Standard Operating Procedures for Surface Water Quality Sampling

Prepared by the

ADEQ Arizona Department of Environmental Quality

Surface Water Section
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Standard Operating Procedures for Surface Water Quality Sampling

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The Arizona Department of Environmental Quality
shall preserve, protect and enhance the environment
and public health, and shall be a leader in the develop-
ment of public policy to maintain and improve
the quality of Arizona's air, land and water resources

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PREFACE

"Standard Operating Procedures for Water Quality Sampling" is a presentation of surface water sampling procedures and related activities by the Arizona Department of Environmental Quality's Surface Water Section (SWS). ADEQ has two main groups that conduct surface water monitoring. The Monitoring Unit conducts ambient monitoring of Arizona's lakes and streams while the Watershed Protection Unit collects data to identify impairment sources in support development of Total Maximum Daily Loads.

This document is meant to be a reference document for monitoring surface water in Arizona. Its main purpose is to maintain consistency among staff over time. It will also serve as a training manual and an information source for agencies, contractors, organizations, and educators for sampling surface waters.

DOCUMENT ORGANIZATION

The SWS Standard Operating Procedures (hereafter referred to as SOPs) is organized in a sequential manner and is meant to outline all the activities before, during and after a sampling trip. It is divided into the following chapters:

Chapter 1) Pre-Trip Administrative Activities
Chapter 2) General Field Procedures
Chapter 3) Chemistry Procedures
Chapter 4) Bacteria Collection
Chapter 5) Measuring Flow
Chapter 6) Automated Sampling Equipment
Chapter 7) Stream Ecosystem Monitoring
Chapter 8) Intermittent Streams
Chapter 9) Post-Trip Procedures
Chapter 10) Data Management

The appendixes cover reference information that is important for water quality sampling.

The SOP's have been designed to allow staff to jump the particular chapter that is needed for a particular project. The following icons are used throughout the text to draw the reader's attention to important procedures.

This symbol is meant to draw the reader's attention to a particular point.

This symbol is meant to alert the reader that this is a critical point that cannot be missed.

This manual, or portions of it, will be updated whenever available technologies, procedures, or quality assurance protocols change. Any reference to specific brand names or model numbers is intended for the sake of clarification purposes and in no way represents an endorsement of such product.

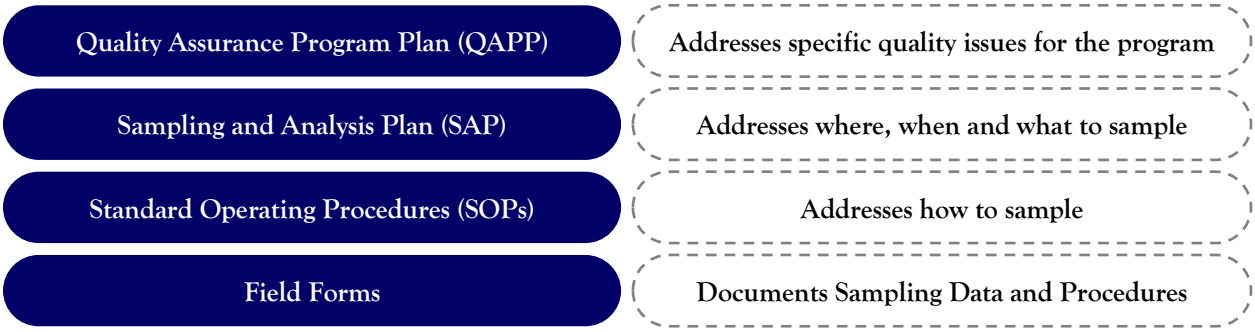
TABLE OF CONTENTS

CHAPTER 1 PRE-TRIP ACTIVITIES

Preparation is the key to a successful monitoring trip. Monitoring staff are responsible for remembering numerous items before they even leave the office. This chapter is designed to help staff prepare for trips by using checklists, calibrating equipment, and considering site safety before they leave the office.

1.1 IMPORTANT DOCUMENTS AND FORMS

This document is used in conjunction with several other documents, each of which answers basic questions related to water quality sampling as indicated below.



Staff should be familiar with each of these documents before attempting to sample.

1.2 FIELD TRIP EQUIPMENT LISTS

Check lists are very important tools to ensure that all the needed equipment is accounted for before going out into the field. Appendix A has checklists sorted by program (lakes, ambient streams, TMDL, etc.). The checklists may not be complete for all projects. Certain projects don't need all of the equipment listed for every trip.

1.3 ORDERING SUPPLIES

It is the responsibility of the lab coordinator and staff to make sure that all supplies are fully stocked in the lab. Staff should contact the lab coordinator if bottles, acid, batteries, bags or any other supplies need to be ordered.

1.4 EQUIPMENT PRE-CALIBRATION

Calibration is a vital step in ensuring that collected data is credible. ADEQ developed a calibration stamp to consistently record all relevant calibration information for multiparameter probes.

All equipment should be calibrated before and after each use in the field and recorded in the equipment log book, which is kept with the unit. This allows the sampler to determine the accuracy of the field parameters taken at the site and ensures that the instrument is ready for the next user. Each time the instrument is pre-calibrated and post -calibrated, the results must be noted in the log

book using the premade calibration stamp, which has prescribed fields to ensure users consistently calibrate equipment (FIGURE 1.1).

A 'Post-Calibration' check is done after staff return from their trip (see Section 9.3)

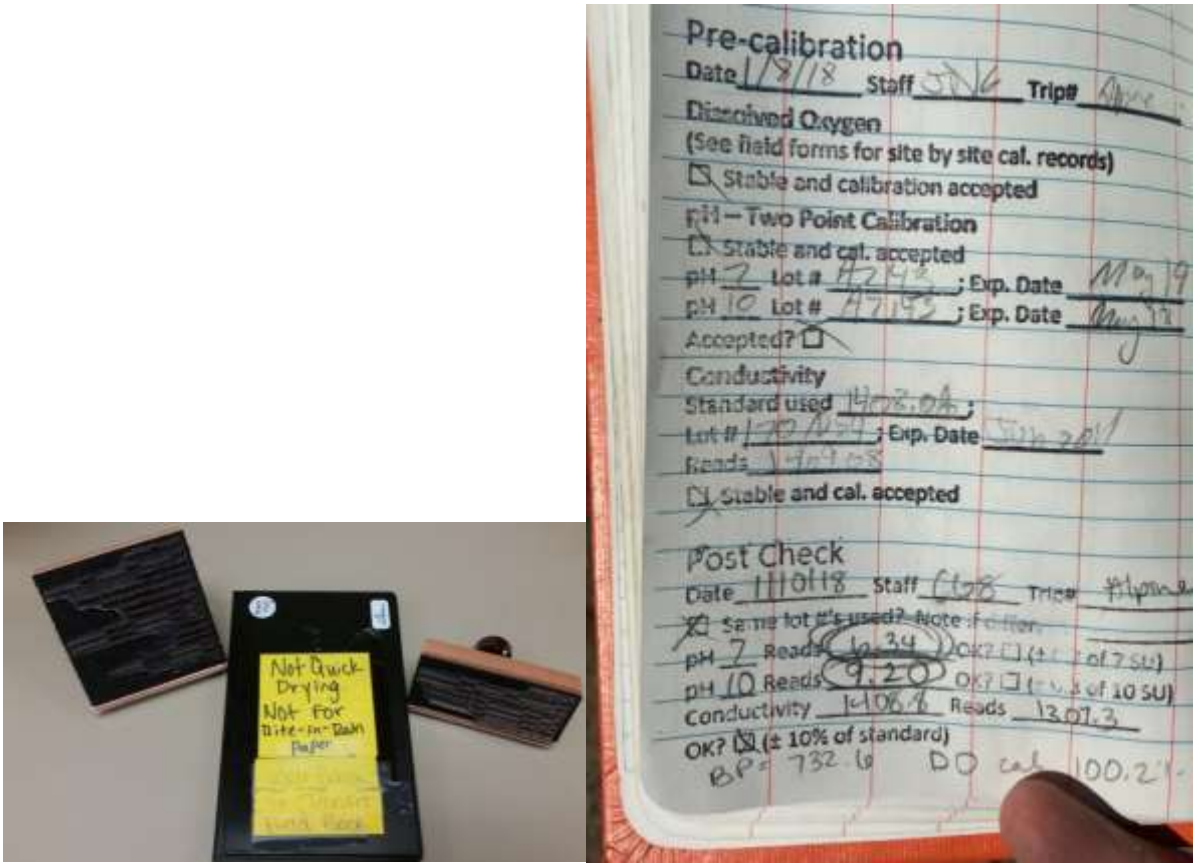


FIGURE 1.1. The calibration stamp is used to standardize multiprobe calibration data and post checks.

1.4.1 GENERAL CALIBRATION INFORMATION

ADEQ currently uses Insitu, Hydrolab and YSI multimeters. The multimeter measures field parameters such as temperature, pH, and conductivity. They consist of two main parts; the surveyor readout unit and the sonde. The surveyor is the computer while the sonde contains the various probes.

The calibration procedures listed in this document are just a subset of the multiprobe manuals. Always consult the respective equipment manual if additional information is needed.

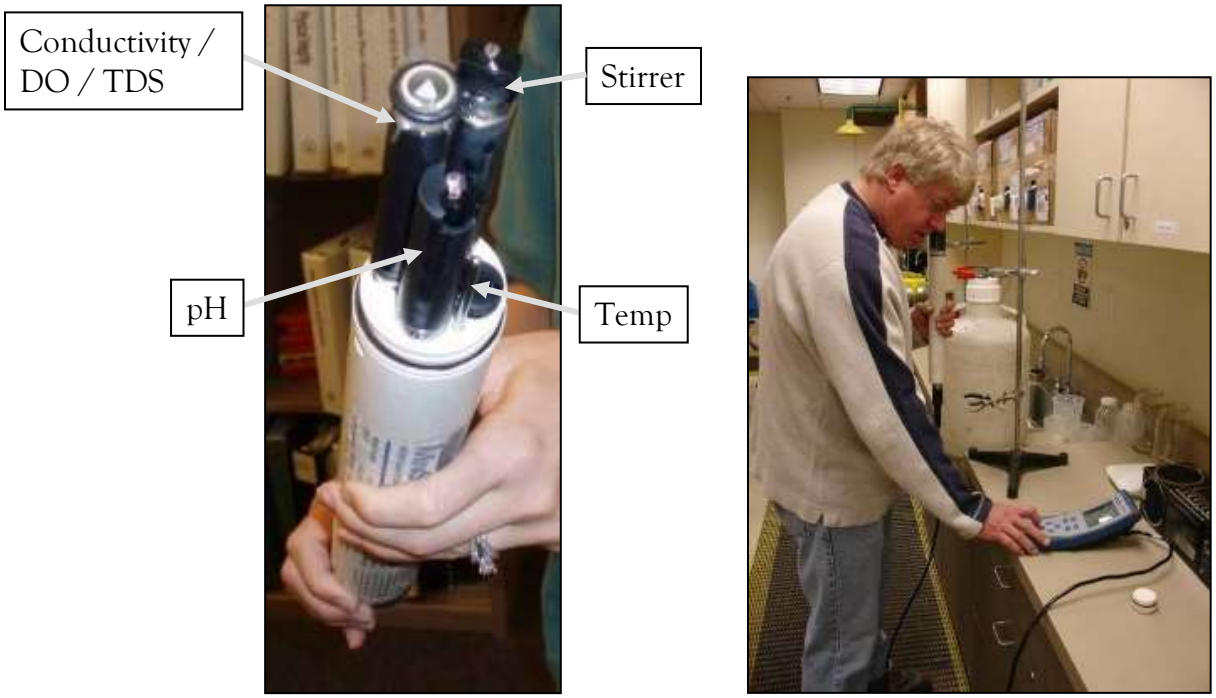


FIGURE 1.2. Multiprobe sensors and calibration.

The sonde and surveyor must be transported and stored in the hard plastic Pelican cases. Proper care of the probes is essential for accurate readings. Regular cleaning will keep the build-up from becoming an operational problem. FIGURE 1.2 shows the location of the sensors on the Hydrolab Minisonde unit and calibration of the unit.

Turn the unit off immediately after use to preserve the battery charge. Protect units from temperatures greater than 122° F (50 °C). Units will automatically shut down at this temperature. The read-out units utilize a liquid crystal display and very cold or very hot temperatures will adversely affect the display read-out; therefore, do not subject units to extreme hot and cold temperatures.

1.4.2 HYDROLAB CALIBRATION PROTOCOLS

When calibrating the units, use the function and cursor keys on the Surveyor 4 read-out units (FIGURE 1.3) to navigate through the procedure.

Try running through the calibration procedure again if the readout states "**calibration out of range**". If the problem occurs again, it may be that the probe in question needs the reference solution replaced. Use fresh reference solution (be sure it hasn't expired) and replace the probes old solution. If the probe will still not calibrate, make notes in the calibration book regarding the problem and have it shipped back to the manufacturer for repair. Do not put the faulty unit back into the cabinet.

Always check the battery reading before taking the unit into the field. The Hydrolab Surveyor 4 read-out units are equipped with a rechargeable nickel metal hydride battery (FIGURE 1.3).

FIGURE 1.3. Surveyor

The fully charged battery holds a charge of 8.5 volts and should be recharged when the level reaches 6.5 volts. Nickel metal hydride batteries can be charged to full voltage at any time, no matter how low the voltage.

1.4.2.1 Specific Electrical Conductance Calibration

There are normally three conductivity standards found in the lab area, 0.1 Molar (M), 0.01 M and 0.001 M potassium chloride (KCl) solutions. Use the 0.01 M KCl unless your site has low or high conductivity. These three standards are typically sufficient for most conditions encountered in the field. The ranges and values assigned to the standards are in most cases given in micro Siemens per centimeter (µS/cm).

When calibrating with the KCl standards, ensure that the solutions have not exceeded the expiration date.

Standard solutions can be disposed of in the lab sink, using tap water to dilute and rinse equipment.

1. Rinse the sensors three times with a half full calibration cup of deionized water to clear the probes of contaminants.
2. Use a paper towel or other non-abrasive absorbent material and dry the electrodes of the Electrical Conductivity (EC) probe. When the electrodes are dry, use the calibration menu on the readout unit to set the EC value to **zero** and push **enter** to save. This is the 1st point of the 2 point calibration. Rinse the sensors one additional time with DI water.
3. Rinse the sensors two times with a small amount of KCl standard solution. Try to use a solution that has a conductivity range somewhere near the conditions expected to be seen in the field.

4. Pour in the same KCl standard that was used when rinsing, until the conductivity electrodes are covered with the solution. Make sure there are no bubbles attached to the EC chamber; if bubbles are present, gently tap the cup to dislodge them.
5. Check the EC readings and look for stabilization of the value before continuing. EC readings are corrected to 25° C, regardless of the ambient temperature of the solution.
6. Use the calibration button on the readout unit to adjust the EC value to the conductance value of the KCl solution; press **Enter**. This saves the calibration reading.
7. If other probes need calibrating, discard the KCl solution and rinse the cup and sensors 2 times with deionized water. When the EC calibration is completed, discard the KCl solution into the sink and flush with tap water. When storing the unit, add a small amount of tap water in the cup to keep the probes moist.
8. Record calibration information in the log book.

1.4.2.2 pH Calibration

When performing a pH calibration, always check the buffer solutions being used and make sure that they are still within the expiration period specified on the container. pH calibration is performed by measuring two buffer solutions of differing and known pH values. This allows the sensitivity, or slope, to be determined. If acidic conditions are expected at the sample site, calibrate using the 4.0 buffer solution and the 7.0 buffer solution. If the sample site typically shows basic conditions of above pH 7, use the 7.0 buffer and the 10.0 buffer.

Always use the 7.0 buffer first and then either the 4.0 or the 10.0 to establish the slope. Because of the basic nature of Arizona's soils, most surface waters are usually above a pH of 7.0.

1. Rinse the cup and sensors two times with a small amount of the 7.0 pH buffer solution.
2. Fill the calibration cup with enough of the 7.0 pH buffer solution to completely cover the pH electrode.
3. Let the temperature and pH values stabilize before recording the current pH value.
4. Use the calibration menu to reset the pH value to 7.00. Save the new calibration value. Record the new value given by the unit in the log-book.
5. Repeat procedures 1 through 4 with a slope solution of either pH 4.00 or pH 10.00.
6. Record calibration information in the log book.

1.4.2.3 Dissolved Oxygen Calibration

Calibration of the dissolved oxygen (DO) probe is performed in the storage cup of the Minisonde unit. Before beginning the calibration process, check the membrane on the DO probe for wrinkles and tears. There should not be any air bubbles present under the membrane. If any of these conditions are present, the membrane should be replaced with a new one before calibration. Hydrolab recommends that the unit be allowed to sit overnight after replacing the membrane. This allows the membrane to stretch and conform itself to the probe. Although calibration can be performed using a known DO concentration, it is easier to use percent saturation DO. Saturation of oxygen in water is determined by air pressure. Most probes have builtin barometers. Use a hand held altimeter capable of reporting ambient air pressure if a probe doesn't have a built in barameter.

1. Fill the calibration cup with tap water to below the DO probe membrane (water must not cover the membrane).
2. If needed, blot the DO membrane gently with a lint-free absorbent cloth or tissue to remove any water droplets. Use a material that is non-abrasive.
3. Invert the cap and slide it over the top of the calibration cup, and let the unit sit for about 5 minutes to allow the conditions inside the cup to stabilize. Do not screw the cap back on. This will increase pressure inside the calibration cup.
4. Use the hand-held altimeter or the barometer in the unit to measure the ambient air pressure (the terms "air pressure" and "barometric pressure" are equivalent). If a barometer is not available or not functioning properly, contact a nearby airport. If the calibration site is at approximately the same elevation and is not too distant from the airport, the air pressure reading should be usable for calibration purposes.

Barometer readings from the Hydrolab or handheld barometer are usually "true" (uncorrected) values of air pressure and can be used "as is" for dissolved oxygen calibration. Weather service readings are usually not "true", i.e., they are corrected to sea level, and therefore cannot be used until they are "uncorrected". An approximate formula for this "uncorrection" (where the BP readings MUST be in mm Hg) is: True BP = [Corrected BP] – [2.5 * (Local Altitude in feet above sea level/100)]. Also note, 25.4 mm of Hg = 1 inch of Hg.

If an altimeter is not available or the altimeter on hand is not functioning properly, there is a basic rule of thumb that can be used to obtain air pressure. Standard pressure at sea level is 29.92 inches of Hg. Atmospheric pressure decreases with increasing altitude. For every increase of 1,000 feet in elevation above sea level, air pressure will decrease approximately 1.0 inch of Hg. This simple formula can be useful, but may not hold up well in cases where there is a DO exceedance that cannot be attributed to naturally occurring conditions. Be sure to qualify the DO data if this method has to be used.

5. Before calibrating the DO probe, record the pre-calibration percent saturation value after the unit has stabilized. Using the calibration menu for % saturation, enter the barometric pressure when prompted. Record the new DO percent saturation reading, which should be at or near 100%. The reading should be stable for about 20 to 30 seconds. If DO is being measured at a number of sites and at substantially different elevations, the unit should be calibrated at each site. Most stream and lake sampling will require DO calibration at each site.
6. Record calibration information in the log book.

1.4.3 YSI CALIBRATION PROCEDURES

Before Calibrating the YSI, connect the Sonde to the unit via cable and turn unit on. Highlight **sonde run** and press **enter**. FIGURE 1.4 shows the basic components of the YSI Sonde and Surveyor.

FIGURE 1.4. YSI Multiprobe for streams

1.4.3.1 Dissolved Oxygen

1. With the calibration cup on the sonde, open up the cap and place approximately 3 mm (1/8 inch) of water in the bottom of the calibration cup. Make certain that the DO and temperature probes are not immersed in the water and are dry (use chem wipe to dry). Engage only 1 or 2 threads of the calibration cup to ensure the DO probe is vented to the atmosphere. Wait approximately 10 minutes for the air in the calibration cup to become water saturated and for the temperature to equilibrate.
2. Press **escape** to return main menu. Select **sonde menu** and press **enter** to connect Sonde to unit. Select **calibrate**, then **dissolved oxy**, and **DO sat**%. *Calibration of dissolved oxygen in the DO % procedure also results in calibration of the DO mg/L mode and vice versa.*
3. Next enter the barometric pressure (mmHg) located at the right bottom of the screen and press **enter**. Allow to stabilize and press enter.
4. Return to the 650 main menu by pressing **escape** 3 times and select sonde run. Allow to stabilize.

The true values for dissolved oxygen, conductivity, and pH should be recorded from the sonde run menu and not the calibration menu.

5. Record calibration information in the log book.

1.4.3.2 Conductivity

1. With the calibration cup attached to the sonde, rinse the cup and conductivity sensor with a small amount of the standard that will be used and discard rinse. Avoid cross-

contamination of standard solutions with other solutions. Make certain that there are no salt deposits around the oxygen and pH probes, particularly if employing standards of low conductivity.

2. Fill the calibration cup with the appropriate standard solution until the conductivity probe is completely immersed in the solution. Gently rotate and/or move the sonde up and down to remove any bubbles from the conductivity cell.
3. Allow at least one minute for the temperature to equilibrate before proceeding.
4. From the calibrate menu select c**onductivity** and then **SpCond**. Enter the calibration value of the standard (mS/cm at 25°C) and press **enter**. The current values of all enabled sensors will appear on the screen.
5. Once the specific conductivity value becomes stable press **enter**. The screen will indicate that the calibration has been accepted. When prompted, press **enter** again to return to the calibrate menu.
6. Return to the 650 main menu by pressing **escape** 3 times and select **sonde run**. Allow to stabilize.
7. Record the calibration information in the equipment logbook.
8. Rinse the sonde in tap or purified water and dry the sonde.

1.4.3.3 pH

1. Rinse the pH probe and calibration cup with pH 7 buffer and discard solution.
2. Fill the calibration cup just above the pH probe with pH 7 buffer.
3. From the calibrate menu, select **ISE1 pH** to access the pH calibration choices and then press **2 Point**. Enter the value of the buffer solution (7.0) and press **Enter**.
4. The current values of all enabled sensors will appear on the screen and change with time as they stabilize in the solution. Allow the pH value to stabilize and press **enter** to calibrate.
5. After the pH 7 calibration is complete, press e**nter** again, as instructed on the screen, to continue.
6. Rinse the probe with pH 10 buffer and then fill the calibration cup above the probe with pH 10 buffer.
7. Enter the value of the second pH solution (10.0) and press **enter**. Allow to stabilize.
8. The current values of all enabled sensors will appear on the screen and change with time as they stabilize in the solution. Allow the pH value to stabilize and press **enter** to calibrate.
9. After the second calibration point is complete, press **enter** again, as instructed on the screen, to return to the Calibrate menu.
10. Return to the 650 main menu by pressing **escape** 3 times and select **sonde run**. Allow to stabilize.
11. Record the pH 10 value in the equipment logbook.
12. Rinse the pH probe and calibration cub with pH 7 solution and discard rinse. Fill the calibration cup above the probe with pH 7 buffer and let the value stabilize. Record pH 7 value in the equipment logbook.
13. Rinse the sonde and calibration cup in water and cap the cup with 1/8 inch of water for storage.

The majority of environmental water of all types has a pH between 7 and 10. If a site will have a low pH then use the pH 4 and 7 buffer solutions to calibrate.

1.4.4 MULTI-PARAMETER TROLL 9000

1.4.4.1 General Calibration Procedures

The Multi-Parameter Troll (MPT) can be used to measure pH, specific conductivity, and dissolved oxygen (DO). The following sections describe the procedures for calibrating each of these parameters. Complete records including the date, pre- and post- calibration values, calibration standard lot numbers and expiration dates, any maintenance performed (e.g. change DO membrane), and any problems encountered during calibration should be recorded in the field book associated with each probe.

Each field case should contain the MPT probe, pH, conductivity, and DO sensors, sensor maintenance kits, a calibration cup (Cal Cup), flow restrictor, stirrer, sensor insertion tool, sensor extraction tool, field book, and computer connection cable.

Maintenance kits for each of the sensors should contain the following:

1. DO Kit
    a. Extra Membranes
    b. DO Polishing Strips
    c. Silicon Grease
    d. 10% NH3 Cleaning Solution
    e. DO Electrode Filling Solution
    f. Cleaning Brush
    g. Storage Bottle
2. Conductivity
    a. Silicon Grease
3. pH
    a. Silicon Grease
    b. Storage Bottle

Maintenance work on the units is normally done on a quarterly basis; equipment that is not being regularly used should be maintained every six months. A computer with Win-Situ 4.0 software installed is required for calibration; the MPT should be calibrated prior to the start of field work, recalibrated as conditions dictate (i.e. changes in barometric pressure) and the calibration checked at the completion of field work.

1.4.4.2 Conductivity

Conductivity should be calibrated first to avoid carry-over from other standards (e.g. pH buffers are highly conductive). Prior to calibration make sure that the conductivity sensor is installed and clean. To install the sensor:

1. Remove any moisture or dirt and use the sensor removal tool to remove the plug or sensor from port 4 (FIGURE 1.5). Retain the plug for future use. The sensor can be cleaned by

rinsing it with tap water, then with deionized water, followed by a rinse with the solution to be used for calibration.

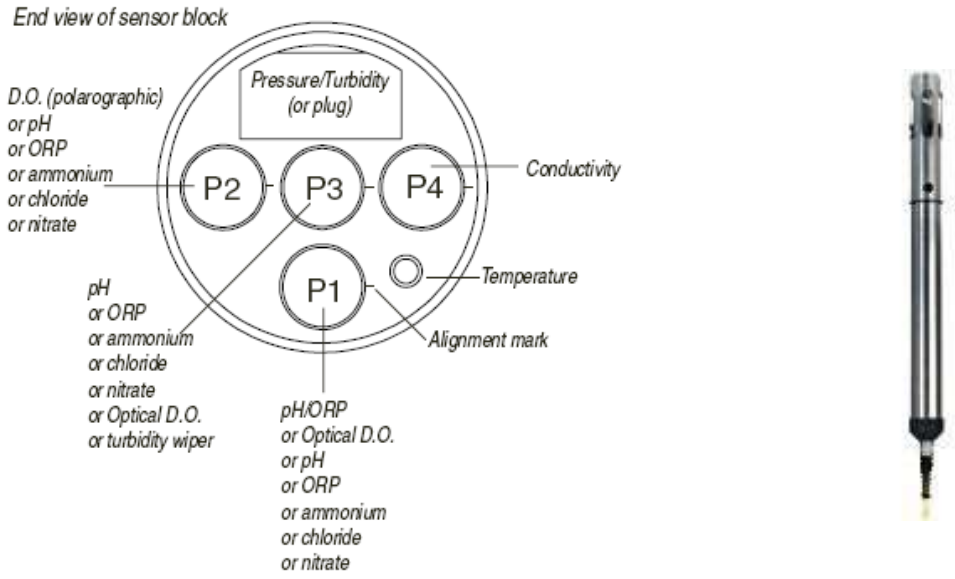


FIGURE 1.5. Sensor Port Configuration (left). Troll 9000 (right).

2. Check lubrication of the sensor o-rings.
3. Handle the sensor by the sides, not the tip and align the mark on the side of the sensor with the mark on the port.
4. Use the sensor insertion tool to press the sensor into the port until it docks with the connector at the bottom. When properly inserted a small gap (width of the sensor removal tool) remains between the widest part of the sensor and the instrument body, for ease of removal.

ADEQ purchases with 0.1 M, 0.01 M and 0.001 M potassium chloride (KCl) solutions that have been prepared, tested and assigned an acceptable range and usually a tested lab value. These standards are typically sufficient for most conditions encountered in the field. If a site has unusually high conductivity readings, it may be necessary to have the lab prepare a standard that more closely resembles the site conditions. The ranges and values assigned to the standards are in most cases given in microSiemens per centimeter (µS/cm).

As a general rule, a mid-range solution (0.01M; 1,434 µS/cm) should be used to calibrate the MPT unless site conditions dictate use of a different solution. When calibrating with the KCl standards, insure that the solutions have not exceeded the expiration date. Standard solutions can be disposed of in the lab sink, using tap water to dilute and rinse equipment. The following steps will be followed to calibrate the conductivity probe on the MPT:

1. With the conductivity sensor installed and plugs or sensors in the other sensor ports, rinse the front end of the MPT with tap water.
2. Insure the PVC base is attached to the Cal Cup, triple rinse and fill the Cal Cup to the fill line with the selected calibration solution. If all the sensors are installed use the lower fill line as a guide (about half full), otherwise fill to the upper line.

3. Insert the front end of the MPT into the open end of the Cal Cup. Thread the Cal Cup onto the body until seated against the o-ring, then back off slightly to avoid over tightening. Ensure that the conductivity probe is completely immersed in standard. The hole in the side of the probe MUST be under the surface of the solution and NOT have any trapped bubbles in the openings.
4. Connect the MPT to a PC with the computer connection cable and establish a connection in Win-Situ 4.0.
5. Select the **MPT** in the Navigation tree. The software will automatically detect and display the installed sensors. If one or more sensors are installed in the wrong port, an error message will be displayed. Simply remove the sensor and install it in the correct position, then "refresh" the device before continuing.
6. Select **conductivity** in the Parameters list. The sensor serial number (SN), type, and recent calibration information is shown. Select Calibrate. The Conductivity Calibration Wizard starts.
7. Select the calibration solution the sensor is soaking in and select **Next** to continue.
8. In the next screen, select **Run** to begin the stabilization. The display will continuously update as readings are taken and compared against the stabilization criteria. Status indicators:
   a. NOT TESTED is displayed until the calibration is selected by pressing **Run**.
   b. UNSTABLE indicates the sensor response does not meet the criteria for a valid calibration point.
   c. NOMINAL indicates the sensor deviation meets early stabilization criteria.

   The Accept button becomes available when nominal stability is achieved, wait until STABLE appears before selecting the Accept button. Calibration proceeds automatically to the next screen. Temperature at the time of calibration is displayed for your information.

Most sensors stabilize within 1-3 minutes if the sensor is properly hydrated before calibration. To minimize stabilization times, do not handle the instrument during the time the sensor is taking readings in the calibration solution.

9. The final screen shows the new cell constant (Kcell) calculated for the selected range during the calibration process. The cell constant should range between 0.34 – 0.4.
10. Select **Finish** in order to program the sensor with the displayed cell constant. The conductivity sensor is now calibrated and ready to use in the range for which it was calibrated.

1.4.4.3 pH

Prior to calibration make sure that the pH sensor is installed and clean. To install the sensor:

1. Remove any moisture or dirt and use the sensor removal tool to remove the plug or sensor from port 1 (FIGURE 1.5). Retain the plug for future use. The sensor can be cleaned by rinsing it with tap water, then with deionized water, followed by a rinse with the solution to be used for calibration.
2. Check lubrication of the sensor o-rings.
3. Handle the sensor by the sides not the tip and align the mark on the side of the sensor with the mark on the port.

4. Use the sensor insertion tool to press the sensor into the port until it docks with the connector at the bottom. When properly inserted a small gap (width of the sensor removal tool) remains between the widest part of the sensor and the instrument body, for ease of removal.

The following steps will be followed to calibrate the pH probe on the MPT:

1. With the pH sensor installed and plugs or sensors in the other sensor ports, rinse the front end of the MPT.
2. Insure the black PVC base is attached to the Cal Cup. Triple rinse the Cal Cup and fill to the fill line with the selected calibration solution. Begin with the lowest buffer value when performing a multi-point calibration. If all the sensors are installed use the lower fill line as a guide (about half full), otherwise fill to the upper line.
3. Insert the front end of the MPT into the open end of the Cal Cup. Thread the Cal Cup onto the body until seated against the o-ring, then back off slightly to avoid over-tightening.
4. Connect the MPT to a PC and establish a connection in Win-Situ 4.0.
5. Select the **MPT** in the Navigation tree. The software will automatically detect and display the installed sensors. If one or more sensors are installed in the wrong port, an error message will be displayed. Simply remove the sensor and install it in the correct position, then "refresh" the device before continuing.
6. Click to select **pH** in the Parameters list. The sensor serial number (SN) and recent calibration information is displayed. Select **Calibrate**.
7. Select the number of calibration points for this calibration and the pH value of the calibration solution for each point. Cal point 1 is the solution the sensor is soaking in now. Select **Next** to continue.
8. In the next screen, select **Run** to begin the stabilization. The display will continuously update as readings are taken and compared against the stabilization criteria. Status indicators:
    a. NOT TESTED is displayed until the calibration is selected by pressing **Run**.
    b. UNSTABLE indicates the sensor response does not meet the criteria for a valid calibration point.
    c. NOMINAL indicates the sensor deviation meets early stabilization criteria.
    The Accept button becomes available when nominal stability is achieved; don't press the Accept button until a STABLE indicator is displayed.
9. If doing a one-point calibration, go to step 12.
10. For a multi-point calibration, remove the Cal Cup, discard the first solution, triple rinse and refill the Cal Cup with the second solution.
11. Select **Run** to begin the stabilization for the second calibration point. Status indicators and controls are the same as for the first calibration point (Step 8).
12. The final screen shows the sensor slope and offset calculated during the calibration process. For a three point calibration, two sets of calculated coefficients will be shown. The slope should range between -50 mV/ph and -62 mV/ph. A value outside this range may indicate a bad sensor and a replacement should be obtained.
13. Select **Finish** in order to program the sensor with the newly calculated calibration coefficients. The pH sensor is now calibrated and ready to use.

1.4.4.4 Dissolved Oxygen

The D.O. sensor performs best in clean water. In environments with high organic content, the membrane can become fouled. Rips, tears, and other damage will also affect membrane performance. For best results, replace the membrane when the slope and offset calculated during calibration change dramatically, and also after a long-term deployment. Whenever the membrane is changed, the sensor must be filled and conditioned for 24 hours prior to calibration. Because the amount of oxygen that can be dissolved in water changes with changing barometric pressure, DO should be recalibrated whenever there is a change in elevation or weather induced pressure fluctuations.

The procedure for filling and changing the membrane is as follows:

1. Remove the soft protective caps from the membrane end and the connector end of the sensor.
2. Remove the membrane module from the sensor body and fill with electrolyte as follows:
   a. Holding the membrane module open-end up, position the electrolyte dispenser against the side of the module without touching the membrane and fill slowly.

To eliminate air bubbles, tap the side of the module briskly with your fingernail or small tool.

3. Insert the sensor into the open end of the membrane module. To minimize air, some of the electrolyte should overflow from the open end as the sensor is inserted.
4. Thread the membrane module to the D.O. sensor.

Install and condition the probe as follows:

1. Remove any moisture or dirt and use the sensor removal tool to remove the plug or sensor from port 2 (FIGURE 1.5). Retain the plug for future use.
2. Check lubrication of the sensor o-rings.
3. Handle the sensor by the sides, not the tip and align the mark on the side of the sensor with the mark on the port.
4. Use the sensor insertion tool to press the sensor into the port until it docks with the connector at the bottom. When properly inserted a small gap (width of the sensor removal tool) remains between the widest part of the sensor and the instrument body, for ease of removal.
5. Put a small amount of clean water in the clean Cal Cup and attach it loosely to the instrument. Do not seal the Cal Cup; it should be at ambient pressure. The sensor membrane can be submerged or above the water level.
6. Connect the MPT to a PC and establish a connection in Win-Situ 4.0.
7. Select the **MP TROLL 9000** in the Navigation tree. All installed sensors will be displayed. Powering of the D.O. sensor begins as soon as the software recognizes the D.O. sensor and displays it in the Navigation tree. This starts the conditioning process.

It is not necessary to maintain the computer connection; conditioning continues as long as the sensor is installed. Be sure the membrane does not leak. There should no be any

drops on the surface or visible air bubbles under the membrane. Condition the sensor for 24 hours before calibrating.

The following steps will be followed to calibrate the DO probe on the MPT:

1. With the D.O. sensor installed, conditioned and plugs or sensors in the other sensor ports, rinse the front end of the MPT thoroughly in clean water to remove contaminants and traces of fluids used for earlier calibrations.
2. Dry the D.O. sensor membrane by shaking the probe and/or gently wiping with a soft swab or the corner of a tissue. Be careful not to damage the membrane.
3. Triple rinse the Cal Cup with tap water and attach it to the MPT. Thread the Cal Cup onto the body until seated against the o-ring, then back off slightly to avoid over tightening.
4. Invert the Troll with Cal Cup attached and remove the black end cap.
5. Gently fill the Cal Cup with clean water until the temperature sensor is completely covered and the membrane at the tip of the D.O. sensor is in air. If any water splashes onto the membrane, gently dry it again.
6. Loosely attach the end cap to the Cal Cup. For proper venting, a small hole in the threads of the cap should be at least partly visible. A clamp or other support may be used to maintain the TROLL 9000 in this inverted position.
7. Connect the MPT to a PC and establish a connection in Win-Situ 4.0.
8. Select **MP TROLL 9000** in the Navigation tree. The software will automatically detect and display the installed sensors.
9. Select **Dissolved Oxygen** in the Parameters list. The sensor serial number (SN) and recent calibration information is displayed.
10. Select **Calibrate**. The D.O. Calibration Wizard starts.
11. Select the number of calibration points; in general a one-point calibration in air will yield satisfactory results. Refer to the MPT operator's manual for a two-point calibration in water.
12. Select the membrane type (the thickness is stamped on membrane module; if not marked, it's a **1-mil Teflon**). Be sure the correct membrane type is selected.
13. Select **air** for first calibration point.
14. Select the default stimulus at saturation. This value is calculated by the software at the current temperature and barometric pressure. Click **Next** to continue
15. Select **Run** to begin stabilization for the first calibration point. The display will continuously update as readings are taken and compared against the stabilization criteria.

Status indicators:
NOT TESTED is displayed until the calibration is selected by pressing Run.
UNSTABLE indicates the sensor response does not meet the criteria for a valid calibration point.
NOMINAL indicates the sensor deviation meets early stabilization criteria.

The Accept button becomes available when nominal stability is achieved; don't press the Accept button until a STABLE indicator is displayed. The calibration proceeds automatically to the next screen. The calculated sensor slope and offset are shown.

A properly functioning sensor with a 1-mil membrane will have a slope in a range of 30-67 nA/(mg/l). Anything outside this range suggests a problem with either the membrane or the sensor. Install a new membrane; if problems persist, a new sensor may be needed. Additionally, the default offset should read 2nA.

16. Select Finish in order to program the sensor with the new calibration coefficients.

1.4.4.5 Storage

If the instrument will be deployed in a day or so, leave all the sensors installed in the MPT. The sensors can be stored for up to two weeks in the instrument with a moist sponge in the bottom of the Cal Cup to provide a moist environment. For long-term storage, the water quality sensors should be returned to their original packaging and the lubricated o-rings should be protected from dust and dirt. The conductivity sensor should be removed, rinsed and stored dry. The pH cannot be stored dry, in order to preserve the sensor's reference solution, store the sensor in the electrode storage bottle in a strong potassium chloride (KCl) solution. Ensure the bulb is immersed to keep it hydrated. The DO sensor should be rinsed with deionized water, capped, and stored dry.

1.4.5 INSITU CALIBRATION

The pH sensor should be stored in pH storage solution or pH 4 when not in use. This should be done anytime the instrument is not deployed for more than 5 days.

DO NOT remove RDO cap unless replacing!

1.4.5.1 Preparation for Use:

1. Take the orange pH port plug out of the sonde unit.
2. Locate the pH probe in the sensor storage bottle and remove.
3. Insert probe into unit.
4. Store sensor storage bottle in safe location.
5. Put batteries in blue tooth unit.

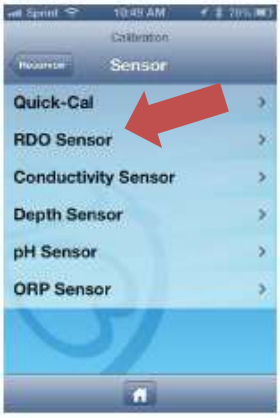
1.4.5.2 Calibration

Tap the Calibration icon  in the inSitu App to access a list of sensors that are available for calibration.

1.4.5.2.1 Dissolved Oxygen

Use the vented cup for calibration

1. Tap the Calibration icon.
2. Tap RDO Sensor.



3. Select 100% Saturation.
4. Place a water-saturated sponge in the bottom of the calibration cup. Place the instrument into the calibration cup, and tap Start.

5. When the calibration is stable, tap the Accept button.
6. To view the calibration report, tap View Report.
7. Rinse the sensors thoroughly with DI water.
8. Record calibration info in log book.

1.4.5.2.2 Conductivity Sensor

1. Tap the Calibration icon to access a list of sensors that are available for calibration.
2. Tap Conductivity Sensor.
3. Tap 1-Point Calibration.

4. Make sure the vented cap is installed on the calibration cup. Fill the cup to the fill line with calibration standard. Place the instrument into the calibration cup, and tap Start.
5. inSitu automatically detects the calibration standard. If not, tap the white box and type in true value of standard.

If your calibration standard references 20° C, tap the Thermometer icon and change the reference temperature.

6. Once the calibration is stable, tap the Accept button.
7. To view the calibration report, tap View Report.
8. Rinse the sensors with DI water.
9. Record calibration info in log book.

1.4.5.2.3 pH Sensor

1. Tap the Calibration icon to access a list of sensors that are available for calibration.
2. Tap pH Sensor.
3. Tap 2-Point Calibration.
4. Make sure the vented cap is installed on the calibration cup. Fill the cup to the fill line with the first calibration buffer. Place the instrument into the calibration cup, and tap Start.
5. When the calibration is stable, tap the Accept button.
6. Fill the cup to the fill line with the second calibration buffer. Place the instrument into the calibration cup, and tap Start.
7. When the calibration is stable, tap the Accept button.
8. To view the calibration report, tap View Report. Document the stabilization of the pH 7 and check Live Reading screen for pH 10 and record value.
9. Record calibration info in log book.

1.4.5.3 How To Store:

1. Take pH probe out of unit and insert orange pH port plug into unit.
2. Take pH probe and put on o-ring and cap. Store probe in sensor storage bottle with appropriate solution (see Section 9.4.1.3 Insitu Maintenance).
3. Take batteries out of blue tooth.

1.4.5.4 In-Situ iPod Maintence & Solutions:

All insitu iPods should be checked for software updates and battery health during quarterly maintenance. Necessary materials are:

- Login information
  - For Monitoring Unit
    - Username: monitoringunit1@icloud.com Password: Monitoringunit1
- iPod USB charging cord and USB outlet

- Active WiFi connection
- In-Situ iOS Application & Battery PRO for Battery Life iOS Application installed on device

1. Turn on the iPod by holding the power button until the Apple Logo appears
2. Select and run the application "Battery Pro for Battery Life"
3. Select the menu at the top left of the application, then navigate to "Battery Details"
4. Record Battery Health (displayed in units mAh) in calibration book
    a. If battery health is in the **"red zone" or below 50% total capacity** See 1.4.5.4.2
        i. Use Total Capacity, not Current Capacity. Total is the overall health, Current is only the battery life remaining at that moment.
        ii. If unsure of Battery status, a manually battery test can be run (Section 1.4.5.4.1)
    b. Return to iPod home screen
5. Plug the iPod into the wall using the charging cord and ensure that the iPod is receiving a charge (Battery icon top right corner is green, or has a lightning bolt icon)
6. Navigate to the settings application (Gear icon) and select General from the menu, then About
    a. Directory tree: Settings>General>About
    b. Record the "Version Details"
7. Navigate back to General in the Settings Menu and select "Software Update"
    a. If update available, tap the begin update option. Allow 30-90 minutes for update
    b. If update unavailable close all applications and shutdown iPod until next Quarter!

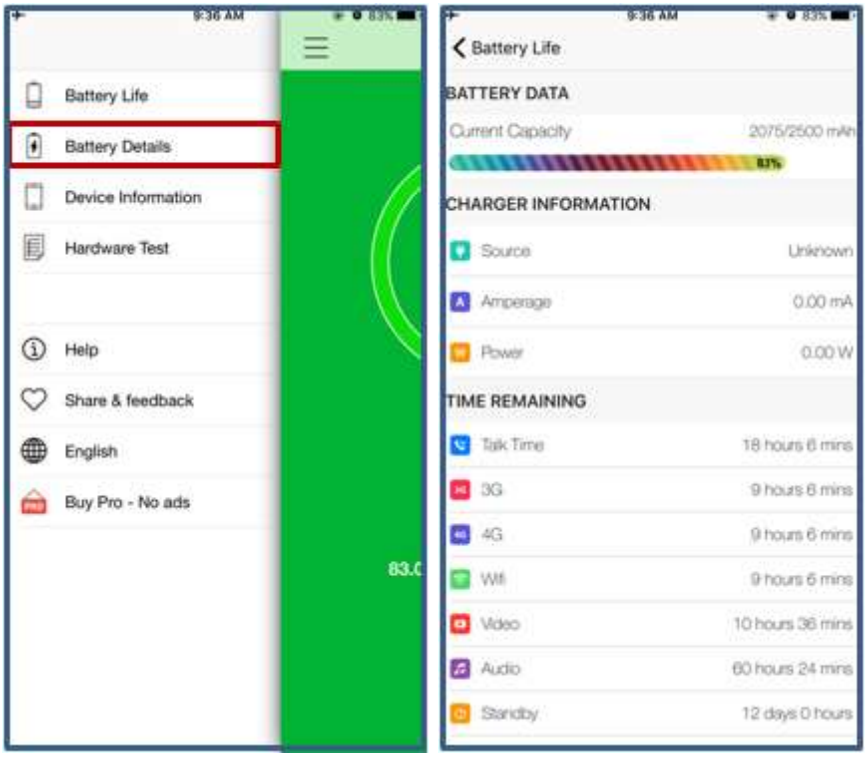


FIGURE 1.6. Battery PRO for Battery Life app.

1.4.5.4.1 Manual Battery Test

This is a test to determine if the Battery Health application is accurate. Recommended to be done to each iPod once per FY.

1. Power on iPod
2. Charge to FULL battery
    a. Avoid "over charging". Once it hits 100% unplug it and record the time
3. Run both the battery health application as well as the insitu application
    a. This is to simulate "field use"
4. Lock the phone (while still on), place at your desk, pocket, etc. You want to keep it with you.
5. Periodically check the current battery capacity, recording the time and battery %
    a. Every few hours is acceptable time frame to check. We are just looking for the battery to behave abnormally.
6. If iPod dies prematurely (<5 hours) there is probably a serious problem assuming no software updates available → **Escalate if dies prematurely**. See 1.4.5.4.2
    a. If iPod stays on 12-24 hours straight without serious battery loss, recharge it, turn it off, and it's ready for use!

1.4.5.4.2 Incase of iPod Health Problems

This section is only applicable if the insitu iPods are having battery health problems. Battery health problems can include, but are not limited to:

- Battery PRO for Battery Life indicates poor battery capacity – This can mean it is in the "red zone" or displays <50% total capacity remaining
- Premature shutdown, iPod is not retaining its battery longer than 5 hours (or less)
- iPod is overheating rapidly during use
- iPod will not charge when plugged into its USB charger (or immediately charges completely but depletes when unplugged)

Potential solutions to escalate are as followed and will vary as time passes and newer models of iPod are developed, as well as software. (These solutions are in order of potential price, low to high).

- [Temporary Solution] Selecting Low Power Mode can provide temporary relief from battery health problems. This can be achieved by going to Settings > Battery > Low Power Mode > and turning it on. This **will** change the performance of the iPods, expectantly slower, and prone to crashing with multiple application use.
- Battery replacement is a potential option, but will be expensive. Prices range from $20 (off brand battery) to $80 for Apple provided support. This does not include installation of the battery.
- Replacement of devices. As of 3/31/2017 In-Situ Inc is still supporting Apple devices, but is moving away from Apple and focusing on Android products. The iSitu application is available on both platforms and can be installed freely and on as many devices as desired. This is the most expensive option, as it is replacing an entire fleet of devices. (Range of price $199-499 per device. Total max price $1500 for three devices.)

1.5 CLEANING EQUIPMENT

1.5.1 CHURN SPLITTER, DH 81 AND SAMPLE BOTTLE CLEANING

Prior to field use, the churn splitter must be cleaned as follows.

1. Wash outside and inside surfaces of the equipment (Chrun, DH81 & sample bottle) thoroughly with tap water and a non-phosphate (e.g., Liquinox) detergent using a non-metallic stiff long-handled brush and let soak for thirty minutes. Before emptying container, run about 100 milliliters of the soap solution through the spigot.
2. Rinse all surfaces thoroughly with tap water.
3. Rinse inside surfaces thoroughly with 500 milliliters of 5% hydrochloric acid (HCl). Run some of the HCl solution through the spigot; however, if the churn splitter contains a metal spring in the spigot, do not open the spigot. For field cleaning, discard acid in a bucket with enough limestone or suitable material to neutralize the acid until it can be disposed of properly at the laboratory. For laboratory cleaning, discard used acid in a waste container labeled "HCl waste" or flush down sink with a copious amount of running water.

FIGURE 1.6. DH-81nozzle and bottle.

4. Rinse all surfaces thoroughly (at least twice) with de-ionized water.
5. After the second rinse, pour approximately 2 liters of de-ionized water into the churn. Swirl the water in the churn; then check the pH with test strip paper. If less than 5.5 SU, discard rinse water and rinse again with de-ionized water.
6. Set cleaned equipment on a suitable drying rack in a contaminant free environment.
7. Double wrap the churn with clean heavy-duty trash bags to protect from contaminants during storage and transportation. Place cleaned DH-81 parts in heavy duty sandwich bags to protect from contaminants.

1.6 FILTRATION AND TUBING

Silicon tubing is needed if dissolved metals are to be collected. The silicon-based tube should be cut to length in the lab before going into the field. While cutting the tubing, wear a pair of clean lab gloves and make the cut with a ceramic knife on a clean surface to prevent contamination of the tubing. After cutting the pieces to length (one tubing per site, plus any extra needed for quality control samples), place them in a clean, sealable plastic bag for transport to the monitoring sites.

Do not allow tube ends to come in contact with any surfaces either in the lab or in the field.

1.7 SITE RECONNAISSANCE

Site reconnaissance a vital part of preparing for a sampling run. The reconnaissance may be as simple as looking up the information on the database to see how to get there and determining who owns the property or it may require a special visit to determine if the site is accessible.

At a minimum the following questions should be considered before heading to a site.

- Who owns the land?
- If it is a private owner, did they grant access just for one trip or for multiple trips? Do they want to be notified before you come?
- Are the directions adequate? Do you need to rewrite them?
- Will the sampling crew need a DH81 or churn splitter?
- Is the site perennial, intermittent or ephemeral?

1.8 SAMPLING PREPARATION FOR STREAM ECOSYSTEM MONITORING

Chapter 7 covers how to conduct Stream Ecosystem Monitoring (SEM). SEM requires looking up the following information before going into the field (See Section 7.4.3).

- Flow regime
- Flow regime category
- The fields listed under the stream type identification (Watershed Area, Valley Type)
- Sinuosity and Slope
- Elevation (for riparian association)

This information will enable the samplers to determine the stream type in the field and verify that the measured bankfull width corrilates with the bankfull widths predicted by the regional curves.

CHAPTER 2 GENERAL FIELD PROCEDURES

This chapter covers general sampling information including field forms, decontamination procedures in the field and site safety.

2.1 FIELD DATA SHEETS

There are several different versions of field data sheets for the Monitoring or Watershed Protection Unit based on the particular waterbody or study of interest. The Monitoring Unit typically uses the form listed in FIGURE 2.1. The Lake Program's field data sheets also must take into account depth and other lake specific parameters such as water clarity. TMDL's field datasheets are site specific.

ADEQ Arizona Department of Environmental Quality

AMBIENT STREAM MONITORING
FY18 FIELD FORM

1.1 CHEMISTRY SITE INFORMATION					
Trip #	_ _ _ _ _ _ - _ _ _ _ _	Sample #	_ _ _ _ _ _ _		
Site Code	_ _ _ _ _ _ _ _ . _ _	Date	_ _ / _ _ / _ _ _ _	Sample Time	
Site Name				Field Crew	

1.2 FIELD DATA					
E. coli		CFU	TDS (if <35mg/l then low level Ca,Mg, hardness)		mg/L
Air Temp.		°C	Sp Cond.		µS/cm
Water Temp.		°C	pH		SU
D.O.		mg/L	Turbidity		NTU
D.O. %		%	Site Photos	☐ Collected	

1.3 FIELD CALIBRATIONS			
% D.O.	Barometric Pressure in mm Hg = _____ ☐ Nominal stability Post-cal. Reading = %_____ ☐ Stable Multiprobe name_____		
Turbidity	Standard =	Standard solution reading =	% Diff =

% Diff = ((Standard Value – Measured Value)/Standard Value) * 100 Typically < 0.5 NTU for lowest standard
Acceptable difference is 0-10%. Rerun if between 5-10%. Do not enter turbidity into WQDB if % difference is greater than 10%.

