Comprehensive Monitoring and Assessment Strategy for Citizen Monitoring Programs

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This document is based on the ten elements as found in "Elements of a State Water Monitoring and Assessment Program" (USEPA, 2003). Our document describes how citizen monitoring data can be incorporated into a statewide water quality database and the data used to assess attainment of beneficial uses of California's surface waters.

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PREFACE

Water is California's most precious resource, and with a population of over 38 million people, the demand for clean water is growing exponentially. At the same time, the health and availability of water to its users is compromised due to urban and agriculture runoff, illegal dumping of pollutants, reduced permeability and habitat destruction.

The State Water Resources Control Board (SWRCB) and its nine Regional Water Quality Control Boards (RWQCB's) are tasked with the protection of California's water resources, but monitoring, assessing and reporting on the state of California's water quality is a monumental task. With 53 watersheds in the state, only one-half of the fresh water bodies are assessed by the SWRCB. This includes 15% of California's rivers, streams and creeks and about 50% of the lakes, pond and reservoirs. In addition, only 53% of California's wetlands and 42% of bays and estuaries are assessed (SWRCB, 2002)

To assist the state in meeting its water quality objectives, the Surface Water Ambient Monitoring Program (SWAMP) was formed in 1999 to "preserve, protect, enhance and restore the quality of California's water resources through monitoring programs, as well as to ensure proper allocation and efficient use of these waters."
(http://www.waterboards.ca.gov/water_issues/programs/swamp/**)**

During this same time period the SWRCB began to initiate a citizen monitoring program. The Clean Water Team (CWT) was developed to further the SWRCB's Non-Point Source efforts at a community level through citizen monitoring. As the SWRCB began to award grants for projects which incorporated citizen monitoring, the Clean Water Team (CWT) became very active in providing direct support to those organizations receiving grant funds. Later, the CWT's focus was directed to support citizen monitoring groups which were participating and contributing towards the state's Clean Water Act 303(d) list and Total Maximum Daily Load (TMDL) programs (Burres 2003). Due to organizational changes in the early 2000's the CWT was incorporated into SWAMP. Over this entire time period the number of citizen water quality monitoring groups across the state grew from just a few to well over 200. (Burres 2007 and 2008)

Data generated by the citizen monitoring (CM) groups, in part, has been used by the state to help fulfill some of the state's water quality objectives and the following goals of the Comprehensive Monitoring and Assessment Strategy to Protect and Restore California's Water Quality 2005 (SWRCB, 2005).

- Surface waters are safe for drinking, fishing, swimming, and support healthy ecosystems and other beneficial uses.
- Individuals and other stakeholders support our efforts and understand their role in contributing to water quality.
- Water quality is comprehensively measured to evaluate protective and restoration efforts.

Unfortunately, citizen data is not universally accepted, and the time that citizen groups put into planning, training, and collecting valuable data is underutilized. During this time of economic crisis and increased degradation of California's water quality, it is more important than ever for

the state to take advantage of the existing data and resources that citizen monitoring groups can provide. One way to facilitate this process is to integrate the data citizen groups generate into a statewide data sharing system.

To support the integration of citizen monitoring data to the statewide data sharing system, the California Citizen Water Quality Monitoring Program (CCWQMP) was created under SWRCB grant contract number 06-308-250-0 and will be reported on within this document funded under this same contract. The goals of the project are to:

a) Develop a process for volunteer data to be uploaded into a statewide database.
b) Help the Non-Point Source (NPS) program and other state and regional programs use citizen monitoring data more effectively.
c) Fill in data gaps with citizen data and create a more robust set of water quality information for California.
d) Use citizen data to when setting state policy(ies), evaluating program success(es), and when assessing both water quality status and trends.
e) Promote and support volunteer water quality monitoring programs throughout the state.

At the same time, citizen monitoring groups and the RWQCBs need to examine how citizen monitoring efforts will fit into the water quality goals and objectives of SWAMP and the California Water Quality Monitoring Council. This "Comprehensive Monitoring Strategy for Citizen Monitoring Programs" will provide a framework for the integration of citizen monitoring data.

BACKGROUND

The Federal Clean Water Act gives states and territories the primary responsibility for implementing programs to protect and restore water quality. In Section 106(e)(1), the Clean Water Act requires the US EPA to determine that a state is monitoring the quality of navigable waters and compiling and analyzing data on water quality. Before the US EPA will award Clean Water Act Section 106 grant funds, states must report their monitoring and assessment activities and submit that information into their obligatory Clean Water Act Section 305(b) report.

To meet these Clean Water Act requirements and provide comprehensive information on the status of beneficial uses of California's surface waters, state programs such as SWAMP are tasked with answering the following questions:

- What is the overall quality of California's surface waters?
- To what extent is surface water quality changing over time?
- What are the problem areas and areas needing protection?
- What level of protection is needed?
- How effective are clean water projects and programs?

The SWAMP program is also designed to go beyond the federal requirements and coordinate a statewide framework of high quality, consistent, and scientifically defensible methods and strategies to improve the monitoring, assessment and reporting of California's water quality. To

help states fulfill their federal requirements, the US EPA produced a document that identified ten elements in a State Water Monitoring and Assessment Program (US EPA, 2003).

The state's Citizen Monitoring groups already help provide data which contributes toward the State's Clean Water Act 305(b) Report, TMDLs, best management practices, storm water permits, and other local and state projects. This document will therefore examine *how* the efforts of over 200 citizen monitoring groups in California fit into the ten elements as presented in the Comprehensive Monitoring and Assessment Strategy to Protect and Restore California's Water Quality (SWRCB, 2005). In the future, this information may be integrated into the California Water Quality Monitoring Council's comprehensive strategy.

