



2010 SWAMP Strategy

2010 Update of the Comprehensive Monitoring and Assessment Strategy to Protect and Restore California's Water Quality

**Prepared by the Surface Water Ambient Monitoring Program
December 2010**



www.waterboards.ca.gov/swamp

Table of Contents

Acknowledgments	1
Executive Summary	2
List of Acronyms.....	5
Introduction	7
1 Strategy	9
2 Monitoring Objectives	15
3 Monitoring Design.....	20
4 Indicators	26
5 Quality Assurance.....	30
6 Data Management	34
7 Data Analysis and Assessment.....	38
8 Reporting	42
9 Programmatic Evaluation.....	46
10 General Support and Infrastructure.....	50
References.....	53
Appendices	55
A. Comprehensive Monitoring and Assessment Strategy for the Citizen Monitoring Program	
B. Summary of Vision Statements, Goals, Objectives, and Tasks	
C. SWAMP Assessment Framework	
D. SWAMP Needs Assessment	
E. Regional Fact Sheets	

List of Tables

Table 1.	SWAMP statewide monitoring programs organized according to waterbody / beneficial use combination.....	17
Table 2.	The SWAMP recommended water quality indicators for general designated use categories (modified from USEPA, 2003)	29
Table 3.	Result counts from SWAMP database as of October 2010	35
Table 4.	Summary of the SWAMP's progress toward meeting the ten monitoring program elements.....	47

List of Figures

Figure 1.	Statewide assessment framework that allows assessment of different monitoring questions at different spatial scales.	21
Figure 2.	Theoretical distributions of monitoring variables across all sites (probabilistic and targeted surveys) and reference sites.....	22
Figure 3.	SWAMP database v2.5 data elements	34
Figure 4.	Evaluation of the SWAMP's monitoring strategy (2005-2010).	46

Acknowledgments

Coordination and collaboration promote consistency and minimize duplication of effort. In that spirit, this document borrows liberally from the work of others. Most of the elements of the Surface Water Ambient Monitoring Program (SWAMP) have been patterned after successful efforts that individual regions, other agencies, and other states are implementing. The result is a stronger, more cost effective program in terms of design and implementation. In particular, Terry Fleming at the U.S. Environmental Protection Agency, Region 9, members of the SWAMP Roundtable, the Scientific Planning and Review Committee, the California Water Quality Monitoring Council, and the National Water Quality Monitoring Council have influenced the development of this document.

This SWAMP Strategy is built on the original SWAMP Strategy (2005), the SWAMP Scientific Planning and Review Committee report (SPARC, 2006), and reports from the California Water Quality Monitoring Council (CWQMC, 2008 and 2010).

Executive Summary

This document is an update to the Surface Water Ambient Monitoring Program (SWAMP) *Comprehensive Monitoring and Assessment Strategy to Protect and Restore California's Water Quality* (Strategy) developed in 2005. This 2010 Strategy update reports on the progress SWAMP has made in the first five years of a ten-year effort to develop a coordinated and comprehensive monitoring framework for Water Board programs. It also highlights steps that need to be implemented to complete the framework and integrate it into other Water Board programs and improve coordination among other state agencies, local agencies and districts, and non-governmental organizations that monitor surface water throughout the state. The Strategy is organized into the USEPA's 10-elements of a comprehensive monitoring program. The goals remain the same as in the 2005 Strategy with updated objectives (which are not listed in order of priority).

SWAMP's mission is to provide resource managers, decision makers, and the public with timely information to evaluate the condition of surface waters throughout California. SWAMP accomplishes this through carefully designed, externally reviewed monitoring programs, and by assisting other entities statewide in the generation of comparable data that can be brought together in integrated assessments that provide answers to current management questions. The SWAMP program has established the following guiding principles as the foundation upon which to prioritize its activities:

- SWAMP monitoring evaluates the physical, chemical, and biological integrity of California's waters.
- Monitoring and assessment at both statewide and regional levels is necessary to protect and restore water quality.
- Monitoring of both high quality waters and those known or suspected to be degraded is essential to a robust ambient monitoring program.
- Monitoring is designed to support a network of information users that include state, federal, and local agencies, the regulated community, the interested public, and their elected representatives.
- Monitoring efforts are prioritized, and coordinated to maximize utility and minimize costs.
- SWAMP seeks to make the most efficient use of data collected by all Water Board programs, as well as the large amount of data collected by other agencies and the regulated community.

In 2008, the [California Water Quality Monitoring Council](#) (CWQMC) was formed to develop a 10-year comprehensive monitoring program strategy for coordinating the water quality and related ecosystem monitoring, assessment, and reporting activities among the various boards, departments, and offices at the California Environmental Protection Agency (CalEPA), the California Natural Resources Agency, the Department of Public Health, and other governmental and non-governmental organizations that monitor California's waters.

The Secretaries of the CalEPA and the California Natural Resources Agency signed a [Memorandum of Understanding](#) (MOU) that requires the boards, departments and offices within the two agencies to integrate and coordinate their water quality and related ecosystem monitoring, assessment, and reporting. The SWAMP Strategy has been updated to include coordination with CWQMC efforts and will be appended to the CWQMC's strategy.

The SWAMP Strategy also incorporates the operating principles, monitoring goals, monitoring objectives and strategies of the State Water Board's [Strategic Plan](#). The SWAMP Strategy is a living document that will be updated every five years. The Strategy will serve as the framework for monitoring priorities at both the State and Regional Water Boards.

The SWAMP was created to fulfill the State Legislature's mandate for a unifying program that would strive to coordinate all water quality monitoring conducted by the State and Regional Boards to assess attainment of all core beneficial uses in all waterbody types. Therefore, continued implementation of the SWAMP monitoring and assessment programs at both the state and regional scales remains a top priority. However, existing resources are not sufficient for the SWAMP to monitor all waterbodies for all beneficial uses, so efforts have been focused on a few statewide assessments of key beneficial uses and supporting regional monitoring. Improving coordination with other Water Board programs and external partners also is identified as a priority throughout this Strategy.

As resources decrease, the need for coordination increases. It is important to note that implementation of the SWAMP's monitoring programs and coordination activities are not mutually exclusive. In fact, each has the potential to inform and enhance the other. For example, the monitoring design for a regional watershed assessment may be different than that for an NPDES discharger, but through coordination and appropriate monitoring design these types of programs can often be nested so that the information from the watershed program informs the NPDES assessment and vice versa. In addition, coordination of monitoring activities with other Water Board programs and partners allows opportunities for logistical and cost advantages (e.g., leverage resources, avoid duplication, share data). The SWAMP supports citizen monitoring throughout the state via the [Clean Water Team](#). A Copy of the Comprehensive Monitoring and Assessment Strategy for the Citizen Monitoring Program is in Appendix A). The Clean Water Team is also critical in operating the [California Water Quality Monitoring Collaboration Network](#).

Finally, the SWAMP has been a leader in developing the monitoring infrastructure (e.g., indicators, methods, quality assurance/quality control [QA/QC], and data management) necessary to support a robust monitoring program while also fostering data comparability and collaboration with monitoring partners. The continued development, maintenance, and implementation of the crucial monitoring infrastructure is another priority for the program.

The SWAMP's Core Implementation Priorities

Statewide & Regional Monitoring & Assessment	Coordination	Infrastructure & Tools
<ul style="list-style-type: none"> ▪ Implement statewide and regional monitoring programs ▪ Guide development of assessment tools that transform data into information on beneficial use support in all state waters. ▪ Apply these assessment tools to monitoring data gathered by SWAMP and others to produce timely, high-quality information for resource management. ▪ Improve and strengthen SWAMP (via coordination, partnerships, peer review, training, funding, etc.) so that it fulfills its monitoring and assessment goals at statewide and regional scales. 	<ul style="list-style-type: none"> ▪ Engage Water Board regulatory and assessment programs to integrate SWAMP monitoring designs, data, and assessment tools into regional and statewide programs. ▪ Coordinate with the CWQMC to prioritize waterbody types and beneficial uses that SWAMP is responsible for assessing and collaborate with and provide guidance to partner organizations that assess those waterbody types and beneficial uses that are not assessed by SWAMP. Lead the CWQMC work groups on fish consumption safety and stream/lake/river ecosystem health, and develop the web portals to make data and assessments available to decision makers and the public. 	<ul style="list-style-type: none"> ▪ Implement Quality Assurance and Data Management Programs to support SWAMP statewide and regional monitoring programs, and to provide tools for partners to produce comparable data. ▪ Implement the SWAMP statewide assessment framework and standards for data comparability, that allow local entities to both contribute data to statewide assessments and view the results of those assessments as context for local monitoring and management.

List of Acronyms

ASBS	Areas of Special Biological Significance
ATL	Assessment Threshold Levels
BOG	Bioaccumulation Oversight Group
CalEPA	California Environmental Protection Agency
CalWQA	California Water Quality Assessment Database
CCAMP	Central Coast Ambient Monitoring Program
CEDEN	California Environmental Data Exchange Network
CFR	Code of Federal Regulations
CRAM	California Rapid Assessment Method
CSU	California State University
CWA	Clean Water Act
CWQMC	California Water Quality Monitoring Council
DDT	Dichloro-diphenyl-trichloroethane (a synthetic insecticide)
DMT	Data Management Team
DO	Dissolved Oxygen
EMAP	Environmental Monitoring and Assessment Program
FCG	Fish Contamination Goal
GAMA	Groundwater Ambient Monitoring and Assessment
GIS	Geographic Information System
IBI	Index of Biotic Integrity
MCL	Maximum Contaminant Level
MLML	Moss Landing Marine Laboratories
MOU	Memorandum of Understanding
MQO	Measurement Quality Objectives
MUN	Municipal and Domestic Supply Beneficial Use
NAWQA	National Water-Quality Assessment Program
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
O/E	Observed/Expected
OEHHA	Office of Environmental Health Hazard Assessment
PCB	Polychlorinated biphenyls



PHab	Physical Habitat
PSA	Perennial Streams Assessment
QA	Quality Assurance
QAMP	Quality Assurance Management Plan
QAPP	Quality Assurance Project Plan
QAPrP	Quality Assurance Program Plan
QC	Quality Control
QMP	Quality Management Plan
RCMP	Reference Condition Management Plan
RDC	Regional Data Centers
REC 1	Water Contact Recreation Beneficial Use
RL	Reporting Limits
SCCWRP	Southern California Coastal Water Research Project
SFEI	San Francisco Estuary Institute
SPARC	Scientific Planning and Review Committee
SPoT	Stream Pollution Trends
SQO	Sediment Quality Objectives
SSO	Site-Specific Objective
SWAMP	Surface Water Ambient Monitoring Program
TAC	Technical Advisory Committee
TDS	Total Dissolved Solids
TIE	Toxicity Identification Evaluation
TMDL	Total Maximum Daily Load
UCD	University of California at Davis
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WER	Water-Effect Ratio
WQX	Water Quality Exchange



Introduction

Adequate and accurate monitoring and assessment information is fundamental to preserving, enhancing, and restoring water quality. The information gathered from Water Board monitoring activities is critical to protect the beneficial uses of water, develop water quality standards, conduct federal Clean Water Act assessments, and to determine the effects of pollution and the success of pollution prevention and water quality improvement programs.

The federal Clean Water Act assigns states the primary responsibility for implementing programs to protect and restore water quality. The Clean Water Act (*Section 106[e]*) requires the U.S. Environmental Protection Agency (USEPA) to determine that a state has established and is operating appropriate methods, systems, and procedures necessary to monitor, and to compile and analyze data on, the quality of navigable waters. In fact, before USEPA will award *Section 106* grants, states must report their monitoring and assessment activities and submit that information in their obligatory *Section 305(b)* reports. However, SWAMP was envisioned to do more than simply fulfill statutory reporting obligations. The program was designed to reach beyond those federal requirements and coordinate a statewide monitoring and assessment framework to improve reporting of the Water Boards efforts and successes in preserving, enhancing, and restoring California's waters.

To meet the Clean Water Act objectives, the Water Boards should be able to answer the following questions:

- What is the overall quality of California's surface water?
- What are the trends in surface water quality over time?
- What are areas needing further protection?
- What are the causes of identified impairments?
- Are the Water Board programs effective?

This Strategy presents SWAMP's vision to fulfill California's Clean Water Act responsibilities and the Water Board's blueprint (outlined in the Strategic Plan 2002, 2008) for improving our monitoring, assessment and reporting activities, to foster a better informed public that translates into behavior changes that ultimately improve water quality.

This 5-year update of SWAMP's [2005 Strategy](#) modifies the long-term implementation plan and its 10-year timeline. This SWAMP Strategy is built on the original SWAMP Strategy (2005), the SWAMP Scientific Planning and Review Committee (SPARC) report ([SPARC, 2006](#)), and reports from the California

Elements of a State Water Monitoring and Assessment Program

1. Monitoring Program Strategy
2. Monitoring Objectives
3. Monitoring Design
4. Core Indicators of Water Quality
5. Quality Assurance
6. Data Management
7. Data Analysis/Assessment
8. Reporting
9. Programmatic Evaluation
10. General Support and Infrastructure



Water Quality Monitoring Council (CWQMC, [2008](#) and 2010).

This document follows the format of USEPA's (2003) [Elements of State Water and Monitoring and Assessment Program](#). This Strategy outlines SWAMP's activities in each of the 10 basic monitoring program elements. For each of the elements, we first report the current status of the program and then discuss our activities and plans to implement the Strategy. A summary of the vision statements, goals, objectives, and tasks is in Appendix B.



1 Strategy

SWAMP's mission is to provide resource managers, decision makers, and the public with timely, high-quality information to evaluate the condition of surface waters throughout California. There were three basic goals outlined in the original Strategy (SWAMP, 2005):

Goal 1.1 Develop SWAMP monitoring strategy for developing and implementing an integrated comprehensive statewide monitoring program in 10 years.