1.4 SAMPLE COLLECTION INFORMATION		
☐ Grab ☐ Equal Width Increment (EWI) ☐ Modified EWI		☐ Equal Discharge Increment
Circle where grab sample taken	LEW----- ¾ ----- ½ ----- ¼ -----REW	Run ☐, Riffle, ☐, Pool ☐

1.5 QUALITY CONTROL SAMPLE INFORMATION		
Type of QC Sample (ie blank, dup,	Your Identifying Code	Lab Tracking Number

1.6 QC POST-CHECK FOR PH & DO
☐ Post check completed; data accurate
☐ Post check completed; QC failed for _____ parameter(s). Flag data with event codes:
Equipment problems assoc with visit & QA-R Rejected data due to QAQC problems in AZWQDB

Form Checked by _____ Page 1 of 5

1.7 SITE OBSERVATIONS (CHECK ALL THAT APPLY UNLESS INDICATED OTHERWISE)	
General appearance in the channel	No refuse visible ☐; Small refuse visible ☐; Small volume refuse common ☐; Large volume refuse (tires, carts) rare ☐; Large volume refuse common ☐.
General appearance along the banks	No refuse visible ☐; Small refuse visible ☐; Small volume refuse common ☐; Large volume refuse (tires, carts) rare ☐; Large volume refuse common ☐.
Water Clarity	Clear ☐; Milky ☐; Light brown ☐; Dark brown ☐; Oily sheen ☐; Greenish ☐; Other_____
Water odor	None ☐; Sewage ☐; Chlorine ☐; Fishy ☐; Rotten eggs ☐; Other_____
Appearance at water's edge (check one)	No evidence of salt crusts ☐; White crusty deposits rare ☐; Numerous white crusty deposits ☐; Banks covered with white crusty deposits ☐.
Fish presence (check one)	Absent ☐; Rare ☐; Common ☐.
Crayfish presence	Absent ☐; Rare ☐; Common ☐.
Sunfish presence	Absent ☐; Rare ☐; Common ☐.
Bull frog presence	Not Observed ☐; Observed ☐
Leopard frog presence	Not Observed ☐; Number observed alive _____; Dead_____
Floating leaves or other organic matter (not algae) (check all that apply)	Absent ☐; Rare ☐; Common ☐.
Leaves or other organic matter on streambed	Absent ☐; Rare ☐; Common ☐.
% Algae cover in the wetted width of the stream 10 meters above and below sample point	%
% Macrophytes cover in the wetted width of the stream 10 m above and below sample point	%

1.8 E. COLI					
Collection Time		Incubation Time		Enumeration Time	
Reagent Used?	☐Coliliert 18 (incubation time = 18 to 22 hours) ☐Colilert (incubation time = 24 to 28 hours)				
Flag (Incubation/Holding Time Exceeded?)					
Holding time is 6 hours from collection. Incubation Period is 18 hours for Colilert technique					

COLILERT RESULTS

Regular/ Duplicate/ Blank	Number Large Wells Positive	Number Small Wells Positive	Most Probable Number (from Table)

Form Checked by ☐

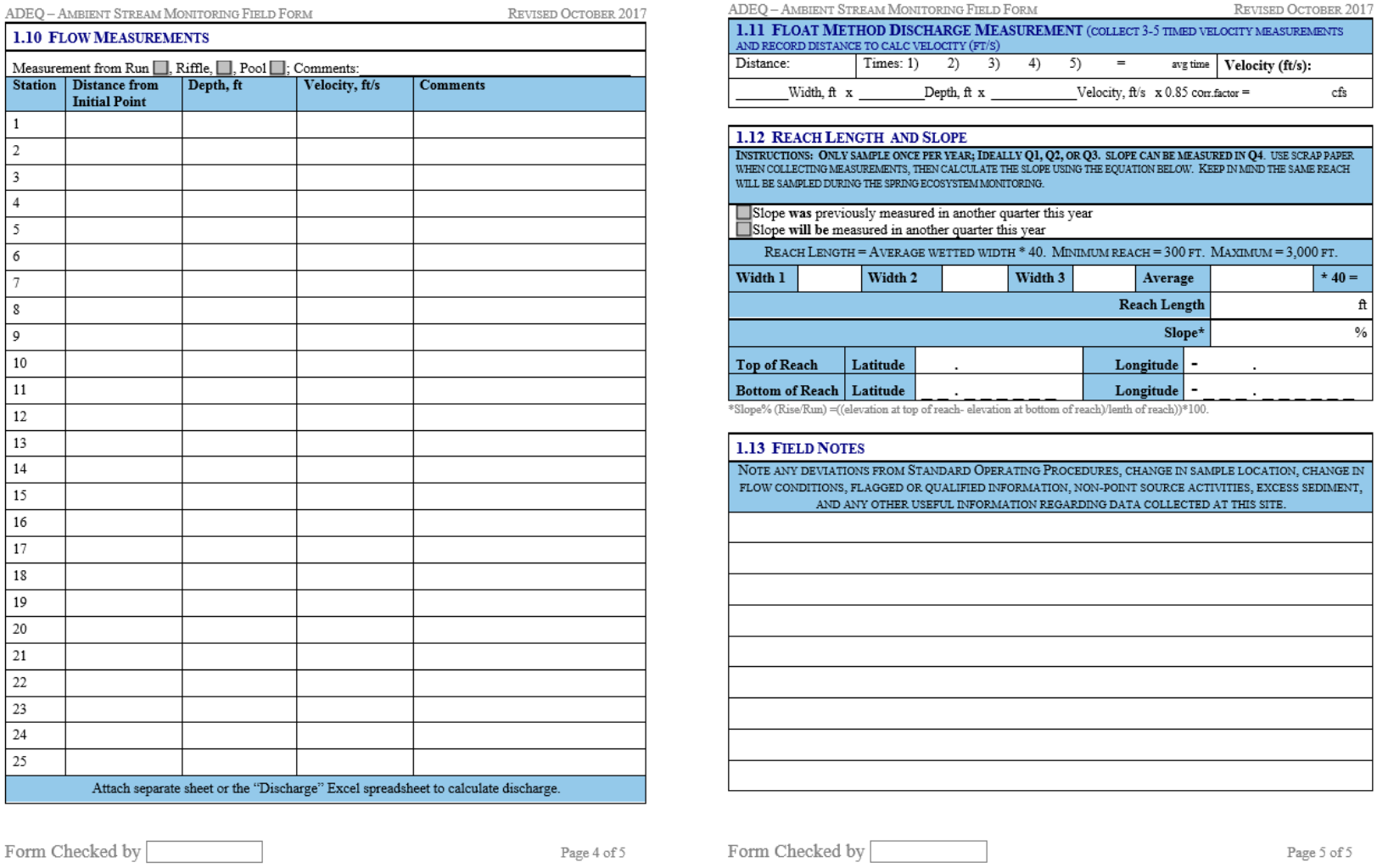
1.9 EVENTS

THIS TABLE INCLUDES FIELD RELATED EVENT CODES YOU WILL ENTER INTO THE WQDB. CHECK THE BOX NEXT TO ALL APPLICABLE EVENTS. USE THE EVENT FLAGS (F1, F2, ETC.) IF YOU WANT TO INCLUDE A COMMENT FOR A PARTICULAR ITEM THAT YOU CIRCLED. INCLUDE FLAG COMMENTS IN SPACE PROVIDED BELOW. IT IS VERY IMPORTANT THAT RECENT OR CURRENT FLOODING BE FLAGGED.

*** = FILL OUT EVERY TIME. YOU MUST FLAG AND EXPLAIN IF THESE ARE NOT CHECKED.**

Check	Description	Flag
☐	*** Baseflow Conditions**	
☐	*** General – Precipitation at sample time. None ☐; Light ☐; Moderate ☐; Heavy ☐; Cloud Cover (%) =**	
☐	*** Weather – Significant rain during past 48 hours may affect results**	
☐	Flow – Low D.O. / high pH attributed to ponding or evaporation of stream	
☐	Flow – Stream dry at time of visit	
☐	Flow – Evidence of recent flooding. Fresh debris line in channel ☐, Grasses Laid Over ☐; Fresh debris line in bushes/trees ☐; Recent flood event greater than baseflow but less than bankfull ☐; Riparian vegetation scoured away ☐; •Flood Width_____ meters.	
☐	Flow – Flood event in progress at time of visit	
☐	Groundwater – DO value attributed to groundwater upwelling	
☐	Flow – Measurement from USGS gauge/records or 3rd party	
☐	Flow – Low flow conditions	
☐	Flow – No active flow, pools or ponded water only	
☐	Flow – Flood > Bankfull occurred recently or in the past season	
☐	Fire (recent) in the watershed is affecting the study reach	
☐	Spring(s) influencing samples	
☐	Weather conditions may affect samples	
☐	Algal bloom	
☐	Fish kill observed	
☐	Fish kill attributed to low DO, high pH or algal toxicity	
☐	Indication of algal toxicity	
☐	Macrophytes – Abundant macrophytes	
☐	Waterfowl – Abundant waterfowl	
☐	SOP – Deviation(s) from standard operating procedures (indicate in 'Field Notes')	
☐	Equipment problems associated with visit (data associated with the equipment not entered)	
☐	Incomplete sampling event – Missing parameter(s) or reports	
☐	Limited sampling event – Selected parameters only	
☐	QC Equipment blank associated with visit	
☐	QA/QC or duplicate sample collected at time of visit	
Flag 1		
Flag 2		
Flag 3		

Form Checked by ☐



ADEQ – AMBIENT STREAM MONITORING FIELD FORM REVISED OCTOBER 2017

1.10 FLOW MEASUREMENTS

Measurement from Run ☐, Riffle, ☐, Pool ☐; Comments:

Station	Distance from Initial Point	Depth, ft	Velocity, ft/s	Comments
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				

Attach separate sheet or the "Discharge" Excel spreadsheet to calculate discharge.

Form Checked by _____ Page 4 of 5

ADEQ – AMBIENT STREAM MONITORING FIELD FORM REVISED OCTOBER 2017

1.11 FLOAT METHOD DISCHARGE MEASUREMENT (COLLECT 3-5 TIMED VELOCITY MEASUREMENTS AND RECORD DISTANCE TO CALC VELOCITY (FT/S)

Distance: | Times: 1) 2) 3) 4) 5) = avg time | **Velocity (ft/s):**

_____Width, ft x _____Depth, ft x _____Velocity, ft/s x 0.85 corr.factor = cfs

1.12 REACH LENGTH AND SLOPE

INSTRUCTIONS: ONLY SAMPLE ONCE PER YEAR; IDEALLY Q1, Q2, OR Q3. SLOPE CAN BE MEASURED IN Q4. USE SCRAP PAPER WHEN COLLECTING MEASUREMENTS, THEN CALCULATE THE SLOPE USING THE EQUATION BELOW. KEEP IN MIND THE SAME REACH WILL BE SAMPLED DURING THE SPRING ECOSYSTEM MONITORING.

☐ Slope **was** previously measured in another quarter this year
☐ Slope **will be** measured in another quarter this year

REACH LENGTH = AVERAGE WETTED WIDTH * 40. MINIMUM REACH = 300 FT. MAXIMUM = 3,000 FT.

Width 1		Width 2		Width 3		Average		* 40 =
						Reach Length		ft
						Slope*		%
Top of Reach	Latitude	.		Longitude	-	.		
Bottom of Reach	Latitude	.		Longitude	-	.		

*Slope% (Rise/Run) =((elevation at top of reach- elevation at bottom of reach)/lenth of reach))*100.

1.13 FIELD NOTES

NOTE ANY DEVIATIONS FROM STANDARD OPERATING PROCEDURES, CHANGE IN SAMPLE LOCATION, CHANGE IN FLOW CONDITIONS, FLAGGED OR QUALIFIED INFORMATION, NON-POINT SOURCE ACTIVITIES, EXCESS SEDIMENT, AND ANY OTHER USEFUL INFORMATION REGARDING DATA COLLECTED AT THIS SITE.

Form Checked by _____ Page 5 of 5

FIGURE 2.1. Field data sheet for ambient stream monitoring.

2.1.1 FILLING OUT DATA SHEETS

The purpose of field data sheets is to document field data, how water samples were collected and other important observations. It is essential that staff write legibly and document information in such a way to enable future samplers and possibly the public to understand the observations and measurements collected in the field (FIGURE 2.2).

An important quality control check is to have the second field person (i.e. a person other than the one who filled out the form) check over the form before leaving the site.

2.1.1.1 Instructions for filling out Reach Observations on the Ambient Stream Form

Narrative observations about the general stream condition can be helpful in diagnosing potential problems. The observations consist of general appearance of the stream reach and stream bank, water appearance and odor, presence of fish, especially sunfish and crayfish as well as hydrological information about flood or drought evidence, flow regime and water source (FIGURE 2.3). Biotic interactions by exotic species such as crayfish and sunfish are an important source of impairment of the macroinvertebrate community. Hydrological information is important for identifying flood or drought impacts, and ensuring that the stream is perennial prior to macroinvertebrate sample collection.

FIGURE 2.2. Staff filling out a site sketch in the field.

1.9 EVENTS

THIS TABLE INCLUDES FIELD RELATED EVENT CODES YOU WILL ENTER INTO THE WQDB. CHECK THE BOX NEXT TO ALL APPLICABLE EVENTS. USE THE EVENT FLAGS (F1, F2, ETC.) IF YOU WANT TO INCLUDE A COMMENT FOR A PARTICULAR ITEM THAT YOU CIRCLED. INCLUDE FLAG COMMENTS IN SPACE PROVIDED BELOW. IT IS VERY IMPORTANT THAT RECENT OR CURRENT FLOODING BE FLAGGED.

*** = FILL OUT EVERY TIME. YOU MUST FLAG AND EXPLAIN IF THESE ARE NOT CHECKED.**

Check	Description	Flag
☐	*** Baseflow Conditions**	
☐	*** General – Precipitation at sample time. None ☐; Light ☐; Moderate ☐; Heavy ☐; Cloud Cover (%) =**	
☐	*** Weather – Significant rain during past 48 hours may affect results**	
☐	Flow – Low D.O. / high pH attributed to ponding or evaporation of stream	
☐	Flow – Stream dry at time of visit	
☐	Flow – Evidence of recent flooding. Fresh debris line in channel ☐, Grasses Laid Over ☐; Fresh debris line in bushes/trees ☐; Recent flood event greater than baseflow but less than bankfull ☐; Riparian vegetation scoured away ☐; •Flood Width_____ meters.	
☐	Flow – Flood event in progress at time of visit	
☐	Groundwater – DO value attributed to groundwater upwelling	
☐	Flow – Measurement from USGS gauge/records or 3rd party	
☐	Flow – Low flow conditions	
☐	Flow – No active flow, pools or ponded water only	
☐	Flow – Flood > Bankfull occurred recently or in the past season	
☐	Fire (recent) in the watershed is affecting the study reach	
☐	Spring(s) influencing samples	
☐	Weather conditions may affect samples	
☐	Algal bloom	
☐	Fish kill observed	
☐	Fish kill attributed to low DO, high pH or algal toxicity	
☐	Indication of algal toxicity	
☐	Macrophytes – Abundant macrophytes	
☐	Waterfowl – Abundant waterfowl	
☐	SOP – Deviation(s) from standard operating procedures (indicate in 'Field Notes')	
☐	Equipment problems associated with visit (data associated with the equipment not entered)	
☐	Incomplete sampling event – Missing parameter(s) or reports	
☐	Limited sampling event – Selected parameters only	
☐	QC Equipment blank associated with visit	
☐	QA/QC or duplicate sample collected at time of visit	

Flag 1	
Flag 2	
Flag 3	

FIGURE 2.3. Reach Observations on the Ambient Stream Monitoring Field Form.

Procedure for Filling Out Reach Observations

The observations take place 10 meters upstream and downstream of the sample point (FIGURE 2.4). Some observations are restricted to the wetted width of the stream and some involve looking at the banks.

- % Algae refers to filamentous algae (not diatoms) and consists of green and blue-green algae that can form small tufts to large beards **attached to substrates** or are **floating** at or near the stream surface. This visual estimate is only within the wetted width of the stream.
- % Macrophytes refers to aquatic vascular plants. Do not count the plants that are found outside the edge of water. Estimate the percent of the wetted width of the stream that is covered by the macrophytes 10 meters upstream and downstream of the sample point. Percent cover is visually estimated and is generally a low number unless there is nutrient enrichment.

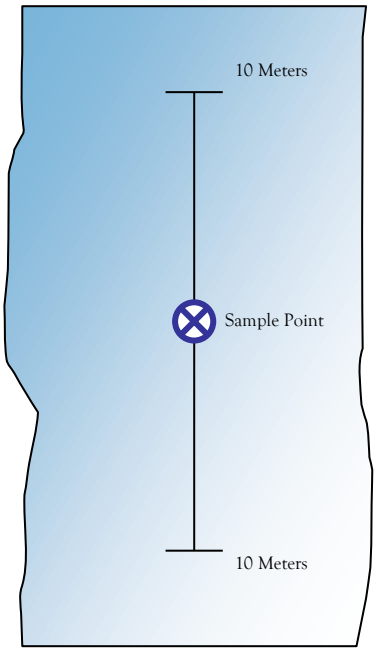


FIGURE 2.4. Plan view of a stream. Look 10 meters up and downstream of the sample point to fill out the reach observations.

2.1.2 PHOTO MONITORING

Photos are taken at each visit to a sampling site. Based on the desired objectives, the photo should provide a representative view of that site. Ideally, the photo should be taken at a fixed point of reference to enable comparison of photos over time.

Be sure the time and date on the camera are correct. Matching the time and date of the photo with your sampling event is the easiest way to keep track of where each photo was taken.

For streams, the minimum number of photos is two: looking upstream from below the sample point and looking downstream from above the sample point.

For lakes, photos should be taken to support any observations, ideally with some recognizable landmark in the background.

Taking additional photos is encouraged. Document the sampling event, any changes from the last visit, outgrowths of filamentous algae on the stream bed, channel obstructions, man-made channel alterations or disturbances, floodplain debris, trash, sediment deposition features, point bars, bank erosion, head cuts, streambed particles, riparian community, wetlands community, bank particle composition, etc. The objective is to fully document the condition of the site and photos are ideal for this purpose.

Photos should be taken to include the sample point with a person framed within the photo to show scale. If the stream channel has been altered since the last site visit, additional photos should be

taken. Site alteration may include recent flood evidence, channel scour, sediment deposition, construction or man-made alterations in the floodplain or channel, or other biological or ecological changes that warrant documentation. All photos taken at a site should have the description of the photo (e.g. looking upstream, looking downstream, dam site).

2.1.2.1 Labeling Photos

Each photo should be labeled with the following information.

- Site ID
- The date the photo was taken
- Description (e.g. looking downstream, erosion along right bank, cottonwood-willow community), and
- Any applicable notes.

Photos should be placed into the respective site file (see Section 10.4 for site file organization).

2.1.2.2 Digital Photos

Representative digital photos should be downloaded to S:\common\photos\water. Create a new site folder on the "S" drive using the site ID, if a site folder does not yet exist. LCCOY002.34 and SRROO-A are examples of a correctly formatted site IDs. Do not add any extra spaces. File names should be in a yyyymmdd format followed by a one word photo description (ex. 20070930up). Be selective with as to how many photos you add to the "s" drive. Two photos per sample event is best. Do not include 20 different pictures of the same sampling event. Extra pictures should be stored on your hard drive.

2.2 EQUIPMENT AND PERSONNEL DECONTAMINATION PROCEDURES

The purpose of this procedure is to provide a description of methods for preventing or reducing cross-contamination and a description of methods that will protect the health and safety of site personnel.

2.2.1 FIELD EQUIPMENT DECONTAMINATION

All reusable sampling equipment should be properly cleaned before going into the field. When sampling and field activities are completed, sampling equipment should be decontaminated before leaving the site. **This should be done at every site.** The purpose of the field decontamination procedures is to remove any impurities that might bias the analytical results or potentially spread invasive organisms.

1. Remove any large debris from the equipment being cleaned (such as mud on boots).
2. Rinse any personal gear (waders, boots, etc.) that has come into contact with the water being sampled with quaternary ammonia.
3. See Section 2.3.5.3.1 for boat decontamination procedures.
4. Rinse any equipment that has come into contact with the water with quaternary ammonia. Probes and sensitive equipment are not generally rinsed with quaternary ammonia but should be rinsed with clean water and wiped down.
5. Take advantage of the sun to dry/decontaminate equipment between sites.

6. Additional care should be taken for sites with known invasive or sensitive species.

2.3 SAFETY PROCEDURES

Personal safety of staff engaged in any field work activity takes is the most important part of any trip into the field. Staff should never place themselves in dangerous or risky situations. Any hazards that are known by field personnel should be communicated to other members of the field crew.

Field work should be postponed if there is indication that engagement in the field activity could cause bodily harm other than the normal risks associated with field work. All field work has some risk associated with it such as driving, hiking on uneven surfaces, wading in streams or working with chemicals while wearing appropriate personal protective gear. This is normal risk. Working during lightening storms, at night, during flash flood conditions, or during snowy weather is not considered "normal risk". If any member of the field crew is uncomfortable with a reasonable self-determined hazardous field condition, it is that person's responsibility to bring this to the attention of the project lead and that person is not required to complete the work assignment. A "reasonable self-determined hazardous field condition" is defined as other than normal risk. The project lead shall not dismiss any person's concerns that field conditions are too hazardous to complete the work assignment.

2.3.1 FIELD TRIP ROUTING AND TELEPHONE CHECK-IN PROCEDURE

Before any field trip is conducted, a Routing Form (FIGURE 2.5) must be completed. Copies shall be given to other staff members assisting on the trip and to the contact person.

Routing Form

Instructions: (1) Click File→ Make a Copy. (2) Name it in this format [yyyymmddd Lead Name]. (3) Update routing form info below. (4) Copy the web address and paste into the Check-In Spreadsheet

License#	[Insert]	Year	[Insert]	Make	[Insert]	Color	[Insert]

#	Employee on Trip	Emergency Contact	Home Phone	Work Phone
1	[Insert]	[Insert]	[Insert]	[Insert]
2				
3				
4				

Daily Check in With	[Insert]	Work Phone	[Insert]	H or M Phone	[Insert]
Trip Lead	[Insert]	Mobile	[Insert]	Date Prepared	[Insert]

1. Date: [Insert] Site: [Insert]
[Insert Itinerary]

Check-In Time: [Insert] Lodging: [Insert] Lodging Phone: [Insert]

2. Date: [Insert] Site: [Insert]
[Insert Itinerary]

Check-In Time: [Insert] Lodging: [Insert] Lodging Phone: [Insert]

FIGURE 2.5. Routing Form

2.3.2 SAFETY GUIDELINES

Safety guidelines are divided into general, streams and lake safety.

2.3.2.1 General Site Safety

The following guidelines apply to all field work by staff employed in the Surface Water Section.

- No sample or measurement is worth the risk of injury.
- Field sampling crews should consist of at least two members unless otherwise approved by the supervisor.
- Be conscious of the whereabouts of rattlesnakes, mountain lions, and other dangerous animals.
- Wear hiking shoes that fit well and use sun screen regularly.
- Open body wounds are entry sites for infection; take the necessary precautions for self protection.
- If there is storm activity in the work area, wait for safer conditions to develop or postpone the work assignment.

- Do not sample at night without approval from the supervisor. If night sampling is approved see Section 2.3.4.
- Do not trespass on private property, Indian reservations, or posted restricted public lands without prior permission and written approval from property owner or administrator.
- If strange or suspicious looking people are in the work area, either wait for them to leave or postpone the work to a later time. Do not force confrontations with strangers and back away from imposed confrontations.
- Take the necessary precautions against exposure to harmful weather conditions (e.g. heat, cold, snow, wind).
- Wear appropriate hiking shoes and apply sunscreen.
- The project lead is responsible for providing water at the work site for drinking and washing. However, it is each person's responsibility to provide enough drinking water for their own use on any work assignment. Do not rely upon others for water needs. Recommended amounts of water for summer work is two gallons per person in the field vehicle and at least one quart per person away from the vehicle.
- It is each person's responsibility to wear proper clothing for the type of work to be performed and the expected weather conditions at the work site.
- Carefully evaluate a given on-site situation to determine if the task can be performed safely. Consider potential hazards to avoid and prepare for worst-case scenarios.
- Always look for escape routes in case of flash floods.
- Always respect the on-site opinions of co-workers regarding safety issues.
- Use a personal flotation device when working around swift or deep waters.
- Consider bringing a weather radio to get the latest weather information.

FIGURE 2.6. Pay attention to and respect signs. They are there for a reason.

2.3.2.2 Stream Site Safety

- Wear protective foot wear when entering streams.
- Do not enter the stream if the water is flowing too fast.
  - Walking in streams and along stream banks are slip-and-fall conditions and it is the observer's responsibility to take appropriate precautions against sustaining personal injury.
- When fording a stream with a vehicle, the following requirements are necessary for evaluating a safe passage;
  - The depth and velocity of the water at the crossing,
  - The vehicle limitations, and adequate experience and driving skills of the operator.
  - Consider what the depth of water under worst conditions could be if a return crossing is necessary.
  - Use extreme caution when entering water deeper than the truck's axle or where the water is higher than the bottom of the truck.
- Chest straps or wader belts should be worn around chest waders to prevent possible overtopping of waders. Don't panic if waders do overtop. You can still swim in waders.

2.3.2.3 Lake Site Safety

A safe trip will depend on bringing all the necessary equipment (see Appendix A) and good communication between team members, especially when launching or trailering the boat.

A "safety meeting" should be held before going out on the lake. The trip lead should briefly describe the weather conditions expected for the day and provide the crew with information about the day's objectives and safety considerations (ex. drive slowly at the north end of the lake because it's shallow). Make sure everyone knows where the first aid kit or other safety equipment is located. A life jacket is required on-board for each person. Give the crew a chance to ask questions or bring up any other concerns

Slipping hazards can be avoided by wearing a shoe with a gripping sole (don't wear flip flops).

2.3.2.4 Fish Backpack Electroshocking Safety

Electrofishing can be dangerous. At least two people have died and over 400 people have been injured during electrofishing operations in the United States in the last 20 years. There are three serious safety concerns about electrofishing activities: 1) drowning; 2) electrocution; and 3) personal injury. The use of personal protective gear can significantly reduce chances of injury.

The following guidelines must be followed by staff collecting fish using the backpack electroshocker.

1. Before beginning sampling, all electroshocking must be checked to ensure it is good working order (no frayed or exposed wires, loose components)
2. All electrofishing gear must receive regular maintenance and inspection.
3. Staff must receive the minimal training in Section 2.3.3.
4. Gloves must be worn by all participants during all electrofishing operations. All gloves must be rubber or PVC, dry in side and free of leaks. Extra gloves should be available.
5. Boots and Waders. All personnel involved in all electrofishing operations will wear hip boots or chest high waders.
6. The use of personal floatation devices in stream shocking operations will be at the discretion of the crew leader and staff.
7. Eye protection. The wearing of polarized lens glasses is recommended to increase visibility and improve the efficiency of fish capture.
8. First Aid Kit. A full first aid kit will be available and location communicated to all staff.
9. No one should reach into the water at any time during electroshocking.
10. The lead is responsible for providing clear instructions for alerting the operator of the shocker to shut off the shocker in the event of a staff member falling into the water.

2.3.3 SAFETY TRAINING

The following training/monitoring are required for all monitoring personnel.

1. First aid (renew every two years)
2. Wilderness First Aid (renew every two years)
3. Boat safety (Lakes personnel; 1 time only)
4. CPR (renew every two years)
5. Electroshocking (applies to all staff who collect fish with the backpack shocker)

2.3.4 STORMWATER NIGHTTIME SAMPLING FIELD SAFETY GUIDELINES

- All daytime safety guidelines apply to nighttime sampling. Additional guidelines for nighttime sampling are listed.
- Participation in nighttime stormwater sampling is voluntary.
- Fording a stream at night under stormy conditions is dangerous and extreme caution should be exercised when doing so.
- Wear a personal flotation device when entering a stream.
- Use a headlamp.
- Do not hike more than 500-feet from the field vehicle.
- Take either a satellite phone or cell phone. A cell phone is sufficient if excellent cell phone coverage is available at the site. If cell phone coverage is insufficient, a satellite phone is required.
- Call or leave a message with the supervisor before leaving after normal work hours and call-in no later than 0900 hours by the next day.
- For sites considered too hazardous to sample at night, reevaluate those sites the next morning before proceeding to take samples.
- Use a weather radio to get the latest weather information.

2.3.5 BOAT SAFETY

ADEQ currently uses a pontoon boat, an aluminum boat and a raft to complete lake work.

The pontoon boat's gas tank holds approximately 20 gallons and needs to be filled with unleaded gas 87 octane or higher quality. The pontoon is started with a key ignition (FIGURE 2.6).

FIGURE 2.6. Backing the pontoon into

The aluminum boat has a gas tank on board. Re-fill it as necessary with high-performance unleaded gas. Prep the motor with the hand pump and make sure the motor is set to "start" on the throttle. Pull the cord (like a lawnmower) several times to get the motor started.

Life vests are legally required to be on-board for each passenger. The crew should have taken the 8-hour Boating Safety course provided by the Coast Guard in order to become familiar with proper boating procedures.

2.3.5.1 Pre-trip checklist

- Bring boat license aboard
- Remove cover, fold up and store under console
- Visually inspect for obvious damage on boat and trailer including breaks, cracks, loose bolts
- Bearings are greased

- Motor mountings are secure
- Rails are secured to the frame
- No oil leaks
- Check power on battery, navigation lights and horn
- Check that power steering fluid level is full
- Tires (including spare) have no cracks or wear and have adequate pressure
- Tie-downs on bow (hand crank) and stern (straps) are not worn and are secure
- Motor oil levels are adequate (dipstick is accessed by removing the hard plastic cover over the motor)
- Fuel level is adequate (considering trip duration and access to gasoline)
- Safety chains and electrical adaptor are connected
- Hitch is secured with cotter pin
- Test electrical for signals, brake lights, and taillights
- Remove tire chocks
- As you are pulling away from the parking space listen for any strange noises coming from the trailer

2.3.5.2 Launching the boat

- Disconnect stern straps and unhook bow clip on crank

Disconnect trailer lights from truck electrical power point (otherwise it will blow a fuse)

- Turn on batteries
- Load the boat with equipment
- Set up the bimini cover if necessary
- Communicate with others about where the person who is responsible for parking the truck and trailer will be picked up
- Check the boat ramp for hazards (swimmers, debris, parked vehicles, etc.)
- Slowly back boat into the water until you see the stern float
- Start boat and slowly back off the trailer
- Let the boat warm up a couple minutes before idling out of no wake zone (get away from the ramp and do not impede boat traffic at ramp)

2.3.5.3 Returning from a trip

2.3.5.3.1 Putting the boat back on the trailer

- Assist the driver of the truck in backing into the water but don't let him/her immerse the tailpipe
- Observe the water depth and raise the motor if necessary (without taking the intake out of the water)
- Slowly drive the boat back up onto the trailer rails
- Hook up bow clip, crank tight, and put in lock position
- Drive boat out of water. While still on the ramp, remove plugs from pontoons and drain out water if necessary. Replace plugs after pontoons drain.

- Pull boat up to parking lot
- Replace stern straps
- Turn off the batteries
- Reconnect electrical trailer/vehicle connections
- Remove anything from boat deck that is not secure for highway travel
- Take out key and store it with you in truck

2.3.5.3.2 Returning equipment and decontamination

Return all equipment to its previous location. Clean field equipment as needed. If any work/maintenance is needed on the boat, log it in the logbook and work with the lab coordinator to get the necessary supplies or repairs.

De-contamination prevents the spread of invasive aquatic plants and animals. After every trip, remove any aquatic plants from the anchors, boat and trailer.

Decontaminate the boat after each trip. To decontaminate, spray the boat and trailer with quaternary ammonia (recommended by Game and Fish as of February 2008) or with a 10% bleach solution or use the decontamination method prescribed by Game and Fish. Be sure to decontaminate any surfaces that were in the water including the trailer, the hull, anchors, anchor ropes and other equipment.

Before leaving the boat parked, turn off batteries, cover the boat and place tire chocks so that the boat cannot roll forward or backward.

Arizona Administrative Code R12-4-1102(B). B. Upon removing a watercraft, vehicle, conveyance, or equipment from any waters listed in Director's Order 2 and before leaving that location, a person shall: 1. Remove all clinging materials such as plants, animals, and mud. 2. Remove any plug or other barrier that prevents water drainage or, where none exists, take reasonable measures to drain or dry all compartments or spaces that hold water. Reasonable measures include, but are not limited to, emptying bilges, application of absorbents, or ventilation.

2.3.6 BORDER SAFETY

The following procedures are to be followed when working in remote areas within 50 miles of the Mexican Border (south of I-10 in the southeast part of Arizona). Increased border activity has resulted in more frequent encounters, thefts, break-ins, and resource destruction. Encounters with illegal immigrants and drug smugglers are potentially dangerous and special precautions need to be taken to ensure employee safety. Projects that are located near populated areas (within city limits) may follow modified border safety procedures but prior approval will be needed from the Section Manager.

The following requirements are necessary for any employee to work near the border.

2.3.6.1 Physical abilities:

- Able to hike over rugged terrain and caring 30 lbs; and

- Have no physical limitations that would prevent prolonged exposure to inclement weather.

2.3.6.2 Training:

- First Aid and CPR;
- Wilderness First Aid;
- Familiarity with USFS Border Safety Documents; and
- Review Border Safety DVD or attend border safety class.

2.3.6.3 Pre-trip Activities

Prior to starting fieldwork (the day before or on the way, as time permits) the project manager should contact Charles Trost with the Border Patrol Station.

Charles Trost II, Public Lands Liaison Agent
U.S. Border Patrol Tucson Sector
Office (520) 748-3211
Cell (520) 255-6600
charles.r.trost@cbp.dhs.gov

Contact the USFS District Office, and/or County Sheriff to determine if the area where fieldwork is being conducted is experiencing any activity that is out of the ordinary or is overtly dangerous at the moment and to inform them of our plans, see Appendix D for a list of local agency contacts. You should provide the local agencies with a description of the vehicle, number of people working in the field, along with the location and duration of the field activities. If the project manager receives information that the area should not be entered then the trip will need to be rescheduled.

The routine ADEQ contact evening check-in policy is not adequate for fieldwork near the border. The project manager, in consultation with their Unit Manager, will determine the appropriate call-in interval for the project. It is recommended that for work in remote areas that an initial call-in should be made as the field crew enters the area and then every 1-2 hours (maximum, but dependent on field conditions) while in the area followed by a check-out call as they leave the area. It is the responsibility of the project manager to ensure that the call-in schedule is followed. If there are multiple teams involved in the sampling effort each team must have and follow a call-in schedule. The designated ADEQ contact must be available by phone for the entire period that employees are in the field, the ADEQ should provide work, home, and cell phone numbers. There will a 30 minute maximum grace period for the field team to call in before the ADEQ contact will begin trying to contact the employees in the field, if after another 30 minutes no contact is made, the ADEQ contact will inform the local agencies of the situation and ask for assistance. For example if the call-in time is 1300 and no message is received by 1330 the ADEQ contact will begin calling all of the available numbers (ADEQ and personal) on the routing form, if by 1400 no contact is made the ADEQ contact will then call the local contacts to seek assistance.

It is imperative that both the project manager and ADEQ contact follow the call-in procedures outlined to ensure that help is sent when necessary but also that false alarms do not happen.

2.3.6.4 Develop Routing Form

See Section 2.3.1 for additional information regarding routing forms.

- Know the area and your route- ensure you have accurate maps;
- If you are sampling established sites include directions to sites and include the latitude and longitude (include datum), if conducting recon provide a description of the area you will be working in (specify area on a map);
- Include specific check-in/check-out procedures;
- Include local contacts (county sheriff, USFS, Border Patrol, and other active agencies in the area) on the routing form- each field person must have a copy along with the ADEQ contact;
- Do not alter your route/timing until you have informed the ADEQ contact of the change in plans;
- Include all phone numbers that will be taken in the field- ADEQ satellite and cell phones along with employee personal cell phone numbers;

2.3.6.5 Field Activities

Once you are in the project area continually assess your surroundings and stay alert- expect the unexpected. Look for indications of recent activity (voices, foot prints, water bottles, food, clothing, etc). While conducting fieldwork make your presence known. Talk to coworkers while working, honk the horn when arriving at a site, blow your safety whistle periodically this will alert anyone in the area that you are there and cause them to avoid you if that is their intention.

2.3.6.6 In-field safety protocols-

- Review the project Health and Safety Plan and routing form details with all coworkers before arriving at first site;
- Follow call-in protocols;
- Be sure to lock vehicle (doors and shell), take water, phones, and personal items) with you when leaving vehicle;
- Park nose out;
- Stay alert;
- Avoid confrontation;
- If you encounter someone play dumb- ask them if they have seen any water in the stream; make it clear you are not there looking for them;
- Work in pairs- at no time should employees be alone while conducting fieldwork.

2.3.6.7 Post-trip Activities

Upon completion of field activities and after leaving the area, check-out with the ADEQ contact to ensure that they know you are no longer in the area thus completing the predetermined call-in schedule. Any suspicious activity should be reported to the appropriate Border Patrol Station after leaving the area. The project manager must inform the ADEQ contact when the field crew has returned the office or hotel for the evening. The project safety procedures should be reviewed by the project manager after each sampling event and adjusted as warranted.

2.3.6.8 Additional safety precautions that may be taken:

- Deploy bilingual signs (on automated equipment, placed in stream when working, etc);

- Provide/learn common Spanish phrases (cheat sheet style);
- Determine if any local agencies will loan out a radio to ADEQ when in the area for emergency use only;
- Most illegal crossers want to avoid contact or confrontation, diffuse any situation by being non confrontational (back away from encounters, raise hands, etc);
- Stay together, no solo wonderings;
- Do not attempt to render aid to unknown persons (it may be a decoy/ploy) to get you out of the vehicle. Call for aid after leaving the area;
- If you fell uncomfortable about the situation or something just does not seem right- leave;
- Ask local agency for an escort;
- Avoid handling trash and unknown substances.

CHAPTER 3 CHEMISTRY PROCEDURES

This chapter describes how to collect chemistry data for lakes and streams. The chapter begins with field measurements and then goes over how to collect water samples in streams and lakes that will be sent to a laboratory.

3.1 FIELD MEASUREMENTS

3.1.1 DISSOLVED OXYGEN, CONDUCTIVITY, PH, TEMPERATURE, AND DEPTH

The following sections provide general instructions that cover the Insitu, YSI and Hydrolab multiprobes for lakes and streams. Additional detail regarding such topics as data logging can be found in the applicable multimeter manual.

3.1.1.1 Dissolved Oxygen

3.1.1.1.1 Dissolved Oxygen – Membrane (YSI/Hydrolab)

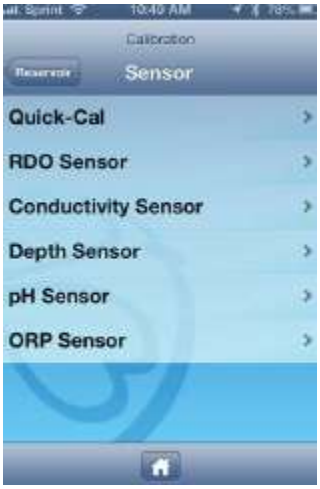
Dissolved oxygen concentrations fluctuate throughout the day. Concentrations are typically highest a little after noon and are lowest at night just before dawn. At the sample site, the dissolved oxygen probe must be calibrated before immersion into a lake or stream. Record all parameter readings on the field data sheet.

1. Fill the calibration cup with water to below the DO probe (do not cover the membrane with water).
2. If there is any moisture on the DO membrane, blot it gently with a lint-free absorbent cloth or tissue such as a chem wipe to remove any water droplets. Use a material that is non-abrasive.
3. Invert the cap and slide it over the top of the calibration cup, and then let the unit sit for about 5 minutes to allow the conditions inside the cup to stabilize. Do not screw the cap back on as this will increase pressure inside the calibration cup.
4. Determine ambient air pressure.
5. Before calibrating the DO, record the pre-calibration percent saturation value after the unit has stabilized.
6. Using the calibration menu for % saturation, enter the current air pressure when prompted.
7. Record the new DO percent saturation reading, which should be at or near 100%. The percent saturation reading should not drift for about 20 to 30 seconds after the calibration procedure.
8. After calibrating the DO probe, ensure that the cables are securely attached to both the sonde (or minisonde) unit and the read-out unit.
9. Attach the probe guard (this is a part of the stirrer unit on the older sonde units) before placing the unit in the stream or lake to avoid damage to the probes.
10. Place the sonde in the water body.
11. Allow a few minutes for the meter to stabilize and then record the DO readings.

FIGURE 3.1. Proper cap position.

3.1.1.1.2 Dissolved Oxygen – Optical (Insitu)

1. Tap the Calibration icon 
2. Tab RDO Sensor



3. Select 100% Saturation
4. Place a water-saturated sponge in the bottom of the calibration cup. Place the instrument into the calibration cup, and tap Start.

The calibration cup must be vented to barometric pressure. If you are using the calibration cup pictured below, make sure the vented cap is installed. If you are using the twist-on storage cup, set the instrument in the cup, but do not twist it into place.

5. When the calibration is stable, tap the Accept button.

6. Record stability, barometric pressure, the post cal reading and probe name on field sheet.

1.3 FIELD CALIBRATIONS		
% D.O.	Barometric Pressure in mm Hg = _____ Post-cal. Reading = %_____ Multiprobe name _____	☐ Nominal stability ☐ Stable

7. Attach stainless steel guard and place collect reading per Section 3.1.2 'Multiprobe Placement'.

3.1.1.2 Depth (Lakes)

For lakes the multiprobe must also be calibrated for depth.

1. Place the probe in the water at a depth of 10 cm.
2. Calibrate the depth to 0.1 m.

3.1.1.3 Specific Electrical Conductivity, pH, and Temperature

With stirrer or probe guard attached, allow meter to stabilize and take reading.

3.1.1.4 Insitu Field Instructions

3.1.1.4.1 View an Individual Reading

1. To view an individual reading, tap the Action icon.
2. Tap View Last Reading.
3. The most recent data in the last ten-second interval appears. Tap the Home icon to return to the Live Readings screen or tap the Envelope icon to email the data.

3.1.1.4.2 Create a New Site (Optional)

You do not need to create a site to get live readings.

1. From the Live Readings screen, tap the Sites button.
2. A list of existing sites appears. If desired site is listed, tap set for the site and skip to step #11.
3. Tap the New Site button. The Site Details screen appears.
4. Tap the Name field. Type the name for the new site and tap Return.
5. To add a description, tap the Description field. Type a description and tap Return. A description is optional.
6. To take a site photo, tap the Camera button, tap the camera icon to take a new photo, tap the Use button. A site photo is optional.
7. To select an existing photo, tap the Album button, tap Cameral Roll, tap an existing photo.
8. To locate your site with Maps or GPS, tap the GPS button (must have wifi) and your current location is automatically associated with the site. You can also enter GPS coordinates, or tap and hold on the map to select a location. Location Services must be turned on for an accurate location to display on the map. See Settings > Location and Security.
9. Tap the Save button.
10. Tap the Set button next to the site you created. Now you are ready to record data associated with the selected site.
11. Tap the Record button on the Live Readings screen to record data. The number on the stopwatch icon represents how many 10-second data intervals have transpired.
12. To stop recording, tap Stop. Only one record needed. Transpose data to field sheet or tablet.
13. You can email the data or download it to a computer once wifi is available.

3.1.1.4.3 View and Email Data from the Selected Site (Optional)

After you have recorded data, you can email the data as a CSV file that can be opened with common spreadsheet software. Make sure the email feature is enabled on the mobile device.

1. Tap the Action icon.
2. Tap View Log List. This shows a list for only the selected site.
3. To select all logs in the list, tap the ALL/NONE button, or to select individual logs, tap them separately.
4. Tap the Envelope icon.
5. An email form appears with the logs that were selected attached.
6. Enter an email address in the To: field.
7. Tap the Send button.

3.1.2 MULTIPROBE PLACEMENT

3.1.2.1 Stream Multiprobe Placement

Place the Multiprobe at the base of a riffle or other areas where the water is moving swiftly (FIGURE 3.2).

FIGURE 3.2. Field parameter collection in a stream.

3.1.2.2 Lake Multiprobe Placement / Determining Lake Stratification

See Section 3.4.

3.1.3 TURBIDITY

For the battery voltage check, press the Diagnostic key identified as DIAG. The number displayed is the battery voltage.

1. It is recommended that the Hach Turbidity meter be placed on a flat surface for taking measurements. Choose a Gelex Secondary Reference Standard that has a turbidity value close to that of the stream or lake (Hach Company, 1993). Thoroughly clean the outer surface of the Gelex Secondary Reference Standard vial of fingerprints, water spots, and evaporate by applying a thin coat of silicone oil and wipe with velvet cloth.
2. Insert the selected Gelex Standard into the instrument cell compartment with the white triangle on the vial aligned to the raised orientation mark on the instrument and take the measurement. The displayed value should be within 5% of the calibration value. If the difference between the measurement and the Gelex Standard calibration value is greater than 5%, re-clean and re-oil the Gelex Reference Standard vial, and take another measurement. If the problem persists, record the values on the Field Data Sheet together with a description of the problem.

FIGURE 3.4. Hach Turbidity Meter.

The turbidity value should be rerun if the percent difference is between 5 and 10 percent. Anything greater than 11 percent should not be entered into the database. Use the event condition 'Equipment problems associated with visit (data associated with the equipment not entered)'.

% Difference = ((Standard Value – Measured Value)/Standard Value) * 100

3. Rinse an empty sample vial several times with stream water. Fill the vial with stream water, replace the cap and wipe the outside surface clean and dry with a soft cotton cloth. For grab samples, the location of the sample should be representative of the entire flow. For composite samples, go through the rinsing process and take the water from the agitated churn splitter to ensure complete mixing of the suspended matter.

If there is any delay between when the vial is filled with stream or composite water and the measurement, invert the vial several times before placing it into the instrument cell compartment.

4. Take at least three turbidity readings. This can be accomplished with two methods; by the meter default or by use of the Signal Average Key. The default setting (Signal Average off) will internally average three measurements and display the result. The signal averaging (Signal Average on) mode averages 10 measurements every 1.2 seconds which compensates for measurement fluctuations caused by the drifting of sample particles through the light path. After 22 seconds, the average of the 10 measurements is displayed.
5. Record the displayed reading and measurement type onto the Field Data Sheet.

6. For very turbid waters, the meter may display a flashing "1,000" value or E-3 error message. This indicates that the turbidity value is greater than 1,000 NTUs. There are two options with this condition: 1) perform a dilution, or record the results as >1,000 NTU. Note this on the field data sheet. Performing the dilution will give a more accurate turbidity value.
7. Add deionized water to the sample vile when sampling is complete.

3.1.3.1 Performing a Dilution for Turbidity

1. It is recommended that a dilution factor (DF) of 10 be used for the turbidity calculation. The DF is the multiplier for the meter reading. For example, if the operator were to dispense 9 mL of deionized water into a 10 mL graduated cylinder and 1 mL of sample water, for a total of 10 mL, the DF is 10 (a ratio of 9:1); therefore, the turbidity value is the meter reading times 10.
2. For samples that are extremely turbid, it may be necessary to make more than one dilution to obtain a meter reading less than 1,000. For multiple dilutions, the procedure is the same as described above; however, for the second dilution, the 9:1 diluted sample becomes the sample to be diluted. If this is the case, and a 9:1 dilution is performed a second time, the DF is 100 (DF of 10 for the first dilution and DF of 10 for the second dilution). The turbidity value is simply the meter reading times 100.

3.1.4 HACH DR/700 COLORIMETER FOR CHLORINE ANALYSIS

This procedure describes how to measure free and total chlorine with the Hach DR / 700 Colorimeter (Hach Company 1993).

3.1.4.1 Field Procedure for Measuring Free Available Chlorine

1. After powering on the instrument, a six digit number, such as 52.05.01, will appear at the bottom of the display window. This is the number of one of several filter modules that are factory installed. The filter module number required for the free chlorine analysis is 52.07.1. If a number other than the free chlorine module is displayed, press the up arrow key, in the edit box, until the correct number appears.
2. Inspect the sample vials provided with the meter for any discoloration of the glass surface or any evaporate remaining from the last analysis. The vials should have been thoroughly washed with a chlorine free detergent and rinsed with deionized water before field use.
3. Triple rinse the vials with sample water and fill a 25 mL vial with sample. Check sample acidity with pH paper. pH needs to be between 6 and 7. If pH >7, add one drop of sulfuric acid solution and measure pH again. Repeat until pH is between 6 and 7.
4. Pour 10 ml of solution into 2-10 ml vials. Place one vial into the cell holder and press ZERO (display will count down). Add the contents of one DPD Free Chlorine Powder Pillow into other vial and shake for 20 seconds. Immediately place vial into cell holder and press READ. Display will count down then show result. Record result.
5. Next, determine any result interferences. This is done by filling a 25 ml vial with sample. Next, Check sample acidity with ph paper. pH needs to be between 6 and 7. If pH > 7, add one drop of sulfuric acid solution and measure pH again. Repeat until pH is between 6 and 7.

6. Add 3 drops of Potassium Iodide Solution to 25 ml vial, mix and wait 1 minute. Add 3 drops of Sodium Arsenite and mix.
7. Pour 10 ml of solution into a 10 ml vial. Add the contents of one DPD Free Chlorine Powder Pillow into vial and shake for 20 seconds. Immediately place vial into cell holder and press READ. Display will count down then show result. Record result. Subtract this result from original result (obtained in #4) to obtain the accurate chlorine result.

3.1.4.2 Field Procedure for Measuring Total Chlorine

Follow the procedures for measuring Free Chlorine above except use the Total Chlorine Powder Pillows and wait 3 minutes before placing the vial into the cell holder.

3.1.5 AIR TEMPERATURE

A variety of thermometers are used to collect air temperature readings. When taking a reading do not place the thermometer in direct sunlight and avoid letting the probe come in contact with the ground.

Figure3.5. Thermometer.

3.2 COLLECTING WATER CHEMISTRY SAMPLES

3.2.1 GENERAL INFORMATION

3.2.1.1 Sampling Order

The order of sample collection, processing, and preservation for specific analytes should be determined before beginning field work and adhered to consistently. TABLE 3.1 describes the order of sample collection (USGS Field Manual, 2004).

Order	Parameter
1	Organic compounds. **Do not field rinse bottles.**
2	Total, dissolved, and suspended organic carbon
3	Inorganic constituents, nutrients, radiochemicals, isotopes: Collect raw samples first, followed by filtered samples. (Field rinse each bottle, as required.) a. Trace metals. b. Separate-treatment constituents (such as mercury, arsenic, selenium) and major cations. c. Major anions, alkalinity, and nutrients. Chill nutrients immediately. d. Radiochemicals and isotopes.
4	Microorganisms

TABLE 3.1. Sampling order for surface water samples.

For composite samples, Suspended Sediment Concentration should be collected from the churn splitter first.

Gloves must be worn while collecting samples. Gloves protect you from contaminants and protect the samples from contamination. Change gloves any time you touch potential contamiants.

3.2.1.2 Sample Bottle Labeling

Each water sample bottle must be labeled with a site code, a site location description, sample collection time and date, analysis, the initials of the observer collecting the water sample, and the agency name. Label the bottle with the appropriate acid sticker if preservative is added. Use a black or blue permanent marking pen, such as a Sharpie or other similar product, to label dry bottles. Handwriting must be precise and legible. Bottles are labeled in the order presented below (FIGURE 3.3). Use clear tape to affix the label.

It is important that the bottle label information matches the information on the Chain of Custody exactly. If an abbreviation is used on the bottle then use the same abbreviation on the Chain of Custody.

Sample Number (required if using edi submissions; see Section 10.2.6)
The sample number is generated by the database and is the address for where the data should be kept.

Sample site identification code
A sample site is given a code based on the water basin, name of the stream or lake, and the river miles or lake monitoring site. Each code is unique for a given sample site. Section 10.3.2 explains how sites are named.

Site location description (optional, except when a site code has not been assigned)
This is a brief generalized description that attempts to convey the location of the sampling point. The description will normally reference a permanent physical feature of some type. An example of this would be "Spring Creek below confluence with Dry Creek," or "Cienega Creek above Marsh Station Road Bridge." If a permanent physical feature is unavailable, the description may be as non-specific as "Trout Creek near Wikieup." Avoid using descriptions that are similar to other site descriptions.

Sample collection time and date
Mark sample bottles with the collection time and date that appears on the field data sheet. Collection times are reported in military time (e.g., 2:30 p.m. = 1430 hours).

Agency name
The placement of the agency name on the bottle informs the receiving lab of the billing entity. If samples have been collected and submitted for another agency or program that has interest in the sample site, label the bottle as "ADEQ for AGFD (or TMDL, etc.)."

Analysis
Indicate what type of analysis the lab should run (ex. Total metals, nutrients, SSC, dissolved metals, or inorganics)

Sampler's initials

The sampler's initials indicate the person responsible for collecting and submitting the water sample. Initials of other field personnel may be applied to the bottle.

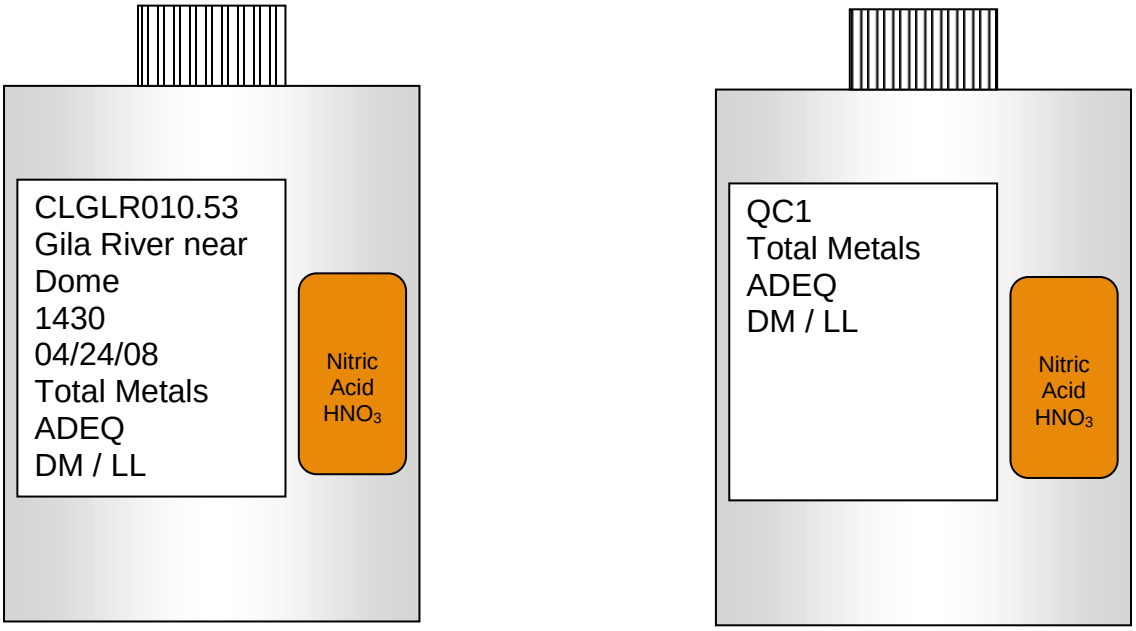


FIGURE 3.3. Properly labeled bottle (left) and a properly labeled QC bottle (right).

Miscellaneous Labeling Requirements

- Water samples that are collected for suspended sediment concentration analysis are labeled prominently as "SSC."
- Dissolved and total metal samples should be acidified and labeled with a nitric acid sticker. Nutrient samples should be acidified and labeled with a sulfuric acid sticker. If problems arise with the acid preservative labels or there is a possibility of them wearing or falling off the bottles during transport, mark the bottles as either "sulfuric acid" or "nitric acid."
- Quality control samples should not be identified so as not to bias the lab. QC samples should be labeled as in FIGURE 3.3. Be sure to write on field form exactly how you identified the QC sample.

3.2.2 COLLECTION BOTTLES

The laboratory will specify the types of collection bottles they would like samples submitted in. The bottle must have been decontaminated by either the lab supplying the bottle or by ADEQ personnel. The lab currently uses 500 mL bottles for the dissolved metals, total metals and nutrients. They use 1 L bottles for SSC and inorganics.

The number of bottles required per site will be dependent on the parameters being analyzed. FIGURE 3.4 illustrates a typical bottle set used in ambient stream monitoring.