Figure 1.

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

The SWRCB currently monitors little over one-half of the state's water bodies. The agency simply does not have the monitoring resources to effectively evaluate all of the surface waters in the state. It is up to the SWRCB, SWAMP and other state agencies, therefore, to work with partners to identify and implement additional monitoring resources to satisfy the water quality goals of the Clean Water Act.

Citizen water quality monitoring groups are an additional, albeit underutilized, resource. There are currently over 200 citizen monitoring groups throughout the state, who collectively donate tens of thousands of hours of their time to monitor water quality every year. The cost of volunteer time is substantial. The assigned value of volunteer time in CA in 2007 was $21.97/hr (Independent Sector, 2009). In light of the current economic climate, it would benefit the state to examine its relationship with citizen monitoring groups. For example, a subset of thirty-five monitoring programs surveyed collect 7,726 data points per year. If we assume each result requires 2 hours of volunteer time that equates to a minimum of $339,480 per year worth of volunteer service.

To determine the quality and quantity of citizen monitoring data, 35 CM groups statewide responded to a survey developed by the California Citizen Water Quality Monitoring Program. Results showed that; the commitment of citizen groups was high; most groups monitored year-round, and the longevity of groups was an average of 11 years (Statement of Needs, 2008). The "workforce" of these groups was made up of approximately 66 citizen monitors per group. The number of sites monitored was also substantive; 54 sites/yr/group and an average of 257 data

points/yr/group. Three-fourths of the groups had documentation for quality assurance, and most groups were trained by regional or state experts. Furthermore, the objectives on which citizen groups focused were synonymous with state water quality monitoring objectives: pollution detection, land-use impacts, establishing base-line data, assessing best management practices, salmonid protection, and flood prevention. In addition to contributing data for the state's 303(d) listing and the 305(b) report, several groups were involved in Phase I and II Stormwater permit monitoring. Almost all groups surveyed were also involved in public outreach and education activities. This strongly supports a principle written into the Comprehensive Monitoring and Assessment Strategy to Protect and Restore California's Water Quality which states "The Water Boards will provide education and outreach opportunities so that Californians understand their responsibilities and abilities to protect water quality."

Citizen monitoring data can, and does, fill spatial and temporal gaps which address the state's water quality objectives. Compatibility of citizen data to that of state data is assured through state or regionally -approved QAPPs, in addition to the SWAMP protocol taught to citizen monitoring groups by state-approved trainers. Furthermore, most citizen groups who have approved QAPPs have been partially or totally dependent on state grants (i.e. Proposition 13, 40, 50, 84, 319h), and are required to submit their data to their RWQCB or SWRCB grant manager.

The state stands to benefit significantly by working with citizen monitoring programs and incorporating their data into one central database. An increase in statewide coordination between regional boards and these citizen water quality monitoring groups will greatly enhance the quantity and quality of monitoring data available to resource managers. This document is intended to incorporate citizen monitoring activities into the SWAMP Comprehensive Monitoring and Assessment Strategy and into and strategy produced by the California Water Quality Monitoring Council.

1. Monitoring Program Strategy

A monitoring strategy for citizen groups which addresses the state assessment framework outlined in this report is comprehensive in scope and covers monitoring objectives, monitoring design, core indicators of water quality, quality assurance, data management, data analysis/assessment, reporting, programmatic evaluation and general support and infrastructure.

Goals of a comprehensive strategy for citizen groups

- Individuals and other stakeholders support citizen monitoring efforts and understand their role in assessing water quality.
- Water quality is comprehensively measured to evaluate baseline conditions and restoration efforts.
- Citizen monitoring data is to be better utilized to support state water quality objectives (*see section 2.)*

Implementation Timeframe

- By December, 2009, the California Data Upload and Checker System (Cal DUCS) (produced under SWRCB Contract No. 06-308-250-0) will be available to all citizen groups for upload of their data into a SWAMP-compatible statewide database.

- A Communication and Outreach Committee made up of citizen water quality monitoring coordinators, RWQCBs, SWAMP and California Water Quality Monitoring Council will ensure;
    - Continued dialogue between the state and citizen monitoring groups
    - Development or enhancement of communication tools such as websites, webinars, newsletters and workshops

Evaluation

- Continued evaluation of the working relationship between citizen monitoring groups and state will be necessary. This may occur via annual (regional and/or state) citizen monitoring workshops, direct Regional Board feedback, presentations to the SWAMP Roundtable, and assessment and enhancement of monitoring programs.

2. Monitoring Objectives

The vision of SWAMP is "to define a complete set of monitoring objectives, based on beneficial use attainment and reflecting the full range of regulatory responsibilities and water quality programs for all water bodies" (SWAMP webpage "SWAMP History and Organization", 2009). In November 2000, SWAMP identified monitoring objectives critical to the design of a monitoring program that are efficient and effective in generating data that serve management decision needs.

Most monitoring objectives for citizen groups include:

- Helping to establish water quality status and trends,
- identifying impaired waters (303(d) listing) which is based on assessment of beneficial uses,
- evaluation of Best Management Practices (BMPs) and ecological restoration implementation.

The table below addresses how the work of CM groups relates to SWAMP regional goals and objectives.