Goal 1.2 Implement the SWAMP monitoring strategy.

Goal 1.3 Promote coordination of monitoring activities and comparability of data.

Current Status

The SWAMP was created in 2000 in response to Assembly Bill 982 (Ducheny, Statutes of 1999) to fulfill the State Legislature's mandate for a unifying program that would coordinate all water quality monitoring conducted by the State and Regional Boards to assess attainment of all core beneficial uses in all waterbody types. The SWAMP monitoring strategy (SWAMP, 2005) was based on the USEPA's (2003) *Elements of a State Water Monitoring and Assessment Program* and the National Water Quality Monitoring Council framework. It is guided by a Roundtable¹ of experienced State and Regional Water Board monitoring coordinators, has continuing access to university and agency experts in chemistry, toxicology, ecology, and hydrology, and has undergone two formal scientific reviews by external national and international experts. In 2006, there was an overall program evaluation by the Scientific Planning and Review Committee (SPARC). The SPARC comments were incorporated into the SWAMP planning. The recommendations are formally adopted into this update of the SWAMP Strategy.

The first few years of the program were dedicated primarily to supporting Regional Water Board programs and developing the monitoring infrastructure and tools necessary to enhance data comparability and data sharing (SWAMP Quality Assurance Program and Data Management Program). The SPARC Report (2006) commended SWAMP's efforts to develop the monitoring infrastructure and to support Regional Water Board programs, and applauded the Regional Water Boards' entrepreneurial spirit and ability to leverage their efforts. However, it also recommended to SWAMP that it expand its efforts to develop robust statewide assessments and a statewide framework to provide information to multiple users for multiple uses. To meet these goals, the SWAMP needed to design and implement probability-based statewide surveys, prioritize its monitoring efforts to address declining

¹ The SWAMP Roundtable is the coordinating entity for the program. Participants include staff from the State and Regional Water Boards, the Department of Fish and Game, the Marine Pollution Studies Lab, Moss Landing Marine Laboratories, contractors and other interested entities.

budgets, and simultaneously seek to maximize the utility of data collected by the various Water Board programs.

In response to the SPARC (2006) review, SWAMP has shifted its strategy toward greater collaboration with partners. This includes greater integration of SWAMP monitoring and assessment activities with other Water Board programs and external partners. SWAMP initiated efforts on many statewide and regional fronts to align sites and schedules with partners who monitor similar waterbody types and beneficial uses. These partners include stormwater agencies, municipal wastewater dischargers, and irrigated lands regulatory programs. SWAMP is continuing its outreach and coordination with these groups. To further facilitate opportunities for collaboration, SWAMP has invited liaisons from other Water Board programs to attend SWAMP Roundtable meetings, and SWAMP liaisons strive to attend the Roundtables of other Water Board programs [Goal 1.3].

The California Water Quality Monitoring Council (CWQMC) was convened in 2008 as a result of [Senate Bill 1070](#) (Kehoe, Statutes of 2006), which was passed by the Legislature and signed by the Governor in 2006. The CWQMC is tasked with coordinating water quality and

related ecosystem monitoring efforts throughout California, with the goal of addressing as many water quality management needs for as many state waters as possible with available funding, including all waterbody types (such as streams, rivers, lakes, reservoirs, estuaries, coastal areas, and wetlands). In June, 2010, SWAMP and the CWQMC held a joint meeting to align strategies and strategy documents. It was agreed that the SWAMP should focus its limited funds for statewide assessments on two questions: “Is it safe to eat the fish?” and “Is aquatic life protected in freshwater streams?” By working with partners and within the CWQMC framework, this Strategy seeks to address as many water quality management needs for as many state waters as possible with available funding, including all waterbody types (such as streams, rivers, lakes, reservoirs, estuaries, coastal areas, and wetlands), and

Types and Extent of Waterbodies: California is a vast state with 158,700 square miles of surface area and a wide range of waterbodies.

WATERBODY CLASSIFICATION	EXTENT
Total Miles of Rivers and Streams	211,513
Perennial River Miles	64,438
Intermittent Stream Miles	124,615
Ditch and Canal Miles	22,059
Number of Lakes/Reservoirs/Ponds	10,141
Acres of Lakes/Reservoirs/Ponds	1,672,684
Miles of Shoreline	3,427
Acres of Wetlands	273,880

all core beneficial uses (swimmable, fishable, drinkable, and aquatic life support). This coordination allows SWAMP to focus its statewide monitoring on beneficial uses associated with fish consumption in major waterbody types and aquatic life use in streams.

Core Implementation Priorities

Statewide & Regional Monitoring & Assessment

- Implement Statewide and Regional monitoring and assessment programs.
- Guide development of assessment tools that transform data into information on beneficial use support in all state waters.
- Apply these assessment tools to monitoring data gathered by SWAMP and others to produce timely, high quality information for resource management.
- Improve and strengthen the SWAMP so that it fulfills its monitoring and assessment goals at statewide and regional scales.

Coordination

- Engage Water Board regulatory and assessment programs to encourage active integration of SWAMP monitoring designs, data, and assessment tools into regional and statewide programs.
- Coordinate with the CWQMC to prioritize waterbody types and beneficial uses that SWAMP is responsible for assessing and collaborate with and provide guidance to partner organizations that assess those waterbody types and beneficial uses that are not assessed by SWAMP. Lead the CWQMC work groups on fish consumption safety and stream ecosystem health, and develop the web portals to bring those assessments to decision makers and the public.

Infrastructure & Tools

- Implement Quality Assurance and Data Management Programs to support SWAMP statewide and regional monitoring programs and provide tools for partners to produce comparable data.
- Implement the statewide assessment framework and standards for data comparability, that allow local entities to both contribute data to statewide assessments and view the results of those assessments as context for local monitoring and management.

Guiding Principles

- SWAMP monitoring evaluates the physical, chemical, and biological integrity of the State's waters.
- Monitoring at both statewide and regional levels is necessary to protect and restore water quality
- Monitoring of both high quality waters and waterbodies known or suspected to be degraded is essential to a robust ambient monitoring program.
- Monitoring is designed to support a network of information users that include state and local agencies, the regulated community, the interested public, and their elected representatives.
- Monitoring efforts are prioritized, and coordinated to maximize utility and minimize costs.
- SWAMP seeks to make the most efficient use of data collected by all Water Board programs, as well as the large amount of data collected by other agencies and the regulated community.

The implementation of the monitoring programs and coordination activities are not mutually exclusive. In fact, each has the potential to inform and enhance the other. The SWAMP monitoring infrastructure (e.g., indicators, methods, quality assurance/quality control [QA/QC], and data management) support SWAMP monitoring but also foster data comparability and collaboration with monitoring partners.

Objectives

Implementing the aforementioned priorities has been the focus of the statewide SWAMP effort for the past three years. Specific actions to continue implementation of these priorities involve multiple strategy elements.

Objective 1.1: Continue to refine and update the SWAMP Strategy [Goal 1.1]

- Integrate the SWAMP Strategy with the CWQMC's strategy to identify gaps in the State's assessment activities, and prioritize SWAMP statewide and regional monitoring to address those gaps and fulfill Clean Water Act requirements.
- Update the SWAMP Assessment Framework (*see Appendix C*) as new assessment tools and strategies become available.
- Update the SWAMP Needs Assessment (*see Appendix D*) as described under Element 10 – General Support and Infrastructure Planning (Objective 10.4).
- Update the SWAMP Strategy document at least every 5 years.

Objective 1.2: Implement the Strategy [Goal 1.2]

- Continue to work through the Roundtable to align the objectives and designs of Regional Board and statewide monitoring to increase opportunities for collaboration and leveraging (elements 2 and 3).
- Continue to support development of new indicators and assessment tools that can be used throughout the state by the various Water Board programs (element 4).
- Continue to build monitoring infrastructure to ensure comparability and enhance sharing of data among State and Regional Water Board programs (elements 5 and 6).
- Continue to perform monitoring at state and regional scales and prepare assessment reports that inform management, increase the visibility of the program and demonstrate the utility of the program (elements 7 and 8).
- Continue to evaluate the program to ensure that it remains technically sound and to ensure that the information being generated is meeting Water Board needs (element 9).
- Assess needs of the SWAMP on an annual basis to ensure there is adequate program staff to administer the program at the Water Boards and to maintain and enhance the expertise and capabilities of the SWAMP contract laboratories to allow continued high quality monitoring and assessment (element 10).

Objective 1.3: Institutionalize SWAMP's monitoring and assessment framework into other Water Board programs that require ambient surface water quality monitoring [Goal 1.3]

Clean Water Team

The [Clean Water Team](#) (CWT) works to build and support the State's Watersheds Stewardship through involvement by Citizen Monitoring in order to reduce and prevent water pollution and recover lost beneficial uses.

Citizen Monitoring is any monitoring activity of aquatic resources, aquatic habitat, and/or water quality that relies in whole or in part on participation by volunteers, students or non-paid staff. All across California and the nation, citizen monitors are monitoring the condition of streams, rivers, lakes, reservoirs, estuaries, coastal waters, wetlands, and wells. Their efforts are of particular value in providing quality data and building stewardship of local waters.

The CWT has been busy working at local levels to help create steering teams and consortiums. These steering teams and consortiums allow citizen monitoring groups and projects to grow through local networking and using shared resources of monitoring knowledge, skills and training. Self reliance and sustainability of these resources will foster the development of robust monitoring programs and promote the long term growth of citizen monitoring and watershed stewardship. To date there are seven organizations located throughout the state: Citizen Monitors of Orange County, Coastal Watershed Council, San Diego Citizen Watershed Monitoring Consortium, San Francisco Estuary Institute, Sierra Nevada Alliance, Sierra Streams Institute, and Stevens and Permanente Creeks Watershed Council.

The CWT assists these groups through six core functions: outreach and communication, technical assistance/quality assurance, training, loans of equipment, event support, and information management.

- Seek support at the State Board level to encourage programs to coordinate ambient monitoring efforts through SWAMP.
- Increase the usefulness and visibility of SWAMP information products to make them more valuable to decision makers and the public, thereby increasing support for the program;
- Meet with programs to understand their assessment needs and seek to optimize designs of statewide programs to maximize utility for Water Board programs
- Increase the number of Water Board programs that utilize SWAMP data, standards and guidance.

Objective 1.4: Coordinate with other Regional and State monitoring programs [Goal 1.3]

- Participate in the CWQMC to identify areas of potential coordination with other agencies within CalEPA and the Natural Resources Agency.
- Coordinate with existing and developing RMPs, including those in the Lake Tahoe basin, Klamath watershed, San Francisco Bay, Sacramento/San Joaquin



Delta, San Joaquin watershed, Central Coast, Los Angeles and San Gabriel Rivers watershed, and Southern California Bight.

- Support development of new RMPs to cover additional regions of the state.
- Continue to support citizen monitoring programs through the [Clean Water Team](#).



2 Monitoring Objectives

Our vision is to clearly articulate monitoring objectives as attainable targets for producing the information needed to answer assessment questions at the statewide and Regional levels.

Goal 2.1 Define statewide monitoring objectives.

Goal 2.2 Define regional monitoring objectives.

Goal 2.3 Develop consensus on shared objectives.

Current Status

In November 2000, SWAMP submitted a comprehensive set of objectives to the State Legislature ([SWRCB, 2000](#)). In February 2005 the SWAMP Roundtable held a workshop to articulate monitoring objectives that could be applied at both State and Regional Water Board scales. There was consensus that the objectives of all Water Board programs could be framed around the protection of core beneficial uses: aquatic life, “swimmable”, “fishable”, and “drinkable”. There are over 25 beneficial uses that vary by waterbody within each Region. However, the concept of core beneficial uses is useful as an organizing framework for monitoring around core uses shared by most waterbodies (Table 1). Protecting these “core beneficial uses” is likely to protect most other beneficial uses.

There also was consensus at the workshop that regardless of beneficial use or waterbody type the monitoring objectives of most Water Board programs could be framed around the following five key questions.

1. **What is the overall quality of waters in the Regions and the State?** CWA *Section 305(b)* requires that states determine the extent to which their waters meet the objectives of the CWA, attain applicable water quality standards, and provide for the protection and propagation of balanced populations of fish, shellfish and wildlife (*40 CFR 130.8*).
2. **To what extent is water quality changing over time?** The California Water Boards must assess and report on the extent to which control programs have improved water quality or will improve water quality for the purposes of “the protection and propagation of a balanced population of shellfish, fish, and wildlife and . . . recreational activities in and on the water” (*40 CFR 130.8[b][2]* and *130.8[b][1]*). Under *Section 319(h)(11)* of the CWA, the California Water Boards must report on reductions in nonpoint source loadings and related improvements in water quality. Under *Section 314(a)(1)(F)*, a state must report on the status and trends of water quality in lakes. The California Water Boards should also be able to identify emerging environmental issues related to new pollutants or changes in activities within watersheds.
3. **What are the areas needing protection and what is the magnitude and extent of problems where they exist?** Under *Section 303(d)*, the California Water Boards must identify impaired waters. The California Water Boards should also identify waters that are

currently of high quality and should be protected from degradation per the State Water Board's [Antidegradation Policy](#).

