Quality Assurance Project Plan

For

Alpine Watershed Group Volunteer Citizen Water Quality Monitoring Program

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APPROVAL SIGNATURES

Alpine Watershed Group:

Title:	Name:	Signature:	Date*:
Alpine Watershed Group Chairman	Jim Donald		
Alpine Watershed Group Vice-Chairman	John Barr		
Project Manager	Hannah Schembri		

California State Water Resources Control Board:

Title:	Name:	Signature:	Date*:
QA Officer	William Ray		
QA Officer	Erick Burres		

California Regional Water Quality Control Board, Lahontan Region

Title:	Name:	Signature:	Date*:
Grant Contract Manager	Bruce Warden		

* This is a contractual document. The signature dates indicate the earliest date when the project can start.

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3. Distribution List

Title:	Name (Affiliation):	Tel. No.:	QAPP No*:
Contractor Project Manager	Hannah Schembri (AWG)	530-694-2327	1
Regional Board Grant Contract Manager	Bruce Warden (RWQCB)	530-542-5416	1
State Board QA Officer	William Ray (SWRCB)	916-341-5583	Original
State Board QA Officer	Erick Burres (SWRCB)	213-576-6788	1
Sierra Nevada Alliance Grant Contract Manager	Joan Clayburgh (SNA)	530-542-4546	1
Sierra Nevada Alliance Grant Contact	Megan Suarez-Brand	530-542-4546	1

4. Project/Task Organization

4.1 Involved parties and roles.

The Alpine Watershed Group (AWG) is a collaborative stakeholder non-profit organization whose mission is to preserve and enhance the headwaters of Alpine County's five watersheds. As the lead agency, AWG will organize the sample collection, field and in-house analysis of samples.

This project will be managed by Hannah Schembri, Alpine Watershed Coordinator. Monitoring will be conducted by citizen monitors trained annually by the State Water Resource Control Board (SWRCB), the Clean Water Team, the Sierra Nevada Alliance or staff. The Alpine Watershed Coordinator will be responsible for all aspects of the project including the organization of field staff, scheduling of sampling days, management of the AWG in-house laboratory, and data management.

Table 1. (Element 4) Personnel responsibilities

Name	Organizational Affiliation	Title	Contact Information (Telephone number and email address)
Hannah Schembri	AWG	Project Manager	530- 694-2185 watershed@alpinecountyca.com
William Ray	SWRCB	QA Officer	916-341-5583 bray@waterboards.ca.gov
Erick Burres	SWRCB	QA Officer	213-576-6781 eburres@waterboards.ca.gov

4.2 Quality Assurance Officer role

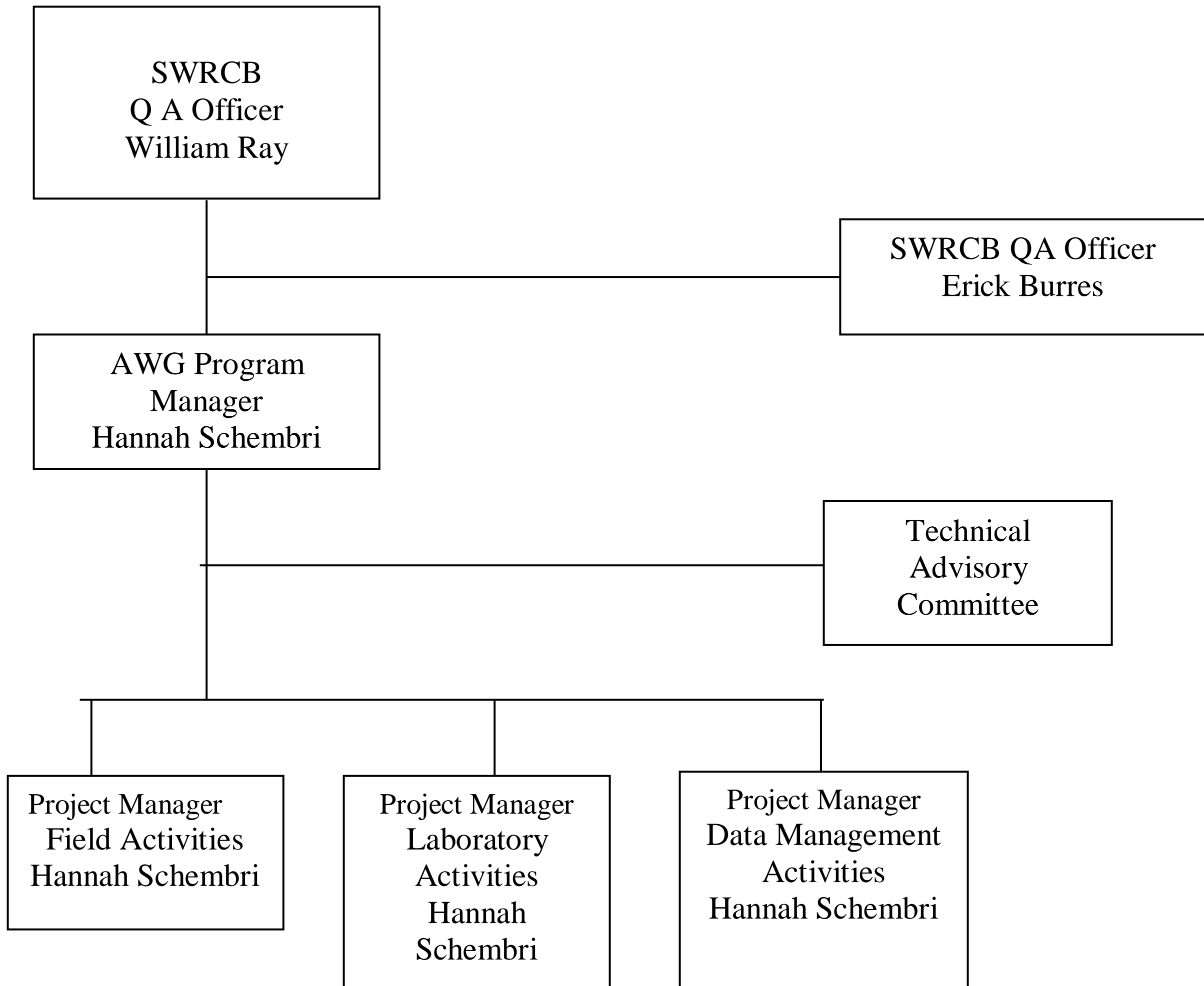
William Ray, SWRCB, will serve as the Quality Assurance Officer for the State of California. Additionally Erick Burres, SWRCB, will serve as a Quality Assurance Officer and will conduct refresher trainings for the volunteer water quality monitors. Their role is to implement the quality assurance and quality control procedures found in this QAPP as part of the sampling, field analysis, and in-house analysis procedures. They will also review and assess all procedures during the life of the contract against QAPP requirements. The QA Officer will report all findings to the Project Manager, including all requests for corrective action. The QA Officer may stop all actions if there are significant deviations from required practices or if there is evidence of a systematic failure. The QA Officers work independently of the Alpine Watershed Group staff.

4.3 Persons responsible for QAPP update and maintenance.

Changes and updates to this QAPP may be made after a review of the evidence for change by AWG's Project Manager and Quality Assurance Officers, and with the concurrence of both the Regional Board's Grant Contract Manager and Quality Assurance Officers. AWG's Project Manager will be responsible for making the changes, submitting drafts for review, preparing a final copy, and submitting the final for signature.

4.4 Organizational chart and responsibilities

Figure 1. Organizational chart.



5. PROBLEM DEFINITION/BACKGROUND

5.1 Problem Statement.

Alpine County encompasses the headwaters for five watersheds. These watersheds are the American, Carson, Mokelumne, Stanislaus, and the Truckee. By monitoring conditions in both aquatic and terrestrial environments, the health of the watersheds can be periodically screened for potential concerns regarding habitat and water quality issues. The Alpine Watershed Group, a locally driven stakeholder group, plans to accomplish this monitoring through a volunteer citizen monitoring program. With implementation of quality assurance, valuable information will be provided for watershed management and pollution screening and prevention.

Bacterial monitoring in the Markleeville Creek watershed has revealed potential impairment of water quality linked to contamination of the water with fecal matter. Alpine Watershed Group (AWG) seeks to characterize the water quality conditions and identify the sources of *E. coli* and *Enterococcus* within the Markleeville Creek river network for the purpose of targeting resources to implement management measures that will alleviate some of these problems. A majority of the Markleeville Creek watershed is composed of National Forest and Wilderness owned and managed by the USDA Forest Service. Additionally approximately half of the residents of Markleeville rely on septic systems. The AWG will collaborate with other agencies and organizations that have an interest in this watershed, to pool monitoring resources for the benefit of all stakeholders including community members, landowners, industry, and regulatory agencies.

The US Forest Service owns the Markleeville Creek Guard Station that is located on the floodplain of Markleeville Creek in downtown Markleeville. The Guard Station has been impacted by flooding on many historical occasions including a 25-year storm event and other storm events. The US Forest Service has entered into an agreement to relocate the Guard Station facilities to Turtle Rock Park and to sell the property to Alpine County for a floodplain restoration project. Restoration design plans are currently being drafted by a consultant through grant funding provided by the California Department of Water Resources Urban Streams Restoration Program. To measure the success and effectiveness of the restoration project on Markleeville Creek, baseline water quality data must be gathered prior to the implementation of the project, and continue to be collected following implementation.

5.2 Decisions or outcomes.

The Standard Set monitoring data will provide information about the physical and chemical state of the watersheds. Bacterial monitoring for Total Coliform, *E. Coli*, and *Enterococcus* will be used to determine if failing septic tanks or grazing practices are impacting tributaries to the Carson River. Bioassessment will provide important baseline data prior to a restoration project. All data available and collected will be screened with previously collected information and used for trend analysis.

5.3 Water quality or regulatory criteria

According to the State of California Lahontan Regional Water Quality Control Board Basin Plan, "the fecal coliform concentration during any 30-day period shall not exceed a log mean of 20/100 ml, nor shall more than 10 percent of all samples collected during any 30-day period exceed 40/100 ml. The log mean shall ideally be based on a minimum of not less than five samples collected as evenly spaced as practicable during any 30-day period. However, a log mean concentration exceeding 20/100 ml for any 30-day period shall indicate violation of this objective even if fewer than five samples were collected."

6. PROJECT/TASK DESCRIPTION

6.1 Work statement and produced products.

Monitoring events will occur with frequency and dates as specified in Table 2 for the Alpine County Volunteer Water Quality Monitoring Program (Program) with water quality parameters being investigated. When possible, storm events will also be monitored. A stream survey and photo monitoring will be conducted bi-annually at Site #1, Site #2, Site #3, Site #4, Site #5, Site #6, Site #7, and Site #8. Bioassessment will be conducted annually. At the end of the Program, AWG will provide a full listing and summary of the data collected including a trend analysis using all data collected. AWG will provide a Final Report stating any evidence for land use impacts, the extent of the impact and any recommended management practices.

The AWG, with the assistance of their Technical Advisory Committee will analyze and interpret compiled monitoring data for this Final Project Report. The Final Project Report will be an analysis of the overall health of the watershed based on monitoring data and will include the following information:

- a data analysis report with any findings,
- a list with descriptions of which land uses are having the greatest impact in the watershed and where they are in proximity to the monitoring sites,
- a list with descriptions of any other possible impacts to the watershed that would require further monitoring,
- any potential restoration projects that our group may address as the result of the monitoring data analysis,
- any potential restoration and/or protection activities that would be feasible as a result of the monitoring data,
- any additional "hot spot" monitoring locations that would assist in assessing the overall health of the watershed
- an overall summary evaluation of our monitoring program that includes: an evaluation of our program (strengths and weaknesses), monitoring sites with specific GPS locations, parameters, number of volunteers, monitoring frequency, technical advisory committee members, status of monitoring equipment, and overall evaluation of program management.

The Final Project Report to be generated at Program conclusion will be reviewed by the TAC and the Sierra Nevada Alliance. This Final Report and raw data will be provided to the TAC, Volunteers, Sierra Nevada Alliance, and the State Water Resources Control Board. The final report will be made available to any interested party or individual by posting on the AWG section of the Alpine County website or by request.

6.2. Constituents to be monitored and measurement techniques.

Chemistry and physical parameters will be monitored using protocols outlined in the *Alpine Watershed Group Water-Quality Field Procedures Manual(see Appendix 8).* This program has a systematic method for visual and other sensory observations. A Stream/Shore Walk Visual Assessment observation sheet, with instructions, is included in the *Alpine Watershed Group Monitoring Manual*. Observations using the Stream/Shore Walk Visual Assessment sheet will be made, at a minimum, once per year. Observational data include color, odor, presence of oil or tar, trash, foam and algae. In addition, the stream habitat quality will be assessed, at least once per year, using the *California Dept. of Fish and Game Physical Habitat Assessment Form.* Observational data include epifaunal substrate/available cover, embeddedness, velocity/depth regimes, sediment deposition, channel flow status, channel alteration, frequency of riffles, bank stability, vegetative protection, and riparian vegetative zone width. Ambient constituents include pH, conductivity, temperature, dissolved oxygen, and turbidity. These parameters will be monitored using protocols outlined in the *Alpine Watershed Group Monitoring Manual*.

Benthic macroinvertebrate (BMI) bioassessment samples will be collected annually at designated sites, from June through October. Biological data will be collected to augment the chemical and physical data. Benthic macroinvertebrates will be used as indicators of water quality and instream habitat complexity. The California

Stream Bioassessment Procedure (CSBP) for measuring basic characteristization of stream habitat and sampling benthic macroinvertebrates will be conducted prior to and following the restoration of the Markleeville Guard Station at four reaches. The Multi-Habitat protocol for sampling benthic macroinverebrates will be applied requiring 11 transects within each 150 meter reach.

Benthic Macroinvertebrate samples will be presorted by volunteers during winter laboratory sessions overseen by a qualified entomolgist. The samples will then be processed and analyzed by a certified California Stream Bioassessment Procedure Laboratory. Chemical and physical measurements will be performed, at a minimum, annually at the time of the BMI sampling. GPS coordinates of sampling sites will be included in the database.

AWG staff and volunteers will collect sterile water samples for *E. coli*, Enterococcus, and Total Coliform counts. While sampling, the field crews will conduct field measurements of temperature, pH, dissolved oxygen, specific conductivity, and turbidity (a.k.a, the five "vital signs") coupled with observation of flow conditions or estimation of the flow discharge; these data will provide information on the conditions in the stream at the time samples were collected. Field measurements will be performed using a variety of meters, electrodes, or probes.

Sample containers will have a label with placeholder for the Sample ID, Station ID, Date, time, and operator initials; the operators will fill out this label before filling the container with sample water. All samples will be collected as grabs, by wading and filling the container directly or through the use of grab poles. Field operators will follow SWAMP SOP (e.g., collect at the centroid of the flow, 0.1 m below the surface, facing upstream) as provided in appendix D of the SWAMP QAMP (SWAMP 2001). All containers will be rinsed three times with ambient water except for the sterile containers for Enterococcus and *E. coli* counts and any container that already has preservative in it; those will be filled once, to the container's shoulder. Alternative methods including extension of sampling devices from the bank will be used where needed, again following procedures delineated in Appendix D of the SWAMP QAMP. Devices will be decontaminated prior to collection at each Station. If sampling devices have to be used, it will be noted in the field data sheet. Field Operators will fill out the Sampling Log part of the data sheet immediately after sampling.

Water samples will be delivered to the staging area for counts of total coliforms, Enterococcus, and *E. coli* using the IDEXX Colilert and Enterolert reagent and QuantiTray system. Turbidity will be analyzed in the lab as well.
Total Coliform, E. coli, and Enterococcus will be determined by the *Colilert and Enterolert® QuantiTray* system. These are the critical constituents to identify impacts from septic system failure or grazing impacts. GPS coordinates of sampling sites will be included in the database.

6.3 Project schedule

Table 2. (Element 6) Project schedule timeline.

Activity	Date (MM/DD/YY)		Deliverable	Deliverable Due Date
	Anticipated Date of Initiation	Anticipated Date of Completion		
QAPP Approval –Project Start Date	4/01/2007	6/01/2007	Approved QAPP	6/30/2007
Citizen Monitoring Refresher and BMI Training	6/01/2007	7/30/2007	Citizen Monitors Trained	7/30/2007
Quarterly Standard Set Sample Event	6/09/2007	6/09/2007	Data Entry	6/30/2007
Bacteria Sample Event	7/15/2007	7/15/2007	Data Entry	7/30/2007

BMI Sample Event	8/16/2007	8/16/2007	Data Entry	8/30/2007
Quarterly Standard Set and Bacteria Sample Event	9/08/2007	9/08/2007	Data Entry	9/30/2007
Bacteria Sample Event	11/17/2007	11/17/2007	Data Entry	11/30/2007
Quarterly Standard Set Sample Event	12/08/2007	12/08/2007	Data Entry	12/30/2007
Quarterly Standard Set Sample Event	03/08/2008	03/08/2008	Data Entry	03/30/2008
Draft Final Report	04/01/2008	05/01/2008	Draft Final Report for Review	5/01/2008
Final Report	05/01/2008	06/01/2008	Final Report	06/01/2008
Quarterly Standard Set Sample Event	6/14/2008	6/14/2008	Data Entry	6/30/2008
BMI Sample Event	8/16/2008	8/16/2008	Data Entry	8/30/2007
Quarterly Standard Set Sample Event	9/13/2008	9/13/2008	Data Entry	9/30/2008
Quarterly Standard Set Sample Event	12/13/2008	12/13/2008	Data Entry	12/30/2008

6.4 Geographical setting

Alpine County, California encompasses the headwaters for five watersheds, and is composed of several interacting landscapes and river systems. These watersheds are the American, Carson, Mokelumne, Stanislaus and the Truckee. The Upper Carson River consists of two forks, the East Fork and the West Fork. These forks converge into the main Carson River near the town of Genoa, Nevada. Markleeville Creek and Silver Creek are tributaries to the East Fork Carson River. Pleasant Valley Creek, Hot Springs Creek, and Millberry Creek are tributaries to Markleeville Creek. Markleeville Creek is a major tributary to the East Fork of the Carson River. Markleeville Creek drains approximately 50 square miles and flows through the community of Markleeville. The majority of this area is National Forest and Wilderness owned and managed by the USDA Forest Service.

6.5 Constraints

The only foreseeable constraint that would postpone any single sampling event is weather that would compromise sampling integrity or volunteer safety. The sampling protocol for the bacteria analysis is intended for dry weather only.

7. Quality Objectives and Criteria for Measurement Data

Data quality objectives for this project will consist of the following:

Field Measurements – Accuracy, Precision, Completeness
Bacterial Analyses – Precision, Presence/Absence, Completeness
Turbidity - Accuracy, Precision, Recovery, Completeness

Accuracy criteria for bacterial testing will be based on presence/absence testing rather than numerical limits due to the difficulty in preparing solutions of known bacterial concentration

Precision measurements will be determined on both field and laboratory replicates. The number of replicates for bacterial testing field measurements will be five.