Table 1. Regional Water Quality Control Board and CM Group objectives

SWAMP Goals and Objectives	Citizen Data Goals and Objectives[1]
• Employing a sampling design that allows the measurement and evaluation of **spatial and temporal trends** in watershed water quality,	Trend data to determine watershed health and to establish a baseline of water quality conditions.
• Using **standard sampling protocols**, SWAMP QAMP procedures and the SWAMP database to **provide statewide consistency and availability of data,**	Ensure use of the SWAMP Advisor and Upload tool (Cal DUCS)
• To monitor and assess the water quality of the regions watersheds with the primary	Collect necessary information to assess objectives for the beneficial use "COLD"

[1] Based on information from a statewide survey in which 35 citizen monitoring groups responded.

objective of **determining if the beneficial uses** are being protected.	(water quality monitoring in cold water waterbodies such as salmonid waterways) and "REC 1" (direct water contact recreation such as swimming beaches)
• Measure **environmental stressors, (i.e. pollutants), biological effects (toxicity tests), and ecological indicators (benthic community analysis)** to evaluate whether beneficial uses are being protected.	Toxicity tests at outfalls, lakes, streams, and bays; bioassessment combined with chemistry to determine if fresh water fish and swimmable waters are being protected
• Determine **if impacts are associated with specific land uses or water management**.	Develop a monitoring design to determine impacts from specific land uses.
• Generate data and associated information for the development of indices to evaluate ecological indicators (**Index of Biological Integrity for macro invertebrates**)	Benthic macro invertebrate (BMI) data was used in over ½ of groups along with physical habitat (P-HAB), chemistry and ambient measurements to determine watershed health. This data can be incorporated into indices and condition assessments.
• To develop **indices of biological integrity** for streams and rivers based on in stream benthic macro invertebrate and algae assemblages, to be used as a tool for evaluating biological integrity	Citizens monitor BMIs, algae, periphyton, P-HAB to determine biological integrity of streams and rivers
• Provide a **screening level assessment of water quality, based on a variety of chemical, physical and biological indicators**. Data is used to evaluate beneficial use support in the surface waters of the region.	Citizens collect chemical, physical, biological data to screen waterbodies.
• Assess whether **water quality conditions are getting better or worse over time.**	Long term data sets evaluate trend data taken for chemistry, bacteria, BMI, bank erosion, etc to measure positive or negative changes over time.
• Monitor surface water throughout the region to determine **ambient water quality** and whether beneficial uses are being impacted.	Ambient data is collected on a monthly to weekly basis to measure water quality conditions.
• **Coordinate all SWAMP activities** to maximize monitoring frameworks already in place and leverage existing resources,	There is high coordination within regional groups or "hubs" but not sufficient statewide coordination.
• **Target water bodies for monitoring where water quality information is scant**.	Through Cal DUCs there will be a system in place to determine where there are data gaps that can be filled.
• **To use ambient water quality data to determine the overall conditions of water bodies in the region for inclusion in the 305(b) Report and the 303(d) list of**	CM groups monitor same places throughout the year and submit data to RWQCB to be included in 303(d) list and 305 (b) Report

impaired water bodies.	
• To provide reliable, high quality information necessary **to produce 305(b) and 303(d) list *that are more comprehensive and more defensible*** than those of past years.	Some, but not all, citizen data is included in the evaluation of impaired water bodies. State agency data sets can be enhanced by CM data.
• Employing a sampling design that allows the measurement and evaluation of **spatial and temporal trends** in watershed water quality,	State agency data sets can be enhanced by CM data, especially with Google Earth which facilitates mapping monitoring sites.

The monitoring objectives used by citizen groups fall within the State's 28 beneficial use categories as found within the water quality control plans, aka basin plans. A large number of citizen monitoring groups monitor primarily for Primary Water Contact Recreation (REC-1) and/or Cold Freshwater Habitat (COLD). This bodes well with the inclusion of citizen data to populate the web portals being developed by SB 1070 California Water Quality Monitoring Council. The web portals currently include:

- Swimming Safety at Beaches (Safe to Swim)
- Human health risk associated with sport fish consumption (Safe to Eat Fish and Shellfish)
- Drinking water safety (Safe to Drink)
- Wetlands status (Wetlands)

The theme-based workgroups developed by the Statewide Monitoring Council are tasked with developing criteria for the inclusion of data collected by multiple sources including citizen monitoring programs. Until then, below is an example from the Central Coast Regional Water Quality Control Board of monitoring criteria for REC-1.

Is there evidence that it is unsafe to swim?
Are swimming conditions improving or getting worse?
Beneficial Use: Water Contact Recreation (REC-1)
Monitoring Objective(s): At sites throughout water bodies that are used for swimming, or that drain to areas used for swimming, screen for indications of bacterial contamination by determining percent of samples exceeding adopted water quality objectives and EPA mandated objectives. Central California Ambient Monitoring Program (CCAMP) data as well as data collected by local agencies and organizations will be used to assess shoreline and creek conditions.
Monitoring Approach: Monthly monitoring for indicator organisms (e.g. *E. coli*, fecal coliform…); compilation of other data sources
Assessment Limitations: CCAMP sampling approach does not meet the frequencies identified in the Central Coast Basin Plan of 5 times in a 30-day period.
Criteria:

- Fecal coliform exceeding 400 MPN/100 ml
- *E. coli* exceeding 235 MPN/100 ml
- Application of the binomial test to sample exceedence rate according to the SWRCB Listing Policy (2004), where

    - Null Hypothesis: Actual exceedance proportion is <=10%
    - Alternate Hypothesis: Actual exceedance proportion >25%
- Geometric mean of fecal coliform samples greater than 200 MPN/100mL

Interpretation: A minimum of five exceedances is required to determine impairment. If the site has exceedances, but there are fewer than five, site is considered partially impaired. The geomean criterion is compared to the geomean of data from the entire sampling year. If a site geomean exceeds the geomean criterion, the site is considered impaired. Trend data will be evaluated using non-parametric approaches, including Seasonal Mann-Kendall and Kruskall-Wallace tests, and by evaluating change in exceedance rate over time.