4. **What are the sources of stressors affecting water quality?** In order to protect and restore beneficial uses of waters, monitoring and assessment programs should identify the causes and sources of impairment. These causes of impairment (e.g., chemical contaminants, physical conditions, and biological contaminants) keep waters from meeting the water quality objectives adopted by the State to protect designated beneficial uses. The sources of impairment are activities, facilities, or conditions that generate the pollutants responsible for causing impairments. Sources of impairment include, for example, modification of hydrology, industrial and municipal wastewater treatment facility discharges, urban and agricultural runoff, and abandoned mine drainage. The California Water Boards should monitor to identify the causes and sources of impairment to support *Section 303(d)* listing / *305(b)* reporting, TMDL calculations, *Section 319* (nonpoint source control), *Section 401* (water quality certifications), and *Section 402* (point source permitting), as well as other projects and programs.
5. **How effective are water quality improvement projects and programs at protecting or restoring beneficial uses?** The California Water Boards should monitor to evaluate the effectiveness of specific projects and overall programs, including but not limited to *Section 319* (nonpoint source control), *Section 314* (Clean Lakes), *Section 303(d)* TMDLs, *Section 402* NPDES permits, *Section 401* water quality certifications, water quality standards modifications, compliance programs (Discharge Monitoring Report information) and generally to determine the success of management measures and water quality improvements projects, especially those implemented with state or federal funds.

SWAMP monitoring is built around these core uses and the five management questions. These are the five basic questions that should be asked by all the Water Board programs whether they be at the State or Regional Board level. The objectives of all SWAMP monitoring at the regional and statewide scales are framed around answering one or more of these five questions for a particular beneficial use and waterbody(s) combination.

The monitoring objectives for the Regional Water Board have been developed for each of the nine Regions and are updated annually (see Regional Fact Sheets, Appendix E). Regional Water Boards are often required to conduct *ad hoc* monitoring on short notice to address immediate threats to water quality. The SWAMP framework provides the flexibility to Regional Boards to address these issues.

The SPARC recommended that SWAMP focus its *statewide* assessment efforts on fewer waterbody/beneficial use combinations and coordinate with other monitoring programs to address other waterbody/beneficial use combinations. SWAMP responded by limiting its statewide efforts to two critical assessment needs: fish consumption safety in all fishable waters and aquatic life in freshwater rivers and streams (Table 1).

The goal of the SWAMP Bioaccumulation Monitoring Program is to address the "Fishable" use through surveys of contaminant concentrations in fish tissue throughout waters of the

state (lakes, coastal waters, rivers). The monitoring program has the following objectives: 1) determine the proportion of lakes, streams, and coastal sites in which edible fish tissues exceed thresholds for specified contaminants; 2) conduct screening of California waters to identify problem areas where additional monitoring should be conducted to determine whether a fish consumption advisory should be developed; and 3) determine, over the longer term, whether these proportions and contaminant concentrations are increasing or decreasing to evaluate the effectiveness of management actions in reducing contamination.

Table 1. SWAMP statewide monitoring programs organized according to waterbody / beneficial use combination

Waterbody Type	Core Beneficial Use			
	Aquatic Life	“Swimmable”	“Fishable”	“Drinkable”
Wadeable Streams	SWAMP – Statewide (Bioassessment & SPoT)		SWAMP – Statewide (Bioaccumulation)	
Large Rivers	SWAMP – Statewide (SPoT)			
Lakes				
Estuaries				
Ocean, Coastal, Bays				
Wetlands				

The goal of the Bioassessment Monitoring Program’s Perennial Streams Assessment is to assess the “Aquatic Life” use in wadeable streams throughout the state. The objectives of the monitoring program are to 1) determine the percentage of California’s perennial wadeable streams that are in good, fair, and poor ecological condition and identify high quality watersheds; 2) provide baseline data for assessing trends over time at both impaired and high quality waters; 3) determine the proportion of stream length associated with various stressors to ecological condition; and 4) determine the relative risks to ecological condition associated with these stressors.

The goal of the Stream Pollution Trends (SPoT) monitoring program is to assess trends in stressors that may be affecting aquatic life in rivers and streams. The objectives of the monitoring program are to 1) determine long-term trends in stream contaminant

concentrations and their biological impacts statewide; 2) relate water quality indicators to land-use characteristics and to the effectiveness of agency management efforts; and 3) establish a network of sites throughout the state to serve as a backbone for collaboration with local, regional, & federal monitoring programs.

The waterbody by beneficial use framework along with the five core management questions has been adopted by the CWQMC as an organizing principle in their efforts to coordinate and integrate monitoring and assessment activities within CalEPA and the Natural Resources Agency.

Objectives

SWAMP will use the beneficial use framework and the five management questions as an organizing framework to integrate SWAMP efforts with other Water Board programs and leverage monitoring and assessment efforts. The integration of SWAMP monitoring infrastructure within Water Board programs will result in better performance measure outcomes for all programs that address the question as to whether the programs are effective.

Objective 2.1: SWAMP will work with programs at the State and Regional Boards to determine how objectives of the three statewide programs can be refined to better support Water Board programs [Goal 2.1]

- BOG will continue to work with Regional Boards to make information accessible and useful to Water Board programs (methyl mercury, listings).
- The Bioassessment work group will work with Water Board programs determine how results from the perennial stream survey can be used to support the objectives of Water Board Programs (e.g., Assessment, Nonpoint Source, NPDES and Stormwater) and policies under development (e.g., Wetlands and Riparian Area Protection Policy, Hydromodification Policy).
- SPoT will continue to work with Regional Boards to evaluate effectiveness of programs to reduce pollutant concentrations and loads at the watershed scale.

Objective 2.2: Continue the evaluation and review of the specific monitoring objectives for Regional Water Board programs [Goal 2.2]

- Regional Water Board SWAMP coordinators will continue to prepare peer-reviewed monitoring plans that identify specific monitoring objectives for monitoring projects.
- Regional Water Board SWAMP coordinators will continue to make information available to staff working on 305(b) and 303(d) assessments.
- Regional Water Board SWAMP coordinators will continue to use objectives to coordinate/integrate/leverage resources within their Region.
- Regional Water Board SWAMP coordinators will work with programs to prioritize and refine objectives to meet Regional needs

Objective 2.3: Develop consensus on shared monitoring objectives with partner programs [Goal 2.3]

- SWAMP will continue to work with partner programs at the Water Boards to align monitoring objectives with the Clean Water Act objectives
- SWAMP will continue to work with its CWQMC work group partners to develop the Safe to Eat Fish Portal and the Healthy Streams Portal.
- SWAMP will continue to work through the CWQMC to identify agency efforts that can be used to address other waterbody/beneficial use combinations.

3 Monitoring Design

Our vision is to develop scientifically sound monitoring designs to guide efficient collection of data to meet SWAMP's monitoring objectives with available resources, and to coordinate monitoring designs among SWAMP programs, other Water Board programs, and other agencies and partners through the CWQMC. The goals expressed in the 2005 Strategy for monitoring design were:

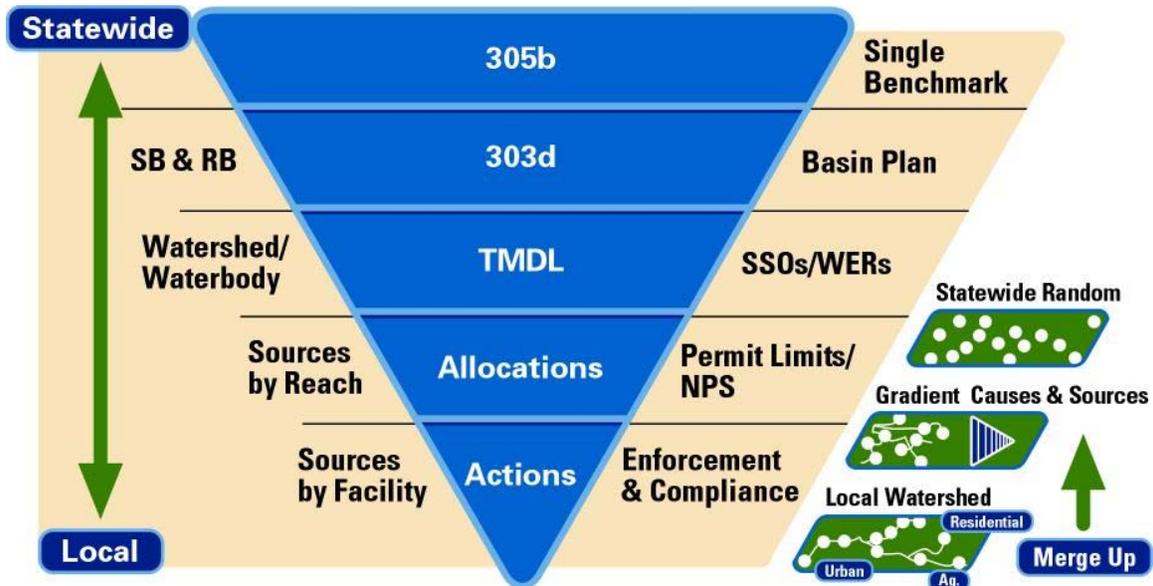
- Goal 3.1 Refine management questions for assessing core beneficial uses for all waterbody types.**
- Goal 3.2 Inventory management questions of existing programs and monitoring entities.**
- Goal 3.3 Develop strategy to answer assessment questions for each waterbody type.**
- Goal 3.4 Design cost-effective monitoring program(s).**
- Goal 3.5 Develop and implement a suite of predictive tools to maximize our ability to effectively manage water quality.**

Current Status

The SWAMP developed a set of objectives and management questions that are consistent with those of other Water Board programs [Goal 3.1] (See Monitoring Objectives section). However, even programs with similar monitoring objectives may need to approach the questions at different scales and may require different monitoring designs. For instance, the NPDES program may focus on differences upstream and downstream of a discharger, the Nonpoint Source (NPS) program may be concerned with restoration at the watershed scale. No single design can meet the needs of all Water Board programs. However, SWAMP has developed the monitoring infrastructure (indicators, methods, QA/QC, and data management) to allow data collected at different scales by various Water Board programs to be integrated (Figure 1). SWAMP is working with each of the major Water Board programs to identify and refine their monitoring questions so that different monitoring designs can be nested within a consistent statewide framework [Goal 3.1 & Goal 3.2].

A continuing goal of SWAMP is to integrate its monitoring designs so that data collected at certain sites and times can be used for more than one program. Beyond the logistical and cost advantages, there are informational advantages because statewide programs provide perspective for regional monitoring and regional programs provide finer detail for the statewide programs (Figure 1). This enhances the value of each assessment for resource management decision making. At a minimum such evaluation of monitoring design should be conducted to avoid duplication of Water Board efforts. The ultimate objective is to better refine the management questions and align monitoring efforts of SWAMP with those of other Water Board programs.

Figure 1. Statewide assessment framework that allows assessment of different monitoring questions at different spatial scales.



The monitoring performed by Regional Water Board programs is predominantly targeted monitoring. This design is good for evaluating trends at a particular location, for comparing conditions upstream-downstream of a particular source for compliance purposes, and for performing general gradient analyses. However, the results from targeted analyses cannot be generally extrapolated in space (upstream or to the watershed as a whole). Furthermore because monitoring funds tend to be limited, this type of monitoring tends to be located in known problem areas. As a result the information from targeted monitoring programs tends to give a biased (i.e., more polluted) picture of the state as a whole ([Rehn and Ode, 2009](#)).

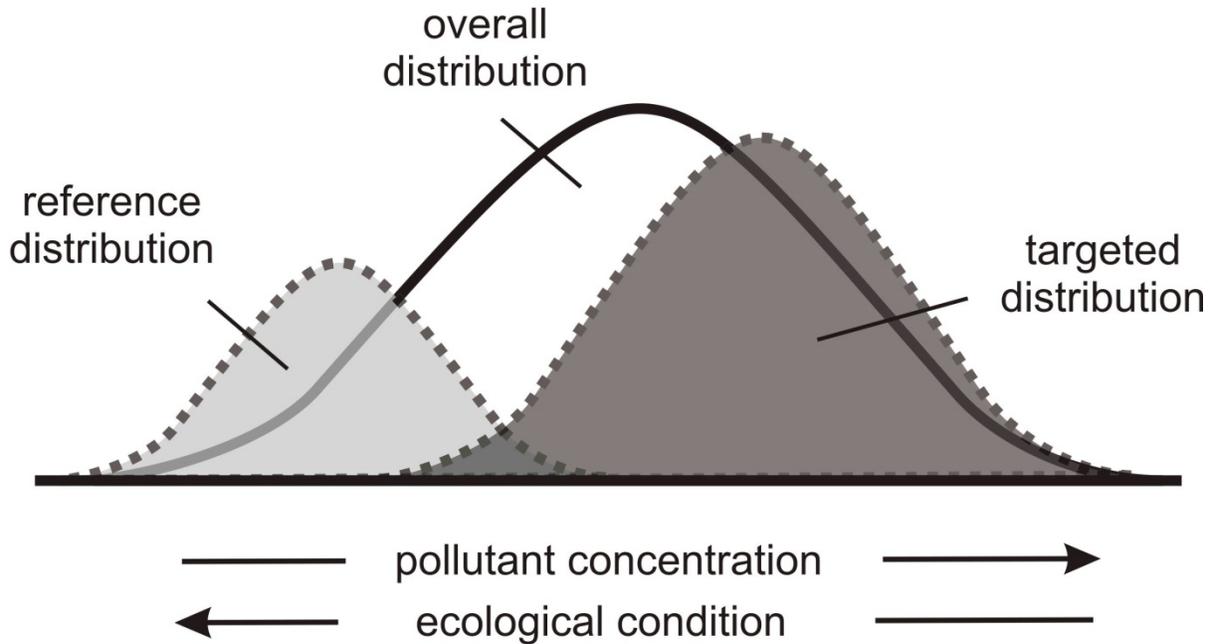
Probability-based monitoring designs are used to provide unbiased estimates of statewide or regional condition. They are better suited to answer questions about the status of a particular resource, such as “what percent of river miles are in poor condition” or “what percent of lakes have fish with tissue contamination levels above an Office of Environmental Health Hazard Assessment (OEHHA) threshold”. They provide information on the overall condition of the resource across a state or region but are not designed to provide information about any particular waterbody.