Recovery measurements will be determined by laboratory spiking of a replicate sample with a known concentration of the analyte. The target level of addition is at least twice the original sample concentration.

Completeness is the number of analyses generating useable data for each analysis divided by the number of samples collected for that analysis.

Method sensitivity is dealt with by the inclusion of the required SWAMP Target Reporting Limits, where such values exist, and by the application of the definition of a Minimum Level as provided by the Inland Surface Water and Enclosed Bays and Estuaries Policy. Target Reporting Limits exist for total coliforms and *E. coli*. Target Reporting Limits were set for the following field analyses in Table 3.

Table 3. (Element 7) Data quality objectives for field measurements.

Group	Parameter	Accuracy	Precision	Recovery	Target Reporting Limits	Completeness
Field Analyses	pH	± 0.2 pH units	± 0.2 pH units	NA	NA	90%
	Conductivity	± 5% or ±10 micromhos, whichever is greater	± 10% or ± 10 micromhos, whichever is greater	NA	2.5 uS/cm	90%
	Dissolved Oxygen	± 5%	± 5%	NA	0.2	90%
	Turbidity	± 5 NTU [SWAMP ± *10% or 0.1, whichever is greater*]	± 5% NTU [SWAMP ± *10% or 0.1, whichever is greater*]	NA	.5 NTU	
	Temperature	± 0.5 °C	± 0.5 °C	NA	.5 °C	90%

Table 4. (Element 7) Data quality objectives for laboratory measurements.

Group	Parameter	Accuracy	Precision	Recovery	Target Reporting Limits	Completeness
Bacterial Analyses	Total Coliforms, Enterococcus, and E. Coli	Positive results for target organisms. Negative results for non-target organisms	R_{log} within 3.27*mean R_{log} (reference is section 9020B 18th edition of Standard Methods)	NA	2 MPN/100 mL	90%
Calif. Stream Bioassessment	Benthic Macro-invertebrates	≤ 5% difference	≤ 5% difference	NA	Level 2 (Family level)	90%

Data collected from previous studies and held in AWG's database will be assessed against the same data quality objectives listed above.

8. SPECIAL TRAINING NEEDS/CERTIFICATION

8.1 Specialized training or certifications.

All citizen monitors must participate in hands-on training sessions on water quality monitoring conducted by staff, the Clean Water Team of the State Water Resources Control Board or the Sierra Nevada Alliance.

In addition to completion of the above described training course, the citizen monitors and the Project Manager must participate in a yearly Quality Control Session conducted by Erick Burres, SWRCB Clean Water Team to be held before one of the quarterly monitoring events. Monitoring kits will be kept at the Alpine Watershed Coordinators office and instruments will be calibrated before each quarterly monitoring event by the trained Project Manager. The Quality Control Sessions will be supervised by Quality Control Trainers and will provide an opportunity for citizen monitors to check the accuracy and precision of their equipment and techniques. Quality Control Trainers are defined as water quality professionals from the U.S. Environmental Protection Agency, the State Water Resources Control Board, and the Regional Water Quality Control Boards. Additional qualified trainers may be recruited and designated by the above agencies from experienced citizen monitoring organizations, universities and colleges, commercial analytical laboratories, and other federal, state, and local agencies.

At the yearly Quality Control Session, the monitor will conduct duplicate tests on all analyses and meet the data quality objectives described in Section 14. If a monitor does not meet the objectives, the trainers will re-train and re-test the monitor. If there is insufficient time at the Quality Control Session to re-train and re-test monitors, the monitor will be scheduled for an additional training session. The monitor will be encouraged to discontinue monitoring for the analysis of concern until training is completed.

The Quality Control Trainers will examine kits for completeness of components: date, condition, and supply of reagents, and whether the equipment is in good repair. The Trainers will check data quality by testing equipment against blind standards. The trainers will also ensure that monitors are reading instruments and recording results correctly. Sampling and safety techniques will also be evaluated. The trainer will discuss corrective action with the volunteers, and the date by which the action will be taken. The citizen monitoring leader is responsible for reporting back that the corrective action has been taken. Certificates of completion will be provided once all corrective action has been completed.

For macroinvertebrate bioassessment, Erick Burres, SWRCB Clean Water Team will train the AWG volunteers and project manager in following the CSBP protocol for citizen monitors. Formal three to five-hour field training sessions will be held at a minimum of once annually. Additional training will occur during subsequent field collection sessions. Laboratory training will occur during each three-hour lab session, held twice monthly as needed between November and February.

No specialized training or certifications is required for the bacteria monitoring. Although no specialized training is needed, all citizen monitors have received an initial training program consisting of at least 8 hours of combined class and field instruction, and a 4 hour combined class and field instruction as a refresher every year. Additional trainings will be conducted if there is identified need for such trainings.

8.2 Training and certification documentation.

Field staff training is documented and filed at AWG's office. Documentation consists of a record of the training date, instructor, participants, whether initial or refresher, and whether the course was completed satisfactorily.

8.3 Training personnel.

The SWRCB Quality Officer (Erick Burres) will oversee most training and training needs. Additional potential trainers include the Alpine Watershed Coordinator, Shasta Ferranto with the Sierra Nevada Alliance, and Megan Suarez-Brand of the Sierra Nevada Alliance. The Lab technician will be versed in the operation of the IDEXX procedures and the CSBP protocol for citizen monitors.

9. Documents and Records

AWG will collect records for sample collection, field analyses, bacterial testing, streamwalk surveys and BMI samples.

AWG has an existing database of field measurements from previous studies. The Program Manager, Hannah Schembri, maintains this database. The Program Manager will also maintain the database of information collected in this project.

All records generated by this project will be stored at AWG's main office.

Copies of this QAPP will be distributed to all parties involved with the project, including field collectors and the AWG in-house laboratory analyst. Any future amended QAPPs will be held and distributed in the same fashion. All originals of this first and subsequent amended QAPPs will be held at AWG. Copies of versions, other than the most current, will be filed separately so as not to create confusion.

Persons responsible for maintaining records for this project are as follows. AWG Project Manager, Hannah Schembri, will maintain all sample collection, sample transport, chain of custody, and field analyses forms, all records associated with the receipt and analysis of samples analyzed for bacterial parameters, and bioassessment samples and will arbitrate any issues relative to records retention and any decisions to discard records.

All records will be passed to the Regional Board Grant Contract Manager at project completion. Copies of the records will be maintained at AWG's office after project completion including the database, which will be maintained indefinitely.

GROUP B: DATA GENERATION AND ACQUISITION

10. SAMPLING PROCESS DESIGN

Field activities will be led by the AWG project manager, and lab analyses will be performed in the AWG In-house Laboratory.

The *Alpine Watershed Group Water-Quality Field Procedures Manual (see Appendix 8)* describes the appropriate sampling procedure for collecting samples for water chemistry. Water sampling apparatus may include Van Dorn Samplers, Niskin Bottles, Kemmerer Tubes, LaMotte Oxygen Samplers, DH 48 Sediment Samplers, extension pole type sampling devices, and hand held plastic containers. Macroinvertebrates will be collected with a D shaped kick net (0.5 mm mesh) mounted on a pole. In those cases where glass bottles are required, plastic samplers are allowed as long as the hold time in the sampling device is minimal before transfer to the glass sample bottle. Sampling devices and sample bottles (that are not pre-sterilized and do not contain preservatives/fixing agents) will be rinsed three times with sample water prior to collecting each sample. For sterile bottles, whirl-paks, and sample bottles which do contain preservatives/fixing agents (e.g., acids, etc.) never rinse with sample water prior to collecting the sample. Also, never use a sample bottle containing preservatives/fixing agents for sampling; in these cases always use a sampling device to collect the sample prior to transferring the sample into the bottle.

Whenever possible, the collector will sample from a bridge so that the water body is not disturbed from wading. All samples are taken approximately in mid-stream, at least one inch below the surface. If it is necessary to wade into the water, the sample collector stands downstream of the sample, taking a sample upstream. If the collector disturbs sediment when wading, the collector will wait until the effect of disturbance is no longer present before taking the sample.

AWG staff and AWG citizen monitors will collect water samples in sterile containers (Whirl-paks) for *E. coli,* Enterococcus, and Total Coliform counts. While sampling, they will conduct field measurements of temperature, pH, dissolved oxygen, specific conductivity, and turbidity (a.k.a, the five "vital signs") coupled with observation of flow conditions and measurement of stage (water level) or flow discharge.

Field crews will visit various locations within the Markleeville Creek watershed for the bacteria samples. Stations for this Project will be located at key points in the river network as well as upstream and downstream of the most prominent communities, to provide representation of potential sources of fecal bacteria. Planned sampling stations will be utilized from a list of access points that have already been established. Actual sampling site locations will be determined during the first sampling trip, and the same spots will be visited again on consecutive trips if accessible and relevant. Inaccessible locations will be substituted with alternative sites in the same reach. The field crews will have the option of collecting two additional samples each date, either from flowing outfalls or in the vicinity of a station to characterize spatial variability. In addition, one blank and one duplicate will be collected during each sampling event. Thus, the field crew may bring back up to ten samples from each event. The lab will be able to receive and process up to ten samples per event. Source ID trips will be conducted six times during the fall and early winter of 2007 (see Table 2: Element 6). Unfortunately the time of day will not be selected deliberately, for logistical reasons, because each crew will need to be at six multiple locations during one sampling day. Monitoring work will be performed for the bacteria samples during dry weather only.

Field measurements will be performed using a variety of meters, electrodes, or probes as described in Element 13 of this QAPP. Grab water samples will be delivered to AWG Laboratory for counts of Total Coliform, Enterococcus, and *E. coli* using the IDEXX Colilert and Enterolert reagent and QuantiTray system.

11. Sampling Methods

Sample containers other than those that are sterilized will be cleaned by the AWG laboratory and delivered to the field crews before each sampling event. The containers will have a label with placeholder for the Sample ID, Station ID, Date, time, and operator initials; the operators will fill out this label before filling the container with sample water. All samples will be collected as grab samples, by wading and filling the container directly. Field operators will follow SWAMP SOP (e.g., collect at the centroid of the flow, 0.1 m below the surface, facing upstream) as provided in appendix D of the SWAMP QAMP (SWAMP 2001). All containers will be rinsed three times with ambient water except for the sterile containers for E. coli counts and any container that already has a preservative in it; those will be filled once, to the container's shoulder. Alternative methods including extension of sampling devices from the bank using a swing sampler will be used where needed, again following procedures delineated in Appendix D of the SWAMP QAMP. Devices will be decontaminated prior to collection at each Station. If sampling devices have to be used, it will be noted in the field data sheet. Field Operators will fill out the Sampling Log part of the data sheet immediately after sampling.

The AWG QA Officer will audit each of the field crews to assure the use of correct sampling procedure, and will record any deviation from SOPs. If there is any reason to suspect sample integrity, the team will be instructed to repeat the sampling using fresh containers and following appropriate procedures, and this action will be documented in the Sampling Log.

12. Sample Handling and Custody

Once pre-labeled sample containers are filled they are stored on ice for transport to the AWG in-house laboratory. Samples for bacteria analyses or Turbidity do not require any additional preservative.

Sample containers for bacterial testing will be 100mL sterilized plastic bottles. Containers for Turbidity will be 1000 mL plastic bottles.

Samples are delivered as follows. Bacterial test and Turbidity samples are taken to AWG's in-house laboratory. Sample holding times are as follows

Table 5. (Element 12). Sample handling and custody.

Parameter	Container	Volume	Initial Preservation	Holding Time
Turbidity	plastic bottles	1000 mL	NA	< 12 Hours
Bacteria	sterile plastic bottles	100 mL	NA	< 6 Hours
BMIs	Wide mouth plastic bottles	1000 mL (variable)	Fixed with ethanol immediately	Not applicable

No special handling or custody procedures are needed. At the time of sample collection the following will be recorded by the collector:

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

Samples may be disposed of when analysis completed and all analytical quality assurance/quality control procedures are reviewed and accepted.

Samples requiring chemical preservation will be fixed prior to transport. When samples are transferred from one volunteer to another member of the same organization for analysis, or from the citizen monitoring group to an outside professional laboratory, then a Chain of Custody form should be used. This form identifies the waterbody name, sample location, sample number, date and time of collection, sampler's name, and method used to preserve sample (if any). It also indicates the date and time of transfer, and the name and signature of the sampler and the sample recipient. In cases where the sample remains in the custody of the monitoring organization, then the field data sheet may be allowed to double as the chain of custody form. It is recommended that when a sample leaves the custody of the monitoring group, then the Chain of Custody form used be the one provided by the outside professional laboratory. Similarly, when quality control checks are performed by a professional lab, their samples will be processed under their chain of custody procedures with their labels and documentation procedures.

For BMI samples, the California Department of Fish and Game Aquatic Bioassessment Laboratory Chain of Custody form will be used.

13. Analytical Methods

This section describes the measurement systems that will be used to collect the data for the Program. The words "Measurement System" are used here as a catch-all term for "Devices and/or procedures used for quantification of environmental characteristics, including instruments used for field measurements and sampling & analysis processes". The measurement systems selected to achieve the Measurement Quality Objectives (MQOs) developed for field measurements are shown in Table 8.

Laboratory Procedures will include detailed review of the quality check outcomes for each analytical run and comparison of recovery and precision to lab control charts to determine whether the measurement system performed within acceptance criteria. This review will be done by the AWG project manager and the AWG QA officer. If any analytical problems are identified, the resulting data will be flagged and the problem will be immediately reported to AWG QA officer, who will discuss how to qualify that batch.

The samples will be stored in the lab until expiration of holding times, and then the sample water (which is essentially creek water) will be discarded into the sanitary sewer. The laboratory will also be responsible for autoclaving of used IDEXX QuantiTrays prior to disposal as garbage.

Table 6. (Element 13) Field analytical methods.

Analyte	**Laboratory / Organization**	**Project Action Limit (units, wet or dry weight)**	**Project Quantitation Limit (units, wet or dry weight)**	**Analytical Method**	
				Analytical Method/ SOP	Modified for Method yes/no
pH	Field monitoring by AWG volunteers	6 - 9 pH units	NA	Standard Methods (*) 4500H+B SOP 3.1.4.3	None
Conductivity	Field monitoring by AWG volunteers	> 1500 micromhos	10 micromhos	Standard Methods 2510B SOP 3.1.3.1 (v3)	None
Dissolved Oxygen	Field monitoring by AWG volunteers	< 5 mg/L	0.1 mg/L	Standard Methods 4500OG SOP 3.1.1.2	None
Temperature	Field monitoring by AWG volunteers	None	-5 ^{o} C	Standard Methods 2550B SOP 3.1.2.1	None

(*) *Standard Methods for the Examination of Water and Wastewater*, 20th edition.

Table 7. (Element 13) Laboratory analytical methods.

Analyte	**Laboratory / Organization**	**Project Action Limit (units, wet or dry weight)**	**Project Quantitation Limit (units, wet or dry weight)**	**Analytical Method**		**Achievable Laboratory Limits**	
				Analytical Method/ SOP	Modified for Method yes/no	MDLs (1)	Method (1)
Total coliform and E. coli	AWG In-house laboratory	< 20 MPN/100mL for E. coliforms	2 MPN/100mL	Standard Methods * 9223B Enzyme substrate method SOP 3.4.1.1	None	Not applicable	2 MPN/100 mL
Turbidity	AWG In-house laboratory	NTU	Not applicable	SOP 3.1.5.4	None	Not applicable	

(*) *Standard Methods for the Examination of Water and Wastewater*, 20th edition.

14. QUALITY CONTROL

Field/Laboratory Blanks: For all conventional water quality analyses, except temperature, dissolved oxygen and pH, field blanks will be analyzed once per year, or as previously specified.

Instructions for Field and Lab Blanks: Sterilized water is taken into the field or used in the laboratory and handled just like a sample. It will be poured into the sample container and then analyzed. When reagents are used in a test method, then the reagents are added to the sterilized water and these types of blanks are referred to as reagent blanks. Field blanks are recorded on the field data sheet.

Temperature blanks will be conducted. A whirl-pak container will be filled with stream water at the time of collection of sample at one site per trip. This whirl-pak will be placed on ice at the same time as the sample and will be utilized in the lab as a temperature blank.

Field Confirmations: When a second method for measuring temperature, dissolved oxygen, and pH is available in the field, then the monitors are encouraged to perform both measurements on a split sample at least once daily. Examples of this sort of redundant measurement would be:

- for temperature, the use of an electronic thermometer (such as those that are built into dissolved oxygen meters) and an armored thermometer;
- for dissolved oxygen, the use of an oxygen meter and/or an indigo carmine colorimetric kit;
- for pH, a meter and a non-bleeding indicator strip.

This will serve to provide backup capability if the more sensitive electronic meters fail, and will provide additional confidence as to the quality of the data. The results of both measurements will be recorded along with the procedure used on the field data sheet. If both results are comparable then the result produced using the method of greater sensitivity will be the one entered in the final data set by the data manager in consultation with the monitoring leader. If the two results are inconsistent, then the monitoring leader will note on the data sheet which of the results will be entered on the final data set by the data manager.

Replicate Samples: Replicate samples are two or more samples collected at the same time and place. When there are only two replicates then these are referred to as duplicates. Replicate samples will be collected bi-annually. Duplicate samples will be collected as soon as possible after the initial sample has been collected, and will be subjected to identical handling and analysis.

Standardization of Instruments and Procedures: At the Quality Assurance Sessions the temperature measurements will be standardized by comparing our thermometers to a NIST-certified or calibrated thermometer in ice water and ambient temperature water. All meters (pH, conductivity, turbidity) will be evaluated at the Quality Assurance Session using standards provided by Project Manager. The Winkler kits for dissolved oxygen will be checked by standardizing the sodium thiosulfate solution in the test kit, and/or by comparing the entire kit to a saturated oxygen standard. Instructions for checking the sodium thiosulfate are included in the test kit. (Additional reagents and glassware must be purchased separately however.) If the result is unsatisfactory, as indicated in the instructions, the sodium thiosulfate and/or other reagent will be discarded and replaced with new reagents.

15. INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

A maintenance log is kept by the monitoring group leader. This log details the dates of instrument and sampling gear inspection, calibrations performed in the laboratory, battery replacement, the dates reagents and standards are replaced, and any problems noted with instruments, samplers, or reagents.

15.1. Temperature

Before each use, thermometers are checked for breaks in the column. If a break is observed, the alcohol thermometer will be placed in nearly boiling water so that the alcohol expands into the expansion chamber, and the alcohol forms a continuous column. Accuracy will be verified by comparing with a calibrated or certified thermometer.