Based on the above criteria, if a CM group wants to tailor their monitoring objectives to have their data included in assessment of beneficial uses; then they need to design their monitoring plan to include some or all of the parameters listed under Monitoring Approach.

3. Monitoring Design

Like SWAMP, citizen monitoring groups utilize monitoring designs which maximize the ability to meet monitoring objectives with existing resources. Many citizen monitoring groups work with their Regional Board representatives to contribute data towards 303(d) listings and to a lesser extent, TMDLs. Remediation plans of impaired water bodies may include addressing a series of issues from pollutants to increased temperature and low flow rates.

Goals of the citizen monitoring integration program:

- To assist the state in filling in spatial and temporal gaps with citizen data.
- To help with long-term monitoring for temporal and spatial trends.
- To target water bodies for monitoring where water quality information is scant.
- To coordinate with other data collection efforts.
- To use ambient water quality data to determine the overall conditions of water bodies in the region for inclusion in the 305(b) Report and the 303(d) list.
- To see if water quality conditions are getting better or worse over time.

To help assist the state in filling in spatial and temporal data gaps, there needs to be a mechanism by which the individual designs of citizen groups can be nested into the statewide program, especially in the waterbodies with beneficial uses that include of swimming, drinking, and fishing. To do this, the following questions need to be addressed;

- *Spatial*
    - *Where do citizen groups monitor? Are the sites represented on a GIS layer?*
    - *Are sites on a 303(d) listed water body that might provide source tracking information?*
    - *Are there areas that are not monitored that should be?*
    - *Are there areas where multiple programs are monitoring that might be able to share resources?*
- *Temporal*
    - *Are sites monitored at appropriate times and frequencies to provide necessary information?*
    - *How often should sites be monitored to answer specific questions?*

- *Citizen monitoring programs should be aware of each Region's sampling design and monitor at Regional Board sites when they are not monitoring.*

- *Design coordination*
  - *Do citizen monitoring programs fill necessary data gaps in the SWAMP monitoring program?*
  - *Do neighboring monitoring programs coordinate with upstream programs?*
  - *Are methods and protocols comparable?*
  - *Is all necessary information being collected, ie. hardness with metals analysis, temperature and pH with ammonia measurements?*

Most citizen groups use a site-specific monitoring design which incorporates fixed stations and targeted monitoring. See the examples below;

Table 2. State Monitoring Designs used by Citizen Monitoring Groups

Monitoring design	Design definition	Examples from citizen group monitoring
Fixed station	Repeated long-term sampling or measurement of parameters at representative points for the purpose of determining environmental quality characteristics and trends.	Snapshot Day, outfall monitoring, World Water Day, and ambient data to determine need for the 303(d) listing
Targeted monitoring	Sampling at location-specific sites which are usually selected for monitoring based on a list of considerations and information needs.	Project effectiveness, ambient conditions for the 303(d) listing and 305(b) report.
Stratified random	A sampling method in which the population is separated into groups (strata) usually based on some internal similarities, then selecting a random sample within each stratum.	BMI by ½ of surveyed groups
Probability-based sampling	A sampling method in which randomness is built into the design so that properties of the sampled population can be assessed in terms of their likelihood of occurrence or existence.	No citizen programs identified.

4. Core Indicators of Water Quality

To evaluate the effectiveness of management actions to improve water quality in the state, SWAMP currently uses core indicators that denote the health of different waterbody types and their associated beneficial uses. Core indicators for each type of waterbody include physical/habitat, chemical/toxicological, and biological/ecological endpoints as appropriate. SWAMP also uses supplemental indicators when they have reasonable expectations that a specific pollutant is present in the watershed, when core indicators suggest impairment, or to support a special study, such as screening for potential pollutants of concern.

In fiscal year 2006-2007, SWAMP refined their core indicators to indentify and develop those that accurately indicate water quality at the federal, state, watershed and project scales. SWAMP intended for these refined indicators to better inform them of the relationship between water quality and the land use activity of the surrounding land and/or effects of landscape changes (ie. timber clear-cutting practices causing increased sediment deposits in salmonid breeding grounds). The indicators tested by SWAMP are also monitored by citizen groups. Table 3 cites the portion of surveyed groups who monitored the water quality indicator(s) specified by the state.

Table 3. 2007 Survey of 35 Citizen Monitoring Groups Statewide

Current SWAMP Indicators	**Indicator Description and Purpose**	**Portion of Surveyed CM Groups Monitoring this Indicator**
Conventional chemistry (DO, pH, etc.)	To assess general health.	80%
Nutrients	To determine attainment of beneficial uses	66%
Fecal Indicator Bacteria	Total coliform, fecal coliform, *E. coli* and enterococcus for MUN, REC-1, and REC-2	57%
Benthic macro-invertebrate community metrics	Fresh water macro-invertebrate communities (via IBI) is used to indicate watershed health, especially in waters that support fish.	51%
Lab analysis	Includes trace metal and organic analytes, including OP, OC, pyrethroid pesticides, PCBs, PAHs, etc. All measured in water, sediment, or tissue for watershed health.	Metals 37%
Sedimentation	Turbidity, TSS (SSC), pebble counts and other streambed metrics are used to determine sedimentation as it affects living organisms in the watershed, especially fish habitat.	11%
Toxicity testing	Toxicity done via bio-assays with fresh and salt water organisms to determine toxicity.	1%

Core Indicator Objectives

It is SWAMP's vision to develop and implement a set of monitoring indicators with assessment thresholds, which can be used to track the status and trends of water quality and to evaluate the effectiveness of management actions to improve water quality in the state. This type of information will also be used by the California Water Quality Monitoring Council to populate the online web portals.