While probability-based designs provide an unbiased estimate of the existing background condition, they are not optimal for defining the reference conditions. The concept of reference is critical to all Water Board programs because it provides context for evaluating narrative objectives. In a state as complex as California, both targeted and probability-based designs are likely to be necessary to define reference ([Ode and Schiff, 2009](#)).

In reality both targeted and probabilistic monitoring designs are required to generate the data necessary for the Water Boards to conduct an accurate assessment of the quality of waters (Figure 2). Targeted monitoring is used to assess conditions at areas at known or suspected

contamination. The statewide probability-based programs provide a large scale context within which Regional Water Board monitoring programs operate. Reference monitoring provides information on desired condition.

Figure 2. Theoretical distributions of monitoring variables across all sites (probabilistic and targeted surveys) and reference sites.



The SWAMP Perennial Steams Assessment (PSA) currently in the 11th year of implementation uses a probabilistic-design to monitor biological condition in streams throughout the state. The PSA design is integrated with USEPA’s National Rivers and Streams Survey. In 2005, SWAMP worked with the Water Boards NPS program (2005-2009) to adjust the monitoring design to address a number of programmatic questions that the NPS program had such as the relationship between land use and biological condition. SWAMP has also worked with Regional Boards 4, 8 and 9 to encourage the Stormwater Monitoring Coalition in Southern California to nest their biological monitoring within the larger statewide PSA. The Lahontan Region (Region 6) has expanded the PSA monitoring in the Sierra.

SWAMP initiated a Reference Condition Management Program (RCMP) to evaluate reference conditions in perennial streams throughout the state. The RCMP also employs random sampling, but the sampling frame is carefully limited through geographic information system (GIS) analysis and reconnaissance to only those stream reaches that are minimally disturbed. In many areas of the state there are no natural areas, so that the best reference sites available are simply those that are the “least disturbed”. Regional Boards 1, 2 and 6 are using a portion of their SWAMP allocations to leverage this effort.

The SWAMP Bioaccumulation Monitoring Program monitors fish contamination throughout the state by employing a design that integrates features of probabilistic and targeted designs. This program randomly samples waterbodies in distinct size class strata statewide, but also targets the most heavily fished locations. The design of the Lakes Bioaccumulation study was adjusted to provide information that would be useful to Regional Boards preparing the 303(d) list. The Los Angeles Region (Region 4) used its Regional SWAMP resources to expand and enhance the statewide Lakes Bioaccumulation fish contamination surveys to include additional lakes in the Region.

The SWAMP Stream Pollution Trends (SPoT) Monitoring Program uses an entirely targeted design to select sites near the base (discharge point) of large watersheds throughout the state. A targeted design is used to detect trends over time at a station and to develop an understanding of the relationships between land use, management activity, and stream pollution in large California watersheds. All of the Regions participated in site selection for the SPoT program to set up a network of long-term sites linked to Regional and stakeholder monitoring programs. The Central Valley Region (Region 5) used its Regional SWAMP resources, in collaboration with the Department of Water Resources, to increase sampling frequency and number of parameters monitored at SPoT sites within the Region.

Much of the targeted monitoring data generated through Regional Board regulatory programs (e.g. NPDES, Irrigated Lands or TMDL program) can be used to help assess the status of waterbodies at the local scale (as required under 303[d]). SWAMP does not intend to replace or supplant monitoring and assessment activities of other Water Board programs but to work with these programs to make more efficient use of the monitoring resources. Each of the statewide programs is designed to provide Water Board programs with background and context necessary to evaluate the data generated by local or regional programs. The San Gabriel Watershed Program (see box) provides an example of nesting of monitoring designs can lead to more efficient use of monitoring and resources [Goal 3.4]. SWAMP will continue to encourage similar efforts to develop watershed

San Gabriel River Regional Monitoring Program (SGRRMP)

The [SGRRMP](#) is a watershed-scale counterpart to existing larger-scale regional monitoring efforts in the southern California region that seek to address questions and concerns about regional conditions and trends (State Water Resources Control Board Surface Water Ambient Monitoring Program, USEPA's Western Environmental Monitoring and Assessment Program, and the Stormwater Monitoring Coalition). Incorporation of local and site-specific issues within a broader watershed-scale perspective was and remains one of the unique features of the SGRRMP. By considering ways to improve overall cost effectiveness of monitoring efforts in the watershed, the plan includes reductions of redundancies within and between existing monitoring programs. Efforts within the program include targeted monitoring of contaminants of concern and adjustment of monitoring locations and sampling frequencies to better respond to management priorities. The multi-level monitoring framework combines probabilistic and targeted sampling for water quality, toxicity, and bio-assessment.

monitoring programs such as those being formed for the Klamath, San Joaquin, Ventura, Los Angeles River, and San Luis Rey Watersheds.

SWAMP has also worked with other statewide programs. SWAMP uses the information generated by the state's Beach program to address the "swimmable" beneficial use at coastal beaches throughout the state. The GAMA program can help address issues related to the quality of drinking water. Both of these programs are using targeted designs to effectively monitor the entire population of high priority beaches or priority groundwater basins. Both the BEACH and GAMA program are actively working with the CWQMC on the data portals. SWAMP will continue to refine and integrate its monitoring designs and leverage support from partners to provide as much high quality information as possible with available funding [Goal 3.4].

SWAMP has explored detailed approaches to further integrate monitoring designs by using probabilistic monitoring with ecological indicators to test assumptions of non-impairment in upper reaches of watersheds where limited or no monitoring has occurred. Effective management of water quality will require a commitment not only to monitoring but also to the development of predictive tools or models. Models are needed to extrapolate measured water quality conditions to unmonitored, comparable areas. This ability to extrapolate or make predictions can be very useful for cost-effective assessment [Goal 3.5].

Objectives

Objective 3.1: Use SWAMP assessment framework based on beneficial uses and management questions to facilitate efficient coordination of SWAMP monitoring with other Water Board programs [Goal 3.1, Goal 3.2, Goal 3.3 & Goal 3.4]

- Make guidance available to other Water Board programs to best design monitoring to address objectives.
- Continue to coordinate with Water Board programs at the statewide level (e.g., NPS, TMDL, and Assessment).
- Work to align the design of SWAMP monitoring efforts with those of other Water Board programs.

Objective 3.2: Use SWAMP assessment framework based on beneficial uses and management questions to engage with the CWQMC and partner programs to optimize monitoring designs and achieve efficiencies through coordination of indicators, surveys, and analyses [Goal 3.1, Goal 3.2, Goal 3.3 & Goal 3.4]

- Build on the web-based [Central Valley Monitoring Directory](#) developed by the Aquatic Science Center, with funding from the Central Valley Water Board and USEPA.
- Determine whether partner program monitoring designs align with and/or compliment SWAMP designs.

- Continue working with and initiating new stakeholder-based regional monitoring programs and to align their designs with SWAMP to achieve efficiencies.
- Lead CWQMC work groups for aquatic life in streams and fish consumption safety so as to promote data comparability and integrated assessments.

Objective 3.3: Implement SWAMP monitoring at State and Regional Board scales to address beneficial uses at waterbodies throughout the state [Goal 3.3, Goal 3.4]

- Align, to the extent possible, the monitoring designs of the statewide and regional SWAMP programs to achieve the most efficient use of data collected (Figure 1).
- Work to integrate statewide monitoring of ecological indicators with local monitoring of known problem areas to best describe the extent of known impairments, identify previously unknown problems, and protect high quality waters.

Objective 3.4: Develop and implement a suite of predictive tools to maximize our ability to effectively manage water quality [Goal 3.5]

- SWAMP will investigate the use of models to extrapolate results from probability based surveys for use in 303(d) listings decisions for identifying both impaired and unimpaired waters.

4 Indicators

Our vision is to develop, select, and implement indicators and assessment thresholds that appropriately represent the condition of the environmental attributes and beneficial uses to be assessed, diagnose the causes and sources of impairment, and evaluate the effectiveness of management actions to improve water quality in California. The 2005 Strategy had the following four goals for indicator development.

- Goal 4.1 Define core indicators for statewide monitoring and assessment for each designated use and for overall watershed health.**
- Goal 4.2 Recommend set of core and supplemental indicators for use at local watershed scale.**
- Goal 4.3 Develop indices for assessment of biological communities for different waterbody types.**
- Goal 4.4 Develop a set of locally appropriate indices of biological integrity (IBI) for wadeable streams.**

Current Status

SWAMP uses and endorses the concept of core and supplemental indicators (Table 2) in Water Board programs at both Statewide and Regional scales. Core indicators are designed to evaluate the status or condition of waterbodies relative to beneficial uses of concern. Core indicators are appropriate statewide, but may not always be cost effective or necessary to include all in statewide monitoring programs.

Supplemental indicators are intended to be more diagnostic and are necessary when waters are known or suspected to be impaired, and effective management action requires an understanding of the causes and sources of the stressors responsible for the impairment. These indicators are often less directly tied to the beneficial uses and more closely related to the chemical/physical/biological mechanisms that either cause impairment or drive the fate and transport of stressors. Examples include toxicity identification evaluations (TIEs), endocrine disruption assays, flow measurement, hydrologic modeling, and GIS analyses. SWAMP and other Water Board programs have been involved with the continuing development of diagnostic indicators, most recently with advanced TIE methods and improved analysis of chemicals of emerging concern (such as pyrethroid pesticides and algal toxins).

Given the diversity in hydrology, land use, and Basin Plans among Regions, Regional Water Boards need the flexibility to pick and choose indicators that are applicable to their management question and appropriate for their Region. Use of SWAMP indicators and performance-based quality control provides data comparability so that Regional data can be combined with statewide data in integrated assessments.

Aquatic Life Use Indicators

Streams: SWAMP has invested substantial resources over the past five years in the development of ecological indicators (macroinvertebrate and algal bioassessment) and ecological metrics such as IBIs to produce biological objectives based on these indicators [Goal 4.3]. The statewide Bioassessment Monitoring Program interacted with the USEPA, the external scientific review committee, and expert groups (e.g., the Southwest Association of Freshwater Invertebrate Taxonomists [SAFIT]) to develop and refine bioassessment methods, metrics for combining taxonomic observations into indices for assessment, and biological objectives as part of standards development. SWAMP fostered the development of IBIs for [North Coast](#), South Coast, the [Central Valley](#), and [Eastern Sierra](#) and has developed observed/expected (O/E) models for the State [Goal 4.4].

SWAMP continues to implement and test the [California Rapid Assessment Method](#) (CRAM) in for use in their statewide stream surveys. The SWAMP developed and implemented a statewide reference condition management plan. This work will help define thresholds for ecological indicators being developed through SWAMP.

Bays and Estuaries: SWAMP also contributes data and coordinates with the State Water Board Ocean Standards Unit in the development of sediment quality objectives (SQOs) for bays and estuaries. The sediment quality objectives are based on synoptic measurement of a suite of sediment indicators including chemistry, toxicity, and benthic ecology, and define thresholds and narrative criteria for their interpretation and use in impairment designations. SWAMP endorses the use of the SQO triad for assessing sediment conditions.

Stream Pollution Trends (SPoT) Program: The SPoT program has adopted indicators from the U.S. Geological Survey (USGS) National Water-Quality Assessment Program (NAWQA) program, and has worked with its external scientific review committee to establish the specific list of indicators most useful for documenting trends in watershed activity and stream pollution over time. SPoT measures pesticides, metals, industrial compounds and toxicity in sediment collected from multiple points in depositional stream reaches low in the target watersheds.

Fish Consumption Use Indicators

The California Toxics Rule provides water quality criteria that can be used to protect fish consumption. However increasingly there is interest in assessing concentration of contaminants in fish tissue. With the exception of methyl mercury there are no water quality standards for fish tissue concentration. The Office of Environmental Health Hazard Assessment has developed fish contamination goals (FCGs) and a set of assessment threshold levels (ATLs) for some of the key bioaccumulative pollutants (mercury, DDT, PCBs, chlordane). The statewide Bioaccumulation Monitoring Program has implemented an analyte list comprised of persistent organic pollutants and trace metals of concern, including PCBs and mercury; and has established target fish and shellfish species which will serve as a foundation for future monitoring and trend analysis.

Swimming Use (REC 1)

There are well-defined water quality standards/thresholds for the evaluation of indicator bacteria for the protection of uses associated with water contact recreation (e.g., REC 1). SWAMP encourages the monitoring total coliform, fecal coliform and enterococcus at coastal beaches and monitoring of *E. coli* in freshwater to be consistent with the State Water Board plans to adopt *E. coli* as a statewide freshwater standard.

Drinking Water Use (MUN)

For uses related to drinking water (MUN), the Maximum Contaminant Levels (MCL) developed by the California Department of Public Health are the primary standards for evaluation. These MCLs are incorporated into all Regional Board Basin Plans.

Objectives

The SWAMP's objectives related to indicators are to coordinate with other State and Regional Water Board programs to continue the alignment of indicators, quality assurance and data management under the framework of the CWQMC; assist in the development of biological objectives based on ecological indicators; and assist in the development and implementation of sediment quality objectives. The SWAMP is committed to the CWQMC work group as a way to share guidance and information on indicators and their appropriate use.