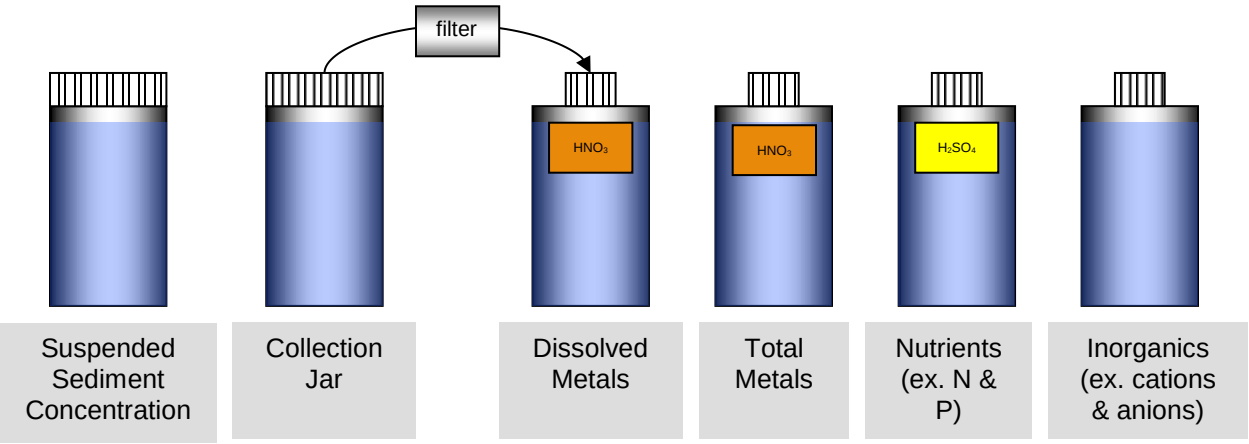


FIGURE 3.4. A typical bottle set for ambient stream monitoring.

FIGURE 3.5. A typical bottle set for ambient lake monitoring.

If the sample plan calls for the analysis of total cyanide, a sample bottle prepared with a solution of sodium hydroxide is required. When total sulfides are to be analyzed, a sample bottle that has been prepared with a solution of zinc acetate and sodium hydroxide is required. The laboratory can supply the preserved bottles upon request.

When sampling a water body that receives discharges of treated effluent, or is composed primarily of treated effluent discharges, a sample for biochemical oxygen demand (BOD) analysis may be required. A BOD sample bottle is typically black plastic or amber glass with an air-tight cap.

Bottles containing acids or bases as preservatives must always be handled with care. Nitrile gloves and eye protection should be worn for safety. Ensure that sample bottle caps are tight before transporting. Acid spilt on skin or clothes must be rinsed and diluted immediately with clean water. When transporting acid vials or lab preserved

sample bottles, keep them separated by preservative type. Some sample preservatives can be chemically incompatible and may react violently when mixed.

3.2.3 FILTERING DISSOLVED METALS

The analysis of dissolved metals requires filtration of the water sample prior to preserving the sample with nitric acid. Ideally, samples should be filtered as soon as possible.

FIGURE 3.6. Groundwater sampling capsule

An unpreserved water sample consists of two analytical components of interest: suspended metals and dissolved metals. Suspended metals are defined as the portion of a water sample that is unable to pass through a membrane filter with a 0.45 micrometer pore size. Dissolved metals are those in solution which are able to pass through the same membrane filter.

ADEQ currently uses peristaltic pumps that operate from any external 12 volt DC or 120 volt AC power source, thus allowing the sample to be filtered in either the laboratory or the field. Typically the pumps are equipped with easy-load pump heads, but some pumps may be equipped with the factory supplied standard pump head design.

The groundwater sampling capsule currently utilized by ADEQ (FIGURE 3.6) is able to filter waters with high suspended sediment concentrations. However, a smaller less expensive filter is available when filtering water with low sediment concentration. Transparent water can usually be filtered with a smaller filter (typically below a turbidity of 5 NTU). All filters should be quality certified by the supplier. Filters are designed for a single use and should be disposed of after each filtration.

FIGURE 3.7. Filtering set-up. Note the peristaltic pump, tubing, collection bottle, receiving bottle, filter and nitrile gloves.

<u>Steps to filter a dissolved metal sample</u>

1. Two clean sample bottles are required; one in which to collect the water, and the second to contain the filtered water. The second bottle should be labeled “Dissolved Metals.” or "Field Filtered".
2. Place the pump on a hard, flat surface (e.g. a table or the pickup tailgate). Position it such that the pump head of the mechanism extends over the edge of the stationary surface (FIGURE 3.7). Remove a section of the clean, pre-cut tubing from the re-sealable plastic bag. Always handle the tubing near the middle to prevent the tube ends from being contaminated.

3. Insert the tubing into the pump mechanism such that both ends are hanging loosely, but not in contact with any surface. Remove the filter from its packaging, taking care to not contaminate the nipple ends of the capsule. Securely attach the tubing to the filter.
4. Check the pump controls to ensure the flow direction of the pump is congruent with the flow direction of the capsule filter. Place the end of the tubing without the filter into either the bottle or the churn splitter.
5. Turn the pump on and allow the filter to fill with water before filling the sample bottle. Allow about twenty five to fifty milliliters of the sample to run out of the out-flow opening to flush the filter. Place the out-flow end of the tubing into the open mouth of the pre-labeled filtrate bottle.
6. Triple rinse.
7. Fill bottle and leave some space in the bottle for the addition of the preservative.
8. After placing the acid-preserved sample into the ice-chest for transport, properly dispose of the filter and tubing.

FIGURE 3.8. Acid droppers.

3.2.4 ACIDIFYING OR PRESERVING METAL AND NUTRIENT SAMPLES

Metal and nutrient samples should be preserved as soon as possible (within 15 minutes of collection). The best way to do this is to take acid dropper bottles with you and preserve samples on site. Our acid preservative droppers have an expiration date of 2 years, from the date on the bottles/packaging, per guidance from Test America. Remember to label your package containing the acid droppers with the expiration date and dispose of residual acid before the expiration date.

Bottle	Preservative	Amount of Acid
Nutrients	Sulfuric Acid	1 vial (2 mL) 40 drops/500mL
Total Metals	Nitric Acid	1 vial (5 mL) 40 drops/500mL
Dissolved Metals	Nitric Acid	1 vial (5 mL) 40 drops/500mL

TABLE 3.2. List of preservative amounts to add to nutrients, total metals, and dissolved metals.

The analyzing lab will provide acid, usually in a dropper or vial format. Follow their preservation instructions. TABLE 3.2 indicated the correct preservative and quantity for each type of analysis. Proper gloves and eye protection should be used before adding acid or filtering. The acid vials that are currently used are illustrated in FIGURE 3.8.

Prior to adding the preservative, make sure that the bottle is either marked with the type of preservative used, or has a color-coded label that corresponds with the preservative vial being added. After adding the preservative vial to the sample bottle, replace the cap on the sample bottle tightly, and invert the sample bottle several times to mix the sample and preservative.

pH test strips can be used to identify sample bottles that, for some reason, may not have been preserved. Invert the bottle several times to make sure it is well mixed. Pour a small amount over the test strip. Do not place the strip into the bottle. The test strip should read a pH of less than 2.

To dispose of the emptied acid preservation vials place them into separate double-bagged zip-lock bags. Upon returning to ADEQ headquarters, flush the vials and caps with tap water and sodium bicarbonate powder and place them in the proper disposal area. Flush the receiving sink of any acid residues with tap water and sodium bicarbonate powder, to neutralize the acid.

3.2.5 COLLECTING FIELD WATER CHEMISTRY QUALITY CONTROL SAMPLES

The Surface Water Section has a Quality Assurance Program Plan (QAPP) that addresses the 'big picture' aspects of quality assurance and control in detail. This section will cover how to collect a quality control sample, which is just one small part of the Surface Water Section's overall QAPP. Please refer to the QAPP for additional detail. TABLE 3.3 summarizes the minimum number of quality control samples should be taken for a given trip. Section 10.2.5 describes the "acceptable limits" for contamination in blank samples and differences between duplicates or splits.

There are a variety of laboratory quality control samples. This manual primarily addresses field quality assurance and quality control. Read the case narrative of the laboratory report to determine if there was any quality assurance or quality control problems from the lab.

3.2.5.1 Quality Control Sampling Frequency

Parameter	Field Splits or Duplicates	Equipment / Churn Blanks	Total
D Metals	None	5%	5%
T Metals	5%	5%	10%
Nutrients	5%	5%	10%
Inorganics	5%	5%	10%
Radiochemistry	5%	5%	10%
Bacteria	1 per trip		
Clean Metals	1 per trip		
Pesticides	5%	5%	10%
Biocriteria	10%	None	10%
Fish Tissue	5%	5%	10%
Algae	5%	None	5%

TABLE 3.3. Minimum percentages of quality control samples to be collected by parameter.

3.2.5.2 Blanks

Blank samples are a check for cross-contamination during sample collection and shipment, and in the laboratory. There are three basic types of quality control blanks: trip, field, and equipment/churn. De-ionized water should be used for metal parameters. Blanks should be prepared by the laboratory that supplies the sample containers. The blank should be numbered, packaged, and sealed in the same manner as other samples in the set.

- Field Blank. A field blank is a water sample that travels with the sample set and is opened and exposed at the sampling point to detect contamination from air exposure. The field

blank, usually deionized water, may be poured into appropriate containers to simulate actual sampling conditions. Contamination of the sample can be from air exposure during the collection process and during storage and transport. *Procedure*: In the laboratory, fill a clean sample bottle(s) with certified deionized water and transport it to the field. Blanks are typically done for dissolved and total metals, inorganics and nutrients, but not for suspended sediment concentration. Place the bottle(s) in the processing area (e.g., truck tail gate) in which the environmental sample(s) are being processed. Open the blank sample bottle to expose the blank sample to the atmosphere for approximately the same period of time to which an individual environmental sample(s) is exposed during sample processing. Store and transport the blank(s) in the same container as the environmental samples.

Blanks can be placed throughout the field process to determine where unintended sources of contamination are coming from. For example, you may put a blank before and after the field filtration step for dissolved metals if you suspected the filter to be the source of contamination. This process would involve filling the "before sample" with DI water and capping it. The "after sample" would involve filling the bottle with DI water and then filtering it into another clean bottle.

- Equipment/Churn Blank. A blank sample is collected form the precleaned sampling equipment in the field prior to collecting the actual field sample. An equipment blank is used to detect contamination introduced by the sampling equipment either directly or through improper cleaning. Blank water is used to fill the sampling equipment and then poured into appropriate containers. *Procedure*: While working in the sample site area (e.g., truck tail gate) in which the environmental sample(s) is being collected and processed, pour the certified deionized water directly into the precleaned churn sample splitter before native water has been introduced into the churn splitter. Run some water through the spigot and fill the sample bottle(s). If a churn splitter is not being used, pour the deionized water from its container directly into the sample bottle(s). Cap the bottle immediately and label. Store and transport the blank(s) in the same container as the environmental samples.
- Trip Blank. A trip blank is a water sample that remains with collected samples during transportation and is analyzed along with field samples to check residual contamination. A trip blank should not be opened by either the sample collector or sample handlers. *Procedure*: Store the trip blank in a container or plastic bag such that the blank bottle is not exposed to ambient conditions during transport to the sample site. At the sample site, remove the trip blank from its container and place in the same cooler as the collected samples during transport to the analyzing laboratory.

3.2.5.3 Duplicate and Split Samples

A split sample is one sample that is divided equally into two or more sample containers and then analyzed by different analysts or laboratories. Splits samples are taken from a churn splitter that has been filled with sub-samples and homogenized. Split samples may be equated to "identical twins" in that they contain the same chemical composition as each other. Laboratory analyses of split samples ideally produce identical results.

Duplicate samples are a set of similar samples collected from the same site, at about the same time, and analyzed in the same manner. Duplicate samples may be equated to "fraternal twins" in that they originate from one source but each sample may contain a slightly different chemical composition. Duplicate samples are usually taken when it is not possible to use a churn splitter to collect sub-samples and produce split samples (i.e., grab samples are collected). Also, some types of analyses preclude the use of a plastic churn splitter (e.g., volatile organic chemicals). Duplicate and split samples are typically done for total metals, inorganics and nutrients, but not for dissolved metals or suspended sediment concentration.

Collection Method

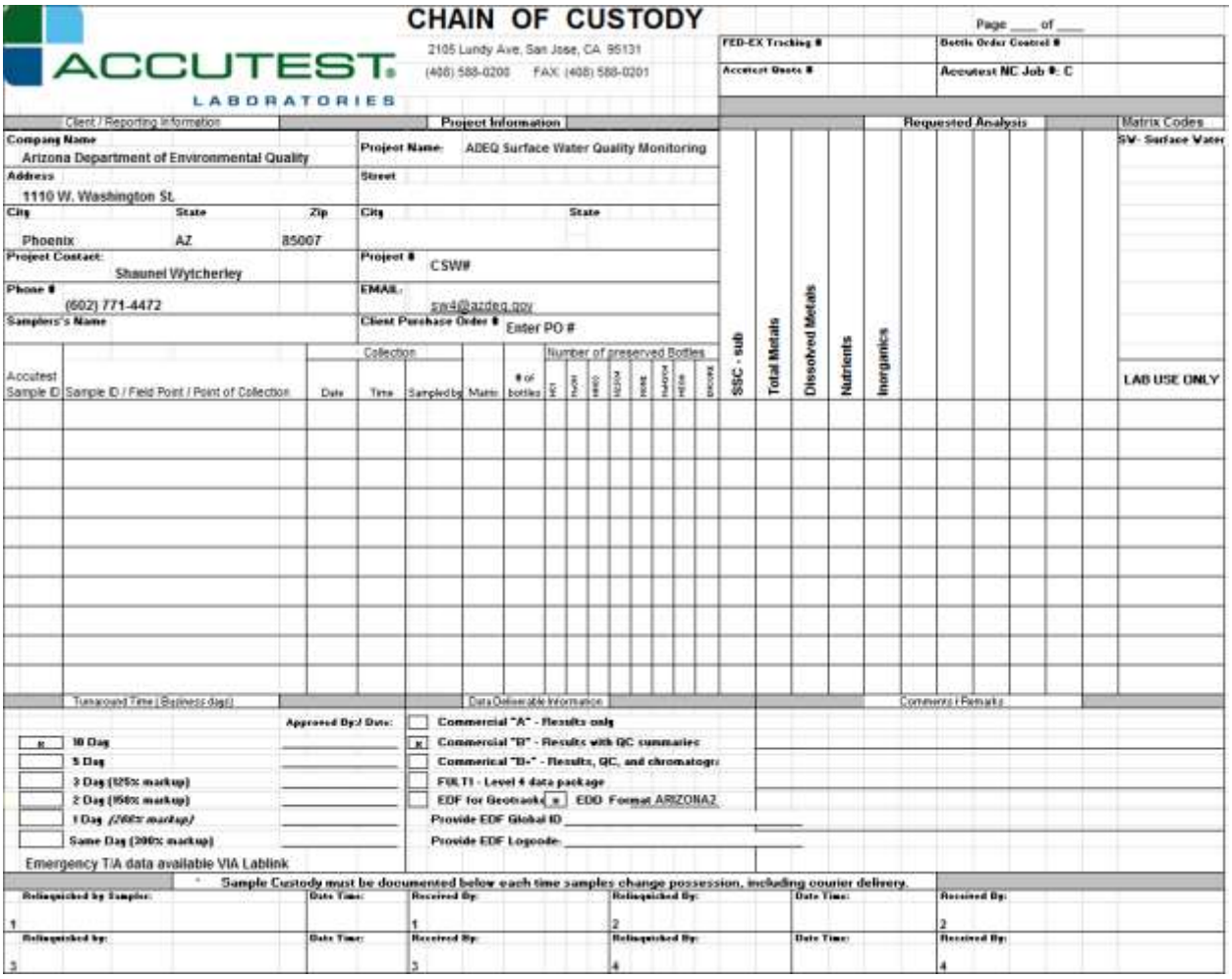
1. Splits are taken from a large sample compositor (churn splitter) that has been filled with numerous subsamples from the source. A 14-liter churn splitter should be used for split samples. Duplicates may be grab or composite samples.
2. The composited split sample is thoroughly mixed before withdrawing subsamples into two distinct chemsets of sample bottles for laboratory analysis.
3. Label appropriately, store and transport the splits in the same container as the environmental samples.

3.2.6 CHAIN OF CUSTODY AND LABORATORY SAMPLE SUBMITTAL FORMS

ADEQ has contracts with several laboratories for sample analyses. Each has their own set of forms to use when submitting samples. An example Chain of Custody is included in FIGURE 3.9

3.2.6.1 General Chain of Custody Guidelines

1. As few people as possible should handle the sample. Transfers between staff and to the lab shall be recorded on the chain of custody.
2. Prior to delivery to the lab, the container holding the samples may be sealed (e.g., evidence tape) for security especially if the container is shipped for analysis.
3. When the samples transfer possession, both parties involved in the transfer (e.g., sampler and lab) must sign, date and note the time on the chain of custody record.



ACCUTEST LABORATORIES

CHAIN OF CUSTODY

2105 Lundy Ave, San Jose, CA 95131
(408) 588-0200 FAX: (408) 588-0201

Page ___ of ___

FED-EX Tracking #
Bottle Order Control #
Accutest Quote #
Accutest NC Job #: C

Client / Reporting Information

Company Name: Arizona Department of Environmental Quality
Address: 1110 W. Washington St.
City: Phoenix State: AZ Zip: 85007
Project Contact: Shaunel Wytcherley
Phone #: (602) 771-4472
Samplers's Name:

Project Information

Project Name: ADEQ Surface Water Quality Monitoring
Street:
City: State:
Project #: CSW#
EMAIL: sw4@azdeq.gov
Client Purchase Order #: Enter PO #

Requested Analysis

Matrix Codes
SW- Surface Water

Accutest Sample ID	Sample ID / Field Point / Point of Collection	Collection: Date	Time	Sampled by	Matrix	# of bottles	Number of preserved Bottles	SSC - sub	Total Metals	Dissolved Metals	Nutrients	Inorganics	LAB USE ONLY

Turnaround Time (Business days)

Approved By:/ Date:

- [x] 10 Day
- [ ] 5 Day
- [ ] 3 Day (25% markup)
- [ ] 2 Day (50% markup)
- [ ] 1 Day (100% markup)
- [ ] Same Day (200% markup)

Emergency T/A data available VIA Lablink

Data Deliverable Information

- [ ] Commercial "A" - Results only
- [x] Commercial "B" - Results with QC summaries
- [ ] Commercial "B+" - Results, QC, and chromatogr
- [ ] FULL T1 - Level 4 data package
- [ ] EDF for Geotracks [x] EDD Format ARIZONAZ

Provide EDF Global ID:
Provide EDF Logcode:

Comments / Remarks

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by Sampler:	Date Time:	Received By:	Relinquished By:	Date Time:	Received By:
1		1	2		2
Relinquished by:	Date Time:	Received By:	Relinquished By:	Date Time:	Received By:
3		3	4		4

FIGURE 3.9. Example of a Chain of Custody

3.2.7 CLEAN SAMPLING OF NATURAL WATERS FOR TRACE METALS

This Standard Operating Procedure is derived from EPA Method 1669. The original method should be consulted for additional information regarding trace metal sampling. However, if the laboratory providing the sampling equipment provides a methodology for clean sampling, this methodology should be followed. The following clean sampling techniques are a combination of EPA Method 1669 and the laboratory's clean sampling methodology.

Trace metals are analyzed for minute concentrations of metals in dissolved waters. The slightest sample contamination will affect the analytical results. The following information is an overview of the clean sampling protocol:

- Utilizes commercially acid pre-cleaned bottles (high density polyethylene is acceptable) and filtering equipment
- Acid cleaned bottles and filtering equipment must be stored and transported in double bags
- Must follow clean hands/dirty hands procedures (Section 3.2.7.1)
- Water samples must be field filtered unless they are received by the lab within 48 hours of collection. Laboratory filtering is acceptable. If field filtered, a deionized water (DIW) blank

and a filter blank are required and all sample handling, filtering, etc. must be completed inside a clean box.

- A field blank or duplicate sample is required

3.2.7.1 Clean Hands/Dirty Hands Pre-Sampling Precautions

The SOP describes field sampling procedures commonly referred to as "clean hands/dirty hands" techniques. Upon arrival at the sampling site, one member of the two person sampling team is designated as "dirty hands" and a second member is designated as "clean hands." All operations involving contact with the sample bottle and transfer of the sample from the sample collection device to the sample bottle are handled by the individual designated as clean hands. Dirty hands is responsible for preparation of the sample (except the sample container itself), operation of any machinery; e.g., pump, and for all other activities that do not involve direct contact with the sample.

Personnel may wear an unlined, long sleeved wind suit consisting of pants and jacket and constructed of nylon or other synthetic fiber to prevent mercury adsorbed onto cotton or other clothing materials from contaminating samples.

When sampling for mercury on a lake, a fiberglass boat with an electric motor and wooden or fiberglass oars is preferred. The boat should be washed and stored in an area that minimizes exposure to dust and atmospheric particles. If an internal combustion engine is required, it should be shut off at a distance far enough from the sampling point to avoid contamination, then the sampling team should manually propel the boat to the sampling point.

3.2.7.2 Manual Grab Sampling

All sampling personnel must don clean gloves before commencing sample collection activity. It is important to minimize the amount of time that the collection container, filtering equipment, and sample are exposed to ambient air. This is because the analyses can detect trace amounts of metal and mercury from the air can potentially contaminate the sample. To minimize air borne contamination, the following clean hands/dirty hands technique is used.

1. Dirty hands opens the cooler or storage container, removes the double bagged sample bottle from storage, and unzips the outer bag.
2. Clean hands opens the inside bag containing the sample collection bottle, removes the bottle, and reseals the inside bag. Dirty hands then reseals the outer bag.
3. Clean hands moves to the collection location and submerges the sample bottle underwater facing upstream and removes the cap allowing the bottle to fill completely. Recap the bottle underwater (Clean hands must ensure that the sample water does not come into contact with the air).
4. Dirty hands reopens the outer plastic bag, and clean hands opens the inside bag, places the bottle inside, and seals the inner bag.
5. Dirty hands seals the outer bag.
6. If the sample is to be analyzed for dissolved metals, it is filtered in accordance with the procedure described in Section 3.2.7.5.
7. Record the bottle number or other information on the Field Data Sheets or field notes.

3.2.7.3 Grab Sampling with a Sampling Device

The following details the sampling technique with a suspended grab sampling device; e.g., DH-81 grab sampler or peristaltic pump (Lakes).

All sampling personnel must don clean gloves before commencing sample collection activity. If it is necessary to attach a bottle to the device in the field, clean hands performs this operation inside the field portable clean bag or box.

1. Dirty hands remove the sampling device from its storage container and opens the outer polyethylene bag.
2. Clean hands opens the second polyethylene bag and removes the sampling device. On those occasions where it may be possible to pre-attach a sample bottle to the sampling device in the laboratory, then the entire assembly, bottle and device, is handled as the bottle alone is in the instructions below.
3. Dirty hands open the cooler or storage container, removes the double bagged sample bottle from storage, and unzips the outer bag.
4. Clean hands open the inside bag containing the sample bottle, removes the bottle, and reseals the inside bag. Dirty hands then reseals the outer bag.
5. Clean hands change gloves.
6. Dirty hands submerges the sampling device to the desired depth.
7. When the bottle is full, dirty hands removes the sampling device from the water.
8. Dirty hands returns the sampling device to its large inner plastic bag; clean hands pulls the bottle out of the collar, unscrews the bottle from the sampling device, and caps the bottle. Clean hands and dirty hands then return the bottle to its double bagged storage. If the sampling device is to be re-used, it must be decontaminated in accordance with Section 3.2.7.6.

3.2.7.4 Sampling with a Continuous Flow Sampling Device

Before putting on wind suits and/or gloves, the sampling team removes the bags containing the pump, tubing, batteries, gloves, plastic wrap, wind suits, and, if samples are to be filtered, the filtration apparatus from the coolers or storage containers in which they are packed. This section applies primarily to lakes.

All sampling personnel must don clean gloves before commencing sample collection activity.

1. Dirty hands removes the pump from its storage bag, and opens the bag containing the new tubing.
2. Clean hands installs the tubing while dirty hands holds the pump. Clean hands immerses the inlet end of the tubing into the sample stream.
3. Both clean hands and dirty hands change gloves.
4. For lakes, place your pumping device (Geopump) on a stable place near the edge of the boat. Dirty hands stabilize the pump and place tubing between the cogs. Dirty hands change gloves and attach a plastic-coated lead weight to the end of the tubing with a zip tie (approximately 6 inches from the tip). Clean hands lower the tubing off the side of the boat to the desired depth without touching the edge of the boat. Dirty hands turns the pump on and allows the pump to run for 5 to 10 minutes or longer to purge the pump and tubing.

5. If the sample is to be filtered, clean hands installs a new cartridge filter at the end of the tubing.
6. The sample is collected by rinsing the sample bottle (with the water from the pump) as dictated by the tier being followed and collecting the sample from the pump. The pump tubing and the filter are discarded after use.

If sampling for mercury, you will collect total mercury, dissolved mercury and methyl mercury. Fill your Dissolved bottle first, then remove the filter and continue using the same tubing to collect the Total Hg and Methyl Hg samples. Have the lab filter the samples if methyl mercury's 48 hour holding time can be met.

Filter blanks should be collected just before placing the sampling train in the water to collect a sample from depth. After the filter blank is collected place the tubing at the appropriate depth and purge the line and filter (same filter as used in blank) before collecting the dissolved mercury sample. After the dissolved sample is collected remove the filter and collect the total and methyl samples.

3.2.7.5 Field Filtering

The sampling procedures described in Sections 3.2.7.2 and 3.2.7.3 are used for samples collected using manual collection systems which require a separate filtering step. Clean sampling filtering apparatus and instructions for use are provided with the sampling bottles from the laboratory. The procedures below are used for sampling with Albion equipment.

If samples are not field filtered then the samples must be shipped to the lab and filtered within 48 hours of sample collection.

3.2.7.5.1 Processing Field Blank and Dissolved Lead and Copper Samples:

Wearing clean gloves and working inside the clean bag (each site needs a new clean bag):

1. Take the syringe filled with blank water and remove from double bags.
2. Remove the end cap from the syringe and turn the syringe outlet end up. Push plunger to expel the air and a small amount of water.
3. Install the syringe filter and turn syringe outlet down. Purge approximately 5 mL through the filter and discard the rinse water.
4. Place the syringe filter flush against the 60 mL bottle rim and apply steady, even pressure, and filter the entire contents of the syringe into the sample bottle.
5. Remove the syringe filter and place it in its original bag.
6. Remove syringe plunger and place it in its original bag.
7. Reinstall filter on syringe and fill with sample water from syringe grab bottle up to stop ring (55 mL). Make sure to shake up sample.
8. Reinstall plunger, turn syringe upright, remove filter, and purge air and small amount of water.
9. Reinstall filter and purge 5 mL of rinse water.

10. Place syringe filter flush against the 60 mL bottle rim and apply steady even pressure. It may take 2-3 min. to filter contents. Only 50-55 mL of sample water needs to be filtered from syringe grab bottle.
11. Recap sample bottle and put into original double bags and record bottle identification number.

3.2.7.5.2 Processing Field Blank for Mercury Sample (red dot equipment):

Wearing clean gloves and working inside the clean bag:

1. Take the Hg-free blank water and remove from double bags.
2. Remove the syringe filter from its double bags, remove the protective end caps. Restore the open filter in its original bag.
3. Remove the syringe plunger completely from the syringe body and place it in the original double bag.
4. Reinstall filter on syringe and fill with Hg-free blank water up to stop ring (55 mL). Recap the blank water bottle.
5. Remove filter from the syringe and turn the syringe outlet end up. Push plunger to expel the air and a small amount of water.

FIGURE 3.13. Field filtering of clean metals.

6. Install the syringe filter and turn syringe outlet down. Purge approximately 5 mL through the filter and discard the rinse water.
7. Place the syringe filter flush against the 250 mL syringe field blank bottle rim and apply steady, even pressure, and filter the entire contents of the syringe into the sample bottle.
8. Repeat steps 2 to 7 until 100 mL of blank water is obtained in the syringe field blank bottle.
9. Recap sample bottle and put into original double bags and record bottle identification number.

Process the mercury sample from the 250 mL syringe grab bottle into the 250 mL composite bottle (Hg) using the above method until 100 mL is obtained. Make sure to shake sample thoroughly.

Field duplicates are processed using the above methodology.

3.2.7.6 Field Decontamination of Equipment

Sampling activity can be planned such that sufficient equipment is brought to the field that field decontamination of the sampling equipment between samples in unnecessary. If it is not possible to plan sampling activity in this manner, dedicated sampling equipment should be provided for each sampling event.

If samples are collected from adjacent sites of the same source water (e.g., immediately upstream or downstream), rinsing of the sampling apparatus (i.e. tubing) with water that is to be sampled should be sufficient.

If it is necessary to cross a gradient (i.e., going from a high concentration sample to a low concentration sample), such as might occur when collecting at a second site, the following procedure may be used to clean the sampling equipment between samples.

1. Inside the clean box, use the "clean hands/dirty hands" procedure to process the dilute nitric acid solution through the apparatus. Dispose of the spent dilute acid in accordance with the project plan.
2. Process 1 L of reagent water through the apparatus to rinse the equipment and discard the spent water.
3. Collect a field blank as described in Section 3.2.7.7.
4. Rinse the apparatus with copious amounts of the ambient water sample and proceed with sample collection.

3.2.7.7 Quality Assurance/Quality Control

The sampling team shall employ a strict quality assurance/ quality control (QA/QC) program. The team must collect equipment blanks, duplicates, and field blanks as described below.

The sampling team is permitted to modify the sampling techniques described in this method to improve performance or reduce sampling costs, provided that reliable analyses of samples are obtained and that samples and blanks are not contaminated. Each time a modification is made to the procedures, the sampling team is required to demonstrate that the modification does not result in contamination of field and equipment blanks.

3.2.7.7.1 Field Blank

To demonstrate that sample contamination has not occurred during field sampling and sample processing, at least one field blank or duplicate must be generated for every 10 samples that are collected.

3.2.7.7.2 Field Duplicate

To assess the precision of the field sampling and analytical processes, at least one field split sample must be collected for every 10 samples that are collected during a given event.

Field blanks are typically done in the beginning and end of a sampling run to identify problems with sampler handling/field techniques and field duplicates in the middle of a sampling run to identify problems with the laboratory.

When the field duplicate sample analytes are >20% of the original sample analyte, add the RPD qualifier to the Results table in the WQDB. The RPD qualifier indicates that the "Relative percent difference exceeded criteria" and data should be selectively used.

The field split is collected by splitting a larger volume (a single container which is filled following clean hands/dirty hands procedures) into two aliquots in the clean box or bag. Using a churn splitter inside a clean bag is normally not practical and will be avoided.

3.3 STREAM COLLECTION TECHNIQUES

3.3.1 COLLECTING A REPRESENTATIVE STREAM SAMPLE

ADEQ employs four techniques for collecting representative water samples from rivers and streams: grab, equal width increment, modified equal width increment and equal discharge increment. TABLE 3.4 describes when each method should be used. The equal width increment, modified equal width increment and equal discharge increment are composite sampling techniques.

Method	When to Use
Grab Sample	Depth < 1 foot, velocity OR < 1.5 ft/s, homogeneous water in stream
Equal Width Increment (EWI)	Depth ≥ 1 foot, velocity AND ≥ 1.5 ft/s, heterogeneous water in stream
Modified EWI	Depth < 1 foot, velocity AND < 1.5 ft/s, heterogeneous water in stream
Equal Discharge Increment	Not commonly used. Same requirements as EWI, but provides a slightly more representative sample for SSC. Use if sand present in 250 micron sieve.

TABLE 3.4. Stream collection method matrix.

All water samples must be collected upstream of any activity that has occurred within the sample reach during field work. This refers primarily to those sampling techniques that involve physical disturbance to the stream bed (e.g. instantaneous flow measurement, pebble counts, macroinvertebrate collection, walking across the channel points in the reach, etc.).

Water samples should be collected after completion of field measurements. In those cases where the water sample cannot be practically taken at the end of the sample visit, it is important to not allow the temperature of the samples to rise significantly above the ambient temperature of the water body being sampled. If an ice chest is not readily available, place the sample bottles in a shaded location in the stream.

For composite samples, the sample for SSC analysis should be withdrawn from the churn splitter first.

A 250 micron sieve may be used to make a visual determination as to whether sand-sized particles are suspended in the water column. Using a 1-liter sample collection bottle, the field person collects a grab sample at the deepest, fastest point in the stream channel. The sampler should take care not to sample any bed material. Slowly empty the water in the sample collection bottle into the sieve and visually inspect the sieve for sand-sized particles. If sand sized particles are not in the sieve, then the observer may collect a grab sample or use the Equal-Width-Increment (EWI) method to obtain a composite sample using a churn splitter. If sand-sized particles are in the sieve, then the sampler

may collect a grab sample or use the equal-discharge-increment (EDI) method to obtain multiple sample bottles for SSC analysis. SSC protocol should be collected in wadeable, perennial streams during normal flows. The SSC field protocol has been adapted from Field Methods for Measurement of Fluvial Sediment (Edwards and Glysson, 1999). The equipment and field methods described in this protocol are designed to yield a representative sample of a water/sediment mixture moving in a stream. Tests performed by the U.S. Geological Survey demonstrate that a composite sample from a churn splitter can provide unbiased and acceptably precise (generally within 20% of the known value) SSC values as large as 1,000 mg/L when the mean diameter of sediment particles is less than about 0.25 mm. At SSC values of 10,000 mg/L or more, the bias and precision of SSC values in churn splitter sub-samples are considered unacceptable (Gray, et al., 2000).

3.3.1.1 Grab Sample Method

1. Determine a representative spot to sample that is well mixed and meets the guidelines in TABLE 3.4. Rinse the bottle with stream water three times to flush out any contaminants that might be present. Dispose of rinsate downstream of your collection point. Collect the sample by inverting the bottle open end down, and lower to half the water column depth taking care not to disturb any sediments on the stream bottom. Turn the bottle so that it is parallel to the stream bed, allowing the air to escape and the bottle to fill.

Label the bottle when it is dry before immersing it into the water.

2. Fill the individual sample bottles leaving space for the introduction of the acid preservative. Secure sample bottle caps tightly.
3. Filter the dissolved metal sample (see Section 3.2.3).
4. Add preservatives (see Section 3.2.4).
5. Place the samples in an ice-chest in an upright position.

3.3.1.2 Equal Width Increment Sample Method

Equal-Width Increment (EWI) sample collection and Equal-Discharge Increment (EDI) sample collection methods were developed and refined by the United States Geologic Survey (USGS). Both techniques utilize an isokinetic depth-integrating sampler (DH-81) that is designed to accumulate a representative water sample both continuously and isokinetically, meaning that the water approaching and entering the sampler intake does not change in velocity. EWI and EDI sampling techniques are commonly used in larger flowing systems which cannot be adequately characterized with a grab sample. The purpose for collecting a EWI sample is to obtain a series of sub-samples, each representing a volume of water taken at equal vertical transit rates and at equal

FIGURE 3.14. 14 liter churn splitter.

widths apart from each other at various intervals across the channel. This ensures obtaining a discharge weighted representative water sample from the entire flow passing through the channel.

Instantaneous discharge of the water body is determined with the flow meter and top-setting wading rod (see Chapter 5 for an explanation on how to take instantaneous discharge).

Samples are collected using a Isokinetic Depth-Integrating Sampler (US DH-81 hand-held sampler, FIGURE 3.10) which consists of four distinct parts: a three foot long metal rod with a plastic-vinyl handle on one end and machined threading on the opposite end; a US DH-81A molded Teflon adaptor which attaches to the threaded end of the wading rod; a US D-77 molded Teflon cap which has an internally molded air-vent tube; a machined Teflon US D-77 Nozzle with a 5/16 inch sample intake opening; and a 1-liter collecting bottle. ADEQ primarily uses the 1/4 inch nozzle, which is for flow velocities between 1.5 and 7.6 ft/sec.

FIGURE 3.10. DH-81 Sampler.

EWI Sampling Procedure

1. Upon arrival at the sample site, remove the churn splitter from its protective plastic bag and rinse it well two to three times with water from the stream. Fill to about 1/2 to 3/4 full and place the capped container in a shaded location in the stream. This will allow the churn splitter and ambient stream water to equilibrate prior to sampling. When ready to collect the sample, remove the cover and empty the churn splitter. Place the cover in the plastic bag to prevent contamination of the water sample when replacing the cover after the sample has been collected (or just keep the cover on).
2. Extend a measuring tape transect across the stream channel, perpendicular to the flow at a sampling location not influenced by side-channel eddies.
3. Measure the instantaneous flow discharge. This preliminary measurement is required in order to perform the EWI. Take note of the location of the fastest flow once the discharge measurement has been completed.
4. The EWI requires multiple sampling points across the transect. The number of sampling points (vertical intervals) to be sampled is based on the following variables:
   - Volume of sample needed for analysis (number of sample bottles to be filled)
   - Size of the churn splitter
   - The depth and velocity distribution in the cross section at time of sampling.

It may take several tries to get the right sample volume for a particular stream. Adjust the number of verticals to get the appropriate volume of sample for the churn splitter.

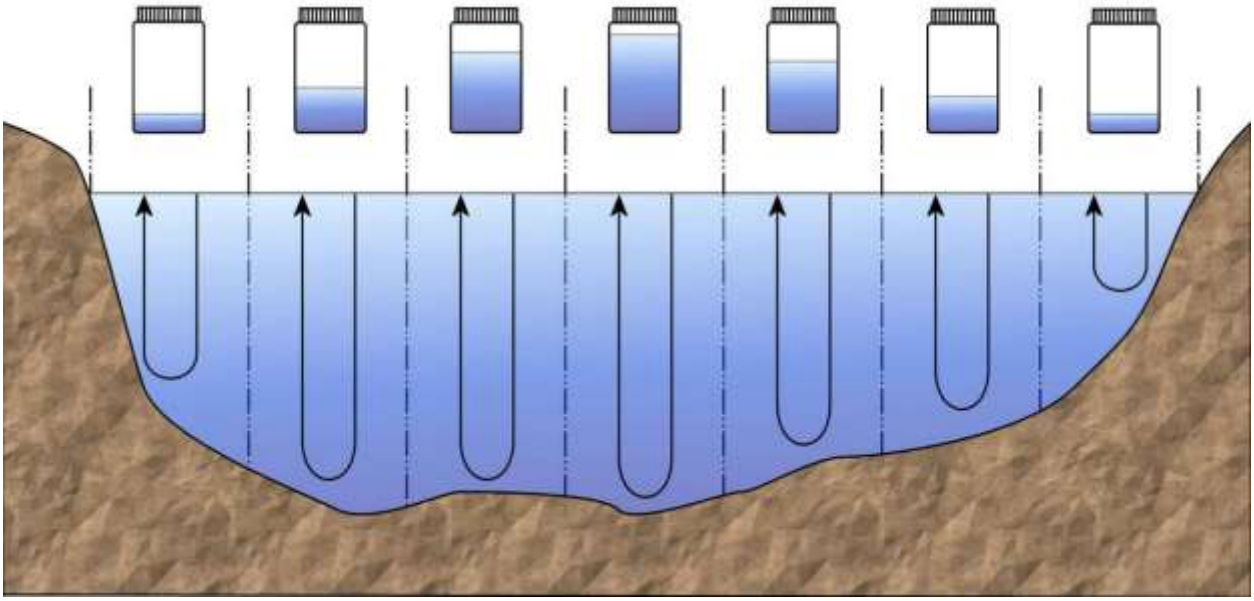


FIGURE 3.11. Depth-integrated samples collected using the equal width increment method.

5. The sampler should pick a reference point on the body (such as a belt buckle) to use as a starting reference point when initiating a vertical transect. All vertical transits across the channel should begin at the same reference point regardless of water depth.
6. Establish the vertical transit rate by determining the location of maximum velocity in the channel obtained from the discharge measurement. In most cases this will be the deepest, fastest point identified along the transect line. The sampler is positioned at the fastest point in the stream. The sampler positions the DH-81 bottle at the predetermined reference point (e.g., belt buckle) and begins lowering the DH-81 with a constant motion to the streambed and then back again to the reference point. During this period the sampler should be counting time from beginning to end of transit. If the first transit attempt did not fill the bottle, empty the bottle, repeat the process and adjust the transit rate until the DH-81 bottle is filled to just below the neck of the bottle. The sampler must repeat the transit if the DH-81 collection bottle is overfilled or underfilled. Once the correct transit rate has been determined, discard the collected water. Do not use this water as part of the final water sample.
7. Using the transit rate established in Step 6, move to either bank and prepare to collect the sub-samples at the established intervals and transit rate. The number of intervals is calculated based on the volume of water to be collected and the size of the churn splitter being used. For example, if four liters of water are needed and a six liter churn splitter is used, a minimum of five liters of sample water is needed. Once the sample water has been withdrawn from the churn splitter to fill the sample bottles, a minimum of one liter must remain in the churn splitter. To calculate the number of intervals, it is known that a full liter will be collected at the fastest flow location and decreasing amounts will be collected on

either side of that location. FIGURE 3.11 illustrates this process. Estimate the number of transit intervals by made taking into account the width of the channel, the depth of water, and the flow rate through the channel cross-section.

8. Once the number of sub-samples has been estimated, the interval width is calculated. For example, if the stream width is 20-feet, and the number of sub-samples is estimated to be 10, then the width of each sample interval would be 2 feet. The actual sampling station within each interval is located at the center of the interval. Beginning at a location of 1 foot from the bank, the intervals are then spaced 2 feet apart, resulting in sample stations at 1, 3, 5, 7, 9, 11, 13, 15, 17 and 19 feet along the 20-foot width.
9. Collect the sample in the first interval with the DH-81 at the predetermined transit rate (Step 6). It is important to remember to begin and end at an established reference point (belt buckle) and maintain a constant rate. A second observer should accompany the sampler carrying the churn splitter to receive the samples.

It is often possible to composite samples at two or more verticals near the banks without having to empty the sample collection bottle into the churn splitter to save time. However, if the collection bottle is over filled during the sample collection process, the bottle must be emptied of its contents and all verticals, which contributed to that particular sub-sample must be recollected.

10. After all the sub-samples have been deposited into the churn splitter, the individual pre-labeled sample bottles can be filled.

Bacteria samples should not be collected from the churn splitter. Plastic churn splitters cannot be autoclaved and thus may already be contaminated before the composite sample is taken.

Churn the sample at a uniform rate of about 9 inches per second. The mixing disc should touch the bottom of the churn on the down stroke but should not be allowed to break the water surface on the up stroke. A minimum of 10 strokes is required before withdrawing the first subsample. Before withdrawing the sample water, run a small quantity of water through the spigot as rinse to remove any contaminants that may have adhered to the inside of the spigot body. If the disk breaks the water surface while a subsample bottle is being filled, momentarily stop the filling process and stroke 10 times before continuing to fill the subsample bottle.

3.3.1.3 Modified Equal Width Increment Sample Collection

The Modified EWI method is often used in small wide streams where depths are less than one foot, and horizontal mixing is insufficient for capturing a representative sample. It is also used in shallow streams where tributary inflows are not well mixed with the dominant mainstream flow. The procedure is designed to produce a sample that is more representative than a grab sample, but not discharge weighted as with the EDI collection method. The sub-samples are collected by hand with the wide-mouth 1-liter collecting bottle at the determined vertical intervals.

Modified EWI Sampling Procedure

1. The procedure for the modified EWI is the same as the EWI in Section 3.3.1.2 with the exception that the no rod is used. The sampler uses their hand instead of the rod.

   For streams of shallow depth where the use of a 1-liter bottle and a churn splitter may be impractical, use a clean 250 milliliter bottle to collect the sample. Establish four sampling points along the transect that are approximately equal in distance from each other. Collect a sub-sample from each point, using a transit rate that fills the bottle completely and evenly at each point along the transect. Cap and invert the bottle several times to mix the sample.

3.3.1.4 Equal Discharge Increment Sample Collection

Equal discharge increment sampling is used when sieving indicates that sand-sized particles are entrained in the water column and the stream is 10-feet wide or wider. If sand-sized particles are entrained in the water column and the stream is less than 10-feet wide, a grab sample may be taken from a single vertical in the deepest, fastest location in the channel.

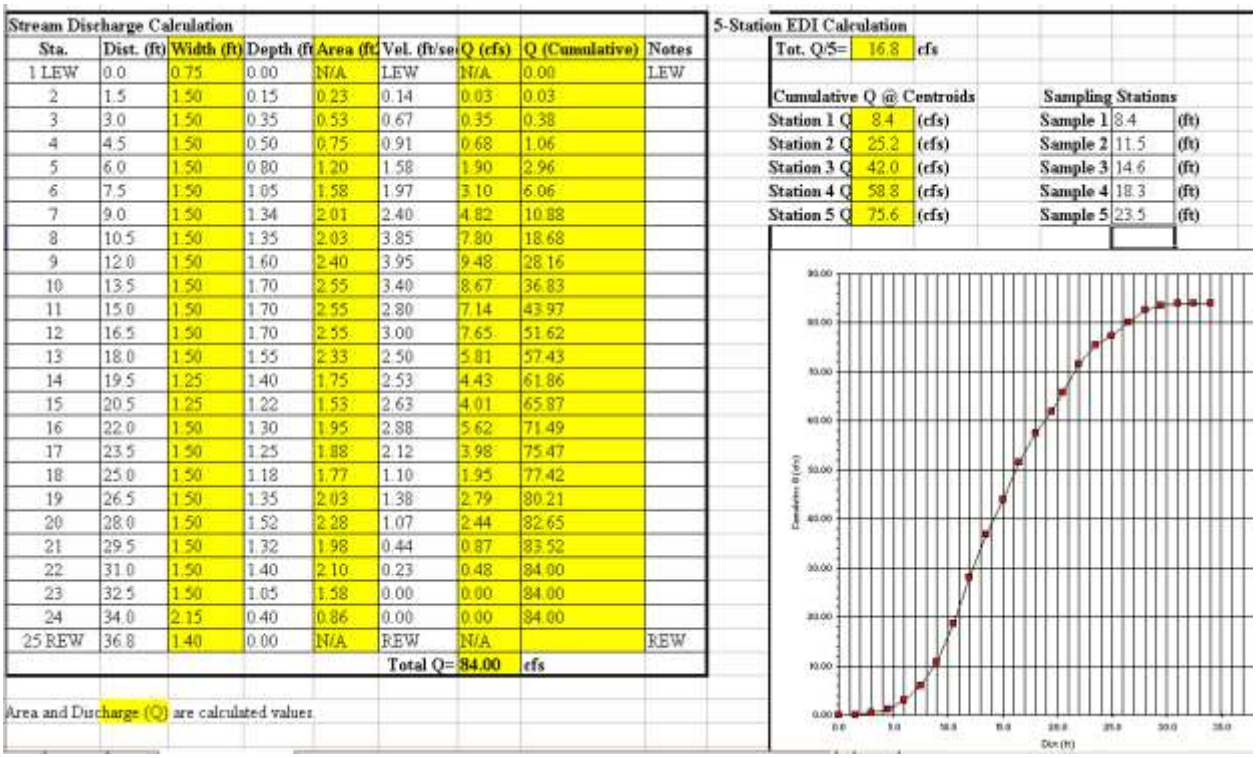
The Equal Discharge Increment (EDI) method produces a discharge-weighted sample that represents all the flow passing through the cross section by collecting a number of sub-samples, each representing equal volumes of discharge. The flow in the cross section is divided into increments of equal discharge and then equal-volume. Depth-integrated samples are collected at the centroid of each increment along the transect. The term centroid refers to the location in the channel transect where discharge is equal on both sides. EDI sample collection is used by ADEQ principally for the collection of suspended sediment concentration samples.

Equal Discharge Increment Procedure

The objective of the EDI is to collect a discharge-weighted sample that represents the entire flow passing through the cross-section by obtaining a series of samples, each representing equal volumes of stream discharge.

1. Place measuring tape across stream channel perpendicular to flow at the sampling site. Determine the stream width from the edges of water.
2. Take discharge measurements using Marsh McBirney flow meter to determine the total discharge and the flow distribution across the channel at the cross section. When recording discharge measurements on the field form, the recorder should include a cumulative discharge column and keep a running total of the cumulative discharge from the LEW.

Use the "EDI Flow Template" excel spreadsheet on a laptop or pocket PC (FIGURE 3.12) to determine the cumulative Q, centroid locations and sample station locations.



Stream Discharge Calculation

Sta.	Dist. (ft)	Width (ft)	Depth (ft	Area (ft	Vel. (ft/se	Q (cfs)	Q (Cumulative)	Notes
1 LEW	0.0	0.75	0.00	N/A	LEW	N/A	0.00	LEW
2	1.5	1.50	0.15	0.23	0.14	0.03	0.03	
3	3.0	1.50	0.35	0.53	0.67	0.35	0.38	
4	4.5	1.50	0.50	0.75	0.91	0.68	1.06	
5	6.0	1.50	0.80	1.20	1.58	1.90	2.96	
6	7.5	1.50	1.05	1.58	1.97	3.10	6.06	
7	9.0	1.50	1.34	2.01	2.40	4.82	10.88	
8	10.5	1.50	1.35	2.03	3.85	7.80	18.68	
9	12.0	1.50	1.60	2.40	3.95	9.48	28.16	
10	13.5	1.50	1.70	2.55	3.40	8.67	36.83	
11	15.0	1.50	1.70	2.55	2.80	7.14	43.97	
12	16.5	1.50	1.70	2.55	3.00	7.65	51.62	
13	18.0	1.50	1.55	2.33	2.50	5.81	57.43	
14	19.5	1.25	1.40	1.75	2.53	4.43	61.86	
15	20.5	1.25	1.22	1.53	2.63	4.01	65.87	
16	22.0	1.50	1.30	1.95	2.88	5.62	71.49	
17	23.5	1.50	1.25	1.88	2.12	3.98	75.47	
18	25.0	1.50	1.18	1.77	1.10	1.95	77.42	
19	26.5	1.50	1.35	2.03	1.38	2.79	80.21	
20	28.0	1.50	1.52	2.28	1.07	2.44	82.65	
21	29.5	1.50	1.32	1.98	0.44	0.87	83.52	
22	31.0	1.50	1.40	2.10	0.23	0.48	84.00	
23	32.5	1.50	1.05	1.58	0.00	0.00	84.00	
24	34.0	2.15	0.40	0.86	0.00	0.00	84.00	
25 REW	36.8	1.40	0.00	N/A	REW	N/A		REW
					Total Q=	84.00	cfs	

Area and Discharge (Q) are calculated values.

5-Station EDI Calculation

Tot. Q/5=	16.8	cfs			
Cumulative Q @ Centroids			Sampling Stations		
Station 1 Q	8.4	(cfs)	Sample 1	8.4	(ft)
Station 2 Q	25.2	(cfs)	Sample 2	11.5	(ft)
Station 3 Q	42.0	(cfs)	Sample 3	14.6	(ft)
Station 4 Q	58.8	(cfs)	Sample 4	18.3	(ft)
Station 5 Q	75.6	(cfs)	Sample 5	23.5	(ft)

FIGURE 3.12. Flow EDI Template.

3. Calculate the EDI. The EDI is determined by dividing the total cumulative discharge by the number of verticals to be sampled. For example, if the total cumulative discharge of the stream is 84 cfs and 5 verticals are to be sampled, then the EDI method is 16.8 cfs. The number of verticals is determined by the sample volume that is needed. If 4 liters of sample are needed then 5 verticals should be used. This will leave 1 liter in the churn.
4. The location of the centroids of the equal discharge increment is determined from the cumulative discharge calculations. The first vertical is located at a point where the cumulative discharge from the LEW is half of the EDI. In the previous example, if the EDI is 16.8 cfs, then the first vertical is located at the point where the cumulative discharge = 8.4 cfs. Subsequent centroids are located by adding the EDI to the cumulative discharge at the first vertical. In our example the second vertical would be located at the point where cumulative discharge = 8.4 + 16.8 = 25.2 cfs relative to the LEW. Use the same approach to determine the centroid discharge amounts for the 3rd to 5th centroids. The spreadsheet will calculate these automatically. Adjust the spreadsheet if the number of verticals need to be adjusted.
5. Use the Cumulative Discharge Curve (FIGURE 3.12 and FIGURE 3.13) to determine the locations of the five sampling stations.

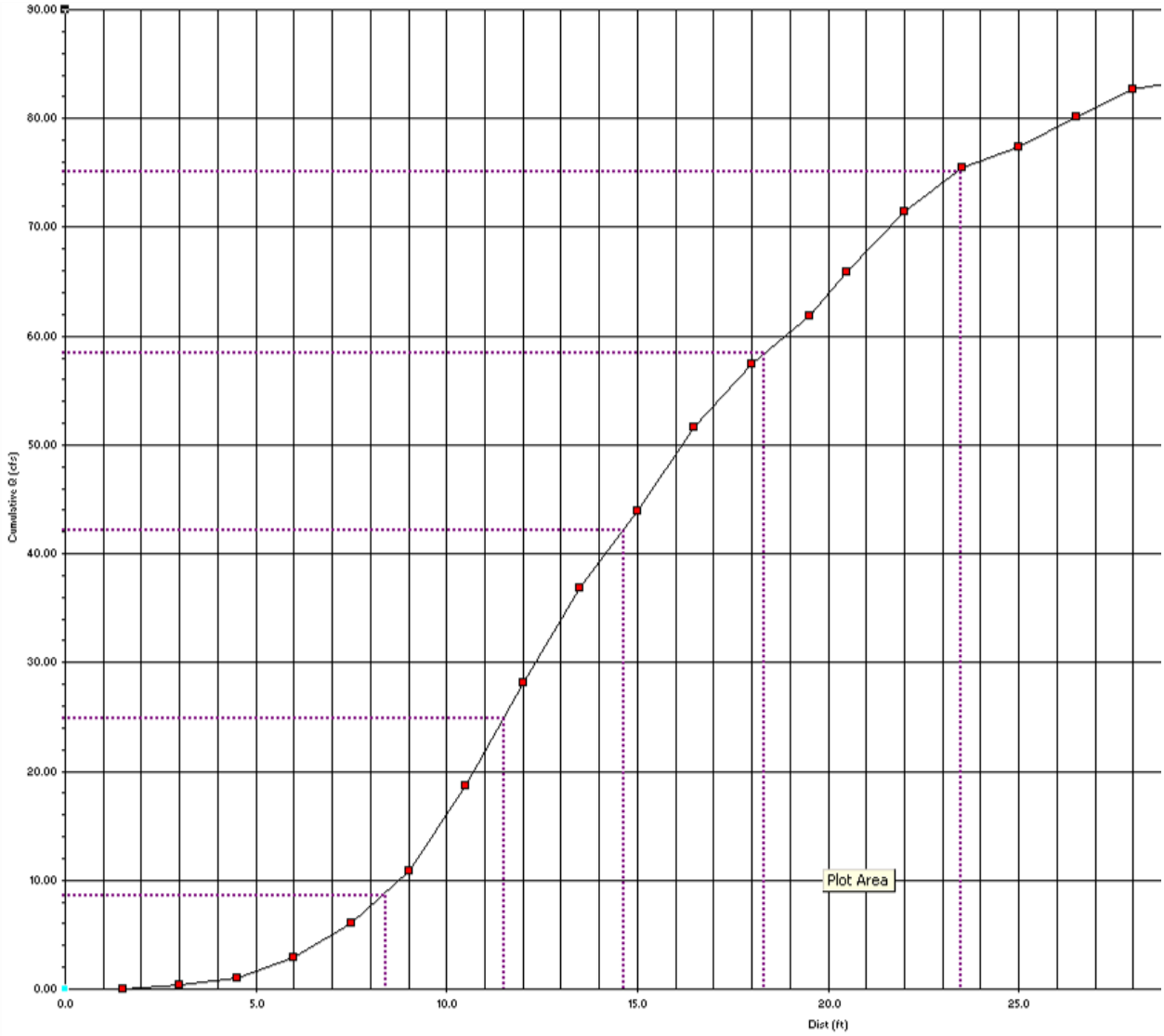


FIGURE 3.13. Close-up view of the Cumulative Discharge Curve from the "Flow EDI Template". Dotted lines represent the 5 cumulative Q centroid locations and the corresponding sample points across the transect.