This requires that a core set of indicators be defined for each water resource type. This includes water quality parameters with physical/habitat endpoints as appropriate, that reflect designated uses, and that can be used routinely to assess attainment with applicable water quality standards throughout the state. SWAMP's core set of indicators must also contribute to statewide tracking

of water quality indicators being implemented under the Environmental Protection Indicators for California project (EPIC). The EPIC project is responsible for maintaining an environmental indicator system to assist environmental programs in evaluating the outcomes of their efforts, and in identifying areas that require more attention.

Citizen groups already collect data for the first of EPIC's main quality indicators, "the assessment of aquatic life and swimming uses." They have also traditionally provided data for the state's TMDL program and for 303(d) listings. Common beneficial use categories addressed by citizen groups have been water contact recreation (REC-1; indicator; bacteria) and cold water fish (COLD; chemical, physical, biological indicators).

Citizen groups, with the help of their Regional Board representatives, can enhance their monitoring efforts by:

- Adopting the state's recommended core and supplemental indicators for use at a local watershed scale.
- Adopting indices for assessment of all beneficial uses as determined by SWAMP and the California Water Quality Monitoring Council.

5. Quality Assurance

One of the main challenges for the acceptance of citizen data is the lack of understanding of the level of quality of citizen monitoring data. Another challenge is the lack of standardization of the vocabulary monitoring groups use when collecting and entering data. Quality Assurance Project Plans (QAPPs) address both issues since QAPPs document project management, data generation and acquisition, assessment and oversight, and data validation and usability in a standard format. The collaborative process required between the data generators (citizen group), the grantor, and the official who must approve of the QAPP ensures a solid foundation for monitoring. This is followed up with quality control, a series of actions (i.e. audits of proper field and lab procedures, etc.) which ensure that the quality of data collected meets the highest standards. Writing a QAPP is labor intensive, but necessary for citizen groups to do if they want their data to be comparable with other statewide programs. Quality control requires consistent effort and oversight.

Citizen groups who are dependent upon state grants are required to create and follow a QAPP, but there are other citizen monitoring groups with no QAPP who collect long-time trend data which could also be useful to the state. These groups may not know about QAPPs, may not know who to go to for help in writing them, may think QAPPs are too difficult and/or time-consuming to write, and/or may think that the scope of the QAPP is out of reach for their monitoring program. SWAMP has developed and online tool called the SWAMP QAPP Advisor designed to help monitoring programs draft QAPPs specific to their projects and it includes all of the necessary QAPP elements.

The California Data Upload and Checking System is being developed to facilitate the transfer of water quality data from monitoring programs to the California Environmental Data Exchange Network. The current data upload tool being built for citizen groups includes a registration page which documents the presence or absence of a QAPP. The upload tool takes a "tiered" approach

for all data submitted as to the quality, complexity, and available documentation. "*Tier" breaks will be established as development of the upload tool evolves*. The upload tool is SWAMP-comparable and encourages the standardization of language used by varying data generators. By including these features, the obstacles of language standardization and QA/QC is addressed. This is an important first step towards making citizen data universally accepted and available.

Recommendations to encourage the continued improvement of citizen group QA/QC will be addressed in the new Cal DUCS for citizen monitoring data upload. The system will contain the following components;

- Technical oversight and direction by SWAMP so that citizen group data will comply with SWAMP's QA/QC program.
- QA/QC 'tiering' for citizen groups via Cal DUCS registration page
- Technical support via the SWAMP Help Desk to ensure quality data

In addition, it is highly recommended that citizen monitoring groups conduct annual or biannual field and lab audits. An interim audit checklist (SWAMP is currently developing one) has been developed by the Citizen Monitoring Program Technical Advisory Committee can be found in Appendix 1.

6. Data Management

How much data the state receives from citizen monitoring groups is dependent upon well planned and executed data management. Acquisition of statewide citizen monitoring data will be extremely successful if the data upload system is user-friendly, has support help, feeds a statewide database and provides online access to the data. Managing the data flow from citizen groups to the state via a central data repository requires the clear delineation of roles and responsibilities at local, regional and state levels.

Table 4. Data Management Roles and Responsibilities for state and CM groups

Organization	Data Responsibilities
Citizen monitoring programs	• Follow SWAMP comparable monitoring protocols. • Thoroughly document and manage data. • Become familiar with and include data management protocols for the upload tool. • Include the data management protocol in their QAPPs.
SWAMP/CWT or RWQCB	• Provide training and written instruction to citizen groups for upload tools.
California Environmental Data Exchange Network (CEDEN)	• Provide a Help Desk for questions about upload tools and IT information to operate Cal DUCS. • Transfer citizen data to statewide database in a timely manner.
California Water Quality Monitoring Council	• Flag data for use in SB1070 theme-based portals. • Disseminate data through online query tools. • Incorporate CM data into theme portals related to water quality conditions.

7. Data Analysis and Assessment

The Cal DUCS system has been developed to facilitate upload of citizen monitoring data into a statewide data management system. Once the data flow begins, access to the data is of the utmost importance to ensure that resource agencies, researchers and all monitoring programs have access to the statewide data set.