15.2. Dissolved oxygen

Dissolved Oxygen Winkler Titration: Before each use, bottles, droppers, and color comparators are checked to see if they are clean and in good working order. Reagents are replaced annually according to manufacturer's recommendation. Thiosulfate will be checked to ensure it is still viable.

15.3. Conductivity and pH

Before each use, conductivity and pH meters are checked to see if they are clean and in good working order. Conductivity and pH meters are calibrated before each use. Conductivity standards and pH buffers are replaced at least annually. Conductivity standards are stored with the cap firmly in place and in a dry place kept away from extreme heat. Do not re-use pH or conductivity standards.

15.4. Turbidity

Nephelometers: Meters and tubes should be checked for cleanliness and proper operation before each use. The tubes should not be smudged or scratched.

16. Instrument/Equipment Calibration and Frequency

Instruments will be calibrated and reagents checked against standards accordingly to the following schedule. Standards will be purchased from a chemical supply company or prepared by (or with the assistance of) a professional laboratory. Calibration records will be kept in the maintenance log at the headquarters location (described in Section 9.) where it can be easily accessed before and after equipment use. Calibrations that are performed by monitors in the field are recorded on the field data sheets, also archived at the headquarters. The frequency of calibration is described in Table 8.

Table 8. (Element 16) Testing, inspection, maintenance of sampling equipment and analytical instruments.

Equipment / Instrument	SOP reference	Calibration Description and Criteria	Frequency of Calibration	Responsible Person
pH meter	SOP 3.1.4.3	pH 7.0 buffer and one other standard (4 or 10)	Every sampling day	AWG Project Manager
Conductivity meter	SOP 3.1.3.1(v3)	Conductivity standard and distilled water	Every sampling day	AWG Project Manager
Dissolved Oxygen (Winkler)	SOP 3.1.1.2	Check sodium thiosulfate and/or against a saturated oxygen standard every 6 months.	Every six months	AWG Project Manager
Turbidity (nephelometer)	SOP 3.1.5.4	For clear ambient conditions use an 1.0 NTU standard, for turbid conditions use an 10.0 NTU standard	Every sampling day	AWG Project Manager
Temperature	SOP 3.1.2.1	NIST calibrated or certified thermometer	Every sampling day	AWG Project Manager

17. INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

All supplies will be examined for correct items, quantities shipped, leakage, or damage as soon as they are received. pH and conductivity standards will be given unique IDs and will be logged in with all their descriptors including lot numbers. When opened, the new Standard solutions will be compared to the old batches. The inspection and checking SOP, which will be examined by the Quality Assurance Officer, are available upon request.

18. NON-DIRECT MEASUREMENTS (EXISTING DATA)

The only non-direct measurements are from the AWG's database and the Carson Water Subconservancy District of data from prior studies. The former database is maintained in accordance with AWG policy as stated earlier. Both sources of data will be reviewed against the data quality objectives stated in Section 7 and only that data meeting all of the criteria will be used in this project.

19. DATA MANAGEMENT

Data will be maintained as established in Section 9 above. AWG will maintain an inventory of data and its forms and will periodically check the inventory against the records in their possession. AWG's database will be backed up on a bi-annual basis and recorded on a CD. Back up records are kept for one year before they are written over. Each back up session validates whether the files on the CD are accurate copies of the original.

GROUP C: ASSESSMENT AND OVERSIGHT

20. ASSESSMENTS & RESPONSE ACTIONS

All reviews will be made by the AWG Project Manager and may include the SWRCB QA Officer. Reviews will take place every year. Reviews will be observed practices against those found in the *Alpine Watershed Group Monitoring Manual* and AWG's sampling SOPs.

If an audit discovers any discrepancy, the QA Officer will discuss the observed discrepancy with the appropriate person responsible for the activity. The discussion will begin with whether the information collected is accurate, what were the cause(s) leading to the deviation, how the deviation might impact data quality, and what corrective actions might be considered.

The AWG QA Officer has the power to halt all sampling and analytical work if the deviation(s) noted are considered detrimental to data quality.

A Technical Advisory Committee is comprised of representatives of the Alpine Watershed Group, the CWSD, South Tahoe Public Utilities District, Ca RWQCB, and SWRCB.

21. REPORTS TO MANAGEMENT

The quarterly report will detail the progress of the project to date and contain all of the data collected. This report will be completed quarterly beginning April 1, 2007. The final report will be completed by June 1, 2008 and distributed according to table below.

Table 9. (Element 21) QA management reports.

Type of Report	Frequency (daily, weekly, monthly, quarterly, annually, etc.)	Projected Delivery Dates(s)	Person(s) Responsible for Report Preparation	Report Recipients
Quarterly Report including raw data	quarterly	April 1, 2007, July 1, 2007, October 1, 2007, January 1, 2008, April 1, 2008	Hannah Schembri	Jim Donald (AWG) John Barr (AWG) Megan Suarez-Brand (SNA)
Final Report	annual	June 1, 2008	Hannah Schembri	Jim Donald (AWG) John Barr (AWG) Megan Suarez-Brand (SNA) Bruce Warden (RWQCB) Erick Burres (SWRCB) William Ray (SWRCB) Technical Advisory Members

GROUP D: DATA VALIDATION AND USABILITY

22. DATA REVIEW, VERIFICATION, AND VALIDATION REQUIREMENTS

Data generated by project activities will be reviewed against the data quality objectives cited in Element 7 and the quality assurance/quality control practices cited in Elements 14, 15, 16, and 17. Data will be separated into three categories: data meeting all data quality objectives, data meeting failing precision or recovery criteria, and data failing to meet accuracy criteria. Data meeting all data quality objectives, but with failures of quality assurance/quality control practices will be set aside until the impact of the failure on data quality is determined. Once determined, the data will be moved into either the first category or the last category.

Data falling in the first category is considered usable by the project. Data falling in the last category is considered not usable. Data falling in the second category will have all aspects assessed. If sufficient evidence is found supporting data quality for use in this project, the data will be moved to the first category, but will be flagged with a "J" as per EPA specifications.

23. VERIFICATION AND VALIDATION METHODS

All data records will be checked visually and recorded as checked by initials and dates. AWG's Project Manager will do all reviews and the SWRCB QA Officer will perform a check of 10% of the reports.

Issues will be noted. Reconciliation and correction will be done by a committee composed of the SWRCB QA Officer, Field citizen monitors, and Project Manager. Any corrections require a unanimous agreement that the correction is appropriate.

24. RECONCILIATION WITH USER REQUIREMENTS

The project's results will be evaluated to determine whether the project's objectives have been satisfied by assessing completeness and assuring that there is adequate statistical power for comparisons. Correlations between different analytes will be reviewed to determine whether they can shed light on bacterial sources. The data will also be reviewed to identify possible anomalies or departures from assumptions made when the project was planned.

There are no limitations on data use for this Project. All data will be released for review by the local stakeholders, the Regional Board Grant Contract Manager, and the QA Officers as soon as the data verification, validation, and qualifying is complete. Comments of this review will be addressed, and, when everything has been reviewed again by the Regional Board Grant Contract Manager, the data will be released into the public domain.

The data generated by this project are compatible with SWAMP and will be used to augment SWAMP data collected with the same intent and design. The data will be transported into the SWAMP database in a single batch if the transport mechanism is active, and will not be available for corrections later. Alternatively, the data will be transported to one of the local data Nodes of the California Environmental Data Exchange Network and will be mined alongside with SWAMP data from that Node.

Appendix 1: Standard Operating Procedures (SOP) 3.1.4.3 – Measurement of pH with a Pocket Meter

Standard Operating Procedure (SOP) 3.1.4.3

By Revital Katznelson, Ph.D.

Measurement of pH with a Pocket Meter

1.0 About this SOP

These instructions describe how to measure pH using the battery-operated pocket meters manufactured by Oakton (and sold by LaMotte or Cole Parmer) as the pHTestr series, with or without temperature compensation. pHTestr models are sold in the regular or the waterproof variety. The instructions are relevant - and probably identical - to all other pocket pH meters with dry electrodes (made by Hana, and others). The "distilled water" referred to in the instruction are sold in supermarkets as "distilled water", "deionized water", "purified water", or "drinking water", and are normally prepared by ion-exchange resins or reverse osmosis. Although the pH may be very low at times, the essential feature is zero conductivity and lack of contaminants. The instrument code is PHEL for these meters.

2.0 Equipment List

Apart from this SOP and the pH meter itself, you will need the following:

- Standard pH buffers
- “Distilled water” in a squirt bottle
- Liquid Waste Container (a wide-mouth jar for used reagents and buffers)
- “Field Data Sheet for Water Quality Monitoring” and instructions in SOP-9.2.1.1(Field)
- “Calibration and Accuracy Checks Sheet” and instructions in SOP-9.2.1.2(Calib)

The "distilled water" (DI) referred to in the instruction is sold in supermarkets as "distilled water", "deionized water", "purified water", or "drinking water”, and these are normally prepared by ion-exchange resins or reverse osmosis. The essential feature is zero conductivity and lack of contaminants.

3.0 Maintenance and Storage

For storage over a few days, you can keep the electrode moist by leaving a few drops of distilled water inside the cap. For long storage, dry the electrode and cap tightly. Store upright at all times! An air bubble inside the tip of the electrode can cause erratic readings (contact trouble, presumably) and should always be kept at the top. If the

electrode shows a visible layer of covering material, clean it with solution recommended by the manufacturer per manufacturer instructions.

The meters do not have an automatic OFF function, so care must be taken to turn them off. They require 3 button batteries of 1.5 V. Make sure you get the type that is equivalent to the type you already had in the meter. Under normal use, batteries can function for over 30 field days. It is always a good idea to keep a spare set of batteries with the field kit.

4.0 Calibration

Dispense calibration buffers in small quantities (about 1 tablespoon, or 15 ml) into their dedicated 1-oz plastic cups. Follow the manufacturer's directions to calibrate the pH meter with pH 7 buffer at the beginning of each field day, after it has been soaked. About once a month, use both pH 7 buffer and pH 10 buffer for serial calibration to assure that the slope is correct. You may need to re-calibrate at 7 after calibrating at 10. Rinse the electrode carefully with DI after each buffer. Indicate whether you needed any calibration action or whether none was taken, by entering "cal" or "none" into the "action field in your calibration form. Also, record pre-calibration and post-calibration values in the "calibration" form as you work, along with your Instrument ID and Standard IDs (and do not forget the date and time!).

Discard the calibration buffers into the liquid waste container for later disposal into the sanitary sewer system. Alternatively, save the used buffer in a separate container for future use. Never return the buffer from the cup into the original standard bottle. You can adjust the output of a pH meter to test whether the output is accurate by checking what the meter "reads" when measuring a standard buffer solution. Make sure you have colorless standards, and test it in the same way you are instructed to test your samples (see below). Use at least two Standard buffers, one of pH 7 and the other at pH 9 or 10. The buffers for pH 4 are available but they are less useful for the range of pH you may encounter in the environment. When you conduct an accuracy check, be sure to use the "DQM Calibration and Accuracy Checks Sheet" provided with its instructions (SOP-9.2.1.2); this form has placeholders ("Fields") for all the documentation you will need to provide, and is essentially identical to the spreadsheet table in your Excel Project File.

5.0 pH measurements using dry-electrode pH meters

Hydrating the electrode

Before going to collect the sample in the creek, allow the pH meter to soak in distilled water for at least 20 minutes. For this purpose, remove the pH meter protective cap, place the electrode in a small clean container, and pour water into the container so that the tip is dipped about 1" in water. Do not turn the meter on. (Although your meter is equipped with a "dry" electrode, it is necessary to let it soak and equilibrate before calibrating it and using it for measurements).

Sample pH measurement

At each station, either test the water directly or pour some of the water sample from the sampling apparatus into a clean small container, creating a depth of about 1”. Turn the pH meter on, and dip the electrode into sample solution. Do not wet above the cap line! Stir gently for a few seconds, watch the changes in the readings, and keep stirring and watching every few seconds until the readings stabilize. Record reading on the field data sheet, making sure the Instrument ID is entered correctly.

Turn off pH meter. Remove pH meter from sample. Rinse tip with distilled water and discard the wash water into the liquid waste container (It was a good idea to get a WIDE MOUTH container so you can squirt the DI on the electrode directly above the liquid waste container…). If you plan to do more pH measurements within the next few hours, you can fill the cap with DI water, enough to keep the electrode submerged

6.0 Monitoring Tips and advice

Pocket pH meters are inexpensive and readily available, but can only produce reliable data with proper maintenance and regular calibration. This is often difficult to achieve, and unless you can assure the delicate attention needed, avoid using these dry electrode pH meters.

Problems we have encountered include:
1) air bubble inside the gel, moving up and down the electrode and interfering with electrical contacts (solution: always keep the meter upright);
2) dry mineral crust forming on the electrode interface after prolonged storage (solution - soak in DI for a while before calibration and use);
3) very slow response with low buffered waters (solution - monitoring the changes in the reading and waiting several minutes for stabilization, with occasional stirring)

Sources and Resources

This SOP is a part of the guidance compendium created by the Clean Water Team, the Citizen Monitoring Program of the State Water Resources Control Board.

Appendix 2: Standard Operating Procedures (SOP) 3.1.5.4 – Turbidity using a Nephelometer ("Turbidimeter")

Standard Operating Procedure (SOP) 3.1.5.4

By Dominic Gregorio and Erick Burres

Turbidity using a Nephelometer ("Turbidimeter")

Nephelometers are electronic turbidity meters that yield results in Nephelometric Turbidity Units (NTUs). NTUs are the standard units for measuring turbidity. Make sure that the turbidity meter that you are using gives results in NTUs. Most small handheld electronic meters that measure turbidity are not nephelometers and are often called "turbidimeters". Each meter is designed with different features and operating functions. Carefully read and follow the manufacturer's instructions when performing turbidity measurements. However, all turbidity measurements should be made by following the general instructions below.

1. Quality Control and Calibration: Always follow the manufacturer's instructions regarding calibration. Some units must be calibrated on the day of the test, while others require less frequent calibrations. For those instruments that do not require daily calibration, make sure to standardize by measuring one or two known standards within (or bracketing) the expected range of the sample prior to making field measurements. If these two standards do not yield accurate measurements then calibrate the unit before actually measuring any water samples. Measure a distilled water field blank (<0.1 NTU) while performing field measurements. After making field measurements then measure one or two standards to determine if the instrument has drifted in its accuracy during the sampling period. Always record the results of any field blanks, standardization, and calibration procedures for future QA/QC reference.

2. If possible, measure turbidity immediately after collecting the sample. If measuring a sample that has not been collected immediately, make sure to mix the sample by gently inverting a few times. Do not agitate aggressively as this will result in air bubbles. If air bubbles do result from mixing make sure that they dissipate before making the measurement. Similarly, always make sure standards are well mixed and free of gas bubbles before use in the meter.

3. The glass tubes must not be scratched or marked in any way. Always make sure that the tubes are dry and clean before placing them in the meter. Clean the surface of the tubes with a clean, soft, and non-abrasive cloth. Make sure there are no smudges or other material on the tubes before taking a reading. If possible, wipe a thin layer of optical oil on the tubes before inserting in the instrument. Use the non-abrasive cloth for this purpose. Do not handle the tubes with bare hands after they are cleaned with the non-abrasive cloth. Always orient the tubes in the

meter in the same way for each measurement. The tubes and meters usually each have a mark that must be lined up before taking the reading.

4. Placing the tube into the Nephelometer: Again, never handle the tube by the glass; instead, handle by the cap only. Place the tube in the proper orientation in the meter according to manufacturer's instructions. For some meters the tubes must be checked for their optical properties and best orientation prior to use. Before taking a reading make sure the lid or cap is placed firmly over the tube to prevent any stray light from entering the instrument. Stray light can interfere with the proper functioning of the instrument and result in inaccurate readings. You can check to see if the lid or cap is preventing stray light by measuring a standard in a dark room vs. full sunlight. There should be no significant difference between readings of the same standard in both conditions.

5. Between monitoring events wash the tubes with warm soap and water, rinse three times, and then perform a final rinse with distilled water. Invert to dry, then cap once completely dry.

The following is an example of field instructions on how to operate a specific turbidity instrument. It was provided by Heal the Bay's Stream Team and is provided as a model on how you can create field instructions for your turbidity instrument.

Turbidity Testing Procedure (Adapted from the LaMotte 2020 Turbidimeter Instruction Manual)
Before beginning please note that the turbidimeter has two operating modes, standard mode and EPA mode. These instructions are for units operating in the EPA mode (triangle icon displayed on the LCD). The meter can only be switched from one mode to the other while turning the 2020 on from the OFF state. The 2020 will remain in whatever mode it was last used in, even if it was turned off.

1) Fill a clean container with at least 50 ml. of sample water and cover. Set sample aside to allow sample to equilibrate to air temperature and let gas escape. Avoid contaminants and analyze as soon as possible.
2) Rinse 2 empty turbidity tubes and caps with a portion of sample. Shake out excess water.
3) Fill both turbidity tubes to the neck by carefully pouring the sample down the side of the tube. This will prevent air bubbles from forming. (Similar to pouring soda or beer into a glass while trying to avoid foam on the top).
4) Cap the tubes and wipe dry with a clean lint free tissue.
5) Carefully invert the turbidity tube twice (do not create air bubbles) just before inserting the tube into the meter,
6) Open the meter lid. Align the indexing arrow on the tube with the indexing arrow on the meter. Insert the turbidity tube into the chamber.
7) Close the lid. Push the READ button. The turbidimeter in NTU units will be displayed within 5 seconds.

8) Record the results from each tube. Take a third reading from a new sample if the first two readings are significantly different.
9) The meter will turn off automatically one minute after the last button push. To turn the meter OFF manually, hold the READ button down for at least2 seconds. Release the button when OFF is displayed.

Tip: For this meter if the sample is higher than 1100 NTU it must be diluted and retested.

Information Regarding the 2020 Turbidimeter Keypad

- When the READ button is first pushed, a number will be briefly displayed that indicates the software version number.
- Three dashes (---) will be displayed when the turbidity measurement is taking place.
- The display will flash after the CAL (calibrate) button is pushed during the standardization procedure until the CAL button has been pushed again to enter the adjusted value.
- OFF will be displayed after the READ button has been held down for two seconds. The button should be released and the meter turned off.
- ER1 (ERROR 1) will be displayed if the battery is low.
- ER2 will be displayed when the measured turbidity is very low.
- ER3 will be displayed when the light source (bulb) has burned out or if the turbidity tube is misaligned.
- BAT will be displayed when the battery is getting low. The readings are reliable but the battery needs to be replaced as soon as possible. Carry extra batteries with the field kit.

Heal The Bay, 2000, Water Quality Training Manual
LaMotte, 2000, 2020-Turbidimeter Instruction Manual

This SOP is a part of the guidance compendium created by the Clean Water Team, the Citizen Monitoring Program of the State Water Resources Control Board.

