher aquatic plant growth in the estuary

Drinking Water

- Determine loads of DBPPs associated with key sources (e.g., agricultural, wetland, riparian, and island drainage).
- Assess potential loads of DBPPs produced by CALFED programs such as Ecosystem Restoration.

- Develop accurate predictive models of pathogen and DBPP behavior and transport, along with other tools to assess and predict the effects of CALFED programs on concentrations of DBPPs (including bromide) reaching major drinking-water intakes in the Delta.
- Assess the potential effects of operational changes (such as reservoir operations, flow barriers, or exports) on delivered water quality using aforementioned models.
- Identify methods for accurate determination of pathogens.
- Identify and develop source control measures for mitigation of pathogen and DBPPs.
- Perform and evaluate pilot scale implementations of source control measures.
- Improve water quality models that predict final DBP concentrations in treatment plants after disinfection.

LINKAGES

Ecosystem Restoration—Water quality is an integral part of ecosystem health. The productivity of the ecosystem depends on such factors as temperature, salinity, nutrient concentrations and dissolved oxygen. Aquatic and sediment toxicity monitoring provide information both on water-quality and ecosystem effects of pollutants. The measurement of contaminant effects on fish reveals the presence of contaminants in the water as well as the resultant effects on fish. Water-quality investigations in the upper tributaries will be linked with other ecosystem measurements such as aquatic life, riparian vegetation, etc.

The following is a partial list of monitoring common to both the Water Quality and Ecosystem Restoration programs.

- Composition and health of benthic invertebrate species can be an indicator of ecosystem health and therefore provide information on contaminants, introduction of non-indigenous species, and productivity of the ecosystem.
- X-2 or salinity monitoring is important both for the ecosystem and water-quality effects.
- The potential water-quality effects of ecosystem restoration activities, such as the creation of shallow-water habitat, setting back levees and/or the flooding of peat islands will be monitored.
- Measurements of constituents important to the productivity of the ecosystem such as microbial communities, sediment quality, light attenuation, salinity and temperature.
- Non-indigenous species affect both the ecosystem and water quality. For example, the non-indigenous species *Potamocorbula,* the Asian clam, filters Bay waters increasing water clarity, but decreasing the nutritive value of the water to aquatic organisms.

Delta Levees and Storage and Conveyance—Water and sediment quality monitoring is important for obtaining water-quality permits for levee maintenance and dredging operations. In turn, dredging and levee building operations need to be closely coordinated with water-quality monitoring. Monitoring of sediment (described in the ecosystem section of this chapter) provides information on water quality, levee erosion, channel scouring and sedimentation. Mitigation and levee- enhancement restoration work required for levee repair work will be closely linked with Water Quality and the Ecosystem Restoration programs.

Water Transfers and Water Use Efficiency—Ground and surface water-quality monitoring will be integrated with the Water Transfers and Water Use Efficiency programs. The quality of water (salinity and concentrations of contaminants such as selenium) will limit water transfers and the reuse of water. Also, measurements of water quantity (both groundwater and

surface water) are important for both the Water Transfers and Water Use Efficiency programs as well as calculations of loading of contaminants for the Water Quality program.

Watershed Management Coordination—Water-quality monitoring in the upper tributaries (above dams) and lower watersheds will be coordinated with the Watershed Management Coordination program. This program will involve local resources and will conduct restoration activities in the upper watersheds that may affect downstream water quality. Water-quality monitoring will provide information on watershed function and human activities, (such as source contaminants) and will be closely coordinated with monitoring of ecosystem attributes (such as vegetation, fish, and invertebrate species).

Table 4-6. Major Existing Water-Quality Monitoring Programs

Program Name	Region	Constituents Monitored								
		General	Metals	Nutrients	Organics	Sediment	Pesticides	Pathogens	Biological	Toxicity
California Department of Fish and Game	Sac.	X					X		X	
Department of Pesticide Regulation	Sac./San Joaquin	X					X			X
Compliance Monitoring, DWR	Bay-Delta	X		X						
Municipal Water-Quality Investigations Program, DWR	Bay/Delta	X	X	X	X		X	X		
State Water Project Water-Quality Monitoring Program, DWR	Bay-Delta	X		X	X			X		
Interagency Ecological program	Bay/Delta	X	X	X			X		X	
Central Valley Ambient Monitoring Studies/RWQCB	Sac./San Joaquin		X							X
San Francisco Estuary Regional Monitoring Program, SF Estuary Institute	Bay-Delta	X	X	X	X	X	X		X	X
National Water-Quality Assessment Program, United States Geological Survey	Sac./San Joaquin	X	X	X	X		X		X	
Sacramento River Watershed Program Monitoring program	Sac.	X	X	X	X	X	X	X	X	X
Toxic Substances Hydrology Project, USGS	Bay-Delta						X			