Objective 4.1: Maintain and implement a set of appropriate monitoring indicators representative of the status of beneficial use support and diagnostic tools for Water Board programs [Goal 4.1, Goal 4.2, Goal 4.3, & Goal 4.4]

- Maintain a list of currently identified status indicators for the SWAMP and partner programs that are representative of ecological and human health attributes of concern.
- Continue assisting with the development of bioassessment methods, metrics, and thresholds for wadeable streams.
- Continue assisting with the development of diagnostic indicators, such as TIEs and analysis of chemicals of emerging concern.
- Keep track of indicator development efforts within the state (including SQOs in Delta, statewide nutrients, new criteria and rapid indicators for pathogens, and contaminants of emerging concern) to identify areas of coordination and partnership with the SWAMP.
- Utilize the State Water Board's [Water Quality Goals](http://www.waterboards.ca.gov/swamp) database for standardizing numeric assessment thresholds.

Objective 4.2: Work within the CWQMC framework to assist in developing, standardizing and implementing indicators to be used by partner programs to assess all waterbody types in California [Goal 4.1 & Goal 4.2]

- Coordinate with CWQMC work groups to identify and share indicators and assessment thresholds and identify opportunities to align assessment and indicator development with other programs within the CalEPA and the Natural Resources Agency.

Table 2. The SWAMP recommended water quality indicators for general designated use categories (modified from USEPA, 2003)

Beneficial Uses	Indicators	
	Core	Supplemental/Diagnostic
Aquatic Life & Wildlife	<p>Conventionals Temperature, Conductivity, pH, DO, nutrients</p> <p>Toxics Metals, Bioaccumulative, Pesticides</p> <p>Toxicity Water and/or Sediment</p> <p>Biological Conditions Invertebrates (streams) Chlorophyll (lakes, streams, estuaries) Algae Wetlands</p> <p>Physical Habitat PHab (streams) CRAM (wetlands)</p>	<p>Other chemicals of concern in water column or sediment</p> <p>TIEs Water and/or Sediment</p> <p>Health of organisms</p> <p>Landscape/Land use Flow</p>
Fish/Shellfish Consumption	<p>Chemical Indicators Mercury, Chlordane, DDTs, PCBs</p> <p>Fecal Indicators (for shellfish) Total and Fecal coliform</p>	<p>Other chemicals of concern in water column or sediment</p> <p>Landscape/Land use</p>
Recreation	<p>Fecal indicators Enterococci, total and fecal coliform (seawater) <i>E. coli</i>, enterococci (freshwater)</p> <p>Other Secchi depth (lakes) Nuisance plant Growth Chlorophyll a Microcystis/Microcystin</p>	<p>Landscape/Land use</p> <p>Other chemicals of concern in water column or sediment</p> <p>Flow Nutrients</p>
Drinking Water	<p>Trace metals Pathogens (Drinking Water Rule, Basin Plan language) Algae (microcystis) Nitrates Salinity Sediments/TDS</p>	<p>Other chemicals of concern in water column or sediment Nutrients</p> <p>Flow Landscape/Land use</p>

5 Quality Assurance

Our vision is to develop, implement, and maintain the quality assurance tools and capabilities needed by SWAMP, and shared with partner programs, to allow comparable data from many sources to be used in comprehensive water quality assessments. The role of SWAMP's quality assurance program is to foster the production of data to inform decision-making (i.e., identifying water quality impairments, fish consumption advisories, TMDL targets, etc.). The goals for this element are as follows:

- Goal 5.1 Implement Quality Assurance Team to provide technical oversight and direction to SWAMP QA activities.**
- Goal 5.2 Develop and document SWAMP Measurement Quality Objectives (MQOs) for each of the core indicators.**
- Goal 5.3 Evaluate the existing QA/QC program, including new methods and program changes, against SWAMP Quality Objectives.**
- Goal 5.4 Implement QA activities to produce data of high consistency/comparability among projects of different scales.**
- Goal 5.5 Implement QC procedures to produce defensible, credible data that meets SWAMP Quality Assurance Program Plan (QAPrP).**
- Goal 5.6 Integrate SWAMP QA/QC procedures in other State Water Board programs.**

Current Status

In January 2005, SWAMP formed its QA Team, consisting of a QA Officer, QA Coordinator and several QA Specialists [Goal 5.1]. The QA Officer leads the team and reports to the SWAMP Program Coordinator and the Water Board QA Program Manager. The QA Team designates a liaison for each major project, Regional Water Board, and testing parameter. The QA Team holds monthly meetings with the QA work group, which consists of the SWAMP Coordinator, the Water Board QA Program Manager, and a representative from US EPA Region 9. The QA Team reports its progress to the SWAMP Roundtable several times each year. The QA Officer produces semi-annual reports to the SWAMP Program Coordinator and the Water Board QA Program Manager as well as other interested parties and organizations.

The initial SWAMP Quality Assurance Management Plan (QAMP) was finalized in 2002 [Goal 5.2]. In 2008, the QA Team, in conjunction with the Roundtable and stakeholders, released the Quality Assurance Program Plan (QAPrP) to replace the 2002 QAMP. The QA Team formed focus groups in May 2005 to address each program testing parameter. There are six focus groups consisting of toxicity testing, organic analytes, inorganic analytes, conventional analytes, bioassessment studies, and field measurements. Each group is used as a resource for sample collection, analysis, reporting, and data assessment [Goal 5.2].

The QA Team also reviews new and existing quality assurance project plans (QAPPs) for Regional Water Boards, bond fund grantees, and partner programs. Since January 2005, the QA Team has reviewed over 170 QAPPs. The QAPPs are compared with the SWAMP Measurement Quality Objectives (MQOs) and the USEPA 24-element QAPP requirements [Goal 5.3]. The QA Team also guided the development of an expert software system to help SWAMP and partner programs develop their QAPPs [Goal 5.6].

In addition, as part of a system-based approach, the QA Team has developed SWAMP-specific standard operating procedures for contract laboratory assessments (audits), data verification, data classification, corrective actions, communication of quality assurance program updates, and quality assurance policy and decision-making [Goal 5.4 & Goal 5.5]. All standard operating procedures are ground-tested prior to finalization and are re-assessed annually.

The QA Team creates and facilitates a framework within which all SWAMP programs and participating partner programs can generate data of known and documented quality, appropriate to project information needs, and comparable for integrated assessments [Goal 5.4 & Goal 5.5]. The QA Team accomplishes this by:

- developing and reviewing planning documents (such as Quality Assurance Project Plans);
- creating templates, checklists and other tools to guide partner programs in developing their QA planning documents;
- establishing MQOs for SWAMP measurement parameters;
- assisting in the development of expert system software;
- participates in kick-off meetings to ensure all parties are familiar with project QA requirements before the project begins;
- conducting laboratory and field audits and recommending corrective actions to improve performance;
- creating standard procedures for and assisting with data classification and verification;
- providing QA reports to management; and
- supporting State Water Board efforts to integrate SWAMP with other Water Board programs.

Within SWAMP, the QAPrP serves as an umbrella document for use by each of SWAMP's contributing projects. It describes the program's quality system in terms of organizational structure; the functional responsibilities of management and staff; the lines of authority; and the interfaces for those planning, implementing, and assessing all activities conducted.

While the focus is on data generated by the SWAMP program, the principles and procedures are applicable to the generation of ambient monitoring data by other State and Regional

Water Board programs. To date SWAMP has worked with the Stormwater Program to develop monitoring plans and QAPPs for their bioassessment monitoring; assisted the Central Valley Regional Water Board to develop QA/QC and data management procedures to meet their program needs; and initiated the effort to add marine matrices MQOs to the QAPrP in collaboration with the Ocean Standards Program [Goal 5.6].

Objectives

The SWAMP QA program conducts a range of continuing activities to provide guidance and facilitate the production of data of known and documented quality that is comparable within the SWAMP program at the Water Boards and with SWAMP's partners in other Water Board units and in the larger California monitoring community. The list of program priorities for the next three to five years includes the following:

Objective 5.1: Maintain the QA Team [Goal 5.1]

- Maintain a QA Team with regularly evaluated roles and responsibilities.
- The QA Team will continue to serve as technical experts to provide the program with oversight and direction and advice on needed standard operating procedures for QA, field and laboratory methods.

Objective 5.2: Develop and document SWAMP MQOs [Goal 5.2]

- The QA Team will maintain updated quality assurance documentation including the QAPrP, project QAPPs, and standard operating procedures. This will include developing, revising and documenting MQOs for all SWAMP field and laboratory parameters; developing field, laboratory and data QA methods for bioassessment; and defining reporting limits for chemistry laboratories.

Objective 5.3: Evaluate existing QA/QC program against SWAMP quality objectives [Goal 5.3]

- The QA Team will ensure that the data classification and verification system is up-to-date and documented in a standard operating procedure.
- The QA Team will ensure that the system is implemented as designed by developing tools and guidance for QAPP development and data classification.

Objective 5.4: Implement QA activities to produce comparable data among projects of different scales [Goal 5.4]

- Provide tools and guidance on develop project QAPPs that are consistent with the SWAMP QAPrP.
- Conduct training workshops, review and approve project and laboratory standard operating procedures, and participate in project kick-off meetings. This will ensure that all project participants understand the QA/QC procedures and activities for which they

are responsible and increase the likelihood that the problems are identified during the project so that corrective action can be implemented.

Objective 5.5: Implement QC procedures to produce defensible, credible data that meets SWAMP QAPrP [Goal 5.5]

- The QA Team will implement QC procedures to ensure the program is being implemented at all phases, from sample collection to analysis to data processing and management. QC activities will include laboratory and field audits, inter-laboratory comparisons/calibration and performance evaluation tests, and data classification and verification.

Objective 5.6: Guidance and tools for partner programs to facilitate data comparability and allow water quality assessments based on combined data sets [Goal 5.6]

- A major focus of the SWAMP program and specifically the QA Team over the next five years will be to work with other Water Board programs to ensure that their ambient monitoring data are collected and stored in a way that they can be combined with other data sets for broader-scale assessments such as 303(d) listing decisions. The State Water Board maintains a Quality Management Plan (QMP), which is the planning document that applies to all of the Water Board's quality systems and requires all Water Board programs to develop QA Program Plans to meet program needs. The State Water Board formed the QA Roundtable to coordinate the development of these plans and assess each programs' needs in terms of data quality objectives. Generally, each program must have data of sufficient quality to assess compliance with water quality standards designed to protect beneficial uses. SWAMP will work with the QA Roundtable to develop recommended reporting limits (RLs) that relate to beneficial use attainment. In addition, the QA Team will provide technical expertise to Water Board programs to develop comparable QA systems to fit their needs.

6 Data Management

Our vision is to manage the flow of data from initial measurement, through acquisition and storage in data management systems, to data output and assessment, so that accurate information is available in a timely manner to decision makers and the public. The original Strategy included the following goals.

- Goal 6.1 SWAMP ambient monitoring data will be stored and checked for comparability in the SWAMP database.**
- Goal 6.2 Provide training and tools to facilitate the use of SWAMP data and information by the State Water Board (intra-agency) and non-State Water Board (Inter-agency) programs.**
- Goal 6.3 Integrate SWAMP data with information collected by the California Water Boards and non-Water Board Programs.**

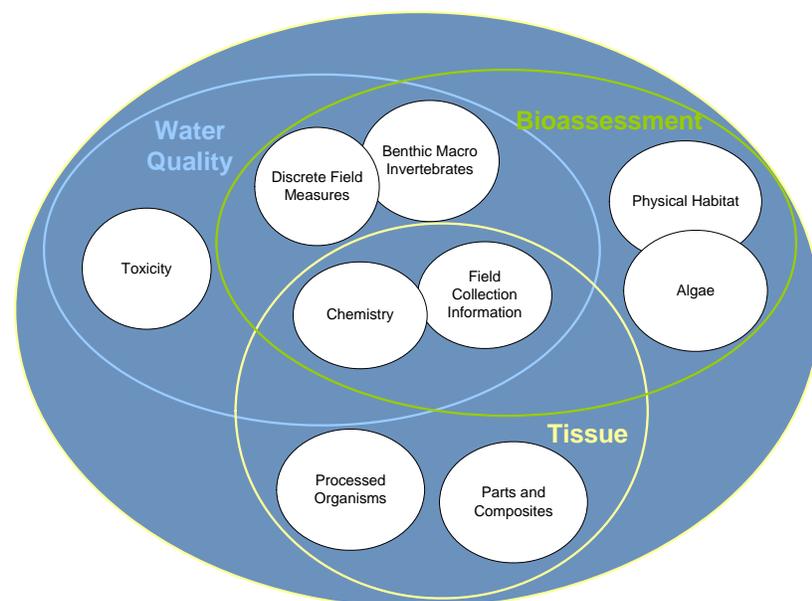
Current Status

Data generated by statewide and Regional SWAMP programs are submitted to the SWAMP database, managed by the Data Management Team (SWAMP DMT) [Goal 6.1]. Staff began development of the SWAMP data management system in 2001, based on a Microsoft Access®. A key component is identical temporary and permanent data tables designed to separate draft data from data of known and documented quality. The SWAMP data management system has continued to build off this initial MS Access-based model, however the permanent side of the database now resides in a MS SQL Server® database. The current v2.5 SWAMP database design has been in place since 2007.

Figure 3 shows the data types that the SWAMP database is able to store: water quality, tissue, and bioassessment. Tables for discrete field measurements, water column and sediment chemistry including bacteria indicators, and water column and sediment toxicity are fully functional. Tables for bioaccumulation including fish, bivalves, birds, and mammal tissue residue have been in place since 2008. Tables for bioassessment data including benthic macro invertebrates, algal, and habitat assessment are in production and will be fully functional in 2011.

