



Reading Your Runoff

A Guide to Water Quality Monitoring

For the Agricultural Water Quality Monitoring Training Program

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standard operating procedures**

reference

March 2008

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water
tool!**



Reading Your Runoff

A Guide to Water Quality Monitoring



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This volume has been prepared by the Coastal Watershed Council with funding from the Community Foundation of Monterey County under the PGE Special Environmental Projects Fund, 2005. This Field Guide is based on prior work funded by the Environmental Protection Agency's 319(h) program (2003) and The California State Coastal Conservancy (1998): "The Freshwater and Marine Team Field Guide." Special thanks go to the Southern California Marine Institute and Heal the Bay for permission to use selected text from their edition.

Additional content in this Field Guide is based on content from the following U.S. EPA documents: "Volunteer Stream Monitoring: A Methods Manual", and "The Volunteer Monitor's Guide to Quality Assurance Project Plans."

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Graphic Production by Antoinette Bauer

Design and layout for this field guide is based on the

City of Santa Monica's "Environmental Directory", 2003 Edition.

Design by Cowan Communication Arts * www.cowcom.com



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Program Definition

Agriculture Water Quality Monitoring Training Program

The Coastal Watershed Council

The **Coastal Watershed Council** is a non-profit organization based in Santa Cruz, California that has been conducting volunteer monitoring programs in the streams and storm drains along the Central Coast for over 12 years. The organization conducts various water quality, habitat, physical and hydrologic (discharge/flow) monitoring programs and has trained hundreds of participants. CWC is dedicated to the collection of high quality, accurate, and consistent data. To make the time and effort of program participants worthwhile, the data collected in all of CWC's programs must attain a certain level of 'quality' to make it usable by resource managers, agricultural growers & operators, local & state decision makers, environmental organizations, private landowners and citizens alike. Only by doing everything required to achieve this data quality, can these monitoring efforts contribute information that is respected by the community of data users, and aid in the protection and enhancement of water quality in our freshwater and marine environments.

In 2005, the Coastal Watershed Council (CWC) received PG&E-SEP Project Fund grants through the Community Foundation of Monterey County to develop the Agricultural Water Quality Monitoring Training Program and produce a field guide for use by the participants. The Agriculture Water Quality Monitoring Training Program (Program) is a creation of CWC and is designed to align the water quality information needs of the agricultural community with the need to protect and enhance water quality conditions in our rivers, streams, estuaries, and ultimately the Monterey Bay and ocean.

The intent of the program is to provide important monitoring skills directly to agricultural operators, so they may conduct sound monitoring of surface water flowing from their own lands and in their local waterways to inform themselves of the conditions and take action if needed. Additionally, there is an urgent need to collect reliable data for local, state and federal decision makers to draw upon when developing land use plans and water quality objectives. Where possible, broad distribution of even the most generic monitoring results and program information among monitoring groups, local, state and federal resource agencies, and throughout the region, will aid in improving water quality conditions in the Salinas River Basin. In order for this to happen the simple steps presented in this program to assure reliable data must be followed.

The Program

This program was specifically designed for agricultural community participants. This field guide will be provided along with a series of topical workshops which will focus on the important concepts and elements that would be needed to conduct a reliable water quality monitoring program on surface flows in the Central Coast of California.

*Know what's
happening on
your land before
someone else
comes to tell you
about it!*

The program's four focus areas are:

- 1 **Water Quality** – parameters & methods, regional objectives and conditions, monitoring strategies
- 2 **Monitoring Equipment** – Hands-on Training with real world equipment
- 3 **Quality Assurance-Quality Control** – What is it? When to do it?
- 4 **Data Storage and Management** – Now that you've got some data, what to do with it?

As well, this grant also funds staff time to conduct individual grower outreach and assistance for participants, and some quick-testing equipment. During on-farm field visits, staff will work directly with growers to address water quality questions, conduct one-on-one water quality monitoring training and quality control sessions with those interested in implementing a water quality monitoring program on their land.

This *Guide to Water Quality Monitoring* and the technical workshops will be provided in both English and Spanish. The PG&E-SEP Project Fund grant that provided for the creation of this Agricultural Water Quality Monitoring Training program will conclude in June 2008.

The Purpose

The purpose of this program is to introduce the most common parameters measured for degradation to water quality, and provide technical training and on-farm support to participants who want to conduct sound monitoring of their own. This Program is intended to give you an understanding of water quality monitoring techniques and the important role water quality plays in the aquatic ecosystem, explain the parameters of concern for your regional watersheds, and then lead you through the specific steps necessary to become a successful monitor.

Armed with this knowledge we hope that participants will implement a monitoring program at their operations, and take advantage of the many locally available resources to change any practices on their operations which may cause negative water quality impacts to improve regional water quality.

What This Program Will Not Do...

The purpose of this water quality monitoring training program and Field Guide is NOT to fulfill the Central Coast Agricultural Waiver monitoring requirements. Rather it is to involve individual participants from the agricultural community in conducting water quality monitoring of their operations, so they can inform themselves of the degree of their own water quality impacts on local streams, rivers, and the ocean, and thus lead them to affirm or address their particular water quality and land stewardship practices based on this knowledge.

Goals and Objectives

Each agricultural operation or group will have their own specific goals and objectives that address the issues of concern in the area they are monitoring. This program is an effort to help local agricultural operators and agricultural monitoring groups collect accurate and useful water quality information to inform their land use practices.

The four fundamental steps required to ensure that any monitoring group collects accurate and consistent data are the:

- Use of standardized monitoring equipment and standard operating procedures (SOPs) [aka, monitoring instructions]
- Incorporation of expert training
- Frequent instrument calibration and protocol testing
- Proper documentation and record keeping

Each piece of equipment recommended for the field kit has been selected for ease of use, durability, acceptable accuracy and precision, and reliability. The monitoring protocols, collection procedures, and Quality Assurance steps are accepted widely among both citizen monitoring programs and professional resource programs. The information collected by participants will be used to inform their monitoring group of the potential impacts of their operations on water quality on surrounding waterways.

The **overall goal of this program** is to train participants to collect information that facilitates:

- Consistent and accurate water quality data collection by all individuals and monitoring groups within the region.
- The identification of waterways that do not meet current water quality standards.
- The use of the data by farm managers, land owners, and agricultural leaders to select appropriate and protective land management actions to prevent water quality impacts on local watersheds due to agricultural operations.

Involvement by the agricultural community as active members in the monitoring of water quality on their operations will allow the **participants to meet the following objectives:**

- To determine the current water quality conditions on their land and in their region (baseline, storm, and event).
- To increase the amount of data collected by the agricultural community at large, and used to inform their actions.
- To assess the effectiveness of restoration efforts and/or Best Management Practices (BMPs) that are implemented to protect against negative impacts to water quality.

4

Program Partners

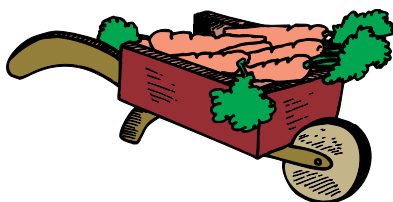
The **Agriculture Water Quality Monitoring Training Program** involves a number of local partners, and has an Advisory Panel which is made up of regional agricultural advisors.

Advisory Panel members include staff from the Monterey County Farm Bureau (MCFB), Agriculture and Land-Based Training Association (ALBA), the Central Coast Agricultural Water Quality Coalition (Coalition), the Monterey Bay National Marine Sanctuary's (MBNMS) Water Quality Protection Program (WQPP), the Agriculture Water Quality Alliance (AWQA), USDA-Natural Resources Conservation Service (NRCS) and the Resource Conservation District of Monterey (RCDMC), individuals from the agricultural community, and the Central Coast Regional Water Quality Control Board (CCRWQCB).

Throughout the program you will be provided safe opportunities to discuss the possible water quality impacts occurring on your operations or in the surrounding area, and given contact information for resource staff that can help you improve water quality in your area confidentially.

Good Reading to you!

As a Program participant you will join others throughout the Lower Salinas River Basin in the pursuit of "clean water," both for your operation's discharge waters and the receiving stream & ocean waters. During the workshops and from the following pages, you will learn how this is possible.



Water Quality Monitoring Vocabulary

The following section presents an alphabetical list of the common words, phrases, jargon, vernacular, definitions, and terminology specific to water quality monitoring programs. Following this section each common parameter will be presented, so these are not included here. [**Bolded** words are contained within this glossary alphabetically]

Numbers

303(d) List of Impaired Waterbodies – Under Section 303(d) of the **Clean Water Act**, states, territories and authorized tribes are required to develop a list of water bodies that do not meet **water quality objectives**, establish load and waste load allocations, or a **total maximum daily load** (TMDL), for each water body that will ensure attainment of water quality objectives, and then to incorporate those allocations into their water quality control plans (**Basin Plan**).

Although it is unconventional to place the Glossary in the front of a reference book, we did this because we believe that by absorbing the vocabulary of a science one can demystify it and make it accessible to everyone.

A

Accuracy – A measure of confidence in how closely an instrument measures the actual or **true value** of the variable being measured. An instrument will also have a range of accuracy expressed in the appropriate units for that equipment; i.e., “0.04 mg/L \pm 4% of reading”. This is not related to **resolution**; however, an instrument’s accuracy can never be better than the resolution of the instrument.

Acidic/Acidity – A state of low pH value (<7); low numbers on the pH scale are acidic solutions like vinegar and lemon juice. A measure of the number of free hydrogen ions (H+) in a solution that can chemically react with other substances.

Acre Foot – Unit used in measuring the **volume** of water at rest, in a reservoir or an aquifer. It is the volume of water that would cover an area of one acre to a depth of one foot. It is equivalent to 43,560 cubic feet. This unit of measure is also used in distribution of water for use in irrigation.

Aerobic – Containing oxygen. Referring to an organism, environment, or cellular process that requires oxygen.

Alkaline/Alkalinity – A state of high pH value (>7); alkaline solutions like bleach and ammonia. A measure of the negative ions which are available to react and neutralize free hydrogen ions.

Ambient Monitoring – All forms of monitoring conducted beyond the immediate influence of a discharge pipe or injection well and may include sampling of water, sediments, and living resources. Monitoring of air, water or soil that is done to determine existing environmental conditions, contaminant levels, rates, or species in the environment, against which future conditions can be compared.

Analysis – Description of how the acquired data will be analyzed (either in the field or the laboratory), evaluated (i.e., QA review/verification/validation), and assessed against its intended use and the quality performance criteria.

Analyte – The substance in an analysis that is being identified or determined, or the chemical constituent that is undergoing analysis. It is the substance being measured in an analytical procedure; aka. a **Parameter**, or a **Constituent**.

Anaerobic – Without oxygen. More specifically, occurring or living without oxygen present; therefore, the chemistry of the system, environment, or organism is characterized by reductive conditions. Many organic contaminants are degraded under anaerobic conditions by anaerobic bacteria called anaerobes. This process is known as anaerobic **biodegradation**. Anaerobes use nitrate, sulfate, iron, manganese, and carbon dioxide as their electron acceptors.

Anoxic – An adjective that means without oxygen. Anoxic ground water is ground water that contains no **dissolved oxygen**. Anoxic ground water conditions at hazardous waste sites are common because **biodegradation** processes often use up all the available oxygen.

Attention Level – A specified level of a measurable constituent which indicates a level of water quality impairment worthy of further investigation. An Attention Level may, or may not, correspond to a legal **Water Quality Objective**.

B

Basic – Any chemical compound that, when dissolved in water, gives a solution with a pH higher than 7.0 (See **Alkaline**).

Basin Plan – Management Plan generated by the Regional Water Quality Control Board to fulfill mandates under the **Clean Water Act**. The goal of the Basin Plan is to provide a definitive program of actions designed to preserve and enhance water quality and to protect designated beneficial uses of water within each region, and across the state.

Beneficial Uses – Management objectives for water quality which are use specific, and water body specific. “State policy for water quality control in California is directed toward achieving the highest water quality consistent with maximum benefit to the people of the State. Therefore, all water resources must be protected from pollution and nuisance that may occur as a result of polluted discharges.” (Water Quality Control Plan for the Central Coast Region (**Basin Plan**)).

Benthic – The lowest level of a body of water, such as an ocean, stream, or lake. It is inhabited by organisms that live in close relationship with (if not physically attached to) the ground, called benthos or benthic organisms.

Benthic-macroinvertebrate – Aquatic organisms that lack a backbone, can be seen with the naked eye, and live on the bottom substrate of streams, rivers or oceans. Benthic-macroinvertebrate populations are monitored as indicators to water quality conditions as many species are extremely sensitive to water pollution or environmental changes.

Best Management Practice (BMP) – Methods that have been determined to be the most effective practical means of preventing or reducing pollution from non-point sources from entering waterways. May include any number, or combination, of management activities, practices, facilities, and/or procedures such as grassed waterways, erosion control berms, or sediment basins.

Bias – An inadequacy in experimental design that leads to results or conclusions not representative of the population under study. The difference between the expectation of the sample estimator (person) and the true population value which reduces the **representativeness** of the sample by systematically distorting it; a predisposition, partiality, prejudice, preference, predilection.

Biodegrade – The breakdown of organic material such as plant and animal matter and other substances originating from living organisms by microorganisms. “Degradation” means decay, and the “bio-” prefix means that the decay is carried out by a huge assortment of bacteria, fungi, insects, worms, and other organisms that eat dead material and recycle it into new forms.

Biodegradation – A process by which organic substances are broken down by living organisms. The term is often used in relation to ecology, waste management, environmental remediation (bioremediation) and to plastic materials, due to their long life span. Organic material can be degraded **aerobically**, with oxygen, or **anaerobically**, without oxygen.

Biological Oxygen Demand (BOD) – A measure of the amount of oxygen consumed by microorganisms while decomposing organic matter, together with the chemical oxidation of inorganic matter. The greater the BOD, the more rapidly oxygen is depleted in the stream. This means less oxygen is available to fish and other forms of aquatic life. Sources of BOD include leaves and woody debris; dead plants and animals; animal manure; failing septic systems; and agricultural and urban stormwater **runoff**.

Biota/Biotic – The total collection of organisms of a geographic region or a time period; the living organisms in the environment.

C

Calibration – A procedure which checks or adjusts an instrument's accuracy by comparison with a **standard** solution or known reference value.

Clean Water Act – The Federal Water Pollution Control Act Amendments of 1972, as amended in 1977, became commonly known as the Clean Water Act. The Act established the basic structure for regulating discharges of pollutants into the waters of the United States. It gives the U.S. EPA the authority to implement pollution control programs such as setting wastewater standards for industry.

Comparability – The extent to which data from one study can be compared directly to either past data from the current project, or data from another study. For example, you may wish to compare two seasons of summer data from your project or compare your summer data set to one collected 10 years ago by state biologists (**methods** and **units of measure** are most critical).

Completeness – A measure of the amount of valid data obtained compared to the amount of data originally planned. (A **Data Quality Objective**)

Compliance Monitoring – A type of monitoring done to ensure the meeting of immediate statutory requirements, the control of long-term water quality, the quality of **receiving waters** as determined by testing **effluents**, or the maintenance of **water quality objectives** during and after construction of a project.

Composite Sample – A mixture of single or **grab samples**. A composite is intended to produce a typical or average sample when wide variations in quality or characteristics occur in the various grab samples. A composite may be made up of equal volumes of individual samples or of single samples which are proportioned to variations in flow or usage.

Concentration – The amount of a given chemical or biological substance in water, sediment, or **biota** that can be measured by an analytical method. (See **Load**)

Constituent – A chemical or biological substance in water, sediment, or **biota** that can be measured by an analytical method. (See **analyte, parameter**)

Contaminant – A material or substance added by humans or natural activities that may, in sufficient concentrations, render the environment unacceptable for **biota**, a **pollutant**. The mere presence of these materials is not necessarily harmful or toxic to animals or humans.

Criteria – Determination of the quantity of data needed and specification of performance criteria for measuring quality. Also used as the Criteria, or threshold, of conditions in a measured waterbody; as in a **Water Quality Objective**: i.e., **DO** must not be lower than 8.0 ppm in a stream supporting species of cold water fish, or Nitrate must not be higher than 10.0 ppm for drinking water, etc.

D

Data – Specific to water quality or **watershed** and environmental evaluation; a group of measurements, facts or observations, collected to document, establish, and evaluate existing or changing environmental conditions.

Data Collection – Description of how and where the **data** will be obtained (including existing data) and identification of any constraints on data collection.

Data Quality Objectives (DQOs) – *Data Quality Objectives* specify the quality of the data needed in order to meet the monitoring project's goals. These performance and acceptance criteria clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential errors. They would include, but not be limited to, the specification of the tolerable **accuracy**, **precision**, and **bias** of measurements, the **completeness** of sampling and measurements, the **representativeness** of sites and/or **results** relative to program objectives and the environment being evaluated, and validity of data.

Detection – A valid **result** for a measured **analyte, parameter**. Frequently, a 'detection' refers to a measurement result that does not meet a stated **Water Quality Objective** one is using as a benchmark.

Detection Limit – This term applies to monitoring and analytical instruments as well as to methods. Detection limit is defined as the lowest **concentration** of a given **analyte** the **methods** or equipment can accurately detect and report as greater than zero. Readings that fall below the minimum detection limit are too unreliable to use in your data set. (See **Increment** and **Sensitivity**)

Deionized Water – Water that has had all of the ions (atoms or molecules) other than hydrogen and oxygen removed (new bottles of Distilled Water are frequently used by laypersons conducting water quality monitoring).

Dissolved Oxygen (DO) – A measure of the oxygen dissolved in water and available for aquatic living organisms to use for respiration.

Discharge (Q) – The **volume** (amount) of water passing a cross-section per unit of time and is generally expressed in cubic feet per second (cfs); the **velocity** of the water (V) multiplied by the area (A) [$Q = VA$]. (See **Flow**)

Drainage Basin – The land area where precipitation runs off into streams, rivers, lakes, reservoirs or the ocean. It is a land feature that can be identified by tracing a line along the highest elevations between two areas on a map, often a ridge. Large drainage basins, like the area that drains into the Salinas River, contain thousands of smaller drainage basins. (See **Watershed**).

10 Duplicate/Replicate Sample – Two (duplicate) or more (replicate) samples of water collected at exactly the same time and place which are prepared, measured, or analyzed for the same parameter – a **quality control** action. (See **Field Duplicate Sample; Replicate**).

E

Effluent – Wastewater discharges of any kind; from a commercial, industrial or residential source, waste water from treatment or commercial processes, urban or agricultural **runoff**.

Effectiveness Monitoring – Monitoring study specifically designed to evaluate the success of a practice or project that is hypothesized to change the environmental conditions. This monitoring would aid in the determination of the appropriateness or *effectiveness* of specific management prescriptions designed and implemented to reduce potential adverse effects on the system being monitored. Since monitoring requires site specific measurements, parameters that reflect temporal, spatial, scale, streamflow variation, and site/reach representation are required in order to properly represent situational variability and extrapolate findings of a process and/or system response to imposed change.

Ephemeral Streams – A stream that flows only during and for short periods following precipitation and flows in low areas that may or may not have a well-defined channel. Some commonly used names for ephemeral streams include: stormwater channel, drain, swale, gully, hollow, or saddle.

Eutrophication – The natural and artificial addition of nutrients to a waterbody, which may lead to depleted oxygen concentrations. Eutrophication is a natural condition that is frequently accelerated and intensified by human activities. It is a process whereby water bodies, such as lakes, estuaries, or slow-moving streams receive excess nutrients that stimulate excessive plant growth (algae, and nuisance plants weeds). This enhanced plant growth reduces **dissolved oxygen** in the water when dead plant material decomposes and can cause other organisms to die.

Environmental Protection Agency (EPA) – A federal agency that works to develop and enforce regulations that implement environmental laws enacted by Congress, especially important to us is the **Clean Water Act**. EPA is responsible for researching and setting national **standards** for a variety of environmental programs, and delegates to states and tribes the responsibility for issuing permits and for monitoring and enforcing compliance.

Exceedance – The amount by which something, especially a pollutant, exceeds a standard or permissible measurement.

F

Field Blank Samples – Samples of uncontaminated deionized (or distilled) water which are filled by the monitors in the field at the same time that the target water is collected. These samples are exposed to the same ambient conditions at the sampling site and subjected to the same analytical or measurement process as other samples. Field blank samples are a **Quality Control** action used to provide information about contamination that may be introduced during sample collection, storage, and transport.

Field Duplicate Samples – Two samples collected at the exact same time by the same person using same technique in the exact same field location. Duplicate samples are tested to ensure no gross sampling errors are occurring.

Fixed-station Monitoring – The repeated long-term sampling or measurement of **parameters** at **representative** points for the purpose of determining environmental quality characteristics and trends.

Floodplain – The low area of land that surrounds a stream and holds the overflow of water during a flood.

Flow – The volume of water that moves over a designated point over a fixed period of time. Water in motion; i.e., flowing in streams, canals, pipelines, and ditches, is measured in units of volume per unit of time—gallons per minute (gpm), cubic feet per second (cfs or ft³/sec), acre-inches per hour and acre feet per day. Cubic feet per second is most commonly used for measuring flow of water moving by gravity from irrigation systems, streams and reservoirs. Gallons per minute is most commonly used for measuring flow from pumps. (See **Discharge**).

Fresh Water – Water that is not salty; without dissolved salts, as opposed to brackish water or salt water; not marine or ocean water. Water from surface flow or ground sources.

G

Geographic information Systems (GIS) – A computerized system for combining, displaying, and analyzing geographic data. GIS produces maps for environmental planning and management by integrating physical and biological information (soils, vegetation, hydrology, living resources) and cultural information (population, political boundaries, roads, bank and shoreline development).

Grab Sample – A single water sample collected at a particular time and place which represents the composition of the water only at that time and place.

12

H

Hypoxia – “Low oxygen” or depletion of dissolved oxygen in an aquatic system. In estuaries, lakes, and coastal waters, low oxygen usually means a concentration of less than 2 parts per million. Hypoxia can be caused by the presence of excess nutrients in water.

Homogeneous – Having the same composition throughout; uniform, blended.

I

Impact – A change in the chemical, physical, or biological quality or condition of a water body caused by external sources.

Impairment – A detrimental effect on the biological integrity of a water body caused by an impact that prevents attainment of the designated use; degradation.

Implementation Monitoring – Monitoring specifically designed to document whether or not management practices were applied as designed. Project and contract administration is a part of implementation monitoring.

Increment – Specific to monitoring equipment or analysis; the increment is the minimum step between valid detection values for that piece of equipment or analytical method.

Infiltration – The flow of water from the land surface into the subsurface.

Intermittent Streams – A stream that flows only during wet periods of the year (30% - 90% of the time) and flows in a continuous well-defined channel. During dry periods, especially in summer months, intermittent streams may go down to a trickle of water and make it appear dry, when in fact there is water flowing through the stream bottom or **substrate**. This is usually caused by the seasonal changes of the local soil water table or during periods of long term drought.

Instrument Detection Limit – The instrument detection limit is the lowest concentration of a given substance or analyte that can be reliably detected by analytical equipment or instruments (see **Detection Limit**).

J

Jackson Turbidity Unit (JTU) – A measurement of the turbidity in a water sample.

K

None

L

Land Uses – The way land is developed and used by people in terms of the type of activity (agriculture, urban or residential, industries, etc.).

Load – Refers to the quantity of a substance entering the environment (the water being tested), in relationship to the **volume** and **velocity** of water moving through the system carrying that concentration; opposed to simply the **concentration of pollutant** in the water which is what most monitoring results are. Load is also the amount of stress placed upon an ecosystem by pollution, physical or chemical, released into it by man-made or natural means.

Logarithmic Scale – Numerical scale on which actual distances from the origin are proportional to the logarithms of the corresponding scale numbers: non-linear progression from one number on the scale to the next.

M

Macroinvertebrate – See **Benthic-macroinvertebrate**.

Marine – The ocean environment or waters (not **fresh water**)

Measurement – The discrete evaluation of the magnitude of some attribute of an object (water in our case), relative to a **unit of measurement**. Measurement usually involves using a measuring instrument or analytical method.

Measurement Range – The range of reliable measurements of an instrument or measuring device.

Method – The techniques that will be used to conduct monitoring; this can mean the instructions for using a specific piece of equipment, running an analysis, collecting a sample, or conducting a site visit. (See **Standard Operating Procedures** or **Protocol**)

Monitoring – The periodic or repeated measurement of some given set or parameters to assess the current status and changes over time of the parameters measured.

N

National Pollutant Discharge Elimination System (NPDES) – A national program in which pollution dischargers such as factories, wastewater treatment plants, cities, or urban areas, are given permits to discharge. These permits contain limits on the pollutants they are allowed to discharge.

Nephelometer – An instrument used for measuring **turbidity** in water using a photometric analytical technique for measuring the light scattered by finely divided turbidity or colloiddally dispersed particles suspended in water.

Nephelometric Turbidity Unit (NTU) – The standard **unit of measurement** used in the water analysis process to measure **turbidity** in a water sample.

Nonpoint Source Pollution (NSP) – Refers to **pollutants** carried by discharges diffused across the landscape resulting from land use practices where wastes are not collected and disposed of in any readily identifiable manner, and those that do not have a single point of origin or a specific outfall. These pollutants are generally mobilized and carried by surface flows or **stormwater runoff**. The major sources are agriculture runoff, forestry, urban drainage, and natural sources such as effects of fire, flood, and landslide, etc. The distinction between point sources and diffuse sources is not always clear but generally applies to the practicality of waste load control.

O

Objective – A desired end point; goal.

Organization – Identification and involvement of the project manager, sponsoring organization and responsible official, project personnel, stakeholders, scientific experts, etc (both formal and informal alliances).