Once the flow of data is streamlined into a central statewide database, there will be many opportunities to use the data. It must be in a format conducive to answering various questions related to water quality conditions. SWAMP will use the data to assess attainment of beneficial uses. The Statewide Monitoring Council will use the data to populate the theme based web portals. Scientists will use the data to answer specific environmental questions related to their research. CM groups will use the data to compare conditions in their watersheds to those around the state.

Needs and recommendations of data analysis and assessment are the following;

- Identify the level of quality assurance required to utilize CM data.
- Identify the gaps in information that CM groups can fill for use by resource agencies.
- Develop guidance by the Statewide Monitoring Council to incorporate CM data into theme based web portals.
- Provide spatial assessment and tracking of management measures to better explain changing water quality conditions.
- Provide statistical tools for improved analysis and understanding of monitoring data.

8. Reporting

Citizen Monitoring programs each have their own means of reporting monitoring results based on grant requirements, monitoring objectives and information sharing. Those mechanisms will be program specific and most likely will remain that way. Examples of how citizen monitoring programs report their results include newsletters, annual reports, online summaries, workshops, and email Listserves, to name a few. However, by creating a mechanism to share regional data with a statewide audience, that data will become increasingly more valuable. A statewide database of comparable information will provide for more statistically rigorous and meaningful reporting.

As demonstrated by the Central Coast Regional Water Quality Control Board, the access to a larger collection of water quality data resulted in a significant increase of proposed waterbody listings for the next 305(b) report and 303(d) list. Without the compilation of multiple datasets, this would not have been possible. It goes without saying that access to additional monitoring data will provide a more comprehensive understanding of the conditions of both surface and ground water throughout the state.

The internet offers an opportunity to provide a large amount of up to date information that is accessible to the masses. The California Environmental Data Exchange Network (CEDEN) website and California Water Quality Monitoring Council's web portals will not only make data more accessible but it will make it much more valuable. Citizen monitoring groups will be more inclined to take the extra steps to ensure quality data and upload it through Cal DUCS knowing it will be used to better inform resource managers and improve water quality conditions. Online

tools such as maps and graphs will reduce the need for traditional annual reports and summaries. Statistical analysis available at the touch of a button will revolutionize the ability of resource managers to make timely management and policy decisions to better protect natural resources. This will increase efficiency and reduce the time it used to take to analyze and develop reports.

9. Programmatic Evaluation

As described in Section 5. Quality Assurance, it is recommended that each CM organization do a programmatic evaluation on an annual or bi-annual basis (Appendix 1). Programs should always be looking for ways to improve and strengthen their program to best meet their objectives. The Cal DUCS upload tools will provide a review of data management efforts and whether they meet the requirements of SWAMP comparable data. The upload templates identify the meta-data that is important to document for each result. The checker tools indicate the data meets the criteria for inclusion into a statewide database. These efforts will require CM programs to evaluate how they manage their data.

There must be support at the state level for the Cal DUCS upload tools. It is a new system that will require improvements and changes based on the various user groups and data upload needs. If the program isn't supported and recommendations by users implemented, the system will fail and the flow of data to a statewide database will cease. The Cal DUCS website provides opportunity for comments through a wiki (http://www.ccamp.info/ceden/php/ceden_menu.php). This type of evaluation is highly recommended because it provides a written list of suggestions to improve the upload tool. These recommendations can be addressed as time allows and will ensure the best upload process possible.

The Statewide Monitoring Council is just beginning its process to provide meaningful information and answers related to important environmental and societal questions. This process has a long way to go, but should seriously take advantage of the data available from CM programs. As the data upload framework is developed, CEDEN and the State Monitoring Council should build in tools that flag all data pertinent to a particular portal to facilitate mining of pertinent data. All websites should provide a mechanism for evaluation and suggestions from the user groups visiting the sites. There are many ways to evaluate and portray monitoring information. The websites should be as flexible as possible to accommodate the many questions and stories the data can provide.

Evaluation of the working relationship between CM groups and the state is important to continue the flow of information and data. CM monitoring programs need to have a contact at their Regional Board for questions and guidance. A Citizen Monitoring Communication and Outreach Committee has been established to facilitate dialogue among CM programs and between CM programs and agency staff (Communications Strategy, 2007). Even this committee will require some commitment from agency staff to coordinate meetings and ensure follow through with recommendations.

10. General Support and Infrastructure Planning for CM Groups

The SWAMP Comprehensive Strategy lists four overarching tactics "to promote an efficient increase in the amount of usable water quality information that is available." Two of these four tactics are particularly applicable to citizen water quality monitoring;

1. "Build stronger partnerships with agencies, watershed groups, ***citizen monitors***, and others to facilitate the sharing of information, the collection of comparable data, and the use of monitoring tools. This includes working closely with the newly-formed Nonpoint Source Tracking and Monitoring Council."

2. "Continue working with monitoring programs currently coordinated through the CA Environmental Data Exchange Network. This coordination will ***increase data comparability, increase the potential for true collaboration with other entities collecting ambient water quality information, and will make data available to the public."***

In order to build stronger partnerships and sustain viable citizen monitoring efforts, increased collaboration is necessary. Citizen monitoring is a valuable resource that has been underutilized by the state in its comprehensive monitoring strategy. Below is the breakdown of needs that are necessary to make this effort successful in the future:

- Identification of data needs by the state that citizen groups can accomplish and the knowledge that their data is being used.
- A communication infrastructure between citizen groups and between citizen groups and agency staff.
- Centralized resource stations by which to acquire and share reference materials, equipment, monitoring information, etc.
- Technical support for a data integration program (Cal DUCS) which allows data flow between citizen groups, RWQCBs and other data users.
- Online accessibility and analysis of current water quality data.

