Tomales Bay Watershed Council Foundation
Tomales Bay Wetlands Restoration and Monitoring Program

Proposition 50 Coastal Non Point Source Pollution Program Grant
SWRCB Agreement # 06-344-552-0

QUALITY ASSURANCE PROJECT PLAN (QAPP)

FINAL Version 1.0

Prepared for
California State Water Resources Control Board

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Last updated:
November 21, 2007

Section A1. Title and Approval Sheet; Preface/Acknowledgements

Project Title	Tomales Bay Wetlands Restoration and Monitoring Program
Lead Organization	Tomales Bay Waterhshed Council Foundation
Primary Contact	Rob Carson, Water Quality Program Manager
Effective Date	This Quality Assurance Project Plan (QAPP) is effective from the date of approval by the State Water Resources Control Board.

QAPP Preface and Acknowledgements

The preparation of this QAPP was funded by a grant from the SWRCB to implement California's Nonpoint Source Pollution Control Program (Proposition 50). This document is adapted from several documents including: the QAPP prepared for the National Park Service, San Francisco Area Network Freshwater Quality Monitoring Protocol (Cooprider and Carson, 2006), the approved QAPP for the Prop. 50 Rural Stormwater Subshed Monitoring Plan (Strausser et al, 2006), the Tomales Bay Rangeland BMP's Pathogen TMDL Implementation Project QAPP (Carson and Eisenberg, 2007) and the QAMP for the San Francisco Bay Regional Water Quality Control Boards' Surface Water Ambient Monitoring Program (SWAMP) (Puckett, 2002). The content from these documents is used frequently within this QAPP.

This QAPP follows the formatting and guidelines set forth by the State Water Resources Control Board (SWRCB) *Guidelines for Preparing Quality Assurance Project Plans* (SWRCB, 1998).

Approvals:

Rob Carson, Project Manager

_____ Date _____

David Lewis, Watershed Council Technical and QA Officer

_____ Date _____

Dale Hopkins, RWQCB Grant Manager

_____ Date _____

William Ray, SWRCB QA Officer

_____ Date _____

Robert Berner, CEO, TBWCF Board

_____ Date _____

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
Tomales Bay Rangeland BMP Pathogen TMDL Implementation Project QAPP 1.0	September 2007	Rob Carson	modification to content (project description & task organization, sampling design, parameters and analytes of interest, assessments and response actions, etc.)	Adaptation for Tomales Bay Wetlands Restoration and Monitoring Program (TBWRMP) project	v. 0.90
TBWCF Tomales Bay Wetlands Restoration and Monitoring Program v. 0.90	September 2007	Rob Carson	Revision of QAPP contents, program description, sampling design, parameters and analytes of interest, assessment and response actions, etc.)	Review of TBWCF WQ TAC	TBWCF Tomales Bay Wetlands Restoration and Monitoring Program v. 0.91
TBWCF Tomales Bay Wetlands Restoration and Monitoring Program v. 0.91	October 2007	Rob Carson	Revisons to Table A-11: MQO's; GWRP sections; Program language; and SOP's	Integrate lab MQO's for RTC; Review by GWRP manager; and input from TBWC WQ TAC	TBWCF Tomales Bay Wetlands Restoration and Monitoring Program v. 0.92
TBWCF Tomales Bay Wetlands Restoration and Monitoring Program v. 0.92	November 2007	Rob Carson	Revisons to Table A-11: MQO's; GWRP sections; Program language; and SOP's	Review comments by SWRCB. Integrate lab MQO's for RTC; Review by GWRP manager;	TBWCF Tomales Bay Wetlands Restoration and Monitoring Program v. 0.93

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A. PROJECT MANAGEMENT

Section A3. Distribution List

Table A-1. QAPP Distribution List

Name	Agency/Affiliation
Rob Carson, Water Quality Program Manager	Tomales Bay Watershed Council Foundation
David Lewis, Technical Advisor	UCCE
Brannon Ketcham, Hydrologist	Point Reyes National Seashore
Lorraine Parsons, Wetlands Ecologist	Point Reyes National Seashore
Dale Hopkins, Grant Manager	San Francisco Bay Regional Water Quality Control Board
William Ray, QA Officer	State Water Resources Control Board
Neysa King, Watershed Coordinator	Tomales Bay Watershed Council Foundation
Robert Berner, CEO Executive Board	Tomales Bay Watershed Council Foundation

Section A4. Project/Task Organization

This QAPP accompanies the Monitoring Plan for the Tomales Bay Wetlands Restoration and Monitoring Program ("the Program").

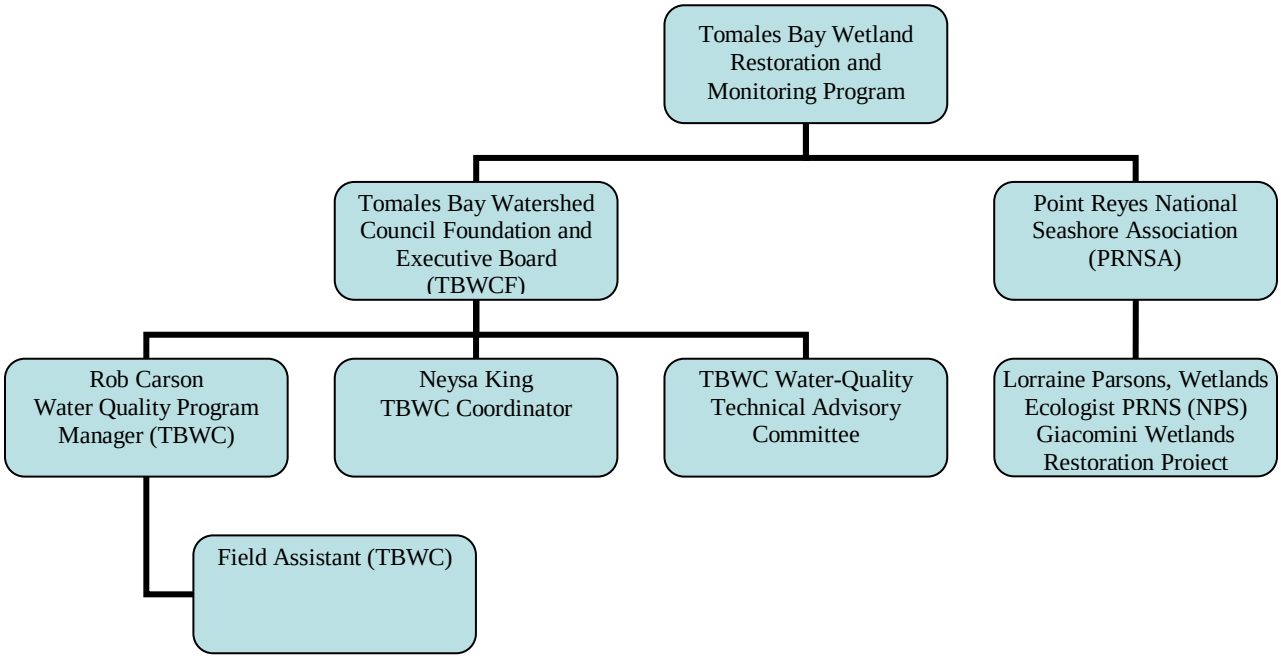
Monitoring and sample collection will be conducted primarily by the Water Quality Program Manager, with field support and assistance from field technician(s) and technical assistance from the Water Quality Technical Advisory Committee. Members of this latter group will take primary responsibility for overseeing the implementation of quality assurance/quality control procedures for the monitoring program The table below summarizes the duties and responsibilities of personnel for this project.

Table A-2. Project Tasks and Responsibilities

Name/ Title	Responsibility
Rob Carson, Water Quality Program Manager (TBWC)	Project Leader, Responsible for collection of monitoring data and data management, oversight of field technician, coordination of report writing. Maintenance of the official, approved Monitoring Plan and QAPP.
David Lewis, Watershed Management Advisor (UCCE)	Water Quality Technical Advisor Assist with sampling design water quality data validation, management, and analysis. Primary Quality Assurance Officer (with assistance of WQ TAC members).
Brannon Ketcham, Hydrologist (PORE)	Water Quality Technical Advisor Not responsible for the delivery of any product.

Lorraine Parsons, Wetlands Ecologist (PORE)	Giacomini Wetlands Restoration Project Manager. Collection of monitoring data, coordination of GWRP restoration and monitoring activities. Water quality technical advisor.

Figure A-1 – Organization and Reporting Structure



Section A5. Problem Definition/Background

Tomales Bay and its watershed is a precious Pacific Coast ecosystem at risk from existing and emerging threats. For this project, local stakeholders and NGOs have partnered with agencies and technical advisors to characterize and reduce threats to water quality and critical habitats. By nesting a major restoration effort within a comprehensive monitoring program, this project employs an integrated strategy to improve water quality, assess effectiveness of restoration in improving water quality at the watershed scale, and identify the next actions needed.

This project will build on the considerable past efforts to characterize water quality threats to Tomales Bay, and attempt to better identify the cause of these threats. A comprehensive Source Area monitoring component will allow the TBWCF to identify and quantify water quality problems within the Bay. Trends Analysis will identify long-term water quality trends and the watershed-level response to a wide range of remediation and restoration efforts proposed to improve the quality of Bay waters. One of the restoration efforts proposed that is expected to have a dramatic effect on water quality is the Giacomini Wetland Restoration Project (GWRP), a

563-acre tidal marsh restoration at the head of the Bay. This restoration project is the single most important measure currently proposed to improve water quality within the watershed. As part of the monitoring program for the restoration project, the National Park Service has conducted pre-restoration monitoring within the ranch and areas to be restored, as well as at other natural tidal marshes, to enable better evaluation of how well restoration improves conditions and functions within the Project Area relative to the conditions and functions that existed prior to restoration and relative to other natural marshes. Under this project, monitoring of these areas will continue and will be integrated with that of Source Area and Trend Analysis programs to allow a broader perspective on the effect of large-scale restoration on water quality within the Tomales Bay watershed.

This nested approach will allow the Program to gauge effectiveness of restoration measures and to identify and prioritize future source reduction, remediation, and restoration projects. Indeed, many regional plans share a common need for the substantial water quality data that this Project will provide. By sharing access to a detailed water quality database, summaries, and analysis, this Project will propel forward plans by numerous local, regional and state organizations.

One of three goals established in the *Tomales Bay Watershed Stewardship Plan: A Framework For Action* (TBWC, 2003) is to ensure water quality in Tomales Bay and tributary streams sufficient to support natural resources and beneficial uses. California's Porter-Cologne Water Quality Control Act and the federal Clean Water Act (CWA) direct water quality programs to implement protection and restoration of the integrity of State waters. Section 303d of the Clean Water Act lists all impaired waters with compromised quality and/or limited use due to an excess of one or more pollutants. Impaired water bodies related to this project are listed in Table A-3. Primary water quality issues in the Tomales Bay watershed that this project intends to address are to improve watershed function overall and specifically the beneficial uses of contact and non-contact recreation, shellfish harvest, riparian corridors and wetlands. This project also specifically fulfills monitoring elements and implementation prescriptions identified in the approved Tomales Bay Pathogen TMDL, and supports the anticipated requirements of the proposed sediment and nutrient TMDLs for the watershed.

Table A-3. CWA Section 303d listed impaired water bodies in Tomales Bay watershed

Water body	Pollutant
Lagunitas Creek	Pathogens, Sediment, Nutrients
Tomales Bay	Pathogens, Sediment, Nutrients, Mercury
Walker Creek	Pathogens, Sediment, Nutrients, Mercury

The Tomales Bay pathogen TMDL (RWQCB December 2005) establishes timelines and performance measures that should be met in order to accomplish the proposed ambient water quality objectives. Under the TMDL, "…stakeholders will collaborate in monitoring efforts" to

identify persistent Non-Point Sources (NPS) of pollution to the Tomales Bay watershed. Once identified, specific actions can be taken reduce delivery from these sources to waterways.

It is the desire of the Council to provide needed water quality information that will assist individuals, organizations and agencies that are responsible for and/or advocating for water quality protection and improvement within the Tomales Bay watershed. The information collected through this program will ultimately be used to increase our collective understanding about the benefits of specific efforts to improve water quality, and our ability to effectively and adaptively manage human impacts on water quality. The quality of the data will be of singular importance to insure is usefulness to stakeholders, organizations and agencies. Data sensitivity is a significant concern amongst both public agencies and various stakeholder groups, and the appropriate use of data, data limitations, etc. will be defined prior to the collection and/or dissemination of any program data. Private property rights will be recognized, statutory responsibilities will be maintained, and voluntary cooperation will be encouraged and protected with data sensitivity considerations.

Water-Quality Monitoring Project (WQMP) Objectives

This plan provides direction for a water quality monitoring program with an initial 10-year timeframe. It is envisioned, however, that the design will include monitoring parameters and a sampling regime that can be carried out indefinitely. The plan and program objectives are to:

1) Provide the watershed community with the required data and analysis to determine improving, constant, or declining trends in bay and tributary water quality;
2) Form and maintain a clearinghouse of water quality data and monitoring activities that facilitates effective and efficient use of limited resources;
3) Serve as source of information that will direct and promote actions to improve water quality; and
4) Provide an understanding of source areas and categories for constituents of concern in the bay and on a sub-watershed and/or tributary scale.