6. A depth-integrated sample is collected at each sampling station using a DH-81 sampler. The transit rate used to collect a sample must be constant in one direction. However, it is not necessary to maintain equal transit rates of ascent and descent within a vertical. Also transit rates can vary at different verticals in the cross-section. A single sample bottle is filled at each vertical (FIGURE 3.14).

It is important that all sample bottles be of equal sample volume.

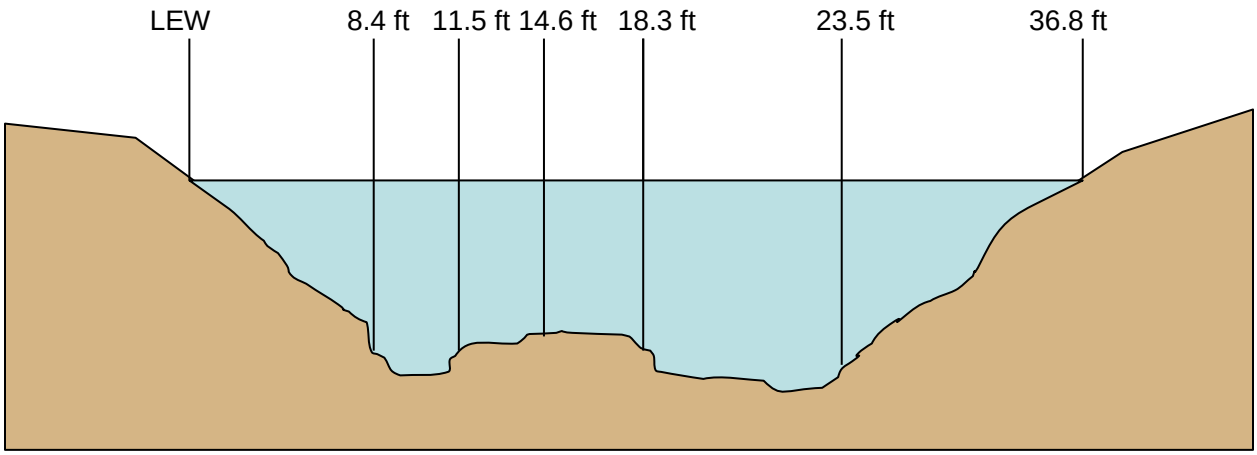


FIGURE 3.14. Cross-section showing the 5 sample locations.

3.4 LAKE SAMPLING TECHNIQUES

The number of samples collected for a particular site will depend on whether or not the lake is stratified. To determine stratification, a multimeter probe will need to be extended to the bottom of the lake at the sample site.

1. Before using the probe you will need to calibrate it for the local barometric pressure and for depth (see Section 3.1.1 for additional detail). When you get to the lake, attach the cable, face and probe.
2. Screw on the probe cover that allows water to pass through. Place the probe in the water at a depth of approximately 10 cm. Record field parameters on field data sheet (percent DO, pH, etc.).
3. Slowly lower the probe to 1m for the second reading. Continue at 1 m intervals until you reach the bottom of the lake. Allow the probe reading to stabilize before recording. Take the last reading at 0.5 m above the suspected bottom of the lake. If the site is extremely deep, consider reading the probe at every 2-5 m. Just be sure to capture at least 3 equally-distanced readings within the epilimnion and the hypolimnion and to identify the thermocline (FIGURE 3.15).

A lake is thermally stratified when there is a change of more than ONE degree Celsius per meter. This depth is called the thermocline.

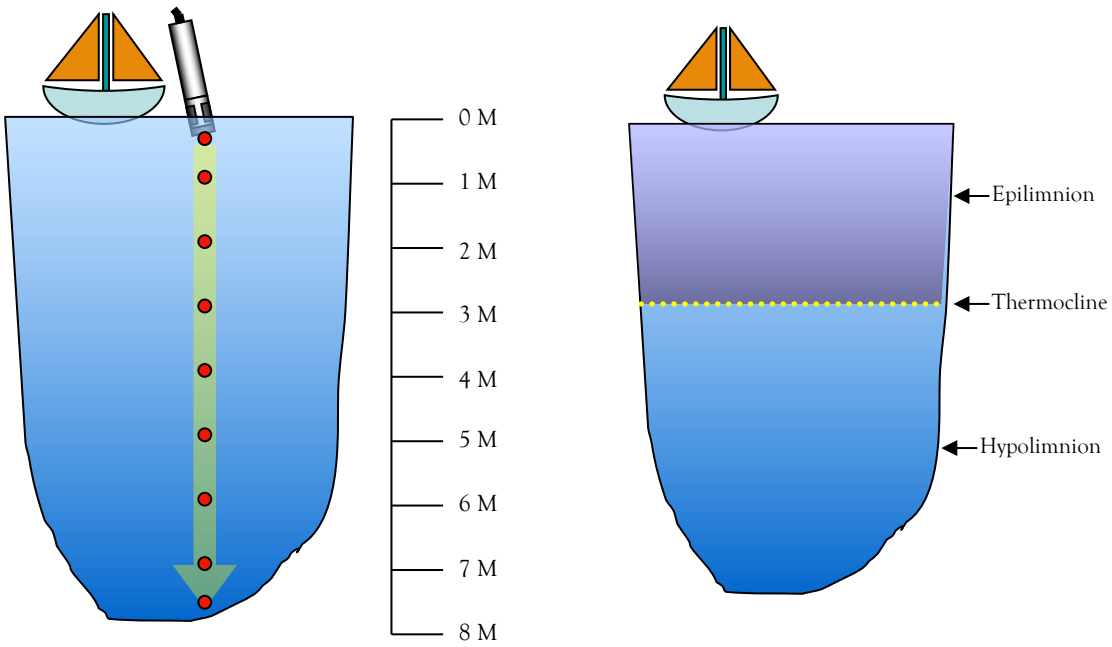


FIGURE 3.15. Red dots represent depths where multiprobe readings are taken.

Repeat any suspect measurements and make notes on the field sheet and in the instrument's logbook if the DO membrane had to be replaced.

The DO membrane will dry out if left exposed to air so, as soon as possible, cover it with the cap including about 5mL of water. When sampling is complete, return the probe to the case and be sure the cap is tight so that the water won't leak out. If there is dirt on the probe, be sure to clean it (gently wash with water) and do any necessary maintenance before returning it to the storage area.

3.4.1 COLLECTING A REPRESENTATIVE LAKES SAMPLE

A representative sample is a collection of grab samples that represent the vertical and spatial components within the main body of the lake. Samples are generally not taken in shallow, stagnant portions of the lake. Instead, lake sampling focuses on the mid-lake sample within geomorphologically distinct subunits of the lake. Examples of subunits may include the forebay, mid-lake and inlet. The morphology of each lake is unique and may require a different number of samples in order to characterize the condition of the lake. A sample is always taken near the dam site as a reference.

A small (<200 acres), round lake may not require more than two sampling locations – one at the dam and one in a more centralized location. A lake with many tributaries may exhibit different chemical concentrations in water near each inlet. While it is not necessary to sample near each inlet, the sampler should make an attempt to capture a sample in an area near main tributary inputs or near a series of similar tributary inputs (FIGURES 3.16 and 3.17).

A minimum of three sampling locations should be taken across a lake unless the lake is small (<200 acres) or has a simple (round, few tributaries, tributaries drain similar watersheds) morphology.

A representative sample relies on repeatable collection practices. Lake sampling for assessment purposes should be conducted with a thief sampler such as a beta bottle. Sample bottles should be filled from a single collection from the 6 liter beta bottle to ensure that local site variation does not contribute to variation between sample bottles. The sample should be homogenized by gently swirling the beta bottle before filling each sample bottle.

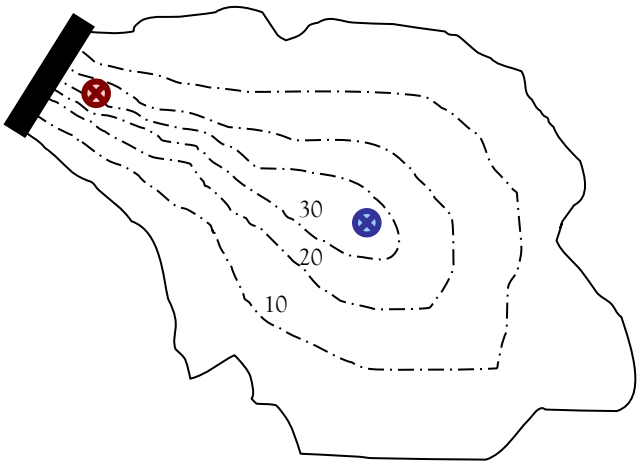


FIGURE 3.16. Simple lake with two sites. Dashed lines represent lake depth. Dam is represented by a solid black rectangle. The site is the blue "x". The dam site is the red "x"

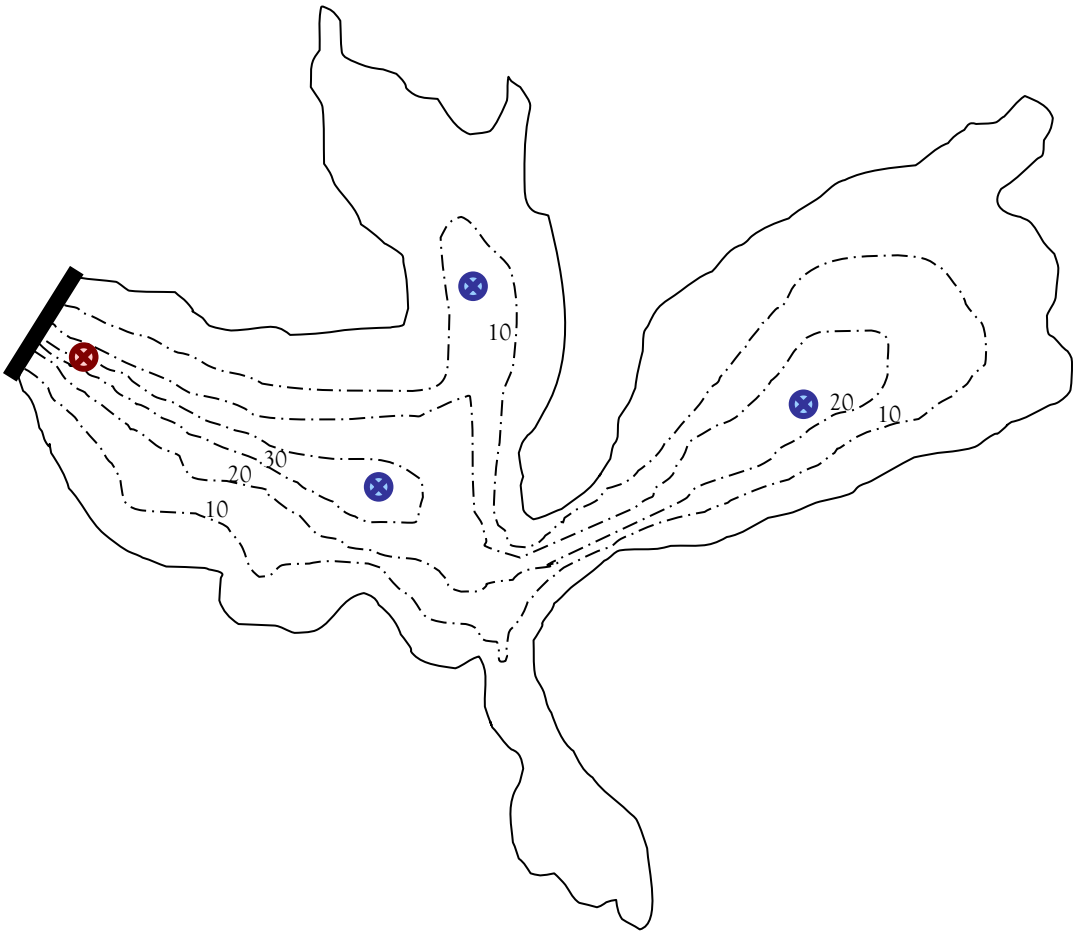


FIGURE 3.17. Complex lake with 4 sites. Dashed lines represent lake depth. Dam is represented by a solid black rectangle. The sites are represented by the "x's". The dam site is the red "x"

3.4.2 WATER SAMPLE COLLECTION

3.4.2.1 Secchi Depth

One sample is always collected in the photic zone of the lake. A secchi disc is used to determine the depth of the photic zone. The photic zone is where visible light penetrates to allow primary production.

1. Attach the secchi disc to a marked rope or to a meter tape (FIGURE 3.18). Lower the disc off the shady side of the boat and remove sunglasses or other visual obstructions. Slowly lower the secchi disc into the water until it disappears. Estimate the depth to the nearest 0.1 m. Record the depth at which it disappears. Lower the disc a little more and then slowly bring it back until it reappears. Record this depth as well. The average of these two values is the secchi depth. Record the secchi depth.
2. Multiply the secchi depth by a correction factor of 1.5. This identifies the depth of the photic zone.

FIGURE 3.18. Secchi disc and marked chain.

3.4.2.2 Beta Bottle

Prior to collecting a beta bottle sample you should have identified if the lake is stratified or not according to Section 3.4.

3.4.2.2.1 Beta Bottle Collection Point in an Unstratified Lake

Only one sampling depth is needed for unstratified lakes. The sampling depth is 1/2 the depth of the photic zone (FIGURE 3.19).

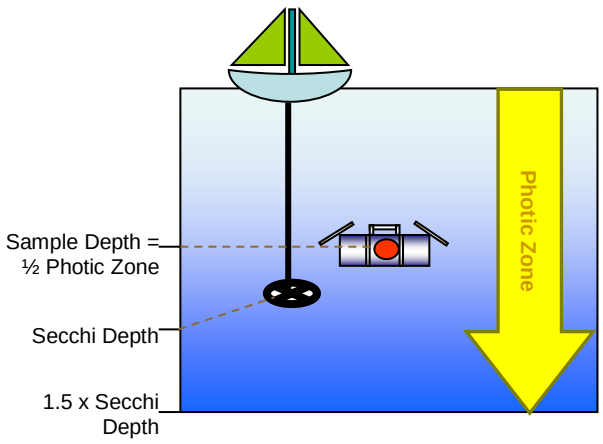


FIGURE 3.20. Beta bottle.

FIGURE 3.19. Sampling location for an unstratified lake.

1. The beta bottle should be rinsed in the lake water before sampling (FIGURE 3.20). Swish it back and forth slowly with the side lids open.

Record top and bottom sampling depth (generally the same).

2. The beta bottle rope is marked in 1 meter units. Lower the beta bottle to the desired depth.

Field parameters from the depth profile must be collected at the same depth as the beta bottle so lab and field chemistry can be compared and standards calculated.

3. Swish the bottle horizontally back and forth and let it sit for approximately 30 seconds. Then deploy the messenger to collapse the lids. Slowly raise the beta bottle out of the water and use the pour spout to empty its contents into sample bottles. Gently swirl the beta bottle between filling up sample bottles. When pressure is low, it may help to loosen the yellow valve or to place something between the lid and the bottle to keep the lid open.
4. The beta bottle should not be cleaned with detergents or bleach. Use tap water and a clean brush to wash the inside and outside of the beta bottle. Keep the lids open while it dries. When dry, collapse the lids as soon as possible so that the cords do not become loose. Store the beta bottle in the plastic suitcase along with the rope and messenger.
5. Use the spigot to fill up the sample bottles.

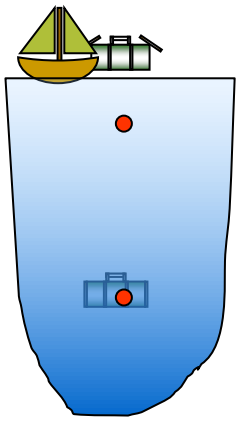


FIGURE 3.21. Stratified Lake Sample Points

3.4.2.2.2 Beta Bottle Collection Points in an Stratified Lake

At least two samples depths should be sampled for a stratified lake (FIGURE 3.21). One sample point will be collected in the epilimnion at the midpoint of the photic zone (see Section 3.4.2.2.1 for additional detail).

The hypolimnion sampling point is located at the deepest part of the lake or as deep as you can send the beta bottle without touching the bottom of the lake.

Field parameters from the depth profile must be collected at the same depth as the beta bottle so lab and field chemistry can be compared and standards calculated.

3.4.2.3 Sediment Sample Collection

A sediment sample is collected for the purpose of determining recent deposition quantities of nutrients and metals. There are two main types of sediment samplers that could be used: Eckman dredge and a Wildco corer.

The Eckman dredge is best to use in shallow, loose soils. The Wildco corer should be used in rocky substrates or at deep sites.

FIGURE 3.22. Ekman dredge.

Eckman dredge

1. Open arms on the Eckman dredge (FIGURE 3.22).
2. Swish it in the water to rinse, and then slowly lower it to the sediment. When you reach the sediment, let it sink in, then send the messenger down to collapse the arms.
3. Slowly raise the dredge out of the water. Open the top to scoop out a sample.
4. Release the unused sediment into the lake.

Wildco corers: pounder method

Wildco corers are meant to collect a core of water by pounding a heavy metal rod into the sediment. With the pounder, you can insert a plastic tube into the metal tube, and then close it off with a black sediment catcher and a white nose piece (FIGURE 3.23).

FIGURE 3.23. Wildco sediment corer.

1. After assembling the corer, make room for the three ropes and decide who will handle each rope. The ropes include the main handle for the corer, the rope for the lever than activates suction, and the rope to raise and drop the pounder.
2. Slowly lower the corer until it touches the sediment. Then, raise the corer approximately 1 m from the bottom and let it free fall. Pound repeatedly (about 3 times), using the ropes to gage how well the pounding is working. When you think the corer is solidly in the soil, raise the lever rope to create suction. Now with all three ropes being pulled, bring the corer to the surface.
3. Bring the corer to a horizontal position in the boat. Carefully remove the nose piece and catcher and scoop out the sample.
4. When you have collected the desired sample volume, return the corer to the lake water for rinsing. Do not expect to remove all the mud. A thorough cleaning should be done in the lab using soapy water.

Wildco corers: Modified KB corer

The Modified KB corer relies on a plunger to provide suction. The sample is collected within a detachable hard plastic tube. This corer is heavier and longer than the pounder and may lose suction more easily. However, because of the weight, it may be easier to identify when you have stuck the corer in the mud. You can avoid losing suction by reaching as far into the water as possible to plug the bottom end.

1. Insert the core tube into the housing sampling apparatus and tighten the hose clamps with a nut driver. Set up the plunger so that it will drop when the messenger is deployed. Use grease if necessary to ensure a tight seal between the plunger and the metal surface.
2. Lower the corer keeping the line taut until you reach bottom. Then pull up the corer to approximately 2 m above the bottom. Let the line slip through the hands until it hits bottom. Then, keep the line taut so that the corer doesn't tilt. Unless you are in rocky substrate, the force of the corer should have been enough to stick into the sediment. Trip the messenger to create the suction.
3. Very slowly raise the corer until the top part reaches the surface of the lake. At this point it is very easy to lose suction and lose the sample. With one person holding onto and stabilizing the corer and the other holding onto the rubber plug and ready to place it on the end of the tube, slowly raise the corer out of the water until the tube is plugged. Then raise the corer completely out of the water and set it vertically on the boat (in a tub or bucket reduces the mess). Loosen the clamps using a nut driver and separate the metal piece from the plastic piece.
4. Collect a sample from the top of the plastic tube which reflects the most recent deposition in the lake. Using the PVC extruder, push the sediment up toward the top of the tube. Place the stage over the opening and secure it with the built in screw. When the water has been extruded so that the soil is almost to the stage, remove excess water with a siphon.
5. Now place a plastic column with 1cm marked on top of the stage. Continue pushing the sediment up till it reaches the 1 cm level. Push the column towards the flat part of the stage. This cleaves off the top 1 cm of soil. Use a plastic spatula to push the soil into the collection jar. Repeat the cleaving process for additional soil volume.
6. Release any unused soil back into the lake and rinse the corer and associated parts in the lake. The sediment sampler should be washed with soap and water between lake surveys or after a sampling run.

3.4.2.4 Zooplankton Sampling

1. Lower 80 μm net in an upright position until the mouth of the net is 0.5 meters above the lake bottom (FIGURE 3.28).
2. Pull the net to surface at a steady rate without stopping (1 ft /sec).
3. At surface, move net up and down without submersing the mouth to rinse contents into collection bucket.
4. Rinse again by spraying water against the outside of net.
5. Remove bucket from net and concentrate contents by swirling bucket to remove excess lake water.
6. Repeat steps 1-5 on opposite side of boat using 243 μm net.

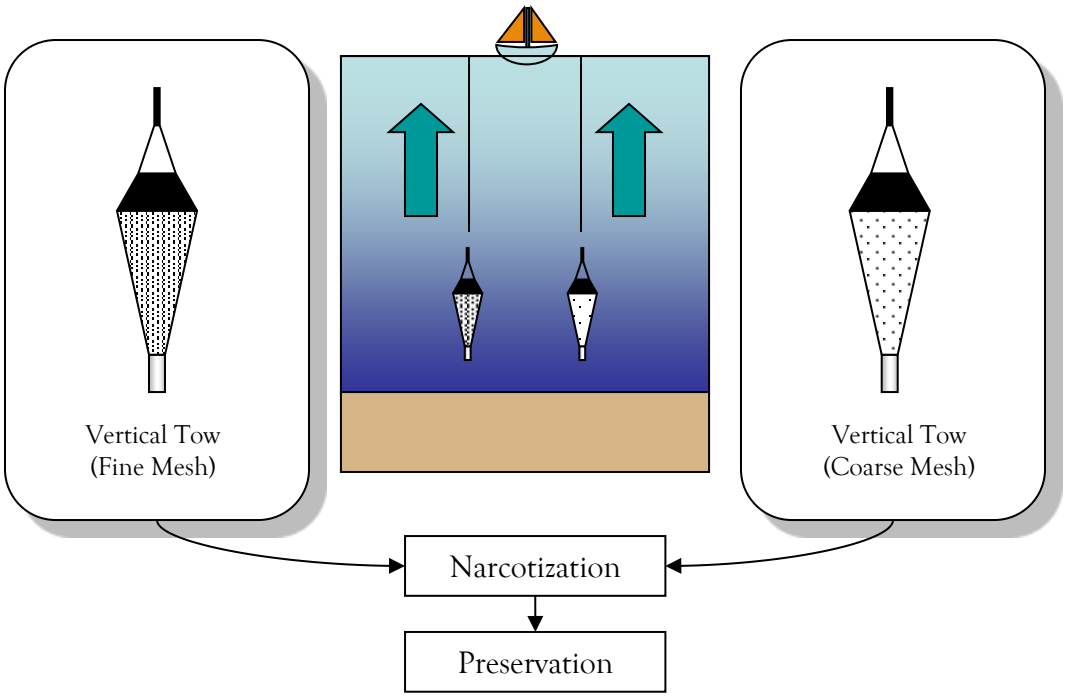


FIGURE 3.24. Coarse and Fine Zooplankton Tow s. Each are lowered 0.5 meters above the lake bottom and then raised to the surface. Samples are then narcotized and preserved.

Set collection bucket in a small container and narcotize zooplankton using water containing a CO_2 tablet (alternatively, Alka-Seltzer or club soda may be used). Wait until zooplankton movement has stopped (usually about 1 minute). Rinse contents of bucket into 125 ml jar using small volumes of DI water. Preserve sample with ethanol by filling sample jar to the 80 mL mark or a little more than half full.

3.4.2.5 Microcystin Sampling

Microcystin is a toxin produced by cyanobacteria and is harmful to humans and animals. ADEQ collects microcystin using three methods. Vertical tows, composite photic zone sample and grab samples. For mid lake samples both vertical tow and composite photic zone samples are collected to estimate total biovolume. Opportunistic grab samples are also collected when blooms are observed.

3.4.2.5.1 Microcystin Vertical Tow Sampling

1. The vertical tow sample is collected using the 50 um mesh zooplankton net (10 inch opening) attached to the 50 um cod collection cup by lowering the net to just above the deepest profile reading above the sediment.
2. The net is steadily raised to the surface and then rinsed on the outside with lake water to ensure that plankton are all washed down into the collection cup.
3. The cup is unscrewed from the net and placed in a small bucket. Using DI water, the inside of the cup is rinsed to concentrate the plankton.
4. Decant the rinsate into the sample bottle. Repeat this procedure as needed to make sure all the plankton is in the sample bottle (usually a 250-ml bottle). Fill the sample bottle 3/4 full of DI and then add a small amount of Formalin. Record the site, method, depth, net used

and preservative on the bottle (ex. CLHAV-A-Vtow, 18m, 50 um, 10" - preserved with Formalin).

5. Calculate the biovolume: mesh size*opening size* depth of pull. Record biovolume corrected microcystin concentration after the data come back from the lab.

3.4.2.5.2 Microcystin Photic Zone Composite Sample

1. Determine photic zone as described in Section 3.4.2.2.1.
2. If the photic zone is less than 2 m, collect three 2-m integrated samples using the 2m PVC sampler (2 liters*3) and composite in a churn splitter. If the optimum photic zone depth is greater than 2 m, collect two 2-m integrated samples plus additional water using the beta bottle at 1.5 m below the intervals below the 2-m integrated sample depth to capture the photic zone.

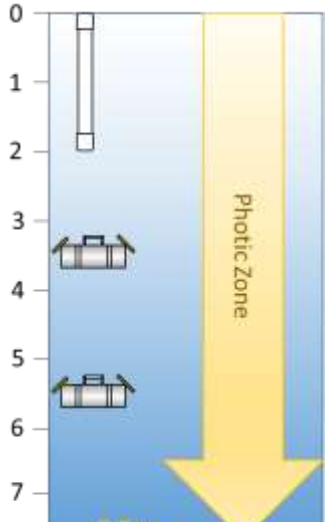


FIGURE 3.29. Composite photic zone sample. Two integrated sample volumes (white PVC near surface) are collected and 2 beta bottles are evenly distributed to collect additional volume deeper in the photic zone.

For example, Site A has an average secchi depth of 7.7 m. The photic zone is determined by multiplying secci depth by 1.5. The goal is to get a good composite representative sample from within the photic zone, so we would collect two 2-m integrated samples (each 2 liters) and evenly distribute one or two beta bottle volumns evenly throughout the photic zone.

Decant 2 L (about 1/3 of the water in the beta bottle) into the churn for each beta bottle collection depth (approximately 6 liters is needed to fill all epilimnion bottles).

Rinse each sample bottle three times with sample water while churning, then fill each sample bottle while churning. These samples would be labeled as CLHAV-A-5.8c. Algae ID samples are preserved with Lugols until a light tea color is obtained. No preservative is added to the Chlor-a/pheo-a/phyco bottle, as it would interfere with the fluorometry reading.

3.4.2.5.3 Microcystin Grab Samples

1. Collect sample in 250 mL bottle using pole or gloves. Sample collection depth in open water is generally 0.5 m below the surface. On a beach, sample collection are collected after wading to about knee depth approximately 6 to 8 inches below the water surface.
2. Preserve samples with lugols and keep out of sunlight.

3.5 FISH TISSUE SAMPLING TECHNIQUES

ADEQ collects fish tissue to determine risks to human health from pollutants such as mercury and pesticides. Because fish spend their entire lives in the aquatic environment, they incorporate chemicals from this environment into their body tissues. Contamination of aquatic resources has been documented for heavy metals, pesticides, and other complex organic compounds. Once these

contaminants reach surface waters, they may be available for bioaccumulation, either directly or through aquatic food webs, and may accumulate in fish and shellfish tissues. Results from fish tissue monitoring can serve as an important indicator of further contamination of sediments and surface water.

This procedure is used by the ADEQ's fish consumption advisory program to collect and process fish tissue samples to be analyzed for chemical contaminants. These procedures are based on established guidelines described in EPA's 2000 guidance for assessing chemical contaminant data for use in fish advisories.

3.5.1 SAMPLE COLLECTION

The fish consumption advisory program will employ several means of fish collection. Collections on lakes and non-wadeable streams are usually accomplished using a boat mounted electrofisher, gill nets or cast nets. Collections on wadeable streams are accomplished using backpack electrofishing techniques, cast nets or gill net "traps". Equipment checklists can be found in Appendix A.

Electroshocking is dangerous. All personnel involved must be be trained before operating and assisting with electroshocking fish (Bryan, et al. AGFD, 2004). See Secton 2.3 for additional electroshocking safety information.

Studies may use fish that are collected by other agencies or that fish that are purchased from recreational anglers. See Section 3.5.3.3 for minimum quality control measures, labeling and handling.

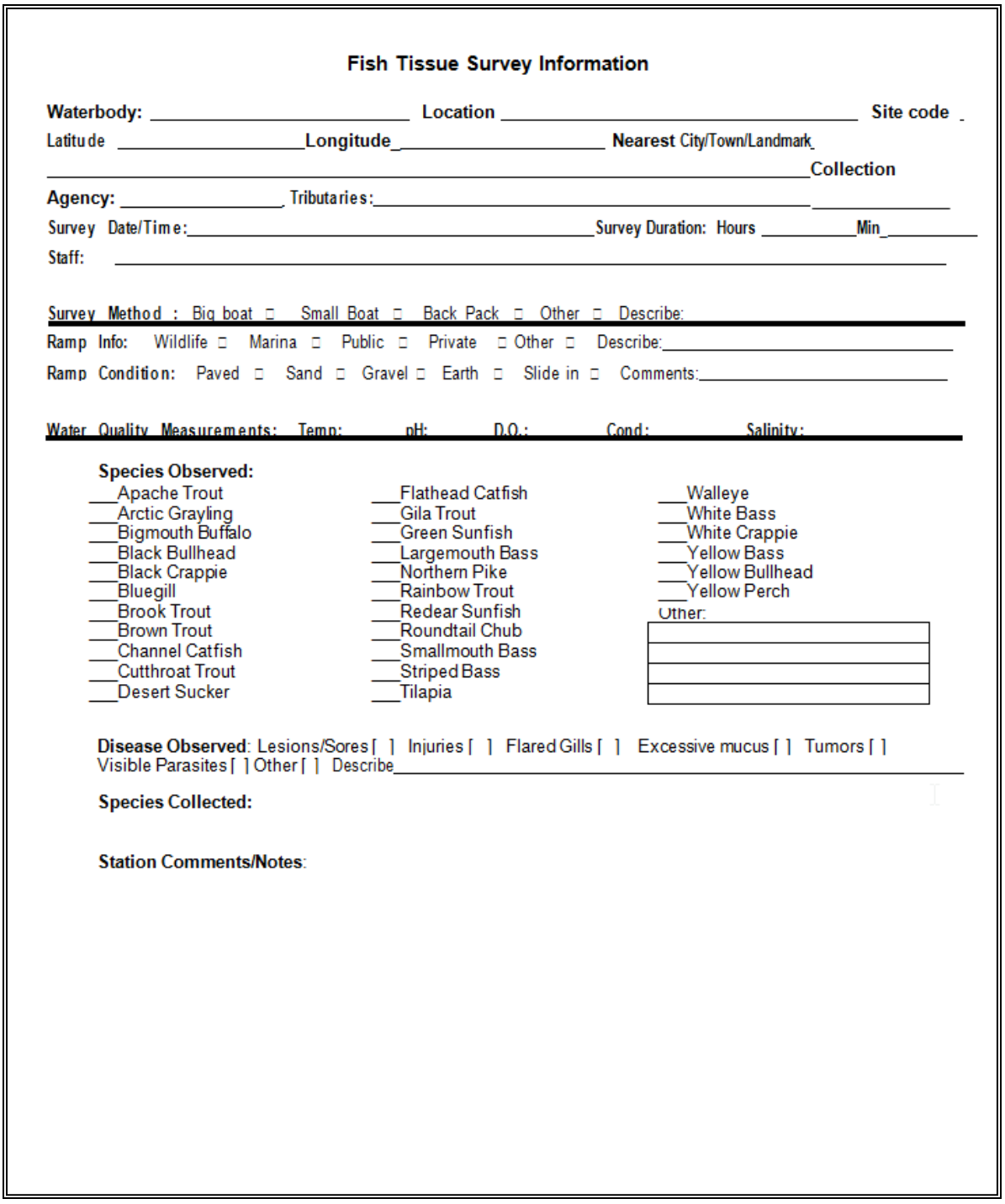
Use the following guidelines when selecting/collecting fish for tissue analysis:

1. Species: The species selected should represent game fish most likely caught and kept by anglers.
2. Size: The size range of fish collected should be representative of:
   a. Those most likely to be caught. "Trophy" fish are much less likely to show up in an angler's creel and may skew data due to their age and size.
   b. Size or slot limits placed on the waterbody by AGFD regulation.
3. Trophic position: High order predators like largemouth bass and walleye tend to bioaccumulate pollutants to a higher concentration due to their place in the food web.
4. Pollutant accrual and storage: Pollutants can be accrued and stored differently due to species and pollutant characteristics. Generally, mercury is stored in muscle tissue and organochlorines are stored in fat. "Oily" fish like the common carp will have the highest organochlorine concentrations and muscular predators like the largemouth bass will accrue mercury at a higher rate.
5. Trophic condition: Check with AGFD prior to sampling to see if the selected waterbody has undergone any large trophic shifts. Fish in poor condition will have less body fat, which can affect pollutant concentrations in the short term and may not be representative of long term values.

The following is a list of Arizona Game Fish. Preferred species are listed in red:

Bass, Largemouth	Carp	Sunfish, Green
Bass, Rock	Catfish, Blue	Sunfish, Hybrid
Bass, Smallmouth	Catfish, Channel	Sunfish, Redear
Bass, Striped Bass	Catfish, Flathead	Tilapia
Bass, Yellow	Crappie, Black	Trout, Apache
Bluegill	Crappie, White	Trout, Brook
Buffalo, Bigmouth	Grayling, Arctic	Trout, Brown
Buffalo, Black	Mullet	Trout, Cutthroat
Bullhead, Black	Northern Pike	Trout, Rainbow
Bullhead, Yellow	Perch, Yellow	Walleye

At each sampling station, ADEQ personnel should fill out a Fish Tissue Survey Form (FIGURE 3.25) to provide additional information regarding the site visit. The form allows field staff to document access conditions, all species observed during sampling, water quality measurements, disease information, and any comments about the station. If fish are collected by another agency, ADEQ personnel will collect as much of the metadata as practical from sampling personnel to fill in the Fish Tissue Survey Form.



Fish Tissue Survey Information

Waterbody: _____ **Location** _____ **Site code** _

Latitude _____ **Longitude**_____ **Nearest** City/Town/Landmark_

_____ **Collection**

Agency: _____ Tributaries:_____

Survey Date/Time:_____ Survey Duration: Hours _____ Min_____

Staff: _____

Survey Method : Big boat ☐ Small Boat ☐ Back Pack ☐ Other ☐ Describe:

Ramp Info: Wildlife ☐ Marina ☐ Public ☐ Private ☐ Other ☐ Describe:_____

Ramp Condition: Paved ☐ Sand ☐ Gravel ☐ Earth ☐ Slide in ☐ Comments:_____

Water Quality Measurements: Temp: pH: D.O.: Cond: Salinity:

Species Observed:

___Apache Trout	___Flathead Catfish	___Walleye
___Arctic Grayling	___Gila Trout	___White Bass
___Bigmouth Buffalo	___Green Sunfish	___White Crappie
___Black Bullhead	___Largemouth Bass	___Yellow Bass
___Black Crappie	___Northern Pike	___Yellow Bullhead
___Bluegill	___Rainbow Trout	___Yellow Perch
___Brook Trout	___Redear Sunfish	Other:
___Brown Trout	___Roundtail Chub	
___Channel Catfish	___Smallmouth Bass	
___Cutthroat Trout	___Striped Bass	
___Desert Sucker	___Tilapia	

Disease Observed: Lesions/Sores [ ] Injuries [ ] Flared Gills [ ] Excessive mucus [ ] Tumors [ ]
Visible Parasites [ ] Other [ ] Describe_____

Species Collected:

Station Comments/Notes:

Figure 3.25. Fish Tissue Survey Form

When sampling sites are close enough samples should be transported to the sample processing laboratory prior to weighing and measurement. Samples should be placed in Ziploc bags by species and cooled to 4° C on wet ice for transport. If the distance from sample site is greater than 200 miles or the time to the lab is greater than 36 hours, samples should be weighed, measured, tagged in the field with location, date, species, length in mm and weight in grams, and sampler initials, and frozen on dry ice. (See Section 3.5.3 - 4 for procedures, FIGURES 3.26 to 3.28).

Figure 3.26. Fish measurement for total length and weight.

3.5.2 MEASUREMENT, LABELING AND TRANSPORT

Fish collected for analyses must be transported to the processing laboratory in such a manner as to prevent decomposition or contamination. Fish should be removed from live wells, holding tanks, or buckets, rinsed with ambient water to remove foreign matter, and placed on a contaminant free surface for sorting. Skins on fish selected for analysis should be examined for breaks or lacerations from sampling gear - a possible source of contamination. If a wound is severe and actively bleeding, the fish should be released or discarded. Missing scales, burns from shocking equipment or small lacerations where the area to be subsampled (3.5.3.1) is clear of injury will not be cause for rejecting the sample. It is up to the lead sampler to determine if a fish should be rejected based on abnormalities.

3.5.3.1 Weight and length measurement

A wet weight is determined for each fish to the nearest gram (FIGURE 3.30) and recorded on the Fish "Fish Tissue Field Datasheet" (FIGURE 3.33). All samples should be weighed on balances that are properly calibrated, tared and of adequate accuracy and precision to meet program data quality objectives. Balance calibration should be checked at the beginning of each weighing session.

A total length ("nose" to end of tail) is determined for each fish to the nearest millimeter using a length board (FIGURE 3.26) and recorded on the "Fish Tissue Field Datasheet" (FIGURE 3.29). When measuring, the mouth of the fish should be closed and the caudle or tail fin should be lightly compressed so that the absolute longest length is measured.

After measurement, larger fish will be dispatched by placing the fish upright (belly down) on a hard surface and administering several sharp blows with a hardwood dowel to the top of the head just behind the eyes. Smaller prey base fish will be dispatched by placing them in in a bucket filled with water so that the fish can only barely swim upright, and dropping in several Alka Seltzer tablets.

Individual fish are identified to species under the supervision of an experienced biologist familiar with Arizona fish fauna. Fish are first identified using current, regional identification manuals and other appropriate taxonomic literature (i.e.: Minkley, W. L. 1973). If questions occur, identifications are verified by other fish taxonomists or by experienced personnel from the Arizona Game and Fish Department.

3.5.3.2 Metals

Fish selected for metals analysis are placed individually in polyethylene bags. Optional: Prior to bagging the fish, a paper tag with a unique identifier, which includes date and waterbody, is affixed to the fish with a zip tie through the mouth and gills (FIGURE 3.27). Labels should contain the following:

- Waterbody
- Date
- Sampler initials
- Length in mm followed by weight in grams
- Fish species on the right hand side

After removing as much air as possible, the bags are sealed and tagged with the date, time, station name, species, and collector(s).

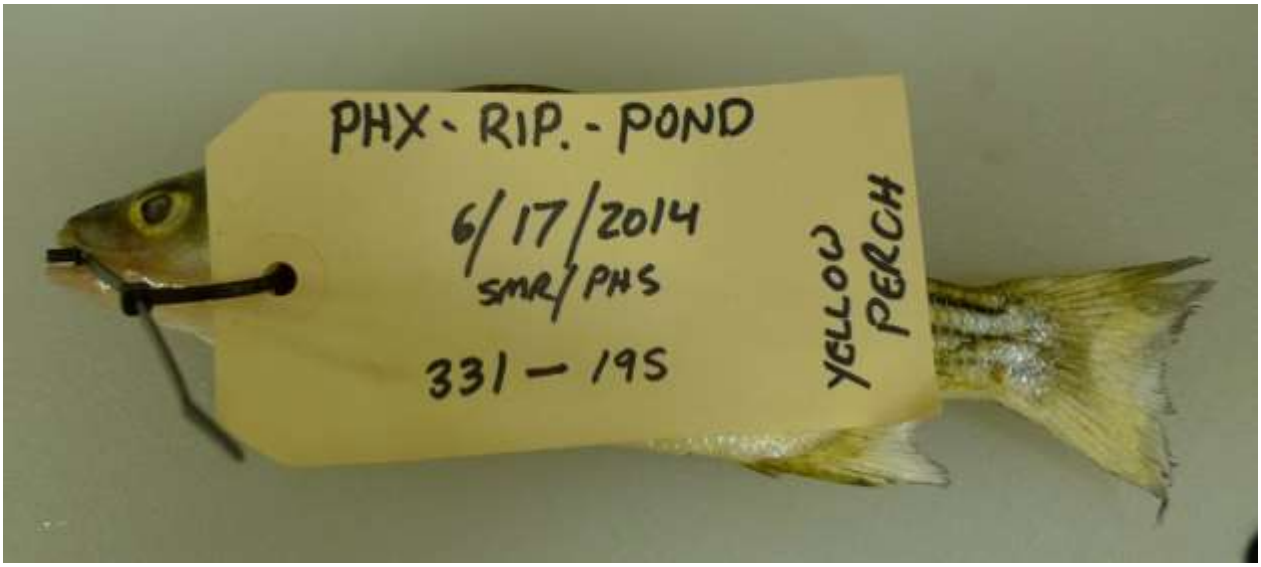


Figure 3.27. Fish labeling.

3.5.3.2 Organics

Fish selected only for organics analyses are tagged and wrapped whole in clean aluminum foil with the dull side of the foil against the skin of the animal. Large spines on any fish should be clipped to minimize puncturing of the foil (FIGURE 3.28). Wrapped fish are sorted by species and placed in labeled polyethylene bags as described for metals samples.

All polyethylene bags will be labeled with location, date, species, length in milimeters and weight in grams, and sampler initials (FIGURE 3.29).

Packaged fish are placed immediately on wet ice and chilled to 4°C for transport back to the laboratory. Samples transported on wet ice should reach the processing laboratory within 36 hours of collection to allow sufficient time for processing.

If samples cannot be transported to the processing lab within 36 hours of collection they should be frozen as whole fish, delivered to ADEQ as soon as possible, and stored at -20 °C until subsampling can be performed. If fish are frozen they should not be allowed to thaw during transport.

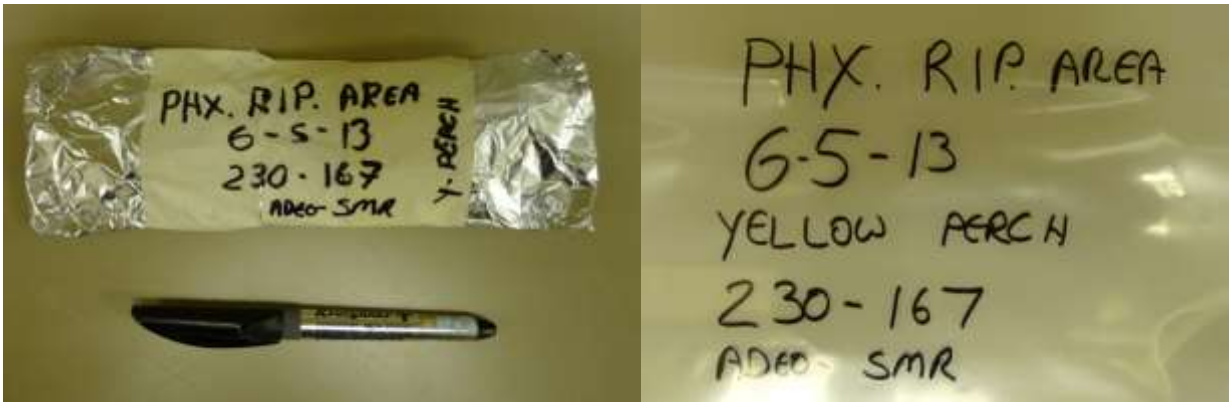


Figure 3.28. Outerbag fish labeling

3.5.3.3 Quality control and labeling of fish received from anglers

- All fish will remain whole and be weighed and measured in the field.
- Fish will be placed either aluminum foil or in ziplock bags as in 3.5.2.1 – 2.
- Individual fish will be labeled on the exterior package with:
  - Waterbody
  - Date (and time)
  - Species
  - Metric length and weight
  - Angler name (if available)
  - Receiving personnel
- Fish will be transported on ice to the ADEQ prep laboratory or frozen within 36 hours to await pickup.
- Fish will only be collected or purchased from anglers by ADEQ staff or AGFD personnel.

3.5.3 SAMPLE PROCESSING

Individual fish received for subsampling should be unwrapped and inspected carefully to ensure that they have not been compromised in any way (i.e., not properly preserved during transport). Any specimen deemed unsuitable for further processing and analysis should be discarded and identified on the sample processing record.

Fish tissue samples can be of two varieties: catchable and whole body prey base. Catchable fish (fish of a size that would be legally caught and consumed by the angling public) should be all of the same species and age class. Fish plugs are typically taken from a single fish (see below for specific protocols). Prey base fish should be all of the same species but can vary in size as long as they are of a size that could be consumed by the predatory fish in question and should be homogenized together

as whole fish. Typically 3 to 10 fish are homogenized through a meat grinder for whole body prey based fish (see below for protocol).

All equipment used in processing samples for metals analysis should be made of stainless steel, glass, or plastic. Chromium and nickel contamination can occur from the use of stainless steel. Therefore, if these metals are of concern, other materials should be used during sample processing. Equipment used in processing samples for organics analysis should be made of stainless steel, glass, or anodized aluminum.

Equipment used in processing samples for organics analysis should be of stainless steel, anodized aluminum, borosilicate glass, polytetrafluoroethylene (PTFE), ceramic, or quartz. Polypropylene and polyethylene (plastic) surfaces, implements, gloves, and containers are a potential source of contamination by organics and should not be used. If a laboratory chooses to use these materials, there should be clear documentation that they are not a source of contamination. Subsampling should be done on glass or PTFE cutting boards that are cleaned properly between fish or on cutting boards covered with heavy duty aluminum foil that is changed after each subsampling. Tissue should be removed with clean, high- quality, corrosion-resistant stainless steel, and ceramic or quartz instruments (Lowenstein and Young, 1986). Tissue homogenates may be stored in borosilicate glass, quartz, or PTFE containers with PTFE-lined lids or in heavy duty aluminum foil. Prior to preparing each composite sample, utensils and containers should be washed with detergent solution, rinsed with tap water, soaked in pesticide-grade isopropanol or acetone, and rinsed with deionized water. Work surfaces should be cleaned with pesticide-grade isopropanol or acetone, washed with distilled water, and allowed to dry completely. Knives, measurement boards, etc., should be cleaned with pesticide-grade isopropanol or acetone followed by a rinse with contaminant-free distilled water between each fish sample (Stober, 1991).

Fish tissue raw data sheet.

Waterbody _____ County _____ Subbasin _____ 8 Digit HUC _____

Latitude _____ Longitude _____ Collection Date _____

Processing Date _____ Date To Lab _____

Station Comments

Species Code	Total Length (mm)	Weight (g)	DEQ Number	Comments

FIGURE 3.29. Fish tissue raw data sheet.

A total length ("nose" to end of tail) is determined for each fish to the nearest millimeter using a length board (FIGURE 3.26) and recorded on the Fish Tissue Raw Datasheet (FIGURE 3.29). When measuring, the mouth of the fish should be closed and the caudle or tail fin should be lightly compressed so that the absolute longest length is measured.

Individual fish are identified to species under the supervision of an experienced biologist familiar with Arizona fish fauna. Fish are first identified using current, regional identification manuals and other appropriate taxonomic literature (i.e.: Minkley, W. L. 1973). If questions occur, identifications are verified by other fish consumption advisory program taxonomists or by experienced personnel from the Arizona Game and Fish Department.

3.5.3.1 Catchable Fish Processing

1. Prior to preparing metals samples, all surfaces in the processing laboratory are washed with a Liquinox® and rinsed with deionized (DI) water. Utensils and containers should be cleaned thoroughly with a Liquinox® solution, rinsed with tap water, soaked in 5 percent HCl , for 12 to 24 hours at room temperature, and then rinsed with DI water.

Utensils made from stainless steel may be cleaned using this recommended procedure with the acid soaking step method omitted (Stober, 1991).

2. Frozen fish samples should only be partially thawed before subsampling (ice crystals should still be visible in the fillet tissue). Subsampling is performed on HDPE cutting board rinsed with DI water between fish from different sites. Subsampling is performed using cleaned bare hands or talc free disposable gloves. Hands or gloves should be rinsed between samples to prevent cross contamination. Knives and biopsy punches are rinsed with 5 percent HCl and DI water between fish from the same station and recleaned or changed between sites.

FIGURE 3.30. Fish preparation.

3. The fillet area should be exposed for subsampling by inserting the knife beneath the scales and skin just forward of the caudal peduncle (FIGURE 3.31). Cut forward, just beneath the skin until the fillet flesh is exposed between the lateral line and the dorsal fin, from insertion point to just behind the gills (FIGURE 3.32). Once the fillet flesh is exposed, use a 6mm biopsy punch to remove > 3.5 grams of muscle tissue (FIGURE 3.33). Place a tared HDPE sample submittal bottle on a scale to assure that you have at least 3.5 grams. Use a stainless

wire plunger to push plugs into the sample bottle. The number of plugs needed to make up 3.5 grams will vary due to muscle thickness and density. Care should be taken not to cut into the gut cavity as it may contaminate the fillet tissue.

Note: For a better grip, hold the fish around the caudle peduncle with a paper towel and place the "nose" against a folded paper towel on the back panel of the bench. Always cut away from your body.

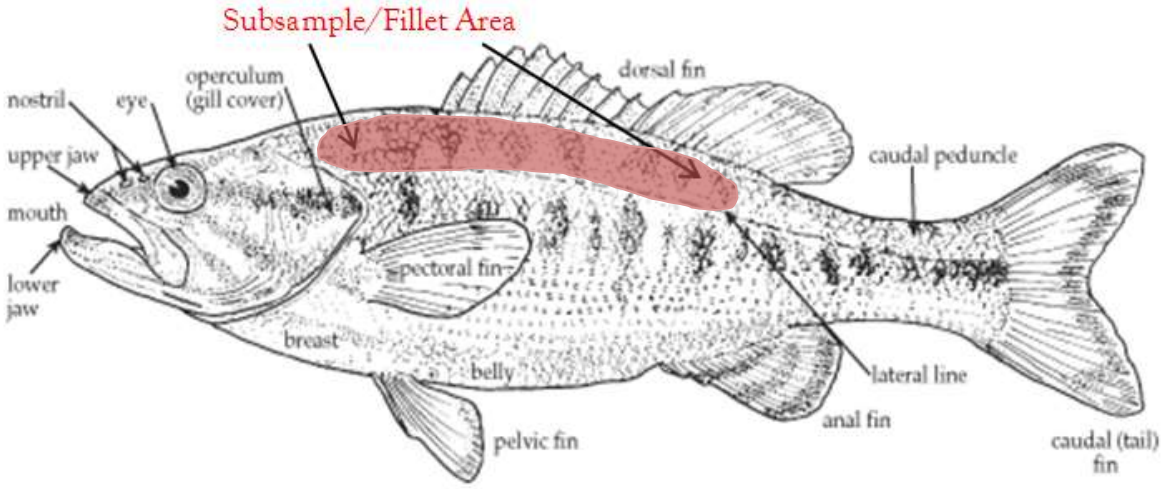


FIGURE 3.31. Basic fish anatomy denoting area to be subsampled.

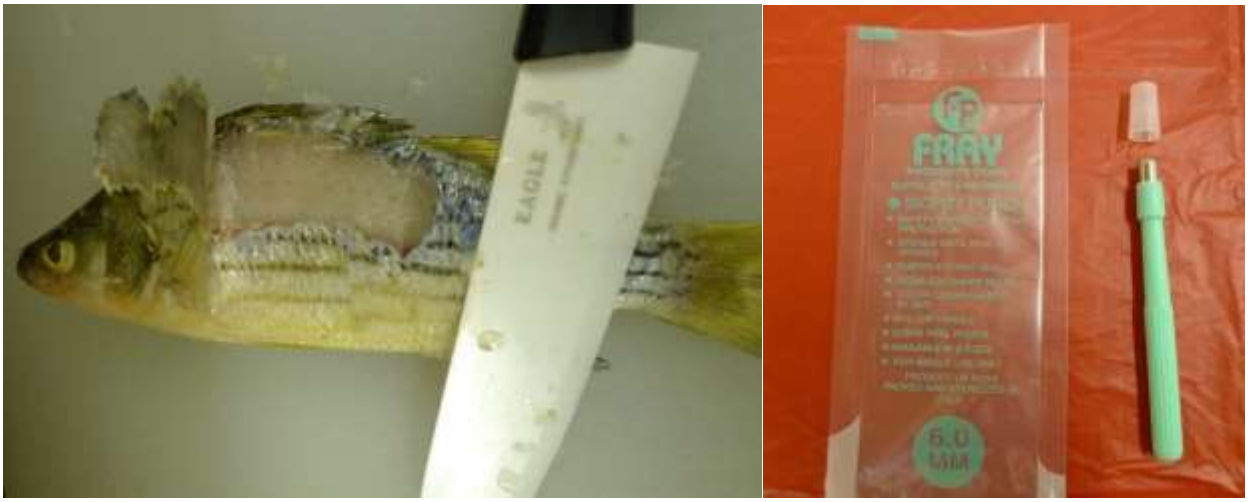


FIGURE 3.32. Skin removed from the subsample/filet section

FIGURE 3.32. Subsampling with a biopsy punch

4. Once more than 3.5 grams of muscle tissue is obtained, the plugs are placed into a precleaned mortar and pestle and ground until the tissue is homogenized, to ensure equal distribution of contaminants throughout the sample.
5. Place labeled bottle with sample back into the freezer until samples are shipped on dry ice to the laboratory for analysis.
6. Place fish carcass with identifying labels back into the freezer until laboratory results are received and QA/QC checks completed.