Oxidation – The loss of electrons by a molecule, atom or ion. This occurs during the interaction between oxygen molecules and all the different substances they may contact, from metal to living tissue (ex., rust: see **Reduction**)

P

Parameter – A distinguishing characteristic or feature of something. An example of a parameter, **constituent**, or **analyte**, is some property being measured or defined about the water, like the concentration of “nitrate” present in the sample, while an example of an *analytical procedure*, or method, is

“cadmium reduction” or “titration”.

Parts Per Million (ppm) – A unit of measure proportionate to the weight of one unit of weight of solute (dissolved substance) per million weights of **solution**. Since one liter of water weighs one million milligrams, one ppm is equal to one milligram per liter (mg/L). Milligram per liter is the preferred unit of measure in many water or waste water analysis systems.

Perennial Streams – Permanently inundated surface stream courses which flow in a well-defined channel. Surface water flows throughout the year (greater than 90% of the time) except in years of infrequent drought.

Permeable – Porous; allows water to penetrate, percolate through it.

pH – A numerical measure of the hydrogen ion concentration used to indicate the **alkalinity** or **acidity** of a substance. Measured on a scale of 1.0 (**acidic**) to 14.0 (**basic**); 7.0 is neutral.

Photosynthesis – The chemical reaction in plants that utilizes light energy from the sun to convert water and carbon dioxide into simple sugars. This reaction is facilitated by chlorophyll.

Pipette – An eyedropper-like instrument used to transport and/or dispense a measured volume of liquid (also called a pipet, pipettor, or chemical dropper)

Point Source Pollution – **Pollution** discharged from discrete, identifiable source such as municipal discharges and wastewater treatment plants, industrial discharges, fish hatchery discharges, confined animal operations, urban and agricultural drains, combined sewers etc.

Pollution – The introduction of contaminants into an environment that cause harm to human health, other living organisms, and the environment. Pollution can be in the form of chemical substances, or energy such as noise, heat, or light. Pollutants can be naturally occurring substances or energies, but are considered contaminants when in excess of natural levels which cause an alteration of the chemical, physical, and biological integrity of water.

Project Goal – Description of the personal or organizational desired end point stated in the project’s development, and achieved by setting practical objectives and deadlines.

Preserved Samples – Water samples that require some type of chemical additive (usually acid) to prevent the water samples from undergoing unwanted chemical reactions.

Precision – The degree of agreement among repeated measurements of the same characteristic [**parameter**] on the same sample or on separate **duplicate** samples collected as close as possible in time and place. It demonstrates how consistent and reproducible field or laboratory methods are by showing how

close repeated measurements are to each other. It does not mean that the sample results actually reflect the **accurate** or “true” value, but rather that your sampling methods and analysis are giving consistent results.

Protocol – Detailed, written, standardized instructions for conducting field and/or laboratory operations. (aka, **Standard Operating Procedure** or **SOP**)

Q

Quality Assurance (QA) – This refers to an overall management system to assure the quality of the data produced in the program; which includes the organization, planning, data collection, quality control (QC), documentation, evaluation, and reporting activities. QA systems and practices ensure that your data will meet defined standards of quality with a stated level of confidence to meet the requirements of your project, and assess the performance criteria of your monitoring program.

Quality Control (QC) – Refers to the routine technical activities whose purpose is, essentially, error control. Since errors can occur in either the field, the laboratory or in the office, QC must be part of each of these functions (e.g., QC samples for both field and laboratory, **replicate** measurements, training, audits, technical assessments, etc.).

Quality Control Samples – Additional samples taken to identify errors and ensure accuracy and precision of sampling techniques and procedures. QC samples help identify when and how contamination might occur. Examples of QC samples are: Field or Laboratory **Blank**, Field or Laboratory **Duplicate** or **Replicate** samples, **Split** samples, and **Spiked** samples.

Quality Assurance Project Plan (QAPP) – The written record of your QA/QC program.

Qualitative – An attribute that exists as a description of kind, type, or direction, as opposed to size, magnitude, or degree; relating to or involving comparisons based on qualities.

Quantitative – An attribute that exists in a range of magnitudes, and can therefore be **measured** or chemically analyzed producing a numerical outcome or **result**. Measurements of any particular quantitative property are expressed as a specific quantity, referred to as a **unit**, multiplied by a number.

R

Range – Specific to monitoring equipment or analysis, the range is the spread from minimum to maximum detection values that an instrument or analytical method is designed to measure accurately.

Reach – A river or stream segment of an arbitrarily designated length. Frequently specified reaches of a waterbody are monitored repeatedly/routinely for a monitoring program.

Reagent – Any prepared substance or chemical added to a sample to create a solution which completes a chemical analysis. Usually generates an expected chemical reaction which indicates the presence/absence of the analyte being sought, or to determine some characteristics of a solution.

Receiving Waters – A river, ocean, stream, or other watercourse into which run-off, wastewater, or treated effluent is discharged; specifically, a **waterbody** which has **beneficial uses** assigned to it which are identified under the regional **Basin Plan**.

Reduction – The addition of hydrogen, removal of oxygen, or the addition of electrons to an element or compound. Example, under **anaerobic** conditions (no dissolved oxygen present), sulfur compounds are reduced to odor-producing hydrogen sulfide (H_2S) and other compounds. The opposite of **oxidation**.

Regional Water Quality Control Board (Regional Board, RWQCB) – There are nine Regional Water Quality Control Boards (Regional Boards) in California. “The mission of the Regional Boards is to develop and enforce water quality objectives and implementation plans that will best protect the **beneficial uses** of the state’s waters, recognizing local differences in climate, topography, geology and hydrology”. Regional Boards develop **Basin Plans** for their hydrologic areas, govern requirements/issue waste discharge permits, take enforcement action against violators, and monitor water quality. (See **Basin Plan**, **Beneficial Uses**, and **Water Quality Objectives**).

Replicate – Any two or more measurements, analysis or samples collected for the purposes of analyzing the methods of monitoring. Generally, **duplicate** is two and replicate is more than two results. (See **Duplicate/Replicate Sample**)

Representativeness – A data quality indicator reflecting the extent to which measurements accurately depict the true environmental condition measured.

Result – A numerical value, or outcome, of a test or **analysis** (either **qualitative** or **quantitative**).

Resolution – The smallest amount of change that the kit or instrument can detect reliably. This is determined by the instrument specifications and/or method.

Runoff/Run-off – Surface flows of water either from storm (rain) events or originating from human activities.

Sample – Any water, or material collected for any measurement or analysis to be done on site or at a laboratory.

Saturated – Inundated; filled to the point of capacity or beyond.

Schedule – Identification of project timeline, resources (including budget), milestones, and any applicable requirements (e.g., regulatory requirements, contractual requirements).

Sensitivity – Related to **detection limits**. The measure of the smallest signal the instrument can reliably detect. Usually, this is defined as the lowest **range** of the instrument, or the ability of an analytical method to discriminate between two measurements. The more sensitive a method is, the better able it is to detect lower concentrations of a variable.

Site – A designated monitoring location which is monitored repeatedly. Frequently used interchangeably with **station**. (See **Station**)

Solute – A substance which is dissolved in a **solvent** (generally a liquid such as water) to form a **solution**.

Solution – A mixture in which one or more substances (**solutes**) are dissolved into another substance (**solvent**), usually a liquid, in such a way that the solute is equally distributed (**homogeneous**) throughout the **solvent** in the form of either molecules (as in a sugar solution) or ions (as in a salt solution).

Solvent – A substance that dissolves other substances, thus forming a **solution**. Water dissolves more substances than any other, and is known as the “universal solvent”.

Spatial – Of or relating to space, place (location).

Spiked Samples – Samples used for **quality control** purposes, a spiked sample is a sample to which a known concentration of the target analyte has been added. When analyzed, the difference between an environmental sample and the analyte’s concentration in a spiked sample should be equivalent to the amount added (the spike) to the **sample**.

Split Sample – Samples used for **quality control** purposes, a split sample is one that has been equally divided into two or more sub-samples. Split samples are submitted to different analysts or laboratories, and are used to measure the precision of the analytical methods by the different individuals or laboratories.

Standard – (aka, **Standard Reference Material (SRM)**) A certified material or substance with an established, known and accepted value for the analyte or property of interest. Standards are used as a gauge to correctly calibrate instruments or assess measurement methods. (See **Water Quality Objective** for EPA Water Quality Standards)

Standard Operating Procedures (SOPs) – A written document detailing the prescribed and established methods used for performing project operations, analyses, or actions. (Aka, a **Protocol**)

State Water Resources Control Board (SWRCB; aka., Water Board) – The Water Board was created by the California Legislature in 1967. The mission of the Water Board is to ensure the highest reasonable quality for waters of the State, while allocating those waters to achieve the optimum balance of beneficial uses.

Station – A designated monitoring location which is monitored repeatedly. Frequently used interchangeably with site. A station is usually a more accurately defined location, and this name is used when equipment is installed, or ‘fixed,’ to the location; as in “fixed-station monitoring”. (See **Site**).

Stormwater/Storm Water – The part of precipitation (rainfall or snowmelt) which travels via flow across surfaces to the storm drain system or receiving waters.

Substrate – Refers to a surface. This includes the material comprising the stream bed or the surfaces to which plants or animals may attach or live upon.

T

Temperature Blank – A container filled with water stored with the water samples in the cooler/ ice chest. A temperature reading is taken of the water when the samples are given to the laboratory. They give an indication of the temperature held inside the cooler/ice chest that samples were stored at appropriate temperatures during transport to the laboratory.

Temporal – Of or relating to time, timing (frequency).

Titration – The addition of small precise quantities of a reagent to a sample until the sample reaches a certain endpoint. Reaching the endpoint is usually indicated by a color change.

Total Maximum Daily Load (TMDL) – The total allowable pollutant load to a **receiving water** such that any additional loading will produce a violation of water quality standards.

Toxic – Relating to harmful effects to biota caused by a substance or contaminant.

Toxicity Test – A procedure to determine the toxicity of a chemical or an **effluent** by using living organisms. A toxicity test measures the degree of effect on exposed test organisms of a specific chemical or effluent.

Tributaries – A body of water that drains into another, typically larger body of water.

True Value – In the determination of **accuracy**, observed measurement values are often compared to a 'known', true, or **standard** value. A true value is one that has been sufficiently well established to be used for the **calibration** of instruments, evaluation of assessment methods or the assignment of values to materials.

Turbidity – The measure of the murkiness or cloudiness of water, indicating the presence of some suspended sediments, dissolved solids, natural or manmade chemicals, algae, etc.

U, V

Unit/Unit of Measure – Any division of quantity accepted as a standard of measurement or exchange; where a measurement is the estimation of the magnitude of some attribute of an object, such as its length or weight, relative to a unit of measurement.

Urban Runoff – Water flowing from city streets and adjacent domestic or commercial properties that may carry pollutants of various kinds into the storm sewer system and/or **receiving waters**.

Validation – Determination upon testing that a representative sample of a piece of water quality measurement equipment has met the requirements of a specified **standard** (as part of a **calibration** procedure).

Velocity – As relates to general water, the time measurement of linear motion (**flow**) in a given direction. For example, water flowing 60 feet in a stream/conduit each minute, has a velocity of 60 feet per minute (fpm) or one foot per second (1 fps).

Volume – The three-dimensional concept of how much space something occupies, often quantified numerically. Water at rest (e.g., ponds, lakes, reservoirs, and in the soil), is measured in units of volume — gallon, cubic foot, acre-inch, and acre-foot. (See **Flow**, and **Discharge**)

Waterbody/Water Body – A natural or man-made basin that drains or stores water, not including jurisdictional wetlands or artificial ponds (See **Drainage basin** or **Watershed**)

Water Measurement Units – There are two conditions under which water is measured—water at rest and water in motion. Water at rest is measured in units of **volume**. Water in motion is measured in units of **flow**, unit of **volume** for a convenient time unit (see **Flow** and **Discharge**).

Water Quality – The chemical, physical, and biological characteristics of water with respect to its suitability for a particular use.

Water Quality Criteria – Maximum concentrations of pollutants that are acceptable, if those waters are to meet water quality standards. Listed in regional **Basin Plans**. (See **Water Quality Objective**)

Water Quality Data – The results of chemical, biological, and physical measurements or observations of the characteristics of surface and ground waters, atmospheric deposition, potable water, treated effluents, and waste water and of the immediate environment in which the water exists.

Water Quality Monitoring – An integrated activity for evaluating the physical, chemical, and biological character of water in relation to human health, ecological conditions, and designated water uses.

Water Quality Objective (WQO) – Written goals for state waters, established by each region and approved by the state, and the U.S. EPA.

From the Central Coast Region Basin Plan:

A prerequisite to water quality control planning is the establishment of a base or reference point. Current technical guidelines, available historical data, and enforcement feasibility were given full consideration in formulating water quality objectives. A distinction is made here between the terms “water quality objectives” and “water quality standards”. Water quality objectives have been adopted by the State and, when applicable, extended as federal water quality standards. (See **Water quality standard**)

Water Quality Standard (WQS) – Federal level goals written for the nation’s waters established by the U.S. EPA. Water quality standards pertain to navigable waters and become legally enforceable criteria when accepted by the U.S. EPA Regional Administrator:

U.S. EPA: Water quality standards are mandated by the **Clean Water Act**. Water Quality Standards define the goals for a **waterbody** by designating its uses, setting criteria to protect those uses, and establishing provisions to protect water quality from pollutants.

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A water quality standard consists of four basic elements:

- 1 Designated uses of the water body (e.g., recreation, water supply, aquatic life, agriculture)
- 2 Water quality criteria to protect designated uses (numeric pollutant concentrations and narrative requirements)
- 3 An antidegradation policy to maintain and protect existing uses and high quality waters
- 4 General policies addressing implementation issues (e.g., low flows, variances, mixing zones)

Watershed – A watershed is the area of land from which **runoff** (from rain, snow, and springs) drains to a stream, river, lake, or ocean. Its boundaries can be identified by locating the highest points of lands around the **waterbody**. Streams and rivers function as the “arteries” of the watershed. They drain water from the land as they flow from higher to lower elevations. (Also called **Drainage Basin, Waterbody**)

X, Y, Z

None



Glossary References

Terms in the following Glossary have been adapted from the following references:

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NC Division of Forest Resources:

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USEPA, The Volunteer Monitor's Guide to Quality Assurance Project Plans. September 1996. DocID: EPA 841-B-96-003.

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<ftp://ftp.wcc.nrcs.usda.gov/downloads/wqam/wqm1.pdf>

U.S. Geological Survey, Toxic Substances Hydrology Program:

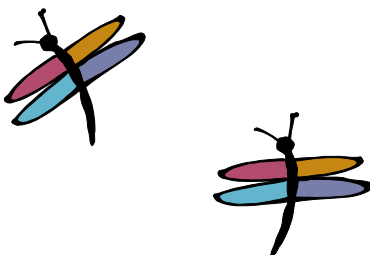
<http://pubs.usgs.gov/fs/fs-027-01/>; <http://toxics/faq/waterquality.html>; <http://toxics.usgs.gov/index.html>

Water Quality Association; The WQA Glossary of Terms:

www.wqa.org/glossary.cfm

Wikipedia: www.wikipedia.org

And other common information sources: text books, the internet, and various state and educational institution websites.



In this Section,
you will learn:

What is water quality?

Common water quality monitoring
parameters and why each is
important.

Basic monitoring strategies and
driving questions for a monitoring
program

10 key elements of
monitoring programs



Introduction to Water Quality

Think about the water you drink, as well as the water you bathe, cook or clean with, the water you use to water your yard or crop, the water flowing in the streams and out to the ocean.

What kind of properties does it have before you use it? Do you know what's in it, or what condition it is in? What happens to the dirty water after you are done with it? These questions reflect upon one of the most important concepts of watershed stewardship—water quality.

Water quality is a term used to describe the chemical, physical, and biological characteristics of water, generally in terms of suitability for a particular—or designated use.

Water quality monitoring is the process of sampling and analyzing water conditions and characteristics. This section will introduce water quality and go on to discuss the various water characteristics that have an effect on the various uses of water bodies and monitoring as a means to measure these characteristics.

Why Water Quality Monitoring is Important

In the mid-1500's Sir Francis Bacon (instrumental in the development of modern inductive science) said, "knowledge itself is power." Today we all understand that through an increased knowledge of a particular issue, especially what is gained through personal experience, we can more readily affect a change in our behavior that leads to an overall improvement on the issue – think about the changes in street litter and household recycling in America since the 1970's.

We monitor water quality conditions in stream flows and storm drain discharges so that we might understand what the conditions are, identify changes, and pursue the sources of pollutants. This gives us the knowledge required to inform ourselves and others, and change conditions at the source – so that we might stop pollution from ever reaching our streams and oceans in the future.

Poor water quality is a health concern for humans and wildlife alike. Pollutants like sediments, nutrients, pesticides, and heavy metals, are commonly found in the Salinas River watershed. Surface runoff carries these pollutants into streams and rivers, all of which ultimately flow into the ocean. Water quality monitoring

at various stations throughout the river system helps to identify where these pollutants originate in the surface flows. Armed with this knowledge, we can identify problems and make changes that will result in the improvement of overall water quality in our area.

Both agricultural production and increasing development in urbanized areas have altered the natural topography and hydrology of most watersheds in California. The purpose of many water quality monitoring programs is to determine to what extent various upstream land use practices are contributing to poor water quality in our rivers, streams, creeks, lakes, harbors, estuaries, and ocean – and to use this knowledge to change these practices where possible so that there is a net reduction in the amount of controllable pollutants entering our waterways.

Water Quality Characteristics

Water characteristics, such as dissolved oxygen, pH, nutrients, and temperature, are known as **parameters**. Parameters can be **chemical**, **physical** or **biological** in nature.

Chemical parameters are a measure of substances such as pH, dissolved solids, conductivity (a measure of dissolved salts and minerals), *dissolved* oxygen, pesticides, heavy metals, oils, and nutrients such as nitrogen and phosphorus, which are dissolved into the water. Monitoring for specific chemicals helps identify the causes for impairment and helps trace the source of the impairment.

Physical characteristics of water include but are not limited to flow, temperature, turbidity, suspended solids and transparency. Physical attributes are useful screening indicators of potential problems, often because they can have an impact on the effects of chemicals in the water and on aquatic life.

Biological parameters refer to aspects of the living environment; objective measurements of aquatic biological communities (usually bacteria, aquatic insects, fish, or algae) used to evaluate the condition of an aquatic ecosystem. Biological data are best used when deciding whether waters support aquatic life or are harmful to human health.

In a typical monitoring program the following two biological parameters are most often measured to determine water quality:

Pathogenic and **Indicator Bacteria** are types of bacteria which are part of the natural environment, not normally found in high numbers in oceans, rivers, or creeks - but always found in sources of fecal contamination. Bacteria that cause disease are called **pathogenic** bacteria. Though **indicator bacteria** are not typically disease-causing organisms themselves, they can be indicative of the presence of such organisms. Studies have shown that when concentrations of indicator bacteria exceed certain levels in waters used for water body contact recreation, individuals exposed to these waters may have a greater chance of getting sick.

Toxicity testing is used to determine whether an aquatic life use is being attained. Toxicity data are generated by exposing selected organisms such as fathead minnows or daphnia ("water fleas") to known dilutions of water taken from the sampling location. These tests can help determine whether poor water quality results from toxins or degraded habitat (we will not discuss toxicity testing in this manual).

The remaining pages of this section describe many common parameters monitored by volunteers, professionals, and agencies. These parameters are monitored for one or more of the following reasons:

- They are important for human health
- They are important for wildlife health
- They are important for some industrial or agricultural uses
- They are part of state water quality standards or federal water quality criteria

Monitoring different aspects of water quality over time enables changes to the aquatic environment to be detected, and an understanding of ecosystem health to develop. Measuring a combination of these parameters allows a complete picture of the status of a water resource to emerge. The combined data can be used to generate information essential for those managing and protecting natural resources, allowing them to determine if the conditions of the water resource are improving or worsening with time and human use.

Water Quality Parameters

The following is a brief discussion of the chemical, physical, biological parameters commonly monitored in water quality programs. There is a more in-depth presentation of these parameters in Section 3, where they are presented with water quality criteria information and equipment options. Standard operating procedures (SOPs) for the most common test methods used when conducting water quality monitoring may be found in Section 4.

Chemical Parameters

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pH

pH is a measure of the level of activity of hydrogen ions in a solution, resulting in its acidic or basic quality (Figure 1). pH is measured on a **logarithmic scale** (non-linear) that commonly ranges from 0 (acidic) to 14 (basic), 7 being neutral. Aquatic organisms are adapted to specific pH ranges and pH outside this range can be toxic.

The pH in most rivers unaffected by humans ranges from 6.5 to 8. The pH range of survivability of most freshwater organisms ranges from about 4.5 to 9. Western soils, which are typically alkaline (basic), are a natural contributor to elevated pH conditions (low acidity) in lakes, rivers, and reservoirs.

Humans contribute to elevated pH primarily in the form of nutrient runoff (most commonly fertilizer), which leads to increased algae growth and higher pH. Low pH can be especially harmful to aquatic organisms as it affects physiological (biological) functions of aquatic life through the reduction of enzyme activity and effectiveness. Acid rain (from automobiles and industry) is a common way that humans reduce pH in the environment.

TDS

Total Dissolved Solids (TDS) is a measure, in parts per million (ppm) or parts per thousand (ppt), of the amount of dissolved materials in the water. Ions such as potassium, sodium, chloride, carbonate, sulfate, calcium, and magnesium all contribute to the dissolved solids in the water. In many instances resource agencies use the terms TDS and salinity interchangeably, since these ions are typically in the form of salts. Measuring total dissolved solids is a way to

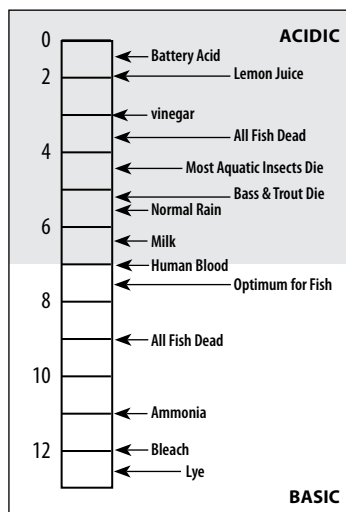


Figure 1. pH Chart with aquatic environmental impacts.

estimate the suitability of water for irrigation and drinking. This is an important parameter for irrigation water as too much salt can reduce or even prohibit crop production while too little salt can reduce water infiltration. And in drinking water, high TDS values may result in a 'salty' taste to the water.

Groundwater often has higher levels of dissolved solids than surface water because of its contact with geologic material (underground), and has had more time to dissolve rock and minerals into the water. When stream flow is at base flow conditions, most of the source water is from groundwater, and dissolved solids concentrations are high. When stream flows are high from rain or snowmelt, dissolved solids measurements are typically low.

EC

Electrical Conductivity is a measure of the ability of a substance to conduct an electrical current, measured in micro-Siemens per centimeter ($\mu\text{S}/\text{cm}$). Ions such as sodium, potassium, and chloride give water its ability to conduct electricity. Conductivity is an indicator of the amount of dissolved salts in a stream. Conductivity measures the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge). Organic compounds like oil, phenol, alcohol, and sugar do not conduct electrical current very well and therefore have a low conductivity when in water. Conductivity is also affected by temperature: the warmer the water, the higher the conductivity. For this reason, conductivity is typically reported as conductivity at 25 degrees Celsius (25°C). Conductivity often is used to estimate the amount of total dissolved solids (TDS) rather than measuring each dissolved constituent separately.

DO

Dissolved Oxygen (DO) is needed by fish and other stream organisms. In unaltered streams, dissolved oxygen levels usually determine the ability for the stream to support aquatic oxygen-dependent life, as defined by temperature, channel grade and elevation. As plant and animal material decays, it consumes dissolved oxygen. Turbulence, interaction with the air, and photosynthesis replenish oxygen in the water. Cold water can hold more dissolved oxygen than warmer water. Dissolved oxygen measurements can be expressed as a concentration, milligrams per liter (mg/L), or as percent saturation (the amount of oxygen the water holds compared to what it could absorb at that temperature).

Nutrients

Nutrients are chemical elements that are essential to plant and animal life and growth. **Ammonia, nitrogen and phosphorus** are nutrients that are important to aquatic life. Some nutrients form a part of the water's TDS, others, such as ammonia, are found dissolved completely into the solution. At high levels, however, they are considered contaminants. High levels of nutrients can cause

increased growth of algae beyond what is normal. Decaying algae mats can cause foul odors and tastes. And as algae, can produce energy or decay which can remove dissolved oxygen from the water, change pH, conductivity, and turbidity conditions. High nutrients in source water (drinking) can also cause severe impacts to human health.

Nutrients are measured in milligrams per liter (mg/L). Commonly measured nutrient parameters include nitrate, ammonia, orthophosphate, and total phosphorus. Both nitrogen and phosphorus are affected by chemical and biological processes that change their form and transfer them to or from water, soil, decaying organisms, and the atmosphere. In this way, nutrients are “cycled” or moved through the environment. In nature, both nitrogen and phosphorus come from the soil and decaying plants and animals. Fertilizers, untreated sewage, as well as domestic and wild animal waste are common sources of nutrients.

Other chemical parameters

Other chemical parameters commonly measured in agricultural settings are various soil minerals, and pesticides. If monitoring for pesticides is of interest to your program, you should contact your local water quality advisors, CA Department of Pesticide Regulation (<http://www.cdpr.ca.gov>) as well as the appropriate certified laboratory to verify that they conduct this type of analysis, and then plan your program according to their specified protocols. We will not discuss the various mineral and pesticide constituents in detail here; however there will be references to proper sample collection procedures for pesticides in Section 4 of this Field Guide.