Questions to be addressed by this (WQMP) monitoring program:

1) What are the natural ranges and the storm, seasonal and annual variability in water quality parameters in the Bay and its tributaries?
2) At what locations do parameters fall outside the natural range and to what duration and extent?
3) What are the pollutant loadings from controllable and uncontrollable sources and in the watershed, and how do the Bay and tributaries relate in this regard?
4) What are the trends in the levels, fate and transport of pollutants in the watershed and the Bay, and how do the Bay and tributaries relate in these regards?
5) How effective are actions to reduce pollutant loads?

Giacomini Wetland Restoration Project (GWRP) Water Quality Monitoring Objectives

This plan addresses the water-quality monitoring objective of the GWRP. For a complete assessment of all long-term monitoring objectives of the project, see complete project literature, including Parsons (2005).

1. Provide strategic water quality monitoring before, during, and after a phased restoration effort to determine the short- and long-term effects of restoration on water quality within the Project Area and on the amount of contaminants delivered to Tomales Bay.
2. Compare water quality conditions in the Project Area before, during, and after restoration to those of natural undiked tidal marshes in the Tomales Bay and adjacent watersheds to determine the degree of divergence prior to restoration and how well over time conditions in the restored Project Area move toward those of natural marshes after restoration.

Questions to be addressed by GWRP water quality monitoring:

1. What is the response to restoration activities with respect to nutrients, pathogen indicators and carbon/productivity indicators?
2. Over time, do conditions within the restored Project Area improve relative to pre-restoration conditions, and do they begin to move closer toward those in natural undiked tidal marshes in the Tomales Bay and adjacent watersheds?
3. Does restoration of the Giacomini wetlands appear to have an effect on the quality of water delivered downstream to undiked natural marshes and Tomales Bay?

Table A-4. Data utilization and Related Management Decisions

Program	Parameter	Intended use of data	Relevant Management Decision
Long-Term Trend Monitoring	Core parameters, bacteria, nutrients, sediment	Determine the long-term trends of water-quality within the Tomales Bay watershed. Compare data from individual sites from one sampling event to another; also compare data from multiple sites within a subwatershed. Provide data to agencies (where appropriate and NOT for regulatory purposes).	Support local, regional, state and federal efforts to monitor water quality in the watershed. Determine the effectiveness of remediation, restoration and source reduction efforts.
Source Area Monitoring	Core parameters, nutrients, bacteria, sediment, stormwater pollution indicators	Determine the sources of water quality degradation within the Tomales Bay watershed. Compare data from individual sites from one sampling event to another; also compare data from multiple sites within a watershed. Provide data to agencies (where appropriate and not for regulatory purposes) and landowners	Make decision on how to present data and work internally with council representatives where applicable, with local landowners, and with agencies to alleviate problems; work with local groups on implementation strategies to reduce pollution to the bay.
Giacomini Wetland Restoration WQ Monitoring	Core parameters, nutrients, bacteria, sediment, carbon/productivity indicators	Determine if restoration actions are improving water quality. Compare data from individual sites from one sampling event to another; also compare data from multiple sites within a watershed. Provide data to local agencies (where appropriate)	Determine the impact of restoration efforts on conditions both within the Project Area and downstream of the Project Area. .

Standards and Water Quality Criteria

While the data collected in this project will not be used for regulatory purposes, it is important to take account of regional water quality objectives in the data analysis process. These objectives provide standards to utilize when interpreting data and relating results to the broader regional framework.

Table A-5 lists the general numeric objectives for physical and chemical parameters in surface waters of this area, as established by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB). These general objectives can be used to determine whether water bodies are meeting specific beneficial uses. For example, un-ionized ammonia levels above the water quality objective would hinder the ability of a stream to support healthy aquatic life (e.g., fish spawning). This would then trigger a management action to reduce the inputs of nitrogen to the streams. It may also dictate more frequent sampling of nutrients, pH, and temperature – factors that affect the amount of ammonia in a stream.

Table A-5. General numeric objectives for physical parameters in surface waters in the San Francisco Bay Area (SFBRWQCB, 1995)

Parameter	**Water Quality Objective**
Dissolved oxygen (tidal waters)	Upstream of Carquinez bridge: 7.0 mg/L minimum
Dissolved oxygen (non-tidal waters)	Cold water habitat 7.0 mg/L minimum Warm water habitat 5.0 mg/L minimum
pH	Less than 8.5 and greater than 6.5
Un-ionized ammonia	Annual Median 0.025 mg/L as nitrogen (N) (freshwater)

For chemical and physical parameters where numeric objectives are not established by the RWQCB, collected data will be compared to various criteria and standards suggested by the EPA, or from the primary literature relating to regional surface waters. More specific information about these criteria can be found in the Standard Operating Procedure (SOP) dealing with that particular parameter (see Appendix C).

The criteria are based on both human health criteria and overall aquatic health. Chronic human toxicity for nitrate occurs at 10 mg/L (San Francisco Bay Regional Water Quality Control Board, 1995). However, this may not be stringent enough for aquatic life (San Francisco Bay Regional Water Quality Control Board, 2003b). Chronic toxicity to aquatic life, especially fish and amphibian eggs, can occur at 1.1 mg/L (Kincheloe et al., 1979; Crunkilton, 2000). Nutrient levels at which algal growth limitation begins are less than 0.5 mg/L for total nitrogen and 0.1 mg/L for total phosphorus (Bowie et al., 1985).

Recent EPA criteria are based on *Ambient Water Quality Criteria Recommendations* for Ecoregions across the country (U.S. Environmental Protection Agency, 2000). A map of the ecoregions can be found at**:** http://www.epa.gov/waterscience/criteria/nutrient/ecomap.html**.** During the development of nutrient criteria for the ecoregions, several sources of data were

consulted including historical and recent nutrient data and reference sites. Ecoregion II (Western Forested Mountains) includes the Tomales Bay watershed. Recommended criteria for Ecoregions II are listed in Table A-6. These are not regulations but are intended to be "starting points" for states and tribes developing water quality standards (U.S. Environmental Protection Agency, 2000a). The EPA Ecoregion values in Table A-6 represent nutrient levels that are generally protective of nutrient over enrichment. However, "States and Tribes should evaluate the information in light of the specific designated uses that need to be protected" (U.S. Environmental Protection Agency, 2000a). Conversely, overly stringent criteria may actually fall below levels of nutrient loading that naturally occur. The EPA encourages the states to develop more refined criteria through the use of local data.

There are also various recommendations for the sediment parameters total suspended solids and turbidity (Table A-6). Similarly, nutrient levels can be compared to several different thresholds until targets or Total Maximum Daily Loads (TMDLs) are set. We will utilize this "multiple thresholds" concept for data analysis. The effects of nutrients and sediment on water quality are discussed further in standard operating procedures in the appendices.

Table A-6. Recommended criteria for nutrients and sediment

Parameter	EPA Quality Criteria for Water (1986)	EPA Aggregate Ecoregion II Criteria (2000b /2003)	Kincheloe et al., 1979; Crunkilton, 2000	Bowie et al., 1985	Sigler et al., 1984	Newcomb and Jensen, 1996
Total Phosphorus (P)	0.1 mg/L	10 ug/L		0.1 mg/L		
Total Phosphates as P	50 ug/L					
Total Nitrogen		0.12 mg/L		0.5 mg/L		
Nitrate	10 mg/L		1.1 mg/L			
∗Acute Total Suspended Solids						> 50 mg/L
∗Chronic (>6 days) Total Suspended Solids (TSS)						> 10 mg/L
ϕTurbidity		1.30 NTU			25 NTU	

∗Total suspended solids are listed in milligrams per liter (mg/L)
ϕTurbidity is listed as nephelometric turbidity units (NTU)

The SFBRWQCB has established criteria for pathogen parameters as they relate to three activities: contact recreation, non-contact recreation, and shellfish harvesting (see Table A-7). These criteria will serve as guidelines for this project to determine the range and variability of pollution levels, locations of pollution loading, the effectiveness of actions to reduce these loads.

Table A-7. General numeric objectives for select beneficial uses in surface waters in the San Francisco Bay Area

Beneficial Use	Fecal Coliform (MPN/100mL)	Total Coliform (MPN/100mL)
Contact recreation	Log mean < 200 90th percentile < 400	Median < 240 No sample > 10,000
Non-contact recreation	Mean < 2000 90th percentile < 4000	
Shellfish harvesting	Median < 14 90th percentile < 43	Median < 70 90th percentile < 230

Section A6. Project/Task Description

The TBWC Water Quality Monitoring Program will implement both long-term and source area sampling to evaluate the condition of Tomales Bay and tributary streams, and the GWRP will augment pre-restoration water quality monitoring efforts by conducting during- and post-restoration water quality monitoring around both impact and control or marsh reference sites. Field parameters will be measured at each sampling site. Laboratory parameters to be measured will vary with project site and will depend on particular pollutant(s) of interest for monitoring. A list of parameters of interest is included in Table A-8.

Logistical constraints, including personnel availability, sample holding time and laboratory hours of operation will limit the number of sites, and the days and storm events that can be sampled. The duration of current funding also limits the long-term data collection objectives laid out in the Project monitoring plan. Each of these constraints has been considered in the project design, and addressed, to the extent possible, to minimize any impacts.

Parameters of Interest

Table A-8. Parameters of Interest for Water Quality Monitoring Projects

Parameter Group	Program	Specific Parameters
Core Parameters	Trends, Source Area, GWRP	Water Temperature, Specific Conductance, pH, Dissolved Oxygen
Pathogens	Trends, Source Area, GWRP	Total Coliforms and Fecal Coliforms (TC/FC) and/or *E. coli (EC);* Coliphage (Source Area & Trends only)
Nutrients	Trends, Source Area, GWRP	Nitrogen (Nitrate, Nitrite, Total Kjeldahl, Ammonia), Phosphorus (Orthophosphate,Total Dissolved Phosphate)
Sediment	Trends, Source Area and (GWRP (turbidity only))	Turbidity and Total Suspended Sediment (TSS) or Suspended

		Sediment Concentration (SSC).
Productivity and carbon indicators	GWRP, And one Trends site, and one inner Bay site.	DOC, Chlorophyll a, Phaeophyton
Storm water pollution indicators	Source Area, GWRP (occasional)	MBAS, Oil/Grease, metals, VOCs,
Discharge	Trends, Source Area, GWRP	Flow velocity and stream cross-sectional area

Quality Assurance

The Monitoring Plan for this project has been developed and will be implemented with the objective of collecting high quality monitoring data that could be of the most use to the Tomales Bay Watershed Council, the National Park Service, U.S. Geological Survey, and California and San Francisco Bay Area monitoring programs. Adherence to the methods and measures laid out in this QAPP will assure the quality of the data. Because this document was developed with the SWAMP QAPP as a template, comparability of quality assurance measures should ensure comparability of resulting data. A technical panel of aquatic resource specialists will be consulted regarding QA/QC measures, plan implementation, and any changes to this QAPP that are deemed necessary.

Data Management, Data Evaluation, and Reporting

Data management, evaluation, and reporting will be high priorities of this project. The NPSTORET database will be the central depository of all data collected by this project, and data can be uploaded to the SWAMP database periodically. NPSTORET Templates are designed to capture all critical field information for uploading data and required meta-data into STORET. These templates should be used whenever feasible to do so as that should streamline the data management process significantly. The discussion of this data management system and links to example NPSTORET templates may be found at www.nature.nps.gov/water/infoanddata. Alternatively, and electronic data deliverable file (EDD) may be generated but it should capture all the ancillary information and meta-data that the NPSTORET templates would.

It is the goal of the data management program to ultimately provide standardized data management, evaluation, and reporting. It is also a goal to be as "paperless" as possible, and to develop a database that will allow internet web access to all parties interested in the data and technical reports produced through this project.