Composite samples, taken as a cost saving way to increase sample number when large numbers of fish are available, are prepared from at least 3 but no more than 10 individuals of the same species. Composite samples from catchable fish are prepared by subsampling equal amounts of tissue from each fish in the sample, using the muscle plug technique. Subsampled material is then homogenized by grinding in a mortar and pestle.

Individuals of different species are never mixed to form composite samples.

3.5.3.2 Whole Body Prey Base Processing

1. Whole body composite samples from prey base fish are prepared by grinding whole fish in a food grade meat grinder. Once ground, place the resultant material in a clean weigh boat and homogenize by stirring with a stainless steel laboratory spatula.

3.5.3.3 Final Sample

The final individual or composite samples should be composed of at least 3.5 g of tissue to ensure an adequate amount of material for analysis. If more sampled material is available, include it for possible lab QA/QC or calibration. Samples are submitted in small, widemouth poly bottles and

labeled with a paper lable with clear tape completely surrounding the bottle and a number on the cap and lable in case the lables get damaged (FIGURE 3.34). Composite sample bottles should be labeled containing the number in the composite and range of sample *lengths* (length is the best surrogate for age/cohort). The range of lengths and weights along should be recorded for data analysis.

3.5.3.4 QA/QC Samples

Five percent of quality control samples will be blanks and five percent splits or duplicates as described in Section 3.2.5. These samples are either comprised of a 7 gram sample taken from a single filet exposure, homogenized and split into two separate sample bottles or, on smaller fish, a subsample is taken from the fillet portion on the opposite side of the fish using the same subsampling procedure as regular samples.

Figure 3.34. Labeled sample bottle

Blanks consist of samples of taken from frozen chicken breast meat using the same method and materials used in taking regular subsamples. Avoid sampling the fat that often is attached to the fillets.

All samples are then sent either directly to the analytical laboratory, (overnight, on dry ice), or frozen immediately and stored at -20°C for later analysis.

Blanks: Processing method blanks will consist of commercially purchased frozen chicken breasts. Do not choose "free range" chicken breasts. Blanks will be processed in the same way as fish tissue following steps 3 – 5 in section 3.5.3.1. Bottles will be labled in the same way as the the bottles from the actual sample except the length and weight will be noted as 404-404 and the species will be noted as *Gallus dom*. Once plugs have been removed, the individual breast piece will be placed in a clean zip lock bag labled with the same information as the bottle and returned to the freezer until sample data is received.

Duplicates: Duplicates will consist of taking twice as much sample as required from the fillet portion of the fish, processing it as per steps 3 – 5 in section 3.5.3.1, and labling both bottles using the regular method but adding an (a) to one of the length/weight designations, eg: 175-342(a).

See section 10.2.5 for acceptance criteria for blanks, duplicates and splits and how to use the quality assurance flagging process to automatically check for data that should be rejected.

3.5.3.4 Disposal of fish carcasses:

Fish carcasses that have been subsampled will be returned to the freezer for storage. Once sample data are received and meet QA/QC criteria, the carcasses can be disposed of in the main garbage dumpster on the east side of the parking garage with special care to assure that garbage pickup will occur within 24 hours.

CHAPTER 4 BACTERIA COLLECTION & PROCESSING

4.1 COLILERT® SYSTEM

The Colilert system utilizes prepackaged reagents which include additives to support the growth of coliform bacteria in addition to specific compounds that react with coliforms in general and *E. coli* specifically. Two options are available, Colilert-18 and Colilert-24,used for the simultaneous detection and confirmation of total coliforms and *E. coli* in fresh waters. The only difference between Colilert-18 and Colilert-24 is the incubation time, indicated by the number after Colilert.

When total coliforms metabolize Colilert'snutrient indicator reagent, ONPG (O-Nitrophenyl-β-d-galacotpyranoside), the reaction produces an easily recognized yellow color. When *E. coli* metabolizes Colilert- nutrient-indicator, MUG (4-Methumbelliferyl-β-d-glucoronide) the sample fluoresces. Colilert-can simultaneously detect these bacteria at 1 cfu/100 ml within 18 to 24 hours for Colilert 18 to 22 to 28 hours for Colilert 24. The test is effective and free of interference in waters with population densities of other heterotrophic bacteria up to 10,000 cfu/100 ml. Non-coliform bacteria that also have these enzymes are suppressed, for the incubation period, by other reagents in the media.

EPA refers to Colilert® as MMO-MUG while Standard Methods for the Examination of Water and Wastewater refers to Colilert® as a chromogenic substrate.

Catalog #WP020-18 and WP200-18 contain 20 and 200 Snap Packs respectively, each containing sufficient Colilert-18 reagent for a 100 ml water sample. The reagents should be stored at 4-25°C away from light.

Samples are collected wearing gloves and using a sealed, sterile 100ml bottle submerged in the stream while facing upstream. The bottle should be opened and recapped under water during sampling so that surface contaminants are not sampled. Samples must be chilled and processed within six hours of sample collection.

4.1.1 QUANTI-TRAY/2000 ENUMERATION PROCEDURE

Gloves must be worn during all bacteria sampling, handling, and processing.

1. Turn on sealer. It will take approximately 15 minutes to warm to operating temperature.
2. Verify that the incubator is operating at 35 +/- 0.5°C.

FIGURE 4.1. Colilert Sealer (left) and incubator (right).

3. Check level of water in bottle against 100ml line, if too much water is present, decant to the 100ml line.
4. Pour the contents of one reagent packet into each sample bottle. When opening the reagent packets, avoid inhaling the media.
5. Cap vessel and shake gently until dissolved and allow the foam at the top the bottle to settle. Chilled samples will take longer to dissolve the reagent. A hot water bath can be used to warm chilled samples.
6. Use a permanent marker to label the foil side of the Quanti-Tray with the following:
    - Site
    - Date
    - In: (incubation time)
    - Out (time when you read the sample – will be blank for now)
    - L: (# of large wells positive for *E. Coli* – will be blank for now)
    - S: (# of small wells positive for *E. Coli* – will be blank for now)
7. Use one hand to hold a Quanti-Tray upright with the well side facing the palm. Gently pull foil tab to separate the foil from the tray. Avoid touching the inside of the foil or tray.
8. Squeeze the upper part of the Quanti-Tray so that the Quanti-Tray bends towards the palm.
9. Pour the reagent/sample mixture directly into the Quanti-Tray avoiding contact with the foil tab. Tap the small wells to release any air bubbles.

Empty wells do not affect the test interpretation as long as the entire sample volume is in the tray. An empty or partially filled well is interpreted the same way as a full well.

10. Place the sample-filled Quanti-Tray onto the Quanti-Tray/2000 rubber insert of the Quanti-Tray Sealer with the well side (plastic) of the Quanti-Tray facing down.
11. Once all samples have been processed note the "time in the incubator" on the back of the Quanti-Tray and place the samples in the incubator.
12. Remove samples from the incubator after 18-22 for Colilert 18 and 24-28 hours for Colilert 24.
13. Wells that are yellow under plain light are positive for total coliforms.

Wells that are yellow AND fluoresce under a black light are positive for *E. coli*. Wells that are just flouresent or yellow are negative for *E. coli*.

Sample results are obtained by counting and recording the number of large and small yellow, fluorescing wells. Once the number of large and small wells is obtained the "most probable number" (MPN) is recorded from the MPN table (TABLE 4.3).

14. Results must be noted on the field sheets, field notebook, or some other type of record.

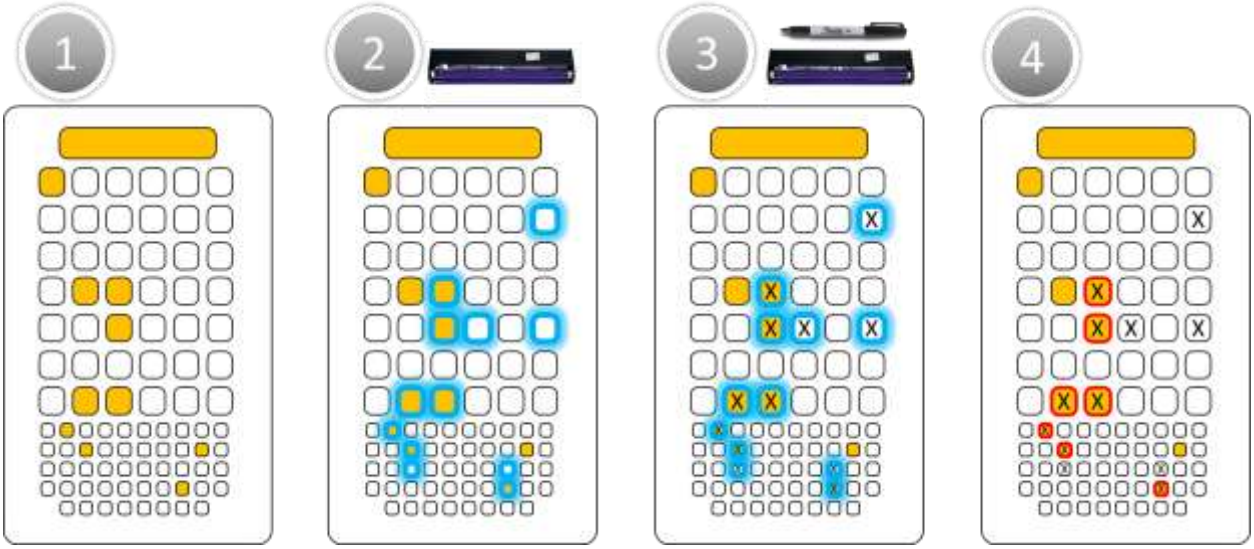


FIGURE 4.2. How to read *E. coli*. 1) Take quantitray out of incubator. 2) Put under black light. 3) Mark wells that fluoresce with a sharpie. 4) Count the number of wells that are yellow and fluoresce. In this case 4 large and 3 small. Based on the MPN table the *E. coli* result is 7.2 cfu/100 mL.

4.1.1.1 E. Coli *Dilutions*

Dilutions can be done if the results are expected to be greater than 2419 cfu/100ml. High cfu counts may be experienced during storm run-off events, high recreational periods, and downstream of known fecal pollution sources. When performing dilutions two sample bottles are collected for each site (FIGURE 4.3).

1. The first bottle is processed following the standard processing procedures outlined above;
2. Using the second sample bottle, pipette 10ml of the sample into an empty IDEXX bottle. Then repeat using a 1ml and 0.1ml pipette into separate IDEXX bottles. Add deionized water to each bottle filling them to the 100ml line;
3. Prepare samples following the procedures outlined above.
4. Multiply the dilution ratio by the result for each sample (TABLE 4.1)
5. Enter the result from the dilution bottle with the greatest amount of sample that is not too numerous to count. In the example given in TABLE 4.1, the value of 25,040 CFU/100 mL would be entered into the database. Add a note to the comment field that you did a dilution.

Change the reporting limit based on the amount diluted. The method reporting limit is 1 CFU/100 mL so a 10X dilution would have a MRL of 10 CFU/100 mL.

Dilution	MPN Value	Multiplier	Result
100%	Too numerous to count	1	Too numerous to count
10%	Too numerous to count	10	Too numerous to count
1%	250.4	100	25,040 CFU/100 mL
0.1%	47	1000	47,000 CFU/100mL

TABLE 4.1. Example of dilution results using Colilert.

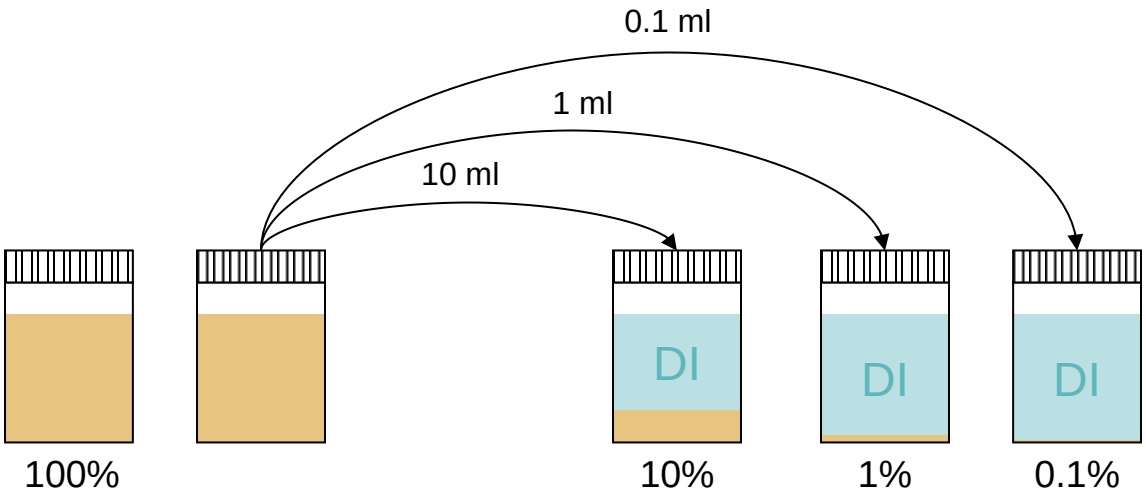


FIGURE 4.3. Bacteria dilutions of 100%, 10%, 1% and 0.1% for sites with bacteria that are expected to be greater than 2419.6 CFU/100 mL The brown liquid is the sample, while the blue is deionized water.

Values <1 on the MPN table should be entered into the WQDB with the lab notation of "LT" and the detection limit of 1 CFU/100 mL.

Duplicate Values should also be stored in the WQDB using the "D" for the Evaluation Purpose.

If multiple dilutions were made, the lowest dilution result should be entered into the Water Quality Database with the appropriate lab qualifier. Other dilution results may be added to sample comment field.

All waste generated by using the Colilert- method is considered a biohazard. The waste material (gloves, bottles, trays, etc) must be placed in red biohazard bags for proper disposal.

Appearance	Result
Yellow AND fluorescence	Positive for *E. coli*
Colorless or slight tinge	Negative for *E. coli* and for total coliforms
Yellow	Negative for *E. coli* Positive for total coliforms

TABLE 4.2. Result Interpretation table for Presence/Absence Procedure

4.1.2 PROCEDURAL NOTES

- Look for fluorescence with a 6 watt, 365 nm, UV light within 5 inches (13 cm) of the sample. Face light away from your eyes and towards the sample.
- Samples are negative if at any time after 18 hours (Colilert-18) or 24 hours (Colilert-24) there is no yellow and/or fluorescence.
- After 22 or 28 hours from inoculation, heterotrophs may overwhelm Colilert inhibition system. Therefore, yellow or yellow/fluorescence first observed after 22 hours from inoculation is not a valid positive.
- A slight tinge may be observed when Colilert- media is added to the sample.
- Do not dilute sample in buffered water. Colilert-media is already buffered.
- In samples with excessive chlorine, a blue flash may be seen when adding Colilert. If this is seen, consider sample invalid and discontinue testing.
- Aseptic technique should be always followed when using Colilert. Dispose of waste in accordance with good laboratory practices.

4.1.3 QUALITY CONTROL PROCEDURES

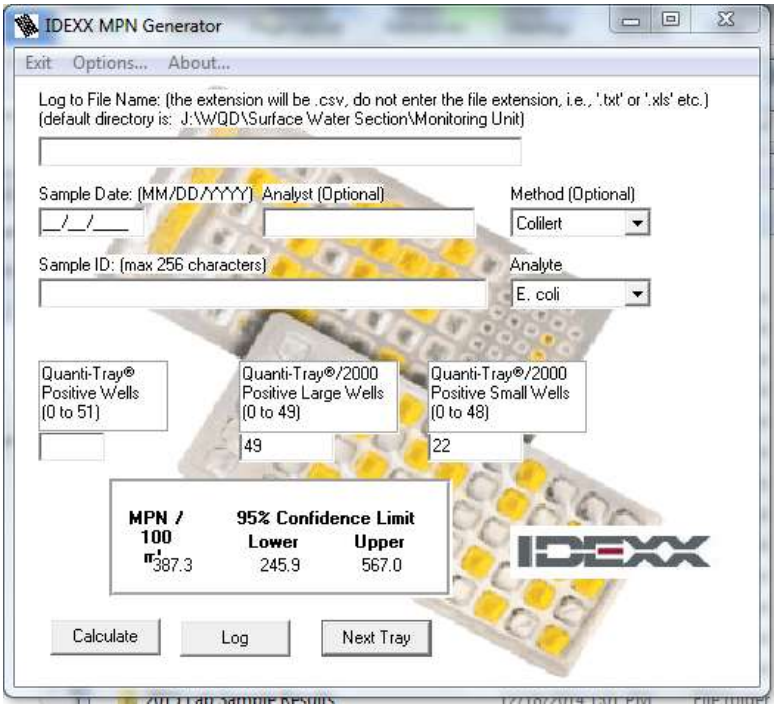
4.1.3.1 Blank Collection and Acceptance Criteria

1. Fill bottle to line with DI (sterile) water. Process sample as listed in the Quanti-Tray/2000 Enumeration Procedure (Section 4.1.1).
2. After the incubation period, **none** of the wells should be yellow or fluoresce. If this occurs then the sample lot associated with the failed QC should be disregarded and not recorded in the database. Section 10.2.5 has additional information on blank contamination.

Use the QA-R flag to reject data due to QA/QC problems. All data within the run to the point of the next blank QC sample should also be flagged. In the result comments field indicate why the data was rejected. For example, "*E. coli* duplicate value out of range".

4.1.3.2 Duplicate Collection and Acceptance Criteria

1. Collect a duplicate sample in the same manner as the original sample. Collect both samples as close in time as possible.
2. Process duplicate sample in same manner as the original.
3. To determine if a duplicate sample is in range of the original, the IDEXX MPN Generator is used (shown below)
    - Enter Method (Colilert or Colilert-18)
    - Enter *E. coli* as Analyte
    - Enter number of large wells and small wells
    - Click calculate



4. The Generator will give the MPN and the 95% confidence range. The duplicate sample's 95% confidence range must fall with-in the range or have overlapping ranges for the duplicate sample to be accepted.

Use the QA-R flag to reject data due to QA/QC problems. All data within the run to the point of the next blank QC sample should also be flagged. In the result comments field indicate why the data was rejected.

IDEXX Quanti-Tray®/2000 MPN Table *(per 100ml)*

# Large Wells Positive	# Small Wells Positive																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
0	<1	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.1	15.1	16.1	17.1	18.1	19.1	20.2	21.2	22.2	23.3	24.3
1	1.0	2.0	3.0	4.0	5.0	6.0	7.1	8.1	9.1	10.1	11.1	12.1	13.2	14.2	15.2	16.2	17.3	18.3	19.3	20.4	21.4	22.4	23.5	24.5	25.6
2	2.0	3.0	4.1	5.1	6.1	7.1	8.1	9.2	10.2	11.2	12.2	13.3	14.3	15.4	16.4	17.4	18.5	19.5	20.6	21.6	22.7	23.7	24.8	25.8	26.9
3	3.1	4.1	5.1	6.1	7.2	8.2	9.2	10.3	11.3	12.4	13.4	14.5	15.5	16.5	17.6	18.6	19.7	20.8	21.8	22.9	23.9	25.0	26.1	27.1	28.2
4	4.1	5.2	6.2	7.2	8.3	9.3	10.4	11.4	12.5	13.5	14.6	15.6	16.7	17.8	18.8	19.9	21.0	22.0	23.1	24.2	25.3	26.3	27.4	28.5	29.6
5	5.2	6.3	7.3	8.4	9.4	10.5	11.5	12.6	13.7	14.7	15.8	16.9	17.9	19.0	20.1	21.2	22.2	23.3	24.4	25.5	26.6	27.7	28.8	29.9	31.0
6	6.3	7.4	8.4	9.5	10.6	11.6	12.7	13.8	14.9	16.0	17.0	18.1	19.2	20.3	21.4	22.5	23.6	24.7	25.8	26.9	28.0	29.1	30.2	31.3	32.4
7	7.5	8.5	9.6	10.7	11.8	12.8	13.9	15.0	16.1	17.2	18.3	19.4	20.5	21.6	22.7	23.8	24.9	26.0	27.1	28.3	29.4	30.5	31.6	32.8	33.9
8	8.6	9.7	10.8	11.9	13.0	14.1	15.2	16.3	17.4	18.5	19.6	20.7	21.8	22.9	24.1	25.2	26.3	27.4	28.6	29.7	30.8	32.0	33.1	34.3	35.4
9	9.8	10.9	12.0	13.1	14.2	15.3	16.4	17.6	18.7	19.8	20.9	22.0	23.2	24.3	25.4	26.8	27.7	28.9	30.0	31.2	32.3	33.5	34.6	35.8	37.0
10	11.0	12.1	13.2	14.4	15.5	16.6	17.7	18.9	20.0	21.1	22.3	23.4	24.6	25.7	26.9	28.0	29.2	30.3	31.5	32.7	33.8	35.0	36.2	37.4	38.6
11	12.2	13.4	14.5	15.6	16.8	17.9	19.1	20.2	21.4	22.5	23.7	24.8	26.0	27.2	28.3	29.5	30.7	31.9	33.0	34.2	35.4	36.6	37.8	39.0	40.2
12	13.5	14.6	15.8	16.9	18.1	19.3	20.4	21.6	22.8	23.9	25.1	26.3	27.5	28.6	29.8	31.0	32.2	33.4	34.6	35.8	37.0	38.2	39.5	40.7	41.9
13	14.8	16.0	17.1	18.3	19.5	20.6	21.8	23.0	24.2	25.4	26.6	27.8	29.0	30.2	31.4	32.6	33.8	35.0	36.2	37.5	38.7	39.9	41.2	42.4	43.6
14	16.1	17.3	18.5	19.7	20.9	22.1	23.3	24.5	25.7	26.9	28.1	29.3	30.5	31.7	33.0	34.2	35.4	36.7	37.9	39.1	40.4	41.6	42.9	44.2	45.4
15	17.5	18.7	19.9	21.1	22.3	23.5	24.7	25.9	27.2	28.4	29.6	30.9	32.1	33.3	34.6	35.8	37.1	38.4	39.6	40.9	42.2	43.4	44.7	46.0	47.3
16	18.9	20.1	21.3	22.6	23.8	25.0	26.2	27.5	28.7	30.0	31.2	32.5	33.7	35.0	36.3	37.5	38.8	40.1	41.4	42.7	44.0	45.3	46.6	47.9	49.2
17	20.3	21.6	22.8	24.1	25.3	26.6	27.8	29.1	30.3	31.6	32.9	34.1	35.4	36.7	38.0	39.3	40.6	41.9	43.2	44.5	45.9	47.2	48.5	49.8	51.2
18	21.8	23.1	24.3	25.6	26.9	28.1	29.4	30.7	32.0	33.3	34.6	35.9	37.2	38.5	39.8	41.1	42.4	43.8	45.1	46.5	47.8	49.2	50.5	51.9	53.2
19	23.3	24.6	25.9	27.2	28.5	29.8	31.1	32.4	33.7	35.0	36.3	37.6	39.0	40.3	41.6	43.0	44.3	45.7	47.1	48.4	49.8	51.2	52.6	54.0	55.4
20	24.9	26.2	27.5	28.8	30.1	31.5	32.8	34.1	35.4	36.8	38.1	39.5	40.8	42.2	43.6	44.9	46.3	47.7	49.1	50.5	51.9	53.3	54.7	56.1	57.6
21	26.5	27.9	29.2	30.5	31.8	33.2	34.5	35.9	37.3	38.6	40.0	41.4	42.8	44.1	45.5	46.9	48.4	49.8	51.2	52.6	54.1	55.5	56.9	58.4	59.9
22	28.2	29.5	30.9	32.3	33.6	35.0	36.4	37.7	39.1	40.5	41.9	43.3	44.8	46.2	47.6	49.0	50.5	51.9	53.4	54.8	56.3	57.8	59.3	60.8	62.3
23	29.9	31.3	32.7	34.1	35.5	36.8	38.3	39.7	41.1	42.5	43.9	45.4	46.8	48.3	49.7	51.2	52.7	54.2	55.6	57.1	58.6	60.2	61.7	63.2	64.7
24	31.7	33.1	34.5	35.9	37.3	38.8	40.2	41.7	43.1	44.6	46.0	47.5	49.0	50.5	52.0	53.5	55.0	56.5	58.0	59.5	61.1	62.6	64.2	65.8	67.3
25	33.6	35.0	36.4	37.9	39.3	40.8	42.2	43.7	45.2	46.7	48.2	49.7	51.2	52.7	54.3	55.8	57.3	58.9	60.5	62.0	63.6	65.2	66.8	68.4	70.0
26	35.5	36.9	38.4	39.9	41.4	42.8	44.3	45.9	47.4	48.9	50.4	52.0	53.5	55.1	56.7	58.2	59.8	61.4	63.0	64.7	66.3	67.9	69.6	71.2	72.9
27	37.4	38.9	40.4	42.0	43.5	45.0	46.5	48.1	49.6	51.2	52.8	54.4	56.0	57.6	59.2	60.8	62.4	64.1	65.7	67.4	69.1	70.8	72.5	74.2	75.9
28	39.5	41.0	42.6	44.1	45.7	47.3	48.8	50.4	52.0	53.6	55.2	56.9	58.5	60.2	61.8	63.5	65.2	66.9	68.6	70.3	72.0	73.7	75.5	77.3	79.0
29	41.7	43.2	44.8	46.4	48.0	49.6	51.2	52.8	54.5	56.1	57.8	59.5	61.2	62.9	64.6	66.3	68.0	69.8	71.5	73.3	75.1	76.9	78.7	80.5	82.4
30	43.9	45.5	47.1	48.7	50.4	52.0	53.7	55.4	57.1	58.8	60.5	62.2	64.0	65.7	67.5	69.3	71.0	72.9	74.7	76.5	78.3	80.2	82.1	84.0	85.9
31	46.2	47.9	49.5	51.2	52.9	54.6	56.3	58.1	59.8	61.6	63.3	65.1	66.9	68.7	70.5	72.4	74.2	76.1	78.0	79.9	81.8	83.7	85.7	87.6	89.6
32	48.7	50.4	52.1	53.8	55.6	57.3	59.1	60.9	62.7	64.5	66.3	68.2	70.0	71.9	73.8	75.7	77.6	79.5	81.5	83.5	85.4	87.5	89.5	91.5	93.6
33	51.2	53.0	54.8	56.5	58.3	60.2	62.0	63.8	65.7	67.6	69.5	71.4	73.3	75.2	77.2	79.2	81.2	83.2	85.2	87.3	89.3	91.4	93.6	95.7	97.8
34	53.9	55.7	57.6	59.4	61.3	63.1	65.0	67.0	68.9	70.8	72.8	74.8	76.8	78.8	80.8	82.9	85.0	87.1	89.2	91.4	93.5	95.7	97.9	100.2	102.4
35	56.8	58.6	60.5	62.4	64.4	66.3	68.3	70.3	72.3	74.3	76.3	78.4	80.5	82.6	84.7	86.9	89.1	91.3	93.5	95.7	98.0	100.3	102.6	105.0	107.3
36	59.8	61.7	63.7	65.7	67.7	69.7	71.7	73.8	75.9	78.0	80.1	82.3	84.5	86.7	88.9	91.2	93.5	95.8	98.1	100.5	102.9	105.3	107.7	110.2	112.7
37	62.9	65.0	67.0	69.1	71.2	73.3	75.4	77.6	79.8	82.0	84.2	86.5	88.8	91.1	93.4	95.8	98.2	100.6	103.1	105.6	108.1	110.7	113.3	115.9	118.6
38	66.3	68.4	70.6	72.7	74.9	77.1	79.4	81.6	83.9	86.2	88.6	91.0	93.4	95.8	98.3	100.8	103.4	105.9	108.6	111.2	113.9	116.6	119.4	122.2	125.0
39	70.0	72.2	74.4	76.7	78.9	81.3	83.6	86.0	88.4	90.9	93.4	95.9	98.4	101.0	103.6	106.3	109.0	111.8	114.6	117.4	120.3	123.2	126.1	129.2	132.2
40	73.8	76.2	78.5	80.9	83.3	85.7	88.2	90.8	93.3	95.9	98.5	101.2	103.9	106.7	109.5	112.4	115.3	118.2	121.2	124.3	127.4	130.5	133.7	137.0	140.3
41	78.0	80.5	83.0	85.5	88.0	90.6	93.3	95.9	98.7	101.4	104.3	107.1	110.0	113.0	116.0	119.1	122.2	125.4	128.7	132.0	135.4	138.8	142.3	145.9	149.5
42	82.6	85.2	87.8	90.5	93.2	96.0	98.8	101.7	104.6	107.6	110.6	113.7	116.9	120.1	123.4	126.7	130.1	133.6	137.2	140.8	144.5	148.3	152.2	156.1	160.2
43	87.6	90.4	93.2	96.0	99.0	101.9	105.0	108.1	111.2	114.5	117.8	121.1	124.6	128.1	131.7	135.4	139.1	143.0	147.0	151.0	155.2	159.4	163.8	168.2	172.8
44	93.1	96.1	99.1	102.2	105.4	108.6	111.9	115.3	118.7	122.3	125.9	129.6	133.4	137.4	141.4	145.5	149.7	154.1	158.5	163.1	167.9	172.7	177.7	182.9	188.2
45	98.3	102.5	105.8	109.2	112.6	116.2	119.8	123.6	127.4	131.4	135.4	139.6	143.9	148.3	152.9	157.6	162.4	167.4	172.6	178.0	183.5	189.2	195.1	201.2	207.5
46	106.3	109.8	113.4	117.2	121.0	125.0	129.1	133.3	137.6	142.1	146.7	151.5	156.5	161.6	167.0	172.5	178.2	184.2	190.4	196.8	203.5	210.5	217.8	225.4	233.3
47	114.3	118.3	122.4	126.6	130.9	135.4	140.1	145.0	150.0	155.3	160.7	166.4	172.3	178.5	185.0	191.8	198.9	206.4	214.2	222.4	231.0	240.0	249.5	259.5	270.0
48	123.9	128.4	133.1	137.9	143.0	148.3	153.9	159.7	165.8	172.2	178.9	186.0	193.5	201.4	209.8	218.7	228.2	238.2	248.9	260.3	272.3	285.1	298.7	313.0	328.2
49	135.5	140.8	146.4	152.3	158.5	165.0	172.0	179.3	187.2	195.6	204.6	214.3	224.7	235.9	248.1	261.3	275.5	290.8	307.6	325.5	344.8	365.4	387.3	410.6	435.2

09-63235-01

TABLE 4.3 IDEXX Quanti-Tray/2000 MPN TABLE

IDEXX Quanti-Tray®/2000 MPN Table (per 100ml)

# Large Wells Positive	# Small Wells Positive																							
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
0	25.3	26.4	27.4	28.4	29.5	30.5	31.5	32.6	33.6	34.7	35.7	36.8	37.8	38.9	40.0	41.0	42.1	43.1	44.2	45.3	46.3	47.4	48.5	49.5
1	26.6	27.7	28.7	29.8	30.8	31.9	32.9	34.0	35.0	36.1	37.2	38.2	39.3	40.4	41.4	42.5	43.6	44.7	45.7	46.8	47.9	49.0	50.1	51.2
2	27.9	29.0	30.0	31.1	32.2	33.2	34.3	35.4	36.5	37.5	38.6	39.7	40.8	41.9	43.0	44.0	45.1	46.2	47.3	48.4	49.5	50.6	51.7	52.8
3	29.3	30.4	31.4	32.5	33.6	34.7	35.8	36.8	37.9	39.0	40.1	41.2	42.3	43.4	44.5	45.6	46.7	47.8	48.9	50.0	51.2	52.3	53.4	54.5
4	30.7	31.8	32.8	33.9	35.0	36.1	37.2	38.3	39.4	40.5	41.6	42.8	43.9	45.0	46.1	47.2	48.3	49.5	50.6	51.7	52.9	54.0	55.1	56.3
5	32.1	33.2	34.3	35.4	36.5	37.6	38.7	39.9	41.0	42.1	43.2	44.4	45.5	46.6	47.7	48.9	50.0	51.2	52.3	53.5	54.6	55.8	56.9	58.1
6	33.5	34.7	35.8	36.9	38.0	39.2	40.3	41.4	42.6	43.7	44.8	46.0	47.1	48.3	49.4	50.6	51.7	52.9	54.1	55.2	56.4	57.6	58.7	59.9
7	35.0	36.2	37.3	38.4	39.6	40.7	41.8	43.0	44.2	45.3	46.5	47.7	48.8	50.0	51.2	52.3	53.5	54.7	55.9	57.1	58.3	59.4	60.6	61.8
8	36.6	37.7	38.9	40.0	41.2	42.3	43.5	44.7	45.9	47.0	48.2	49.4	50.6	51.8	53.0	54.1	55.3	56.5	57.7	59.0	60.2	61.4	62.6	63.8
9	38.1	39.3	40.5	41.6	42.8	44.0	45.2	46.4	47.6	48.8	50.0	51.2	52.4	53.6	54.8	56.0	57.2	58.4	59.7	60.9	62.1	63.4	64.6	65.8
10	39.7	40.9	42.1	43.3	44.5	45.7	46.9	48.1	49.3	50.6	51.8	53.0	54.2	55.5	56.7	57.9	59.2	60.4	61.7	62.9	64.2	65.4	66.7	67.9
11	41.4	42.6	43.8	45.0	46.3	47.5	48.7	49.9	51.2	52.4	53.7	54.9	56.1	57.4	58.6	59.9	61.2	62.4	63.7	65.0	66.3	67.5	68.8	70.1
12	43.1	44.3	45.6	46.8	48.1	49.3	50.6	51.8	53.1	54.3	55.6	56.8	58.1	59.4	60.7	62.0	63.2	64.5	65.8	67.1	68.4	69.7	71.0	72.4
13	44.9	46.1	47.4	48.8	49.9	51.2	52.5	53.7	55.0	56.3	57.6	58.9	60.2	61.5	62.8	64.1	65.4	66.7	68.0	69.3	70.7	72.0	73.3	74.7
14	46.7	48.0	49.3	50.5	51.8	53.1	54.4	55.7	57.0	58.3	59.6	60.9	62.3	63.6	64.9	66.3	67.6	68.9	70.3	71.6	73.0	74.4	75.7	77.1
15	48.6	49.9	51.2	52.5	53.8	55.1	56.4	57.8	59.1	60.4	61.8	63.1	64.5	65.8	67.2	68.5	69.9	71.3	72.6	74.0	75.4	76.8	78.2	79.6
16	50.5	51.8	53.2	54.5	55.8	57.2	58.5	59.9	61.2	62.6	64.0	65.3	66.7	68.1	69.5	70.9	72.3	73.7	75.1	76.5	77.9	79.3	80.8	82.2
17	52.5	53.9	55.2	56.6	58.0	59.3	60.7	62.1	63.5	64.9	66.3	67.7	69.1	70.5	71.9	73.3	74.8	76.2	77.6	79.1	80.5	82.0	83.5	84.9
18	54.6	56.0	57.4	58.8	60.2	61.6	63.0	64.4	65.8	67.2	68.6	70.1	71.5	73.0	74.4	75.9	77.3	78.8	80.3	81.8	83.3	84.8	86.3	87.8
19	56.8	58.2	59.6	61.0	62.4	63.9	65.3	66.8	68.2	69.7	71.1	72.6	74.1	75.5	77.0	78.5	80.0	81.5	83.1	84.6	86.1	87.6	89.2	90.7
20	59.0	60.4	61.9	63.3	64.8	66.3	67.7	69.2	70.7	72.2	73.7	75.2	76.7	78.2	79.8	81.3	82.9	84.4	85.9	87.5	89.1	90.7	92.2	93.8
21	61.3	62.8	64.3	65.8	67.3	68.8	70.3	71.8	73.3	74.9	76.4	77.9	79.5	81.1	82.6	84.2	85.8	87.4	89.0	90.6	92.2	93.8	95.4	97.1
22	63.8	65.3	66.8	68.3	69.8	71.4	72.9	74.5	76.1	77.6	79.2	80.8	82.4	84.0	85.6	87.2	88.9	90.5	92.1	93.8	95.5	97.1	98.8	100.5
23	66.3	67.8	69.4	71.0	72.5	74.1	75.7	77.3	78.9	80.5	82.2	83.8	85.4	87.1	88.7	90.4	92.1	93.8	95.5	97.2	98.9	100.6	102.4	104.1
24	68.9	70.5	72.1	73.7	75.3	77.0	78.6	80.3	81.9	83.6	85.2	86.9	88.6	90.3	92.0	93.8	95.5	97.2	99.0	100.7	102.5	104.3	106.1	107.9
25	71.7	73.3	75.0	76.6	78.3	80.0	81.7	83.3	85.1	86.8	88.5	90.2	92.0	93.7	95.5	97.3	99.1	100.9	102.7	104.5	106.3	108.2	110.0	111.9
26	74.6	76.3	78.0	79.7	81.4	83.1	84.9	86.6	88.4	90.1	91.9	93.7	95.5	97.3	99.2	101.0	102.8	104.7	106.6	108.5	110.4	112.3	114.2	116.2
27	77.6	79.4	81.1	82.9	84.6	86.4	88.2	90.0	91.9	93.7	95.5	97.4	99.3	101.2	103.1	105.0	106.9	108.8	110.8	112.7	114.7	116.7	118.7	120.7
28	80.8	82.6	84.4	86.3	88.1	89.9	91.8	93.7	95.6	97.5	99.4	101.3	103.3	105.2	107.2	109.2	111.2	113.2	115.2	117.3	119.3	121.4	123.5	125.6
29	84.2	86.1	87.9	89.8	91.7	93.7	95.6	97.5	99.5	101.5	103.5	105.5	107.5	109.5	111.6	113.7	115.7	117.8	120.0	122.1	124.2	126.4	128.6	130.8
30	87.8	89.7	91.7	93.6	95.6	97.6	99.6	101.6	103.7	105.7	107.8	109.9	112.0	114.2	116.3	118.5	120.6	122.8	125.1	127.3	129.5	131.8	134.1	136.4
31	91.6	93.6	95.6	97.7	99.7	101.8	103.9	106.0	108.2	110.3	112.5	114.7	116.9	119.1	121.4	123.6	125.9	128.2	130.5	132.9	135.3	137.7	140.1	142.5
32	95.7	97.8	99.9	102.0	104.2	106.3	108.5	110.7	113.0	115.2	117.5	119.8	122.1	124.5	126.8	129.2	131.6	134.0	136.5	139.0	141.5	144.0	146.6	149.1
33	100.0	102.2	104.4	106.6	108.9	111.2	113.5	115.8	118.2	120.5	122.9	125.4	127.8	130.3	132.8	135.3	137.8	140.4	143.0	145.6	148.3	150.9	153.7	156.4
34	104.7	107.0	109.3	111.7	114.0	116.4	118.9	121.3	123.8	126.3	128.8	131.4	134.0	136.6	139.2	141.9	144.6	147.4	150.1	152.9	155.7	158.6	161.5	164.4
35	109.7	112.2	114.6	117.1	119.6	122.2	124.7	127.3	129.9	132.6	135.3	138.0	140.8	143.6	146.4	149.2	152.1	155.0	158.0	161.0	164.0	167.1	170.2	173.3
36	115.2	117.8	120.4	123.0	125.7	128.4	131.1	133.9	136.7	139.5	142.4	145.3	148.3	151.3	154.3	157.3	160.5	163.6	166.9	170.0	173.3	176.6	179.9	183.3
37	121.3	124.0	126.8	129.6	132.4	135.3	138.2	141.2	144.2	147.3	150.3	153.5	156.7	159.9	163.1	166.5	169.8	173.2	176.7	180.2	183.7	187.3	191.0	194.7
38	127.9	130.8	133.8	136.8	139.9	143.0	146.2	149.4	152.6	155.9	159.2	162.6	166.1	169.6	173.2	176.8	180.4	184.2	188.0	191.8	195.7	199.7	203.7	207.7
39	135.3	138.5	141.7	145.0	148.3	151.7	155.1	158.6	162.1	165.7	169.4	173.1	176.9	180.7	184.7	188.7	192.7	196.8	201.0	205.3	209.6	214.0	218.5	223.0
40	143.7	147.1	150.6	154.2	157.8	161.5	165.3	169.1	173.0	177.0	181.1	185.2	189.4	193.7	198.1	202.5	207.1	211.7	216.4	221.1	226.0	231.0	236.0	241.1
41	153.2	157.0	160.9	164.8	168.9	173.0	177.2	181.5	185.8	190.3	194.8	199.5	204.2	209.1	214.0	219.1	224.2	229.4	234.8	240.2	245.8	251.5	257.2	263.1
42	164.3	168.6	172.9	177.3	181.8	186.5	191.3	196.1	201.1	206.2	211.4	216.7	222.2	227.7	233.4	239.2	245.2	251.3	257.5	263.8	270.3	276.9	283.6	290.5
43	177.5	182.3	187.3	192.4	197.6	202.9	208.4	214.0	219.8	225.8	231.8	238.1	244.5	251.0	257.7	264.6	271.7	278.9	286.3	293.8	301.5	309.4	317.4	325.7
44	193.6	199.3	205.1	211.0	217.2	223.5	230.0	236.7	243.6	250.8	258.1	265.6	273.3	281.2	289.4	297.8	306.3	315.1	324.1	333.3	342.8	352.4	362.3	372.4
45	214.1	220.9	227.8	235.2	242.7	250.4	258.4	266.7	275.3	284.1	293.3	302.6	312.3	322.3	332.5	343.0	353.8	364.8	376.2	387.9	399.8	412.0	424.5	437.4
46	241.5	250.0	258.8	268.2	277.8	287.8	298.1	308.8	319.9	331.4	343.3	355.5	368.1	381.1	394.5	408.3	422.5	437.1	452.0	467.4	483.3	499.6	516.3	533.5
47	280.9	292.4	304.4	316.9	330.0	343.6	357.8	372.5	387.7	403.4	419.8	436.6	454.1	472.1	490.7	509.9	529.8	550.4	571.7	593.8	616.7	640.5	665.3	691.0
48	344.1	360.9	378.4	396.8	416.0	436.0	456.9	478.8	501.2	524.7	549.3	574.8	601.5	629.4	658.6	689.3	721.5	755.6	791.5	829.7	870.4	913.9	960.6	1011.2
49	461.1	488.4	517.2	547.5	579.4	613.1	648.8	686.7	727.0	770.1	816.4	866.4	920.8	980.4	1046.2	1119.9	1203.3	1299.7	1413.6	1553.1	1732.9	1986.3	2419.6	>2419.6

09-63235-01

TABLE 4.3 IDEXX Quanti-Tray/2000 MPN TABLE

CHAPTER 5 MEASURING FLOW

Stream discharge is the volume of water passing through a cross-sectional area per unit of time. As such, discharge is expressed in terms of volume per unit of time such as cubic feet per second. Different types of discharge measurement methods may require the use or application of different units of measurement. Flows measured by gauging a cross-section are typically reported in cubic feet per second; flows measured volumetrically are recorded in units of gallons per minute or gallons per second. ADEQ converts all discharge measurements to cubic feet per second (CFS) for consistency.

5.1 INSTANTANEOUS DISCHARGE WITH FLOW METER

Instantaneous discharge with a flow meter is calculated as the velocity (V) in feet per second multiplied by cross-sectional area (A) in square feet. For metered measurements, cross-sectional area is determined by stringing a graduated tape (1/10 ft. increments) across the channel to measure distance at cross-section stations where depth and velocity are measured. Depth of water is measured with a top setting rod having 1/10 foot increments. Area is depth multiplied by width in small increments (Harrelson et al., 1994).

FIGURE 5.1. HACH FH950 flow meter.

ADEQ primarily uses the Hach FH950 handheld flow meter which can be operated by one person (FIGURE 5.1). Older Marsh-McBirney Flow Meters are also used to measure velocity and depth at a pre-determined position in the channel (Marsh McBirney Inc., 1999). Select a location in the stream channel that will provide a representative measurement of the entire flow.

Do not select a location with a split channel, on a meander, or one with an obstruction immediately upstream from the measurement location.

Document dry streams in the database by selecting 'No; Stream Dry' under sample taken in the 'Sample/Result Data Entry' screen. See Section 10.2.4.1 for additional detail.

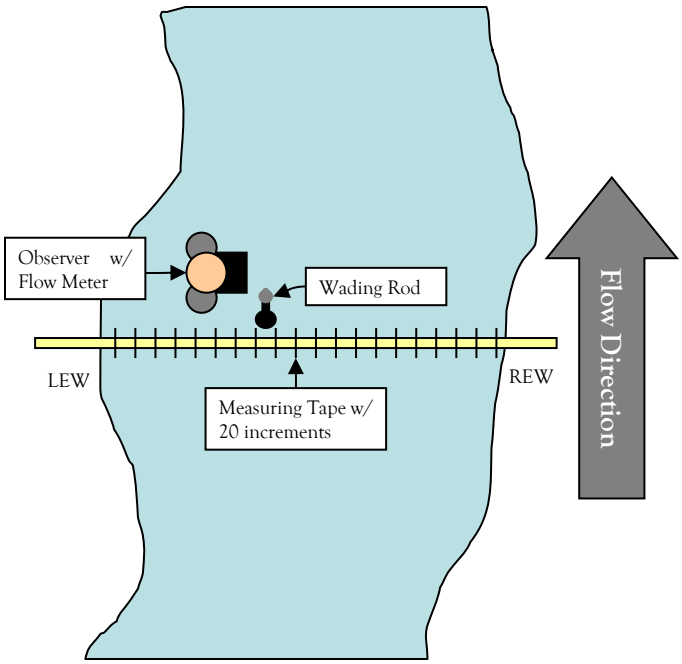


FIGURE 5.2. Plan view of observer and measuring tape with respect the stream.

FIGURE 5.3. Stant to the side of the meter not directly behind it..

5.1.1 FIELD PROCEDURE FOR HACH FH950

1. Extend the tape across the channel from bank-to-bank and perpendicular to the flow. Each end of the tape should be tied to a tent peg or other firmly secured. The tape should be taut with as little sag as possible.

If the channel is wide and the wind is blowing, tie strips of flagging on the tape to keep it from whipping.

2. Attach the meter sensor to the top-setting wading rod, place the sensor in the flow, turn the meter on, and check the reporting units. The meter should be set for reading flow in feet per second.
3. In the Main Menu, select Profiler.

4. Enter the Operator name.
5. In the Profiler menu, select 'Stream' and enter a name for the stream profile (ex. Salome Creek).
6. Enter 0 for stage referece. This is typically an elevation value from an immovable object such as a survey marker or bridge and is not needed for our purposes.
7. In the Station menu select Edge/Obstruction. Select left or right edge of water.

Left and right edge of water is determined by looking down stream and is the point where the tape starts. The observer should move toward the LEW, and read the measurement off the tape at the water-bank interface and calculate the width of channel. The number of observations should be between 15 and 20 stations. For narrow streams do not place stations closer than 0.3 feet apart.

8. Select and enter Depth information. If at an edge, the meter automatically sets this value to 0.00. The meter calls this 'maximum flow depth'.

9. Select the Station or 'Distance to Vertical' and enter information (how far from the left or right edge of water).

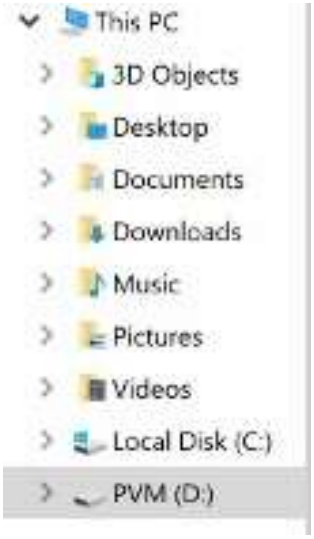
10. Select Measure Velocity. Select the number of points on the vertical to collect. For streams less than an average of 1 ft/s and 1 foot deep use the one point method at 0.6. For streams greater than an average of 1 ft/s and 1 foot deep use the two point method at 0.2 and 0.8. Select Capture to start measurement process.
    a. *For depths ≤ 2.5 feet*. The observer positions the wading rod vertically with the sensor pointed upstream into the flow. Determine the depth of water from the rod depth gauge to the nearest 10^{th} of a foot. If the water level is at the half way mark between 0.4 feet and 0.5 feet on the depth gauge (hexagonal rod); in this case the reading is 0.45 feet. If the water level is between 0.4 and 0.45 or between 0.45 and 0.5, round off to the nearest 1/10 foot increment. The depth measurement is recorded under "Depth". Depress the unlocking lever and move the round rod up to depth you just recorded. This is 0.6 of the depth. Record the velocity for that station after the meter stabilizes.
    b. *For depths > 2.5 feet*. Use the two-point method for measuring flow. The one-point method measures flow at 0.6D (Depth), while the two-point method requires an average of flow measurements taken at 0.2D and 0.8D (Corbett, 1962). If the depth is 2 feet, the single-point method requires a measurement at 1.2 feet (2 ft. x 0.6). If the depth is 3.5 feet, the two-point method requires readings at 0.7 feet. (3.5 ft. x 0.2) and 2.8 feet (3.5 ft. x 0.8). Record the average of the two velocities for that station after the meter stabilizes.

11. Select Next to go to the next station
12. Repeat steps 7 to 10 for the remaining stations.
13. When all measurements for all stations in the profile are complete, select Channel Summary to view the results.
14. Select save and exit and name your file so you can access later.

5.1.1.1 Download and Print Discharge Data

1. Plug unit into computer usb using the port on the right side of the unit. For first time use, the computer you are plugging the unit into may have to download drivers which can take a couple minutes.

2. Open windows explorer and navigate to your file. The FH950 stores files as tab separated files.



3. Open the tab separated value file with excel and print out the output for the site file and enter the following fields into the database:
   - Stream width
   - Discharge
   - Crosssectional area
   - Average depth
   - Average velocity (if you want average velocity you will need to add a formula below the average velocity column to calculate the average velocity.

	A
1	Profile Name: FRAN
2	Operator Name: SMR
3	11:42:21 11.14.2017
4	
5	Stage Reference: 0 ft
6	
7	Model: FH950
8	s/n: 1617310003423
9	Boot: v1.00
10	Application: v1.06
11	
12	Sensor Type: Velocity Only
13	s/n: 1616903337976
14	Boot: v1.00
15	Application: v1.02
16	
17	Filter: FPA Parameter: 10 s
18	Pre-filter: On Rank: 5
19	EMI: 60Hz.
20	
21	Station Entry: Non-fixed
22	Flow Calculation: Mid-section
23	Start Edge: Right edge water
24	# of Stations: 15
25	Stream Width: 7.40 ft
26	Total Discharge: 2.58 ft^3/s
27	Total Area: 6.40 ft^2
28	Mean Depth: 0.86 ft

30	Measurement Results:														
31	Time	Station	Location (ft	Method	Depth (ft)	Edge Factor	Surface (ft/	0.2 (ft/s)	0.4 (ft/s)	0.6 (ft/s)	0.8 (ft/s)	Bed (ft/s)	Average Vel	Area (ft^2)	Flow (ft^3/s)
32	11:32:04	1	4.6	0 point	0	-	0	0	0	0	0	0	0	0	0
33	11:33:10	2	5	1 point	0.8	-	0	0	0	0.05	0	0	0.05	0.28	0.01
34	11:34:03	3	5.3	1 point	0.8	-	0	0	0	0.07	0	0	0.07	0.24	0.02
35	11:34:58	4	5.6	1 point	0.85	-	0	0	0	0.16	0	0	0.16	0.25	0.04
36	11:35:27	5	5.9	1 point	0.9	-	0	0	0	0.25	0	0	0.25	0.4	0.1
37	11:36:09	6	6.5	1 point	0.9	-	0	0	0	0.79	0	0	0.79	0.49	0.39
38	11:36:55	7	7	1 point	1	-	0	0	0	0.91	0	0	0.91	0.5	0.45
39	11:37:30	8	7.5	1 point	1	-	0	0	0	0.94	0	0	0.94	0.5	0.47
40	11:38:02	9	8	1 point	1	-	0	0	0	0.55	0	0	0.55	0.5	0.27
41	11:38:32	10	8.5	1 point	0.95	-	0	0	0	0.37	0	0	0.37	0.47	0.18
42	11:39:09	11	9	1 point	1	-	0	0	0	0.23	0	0	0.23	0.5	0.12
43	11:39:54	12	9.5	1 point	1.1	-	0	0	0	0.23	0	0	0.23	0.55	0.13
44	11:40:37	13	10	1 point	1	-	0	0	0	0.55	0	0	0.55	0.75	0.41
45	11:41:34	14	11	1 point	0.95	-	0	0	0	-0.02	0	0	-0.02	0.95	-0.02
46	11:41:57	15	12	0 point	0	-	0	0	0	0	0	0	0	0	0
47												average velocity	0.338667		

5.1.2 FIELD PROCEDURES FOR MARSH MCBURNEY FLOW MATE

1. Extend the tape across the channel from bank-to-bank and perpendicular to the flow. Each end of the tape should be tied to a tent peg or other firmly secured structure. After the tape has been tied to the tent pegs, the tape should be taut with as little sag as possible.

If the channel is wide and the wind is blowing, tie strips of flagging on the tape to keep it from whipping.

2. Attach the meter sensor to the top-setting wading rod, place the sensor in the flow, turn the meter on, and check the reporting units. The meter should be set for reading flow in feet

per second. Press down on the **ON/C** and **OFF** keys simultaneously to cycle between feet per second and meters per second.

The meter can be set to average flows over a set period of time. To set the fixed point average, press the ↑ and ↓ keys simultaneously until the display shows the letters Fixed Point Averaging (FPA). Press ↑ or ↓ keys until the FPA increment is set to 10 seconds. Wait until the display automatically switches back to velocity.

3. The observer taking the measurements should move to one edge of the channel, for example the right edge of water (REW), as determined by facing downstream. Position one eye directly above the tape at the exact location where the water and the bank interface, and call out the measurement to the Recorder, for example the reading is 0.8 feet. This number should be recorded under "Distance from Initial Point" together with the abbreviation REW (right edge of water).
4. The observer should move toward the LEW, and read the measurement off the tape at the water-bank interface and calculate the width of channel. Divide the width by 20 and round to the nearest whole number. USGS recommends that no more than 5% of the stream discharge be represented in each sub-sectional area of the cross-section; in practice, this usually equates to 20 to 25 measurements across the width of the stream. For example, if the channel is 58 feet wide, 58 / 20 = 2.5; round up to 3.0. Take flow measurements every 3 feet.

FIGURE 5.2. Top set wading rod.

For narrow channels the minimum spacing is 0.3 feet.

5a. *For depths ≤ 2.5 feet*. The observer positions the wading rod vertically with the sensor pointed upstream into the flow. Determine the depth of water from the rod depth gauge to the nearest 10th of a foot. If the water level is at the half way mark between 0.4 feet and 0.5 feet on the depth gauge (hexagonal rod); in this case the reading is 0.45 feet. If the water level is between 0.4 and 0.45 or between 0.45 and 0.5, round off to the nearest 1/10 foot increment. The depth measurement is recorded under "Depth". Depress the unlocking lever and move the round rod up to depth you just recorded. This is 0.6 of the depth. Record the velocity for that station after the meter stabilizes.