The SWAMP DMT provides technical support, tools and training for submitting data to the database [Goal 6.2]. The DMT

Figure 3. SWAMP database v2.5 data elements



maintains the existing data and data systems and develops tools for retrieving data from the database. Data is entered into the SWAMP database either through data entry forms or loaded through specialized data loaders. Maintaining existing data in the SWAMP database makes up another large portion of the SWAMP DMT resources. The SWAMP DMT staff serves as project management liaisons for all SWAMP projects. This includes working with the appropriate regional board staff person to make sure the data sets are complete, classifying all results for data quality, and migrating project data to the permanent side of the database.

Table 3. Result counts from SWAMP database as of October 2010

	Samples	Field Results	Toxicity Tests	Lab Results	Tissue Results	Benthic Results
Initial Monitoring Effort (Temp ¹)	16,339	1,225,834	101,157	976	27,891	268,426
Data of Known & Documented Quality ²	45,062	108,712	669,201	6,675	74,840	462
TOTAL	61,401	1,334,546	770,358	7,651	102,731	268,888

¹ Data stored on the temporary side of the SWAMP database.

² Data have been verified against the SWAMP measurement quality objectives.

SWAMP participants can query the SWAMP database to access data for Water Board assessments [Goal 6.2]. Basic data access queries have been built to allow SWAMP users immediate access to both the temporary and permanent side of the database. SWAMP is actively engaged in the development and implementation of a number of assessment tools, such as the automated query tools for generating lines of evidence for the integrated CWA *Section 305(b)* and *303(d)* assessments. The DMT also provides information for the Water Board's annual performance report.

Data comparability within SWAMP, with other Water Board programs and with other agencies is another important goal for SWAMP [Goal 6.3]. The DMT has provided training sessions in data entry for field data collectors and in data formatting to laboratories. The DMT has created and periodically updates manuals for training on database use and analytical query tools to assist the State Water Board (intra-agency) and non-State Water Board (inter-agency) programs in accessing data and using the SWAMP database. The DMT also maintains a data management comparability help desk.

SWAMP also established four Regional Data Centers tasked with working with local data providers to submit data into the [California Environmental Data Exchange Network](http://www.waterboards.ca.gov/swamp) (CEDEN), which was launched to the public in August 2010. Data stored in the SWAMP database are exported to CEDEN on a regular basis and made available to the public through online query tools. Data generated by partner programs are submitted to one of the four Regional Data

Centers (RDCs), operated by Moss Landing Marine Laboratories (MLML), the Southern California Coastal Water Research Project (SCCWRP), the San Francisco Estuary Institute (SFEI), and the University of California at Davis (UCD). Each of the RDCs receives data in SWAMP comparable formats and transfers data to the CEDEN, funded by SWAMP, to act as a clearing house for water quality data used in comprehensive assessments. CEDEN also will be a primary source of data for the CWQMC's [My Water Quality](#) web portals that present answers to key assessment questions asked by decision makers and the public. SWAMP is committed to the CWQMC work group and web portal approach as a way to share guidance and information on indicators and their appropriate use, leading to increased data sharing and comprehensive assessments based on data from multiple programs.

Objectives

The SWAMP DMT will continue to maintain and improve the SWAMP database system and products for all SWAMP data elements and will maintain and update the database as new technologies are developed. The DMT will continue to load SWAMP ambient monitoring data to the temporary side, verify and classify it, and then transfer it to the permanent side. The DMT also will continue to develop tools and training modules as well as coordinate the State Water Board and non-Water Board programs to facilitate the use of the SWAMP database and data to increase data comparability throughout California.

SWAMP will continue to work with the RDCs to improve and expand on current data tools as well as provide new tools and new data to help turn data into information. The RDCs will continue to work with programs to upload their data into the CEDEN system and to expand the types of data currently available through the CEDEN. CEDEN will provide automated services for grant recipients and smaller data generators to assist them in uploading their data to the system. CEDEN will continue to work with the SWAMP DMT and the State Water Board staff to provide data formats which are required for the integrated assessment report application and increase the use of this tool beyond SWAMP. CEDEN will provide exports of CEDEN data to the USEPA WQX system for use in currently available applications, and to help programs meet their Federal data submittal requirements. CEDEN also has plans to automate many of the Bioassessment analysis functions being developed by the SWAMP Bioassessment work group and the SWAMP DMT to expand the use of bioassessment data in regulatory purposes.

Objective 6.1: Develop and implement a data management system that maintains and documents the integrity of SWAMP data and metadata from initial measurement to final assessment, and efficiently retrieves data to answer SWAMP assessment questions [Goal 6.1]

- Maintain the SWAMP database capable of storing ambient monitoring data elements.
- Verify and classify all SWAMP data to clearly document quality.
- Develop effective methods for querying and extracting data from the SWAMP database and CEDEN in formats useful for answering assessment questions.

- Develop and update the Data Management Plan and business rules to manage data flow.

Objective 6.2: Facilitate data comparability within SWAMP, with other Water Board programs, with CWQMC partners, and with participating stakeholder monitoring programs [Goal 6.2]

- Work with the Water Board's Assessment Unit, SWAMP participants, and the Regional Data Centers to define the minimum data elements needed to submit data to CEDEN.
- Conduct training on input to SWAMP database.
- Staff the data management help desk.
- Maintain automated data checker applications for all entities submitting to the database.
- Initiate user group meetings to share data management information.
- Continue to work within the Regional Data Centers to incorporate new data types and to incorporate the best data management practices.

Objective 6.3: Facilitate data exchange within SWAMP, with other Water Board programs, with CWQMC partners, and with participating stakeholder monitoring programs [Goal 6.3]

- Maintain updated replicated databases at each Regional Data Center as well as the CEDEN master replicate.
- Efficiently export data between the SWAMP database and CEDEN.
- Expand CEDEN by using existing resources at the RDCs and leveraging professional contacts within a regional area and work with other programs to develop formats and crosswalks to allow for the exchange of data with CEDEN.
- Develop applications that allow users to query data on the web and allow for downloading of data in standard formats.
- Develop systems to extract data from CEDEN to populate the Water Board 305b/303d on line Integrated Assessment of water quality conditions and impaired waters in California.
- Develop systems to extract data from CEDEN to populate the CWQMC on-line web portals where information can be easily accessed by decision makers and the public.
- Make the CEDEN network self-sustaining.

7 Data Analysis and Assessment

Our vision is to provide a consistent science-based assessment framework that integrates data from SWAMP and partner programs to effectively answer assessment questions and inform water quality management decisions at the State and Regional levels. The original goals of the Strategy are as follows:

- Goal 7.1** Develop a method for assessing standards attainment for listing purposes (303[d]).
- Goal 7.2** Develop guidance to assist in 303(d) and 305(b) assessments, consistent with the 303(d) listing policy.
- Goal 7.3** Contribute to statewide and regional assessments to achieve comprehensive assessment of all waterbodies for all beneficial uses.

Current Status

Assessment is the translation of monitoring data into information relevant to identified management issues. The overall focus of the SWAMP Strategy is that all Water Board activities contribute to identifying high priority assessment questions and providing answers to those questions to aid resource managers and the public in making informed policy decisions.

The SWAMP contributes to the determination of beneficial use support for all California waters under CWA *Section 305(b)*, and the identification of waters not supporting beneficial uses (i.e., impaired waters) as required by CWA *Section 303(d)* (see box). Both of these assessments are described in the biannual [Integrated Report](#). The SWAMP provides data, tools and expertise to the State and Regional Water Board assessment units to develop lines of evidence for beneficial use support ratings and impairment designations consistent with the State Water Board’s (2004) [Policy for Developing California’s Clean Water Act §303\(d\) List](#) [Goal 7.1 & Goal 7.2]. The

Beneficial Use Support Categories	
1	1) A water that supports a minimum of one California Beneficial Use for each Core Beneficial Use that is applicable to the water; and 2) has no other uses impaired.
2	1) A water that supports some, but not all, of its California beneficial uses; and 2) has other uses that are not assessed or lack sufficient information to be assessed.
3	A water with water quality information that could not be used for an assessment, for reasons such as: monitoring data have poor quality assurance, not enough samples in a dataset, no existing numerical objective or evaluation guideline, the information alone cannot support an assessment, etc.
4A	1) A water segment where ALL its 303(d) listings are being addressed; and 2) at least one of those listings is being addressed by a USEPA approved TMDL.
4B	A water segment where ALL its 303(d) listings are being addressed by action(s) other than a TMDL.
5	A water segment where standards are not met and a TMDL is required, but not yet completed, for at least one of the pollutants being listed for this segment.

SWAMP funded the development of the California Water Quality Assessment Database (CalWQA) which is the primary tool use by 303(d) staff at the State and Regional Water Boards to develop the Integrated Report.

SWAMP conducts three priority statewide assessments [Goal 6.3]:

- The Bioaccumulation Monitoring Program has completed its first assessment of [California lakes](#) and is beginning its assessment of [coastal waters](#).
- Bioassessment Monitoring Program: The PSA currently is in the middle of its 11th sampling year. They have produced the following reports: SWAMP recently completed a draft technical report that will provide source material for a series of management reports that will showcase the many potential applications of PSA data in Water Board management programs. The RCMP's [programmatic plan](#) has been peer-reviewed, finalized, and posted at the State Water Board's website. The RCMP will be further refined to define regionally appropriate stressor thresholds for screening and selecting reference sites and to establish alternate strategies for identifying appropriate reference sites in areas that lack a sufficient number or distribution of minimally disturbed candidate sites.
- Stream Pollution Trends (SPoT) Monitoring Program has completed its first two years of monitoring, with one of those years substantially limited due to funding shortfalls. Those data currently are being assessed to establish baselines for long-term trends and to investigate relationships between land use and stream pollutant concentrations and toxicity. A report on the first two years is due in 2011.

Regional SWAMP programs conduct a variety of assessments to determine compliance with Basin Plan objectives, categorize impaired waters, identify causes of impairment, locate and manage pollution sources, regulate discharges, and manage nonpoint sources such as urban stormwater and agricultural runoff [Goal 7.3]. These SWAMP assessments can be found on Regional Water Board websites (e.g., <http://www.ccamp.org/>). The regional assessments utilize SWAMP monitoring design, quality assurance, and data management tools to ensure that data are collected in a manner consistent with the statewide programs and can be combined for broader scale assessments.

The SWAMP is aligning many of its programs with the California Water Quality Monitoring Council's (CWQMC) approach to assessment. The CWQMC has formed work groups that are tasked with developing assessment questions around themes: Is it safe to eat fish and shellfish?; Is it safe to swim at my beach?; Is our water safe to drink?; and Are our ecosystems healthy? The work groups then identify and obtain data sets to answer the questions and develop web portals to convey the assessments to the public. The SWAMP has taken the lead on two work groups to develop CWQMC web portals that provide easily accessible assessments of the health of aquatic life in streams and the level of contaminants in sport fish and shellfish in all California waters. These work groups operate under the CWQMC guidelines to develop the two web portals, participate in the development of

thresholds for beneficial use support assessment, and establish report card formats for communicating water quality conditions.

The CEDEN data exchange network initially supported through SWAMP funding provides data for web portals addressing a range of beneficial uses and waterbody types (See Data Management section).

Objectives

Objective 7.1: Apply SWAMP tools and expertise to high priority assessments [Goal 7.1 & Goal 7.2]

- Provide guidance and tools to assist in CWA 305(b)/303(d) assessments including the translation/interpretation of narrative standards.
- Ensure that SWAMP data generated from statewide and Regional Board monitoring efforts is available for use in integrated report.
- Support the development and sharing of tools (such as automation software) to facilitate assessment of compliance with Basin Plan objectives.
- Support the development and sharing of tools (such as the Central Coast Ambient Monitoring Program's [CCAMP's] automation software) to assess impaired waterbodies and overall resource conditions (303d/305b).

Objective 7.2: Implement the three SWAMP statewide assessments [Goal 7.3]

- The Bioaccumulation monitoring program will continue its assessment of coastal waters and plan for subsequent assessment of large rivers.
- Assess the ecological condition of perennial streams and reference sites. PSA is currently (2008-2011) focused on increasing representation across California's major ecoregions. Highest priority for the RCMP will be given to sampling reference sites as needed to support the development of biological objectives.
- Assess trends in stream pollution and relationships with land use and management action. In 2010, the SPoT monitoring program will complete its first assessment of stream contamination and toxicity in large California watersheds. SPoT will begin its trend analysis with the second assessment in 2011.

Objective 7.3: Use CWQMC Portals as a framework for assessment [Goal 7.3]

- Coordinate SWAMP assessment strategy with the CWQMC to identify waterbody types, beneficial uses, and management questions that SWAMP will address.
- Integrate, where appropriate, data from different indicators and designs to generate efficient statewide assessments.

- Create a general and adaptable set of thresholds against which to compare all SWAMP measurements for report cards and policy action at the statewide and Regional levels.

Objective 7.4: Implement and assist with special assessments for identified resource management issues [Goal 7.3]

- Provide data for and assist with the development of Sediment Quality Objectives (SQOs).
- Provide monitoring expertise and guidance for assessment of Areas of Special Biological Significance (ASBS).
- Partner with other Water Board programs, the USEPA, and other agencies on shared assessments such as the National Surveys for Lakes, Streams, Coastal Waters, and Wetlands.

8 Reporting

Our vision is to make all SWAMP data available to the public, to translate SWAMP data into information useful for making resource management decisions, and to provide timely reports in formats most accessible to target audiences. To accomplish this, the SWAMP identifies target audiences, selects the most effective media to reach them, and provides a range of products from newsletters and fact sheets to interpretive reports and statutory documents, such as the Integrated Report (Clean Water Act (CWA) *Section 303(d)* list / *305(b)* Report), and the CWQMC's [My Water Quality](#) web portals.