Table A-9. Project Task Extended Timetable

Deliverables	2007	2008	2009	2010
Develop QAPP	X			
Meet with local technical experts to review monitoring protocol	X			
Finalize Monitoring Plan	X			
Conduct equipment inventory and calibration, purchase any needed equipment	X	X		
Collect long-term monitoring data	X	X	X	X
Collect source-area samples (winter, storm-based)	X	X	X	X

Implement Giacomini Wetland Restoration	X	X	X	
Collect GWRP Pre-Restoration Monitoring Data	X	X		
Collect GWRP WQ Data During and Post restoration		X	X	X
Produce quarterly progress reports	X	X	X	X
Produce Pollution Load Reduction Report			X	X
Share results with council members, ranchers, and local community through various outreach efforts	X	X	X	X
Produce final project report				X

Table A-10. Overview of Water Quality Monitoring Sites and Parameters

Sampling Location	Type of Site	# of Sample Stations	Potential WQ Parameters	Frequency for WQ Sampling	# of Samples/ matrix per year
LONG-TERM TRENDS MONITORING					
Lagunitas Creek	Stream site (Long-Term Trends)	1	Field: Core, Discharge Lab: Bacteria, Nutrients, Sediment	Weekly samples during saturated Fall, Winter and Spring periods. Twice monthly during base flow conditions (late Spring, summer and early Fall)	d52
San Geronimo Creek	Stream site (Long-Term Trends	1	Field: Core, Discharge Lab: Bacteria, Nutrients, Sediment	Weekly samples during saturated Fall, Winter and Spring periods. Twice monthly during base flow conditions (late Spring, summer and early Fall)	d52
Olema Creek	Stream site (Long-Term Trends	1	Field: Core, Discharge Lab: Bacteria, Nutrients, Sediment	Weekly samples during saturated Fall, Winter and Spring periods. Twice monthly during base flow conditions (late Spring, summer and early Fall)	d52
West Side Bay Tributaries	Stream site (Long-Term Trends	1	Field: Core, Discharge Lab: Bacteria, Nutrients, Sediment	Weekly samples during saturated Fall, Winter and Spring periods. Twice monthly during base flow conditions (late Spring, summer and early Fall)	d52
East Side Bay Tributaries	Stream site (Long-Term Trends	1	Field: Core, Discharge Lab: Bacteria, Nutrients, Sediment	Weekly samples during saturated Fall, Winter and Spring periods. Twice monthly during base flow conditions (late Spring, summer and early Fall)	d52
Walker Creek	Stream site (Long-Term Trends	1	Field: Core, Discharge Lab: Bacteria, Nutrients, Sediment	Weekly samples during saturated Fall, Winter and Spring periods. Twice monthly during base flow conditions (late Spring, summer and early Fall)	d52
Chileno Creek	Stream site (Long-	1	Field: Core, Discharge	Weekly samples during saturated Fall, Winter and	d52

	Term Trends		Lab: Bacteria, Nutrients, Sediment	Spring periods. Twice monthly during base flow conditions (late Spring, summer and early Fall)	
Keyes Creek	Stream site (Long-Term Trends	1	Field: Core, Discharge Lab: Bacteria, Nutrients, Sediment	Weekly samples during saturated Fall, Winter and Spring periods. Twice monthly during base flow conditions (late Spring, summer and early Fall)	d52
White Gulch (West Side Reference Tributary)	Stream site (Long-Term Trends	1	Field: Core, Discharge Lab: Bacteria, Nutrients, Sediment	Weekly samples during saturated Fall, Winter and Spring periods. Twice monthly during base flow conditions (late Spring, summer and early Fall)	d52
Trib at MP 36.17 (East Side Reference Tributary)	Stream site (Long-Term Trends	1	Field: Core, Discharge Lab: Bacteria, Nutrients, Sediment	Weekly samples during saturated Fall, Winter and Spring periods. Twice monthly during base flow conditions (late Spring, summer and early Fall)	d52
Tomales Bay Sites	Bay Sites (Long-Term Trends)	4	Field: Core, Turbidity Lab: TC/FC/EC, Nitrogen, Phosphate, DOC, Chlorophyll a, phaeophyton	Weekly samples during saturated Fall, Winter and Spring periods. Twice monthly during base flow conditions (late Spring, summer and early Fall)	d38
GIACOMINI WETLAND RESTORATION WATER-QUALITY MONITORING					
Giacomini Restoration Monitoring	Project Area and Reference Marshes	35 sites in Project Area (16 reference sites)	Field: Core, Flow, Turbidity	Quarterly samples	
Giacomini Restoration Monitoring	Project Area and Reference Marshes	14 sites in treatment area (10 reference sites)	Lab: TC/FC/, Nitrogen, Phosphate, DOC, Chlorophyll a, Phaeophyton	Quarterly samples	
SOURCE AREA MONITORING					
Source Area Sites	Stream and drainage sites in targeted watersheds	3-4 Source Area watersheds/Yr	Field: Core, Discharge Lab: TC/FC/EC, coliphage, Nutrients, Sediment, Stormwater pollution indicators (MBAS, Oil/Grease, metals, VOC's)	3-5 storm events over winter and spring (November-April)	3-5/site/year

Maps of the project sites and their associated sampling locations are included in Appendix B.

Section A7. Measurement Quality Objectives (MQOs) and Criteria for Measurement Data

MQO's are qualitative and quantitative statements of the quality of data needed to support specific decisions or actions. Data acceptability criteria are included in MQOs. The purpose of MQOs is to document 1) the intended use of the data in order or importance, 2) decision to be made when data are obtained, and 3) decision makers who will use the data (California Department of Water Resources, 1998). Decision makers for this program will generally be the same for each parameter. Recommendations will be developed by technical advisors and park managers. These recommendations in the form of reports or summaries will be made to managers such as Resource Management Chiefs and Park Superintendents. Other decision makers may include local agencies and landowners. All data including core parameters, bacteria, nutrients, and sediment have the same intended uses since they all help identify pollution sources and the effectiveness of BMP implementation.

Table A-11 provides a summary of measurement quality objectives of this project, including project action limits where available, in addition to Accuracy, Precision, Recovery, target reporting limits and data completeness targets.

Table A-11. Measurement Quality Objectives

Parameter	Laboratory or Field	Instrument or Method	Accuracy	Precision	Recovery	Target Reporting Limits	Completeness
pH	Field	Oakton pHTestr 30	+/- 0.2 pH units	+/- 0.2 pH units	N/A		90%
Conductivity	Field	YSI 85	+/- 5 uS/cm or +/- 3% of the measured value, whichever is greater	+ 5 uS/cm or +/- 3% of the measured value, whichever is greater	N/A		90%
Dissolved oxygen	Field	YSI85	+/- 5%	+/- 5%	N/A		90%
Temperature	Field	YSI85 or HOBO Temp logger	+/- 0.5 ^{o}C	+/- 0.5 ^{o}C	N/A		90%

Total coliforms and E. coli	Analytical Sciences or NPS Bacteria Lab	SM 9223B (IDEXX QuantiTray)	Positive results for target organisms. Negative results for non-target organisms	R_{log} within 3.27*mean R_{log} (reference is section 9020B 18th edition of Standard Methods)	N/A	1 MPN/100 mL	90%
Total and fecal coliform	Analytical Sciences	SM9221	Positive results for target organisms. Negative results for non-target organisms	R_{log} within 3.27*mean R_{log} (reference is section 9020B 18th edition of Standard Methods)	N/A	2 MPN/100 mL	90%
Coliphage	UC Riverside Lab	EPA 1602		+/- 46%	Detect – 120%	N/A	90%
Total Kjeldahl Nitrogen (TKN)	Analytical Sciences or RTC	SM4500 or EPA 351.2	+/- 20%	+/- 25%	+/- 20%	0.10 mg/L	90%
Nitrate as N	Analytical Sciences or *RTC*	EPA 300.0	+/- 20% *+/- 2%*	+/- 25% *+/- 1%*	+/- 20% *+/- 2%*	0.1 mg/L *1400 ng/L (0.1uM)*	90%
Nitrite as N	Analytical Sciences or *RTC*	EPA 300.0	+/- 20% *+/- 1%*	+/- 25% *+/- 1%*	+/- 20% *+/- 1%*	0.05 mg/L *1400 ng/L (0.1uM)*	90%
Ammonia-Nitrogen	Analytical Sciences or *RTC*	EPA 350.3 or SM 4500-F	+/- 20% *+/- 1%*	+/- 25% *+/- 1%*	+/- 20% *+/- 2%*	0.1 mg/L *700 ng/L (0.01uM)*	90%
Orthophosphate	Analytical Sciences or *RTC*	EPA 365 or EPA 300	+/- 20% *+/- 1%*	+/- 25% *+/- 1%*	+/- 20% *+/- 5%*	0.10 mg/L *3100 ng/L (0.1 M)*	90%

Total Dissolved Phosphate	Analytical Sciences or RTC	EPA 365 or EPA 300	+/- 20%	+/- 25%	+/- 20%	0.50 mg/L	90%
Dissolved Organic Carbon (DOC)	Analytical Sciences	SM5310C or EPA 415.1	+/- 20%	+/- 25%	+/- 20%	0.50 mg/L	90%
Chlorophyll a and Phaeophyton	Analytical Sciences or RTC	SM10200H	+/- 20%	+/- 25%	+/- 20%	1.0 mg/m3	90%
Turbidity	Analytical Sciences	Hach 2100 Turbidimeter	+/-2 NTU or +/-5 % of the measured value, whichever is greater (USGS) +/- 2% (Hach)	+/-2 NTU or +/-5 % of the measured value, whichever is greater (USGS) +/- 2% (Hach)	N/A	0.1 NTU	90%
Total Suspended Solids (TSS)	Analytical Sciences	SM 25040D or EPA 160.2	+/- 20%	+/- 25%	+/- 20%	1.0 mg/L	90%
MBAS	Analytical Sciences	SM 5540	+/- 40%	20% RPD	60-140%	0.005 mg/L	90%
Oil/Grease	Analytical Sciences	EPA 418.1* *EPA1664A (SWAMP preferred method) is less sensitive to the low levels of Oil/Grease.that this program will likely encounter	+/- 30%	MS/MSD 25% Laboratory duplicate minimum.	Matrix spike 80% - 12% or control limits at +/- 3 standard deviations based on actual lab data.	0.5 mg/L* *A.S. lab can provide **0.25 mg/L** TRL (lower than method sensitivity for EPA 1664A)	90%

Total Metals:	**Analytical Sciences**		**Standard Reference Materials (SRM, CRM, PT) 75%-125%**	**MS/MSD ±25% RPD. Lab duplicate minimum**	**Matrix spike 75%-125%**		**90%**
Cadmium		EPA 6010B	"	"		0.01 µg/L	90%
Chromium		EPA 6010B	"	"		0.10 µg/L	90%
Copper		EPA 6010B	"	"		0.01 µg/L	90%
Lead		EPA 200.9	"	"		0.01 µg/L	90%
Mercury		EPA 7470A	"	"		0.2 ng/l	90%
Silver		EPA 6010B	"	"		0.02 µg/L	90%
Zinc		EPA 6010B	"	"		0.10 µg/L	90%
Volatile Hydrocarbons: (individual constituents listed below)	**Analytical Sciences**	**EPA 8260B**	**Standard Reference Materials (SRM, CRM, PT) within 95% CI stated by provider of material. If not available then with 50% to 150% of true value**	**MS/MSD ±25% RPD or control limits at ±3 standard deviations based on actual lab data. Lab replicate minimum**	**Matrix spike 50%-150% or control limits at ±3 standard deviations based on actual lab data.**	**1.0 µg/L (or 12 µg/L for Tertiary Butyl Alcohol (TBA))**	**90%**
Dichlorodifluoromethane (F-12)		"	"	"	"	1.0 µg/L	90%
Chloromethane		"	"	"	"	1.0 µg/L	90%

Vinyl chloride	“	“	“	“	1.0 µg/L	90%
Chloroethane (CE)	“	“	“	“	1.0 µg/L	90%
Bromomethane	“	“	“	“	1.0 µg/L	90%
Trichlorofluoromethane (F-ll)	“	“	“	“	1.0 µg/L	90%
Trichlotrifluoroethane (F-I13)	“	“	“	“	1.0 µg/L	90%
1,I-Dichloroethene (l,I-DCE)	“	“	“	“	1.0 µg/L	90%
Methylene Chloride	“	“	“	“	1.0 µg/L	90%
trans-l,2- Dichloroethene	“	“	“	“	1.0 µg/L	90%
1,I-Dichloroethane (l,l-DCA)	“	“	“	“	1.0 µg/L	90%
cis-l,2- Dichloroethene (c 1,2-DCE)	“	“	“	“	1.0 µg/L	90%
2,2-Dichloropropane	“	“	“	“	1.0 µg/L	90%
Chloroform (THMI)	“	“	“	“	1.0 µg/L	90%
Bromochloromethane	“	“	“	“	1.0 µg/L	90%
1,1, I-Trichloroethane (TCA)	“	“	“	“	1.0 µg/L	90%
1,2-Dichloroethane (EDC)	“	“	“	“	1.0 µg/L	90%
1,I-Dichloropropene	“	“	“	“	1.0 µg/L	90%
Carbon Tetrachloride	“	“	“	“	1.0 µg/L	90%
Benzene	“	“	“	“	1.0 µg/L	90%
Trichloroethene (TCE)	“	“	“	“	1.0 µg/L	90%
1 ,2-Dichloropropane (DCP)	“	“	“	“	1.0 µg/L	90%
Dibromomethane	“	“	“	“	1.0 µg/L	90%
Bromodichloromethane (THM2)	“	“	“	“	1.0 µg/L	90%
cis-l,3-Dichloropropene	“	“	“	“	1.0 µg/L	90%
Toluene	“	“	“	“	1.0 µg/L	90%
1,1,2- Trichloroethane	“	“	“	“	1.0 µg/L	90%
1,3 - Dichloropropane	“	“	“	“	1.0 µg/L	90%
Dibromochloromethane (THM3)	“	“	“	“	1.0 µg/L	90%
Tetrachloroethene (PCE)	“	“	“	“	1.0 µg/L	90%
1,2-Dibromoethane (EDB)	“	“	“	“	1.0 µg/L	90%
Chlorobenzene	“	“	“	“	1.0 µg/L	90%