Physical Parameters

Flow

Stream flow (discharge, Q) is the volume of water discharged or moving through a stream at any given time. Stream flow often is expressed in cubic feet per second (cfs) or sometimes as gallons per minute (gpm). The discharge of a stream can vary on a daily, weekly, monthly, and seasonal basis in response to precipitation, snowmelt, dry periods, and water withdrawals. Stream flow affects water chemistry; thus, water quality measurements should always be interpreted in relation to stream flow when possible. Water quality measurements are most commonly taken as a **concentration** of a given parameter. Concentrations can be coupled with stream flow information to give a measure of **load** for that parameter.

Stage is a way to measure the surface water level. Stage is simply the height of the water surface relative to the height of a reference marker that doesn't change. Stage is measured with a metered scale, a **staff gage**, permanently positioned along the water's edge.

The staff gage is used for a quick visual indication of the surface level in reservoirs, rivers, streams, irrigation channels, weirs and flumes, and wherever accuracy and readability are important. The stage of a stream or lake is the height of the water surface above an established plane. The water surface elevation referred to some arbitrary or predetermined gage level is called the gage height. Gage height is often used interchangeably with the more general term stage, although gage height is more appropriate when used with a reading on a gage. Stage or gage height is usually expressed in feet and hundredths of a foot.

Water Temp

Water temperature is a crucial aspect of aquatic habitat for two reasons. First, water temperature affects nearly all other water quality parameters. Second, aquatic organisms are adapted to certain temperature ranges. As the upper and lower limits of the range are approached, the organism becomes more susceptible to disease. Also, fish that spend extra energy searching for cool areas might be at a disadvantage when competing for food. Stream temperature is regulated by solar energy, the surface area of the stream, shade, the volume of water moving through the stream, and a variety of other factors like percent cover of vegetation, urban and commercial sources of water, etc.

Turbidity

Turbidity is a measure of the amount of particulate matter (organic and inorganic) and dissolved color that is suspended in water. Water that has high turbidity appears cloudy or opaque. High turbidity can cause increased water temperatures because suspended particles absorb more heat and can also reduce the amount of light penetrating the water. High levels of turbidity make it difficult for fish to find prey or breathe, and indicate high levels of suspended solids. Turbidity often is measured as a way to estimate amounts of suspended solids. Turbidity is an optical property, however, and does not directly reflect the amount or types of solids; thus it must be used carefully. Turbidity is measured in Nephelometric Turbidity Units (NTU), or Jackson Turbidity Units (JTU).

Suspended Solids

Suspended solids are particles of sand, silt, clay, and organic material moving with the water or along the bed of the stream. Suspended solids usually are measured as a concentration, milligrams per liter (mg/L). High levels of suspended solids can cause problems for aquatic organisms, both as the solids travel through the water and after they are deposited on the streambed. Suspended solids can reduce visibility, making it hard for fish to find prey. Solids also can clog the gills of fish and suffocate macroinvertebrates such as insects.

Transparency

Transparency or water clarity measures the ability of light to pass through water. Secchi depth is the depth to which one can see into a lake and is an indication of water clarity. This measurement—an alternative to measuring turbidity—is obtained by lowering a black and white Secchi disk into the water and recording the depth at which it is no longer visible as well as the differences in color. An adaptation of the Secchi disk is a transparency tube which is used in the shallower waters of streams. Water clarity is measured in feet with a Secchi disk, or in centimeters with a transparency tube.

Biological Parameters

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Coliform bacteria are used as one indicator of water contamination. Most coliform bacteria do not transmit diseases, but they are a very common group of bacteria and are prevalent in fecal material of warm-blooded animals. As such, they can be an indication of contamination from livestock, faulty septic systems, sewer line failure, etc. However, coliform bacteria are also a natural component of the aquatic ecosystem, and can originate from natural sources such as decaying organic matter (detritus) and wildlife. Not all coliform bacteria originate from fecal sources. High measurements of total coliform need to be interpreted considering these natural sources.

Pathogenic Indicators

Bacteria such as *Escherichia coli* (*E. coli*) or fecal coliform, and total coliform are measured as indicators of more harmful bacteria referred to as pathogens. High numbers of these types might indicate the presence of other bacteria that cause illness. Total coliform is a measure of all bacteria present, while *E. coli* and fecal coliforms are specifically indicative of warm blooded animals as sources. Most analytical methods involve growing bacteria in a water sample on a Petri dish and counting the colonies. The results are given as the number of colony forming units (CFU) per 100 milliliters (ml) of water or, more commonly, as a statistical reporting of colony production, referred to as the most probable number (MPN) of colony forming units. Bacteria populations fluctuate in response to stream flow, temperature, energy sources, disturbance of the streambed, time of year, and time of day. Bacteria can survive for long periods on land and in stream sediments as well as suspended in the water column.

Field Conditions & Observations

Observations of **Field Conditions** are important pieces of information to collect whenever any monitoring is done as they could have an affect on your monitoring results. Information about what's happening in the field is vital to understanding the environment you are monitoring.

It is important to record information on the conditions you observe at the site, such as weather, streamflow, presence or absence of animals, soil or bank conditions, vegetation (specifically noting any changes), as well as technical information like who was present, sample collection and handling, and equipment notes. These are all vital pieces of information important to your actual monitoring results.

Example: The growth and development of the vegetation canopy of a stream side willow planting might affect the water temperature, and therefore the dissolved oxygen, pH, conductivity, or other water quality parameters you are measuring. Therefore a measurement of the willow survival rates, leaf development, height in inches or feet, the amount of stream channel cover, etc, should be included in your water quality field data collection.

Land Use Impacts on Water Quality

If you have a concern that certain land uses or activities in your watershed may be impacting water quality, you may be able to focus your monitoring efforts. Many land uses have specific types of water quality impacts associated with them. For example, excess lawn fertilizers and pet waste often result in runoff from residential areas containing high levels of bacteria and phosphorus or nitrogen. Table 1 contains a list of common land uses and potential water quality impacts.

Table 1. Common water quality impacts potentially associated with selected land uses.

Source	Common Pollutants or Impacts
Rangeland Agriculture and Grazing	Sediment, fecal bacteria, turbidity, nutrients, thermal impacts
Construction	Sediment, turbidity, total suspended and dissolved solids, thermal impacts, dissolved oxygen or biochemical oxygen demand
Cropland	Sediment, turbidity, total solids, nutrients, thermal impacts, pesticides
Forestry	Sediment, turbidity, total solids, thermal impacts
Lawns/Golf courses	Nutrients, turbidity, total solids, bacteria, pesticides
Marinas/Boat usage	Nutrients, bacteria, petroleum hydrocarbons, metals
Mining	Sediment, alkalinity, pH, total dissolved solids, leached metals
Recreation	Fecal bacteria, nutrients, turbidity, total solids
Septic systems	Fecal bacteria, nutrients, dissolved oxygen/biochemical oxygen demand, conductivity, thermal impacts
Sewage treatment plants	Dissolved oxygen/biochemical oxygen demand, turbidity, total solids, conductivity/salts, nutrients, fecal bacteria, thermal impacts, pH, manufactured chemicals
Suburban/Urban runoff	Turbidity, nutrients, pesticides, thermal impacts, conductivity/salts, dissolved oxygen/biochemical oxygen demand, bacteria, metals, petroleum hydrocarbons

Source: USDA Cooperative State Research, Education, and Extension Service (CSREES)
www.usawaterquality.org/volunteer/Outreach/DesigningYourStrategy.pdf

Where do Water Quality Objectives come from?

Each state is obligated to adopt water quality standards for both marine and inland surface waters within their jurisdiction under the Clean Water Act. Water quality standards consist of a list of designated **beneficial uses** and **water quality objectives** designed to protect those uses.

In California, The State Water Resources Control Board (Water Board or State Board) is responsible for making sure this occurs. The State Board assigns water quality standards for marine waters within 3 miles of the coast. These water quality standards for the marine environment are contained in the California Ocean Plan. (The California Ocean Plan can be viewed at <http://www.swrcb.ca.gov/plns/pols/>)

For inland waters, the State Board allocates this responsibility to the nine Regional Water Quality Control Boards (Regional Boards) (Figure 2). The Salinas River watershed runs south to north, right down the middle of Region 3, the Central Coast Regional Water Quality Control Board jurisdiction.

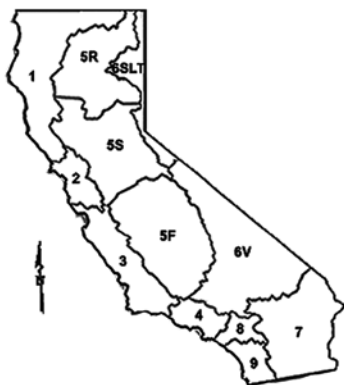


Figure 2. The nine Regional Water Quality Control Board regions of California.
<http://www.swrcb.ca.gov/regions.html>

Beneficial Uses & the Basin Plan

Every surface water body is considered to have some use or uses that benefit the general public, wildlife, or aquatic life; these are called **beneficial uses**. Just a few examples of beneficial uses are COLD or WARM water Fishery, Commercial and Sport Fishing, Recreational Body Contact, Wildlife Habitat, Marine Habitat, and Agricultural Water Supply.

Each Regional Board creates a document known as a **Basin Plan** that specifically designates beneficial uses and **water quality objectives** for all surface water bodies within their region. The Basin Plan also incorporates the water quality objectives created in the California Ocean Plan. In the Central Coast area (Region 3), there are 24 separate beneficial uses designated on almost 500 named waterbodies identified in 13 sub-basins that have been incorporated into the Basin Plan. Figure 3 shows the waterbodies of the Central Coast Regional Water Quality Control Board.¹ You can view a copy of the Basin Plan for the Central Coast on-line at: <http://www.waterboards.ca.gov/centralcoast/BasinPlan/Index.htm>



Figure 3. Designated watershed areas for the Central Coast Hydrologic Planning Area (Figure 2-1 from the Central Coast Regional Water Quality Control Board - Water Quality Control Plan (a.k.a., Basin Plan, 2003.))

¹ http://www.waterboards.ca.gov/centralcoast/BasinPlan/BP_text/chapter_2/figs_n_tables/fig_2-1.doc

Once the beneficial uses for a water body are designated, it must be determined if the water body can support these uses. This is accomplished by various means of testing the water and comparing the results to the water quality objectives stated in the Basin Plan. Many governmental organizations have staff in the field to do this as part of their legal obligations to determine the quality of water in their state per the Clean Water Act; such as the Department of Water Resources, the State and Regional Boards, and the California Environmental Protection Agency. Many of the resource protection agencies like the California Department of Fish and Game, and U.S. Fish and Wildlife Services, and NOAA Fisheries, among others, also collect data on surface water quality. And various City and County Government, Educational, Federal Government, Industry, Municipal, Non-Profit and Research Institutes also monitor water quality of surface waters.

Additionally, on the Central Coast, Central Coast Water Quality Preservation, Inc. (CCWQP) collects water quality information associated with the region's Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands adopted by the Central Coast Regional Water Board in July 2004.

Water Quality Objectives

Water Quality Objectives (WQO) are the enforceable limits of a given water quality metric (like temperature, dissolved oxygen or nitrate) that are set at levels intended to be protective of the designated beneficial uses.

In some cases, the objectives are ranges of measurable values, like pH that must be between 6 and 8, in other cases a value may not fall below or exceed a specific value, like nitrate must not be higher than 10 mg/L (the US EPA drinking water standard) for the beneficial use of REC1, or Recreational uses with full body contact (like swimming). In other cases, the value may not exceed baseline values found in the waterbody by more than a set amount.

Example: If a water body has a designated beneficial use of Cold Water Fishery (COLD), then the temperature for the given water body must be such that the fish can survive. Here on the Central Coast that general objective states that "normal temperatures may not be increased by more than 5° centigrade."

WQOs are established for "receiving waters" and not discharge waters; so be aware of the impacts that all discharge can have on the waterbody that it flows into. Receiving waters are any rivers, streams, estuaries, ocean, or other waterbody into which urban or storm runoff, agricultural discharges or treated wastewater is discharged. In the Central Coast region, there are 99 designated waterbodies listed in the Basin Plan² - rivers, streams, lakes,

² http://www.waterboards.ca.gov/centralcoast/BasinPlan/BP_text/chapter_2/figs_n_tables/table_2-1.doc

reservoirs, bays, harbors, estuaries, and beaches - each with its own set of beneficial uses and water quality objectives. There are also water-body-specific objectives that are more exact.

What is a TMDL?

Under **Section 303(d)** of the **Clean Water Act**, states, territories and authorized tribes are required to develop a list of water bodies that do not meet EPA water quality standards, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that these jurisdictions establish priority rankings for water on the lists and develop action plans, called **Total Maximum Daily Loads (TMDL)**, to improve water quality³.

Section 303(d) Section states:

Each State shall establish for the waters identified in paragraph (1)(A) of this subsection, and in accordance with the priority ranking, the total maximum daily load, for those pollutants which the Administrator identifies under section 1314(a)(2) of this title as suitable for such calculation. Such load shall be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality.

The States comply with this requirement by periodically assessing the conditions of the rivers, lakes and bays and identifying them as “impaired” if they do not meet water quality standards. These waters, and the pollutant or condition causing the impairment, are placed on the **303(d) List of Impaired Waters**. In addition to creating this list of waterbodies not meeting water quality standards, the Clean Water Act mandates each state to rank each waterbody by factors such as the severity of the problem, potential to restore beneficial uses, availability of data, etc., and develop TMDLs for each waterbody listed. TMDLs will be developed based on a schedule that accounts for priority ranking, availability of resources, and other considerations.

The TMDL is the maximum amount of a particular material that a waterbody can assimilate on a regular basis and still remain at levels that protect beneficial uses designated for that waterbody.

TMDLs are developed by analyzing data and information provided by existing or commissioned studies, and/or by stakeholders interested in the waterbody or conditions being investigated; development results in a clear definition of water quality problems in a waterbody or watershed, a numeric value for the

³ http://www.waterboards.ca.gov/tmdl/303d_lists2006approved.html

TMDL, and a separate implementation plan that identifies how the problems will be solved and the TMDL achieved. The implementation plans identify new requirements, based on existing regulations, in conjunction with other existing water quality management activities. The implementation plans identify which requirements or activities (via voluntary or regulatory programs) apply to which agencies, landowners, resource managers, and/or the public. Typically, TMDLs and their implementation plans will be developed by Regional Board staff, and approved by adoption into the Regional Board's Basin Plan.⁴

Just like the programs mentioned above, your monitoring results should be compared to the appropriate water quality objectives to determine if your waterbody is supporting the designated beneficial uses.

Note:

- **Receiving waters** are creeks and streams, lakes and reservoirs, flood control channels, rivers, bays and estuaries, and the oceans.
- Beneficial uses, water quality objectives, basin plans and TMDLs are written for **receiving waters** not discharge waters.
- Water quality measurement or analysis results taken from discharge waters must be put in the context of the receiving waters that they discharge into.

How Your Monitoring Helps Protect Water Quality in the Region

With numerous listings of impairments in our region, an incredible amount of water quality information needs to be collected to insure that the decisions being made are well informed. It is impossible for any one group or agency to do this. You can choose to contribute your data to local non-regulatory resource groups who can use it to paint a picture of general environmental conditions for each creek. This will help to focus the restoration energies where it will matter the most.

However, most importantly, your data will show you where water quality is poor, in direct relation to your land, and land use practices. This will inform you of your inputs and allow you to make decisions about your practices in the privacy of your own operation.

If you find that you are contributing to water quality pollutant loads, then you can choose to change your practices to reduce the pollutants coming off your land. By doing this, no matter how small a change you might make, you will be reducing the overall contribution of pollutants from agriculture – and you will be improving the water quality of the whole region, one farm at a time!

⁴ <http://www.waterboards.ca.gov/centralcoast/TMDL/index.htm>

If you find that you are not contributing to water quality pollutant loads, then you can choose to maintain or improve your practices to reduce pollutants coming off your land.

You can be a part of the solution for improving water quality on the Central Coast of California.

*Get to know your watershed better -
including its beauty and its problem areas.*

Water Quality Monitoring Strategies

For many years, agencies and citizens across the United States have been monitoring water quality as a way to track pollution and determine the condition of aquatic ecosystems.

Water quality monitoring results and information are collected to:

- Census the water quality status of a particular water body
- Identify particular pollutants of concern
- Target sources of pollution
- Determine the effectiveness of watershed restoration and enhancement projects
- Detect trends

Individuals and volunteers have begun to monitor additional aspects of aquatic systems to gain a more complete picture of watershed health. These aspects include stream water quality, the physical structure of the stream channel, and various habitat conditions. By monitoring water quality, stream life, and habitat, you can develop a better understanding of the health of stream ecosystems that surround you.



Figure 4 . Volunteers monitoring water quality in Nobel Gulch, Santa Cruz County (CWC, 2006)

Developing a monitoring program that meets your informational needs is important; the next section will discuss basic types of monitoring approaches.

Planning Your Monitoring Activities

Before you begin...

The basic determining factors you will need to know before you can start a monitoring program are presented here in a series of nested questions. Use these questions as a launching point to focus your water quality monitoring program:

What is the water quality “problem”?

- What are the water quality concerns in your area? (excess nutrients, or high turbidity?)
- What are the conditions, impacts, changes, you have observed?
- What water quality impacts might you be contributing to in your area?

Why do you want to monitor water quality?

- What is your question? – What are your goals?
- What do you want to know vs. what do you need to know about water quality?
- What parameters are important to your question?

What is the technical ability your program will need?

- Will you be able to do this in-house, or will you need others?
- Will you need to use field equipment or a laboratory? Or both?
- Will simple equipment and analysis answer your question, or not?

When are you going to monitor? – is it important to your question?

- How long will you monitor? (just once, for weeks, months, years...?)
- How frequently? (daily, weekly, monthly...?)
- What time of day will you monitor? (dawn, 9:00, noon, when you can...?)

Where are you going to monitor? – is it important to you question?

- What watershed are you in? – Where does water come into the picture?
- Where does it go when it leaves the site?
- Where will you monitor? Where are your specific site locations?
- Who else is monitoring in the area – where?, and for what?

What is your budget? – time is money, money is time...

- How many dollars do you have?
- Who will conduct the monitoring? – How much time do they have?
- How long will those resources last?

Having a detailed understanding of your problems, goals and limitations will guide you to determine your monitoring strategy. Having a written manual helps to ensure consistency between monitors over time, and is an important quality assurance element for many programs.

An environmental monitoring program should not be done to pass time and spend money. It should be designed to collect information that will answer your important questions. Water quality questions vary considerably, and can easily grow out of control if you are trying to determine every variable and influencing factor possible. Determining your most valuable question, and designing the monitoring program to collect the information necessary to answer that question should be the approach.

A **monitoring strategy** describes what, how, and where you will monitor in order to answer a particular water-quality question. A **monitoring plan** is your strategy articulated in a single coherent document. In order to gain useful data from a water quality monitoring program, it is essential to articulate the question you are trying to answer. From this question you develop the goals and objectives for the project. In turn, these goals and objectives will guide you in designing a monitoring strategy.

Your monitoring question will guide you in deciding which parameters, where, and when to sample.

Examples of water quality monitoring questions include:

- Have suspended sediment levels changed over time at a site?
- How do nutrient levels vary among streams that flow through areas with different land uses?
- Has water temperature changed as a result of planting willows along a small stream?
- Has the implementation of a new land management practice changed the water quality conditions?

Can you see how each question might produce a different monitoring strategy?

The following two examples are additional approaches to designing your monitoring questions, goals, and strategies from other programs. Figure 5 provides a flow chart of a monitoring program design approach starting with

the problem and ending with evaluation of outcomes, while Table 2 provides an example of increasingly specific goals and objectives for a monitoring program. Note: there are many unmentioned opportunities for evaluation and feed-back loop in these examples, or any process you might take, to get at the best approach for designing your monitoring program.

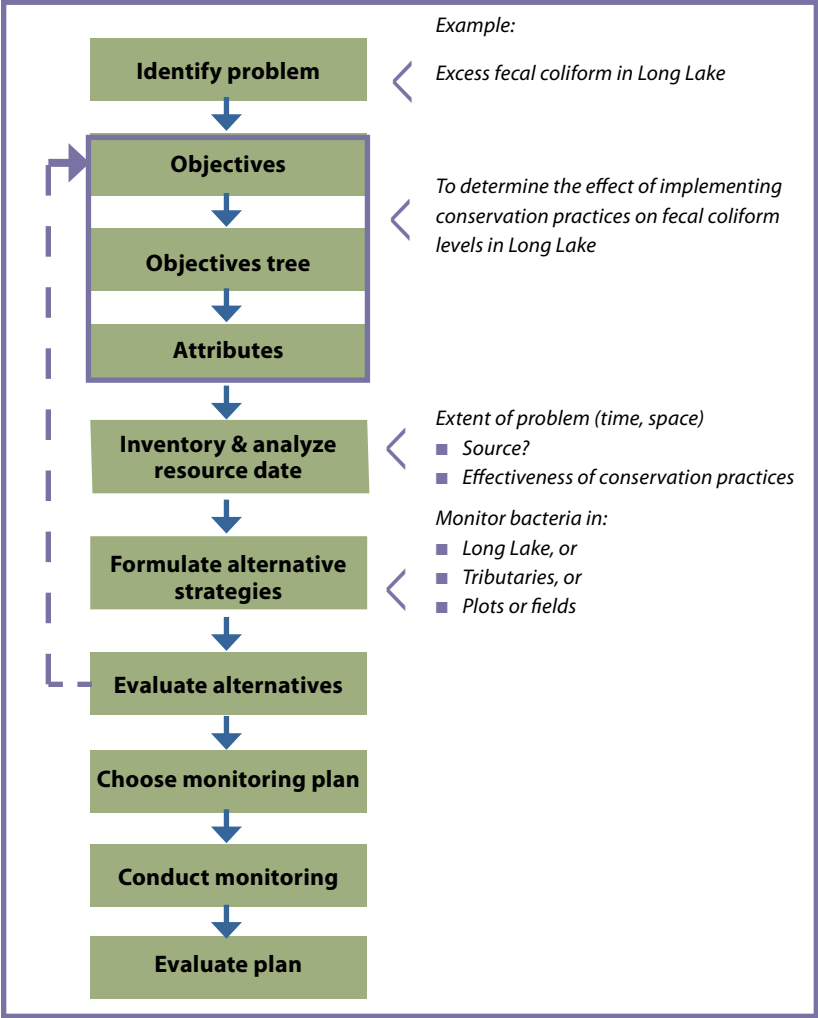


Figure 5. Steps in decision making for a water quality monitoring systems. *National Water Quality Handbook*, September 2003. http://www.info.usda.gov/scripts/lpsiis.dll/H/H_450_600_a.pdf

Table 2. Example of increasingly specific goals for a watershed monitoring project (produced by the Oregon Department of Environmental Quality Volunteer Monitoring Coordinator, Oregon State University, 2002).

Purpose	Goal	Method
Support total maximum daily load (TMDL) development.	Collect data of appropriate quality for use in temperature computer models.	Measure continuous temperature and flow (end of summer) at the mouth of major tributaries to the mainstem river. Compile temperature data and quality assurance information forms. Submit data electronically in forms at end of season.
Fill data gaps identified in watershed assessment.	Measure water quality and habitat in low-gradient streams flowing through agricultural lands	Measure pH, dissolved oxygen, and temperature frequently enough to detect diurnal fluctuations in summer. Collect macroinvertebrates in early fall and compare results from professional identification with those from reference sites.
Educate community about links between water quality and land use.	Collect sufficient data to demonstrate differences in water quality in streams bordered by healthy and degraded riparian zones.	Assemble existing water quality information from two contrasting areas and summarize in a poster for library display. Measure shade, channel width, and substrate once a year and water quality quarterly at two contrasting sites. Interpret data by comparing existing standards and illustrating differences in seasonal fluctuations.
Monitor effectiveness of restoration projects.	Collect sufficient water quality data to detect trends or for at least 5 years.	Measure shade, flow, and channel characteristics at restoration sites once a year. Collect continuous data upstream and downstream of restoration sites during each summer. Use appropriate step trend analysis to compare data collected before and after a restoration project.

Variability

One of the challenges of designing a water quality monitoring strategy and interpreting the resulting data is that stream conditions can change hourly, daily, seasonally, annually, and over the long term, even without human impacts. Dissolved oxygen concentrations, for example, can change throughout the day as water temperature changes and algae respire. Stream flow will vary from day to day, month to month, and between years. These changes affect the levels of many water quality parameters. To yield useful information, a monitoring strategy must address this environmental variability.

Temporal variability refers to how conditions change over time.

Spatial variability refers to how conditions change from place to place.

Both temporal and spatial variability are present, irrespective of when or where monitoring is conducted. A goal of a well planned monitoring program is to characterize the temporal and spatial variability of the water.

The following monitoring approaches are basic descriptions of different ways you could address these variables of space and time, in standardized approaches.

Types of Monitoring Approaches

Ambient, Discharge, Baseline, Trend, and Effectiveness monitoring are the most common types of monitoring used to address common monitoring questions. This section briefly introduces each type and applies it to monitoring stream temperature. These and other monitoring types are discussed further in many of the resources listed at the end of this chapter.

Ambient Monitoring

Ambient monitoring involves collection of information from receiving water bodies beyond the immediate influence of a discharge pipe, injection well, or other source. Ambient monitoring is generally not specific to any particular project, practice, or land use.

Ambient monitoring programs have typically fixed station networks and record conditions in the aquatic environment—streams, lakes, bays, estuaries, and oceans, and may include sampling of sediments and living resources, as well as chemical, physical, and biological analyses.

Discharge Monitoring

Discharge monitoring involves collection of information from specific inputs to receiving water bodies from any number of different sources, such as agricultural return flows, urban runoff, or waste water treatment plant effluent.

Baseline Monitoring

Baseline monitoring establishes a reference point of conditions at a given place and time. This reference point then can be compared with future conditions, or against a given standard. For example, a few typical questions for baseline monitoring might be “What is the Temperature at a specific site right now, and how does that compare to the water quality objective?” or “What are the current nutrient levels of samples collected in natural streams, at the bottom of an agricultural watershed?” For baseline monitoring one should collect measurements for a set amount of time at a particular point in the watershed.