- Goal 8.1 Produce timely and complete water quality reports and lists as required by the Clean Water Act and consistent with current USEPA guidance.**
- Goal 8.2 Report to the public on water quality taking into account the needs of interested audiences. Use various formats and media such as brochures, fact sheets, report cards, oral presentations, and the Internet.**
- Goal 8.3 Produce technical reports and peer reviewed journal articles resulting from monitoring program activities.**

Current Status

The SWAMP provides data and participates in assessments to compile reports and lists required under the Clean Water Act including [Goal 8.1]:

- The CWA *Section 305(b)* water quality assessment report, which characterizes the condition and quality trends of monitored waters within the state and is due on April 1 of even-numbered years. This is the primary state surface water quality assessment report to USEPA and draws upon information from SWAMP, the Nonpoint Source program, TMDLs, and other national, state and local assessments.
- The CWA *Section 303(d)*, which list identifies all impaired waters based on existing and readily available information. The list is also due on April 1 of even-numbered years.
- Development and submission of *Section 305(b)* water quality assessment reports and *Section 303(d)* lists of impaired waters can be integrated. The Integrated Report will satisfy CWA reporting requirements for both *Section 305(b)* water quality reports and *Section 303(d)* lists. The SWAMP represented a significant source of data in the 2010 Integrated Report. SWAMP data were used in the generation of 11,616 lines of evidence (LOEs, 52% of the total number), or individual data assessments, supporting the development of 2010 *303(d)* list.
- The annual data update requirement may be satisfied by uploading monitoring data to the national Water Quality Exchange (WQX) warehouse or updating the *305(b)* assessment information in the California Water Quality Assessment (CalWQA)

database which is compatible with the USEPA National Assessment Database. SWAMP funds were used to support the development of CalWQA.

- *Section 406* of the Clean Water Act, as amended by the Beaches Environmental Assessment and Coastal Health Act of 2000, requires states with *Section 406* grants to submit information on monitoring and notification programs for coastal recreation waters. Details on the California program are included in the Annual Clean Beach Initiative Report to the Legislature.

In addition the SWAMP provides data for a number of reports that satisfy California State requirements [Goal 8.2]:

- In 2009, the Water Boards released the first annual [Performance Report](#). The second annual report was released in September 2010. The first two reports focus primarily on the Water Boards activities to protect water quality (e.g., number of permits issued, inspections conducted, enforcement actions issued). However the long-term vision is that the Performance Report also will measure the Water Boards performance in terms of environmental outcomes such as water quality improvement. Results from SWAMP's statewide assessments were used to report on [ecosystem health](#) in the Water Board's Annual Performance Report [Goal 8.2]. Those report cards were an initial step toward the long-term goal of reporting environmental outcomes.
- The California Water Quality Monitoring Council provides recommendations for improving monitoring and assessment through coordination among local, regional, state and federal agencies and other entities that collect water quality data in California. Their efforts focus on developing theme-based [web portals](#) for reporting water quality and associated ecosystem health information to answer questions important to resource managers and the public as a means for developing collaborative relations among monitoring entities and thereby improving the efficiency and effectiveness of monitoring, assessment, and reporting.

SWAMP provides and supports a variety of reports. Most of the reports are available to the public in paper and electronic form and include fact sheets, data reports, quality assurance reports, interpretative reports and the Integrated Report. These reports provide an analysis and interpretation of the data collected. Technical reports are summarized in fact sheets that capture key findings in a more accessible format [Goal 8.3].

Technical reports from the statewide SWAMP programs are available on the SWAMP website. The Bioaccumulation Program has published a review of historical data on bioaccumulation in fish and shellfish ([Davis et al., 2007](#)), as well as an assessment of edible fish contamination in California lakes ([Davis et al., 2010](#)). The Bioassessment Program has continued a series of reports on the ecological health of California streams ([Ode and Rehn 2005](#); [Ode, 2007](#)) and will be producing a scientific report on the first 8 years of the PSA along with a series of management reports. They have also contributed to a series of reports on the development of bioassessment indicators and metrics. The SPoT program's first report is due in 2011. All of these programs have contributed data used in the Integrated

Report. SWAMP has also produced a number of reports on special studies [Goal 8.2 & Goal 8.3]. SWAMP reports can be found at:

http://www.swrcb.ca.gov/water_issues/programs/swamp/reports.shtml.

SWAMP Regional programs have produced numerous reports to address Basin Plan priorities and local issues. These can be found at:

http://www.swrcb.ca.gov/water_issues/programs/swamp/regionalreports.shtml.

SWAMP funds have also been used to develop reports to support specific programs. In 2008, the SWAMP worked with the Ocean Planning Unit to assess aquatic life use in [Bays and Estuaries](#) using the newly developed sediment quality objectives. This report was provided to the State Water Board to inform their decision to adopt the SQOs. SWAMP also supported monitoring of Areas of Special Biological Significance (ASBS). A report on the status of water quality in ASBSs is expected in late 2010. Also in 2008 SWAMP supported the assessment of the [quality of estuarine wetlands](#) throughout the state using the California Rapid Assessment Method (CRAM). This report supported the [State of the State's Wetlands](#) report (Natural Resources Agency, 2010). CRAM methods are currently being deployed as part of the SWAMP's Bioassessment Monitoring Program. It is hoped that this work will ultimately support CRAM development and Water Board efforts to formulate its riparian policy.

Objectives

Objective 8.1: Produce timely and complete water quality reports and lists as required by the Clean Water Act and consistent with current USEPA guidance [Goal 8.1]

- Contribute the necessary quantity and quality of SWAMP data for use in the Integrated Report including healthy streams.
- Assist in developing guidance for defining whether a waterbody has been adequately assessed and when there is sufficient information to assign a waterbody to Category 1 (fully supporting all beneficial uses).
- Participate in data analysis and preparation of the Integrated Report.

Objective 8.2: A web-based reporting system that effectively transfers information to decision makers and the public [Goal 8.2]

- A SWAMP website that posts SWAMP assessment products and draws target audiences.
- A CWQMC fish and shellfish consumption safety web portal maintained by the SWAMP Bioaccumulation Oversight Group (BOG).
- A CWQMC stream ecosystem health web portal maintained by the SWAMP Healthy Streams Partnership.
- A CEDEN system capable of exporting data through efficient query tools and able to support information delivery to the public through CWQMC web portals.

- An Integrated Report website that includes an interactive map that delivers detailed water quality assessment information to the public.
- Provide information for the Water Board's Annual Performance Report including recommendations for reporting environmental outcomes.

Objective 8.3: A SWAMP water quality reporting strategy that uses various formats to most effectively reach target audiences [Goal 8.2]

- Up-to-date SWAMP website providing access to all communication products.
- Regular manager's reports, fact sheets, brochures, and report cards summarizing state and regional assessments.
- Regular publication of the Monitor newsletter.
- Presentations to colleagues at the National Water Quality Monitoring Conference and other professional meetings and workshops.
- Email subscriptions and press releases to alert target audiences of product releases.
- A series of webinars to present assessment tools, program descriptions, monitoring results and assessments to a wide audience.

Objective 8.4: Effective communication with agency management [Goal 8.2]

- Presentations and briefings to management at the Water Boards and partner agencies.
- Presentations to the CWQMC.
- Liaison to Roundtable meetings for other Water Board units such as TMDL and NPS.
- Timely water quality reports to agency managers and decision makers.

Objective 8.5: Technical reports and peer reviewed journal articles resulting from SWAMP activities [Goal 8.3]

- Technical reports for all statewide and regional assessments available within two years of data collection.
- Support for publication in scientific journals as a form of external peer-review.

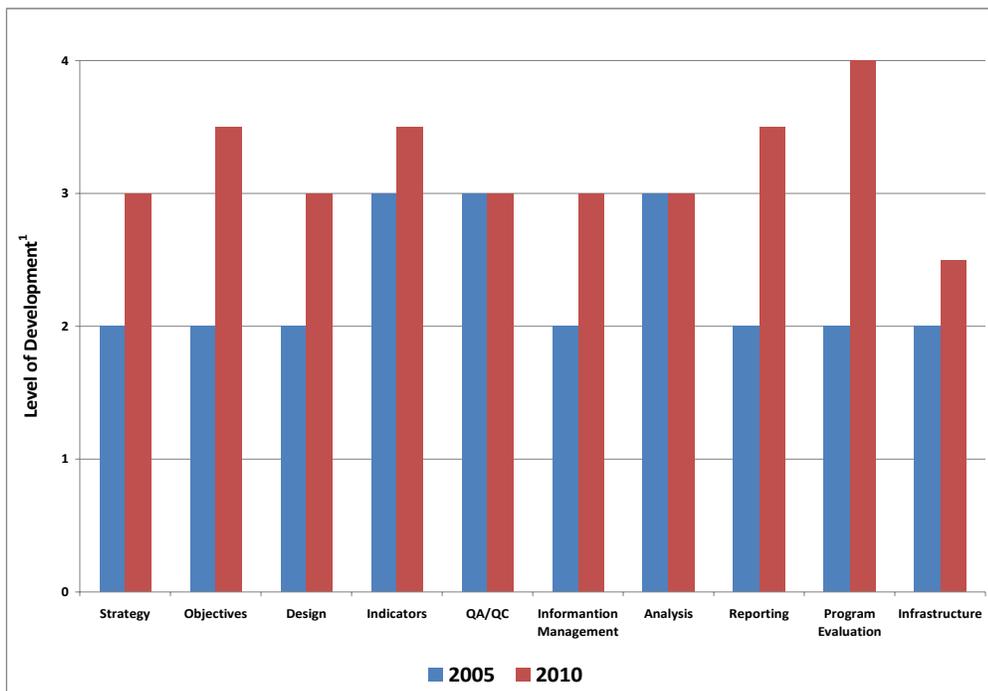
9 Programmatic Evaluation

Our vision is to conduct periodic reviews of each aspect of the program to determine its scientific validity, whether it is being implemented as designed and how well it serves the water quality decision needs of the state.

This will require the California Water Boards, in consultation with USEPA Region 9, to conduct periodic reviews of the SWAMP program to determine how well the program is being implemented and how well it serves the water quality decision needs for all State waters, including all waterbody types. This review must include an evaluation of the monitoring program strategy to determine how well each of the 10 elements is addressed and how to incorporate needed changes and additions into future monitoring cycles. This evaluation will take into consideration the effects of funding shortfalls on implementation of the monitoring program strategy.

In 2005, SWAMP was evaluated against the 10 monitoring program elements. In 2010, an evaluation by USEPA showed that the program made significant progress in each of the 10 elements (Figure 4 and Table 4).

Figure 4. Evaluation of the SWAMP’s monitoring strategy (2005-2010)



¹ Level of Development: Levels 1 and 2 are not consistent with the *Elements* (USEPA, 2003) guidance, Level 3 programs are consistent with the Elements Guidance, and Level 4 represents an enhanced program.

Table 4. Summary of the SWAMP’s progress toward meeting the ten monitoring program elements

Element	Evaluation of SWAMP 2010
Strategy	The SWAMP Strategy was revised to acknowledge formation of the California Water Quality Monitoring Council (CWQMC), which is a multi-agency work group. State Water Board does not have the resources to monitor all water resources within the State. The SWAMP Strategy is being integrated with the CWQMC to provide framework for increased coordination of monitoring and assessment.
Objectives	The original Strategy called for SWAMP to address four core beneficial uses (swimmable, fishable, aquatic life use, drinking water) in multiple waterbody types across the State. The SWAMP is now focusing on aquatic life use in streams and fish tissue contamination in lakes, coastal zone and rivers. The CWQMC is being used as a forum to coordinate with other State and federal agencies to generate data to assess beneficial uses in other waterbodies.
Design	The SWAMP implemented probabilistic monitoring statewide for aquatic life use in perennial streams and fish contaminants in lakes and coastal waters. Challenges remain in working with designs of other agencies to meet overall objectives.
Indicators & Thresholds	Refining biological indicators for streams including invertebrates, periphyton and riparian wetlands. Working with Department of Public Health on thresholds for bioaccumulation. Need to work with resource agencies to explore and develop other indicators for aquatic life use.
QA/QC	Developed statewide QA/QC program for the SWAMP activities performed by Regional Water Boards and Statewide surveys. Now integrating the SWAMP QA/QC procedures into other State Water Board programs or the programs of other State agencies. Emphasis is on defining appropriate levels of comparability.
Information Management	Developed data management structure for multiple data types (water quality, toxicity, sediment and tissue contaminants, physical habitat, macroinvertebrates). The SWAMP is not able to support all state ambient data needs. SWAMP is supporting development of the California Environmental Data Exchange Network as a tool for agencies to share data. SWAMP is also working with CWMQC to develop theme-based web portals built around four core beneficial uses as a means to communicate information to the general public. There are challenges associated with getting agreements to establish standardized formats for data exchange.
Analysis & Assessment	Significant effort has been invested on development of tools for use in 305b and 303d assessments. Challenges remain in institutionalizing use of biological endpoints in 303d listing in all nine Regional Water Boards across the State.
Reporting	Produced several statewide condition surveys (aquatic life use in perennial streams, fish contamination in lakes, sediment quality in coastal waters). The SWAMP also produced a diverse array of other products including regional reports, special studies, fact sheets, newsletters, press releases, and presentations at professional meetings. Link to the SWAMP statewide reports webpage .
Programmatic Evaluation	A programmatic peer review of the SWAMP was completed in 2005. Since then, peer reviews have been focused on particular aspects of the program (e.g., Bioaccumulation Survey and Reference Approach). These come at a cost, but are well worth it.
Infrastructure Planning	Funding for basic infrastructure is a challenge. Program needs evaluated during CWA <i>Section 106</i> negotiations and workplan development. The SWAMP is evaluating options for potential sources of funding to reduce its reliance on <i>Section 106</i> funds.