1,1,1,2- Tetrachloroethane	“	“	“	“	1.0 µg/L	90%
Ethylbenzene	“	“	“	“	1.0 µg/L	90%
m,p-Xylene	“	“	“	“	1.0 µg/L	90%
Styrene	“	“	“	“	1.0 µg/L	90%
o-Xylene	“	“	“	“	1.0 µg/L	90%
Bromoform (THM4)	“	“	“	“	1.0 µg/L	90%
1,l ,2,2- Tetrachloroethane	“	“	“	“	1.0 µg/L	90%
Isopropylbenzene	“	“	“	“	1.0 µg/L	90%
1,2,3- Trichloropropane	“	“	“	“	1.0 µg/L	90%
Bromobenzene	“	“	“	“	1.0 µg/L	90%
n-Propyl Benzene	“	“	“	“	1.0 µg/L	90%
2-Chlorotoluene	“	“	“	“	1.0 µg/L	90%
4-Chlorotoluene	“	“	“	“	1.0 µg/L	90%
1,3,5- Trimethylbenzene	“	“	“	“	1.0 µg/L	90%
tert -Butylbenzene	“	“	“	“	1.0 µg/L	90%
1,2,4-Trimethylbenzene	“	“	“	“	1.0 µg/L	90%
sec-Butylbenzene	“	“	“	“	1.0 µg/L	90%
1,3-Dichlorobenzene	“	“	“	“	1.0 µg/L	90%
1,4-Dichlorobenzene	“	“	“	“	1.0 µg/L	90%
1,2- Dichlorobenzene	“	“	“	“	1.0 µg/L	90%
p-Isopropyltoluene	“	“	“	“	1.0 µg/L	90%
n-Butylbenzene	“	“	“	“	1.0 µg/L	90%
1,2- Dibromo- 3-chloropropane	“	“	“	“	1.0 µg/L	90%
1,2,4- Trichlorobenzene	“	“	“	“	1.0 µg/L	90%
Naphthalene	“	“	“	“	1.0 µg/L	90%
Hexachlorobutadiene	“	“	“	“	1.0 µg/L	90%
1,2,3- Trichlorobenzene	“	“	“	“	1.0 µg/L	90%
Tertiary Butyl Alcohol (TBA)	“	“	“	“	12.0 µg/L	90%
Methyl tert-Butyl Ether (MTBE)	“	“	“	“	1.0 µg/L	90%
Di-isopropyl Ether (DIPE)	“	“	“	“	1.0 µg/L	90%

Ethyl tert-Butyl Ether (ETBE)	"	"	"	"	1.0 µg/L	90%
Tert-Amyl Methyl Ether (TAME)	"	"	"	"	1.0 µg/L	90%

Goals for Achieving Measurement Quality Objectives (MQO's)

Measurement quality objectives will be achieved in a number of ways including:

- Following standard operating procedures (SOP) with standardized field and laboratory methods (see appendices),
- Follow the recommendations of the TBWC Water Quality Technical Advisory Committee which will serve to provide on-going peer review of all water quality monitoring activities within this project, with QA oversight being one of the primary focuses; and
- Documenting the comparability of laboratory and field methods that are consistent with the MQO's.

The intent is to provide the minimum standards and guidelines that this project should utilize, with strong encouragement to use more stringent criteria and to adopt methodologies that improve upon these minimum standards. The major goal that this QAPP can accomplish is to have representative, comparable, accurate and precise data that can be shared statewide and nationwide, to the extent possible. Refer to Table A-12 below to see a summary of data quality assurances.

Table A-12: Overview of Data Quality Assurances

Data Comparability Issue	Data Quality Assurances
Sufficiency of Metadata	• Metadata requirements of NPSTORET are comprehensive, ensuring that methods, analyses and handling of both samples and data are documented in the same place as the data itself (including the attachment of the protocol and SOP documents themselves). • Systematic verification of data in the database, as well as periodic review of stated procedures and included documentation (SOP's). • The Protocol Narrative and SOP's will thoroughly document all field and laboratory methods, including QA/ QC measures.
Field Methods	• Standard USGS or SWQCB (SWAMP) protocols will be followed, as explained in the SOP's. • Documentation of equipment calibration frequency and acceptance criteria.
Lab Methods	• Contract laboratories analyzing TBWCF samples will be NELAP (or CA-ELAP) certified for the parameter and analysis being conducted. • Other laboratories used for specialized analysis (trace-level nutrient analysis or coliphage) will follow standard methods and will follow the QA/QC guidelines laid out in this QAPP • All methods used for laboratory samples will follow Standard Methods using APHA/AWWA/WEF methods or comparable EPA methods. • Laboratory QC measures will include matrix spikes, method blanks, calibration standards, lab and field-duplicated samples and documentation of sample handling and analytical results.
Sensitivity	• For lab parameters: Calculation of both Method Detection Limit (MDL) and Minimum Level of Quantitation (ML).

	• For field or "core" parameters: Quarterly collection of seven replicate samples or measurements in order to calculate the Alternative Measurement Sensitivity (AMS).
Precision	• For Field Measurements: Duplicate at least one measurement, or 10% of a days' samples (whichever is larger). • For Lab Measurements: Duplicate analysis of 10% of samples. Report the Relative Percent Difference (RPD).

Table A-12. (cont'd) Overview of Data Quality Assurances

Data Comparability Issue	Data Quality Assurances
Bias	• Maintain consistent personnel and methodology where possible. • Overlap a minimum of seven (7) measurements when personnel changes, thirty (30) when a method or equipment changes, and fifty (50) when replacing surrogate estimators like FIB. • Analyze such overlapping samples to determine the contribution of bias (if any) to any variance in the data. • Control bias by: Use and analysis of "blank" samples (Field, Trip or Lab Blanks) to determine contamination by methodology.
"Accuracy"	• For the purposes of this protocol, the term "accuracy" should be taken to be the "uncertainty in accuracy" and is a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations. Measurement uncertainty will be controlled quantitatively through calculations of sensitivity, precision and bias.

This protocol is based largely on the USGS National Field Manual for the Collection of Water-Quality Data (Wilde *et al*, various dates), and the state of California's Surface Water Ambient Monitoring Program (Puckett, 2002). The generally accepted goal of the water quality monitoring program is to ***"standardize where possible; document otherwise"***. The need for flexibility to accommodate site-specific sample collection needs was acknowledged, along with the need to standardize methods to the extent possible. Data quality will be attained by maximizing and documenting the accuracy and precision of the methods used. Any changes in procedures due to equipment changes or to improved precision and accuracy will be documented. Wherever possible, there should be overlap in sampling methods as well as overlap of staff when turnover occurs.

The appropriate use of previously-collected data will be dictated by a review of methods used including: laboratory reporting limits, data completeness, and the availability of field and laboratory standard operating procedures that guided data collection and analytical efforts. If the standards were at least as stringent as those put forward in this document, then the data will be deemed fully comparable. In those cases where particular metadata is unavailable for a previously-collected dataset, its use will be flagged and the specific limitations of its use made explicit in any data analysis that includes this data.

Data quality objectives include representativeness, comparability, completeness, and precision. These are discussed further on the following page (*from* Puckett, 2002):

Representativeness

The representativeness of the data is mainly dependent on the sampling locations and the sampling procedures adequately representing the true condition of the sample site. Requirements for selecting sample sites are discussed in more detail in the protocol narrative. Selection of appropriate sample sites and the use of only approved/documented analytical methods will ensure that the measurement data does represent the conditions at the investigation site, to the extent possible. Assuring representativeness of the data will be accomplished by using methods used by the USGS (collector sites, cross-section checks, sampling from the centroid of flow, etc.) A combination of assuring representativeness, plus selecting sites upstream of bridges and culverts (as detailed in Standard Operating Procedure (SOP #12, Site Selection & Documentation)), and randomly selecting where to start sampling the midpoints and cross-sections upstream will assure both reasonable representativeness of the target population while still maintaining good data comparability with regional USGS data

Some constraints to sampling representatively include difficult or unsafe access, particularly during storm events. Also, due to laboratory closures and lack of staff availability during the winter holidays when major storm events often occur, valuable water quality data may not be captured. Other constraints to sampling representatively are that sites will primarily be located within park boundaries and will not necessarily represent the larger watershed. This will not be a significant concern since parks encompass several watersheds in their entirety. However, watersheds with significant portions located outside park boundaries may not be sampled in some cases due to access issues, relative lack of management options, or other limitations.

Comparability

The comparability of data produced by this project is predetermined by the commitment of its staff and contracted laboratories to use standardized methods, where possible, including USGS field methods and U.S. Environmental Protection Agency (EPA) approved analytical methods, or documented modifications that provide equal or better results. These methods have specified units in which the results are to be reported. For internal data comparability, the attached SOP's carefully describe the methods to be followed during water quality sampling. If followed carefully, these should provide the methodological and temporal consistency that will ensure internal data comparability. This includes such discussions as training, overlap of sampling methods when equipment, personnel or methods change, and documentation of bias between old and new methods. The comparability of this data to the data collected by outside entities from the state to consultants and volunteers will depend on the documentation of methodologies and QA/QC practices of these groups. The project manager will meet with outside project leaders to determine and document methodologies of outside projects. One of the central ways the TBWC monitoring program will insure the comparability of their data to outside groups is to follow some basic information quality guidelines by integrating a high degree of transparency about data and methods used to generate the data, including quantifying the limits of Measurement Quality Objectives specifications for precision, bias and sensitivity.

Because the state was involved in discussions through guidance and review of this protocol, data collected as part of water quality monitoring activities or related projects should be directly comparable to the state-collected data. Regular consultation with outside monitoring groups will establish and/or maintain a high level of comparability wherever possible. All contracted labs will use standardized methods and all labs used in the Trends monitoring analysis will be NELAP or CA ELAP-certified. Some specialized laboratory analysis including trace-level (ng/L) nutrient analysis and coliphage will be conducted at university-affiliated research laboratories using approved and standard methods and will follow all QA/QC methods laid out in this QAPP.

Completeness

The completeness of data is basically a relationship of how much of the data is available for use compared to the total potential data before any conclusion is reached. Ideally, 100% of the data should be available. However, the possibility of data becoming unavailable due to equipment failure, laboratory error, insufficient sample volume, or samples broken in shipping must be expected. Also, unexpected situations may arise where field conditions do not allow for 100% data completeness. Therefore, 90% data completeness is required for data usage in most cases.

Precision and Accuracy

The precision and accuracy of data are determined by particular actions of the analytical laboratory and field staff. The precision of data is a measure of the reproducibility of the measurement when an analysis is repeated. It is reported in Relative Percent Difference (RPD) or Relative Standard Deviation (RSD). The accuracy of an analysis is a measure of how much of the constituent actually present is determined. It is measured, where applicable, by adding a known amount of the constituent to a portion of the sample and determining how much of this spike is then measured. It is reported as Percent Recovery. The acceptable percent deviations and the acceptable percent recoveries are dependent on many factors including: analytical method used, laboratory used, media of sample, and constituent being measured.

It is the responsibility of the program manager to control the precision and accuracy of the field data, while verifying that the data are representative. For samples that undergo laboratory analysis, the analytical data's precision, accuracy, and comparability are mainly the responsibility of the laboratory. The program manager also has prime responsibility for determining that the 90% data completeness criteria are met or for justifying acceptance of a lesser percentage.

Laboratories performing the analysis of samples for this project have developed precision and accuracy limits for acceptability of data. For parameters and matrices which have EPA established criteria, the limits are either equal to, or more stringent than, the established limit.

Section A8. Special Training/Certification

Field

Proper training of field personnel represents a critical aspect of quality control. As such, the individual responsible for maintaining QAPP compliance (QA officer) will be responsible for

training of field personnel and for performing field audits. Further details of staff training are presented in the TBWC WQ SOP. Safety issues related to water quality work are presented and all field staff will be well-versed in this SOP. The USGS offers a comprehensive two-week training course in field methods entitled "Field Water-Quality Methods for Ground Water and Surface Water" for hydrologic field technicians. This training may be available for staff when slots are available.

Scientists at federal and county agencies have been conducting water quality related activities for several years and can provide training if necessary to network staff. However, the project manager is expected to be independent and knowledgeable in chemistry and water sampling techniques.

All technical staff involved in data collection will have educational background and/ or experience in biological or physical sciences. The program manager will have specialized experience in water quality or closely related aquatic resource. Where necessary (e.g., with staff turnover, adoption of new methods, etc.) local technical experts (universities/agencies) will be called upon for training assistance. Familiarity with GPS navigation will also be a qualification (or training will be provided). First Aid and CPR training are highly recommended. Boater certification will not be needed at this time, but may be considered in the future. Field personnel will receive training in a variety of discharge (flow) measurement methods (e.g., low flow, high flow bridge-deployed).