Appendix 3: Standard Operating Procedures (SOP) 3.1.3.1 – Measurement of Electrical Conductivity Using a Pocket Meter

DQM Standard Operating Procedure (SOP) 3.1.3.1 (V3)

By Revital Katznelson, Ph.D.

Measurement of Electrical Conductivity Using a Pocket Meter

(This paragraph is common to all DQM SOPs. If you have seen it already, please skip to Section 1 below). This is a new type of guidance, created as part of the Data Quality Management (DQM) System implemented by the Clean Water Team (CWT) to support collection of reliable data of known quality in a fully documented, scientifically defensible manner.

1.0 Overview

These instructions describe how to measure conductivity using the battery-operated pocket meters manufactured by Oakton (and sold by numerous vendors) as the TDSTestr series or the EC-Testr series. Please refer to IP-3.1.3(EC), available with the Clean Water Team, for background information on total dissolved solids (TDS) and conductivity; this will explain the relationship between the term "TDS" in the product name and the output of these meters in conductivity reporting units, microsiemen or milisiemen. The reader is encouraged to select instruments that report in microsiemen. The TDSTestr3 model (recently renamed EC-Testr Low) provides for the range of 10 to 1990 microsiemen, and the range of the TDSTestr4 (now called EC-Testr High) is 0.1 to 19.90 milisiemen. Both are available in a waterproof model. If you anticipate monitoring water bodies with very little salts (e.g., waters dominated by rainwater or snowmelt), look for the more sensitive meters, e.g. those that have a resolution of 1 uS and a range of 1-200 uS. The old models had a screw for manual calibration, while some of the new models have arrow-buttons for manual calibration or an automatic calibration feature. All pocket meters of the TDSTestr series have a built-in automatic temperature compensation (ATC) device. Other TDS or EC meters may have minute differences in the appearance but the procedures and record keeping steps are probably identical.

(This paragraph is common to all Instrument-specific DQM-SOPs). The sections of this SOP are organized as follows: Equipment list, maintenance and storage, calibration and record keeping, conductivity measurement, monitoring tips, and detailed guidance on how to control, check, record, and report (CCRR) the accuracy and the precision of the measurements. Relevant definitions as well as contact information are provided at the end of this SOP. In must be noted that there are many other SOPs, available from different organizations, which also provide instructions for the use of pocket conductivity meters. However, the objective of this particular SOP is to provide a new type of guidance as part of the Data Quality Management (DQM) System implemented by the Clean Water Team (CWT) of the State Water Resources Control Board. It provides guidance at the level of detail and specificity that will allow users to generate reliable data of known quality in a fully documented, scientifically defensible manner.

2.0 Equipment List

Apart from this SOP and the Pocket Meter itself, you will need the following:

1. Calibrator Standard

2. a small (1-oz) cup for Standard
3. a medium (9-oz) cup for sample solution
4. “Distilled water” in a squirt bottle
5. Liquid Waste Container, a wide-mouth jar for rinse water and used Calibration Standard
6. “Field Data Sheet for Water Quality Monitoring”
7. “Calibration and Accuracy Checks Sheet”.

The "distilled water" referred to in the instruction is sold in supermarkets as "distilled water", "deionized water", "purified water", or "drinking water”, and these are normally prepared by ion-exchange resins or reverse osmosis. The essential feature is zero conductivity and lack of contaminants.

3.0 Maintenance and Storage

The conductivity pocket meters are low-maintenance devices and can be stored dry. If the electrodes show a visible layer of covering material, clean them with solution as recommended per manufacturer instructions.

4.0 Calibration and Record Keeping

The temperature of the Calibrator Standard during calibration is very important, because conductivity is highly dependent on temperature. Your Calibrator Standard shows the conductivity value your instrument should be adjusted to at a specified temperature, usually 25 C. Even if you have the automatic temperature compensation (ATC) feature, calibrate your meter at 25 C (see instructions below). When you calibrate your instrument, use a copy of the “DQM Calibration and Accuracy Checks Sheet” provided with this SOP or by your technical liaison: this form has placeholders (“fields”) for all the documentation you will need to provide, and is essentially identical to the spreadsheet table in your Excel Project File. The recommended procedure for calibration of the manually-calibrated model involves the following steps:

Step C1: Enter the date, time, Instrument ID, Calibrator Standard ID, and other relevant information into your "DQM Calibration and Accuracy Checks Sheet".
Step C2: Pour about 15 ml of the Calibrator Standard into a small (1-oz) plastic cup and heat it in your hands, checking the temperature continuously until it reaches 25 C.
Step C3: Rinse the tip of your conductivity meter with DI and gently shake off the excess DI. Dip the conductivity meter in the warmed Calibrator Standard solution and record the reading value prior to calibration on your "DQM Calibration and Accuracy Checks Sheet".
Step C4: If the reading is more than 20 microS from the specified (theoretical) Calibrator Standard value (for the Testr3 model), hold the instrument inside the Calibrator Standard solution in its cup **without touching the cup itself** and turn the calibration screw with a tiny screwdriver until the reading is the closest you can get to the standard (it will probably fluctuate by 10 microS back and forth – we have to live with that). **Caution! Do not turn the screw more than a fraction of a circle at a time, and watch the response**. In other words, do not lose the calibration "thingie" that is held by the calibration screw (as sometimes happens when people turn the screw too much, the "thingie" falls off the screw, and gets lost inside the instrument). If you have a newer model with calibration arrow buttons, use those to adjust the reading up or down while the instrument is in the solution, at 25 C, and is not touching the cup itself.
Step C5: If you have made any adjustments, enter "manual cal" in the "Action" field on your "DQM Calibration and Accuracy Checks Sheet", and record the reading after calibration in the appropriate field. If the result showed the theoretical value of your Calibration Standard, and you did not adjust the screw, write "none" in the "Action" field.
Step C6: Rinse the tip of your conductivity meter thoroughly with DI and gently shake off the excess DI.
Note: If your instrument has automatic calibration, make sure that the **Calibrator Standard used is the correct one as specified by the manufacturer** (and if it is not specified in the manufacturer's instructions, do not use the instrument). As in the case of manual adjustment, always use Calibrator Standard at 25 C (even if the manufacturer's instructions do not tell you to). Keep all records in the relevant fields of the "DQM Calibration and Accuracy Checks Sheet" as instructed above (in steps C1, 2,3) for the manual calibration. In the "action" field, write "none" if you have not adjusted the reading and skip the next field; or "auto cal" if you have used the automatic calibration feature (and be sure to enter the theoretical value of the Calibrator Standard you have used in the appropriate field).

5.0 Conductivity measurements

Step 5.1 Pour some of your water sample into a small clean container. If your meter is not the waterproof model, fill container with enough sample liquid to submerge 1” of the tip (not more).
Step 5.2 Record the Instrument ID which is written on your meter in the appropriate field, in the conductivity row on the “DQM Field Data Sheet for Water Quality Monitoring”
Step 5.3 Remove the conductivity meter protective cap. Turn the meter on, and dip the electrode into sample solution. Do not wet above the cap line! Watch for the flashing range indications and the units on the display panel.
Step 5.4 Stir gently every few seconds, until the readings stabilize. This probe automatically compensates for temperature, so it may take a couple of minutes for the values to stabilize. If you do not have an ATC feature, put a thermometer in the cup together with your conductivity meter and record the temperature in the cup in the Comment field, conductivity row, of your “DQM Field Data Sheet for Water Quality Monitoring”.
Step 5.5 Record units on your “DQM Field Data Sheet for Water Quality Monitoring”, as micromhos per centimeter (microsiemen) or as millisiemen, depending on the instrument you have used.
Step 5.6 Hold the instrument inside the solution in the cup **without touching the cup itself** and read the result. Record the Result value (reading) on the “DQM Field Data Sheet for Water Quality Monitoring”, making sure the Instrument ID has been entered correctly.
Step 5.7 Turn off meter. Remove meter from sample. Rinse tip with distilled water and cap.

6.0 Monitoring Tips

The meters do not have an automatic OFF function, so care must be taken to turn them off. They require 4 button batteries of 1.5 V. Make sure you get the type that is equivalent to the type you already had in the meter. Under normal use, batteries can function for over 30 field days. It is always a good idea to keep a spare set with the field kit.
If you are using the low-range meter (0 to 1990 microsiemen) in slightly salty waters you may find that the conductivity is outside the range of your meter. You can still gather data by diluting your sample in distilled water. Use the small, 1 oz cup, to take one full-cup volume of sample into a larger cup, and then to take one full 1-oz cup of distilled water into the same larger cup. Mix and measure the conductivity of the mixture. If it is within range, record the reading and note that it should be multiplied by 2. However if it is still out of range you can keep adding increments of full 1-oz cup of distilled water – keeping track of how many you have added – till your meter can read it within range, and then record the reading and the total number of full 1-oz cups (including the one with sample). When you dilute a sample, always record the result of the actual measured value in the “**2nd/rep/dup/dil**” cell and always record the dilution factor; thus you will be writing something like “1300uS x 3 dil”.

7.0 Accuracy and Precision CCRR (control, check, record, and report)

7.1 Accuracy

Accuracy is the extent of agreement between an observed value (measurement result) and the accepted, or true, value of the parameter being measured. The best way to control

accuracy is to calibrate often, and at the prescribed temperature! The temperature of the Standard during accuracy checks and calibration adjustments is very important, because conductivity is highly dependent on temperature. For routine monitoring, when a conductivity meter is used only by one crew, the accuracy checks and calibration adjustments should be done at ambient temperature. However, in situations where many crews are using the same instrument sequentially (typically for mass monitoring events, e.g., snapshot monitoring day), it is recommended to check and calibrate at 25 C every time so all users will have the same reference point for the instrument drift.

7.1.1 First measure of inaccuracy: Drift from the calibrated state:.

How often should you check/calibrate? That would probably depend on the drift of your instrument, i.e., on how fast it moves away from the correct value as represented by your Standard. When you are not familiar with your instrument, check the calibration status every trip to see if the instrument still reads the Standard correctly, and calibrate again if needed. Follow the instructions in Section 4.0 above when recording your activities on the "DQM Calibration and Accuracy Checks Sheet". Always record the value your instrument reads before calibration to keep careful documentation of the drift; this is your **first measure of accuracy.**

Once you are more comfortable with your instrument you can pace your accuracy checks at longer time intervals. The recommended frequency of accuracy checks (and calibration adjustments if needed) is different for two distinct Scenarios:

- Snapshots and other one-time monitoring events – do an accuracy check (and adjust reading if needed) before the event. Then do an accuracy check immediately after the event; record the drift between the two.
- Routine monitoring – if you conduct accuracy checks/calibration every second trip; record the drift that occurred between the calibration at the start of the first trip and the reading of the accuracy check (before calibration adjustment) at the start of the third trip.

7.1.2 Second measure of inaccuracy: Deterioration of the Standard

Many groups use their "Resident" Standard for routine accuracy checks and calibration adjustments. However, Standards do change over time, and it is prudent to perform "Comparison of Standards" wherein the Resident is compared to an External Standard (or the old bottle of Standard is compared to the new one). Any instrument with good resolution can be used for this type of comparison (preferably after it has been checked/calibrated against one of the Standards). Comparisons of "Resident" to External Standards are needed to account for drift in the Resident Standard itself, which is your **second measure of accuracy**. Comparisons with External Standard can be done at regional Intercalibration Exercise events, otherwise known as "instrument calibration party", particularly when CWT coordinators bring fresh batches of certified Standards. If you are a Technical Leader or a Trainer it is your responsibility to attend, compare your Standard with the External Standard, and make sure you know how far you may be from the true value. The CWT provides a Field Data Sheet for Comparisons of Standards to capture that information.

7.1.3 Drift and Data Quality Indicators for Accuracy

Your Trainer will use your calibration and accuracy checks records to calculate inaccuracy –sometimes called bias – based on the Drift. Note that this drift, i.e., the

differential between the reading of the instrument in the Standard and the "true" value of the Standard, has to reflect accuracy checks done **before** calibration adjustments, and is relevant to the set of Results that were collected prior to that accuracy check. In other words, you essentially adjust the reading in the morning – to make your data as accurate as possible by eliminating the drift – and then you do an accuracy check at the end of day. Assuming that the instrument drifts from the calibrated state in one direction only, the drift you see in the evening reflects the worst case distance that your day's Results can be from the "true" value. If you attach that distance (i.e., the drift you found in the evening) to the results of that day, the person using your data will know that it could not be further than that.

The same principle applies if you conduct periodic accuracy checks and calibration adjustments (rather than morning calibration adjustment and evening accuracy check). For each monitoring period (say, Trips # 4 to # 6), the reading in the Standard - as captured at the end of Trip # 6 of that period (and **before** any adjustment) - is the Drift you report in association with all the Results collected during Trips #4, #5, and # 6 of that period. If you find that your Resident Standard has drifted (as compared to Certified standard) over the time that includes Trips #4 to #6, add the extent of the Standard Drift to the drift from the calibrated state you found for Trips #4, #5, and # 6 of that period. This data quality indicator, or measure of inaccuracy, can be reported either as the differential (in uS) or as a percent of the Result value. Further guidance for the Trainer on how to use the Data Quality Management tools to report inaccuracy will be provided in DQM-SOP-9.3.2.2(err).

7.2 Precision

The precision of your instrument is a measure of how close repeated measurements, done with the same instrument, are to each other. You can control the precision of your instrument by eliminating sources of error or reducing their effect on the result of the measurements, for example by waiting for the reading to stabilize, avoiding contact between the instrument and the cup when taking the reading, and adhering to consistent measurement conditions in terms of sample volume, temperature, mixing, etc.

To check precision, collect two samples from the creek at the same time and measure their conductivity; these "field duplicates" are a part of your routine Field QA/QC. You can also have two people measure conductivity of the same sample, or otherwise generate sets of "replicate" results that pertain to the same sample. Generate such pairs every third trip, and every time you introduce new monitors to your team, and record the additional measurement results in the "**2nd/rep/dup/dil"** field on your "DQM Field Data Sheet for Water Quality Monitoring".

You should have several pairs of repeated measurements (replicates or duplicates) for each Project. Once entered into the DQM Project File, your Trainer or Technical leader will use them to calculate and report the precision of your instrument as the Relative Percent Difference (RPD) per DQM-SOP-9.3.2.2(err). RPD is the arithmetic difference between the two Results, multiplied by 100 and divided by their average, and is usually reported as absolute numbers because negative numbers are not indicators of bias in this case. In the rare situation where you obtains triplicates or even more than three repeated measurements of the same sample, calculate the Coefficient of Variation (%CV), which is the standard deviation multiplied by 100 and divided by the mean. Note that RPDs and %CV are not the same, kind of like apples and oranges, and you cannot add them up.

Please seek further guidance on these Precision measures. If the resolution of your instrument is low – as is the case when you use the TDSTestr4 that has increments of 100 microsiemen – you may not be able to see any difference between your repeated readings (especially if you are monitoring waters of low conductivity), because these differences are minute in comparison to the increments available on the instrument. In that case you can report your precision as "better than the resolution of the instrument". This statement emphasizes the need to get the instrument with the resolution and range that are appropriate for your work.

7.3 Blanks

Testing the response of your instrument in distilled or deionized water is a very good practice (if you know that your water is indeed of zero conductivity…). Keep routine checks and record them on the "DQM Calibration and Accuracy Checks Sheet" as separate accuracy check records (i.e., enter "DI" in the Tested Material cell). Note: I have never seen a drift from zero, and I do not know if these instruments can show negative values (RK, 7/8/02). If you trust your DI and your instrument reads something different than zero in it, call your tech support coordinator…

7.4 CCRR Definitions

(This section is common to all Instrument-specific DQM-SOPs) These terms are defined here because they are essential for understanding the instructions. These and many other terms are defined in the Glossary at the end of the generic SOPs for Field Operators (DQM-SOP-9.2.1.1(Field) and DQM-SOP-9.2.1.2(Calib), and in the comprehensive Compendium glossary.

Instrument: a probe, electrode, reagent kit, indicator strip, or any other type of device used for field or laboratory measurements.

Accuracy Check: Comparison of the reading, or output, of a measurement device with a value believed to be the "true" value. The "true" value may be represented by any Standard Material (e.g., known natural reference conditions such as freezing point, Standard Solution, etc). An "Accuracy Check" is different from a Calibration, since it is only a comparison and does not result in an adjustment of the reading of the measurement device.

Calibration (or Calibration Adjustment): Modification of the output of an adjustable-reading instrument, to make it reflect a value that represents the "true value" (as manifested by a given Standard or by a natural value). Note: The EPA's definition for "Calibration" is, essentially, a combination of "accuracy check (comparison) and adjustment if needed"; it is not specific enough for communication of what you did when you say "I calibrated the instrument".

Standard Material: A catch-all term for Solutions (e.g., Standard Buffer), devices (e.g., Certified thermometer), or natural reference points (e.g., Water saturated with dissolved oxygen at a given temperature), that represent a value believed to be the "true" value.

Standard Solution: A solution containing a known concentration of a substance or has a known property, prepared or purchased for use in the analytical laboratory or in the field. Each bottle of these types of Standards has a **unique Standard ID,** for example "STB-EC2". Every bottle of Standard with its unique ID can be described in one or more of the following definitions:

- "**Resident Standards**" – solutions that each monitoring entity or group owns and uses routinely for calibration and/or accuracy checks.

- "**External Standards**" - solutions used in events such as Intercalibration Exercises, often brought by the QA/QC officer for comparison with the Resident Standards brought by the participating groups;
- "**Certified Standards**" include any Standard that is traceable to NIST or ASTM. Resident and External Standards can all be Certified Standards as well. A Certified Standard is considered the "ultimate authority" if valid, i.e., if the bottle was (a) used before the expiration date; (b) has been stored tightly capped; and (c) has not been exposed to extreme temperatures or sunlight.

8.0 Sources and Resources

(This section is common to all DQM-SOPs, except for the title and SOP number in the citation) This SOP is an integral part of the Data Quality Management (DQM) System implemented by the Clean Water Team, the Citizen Monitoring Program of the California State Water Resources Control Board.

For an electronic copy, to find many more CWT guidance documents, or to find the contact information for your Regional CWT Coordinator, visit our website at www.swrcb.ca.gov/nps/volunteer.html

If you wish to cite this SOP in other texts you can use "CWT 2004" and reference it as follows:

"Clean Water Team (CWT) 2004. Measurement of Electrical Conductivity Using a Pocket Meter, DQM SOP-3.1.3.1. 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."

Appendix 4: Standard Operating Procedures (SOP) 3.1.2.1 – Measurements of Temperature with Bulb and Min-Max Thermometers

SOP-3.1.2.1

Standard Operating Procedure (SOP) 3.1.2.1

BY REVITAL KATZNELSON, PH.D.