FIGURE 5.4. Discharge measurement.

5b. *For depths > 2.5 feet*. Use the two-point method for measuring flow. The one-point method measures flow at 0.6D (Depth), while the two-point method requires an average of flow measurements taken at 0.2D and 0.8D (Corbett, 1962). If the depth is 2 feet, the single-point method requires a measurement at 1.2 feet (2 ft. x 0.6). If the depth is 3.5 feet, the two-point method requires readings at 0.7 feet. (3.5 ft. x 0.2) and 2.8 feet (3.5 ft. x 0.8). Record the average of the two velocities for that station after the meter stabilizes.

6. Repeat steps 3-5 until the left edge of water is reached. Record the LEW distance under "Distance from Initial Point" with the abbreviation LEW next to it.

7. Use the excel sheet to calculate discharge (See Chapter 9 - Post-Trip Procedures).

5.1.1.1 Meter Error Messages

The displaying of errors alerts the user of possible problems with either the meter or the process. Errors can be displayed as messages or numerical codes. There are three error messages and five numerical codes.

With the exception of **Err 2**, error codes freeze the display. Turn the unit OFF, and then back ON to clear the display. If the error message persists, return the meter to the manufacturer for maintenance.

Low Bat - Indicates low battery voltage. Replace the batteries with two D cells. This operation will require a screwdriver or coin to open the battery compartment.

Noise - Indicates electrical noise is present in the flow. The noise flag usually comes on for a few seconds right after the sensor is placed in the water. This is normal. If the noise level is too high to get accurate readings, the screen will blank out.

Con Lost - Indicates sensor electrodes are out of the water or have become coated with oil or grease. After a few minutes, the unit will turn itself off. If the electrodes are coated, clean the sensor with a mild soap and a soft cloth.

Numbered Error Messages

- **Error #1** - Problem with sensor drive circuit. Check sensor disconnect.
- **Error #2** - Memory full error. Memory must be cleared before another reading can be stored.
- **Error #3** - Incorrect zero adjust start sequence. Reinitiate zero start sequence.
- **Error #4** - Zero offset is greater than the zero adjust range. Repeat the zero adjust procedure. If error is still displayed, unit needs servicing.
- **Error #5** - Electroconductivity lost or noises detected during zero adjust. Usually caused by the sensor being out of the water.

5.1.1.2 Key Summary

The function keys can be operated as single key functions or two-key functions.

One Key Function

- ON/C - Turns Unit ON. Clears the display and restarts the meter.
- OFF - Turns Unit OFF.
- ↑ Increments FPA (fixed point averaging), TC (Time Constant), and Memory Location.
- ↓ Decrements FPA, TC, and Memory Location.
- RCL - Alternates between Recall and Real-Time Operating Modes.
- STO - Stores Values in Memory.

Two Key Function

- ON/C + OFF - Change Units, Turns Beeper ON/OFF.
- ↑+ ↓ - Alternates between FPA (fixed point averaging) and rC (Time Constant) Filtering.
- ON/C + STO – Memory may be cleared from either the real-time or recall mode by pressing ON/C and STO simultaneously.
- RCL + STO - Initiates zero adjust sequence. Zero stability is ± 0.05 ft/sec.

5.2 FLOAT METHOD

The float method is a simple means of estimating discharge in low or high flow streams where the Marsh McBirney flow meter will not operate or is not safe to operate.

5.2.1 FLOAT METHOD PROCEDURE

1. Measure and mark two points along the length of the channel, at least two to three channel widths apart, at the channel cross-section. Record this value on the field form.
2. Measure three depths across at the channel cross-section. Average the 3 depths and record the value on the field form.
3. Two observers are best. One tosses the float into the channel above the marker and calls out when it crosses the upstream point. The float should be something that will partially submerge in the water such as an apple or stick. Toss each float a different distance from the bank to obtain an average of velocities.
4. The downstream observer starts the timer, sighting across the stream from the lower point. When the float passes, stop the watch and record the time. Repeat the procedure 5 to 10

times. Determine the mean surface velocity. A coefficient of 0.85 is commonly used to convert the velocity of a surface float to mean velocity in the vertical (USGS Field Manual, 2004).

5. Using the previously measured cross-sectional area (A), multiply velocity (V) times area to find discharge (Q= VA). Record it on a data sheet with date, time, etc. If the cross-sectional area cannot be obtained because of unsafe wading conditions, record the velocity. If it is possible to return to the site under favorable conditions, measure the cross-sectional area and compute the estimated Q (Harrelson et al, 1994).

5.3 U.S.G.S. STAFF GAGE

At sites located near or next to a U.S.G.S. gauging station, a discharge measurement can be made by recording the time of day and the staff gauge height. On the U.S.G.S. web page http://waterdata.usgs.gov/nwis/, find the appropriate gauging station and determine the discharge from the table provided and record on the field data sheet for that site.

5.4 VOLUMETRIC MEASUREMENT

The volumetric measurement of discharge is only applicable to small discharges, but it is the most accurate method of measuring such flows. In this method the hydrographer observes the time required to fill a container of known capacity, or the time required to partly fill a calibrated container to a known volume.

Volumetric measurements are usually made where the flow is concentrated in a narrow stream, or can be so concentrated, so that all the flow may be diverted into a container (Examples or possible locations include: V-notch weir, artificial control where all the flow is confined to a notch or to a narrow width of catenary-shaped weir crest, and a cross section of natural channel where a temporary earth dam can be built over a pipe of small diameter, through which the entire flow is diverted).

Volumetric measurements have also been made when no other type of measurement is feasible, as for example on small streams composed of a series of pools behind broad-crested weirs. At low flows the depth of water on the weir crest is too shallow to be measured by current meter, and the velocity in the pools is too slow for such measurement. Discharge is measured by taking timed samples of flow sufficient to fill a container of known volume held along the downstream face of a control.

5.5 EXCLUDING LOW-FLOW SAMPLES FROM THE CWA ASSESSMENT

This protocol is presented to assist samplers in documenting low or no flow conditions that may determine whether resulting data is suitable for use in the CWA 305(b) Water Quality Assessments report and to provide justification for data exclusion where necessary. This method will provide documentation of conditions in a standard format that provides an after-the-fact justification for exclusion of data collected from water quality assessments when deemed necessary.

The low flow protocol should be considered an opt-out procedure, with the default assumption being that water sampled and data recorded is presumed to be suitable for

assessment unless this protocol is specifically invoked, employed, and the results documented in the sample records.

If the sampler's purpose is not compatible with assessment activities, following and documenting the results of this protocol are advised.

A unit-width discharge (UWD) or unit discharge can be used to determine in certain analyses what the flux (flow rate) of fluid is passing through a plane (cross-section) per unit of time. The UWD is expressed in terms of L2 T-1 where L indicates a length unit and T indicates a time unit. It may also be expressed as L3 /LT (as in cfs/ft). While a standard flow rate expressed in terms of cubic feet per second (cfs) gives a general indication of the magnitude of flow, it does not tell how concentrated that flow may be. A one-cfs flow through a culvert may be moving at a relatively brisk rate with mixing and some turbulence; a one-cfs flow through a cross-section of 50 square feet will be moving languidly and is likely not well-mixed; it may be hard to tell there is any flow at all in such a case without careful measurements, even though water is clearly present (FIGURE 5.4).

A unit-width discharge value provides an indication of how concentrated or diffuse total flow may be. The UWD is calculated simply as the discharge divided by the width of the stream at the location, or alternatively, where flow assessments following this protocol are made, as the product of the depth and a single representative flow velocity.

Waters that are not actively flowing at a brisk enough rate may be subject to higher rates of evaporation, which can adversely affect chemical analyses and reporting.

A benchmark of 0.1 cfs/ft is adopted as the quantified threshold to identify protocol low-flow (LF) conditions.

Low Flow Protocol:

1. Evaluate whether this protocol is necessary to employ.
   a. Is the sampler's purpose to collect data that can be used for the 305b Assessment?
   b. Is water clearly and visibly flowing at a rate that will allow representative sampling in a low flow condition?

   If either or both questions can be answered yes, this protocol is not necessary. If either question is answered "no" or doubt exists for either case, proceed with documentation for possible LF data exclusion.
2. Make notes documenting site characteristics that may support your determination (e.g., site geomorphology indicators suggesting a lack of channel-forming flows, [swales, etc.], vegetation encroachment on the channel, and visible current indicators, if any).
3. Determine the depth location as one of the following three possibilities, in order of importance _ the thalweg, the location with fastest flow, or the approximate center of the channel. Note: it is not necessary to string a measuring tape to complete this step.
4. Take one flow measurement using the 0.6 depth method with the flow rod depth selector set for the local depth.

5. Record the flow velocity value. If the flow velocity is 0, document the value. Flow is not present, and the LF condition is considered qualified. The sampler may elect to refrain from sampling or to exclude the sample collection as "Not for assessment" purposes, based upon this qualification when entering data later.
6. If flow velocity is greater than 0 fps, record the measurement station depth.
7. Using the formula QUWD = D*V, calculate an approximate unit discharge for the site. Adjust the calculated discharge by multiplying by the appropriate velocity. If velocity is greater than 0.25 fps, apply a correction factor of 0.85 to the velocity to account for energy losses due to channel drag.
8. If the unit discharge is less than 0.1 cfs/ft, flow is below the threshold determined by this LF protocol. This LF condition is also considered qualified. Document the value. The sampler may elect to refrain from sampling or to flag any sample collection as "not for assessment" based upon this qualification.
9. If the unit discharge is greater than 0.1 cfs/ft, document the value and proceed with sampling activities. Flow is above the LF unit discharge threshold, and samples will likely not show any adverse effects from chemical composition concentration due to low flow conditions. No qualification of flow is necessary.

FIGURE 5.4. Source identification/flow extent visit to a site exhibiting low flow conditions, March 2014. Note the wetland plant indicators encroaching in the waterway and the lack of distinguishing

channel geomorphology or obvious flow (reeds unaffected by current). Unit–width discharge 0.07 cfs/ft. width; boron exceedance recorded here.

CHAPTER 6 AUTOMATED FIELD EQUIPMENT

The TMDL Unit utilizes a wide variety of automated equipment to collect water quality, stream stage, and meteorological data. A list of materials potentially required to install equipment is listed in Appendix A. Each installation is unique and should be well thought out to ensure all necessary items are available. Specific installation requirements for each instrument are discussed below in the appropriate section.

6.1 RAIN GAGE

Precipitation data is often needed to calibrate hydrologic models. If no precipitation data is available for a particular watershed a rain gage can be deployed to collect data for use in any future modeling needs. The TMDL Unit uses Texas Electronics 8" Rain Gages. The rain gage consists of a tipping bucket mechanism and a HOBO Event Data Logger. The buckets tip in response to every 1/100 inch of precipitation, which is recorded as an event on the HOBO Event Data Logger. Prior to deployment the logger should be connected to a computer and "named" for the site where it will be deployed. This will place the site name in the header of the data when it is downloaded. The logger is connected to the tipping buckets relay output via two wires and has a red light that blinks every two seconds while it's logging and blinks rapidly four times as it stores an event.

It is important that the serial numbers associated with the gage and the location of the deployment is recorded on the TMDL equipment inventory list and any changes are noted promptly.

6.1.1 PLACEMENT

The rain gage should be mounted in a relatively level spot, which is representative of the surrounding native area (do not place on paved surfaces). The lip of the funnel should be horizontal and at least 30 cm above the ground. Consideration should be given to average snow depth if the gage is placed in an area that receives sufficient snowfall to bury the gage. The gage should be placed away from objects that could obstruct wind or rain. The distance should be 2-4 times the height of the obstruction. Potential mounting options include a fence post for taller installation needs or attached to a typical garden paver. The bucket should be secured to an anchored object via a lock and cable.

6.1.2 PRE-TRIP ACTIVITIES

Before leaving to retrieve data sign out a "Rain Gage Bag". The bag contains all the necessary tools for maintaining and downloading data for the rain gages. The project manager should insure that the bag contains the following:

1. HOBO Shuttle;
2. Enough batteries to replace each HOBO Event Data Logger serviced and two additional for the shuttle;
3. Cleaning supplies (paper towels and filled water bottle);
4. Tools (screwdrivers, wrench, and level);
5. Communication cables (shuttle and PC); and
6. Equipment manuals.

The HOBO Shuttle's clock should be checked before leaving for the field. Launching the shuttle while it is connected to a host computer will synchronize the shuttle's clock to the computer's clock. This will ensure that the event loggers are relaunched with an accurate time and date settings. To launch the shuttle, connect to the host computer with the cable provided (serial port cable). Open the Boxcar Pro software and select launch from the logger menu. Boxcar Pro will automatically synchronize the shuttle clock and the battery status. Replace the shuttle batteries if necessary. The shuttle must be relaunched after changing its batteries.

It is recommended that a laptop, with Boxcar software loaded, be brought in the field as a backup to the HOBO Shuttle. If problems are encountered while downloading the data the laptop may be needed.

6.1.3 MAINTENANCE AND CALIBRATION

The funnel, screen, tipping buckets, and tipping mechanism must be kept clean. Routine maintenance should be scheduled to remove any accumulation of dirt, dust, and foreign material. A general 1-3 month maintenance schedule should be followed and include:

1. Clean funnel, screen, and tipping buckets;
2. Inspect tipping buckets for proper operation (i.e. test tips);
3. Check to make sure HOBO Event Logger is logging the events as they occur (during a test tip the LED should blink quickly four times as it logs the event
4. Insure gage is level; and
5. Replace HOBO Event Logger battery (CR2032) annually.

The rain gages should be calibrated annually. Calibration can be accomplished using a graduated cylinder. The event logger should be downloaded before calibrating and relaunched after calibration if the gage is being calibrated during deployment. If deployed, a laptop computer should be brought to download and display the test data. Clean and wet the gage thoroughly allowing water to flow through the gage before beginning the test, this reduces the chance of water adhering to portions of the gage and causing errors in the calibration. Allow 824 mL of water to flow through the funnel at the rate of 1mL per second. The number of tips can be counted manually and verified by displaying the logger data. Best results are obtained by running multiple tests and by using multiple volumes of water. 824mL of water should yield 100 +/- 3 tips; therefore, 8.24 mL of water should cause the bucket to tip once.

Should the gage need adjustment, change the heights of the two calibration post adjustment screws. Rotate each screw by a small amount and recheck the calibration for the new screw positions using 8.24 mL of water. The calibration posts should be adjusted upward (counter clockwise) whenever the amount of water needed to cause the bucket to tip is more than 8.24 mL. Whenever less water is needed the posts should be adjusted downward (clockwise). Do not dry the tipping buckets during the calibration process. Carefully tighten the locking nuts on the calibration screws after completing the adjustments.

6.1.4 DOWNLOADING DATA

Data can be downloaded from the event logger in the field by using the HOBO Shuttle or laptop computer. Connect the event logger to the shuttle by plugging the foot long cable stored inside the shuttle cover into the event logger. Press the black button located on top of the shuttle to start offloading the logger. The series of LED lights on the shuttle will progress through the offload process starting with a blinking orange LED while offloading. Once the offloading of data is complete the shuttle will check the battery status of the logger. If the battery level is below 30% the red "Change Battery" LED will blink. Disconnect the shuttle, replace the batteries, reconnect, and press the black button. Once the battery test passes the orange "Testing" LED will blink, press the button to proceed. Press the button again to relaunch the event logger. When the green LED indicating successful download is blinking, press the button one more time. If the red "Com failure" LED blinks, check the connections and press the button once to clear the failure and to attempt offloading again. If the failure continues, replace the batteries in the event logger and attempt once again. Remove the event logger from the rain gage if the communication failure cannot be fixed in the field and return to the manufacturer for repair. The event logger can also be offloaded using a laptop computer by connecting the serial cable, opening Boxcar Pro and selecting "readout" from the logger menu. Once the logger has been relaunched the old data is erased. When placing the event logger back into the rain gage it is imperative that the wire connecting the logger to the tipping bucket mechanism does not obstruct the movement of the tipping buckets (FIGURE 6.1).

FIGURE 6.1. View of rain gage with funnel and screen removed. Note that the tipping buckets are free of any cables or wires that may hinder them from moving freely.

It is recommended that a laptop, with Boxcar software loaded, be brought in the field as a backup to the HOBO Shuttle. If problems are encountered while downloading the data the laptop may be needed.

6.1.5 POST-TRIP ACTIVITIES

Upon return to the office replace consumables in the HOBO bag (batteries, towels, etc) and offload data from the HOBO Shuttle. Data is offloaded from the shuttle by connecting it to a computer, opening BoxCar Pro, and selecting HOBO Shuttle Readout from the logger menu. The program will offload the data from the event logger. Be sure to store each logger's data to the user-defined location (do not use the default location), check the shuttle's battery and synchronize its clock. Data will not be erased from the shuttle until it has been "offloaded" and then used to offload another event logger. Once consumables have been replaced and the shuttle has been offloaded place the bag back in the cabinet for future use.

6.1.6 FILE STORAGE

Electronic files should be stored on the project manager's d-drive within the project's file structure. Copies of data files must also be maintained on the project manager's m-drive or on a CD. Raw data files should also be maintained to preserve data integrity. As new data is collected it should be added to a running list of compiled data.

All field activities related to installation, data downloads, maintenance, calibration, etc. must be documented in the project field notebook. Observations noted should include, but are not limited to date and time, cleanliness of equipment upon arrival, actions taken (cleaned funnel, checked level, etc.), destination of downloaded files, problems encountered, check serial numbers, etc.

6.2 TEMPERATURE GAGES

ADEQ uses HOBO Pro Temperature Gages. The gages are deployed in conjunction with rain gages at sites where snow is possible and in watersheds where no temperature data is available. The gages contain a HOBO Event Logger encased within a series of air baffles. Prior to deployment the event logger should be connected to a computer and "named" for the site where it will be deployed. This will place the site name in the header of the data when it is downloaded. The temperature is logged every 15 minutes.

It is important that the serial numbers associated with the gage and the location of the deployment is recorded on the TMDL equipment inventory list and any changes are noted promptly.

6.2.1 PLACEMENT

The gage should be placed away from objects that could obstruct wind or rain. The distance should be 2-4 times the height of the obstruction. The gage should be placed approximately three feet above the ground to avoid saturating the gage.

6.2.2 DOWNLOADING DATA

Data can be downloaded from the event logger in the field by using the HOBO Shuttle or laptop computer. Connect the logger to the shuttle by plugging the foot long cable stored inside the shuttle cover into the logger. Press the black button located on top of the shuttle to start offloading the logger. The series of LED lights on the shuttle will progress through the offload process starting with a blinking orange LED while offloading. Once the offloading of data is complete the shuttle will check the battery status of the logger. If the battery level is below 30% the red "Change Battery" LED will blink. Disconnect the shuttle; replace the batteries, reconnect, and press the black button. Once the battery test passes the orange "Testing" LED will blink, press the button to proceed. Press the button again to relaunch the event logger. When the green LED indicating successful download is blinking, press the button one more time. If the red "Com failure" LED blinks, check the connections and press the button once to clear the failure and to attempt offloading again. If the failure continues, replace the batteries in the event logger and attempt once again. Remove the logger from the rain gage if the communication failure cannot be fixed in the field and return to manufacturer for repair. The logger can also be offloaded using a laptop computer by connecting the serial cable, opening Boxcar Pro and selecting "readout" from the logger menu. Once the logger has been relaunched the old data is erased.

6.2.3 POST-TRIP ACTIVITIES

Data is offloaded from the shuttle by connecting it to a computer by opening BoxCar Pro, and selecting HOBO Shuttle Readout from the logger menu. The program will offload the data from the logger. Be sure to store each logger's data to the user-defined location (do not use the default location), check the shuttle's battery and synchronize its clock. Data will not be erased from the shuttle until it has been read out and then used to offload another event logger.

6.2.4 FILE STORAGE

Electronic files should be stored on the project manager's d-drive within the project's file structure. Copies of data files must also be maintained on the project manager's m-drive or on a CD. Raw data files should also be maintained to preserve data integrity. As new data is collected it should be added to a running list of compiled data.

All field activities related to installation, data downloads, maintenance, calibration, etc. must be documented in the project field notebook. Observations noted should include but are not limited to, date and time, cleanliness of equipment upon arrival, actions taken, destination of downloaded files, problems encountered, check serial numbers, etc.

6.3 PORTABLE (AUTOMATIC) SAMPLERS

6.3.1 GENERAL OVERVIEW

The TMDL Unit utilizes portable (often referred to as automatic samplers) to supplement grab sampling efforts. Portable samplers are deployed and programmed to start sampling as water levels rise. The use of portable samplers allows for the sampling of storm events over a larger portion of the hydrograph at more locations than could be accomplished by traditional grab sampling methods. The samplers typically are configured to hold 24 one liter bottles and can be programmed to collect samples over varying time frames (i.e. one bottle every hour or two bottles every two hours). The autosamplers are powered by a 12-volt rechargeable battery which will hold enough charge to complete a sampling program for up to five weeks. In order to continuously charge to the battery during deployment 5-W solar panels are available for use with the ISCO samplers.

Currently the TMDL Unit uses portable samplers manufactured by American Sigma (models 800 and 900 Max; FIGURE 6.2) and Teledyne ISCO (model 6712). Both brands are constructed and operate similarly. They consist of a base that holds the bottles, controller section, and a lid. The controller section houses the electronics, pump, distributor arm, and battery. Standard configurations are battery powered but 5W solar panels can be installed to continually charge the battery.

FIGURE 6.2. Sigma 900 Max autosampler (left) and ISCO 6712 autosampler (right)

6.3.2 QUALITY CONTROL

Prior to deploying a sampler to a new location the intake, pump, and distributor tubing must be replaced and the unit completely cleaned. Additionally, if polyethylene bottles are used they are project and site specific and cannot be used at sites other than where they were originally deployed. Typically two sets of bottles are ordered for each site, one to replace the other after samples are collected. Bottles are acid washed when new and after each sampling event. The bottles are capped, bagged and placed inside a container during storage and transport. The bottle sets should be labeled to indicate the site and set (e.g. "A" or "B") once they have been deployed so that they can be identified independently. The sample volume should be calibrated before each deployment to ensure bottles will be filled properly. Volume calibration can be performed using the volume calibration/test-run kit developed by the TMDL Unit.

Bottle and equipment blanks should be collected and analyzed for the same parameters that are being sampled through the autosampler prior to deployment. Equipment blanks are collected after the tubing has been replaced and prior to field deployment. Typically one liter bottle of DI water is pumped through the intake, pump and distributor tubing into one of the new bottles (after acid cleaning), then poured into a regular sample bottle supplied by the analytical laboratory. Bottle blanks should be collected for each set of bottles after the initial acid wash (as part of the equipment blank) and periodically throughout the project as the bottles are cleaned prior to redeployment.

Ideally several grab samples will be collected simultaneously with autosampler sample collection to determine that the autosamplers are not biasing the results.

6.3.3 PLACEMENT/DEPLOYMENT

Portable samplers can be deployed for long or short terms depending on the requirements of the project. Regardless of the length of deployment, installation should follow the same general guidelines listed below:

- Place and secure sampler above potential high water line, see FIGURE 6.3
- Run intake tubing and float switch wiring from autosampler to stream and secure (long-term deployments should include anchored PVC pipe which the tubing and wire is routed through), see FIGURE 6.4

- The intake strainer should be placed approximately 4" above the stream channel to avoid sampling bedload material;
- Secure float switch in stream and attach wiring to autosampler.

The TMDL Unit utilizes simple float switches to activate the automatic samplers in response to changes in water level, see FIGURE 6.5 for an example. When deploying autosamplers care must be taken to minimize vandalism, lose of equipment, and required maintenance while allowing for sample retrieval under adverse weather conditions.

See Appendix A for a list of equipment needed for installation of autosamplers and Appendix H for detailed instructions for float switch construction.

FIGURE 6.3. Example autosampler installation scenarios- under bridge (left) and secured to bridge support (right)

FIGURE 6.5. Float switch (black) connected to PVC cap

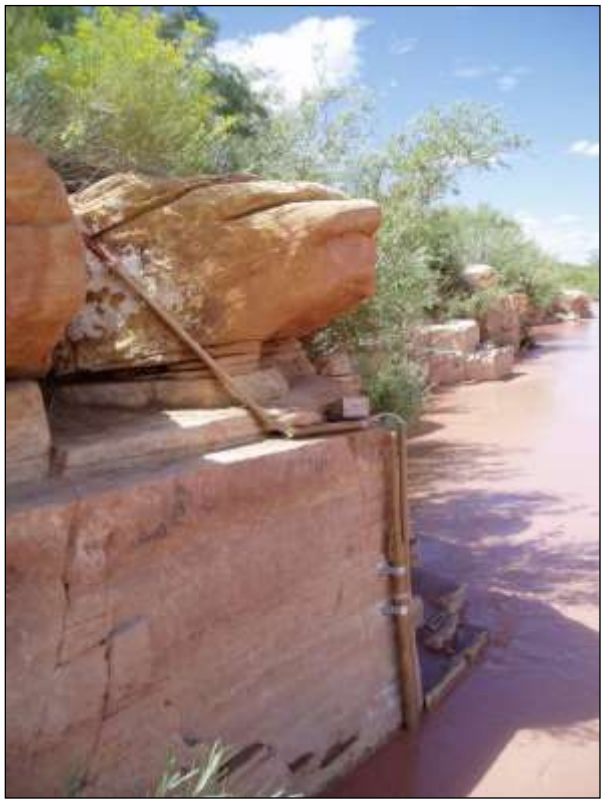


FIGURE 6.4. Examples of intake tubing (with strainer attached) and float switch installations, note anchoring to fix objects.

In order to determine the discharge at time of sampling the sampler should be deployed at or near a USGS gaging station or with a level logger. If deployed with a level logger a stage to discharge relationship will have to be developed by measuring the instantaneous discharge at several stages of flow. This task is normally accomplished through discharge measurements taken when collecting grab samples.

6.3.4 PROGRAMMING OPTIONS

Autosamplers have a wide range of programming options. Although the different manufacturers have slightly different "buttonology", each operate in a similar fashion, see FIGURE 6.6. They can be programmed, using the keypad, to collect individual or multiple samples at programmable time intervals.

FIGURE 6.6. Overview of autosampler keyboards- Sigma 900 Max (left) and ISCO 6712 (right)

Appendix J contains an example of a Sigma and ISCO program. It is important to keep in mind that the number of bottles collected per sample and the sampling interval are dependent on the data needs of the project. Additionally, the required analytical sample volume and holding times need to be considered.

6.3.5 EQUIPMENT KEYS

Equipment that is deployed in the field for any extended period of time must be secured to prevent theft. A large number of keys and locks have been used within the unit. To enable access to equipment for sample and data collection it is the project manager's responsibility to record the key number and the corresponding location that the key fits. This is best recorded in the cover of the field notebook and in a spreadsheet.

6.4 WATER LEVEL LOGGERS

Water level loggers typically consist of a pressure transducer used to record water level and temperature in a stream or lake over a period of time. Water level loggers are designed for long-term

deployment. They can be deployed and left unattended for months at a time, collecting water level data at user-defined intervals and storing it digitally into logger memory. By operating in a continuous 24/7 monitoring mode, water level loggers eliminate many of the hassles of manual data collection approaches and facilitate monitoring of multiple locations at the same time.

The logger data, in conjunction with several manually obtained stream discharge measurements (obtained at different stages), and a survey channel cross section provide the information required to construct a stage-discharge relationship. Once this relationship is established, stream discharge can be estimated on the basis of the stage data alone.

6.4.1 GENERAL CARE

Loggers should be installed where the stream channel is most stable (e.g. bedrock lined channel). In most cases the logger should be placed inside a slotted PVC pipe or similar material that serves as a stilling well that will dampen water level fluctuations and protect the logger. The pipe may be secured to a permanent structure, buried in the riverbank, secured with rocks, or fastened to the bank with rebar or similar material, see FIGURE 6.4. Once installed a reference point should be established upon which future water depth measurements can be made. For example, the bottom of the stream channel if bedrock lined or the PVC cap at the end of the well screen could be used as the reference point. It is important that the reference point be stable throughout the span of the project.

Loggers should be cleaned and downloaded every six weeks. Depending on the model, batteries should be replaced/checked every six months. Most loggers come pre-calibrated from the factory, where possible real-time measurements should be taken and compared to the data recorded by the logger. The calibration on the loggers, regardless of manufacturer, should be checked upon installation and every six months during deployment. The calibration can be checked by filling a known length (e.g. three feet) 1" PVC pipe with water, placing the pressure transducer in the pipe and reading the level recorded by the logger. A "dry" (pressure transducer not submerged in water) reading should equal zero. If the measurements are off by more than two-tenths of a foot, the logger should be sent back to the factory for calibration.

Once a level logger is installed, a stream channel cross-section must be completed following the procedures discussed in Sections 8.2 and 8.3 of the Standard Operating Procedures for Water Quality Sampling. The cross-section transect should include the position of the level logger and reference point. If large deposition or scour events occur a new cross-section will need to be completed.

The following sections describe the procedures for logger set-up, deployment, and data retrieval of three common water level loggers used by the ADEQ TMDL Unit. The necessary materials needed to perform routine maintenance are included in Appendix A.

6.4.2 LEVEL LOGGER FIELD OBSERVATIONS

During each site visit several observations must be made and include:

- Current water level as measured from the reference point (if dry, record as "dry");
- Compare actual water depth to real-time instrument reading;

- Changes in stream channel (material, geometry, etc) since last visit;
- Logger time relative to laptop, GPS, or other accurate reference time;
- File path where data was saved; and
- Serial number of logger.

6.4.3 HOBO® U-20 WATER LEVEL LOGGERS

The HOBO® U-20 Water Level Logger is a completely self-contained unit meaning there are no vent tubes or desiccants to maintain, see FIGURE 6.7. This non-vented logger is compact, and requires minimal maintenance. However, the logger depends on either a second logger, or weather station to correct for changing barometric pressures. The procedures for setup, deployment, data retrieval, and barometric pressure compensation are discussed below. The HOBOware™ Software Kit loaded onto a computer and an optic USB Base Station are required for logger setup and retrieval.

The following steps should be taken for the deployment of the HOBO® U-20 Water Level Logger:

1. Install the HOBOware™ Software onto computer.
2. Plug the USB-Optic Base Station cable into a USB port on the computer. If the base station has never been connected to the computer before, it may take a few seconds for the new hardware to be detected by the computer. It may also be necessary to reboot the computer.
3. Unscrew the black plastic end cap from the logger by turning it counter-clockwise.
4. Align flat areas of the logger and base station, then insert the logger. Gently twist the logger to be sure that it is fully seated in the base station. If the logger has never been connected to the computer before, it may take a few seconds for the new hardware to be detected by the computer.
5. Click the Launch icon on the toolbar. This displays the logger's launch window.
6. Review the default launch settings and make any necessary changes. Enter a new name in the description field and select or deselect channels to log. You must select absolute pressure and temperature. Determine the appropriate logging interval and program the logger. Loggers are usually set to record data at 15 minute intervals. You may start logging immediately or choose the date/time you wish logging to start.
7. Click **Launch** to begin logging. HOBOware displays the progress of the launch and warns you not to unplug the logger while it is being configured.
8. Once this is complete you can unplug the logger. Make sure to screw the black plastic end cap back onto the logger before deployment.

FIGURE 6.7. HOBO U-20 Level Logger

The logger is now ready to be installed in the stream channel or lake. At the end of the logging period, the following steps should be followed in downloading the HOBO® U-20 Water Level Logger:

1. Connect the logger to the computer (see logger deployment steps 2-3).

2. Click the Readout icon on the toolbar, or choose readout from the logger menu. A message will ask whether you want to stop the logger; click OK.
3. Wait while the data is read out from the logger.
4. HOBOware prompts you to save the data. Specify the location and name of the file and click Save.
5. A Plot Setup dialog box will appear. When you have made your selections, click the plot button.
6. From the displayed plot you can export the data to Excel; under the file menu select Export Points as Excel Text. This will prompt another save screen; input the file name and location and click save.

6.4.3.1 Barometric Pressure Compensation

Storms and changes in elevation have a significant impact on barometric pressure. Stormy weather can produce up to 25 millibars of pressure differential during a single day. Since one millibar equals one centimeter of water this equates to almost 10" of error in water level readings. The HOBO® U-20 Water Level Logger does not automatically correct for changing barometric pressures; instead a second water level logger, a HOBO Weather Station, or import ASCII formatted barometric data must be used to correct for barometric compensation. When a second logger is used it should be placed in a secure location near the logger, and should be set up to record at the same times as the HOBO Water Level Logger. The HOBOware™ Software uses a barometric compensation assistant to convert water pressure data to water level or sensor depth values, and compensate for barometric pressure.

To use the barometric compensation assistant:

1. Open the HOBOware™ Software;
2. Open the data file to be corrected;
3. When the Plot Set Up dialog box opens, select the Barometric Compensation Assistant under data assistants, and click the Process key;
4. To use the barometric data file from another HOBO logger, click the Use Barometric Data file button and browse to the .hobo file that contains a pressure series from an overlapping time period;
5. Name the new file, and click Create New Series. The new series will be displayed. The new series file can then be exported to Excel (see step 6 above).

6.4.4 GLOBAL WATER WL15 AND WL16 WATER LEVEL LOGGERS

The Global Water WL15 Water Level Loggers consists of a pressure transducer connected to a data recorder by a sensor cable, see FIGURE 6.8. WL16 models also record temperature but their basic operation is similar to the WL15.

The following steps should be followed in setting up the Global Water Level Loggers for deployment:

Figure 6.8. Global Water Level Logger

1. Install the Global Logger Software (verify version if using a WL16) onto a laptop computer;
2. Verify the logger is reading accurately by placing the transducer in a three foot long PVC pipe filled with water. Launch the Global Water Software and check the real-time reading of the logger. At the main screen "check" the "Sample Continuously" box to view real-time values. If the reading is within 0.05' of 3.0' the logger is properly calibrated;
3. Make sure the computer is reading the correct date and time;
4. Double click the "**Global Logger**" icon. Once the main Global Logger window will appears, select the clear memory button.

Make sure that data has been saved before pressing this button.

5. Click the "**Synchronize Time**" button; this will synchronize the logger time with that of the computer;
6. Click on the "**Setup**" button; here you can specify the logger/site name and the sample interval. In general loggers should be set to record data at 15 minute intervals;
7. The logger comes pre-calibrated from the factory; however site specific calibrations can be made. Refer to the Water Level Logger Users Guide (Global Water Instruments Inc, 2002) for the calibration procedure; and
8. Click **OK**, the logger is now ready for deployment.

The following steps should be followed in downloading the Global Water WL15 Water Level Logger:

1. Double click the "**Global Logger**" icon. Once the Global Logger main window will opens, click the "**Get History Data**" button;
2. A historical data viewer window will open. Save the current reading by clicking the "**Save to File**" button, select the location to save data and a file name, and click **save**. The file will save as a comma separated file that can be opened in Excel.

Data should be downloaded every six weeks. In addition, the Global Water WL15 Water Level runs on a 12V lithium battery which should be changed every six months. The battery is accessed by unscrewing the black cap on the end of the data logger. The screen on the end of the sensor should be periodically checked for clogging. The screen can be cleaned with soap and water and/or scrubbed gently with a toothbrush.

The Global Water WL15 Water Level's cable contains a vent tube that automatically corrects for barometric pressure compensation. This vent tube must not be kinked or obstructed, or erroneous

data will result. Additionally, the data logger is water resistant, not waterproof. It should not be submerged and should be protected from condensation and rainfall.

6.4.5 IN-SITU LEVEL TROLL 500 WATER LEVEL LOGGERS

The Level Troll 500 Water Level Logger is a completely sealed unit that contains pressure and temperature sensors with an optional vented or non-vented pressure sensor, see FIGURE 6.9.

The following steps should be followed in setting up the Level Troll 500 Water Level Logger for deployment:

1. Remove the protective caps from the Level Troll and vented/communication cable.
2. Slide back the sleeve on the cable connector.
3. Orient the "flats" (grooves) so they will mate up, and insert the Level Troll connector firmly into the vented/communication cable connector. Slide the sleeve on the cable toward the Level Troll body until the pin on the body pops into the round hole in the slot on the cable connector.
4. Grasp the knurled (textured) section of the cable connector in one hand and the Level Troll body in the other. Push and twist firmly so that the pin on the body connector slides along the slot on the cable connector and locks securely into the other hole.
5. Connect vented/communication cable to the PC serial port via the TROLL COM cable and make sure that Win-Situ software is loaded onto the computer.
6. Start Win-Situ by double-clicking the shortcut created on the desktop. When the Win-Situ application window opens, select File menu >Settings and check your PC's COM port (usually COM 1 for direct serial port connection). Click the "**OK**" button.
7. Click the "**Connect**" button to connect to the Level Troll. The software will connect to the Level TROLL and display current level/depth, pressure, and temperature readings (pressure and temperature for a BaroTROLL).
8. Set the clock. Both the device clock and the system (PC) clock are shown on the dashboard when the device is connected. The clocks update every two seconds. If the device clock is more than two seconds off from the system clock, the device clock is displayed in red. To synchronize the clocks, click the **Sync** button.
9. To prepare the device to log data, first select the Logging tab. Click the "**New**" button. The Logging Setup Wizard will prompt you through the configuration of a data log—including the site, log name, parameters to measure, sample schedule, start time, stop time, output (pressure, depth, or water level with a reference), and other options.

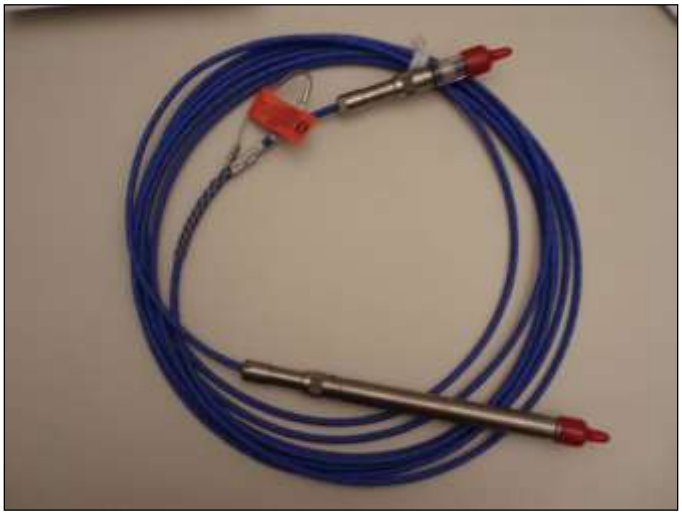


FIGURE 6.9. In-situ Water Level Logger with vented cable attached

To start logging:
A "Pending" (scheduled) log will start at its programmed time. You can start a "Ready" (manual) log at any time while connected by selecting the log and pressing "**Start**" to start logging;
To stop logging:
Select the log and press the "**Stop**" button or suspend (temporarily stop) it with the "**Pause**" button.

10. After entering the logging program, you're ready to Exit the software (File menu > Exit). Disconnect the Troll Com cable by grasping the knurled (textured) section of the cable connector in one hand and the Troll Com cable in the other. Twist in opposite directions to unlock the Troll Com cable from the vented cable.
11. Install the instrument in its field location.

The following steps should be followed in downloading the Level Troll 500 Water Level Logger:
1. Connect logger to computer as described above;
2. Start Win-Situ software; and
3. Select the log and press the "Download" button.

Similarly to the Global Water WL15, the Level Troll cable contains a vent tube that automatically corrects for barometric pressure changes. This vent tube must not be kinked or obstructed, or erroneous data will result. Additionally, the data logger is water resistant, not waterproof. It should not be submerged and should be protected from condensation and rainfall.

6.5 FIRST FLUSH SAMPLING

First Flush sampling is a sampling method used in conjunction with storm flow sampling for TMDL analyses generally in ephemeral streams. A first-flush sample allows for the collection of a one-liter sample in the first moments after streamflow begins. Such flushes often carry some of the highest concentrations of the constituents of concern and therefore are valuable as a worst-case representative sample.

FIGURE 6.10. First flush samplers. Photo credit Cole Palmer

6.5.1 USE AND SITE SELECTION

The advantage of using first-flush samplers over auto-samplers for collecting the first moments of the storm have largely to do with cost, portability, and relative ease of deployment. Numerous first flush samplers can be placed at various strategic locations (at the mouths of several feeding tributaries, for example) at a fraction of the cost and time of an auto-sampler installation. First flush samplers are an excellent low-tech method for characterizing water contributions over an entire area or network in the first moments of storm flow; this is one of their greatest benefits. However, since they are passive collectors, they can only collect one liter at one time, thus they do not allow for characterizing the water quality throughout the duration of storm flow. If more than one liter is needed for the desired analytical work, multiple samplers may need to be deployed within a small radius of the planned sample site. They must be retrieved, collected, and re-set prior to each subsequent storm flow.

The first-flush sampler consists of a one liter Nalgene bottle with a specifically-designed cap (FIGURE 6.10). The cap is designed so that sediment-laden water falling on top of the cap is diverted radially around an ellipsoid-shaped bulb having the same radius as the collection bottle. At the outer edge of the ellipsoid, sediment particles are shed by gravity outside the collection bottle, while the water continues to adhere to the surface of the ellipsoid and run to the center collection point below the bulb.

6.5.2 EQUIPMENT LIST

The installation of a first-flush sampler will require the following items:

- One-liter Nalgene bottle with first-flush collector top
- Protective (PVC/ABS) casing with slotted (grated) cap and base. These may be either purchased from the supplier or built in-house
- 6 - ¼" diameter hex-headed tapping screws w/ slotted top
- Nut driver or flat-bladed screwdriver (stubby version best)
- Portable drill with 1/8" bit
- Nylon sleeve or harness (constructed prior to installation)
- Super glue or quick-dry epoxy
- Spade/shovel. A long-nose shovel is very useful
- Post-hole digger
- Pick
- Pry-bar
- Rebar with visible plastic cap for sites that might be buried/inundated with sediment

FIGURE 6.11. Basic cleaning equipment

The routine maintenance and re-setting of an installed first flush sampler will require the following:

- 1 to 2 gallon bucket for rinsing
- De-ionized (DI) water, 2-5 gallons (depending on number of samplers to clean)
- Nitrile gloves
- Pressurized sprayer
- Sterilized and sealed replacement Nalgene bottles
- Scrub brush
- Toothbrush

Additionally, if it becomes necessary to extract the whole casing tube to retrieve the sample, items from the installation list may be required to re-bury the casing after re-set.

6.5.3 INSTALLATION

If the First Flush sampler is going to be placed in the bed of the drainage, it is best to locate a spot where the composition of the channel is somewhat unconsolidated and the particle size is cobble or smaller. Stream channels with a consolidated, hard packed bed and large particle size tend to be difficult to work with. The black PVC tube which holds the Nalgene sampling bottle is placed in a hole that has been excavated in the bed. Depending on the selection of the spot, the tools utilized have much to do with the composition of the bed material. In unconsolidated sandy beds it may be possible to get by with just a post-hole digger or shovel. In other areas the use of implements such as a pick axe and pry bar may be needed to loosen the material enough to dig the hole. The top of the tube should be positioned so that it is flush or just slightly higher than the existing surface of the channel (FIGURE 6.12). This will require that the hole be dug to a depth of approximately 2 feet. The tube is equipped with covers on each end that are slotted to allow for drainage. Placing a layer of loose material beneath the tube can help to drain away some of the excess water. If the desire is to collect a sample that is not a part of the first initial pulse, the tube can be positioned higher to sample the storm flow occurring as the runoff increases (FIGURE 6.13). When the tube is located at the proper height, begin replacing the excavated bed material around the outside of the tube. While refilling the hole, make sure that the tube is not tilted or sitting at an awkward angle. If available, use a bubble level to check on the position of the tube as the bed material is filled in around it. If the sampler needs to be stationed in a drainage with unworkable bed material, it may be necessary to find a spot in the drainage where the channel drops enough that the sampler can be positioned to capture the flow. These can normally be found in bedrock outcrops, or where you have a channel that has eroded down to a denser geologic feature that has over time formed a water fall as the softer material below it has been eroded away. In some cases it may be possible to attach the tube to an anchoring device such as a piece of rebar or a steel

FIGURE 6.12. Flush installation.

FIGURE 6.13. Raised installation.

post hammered into the bed. If the bed material will not allow this, it may be necessary to attach the tube directly through the use of a hammer drill and anchor bolts.

If the sampling bottles are going to be re-used, mark the bottles so that they are not mixed up between sites. Bottles should be kept both project and site specific. Although the First Flush sampler is equipped with a zip-tie device at the top of the sampler for removal after the sample has been collected, many times the protective tube will fill with debris, making its removal difficult. To assist in removal of the sampler, personnel of the Watershed Protection Unit have designed a sleeve made of ½ inch nylon strapping. Several sleeves have been produced and are available for use. The sleeve consists of a length of strapping approximately four feet long that is placed in a U-shape around the sampler length wise. Two sections of strapping, each one foot in length are wrapped around the sampler near the bottom and the top. Glue is used to secure the sections to the length wise piece of strapping, and then a needle and heavy thread are used to further secure the spots where glue was used to hold the strapping together. When this is finished, attach the two pieces of a side release buckle to the ends of the length wise section of strapping. An open flame can be used to seal the ends of the strapping so they do not fray or unravel. FIGURE 6.14 illustrates the sampler and sleeve.

FIGURE 6.14. Sampler with Nylon Sleeve

After placing the sampler into the sleeve, slide the bottle into the tube until the bottle is sitting on the bottom of the tube. Take the slotted top and place it on the tube as you feed the ends of the nylon strapping with the attached buckle sections through the slots. After the top has been securely fitted into the tube, take the buckle sections and secure them together over the top of the slotted top. This helps to keep the strapping in place and also helps to make the sampler more visible if it becomes covered with debris. The buckle can also be attached to the underside of the vented top by a zip-tie if that is more appropriate. If there is concern that excess debris deposited by storm flows may make the sampler harder to locate, drive a piece of re-bar into the ground next to the sampler

and cap it for safety. When the sampler is in place, be sure to take a GPS reading and as many photos as needed.

6.5.4 SAMPLE RETRIEVAL AND RE-SET

Once the sampler is in place, begin to monitor the rainfall in the area through the use of remote sensing devices if possible. If remote sensing equipment is unavailable, rainfall can be monitored by the use of internet sources such as the National Weather Service or NOAA. Once sufficient rainfall has occurred to initiate storm flow run-off (in Arizona usually greater than 0.5 inches), the individual monitoring the sampler should return to verify that a sample has been collected. If further samples are needed, clean Nalgene bottles with tops should be brought to the site. Be sure that the bottles are labeled with the correct project and site ID. Equipment for cleaning the sampler should also be brought to the site. Cleaning equipment consists of a box of nitrile gloves, a five gallon bucket, a container of tap water (amount needed will depend on the number of samplers to be cleaned), a clean plastic brush for scrubbing off the debris, a clean pump-pressurized sprayer filled with de-ionized distilled water, and a container of DI water for back-up. When the sampler has been located, remove the slotted top from the tube. If the tube has become filled with debris, attempt to remove as much from around the sampler as you can. Once the debris has been removed, grasp both sides of the nylon strapping with each hand and slowly pull the sampler from the tube. Don't pull by just the buckle, which puts undue pressure on the clasp. In some cases the sampler may be packed so tightly that it will require removal of the entire tube. Once the tube has been removed, remove the slotted bottom and rap on the surface of the tube with a hammer or other tool to loosen the debris. This should cause the sampler to become loose enough that it can be pulled from the tube. After removing the sampler from the tube, unscrew the Nalgene bottle from the cap and place a clean top on it. Because the bottle has been pre-labeled, it can be placed directly into the ice chest at this point. After putting on a pair of the nitrile gloves take the specially designed cap and place it into the five gallon container which should contain enough of the tap water that the cap will be completely covered. Let the cap soak in the water for a few minutes to help soften up any dirt or debris that has adhered to the surfaces of the cap. At this point, take the brush and gently scrub the debris from the cap. Occasionally dip it in to rinse off the loosened debris. Take the cap apart and once again follow the same process with each individual section. When the individual pieces of the cap have been cleaned of all debris, take each section and rinse them completely with DI water from the pump sprayer. Once the pieces have been rinsed, reassemble the cap and attach it to a clean, pre-labeled Nalgene bottle. Re-attach the nylon sleeve to the sampler, and place it back into the PVC tube. It is recommended to change gloves at each sampling site.

6.5.5 DATA MANAGEMENT

First Flush samplers are an efficient method of collecting the first pulses of storm flow run-off. However, it is a somewhat low-tech device in that it is not equipped in any way to indicate the exact time that the sample was collected. Unless you happen to be at the site when the storm flows begin, the sample time must be estimated. This can be done by looking at the rainfall information from the area. Some internet weather sites collect weather data from small weather stations which are in some cases run by private citizens. If there are no stations at the sample site, locate the nearest one to the area and review the recent rainfall data. This may give an indication as to approximately when the initial flows began. When entering the data, add the event description "APPROXIMATE

SAMPLE TIME OR SAMPLE TIME UNKNOWN". Once the sample has been processed it can then be submitted to the lab for analysis. If grab samples were also collected at or around the FF site, it will help to avoid confusion if the sample is labeled with either G or FF, both on the bottle and on the comment field of the submittal form. When the final analysis results are being uploaded into the surface water database, be sure to indicate "FIRST FLUSH" in the drop down field of the Sample & Test Results window.

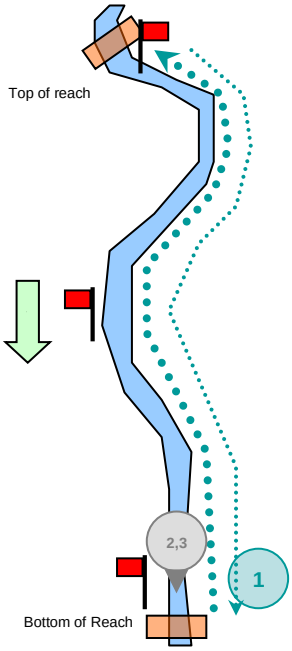
CHAPTER 7 STREAM ECOSYSTEM MONITORING

This chapter covers how to collect macroinvertebrates, algae and habitat data using the Stream Ecosystem Monitoring (SEM) methods and field form. SEM data is typically collected during the spring index period for macroinvertebrates.

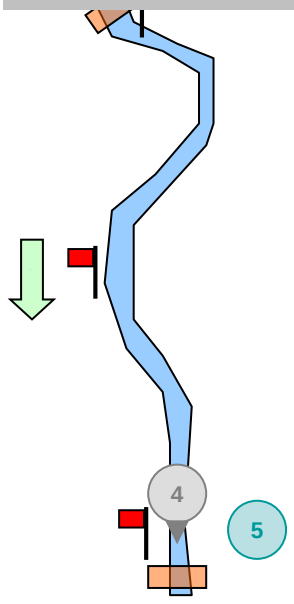
7.1 SAMPLING ORDER

The following section provides a general outline to efficiently collect chemistry, algae, macroinvertebrate and habitat data at a particular site with a two person team. Person one is identified in blue. Person two is identified in grey. Each task is listed in the circle corresponding to each person's color.

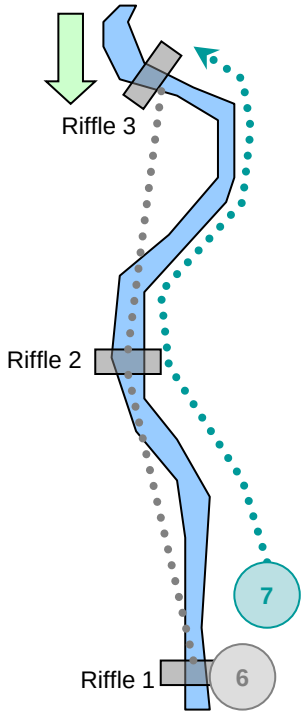
The information contained in this section is meant to summarize the order of data collection in the field from the chapters that follow.



1. Lay out reach. The reach length should equal 40 times the wetted width. The minimum reach is 300 feet. This person needs the tape measure, flagging and a knowledge of their pace. Begin the site sketch from the bottom of the reach recording the number of paces of riffles, pools, runs on the SEM form. Note the 3 good riffles for macroinvertebrate sampling. Calculate percent riffle, run and pool for algal sampling.
2. Take field measurements w/ multimeter.
3. Collect water samples (and any other QC or additional parameters). Use DH-81 and churn splitter if avg depth > 1 foot, avg velocity > 1 ft/s, or grab sample not appropriate.

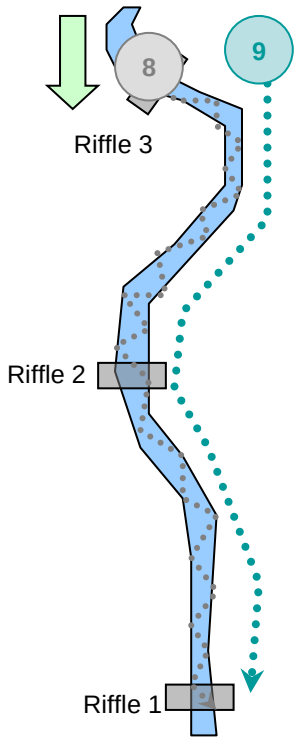


4. Take discharge measurements. Measure wetted width. Divide by 20. Minimum width separation 0.3 ft (for small streams). For depths > 2.5 ft use 2 point method (0.2 and 0.8 depths rather than 0.6 depth).
5. Record discharge. Take photos at the top and bottom of the reach (up, down, banks).



6. Collect bugs in 3 riffle habitats. One minute kicks over a 1 square meter area. Place bugs in bucket at each riffle. Take densiometer readings.
7. Record and fill out remainder of sheets including site sketch.

8. Record and fill out riparian portion including the site sketch.
9. Do the reach wide pebble count. Goal is 100 reach wide particles evenly spaced. Do % algae and macrophyte cover along with the reachwide pebble count. For cold water streams, do transect pebble counts and embeddedness at same riffles (33 pebbles per transect).
10. Collect Rosgen channel data, riparian tree data and fill out proper functioning condition, habitat score and Pfankuch stability evaluation as a team.



7.2 COLLECTING MACROINVERTEBRATES

Macroinvertebrate sampling is conducted to better assess the aquatic and wildlife designated use of perennial, wadeable streams. ADEQ has developed bioassessment tools in the form of Indexes of Biological Integrity (IBI) along with habitat evaluations for this purpose. There are two IBIs, the Warm water IBI and Cold water IBI. The procedure for calculating the IBIs is found in the Biocriteria Implementation Procedures (ADEQ, 2015) and in the Surface Water Standards Rules (A.A.C. R18-11-108). The Habitat evaluations in the SEM method are for the purpose of assessing channel, riparian and habitat conditions; potential stressors on macroinvertebrate community condition.