Field personnel will be evaluated on their field performance during field QA audits conducted by a technical advisor and member of the WQ TAC. Field performance audits are recommended every year, or more often if necessary. If any deficiencies within a crew are noted during this QA audit, they will be documented and remedied prior to continued field sampling. This can be accomplished by additional training or by changing personnel, but verification of correction of any deficiencies must be documented in writing prior to the resumption of further sample collection activities. Documentation of field performance audit results and remediation measures will be maintained by the QA officer, and will be appended to the TBWC WQ SOP, and included in the appropriate monthly reports to the Grant Manager.

Laboratory

Meetings, whether by phone or in person, will be held with the laboratory (-ies) at regular intervals to review QA/QC procedures and make recommendations for future revisions to the QAPP. The more frequent the interactions with laboratory staff the better the understanding of any key issues or correction of problems will be. Issues such as timing of sample transport and analysis and lab capability and capacity for samples are important to QA/QC data completeness objectives.

Section A9. Documentation and Records

- All field data gathered will be recorded on standardized field data entry forms that include metadata to be entered into the NPSTORET database.
- Data will be scanned upon receipt from laboratory and during and immediately after field measurements.

- Data will be more thoroughly reviewed within a week after each sampling event for inconsistencies related to field personnel, how well SOPs are followed, and how timing and logistics of sample collection and transport to laboratories may be affecting sample data.
- Field data will not be entered into the database until laboratory results have arrived.
- Field and laboratory data sheets will be copied and stored in a "data to be entered" folder.
- Original copies of datasheets and laboratory chain of custody forms will be stored in the Program Managers office.
- WQ Program Manager will work with field technicians to ensure that data is well-understood and entered into the proper fields in NPSTORET.
- Data will be entered into the TBWC NPSTORET database no less than once a month to ensure adequate interpretation of field notes and receipt of proper laboratory QA/QC information. Each datasheet will be initialed and dated by the person entering the data.
- A different individual than the one that entered the data will verify the datasheet information against the database, and initial the field form as having been validated.
- Data will also be validated; during this process questionable data are identified, reviewed, and corrected if necessary.
- After data entry, verification, and validation, copies will be retained by the person entering the data for one year. After that time or another appropriate time, data will be archived.

Records that will be considered part of the data report package includes the following:
- Field Forms
- List of GPS coordinates for stations
- Laboratory Chain-of-Custody Forms
- Laboratory Analysis Reports
- All electronic entries in the NPSTORET database within the TBWC Giacomini Monitoring, Long-Term Trends, and Source Area project headings.

The electronic database is backed up automatically as part of a monthly system backup. Files are archived and retained for a year. Access to backup files is coordinated through the project manager. Ensuring data backup is part of normal program operations.

Sample datasheets are included in the Appendix A of this document. Chain of custody forms vary depending upon the laboratory. Reporting of results including summary charts and reports are explained in more detail in the TBWC WQ Monitoring Plan.

The Program Manager is responsible for suggesting changes to the QAPP to the WQ TAC, and is also responsible for making sure all concerned parties receive notification of QAPP updates, and for making a copy available to interested parties.

B. DATA GENERATION AND ACQUISITION

Section B1. Sampling Process Design (Experimental Design)

The water quality sampling design for the Tomales Bay Wetlands Restoration and Monitoring Program has been developed with consultation from David Lewis, UCCE Watershed Management Advisor.

This water quality monitoring project takes an approach with three elements. The first element is pre-, during, and post-restoration monitoring at key sites in the Giacomini Wetland Restoration Project (GWRP) impact area and control sites. The second and third elements are part of the Water Quality Monitoring Program (WQMP): the second is long-term Trend monitoring at fixed-sites in major freshwater tributaries to Tomales Bay and a series of sites within the bay, while the third element is a comprehensive Source Area monitoring to identify at the sub-watershed and tributary scales, the sources of pollution to the bay.

A summary of project organization is presented below, but a complete discussion of experimental design, and project elements can be found in the project Monitoring Plan (Carson, 2007, section IV).

The Giacomini Wetland Restoration Water-Quality Monitoring
The GWRP water-quality monitoring element involves quarterly field visits to collect field parameters and sampling for laboratory analysis of nutrient, carbon and pathogen parameters. Sites include 14 fixed sites in the project impact area, and nine (9) to ten (10) samples in reference or control study areas.

Sites have been identified by program staff, and documented using photographs, GPS receivers, and written descriptions of access. Sampling locations are located on National Park Service and on California State Land Commission or Audubon Canyon Ranch lands. Where access to leased or privately-owned land is necessary or desirable, an agreement with the land-holder has been or will be established.

Long-Term Trends and Source Area Water-Quality Monitoring
For the WQMP, the long-term Trends monitoring element involves weekly sampling during late Fall, Winter and early Spring, and twice-monthly sampling during summer base-flow for both field and laboratory parameters at nine to twelve fixed-site monitoring locations in major sub-watersheds of Tomales Bay (including two reference tributaries with minimal human land-use activities). In addition to weekly sampling in the freshwater tributaries to Tomales Bay, four sites in the bay will be sampled with the same frequency to characterize the long-term trends in Tomales Bay itself. This data will be instrumental in calibrating circulation and nutrient models being developed by academic researchers working in the Bay.

The Source Area monitoring element will be focused on identifying sources and quantities of water pollutants to Tomales Bay and its freshwater tributaries. This monitoring will be storm-based, and the number of and location of sites as well as the parameters of interest will be targeted based on the results of previous storm sampling, known pollution source areas, and priorities identified by the TBWC Water-Quality Technical Advisory Committee (WQ TAC) and the TBWC Foundation.

Sites have been identified by project staff through field visits and consultation with the UCCE Watershed Management Advisor. These sites will be photographed and their locations documented with a GPS receiver/ GIS software. In addition to the UTMs and photographs, written directions will aid staff in relocating the sampling sites.

The key parameters identified by the monitoring plan are considered critical information to be collected in the field, or analyzed in the laboratory. This water quality data will be used to measure the effectiveness of management activities, and to identify areas that require additional management attention. Other data that will be collected for informational purposes only will include current weather conditions, and observation of recreational and land-use in the area surrounding the sampling site, as well as any incidental observations made at the time of sampling.

Most water-quality parameters are subject to significant seasonal and diurnal variability. For long-term Trends monitoring, in order to provide comparable data from visit to visit, all stations will be visited at approximately the same time of day for each visit, thereby limiting the diurnal variability that will be reflected in the collected data.

Sampling locations will be at publicly-accessible sites. Where access to leased or privately-owned land is necessary or desirable, an agreement with the land-holder will be established.

It is important to note that safety of personnel is always a priority. Sampling during storm events is of particular concern. The "flashy" nature of streams in the area mean water level rises rapidly during a storm event. Sampling personnel will follow the TBWC Standard Operating Procedure section for Personnel Training and Safety. For example, this SOP states that one should not attempt to wade in a stream for which values of depth multiplied by velocity are greater than or equal to 10 ft^3/s. If these conditions, or other unsafe circumstances, occur, sampling schedule may be modified. If a sampling site becomes inaccessible during a particular event, attempts will be made to sample at that site during the next round of sampling. If a site becomes permanently inaccessible, an appropriate alternative site (slightly upstream or downstream perhaps) may be established. Any new site established would be documented as such in the database.

The two most significant sources of bias in water quality monitoring are from field techniques used by personnel, and from the equipment used to perform the analyses. Training is discussed in detail in the TBWC SOP, but will include repeated station visits with experienced and inexperienced field personnel. Bias can be estimated by an overlap a minimum of seven (7) measurements when personnel changes, thirty (30) when a method or equipment changes, and fifty (50) when replacing surrogate estimators like FIB. Analysis of such overlapping samples can determine the contribution of bias (if any) to any variance in the data.

The data generated from this effort will have a high level of variability. The descriptive variables will be used to normalize concentration results or to calculate flux and load for a given parameter. These steps will allow for comparison of results across the different locations. Admittedly, the comparison of tributary and bay locations requires additional normalization because of the simultaneous influences of discharge and tides. These data will also be valuable as boundary conditions to calibrate and test the UC Berkeley Tomales Bay hydrodynamic model.

Analysis of trends will be conducted graphically and through time series analysis. Graphical analysis will include the representation of concentration, flux, and load values as a function of time. These graphics will provide anecdotal indications of water quality trends including seasonal and annual fluctuations. Time series analysis for upward or downward trends in concentration, flux, and load will be conducted according to Helsel and Hirsch (1995) or other suitable and accepted methods (Hirsch et al., 1991; and Helsel, 1987). This will include nonparametric statistical methods including data transformation to account for lack of normal distribution in the data.

B2. Sampling Methods

All measurements and sampling associated with monitoring activities will be conducted according to the TBWCF WQ SOP which is largely based on USGS National Field Manual water-quality protocols (Wilde *et al*, various dates) and the state of California's Surface Water Ambient Monitoring Program (Puckett, 2002).

Detailed information for each group of parameters (including specific field techniques for collection, preservation and analysis) is available in the following SOP (which is located in the Appendix C).

SOP sections addressing Field, Sampling and Laboratory Activities:

- Equipment and Field Preparations
- Field Methods for Measurement of Core Parameters
- Field and Laboratory Methods for Fecal Indicator Bacteria
- Field and Laboratory Methods for Sampling Nutrients
- Field and Laboratory Methods for Sediment
- Field and Laboratory Methods for Discharge Measurements

Samples and duplicate samples will be collected at the same time and place using the "grab" or "hand-dipped" method. Therefore samples will not be homogenized or composited before delivery to the laboratory facility for analysis. Preservatives will be pre-added to sample bottles by the contract laboratory. Samples sent to Romberg-Tiburon Center for trace-level nutrient analysis will be filtered in the field using methods described in the program SOP.

The SOP section detailing Equipment and Field Preparations addresses the maintenance, cleaning, and calibration of field sampling equipment. Product manuals for the equipment also give guidance on proper cleaning procedures. These directives will be followed by field staff. While sampling in the field, a bottle of distilled water will be used to rinse probes and sensors between sites. Bottles used for sampling are provided by the laboratory and thus have been cleaned and treated according to the appropriate standard methods.

Problems that occur with equipment will be addressed by the Program Manager with assistance from the Technical Advisor(s). This may include cleaning, re-calibration, and or sending equipment to company for repairs. If equipment is being repaired and a different instrument is used in the interim, this will be documented in the data sheet for each sampling station/event.

Field QA audits will be conducted periodically by a member of the WQTAC. If any deficiencies within a crew are noted during this QA audit, they will be documented and remedied prior to continued field sampling. This can be accomplished by additional training or by changing personnel, but verification of correction of any deficiencies must be documented in writing prior to the resumption of further sample collection activities.

If there is a change in the protocol such as a change in sampling method, equipment, or staff, then there will be overlap of methods and personnel where possible.

Analytical laboratories will follow local, state and federal regulations and their respective lab operating procedures with respect to the disposal of analytical by-products. Program staff will generate no hazardous by-products from sampling activities. The incidental generation of weak acid, or strong ionic-concentration solutions used in equipment calibration will be neutralized and disposed of in accordance with local and state regulations.

Section B3. Sample Handling and Custody Requirements

Proper sample handling procedures for water, sediment, and biological samples are provided in Table B-1. This table provides a summary of recommended sample containers, sample volumes, initial preservation, and maximum storage times for water samples. In the field, all samples will be packed in frozen ice packs (or dry ice for trace-level nutrient samples for RTC) during transport or shipment, so that they will be properly preserved. Samples will be transported in insulated containers. All caps and lids will be checked for tightness prior to transport. All samples will be handled, prepared, transported and stored in a manner so as to minimize bulk loss, analyte loss, contamination or biological degradation. Sample containers will be clearly labeled with an indelible marker. Where appropriate, samples may be frozen in a clean freezer to prevent biological degradation. Water samples will be kept in glass or plastic bottles and will be preserved as indicated until analyzed.

In the case of this monitoring program, samples will be transferred to laboratory custody via a laboratory runner coming to program headquarters to retrieve samples, or via delivery by field personnel. Once they have verified the number and type of samples, and the completeness of the Chain-of-Custody form, they will sign the COC form and assume control of the samples. A copy of the completed COC form will be made by the field technician, and kept with the rest of the field records until the laboratory report is delivered to the project manager.