Measurements of Temperature with Bulb and Min-Max Thermometers

This SOP provides instructions for the use of devices that record temperature-dependent change in volume, such as bulb thermometers made with mercury or dyed alcohol solution in a bulb and thin capillary, or U-shaped tube thermometers filled with mercury and equipped with minimum-maximum stopper locks. To facilitate data management, please use thermometers that report the temperature in °C if you can.
Note: Use of mercury thermometers is being phased out.

Bulb Thermometers

Bulb thermometers come in all kinds, lengths, and shapes, and are usually made of glass (although some thermometers are made of plastic). Many glass thermometers are sold with an "armor" made of a perforated metal or plastic sheath, to protect the delicate glass.
Step 1: To measure temperature of a solution with a bulb thermometer, immerse the thermometer in the tested solution.
Step 2: Allow a minute or so for equilibration, then read while still immersed in the solution.
Step 3: Reporting the data:

- Add or confirm the Instrument ID on the field data sheet
- Make sure that both the temperature value and the unit are recorded

Minimum-Maximum Thermometers

U-shaped tube thermometers are usually filled with mercury and have an air reservoir on one end (on the left side for this SOP). Movement of the mercury in the U pushes the minimum or the maximum stoppers up where they remain even after the temperature changes. This happens because the stoppers are made of metal rods, and there is a flat magnet closely behind the tube, so they get stuck. Min-Max thermometers can be used in water or air. They can be deployed over a desired period of time to obtain records of the minimum and the maximum that had occurred during that deployment period, without having to be present. Unfortunately, they can record only one minimum and one maximum value per one deployment period, and need to be reset manually prior to a subsequent deployment.

Step 1: Inspect the device before use, to ensure that there are no air bubbles in the continuum of mercury in the U-shaped tube.

Step 2: To reset the thermometer, hold it upright and press the central ridge toward the back – this will push the magnet (that holds the stoppers in place) backwards and release the stoppers. Wait until both stoppers slide down and reach the tops of the mercury columns.

Step 3: Deploy the device for the desired period of time at the desired location. Make efforts to deploy in an upright position. Note that the entire device has to be in the ambience of the environment you are recording: it does not have a sensitive point like bulb thermometers or thermistor probes.

Step 4: Retrieve the thermometer and read the temperature scales at the following places:

- Current temperature – where the mercury levels are at the time of retrieval (they should be identical on both arms; note that the scale on the left arm is upside-down)
- Minimum temperature – where the bottom of the left-arm stopper is upon retrieval (note that the scale is upside-down)
- Maximum temperature - where the bottom of the right-arm stopper is upon retrieval.

Step 5: Record the three values on your data sheet, reporting the data:

- Add placeholders for Minimum and Maximum temperatures on your data sheet, if absent.
- Add or confirm the Instrument ID on the data sheet
- Make sure that both the temperature values and the units are recorded

Step 6: Reset the device as in Step 2 to prepare it for the next deployment.

Monitoring Tips

Bulb thermometers used for environmental monitoring **are different from thermometers used to measure body temperature** in that they do NOT have that tiny twist in the capillary tube (which prevents the mercury from rolling back after removal from the body and requires vigorous shaking of the thermometer before the next measurement). Consequently, the operator of an environmental bulb thermometer, when measuring water temperature, MUST read the temperature **while the bulb is still in water**! The same requirement applies to thermistor probes. This can be made easier by taking some of the creek water into a cup, keeping the thermometer in it and bringing it to eye level for rapid reading. The Kemmerer sampling apparatus provided by LaMotte has a special hole for the thermometer, so that the thermometer remains in the sampling apparatus while filling and retrieving, and can be read directly through the transparent wall of the apparatus immediately after retrieval.

When you measure air temperature, remember that a wet thermometer is "contaminated" in the sense that the water will alter your values. To avoid this, either dry the thermometer thoroughly before measuring air temperature, or dedicate one thermometer for water and a second thermometer for air only - and keep the second one dry at all times (buying two and dedicating may be the only solution if you are using the LaMotte armored thermometers with the blue plastic perforated sheath (i.e., the coating with holes), because there is no way of drying everything inside the armor within the time it takes to hop from one station to the next).

Whether you are using a bulb thermometer or a Minimum-Maximum thermometer, remember:

- never shake the thermometer upside down
- always keep flat or upright, never upside down
- avoid exposure to extreme heat

If you are using one of the older models of Minimum-Maximum thermometers and you MUST open the device, do it inside a white bag to catch the tiny spring that WILL fly out and which cannot be replaced.

Sources and Resources

This SOP is a part of the guidance compendium created by the Clean Water Team, the Citizen Monitoring Program of the State Water Resources Control Board.

Appendix 5: Standard Operating Procedures (SOP) 3.1.1.2 – Measurements of Dissolved Oxygen with the Modified Winkler Titration

Standard Operating Procedure (SOP) 3.1.1.2

BY THE COYOTE CREEK RIPARIAN STATION

Measurements of Dissolved Oxygen with the Modified Winkler Titration

The following instructions assume the use of the all-liquid reagent kit for measuring dissolved oxygen in the field, as provided by LaMotte (other field kits would present small variations in the way reagents are packaged and dispensed, and in minute details of the titration equipment).

It is assumed that the water sample has been collected with appropriate devices. Sampling techniques for collecting a water sample without contact with air are available in this Compendium (SOP-2.1.1.2 Water sampling using the Kemmerer Bottle, and SOP-2.1.1.3 Water sampling using the syringe pump apparatus.)

Measurement of Dissolved Oxygen

The procedure is composed of several steps, broken into two phases: In the first phase the oxygen in the sample is "fixed" by reagents that we add to the sample bottle, to form a chemical complex between the free oxygen and some of the reagents. In the second phase the amount of the complex (which reflects the original concentration of dissolved oxygen in the sample) is quantified by slowly adding a "neutralizing agent" until all the complex molecules disappear. This process is called "titration", the neutralizing agent is called "titrant", and the amount of titrant used reflects the original oxygen concentration in the sample.

Phase 1: Fixing the sample

1.1 Once you have collected the sample in the D.O. bottle, examine the full bottle to make sure no air bubbles are trapped inside. (An air bubble will produce false, high readings. If an air bubble is present, another sample must be taken from the creek). Fix the sample immediately after collection (see steps 1.2 and 1.3 below).

1.2 Add **8 drops of Manganous Sulfate Solution** *(white cap)* and **8 drops of Alkaline Potassium Iodide Azide *(white cap).*** Some of the sample will overflow as chemicals are added, but sufficient amounts of the oxygen-reacting chemicals will fall to the bottom of the bottle. These concentrated reagents are added in excess, so if you put 7 or 9 drops it is probably still accurate. **Cap** the D.O. bottle immediately after adding the second reagent. The overflow assures that when the sample bottle is closed, the cone inside the

cap will push excess liquid out and no air will be trapped inside. **Mix** the content of the D.O. bottle by inverting several times. The liquid will turn cloudy, and then a precipitate (chunks of solid flakes) will form. Allow the precipitate to settle below the shoulder of the bottle before proceeding. Proceeding too quickly may result in an incomplete reaction and produce false low readings.

1.3 Add **8 drops of Sulfuric Acid, 1:1** *(red cap).*
Cap the bottle, wipe the excess liquid from the external surface of the bottle *(this stuff is nasty!)* and gently mix the content until all the precipitate has dissolved. At first you will see the fluffy precipitate turn into brown flakes, looking very different from the particulates in the original sample, and you need to wait until these flakes dissolve. If the brown flakes are still there after a few minutes, add a few more drops of acid. A clear-yellow (low D.O.) to brown orange color (high D.O.) will develop, depending on the oxygen content of the sample. The sample is now fixed. Following completion of this step, contact between the water sample and the atmosphere will not affect the test results, and you may store the fixed sample for a few hours (not overnight).

Phase 2: Titrating the complex

2.1 Rinse the titration vial and the direct-reading titrator syringe with deionized water (DI).

2.2 Fill the direct reading titrator (*syringe)* with the titrant solution, **Sodium Thiosulfate 0.025N.** To do this, first **insert** the titrator into the plastic fitting of the titrant solution bottle (hold it close to the tip when you do this). **Invert** the bottle and slowly **withdraw** the plunger until the bottom of the plunger is opposite the zero mark on the scale (Figure 1). Small air bubbles may appear in the titrator barrel. Expel the bubbles by partially filling the barrel and pumping the titration solution back into the inverted reagent container, or by tapping the barrel of the syringe with your finger to dislodge clinging air bubbles. Repeat these actions until the bubbles disappear.) Turn the bottle right-side-up and remove the titrator.

2.3 **Transfer** 20 ml of the fixed water sample from the D.O. bottle into the titration vial. Remember to read the measurement from the bottom of the meniscus.

2.4 Insert the full titrator syringe into the center hole of the titration vial cap. While swirling the vial, slowly press the plunger until the water sample becomes pale yellow. **Do not titrate beyond a pale yellow tinge**.

2.5 Add **8 drops** of the **Starch Indicator Solution** to the titration vial. The liquid should turn blue. **Cap** the vial.

2.6 **Insert** the full titrator syringe into the center hole in the cap of the titration vial. While swirling the vial, slowly press the plunger until the water sample solution is less blue. Continue to press the plunger to add one drop of titrant at a time**. Swirl** to mix THOROUGHLY after each drop. Continue until the blue color instantly turns colorless.

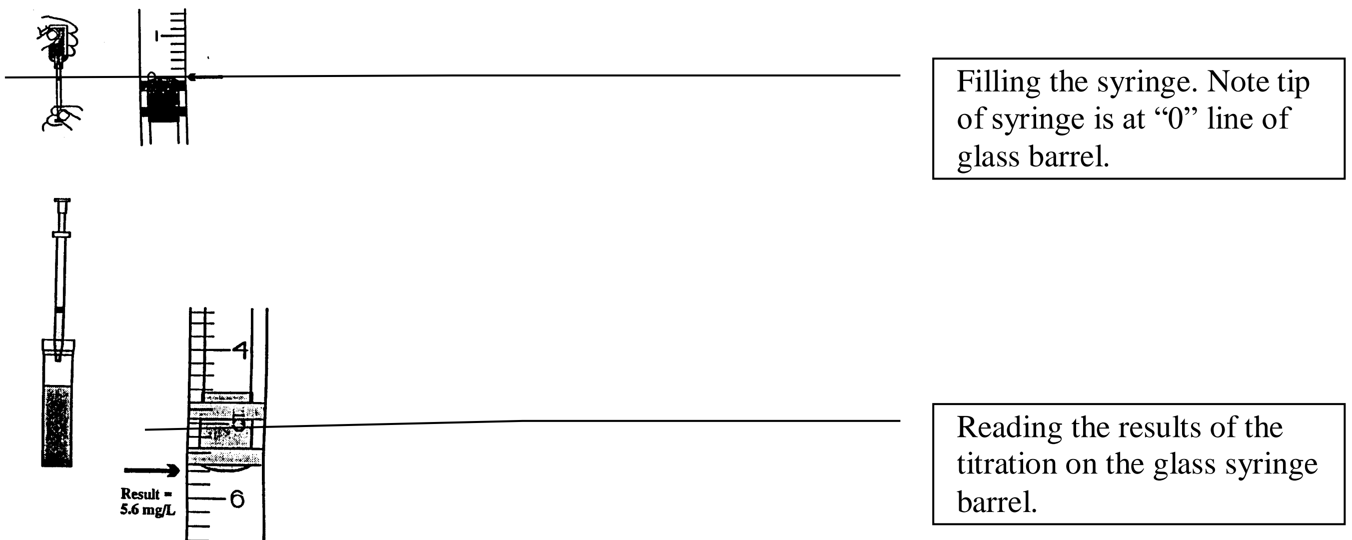
Color changes will occur where the drop first contacts the sample, but the drop must be dispersed throughout the sample. The entire solution will turn clear and remain that way for 1-2 minutes when the entire sample is at the endpoint.

If the plunger tip reaches the bottom line of the titrator before endpoint color change, record the volume already used, and then refill the titrator and continue the titration.

2.7 Read the test results where the plunger tip meets the scale (Figure 1). Each minor division on the scale equals 0.2 mg/l (parts per million, or ppm). If the titrator was refilled, add the first 10 mg/l to the last reading to reflect the total amount of reagent dispensed. (See Note below)

2.8 Record the results as mg/l dissolved oxygen in the "Value" column in your field data sheet. If you repeat the titration of the same fixed sample, you are conducting a "replicate measurement". In this case, record the second titration in the rep/dup/range column and add "rep" (this means it was a replicate titration). If you take a new sample form the creek within a few minutes and repeat both phases 1 and 2, it is considered a "field duplicate". In that case, record the result of the second DO test in the rep/dup/range column and add "dup".

Figure 1. Filling and Reading the Titrator in the Dissolved Oxygen Measurement.



After you have completed all the titration steps and recorded the results, discard the titrated solution from the vial into the waste bucket. Thoroughly rinse the titration vial with distilled water and discard in waste bucket.
After all D.O. titrations are complete, thoroughly rinse the D.O. bottle, the titration vial, and the titrator syringe with distilled water, putting the waste into the waste bucket for proper disposal.

Note: Check with your monitoring team leader that your result is reasonable. If there is any concern that the D.O. value is not correct, repeat your measurement. For example, if the titration was overrun, do not record the data, but redo the titration. There is enough volume of fixed sample for three repeats. If the entire procedure (sampling, fixing, titrating) was done correctly and the value is unusually low, another water sample may also be taken and the entire preparation repeated.

What to expect:

Cool, fast flowing turbulent water is expected to contain D.O. at saturation levels (9-10 mg/l, depending on the temperature). The fixed sample is orange, and a nearly a full syringe of titrant is needed. Algae and aquatic plants will add D.O. to the water in the light, as a result of photosynthesis. Pools may have supersaturation (levels above saturation) of oxygen if there are algae or plants in them or immediately upstream, even if the water is turbid. In that case the fixed sample will appear very orange, and a few drops of acid may be needed to dissolve the brown flakes. Refill of the titrator syringe will be necessary, and should be done as quickly as possible. Turbid, smelly water in stagnant pools may be depleted of oxygen. The fixed samples will be yellow or pale yellow, and the titrant should be added careful (drop by drop) immediately at the beginning of the titration. If the D.O. of the sample is below 4.0 mg/l, another sample needs to be collected and the D.O. test should be repeated.

<u>Accuracy Checks</u>

Because you cannot really obtain an oxygen "Standard", you need to conduct accuracy checks often. One of these checks is to measure D.O. in clean water (e.g., deionized water, DI) at dissolved oxygen saturation at a given temperature. Please refer to the Information Paper on dissolved oxygen for further information. Essentially, you can use clean water that has been at ambient temperature, not in the refrigerator, and prepare a saturated DI sample by transferring about a glass of water, from cup to cup back and forth, about 20 times, creating turbulence and ample contact with air. Then you use this sample to fill a D.O. bottle, measure temperature, and fix the sample for titration.

You can also buy and use a "standard" solution, prepared by the manufacturer specifically for the Winkler titration, to test the strength of your sodium thiosulfate titrant. This standard represents a phase equivalent to fixed and acidified sample (i.e., the orange solution in the D.O. bottle after reagents 1, 2 and 3 have been added).

<u>Monitoring Tips</u>

For the Winkler titration - sulfide interferes with the reagents and may mask the presence of low D.O. levels. Sulfide and D.O. usually do not co-exist, but if it is desirable to detect traces of D.O., the sulfide must be precipitated with zinc acetate and the supernatant be used for the Winkler titration.

Sources and Resources

This SOP was created by personnel of the Coyote Creek Riparian Station (CCRS 1993) and was later revised by Woodward Clyde Consultants (WCC 1996) and by SFEI (1996) It was refined for this Compendium by the Clean Water Team implementing the Citizen Monitoring Program of the State Water Resources Control Board in 2000.

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Appendix 6: Standard Operating Procedures (SOP) 3.4.1.1 – Coliform Bacteria Analysis: Colilert 18 hr. Method with Quanti-Trays

Standard Operating Procedure (SOP) 3.4.1.1

By Dominic Gregorio

Coliform Bacteria Analysis: Colilert 18 Hr. Method with Quanti-Trays®

Total coliform bacteria, fecal coliform bacteria, and *E. coli* are all considered indicators of water contaminated with fecal matter. Contaminated water may contain other pathogens (micro-organisms that cause illness) that are more difficult to test for. Therefore these indicator bacteria are useful in giving us a measure of contamination levels.

E. coli is a bacterial species found in the fecal matter of warm blooded animals (humans, other mammals, and birds). Total coliform bacteria are an entire group of bacteria species that are generally similar to and include the species *E. coli*. There are certain forms of coliform bacteria that do not live in fecal matter but instead live in soils. Fecal coliform bacteria are coliform bacteria that do live in fecal matter, including, but not limited to, the species *E. coli*. Most of the fecal coliform cells found in fecal matter are *E. coli*. Therefore, all *E. coli* belong to the fecal coliform group, and all fecal coliform belong to the total coliform group.

Colilert-18 is used for the simultaneous detection and confirmation of total coliforms and *E. coli* in fresh and marine waters. It is based on IDEXX's patented Defined Substrate Technology® (DST®). When total coliforms metabolize Colilert-18's nutrient-indicator, ONPG, the sample turns yellow. When *E.coli* metabolize Colilert-18's nutrient indicator, MUG, the sample fluoresces. Colilert-18 can simultaneously detect these bacteria at 1 MPN/100ml within 18 hours even with as many as 2 million other heterotrophic bacteria cells per 100ml present.

Equipment and Supplies

1) Disposable rubber gloves.

2) Sealed Whirlpack bags or sterile plastic bottles for sampling.

3) A clean ice chest and frozen plastic sealed "blue" ice.

4) A refrigerator maintained at a temperature of 4° C.

5) An incubator capable of maintaining a temperature of 35° C ± 0.5° C.

6) An IDEXX sealer.

7) A tightly closed or sealed vessel of distilled water.

8) Antibacterial solution (e.g., Lysol spray).

9) Sterile 10 ml pipettes and a pipette pump.

10) Quanti-trays and sterile 100 ml mixing bottles supplied by IDEXX Corp.

11) A 6 watt, 365nm, ultra-violet (UV) light.

12) Sterile Colilert media, pre-packaged from IDEXX Corporation. Media will be stored at 4-25°C away from light. Media will be used prior to the manufacturer's expiration date.

SAFETY CONSIDERATIONS

1) When sampling in potentially contaminated waters take all precautions to prevent coming into contact with the water. These precautions include wearing rubber gloves and washing with antibacterial soap following sampling and analysis.

2) Never sample waters after a known sewage spill or when the waters are officially closed by a Public Health Officer.

3) Never sample when river, surf or beach/shore conditions are hazardous.

4) Never sample in stream bank areas in which there is the potential for falling into the stream. Never sample during flood stage conditions.