Baseline monitoring is always the first step in any project implementation that is expected to change water quality conditions, and is the basis for both **trend** and **effectiveness** monitoring programs. Baseline monitoring is done with the explicit purpose of comparison to a change; whether that is just over time, or in anticipation of an expected change (Example: management practice/project implementation).

Trend Monitoring

Trend monitoring involves repeated measurements at a site over a period of time to identify changes over time. These measurements are examined to see whether a pattern emerges such as an increase, decrease, or cycle. A typical trend monitoring question about temperature might sound like “Has stream temperature increased over time at a particular site?” To understand why stream temperature has changed at a site, it is important to measure other factors that affect stream temperature. Stream flow, for example, is extremely important. The smaller the volume of water, the more easily it heats. Therefore, stream flow should be considered when developing a monitoring strategy to observe water temperature changes. It also is important to make measurements at the same times each year for consistency.

Effectiveness Monitoring

Effectiveness monitoring is used to determine whether a management activity has produced the desired water quality benefits in relation to ambient water quality. For an irrigation-related practice, one might measure uniformity of sprinkler spray throughout a field to assess benefits to their crops. One might measure water temperature to address the question “Did planting cottonwoods along the stream improve (e.g., reduce) water temperature?”

Three common approaches to effectiveness monitoring are to monitor:

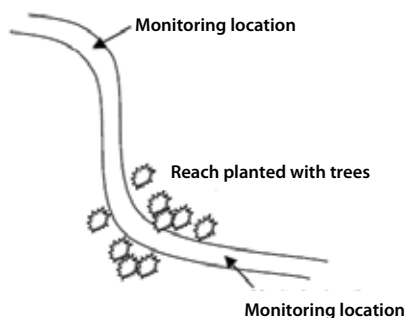
- Before and after the project
- Upstream and downstream of the project, or
- With paired reaches of the stream or paired streams

The following example will illustrate the basic concepts used in establishing monitoring sites with temporal (before and after) and spatial (above and below, and paired) controls.

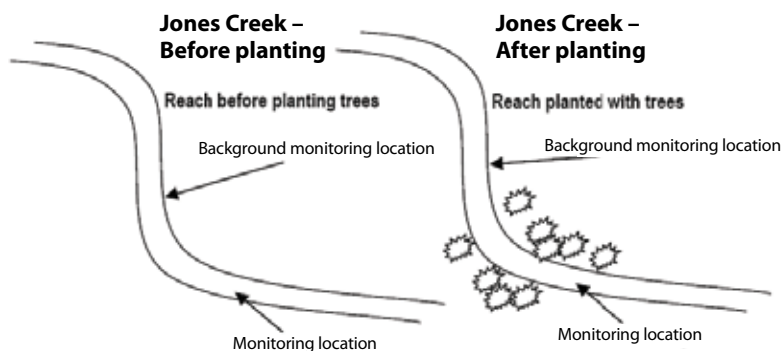
Example: Jones Creek willow planting restoration project

Question – Will planting willows along the stream bank reduce water temperatures in the creek?

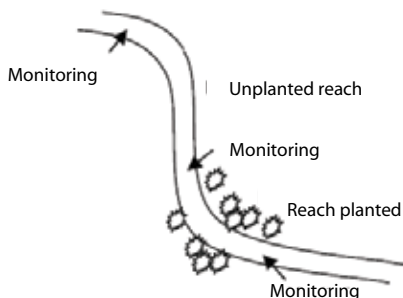
Above and below monitoring conducted at two monitoring locations at one project site on Jones Creek, one above the project site, and one below. Monitoring is conducted after the project; there is limited ability to determine a change in conditions.



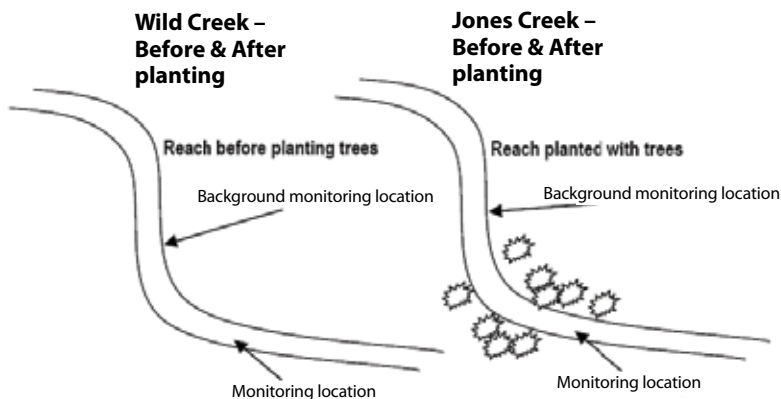
Before and after monitoring is conducted at the project site on Jones Creek. In this example there is one monitoring site above the project site and one below. Monitoring is conducted before project implementation and again after the project is completed to see if there was a change. Additional variables should be considered with “before and after” monitoring. For example, air temperature changes in land use/crop rotations on adjacent fields (may change every few months, and irrigation patterns change with the crops), differences in weather patterns, etc.



Paired Reach monitoring is similar to “above and below” monitoring because it is conducted at one project site and one reference site upstream on the same creek. Monitoring is ideally conducted at both reaches before project implementation and again after project completion to see if there was a change. The unplanted site is a “reference reach” with approximately identical conditions to the project site.



Paired Stream monitoring is a variant of paired reach monitoring conducted on two separate streams. Monitoring is conducted downstream of the main project site and at a reference site on a different creek (Wild Creek) both before and after the Jones Creek planting project.



Elements of a Monitoring Program

Once you’ve determined what, and why you will monitor, you will want to create a monitoring procedures manual just for your program. This guidebook was designed to provide all the basic information necessary for you to do this for your program, but there are many questions about your program that cannot be known. There are numerous resources and advisors in our region to help you build your water quality monitoring program – Take Advantage of Them! (Please review the inside back cover of this field guide)

Although you may never completely incorporate many of the following technical elements into your water quality monitoring program, it is important to have a general understanding of what they are, and know that they are part of any structured water quality monitoring program you might interact with or receive data from.

The following provides a concise list of the important elements of any water quality monitoring program. The “Ten Components of a Successful Water-Quality Monitoring Program” is a section of the article **“Water Quality Monitoring”** by, **Kitt Farrell-Poe (2005), Arizona Cooperative Extension, for their Arizona Master Watershed Steward Program.**

This article introduces considerations for anyone wishing to start a water-quality monitoring program. These considerations and others are discussed in more detail in publications such as *Volunteer Stream Monitoring: A Methods Manual* (USEPA, 1997), *The Volunteer Monitor’s Guide to Quality Assurance Project Plans* (USEPA, 1996), *Starting Out in Volunteer Water Monitoring* (USEPA, 1998; www.USEPA.gov/owow/monitoring/volunteer/startmon.html) and the *Designing Your Monitoring Strategy: Basic Questions and Resources to Help Guide You* (USDA-CSREES Volunteer Water Quality Monitoring Project):

Ten Components of a Successful Water-Quality Monitoring Program

1. A diverse Technical Advisory Committee. *Get some Advice*

A Technical Advisory Committee (TAC) is a group of people who can provide technical review of all stages of the monitoring project. Many granting programs require review by some type of technical review committee.

Ask for input from a diverse group of local resource and water quality advisors before you start a monitoring program. Don’t forget that there are many local resource organizations such as the Resource Conservation District (RCD), Natural Resource Conservation Services (NRCS), or Farm Bureau offices, as well as local research institutes, universities, and non-profit organizations that can help with this process.

In the TAC/Advising group you can:

- Work together to develop a sound approach to collecting information

that will inform your water quality questions and contribute information to the region.

- Learn what others are doing and why, what equipment or laboratory would be best to use for your program.
- Understand what the water quality impacts are, and what is likely to affect water quality in your area.
- Evaluate your monitoring questions and/or concerns, and evaluate resulting data.

2. Clear monitoring questions.

Know what you want

A clear monitoring question is essential for producing useful monitoring results. Defining the problem, goals, and objectives at the beginning of a monitoring project will help structure the monitoring so that the data collected provide reliable answers to

the questions. Draw on your local advisors to help define your water quality monitoring question and program goals. The EPA¹ & USDA² have extensive materials online to assist you with this process.

3. Quality Assurance Project Plan (QAPP) *Define your program*

A Quality Assurance Project Plan outlines monitoring procedures in detail so that the samples, data, and reports are of high enough quality to meet project objectives. It describes the field, laboratory, and data management protocols; procedures for training and overseeing monitors; and data interpretation and presentation methods. Ideally, the plan is developed in collaboration with your advisors or TAC, and is approved by funding agencies or those that will use the data. In California, the Regional Water Quality Control Board staff in your region provides input into these plans, and State Water Resources Control Board's QA Officer approves them. Anyone receiving state resources to conduct water quality improvement projects, or to conduct water quality monitoring, must have one. USEPA's The Volunteer Monitor's Guide to Quality Assurance Project Plans provides step-by-step instructions on how to develop a quality assurance project plan³.

4. A well-designed sampling strategy. *Make a Plan*

A sampling design or strategy is the "what, where, when, and how" of water-quality monitoring. Choose parameters, sampling schedules, sampling locations, and methods that will answer your monitoring questions, then lay it out in a simple monitoring plan documenting your efforts...*it need not be complicated!*

5. Appropriate testing methods. *Choose your methods*

The method you choose to measure each parameter plays a large role in the overall quality of your data. In choosing methods, take the following factors into consideration. Precision and accuracy describe the repeatability of the measurement and how close it is to the true value of the parameter, respectively.

Most parameters can be measured at varying levels of precision and accuracy. A colorimetric pH kit, for example, might measure pH to a precision and accuracy of +/- 1 pH unit. A pH meter and probe, on the other hand, might measure pH with a precision and accuracy of 0.1 pH unit. Equipment such as a pH meter must be properly calibrated to produce both precise and accurate in measurements. Cost generally increases as precision and accuracy increase. It is not always necessary to use highly accurate methods, so you might want to prioritize where to put your money. The level of expertise necessary to produce reliable data depends on the method. Depending on the time available for training and supervision of monitors, you might want to choose a simple method with few steps and chemical reagents versus a more complex method.

6. Quality Assurance (QA) and Quality Control (QC).

Check Yourself

Quality Assurance and quality control, often referred to as QA/QC, ensure the quality of the data. Quality Assurance is the overall project management, including organization, planning, data collection, documentation, and quality control. Quality Control, on the other hand, is a series of technical activities

conducted routinely to minimize errors. Errors can occur in the field, laboratory, or office, so QC should be included in all aspects of the project. Examples of QC activities include repeating field measurements, calibrating equipment properly, splitting samples with a professional laboratory, reviewing data sheets for errors, and checking an electronic database against data sheets. The Volunteer Monitor's Guide to Quality Assurance Project Plans provides more detailed guidance on QA/QC activities (USEPA, 1996).

7. Training. *Do it Right!*

Monitoring staff or volunteers must receive training and commit to collect data according to the monitoring plan and selected methods. Staff or volunteers must coordinate sample collection, equipment calibration and maintenance, and chemical management (if any). Training should be conducted periodically, even if participants have been monitoring for a long time. Include a description of the training procedures and schedule in the monitoring plan.

8. Safety. *Protect yourself*

Always follow safety precautions in the field and laboratory; no water sample is worth injury, exposure, or death. Encourage individuals collecting field data to work with a partner at all times. If possible cancel monitoring during hazardous weather, *and - take appropriate precautions when conducting storm monitoring*. If monitors will be wading streams, provide training on estimating hazardous stream flows. In both the laboratory and the field, wear gloves and goggles when using chemicals. Dispose of chemicals properly.

9. Data management.

Keep Track of it

Collect and store data so that they are easily accessible in case your project experiences staff turnover or receives requests for data from outside organizations. Use a standardized notebook or field data sheet when collecting water samples and testing them in the field. Data sheets will help you be consistent in your field procedures. They also provide space to record observations that might help you interpret the data. Store results on a computer and back them up on disks. Whether you use a database program or spreadsheet program, the format should be easy for someone outside the project to understand. The State Water Resources Control Board and Regional Boards do have a preferred data storage format for sharing data, all data collected under State resources must be compatible with the Surface Water Ambient Monitoring Program (SWAMP; the statewide monitoring effort designed to assess the conditions of surface waters throughout the state of California: www.swrcb.ca.gov/swamp).

10. Data interpretation and presentation. *Prepare & Share*

Data interpretation and presentation are the final steps, and often the ultimate goal, of monitoring. When designing a monitoring plan, it is critical to include enough time and funding for data interpretation and presentation to the community, TAC, agencies, and other stakeholders. These steps allow the data to be used by water resource management agencies, landowners, and local decision makers. When interpreting data, keep in mind the questions you asked when developing your monitoring plan. Use charts and graphs to attempt to answer the

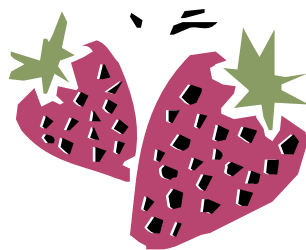
questions. Ask the TAC to review drafts of your reports and findings before you present them to the public. When presenting your results and findings, keep your audience in mind. Different groups might want different products. An agency, for example, might be interested in tables, or might prefer to receive the data electronically. Local residents, on the other hand, might be more interested in seeing the information in newspaper articles, a poster at the local library, or an easy-to-read publication. For a lay audience, it is important to: Use charts, graphs,

maps, and pictures; Reduce tables of numbers to summary statistics; and Write clearly and eliminate technical terms.

¹ EPA's Volunteer Monitoring Program <http://www.epa.gov/owow/monitoring/volunteer/epasvmp.html>

² Volunteer Water Quality Monitoring National Facilitation Project <http://www.usawaterquality.org/volunteer/>

³ The Volunteer Monitor's Guide To Quality Assurance Project Plans <http://www.epa.gov/owow/monitoring/volunteer/qappcovr.htm>.



What's next...?

Now that you have a sense of the importance of monitoring water quality, whether it's for the sake of improving management your operation, contributing to regional understanding or both! The next section will provide greater detail into water quality parameters: what they mean and how they are measured.

Section 2 provides a detailed discussion of the parameters to monitor in a water quality monitoring program, objectives for monitoring water in or discharging into a stream, equipment options, and operating procedures for basic monitoring methods.

Principle Citation for Section 1:

Volunteer Water Quality Monitoring National Facilitation Project • <http://www.usawaterquality.org/>

U.S. EPA, The Volunteer Monitor's Guide To Quality Assurance Project Plans • <http://www.epa.gov/owow/monitoring/volunteer/qappcovr.htm>.

The EPA Volunteer Monitoring Program • <http://www.epa.gov/owow/monitoring/volunteer/epasvmp.html>

"Water Quality Monitoring" Arizona Cooperative Extension, Arizona Master Watershed Steward Program. Kitt Farrell-Poe (2005)

In this Section,
you will learn:

Common water quality
monitoring parameters and why
each is important

What the regional water quality
objectives are for each

and some basic equipment
options



Water Quality Parameters & Equipment

2

Measuring Physical Parameters in the Field

This section consists of a detailed description of many of the parameters commonly measured in water quality programs in our region. As well there are references to the appropriate water quality objectives for the Central Coast, and a list of some inexpensive field equipment options for your use. It is important to note that program objectives will influence the equipment used.

A few Equipment Notes...

Increment, Detection Limit & Measurement Range

The **increment** is the fixed amount of difference an instrument or method can measure; if you count consecutively from 1 to 10, you increment by one. For example, Conductivity probes measure in increments of 10, from zero to 19.90 mS; pH strips measure from 4.5 to 10 in increments of 0.5 pH units; DO Winkler test kit measure in increments of 0.02 ppm

The term **detection limit** can apply to monitoring and analytical instruments as well as to laboratory methods. In general, detection limit is defined as the lowest concentration of a given pollutant your methods or equipment can accurately detect and report as greater than zero. Readings that fall below the detection limit are too unreliable to use in your data set. Furthermore, as readings approach the detection limit (that is, as they go from higher, easier-to-detect concentrations to lower, harder to detect concentrations) they become more suspect.

Note, the **minimum detection limit** of any equipment or lab test should be well below the relevant water quality objective and the detection range of the equipment should reflect expected values. For example, some nitrate test kits have an upper detection limit that is too low to resolve the high nitrate levels seen in some Central Coast streams.

And lastly, the **measurement range** is the range of reliable measurements of an analysis method, an instrument or measuring device. Preassembled kits usually come with information indicating the measurement range that applies. For example, you might purchase a pH meter which is capable of detecting pH levels falling between 6.1 and 8.1. However, pH can theoretically range from 0.0 to 14.00. If acidic conditions (below 6) are a problem in the waters you are monitoring, you will need to use a kit or meter that is sensitive to the lower pH ranges; below 6.1 pH units.

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parameters

1. Air Temperature

Air temperature is an important factor in surface water temperature, and can affect dissolved oxygen and pH or other chemical processes which you might be measuring in the water. Temperature is usually measured in degrees Celsius (°C) or degrees Fahrenheit (°F).

Factors which can affect air temperature include sunlight energy, seasonal and daily changes, vegetation cover (shade), humidity and wind conditions.

Common Regional Water Quality Objective: None

Equipment Options: Bulb thermometer (alcohol spirit liquid; no mercury; \$20), digital thermometer (thermister; \$30-50) or integrated thermometer (i.e., a pH or DO meter which measures temperature as well)



2. Water Temperature

Water temperature has direct effects on water chemistry and the functions of aquatic organisms. Temperature is usually measured in degrees Celsius (°C) or degrees Fahrenheit (°F). Water temperature influences the dissolved oxygen content of the water; the rate of chemical reactions; photosynthesis by algae and other aquatic plants; the metabolic rates of organisms; the sensitivity of organisms to toxic wastes, parasites and diseases; and the timing of reproduction, migration and aestivation of aquatic organisms.

Factors which can affect water temperature include sunlight energy, seasonal and daily changes, shade, air temperature, water depth, inflow of groundwater or surface water, the color and turbidity (cloudiness) of the water, soil erosion, urban, agricultural and storm water runoff.

Common Regional Water Quality Objective

CC Basin Plan: The temperature of any cold or warm freshwater habitat shall not be increased by more than 5°F (2.8°C) above natural receiving water temperature.

Equipment Options: Bulb thermometer (alcohol spirit liquid; no mercury; \$20), digital thermometer (thermister; \$30-50) or integrated thermometer (i.e., a pH or DO meter which measures temperature as well)



3. pH

pH is a measure of how acidic or alkaline the water is at the time of testing. pH is measured on a scale from 1.0 to 14.0. Neutral pH is 7.0. Acidic pH is less than 7.0, and alkaline is greater than 7.0. The pH of a waterbody affects the ability of plants and wildlife to function and live.

Factors which can affect pH are environmental conditions that drive other chemical reactions resulting in an increase or decrease in acidity in the water, air pollution (primarily from exhaust), and surface runoff that contains wastewater from logging or mining sites, farms, and commercial and residential developments which include chemicals and other constituents that alter pH levels.

Common Regional Water Quality Objective

CC Basin Plan: The pH value shall not be depressed below 7.0 or raised above 8.5. Changes in normal ambient pH levels shall not exceed 0.5 in fresh waters.

Equipment Options: pH Strip package (100ct; \$18), pH probe (\$60-250), or meter (\$200-600)



4. Dissolved Oxygen

Dissolved oxygen (DO) refers to the amount of oxygen dissolved in water. DO is usually measured in percent saturation (%) or part per million (ppm) which is equivalent to milligrams per liter (mg/L). The dissolved oxygen concentration in water can directly affect reproduction, incubation, changes in species, and death of adult and juvenile fish and other organisms. Maximum amounts of DO are produced with the energy of the late afternoon sun, while minimum measurements would be expected just before sunrise. Note: DO would be measured in natural systems (stream, lagoon, ocean), but would not be measured in flows originating from urban or agricultural uses.

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Factors which affect the dissolved oxygen concentration include altitude, time of day or season, and water temperature. Low dissolved oxygen levels usually result from algal blooms, human waste and animal waste. DO sources such as photosynthesis, sinks like the decay of organic material, and salinity also affect the DO in water.

Common Regional Water Quality Objective

CC Basin Plan: The dissolved oxygen concentration shall not be reduced below 7.0 mg/L at any time for COLD Water Habitat. The dissolved oxygen concentration shall not be reduced below 5.0 mg/L at any time for WARM Water Habitat.

Relative Basin Plan notes: For waters not mentioned by a specific beneficial use, dissolved oxygen concentration shall not be reduced below 5.0 mg/L at any time. Median values should not fall below 85 percent saturation as a result of controllable water quality conditions.

Equipment Options: There are two basic methods for measuring DO in water, with a Winkler test kit (\$75) or with a digital DO meter (\$650-2000). We will provide basic instructions for both.



5. Electrical Conductivity (EC), Salinity (Sal), and Total Dissolved Solids (TDS)

Conductivity measures the ability of water to pass an electrical current. Conductivity is usually measured in micro-Siemens (μS) or milli-Siemens (mS). The concentration of dissolved solids or the conductivity of water is directly affected by the geology in the area that the stream or river flows through and the substrate or stream bottom material. Streams that run through areas with granite bedrock tend to have lower conductivity because granite is composed of more inert materials that do not ionize (dissolve into ionic components) when washed into the water. On the other hand, streams that run through areas with clay soils tend to have higher conductivity because of the presence of materials that ionize when washed into the water. Ground water inflows can have the same effects depending on the bedrock they flow through.

Discharges to streams can change the conductivity depending on their make-up. A failing sewage system would raise the conductivity because of the presence of chloride, phosphate, and nitrate; an oil spill would lower the conductivity.

Conductivity indirectly measures the presence of inorganic dissolved solids such as chloride, nitrate, sulphate, phosphate, sodium, magnesium, calcium, iron, and aluminum. These minerals and salts enhance the ability of water to conduct electricity. Rain water will therefore have low or zero conductivity as it has no minerals or salts dissolved in it. Tap water will vary by area, but will generally be low in minerals and salts, while well water will be higher in minerals and salts as it has had contact with the geology.

Salinity is a measure of all the salts dissolved in water. Salinity is usually measured in parts per thousand (ppt). The average ocean salinity is 35ppt and the average river water salinity is 0.5ppt or less. This means that in every kilogram (1000 grams) of seawater, 35 grams are salt. Because the water in estuaries is a mix of fresh water and ocean water, the salinity in most estuaries is less than the open ocean. Bottom water almost always contains more salt than surface waters.

Salinity is also a measure of how well electricity travels through the water. Water that has dissolved salt in it will conduct electricity better than water with no dissolved salt. The more salt that is dissolved in the water, the better the water conducts electricity.

Total Dissolved Solids (TDS) is based on the electrical conductivity (EC) of water. TDS is usually measured in parts per million (ppm). TDS is calculated by converting the EC by a factor of 0.5 to 1.0 times the EC, depending upon the levels. Total dissolved solids consist of calcium, chlorides, nitrate, phosphorus, iron, sulfur and other ion particles that will pass through a filter with pores of around 2 microns (0.002 cm) in size. The concentration of total dissolved solids

affects the water balance in the cells of aquatic organisms. Total dissolved solid measurements can also be useful as an indicator of the effects of runoff from construction, agricultural practices, logging activities, sewage treatment plant discharges and other sources. Concentrations often increase sharply during rainfall, especially in developed watersheds.

Failing septic tanks, sewage spills, commercial and industrial releases, and urban and agricultural runoff all contribute to high conductivity measurements in surface flows. Conversely, organic substances like oil, alcohol, and grease are poor conductors of electricity and will yield low conductivity measurements. Temperature also plays an important role in water's ability to pass electrical current. The warmer the water, the easier it is to pass electrical current, and the higher the conductivity.

Factors affecting salinity & TDS are similar to conductivity, some other notable influences are: Freshwater and rain water introduced to any system will decrease the concentration of salts and minerals, therefore reducing the values of Salinity & TDS. As well, higher air temperatures will increase evaporation, therefore increasing the concentration of salinity and TDS.

Common Regional Water Quality Objective

CC Basin Plan: none

Relative Basin Plan notes: Salt concentrations for irrigation waters shall be controlled through implementation of the anti-degradation policy to the effect that mineral constituents of currently or potentially usable waters shall not be increased. It is emphasized that no controllable water quality factor shall degrade the quality of any ground water resource or adversely affect long-term soil productivity.

Ground waters in the Upper Valley of the Salinas River Sub-basin have average Total Dissolved Solids (TDS) concentrations that range from 300 mg/L to over 3000 mg/L.

Equipment Options: Simple probes are the most economical options (\$70-100), or integrated thermometer (i.e., a pH, DO, or TDS meters which measure EC/Salinity as well). (These meters come in different ranges, so be sure to account for your needs.)



6. Turbidity and Water Clarity

Turbidity is a measure of the cloudiness or haziness of a fluid, caused by individual particles (suspended solids) that are generally invisible to the naked eye, similar to smoke in air. Turbidity is measured in Jackson Turbidity Units (JTU), Nephelometric Turbidity Unit (NTU), or Formazin Turbidity Units (FTU): NTU are roughly equivalent to FTU, and these are only somewhat related to JTU.

JTU vs. NTU?

There is some disagreement amongst scientists about the relationship between JTU and NTU. According to Standard Methods for the Examination of Water and Wastewater, "40 NTU has an approximate turbidity of 40 JTU when measured on the turbidimeter; therefore, results in NTU will approximate results from the JTU kit outside of this range - but will not be identical". The closeness of these readings will vary depending on the nature of the sample being measured. It appears that 40 NTU is approximately equal to 40 JTU, but at other turbidities, the two units are not equivalent, and may or may not approximate each other. The main reason for this is that the two measurement units refer to different instruments and different calibration materials. Both are still used today, however most professionals use NTU (or the equivalent Formazin Turbidity Unit, (FTU)).