Table B-1. Summary of Sample Handling Requirements

Analyte	Sample Container	Minimum Sample Volume/Typical Sample Volume	Holding Time	Preservation
Total Kjeldahl Nitrogen (TKN)	Polyethylene bottles	600 mL	Recommend: 7 days; Maximum: 28 days	Cool to 4°C

Nitrate and Nitrite	Polyethylene bottles	125 mL/150 mL 20 mL (RTC)	48 hours 1-2 weeks (RTC)	Cool to 4°C RTC: Filter on baked GF/F) freeze on dry ice to preserve
Ammonia	Polyethylene bottles	125 mL/500 mL 27 mL (RTC)	48 hours 28 days with preservative 1-2 weeks (RTC)	Sulfuric acid preservative, Cool to 4°C RTC: Filter on baked GF/F) freeze on dry ice to preserve
Orthophosphate	Polyethylene bottles	250 mL 20mL (RTC)	24 hours 1-2 weeks	Cool to 4°C RTC: Filter on baked GF/F) freeze on dry ice to preserve
Total Dissolved Phosphate	Polyethylene bottles	250 mL	24 hours	Cool to 4°C
Fecal & Total Coliform or Total Coliform and *E. coli*	125 ml sterile plastic (high density polyethylene or polypropylene) container	100 ml volume sufficient for both fecal and total coliform analyses	6 hours at 4°C, dark for regulatory data use; lab must be notified well in advance. Possibly 24hr hold time at 4C dark, if non-regulatory data use.	Sodium thiosulfate is pre-added to the containers in the laboratory (chlorine elimination). Cool to 4°C; dark.
Coliphage	Polyethylene bottle	250 mL	48 hours	Cool to 4°C, dark
Suspended Sediment Concentration (SSC) or Total Suspended Solids (TSS)	500 ml clean plastic bottle	500 ml (one bottle)	7 days	Cool to 4°C
Turbidity	glass vial	15 mL	NA	NA
Dissolved Organic Carbon	Glass vial	2x 40mL vials	28 days	Sulfuric acid preservative, cool to 4°C
Chlorophyll a and Phaeophytin	Amber Polyethylene bottle	2L (1 bottle or 2x 1L amber bottles)	48 hours	Cool to 4°C, dark
MBAS	Glass or polyethylene bottle	500 ml	48 hours at 4°C, dark	Cool to 4°C, dark
Oil/Grease	1L glass jar with Teflon lid-liner, rinsed with hexane or methylene chloride	1 1L (1000mL) jar	28 days at 4°C, dark.	Cool to 4°C, dark. Acidify in lab within 48 hrs, with pre-acidified container (2mL H_2SO_{43}), for pH<2.
Total Metals	60 ml polyethylene bottle, pre-cleaned in lab using HNO_3	60 ml (one bottle) if salinity <0.5 ppt 180 ml (three bottles) if salinity >0.5 ppt	Once sample is acidified, can store up to 6 months at room temperature	Cool to 4°C, dark. Acidify in lab within 48 hrs, with pre-acidified container (ultra-pure HNO_3), for pH<2.

VOC's	40 ml VOA vials	120 ml (three VOA vials)	14 days at 4°C, dark	All vials are pre-acidified (50% HCl or H_2SO_4) at lab before sampling. Cool to 4°C, dark

Laboratory Custody Log

The laboratory chosen to analyze samples will either be National Environmental Laboratory Accreditation Program (NELAP) certified (or CA ELAP-certified); or will use standard methods and procedures and will provide a QA report with each analytical report. Laboratories will maintain custody logs sufficient to track each sample submitted, the temperature on receipt,and to analyze or preserve each sample within specified holding times.

Field Log

The following items will be recorded on data sheets for each sampling station:

- Time of sample collection;
- Sample ID numbers,
- The results of any field measurements (temperature, D.O., pH, conductivity, turbidity) and the time that measurements were made;
- Qualitative descriptions of relevant water conditions (e.g. color, flow level, clarity) or weather (e.g. wind, rain) at the time of sample collection;
- A description of any unusual occurrences associated with the sampling event, particularly those that may affect sample or data quality.

Field personnel will have custody of samples during field sampling. Chain of custody forms will accompany all samples during transport/shipment to the contract laboratories. Field personnel will enter sampling time and other relevant data on the chain of custody forms. All water quality samples will be transported to the analytical laboratory directly by the field crew or by overnight courier. See Appendix A for field data sheets and current chain of custody form. Chain of custody forms vary depending on the laboratory.

Section B4. Analytical Methods Requirements

A discussion of analytical methods for each target parameter can be found in the appropriate section of the SOP in the appendix of this document.

In-situ dataloggers will be used to characterize diurnal and seasonal variation of water temperature at long-term and some source sampling sites as appropriate. These instruments will be deployed, maintained, and calibrated in accordance with the guidelines presented in USGS Technical Methods Report 1D3 (Wagner et al, 2006). A detailed protocol adapted from the USGS document for the use of temperature loggers can be found in the program SOP sections on Equipment Preparation, and Measurement of Core Parameters.

For the Trends monitoring all labs will follow NELAP or CA-ELAP requirements for quality assurance. For the GWRP and source area programs, nutrient parameters may be sent to RTC for trace-level analysis (ng/L) depending on lab availability, and detection limits offered by contract labs. For the WQMP, bacteria analysis may be conducted at the NPS lab at Point Reyes

NS using standard protocol for the detection of Total Coliform and E. coli in water using IDEXX QuantiTray(SM9223B) due to holding time constraints and flexibility of field activities. Any laboratory facility conducting analysis will follow approved and standard methods and these QAPP requirements for Quality Assurance, and standard protocol. These requirements include the provision of a QA report with every data set, utilization of the Method Blank Analysis, Applied Matrix Spike, and Spike Duplicate system to ensure data accuracy and precision. The lab determines values for identified parameters using analytical protocols approved by EPA, ASM and the SWRCB's SWAMP.

All laboratory analysis will be performed within the EPA holding times listed in Table B-1. The lab will prepare a report of the results of the laboratory analysis of collected samples and send it to the Program Manager. This process is expected to take one or two weeks from the time of sample collection. This timeline is expected to be adequate for the program manager to achieve timely validation of analytical data, perform and assess QA results, and meet data storage requirements of this program.

All laboratories must document the methods they use, the SOPs, and the data acceptability criteria of their analytical capabilities in their QA Program Plan and QA Manual. The chosen lab utilizes standard methods of analysis for the conventional parameters included in this project. The method numbers used by the contract laboratory for each analytical procedure they will perform is available in the laboratory's QA Plan on file with that laboratory. These procedural documents identify particular equipment or instrumentation necessary for analysis as well as the manner of sample disposal. The acceptability criteria within which analytical procedures must be performed within are outlined in Table A-11.

The laboratory supervisor of the contracted lab has primary responsibility for responding to a failure of analytical systems. Solutions which are consistent with the measurement objectives will be reached in consultation with the project manager.

Corrective Action for Laboratory Activities:

Failures in field and laboratory measurement systems involve, but are not limited to, such things as instrument malfunctions, failures in calibration, sample jar breakage, blank contamination, and quality control samples outside of the defined limits (Data Acceptability Criteria) listed in Table A-11. In many cases, the field technician or lab analyst will be able to correct the problem. If the problem is resolvable by the field technician or lab analyst, then they will document the problem in their field notes or laboratory record and complete the analysis. If the problem is not resolvable, then it is conveyed to the respective supervisor, who will make the determination if the analytical system failure compromised the sample results and should not be reported. The nature and disposition of the problem is documented in the data report that is sent to the Project Leader.

Detection limits may be affected by instrument sensitivity or by bias due to contamination or matrix interferences. Common laboratory practice is to adjust detection limits upward in cases where high instrument precision (i.e., low variability) results in calculated detection limits that are lower than the absolute sensitivity of the analytical instrument. In these cases, best professional judgment is used to adjust detection limits upward to reduce false positives and

values below the detection limit are not reported. In all cases, results cannot be reported for values less than the Method Detection Limit (MDL). Most MDLs are considerably lower than water quality objectives and provide the foundation for having a high level of certainty in the data (Puckett, 2002).

Data below or beyond an MDL will not be presented numerically. Data falling between the MDL and minimum level of quantitation (ML) are considered detected but not quantifiable and can be given a result of Present, below quantification level. The ML is equal to the MDL multiplied by five (or some number between 1 and 10 that may be determined by the analytical laboratory).

The Tomales Bay Wetland Restoration and Monitoring Project through the GWRP and the WQMP will follow recommendations in the recent Helsel (2005) book for recommended use of detection and quantification limits:

We will not report into a database any value higher than the MDL but lower than the ML. Instead, the detection condition field is set to "Present, below Quantification Limit". With that detection condition, STORET automatically enters "*Present <QL" in the result field. (A major advantage of this approach is that no "estimates" are treated as quantitative when in fact they are not quantitative.)

In (eventual) statistical analyses, values between the MDL and ML are best interpreted using either an interval-censored method (parametric), or a rank-based method (nonparametric) where all in-between values are represented as the same tied rank. The older recommendation of censoring to half the MDL is clearly no longer recommended. Helsel (2005) also gives recommendations for how not to report into data bases (for example, never report single values below the MDL or even the ML, and do not report nondetects as half the detection limit. One should also not report nondetects as a negative (“-“) sign followed by the actual MDL value, because someone invariably decides it really is a negative number.

In Summary:

- Values below the Method Detection Limit (MDL) are to be reported as a (<) sign followed by the actual MDL value, and flagged with an ND = not detected.
- Values between the MDL and the ML (or quantification limit) should be reported as “*Present, below Quantification Limit”.
- Values above the ML (or quantification limit) are deemed as acceptable values without reservation, and are shown as the actual measured value, and assigned a QA code of A (acceptable without reservation).

In general, laboratories should strive to meet target reporting limit recommendations for undetected analytes. In those cases where high concentrations of some analytes require analysis of a diluted sample and the dilution results in non-detects for other analytes, analysis of the sample at several different dilutions may be required to meet program detection limits as fully as practical. Table A-11 lists analytical methods and measurement quality objectives (MQOs) for all water quality parameters except flow. In addition to the MDL, these include precision, and systematic error/bias/percent recovery. Details of QA/QC for flow measurements will be outlined in a separate protocol.

Section B5. Quality Control Requirements

Laboratory Quality Control Requirements

Quality control operates to make sure that data produced are satisfactory, consistent, and dependable. Under performance-based chemistry, laboratories are not required to use a single, standard analytical method for each type of analysis, but rather are free to choose the best or most feasible method within the constraints of cost and equipment that is suitable for meeting the data quality objectives (DQO's), as outlined in **Table A-11** (Measurement Quality Objectives). This table provides specific guidelines for measurement precision, accuracy, and levels of detection that are reflected in sampling, handling, and analysis requirements to satisfy a large spectrum of potential management questions. Each laboratory will continuously demonstrate proficiency and data comparability through routine analysis of accuracy-based performance evaluation samples, split samples, and reference materials representing actual sample matrices. No single analytical method has been officially approved for low-level analysis of organic and inorganic contaminants in water or sediments. Recommended methods are available and are provided in **Table A-11** (Measurement Quality Objectives).

Laboratories providing analytical support for chemical or biological analyses will have the appropriate facilities to store, prepare, and process samples and appropriate instrumentation and staff to provide data of the required quality within the time period dictated by the project (Puckett, 2002). Laboratories are expected to conduct operations in a way that includes:

1. A program of scheduled maintenance of analytical balances, microscopes, and other laboratory equipment and instrumentation.
2. Routine checking of analytical balances using a set of standard reference weights (American Society of Testing and Materials (ASTM) Class 3, NIST Class S-1, or equivalents).
3. Checking and recording the composition of fresh calibration standards against the previous lot. Acceptable comparisons are <5 percent difference from previous value.
4. Recording all analytical data in bound (where possible) logbooks, with all entries in ink, or electronic format.
5. Monitoring and documenting the temperatures of cold storage areas and freezer units once per week.
6. Verifying the efficiency of fume hoods.
7. Having a source of reagent water meeting ASTM Type I specifications (ASTM, 1984) available in sufficient quantity to support analytical operations. The resistivity of the reagent water will not exceed 18 megaohm at 25°C. Alternately, the conductivity of the reagent water will exceed 10 μmhos/cm.

8. Labeling all containers used in the laboratory with date prepared, contents, initials of the individual who prepared the contents, and other information as appropriate.
9. Dating and safely storing all chemicals upon receipt. Proper disposal of chemicals when the expiration date has passed.
10. Having QAPP, SOPs, analytical methods manuals, and safety plans readily available to staff.
11. Having raw analytical data, such as chromatograms, accessible so that they are available upon request.

Laboratories will be able to provide information documenting their ability to conduct the analyses with the required level of data quality. Such information might include results from interlaboratory calibration studies, control charts and summary data of internal QA/QC checks, and results from certified reference material analyses (Puckett, 2002). Laboratories should provide a laboratory QA plan, SOPs, Analytical Methods Manual, Instrument Performance Information, and Control Charts.

There is a broad range in the quality of waters within the Tomales Bay watershed. For more pristine waters (those in wilderness areas), it is critical that laboratories be able to provide low-level detection of pollutants. Some of the approaches required will include laboratory matrix spikes, laboratory method blanks, calibration standards, laboratory- and field-duplicated samples, and others as appropriate. The definition and use of each of these types of quality control samples are explained further below (Puckett, 2002).

If a control limit is exceeded the analyst will investigate to determine the cause and retest affected samples. The investigation should include re-checking calculations, verifying that recorded information is correct, inspecting equipment for damage, performing cleaning and maintenance of equipment, recalibrating using fresh standards, and preparing new QC samples. Activities will be recorded in lab or field notebook and instrument log books, discussed with the QA Officer and corrective actions determined and implemented.

Measurement Quality Objectives (MQOs)

Some MQOs and quality control checks are defined below (*from* Puckett, 2002):

Completeness

Data completeness is the amount of data collected compared against the expected amount. GWRP and WQMP will strive for at least 90% data completeness.