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Appendix 1 – Quality Assurance Checklist

California Citizen Monitoring Quality Assurance Checklist

In order for citizen data to be better utilized by the Water Board and other groups towards satisfying the state's water quality objectives, the quality control (QC) of how data is collected, analyzed, and stored by all citizen monitoring groups must be documented. Although many citizen monitoring groups already practice rigorous QA/QC protocol, this process is not practiced state-wide, and/or is practiced but not documented. In such cases, there is no assurance for potential data-users (ie. other citizen groups, NGOs, state and federal agencies) of the quality of citizen-generated data, or assurance that the state-approved protocol written in a QAPP has been followed. Thorough checklists help avoid the causes of unacceptable data (Table 5).

Ideally, citizen monitoring programs should be reviewed annually by an independent party who is familiar with SWAMP protocols. The categories included in the checklist below are; pre-field checks; field checks; post sampling activities; packaging and shipping; lab checks; and data management. Addressing these categories help to satisfy QA/QC requirements while increasing the validity of data and its usability.

Table 5. Most popular reason for bad data

MOST POPULAR REASONS FOR BAD DATA…
1. Non-functioning or improperly calibrated equipment
2. Lack of clear communication in the field
3. Lack of legible and complete data entry forms (i.e. legible numbers, correct sig figs, and UNITS)
4. Incorrectly labeled sample containers
5. Contaminated samples
6. Out-of-date reagents
7. Incorrect holding times of samples sent to lab
8. Incorrect temperature of samples in transit to lab
9. Lab errors
10. Monitoring sites don't accurately represent reach conditions (due to lack of access to private property)
11. Inconsistent and/or incorrect data entry
12. Insufficient data management system/lack of documentation

Lead reviewer	Date
Lab Manager	QA Officer
Organization	
Address	
City	
State	Zip Code
Phone	Email
Project website	
Project type (i.e. ambient, storm water, etc)	
Duration (on-going or one-time only)	
Project start date:	Project end date:
Project Purpose (why?)	
Study area (where?)	
Study design (how?)	
Circle data type; water quality sediment quality transect flow stream profiles benthic bioassessment toxicity physical habitat other_____	

STEP 1 = PRE-FIELD CHECKS	yes	no	n/a	Comments
1.1 QAPP (quality assurance plan program)				
a) Do you have a QAPP?				
b) Regional or State Water Board approved?				
c) When was QAPP last updated?				
d) Are the SOPs listed in your QAPP?				
e) Are sub-contractors aware of your QAPP?				
1.2 Instrument calibration & maintenance				
a) Are instruments properly calibrated according to SOPs?				
b) Are results and opened reagents kept in separate notebook?				
c) Is the expiration date on all reagents and standards?				
d) Are calibrations documented?				
e) Are SOPs for equipment followed?				
f) Are there back-up parts for instruments?				
1.3 Gear				
a) Are containers and chests used to hold gear clean?				
b) Are containers and chests used to hold gear labeled?				
c) Is sampling set up in a way to prevent contamination?				
d) Is spare gear packed?				
e) Is there a check list for gear in pack before it goes out?				
1.4 Field Data Sheets				
a) Are sheets specific to data type (ambient, toxicity, bio)				
b) Do data sheets have name, date, time, location (lat & long), equipment ID and sample ID?				
c) Is there a space for the results of field measurements?				
d) Is there a space for water and weather conditions?				
e) Is there a comment section?				
1.5 Permission to access sites				
a) Do samplers have permission to access sites?				
b) Do samplers have access to locked gates and other closed entries?				
1.6 Tidal and temporal flow				
a) Are creeks assessed for presence/absence of flow or water?				
1.7 Safety				
a) Do you take safety precautions while sampling?				
b) Do you have a safety plan for accidents in the field?				
c) Are flow conditions taken into consideration before going into the field?				
1.8 Instructions				
a) Are important instructions reviewed with volunteers before going out?				

STEP 2 = IN THE FIELD	yes	no	n/a	Comments
2.1 Field documentation				
a) Is *verbal* confirmation used between sampler and note-taker?				
b) Are all field sheets complete and all spaces filled (i.e. "0" or n/a)				
2.2 Decontamination procedures				
a) Are gloves worn?				
b) Is cross-contamination avoided between sites?				
c) Are clean surfaces used in the field?				
d) Are intermediate sampling devices cleaned between sampling sites?				
2.3 Sample containers				
a) Are containers clean and/or uncontaminated?				
b) Is appropriate container used for sample type?				
c) Is size of container correct?				
d) Are containers rinsed (if required) and filled to appropriate level?				
2.4 Sampling and field procedures				
a) Do you follow written protocols?				
b) Are samplers aware of holding times?				
c) Are samples properly preserved?				
d) Are samples collected in appropriate location of stream for project objective?				
e) Is sampling depth, flow, and velocity taken into account?				
f) Are water samples collected first and sediment samples second?				
g) Is each sample labeled with sample ID, date, location, and time?				
h) Is data flagged when instruments out of range?				
2.5 Quality control samples				
a) Are travel blanks included with samples?				
b) Are appropriate sources of H2O used for the blanks of each analyte?				
c) Are equipment blanks run when new equipment is used or equipment has just been cleaned?				
d) Are field blanks collected at a rate of 5% for the length of the project or for trace-metals, Hg, aqueous VOA, sediment VOA, aqueous DOC and bacteria?				
e) Are field blanks for all remaining analytes collected at the beginning of the sample period?				
f) Are field duplicates collected for at a rate of 5% for the length of the project or once per field event?				
g) Are samples collected for MS/MSD purposes first composited and then split?				
h) Are QA samples submitted "blind" to the laboratories?				
i) Are there SOPs that specifically describe field procedures for QC samples?				
j) Who is responsible for QA sample frequency and volume requirements?*				
k) Are copies of QC sample results available?				
2.6 Quality control samples (cont.)	**yes**	**no**	**n/a**	**Comments**
a) a) If QC samples identify a problem, are corrective actions taken prior to future sampling events?				
b) percentage of: dups____splits____blind____replicates___				
2.7 Aqueous sample collection				
a) Are containers rinsed 3X with site water prior to filling (excluding pathogen and preserved samples)				
b) Are whirl packs filled ¾ with pathogen samples?				
c) Are aqueous samples taken prior to other sample types?				
d) Is care taken not to disturb bottom sediment during sample collection?				
e) Are clean hands procedures used for trace metal and				