Water clarity measurements give us an idea how deep light can penetrate into the water, thus affecting how deep bottom grasses can grow. Clarity is measured in lakes, reservoirs, and the ocean using a Secchi disk. This black and white disk is lowered into the water until it can no longer be seen; the depth (Secchi depth) is then recorded (in feet or meters) as a measure of the transparency of the water (inversely related to turbidity). The Secchi disk has the advantages of integrating turbidity over depth (where variable turbidity layers are present), being quick and easy to use, and inexpensive. Just as a Secchi disk is used as a measure of lake quality, a Transparency Tube can be used to estimate stream quality as it relates to solids in the water (in centimeters). At sites where the water is too shallow or there is no access for lowering a disk, the dual-cylinder Turbidity Test is done (JTU).

Factors affecting turbidity and clarity vary, but watersheds in general have a natural turbidity level with inputs from natural erosion, organic decay and algae. Because of the number of suspended plants and animals (plankton) found within stream systems, turbid water can also be considered natural, however turbidity can also be an indicator of erosion, excessive nutrient loading and abnormal algal growth.

Common Regional Water Quality Objective:

CC Basin Plan: Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increase in turbidity attributable to controllable water quality factors shall not exceed the following limits: Where natural turbidity is between 0 and 50 Jackson Turbidity Units (JTU), increases shall not exceed 20 percent. Where natural turbidity is between 50 and 100 JTU, increases shall not exceed 10 JTU. Where natural turbidity is greater than 100 JTU, increases shall not exceed 10 percent. Look to prior ambient or baseline monitoring program in your area for a natural turbidity level in your local streams (See www.ccamp.org for the Central Coast region.)

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Equipment options: Turbidity measurements in NTU and FTU are taken with photometric Turbidity Meters (\$700-1300), which operate by passing a beam of infrared light through a vial containing the sample to be tested and measuring the light-scattering properties of a sample's particulates. Turbidity measurements in JTU are measured with an inexpensive 'dual-cylinder' Turbidity Kit (JTU; \$50). Water Clarity is measured with Secchi Disc (ft or meter; \$5-50) or Transparency Tubes (centimeters; \$75).



7. Nutrients (Nitrate-Nitrogen, Phosphorus, and Ammonia-Nitrogen)

Nutrients are naturally occurring in water bodies and are essential for plants and animals in an aquatic ecosystem. Nutrients are usually measured in parts per million (ppm). These nutrients originate from both naturally occurring sources and from areas of human development. Naturally occurring sources include soils, eroding rocks, and terrestrial animal and plant waste washing into the water ways.

Nitrate represents the most completely oxidized state of nitrogen, and is commonly found in water. Nitrate-forming bacteria convert nitrites into nitrates under aerobic conditions; Bacteria and other natural processes convert nitrogen into a form that can be used by plants; Plants take in nitrogen as nitrate (NO_3^-), nitrites (NO_2^-), and ammonia (NH_3); even lightning converts large amounts of atmospheric nitrogen (N_2) directly to nitrates.

Many granular commercial fertilizers contain nitrogen in the form of **nitrates**. High levels of nitrates in water may indicate biological wastes in the final stages

of stabilization, or run-off from heavily fertilized fields. Though nitrates are essential plant nutrients, when present in excessive amounts they can cause explosive plant and algal growth. Such an increase in aquatic plant growth affects dissolved oxygen concentrations and water temperature. In water that has low levels of dissolved oxygen, nitrogen will be found in the form of ammonia. Drinking waters containing excessive amounts of nitrates can cause infant methemoglobinemia (blue baby syndrome). For this reason, a maximum concentration level in drinking water has been established by the USEPA in accordance with the Safe Drinking Water Act.

Phosphorus is a nutrient that is essential for plants and animals, and is needed for the conversion of light energy to chemical energy during photosynthesis. It occurs in natural water and wastewaters almost solely as **phosphate**.

A phosphate, is a salt of phosphoric acid and is a required nutrient for plants. A certain amount of phosphate is essential for most plants and animals, but too much phosphate in water can contribute to eutrophication, especially when large amounts of nitrogen are also present. Dissolved phosphorus, or orthophosphate, is a useful indicator of potential problems associated with excessive plant growth.

Phosphorus may come from excessive erosion, animal waste, or sewage, while phosphates may enter water from agricultural run-off, urban runoff, and as biological and industrial wastes. They may be added to water in municipal and industrial water treatment processes to control corrosion. Orthophosphate (PO₄-P) is a common measure, and is chemistry-based term that refers to the phosphate molecule all by itself.

Ammonia is a product of the microbiological decay of animal and plant protein. It can be directly reused by plants to produce protein. Ammonia and ammonia compounds are applied directly as fertilizers.

Ammonia in ground water is normal and is due to microbiological processes. The presence of ammonia nitrogen in surface waters usually indicates domestic or agricultural pollution. Ammonia is extremely toxic to aquatic life. Ammonia is also a naturally occurring by-product of animal excretions and organic decomposition. In reference streams, nitrate-nitrogen and ammonia-nitrogen concentrations are generally below 0.10 mg/L. Temperature and pH are the most important conditions that control the equilibrium between ammonia (NH₃; toxic form) and ammonium (NH₄⁺) in the water column.

Factors which can affect nutrient levels from human development include wastewater treatment plants; runoff from fertilized agriculture, lawns, and golf courses; runoff from grazing animals; urban runoff; and commercial cleaning activities. Problems occur when large amounts of nitrogen, phosphorous or ammonia nitrogen are introduced into the ecosystem. As a result, there can be excessive algal growth depleting the available oxygen that fish and other

aquatic organisms depend upon. This imbalance can affect biological growth as well, causing bacteria present to bloom or die depending on the species.

Common Regional Water Quality Objective

CC Basin Plan: Nitrate-nitrogen ($\text{NO}_3\text{-N}$) – should not exceed 10 mg/L nitrate as N (Drinking water standard); CCAMP Attention Level: Nitrate ($\text{NO}_3\text{-N}$) – should not exceed 2.25 mg/L.

Orthophosphate ($\text{PO}_4\text{-P}$) – should not exceed 0.12 mg-P/L (this denotes 0.12 mg/L of phosphate expressed as phosphorus). EPA guidance states that total phosphorus should not exceed 0.1 mg-P/L in flowing streams. The tentative CCAMP attention level is 0.12 mg /L total phosphate as P.

Ammonia (NO_3) – Maximum concentration of unionized ammonia is 0.025 mg/L. (Note common field methods do not measure unionized ammonia and test results must be converted to this unit: One milligram per liter of ammonia-nitrogen is equivalent to 1.22 mg/L of ammonia.) This is an important reason why pH is an important parameter, as pH affects ammonia-ammonium balance.

Note: for exact reporting of nutrient levels samples of target water should be taken to a laboratory to be tested for nutrients; methods are more precise and results are more accurate. However, there is great value for informational purposes that individuals doing monitoring run quick tests that inform their practices and direct management actions to improve water quality. If the test results are within the stated objectives (good), or exceed the objectives (bad), a precise result does not matter as much as the information of the state of water quality in the moment.

Two field tests are commonly used to measure the different forms of nitrogen in waterbodies: nitrate-nitrogen ($\text{NO}_3\text{-N}$), Orthophosphate ($\text{PO}_4\text{-P}$), and ammonia-nitrogen ($\text{NH}_3\text{-N}$). Inorganic sources of nitrates include wastewater treatment plants, runoff from animal manure storage areas, runoff from fertilized lawns and croplands, failing or improperly maintained septic systems, and industrial discharges containing corrosion inhibitors.

Equipment Options: Nutrient TestStrip packages (25ct; \$18), Ion specific meters (\$250), or Multi-parameter meter (\$400-1000, to over \$4000) [Many other tests are available for organic forms of nutrients.]



Note: Quick Test strips are available for many parameters; quality and instructions will vary, please follow specific instructions on your equipment.

The HACH Company sells the following easy to use TestStrips which are ideal in screening the presence of the nutrients described above:

- Nitrate and Nitrite Test Strips: Nitrate, 0-50 mg/L; Nitrite, 0-3 mg/L
- Ammonia (Nitrogen) Test Strips, 0-6.0 mg/L
- Phosphorus, Orthophosphate (reactive) Test Strips, 0-50 mg/L

What's next...?

Now you have a better sense of the parameters to monitor in a basic water quality monitoring program as well as some of the TYPES of data you will be collecting and the methods you can use to collect them. The next section outlines the steps you need to take to ensure the data you collect is valuable and of high quality, and outlines basic record keeping models.

Principle Citation for Section 2:

Central Coast Regional Water Quality Control Board:

Water Management Plan (Basin Plan) •

<http://www.swrcb.ca.gov/rwqcb3/BasinPlan/Index.htm>

Central Coast Ambient Monitoring Program. • www.ccamp.org

Coastal Watershed Council Volunteer monitoring guidance •

www.coastal-watershed.org

EPA Volunteer Monitoring Program •

<http://www.epa.gov/owow/monitoring/volunteer/epasvmp.html>

Volunteer Water Quality Monitoring National Facilitation Project •

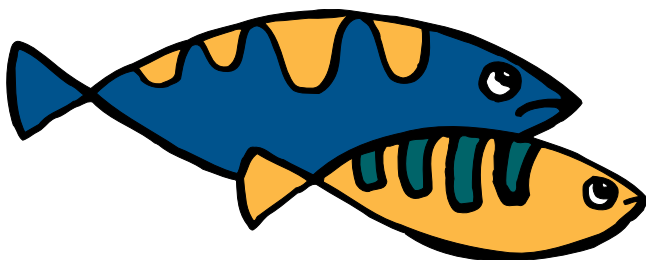
<http://www.usawaterquality.org/>

In this Section,
you will learn:

The principle concepts
behind "QA - QC"

Common QC practices

What kind of recordkeeping
is required for a water
quality program



Making Data Useful 3

QA-QC & RECORDKEEPING— BRINGING VALUE TO THE NUMBERS

Quality Assurance and Quality Control Assessment Measures

Although there are many intricate layers of additional tasks you could incorporate into your monitoring program to assure the best quality data possible the following section introduces the most fundamental requirements of quality assurance and quality control steps needed to produce valid data.

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making data useful

QA-QC...What does it mean?

Quality assurance and quality control measures are those activities you undertake to demonstrate the accuracy (how close to the real result you are) and precision (how reproducible your results are) of your monitoring.

Quality Assurance (QA) generally refers to a broad plan for maintaining quality in all aspects of a program. This plan should describe how you will undertake your monitoring effort: proper documentation of all your procedures, equipment and methods evaluation measures, training of volunteers, study design, data management and analysis, and specific quality control measures. Quality assessment is your assessment of the overall precision and accuracy of your data, and ensures that your data will meet defined standards of quality with a stated level of confidence.

Quality Control (QC) refers to the routine technical activities whose purpose is, essentially, error control. Since errors can occur in either the field, the laboratory or in the office, QC must be part of each of these functions. QC consists of the steps you will take to determine the validity of specific sampling and analytical procedures. QC should include both internal and external measures. QC measures assure proper protocols are being performed during monitoring and sample collection in the field, in the laboratory, and during data entry and information processing.

- **Internal Quality Control** is a set of measures that the project undertakes among its own samplers and within its own environment or laboratory to identify and correct analytical errors. Examples include monitor training and certification, proper equipment calibration and documentation, laboratory analysis of samples with known concentrations or repeated analysis of the same sample, and collection and analysis of multiple samples from the field.

- **External Quality Control** is a set of measures that involves laboratories and people outside of the program. These measures include performance audits by outside personnel, collection of samples by people outside of the program from a few of the same sites at the same time as your people, and splitting some of some of the samples for analysis at another laboratory.

Together, QA and QC help you produce data of known quality, enhance the credibility of your group in reporting monitoring results, and ultimately save time and money. However, a good QA/QC program is only successful if everyone consents to follow it and if all project components are available in writing. A Quality Assurance Project Plan (QAPP) is the written record of your QA/QC program. (See <http://www.swrcb.ca.gov/swamp/qapp.html> for more information).

The three principle concerns of any monitoring program are accuracy, precision and contamination:

- **Accuracy** is assessed through the use of instrument calibration and spiked samples in the laboratory.
- **Precision** is assessed through analysis of duplicate measurements and samples, and the comparison of the duplicate results.
- **Contamination** is assessed through analysis of blank samples.

The QC practices that support these three assessments are described below.

Quality Control and Assessment Measures

The following are the most important QC activities needed in any monitoring program:

- Use accepted equipment/methods, and follow accepted instructions, or **Standard Operating Procedures (SOPs)**.
- **Train** all monitors in the Monitoring strategy, locations and SOPs. Periodically retrain them, review their results.
- **Care** for your equipment, clean it, store it properly, follow all manufacture's instructions.
- **Review** field and lab results right away - and carefully. When errors are found, review with the monitors or data managers; retrain as needed.
- **Calibrate the equipment, and test the methods.**

The rest of the section on QA-QC will guide you toward these activities.

SOPs are essential to standardizing the actions of the monitors and associated program personnel. Adopt standardized protocols like those presented in this program and Field Guide: ones that have come from sources such as the manufacturers of the equipment, US EPA, the State and Regional Water Boards, researchers and laboratories. Remember there are not just protocols for using the tools, but for all aspects of the monitoring program, from data sheet preparation and standardized collection points, to laboratory delivery and data entry.

Training - Training participants to understand and follow the SOPs before they begin to monitor, and refreshing periodically throughout the program, is critical to producing useful information. Training all participants in the monitoring methods is essential to controlling user errors leading to contamination and incorrect results. If monitors understand the importance of following protocols and caring for the equipment then they will produce more reliable results.

Care and maintenance of equipment, including proper storage is essential to producing useful information. Without confidence in your equipment you cannot have confidence in your results. Not only are some tools sensitive to abuse, like glass thermometers and electronic sensors, some have membranes or seals that need replacing, many build up corrosion on metals parts, and others cannot be exposed to the sun or strong light. Many kits have corrosive or even toxic chemicals that could lead to a human health hazard if not maintained properly. As well, chemical reagents have a limited period of time that they will produce a standard reaction, an expiration limit, just like milk or medicine. Be sure all reagents and tools are in good working condition before monitoring.

Review field data immediately. All field data sheets should be reviewed before leaving the site for completeness and proper completion.

Calibration of equipment is more than care and maintenance; it is the testing of equipment against standardized solutions of a known value to see if the equipment is properly functioning. At a minimum calibrate two times a year, before and after significant maintenance or changing batteries or reagents, and before and after large, meaningful events.

We should point out that there are two separate actions we are talking about: comparison against another tool – for a thermometer that cannot be adjusted; and calibration against a known Standard Solution or other material.

Although we will not go into calibration specifics for all the equipment we suggest here you should review the instructions from the manufacturer or supplier as to its proper care and calibration. We recommend that as each piece

Why does calibration matter?

Suppose you place a pie in the oven set for 300 degrees, but when you come back after 30 minutes you find it is black as charcoal ...

Was it something wrong with the pie, or the oven?

What if you discover it is because the inside temperature of the oven was really 500 degrees – even when the knob was set to 300.

What was the problem?

The oven was not calibrated to the knob.

It's the same for a conductivity probe or nitrate meter...

of equipment is acquired you take on the responsibility for understanding its care and proper use. The more effort you make to assure your equipment is producing precise (repeatable) and accurate (true) results, the more useful your data will be, and the more worthwhile your time and resources.

QA Field & Lab Samples

The following details some of the QC practices you can do in the field to test your equipment, monitors, and labs.

Internal checks are performed by the project field monitors, program staff, and equipment to identify and correct procedural errors.

Field Blanks – A field blank is “clean” deionized water which is processed in the field or treated as a sample. It is used to identify errors or contamination in sample collection and analysis.

Field Duplicates – A field duplicate is a duplicate water sample collected by the same team, at the same place, at the same time as the original sample. It is used to estimate sampling precision, as well as environmental variability.

Matrix Spike Samples – A known concentration of the constituent being measured is added to the sample to evaluate the affect of the sample water (matrix) on analytical accuracy. The lab may request additional sample water to perform this test.

Calibration Blank – A calibration blank is deionized water processed like any of the samples and used to “zero” the instrument. It is the first “sample” analyzed and used to set the meter to zero. This is different from the field blank in that it is “sampled” in the laboratory. It is used to check the measuring instrument periodically for “drift” (the instrument should always read “0” when this blank is measured). It can also be compared to the field blank to pinpoint where contamination might have occurred.

Calibration Standards – Calibration standards are used to calibrate a meter. They consist of one or more “standard concentrations” (made up in the laboratory to specified concentrations) of the indicator being measured, one of which is the calibration blank. Calibration standards can be used to calibrate the meter before

How often are QA samples necessary?

Each monitoring program will need to define the level of detailed QA-QC checks it will perform in its monitoring plan and QAPP (or more general program documentation).

However, as a general rule, plan on at least one set of QA-QC samples per 10 samples collected, and one field blank every time samples are taken to the laboratory.

Calibration Blanks should be run periodically to assure monitors are following protocols and equipment is performing properly, in both field and laboratory environments.

running the test, or they can be used to convert the units read on the meter to the reporting units (for example, absorbance to milligrams per liter).

a little extra Jargon!

The following are definitions of some common QA-QC technical words:

Accuracy is a measure of confidence in a measurement; the smaller the difference between the measurement of a parameter and its “true” or expected value, the more accurate the measurement. Measurement accuracy can be determined by comparing a sample that has a known value, such as a standard reference material or a performance evaluation sample, to a monitor’s measurement of that sample.

Precision is the degree of agreement among repeated measurements of the same characteristic on the same sample or on separate samples collected as close as possible in time and place. It tells you how consistent and reproducible your field or laboratory methods are by showing you how close your measurements are to each other. It does not mean that the sample results actually reflect the “true” value, but rather that your sampling and analysis are giving consistent results under similar conditions. Typically, precision is monitored through the use of replicate samples or measurements.

Representativeness is the extent to which measurements actually depict the true environmental condition or population you are evaluating. A number of factors may affect the representativeness of your data. For instance, are your sampling locations indicative of the waterbody? Data collected just below a pipe outfall is not representative of an entire stream. Minimizing the effects of variation is critical in the development of your sampling design.

Comparability is the extent to which data from one study can be compared directly to either past data from the current project or data from another study. For example, you may wish to compare two seasons of summer data from your project or compare your summer data set to one collected 10 years ago by state biologists. Using standardized sampling and analytical methods, units of reporting, and site selection procedures helps ensure comparability.



Keeping track of all that data - Data - DATA!

The following section will describe the type of information one should collect, what are the two basic methods for collecting it, and how you might store the information.

Planning for Monitoring Data - Recordkeeping!

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It is hard to overemphasize the importance of having established methods of handling monitoring data, analyzing that data, and presenting results effectively to others.

Without these tools and processes, the data that monitoring program managers have labored hard to collect are virtually useless, and the program will surely fail to meet its goals.

Many decisions will be made before the first field data sheet is filled out. Individuals you share information with, data users, will be particularly concerned about:

- Procedures used to verify and check the raw field and laboratory data
- Databases and software used to manage the data
- Analytical procedures used to convert the raw data into findings and conclusions
- Reporting formats

Data users may, for example, be able to offer concrete suggestions about databases and presentation formats that will make the data more accessible to them. Data users will be able to compare your results to those of others, and help make decisions about land management practices affecting water quality. To ensure that all questions about the validity of the data can be answered, the program should develop and implement a quality assurance—quality control plan. This plan should identify key personnel with responsibilities for data management and data analysis and clearly indicate all the steps the program will take to handle the data.

Program organizers should make every effort to involve a range of advisors and program staff in all aspects of data management and presentation. Sufficient time should be budgeted to the tasks that are involved.

Managing Monitoring Data

The following steps will help ensure that the data collected in your program are well managed, credible, and of value to potential data users.

Develop a Coding System

A coding system will help simplify the tracking and recording of data. Make sure, however, that the system you create is easily understood and simple to use. Codes developed for sample sites, parameters, and other information on field and laboratory sheets should parallel the codes you use in your database. If you will be sharing your information with a state or local natural resource agency, you may want your coding system to match or complement the agency system.

Sampling Sites

Because sample sites tend to change over time, it is important to have a site numbering system that accommodates change. A good convention to follow is to use a site coding system that includes an abbreviation of the waterbody and a site number (e.g., SALIN-XXX for a site on the Salinas River). For consistency, you might choose to start the numbers at SALIN-100, or SALIN-001, and add sequentially as you establish new sites (e.g., the first Salinas River site would be SALIN-101, the second SALIN-102, etc.). Leave extra numbers between sites to allow for your program's future expansion.

Water Quality Parameters

It is also important to develop a coding system for each of the water quality parameters you are testing. These are the codes you will use in the database to identify and extract results. To keep the amount of clerical work to a minimum, abbreviate without losing the ability to distinguish parameters from one another. For example, EC typically represents Electrical Conductivity and DO Dissolved Oxygen.

Water Quality Equipment

Because each measurement is unique to the equipment that was used, and equipment also tends to change over time, it is important to have an equipment coding system that accommodates change. As well, the calibration or verification checks you do to verify your equipment is working correctly are unique to that piece of instrumentation. It is important to be able to identify a piece of equipment that is not producing valid measurements and eliminate it from your program.

Review Field Data Sheets

The monitoring program coordinator should screen and review the field data sheets as they are received. This involves some basic "reality checks." Questions that should be kept in mind include the following:

**Are the results as might be anticipated, or are they highly unexpected?
If unexpected, are they still within the realm of possibility?**

For example, can the kit or technique the monitor used actually produce results like that? Does the monitor offer any possible explanations for the results? Also check for consistency between similar parameters. For example, total dissolved solids and conductivity should track together--if one goes up, so should the other. So should total solids and turbidity.

Are there outliers? (Findings that differ radically from past data or other data from similar sites.)

Follow up on any data that seem suspect or out of range. If you can't come up with an explanation for why the results are so unusual, but they are still within the realm of possibility, you may want to flag the data as questionable. Ask an experienced monitoring advisor or program staffer to sample at that site as a backup until uncertainties are resolved, or work with the monitor to verify that proper sampling and analytical protocols are being followed.

Are the field data sheets complete?

If a monitor is consistently leaving a section of the sheet incomplete, follow up and ask why. Instructions may not always be easily understood. All sheets should include site location and identification, name of the monitor, date, time, and weather conditions. Blank fields should be marked or explained on each datasheet.

Are all measurements reported in the correct units?

You should minimize the chance for error by including on the data form itself any equations needed to convert measurements, and specify on the form what units should be used. Check the math. All field data sheets should be kept on file in the event that findings are brought into question at a later date.

Review Information in Your Database

Once data enters a computerized database, it can take on a life of its own. It is a phenomenon of human nature that data suddenly seem more believable once computerized. Therefore, be sure to carefully screen information as soon as you enter it into a database. Then review a printout (preferably with a fresh pair of eyes) against the original field data sheets. If you uncover unusual data points that cannot be explained by backup information on the field data sheets or the comment field in the database, flag the data as questionable until it can be verified. Check a minimum of 10% of all data sheets to verify data entry is happening correctly. If problems are identified, retrain the data entry person. (Never discard original datasheets or notes until the program is complete, keep for a minimum of three years.)

Review Your Final Results

Once monitoring data has been entered into a database, the next step is to generate reports on the findings of the data. Even at this stage you should continue to look for inconsistencies and problems. For example, you should:

- Review findings against previous years' data
- Look for outliers on graphs and maps
- Not remove data just because you don't like it, but do investigate findings that are unusual or can't be explained
- Feel fully confident that you have assembled the best possible picture of water quality conditions in your study streams by the time you present your final results to your data users

Notebooks, sheets and storage

The two most common methods of data collection for water quality monitoring programs are either bound field notebooks or standardized field data sheets, or forms. The following is a brief list of suggested fields for either of these data collection methods, and the subsequent storage of the physical papers involved.

Data Fields

It is important to define the fields of information you want to collect (data), and be sure to delineate the page in a standardized way so that you are sure to collect all the needed information. Don't try to remember the information you need to collect each time, instead lay out your page before you go to the site to monitor. Information should be arranged on the page in a manner that allows for extensive notes when necessary, but always collects the basic information important to your program.

You should plan on collecting the following basic information no matter what paper data collection method you use. This information is relevant to any water quality program, however you may have additional information specific to your program or project that you'll want to add.

- Enter the **date** you monitored or visited the site and made observations.
- Number each **page** for that date; determine how you will indicate each site visit from the others. Indicate if this is page 1 of 2 etc.
- Be sure to record the **time you arrive**, and we recommend you also record the **time you depart**. This will help you both to bracket the window of time you were present at the site, and help you to plan adequate time for your monitoring.

- It is important to record the **time of measurement**, and the **time samples were collected**. Both of these could prove critical if a spill is detected somewhere within the system.
- Even though you know who you are, be sure to include your **name** on every page. You never know when you might need to present this information to others and this will assure them that you collected the data. Record the names of others with you on each day, as the members of your team may be able to support your findings at a later date.
- Create a field or series of check boxes to record the **environmental conditions** during the visit; sky clear, overcast, or cloudy?; Is it still or breezy, or blustering?; Is it raining or dry?; Is the flow high, low or stagnant? – can you take a flow measurement?
- Record any **wildlife** present at the site. This information can both indicate a problem or that the conditions are good for wildlife at the site.
- Record any **livestock** or **domestic animals** present at or around the site.
- Indicate if you used a **collection device** (a bucket, cup, or sampler) or took measurements or water samples directly from the flow.
- Indicate if samples were collected for later analysis either by your program or at a laboratory. Always provide a **sample ID** for each individual sample collected.
- If you collect samples for later analysis at a laboratory, be sure to provide a **chain-of-custody** signature line with a date/time field for the laboratory to sign for the receipt of your samples when they are dropped off.
- Record each **measurement result** taken, a table structure is best for this information. Indicate if a replicate measurement is taken, and if there was any trouble with the equipment, any questionable practices or chemicals used on that day.
- Record the **unit that the measurement** is in; mg/L, ppm, degree C etc. Different methods measure the same parameter, but may produce results in differing units.
- Record the **instrument ID** with each measurement taken-important for tracking results back to specific instruments.
- Allow room for a site map and/or sketch. This simple diagram will allow you to recall things better, and will also help you to indicate when changes happen to the site, like stream bank failures or falling trees, etc.