5) Never sample alone on streams or storm drains.

6) Never sample from bridges or roads where there is the potential for being at risk from automobile traffic.

7) Always wash down all surfaces used in the processing of samples with anti-bacterial solutions (e.g., Lysol, etc.) once the Quantitrays are in the incubator or after a spill of a sample.

8) All spent Quanti-trays containing live bacterial cultures (positive, yellow wells) must be autoclaved prior to disposal. Develop a partnership with a college, laboratory, public health agency or hospital that can accept and autoclave the spent Quanti-trays.

FIELD SAMPLE COLLECTION PROCEDURE

1) Sterile sample bottles will be used (Whirl-Pak bags are acceptable) and will be labeled with the proper sample ID. The sampler will use aseptic technique, making certain that the bottle does not touch the benthic substrate (rock, sand, or mud on the bottom of the waterbody). Therefore, make an effort, within reason, to prevent sediment from entering the sample containers.

2) When samples are collected on a beach, it will be collected on an incoming wave. In all cases (beach or stream) the sampler must be downstream and away from the bottle, and the mouth of the bottle must face into the current.

3) After the sample is taken, the bottle will be immediately tipped to decant enough sample to ensure 1-2 inches of airspace in the sample bottle. The bottle will be tightly capped or twist closed (in the case of the Whirlpack) and promptly stored on ice (target temperature 4° C) in a clean ice chest.

4) Laboratory analysis should begin within 6 hours of sample collection and within two hours of receiving the sample at the lab.

PREVENTION OF CONTAMINATION OR INTERFERENCES IN THE LABORATORY

1) Laboratory Sterile Technique: When performing bacterial analysis all laboratory personnel will wash hands prior to beginning tests and will wash hands thereafter whenever their hands become soiled with samples, etc. All counters must be cleaned with a bactericide prior to performing tests. Sample bottles or Whirlpacks must be inverted (to mix) prior to opening in the lab. After opening the samples, subsamples for dilutions must be performed as soon as possible to minimize the potential for contamination. Only sterile pipettes must be used for subsampling.

2) Sterile Dilution Water: Water used to prepare culture media and reagents will be sterile distilled water stored out of direct sunlight to prevent growth of algae. All marine water samples must be diluted by at least 1:10 with distilled sterile water.

3) In samples with excessive chlorine, a blue flash may be seen when adding Colilert-18. If this is seen, consider sample invalid and discontinue testing.

4) False Positives: These are wells in which a different bacteria species (other than coliform bacteria) has grown and caused a color change. Even when all of the above precautions are followed there may still be false positive wells in the incubated quanti-trays. Do not record false positives as positive wells. However, you should make a note in your lab book or lab data sheet regarding the presence of the false positives for future reference.

Lab Procedures

1) Different types of water samples require different types of preparation as follows:
   a) For sterile (blank) water or relatively clean fresh water pour 100 ml of sterile water or sample directly into the sterile 100 ml mixing bottle (by filling to the 100 ml line) and add one package of the reagent. Cap and shake until dissolved.
   b) For fresh water that is suspected to contain contamination, pour 50 ml of sterile distilled water into the mixing bottle and add one package of the reagent. Cap and shake until dissolved. Then, after the foam subsides, using a sterile pipette add 10 ml of sample and top off with 40 ml (to the 100 ml line). Cap and shake again. This is a 1:10 dilution.
   c) For all marine or estuarine water samples (salinity greater than 5 ppt), pour 50 ml of sterile distilled water into the mixing bottle and add one package of the reagent. Cap and shake until dissolved. Then, using a sterile pipette add 10 ml of sample and top off with 40 ml (to the 100 ml line). Cap and shake again. This is a 1:10 dilution.

2) Make sure there is little or no foam left in the headspace of the mixing bottle prior to moving on to the next step.

3) Pour sample/reagent mixture from the mixing bottle into a quanti-tray and seal in the IDEXX Sealer.

4) Place the sealed tray in a 35±0.5°C incubator for a minimum of 18 hours and a maximum of 22 hours (includes warming time). This is the incubation period.

Quality Control Elements

1) Duplicate Analyses: A minimum of 5 % of the samples on a given day should be subsampled and run in duplicate. At least one duplicate should be run on every day in which the analyses are run. An attempt will be made to select samples that yield positive results (i.e., suspected of contamination) for the duplicate analyses.

2) Negative Blanks: One blank (sterile) water sample will be analyzed per batch of samples processed.

3) External Reference Samples: A positive control is a sample prepared in the lab to contain a known approximate concentration of coliform bacteria. An external reference sample is a positive control prepared and provided by a professional laboratory. The external reference sample is split. You should analyze the split external reference and compare your results to the professional lab. At least two external reference samples must be run per year.

Determining the Most Probable Number of Coliform Cells Per 100ml of Sample

1) Following the incubation period, observe and count the number of positive wells. For *E. coli* look for fluorescence with a 6 watt, 365nm, UV light within 5 inches of the sample. Face light away from your eyes and towards the sample.

2) For total coliform and *E. coli* use the following **Result Interpretation Table**:

Appearance	Result
Colorless or slight tinge	negative for total coliforms and *E. coli*
Yellow equal to or greater than the comparator (supplied by IDEXX)	positive for total coliforms
Yellow equal to or greater than the comparator and fluorescence	positive for *E. coli*

Note: Fluorescent wells that are not yellow (i.e., wells which are not positive for total coliforms) cannot be considered positive for *E.coli*. **In other words, these are false positives for *E. coli*.**

3) Refer to the MPN table (provided by IDEXX) specific to the type of quanti-tray used (51 well or 97 well type of quanti-tray) to obtain a Most Probable Number per 100 ml of sample.

4) If a dilution was performed, after obtaining the initial MPN result from the table, multiply that result by the dilution level to obtain the final result (e.g., if a 1:10 dilution was employed, multiply the result from the MPN table by 10 to get the final result in MPN/100 ml).

5) Samples are negative if at any time after the incubation period is complete there is no yellow or yellow/fluorescence. Yellow or yellow/fluorescence observed before 18 hours is a valid positive. However, after 22 hours from inoculation, heterotrophic bacteria may overwhelm Colilert-18's inhibition system. Therefore, yellow or yellow/fluorescence first observed after 22 hours from inoculation is not a valid positive.

Technical Assistance

For IDEXX technical assistance call 1-800-321-0207 or 207-856-0496.

References:

1) IDEXX Colilert (18 hour) Manual
2) Enzyme Substrate Coliform Test Method 9223, Standard Methods for the Examination of Water and Wastewater, 20th ed., American Public Health Association, Washington D.C., 1998
3) Quality Assurance Plan for the Southern California Bight 1998 Project, Microbiology Committee, Southern California Coastal Water Research Project

This SOP is a part of the guidance compendium created by the Clean Water Team, the Citizen Monitoring Program of the State Water Resources Control Board.

Appendix 7: Standard Operating Procedure (SOP) 3.4.2.1 - Enterococcus Bacteria Analysis: Enterolert™ Method with Quanti-Trays®

Standard Operating Procedure (SOP) 3.4.2.1

By Dominic Gregorio

Enterococcus Bacteria Analysis: Enterolert™ Method with Quanti-Trays®

Water contaminated with fecal matter may contain pathogens (bacteria and other micro-organisms that cause illness). Many pathogens are difficult measure in water samples. Certain bacteria, however, are relatively easy to measure in water samples and, if present, are used to measure the level of fecal contamination. These types of bacteria are referred to as indicator bacteria. Enterococcus bacteria are one such indicator of fecal contamination in water.

The general term enterococcus has been used for years to describe a group of gram-negative, coccoid shaped bacteria species, including *Streptococcus* species, found in the intestinal tracts (and therefore feces) of humans and other warm blooded animals. Recently, researchers have proposed the use of the term *Enterococcus* as a genus that includes these species of streptococcal bacteria. Therefore the species *Streptococcus faecium* and *Streptococcus faecalis* are now synonymously referred to as *Enterococcus faecium* and *Enterococcus faecalis.*

Enterolert™ reagent is used for the detection of enterococcus bacteria (enterococci) such as *E. faecium* and *E. faecalis* in fresh and marine water. This product is based on Defined Substrate Technology® (DST™) and utilizes a nutrient indicator that fluoresces when metabolized by enterococci. When the reagent is added to the sample and incubated, bacteria down to one MPN (most probable number) in a 100ml sample can be detected within 24 hours.

Equipment and Supplies

13) Disposable rubber gloves.

14) Sealed Whirlpack bags or sterile plastic bottles for sampling.

15) A clean ice chest and frozen plastic sealed "blue" ice.

16) A refrigerator maintained at a temperature of 4° C.

17) An incubator capable of maintaining a temperature of 41° C $\pm$ 0.5° C.

18) An IDEXX sealer.

19) A tightly capped or sealed vessel of distilled water.

20) Antibacterial solution (e.g., Lysol spray).

21) Sterile 10 ml pipettes and a pipette pump.

22) Quanti-trays and sterile 100 ml mixing bottles supplied by IDEXX Corp.

23) A 6 watt, 365nm, ultra-violet (UV) light.

24) Sterile Enterolert media, pre-packaged from IDEXX Corporation will be used. Media will be stored at 4-30°C away from light. Media will be used prior to the manufacturer's expiration date.

SAFETY CONSIDERATIONS

9) When sampling in potentially contaminated waters take all precautions to prevent coming into contact with the water. These precautions include wearing rubber gloves and washing with antibacterial soap following sampling and analysis.

10) Never sample waters after a known sewage spill or when the waters are officially closed by a Public Health Officer.

11) Never sample when river, surf or beach/shore conditions are hazardous.

12) Never sample in stream bank areas in which there is the potential for falling into the stream. Never sample during flood stage conditions.

13) Never sample alone on streams or storm drains.

14) Never sample from bridges or roads where there is the potential for being at risk from automobile traffic.

15) Always wash down all surfaces used in the processing of samples with anti-bacterial solutions (e.g., Lysol, etc.) once the Quanti-trays are in the incubator or after a spill of a sample.

16) All spent Quanti-trays containing live bacterial cultures (positive, yellow wells) must be autoclaved prior to disposal. Develop a partnership with a college, laboratory, public health agency or hospital that can accept and autoclave the spent Quanti-trays.

FIELD SAMPLE COLLECTION PROCEDURE

5) Sterile sample bottles will be used (Whirl-Pak bags are acceptable) and will be labeled with the proper sample ID. The sampler will use aseptic technique, making

certain that the bottle does not touch the benthic substrate (rock, sand, or mud on the bottom of the water body). Therefore, make an effort, within reason, to prevent sediment from entering the sample containers.

6) When samples are collected on a beach, it will be collected on an incoming wave. In all cases (beach or stream) the sampler must be downstream and away from the bottle, and the mouth of the bottle must face into the current.

7) After the sample is taken, the bottle will be immediately tipped to decant enough sample to ensure 1-2 inches of airspace in the sample bottle. The bottle will be tightly capped or twist closed (in the case of the Whirlpack) and promptly stored on ice (target temperature 4° C) in a clean ice chest.

8) Laboratory analysis should begin within 6 hours of sample collection and within two hours of receiving the sample at the lab.

PREVENTION OF CONTAMINATION OR INTERFERENCES IN THE LABORATORY

5) Laboratory Sterile Technique: When performing bacterial analysis all laboratory personnel will wash hands prior to beginning tests and will wash hands thereafter whenever their hands become soiled with samples, etc. Use tight fitting sterile latex gloves when working with samples in the lab. All counters must be cleaned with a bactericide prior to performing tests. Sample bottles or Whirlpacks must be inverted (to mix) prior to opening in the lab. After opening the samples, sub samples for dilutions must be performed as soon as possible to minimize the potential for contamination. Only sterile pipettes must be used for sub sampling.

6) Sterile Dilution Water: Water used to prepare culture media and reagents will be sterile distilled water stored out of direct sunlight to prevent growth of algae. All marine water samples must be diluted by at least 1:10 with distilled sterile water.

7) False Positives: These are wells in which a different bacteria (other than enterococci) has grown and caused a biochemical reaction resulting in fluorescence. Even when all of the above precautions are followed there may still be false positive wells in the incubated quanti-trays. Do not record false positives as positive wells. However, you should make a note in your lab book or lab data sheet regarding the presence of the false positives for future reference.

Lab Procedures

5) Different types of water samples require different types of preparation as follows:
   a) For sterile (blank) water or relatively clean fresh water pour 100 ml of sterile water or sample directly into the sterile 100 ml mixing bottle (by filling to the 100 ml line) and add one package of the reagent. Cap and shake until dissolved.

b) For fresh water that is suspected to contain contamination, pour 50 ml of sterile distilled water into the mixing bottle and add one package of the reagent. Cap and shake until dissolved. Then, after the foam subsides, using a sterile pipette add 10 ml of sample and top off with 40 ml (to the 100 ml line). Cap and shake again. This is a 1:10 dilution.
c) For all marine or estuarine water samples (salinity greater than 5 ppt), pour 50 ml of sterile distilled water into the mixing bottle and add one package of the reagent. Cap and shake until dissolved. Then, using a sterile pipette add 10 ml of sample and top off with 40 ml (to the 100 ml line). Cap and shake again. This is a 1:10 dilution.

6) Make sure there is little or no foam left in the headspace of the mixing bottle prior to moving on to the next step.

7) Pour sample/reagent mixture from the mixing bottle into a quanti-tray and seal in the IDEXX Sealer.

8) Place the sealed tray in a 41° ± 0.5° C incubator for a minimum of 24 hours and a maximum of 28 hours (includes warming time). This is the incubation period.

Quality Control Elements

4) Duplicate Analyses: A minimum of 5 % of the samples on a given day should be sub sampled and run in duplicate. At least one duplicate should be run on every day in which the analyses are run. An attempt will be made to select samples that yield positive results (i.e., suspected of contamination) for the duplicate analyses.

5) Negative Blanks: One blank (sterile) water sample will be analyzed per batch of samples processed.

6) External Reference Samples: A positive control is a sample prepared in the lab to contain a known approximate concentration of enterococcus bacteria. An external reference sample is a positive control prepared and provided by a professional laboratory. The external reference sample is split. You should analyze the split external reference and compare your results to the professional lab. At least two external reference samples must be run per year.

Determining the Most Probable Number of Enterococci Cells Per 100ml of Sample

1) Following the incubation period observe and count the number of positive (fluorescent) wells. For enterococci look for blue fluorescence with a 6 watt, 365nm, UV light within 5 inches of the sample. Face light away from your eyes and towards the sample. . The fluorescence intensity of positive wells may vary.

2) Wells that fluoresce yellow or yellow-green are false positives.

3) Refer to the MPN table (provided by IDEXX) specific to the type of quanti-tray used (51 well or 97 well type of quanti-tray) to obtain a Most Probable Number per 100 ml of sample.

4) If a dilution was performed, after obtaining the initial MPN result from the table, multiply that result by the dilution level to obtain the final result (e.g., if a 1:10 dilution was employed, multiply the result from the MPN table by 10 to get the final result in MPN/100 ml).

5) If the sample is inadvertently incubated over 28 hours without observation, the following guidelines apply: Lack of fluorescence after 28 hours is a valid negative test. Fluorescence after 28 hours is an invalid result. In other words, only positive results obtained using the proper incubation period (24-28 hours) are valid.

Technical Assistance

For IDEXX technical assistance call 1-800-321-0207 or 207-856-0496.

References:

1. IDEXX Enterolert Manual
2. Quality Assurance Plan for the Southern California Bight 1998 Project, Microbiology Committee, Southern California Coastal Water Research Project

This SOP is a part of the guidance compendium created by the Clean Water Team, the Citizen Monitoring Program of the State Water Resources Control Board.

Appendix 8: Alpine Watershed Group Water-Quality Field Procedures Manual

Sierra Nevada Alliance

Alpine Watershed Group

WATER-QUALITY MONITORING FIELD PROCEDURES MANUAL

1st Edition, Prepared by South Yuba River Citizens League

Information compiled from US Environmental Protection Agency and California State Water Resources Control Board *Clean Water Team.*

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Thank you for your commitment to help assess the health of your watershed. Volunteers are **THE** critical component to the success of a water quality-monitoring program. The purpose of this manual is to orient you with the procedures for water-quality monitoring.

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Alpine Watershed Group: Since 2004, the Alpine Watershed Group, a non-profit organization, has bee preserving and enhancing the natural system functions of Alpine County's watershed for future generations. The group works by inspiring participation to collaborate, educate, and proactively implement projects that benefit and steward the county's watersheds. www.alpinecountyca.com

Sierra Nevada Alliance: Since 1993, the Alliance, a non-profit organization, has been protecting and restoring Sierra lands, water, wildlife and communities. The Sierra Watersheds Program goal is to ensure that the Sierra's 24 major watersheds have active, informed efforts to restore and protect their rivers, lakes and streams thereby protecting critical habitats and restoring watershed health in the Sierra Nevada. We do this by networking, distributing information, offering financial support, hosting trainings and workshops, inspiring and educating. www.sierranevadaalliance.org

South Yuba River Citizens League RiverScience program focuses on the development of scientifically valid restoration efforts and community-based monitoring. SYRCL's River Science program uses water quality monitoring and analysis, research, education, advocacy, and collaboration to help protect and restore the Yuba Watershed. With over 70 trained volunteers from the community, SYRCL's River Monitoring Program is now completing its 4th year of collecting water quality data. www.syrcl.org

Clean Water Team (CWT) is the citizen-monitoring program of the California State Water Resources Control Board. The CWT Coordinators are members of the Regional Programs Unit, Watershed Pollution Prevention Section. The mission of the Clean Water Team is *"to build and support the States Watersheds' Stewardship through involvement in Citizen Monitoring in order to reduce and prevent water pollution."* http://www.swrcb.ca.gov/nps/mission.html

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Section One: Orientation and Basic Sampling Methods

1. Introduction

Thank you for being a volunteer for the Alpine Watershed Group Water Quality Monitoring Program. The future health of Alpine County's watersheds depends upon your efforts for monthly chemical water testing and bi-yearly stream assessment surveys. You are extremely appreciated!

This manual will address protocol and considerations for every aspect of your sampling procedures, to help you- and to insure the sampling happens in an accurate, scientific manner. Data collected from your monthly samples will be entered into a database and results will be evaluated by Alpine Watershed Group the South Yuba River Citizens League, and the State Water Resources Control Board. Determinations for future efforts to improve water quality in Alpine County's watersheds will be based upon your efforts.

Alpine Watershed Group hopes that you will enjoy the experience of being a monthly monitor. It's not always an easy job! Please allocate enough time for your sample collection and do not hesitate to contact Laura Lueders, program coordinator, if you have any needs, questions or schedule changes.

Every month the monitoring coordinator will contact you to confirm your monitoring date and time. **Please be prompt in answering back!** Please try to inform us of scheduling considerations well in advance of your time, since samples are meant to be collected at the same time of day from month to month. This will give us time to re-schedule you or find a replacement monitor for that month.