Precision criteria: Precision is the reproducibility of an analytical method. Each laboratory is expected to maintain control charts for use by analysts in monitoring the overall precision of the CRM (Certified Reference Materials) or LCM. Upper and lower control chart limits (e.g., warning limits and control limits) will be continually updated; control limits based on 99% confidence intervals around the mean are recommended. The relative standard deviation (RSD) will be calculated for each analyte of interest in the CRM based on the last 7 CRM analyses.

Laboratory Replicates for Precision

A minimum of one field sample per set of water samples submitted to the laboratory will be processed and analyzed in duplicate to determine precision. The relative percent difference

among duplicate samples (RPD expressed as percent) will be less than the targets in the Precision column in Table A-11.

Each measured value is compared against the known value of the standard, and accuracy is expressed as the relative percent difference.

$$\mathbf{RSD} = \frac{\mathbf{[V_m - V_k]}}{\mathbf{V_k}}$$

Where: RSD = the relative standard deviation
Vm = the measured value,
Vk = the known value.

Relative percent difference (RPD) is the RSD x 100%.

A laboratory control spike (LCS) and duplicate (LCSd) will be analyzed to determine percent recovery of each specific method. In addition, the State of California ELAP requires that 1 in 20 samples have a CMS, or client matrix spike. Therefore, in addition to the laboratory spikes, the client's samples are also spiked. However, CMS' are not conducted for bacteria samples (Mark Valentini, personal communication, December 2004).

Laboratory Method Blank

Laboratory method blanks (also called extraction blanks, procedural blanks, or preparation blanks) are used to assess laboratory contamination during all stages of sample preparation and analysis.

Surrogates

Surrogates are compounds chosen to simulate the analytes of interest in organic analyses. Surrogates are used to estimate analyte losses during the extraction and clean-up process and must be added to each sample, including QA/QC samples, prior to extraction.

Matrix Spike and Matrix Spike Duplicate

A laboratory fortified sample matrix (commonly called a matrix spike, or MS) and a laboratory fortified sample matrix duplicate (commonly called a matrix spike duplicate, or MSD) will be used both to evaluate the effect of the sample matrix on the recovery of the compound(s) of interest and to provide an estimate of analytical precision. Recovery is the accuracy of an analytical test measured against a known analyte addition to a sample.

Travel Blanks - The purpose of the travel blank is to determine if there is any cross-contamination of volatile constituents between sample containers. Travel blanks are not required for other analytes, but are encouraged to be utilized for other analytes as possible and appropriate.

Field Duplicates - Duplicate samples will be collected for all parameters at an annual rate of 5% of total samples to be collected within a given year's monitoring plan. The duplicate sample will be collected in the same manner and as close in time as possible to the original sample. This effort is to attempt to examine field homogeneity as well as sample handling, within the limits

and constraints of the situation. The precision for determining precision of field duplicates is described in the Data Analysis SOP (Appendix C).

Field Blanks - A field blank is designed to assess potential sample contamination levels that could occur during field sampling and sample processing. Field Blanks (DI water) are taken to the field, transferred to the appropriate container, preserved (if appropriate), and otherwise treated the same as the corresponding sample type during the course of a sampling event. Field blanks are to be collected at a 5% rate for the following nutrient and bacteria samples. Field blanks for other analytes should be conducted upon initiation of sampling, and if field blank performance is acceptable, further collection and analysis of field blanks for these other media and analytes need only be performed on an as-needed basis, or during field performance audits.

When quality control limits are exceeded, laboratory staff will try to determine the cause and initiate appropriate corrective actions. This may include recalibrating and reanalyzing all suspect samples or flagging all suspect data.

Copies of laboratory QA/QC work will be included with analytical results and kept on file. Measurements for which quality control values are exceeded will also be flagged in the park's electronic database, and omitted from reporting analyses. Efforts will be made to identify and eliminate any sources of contamination and/or deficiencies in practices during field sampling which may have caused these control limits to be exceeded. Any actions taken will be recorded in the log for sampling equipment, and in the database for that sample event.

Table B-2 QA protocols

Measurement Parameter	**QA Protocol**
Nutrients	Duplicates 10% of samples, lab matrix spike, Field or Trip Blank
Dissolved Organic Carbon	Duplicates 10% of samples, lab matrix spike, Field or Trip Blank
Chlorophyll a	Duplicates 10% of samples, lab matrix spike, Field or Trip Blank
Phaeophytin	Duplicates 10% of samples, lab matrix spike, Field or Trip Blank
Bacteria	Lab and field duplicates, Field or Trip Blank
*Total Suspended Solids	Lab and field duplicates, Field or Trip Blank
Turbidity	Equipment blanks and duplicates
MBAS	Duplicates 10% of samples, lab matrix spike, Field or Trip Blank
Oil/Grease	Duplicates 10% of samples, lab matrix spike, Field or Trip Blank
Total Metals	Duplicates 10% of samples, lab matrix spike, Field or Trip Blank
VOC's	Duplicates 10% of samples, lab matrix spike, Field or Trip Blank

*Also refer to laboratory QA manuals for lab parameters

Section B6. Instrument/Equipment Testing, Inspection, and Maintenance Requirements

To minimize or avoid downtime of measurement instruments, all field sampling and laboratory equipment will be maintained in good working order. Also, spare equipment or common spare

parts (e.g., batteries, D.O. membranes, and pH electrodes) will be available so that repairs or replacement can be made as quickly as possible and measurements will not be lost. All field equipment having manufacturer-recommended schedules of maintenance will receive preventive maintenance according to that schedule (see Table B-3). Other equipment used only occasionally will be inspected at least monthly. After use in the field, all equipment will be re-checked for needed maintenance.

Problems that occur with field equipment will be addressed by the Program Manager with assistance from the Technical Advisors. This may include cleaning, re-calibration, and or sending equipment to company for repairs. If equipment is being repaired and a different instrument is used in the interim, this will be documented in the data sheet for each sampling station/event.

For complete information on equipment preparation and maintenance procedures including cleaning, calibration and post-field calibration checks, see the program SOP section: Equipment and Field Preparations..

Laboratory Equipment - Electronic laboratory equipment usually has recommended maintenance prescribed by the manufacturer. These instructions will be followed as a minimum requirement. Due to the cost of some laboratory equipment, back up capability may not be possible. But all commonly replaced parts will have spares available for rapid maintenance of failed equipment. Such parts include but are not limited to: batteries; tubes; light bulbs; tubing of all kinds; replacement specific ion electrodes; electrical conduits; glassware; pumps; etc.

A separate log book will be maintained for each type of equipment whether field or laboratory. All preventive or corrective maintenance will be recorded. This includes laboratory equipment cleaning, which will follow manufacturer recommendations, or laboratory protocols, whichever is more conservative. All contract labs will maintain this documentation with the total history of maintenance performed will be available for inspection during a systems audit.

Table B-3: Instrument/Equipment Testing, Inspection and Maintenance

Equipment	Maintenance	Testing or Inspection Activity	Frequency	Responsible Person
GBC Specrophotometer	In House or GBC	wavelength verification	Yearly	Supervising Chemist
Spectronic 20 Spectrophotometer	In House of Fisher	wavelength verification	Yearly	Supervising Chemist
Buck IR Spectophotometer	In House or Buck	upon CCV failure	As Needed	Supervising Chemist
HF Scientific Turbidimeter	In House	upon CCV failure	As Needed	Supervising Chemist
Varian 8400 GC/FID	Varian or Full Spectrum	upon CCV failure	As Needed	Supervising Chemist

Hewlitt Packard 5890 GC/PID/FID	Full Spectrum	upon CCV failure	As Needed	Lab Director
Varian Zeeman Graphite Furnace	Varian	upon CCV failure	As Needed	Lab Director
Varian Liberty Axial ICP	Varian	upon CCV failure	As Needed	Lab Director
Denver Balance	Wine Country Balances	cleaning	Yearly	Quality Assurance Facilitator
Idexx Quantitray Sealer	Idexx	tray sealer check	Monthly	Supervising Chemist
Dionex ICS 90 Ion Chromatograph	In House	upon CCV failure	As Needed	Supervising Chemist
Fisher Isotemp Incubator	Fisher Scientific	In House Monitoring	As Needed	Supervising Chemist

Section B7. Instrument Calibration and Frequency

An instrument or device used in obtaining an environmental measurement must be calibrated by the measurement of a standard. Every instrument or device has a specialized procedure for calibration and a special type of standard used to verify calibration. See instrument manuals for further details. A log book will be kept to record dates of calibration and any equipment errors or failures, battery changes, changes of calibration solutions, and repair notes. The log book will also contain calibration methods, this schedule of inspections and calibrations, and a list of needed supplies and equipment. When a change in equipment occurs, overlapping measurements will be made using both the old and new equipment in order to document precision in reproducibility. Detailed information about calibration procedures for specific equipment can be reviewed in SOP #3: Equipment and Field Preparations.

Instruments used for laboratory analysis of water samples are maintained by the analytical laboratory that is contracted to perform the analyses. State and national certification programs for analytical laboratories evaluate the adequacy of equipment maintenance and calibration. The project manager will verify that the contracted lab meets national and state certification standards, or has in place adequate procedure and QA measures to ensure data quality.

SOPs for laboratory equipment and devices needing calibration are referenced in the contract labs QA plans on file with the contracting laboratory. Electronic meters, analytical balances, thermometers, or temperature gauges will have verifiable calibration records. Laboratory reagents are standardized to verify that the percentage or normality is that which is prescribed for the analytical method. Laboratory instrument deficiencies will be resolved and documented according to the procedures outlined in the lab QA plan. (Puckett, 2002)

Table B-4. Routine Field Instrument Inspections and Calibrations

Parameter	Calibration Frequency	Acceptance Criteria	Corrective Actions
Temperature Liquid-in-glass thermometer:	Every 3 to 6 months, using a 2-point calibration check, and annually, using a 3-point calibration check 10% of the readings taken each day must be duplicated, or a minimum of 1 reading if fewer than 10 samples are read.	±1.0 ºC	Re-test with a different thermometer; repeat measurement
Temperature Thermistor thermometer: (including temperature dataloggers)	Every 3 to 4 months, check calibration, annually, using a 5-point calibration	Same as above	Re-test with a different thermometer; repeat measurement
Specific Conductance	Prior to field mobilization, at the field site, and calibration check at day's end; 10% of the readings taken each day must be duplicated or a minimum of 1 reading if fewer than 10 samples are read.	±5%	Re-test; check low battery indicator; use a different meter; use different standards; repeat measurement
Dissolved oxygen	Prior to field mobilization, at the field site, and calibration check at day's end	±10%	Re-enter altitude; re-test; check low battery indicator; check membrane for wrinkles, tears or air bubbles; replace membrane; use a different meter; repeat measurement
pH meter	Prior to field mobilization (three point calibration using buffer solutions (pH 4,7, and 10)) At the field site, and calibration check at day's end (one point calibration) 10% of all reading taken each day must be duplicated or a minimum of 1 reading if fewer than 10 samples are read.	±0.2 pH unit; ±0.2 pH unit RPD ±0.1 pH unit	Re-test; check low battery indicator; use different standards; repeat measurement
Flow meter (velocity meter)	Prior to field mobilization, before each sampling run; some flow meters required and annual calibration by the manufacturer		

-All instruments should be visually inspected before use
-Check batteries before use
-Rinse all equipment after use
-Insure that pH electrodes and D.O. membrane remain moist

Table B-5: Laboratory Instrument/Equipment Calibration and Frequency

Equipment	Calibration Descripton	Calibration Criteria	Frequency	Responsible Person
GBC Specrophotometer	3 point calibration curve	% RSD < 20	As Needed	Linda Kadrmas
Spectronic 20 Spectrophotometer	3 point calibration curve	% RSD < 20	Daily	Lance Molinaro
Buck IR Spectophotometer	3 point calibration curve	% RSD < 20	As Needed	Annette Raible
HF Scientific Turbidimeter	3 point calibration curve	% RSD < 15	Daily	Lance Molinaro
Varian 8400 GC/FID	5 point calibration curve	% RSD < 20	As Needed	Annette Raible
Hewlitt Packard 5890 GC/PID/FID	5 point calibration curve	% RSD < 20	As Needed	Kimon Aceto
Varian Zeeman Graphite Furnace	3 point calibration curve	% RSD < 20	Daily	Mike Fisher
Varian Liberty Axial ICP	3 point calibration curve	% RSD < 20	Daily	Mike Fisher
Denver Balance	Checked via certified weights	$\pm$ 0.5%	Daily	Gail Herman
Idexx Quantitray Sealer	NA	NA	NA	Kellie McMullen
Dionex ICS 90 Ion Chromatograph	5 point calibration curve	% RSD < 10%	Daily	Mike Fisher
Fisher Isotemp Incubator	Temperature Monitoring	$\pm$ 0.5^{o}C	2x Daily	Kellie McMullen

Section B8. Inspection/Acceptance Requirements for Supplies and Consumables

Supplies will be examined for damage as they are received. The following supplies will receive additional checks as follows.

pH and conductivity standards will be checked by comparing their readings with those generated by the current lot of standards. Standards must agree within the specified calibration acceptance limits.