Examples of a basic datasheet and a chain-of-custody form will be found in the reference document section in the Reference Section.

Field Notebooks

Notebooks can be program or project specific and can include various levels of detail.

Simple, “composition” books like students use, or fancy journals from a catalog – both work, but make sure that the pages are bound together and that only measurements, observations and notes related to the monitoring program and the monitoring sites are put in these books. Loose leaf paper is a possibility, but if the notebook is dropped pages can be set free in the wind and may be lost or damaged.

Although the fancy journals are not as necessary as having a standard method for filling them out, they do frequently come in waterproof paper, which will be helpful if you happen to be *around water*.

Field Data Sheets

A ‘data sheet’ for use in your monitoring program can be as simple as a hand drawn page you copy on a machine, to a form created on a computer and printed for use. When ever possible use water proof paper as you are expecting to be in the presence of water - and it’s possible the page could get wet.

Designing datasheets can be fun or tedious. Don’t try to put too many fields on one page; if you need to, design a two page form.

Paper Data Storage

The simplest method for storage of field notebooks requires that the notebook be coded as well. As the program will be ongoing, and multiple visits to sites will be required, then acquire numerous identical notebooks, number or code them in a way relevant to your program, and then issue them in series like volumes of a book. This way they can be stored and information can be traced to a volume. By using identical books then you are assured they will all fit on the same shelf, and can be easily stored together.

The simplest method for storage of field datasheets is a three ring binder. Once the datasheet has been completed, it can be stored with others in the binder. You can use binder divider tables to delineate stations or dates as your program needs require. You can store different types of data relative to the program or project together, and you can also create volumes as necessary.

Electronic Data Storage

If you are familiar with and have access to modern computers, then data can easily be stored in an electronic format you use on your computer. Simple table structures can be used to record the information, do basic math and statistics, and provide a method of transferring the information in a fraction of the space of your volumes of datasheets.

More complex database programs can be created to be used to store and process your data as well. Ask for input from your advisors before investing in a database program.

A Note on Data Management Systems...

There are numerous sophisticated databases and data storage systems on the market or on the internet which water quality monitoring programs contribute to. However, a simple program for local purposes will benefit from a simple data management system that gets used verses a sophisticated or complex system that doesn't.

In Closing

Once the notebook format or datasheet is finalized, make sure everyone using it is trained to completely fill it out. This is very important - as incomplete datasheets leave many questions behind. If a data field is not necessary on that particular day, then draw a line through it and indicate in the notes why that measurement wasn't taken, or provide an explanation relevant to your program. This way everyone will understand what happened later when the data is being reviewed.

Although not everyone will take all the QAQC and Data Management steps described in Section 3, it is important to know about them and understand their importance in the world of water quality monitoring. Each additional step you add to your program will assure yourself, and those you share information with, that your findings are correct. In the age of staggering amounts of information available to each of us, the simpler you can make the system the more likely you are to use it. The more likely you are to use it, the more likely the data will become information that you can use to inform your practices.



What's next...?

Section 4 will provide detailed instructions for setting up and conducting a water quality monitoring program. The information from Section 3 on QA-QC & Data Management, coupled with the SOPs which have been included for the most common methods of sample collection and field measurements will give provide everything needed to start designing a monitoring program for your operation or watershed.

At the end of the Field Guide there is a brief Reference section which will provide all the Citations for this Field Guide, many template documents, online links for more information, and template forms (data sheets, chain-of custody form, and calibration records). The very last item included is a Local Resources list which includes contacts for regional partners to help you with your monitoring program. This list of local resource agencies and organizations is for the Central Coast, California - Don't hesitate to call - we're all out there waiting to to help you succeed.

Principle Citations for Section 3:

Volunteer Monitor's Guide to Quality Assurance Project Plans
(EPA 841-B-96-003; 09/96);
"Volunteer Stream Monitoring Manual: A Methods Manual"
(EPA 841-B-97-003; 11/97)
Coastal Watershed Council Volunteer monitoring guidance •
www.coastal-watershed.org

In this Section,
you will learn how to Do it! :

How to prepare for monitoring.

What are the basic water quality
sample collection procedures to
take samples to a lab

What are the principle SOPs for
parameters we measure.

How to use the simplest equipment
options



Monitoring 4 Water Quality

This section provides a more detailed description for monitoring the parameters we most commonly measure while conducting water quality programs. It is straightforward and lists the steps required for successful monitoring.

Prepare for Water Quality Monitoring

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Before taking measurements

- Prepare yourself; dress appropriate, bring boots, food & water, rain gear, cell phone, etc.
- Gather all the documents needed; data sheets, maps of sites, SOPs, etc.
- Collect the monitoring equipment and supplies needed, pack for travel, weather, other?
- Prepare your sampling protocols; call labs, and gather sample containers.
- Make a plan, know that you have everything you need to conduct the testing

The following are the basic steps for conducting monitoring.

Personal preparedness

Be alert and prepared to make the most of your time, wear the appropriate clothing and boots, bring a first aid kit and drinking water, and what ever else you need to support yourself during the monitoring period.

Be sure to prepare all the necessary equipment, organize data sheets or notebooks, clean all collection devices, and follow all your Quality Assurance-Quality Control steps per the adopted instructions for your monitoring program.

Always consider your safety – you are more important than data. Work in teams or be sure to leave a record of where you are going that day, things can happen in the field, and you might need help. Safety needs should permeate your monitoring program just like your other work operations.

The following list of safety precautions is standard for monitoring programs:

Your safety and health are of number-one importance, particularly when you are working outside, in creeks and ditches. There are several important things to remember when you are monitoring at a stream or other body of water.

Before Visiting Your Site

- Always monitor with at least one partner. Teams of three or four are preferred. This is especially important during storm events or other dangerous conditions.
- Always let someone else know where you are, when you intend to return, and what to do if you don't come back at the appointed time. Carry a cell phone if you can.
- Carry the phone number and location of the nearest medical center to your monitoring site and the location of a pay phone should you need to call for help.
- Carry the phone number of your program coordinator or supervisor.
- Listen to weather reports. Do not go sampling if severe weather is predicted (i.e. lightning, flooding, ice etc.); Stop monitoring if a storm occurs while you are at the site (unless this is your purpose).
- Carry a list of any important medical conditions of team members (e.g. heart conditions or allergic reactions to bee stings) and emergency responses needed.
- Carry a First Aid Kit and be sure to check the contents before leaving to monitor.
- Some of the chemicals in the test kits are poisonous if ingested. Carry the number to the local poison control center and the MSDS* Sheets for the chemicals to provide any emergency responder.

* Material Data Safety Sheets provide detailed human health and hazard information on each chemical

Rules to Monitor By

- Never wade in swift or high water. – DO NOT monitor if the stream is at flood stage.
- If you drive, park in a safe location. Be sure your car doesn't pose a hazard to other drivers and that you don't block traffic.
- Put your wallet and keys in a safe place. If wading in the stream place them in a watertight bag you keep attached to your waist or they might end up downstream.

- Never cross private property without the permission of the landowner.
- Confirm that you are at the proper site location by checking maps, site descriptions, or directions.

Document preparedness

Be sure you have the proper data sheets, forms and record keeping tools you need to complete your monitoring records for the day. Whatever system you adopt, notebook, data sheets, or a laptop in the field, be consistent with your recordkeeping and collect all the required data each time you monitor. If you are collecting samples for laboratory analysis be sure to have a proper chain-of-custody form for the laboratory with all of your samples logged onto it before arriving at the laboratory.

Store a binder with copies of empty forms and copies of past data sheets with the monitoring equipment kit. You'll never be caught without a data sheet and the past data sheets will help if you identify problems while you're monitoring: If you have all the past measurements, it can help you determine if you have an unusual findings, and is also helpful when you are rotating teams, as it lets each team know what the last team's results were.

Equipment preparedness

DON'T WASTE YOUR TIME – Be sure to check all equipment before going out to assure it is clean, functioning, and ready for use that day.

If you are collecting samples for laboratory analysis, make sure you have adequate supply of gloves and the proper sample collection devices (pole sampler, buckets, etc), which have been cleaned per your instructions and any special bottles or bags from the laboratory. Don't bring water in an old jar to the laboratory and hope for useable results – the laboratory might not take it, and you won't have confidence in the data produced.

Care and Cleaning of Test Equipment & Kits

General Care

Protect and store your monitoring equipment to assure its proper working condition and continued usefulness. If possible always store the equipment in the same location to assure it is protected from loss or misplacement and so that others using the same work area respect its value.

When possible, place all the equipment you need to perform your monitoring into a single properly sized bin with a lid; this way you can keep it clean, together, and ready for you the next time you go out! Don't try to cram it all into a too-small container, or leave pieces out to get knocked around or lost.

If you need to share the equipment with others, then incorporate a policy that each monitoring person/team cleans and inventories the equipment so the next team always knows it is in working order when they want to use it – and are not faced with missing or damaged equipment or supplies. When something is damaged, missing, expired or used up, then communicate that replacement need right away so that the next team are not left with faulty or missing monitoring equipment when they need to go out.

General Equipment Cleaning

Don't allow equipment or chemical test kits to sit with sample water or reagents on them over night – this can cause corrosion, clogging up of the sensitive detection elements, or chemical reactions inside the kits. Any residual contamination may alter test results, and mold and mildew can develop if the equipment is sealed in tight containers while wet from monitoring or cleaning.

Monitoring Equipment and test kits (probes, mixing bottles, syringes, sample tubes, boxes, etc) should be rinsed and dried after each use. The equipment should be more thoroughly cleaned periodically per your program needs, or anytime the monitoring water is particularly dirty or the equipment shows signs of corrosion. The equipment, test kits, and storage bin should be dry when put away. Wipe out the equipment storage/travel bin after each use.

Cleaning Supplies List

- Detergent - phosphate-free and nonabrasive
- Soft Clothes - cheesecloth works well (lint free)
- Brushes - various shapes and sizes
- Deionized Water
- Clean tap water

Cleaning procedure

- 1 Rinse probes, jars, tubes, etc, with cold tap water.
- 2 Clean gently with a mild nonabrasive detergent (phosphate-free) or a solvent such as isopropyl rubbing alcohol. If necessary use a brush to clean all hard surfaces.
- 3 Be cautious of sensitive equipment, membranes or digital displays.
- 4 Note any build up or corrosion and take care of it per the equipment instructions.
- 5 Rinse three times with distilled or deionized water.
- 6 Use a soft cloth (cheesecloth works well) for drying or allow to air dry. Never use paper towels or plain tissues on delicate surfaces.

Note: These are general instructions for maintaining clean equipment. Please

follow all of the manufacturer's instructions for cleaning probes, meters, and other sensitive or sophisticated equipment. Replicated equipment blanks are a good way to reassure that residues do not affect sample results.

Necessary Supplies

Make Sure You Have What You Need for a Successful Trip!

Required supplies for successful monitoring:

- **Site list** (be sure to go to the same places every time for ambient or project monitoring)
- **Blank Data sheets** – with binder or clipboard (standardized forms or notebook)
- Working pens/pencils/water proof markers
- **Watch** – with SECOND Hand, or Digital (a kitchen timer is best in some cases)
- **Latex gloves** – ALWAYS wear gloves while collecting samples, running tests or handling test kit. BE SURE TO wear gloves when taking samples so as not to contaminate samples or make results questionable
- **Safety glasses** – Use for eye protection if collecting fast flowing water and working with chemicals
- **Distilled Water** – VIP! And Lots of it! Used to rinse at every step of running the tests
- **Paper Towels** and **Newspaper** – to keep your hands dry and to pick up all minor spills
- Your **“Monitoring Kit”** with **Protocol Instructions** – Run through your specific equipment checklist and protocols to make sure you have all the materials needed.
- **Waste bottle with lid** – well marked Use for disposing of any solution water you make during the analysis.
- **Waste bag** or **container with lid** – well marked Use for everything else!
- **First Aid Kit** – Only for scratches and scrapes - refer to Poison Control for chemical exposure of any chemicals you are using.

If collecting samples for laboratory analysis, add the following:

- Pre-labeled **Sterile Collection containers** (from laboratory) or **Whirl-Pak bags** —Make sure you have more than needed in case you break or contaminate one; especially if using any glass containers.
- **Permanent marker** – Use to label containers Whirl-Pak bags PRIOR to taking sample - when bags are dry.
- **Cooler with ice** – for transportation of water samples to laboratory.
- **Temperature Blank** and **Thermometer** – If thermometer is liquid filled - make sure liquid is not separated, and no bubbles are present.

Laboratory Samples

Many more water quality parameters can be analyzed in the laboratory than in the field, and most all biological analysis, like bacteria, must be performed in a laboratory. Take advantage of the local laboratories for conducting your water quality analysis, and to check your field results by periodically doing tests in the field and in the laboratory and comparing the methods and results. This laboratory 'back up' result will help you understand your monitoring results better, and assure your methods are being implemented correctly (see QAQC section for more information on the reasons we take these types of samples).

It is important to contact the laboratory to get the appropriate bottles and inform them of your sample collection and delivery schedule ahead of time. The procedures for collecting the basic types of samples collection are described following this list of common sample types and general information. All of the professional laboratories in our area* will provide the appropriate containers for you to use along with specify instructions for their containers, specific to their methods. *The following is general information – Always follow the laboratory's instructions over these.*

Sample Label

Each sample delivered to the laboratory must be accompanied by four basic pieces of information to be valuable to you or others. Write directly onto the sample bottle or bag with a permanent marker before filling the samples so the information won't wash away.

Required label Information (i.e.):

Date of collection	10/24/2007 (Be sure to include mo/day <u>and</u> year)
Time of collection	04:45 pm or 1645 (Be sure to include AM/PM or use 24 hr time)
Location name, or ID code	SANGR-21 (Station ID)
Collector Name, or ID Code	TCDoan , or CWC (org code), or ZHB-122 (your code?).

You always need to know where a sample came from (location), when it was collected (date/time) and by whom (collector) if you want to be able to track your results back to a monitoring event, share your information, or address a specific management practice.

Collecting Water Samples

No matter what information is provided here, all water samples should be collected in strict accordance with laboratory instructions.

When taking samples to a laboratory, be sure to follow their specific protocol. All samples take to the laboratory should be accompanied by a “Chain-of-Custody” (COC) document which lists each sample, the collector and location or sample ID (see document examples in Reference Section).

All samples of water going to a laboratory must be placed on ice immediately after collection to keep them cool. This environment will slow or prevent reactions or growth inside the sample. It is an accepted procedure to store water samples in an environment that is below 4°C between collection and delivery. A temperature blank should be placed in the cooler so this environment can be tested.

Water Sample Types

Standard samples/Grab samples are used to collect multiple measurements from one sample such as turbidity, pH, and conductivity. In addition, water samples to be analyzed for nitrates, phosphates, pesticides, and toxicity are all collected in this manner.

Standard sample containers are rinsed in the waterbody or with the sample water three times before being filled. This insures that any water left in the sample container is the same as the actual water being sampled. During some events one large grab sample is collected and then split between various laboratory bottles for analysis of different parameters.

Composite/Aggregate Samples are created when water is collected at more than one location or at different times and then blended together before being measured or placed in bottles for laboratory analysis.

Note: Check with the laboratory to assure your methods. For example: metals and pesticides must be collected in metal or glass containers and cannot be collected in plastic containers as they adhere to the plastic. This affects what you use to make your collection of a grab or composite sample as described above.

Bacteria samples must be collected in sterile containers or Whirl-pak bags. The sterile laboratory containers have been specially cleaned so that they contain no bacteria that might contaminate the water samples. Whirl-pak bags are purchased from suppliers and are sterile until opened. When collecting bacteria samples, always wear gloves and take precautions not to contaminate the sample. Never rinse the sample container with anything. Bacteria samples should always have air space at the top of the bottle, called head-space; do not fill bacteria sample containers completely (see Procedure for collection a bacteria sample below).

Preserved samples are water samples that require some type of chemical additive to prevent the water samples from undergoing unwanted chemical reactions. Bottles must be retrieved from the laboratory and will be sealed with these chemicals already inside. Testing for various nutrients, metals, and many other parameters require a preservative or a 'fixing agent' to prevent the sample from changing significantly between when you collected it and when it is analyzed at the laboratory. Never place preserved sample containers directly into a waterbody, and do not allow the bottles to overflow. Always use the specially designated "filling container" to fill sample bottles containing preservative, always wear gloves, and never rinse the sample container.

Field Duplicate samples are samples collected at the exact same time by the same technique in the exact same spot. Duplicate samples are tested in laboratories to ensure no sampling errors are occurring. It may be necessary to provide a field duplicate sample to the professional laboratory each time you send samples.

Field Blank samples are samples of uncontaminated deionized water that are exposed to the same ambient conditions at the sampling site and subjected to the same analytical or measurement process as other samples. Field blank samples used to provide information about contamination that may be introduced during sample collection, storage, and transport. It may be necessary to provide a field blank to the professional laboratory each time you send samples.

Sample Containers

Water samples can be collected and delivered to the laboratory in sterile plastic or glass bottles or plastic bags.



Sample containers should be filled directly from the flow of water to be analyzed whenever possible. If it is unsafe or too deep, use pole sampler or other appropriate devices. Be sure to change bottles or have a cleaning procedure for these extra pieces of equipment between monitoring days, and between locations on a single day, to assure you do not cross-contaminate the water samples.

Temperature blanks give an indication of the temperature held inside the cooler/ice chest that samples were stored in during transport to the laboratory (to make sure samples were stored at appropriate temperatures). A temperature blank is a container filled with water that is stored in the cooler/ ice chest with all the water samples. A temperature reading is taken of the water when the samples are given to the laboratory.

Conducting Water Quality Testing

Physical observations and measurements, chemical analysis, and collection of laboratory samples can all be done in the field for your monitoring program. Work downstream-to-upstream; starting at the most upstream site can impact conditions at a more downstream site.

Order of Operations

A standard order for collecting information at a monitoring site is as follows:

Arrive at site and make note of the location, date, time, and persons present.

Collect samples to be delivered to a laboratory **FIRST** and place then on ice in a sealed cooler; record time of collection. (Collect one Field Blank for each trip to the lab)

Make physical observations and record environmental conditions, sketch site and any changes you notice have occurred since the last time you were there (detailed notes on the first visit help with noticing changes).

Make infield measurements, collect water and conduct in-field chemical analysis you might be making; record time of measurements/analysis.

Check data sheet for missing information, pack equipment and check to assure nothing is left behind, and record departure time.

Location Observations

Making Physical Observations of Environmental Conditions at Site

Water quality testing also requires visual observation skills as well as being able to focus on the technical monitoring instructions.

88 Physical observations are those about the site; the size of the drainage or stream, the amount of water, the state of the bank, vegetation or the presence of trash or debris etc. Make brief but careful observations of what you see each time you monitor. Be sure to include date and time of site visit.

Environmental conditions are those about the environment you are monitoring in, weather and sky etc. These can have an affect on the parameters you are monitoring (a cloudy day could result in a lower water temperatures). Record the weather conditions (cloudy, windy, or bright sun), note whether it is raining or has rained recently, also note the presence of wildlife, and water properties like water clarity or appearance, color, and the presence of odors in the area or from the water.

Looking at past site visit notes or sketches before arriving, or while present, can help you to determine changes in the site which might be affecting water quality at your site, or upstream or downstream your site. Examples: Changes in the vegetation present can lead to an increase or decrease in water temperature (i.e., less cover higher/more cover lower temperatures); Changes in bank stability or increased flows can lead to increased turbidity.

The rest of this section is comprised of real monitoring protocols for conducting water quality monitoring in surface water flows with common, readily available and generally inexpensive, yet reliable equipment for the following parameters:

Collecting Water Samples

Air Temperature

Water Temperature

pH

Dissolved Oxygen

Electrical Conductivity/TSS/Salinity

Turbidity/Water Clarity

Nutrients; Nitrate/Orthophosphate/

Ammonia Nitrogen

Using Standard Operating Procedures

This section details the process of using the monitoring equipment.

Standard Operating Procedures, or SOPs, are the accepted instructions for common water quality metrics using standard equipment commonly accepted by monitoring professionals.

The following instructions for sample collection and field measurements are taken from protocols developed by the U.S. Environmental Protection Agency, the State Water Resources Control Board's Clean Water Team, and the manufacturers of the equipment.

As described above, water quality results should be compared to the General Water Quality Objectives (WQO's) designated in the General Basin Plan for the Central Coast by the Central Coast Regional Water Quality Control Board and their Central Coast Ambient Monitoring Program (CCAMP), or the U.S. Environmental Protection Agency. In order to ensure valuable data, a state approved Quality Assurance Project Plan and Monitoring Plan was developed specifically for each program.

Collecting Water Samples

Preparation of Sampling Containers

If using a laboratory, skip this section on container preparation as the laboratory will do this. Proceed to Grab Samples.

Reused sample containers and glassware must be cleaned and rinsed before the first sampling run and after each run by following either Method A or Method B described below. The most suitable method depends on the parameter being measured.

Method A: General Preparation of Sampling Containers

The following method should be used when preparing all sample containers and glassware for monitoring conductivity, total solids, turbidity, pH, and total alkalinity. Wear latex gloves!

- Wash each sample bottle or piece of glassware with a brush and phosphate-free detergent.
- Rinse three times with cold tap water.
- Rinse three times with distilled or deionized water.

Method B: Acid Wash Procedure for Preparing Sampling Containers

This method should be used when preparing all sample containers and glassware for monitoring nitrates and phosphorus. Wear latex gloves!

- Wash each sample bottle or piece of glassware with a brush and phosphate-free detergent.
- Rinse three times with cold tap water.
- Rinse with 10 percent hydrochloric acid.
- Rinse three times with deionized water.

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Procedure for Collecting Grab Samples

A grab sample is a discrete water sample collected at a particular time and place. A grab sample is most often collected manually with appropriate sampling equipment.

In general, samples are collected away from the streambank in the main current. Never sample stagnant water. The outside curve of the stream is often a good place to sample, since the main current tends to hug this bank. In shallow stretches, carefully wade into the center current to collect the sample. A boat will be required for deep sites. Try to maneuver the boat into the center of the main current to collect the water sample.

When collecting a water sample for analysis in the field or at the laboratory, follow the steps below.

Using Screw-cap Bottles

To collect water samples using screw-cap sample bottles, use the following procedures:

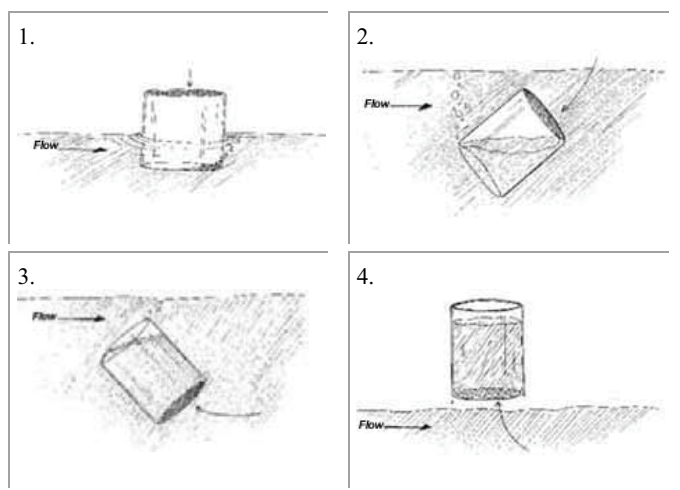
Label the bottle with the site number, date, time and name of person or group ID. Take all samples in the main flow of current, facing upstream.



Remove the cap from the bottle just before sampling. Wear gloves and avoid touching the inside of the bottle or the cap. If you accidentally touch the inside of the bottle, use another one.

Wade into stream. Try to disturb as little bottom sediment as possible. In any case, be careful not to collect water that has sediment from bottom disturbance. Stand facing upstream. Collect the water sample on your upstream side, in front of you. You may also attach your bottle to an extension pole to sample deeper water.

From Boat. Carefully reach over the side and collect the water sample on the upstream side of the boat.



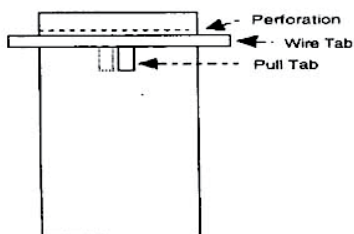
- 1 Hold the bottle near its base and plunge it (opening downward) below the water surface. If you are using an extension pole, remove the cap, turn the bottle upside down, and plunge it into the water, facing upstream. Collect a water sample 8 to 12 inches beneath the surface, or mid-way between the surface and the bottom if the stream reach is shallow.
- 2 Turn the bottle underwater into the current and away from you.
- 3 In slow-moving stream reaches, push the bottle underneath the surface and away from you in an upstream direction. Be careful not to disturb or scrape bottom sediments.
- 4 Leave a 1 inch air space (Except for DO). Do not fill the bottle completely (so that the sample can be shaken just before analysis). Recap the bottle carefully, remembering not to touch the inside.

Log the sample ID number and/or site number on the Chain of Custody form and/or the appropriate field data sheet.

Using Whirl-pak® Bags

Wear gloves and avoid touching the inside of the bag at all times. If you accidentally touch the inside of the bag, *discard it and use another one.*

- 1 Label the *unopened* bag with the site number, date and time of collection, analysis to be performed, and name of person or group ID.