SWAMP should be evaluated as part of a continuous improvement feedback loop. This may include, for example, undertaking audits focused on implementation of the monitoring program objectives, quality assurance protocols, and laboratory and data assessment procedures.

Goal 9.1 Ensure that the program is being implemented as designed.

Goal 9.2 Ensure that the SWAMP program is meeting the needs of other Board programs (for example, the TMDL or NPS programs).

Goal 9.3 Ensure that the program is technically sound.

Current Status

Currently, the SWAMP program receives input, review and guidance from a number of entities that assist the program:

SWAMP Roundtable: Coordination of the SWAMP is achieved through monthly meetings of the SWAMP Roundtable. The Roundtable is composed of State and Regional Water Board staff and representatives from other agencies and organizations, including the Department of Fish and Game, the Marine Pollution Studies Laboratory, and the University of California. Interested parties, including members of other agencies, consultants or other stakeholders are welcome to participate. Roundtable members provide programmatic, technical, and logistical support and guidance on the implementation of the program. Generally, decisions are made by consensus. The strength of the current program resides in the Roundtable. Together, the skills, knowledge, abilities, and perspectives of the individual members combine to form a coordination entity stronger than its individual participants [Goal 9.1].

California Water Quality Monitoring Council: The CWQMC is co-chaired by the CalEPA and the Natural Resources Agency and is comprised of stakeholders from the regulated community, non-governmental organizations, and academia. The CWQMC serves as a review body for the SWAMP and recently reviewed a draft of the SWAMP Strategy revision, which will be appended to the CWQMC's comprehensive monitoring strategy [Goal 9.2].

Watershed Technical Advisory Committees: Some regions have elected to receive reviews and coordinate their watershed assessments by relying on locally appointed technical advisory committees (TACs). The TAC functions vary and may include planning and/or review. Although effective for individual regions, TACs' inconsistent implementation among regions limits their overall program value [Goal 9.3].

Scientific Planning and Review Committee: An external scientific panel, the Scientific Planning and Review Committee (SPARC) was organized by SWAMP to review monitoring objectives, design, approaches, indicators and other relevant topics. Committee members are representatives from federal and state agencies and academics with expertise in fields such as monitoring program management, monitoring design, ecology, chemistry, quality assurance, pathogens, toxicology, and statistics. The SPARC met in 2005 and produced a set of written recommendations, finalized in 2006. Since then, each of the three SWAMP

statewide programs has convened its own external scientific review committees to guide these programs [Goal 9.1, Goal 9.2 & Goal 9.3].

External Scientific Review for the three SWAMP statewide programs: The Bioaccumulation, Bioassessment, and Stream Pollution Trends monitoring programs each have convened external scientific review committees that meet as needed to review program objectives, designs, indicators and assessments. These committees are comprised of nationwide experts in the programmatic and technical aspects of relevant disciplines, and include managers of related federal programs such as USEPA Environmental Monitoring and Assessment Program (EMAP) and USGS NAWQA [Goal 9.3].

Objectives

Objective 9.1: Evaluate workplans, perform audits, and develop performance measures to ensure the program is implemented as designed [Goal 9.1]

- Review annual and/or multi-year workplans, including the Regional SWAMP workplans and monitoring plans, to ensure that all program elements are addressed in workplans.
- Use information from regional audits to document extent of compliance with elements.
- Develop program performance measures and report on them annually.

Objective 9.2: Evaluate the program to ensure it is meeting the needs of other Water Board programs [Goal 9.2]

- Annual evaluation by SWAMP.
- Annual evaluation by USEPA.
- Periodic evaluation by program offices.

Objective 9.3: Employ peer review to ensure that the program is technically sound and scientifically defensible [Goal 9.3]

- Continue technical review of all monitoring plans and technical reports.
- Develop and implement process to respond to the [Scientific Planning and Review Committee](#) (SPARC) recommendations.
- Conduct focused review of program elements to ensure they are implemented as designed and in a cost-effective manner.
- Participate in triennial review of the CWQMC comprehensive monitoring strategy as required by the enabling legislation ([Senate Bill 1070, Kehoe](#), Statutes of 2006).

10 General Support and Infrastructure

Our vision is to provide the support needed to implement a coordinated and comprehensive monitoring and assessment program, and to maintain the infrastructure and program capabilities necessary to accomplish program goals.

Goal 10.1 Provide ongoing program coordination, administration and oversight.

Goal 10.2 Update the SWAMP needs assessment.

Current Status

SWAMP is currently funded at approximately 7 percent of the original estimate in the 2000 Needs Assessment. The lack of adequate resources has seriously limited what SWAMP is able to accomplish. It is highly unlikely that the program will ever have the resources described in 2000. This Strategy update reflects our current efforts to increase support for SWAMP by increasing the value and access to SWAMP information products, and to coordinate with partners who can assist with coverage of other Clean Water Act monitoring requirements.

SWAMP has since greatly reduced its monitoring scope and has targeted its statewide programs on two critical areas: contamination of edible fish and shellfish in all waterbody types, and aquatic life beneficial uses in streams. To meet the Clean Water Act requirements of assessing all waters for all beneficial uses, SWAMP needs to both seek additional funding and increase its coordination with partner programs that monitor areas where SWAMP cannot.

SWAMP has had partial success in both areas. The USEPA and the State Water Board have allocated CWA *Section 106* funds to support the SWAMP statewide programs at their current levels. SWAMP Regional and infrastructure allocations have declined, and additional funding sources need to be identified. Our coordination efforts were greatly enhanced with the creation of the California Water Quality Monitoring Council. The CWQMC has recommended and begun implementation of a system of theme-based work groups to address the range of waterbody type/beneficial use combinations in need of assessment. SWAMP is taking responsibility for the Safe to Eat Fish and Shellfish work group and the Aquatic Ecosystem Health in Streams, Rivers, and Lakes work group. A web portal for the [Safe to Eat Fish and Shellfish](#) theme was released in 2010 and currently is being enhanced with new data and assessments. The Healthy Streams Partnership is developing the Aquatic Ecosystem Health in Streams, Rivers, and Lakes web portal for release in 2011.

The SWAMP also is actively recruiting partners in other Water Board programs, other CalEPA and Natural Resources agencies, the regulated community, and citizen monitoring organizations. By providing tools for data comparability and exchange, SWAMP is encouraging these entities to generate and contribute data that can be integrated into comprehensive assessments that would otherwise exceed SWAMP's scope. SWAMP's statewide programs share sites and indicators with partners to provide statewide perspective

for local programs and greater spatial detail for statewide assessments. SWAMP's Regional programs actively partner with local entities to leverage SWAMP funds and increase the information value of resulting assessments. SWAMP also is working with the State Water Board's Quality Assurance Program and the recently assembled QA Roundtable to develop Quality Assurance Program Plans for all Water Board programs that collect ambient surface water monitoring data.

One area in need of infrastructure improvement, as identified by both the Roundtable and the CWQMC, is the contracting process by which SWAMP accesses the capabilities of the University of California (UC) and California State University (CSU) to conduct monitoring, data management, and assessment. The State Legislature has begun to address this issue with the passage and signing of Assembly Bill 20 (Solorio, Statutes of 2009) that requires the Department of General Services, to establish a model contract with standard contract provisions for UC and CSU agreements. This may be one step toward streamlining a contract process that currently requires multiple reviews and results in lengthy delays.

Objectives

Objective 10.1: Increased visibility and usefulness of SWAMP information through targeted reporting and dissemination via the CWQMC web portals [Goal 10.1, Goal 8.2]

- By engaging partners and making monitoring information more accessible on the CWQMC web portals and other outlets, SWAMP intends to increase its outreach and make its programs more valuable to the public and decision makers (Element 8).

Objective 10.2: Provide ongoing program coordination, administration and oversight [Goal 10.1]

- Support Water Board staffing levels adequate to manage SWAMP contracting and administrative needs.
- Identify and implement the most effective method of contracting for the program.
- Maintain laboratory and field capability adequate to handle current and anticipated monitoring workload.
- Maintain the expertise and capabilities of SWAMP contract laboratories to allow continued high quality monitoring and assessment.
- Document the history of key SWAMP communications, decisions, budgets, and products to support SWAMP institutional memory.

Objective 10.3: Provide regional coordination [Goal 10.1]

- SWAMP Regional Coordinators will strive to coordinate monitoring among Water Board programs and other agencies and entities at a regional scale; however, resource constraints may limit their ability to do this in a comprehensive manner.
- Provide administrative oversight.

- Support travel required to attend the National Water Quality Monitoring Conference and other key opportunities to get review and insights for program improvement.
- Identify other state-funded monitoring that could be more professionally, efficiently, and cost-effectively conducted by the SWAMP.
- Work with the CWQMC to develop proposals to improve monitoring to determine effectiveness of state financed water quality improvement projects.

Objective 10.4: Update the SWAMP Needs Assessment [Goal 10.2]

As the SWAMP pursues this dual approach to program support, staff will need to identify current and future resource needs to fully implement the SWAMP Strategy. As part of an ongoing triennial review and planning process, the following needs should be assessed, considering current conditions and planned improvements:

- Identify the required number of staff needed for the SWAMP program implementation;
- Identify the laboratory support needed to conduct high quality analyses and manage data according to SWAMP procedures;
- Identify training needs for program implementation by field, laboratory, data management and data assessment staff;
- Identify annual monitoring needs of Regional Water Boards;
- Identify annual monitoring needs of the State Water Board;
- Prepare budget for upcoming year; and
- Forecast budget needs for three years.

References

California Water Quality Monitoring Council (CWQMC). 2008. Maximizing the Efficiency and Effectiveness of Water Quality Data Collection and Dissemination and Ensuring that Collected Data are Maintained and Available for Use by Decision-makers and the Public. Recommendations of the California Water Quality Monitoring Council.

California Water Quality Monitoring Council (CWQMC). 2010. A Comprehensive Water Quality Monitoring Program Strategy for California. Recommendations of the California Water Quality Council. Submitted to the Secretaries for Environmental Protection and Natural Resources.

Davis, J.A., J.L. Grenier, A.R. Melwani, S.N. Bezalel, E.M. Letteney, E.J. Zhang, and M. Odaya. 2007. Bioaccumulation of Pollutants in California Waters: A Review of Historic Data and Assessment of Impacts on Fishing and Aquatic Life. A Report of the Surface Water Ambient Monitoring Program (SWAMP). California State Water Resources Control Board, Sacramento, CA.

Davis, J.A., A.R. Melwani, S.N. Bezalel, J.A. Hunt, G. Ichikawa, A. Bonnema, W.A. Heim, D. Crane, S. Swenson, C. Lamerdin, and M. Stephenson. 2010. Contaminants in Fish from California Lakes and Reservoirs, 2007-2008: Summary Report on a Two-Year Screening Survey. A Report of the Surface Water Ambient Monitoring Program (SWAMP). California State Water Resources Control Board, Sacramento, CA.

Natural Resources Agency. 2010. State of the State's Wetlands: 10 Years of Challenges and Progress. Natural Resource Agency, State of California, Sacramento, CA.

Ode, P.R. 2007. Ecological condition assessment of California's perennial wadeable streams. Report to the State Water Resources Control Board's Nonpoint Source Program. California Department of Fish and Game Aquatic Bioassessment Laboratory, Rancho Cordova, CA.

Ode, P.R. and A.C. Rehn. 2005. Probabilistic assessment of the biotic condition of perennial streams and rivers in California. Report to the State Water Resources Control Board. California Department of Fish and Game Aquatic Bioassessment Laboratory, Rancho Cordova, CA.

Ode, P.R. and K. Schiff. 2009. Recommendations for the development and maintenance of a reference condition management program (RCMP) to support biological assessment of California's wadeable streams. Report to the State Water Resources Control Board's Surface Water Ambient Monitoring Program (SWAMP). California Department of Fish and Game Aquatic Bioassessment Laboratory, Rancho Cordova, CA. Southern California Coastal Water Research Project, Costa Mesa, CA

Rehn A.C. and P.R. Ode. 2009. Synthesis Report: Integrating probability and targeted survey designs in regional stream condition assessments with examples from southern coastal California. California Department of Fish and Game Aquatic Bioassessment Laboratory, Rancho Cordova, CA.

Scientific Planning and Review Committee (SPARC). 2006. Review of California's Surface Water Ambient Monitoring Program. Southern California Coastal Research Project, Technical Report 486.

State Water Resources Control Board. 2000. Report to the Legislature, Proposal for a comprehensive ambient surface water quality monitoring program. State Water Resources Control Board, Sacramento, CA

State Water Resources Control Board. 2001. Strategic Plan: A vision for the Future. California Water Boards, Sacramento, CA

State Water Resources Control Board. 2004. Water Quality Control Policy for developing California's Clean Water Act Section 303(d) list. State Water Resources Control Board, Sacramento, CA.

Surface Water Ambient Monitoring Program (SWAMP). 2005. Comprehensive Monitoring and Assessment Strategy to Protect and Restore California's Water Quality. State Water Resources Control Board Surface Water Ambient Monitoring Program, Sacramento, CA.

Surface Water Ambient Monitoring Program (SWAMP). 2006. Water Quality Assessment of the Condition of California Coastal Waters and Wadeable Streams. State Water Resources Control Board Surface Water Ambient Monitoring Program, Sacramento, CA

U.S. Environmental Protection Agency (USEPA). 2003. Elements of a state water monitoring and assessment program. U.S. Environmental Protection Agency, Washington D.C.

Appendices

- A. Comprehensive Monitoring and Assessment Strategy for the Citizen Monitoring Program
- B. Summary of Vision Statements, Goals, Objectives, and Tasks
- C. SWAMP Assessment Framework
- D. SWAMP Needs Assessment
- E. Regional Fact Sheets