7.2.1 SITE SELECTION

The stream reach length for Stream Ecosystem Monitoring should be one of the following:

1. 40 times the wetted width of the stream.
   - A. A minimum reach length of 300 feet.
   - B. A maximum reach length of 3,000 feet.

The stream reach should be selected to represent typical habitat conditions found in the larger stream segment. The stream reach length should begin at the top of a riffle or run and end at the bottom of a riffle or run.

7.2.2 REFERENCE SITE SELECTION

If the reach is to be used as a reference or background reach, the following general criteria must be met:

- No known discharges upstream
- No major impoundments upstream
- No human caused channel alterations at the site; e.g. diversions, dredge and fill projects
- No known mines upstream in the watershed
- At least 0.5 miles downstream of road crossings
- The site should be perennial. The indicators for perennial condition are likely to be the presence of fish, univoltine insects (i.e. one generation per year), and healthy unstressed riparian plants
- The site should be free of local land use impacts
- There should be no recorded violations of pH or dissolved oxygen water quality standards
- The Habitat Assessment Index score should be greater than 14
- Reach percent fines for cold water < 12%; warm water < 26%
- Proper functioning condition percent of ideal score > 80%
- Pfankuch rating ≥ Good
- Canopy percent cover for cold water > 29%; warmwater > 15%
- Crayfish should not be present or present in low abundance
- No recent fire in the watershed
- No recent major floods (>10 yr return interval) within the past year

7.2.3 WHEN TO SAMPLE MACROINVERTEBRATES

The narrative biocriteria standard (A.A.C. R18-11-108.01) applies to wadeable, perennial streams with either an aquatic and wildlife cold or warm designated use. The following sampling conditions and time frames must be met in order to collect macroinvertebrates for ADEQ bioassessment purposes. A stream reach must be:

- **Wadeable**. Wadeable means no deeper than can be safely waded across when collecting samples.
- **Perennial**. Perennial refers to stream segments which flow continuously throughout the year (excluding effluent dependent waterbodies).
- **Contain fast-flowing riffle or run habitat**. Riffle habitat refers to the portions of streams where moderate velocities and substrate roughness produce moderately turbulent conditions which break the surface tension of the water and may produce whitewater. Run habitat refers to segments of streams where there is moderate velocity water, but non-turbulent conditions which do not break the surface tension of the water and do not produce whitewater (Bain and Stevenson, eds.1999).
- **Sampled during the spring index period** (April-May for warm water streams (<5,000 ft.) and May-June for cold water streams (>5,000 ft)). The spring index period is described as a period of time following winter runoff in which baseflow conditions will be found in most streams.

Baseflow conditions generally are achieved post winter runoff in the desert streams in April-May and in mountain streams in May-June. A period of 4 weeks post-bankfull flood condition is generally required prior to macroinvertebrate sampling, even during the spring index sampling period. Hydrologic conditions are checked in the office prior to a site visit and field conditions are documented on the SEM form macroinvertebrate conditions table in the field prior to sampling to confirm that sampling is occurring during the correct sample collection conditions.

Macroinvertebrate samples are not collected when the following conditions occur:

- A bankfull or greater magnitude flow event has occurred within 4 weeks of site visit or when extreme high flow events have occurred, resulting in deep scouring of the streambed and benthic community such that the macroinvertebrate community will not recover within the spring index period.
- A 10 year or greater flood event has occurred within 6 months of the sampling event.
- Extended drought conditions have reduced flow from previously perennial condition to pools only or stagnant wetland habitat.
- Stream substrates that are dominated (consisting of >50% of that substrate type) by bedrock, or travertine are considered non-target conditions.

Macroinvertebrate samples should be collected before pebble counts and before any disturbance to the stream channel by investigators. The collection begins at the downstream end of the assessment reach and proceeds upstream.

FIGURE 7.1 D-frame net with 500 micron mesh net.

A macroinvertebrate sample consists of a three-minute timed composite sample from kick samples collected with a D-frame dip net (FIGURE 7.1) from three riffle habitats within the study reach. The target sampling area is approximately one square meter per each one minute sample. Select three or more riffles which represent the variety of substrate sizes, velocities, depths, and habitats found within the reach. Collect one-minute timed samples from each of three habitats or divide the time as needed among the variety of habitats. If three good-sized riffles are not available to be sampled, spread the three minute sample time over whatever riffle/run areas are available.

INTERMITTENT STREAMS:

A macroinvertebrate sample consists of a proportional multi-habitat three minute composite sample. Samples are collected using a D-frame dip net (FIGURE 7.2).

1. **Pace out the reach and identify the percent of riffle, run, and pool habitat available.**

2. **Allocate the correct proportional time to each habitat for sampling. For example, if an intermittent stream reach had 25% riffle, 50% run, and 25% pool habitat you would kick for .5 minute (30 seconds) in the riffle habitat, 1.5 minutes in the run habitat, and .5 minute in the pool habitat and compile the sample into the same bottle.**
3. **Select areas which represent the variety of substrate sizes, velocities, depths, and habitats found within the reach. Divide the allocated time as needed within the same habitat.**

7.2.4 HOW TO SAMPLE MACROINVERTEBRATES

After the riffle habitats within the reach have been selected, the first sample should be at the most downstream riffle.

1. Fill a bucket half full with stream water.
2. Place the D-frame (FIGURE 7.2) net on the stream bed in the path of flowing water, and agitate a one square meter area of substrate vigorously for one minute by kicking and hand scrubbing cobbles to dislodge material. Sample as much variation of the flow and substrate as possible including large and small substrates.
3. Deposit the contents of the net into the bucket. At this point there is no need to pick the net clean.
4. Repeat the sampling procedure for the second and third riffles, moving in an upstream direction through the reach. After the last riffle, rinse as many invertebrates into the bucket as possible. Use forceps to remove organisms attached to the D-frame net. Before leaving the site, the D-frame dip net, bucket, and sieve should be rinsed and scrubbed to dislodge small invertebrates, egg masses, and organic material, so that it is not transferred to the next site. Spray the net and bucket with Quat 128 decontaminating solution before leaving the site.
5. Swirl the contents of the bucket and pour the organic non-sediment portion into a 500 µm mesh sieve.
6. Add water again to the bucket, swirl and pour the contents into the sieve. Repeat this procedure several times until all insects and organic debris are emptied and only sediment remains.

FIGURE 7.2. Macroinvertebrate sampling.

7. Transfer the remaining sediment into a dissecting tray and search the sediment for any remaining organisms. Discard the remaining sediment.
8. Gently, squeeze the sample to remove excess water from algae laden samples. Using a plastic spoon or hands, gently dispense the sample from the sieve into a wide mouth, one-liter sample jar. Fill the jar up to three-quarters full. If additional sample remains in the sieve,

use an extra jar to contain it. Rinse any leftover material in the sieve into a corner and gently spoon out as much as possible. Check the sieve for any remaining animals If the sample will not fit into two jars, then field split the sample.

A field split consists of dividing the collected material in half. Half of the material is returned to the stream. Half is placed in the collection jar(s). Be sure to mark the field split check box in the "Biological Sampling" part of the form. To perform a one-half field split, evenly spread the entire sample in a white dissecting tray and divide the sample with your hands into two equal portions. Place one half of the sample into the two sample jars and discard the other half into the stream. Note on the field form that the sample was "field split 1/2 or 50%" retained. A quarter split can be performed if a half-split still provides too much sample material to fit in two jars.

The total time spent kicking should total 3 minutes for a 3 square meter area. More than three riffles can be used, but it is important to be consistent with sampling time and sampling area. Use a stop watch to keep track of time.

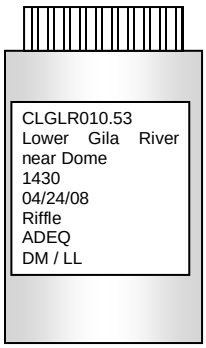
9. Place one label (see Section 7.2.6) inside the jar(s); add enough 99% isopropyl alcohol (or ethanol) to fill the jar.
10. Seal and label the exterior of the jar(s).

7.2.5 DUPLICATE SAMPLES

Duplicate macroinvertebrate samples should be collected for ten percent of the total number of samples. To collect a duplicate sample repeat the procedure described in Section 7.2.4 in the same riffle, but different location than you previously kicked for the regular sample. Do not kick the same area twice. You can collect the second macroinvertebrate sample in a separate bucket concurrently with the first sample in one pass through the study reach. Do not split a combined sample for the duplicate.

7.2.6 MACROINVERTEBRATE SAMPLE LABELING

Each macroinvertebrate sample should have two identification labels. One should be taped on the outside of the bottle while the other one should be penciled on "write-in-the-rain" paper and placed inside the jar, visible from the outside. If more than one jar is used for a sample, put jar numbers on all labels (e.g., 1 of 2, 2 of 2). Each tag should have the following information at a minimum.



- Stream name
- Site code number
- Habitat sampled (riffle)
- Date and Time
- ADEQ and collectors' initials

Quality control samples should be identified with a unique identifier such as DUP1-PHS. Leave the date and time blank. Be sure to record the unique identifier on the field form so that the data can be compared when the results come in.

FIGURE 7.3. Flammable storage.

7.2.7 STORAGE

After samples have been preserved with 99% isopropyl alcohol, samples should be placed in an ice chest with ice to cool the sample. This prevents overheating and degradation of the sample, and prevents fumes from developing inside truck camper shells. Samples should be stored in a cool environment and within flammable storage areas in the ADEQ laboratory prior to shipping to the receiving laboratory (FIGURE 7.3).

7.2.8 CHAIN OF CUSTODY

To complete the Chain of Custody, samples shall be locked in field trucks when sampling personnel are away from the truck. Sample jars shall be placed in the large, flammable cabinet in the equipment storage area of the ADEQ laboratory for storage, prior to shipping. The use of tamper-evident tape on shipping boxes to prevent tampering with samples during shipping is required. A Chain of Custody form shall accompany the samples during shipment.

7.3 CHLOROPHYLL & PERIPHYTON

The chlorophyll protocols in this section are adopted from EPA's 2013 National River and Stream Assessment methods (USEPA, 2013) and the periphyton/benthic algae protocols are based on the EPA's Multihabitat sampling approach from the Rapid Bioassessment Protocols document (USEPA, 1999).

7.3.1 SAMPLE COLLECTION

Collect the chlorophyll and benthic algae samples in the following order:

1. Water column, 2-liter chlorophyll sample
2. Benthic algae composite sample

7.3.1.1 Water Column Chlorophyll-a

1. Rinse the 2 L amber Nalgene bottle 3 times. Discard the water downstream.
2. Fill the 2 L amber Nalgene bottle with stream water as a grab sample at the water sample location. Cap the bottle tightly and place in an ice chest as soon as practical.

This sample will be filtered later and the bottle will be reused at future sites, therefore it is not necessary to label this bottle. Place the sample bottle in a cooler with ice to store until processing, or if the cooler is not available, keep cool in stream water.

7.3.1.2 Benthic Algae Chlorophyll-a and Identification

Sampling the benthic algae for a composite 500 mL sample requires collection of 10 subsamples from a number of transect locations, determined by the percentage of habitats present in the study

reach. The following steps outline the determination of subsampling locations in the reach. Be sure to collect the benthic algae sample prior to the macroinvertebrate sample.

1. Identify the study reach length, using 40 x the average wetted width. Conduct the Reach Complexity survey by pacing off the length of riffles, runs and pools within the study reach and then calculating the percentage of each habitat type. A representative number of benthic algae subsamples will be collected from transects at representative riffles, runs and pools. For example, if the study reach has 60% run, 30% riffle and 10% pool habitat, select six runs, three riffles and one pool in the reach apportioned throughout the study reach. Mark the transect locations with a staked flag. Collect a subsample for the composite benthic algae sample from each of the 10 transect locations at either Left (1/4 mark), Center or Right (3/4 mark) positions. Beginning at the downstream most transect, collect the first subsample at the ¼ position, then rotate from center to right ¾ position and back to left ¼ position as you move upstream from transect to transect. Do Not collect subsamples from shallow stream edge areas! Use the following procedure, dependent on the sample substrate:
   A. To collect the benthic algae subsamples, use one of the following methods:
      1) Cobble and woody debris
         i. Locate a cobble particle or piece of woody debris in the correct position on the transect (L, C or R) that is <15 cm diameter with a relatively flat upper surface, and that can be easily removed from the water and held in your lap. Place the 2" circular delimiter onto the cobble/wood in situ, making sure to encompass any filamentous algae that is overlying the particle. Pick up the substrate and place into a plastic funnel which drains into a 500-mL sample bottle, with 50mL volume graduations marked on it.
         ii. Use a Scalpel to create an outline on the inside of the circular delimiter, and scrape any filaments/thick biofilm off and place into the 500mL composite bottle.
         iii. Next, brush the defined substrate area within the delimiter into the funnel by brushing with a stiff-bristled toothbrush for 30 timed seconds. Take care to ensure that the upper surface of the substrate is the surface that is being scrubbed, and that the entire surface within the delimiter is scrubbed, including the inside edges of the delimiter. You should see a bald spot on the cobble when you are done brushing.
         iii. Fill a wash bottle with river water. Using water from this bottle, wash the dislodged algae biofilm off the cobble/wood, off the toothbrush, and off the funnel into the 500-mL bottle to bring the composite bottle volume up to approximately 50 mL for that transect or up to the next graduation mark on the bottle.
      2) Boulders and bedrock
         i. Obtain help from 2nd field person. For substrate that cannot be removed, use the delimiter to mark the area, in-situ. Have one person, use the toothbrush to scrub the surface within the delimiter. Have the second person carefully syringe out the scrubbed material

to collect the 50mL subsample. Only use this sampling method if boulder/bedrock is your primary substrate in the habitat.

3) Fine sediment (eg, runs or pools where no cobbles are present):

i. Use the 2" circular delimiter to define a 20.3-cm^2 area of soft sediments.

ii. Vacuum the top 1 cm of sediments from within the delimited area into a de-tipped 60-mL syringe with a short length of tubing attached.

iii. Empty the syringe into the same 500-mL plastic bottle as above. If the volume of the vacuumed sediment is not 50 mL, add additional stream water to the bottle to raise the level to the next graduation.

C. Keep the composite sample cool and dark, by placing into a portable cooler with a blue icepack when moving between transects. (The samples need to be kept cool and dark because a chlorophyll sample will be filtered from the composite sample)

2. Repeat the subsample collection at each transect, moving in an upstream direction until a total of 10 subsamples have been collected and composited in the 500mL sample jar. Wrap the sample jar in aluminum foil before placing in the ice chest.

3. After the 10 subsamples have been collected, gently mix the 500-mL bottle, by inverting 2-3 times. Record the total volume of the composite sample in the periphyton section of the SEM Form.

3. If all 10 samples are not collected, record the number of transects, the total volume of the composite sample, and reason for any missed collection on the field forms.

7.3.2 PROCESSING

Process the chlorophyll and benthic algae samples in the following order:

1. Water column chlorophyll sample
2. Benthic algae chlorophyll sample
3. Benthic algae identification sample

7.3.2.1 Processing - Water Column Chlorophyll-a

1. In a hotel room a the end of the day, filter the 2L water sample for chlor-a. Use clean forceps to place a Pall GF/F glass fiber filter in the graduated filter holder apparatus with the gridded/stippled side of the filter facing down.

2. Retrieve the 2 liter amber chlorophyll sample bottle from the cooler and shake the bottle to homogenize the sample. While filtering the sample, keep the amber bottle in the cooler on ice.

3. Measure 250 mL of water with a graduated cylinder and pour into the filter holder, and use the vacuum pump to draw the sample through the filter (do not exceed 9 inches of Hg). If 250 mL of sample water will not pass through the filter, change the filter, rinse the apparatus with DI water, and repeat the procedures using 100-mL of sample water.

If the water is green or turbid, use a smaller volume, such as 100mL to start with.

4. Observe the filter for visible color. If there is visible color, proceed to step 5; if not, repeat steps 3 & 4 until color is visible on the filter or until a maximum of 2,000 mL have been filtered (we typically collect 1000mL). Rinse the upper portion of the filtration apparatus and graduated cylinder thoroughly with DI water to include any remaining cells adhering to the sides and pump through the filter.
5. Record the actual sample volume filtered on the field sheet and sample label.

Monitor the level of water in the lower chamber to ensure that it does not contact the filter or flow into the pump. Remove the bottom portion of the apparatus and pour off the water from the bottom after every 250mL is pumped.

6. Remove filter funnel from base without disturbing filter.
7. Remove the filter from the holder with clean forceps. Avoid touching the colored portion of the filter. Fold the filter in half, and in half again, with the colored side folded in on itself.

8 Place the folded filter into 30 mL screw-top amber bottle. Tighten the cap. Failure to tighten the lid completely could allow water to infiltrate into the sample and may compromise its integrity.
9. Record the sample information and volume filtered on a chlorophyll label and attach it to the bottle as indicated below. Ensure that all written information is complete and legible. Cover with a strip of clear tape.

CLGLR010.53
1430
04/24/14
Water Column Chlor-a
ADEQ
PHS
Vol Filtered = 1000 mL

10. Place in a self-sealing plastic bag. Place this bag into separate cooler of ice and blue ice packs for chlorophyll samples.
11. Store samples in the ADEQ Lab freezer and Deliver chlorophyll samples to the lab within 1 week. Lab turnaround time is 1 month.

7.3.2.2 Processing - Benthic Algae Chlorophyll-a

In a hotel room at the end of the day, filter a 50mL aliquot of the 500mL benthic composite for benthic chlor-a. Thoroughly mix the sample by shaking the 500mL sample bottle for 10 seconds. If there are still clumps of algae, insert a stirrer and mix for 10 seconds, then repeat the 10 second shaking.

1. If there is a lot of filamentous algae present and the filaments settle out quickly and create color zonation in the 500mL bottle, use a turkey baster to sample from the middle portion of the composite bottle.
2. Immediately pour off 25mL into volumetric cylinder (no settling time), then filter the 25mL subsample through a Pall 47 mm 0.7 micron GF/F glass fiber filter, with gridded/stippled side down. Vacuum pressure from the pump should not exceed 10 inches of Hg to avoid rupture of fragile algal cells.
3. Remove the filter from the filter apparatus, then fold the filter into quarters and place in a 30mL amber sample bottle.
4. Repeat the shaking/mixing of the composite sample and immediately pour (no settling time) and filter a second 25mL aliquot onto a new GFF filter in the same apparatus. Rinse the filter top with a little DI water and filter that through with the subsample. Remove the filter from the filter apparatus, then fold the filter into quarters and place in a 30mL amber sample bottle.
5. Chlorophyll-a can degrade rapidly when exposed to bright light, so processing in dim light indoors is best, or outdoors in shade, next best.

Use a clean millipore filter top for each sample site, on a multi-site trip. If you must reuse a filter top, wash with a soft bristle brush, then rinse three times and wipe dry prior to reusing. Monitor the level of water in the lower chamber to ensure that it does not contact the filter or flow into the pump. Remove the bottom portion of the apparatus and pour off the water from the bottom as often as needed.

If 25 mL of sample will not pass through the filter after several minutes, discard the filter and rinse the chamber thoroughly with deionized water. Decant a second subsample using 10 mL of sample.. Be sure to record the actual volume sampled on the sample label and the Field Form.

6. Prepare a sample label with the Site ID, time, date, analysis, agency, your initials, and volume filtered as in the following example. Cover the label and lid with a strip of clear tape.

CLGLR010.53
1430
04/24/14

Periphyton Chl a
ADEQ
PHS
Vol Filtered = 25 mL

7. Place the 30mL amber sample bottle into a self-sealing plastic bag and place immediately into small cooler packed with blue ice
8. Record the volume filtered on the field form. Double check that the volume recorded on the collection form matches the total volume recorded on the sample label.
9. Store samples in the ADEQ Lab freezer and Deliver chlorophyll samples to the lab within 1 week. Lab turnaround time is 1 month.

7.3.2.3 Processing - Benthic Algae Identification Sample

1. After the benthic chlorophyll sub-sample has been removed, obtain the periphyton identification 250mL sub-sample.
2. Shake the composite bottle for 10 seconds, then immediately pour off the a subsample into the 250mL graduated cylinder, then and place the contents into a 250 mL wide mouth sample bottle.
3. Use a dropper bottle, syringe or bulb pipette to add 2ml of lugol solution to preserve the sample (1 dropperful =2ml). Continue to add by dropperful until a weak tea color is obtained. Invert gently to distribute the preservative. Cap the 250mL sample jar tightly and seal with plastic electrical tape.
4. Prepare a sample label with the Site ID, time, date, analysis, agency, your initials, and Sample volume. Cover the label with a strip of clear tape.
5. Check preservation before storing samples in the ADEQ refrigerator, for batch shipping. If the tea color has dissipated; add more lugols until the tea color is restored.

7.4 HABITAT ASSESSMENTS

The habitat assessment provides ecological information needed to interpret macroinvertebrate bioassessments and bottom deposits. Habitat and chemistry data provide an ecological context in which to place the macroinvertebrate data. Causes and sources of aquatic life impairment can be identified using chemical, physical, biological and land use information produced in the habitat assessment. **Ideally try to collect this habitat assessment data when the stream is flowing, but for intermittent streams collect the data even if the stream is not flowing.**

Filling out habitat forms requires a little bit of homework. Elevation, watershed area, predicted cross-sectional area, valley type, slope, stream order, estimated floodprone width and sinuosity (SEM Form Section 2.1 and 2.5) should be determined before going into the field so that the Rosgen "Stream Type" can be accurately determined.

The following sections follow the Stream Ecosystem Monitoring form except for the first several pages of the form, which match the Ambient stream monitoring form used during 'chemistry only' surveys, which occur during the summer, fall and winter

quarters. Additional information for these sections can be found in the previous chapters.

7.4.0 STREAM REACH AESTHETICS

The stream reach aesthetic rating is meant to support the narrative nutrient standard and nutrient criteria development (R18-11-108) by evaluating how appealing the stream channel is for recreation, based on the abundance of nuisance algae, macrophytes or fungi as well as other factors, such as tires, car parts, trash, eroding banks, cows, or odors that can impair the recreational use of streams.

1.8 AESTHETICS (IS SITE CONSIDERED APPEALING FOR IN-STREAM RECREATION?)
☐ Beautiful stream/very appealing/pristine. Ability to wade or swim maintained/not degraded.
☐ Appealing but not pristine, minor aesthetic problems, good for contact recreation.
☐ Moderate aesthetic problems, neutral in appeal, contact recreation slightly impacted.
☐ Moderately unappealing, multiple aesthetic problems/disturbances, contact recreation substantially reduced.
☐ Very unappealing/highly disturbed, multiple aesthetic problems, contact recreation unlikely

7.4.1 STREAM TYPE IDENTIFICATION

Determining the Rosgen stream type requires several measurements to be collected including slope, valley type, watershed area, predicted cross-sectional area, sinuosity and stream order. Slope and sinuosity are used directly in determining the stream type (FIGURE 7.10). The other fields are used to make sure that the stream type you came up with is correct.

The watershed area can be determined by looking up the value in the water quality database, using USGS streamstats at https://streamstats.usgs.gov/ss/ , or using a GIS watershed delineation program (Appendix C). Use FIGURE 7.5 to determine the cross-section area based on the size of the watershed. Indicate which regional curve is used (FIGURE 7.4). Slope should be obtained directly using field measurements rather than using topos map, which can be inaccurate (Se Section 7.4.3.7).

2.1 STREAM TYPE IDENTIFICATION (OFFICE MEASUREMENTS)			
Elevation (ft)		Sinuosity	
Watershed Area (mi^2):		Stream Order	
Predicted Cross-section Area (ft^2)		Which Regional Curve Used?	☐ Central/Southern (M Gila, lower Salt, Santa Cruz, Verde, San Pedro) ☐ Eastern AZ/NM (U Gila, LCR, upper Salt)
Floodprone width (ft) ☐ GIS measured		Map printed showing flood prone width and depositional features (must have scale)	☐ Check if done
Slope (GIS calc)		PFC previous/last evaluation	

FIGURE 7.4. SEM Form. Stream Type Identification.

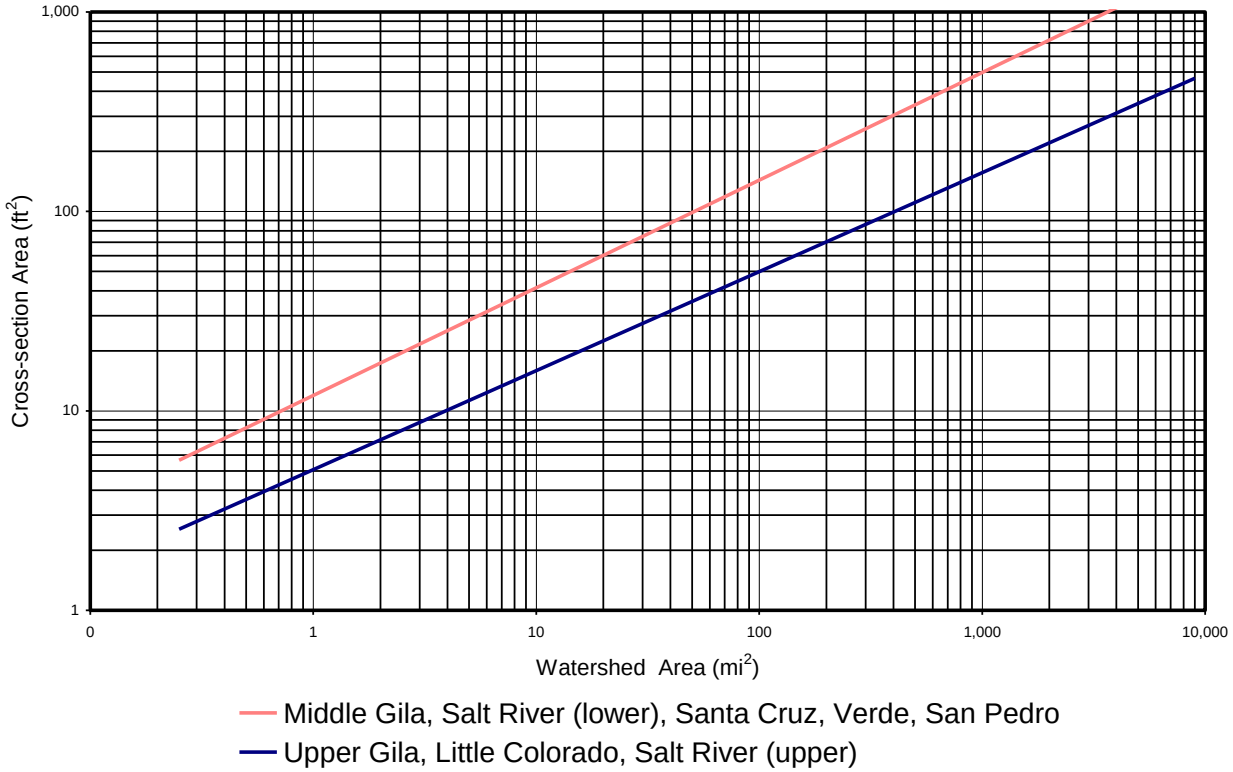


FIGURE 7.5. Cross-sectional area based on watershed size (Moody et al., 2003).

7.4.2 REACH LENGTH AND COMPLEXITY

7.4.2.1 Reach Length

Determine reach length by:

1. Take at least three representative wetted width measurements.
2. Average the stream width measurements.
3. Multiply the average stream width by 40 to get the total reach length (FIGURE 7.6). **For intermittent streams, if the channel is dry at the time of visit multiply bankfull width by 40 to obtain the reach length.**

2.2 REACH LENGTH								
REACH LENGTH = AVERAGE WETTED WIDTH * 40. MINIMUM REACH = 300 FT. MAXIMUM = 3,000 FT.								
Width 1		**Width 2**		**Width 3**		**Average**		*** 40 =**
						Reach Length		ft
Top of Reach	**Latitude**	.			**Longitude**	-	.	
Bottom of Reach	**Latitude**	.			**Longitude**	-	.	

FIGURE 7.6. SEM Form. Reach length.

4. Record the latitude and longitude at the top and bottom of the reach in NAD 83 and in decimal degrees.

7.4.2.2 Reach Complexity & Flow Regime

7.4.2.2.1 Reach Complexity

Transfer the number of riffle, run and pool paces from the site sketch to the reach complexity counts in this section. The counts are summed up from individual paces recorded on the site sketch. Conduct the site sketch first, by pacing off the reach, recording the length of the pools, riffle and run habitats. (FIGURE 7.39; see Section 7.4.19 – "Site Sketch"). Walk along the streambank closely following the contour of the channel. **If an intermittent site is completely dry, this section can be skipped. If the stream is partially wet, calculate as much of the reach complexity as possible.**

To determine how many feet are in your specific pace, lay out at least 100 feet of tape and count the number of paces it takes you to walk 100 feet. 100 divided by the number of paces equals the number of feet in your pace.

2.3 REACH COMPLEXITY

Habitat	Number of ☐ Paces, ☐ feet, ☐ meters	Total
Pool		
Riffle		
Run		
	Riffle / Pool Ratio =	
	My Pace =	to a foot

FIGURE 7.7. Reach complexity.

7.4.3 FIELD MEASUREMENTS FOR DETERMINING STREAM TYPE

Rosgen (1994) developed a stream type classification system which provides a basic understanding of channel processes. The stream type must be identified prior to collecting other measurements for the stream stability assessment, such as depositional pattern, Pfankuch channel stability rating and stream type evolutionary scenario (FIGURE 7.8).

If bank-pins and cross-sections have already been done for you site then take the measurements at the same location. Check the site file for this information.

2.6 STREAM TYPE MEASUREMENTS (FIELD MEASUREMENTS)				
Measurement	Comment/Cal	X Section 1	X Section 2	Bankfull Indicators Used
Bankfull Width				☐ Top of point bars
Bankfull Max. Depth	At thalweg			☐ Change in particle size
Correction Factor	Determined by X-section type			☐ Slope break
Bankfull Mean Depth	= (BF Max Depth) * (Correction Factor)			☐ Vegetation line
Cross-sectional Area	= (BF Mean Depth) * (BF Width)			☐ Undercut banks
2 times BF Max Depth	= (2*BF Max Depth)			☐ Presence of a floodplain at the elevation of incipient flooding
Floodprone Width	Measure width at 2 * BF Max Depth (Note if estimated)			☐ Is flood debris above bankfull elevation? (if so, document cross-sectional area.)
Entrenchment Ratio	= (Floodprone width) / (BF Width)			Valley Type
Width / Depth Ratio	= (BF Width) / (BF Mean Depth)			☐ I ☐ II ☐ III ☐ IV ☐ VI ☐ VIII
STREAM TYPE =				

FIGURE 7.8. SEM Form. Measurements for Determining Stream Type

The following information is needed to determine Stream Type:

- Entrenchment ratio (floodprone width/bankfull width) (determined in the field). For larger streams it is better to estimate floodprone width in the office using GIS.
- Bankfull width/bankfull mean depth ratio (determined in the field)
- Sinuosity. Use FIGURE 7.9 to estimate sinuosity (determined at the office) or calculate using a simple ratio of stream distance between two points which are 2 meander lengths apart, to straight line distance between those two points, as measured in GIS or on a topo map.

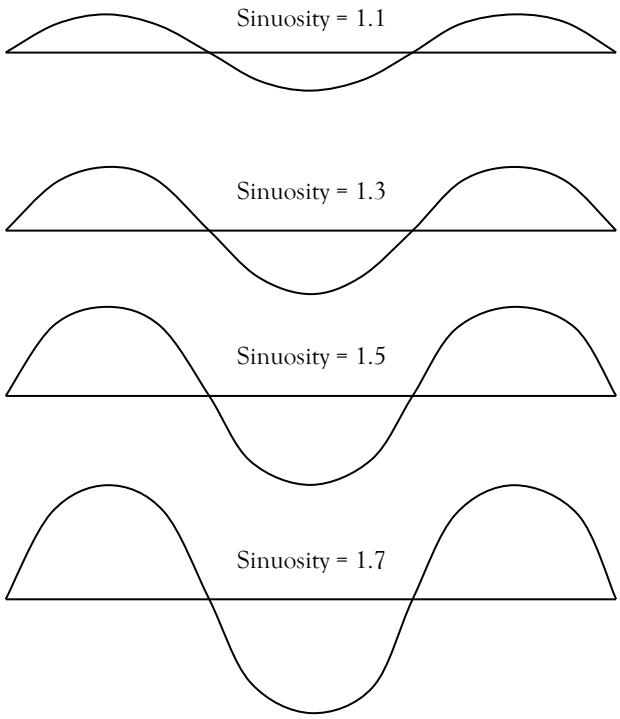


FIGURE 7.9. Classes of sinuosity of a stream channel.

- Reach slope. Percent slope = [Change in Elevation (ft)/ Distance of Reach (ft)] *100 (determined at the office)
- Channel bed material, median particle diameter (D50) (determined in the field)

The following sections will explain how to calculate each of these metrics and explain how to determine stream type. Fill in the values in the "Stream Type Measurements" on the SEM form. After completing this section you will be able to use FIGURE 7.10 to determine the stream type and FIGURE 7.5 to determine how close the stream reach is with respect to the regional curve.

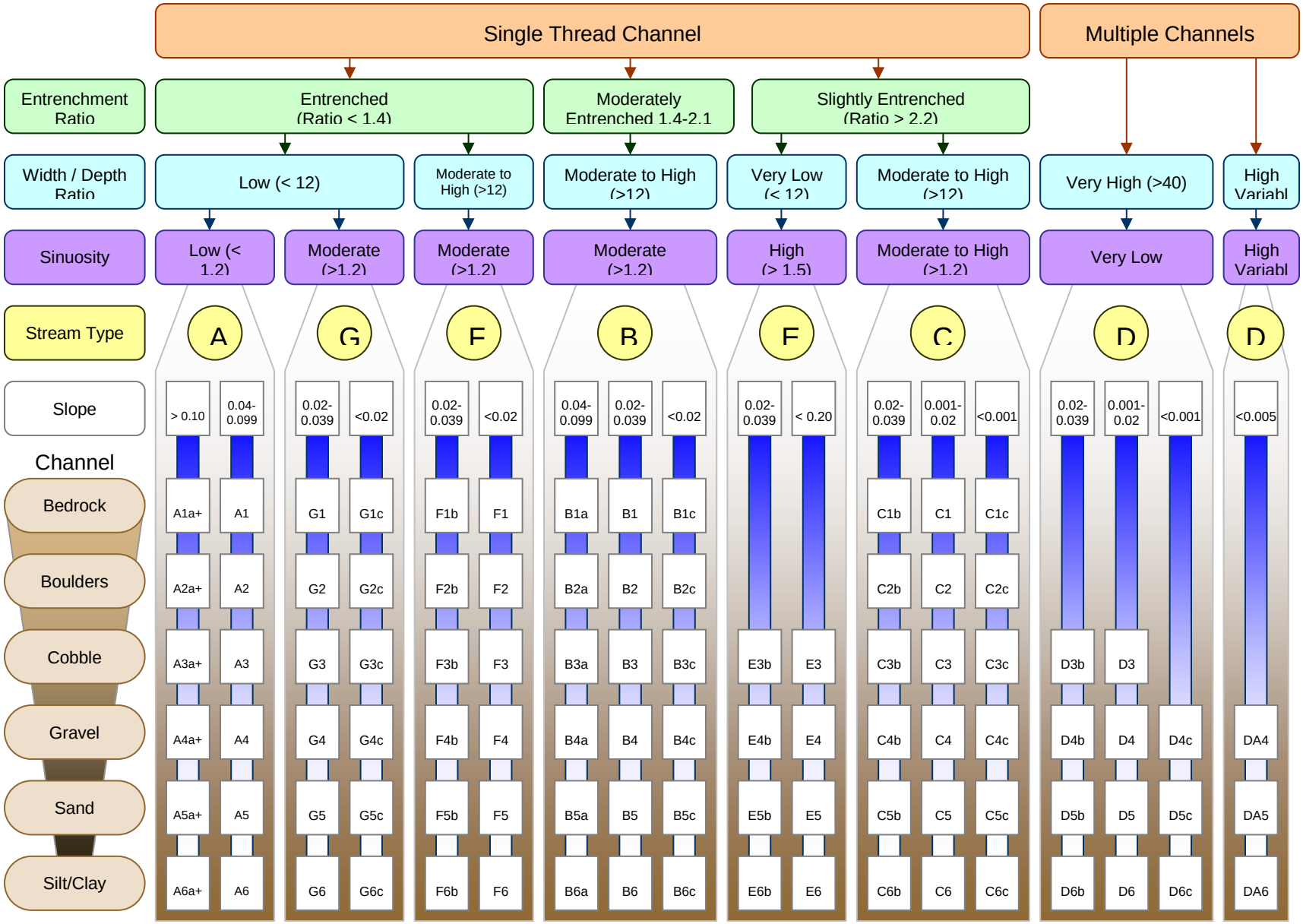


FIGURE 7.10. A Key for Rosgen Stream Type Classification (Rosgen, 1996).

7.4.3.1 Determining Bankfull Width

Rosgen's classification system for identifying different channel types is based on a common frame of reference among all streams; the bankfull elevation.

The bankfull stage is the elevation at which incipient flooding occurs; that is the point at which stream flow overtops the natural channel banks and spreads across the floodplain.

Evidence from a large number of rivers suggests that these flows are frequent, moderate sized flows with a typical return interval of 1-2 years and that they represent the channel forming or maintenance flows. Similar return intervals were empirically identified for Arizona streams, where the range of return intervals for over 30 gauged stations was determined to be 1.1 – 1.8 years (Moody and Odem, 1999).

The bankfull discharge is also equivalent to the "effective discharge"; the flow which transports the greatest volume of sediment over time. Though very high flows can move significant amounts of material, they occur infrequently and therefore transport only a small fraction of the total sediment volume over time. However, frequent moderate flood events typically carry the greatest amount of sediment; thus the bankfull flow is the most common channel shaping flow. The bankfull elevation must be consistently identified in the field in order to correctly identify the stream type. The stream type depends on measurements of bankfull width/depth ratio and entrenchment ratio which are dependent upon measurements of the bankfull stage.

Field Procedure for Identifying Bankfull without a Laser Level

1. Walk a stream reach of a minimum of two meander lengths or 40 times the wetted width and look for bankfull indicators, such as:

- topographic breaks in slope
- tops of point bars
- changes in vegetation
- changes in size of bank or bar materials
- evidence of an inundation feature such as small benches
- the presence of a floodplain
- exposed root hairs below an intact soil layer indicating exposure to erosive flow
- bank undercuts.

Vegetation is usually not a good bankfull indicator and must be used with caution. At high elevations, an ash tree or willow tree line may at times be useful; however, a grass or seep willow line at any elevation is not.

FIGURE 7.11. Left: Bankfull identified by tape measurer at slope break. Right: Multiple bankfull indicators (change in particle size, top of point bar, slope break).

2. Place stake flags, pieces of flagging, or other marking devices on the identified points along the reach where bankfull indicators are present. If bankfull stage has been properly identified, the stake flags should delineate a line identifying bankfull depth.
3. Stretch the tape measure across the stream channel at a riffle where the bankfull indicators are good. Pick a spot that is representative of the reach and is in a straight segment of the river. Make sure the tape is level. Avoid taking bankfull widths on meanders.
4. Repeat steps 2 and 3 at a second riffle, if needed to confirm.

7.4.3.2 Bankfull Maximum Depth

1. Measure the distance from the bottom of the stream (in the thalweg) to the top of the tape using a stadia rod (FIGURE 7.12).

Alternately, the sampler may also use a clinometer to sight to the pole assuming that the clinometer is level with bankfull.

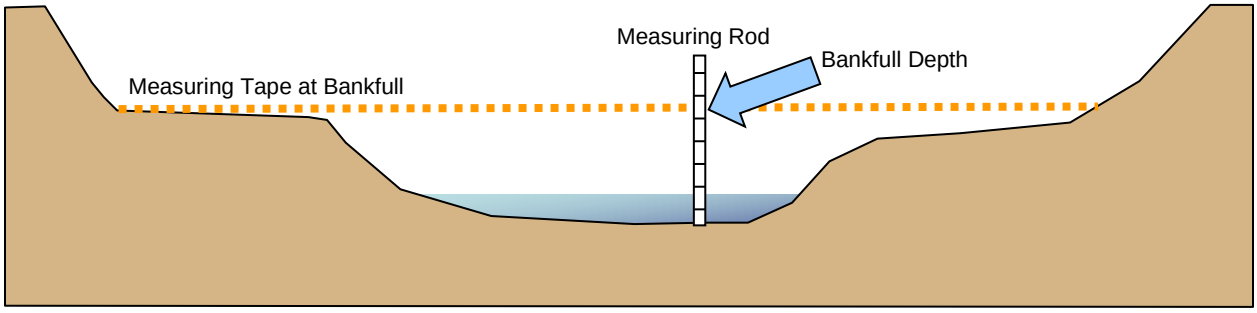


FIGURE 7.12. Measuring bankfull depth.

7.4.3.3 Correction Factors

Correction factors can vary from about 0.4 to 0.8 depending on the shape of the stream's cross-section. TABLE 7.1 provides common cross-sections and their corresponding correction factors.

0.6 is the average coefficient for all streams.

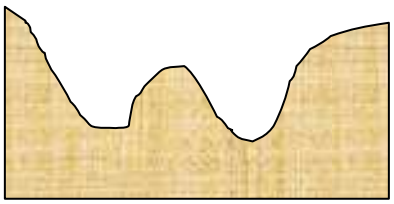
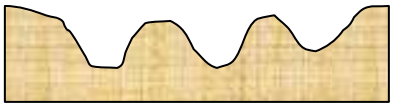
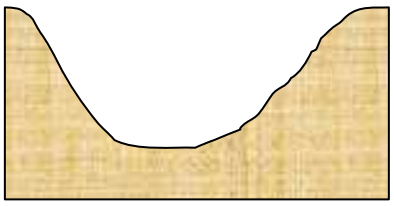
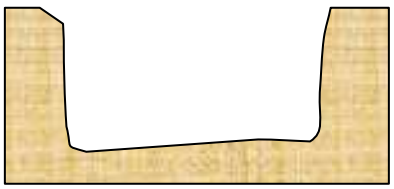
Type	Cross-section	Correction Factor
Triangular		0.5
Skewed		0.5
Bimodal		0.5
Multi-modal		0.35
Basin shaped		0.67
Nearly rectangular		0.75

TABLE 7.1. Correction factors based on cross-section type (Lawson, unpublished data, 2008).

7.4.3.4 Field Bankfull Mean Depth

Mean depth is calculated by multiplying the bankfull maximum depth by the appropriate coefficient in TABLE 7.1.

7.4.3.5 Cross-Sectional Area

Multiply "mean depth" times average "bankfull width" to obtain the cross-sectional area.

7.4.3.6 Floodprone width

The flood prone width is the channel width located at an elevation that is 2 times the maximum bankfull depth (FIGURE 7.13). You may need to measure this distance in GIS if the channel is wider than 100 meters.

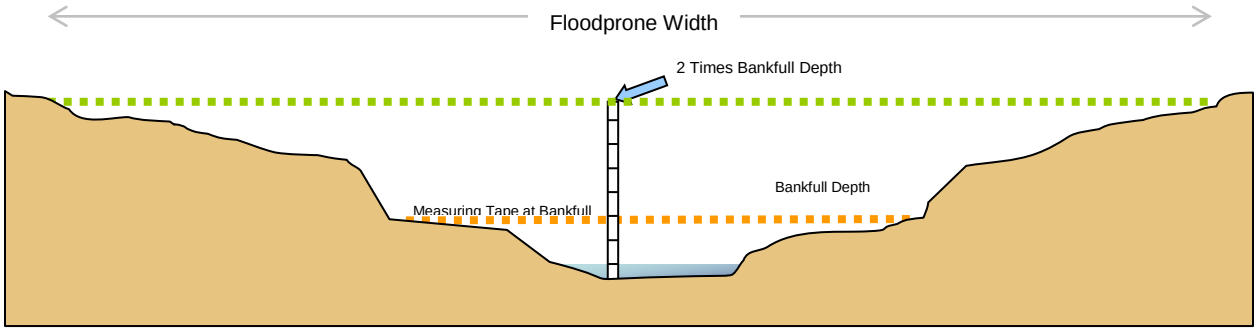


FIGURE 7.13. Floodprone is represented by the green dotted line and the width of the channel at 2 times bankfull depth.

7.4.3.7 Field Determine Slope

1. Determine the reach length (average wetted width *40) and mark off the top and bottom of the reach using flagging.
2. Position the tripod on the bank with an unobstructed view of as much of the reach as possible.
3. Make sure the tripod legs are set firmly in the ground and level the base plate.
4. Attach the transit level (FIGURE 7.13.A) to the tripod, adjusting the leveling screws as necessary until the bubble is centered.
5. Adjust the focus and brightness to the user's preference.
6. Staff person #1 holds the stadia rod at the water's surface at one end of the reach. Keep the stadia rod as vertical as possible with the numbers facing the transit level.
7. Staff person # 2 then sites through the transit level and records the measurement to the nearest centimeter on scrap paper.
8. Collect a measurement at the other end of the reach and repeat steps 5 and 6.
9. Calculate the % Slope: **((Elevation at the top of the reach - Elevation at the bottom of the reach)/Length of the reach)*100**, and add the value to the data sheet.

FIGURE 7.13.A. Transit level

Back sighting might be necessary if you are unable to sight the entire reach. In this case collect a measurement at the furthest point upstream that can be read using the transit level. Have the staff person remain at that spot holding the stadia rod, while the other staff person moves the transit level and tripod to a new location. Then collect the back

sighting measurement and subtract the value from the last recorded value. Continue with steps 5 and 6.

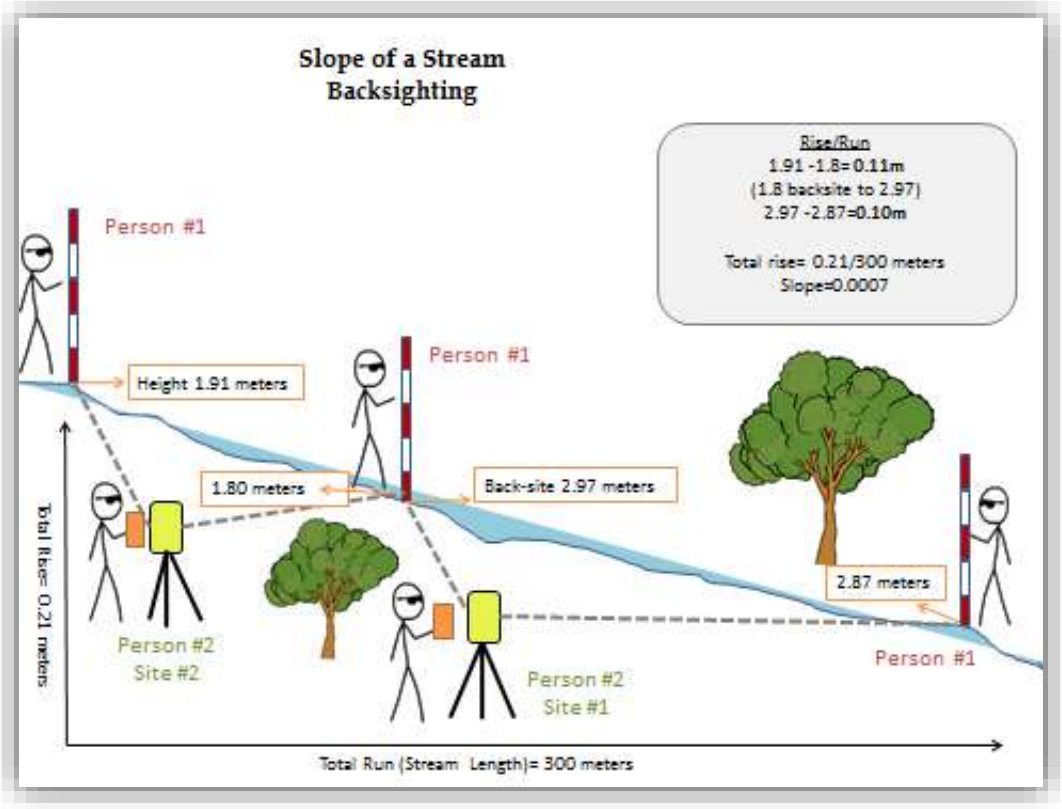


FIGURE 7.13.B. Backsighting example.

7.4.3.8 Determining Stream Type

1. Compare the field calculated cross-section value against the appropriate regional curve value. The field value should be similar or close to the predicted value. If the field value is very dissimilar from the predicted value then reexamine the measurements and bankfull identification. Typical explanations are an incorrect bankfull depth, a water diversion, or an impoundment in the watershed. If the issue cannot be resolved, use the field observed bankfull indicators to obtain cross-sectional area.
2. Use the Rosgen classification chart (FIGURE 7.10) to identify the stream type.
   a. **Entrenchment Ratio** is calculated by dividing floodprone width by bankfull width.
   b. **Bankfull width/depth ratio** is calculated by dividing bankfull width by bankfull mean depth.
   c. **Sinuosity** can be calculated from a topographical map or aerial photo for the study reach. Sinuosity can also be estimated by using FIGURE 7.9.
   d. Calculate **slope** in the field, if possible, using a transit level according to Section 7.4.3.7.

((Elevation at the top of the reach - Elevation at the bottom of the reach)/Length of the reach)*100

e. The median particle size (D50) can be determined from the reach pebble count cumulative percent data or from a graph of the cumulative percent by particle size class.

3. Determine **stream type** by using Rosgen's classification chart (FIGURE 7.10) and the five classification variables.

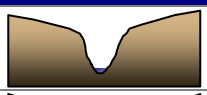
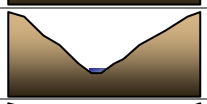
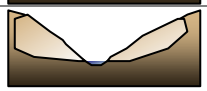
The classification system scheme sorts fluvial streams into broad stream types A through G, representing the following categories:

A – Headwater
B – Intermediate
C – Meandering alluvial
E – Meandering alluvial with high sinuosity and low w/d ratio
D – Braided
F – Entrenched
G – Gully

These broad categories are further refined by the addition of slope ranges and median particle size to produce 41 categories of stream types which are described and photographed in detail in Rosgen (1996).

7.4.3.9 Determining Valley Type

Rosgen delineated eleven valley types and associated them with stream types (TABLE 7.2). Valley Types V, VII, X, and XI are unlikely to be found in Arizona and are not listed. For a discussion of valley types, see Rosgen (1996), Chapter 4.

Valley Type	Environment	Geomorphic Characteristics	Profile	Stream Type	
				Dominant	Other
I	Rugged mountains	Narrow valleys		A,G	
II	Less rugged mountains	Narrow valleys		B	G
III	Broad valleys in mountains	Incised upland rivers with alluvial fans at confluence		A,B,G,D	
IV	Gorges, canyons &	Confined alluvial valleys		F	C

Valley Type	Environment	Geomorphic Characteristics	Profile	Stream Type	
				Dominant	Other
	confined alluvial valleys				
VI	Fault line valleys			B	C,F
VIII	Developed floodplains	Alluvial terraces and floodplains		C,E	D,F,G
IX	Dune plains			C,D	

TABLE 7.2. Valley types and their associated stream types (Rosgen, 1996).

7.4.4 REACH OBSERVATIONS

7.4.4.1 Reach Habitat Quality

Knowing the habitats present and their abundance assists with conducting the habitat assessment at the end of the survey. Note whether cobble, undercut banks, etc. are absent, rare, common, or abundant in the wetted width of the stream channel throughout the reach (FIGURE 7.15). **If the intermittent stream is dry, use the bankfull width (instead of wetted width) area to collect this data.**

Absent = None present.
Rare = Some present, but not very much.
Common = Moderate amount present
Abundant = Dominant throughout reach.

2.4 REACH HABITAT QUALITY				
Reach length equals 2 meander lengths or 20-30 times bankfull width of the stream. Use a minimum 300-feet reach to identify habitat types for large streams or rivers.				
Undercut banks	Absent ☐;	Rare ☐;	Common ☐;	Abundant ☐
Leaf packs	Absent ☐;	Rare ☐;	Common ☐;	Abundant ☐
Root masses	Absent ☐;	Rare ☐;	Common ☐;	Abundant ☐
Submerged logs / snares	Absent ☐;	Rare ☐;	Common ☐;	Abundant ☐

FIGURE 7.15. SEM Form. Habitat Quality.

7.4.5 DEPOSITIONAL FEATURES

Channel changes due to floods, direct disturbances, change in riparian vegetation or flow regime are reflected in depositional features in streams. Excess sediment deposits are an indicator of imbalance in the channel or its watershed. For the depositional features parameter, mark all categories that apply to the stream channel within the study reach. Keep in mind that Rosgen A and B type streams are usually without depositional features.

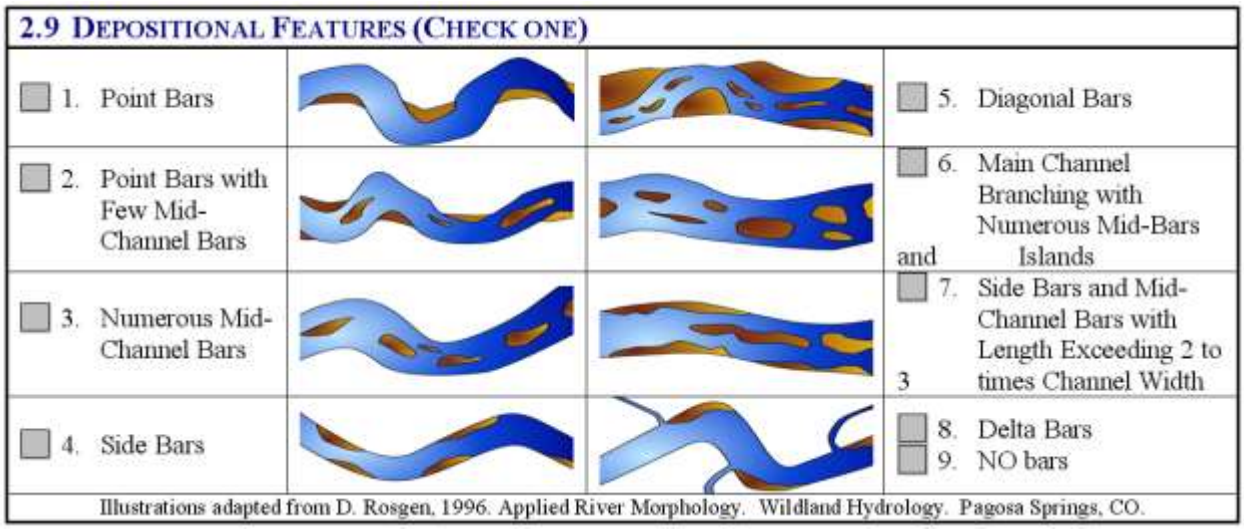


FIGURE 7.16. SEM Form. Depositional Features.

A bar is defined as a submerged or exposed accumulation of sand, gravel, or other alluvial material formed within an active channel, along the banks, or at the terminus of a stream where a decrease in velocity induces deposition.