Sketch of a Whirl-pak® bag

- 2 Tear off the top of the bag along the perforation above the wire tab just prior to sampling (see figure).
- 3 Wade into stream, or approach outlet, or source of flowing water. Try to disturb as little bottom sediment as possible. Stand facing upstream. Collect the water sample in front of you. Be careful not to collect water that contains bottom sediment.
- 4 Hold the two white pull tabs in each hand and lower the bag into the water with the opening facing upstream. With the bag submerged, pull out on the side tabs to open the bag until it fills with water (see procedure above). The bag should begin to fill with water.

With the bag underwater, pull the wires away from one another to close the bag; remove the sample bag from the water.

- 5 Hold the Whirl-Pak from the wire ends, and quickly 'whirl' or flip the bag away from your body two to three times to ensure a water tight seal. (Be careful not to flick water in your face)
- 6 Place the bag upright into the ice chest inside a larger bag. Be sure the sample is thoroughly surrounded with ice – but no ice water can get into sample.
- 7 Log the sample ID number and site ID number on the Chain of Custody form and/or the appropriate field data sheet.

When Collecting Bacteria Samples:

Deliver the bacteria samples to the laboratory within 6 hours of collection.

If samples are delivered more than 6 hours after time of collection they are compromised and results are not valid.

Samples Requiring Special Collection and Handling

Each lab will direct you to the correct sampling procedure for the analysis you are requesting, and if asked will help you to understand and follow the QA requirements such as what collection tools or precautions you must use to assure a good, clean sample.

If your analysis requires you to collect in glass or metal bottles, you can be sure that there is a concern with the parameter reacting with plastic - therefore do not use a plastic bucket to collect water. Check with your lab or advisors to be sure you don't do something that would invalidate the analysis of your sample.

Pesticide samples

There are no special considerations for pesticides other than to collect samples in glass bottles; ask the lab to provide you the correct containers for your requested analysis.

Most labs conducting pesticide analysis will require amber glass bottles that are filled all the way to the top. These bottles are to be immediately placed on ice and out of direct sunlight.

The State of California's SWAMP program recommends that the sample container used for pesticides and herbicides be a new, clean, unused amber glass jar with a Teflon-liner inside the cap.

Procedure for Collecting Pesticide Samples:

- Collect one liter of water for every group of pesticides to be analyzed (organophosphates, pyrethroids, etc.). EACH ANALYSIS TYPE REQUIRES A SEPARATE JAR.
- Minimize the air space in the top of the jar.
- Preserve immediately after collection by placing on ice out of the sunlight.

Using the Equipment

Air Temperature

Procedure for Air Temperature

Equipment Required: Digital or Bulb Thermometer

Take the air temperature by holding the thermometer away from body and at least 4 feet from the ground or hang from a convenient branch at least 4 feet from the ground.

Keep thermometer out of direct wind and sun.

Do not hold thermometer close to your body or in your hands, because your hands will warm the thermometer with your body heat. The sensing element is at the bottom of each instrument or probe.

Hold or let the thermometer hang for two minutes and then read the thermometer while it's still hanging in same place. Record the value to the nearest 0.5°C in the space provided on your data sheet.

NOTE: Store bulb thermometers completely horizontal or completely vertical to avoid liquid separation. If liquid separates, do not try to 'shake' the liquid down, you could break the thermometer. Be sure to turn off digital thermometers.

Example of a Well water sample collection procedure:

Example of well water sample collection procedure for Pesticides:

Samples were collected in 1-L amber glass bottles with Teflon-lined caps and usually collected from Schrader valves. Prior to sampling, pumps were run for at least 10 min to clear the casing of standing water and to bring in fresh water from the aquifer. The sample bottles were rinsed with well water and then refilled in a manner that minimized aeration. Field blanks were prepared at each site with deionized water and were analyzed only when pesticide residues were detected in the primary samples. Preservative procedures, such as adjusting the acidity of samples, were conducted as appropriate for each analyte. After sample collection, bottles were stored on wet ice and subsequently stored in a refrigerator at 4°C until analysis.

Water Temperature

Procedure for Water Temperature

Equipment Required: Digital or Bulb Thermometer

Take the water temperature directly from the flow being monitored if at all possible.

Hold the thermometer in the water for two minutes and then read the thermometer from the water—Do not take the thermometer out of the water to read the temperature, as it will immediately begin to change with the environmental conditions.

Record the value to the nearest 0.5°C in the space provided on your data sheet.

NOTE: If you need to measure the water temperature from an unsafe or inaccessible location, you may collect water in a container and measure the

temperature from this container. Note – if you do this, the reading must be taken immediately after collection as the environment will change the water temperature rapidly, and you should only hold the container from its rim so as to not heat the water with your hands.

pH

Procedure for pH with Quick Test Strips

Equipment Required: pH strip and package

- 1 Remove one strip from package and recap package. (Use two strips simultaneously to take a replicate measurement.)
- 2 Dip the strip directly into the water being sampled; submerge beyond all color bars.
- 3 Remove the strip from the water & 'flick' strip to shake off water droplets on strip surface.
- 4 IMMEDIATELY compare the three color bars on the strip to the scale on the package, chose the best color match of all three colors. Do not estimate between the numbers on the scale.
- 5 Record your measurement on the data sheet.

Note: Be sure to choose the 'best match' for all three color bars. Be sure to compare test strip to scales on both sides of the package. Record the associated pH value as your pH reading on your data sheet.

Procedure for pH with Oakton pHTestr (probe)

Equipment Required: Oakton pHTestr Basic, pH buffers (standards: pH 4, pH 7, and pH 10), and Tap water.

CONDITIONING:

Condition the unit before first use.

Remove cap, dip sensor in tap water for 1 hour. This activates sensor and dissolves crystals.

Calibration:

Select pH 7 buffer for general testing; pH 4 for acidic and pH 10 for basic samples.

- Press ON/OFF button.
- Dip sensor in chosen buffer about 2 cm deep and stir gently. Wait for displayed value to stabilize at or near pH buffer chosen.



- Press CAL button. When display flashes, press HOLD/CON button to confirm. Calibration is complete.
- Repeat with next buffer solution.

pH Testing:

- 1 Press **ON/OFF** button.
- 2 Dip sensor in sample.
- 3 Press HOLD/CON button to hold reading. Press again to release.
- 4 Record result on data sheet.

Changing Batteries:

Twist open the battery compartment lid. Replace old batteries with new ones noting polarity as shown in battery compartment.

Note: You must recalibrate after every battery change.

Error Messages:

E 1 – Weak batteries; need replacement.

E 2 – Wrong or bad buffer value (out of range); sensor is faulty or not in contact with sample solution.

Dissolved Oxygen (DO)

Procedure for DO Winkler Method

The Winkler test is used to determine the level of dissolved oxygen in fresh or saline water.



Equipment/ Reagents Required: LaMotte Dissolved Oxygen test kit # 5860

WARNING: Reagents marked with an * are considered hazardous substances.

The Winkler method involves filling a sample bottle with water to be tested. Dissolved oxygen is then “fixed” (or chemically held in suspension and will not change) using a series of reagents that form an acid compound that is titrated. The amount of the titration reagent used directly corresponds to the amount of

QTY	CONTENTS	CODE
30 mL	Manganous Sulfate Solution *	4167-G
30 mL	Alkaline Potassium Iodide Azide *	7166-G
30 mL	Sulfuric Acid, 1:1 *	6141WT-G
60 mL	Sodium Thiosulfate, 0.025N *	4169-H
30 mL	Starch Indicator Solution	4170WT-G
1	Direct Reading Titrator, 0 – 10 scale	0377
1	Titration Tube, 20 mL, w/cap	0299
1	Glass Water Sampling Bottle, 60 mL,	0688-DO

DO in the water tested (ppm or mg/L). This test was first developed in 1888.

DO samples should represent average conditions in the stream reach being measured. The best place to collect a sample collected is in the middle of the stream at least a few inches below the water surface. If the sample must be collected from the shore, be sure to pick a site where there is enough current to ensure adequate mixing – don't sample from stagnant, slow moving water if it is not representative of the stream segment.

Part 1 - Collecting Samples

- To avoid contamination, thoroughly rinse the Water Sampling Bottle (0688-DO) with Distilled (DI) water three times.
- Next rinse Water Sampling Bottle with sample water three times. Pour out all remaining rinse water.
- Tightly cap the bottle and submerge to the desired depth.
- Remove the cap and allow the bottle to fill while remaining underwater.
- Tap the sides of the submerged bottle to dislodge any air bubbles clinging to the inside.
- Replace cap while the bottle is still submerged.
- Retrieve the bottle and examine it carefully (gently turn upside down) to make sure that no air bubbles are trapped inside. Once a satisfactory sample has been collected, proceed immediately to "fix" the sample.

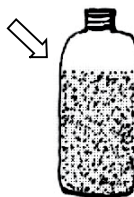
Part 2 - Fixing the Water Sample for Winkler Dissolved Oxygen Test

The water sample must be "fixed" which is a procedure that ensures it will not be affected by exposure to air. If an unfixed sample is exposed to air, the results may be skewed.

Be careful not to introduce air into the sample while adding the reagents. Simply

drop the reagents into sample, cap carefully, and gently mix.

- Remove cap from bottle and set aside, keep clean.
- Immediately add 8 drops of *Manganous Sulfate Solution (4167) and 8 drops of *Alkaline Potassium Iodide Azide (7166).
- Cap and mix by inverting several times. A precipitate (dark flakes, called 'floc') will form.
- Allow the precipitate to settle below the shoulder of the bottle before proceeding.
- Add 8 drops of *Sulfuric Acid, 1:1 (6141WT).
- Cap and gently invert the bottle until the reagent and the precipitate have dissolved. A clear yellow to brown-orange color will develop, depending on the oxygen content of the sample.



Note: At this point the sample has been fixed and contact between the sample and the atmosphere will not affect the test result. Samples may be held at this point and titrated later.

Part 3 - Titrating the Dissolved Oxygen Result

- Fill the titration tube (0299) to the 20 ml line with the "fixed" sample and cap.
- Fill the Direct Reading Titrator (syringe 0377) with Sodium Thiosulfate, 0.025N (4169).
- Insert the titrator into the center hole of the titration tube cap.
- While gently swirling the tube, slowly press the plunger to titrate until the yellow-brown color is reduced to a very faint yellow. (You can also dispense a small amount of Sodium Thiosulfate, swirl, and dispense some more; 1 increment at a time).
- Remove the titrator and cap, placing them to the side on a clean surface. Be very careful not to disturb the titrator.
- Add 8 drops of Starch Indicator Solution (4170WT). The sample should turn dark blue.
- Replace the cap and reinsert the titrator – again be very careful not to disturb the titrator or dispense any Sodium Thiosulfate from it.
- With the tip of the titrator re-inserted into the opening of the titration tube cap, slowly depress the plunger to dispense the Sodium Thiosulfate titrating solution one drop at a time. Gently swirl the tube to mix the solution.
- Continue adding the Sodium Thiosulfate titrating solution (4169) one drop at a time until the color changes from blue to



clear.

- Remove the titrator and carefully read the scale along the side; each major increment is worth 1.0, and each minor increment is 0.02.

Note: If the plunger tip on the syringe reaches the bottom line on the titrator scale (10 ppm) before the endpoint color change occurs, refill the titrator and continue the titration process. When recording the test result, be sure to include the value of the original amount of reagent dispensed (10 ppm).

- Record the final numerical value on your data sheet in ppm (or mg/L).

If no additional tests are to be made, discard the titrating solution in the waste container provided in the field kit. Thoroughly rinse the titrator (syringe) and the titration tube with distilled water and discard that water into the same waste container.

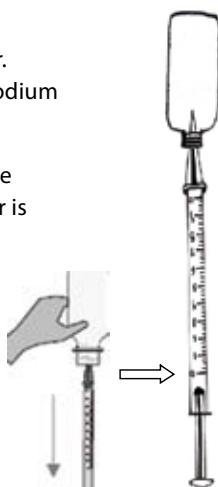
How to Use and Fill the Titrator

Depress the plunger of the titrator completely to expel air. Insert the titrator (syringe) into the plastic fitting of the Sodium Thiosulfate titrating solution bottle (4169) (Figure 3-15).

To fill the titrator invert the bottle and slowly withdraw the plunger until the bottom of the plastic part of the plunger is opposite the zero mark on the scale of the titrator

Turn the bottle right side up and remove the titrator from the Sodium Thiosulfate. Cap the Sodium Thiosulfate and set aside.

Note: If small air bubbles appear in the Titrator barrel, expel them by partially filling the barrel and pumping the titration solution back into the reagent container. Repeat until bubble disappears.

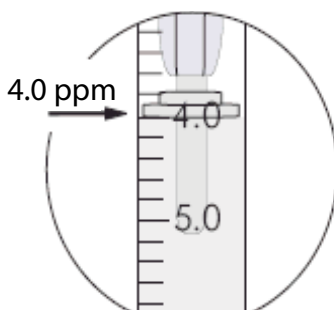


Return to the Titration instructions, step 3

Reading the Titrator

Read the test result directly from the scale opposite the bottom of the plunger tip.

Note: Each minor division on the titrator scale equals 0.2 ppm.



Procedure for Dissolved Oxygen Using the YSI Model 55 DO Meter

Equipment/ Reagents Required: YSI 55 Dissolved Oxygen meter.

There will be manufacturer's instructions for properly preparing the meter before you take measurements, this guide assumes you have followed those and are ready to start monitoring with your meter.



Dissolved oxygen calibration must be done in an environment with a known oxygen content. Since the amount of oxygen in the atmosphere is known, it makes an excellent environment for calibration (at 100% relative humidity). The calibration/storage chamber contains a moist sponge to create a 100% water saturated air environment.

To accurately calibrate the YSI Model 55, you will need to know the following information:

- The approximate **altitude** of the region in which you are located. Sea level is zero.
- The approximate **salinity** of the water you will be analyzing. Fresh water has a salinity of approximately zero. Sea water has a salinity of approximately 35 parts per thousand (ppt). If you are not certain what the salinity of the sample water is, use a Salinity/Conductivity meter to determine it.

Step 1 - Calibrating the YSI 55 DO Meter.

(The meter must be calibrated at every site).

- Ensure that the sponge inside the instrument's calibration chamber is wet. Insert the probe into the calibration chamber.
- Turn the instrument on by pressing the **ON/OFF** button on the front of the instrument. Wait for the dissolved oxygen and temperature readings to stabilize (usually 15 minutes is required after turning the instrument on).
- To enter the calibration menu, use two fingers to press and release both the **UP ARROW** and **DOWN ARROW** keys at the same time.
- The LCD will prompt you to enter the local altitude in hundreds of feet. Use the arrow keys to increase or decrease the altitude. [EXAMPLE: Entering the number 12 here indicates 1200 feet.]
- When the proper altitude appears on the LCD, press the **ENTER** key. The Model 55 should now display **CAL** in the lower left of the display, the calibration value should be displayed in the lower right of the display and the current DO reading (before calibration) should be on the main display.
- Make sure that the DO reading (large display) is stable, then press the

ENTER button. The LCD will prompt you to enter the approximate salinity of the water you are about to analyze. You can enter any number from 0 to 40 parts per thousand (ppt) of salinity. Use the arrow keys to increase or decrease the salinity setting. When the correct salinity appears on the LCD (zero for fresh water), press the **ENTER** key. The instrument will return to normal operation.

Once the calibration process is complete, the only keys which will remain operational are the MODE key, the LIGHT key and the ON/OFF key. You can move back and forth from reading dissolved oxygen in the mg/L mode or the % air saturation mode by pressing the MODE key. If you are working in a dark area and have difficulty reading the LCD, press and hold the LIGHT key to activate the back-light of the YSI Model 55. The ON/OFF key turns the instrument on or off.

For best results:

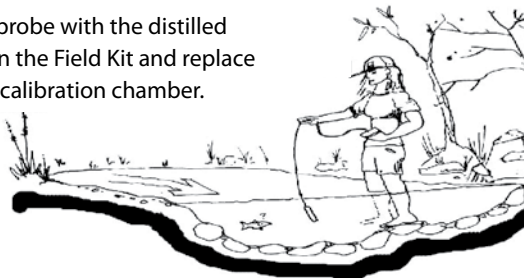
- Each time the Model 55 is turned off, re-calibrate before taking measurements.
- Calibrate at a temperature within $\pm 10^{\circ}\text{C}$ of the sample temperature.

Repeat this process each time you sample a new monitoring site.

Step 2 - Measuring Dissolved Oxygen

- Remove the probe from the calibration chamber. Lower the probe in the water halfway between the surface and the bottom of the water you are sampling (at least 3.5 inches below the surface water). Do not let the probe hit the bottom as this may cause damage to the meter.

Note: Rinse the probe with the distilled water provided in the Field Kit and replace the probe in the calibration chamber.



- Slowly move the probe tip through the water at a rate of one foot per second. This can be accomplished by gently bobbing the probe tip up and down in deep water or moving it back and forth through the water.
- Wait for the reading on the meter stabilize then record the temperature and dissolved oxygen measurement in the % saturation column on the Data Sheet. Do not stop moving the probe tip through the water.
- Press the MODE button to switch the meter into the mg/L mode.
- Wait for the reading on the meter stabilize then record the temperature

and dissolved oxygen measurement in the mg/L. column on the field sheet.

- Move your next location and repeat steps 1-6, and record the results on the field sheet. If you turn the meter off you must re-calibrate.

Procedure for

Dissolved Oxygen with the Oakton 100 DO Meter

There will be manufacturer's instructions for properly preparing the meter before you take measurements, this guide assumes you have followed those and are ready to start monitoring with your meter.

Dissolved Oxygen calibration in percent saturation (%)

You can calibrate the DO 100 quickly and easily in air. The exact calibration value depends on barometric pressure. The meter is set to a factory default of 760 mm Hg, which results in a calibration value of 100% saturation in air.



NOTE: If the barometric pressure setting has been changed from 760 mm Hg, the calibration value in air will automatically adjust to a value other than 100%. The adjusted value will be correct for the new barometric pressure setting.

Step 1 – Calibrating the meter to % Saturation. (The meter must be calibrated at every site).

- Rinse the probe well with deionized rinse water or rinse solution. For best accuracy, wrap the end of the probe in a damp cloth. Do not touch the membrane.
- Press the MODE key to select the % saturation mode.
- Press the CAL key. The CAL indicator will appear above the primary display. The primary display shows the current value of the measurement and the secondary display will show 100.0.
- Hold the probe in the air. Wait for the reading to stabilize. If the Ready indicator feature is enabled, it will appear when the reading is stable.
- Press the ENTER key. The meter automatically calibrates to 100.0% air saturation and returns to Measurement mode. During measurement, the probe can be:
 - Fully immersed in the solution.
 - Partially immersed in the solution.

Do not allow the probe's membrane surface to touch anything! The probe guard (the piece with holes fitted over the end of the probe) protects the membrane; you should leave this piece attached to the probe at all times.



IMPORTANT: since the DO probe consumes oxygen from the sample, the sample must constantly flow past the membrane to achieve more accurate readings.

Step 2 - Measuring Dissolved Oxygen

- Rinse the probe well with deionized rinse water or rinse solution.
- Press the MODE key to select the appropriate measurement mode: mg/L, (ppm)* or %.
- Dip the probe into the sample.
- Stir the probe gently to homogenize the sample. Make sure that the sample is continuously flowing past the membrane sensor. Note the reading on the display. If the READY indicator is switched on, it will appear when the reading is stable.

Record the result on the data sheet as % or mg/L (ppm).

Most commonly used units for standard DO measurement results)

Electrical Conductivity (EC), Salinity (Sal), and Total Dissolved Solids (TDS)

What is the difference between measuring conductivity, salinity, and Total Dissolved Solids (TDS)?

The test probes are the same for conductivity salinity and TDS; but in a salinity or TDS meter a correction factor is applied to the reading. The correction factor takes the conductivity reading and converts it to ppt of salt for salinity, and monitors how much current is passing between the electrodes as a gauge of how many ions are in solution and converts it to ppm for TDS.

Procedure for Conductivity with the Oakton Pocketest

Equipment Required: Oakton Conductivity Pocket Meter (ECTestr Low, 0 to 1990 μ S; ECTestr High, 0 to 19.90 mS)

NOTE: 1 milli-Siemens (mS) equals 1000 micro-Siemens (μ S). Example:
5.0 mS = 5000 μ S.



Remove cap from meter, Press 'ON/OFF' button to turn meter on.

- Dip Electrode end of meter directly into flowing water, or into container. Make sure electrodes remain fully submerged for 30 sec.

- Wait for reading to stabilize (meter is measuring temperature).
- Record the result on the data sheet
- Press 'ON/OFF' button to turn meter off. Rinse the electrode in distilled water. Replace the cap.

Note: Once the meter display has settled, you can press the "HOLD" button to freeze the display, as it will change once you remove the electrodes from the water.

NOTE: 1 part per thousand (ppt) equals 1000 parts per million (ppm).

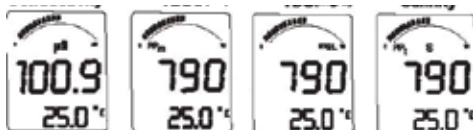
Example: 3.1 ppt = 3,100 ppm

Procedure for EC/TDS/SAL with the Lamotte Pocketester

Equipment Required: Lamotte EC/TDS/SAL Pocketester Code 1749

This meter can be set to measure Conductivity, TDS (ppm), TDS (mg/L) or Salinity (ppt).

- Remove cap from meter, Press 'ON/OFF' button to turn meter on.
- Press and hold the **MODE/HOLD** button for 3 seconds. The display will begin to scroll through the units. [uS or mS (Conductivity) ppm or ppt (TDS) mg/L or g/L (TDS) ppm or ppt (Salinity "S")]



- Release the **MODE/HOLD** key when the desired mode is displayed.
- Fill a sample cup to the 20 ml line with the test sample. Sample depth must be greater than or equal to 1.5 inches.
- Immerse the TRACER electrode in the sample. Make sure the electrode is completely submersed.
- Press the **ON/OFF** button. (**8888** and then **SELF CAL** will appear in the display during the initial diagnostics).
- Slowly stir the sample with the TRACER to remove air bubbles.
- The meter will auto-range to the proper range and the reading will be displayed. (The display will flash "0000" while auto ranging.)
- Press 'ON/OFF' button to turn meter off. Rinse the electrode in distilled water. Replace the cap.

Turbidity and Water Clarity

Turbidity

Procedure for LaMotte Turbidity Kit 7519

Equipment Required: Dual-Cylinder Turbidity kit (LaMotte 7519)



This visual comparison test kit is designed for use in shallow waters where Secchi disc depth reading is not feasible. Readings are made by using a standard turbidity reagent to match the turbidity of a water sample. This turbidity measurement compares a turbid sample with a clear sample, then by adding drops of a special clouding solution to the clear sample until it appears as cloudy as the turbid sample. The results are measured in Jackson Turbidity Units (JTUs).

- Fill one turbidity column to the 50 ml line with the sample water. If the black dot on the bottom of the tube is not visible when looking down through the opening of the tube, then pour out water until you get to the 25 mL line.
- Fill the second turbidity column with distilled water that is equal to the amount of sample water being used above.
- Place the two tubes side by side and note if there is a difference in clarity. If the black dot is equally clear on both tubes, record the results as 0. If not, proceed to the next step.
- Shake the standard turbidity reagent vigorously. Add 0.5 mL to the distilled water tube. Use the stirring rod to stir contents of both tubes (wipe off the stirring rod with a dry paper towel after each stir).
- Check for the amount of turbidity by looking down through the water at the black dot. If the turbidity of the sample water is greater than that of the distilled water, continue to add the reagent in 0.5 mL increments to the distilled water tube, mixing after each addition until the turbidity equals the sample.
- Record the total amount of turbidity reagent added.

QUALITY CONTROL TIPS for the Turbidity - Kit

- 1 Do not view the test in direct sunlight.
- 2 Stir the solution in each tube right before comparing the cloudiness.
- 3 Shake the Standard Turbidity Reagent throughout the testing.
- 4 Measure the Standard Turbidity Reagent carefully.
- 5 Ignore the apparent color of the sample. Look only at the fuzziness of the target.

Turbidity Test Result Scale

# of Additions	Amount in mL	50 mL Sample	25 mL Sample
1	0.5	5 JTU	10 JTU
2	1.0	10 JTU	20 JTU
3	1.5	15 JTU	30 JTU
4	2.0	20 JTU	40 JTU
5	2.5	25 JTU	50 JTU
6	3.0	30 JTU	60 JTU
7	3.5	35 JTU	70 JTU
8	4.0	40 JTU	80 JTU
9	4.5	45 JTU	90 JTU
10	5.0	50 JTU	100 JTU
15	7.5	75 JTU	150 JTU
20	10.0	100 JTU	200 JTU

Water Clarity

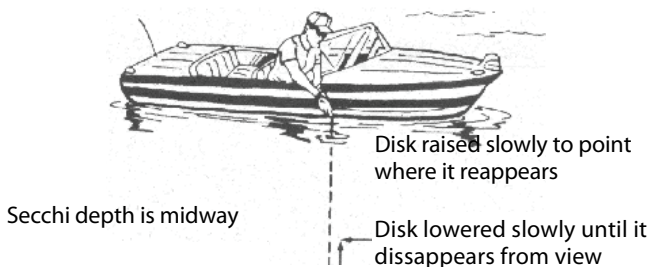
Procedure for Water Clarity with Secchi Disk

Equipment required: Secchi disc, 50-100M cord, weight

The Secchi Disk is a white (salt water) or half black and half white/half black 20 centimeter (cm) diameter plastic disk with a weight on the bottom. A measured line is attached with tick marks at every 10 cm, and thicker tick marks to denote every meter. Always take Secchi disk measurements sheltered from the wind and sun.