Bacterial media will be checked against positive, negative and sterility checks. These checks are the same as those described in section 15.

Analytical Sciences maintains a supply inspection and checking SOP, which has been examined by TBWC's Quality Assurance Officer. The SOP is incorporated into this QAPP.

Field supplies will be ordered as needed to keep on hand common spare parts and consumable items. Any calibration solutions with expiration dates will be discarded after expiration. New solutions will be ordered prior to expiration of current solutions. Ordering information and packing lists of received items will be kept on file. Items will be checked on receipt for damage and verified that correct item received. Supplies and records will be stored at the TBWC office. The Program Manager is responsible for ordering, checking and maintaining all field supplies.

Section B9. Data Acquisition Requirements (Non-direct Measurements)

Water quality monitoring data from sources other than this monitoring plan are not necessary to achieve the objectives of this program, but will be collected and assessed for comparability with program data to increase the potential trend inferences. To this end, such data sets, and associated metadata will be entered into the TBWCF water-quality database under separate project headings. Acceptance criteria for such data sets are equivalent to those listed in Table A-11, and also depend on the documentation of SOP's that are equivalent or better than those for this program. Data that does not meet these criteria will not be used in program data analysis. However, data collected by NPS, NOAA, USGS or University monitoring programs (e.g., weather and stream hydrology data) will be utilized in conjunction with the water quality data generated by this program.

The use of data obtained from these sources may be used in planning efforts and data assessment/data interpretation activities provided that these data were collected in projects which were supported by an approved QAPP or, at a minimum, utilized approved and documented standard methods. While the TBWCF does not foresee limits to the validity of such supportive data, project staff must use their professional discretion for the use of this data for these purposes. These data are usually obtained in electronic format and should be inspected in their raw form by automated data editing procedures, where possible, as well as by Program Manager before data reduction and interpretation is undertaken for the uses described, or other uses as applicable.

Section B10. Data Management

A general overview has been provided in sections A6 (Project /Task Description) and A9 (Documents and Records). Data management is covered in detail in the TBWRMP Monitoring Plan (Carson and Lewis, 2007) including database structure and metadata requirements. Project

staff will coordinate closely with Program Manager regarding use of, and modifications to the database, and management of data including movement of data into the SWAMP database.

Table B-6: Data Management Reponsibilities

Data Management Task	**Responsible Party**
Collection of Program Field and Analytical Data	Program Manager or field technician
Review of Laboratory and Equipment QA/QC data	Program Manager
Data Entry including metadata, field and lab data	Program Manager or field technician
Verification of Data and Review of Database QA measures	QA Officer or WQ technical advisor
Data Analysis	Program Manager and WQ technical advisors
Report Preparation and Data Dissemination	Program Manager

All field data gathered will be recorded by the Program Manager or field technician on standardized field data entry forms that include metadata to be entered into the NPSTORET database. These forms are included in Appendix A.

A distinct project, with associated sampling stations and characteristics, will be set up in the NPSTORET. The water quality monitoring data collected in this effort will be entered under this separate project. All reports generated will contain the project title and grant agreement number to aid in future tracking of project documents and records.

Standard data management and record-keeping practices for this project include:

- Data will be scanned upon receipt from laboratory and during and immediately after field measurements.
- Data will be more thoroughly reviewed within a week after each sampling event for inconsistencies related to field personnel, how well SOPs are followed, and how timing and logistics of sample collection and transport to laboratories may be affecting sample data.
- Field data will not be entered into the database until laboratory results have arrived.
- Field and laboratory data sheets will be copied and stored in a “data to be entered” folder.
- Original copies of datasheets and laboratory chain of custody forms will be stored in the WQ Program Manager’s office.
- WQ Program Manager will work with the field technicians to ensure that data is well-understood and entered into the proper fields in NPSTORET.
- Data will be entered into the TBWC NPSTORET database no less than once a month to ensure adequate interpretation of field notes and receipt of proper laboratory QA/QC information. Each datasheet will be initialed and dated by the person entering the data.
- A different individual than the one that entered the data will verify the datasheet information against the database, and initial the field form as having been validated.
- Data will also be validated; during this process questionable data are identified, reviewed, and corrected if necessary.
- After data entry, verification, and validation, copies will be retained by the person entering the data for one year. After that time or another appropriate time, data will be archived.

Continuous temperature monitoring data collected as part of this project will be stored in both raw and formatted data files on a TBWCF computer, and backup up using the data management procedures outlined in this document. The Program Manager will investigate data storage options including SWAMP data management tools for storage and retrieval of continuous data.

ASSESSMENT AND OVERSIGHT

Section C1. Assessments and Response Actions

Field staff will sometimes be required to work independently, though ideally there will be two individuals in the field. Having two individuals not only is a safety measure, but can also serve as a quality control measure. In most cases, the primary individual conducting monitoring will be the WQ Program Manager. Additional field assistants may be seasonal technicians or volunteers as available.

Field audits will be conducted by the QA officer for this project (a member of the Technical Advisory Committee), at least twice a year or more frequently depending on staff turnover, but no less frequently than each 6-months following the start of sampling The QA officer will have the authority to stop sampling activities until further training has rectified any deficiencies. The results of these assessments will be kept on file in the TBWC office, and will be included in the appropriate monthly progress report to the grant manager.

If problems during field sampling arise, the WQ Program Manager will determine whether sampling should be re-scheduled or sampling equipment/methods modified. Records will be kept of all quality control issues and corrective actions.

If site conditions or method improvements/modifications require protocol revision, the Program Manager will discuss these changes with field crew and document protocol revision. If major changes are warranted, the technical advisors will meet to discuss recommended changes. Final revisions to the QAPP will be approved by the SWRCB. If necessary, a group of local technical experts will meet to discuss methods issues.

Section C2. Reports to Management

Monthly progress reports shall be submitted by the Program Manager to the RWQCB Grant Manager providing a brief description of the work performed, accomplishments during the month, milestones achieved, monitoring results (if applicable), and any problems encountered in the performance of the work for this project.

Summary reports will be provided to TBWCF and SWRCB on an annual basis. Additionally, a comprehensive report will be created at the completion of the project for more detailed analysis. The comprehensive reports will include a Quality Assurance Report explaining the results of data completeness and other QA/QC issues.

The project lead will be responsible for the compilation of these reports; the Technical Advisors will oversee the process and ensure inclusion of all necessary elements and will help to produce the QA report, and provide support for data management.

DATA VALIDATION AND USABILITY

Section D1. Data Review, Verification, and Validation Requirements

The EPA has recently provided a comprehensive guidance document (EPA 2001), entitled *Guidance on Environmental Data Verification and Data Validation (EPA QA/G-8)*. The purpose of this guidance is to explain how to implement data verification and data validation, and to provide practical advice and references. Although data verification and data validation are commonly-used terms, they are defined and applied differently in various organizations and quality systems. The Surface Water Ambient Monitoring Program (SWAMP) follows EPA's informal guidance on this topic, as provided in EPA 2001, and incorporates the following definitions (*from* Puckett, 2002):

Data Verification is confirmation that what has been entered into the database is what is actually on the datasheets. Data verification is the process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual requirements (Puckett, 2002).

Data Validation is an "analyte-and sample-specific process that extends the evaluation of data beyond method, procedural, or contractual compliance (i.e., data verification) to determine the analytical quality of a specific data set" (Puckett, 2002). In other words, data validation is the final step in assuring the accuracy of data transfer from raw to digital form. Questionable data are identified, reviewed, and corrected if necessary. Automatic validation that checks the data as it is entered will also occur. These automatic validations are programming elements that "censor" the data based on known ranges. Therefore the data manager would not be allowed to enter data that is invalid or nonsense such as 16 for pH or a date in the future. Through this process, outliers are identified. Examples of common errors are missed decimal places, numerical data placed in the wrong field (for example, the database shows a pH of 12 when 12 is actually the water temperature). Outliers can be identified through simply graphing all observations for a given station and parameter or graphing all station data together if there is only low to medium variability.

Section A7 in this document describes SWAMP criteria that should be used for accepting, rejecting, or qualifying project data.

Section D2. Validation and Verification Methods

All data reported for this water quality monitoring program will be subject to checks for errors in transcription, calculation, and computer input. These checks are described in section A9 and B10. Field data are initially validated by data graphing and recognition of outliers needing verification. In addition, the NPSTORET database has automatic validation checks, based on known ranges, which run as data is being entered. Questionable data identified will be reviewed,

and if necessary, corrected. Any corrections made will be initialed and dated on the data sheet. Each field form (included in Appendix A) contains a validation box that will be checked after review of the data. At this point, separate checklists or forms are not used for verification/ validation.

When laboratory data are reported to the Project Leader or technician, outliers or other questions that arise with the data will be investigated. Usually, the individual who reported the data is contacted directly to resolve any discrepancies. The Program Manager or field technician will also review the sampling event field notes to try to explain any possible discrepancies. When the Program Manager or field technician is satisfied with the accuracy of the laboratory data in question, he or she signs the data form and puts it in the proper folder for data entry. Any changes to the data forms will be noted, initialed and dated on the form. Any actions taken as a result of the data review will also be noted on the data sheet. When laboratory forms are accurate and complete, the Program Manager or field technician will then follow standard steps of data processing. Relevant notes regarding the data in question will be included in the comment section of that sample's form in the database. Also, suspect data will be "flagged" in the database and associated with an explanatory code for the relevant QA/QC issue. Such "flagged" data will not be used for reporting purposes unless accompanied by the associated explanatory code.

The WQ Program Manager has primary responsibility for verifying and validating different components of the project data/ information. However, because this individual is also responsible for sample collection and data entry, the QA Officer or other WQ Technical Advisors will assist with data validation.

Laboratory data verification and validation processes are in accordance with their operating procedures, and will be consistent with advice in EPA QA/G-8 (EPA 2001), and the SWAMP program (Puckett, 2002). Documentation of these procedures is kept on file in each lab, and is available for review by program staff upon request.

Section D3. Reconciliation with Data Quality Objectives

Any data that do not meet DQO will not be used. If data quality issues arise, a determination will be made on whether the error was caused by equipment failure or operator error. If additional staff training, equipment repair, or minor revisions to the protocol or SOPs do not correct the problem, then the DQOs will be re-evaluated for feasibility of attainment. If they are determined to be unattainable, then they will be modified or the use of the parameter(s) in question will be evaluated. In some cases, a parameter may be eliminated if no reasonable/acceptable DQOs can be attained (Ward, 2004).

If errors or discrepancies are noted during data validation between the field sheets and the database, the data on the field sheet will be taken as the correct values, and appropriate changes will be made to the database. If the field sheet is unreadable, then the value will be flagged in the database, and not used for reporting purposes.

In reports and projects produced from this data, we will include a QA report that details any limitations of the data, including verification issues. Any such data will not be reported to the SWAMP database.

Analysis of trends will be conducted graphically and through time series analysis. Graphical analysis will include the representation of concentration, flux, and load values as a function of time. These graphics will provide anecdotal indications of water quality trends including seasonal and annual fluctuations. Time series analysis for upward or downward trends in concentration, flux, and load will be conducted according to Helsel and Hirsch (1995) or other suitable and accepted methods (Hirsch et al., 1991; and Helsel, 1987). This will include nonparametric statistical methods including data transformation to account for lack of normal distribution in the data.

The project needs sufficient numbers of data points, as represented by the completeness data quality objective in order to do trend analyses, define source area monitoring results, and determine the impact of restoration efforts on water-quality. A failure to achieve the numbers of samples cited in the Project documentation could mean a loss in the statistical power of inferences made from program data.

LIST OF ACRONYMS

CMS	Client Matrix Spike
COC	Chain of Custody
CWA	Clean Water Act
DFG	Department of Fish and Game
DHS	Department of Health Services
DQO	Data Quality Objective
DWR	Department of Water Resources
ELAP	Environmental Laboratory Accreditation Program
EMAP	Environmental Monitoring and Assessment Program (EPA's)
GWRP	Giacomini Wetland Restoration Program
LCS	Laboratory Control Spike
MDL	Method Detection Limit
PBMS	Performance-Based Measurement System
pagePQL	Practical Quantitation Limit
QAMP	Quality Assurance Management Plan
QAPP	Quality Assurance Project
QA/QC	Quality Assurance/Quality Control
RDL	Reporting Detection Limit
RPD	Relative Percent Difference
RSD	Relative Standard Deviation
RTC	Romberg Tiburon Center (SFSU)
RWQCB	Regional Water Quality Control Board
SFEI	San Francisco Estuary Institute
SOP	Standard Operating Procedure
SWAMP	Surface Water Ambient Monitoring Program

SWRCB	State Water Resources Control Board
TMDL	Total Maximum Daily Load
TBWCF	Tomales Bay Watershed Council Foundation
WQMP	Water Quality Monitoring Program (TBWCF)
TBWRMP	Tomales Bay Wetland Restoration and Monitoring Project ("the Project")
UCCE	University of California Cooperative Extension
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WQ TAC	Water-Quality Technical Advisory Committee (TBWCF)

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