2. Safety Considerations

One of the most critical considerations for a volunteer monitoring program is the safety of its volunteers. All volunteers should be trained in safety procedures and should carry with them a set of safety instructions and the phone number of their monitoring coordinator. Safety precautions can never be overemphasized.

The following are some basic safety rules. At the site:

- Always monitor with at least one partner. Always let someone else know where you are, when you intend to return, and what to do if you do not come back at the appointed time.
- Have a first aid kit handy. Know any important medical conditions of team members (e.g., heart conditions or allergic reactions to bee stings). It is best if at least one team member has First Aid/CPR training.

- Listen to weather reports. Never compromise your safety if severe weather is predicted or if a storm occurs while at the site.
- Never wade in swift or high water (above knee height).
- 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, such as a watertight bag you keep in a pouch strapped to your waist. Without proper precautions, wallet and keys might end up downstream.
- Never cross private property without the permission of the landowner. If INSERT WATERSHED GROUP NAME directions lead you to private property, verify with INSERT WATERSHED GROUP NAME that permission has been granted.
- Watch for irate dogs, farm animals, wildlife (particularly snakes), and insects such as ticks, hornets, and wasps. Know what to do if you get bitten or stung. Advise your partners if you are allergic, and carry a sting kit with you to the field.
- Watch for poison oak and other types of vegetation that can cause rashes and irritation.
- Never drink the water in a stream. Assume it is unsafe to drink, and bring your own water from home. After monitoring, wash your hands with antibacterial soap before eating.
- Do not walk on unstable stream banks. Disturbing these banks can accelerate erosion and might prove dangerous if a bank collapses. Disturb streamside vegetation as little as possible.
- Be very careful when walking in the stream itself. Rocky-bottom streams can be very slippery and can contain deep pools; muddy-bottom streams might also prove treacherous in areas where mud, silt, or sand have accumulated in sink holes. If you must cross the stream, use a walking stick to steady yourself and to probe for deep water or muck. Your partner(s) should wait on dry land ready to assist you if you fall. Do not attempt to cross streams that are swift and above the knee in depth.
  If you are sampling from a bridge, be wary of passing traffic. Never lean over bridge rails unless you are firmly anchored to the ground or the bridge with good hand/foot holds.
- **If at any time you feel uncomfortable about the condition of the stream or your surroundings, stop monitoring and leave the site at once. Your safety is more important than the data!**

When using chemicals:

- Know your equipment, sampling instructions, and procedures before going out into the field. Prepare labels and clean equipment before you get started.

- Keep all equipment and chemicals away from small children. Many of the chemicals used in monitoring are poisonous. Tape the phone number of the local poison control center to your sampling kit.
- Avoid contact between chemical reagents and skin, eye, nose, and mouth. Never use your fingers to stopper a sample bottle (e.g., when you are shaking a solution).
- Know chemical cleanup and disposal procedures. Wipe up all spills when they occur. Return all unused chemicals to your program coordinator for safe disposal.
- Close all containers tightly after use. Do not switch caps. Let us know if you think you did, or if items are lost.
- Know how to use and store chemicals. Do not expose chemicals or equipment to temperature extremes (such as in a parked car during the summer) or long-term direct sunshine.
- Rinse test vials with deionized or distilled water after each test; dry hands and outside of vial.
- Wipe up spills when they occur.
- **Do not pour used chemicals or samples onto the ground or into the creek! Place all solutions and used chemicals in a waste container and dispose of them down a sink connected to a sewer system (not a septic tank) or return them to the program coordinator.**

Some items you may want to bring with you when monitoring:

1. Water (canteen)
2. Whistle
3. Compass
4. Pocket knife
5. Camera
6. Water shoes
7. Metric tape measure
8. Flashlight or head lamp and batteries
9. Small towel
10. Waterproof pen
11. Fingerless gloves or hand warmers
12. Sunscreen and sunglasses
13. Insect repellent
14. Raingear, fleece jacket, polypropylene long underwear
15. Extra pair of pants, shirt, socks (wool)
16. Hat
17. Food Snacks – Energy bar, fruit, and nuts
18. Cooler with blue ice (if collecting grab samples to be taken back to lab)
19. Binoculars
20. Emergency survival blanket
21. Waterproof matches

Section Two: Collecting Procedure

1. Water Sampling

General Sampling Techniques

Always sample away from the stream bank in the main current and upstream from where you are standing, in or near the stream. Your behavior should never affect the water sample. The outside curve of the stream is often a good place to sample since the main current tends to hug this bank. Take measurements within the river/creek itself if high river flows are not a problem. This usually means a water depth of less than knee height at the deepest part of the site. If there is a high flow level in the river/creek, then collecting water using the sampling poles provided by the program may be advisable. Collect all your samples from the same location in the river.

Sampling Pole Techniques

Rinse out the sampling bottle attached to the pole 2-3 times with creek water. While standing downstream, put sampling pole perpendicular to bottom of stream. Push it underwater so the sample comes from the middle of the water column. Allow to fill with water and then bring bottle to shore. Immediately measure for temperature, pH, and conductivity. Get a fresh water sample every time for each additional parameter: dissolved oxygen, turbidity, fecal coliform, and metals

Sample Collection Technique for Screw-Cap Bottles

This technique is used to collect water samples in screw-cap sample bottles for tests such as turbidity, fecal coliform and heavy metals.

- Label the bottle with the site number, date, time and your name or initials. Use waterproof pen, if possible.
- Remove the cap from the bottle just before sampling. Avoid touching the inside of the bottle or the cap. In high flows, use a sampling pole. Rinse the sampling bottle on the pole 3 times prior to decanting water into sample bottle. If you accidentally touch the inside of the bottle, use another one.
- Wading. Try to disturb as little bottom sediment as possible. In any case, be careful not to collect water that contains bottom sediment. Stand facing upstream. Collect the water sample in front of you (upstream).
- Hold the bottle near its base and plunge it (opening downward) below the water surface. Collect a water sample 6 to 12 inches beneath the surface or mid-way between the surface and the bottom if the stream reach is shallow.
- Turn the bottle underwater into the current and away from you (upcurrent).
- Leave a small air space, so that sample can be shaken before analysis.
- Check off the test on your appropriate field data sheet. This is important because it tells the monitoring coordinator which bottle goes with which site.
- If the samples are to be analyzed in the lab (e.g. coliform and metals), place them in the cooler for transport to the laboratory.

Section Three: Water Monitoring Parameters

1. Air Temperature

How to measure air temperature

Hang the thermometer on a tree branch in the shade for 10 minutes to equilibrate. Keep it away from cool water, hot rocks, and your body.

- First record the thermometer ID number on your data sheet.
- To measure the air temperature, hold the thermometer at arm's length, shaded from direct sunlight, at shoulder height..
- When using the meter, allow the temperature reading to stabilize at a constant temperature reading.
- Return the thermometer to the branch and recheck temperature in 10 minutes.
- Return the thermometer to the branch and recheck temperature in 5 minutes.
- Keep all readings within a 20 minute time frame

2. Water Temperature

Water temperature is the measure of the average kinetic energy of water molecules. It is measured on a linear scale of degrees Celsius or degrees Fahrenheit. The formula for conversion between Fahrenheit and Celsius is:
(°F - 32) x 5/9 = °C. Always indicate whether temperature has been recorded in degrees Celsius or degrees Fahrenheit.

Importance of Water Temperature
Temperature is one of the most important water quality parameters. Aquatic organisms from microbes to fish are dependent on certain temperature ranges for their optimal health. Optimal temperatures for fish depend on the species: some survive best in colder water, whereas others prefer warmer water. If water temperatures are outside this optimal range for a prolonged period of time, organisms are stressed and can die. Temperature affects the oxygen content of the water (oxygen levels become lower as temperature increases); the rate of photosynthesis by aquatic plants; the metabolic rates of aquatic organisms; and the sensitivity of organisms to toxic wastes, parasites, and diseases.

Factors Affecting Water Temperatures
Natural Factors

- Sunlight energy such as seasonal and daily changes, effects of shade (cover), and air temperature
- Wind speed at water surface
- Stream flow
- Depth of water
- Inflow of groundwater which is usually colder than creek water
- Inflow of surface water including a drainage ditch or another creek
- Color and turbidity of water (suspended sediment absorbs heat)

Human Factors

- Removal of riparian vegetation
- Soil erosion, filling in deep pools that were once cold, dark refugia for fish
- Stormwater runoff from hot impervious surfaces
- Alterations to stream morphology, substrate and flow
- Cooling water discharges from power plants
- Water diversion or storage resulting in decreased flows
- Water originating from surface or bottom of reservoir

Acceptable Water Temperature Ranges

Acceptable ranges cannot be assigned without understanding the aquatic ecosystem. The maximum tolerable temperature depends on the species.

Maximum weekly average temperature for growth and short-term maximum temperatures for selected fish Adapted from EPA's *Draft Volunteer Stream Monitoring: A Method Manual. An Analysis of the Effects of Temperature on Salmonids of the Pacific Northwest with Implications for Selecting Temperature Criteria.* Sullivan, K., D.J. Martin, R.D. Cardwell, J.E. Toll, and S. Duke. 2000

Species	Growth	Maxima	Spawning*	Embryo Survival**
Bluegill	32°C (90°F)	35°C (95°F)	25°C (77°F)	34°C (93°F)
Carp		21°C (70°F)	33°C (91°F)	
Channel catfish	32°C (90°F)	35°C (95°F)	27°C (81°F)	29°C (84°F)
Largemouth bass	32°C (90°F)	34°C (93°F)	21°C (70°F)	27°C (81°F)
Rainbow trout	19°C (66°F)	24°C (75°F)	9°C (48°F)	13°C (55°F)
Sockeye salmon	18°C (64°F)	22°C (72°F)	10°C (50°F)	13°C (55°F)
Coho Salmon	16.5°C (62°F)	22°C (72°F)		
Steelhead	20.5°C (69°F)	24°C (75°F)		
Chinook		24°C (75°F)	6-13°C (43-55°F)	5-13°C (41-55°F

* The optimum or mean of the range of spawning temperatures reported for the species.
** The upper temperature for successful incubation and hatching reported for the species

How to Measure Water Temperature

(Make 3 to 5 measurements) First presoak the pH meter/thermometer with river water in an upright position for at least 10 minutes. Put a few drops of creek water in cap. Replace cap and set upright in shade with power off for 10 minutes. If soaking in a container, fill container with 1" creek water. Remove meter cap and set upright in container in shade for 10 minutes with power off. Be sure water level stays below the meter's buttons.

To turn the meter on and check the battery status
Press and hold the MODE button until the Liquid Crystal Display (LCD) lights up. All the used segments on the LCD will be visible for 1 second (or as long as the button is pressed), followed by the percent indication of the remaining battery life (e.g. % 100 BATT).
Taking measurements
Submerge the electrode in the water to be tested while stirring it gently. The measurements should be taken when the stability symbol (small clock) on the top left of the LCD disappears. The pH value automatically compensated for temperature is shown on the primary LCD while the secondary LCD shows the temperature of the sample.

To freeze the display
While in measurement mode, press the SET/HOLD button. HOLD appears on the secondary display and the reading will be frozen on the LCD (e.g. pH 5.7 HOLD). Press any button to return to normal mode.

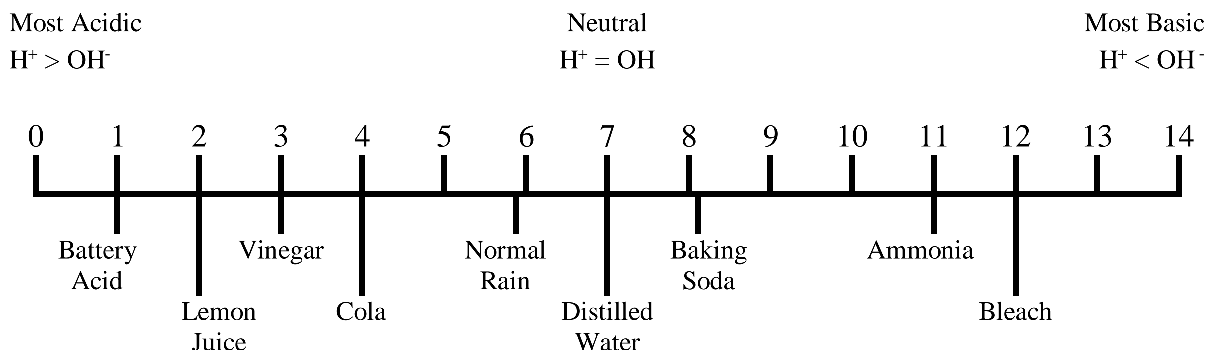
To turn the meter off
While in normal mode, press the MODE button. OFF will appear on the secondary display. Release the button.

- Before taking any measurements make sure the meter has been calibrated (CAL tag present on the LCD)
- If measurements are taken in different samples successively, rinse the probe thoroughly to eliminate cross-contamination; and after cleaning, rinse the probe with some of the sample to be measured.

3. pH

pH is a term used to indicate the alkalinity or acidity of a substance as ranked on a scale from 1.0 to 14.0. Acidity increases, as the pH gets lower. The pH scale measures the logarithmic concentration of hydrogen (H+) and hydroxide (OH-) ions, which make up water (H+ + OH- = H_2O). When both types of ions are in equal concentration, the pH is 7.0 or neutral. Below 7.0, the water is acidic (there are more hydrogen ions than hydroxide ions). When the pH is above 7.0, the water is alkaline, or basic (there are more hydroxide ions than hydrogen ions). Since the scale is logarithmic, a drop in the pH by 1.0 unit is equivalent to a 10-fold increase in acidity. So, a water sample with a pH of 5.0 is 10 times as acidic as one with a pH of 6.0, and a pH of 4.0 is 100 times as acidic as a pH of 6.0.

pH Scale Showing the Value of Some Common Substances



Source: U.S. Fish and Wildlife Service

Importance of pH

pH affects many chemical and biological processes in the water. For example, different organisms flourish within different ranges of pH. The largest variety of aquatic animals prefers a range of 6.5-8.0. pH outside this range reduces the diversity in the stream because it stresses the physiological systems of most organisms and can reduce reproduction. Low pH can also allow toxic elements and compounds to become mobile and "available" for uptake by aquatic plants and animals. This can produce conditions that are toxic to aquatic life, particularly to sensitive species like rainbow trout. Changes in acidity can be caused by atmospheric deposition (acid rain), surrounding rock, and certain wastewater discharges.

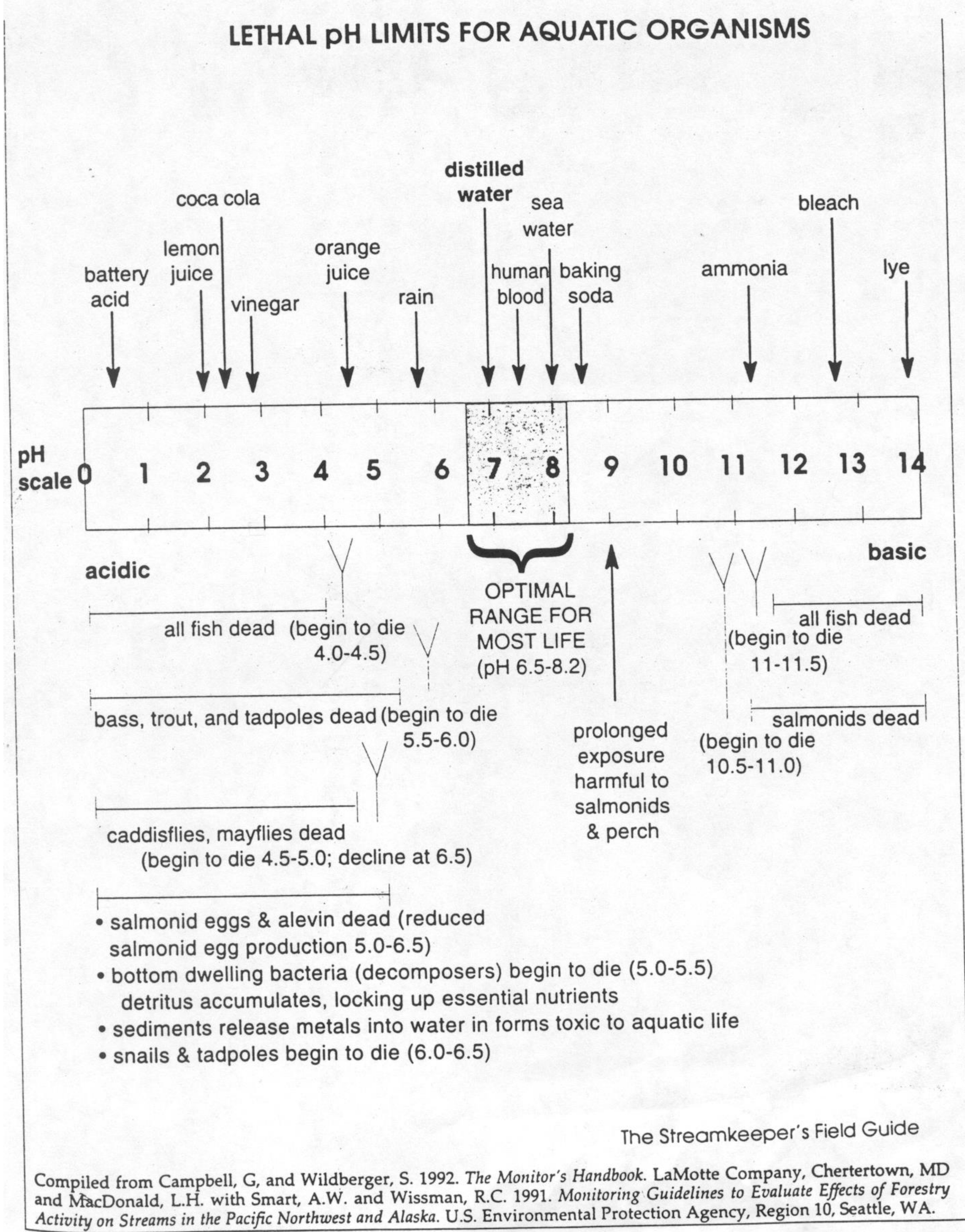
Input of basic or acidic substances (man-made or natural)
pH can change because of external inputs. You might measure a difference in pH along a stream due to:

- Changes in tree types surrounding the water, for example conifer needles are acidic and maple leaves are basic
- Changes in adjacent soils or rock types and erosion events
- Changes in the stream bottom material, for example the difference between gravel, silt, and bedrock
- Large changes in temperature affecting the CO_2/O_2 (carbonic acid) cycle in the water.
- Changes in human activity affecting the stream.