Note: The greatest value of the Secchi disc measurements occurs when each lake compares its own readings from week to week, month to month and season to season. No comparisons between lakes should be made unless similarities in measurements are followed vigorously. Several factors are involved, such as the eyesight of the viewer, the time of day the readings are taken (midday- between 10 and 2 is preferred), the reflectance of the disc, the color of the water, clay particles or other materials suspended in the water, etc.





Note: Secchi depth is to be taken in deep water, and will require a boat or pier.

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Measuring Water Clarity

Lower the Secchi Disk into the water until it just disappears.

Record the depth at the point where the Secchi disk disappears by counting the tick marks on the measured line. Each small tick mark is 10 cm and the large tick marks are meters.

Slowly raise the Secchi disk until it just reappears. Record the depth where the Secchi disk just reappears using the measured line.

Average the two depth readings (depth in step 2+ depth on step 4, then divide by two).

Record the result as Transparency on your field sheet.

The deeper the Secchi disk can be lowered into the water and is still visible, the clearer or less turbid the water.

QUALITY CONTROL TIPS for Turbidity - Secchi Disk

- 1 View the disk in the shadow of a dock or boat to avoid glare.
- 2 Add weight if the disk does not travel vertically through the water due to strong currents.

Procedure for Water Clarity with the Transparency Tube

Equipment Required: Transparency tube

Only do this test if there is daylight, never attempt in the dark. This tool requires two people to operate; one to release water, one to view through tube.

- Close the drain tube by squeezing the crimp.
- Fill the transparency tube with the water sample.
- While looking down through the opening of the tube,



Measuring Nutrients

Nitrate-Nitrogen

Procedure for HACH Nitrate-Nitrite Test Strip

Equipment Required: HACH Nitrate-Nitrite test strip package (Cat. 327454-25); watch with second hand or timer with second count.

Measuring Nitrate and Nitrite Concentrations

- Dip a strip into water for 1 second (or pass under gentle water stream) and remove. So not shake excess water from the test strip.
- Hold the strip level, with pad side up, for 30 seconds. Compare the NITRITE test pad (inner pad) to the NITRITE color chart on container.
- At 60 seconds, compare the NITRATE test pad (outer pad) to the NITRATE color chart. Estimate results if the color on the test pad falls between two color blocks.

Note: The Nitrate Test actually measures the sum of both nitrate-nitrogen and nitrite- nitrogen in the sample.

IMPORTANT: KEEP CAP ON TIGHT BETWEEN USES. STORE AT ROOM TEMPERATURE.

Procedure for Nitrate Using the HANNA HI93728

Equipment Required: Hanna Nitrate ISM (Range: 0.00 to 30.0 mg/L (ppm)); watch with second hand or timer with second count.

The HI 93728 meter measures the nitrate-nitrogen (NO₃_N) content.

As equipment varies, please see your individual meter's instructions.



Method: Adaptation of the cadmium reduction method. The reaction between nitrate–nitrogen and the reagent causes an amber tint in the sample (HI 93728)

1 Meter (HI 93728)

1 Packet Nitrate Powder reagent (HI 93728-0)

2 glass cuvetts with lids

Soft absorbent lint-free lens cloth

To perform this test, standard water samples should be collected following the procedure described in the “Collecting Water Samples” section.

Measuring Nitrate Concentrations

- Turn the meter on by pressing ON/OFF.
- When the LCD displays “ - - - ” it is ready
- Add **6 ml** of sample water to the cuvet and replace the cap
NOTE: Carefully wipe the cuvet dry with the cloth before placing in the chamber. DO NOT allow water to get in the meter chamber
- Place the cuvet into the chamber and ensure that the notch on the cap is positioned securely into the groove
- Press **ZERO** and “SIP” will appear on the display for a few seconds and the display will show “**0.0**”. Now the meter is zeroed and ready for measurement
- Remove the cuvet and carefully add all the contents of one packet of HI 93728 powdered reagent
- Replace the cap and immediately **shake vigorously for exactly 10 seconds** by moving the cuvet up and down.
- Continue to mix by inverting the cuvet gently and slowly for 50 seconds, while taking care not to induce air bubbles. A deposit could remain but it does not affect the measurement. Be careful to time the shaking period, incorrect timing could affect the measurement
NOTE: Carefully wipe the cuvet dry with the cloth before placing in the chamber - DO NOT allow water to get in the meter chamber.
- Reinsert the cuvet into the instrument chamber, take care not to shake it further.
- Press READ TIMED and the display will show the countdown prior to the measurement. Alternatively, wait for 4 minutes and 30 seconds and press READ DIRECT. In both cases “SIP” will appear during measurement.
- The instrument directly displays concentration in mg/L of nitrate- nitrogen on the LCD.
- Record result on the data sheet.
- To convert the reading to mg/L of nitrate (NO₃-), multiply by a factor of 4.43. (Always record the instruments result before doing the conversion so errors can be detected and repaired)

Ammonia Nitrogen

Procedure for Ammonia Nitrogen Using the HANNA HI93700

Equipment Required: Hanna Ammonia ISM (Range: 0.00 to 3.00 mg/L (ppm)); watch with second hand or timer with second count. The HI 93700 meter measures the ammonia nitrogen (NH₃-N) content in water, wastewater and seawater.



Method: Adaptation of the ASTM Manual of Water and Environmental Technology, D1426-92, Nessler method. The reaction between ammonia and reagents causes a yellow tint in the sample.

- 1 Ammonia Low Range Meter (HI 93700)
- 2 sample cuvetts with lids
- Reagent labeled "A, Add This First" (HI93700A-0)
- Reagent labeled "B, Add This Second" (HI93700B-0)
- One Transport Cap
- Soft absorbent lint-free lens cloth
- "Ammonia" waste water bottle

To perform this test, standard water samples should be collected following the procedure described in the "Collecting Water Samples" section.

Measuring Ammonia Nitrogen Concentrations

- Rinse cuvet once with distilled water.
- Rinse cuvet twice with sample water.
- Turn the meter on by pressing ON/OFF.
- Fill the cuvet up to the 10ml line (3/4" below rim) with sample water and replace the cap.
- Wipe cuvet off with ChemWipes—there can be no water or smudges!
- Place the cuvet into the holder and ensure that the notch on the cap is positioned securely into the groove.
- Press ZERO and "SIP" will appear on the display
- Wait for a few seconds and the display will show "-0.0-". Now the meter is zeroed and ready for measurement.
- Remove the cuvet and add 4 drops of the First Reagent (A), holding the dropper straight down.
- Replace the cap and swirl the solution in a circular motion, creating a vortex within the cuvet, for 10 seconds.
- Add 4 drops of the Second Reagent (B), holding the dropper straight down.

- Replace cap and swirl, as before, for 10 seconds.
- Wipe any water or smudges on cuvet with a ChemWipe, then Reinsert the cuvet into the instrument.
- Press READ TIMED and the display will show the countdown prior to the measurement. "SIP" will appear after the timer count and during the measurement.
- The instrument directly displays concentration in mg/L of ammonia nitrogen. Record this number on your data sheet.

Orthophosphate

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Procedure for Orthophosphate Using the HANNA HI93713

Equipment Required: Hanna Orthophosphate ISM (range 0.0–2.5 mg/L); watch with second hand or timer with second count.

The HI 93713 meter measures phosphate (PO_4^{3-}) content in water, wastewater and seawater in the 0.00 to 2.50 mg/L (ppm) range.

Method: Adaptation of the ascorbic acid method. The reaction between phosphate and the reagent causes a blue tint in the sample.



1 Phosphate Low Range Meter (HI 93713)

Two glass cuvetts

Hach brand PO_4 Reagent packets (small silver packets of powder reagent)

ChemWipes

Distilled H_2O

"Orthophosphate" waste water bottle.

To perform this test, standard water samples should be collected following the procedure described in the "Collecting Water Samples" section.

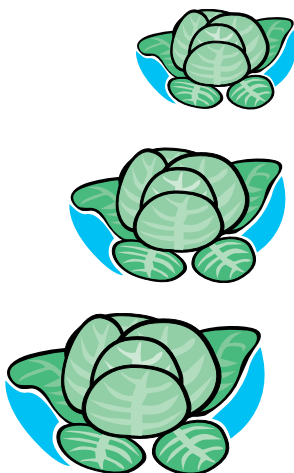
Measuring Ammonia Orthophosphate Concentrations

- Rinse the cuvet once with distilled water.
- Rinse the cuvet twice with sample water.
- Turn the meter on by pressing ON/OFF.
- Fill the cuvet up to the 10ml line (3/4" below the rim) with sample water and replace the cap.
- Wipe cuvet off with ChemWipes—there can be no water or smudges!
- Place the cuvet into the holder and ensure that the notch on the cap is positioned securely into the groove.

- Press ZERO and "SIP" will appear on the display.
- Wait for a few seconds and the display will show "-0.0-". Now the meter is zeroed and ready for measurement.
- Remove the cuvet and add the contents of one HACH brand PO₄ reagent.
- Replace the cap and swirl for 60 seconds in a circular motion (if done correctly, the water will create a vortex).
- Re-wipe cuvet with ChemWipes.
- Reinsert the cuvet into the instrument.
- Press "READ TIMED" and the display will show the countdown prior to the measurement. "SIP" will appear after the countdown, during the measurement.
- The instrument directly displays concentration in mg/L of orthophosphate.
- Record the reading on your data sheet.

(The water quality objective for orthophosphate (PO₄) is 0.37 ppm.)

Good testing!



Major Reference Citatations

Central Coast Regional Water Quality Control Board:

Water Management Plan (Basin Plan) •

<http://www.swrcb.ca.gov/rwqcb3/BasinPlan/Index.htm>

Central Coast Ambient Monitoring Program. • www.ccamp.org

Coastal Watershed Council Volunteer monitoring guidance •

www.coastal-watershed.org

Environmental Inquiry, Cornell University and Penn State University:

<http://ei.cornell.edu>

National Water Quality Handbook, September 2003.

http://www.info.usda.gov/scripts/lpsiis.dll/H/H_450_600_a.pdf

North Carolina Division of Forest Resources:

www.dfr.state.nc.us/water_quality/wq_typeswater.htm

State Water Resources Control Board (SWRCB), Water Words:

http://www.waterboards.ca.gov/publications_forms/available_documents/waterwords/

U.S. Department of the Interior, U.S. Geological Survey:

<http://acwi.gov/monitoring/glossary.html>

USEPA, The Volunteer Monitor's Guide to Quality Assurance Project Plans.

September 1996. DocID: EPA 841-B-96-003.

www.epa.gov/volunteer/qappcovr.html

USEPA Volunteer Monitoring Program •

<http://www.epa.gov/owow/monitoring/volunteer/epasvmp.html>

USEPA, Volunteer Stream Monitoring: A Methods Manual. November 1997.

DocID: EPA 841-B-97-003. www.epa.gov/volunteer/stream

USEPA, Water Science: www.epa.gov/waterscience

USDA, NRCS, National Handbook of Water Quality Monitoring Part 600.

December 1996. <ftp://ftp.wcc.nrcs.usda.gov/downloads/wqam/wqm1.pdf>

U.S. Geological Survey, Toxic Substances Hydrology Program:

<http://pubs.usgs.gov/fs/fs-027-01/>; <http://toxics/faq/waterquality.html>; <http://toxics.usgs.gov/index.html>

Volunteer Water Quality Monitoring National Facilitation Project •

<http://www.usawaterquality.org/>

Water Quality Association; The WQA Glossary of Terms:

www.wqa.org/glossary.cfm

Water Quality Monitoring" Arizona Cooperative Extension, Arizona Master Watershed Steward Program. Kitt Farrell-Poe (2005)

Wikipedia: www.wikipedia.org

And other common information sources: text books, the internet, and various state and educational institution web-sites.

Useful Documents and Websites

For more technical guidance information...

Central Coast Regional Water Quality Control Board -Central Coast Ambient Monitoring Program (CCAMP) <http://www.ccamp.org>

State Water Resources Control Board - Nonpoint Source (NPS) Pollution Control Program -The Clean Water Team (CWT) Guidance Compendium for Watershed Monitoring and Assessment:
<http://www.swrcb.ca.gov/nps/cwtguidance.html#40>

State Water Resources Control Board - Surface Water Ambient Monitoring Program (SWAMP) <http://www.swrcb.ca.gov/swamp/>

State Water Resources Control Board - Water Words:
http://www.waterboards.ca.gov/publications_forms/available_documents/waterwords/

USEPA, The Volunteer Monitor's Guide to Quality Assurance Project Plans. September 1996. DocID: EPA 841-B-96-003.
www.epa.gov/volunteer/qappcovr.html

USEPA, Volunteer Stream Monitoring: A Methods Manual. November 1997. DocID: EPA 841-B-97-003. www.epa.gov/volunteer/stream

United States Department of Agriculture Natural Resource Conservation Service; National Water Quality Handbook, September 2003.
http://www.info.usda.gov/scripts/lpsiis.dll/H/H_450_600_a.pdf

Funding Source Information

PG&E Special Environmental Project (SEP) of the Central Coast Regional Water Quality Control Board of the California Environmental Protection Agency.

The Non-point Source Pollution Projects Fund, seeks applications from capable organizations wishing to develop and implement projects to reduce runoff of sediment, fertilizer, nutrients, pesticides, herbicides, and other pollutants from commercial agriculture and other activities into Elkhorn Slough, Moss Landing Harbor, and tributary watersheds, including the lower Salinas River, Moro Cojo Slough, Reclamation Canal, and Tembladero Slough.



Water Quality Field Datasheet

[Your Org Name/Logo Here]

Field Data Sheet

Please Use one sheet for each Station. Use back for comments.

Date:

Arrival Time:

Watershed:

Watershed Group Name:

Site map is attached to this data sheet, please update if necessary.

GPS Coordinates:

Document Tracking number: **DOC_ID#**

Datum:

W:

N:

GPS ID:

Hydrologic Unit ID:

Station (Site) ID:


Waterbody:

Waterbody Type:

115

reference

Flow discharge (circle one): Stagnant (NOT Flowing); Moderate (< 5 gal/sec); Trickle (< 1 quart/sec); High (> 5 gal/sec)		Water Clarity (circle one): clear cloudy murky		WQ Monitors TEAM LEADER (list full name & phone #): Phone: () - 2) <input type="text"/> 3) <input type="text"/> 4) <input type="text"/> 5) <input type="text"/> (list additional names on back)	
Weather Conditions (circle one): - SKY - no clouds partly cloudy heavy clouds overcast		Has it rained within the last 24 hours? Y / N - PRECIPITATION - none foggy misty rain		- WIND - none breezy windy blustery	

 **Time of Field Measurements:**

INSTRUMENT ID	PARAMETER	RESULT	Replicate	UNITS	(circle appropriate unit)
	Air Temperature	<input type="text"/>	<input type="text"/>	F or C	
	H2O Temperature	<input type="text"/>	<input type="text"/>	F or C	
	pH	<input type="text"/>	<input type="text"/>	pH units	
	Dissolved Oxygen	<input type="text"/>	<input type="text"/>	mg/l (ppm)	
	Conductivity	<input type="text"/>	<input type="text"/>	µS mS	
	Turbidity	<input type="text"/>	<input type="text"/>	JTU NTU	
	Transparency	<input type="text"/>	<input type="text"/>	cm	
		<input type="text"/>	<input type="text"/>	UNIT	
		<input type="text"/>	<input type="text"/>	UNIT	
		<input type="text"/>	<input type="text"/>	UNIT	

Notes and Observations :
(include any equipment comments/problems or observations such as water color, trash composition, etc.)

Fish or Wildlife Observed:
(describe number seen, birds, livestock, fish, etc)

Sample Collection:

Sample ID: Site ID + sample code	Time Collected:	AM PM	Collected by: Name	Type:	Container type: bag/bottle/jar - plastic/glass
				Bacteria	
				Nutrient	
				QA/Field Blank	

Sample Custody:

Relinquished By:	Received By:
Date / Time:	Date / Time:

This event sponsored by the _____
In collaboration with the _____

Do not jeopardize your personal safety to complete this datasheet.

Water Quality Field Datasheet

Field Data Sheet

Please Use one sheet for each Station. Use back for comments.

[Your Org Name/Logo Here]

GPS Coordinates:

Document Tracking number: **DOC_ID#**

Datum: _____

W: _____

N: _____

GPS_ID: _____

Hydrologic Unit ID: _____

Station (Site) ID: _____

Waterbody: _____

Waterbody Type: _____

Watershed Group Name: _____

Site map is attached to this data sheet, please update if necessary.

Flow discharge (circle one): Stagnant (NOT Flowing); Moderate (< 5 gal/sec);	Water Clarity (circle one): Trickle (< 1 quart/sec); High (> 5 gal/sec);	clear cloudy murky
Weather Conditions (circle one): Has it rained within the last 24 hours? Y / N --SKY-- no clouds partly cloudy heavy clouds overcast --PRECIPITATION-- none foggy misty rain --WIND-- none breezy windy blustery		
WQ Monitors TEAM LEADER (list full name & phone #): Phone: () - - (list additional names on back)		

Time of Field Measurements: _____			
INSTRUMENT ID	PARAMETER	RESULT	UNITS
	Air Temperature		F or C
	H2O Temperature		F or C
	pH		pH units
	Dissolved Oxygen		mg/l (ppm)
	Conductivity		µS mS
	Turbidity		JTU NTU
	Transparency		cm
			UNIT _____
			UNIT _____
			UNIT _____
Notes and Observations : (include any equipment comments/problems or observations such as water color, trash composition, etc.)			Fish or Wildlife Observed: (describe number seen, birds, livestock, fish, etc)

Sample Collection:				
Sample ID: Site ID + sample code	Time Collected:	AM/PM	Collected by: Name	Type: Container type: bag/bottle/jar - plastic/glass
				Bacteria
				Nutrient
				QA/Field Blank
Sample Custody:				
Relinquished By:			Received By:	
Date /Time:			Date /Time:	

This event sponsored by the _____
in collaboration with the _____

Do not jeopardize your personal safety to complete this datasheet.

Lab Sample Chain-of-Custody Form

[Your Org Name Here]

Page _____ of _____

Project Name _____

Laboratory & Analysis:

Date of Sample: _____

[This is the Only place for the date - Don't forget it]

Event Name: _____

Sample ID	Time Collected	Collected By	Container Type	Sample Type [Analysis]	Sample Goes To: [Laboratory name]
304-SANLO-24-B	10:48 AM	Tamara Doan	Lab Jar	Bacteria (B)	Santa Cruz County DEHS
304-SANLO-24-B	12:42 PM	Tamara Doan	WHIRLPAC	Filtrate (F)	Santa Cruz County DEHS
202-SANPE-11-N	12:42 PM	Debie Chirco	WHIRLPAC	Nutrients (N)	Santa Cruz County DEHS
202-SANPE-11-ND	12:42 PM	Debie Chirco	WHIRLPAC	Nutrient Duplicate (ND)	San Mateo County DEHS
30-ELKHO-11-M	2:20 PM	T.J. Smith	Glass Bottle	Metals Analysis	San Mateo County DEHS
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

SAMPLE CUSTODY
RELINQUISHED BY

DATE/TIME

RECEIVED BY

DATE/TIME

[Name of your person handling samples to the lab personnel: time they received samples]

Make a new sheet for additional samples from today - & - Make a new sheet for each different date or monitoring event

[Name of person at the lab receiving your samples: time the lab receives the samples]

Instrument Calibration Record Form

DQM Calibration and Accuracy Checks Data Sheet

Event _____

Project ID _____

Page _____ of _____

		Record 1	Record 2	Record 3
A	Instrument ID			
B	Parameter			
C	Unit			
D	Date of Calibration or Accuracy Check			
E	Time of Calibration or Accuracy Check			
F	Intent or associated event			
G	Temperature (C) at Calibration or Accuracy Check (and thermometer ID)			
H	"True" value of Standard [see on the label] or natural point			

Are you calibrating an instrument with adjustable readings? If Yes - skip to box K; if No - do Accuracy Checks (boxes I, J) and O, P.

I	Tested Material (enter ID of Standard or NIST thermometer, or saturated water, or distilled water)			
J	Reading (result in Tested Material)			

Use boxes K, L, M, N below when calibrating an instrument that has adjustable readings.

K	Calibrator Standard ID			
L	Reading before calibration			
M	Action taken			
N	Reading after calibration			

Use for all calibration and accuracy checks

O	Cal/Accur Check Operator (your name)			
P	Comments			

Note: If you are calibrating an oxygen electrode, write "air" or "saturated water" in the "Calibrator Standard ID" box above.

If you calibrate in air and can measure the absolute barometric pressure, write the value and unit here _____ otherwise please indicate your elevation above sea level _____.

Document Source: "Clean Water Team (CWT) 2004. Use of the DQM Calibration and Accuracy Checks Data Sheet, DQM SOP-9.2.1.2(V3) in: The Clean Water Team Guidance Compendium for Watershed Monitoring and Assessment, Version 2.0. Division of Water Quality, California State Water Resources Control Board (SWRCB), Sacramento, CA." For more information : <http://www.swrcb.ca.gov/nps/cwtguidance.html>

Calibration Equations for Judging Precision and Accuracy of Measurement Equipment

Precision:

A = Measured Value	
B = Replicate Value	
Precision:	$= \left[\frac{ A-B * 100}{(A+B)/2} \right] = \%$

Example: A = Measured Value = 1210
 B = Replicate Value = 1150

$$\frac{|1210 - 1150| * 100}{(1210 + 1150) / 2}$$

$$\frac{|60| * 100}{(2360) / 2}$$

$$\frac{6000}{1180}$$

5.084

Precision: =

Accuracy:

X = Pre Calibration Reading	
Y = Calibrated Reading	
SV=Standard Value ("known")	
	$\left[\frac{(X - Y) * 100}{SV} \right] = \%$

Example: X = Pre Calibration Reading = 1440
 Y = Calibrated Reading = 1410
 SV=Standard Value ("known") = 1413

$$\frac{(1440-1410) * 100}{1413}$$

$$\frac{(30) * 100}{1413}$$

$$\frac{3000}{1413}$$

2.12

Accuracy: =

CENTRAL COAST WATER QUALITY RESOURCES

There are many technical advisors in our area to assist you in your efforts to improve water quality on or around your agricultural operation. These individuals can provide free, confidential evaluations of your water quality situation and offer practical alternatives for your consideration.

Agricultural Land Based

Training Association

Watershed Outreach Coordinator
Craig Ficenece
Salinas, CA
(831) 682-6813
Email: craig@albafarmers.org
www.albafarmers.org

Central Coast Agricultural Water Quality Coalition

Water Quality Program Coordinator
Christopher C. Goodson,
Soquel, CA
(831) 227-5404
Email: goodsonwq@yahoo.com
www.agwaterquality.org

Central Coast Regional Water Quality Control Board

<http://www.swrcb.ca.gov/rwqcb3/>

Ag-Waiver Program Coordinator
Corrine Huckaby
San Luis Obispo, CA
(805) 549-3504
Email: chuckaby@waterboards.ca.gov
<http://www.waterboards.ca.gov/centralcoast/AGWaivers/Index.htm>

Central Coast Vineyard Team

Executive Director
Kris O'Connor
Paso Robles, CA
(805) 369-2288
Email: kris@vineyardteam.org
www.vineyardteam.org

Central Coast Water Quality Preservation, Inc.

Program Manager
Sarah Greene
(831) 761-8644 (office)
Email: sgreene@ccwqp.org
www.ccwqp.org

Coastal Watershed Council (CWC)

Program Manager
Tamara Doan
Santa Cruz, CA
(831) 464-9200
Email: tcdoan@coastalwvs.org
www.coastal-watershed.org

Community Alliance with Family Farmers (CAFF)

Central Coast Regional Coordinator
Sam Earnshaw
Watsonville, CA
(831) 722-5556
Email: sambo@cruzio.com, www.caff.org

Farm Bureaus

Monterey County Farm Bureau

Environmental Resources Coordinator
Traci Roberts
Salinas CA
(831) 751-3100
Email: Traci@MontereyCFB.com
www.MontereyCFB.com

Santa Cruz County Farm Bureau

Executive Director
Jess Brown
Watsonville, CA.
(831) 724-1356 or (831) 688-0748
Email: sccfb@sbcglobal.net

Natural Resources Conservation Service (NRCS) – USDA

www.ca.nrcs.usda.gov

Range Management Specialist
John Warner
Hollister, CA
(831) 637.4360 x112
Email: john.warner@ca.usda.gov

Hydrologist & Resource Conservationist

Nick Lasher
Salinas, CA
(831) 424-1036
(831) 710-2540 (cell)
nick.lasher@ca.usda.gov

District Conservationist –
Monterey County
Robert LaFleur
Salinas, CA
(831) 424-1036 ext. 101
Email: Robert.LaFleur@ca.usda.gov

District Conservationist -
Santa Cruz County
Richard Casale
Capitola, CA
(831) 475-1967
Email: Richard.Casale@ca.usda.gov

Monterey Bay National Marine Sanctuary

Water Quality Protection Program

WQPP Director
Bridget Hoover
Monterey, CA
(831) 647-4217
Email: Bridget.Hoover@noaa.gov
<http://montereybay.noaa.gov/resourcepro/water-pro.html>

Agriculture Water Quality Alliance

Agriculture Water Quality Coordinator
Lisa Lurie
(831) 647-4219
Email: Lisa.Lurie@noaa.gov
www.awqa.org

Citizen Monitoring Network

Network Coordinator
Anna Holden-Martz
(831) 647-4227
Email: Anna.Holden@noaa.gov
<http://montereybay.noaa.gov/monitoringnetwork/welcome.html>

Resource Conservation Districts

Resource Conservation District of Santa Cruz County

Executive Director
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Farm Water Quality Planning

County Resource Directory in English
http://groups.ucanr.org/signup/Countywide_Resources_for_Farmers/
County Resource Directory in Spanish
<http://uccce.ucdavis.edu/files/filelibrary/5436/43957.pdf>



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