STEP 3 = POST SAMPLING SITE/FIELD ACTIVITIES	yes	no	n/a	Comments
3.1 Equipment count				
a) Is all equipment accounted for?				
3.2 Aquatic Introduced Species decontamination				
a) Is decontamination protocol in QAPP followed?				
3.3 Field Data Sheet Review				
a) Is form complete (i.e. have ALL spaces filled in, incl "0" or n/a)				
b) Is form legible (i.e. in neat print, numbers readable)				
c) Are numbers written to include all significant figures?				
d) Do data sheets have a proper storage location?				
e) Is there proper use of vocabulary (no abreviations)				

STEP 4 = PACKAGING AND SHIPPING	yes	no	n/a	Comments
a) Is there a chain of custody?				
b) Is a COC enclosed in each shipment?				
c) Verify holding time compliance				
d) Are courier services able to deliver to lab on time?				
e) Has receiving lab had problems with temp of samples?				
f) Verify sample preservation				
g) Are sample containers sealed with tape?				
h) Are glass bottles cushioned to prevent breakage?				
i) Are ice chests sealed before shipping?				

STEP 5 = LAB (independent)	yes	no	n/a	Comments
5.1 QAPP that includes;				
a) EPA approved methods?				
b) Follow QA from "Manual for Certification of Labs Analyzing Drinking Water" and "Standard Methods for Examination of water and waste water"				
c) Validation with certified lab (via cross checks)?				
d) Chain of custody				
e) Spikes				
f) Replicates				
g) Duplicates				
h) Splits				
i) Blanks				
j) QA dependency				
k) Proper number of blanks, dups, splits, standards sent (i.e for nitrates)				
5.2 How does lab follow- up with errors?* (i.e. out of range, false positives, etc)				
5.3 Is there a chain of custody?				
a) Verify holding time compliance?				
b) Verify sample preservation?				

STEP 6 = DATA MANAGEMENT	yes	no	n/a	Comments*
6.1 Oversight				
a) Is there a QA officer?				
b) Is there documentation from a QA officer?				
c) What is supervisory protocol (if interns are used?)*				
d) If consultant is used, what is their protocol?*				
6.2 Data entry				
a) Is data sheet complete?				
b) Is data checked for transcription errors?				
c) What % of data is hand-checked (for data entry)?				
d) What % is checked for lab data?				
6.3 What is checked? (circle all that apply) units, conversions, out-of-range numbers, same vocabulary, checks for duplicates, splits, QAPP- acceptable limits				
6.4 How are the following checked?*				
a) Verification (*i.e.*)				
b) Validation (*i.e.*)				
c) Precision (*The repeatability of a measurement.*)				
d) Accuracy (*The closeness of a measurement to the true value of the parameter measured.)*				
6.5 How are anomalies handled?* (i.e. out of range samples, non-detects, matrix spikes, replicates, outliers, etc.)				

Appendix 2 – Data Users

Citizen data is used by local groups, organizations, and state and federal agencies (Table 6). Audiences use this data for several purposes;

- To fulfill state water quality grants,
- to work with Fish and Game on salmonid restoration,
- to work with cities on NPDES permitting,
- to provide data for the 303d listing (and the 305b report),
- to establish ambient baseline data,
- to monitor e-coli to be used by the Department of Public Health,
- to keep track of river flow rates,
- and to educate the public about watersheds and citizen group project results.

As of 2007 there are over 200 citizen monitoring groups statewide with, on average, 66 volunteers per group who monitor an average of over 32 sites and over 232 data points per group. These groups are trained to meet SWRCB-approved protocol, including the creation of QAPPs. Citizen groups oftentimes provide data to several organizations and agencies at the same time. For example, the Friends of the Van Duzen River in Region 1 works with the SRWCB, CA Fish and Game, Friends of the Eel River, local community stakeholders, Mendocino Redwood Co. and Salmon Forever. In addition, they work with local school groups as part of their education and outreach program.

Table 6. Key Audiences for Citizen Water Quality Data

Key audience category	Key audience groups
Federal	• National Marine Sanctuary Program • National Estuary Program • National Marine Fisheries Service • Bureau of Land Management • US EPA • United States Geological Survey
State	• CA Department of Fish and Game • State Water Resources Control Board • CA Regional Water Quality Control Board • CA State Parks
Academia	• K-12 Watershed education • State Universities and Colleges • Cooperative Extension programs • Local High Schools • Local Elementary Schools
County	• County Environmental Health Departments • Resource Conservation Districts
Cities	• Public Works
Town	• Town Council • Town Parks
Non-government organizations	• Salmon Forever • Surfriders • Keeper Programs • National Resource Defense Council • Sierra Club
Other	• California Stormwater Quality Association • Bay Area Stormwater Management Agencies Association