Other Factors

- In fresh water, increasing temperature decreases pH.
- Waters with high algal growth can show a diurnal change in pH. When algae grow and reproduce they use carbon dioxide. This reduction causes the pH to increase. Therefore, if conditions are favorable for algal growth (sunlight, warm temperatures), the water will be more alkaline. Maximum pH usually occurs in late afternoon, pH will decline at night. Because algal growth is restricted to light penetrating zones, pH can vary with depth in lakes, estuaries, bays and ocean water.
- High levels of bacterial activity in sediments can cause associated water to become acidic.
- Manmade inputs that reduce pH include acid rain (from automobiles or industrial sources) and acid mine drainage. Nutrients con indirectly affect pH by stimulating algal growth.

Aquatic Organism Tolerances



How to Measure pH
(Make 3 to 5 measurements) First presoak the pH meter with river water in an upright position for at least 10 minutes. Fill cap with a few drops of creek water. Replace cap and set upright in shade with power off for 10 minutes. If soaking in a container, fill container with 1" creek water. Remove meter cap and set upright in container in shade for 10 minutes with power off. Be sure water level stays below the meter's buttons.

To turn the meter on and check the battery status
Press and hold the MODE button until the Liquid Crystal Display (LCD) lights up. All the used segments on the LCD will be visible for 1 second (or as long as the button is pressed), followed by the percent indication of the remaining battery life (e.g. % 100 BATT).

Taking measurements
Submerge the electrode in the water to be tested while stirring it gently. The measurements should be taken when the stability symbol (small clock) on the top left of the LCD disappears. The pH value automatically compensated for temperature is shown on the primary LCD while the secondary LCD shows the temperature of the sample.

To freeze the display
While in measurement mode, press the SET/HOLD button. HOLD appears on the secondary display and the reading will be frozen on the LCD (e.g. pH 5.7 HOLD). Press any button to return to normal mode.

To turn the meter off
While in normal mode, press the MODE button. OFF will appear on the secondary display. Release the button.

Repeat twice more, for triplicate readings.

- Before taking any measurements make sure the meter has been calibrated (CAL tag present on the LCD)

If measurements are taken in different samples successively, rinse the probe thoroughly to eliminate cross-contamination; and after cleaning, rinse the probe with some of the sample to be measured.

4. Conductivity

Conductivity is the ability of water to conduct an electrical current. Dissolved ions in the water are conductors. The major positively charged ions are sodium (Na^+) calcium (Ca^{2+}), potassium (K^+) and magnesium (Mg^{2+}). The major negatively charged ions are chloride (Cl^-), sulfate (SO_4^{-2}), carbonate (CO_3^{-2}), and bicarbonate (HCO_3^-). Nitrates (NO_3^{-2}) and phosphates (PO_4^{-3}) are minor contributors to conductivity, although very important biologically.

Salinity is a measure of the amount of salts or ions in the water. Because dissolved ions increase salinity as well as conductivity, the two values are related. The salts in sea water are primarily sodium chloride (NaCI). However, other saline waters, such as Mono Lake, owe their high salinity to a combination of dissolved ions including sodium, chloride, carbonate and sulfate.

Importance of Conductivity (TDS)

Conductivity can affect the quality of water used for irrigation or drinking. Most aquatic biota tolerate a range of conductivity. However, the ionic composition of the water can be critical. For example, cladocerans (water fleas) are far more sensitive to potassium chloride than sodium chloride at the same concentration.

Conductivity will vary with water source such as ground water, water drained from agricultural fields, municipal wastewater and rainfall. Therefore, conductivity can indicate groundwater seepage or a sewage leak.

What Affects Conductivity of Water

- Soil and rocks release ions into the waters that flow through or over them. The geology of a certain area will determine the amount and type of ions.
- Salinity and conductivity of coastal rivers is influenced by tides. Sea spray can carry salts into the air that then fall back into the rivers with rainfall.
- De-icing salt used on roads and driveways can easily end up in nearby streams and affect salinity until diluted by large volumes of low salinity water.
- Flow of rivers into estuaries can greatly affect salinity as well as the location of the estuarine mixing zone. This is very important to the survival of estuarine organisms.
- Fresh water lost by evaporation will increase the conductivity and salinity of the waterbody. Warm weather can increase ocean salinity.
- As temperature increases, conductivity increases. Salinity is the amount of salt actually present in the water; therefore, it is not dependent on temperature.

Acceptable Conductivity Ranges

Here are some values of conductivity and salinity to give you an idea of possible data ranges you might encounter in the field. Waters that might have higher conductivity than reported here are rivers or drainage ditches dominated by subsurface agricultural return flows; ephemeral streams or pools late in the season; tidally influenced coastal waters; and naturally saline lakes or ponds.

Conductivity of Water

Water Type	**Conductivity** (mhos/cm or µS)
Distilled Water	0.5 - 3.0
Melted snow	2 - 42
Potable water in U.S.	30 - 1500
Irrigation Supply Water	< 750

How to Measure Conductivity

(Make 3 to 5 measurements) First presoak the meter with river water in an upright position for at least 5 minutes Fill cap with a few drops of creek water. Replace cap and set upright in shade with power off for 10 minutes. If soaking in a container, fill container with 1" creek water. Remove meter cap and set upright in container in shade for 10 minutes with power off. Be sure water level stays below the meter's buttons.

- Remove the conductivity meter protective cap. Turn the meter on, and dip the electrode into river water or sampling arm vessel. Do not wet above the cap line!
- Stir gently every few seconds, until the readings stabilize. The probe automatically compensates for temperature, so it may take a couple of minutes for the values to stabilize. Be patient.
- Record value in microsiemen (µS).
- Turn off meter.
- Repeat twice more, for triplicate readings.

5. Dissolved Oxygen (DO)

The amount of oxygen dissolved in water, and is measured in micrograms per liter or parts per million (ppm).

Importance of Dissolved Oxygen (DO)

The creek system both produces and consumes oxygen. It gains oxygen from the atmosphere and from plants as a result of photosynthesis. Running water, because of its churning, dissolves more oxygen than still water, such as that of a reservoir behind a dam. Most aquatic organisms need oxygen to survive and grow. Some species such as trout and stoneflies require high levels of DO, while other species such as catfish, worms and dragonflies do not. The following may happen if there is not enough oxygen in the water—death of adults and juveniles; reduction in growth; failure of fish eggs/insect larvae to survive; change in species present; and/or growth of toxic or smothering bacteria, fungi, or algae.

Factors Affecting Dissolved Oxygen Levels in Water

<u>Pollution</u>

If organic material (e.g. algae) or waste (e.g. septic leaks) is present in water, bacteria quickly move in to decay the material. As they respire and feed on the decaying material, they use up oxygen and generate CO_2 in the water. Large algae blooms (caused by events like people dumping lawn clippings or leaves, or fertilizer runoff) can create near-zero oxygen conditions in creeks.

<u>Temperature</u>

As temperature increases, the less oxygen can be dissolved in water. When water holds all the DO it can at a given temperature, it is said to be 100 percent saturated with oxygen. Water can be supersaturated with oxygen under certain conditions (e.g. below large dams where discharging flows are very turbulent).

The following table shows the concentration of dissolved oxygen that is equivalent to the 100 percent saturation for the noted temperature (and normal barometric pressure). For fresh water only!

Dissolved Oxygen 100% Saturation at Sea Level

Temperature (degrees Celsius)	Dissolved Oxygen (mg/L)	Temperature (degrees Celsius)	Dissolved Oxygen (mg/L)
0	14.6	16	9.9
1	14.2	17	9.7
2	13.8	18	9.6
3	13.5	19	9.3
4	13.1	20	9.1
5	12.8	21	8.9
6	12.5	22	8.7
7	12.1	23	8.6
8	11.8	24	8.4
9	11.6	25	8.3
10	11.3	26	8.1
11	11.0	27	8.0
12	10.8	28	7.8
13	10.5	29	7.7
14	10.3	30	7.6
15	10.1	31	7.5

Sources of Dissolved Oxygen (DO)
Oxygen is added to water by:
Re-aeration
Oxygen from air is dissolved in water at its surface, mostly through turbulence. Examples of this include water tumbling over rocks (rapids, riffles, curves in the waterway) and wave action.

Photosynthesis (during daylight)
Plants produce oxygen when they photosynthesize. DO is generally highest in the late afternoon, and lowest in the early morning hours before sunrise.

Consumption of Dissolved Oxygen (DO)
Dissolved oxygen is used in two major ways—both of which contribute to the Biological Oxygen Demand (BOD) of the creek system.

Respiration
- Aquatic organisms breathe and use oxygen.
- Large amounts of oxygen are consumed by algae and aquatic plants at night (when large masses of plants are present).
- Large amounts of oxygen are consumed by decomposing bacteria (when there are large amounts of dead material to be decomposed, there will be significant numbers of bacteria).

Substances
Examples of substances that breakdown and use oxygen in the process are generally biodegradable and include dead organic matter, algae, sewage/feed lot waste, yard clippings/yard waste, oil/grease, and fertilizer runoff.

Causes of Low Dissolved Oxygen (DO) Levels
- Increases in water temperature
- Algal blooms
- Human waste
- Animal waste (especially from feedlots/dairy farms)
- Depletion near the bottom of reservoirs by bacteria

Other Factors
- Altitude—water holds less oxygen at higher altitudes
- Salinity—dissolved oxygen decreases, as salinity increases
- Mineral content--dissolved oxygen decreases, as the mineral content and concentration of the water increases

Acceptable Dissolved Oxygen (DO) Ranges

The following table gives specific DO values for the survival of different species:

Biologic Effects of Decreasing Dissolved Oxygen (DO) Levels on Salmonids, Non-Salmonids Fish, and Aquatic Invertebrates

	DO (mg/mL)	
	Instream	Intergravel
I Salmonid waters		
A. Embryo and larval stages		
No production impairment	11	8
Slight production impairment	9	6
Moderate production impairment	8	5
Severe production impairment	7	4
Limit to avoid acute mortality	6	3
B. Other life stages		
No production impairment	8	
Slight production impairment	6	
Moderate production impairment	5	
Severe production impairment	4	
Limit to avoid acute mortality	3	
II. Non-Salmonid waters		
A. Early Life stages		
No production impairment	6.5	
Slight production impairment	5.5	
Moderate production impairment	5	
Severe production impairment	4.5	
Limit to **avoid** acute mortality	4	
B. Other life stages		
No production impairment	6	
Slight production impairment	5	
Moderate production impairment	4	
Severe production impairment	3.5	
Limit to avoid acute mortality	3	
III. Invertebrates		
No production impairment	8	
Some production impairment	5	
Limit to avoid acute mortality	4	

How to Measure Dissolved Oxygen
(Follow each step precisely and take 3 measurements)
Set up your test bottles in a shady, flat area. Once you collect your samples, it is very important that you **immediately** proceed through step #6 of the instructions in the Lamotte kit . If you let your sample sit for any period of time, the amount of dissolved oxygen in the water can change, giving you inaccurate readings.

- Rinse the DO sampling bottle with creek water.
- It is important not to introduce air into the sample. Face upstream in the main current where there is no whitewater. Uncap sampling bottle and plunge underwater into the vertical center of water column. Tip and fill completely.
- Tap the sides of the bottle to dislodge any air bubbles. Be sure that no air bubbles are trapped inside. Cap bottle underwater.
- If you are using a sampling arm, remove the cap at the moment just before filling the bottle. Tilt the bottle and fill the sample bottle using the watertaken with the arm. Do this slowly and fill bottle to the top (by tilting bottle up). Tap sides of bottle to remove any bubbles that appear in the bottle and cap bottle.
- Put on gloves.
- Using the Winkler method with the LaMotte Dissolved Oxygen Test Kit, Code 5860, add 8 drops of **Manganous Sulfate Solution** AND
- Add 8 drops of **Alkaline Potassium Iodide Azide**; some liquid will overflow out of the bottle. Be sure to hold bottles vertically and press drops out slowly. Cap the two chemical solution bottles.
- Cap the sample bottle and mix by inverting several times. A precipitate will form.
- Set sample bottle down for a few minutes and allow the cloudy precipitate to settle below the shoulder of the bottle.
- Immediately add 8 drops **Sulfuric Acid 1:1**.
- Cap and gently invert the bottle to mix the contents until the solid precipitate and the reagent have totally dissolved. The solution will be clear yellow to orange if the sample contains dissolved oxygen. ***Note: At this point the sample has been "fixed" and may be stored for days or weeks. *** Triplicate samples may be run together until this point, adding each treatment to all 3 bottles consecutively. After this point, titrate the samples separately. This is also the point at which you record for time of sample collection for D.O. on your data sheet.***
- Titration: fill the titration tube so that the <u>meniscus</u> of the liquid is at the 20 mL line with the fixed sample. Cap the tube with its flat lid.
- Depress plunger of the Titrator.
- Insert the Titrator into the plug in the top of the **Sodium Thiosulfate, 0.025N** titrating solution.

- Invert the bottle and slowly withdraw the plunger until the shoulder of the plunger (the end in contact with the solution) is opposite the zero mark on the scale. ***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, or you can tap the side of the barrel to remove bubbles. Repeat until bubble disappears.

- Turn the bottle upright and remove the Titrator. If the sample is a very pale yellow, go to Step 19.
- Insert the tip of the Titrator into the opening of the titration tube cap.
- Slowly depress the plunger to dispense the titrating solution. After every two drops, swirl the solution to mix in the sodium thiosulfate. Titrate until the yellow-brown color changes to a very pale yellow. Hold sample against a white sheet of paper to see color changes more accurately.
- Tap the Titrator to remove any drops of solution on the end, and then carefully remove the Titrator and cap. Do not disturb the Titrator plunger.
- Add 8 drops of **Starch Indicator Solution**. Gently swirl to mix in starch to sample solution. The sample should turn blue.
- Cap the titration tube. Insert the tip of the Titrator into the opening of the titration tube cap.
- Continue titrating one drop at a time until the blue color disappears and the solution becomes colorless. Swirl after each drop is added. It usually only takes one or two drops of sodium thiosulfate to turn the blue solution to clear. ***Note: If the plunger tip reaches the bottom line on the scale (10ppm) before the endpoint color change occurs, refill the Titrator and continue the titration. Add the value of the original amount of reagent dispensed (10ppm) to the second volume when recording the test result.***
- Record the test result where the Titrator tip (where the plunger meets the solution inside the barrel) meets the scale. Have you partners check your reading so you all agree. Record as ppm Dissolved Oxygen. Each minor division on the Titrator scale equals 0.2 ppm. When testing is complete, discard titrating solution in Titrator into waste bottle.
- Between samples, rinse titration tube with a small amount of the next sample to be tested. This avoids leaving trace amounts of sodium thiosulfate in the titration tube which could skew subsequent sample readings.

6. Turbidity

Turbidity is a measure of water clarity and how much the material suspended in the water decreases the passage of light through the water. Suspended materials include soil particles (clay, silt, and sand), algae, plankton, microbes, and other substances. These materials are typically in the size range of 0.004 mm (clay) to 1.0 mm (sand). Turbidity can affect the color of the water. Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. Suspended materials can clog fish gills, reducing the resistance to disease in fish, lowering growth rates, and affecting egg and larval development. As particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macroinvertebrates.

Sources of Turbidity

- Soil erosion
- Waste discharge
- Urban runoff
- Eroding stream banks
- Large numbers of bottom feeders (such as carp), which stir up bottom sediments
- Excessive algal growth (e.g. phytoplankton)

Why Measure for Turbidity

Turbidity can be useful as an indicator of the effects of runoff from construction, agricultural practices, logging activity, discharges, and other sources. Turbidity often increases sharply during a rainfall, especially in developed watersheds, which typically have relatively high proportions of impervious surfaces. The flow of storm water runoff from impervious surfaces rapidly increases stream velocity, which increases the erosion rates of stream banks and channels. Turbidity can also rise sharply during dry weather if earth-disturbing activities are occurring in or near a creek without erosion control practices in place.

Regular monitoring of turbidity can help detect trends that might indicate increasing erosion in developing watersheds. However, turbidity is closely related to stream flow and velocity and should be correlated with these factors. Comparisons of the change in turbidity over time, therefore, should be made at the same point at the same flow.

Turbidity is not a measurement of the amount of suspended solids present or the rate of sedimentation of a stream since it measures only the amount of light that is scattered by suspended particles. Measurement of total solids is a more direct measure of the amount of material suspended and dissolved in water.

How to Measure Turbidity

A turbidity meter consists of a light source that illuminates a water sample and a photoelectric cell that measures the intensity of light scattered at a 90 degree angle by the particles in the sample. It measures turbidity in formazine turbidity units (FTU). Meters can measure turbidity over a wide range from 0 to 1000 FTUs. A clear mountain stream might have a turbidity of around 1 FTU, whereas a large river like the Mississippi might have a dry-weather turbidity of around 10 FTUs. These values can jump into hundred of FTUs during runoff events.

How to collect a "grab" sample for turbidity

- Label the bottle with the site number, date, time and your name or initials. Use waterproof pen, if possible.
- Remove the cap from the bottle just before sampling. Avoid touching the inside of the bottle or the cap. In high flows, use a sampling pole. Rinse the sampling bottle on the pole 3 times prior to decanting water into sample bottle. If you accidentally touch the inside of the bottle, use another one.
- Wading. Try to disturb as little bottom sediment as possible. In any case, be careful not to collect water that contains bottom sediment. Stand facing upstream. Collect the water sample in front of you (upstream).
- Hold the bottle near its base and plunge it (opening downward) below the water surface. Collect a water sample 6 to 12 inches beneath the surface or mid-way between the surface and the bottom if the stream reach is shallow.
- Turn the bottle underwater into the current and away from you in an upstream direction.
- Leave a small air space, so that sample can be shaken before analysis.
- Check off the test on your appropriate field data sheet. This is important because it tells the monitoring coordinator which bottle goes with which site.

Turbidity Meter Procedure

- Turn the meter on by pressing the ON/OFF key.
- The meter will carry out a self-test displaying a full set of figures. After the test, the LCD will change to the measurement mode.
- When the LCD displays "----" the meter is ready to measure.
- Fill a clean cuvette up to one quarter inch (0.5 cm) from its rim with the thoroughly agitated sample (allow sufficient time for bubbles to escape before securing the cap—**do not over tighten the cap**.
- Wipe the cuvette thoroughly with a lint-free tissue before inserting into the measurement cell. The cuvette must be completely free of fingerprints and other oil or dirt, particularly in the area where the light goes through (approximately the bottom 2 cm/1 inch of the cuvette).
- Place the cuvette into the cell and check that the notch on the cap is positioned securely into the groove.
- The mark on the cuvette cap should point towards the LCD.
- Press the READ/↑ key and the LCD will display a blinking "SIP" (Sampling in Process). The turbidity value will appear after approximately 25 seconds.
- Even though **HI 93703** covers a very wide range of turbidity values, for very accurate measurements of samples exceeding 40 FTU, Standard Methods require dilution (see manual).

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