- A point bar is found on the inside of meander bends.
- Diagonal bars form diagonally to a stream channel, and may extend completely across the channel.
- Mid-channel bars form in the mid-channel zone and do not extend completely across the channel.
- Islands are exposed bars or land segments within the stream channel that are relatively stable and normally surrounded by water.
- A side bar (or lateral bar) is located at the side of a stream channel, usually associated with the inside of slight curves.
- Delta bars are formed immediately downstream of the confluence of a tributary and the main stream (Armantrout, 1998).

7.4.7 PEBBLE COUNTS

Pebble counts measure the range of particle sizes in a wadeable perennial stream. Excess sediment can have adverse effects on the habitation, growth and propagation of aquatic life. ADEQ has adopted a narrative standard (R18—11-108.02) for bottom deposits which is determined by measuring stream bottom particles or "pebbles" in a systematic way to obtain a value for percent fine sediment in the streambed. Implementation procedures for bottom deposits have also been developed (ADEQ, 2015).

The elevation or the applicable designated use of the stream must be known in order to choose the right pebble count procedure. TABLE 7.3 has the bottom deposit standard for warm and coldwater streams. The standard is exceeded when a cold water stream has more than 30% fines and a warmwater stream has more than 50% fines..

Designated Use	Elevation	Exceedance of the Bottom Deposit Criterion (% of fine sediment <2mm)	Pebble Count Procedure to Use
A&Wc	>5000 ft	> 30 %	Riffle & Reach (Section 7.4.7.1 and 7.4.7.2)
A&Ww	<5000 ft	> 50 %	Reach (Section (7.4.7.2)

TABLE 7.3. Pebble count standards and appropriate procedures.

The riffle pebble count is collected to identify the percent fines within the riffle habitat in cold water streams where macroinvertebrate collections occur. In other words, it is a procedure for characterizing particle size distributions of riffle habitats of a study reach. The reachwide pebble count is used to identify the percent fines in all habitats of a warmwater stream, but also to identify the Rosgen Stream Type in both cold and warmwater streams. The percent fines data is used to evaluate whether a bimodal particle size distribution exists and to determine the amount of fine sediment in the substrate, affecting colonization space for aquatic life. The data is also used to determine whether changes in the substrate are occurring over time.

7.4.7.1 Riffle Pebble Count

The riffle pebble count is conducted in three riffles and is a modified version of the Wolman pebble count (Leopold, et al. 1964). The purpose of the riffle pebble count is to calculate percent fines sediment in riffles. The ADEQ riffle pebble count consists of measuring particles at equal increments across multiple transects within the wetted width of riffle habitats where the macroinvertebrates were collected. The count objective is 100 particles.

Riffle pebble counts are only required for coldwater streams (stream > 5,000 feet in elevation.

Riffle Pebble Count Procedure

1. Establish the study reach (see Section 7.4.2). Pebble count measurements will be collected along three transects/riffles where the macroinvertebrates were collected. Begin work at the most downstream transect and move in an upstream direction to the midstream and upstream transects.
2. Divide the stream width by thirty-three to obtain the increment needed to collect thirty-three particles across the transect in a single pass. Do not collect particles closer than 0.3 tenths of a foot apart.

Sand will feel gritty while silt and clay will feel smooth or slick.

If thirty-three particles cannot be collected in one pass along the transect, make a second or third pass as close as possible to the transect, and work in an upstream direction without working the same area.

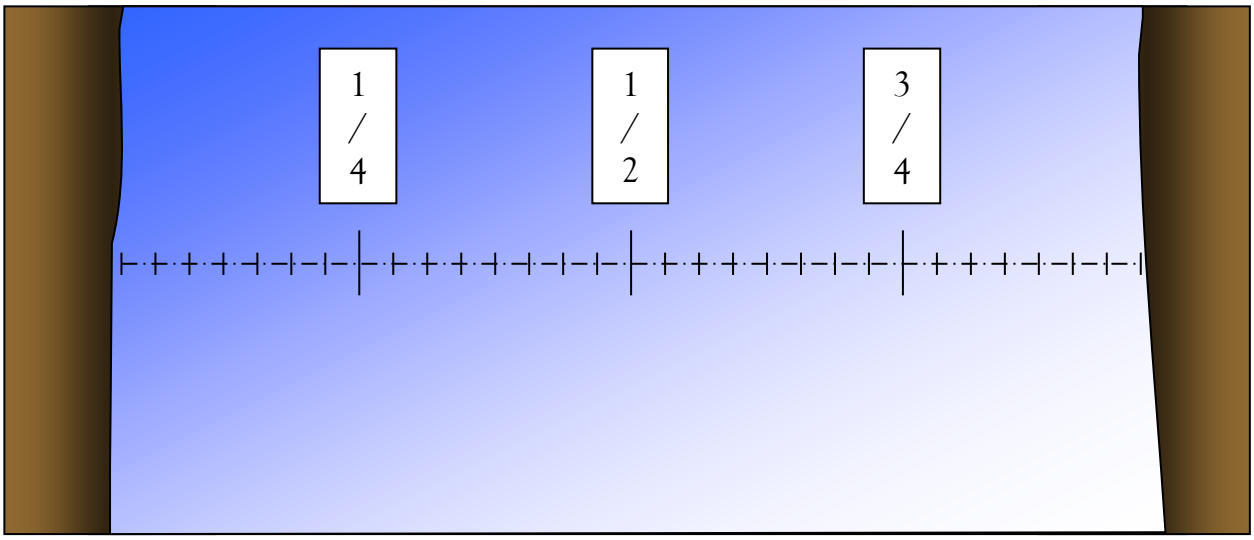


FIGURE 7.18. Visual representation of stream divided into 1/4, 1/2, and 3/4 segments.

A measuring tape may be used to divide the stream into 33 equal increments. It is quicker and just as representative to visually divide the stream into quarter segments. Pick 8 pebbles from each quarter. The 8 pebbles should be equally spaced and should be at least 4 inches apart (FIGURE 7.18).

3. Use the tip of your boot or a pointer to take a particle reading. Extend the forefinger, and without looking down, pick up the first pebble touched, and measure the intermediate axis in millimeters (FIGURE 7.19). The intermediate axis is neither the longer nor shorter of the three perpendicular sides. Determine the Size Range from the Field Data Sheet and record the tally (FIGURE 7.20). For embedded or very heavy rocks, measure them in place by measuring the smaller of the two exposed axes.

There is a tendency to look down and select a pebble, but this should be avoided or the results will be biased toward larger particle sizes.

4. Discard the measured pebble downstream, move to the next station, and repeat step 3.
5. Continue working across the transect from wetted edge to wetted edge of the streambed (FIGURE 7.21). After completing the first thirty-three measurements at this transect, move upstream to the next transect, and repeat the process.
6. Once the count has been completed, and before leaving the stream, sum the tallies to ensure that the goal of 100 particles have been counted.
7. Estimate the embeddedness of all the particles in the transect and record the percentage on the field form. In other words, gravel, cobble, and boulder particles are surrounded by what percentage of fine sediment? This value will be used in the Habitat Assessment (Section 7.4.18).

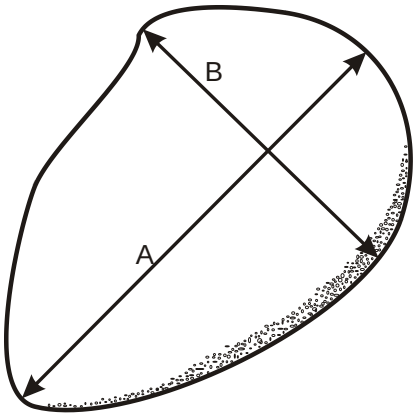


FIGURE 7.19. Axes of pebble. A = Longest Axis (length). B = Intermediate Axis (width). Thickness = Shortest Axis

Bedrock is always counted as 0% embedded; Silt/clay and sand are counted as 100% embedded.

Instructions: Tally 100-pebbles in riffle habitat only. Measure particles at equal increments across 3 transects within the wetted width throughout the reach. A reachwide and transect/riffle pebble count is required for coldwater streams.

2.9 COLDWATER - TRANSECT PEBBLE COUNT

Size Class	Size (mm)	Tally	Count
Silt/Clay	<0.062		
Sand	0.063 – 2.0		
Very Fine Gravel	3 – 4		
Fine Gravel	5 – 8		
Medium Gravel	9 – 16		
Coarse Gravel	17 – 32		
Very Course Gravel	33 – 64		
Small Cobble	65 – 90		
Medium Cobble	91 – 128		
Large Cobble	129 – 180		
Very Large Cobble	181 – 256		
Small Boulder	257 – 512		
Medium Boulder	513 – 1024		
Large Boulder	1025 – 2048		
Very Large Boulder	2049 – 4096		
Bedrock	>4097		

Attach separate sheet or the "Pebble Count" Excel spreadsheet to summarize and calculate pebble count metrics.

2.10 EMBEDDEDNESS

Use a Visual Estimate Only for riffle embeddedness. The visual estimate is used to fill out the Habitat

Gravel, cobble and boulders are surrounded by how much fine sediment in the riffles? (Check One)

- ☐ 0 – 25 %
- ☐ 26 – 50 %
- ☐ 51-75 %
- ☐ 76-100 %

Riffle D100

FIGURE 7.20. SEM Form. Transect/Riffle pebble count form.

7.4.7.2 Reachwide Pebble Count

The ADEQ reachwide pebble count is a distilled version of the Zigzag Pebble Count Method (Bevenger and King, 1995). This count is a direct measure of the median particle size for the entire reach.

FIGURE 7.21. Pebble count.

Reachwide Pebble Count Procedure

1. Mark the reach off with flagging tape or pins. Divide the reach in half, quarters or tenths which will enable the samplers to assess if they are on track with their pebble counts.
2. Randomly choose a starting spot in the wetted width of the channel by looking at the second hand of your watch (TABLE 7.4)

Seconds	Sampling Location
1 & 6	LEW
2 & 7	1/4

Seconds	Sampling Location
3 & 8	1/2
4 & 9	3/4
5 & 0	REW

TABLE 7.4. Use the last digit on your watch to randomly choose the beginning point for the 5 point method.

3. Take the total number of paces (ie. reach length) obtained from step 1 and divide it by 100. This will give you the number of paces that need to be walked for each of the 100 pebbles that will be sampled. For example, if your reach is 350 paces long then you will need to count a pebble every 3.5 paces. This works best if the recorder paces along side the sampler so that the sampler has a point of reference as they are zigzagging across the stream.
4. Begin sampling the reach as diagramed in FIGURE 7.22. Use the tip of your boot or a pointer to take a particle reading. Extend the forefinger, and without looking down, pick up the first pebble touched, and measure the intermediate axis in millimeters (FIGURE 7.19). The intermediate axis is neither the longer nor shorter of the three perpendicular sides. Determine the Size Range from the Field Data Sheet and record the tally. For embedded or very heavy rocks, measure them in place by measuring the smaller of the two exposed axes. Discard the measured pebble downstream.

   Make a visual estimate of what percent of the particle is embedded. Embeddedness is the percent of a particle surrounded by sand, silt and other small particles. **Bedrock is always counted as 0% embedded; Silt/clay and sand are counted as 100% embedded. For intermittent dry streams the pebble count should be done from bankfull to bankfull rather than wetted width.**
5. At the same spot where you measured the pebble, also note the type of **macrophyte or algae** present for each of the 100 pebble count locations. Identify the plant type, using the list provided on the field form (FIGURE 7.28) and the field plant ID guide (Jones, 2011).
6. Record the tally on the reachwide pebble count field form, in consecutive order (FIGURE 7.25). Make sure to write values from left to right on each row because the number of runs, for calculating diversity, is dependent on the number of consecutive sightings of the same plant species. Mark your observations using the assigned code letters for each species (A = algae and M = Macrophyte).
7. For macrophyte and algae percent cover, calculate the percent plant cover as follows: After marking plant cover observations for the 100 stations along the reach length, calculate the percent plant cover. Count the number of macrophyte and algae observations / 100 to calculate plant cover % as follows:

$$C\% = (Np/Nt) \times 100$$

Where: C% = cover percent
Np = number of plant (algae + macrophyte) "points"
Nt = total number of points (=100)

This will give you a measurement of the percent cover of the stream bed by plants.

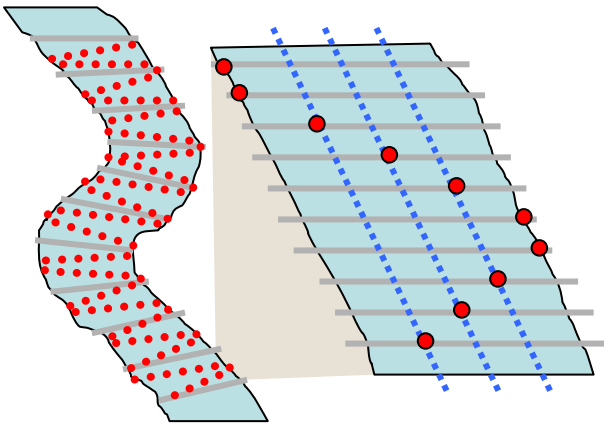


FIGURE 7.22. The reach wide pebble count. The stream is divided into 5 vertical segments and 20 lateral segments for a total pebble count of 100.

There is a tendency to look down and select a pebble, but this should be avoided or the results will be biased toward larger particle sizes.

8. Continue working up or down the reach until you reach the stream edge. Be sure to sample the edge twice as you zig zag through the stream (see FIGURE 7.22). This will ensure an equal representation of all sampling stations.
9. The pebble count tallies must be graphed to determine the D15, D50 (median particle size), and D84 classes (See Section 9.2, Pebble Count - Post-trip procedures).

Parts of the reach may not be wadeable due to deep pools or fast flowing water. If wadeable, Wade in as close to the specified location and either measure the size of the particle between your feet, take a visual estimate if you can see the particle, or jab the substrate with a pointer to estimate size class. If you cannot enter the deep pool, use your pointer to jab a particle at approximately 1m from the stream edge and estimate the size class. Record the number of estimated particles on the field form under "estimated tally" Be sure to comment on the number of estimated particles in the database. The Bottom deposits standard will not apply if more than 25% of the reach will have estimated values

7.4.7.2.1 How to Calculate Number of Runs and Diversity

Aquatic plant diversity is a measure of both species richness and evenness of the species distribution in the study area. High abundance with low diversity is an indicator of nutrient stress. Using the algae and macrophyte observations recorded for the percent plant cover estimate, calculate the plant diversity (Sequential Comparison Index , Cairns, et al., 1968).

1. Count the number of runs of each plant type present, including algae, macrophytes and fungal growths, but not including blanks or root masses. Data will be organized by the number of "runs" or consecutive instances of encountering the same plant in subsequent samples and counted as in this example, where X, Y, Z, C, A and O are different plant species and the numbers indicate number of runs:

XX O X OOOO YY Z A C AAA
1 2 3 4 5 6 7 8 9

2. Calculate the diversity using the following formula, where the number of runs is divided by the number of samples (total number of plant points observed).

DI = (number of runs) / (number of Total plant points)

3. This formula will yield a number between zero and one. This Diversity index number will then be compared to the following table to yield a diversity rating category:

Rating	Score
Poor	0 – 0.3
Fair	0.3 – 0.6
Good	0.6 – 1.0

Instructions: Tally 100-pebbles in throughout the reach using the 5 point or 9 point method. Don't include bedrock in the 100 count tally. Sand/Silt = High Embeddedness. Bedrock = 0. A reachwide and transect riffle pebble count is required for coldwater streams.

2.14 REACHWIDE - (WARM AND COLDWATER STREAMS)

Size Class	Size (mm)	Reach	Riffle	Count
Silt/Clay	<0.062			
Sand	0.063 – 2.0			
Very Fine Gravel	3 – 4			
Fine Gravel	5 – 8			
Medium Gravel	9 – 16			
Coarse Gravel	17 – 32			
Very Course Gravel	33 – 64			
Small Cobble	65 – 90			
Medium Cobble	91 – 128			
Large Cobble	129 – 180			
Very Large Cobble	181 – 256			
Small Boulder	257 – 512			
Medium Boulder	513 – 1024			
Large Boulder	1025 – 2048			
Very Large Boulder	2049 – 4096			
Bedrock	>4097			
Estimated Tally	Enter D100 (Largest particle)	Reach D100	Riffle D100	

2.15 EMBEDDEDNESS

Category	Low	Med	High
Range	0 – 33	34 – 66	67 100
Tally	Mid-pt = 17	Mid-pt = 52	Mid-pt = 83
A = Tally Sum by Class			
B = Class Mid-pt * A	17 * A	52 * A	83 * A
C = Sum of A across classes			
D = Sum of B across classes			
Mean Embeddedness = D/C			
Attach separate sheet or the "Pebble Count" Excel spreadsheet to summarize and calculate pebble count metrics.			

2.16 PLANT ID (USE CODES IN 2.13)

1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64
65	66	67	68	69	70	71	72
73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88
89	90	91	92	93	94	95	96
97	98	99	100				

Algae Points		% Algae	
Plant Points		% Plant	
(a) # of runs		(b) Total Points	
(a/b) diversity			
Algae Richness Macrophyte Richness		☐ Skewed sample	

FIGURE 7.23. SEM Form. Reachwide Pebble Count Forms.

7.4.8 RIFFLE GEOMETRY

The objective of this method is to calculate the Length/width ratio needed for the Habitat Index. Distances can be measured by paces or by tape measure. Measure the length and width of each of the three riffles where macroinvertebrates were collected and record on the field form (FIGURE 7.24). The width is from the wetted edge of one bank to the other. The length is measured from the top to the bottom of a riffle. **For intermittent streams, this could be hard to calculate if the stream is dry and is an optional measurement.**

For the Riparian width on each bank, pace or estimate the riparian width at the same location where the riffle width was taken. Measure from the edge of the stream to the edge of the floodplain, where riparian plants no longer make up 50% of the species. Note if the riparian width was GIS estimated for larger river systems.

Calculate the length/width ratio by dividing the riffle length by the riffle width.

2.11 RIFFLE GEOMETRY (USE RIFFLES WHERE BUGS COLLECTED)

Riffle #	Length	Width	Riparian Width (left bank)	Riparian Width (right bank)	Length / Width Ratio
1					
2					
3					
				Average length / Width Ratio	
				☐ Paces, ☐ feet, or ☐ meters	

FIGURE 7.24. Riffle geometry.

7.4.9 CANOPY DENSITY

Percent canopy density is measured with a concave Spherical Densiometer, manufactured by Forest Densiometers, Bartlesville, Oklahoma. New densiometers should be modified by placing narrow strips of black tape at a right angle forming a "V" as shown in FIGURE 7.25. This will provide 17 intersect recording points. The modification improves the measurement of canopy closure (Platts et al, 1987). To facilitate the reading of the mirror surface in the field, place black dots at the intersections of all lines with a Sharpie.

The Spherical Densiometer optically identifies a series of points in the canopy above the sampling location. The observer records the number of shaded points.

FIGURE 7.25. Modified Spherical Densiometer.

Canopy Density Procedure

1. Canopy density readings are taken at the same transects as the transect pebble counts and riffle bug sample locations (i.e. three transects). For streams less than or equal to 16 feet wide (wetted width) the four measurements are taken (FIGURE 7.26);
   - at right edge of water facing the right bank,
   - at mid-channel facing upstream,
   - at mid-channel facing downstream, and
   - at left edge of water facing the left bank.

   For streams greater than 16 feet wide also take measurements at ¼ and ¾ the wetted width looking upstream and downstream. **For intermittent dry streams take measurements at bankfull and the center of the channel at the bottom, middle, and top of the reach.**

2. Squat at edge of water and facing the stream bank, hold the instrument level, away from the body, with the "V" pointing toward the observer. Position the densitometer twelve inches above the water surface, and twelve inches from the bank and edge of water.

The observers head reflection should be touching the top of the uppermost grid line.

3. Count all intersecting points on the densitometer where vegetation is present and record that number on the field data sheet.
4. Repeat at the middle upstream, middle downstream and other edge of water.
5. On the SEM form, sum the tallies for each column. Each column represents a cross-section. Sum the cross-section tallies and divide by 3 to obtain the mean number of points.

Do not intermingle the 4 point and 8 point method in one study reach.

2.12 CANOPY DENSITY			
Position	**Upper Reach**	**Mid-Reach**	**Lower Reach**
REW			
¼ Upstream (if > 16')			
¼ Downstream (if > 16')			
Middle – Looking Upstream			
Middle – Looking Downstream			
¾ Upstream (if > 16')			
¾ Downstream (if > 16')			
LEW			
Sum			
Number of Points =	Sum of three columns _____ / 3 = _____		
Stream width ≤ 16 ft	Percent Canopy Density = Number of Points x 1.47 =		%
Stream width > 16 ft	Percent Canopy Density = Number of Points x 0.735 =		%

FIGURE 7.26. SEM Form. Canopy Density..

7.4.9.1 Determining Stream Order

Stream order can range from a "1" for a headwater stream to around a "10" for a very large river. The Amazon River is the highest order river on Earth with a Strahler stream order of "12."

When two first-order streams come together, they form a second-order stream. When two second-order streams come together, they form a third-order stream. Streams of lower order joining a higher order stream do not change the order of the higher stream. Thus, if a first-order stream joins a second-order stream, it remains a second-order stream. It is not until a second-order stream combines with another second-order stream that it becomes a third-order stream (FIGURE 7.27). A GIS shapefile has been created to make determining stream order easier.

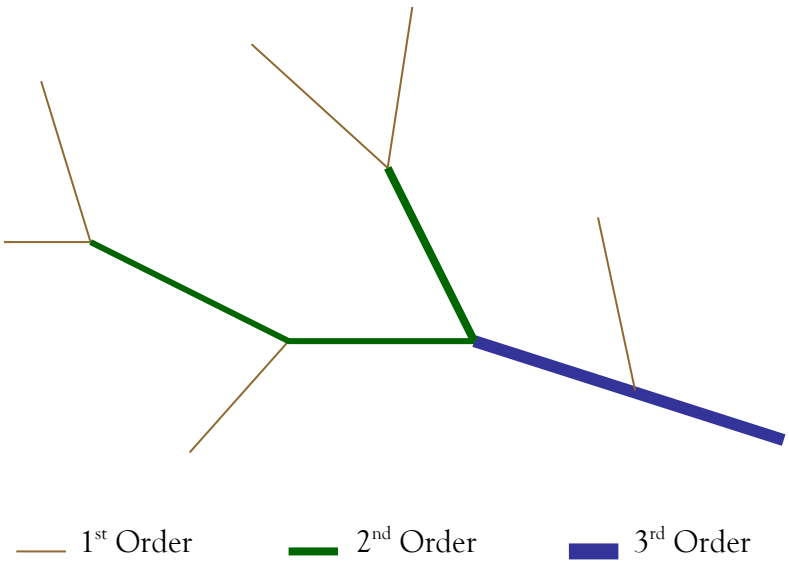


FIGURE 7.27. Determining Strahler stream order.

7.4.10 RIPARIAN SPECIES

Riparian zones are vital to the protection of aquatic habitat. Riparian plants have been shown to reduce the amount of pollutants that can enter the stream. Riparian trees, shrubs and herbs are hydrophytic plants that are found between (and sometimes in) the stream and the upland area. The upland area is generally defined as the area that has 50% or fewer of its species as facultative or obligate species (ACOE, 1988). Use the "ADEQ Guide to Algae and Plants" or associated field guides to identify algae and plant in the riparian zone (Jones, 2011) to identify common plants and algae.

2.13 PLANT DIVERSITY (TALLY ACROSS REACH)			
Check which algae and macrophytes are present in the wetted width. Record the tally in the space below using the codes provided next to each organism. A = Algae M = Macrophyte.			
☐ A	(aCl) - *Cladophora* (hair like feel, long beards)	☐ M	(mW) - Watercress (*Rorippa*)
☐ A	(aSg) - *Spirogyra* (slimy to touch, bright green)	☐ M	(mMF) - Monkey flower (*Mimulus*, yellow flower)
☐ A	(aN) - *Nostoc* (looks like jelly beans or round black to blue colored nodules)	☐ M	(mPW) - Pondweed (*Potomogeton*, submerged water grass)
☐ A	(aBG) - Blue-greens (blue-green to black in color, e.g. *Oscillatoria*, *Anabena*)	☐ M	(mCb) Columbine (yellow flower)
☐ A	(aV) - *Vaucheria* (dark green felt-like mats)	☐ M	(mB) - Buttercup (*Ranunculus*)
☐ A	(aSt) - Stonewort's (feels gritty, looks like a vascular plant, found in upwelling zones)	☐ M	(mMf) - Eurasian water milfoil (*Myriophyllum*) INVASIVE
☐ A	(aH) - *Hydrodictyon* (bright green, net forming algae)	☐ M	(mHy) - Hydrilla INVASIVE
☐ A	(aP) - *Praesiola* (cold water algae, looks like sea lettuce)	☐ M	(mR) - Rush
☐ M	(mL) - *Lemna* / Duckweed	☐ M	(mMs) - Moss
☐ M	(mSp) - Speedwell	☐ M	(mSe) - Sedge
☐		☐	
☐		☐	

FIGURE 7.28. SEM Form. Riparian Species and Regeneration Potential of Riparian Trees.

7.4.11 BIOLOGICAL OBSERVATIONS

This section seems very similar to the "Site Observations" at the beginning of the field form. The main difference is that the Biological Observations are taken throughout the reach instead of 10 meters up and downstream of the sample point. These items help interpret the benthic chlorophyll data collected from the stream bottom. Dominant algae color is the color of the stream bottom given by the algae and macrophytes. For example, Diatoms will give off a light brown color, whereas growing cladophora mats will be Green. "Condition of aquatic plants" refers to stage of growth or decay and helps interpret chlorophyll/pheophytin ratios in the benthic chlorophyll data. Floating algae mat refers to mats that are buoyant and floatable. "Length of filamentous algae" refers to length of strands, such as cladophora that can grow "beards" meters long; this is a visual estimate. Algal slime on rocks refers to thickness of the diatom cover/biofilm on the stream bottom substrate.

2.8 BIOLOGICAL OBSERVATIONS	
Dominant Algae Color: ☐ Green; ☐ Green/light brown; ☐ Light brown; ☐ Brown-reddish; ☐ Dark brown/black	
Condition of aquatic plants: ☐ Growing; ☐ Mature, ☐ Decaying	
Floating algae (detached clumps/mats) floating downstream: 1) <1% 2) 1-25% 3) 26-50% 4) 51-100%	
Length of Filamentous algae: Short <2cm long, Medium 2-10cm, Long >10cm	
Algal slime on rocks, wood, etc. (not filamentous)	☐ Absent; ☐ thin coating<0.5mm; ☐ common 0.5-3mm thick; ☐ thick coating >3mm

FIGURE 7.29. Biological Observations.

7.4.13 REGENERATION POTENTIAL OF RIPARIAN TREES

Observations of regeneration capacity aid in evaluating the health of the riparian community. A stressed community will exhibit reduced age class diversity, changes in percent cover, loss of species diversity and increased abundance of exotic species. To complete the regeneration potential table, record the presence of the five most common trees in four age classes; mature trees, young trees, saplings, and seedlings. The observations for all size classes are taken at breast height or approximately 5 feet above the ground. For example, to determine if a tree fits into the mature tree category look at trees throughout the study reach at 5 feet high and see if they are greater than 16 inches in diameter. The community is considered in best condition if tree species are abundant in three age classes (FIGURE 7.32). Identify unknown species in the empty boxes if common (>25%). Be sure to distinguish age classes for unknown species.

2.17 RIPARIAN & INVASIVE SPECIES

USE THE ADEQ GUIDE TO ALGAE AND PLANTS TO IDENTIFY RIPARIAN AND INVASIVE SPECIES.

Macrophytes	Grasses & Shrubs		Trees		Invasive
☐ Buttercup	☐ Bamboo	☐ Spikerush	☐ Alder, Arizona	☐ Walnut, Arizona	☐ Russian knapweed
☐ Checkered Mallow, NM	☐ Bulrush, Hardstemed	☐ Vine Mequite	☐ Alder, Thinleaf	☐ Willow, Arroyo	☐ Russian olive
☐ Columbine	☐ Cattail	☐ Arrowweed	☐ Ash, Velvet	☐ Willow, Bebb	☐ Water hyacinth
☐ Monkey Flower	☐ Deer Grass	☐ Desert Broom	☐ Boxelder	☐ Willow, Bonpland's	☐ Salt ceder
☐ Primrose, Floating	☐ Desert Saltgrass	☐ Willow, Arizona	☐ Cottonwood, Fremont	☐ Willow, Coyote	☐ Parrot's feather
☐ Gooseberry	☐ Horsetail	☐ Willow, Seep	☐ Cottonwood, Narrowleaf	☐ Willow, Pacific	☐
☐ Spearmint	☐ Muhly, Alkaki	☐	☐ Maple, Big Toothed	☐ Willow, Goodding	☐
☐ Speedwell	☐ Reed, Giant	☐	☐ Maple, Rocky Mountain	☐ Willow, Scouler	☐
☐ Watercress	☐ Sacaton	☐	☐ Sycamore, Arizona	☐	☐
☐ Buttercup	☐ Sedge	☐	☐ Tree tobacco	☐	☐

2.18 REGENERATION POTENTIAL OF RIPARIAN TREES

Species in order of dominance	Mature Trees >16" @ 5 ft height	Young Trees <16" >1¼" @ 5 ft. height	Saplings < 1 ¼"	Seedlings New growth
1				
2				
3				
4				
5				

Age Classes of Riparian Tree Species
(Classify according to species present, not just the dominant tree type of that plant association)

☐	Species abundant in 3 age classes	☐	Abundant in 2 age classes	☐	One age class present	☐	No regeneration evident, few mature trees present, no saplings or seedlings, or if present, they are heavily grazed

FIGURE 7.32. Riparian species and regeneration potential.

7.4.14 ESTIMATING RIPARIAN VEGETATION COVER

Estimating percent cover of different canopy layers of the riparian community is a semi-quantitative measure of riparian condition. Record the estimated percent cover of the over story of riparian trees, the understory of shrubs, ground cover and barren ground within the floodplain. Consider each vegetative layer separately with a score of 0-100 percent for each (FIGURES 7.33 and 7.34).

FIGURE 7.33. Figure used for estimating percent areal cover.

2.19 RIPARIAN VEGETATION COVER

Record the percent cover of each vegetation type within the floodplain. Consider each vegetative layer separately with a score of 0 – 100% for each (See above figure). The object is to identify what vegetation type is holding the banks and floodplain together.

Riparian Vegetation Cover	Estimated Percent Cover
Canopy of riparian trees > 15 feet high	
Understory of woody shrubs, saplings, herbs, grasses and forbs – 1.5 to 15 feet high	
Ground cover of woody shrubs, seedlings, herbs, and forbs - < 1.5 feet high	
Barren or bare dirt	

FIGURE 7.34. SEM Form. Riparian Vegetation Cover

7.4.15 NON-POINT SOURCE OBSERVATIONS

Sources of potential impairment must be identified as part of the bioassessment process. Sources adjacent to the study reach as well as sources within the watershed are identified from visual observations in the field and from topographic maps or aerial photos.

2.20 NON-POINT SOURCE CODES			
Add a Circle for direct sources and an asterisk for sources in the watershed in the Source Category column. Bold indicates common categories.			
Code	**Source Category**	**Code**	**Source Category**
0100-Wastewater	0100-Industrial Point Source		5990-Sand/gravel Mining
Industrial	0200-Municipal Point Source	6000-Land Disposal/	6200-Wastewater
	0500-Collection System Failure	Storage/Treatment	6300-Landfills
	0900-Sewage Lagoons		6350-Inappropriate Disposal/wildcat
1000 - Agriculture	1100-Non-Irrigated Crop		6400-Indust. Land Mangment
	1200-Irrigated Crop		**6500-Wastewater Treatment septic sys.**
	1300-Specialty Crop - Citrus /nuts /fruits		6600-Hazardous Waste
Grazing	**1350-Grazing Related Sources**		**6700-Septic Disposal**
	1400-Pasture Grazing		6800-Waste Storage/AST leaks
	1500-Range Grazing		6900-Waste Storage/UST leaks
1600 - CAFO	Animal Feeding Operations	7000-Hydromodification	7100-Channelization
1700-Aquaculture	Fish Hatchery		7190-Channel Erosion/incision
2000 - Silviculture/	2100-Harvesting/Residue Management		7200-Dredging
Forestry	2200-Forest Mngm-pumped drainage		7300-Dam Construction
	fertilization/pesticide app		7350-Upstream Impoundment
	2300-Road Construction/maintenance		**7400-Flow Regulation/Modification**
	2990-Reforestation		**7550-Other Habitat Modification**
3000-Construction	**3100-Highways/roads/bridges**		**7555-Erosion materials from tribs**
	3200-Land (Re-)Deveopment		7600-Removal of Riparian Veg
4000-Urban Runoff	4190-Municipal		**7700-Streambank Modification/Destab.**
/Stormwater	4191-Commercial		7800-Drainage/filling of wetlands
	4192-Residential-Non commercial auto pet waste etc.		**7850-Groundwater Withdrawal**
	4400-Illicit connections/illegal hookup	7900-Marinas/Boating	7990-Pumpouts
	4450-Dry weather flows		7991-Sanitary on-vessel discharges
	4500-Hwy/road/bridge runoff		7992-other on-vessel discharges
	4590-Post-development erosion/sed.		7994-Boat Construction
	4600-Non-urban runoff/erosion/sediment		7995-Boat Maintenance
	4650-Salt Storage Sites		7997-Fueling
5000-Resource	5100-Surface Mining		7996-Shoreline Erosion
Extraction	5200-Subsurface Mining	8000 - Other NPS	8050-Erosion from Derelict Land
	5290-Open Pit Mining	Pollution	8100-Atmospheric Deposition
	5300-Placer Mining		8400-Spills
	5400-Dredge Mining		**8600-Natural Sources (such as fire)**
	5500-Petroleum Activities		8910-Groundwater Loadings
	5600-Mill Tailings		8950-Wildlife
	5700-Mine Tailings	8500-Hist. pollutants	8590-Contaminated Sediments
	5800-Abandoned Mine (Drainage)		8591-Clean Sediments
NPS Codes and Observations			8592-Other Historical Pollutants
		8700-Turf Management/	**8700- Rec and Tourism (non-boating)**
		Recreation/non-boating	8710-Golf Courses
			8790-Yard Maintenance
			8791-Other Turf Management

FIGURE 7.35. SEM Form. Non-point Source Codes.

7.4.16 PFANKUCH CHANNEL STABILITY EVALUATION

The Pfankuch Channel Stability Evaluation (Pfankuch, 1975) is a channel stability assessment tool, recommended by Wildland Hydrology's Dave Rosgen in making evaluations of channel stability

(Rosgen, 1996). The original scoring form was developed by Dale Pfankuch in 1975 (USFS, 1975). The original form assessed stream condition based on 15 parameters. The evaluation is segregated into three categories: upper banks, lower banks, and channel bottom. Each category has three to four ratings. The sum of the category ratings is transformed into an adjective rating of stream stability (e.g., Excellent, Good, Fair, and Poor), using Rosgen stream type.

Pfankuch's original evaluation was designed for use in western U.S.A. mountain stream channels, but did not provide for the varieties of stream type. Rosgen (1996) incorporated the evaluation into his river classification system, but dropped the "excellent" rating. The following format is the Rosgen modified Pfankuch channel stability rating form.

3.1 MODIFIED PFANKUCH CHANNEL STABILITY EVALUATION (LEVEL III)

THE PFANKUCH EVALUATION HAS 3 SECTIONS; UPPER BANKS, LOWER BANKS, AND CHANNEL BOTTOM. THE LOW SCORE IS THE IDEAL CONDITION. YOU MUST SELECT ONE OF THE SCORES GIVEN; NO BETWEENERS!
THE PFANKUCH WORKSHEET SHOULD BE FILLED OUT LAST AND TOGETHER WITH ALL FIELD HANDS.

Description	Rating
A. "UPPER BANKS" are the terrestrial banks adjacent the floodplain, and above bankfull elevation. This landform comes into play only during floods. This category is designed to aid in rating the relative resistance to detachment and transport of particles (large and small, organic and inorganic) by floods.	
a) "Landform Slope" is the slope of the terrestrial banks adjacent the floodplain. This can be estimated or measured with an Abney level (or similar device). Always choose the worst condition for the rating. If you have one floodplain at 30% and the other at >60%, rate the steeper slope because that is the area where erosion will be occurring at flood.	
a) Excellent: Side slopes to the channel are generally less than 30% on both banks	2
b) Good: Side slopes up to 40% on one or occasionally both banks	4
c) Fair: Side slopes to 60% common on one or both banks	6
d) Poor: Steep slopes, over 60%, provide larger volumes of soil for downstream sedimentation from lateral bank cutting.	8
b) "Mass Wasting" involves existing or potential detachment of relatively large pieces of earth. Mass movement of banks by slumping or sliding introduces large volumes of soil and debris into the channel. This condition is common at meanders or on incised channels where high banks exist at great angles, especially over 60%.	
a) Excellent: There is no evidence of mass wasting that has or could reach the stream channel in recent times.	3
b) Good: There is evidence of infrequent and / or very small slumps. Those that exist may occassionally be "raw" but predominantly the areas are revegetated and relatively stable.	6
c) Fair: Frequency and / or magnitude of the mass wasting situation increases to the point where normal high water (bankfull or a little less) aggravates the problem of channel changes and subsequent undercutting or unstable areas with increased sedimentation.	9
d) Poor: Mass wasting is not difficult to detect because frequency or size of eroding areas or proximity of banks are so close to potential landslides that increases in flow will trigger landslides.	12
3. "Debris Jam" includes those floatable objects that have been deposited on stream banks, in the floodplain, by man or by natural processes. It usually consists of tree trunks, limbs, twigs, and leaves. It forms obstructions, flow deflectors, and sediment traps. This inventory item assesses the potential for increasing these impediments to the natural direction and force of flow where they now lay. The Pfankuch evaluation considers debris jams to be a negative influence on the stream channel except when it is protecting the floodplain banks	
a) Excellent: Some small debris may be present on the floodplain banks (<10%).	2
b) Good: Some debris present but it is small enough to be floated away in time. Only small jams could be formed with this material alone (10 – 30%).	4
c) Fair: There is a noticeable accumulation of all sizes and the stream is large enough to float it away (31 –50%).	6
d) Poor: Moderate to heavy accumulations are present due to fires, insect damage to trees, disease mortality, windthrow, and logging slash. High flows will float some debris away and the remainder will cause channel changes (> 50%).	8

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Description	Rating
4. "Vegetative Bank Protection" concerns the vegetative component in the floodplain. Factors to consider for this rating are the density of plant stems, varieties of vegetation, plant vigor, and recruitment(→see Section 2.19 combined cover).	
a) Excellent: Trees, shrubs, grass and forbs combined cover is more than 90% of the ground. Openings in the ground covers are small and evenly dispersed. A variety of age classes and species are represented. Growth is vigorous and reproduction of species in both the under- and over-story is proceeding at a rate to insure continued ground cover conditions. A deep dense root mat is inferred.	3
b) Good: Plants cover 70 to 90 percent of the ground. Shrub species may be more prevalent than trees. Openings in the tree canopy are large. While the growth vigor is generally good for all species, recruitment of new individuals may be sparse or lacking entirely. A deep root mat is not continuous and more serious erosive incursions are possible in the openings.	6
c) Fair: Plant cover ranges from 50 to 70 percent. Lack of vigor is evident in some individuals and / or species. Seedling reproduction is nil. Most of the floodplain does not have a deep root mat.	9
d) Poor: Less than 50 percent of the ground is covered. Trees are essentially absent. Shrubs largely exist in scattered clumps. Growth and reproduction vigor is generally poor. Root mats discontinuous & shallow.	12
Upper bank total	
B. "LOWER BANKS" is the area between bankfull and base flow. Aquatic, semi-aquatic, and terrestrial plants may grow here.	
a) "Channel Capacity" Channel width, depth, gradient and roughness determine the volume of water that can be transmitted. Over time channel capacity has adjusted to the size of watershed above the reach, vegetation and climate changes. Indicators of change are widening or deepening which affects the W/D ratio. When the capacity is exceeded, deposits of soil are found on the banks and organic debris may be found hung up on bank vegetation. These are expresssions of the most recent flood event. Estimate what normal peak flow (bankfull) is and whether the present cross section is adequate to handle the load without bank/bed deterioration. Look for cut banks that are >bankfull height and measure Bank height ratio: total bank height from toe of bank to top/bankfull height from toe of bank.	1
a) Excellent: Cross sectional area is ample for present peak volumes. W/D ratio is appropriate for stream type.	2
b) Good: Adequate cross sectional area contains most peak flows. Bank height ratios up to 1.1 (stable is 0.8 to 1.2)	3
c) Fair: Channel barely contains the peak runoff in average years or has oversized W/D ratio of -1.2 to 1.4 or incising with W/D ratios 1.2 to 1.5. BHR 1.1 to 1.3	4
d) Poor: Channel capacity is inadequate or over-width. Overbank floods common as indicated by condition of the bank vegetation and position/accumulation of debris with W/D ratio <0.6 or >1.4 becoming incised. BHR >1.3	

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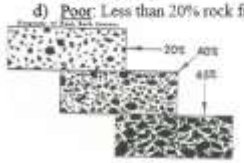
Description	Rating
2. "Bank Rock Content" Examination of the materials that make up the channel bank will reveal the relative resistance of this component to detachment by flow forces. Since the banks are perennially and intermittently both aquatic and terrestrial environments, these sites are harsh for most plants that make up both types. Vegetation is, therefore, generally lacking and it is the volume, size and shape of the rock component which primarily determine the resistance to flow forces.	
a) Excellent: Rock makes up 65% of more of the volume of the banks. Within this rock matrix large, angular boulders 12" (on their largest axis) are numerous	2
b) Good: Banks 40-65% rock which are mostly small boulders and cobble ranging in size form 6-12" mean diameter. Some may be rounded while others are angular.	4
c) Fair: 20-40% of bank volume rock. While some big rock may be present , most fall into the 3-6" diameter class.	6
d) Poor: Less than 20% rock fragments, mostly of gravel sizes 1-3" diameter.	8
	
3. "Obstructions to Flow" is an inventory of objects within the stream channel, like rocks, embedded logs, bridge pilings, etc., that change the flow and sometimes the velocity. Obstructions may produce adverse stability effects when they increase the velocity and deflect the flow into unstable and unprotected banks and across unstable bottom materials. They also may produce favorable impacts when velocity is decreased by turbulence and pools are formed (See → Section 2.3).	
a) Excellent: Logs, rocks, and other obstructions to flow are firmly embedded and produce a pattern of flow which does not erode the banks and bottom or cause sediment buildup. Pool/riffle relationship stable.	2
b) Good: Obstructions to flow and sediment traps are present, causing cross currents which create some minor bank and bottom erosion. Some of the obstructions are newer, not firmly embedded and move to new locations during high flows. Some sediment is trapped in pools decreasing their capacity.	4
c) Fair: Moderately frequent and quite often unstable obstructions, cause noticeable seasonal erosion of the channel. Considerable sediment accumulations behind obstructions.	6
d) Poor: Obstructions and traps are common, are often unstable to movement and cause a continual shift of sediments at all seasons. Since traps are filled as soon as formed, the channel migrates and widens.	8

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Description	Rating
4."Cutting" Signs of channel downcutting are loss of vegetation by scouring and uprooting. In channels devoid naturally of vegetation, the first sign is an increase in the steepness of the channel banks beginning at the top and proceeding to the entire bank becoming a vertical wall. If plant roots bind the surface horizon of the adjacent upper bank into a cohesive mass, undercutting will follow. Eventually the weight of the overhang will slump into the channel. Unconsolidated banks with or without vegetation will be nibbled away and never develop an overhang.	
a) Excellent: Very little or no cutting is evident (<5%). Raw, eroding banks are infrequent, short and predominately less than 6" high.	4
b) Good: Some intermittent cutting along channel outcurves and at prominent constrictions (5-30%). Eroded areas are equivalent in length to the channel width and the vertical cuts are predominately less than 12".	6
c) Fair: Significant bank cutting occurs frequently in the reach (30-60%). Raw vertical banks 12" to 24" high are prevalent as are root mat overhangs and sloughing.	12
d) Poor: Nearly continuous bank cutting (60-100%). Some reaches vertical cut faces over 2 feet high. Undercutting, sod -root overhangs and vertical side failures may also be frequent in the rated reach.	16
4. "Bar Development & Deposition" The appearance of sand and gravel bars where they did not previously exist may be one of the first signs of upstream erosion. These bars grow in depth and length with continued watershed disturbance. Width changes are in shoreward directions as overflow deposition takes place on upper banks. Deposition may also occur on inside of bends particularly if active cutting is taking place on the opposite shore. Deposits are also found where there is a sudden flattening of stream gradient, ie. Below geologic nick points. Not applicable to A, E, G type streams and geologically constrained streams (score as 4).	
a) Excellent: Little or no deposition of fresh silt, sand or gravel in channel bars in straight reaches or point bars on the inside banks of curves.	4
b) Good: Some fresh deposits on bars and behind obstructions. Sizes tend to be predominantly from the larger size classes - coarse gravels.	8
c) Fair: Deposits of fresh, coarse sands and gravels observed with moderate frequency. Bars are enlarging and pools are filling so riffle/runs predominate.	12
d) Poor: Extensive deposits of predominately fresh, fine sands, some silts, and small gravels. Accelerated bar development common. Storage areas are full and sediments are moving even during low flow periods.	16
Lower bank total	

C. "CHANNEL BOTTOM" condition is the evaluation of sediment deposition within the bankfull channel.	
1. Angularity: Rocks from stratified, metamorphic formations break out and work their way into channels as angular fragments that resist tumbling. Their sharp corners and edges wear and are rounded in time, but they resist the tumbling motion. These angular rocks pack together well and may orient themselves like shingles (imbricated). In this configuration they are resistant to detachment. In contrast, igneous rocks often produce fragments that round up quickly, pack poorly and are easily detached and moved downstream. Excellent to Poor ratings relate to the amount of rounding exhibited and secondarily the smoothness or polish the surfaces have achieved. Some rocks never do smooth up in the natural environment, but most round up in time. Both conditions are relative within the inherent capability of the respective rock types. a) Excellent: Sharp edges ad corners. Plane surfaces rough. b) Good: Rounded corners and edges. Surfaces smooth and flat. c) Fair: corners and edges well rounded in 2 dimensions d) Poor: well-rounded in all dimensions. Surfaces smooth. 	 1 2 3 4
2. Brightness: Rocks in motion "gather no moss", algae or stain either. They become polished by frequent tumbling and, as a general rule, appear brighter in their chroma values than similar rocks which have remained stationary. The degree of staining and vegetative growths relate also to water temperature, seasons, nutrient levels, etc. In some areas a "bright" rock will be "dulled" in a matter of weeks or months. In another it may take years to achieve the same results. Nevertheless, even slight changes during the spring runoff should be detectable during the next summer's survey. a) Excellent: Less than 5% of the total bottom should be bright, newly polished and exposed surfaces. Most will be covered by growths or a film of organic stain. Stains may also be from minerals dissolved in the water. b) Good: 5 to 35% of the bottom appears brighter, some of which may be on the larger rock sizes. c) Fair: About a 50-50 mixture of bright and dull with a 15% leeway in either direction (i.e., a range of from 35 to 65% bright materials). d) Poor: Bright, freshly exposed rock surfaces predominate with two-thirds or more of the bottom materials in motion recently.	 1 2 3 4
3. Consolidation (Particle Packing): Under stable conditions, the array of rock and soil particle sizes pack together. Voids are filled. Larger components tend to overlap like shingles (imbricate). So arranged, the bottom is quite resistant to even exceptional flow forces. Some rock types (granitic) are less amenable to this packing process and never reach the stable state of others. a) Excellent: An array of sizes are tightly packed and wedged with much overlapping which makes it difficult to dislodge by kicking. b) Good: Moderately tight packing of particles with fast water parts of the cross-section protected by overlapping rocks. These might be dislodged by higher than average flow conditions, however. c) Fair: Moderately loose without any pattern of overlapping. Most elements might be moved by average high flow conditions. d) Poor: Rocks in loose array, moved easily by less than high- flow conditions and move underfoot while walking across the bottom. The shape of these rocks tends to be predominantly round and sorted so that most are of similar size.	 2 4 6 8

4. "Bottom Size distribution" Two elements of bottom stability are rated: 1) shifts from the natural variation of component size classes and, 2) the percentage of all stable materials. Bedrock, large boulders, and cobble stones are considered "stable" elements in the average situation. Obviously, smaller rocks in smaller channels might also be classed as stable. Bedrock always results in an excellent classification of that reach. If a shift has occurred where there are larger percentages of large rock in small streams or smaller sizes in large streams, the condition class most appropriate should be checked (see Section 2.14 Reachwide pebble count; look at %particles cobble to bedrock). a) Excellent: There is no noticeable change in size distribution. The rock mixture appears to be normal for the kind of geologic sources in the basin and the flow forces of streams of this size and location in the watershed (stable materials 80-100%). b) Good: Slight shift in either direction. (stable materials 50-80%) c) Fair: Moderate shift in size classes. (stable materials 20-50%) d) Poor: Marked, a pronounced shift. (stable materials <20%)	4 8 12 16
5. Scouring and/or Deposition: Items of size, angularity and brightness should lead you to some conclusions as to the amount of scouring and/or deposition that is taking place along the channel bottom. (→see Section 2.14 Reachwide pebble count to assist determination of substrate instability). a) Excellent: Neither scouring nor deposition is much in evidence. Up to 5% of either or a combination of both may be present along the length of the reach (ie, 0-5 feet vertical drop in 100 feet of channel length) b) Good: Affected length ranges from 5 to 30%. Headcuts are found mostly at channel constrictions or where the gradient steepens. Deposition is in pools and backwater areas. Sediment in pools moves through so pools change only slightly in depth but greatly in composition of their size classes. c) Fair: Moderate changes are occurring, 30 to 50% of the bottom is in a state of flux. Cutting is taking place below obstructions, at constrictions and on steep grades. Deposits in pools now tend to fill the pools and decrease their size. d) Poor: Both cutting and deposition are common; >50% of the bottom is moving not only during high flow periods but at most seasons of the year; silt/clay to gravels are dominant particle size.	6 12 18 24
6. Aquatic Vegetation: When some measure of stabilization of the soil-rock components is achieved, the channel bottom becomes fit habitat for plant and animal life. This process begins in the slack water areas and eventually may include the swift water portions of the stream cross section. With a change in volume of flow and/or sedimentation rates, there may also be a temporary loss of the living elements in the aquatic environment. This change in macro-aquatic biomass such as clinging moss, algae and macrophytes is a good indicator of channel stability. a) Excellent: Clinging plants are abundant throughout the reach from bank to bank. A continuous mat of vegetation is not required but moss/algae are readily seen in all directions across the stream. b) Good: Plants are quite common in the slower portions of the reach but thin-out or are absent in the swift flowing portions of the stream. c) Fair: Plants are found but their occurrence is spotty. They are almost totally absent from rocks in the swifter portions of the reach and may also be absent in some of the slow and still water areas. d) Poor: Clinging plants are rarely found anywhere in the reach. (This is an unusual situation but could happen under a combination of adverse environmental conditions).	 1 2 3 4
Channel bottom total	
Total Pfankuch Score: Sum of "Upper Banks", "Lower Banks", and "Channel Bottom"	
Rosgen Stream Type	
Pfankuch Rating category (Good, Fair, Poor)	

Sediment Supply Condition (use Bottom Deposits & Bar Deposition parameters to evaluate)	Stream Bed Stability	Width Depth Ratio
☐ Extreme – Substrate is nearly all runs, few if any riffles and/or mid, side-channel or delta bars are present throughout the reach	☐ Aggrading – Excess bottom deposits and/or bar features are present indicating increased sedimentation, channel is likely wide and shallow	☐ Very High - Substrate is nearly all runs with no defined thalweg, and/or mid, side-channel or delta bars are present throughout the reach; probably wide and shallow
☐ Very High – Loss of pool & riffle habitat due to sedimentation and/or excess bar features are present	☐ Degrading – Lack of fine sand & gravel compared to bar feature materials; vertical raw banks are usually present	☐ High – Some loss of riffle or pool habitat, some excess bar features
☐ High – Stream bottom is moderately affected by sedimentation and/or excess bar features are present	☐ Stable – No excess bar features or excess sediment in pools	☐ Normal – riffle & pool habitat is maintained for that channel type
☐ Low – Stream bottom is not affected by sedimentation and there are no excess bar features		☐ Low – Entrenched channel with eroding banks

CONVERSION OF STABILITY RATING TO REACH CONDITION BY STREAM TYPE (ROSGEN, 1996)

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
GOOD	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60
FAIR	44-47	44-47	91-129	96-132	96-132	81-110	46-58	46-58	61-78	65-84	69-88	61-78
POOR	48+	48+	130+	133+	133+	111+	59+	59+	79+	85+	89+	79+
Stream Type	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**D3**	**D4**	**D5**	**D6**		
GOOD	38-35	38-35	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98		
FAIR	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125		
POOR	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+		
Stream Type	**DA3**	**DA4**	**DA5**	**DA6**	**E3**	**E4**	**E5**	**E6**				
GOOD	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63				
FAIR	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86				
POOR	87+	87+	87+	87+	87+	97+	97+	87+				
Stream Type	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**
GOOD	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
FAIR	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
POOR	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

FIGURE 7.36. SEM Form. Pfankuch Assessment.

7.4.17 PROPER FUNCTIONING CONDITION (PFC) ASSESSMENT

Proper Functioning Condition (PFC) is a qualitative method for assessing the condition of riparian-wetland areas (Prichard et al, 1993). The term PFC is used to describe both the assessment process, and a defined, on-the-ground condition of a riparian-wetland area.

The PFC assessment refers to a consistent approach for considering hydrology, vegetation, and erosion/deposition (soils) attributes and processes to assess the condition of riparian-wetland areas. A checklist is used for the PFC assessment which synthesizes information that is essential for determining the overall health of a riparian-wetland system. The on-the-ground condition termed PFC refers to how well the physical processes are functioning. PFC is a state of resiliency that will allow a riparian-wetland area to hold together during high-flow events with a high degree of reliability. This resiliency allows an area to produce desired values, such as fish habitat, bird habitat, or forage, over a period of time. Riparian-wetland areas that are not functioning properly cannot sustain these values.

The PFC form consists of a set of guidelines for filling out the checklist. The guidelines are from Bureau of Land Management training courses and training materials. The guidelines should accompany the checklist into the field and be referred to as the checklist is being filled out by the assessment team.

Several of the field data sheet habitat measurements should be used to assist the PFC evaluations, such as depositional features, pebble count, regeneration potential, and Rosgen stream type. If a "No" answer is given for any of the PFC items, a remark must be given that describes the condition. The number of yes and no answers on the checklist are used to summarize the overall condition into one of six categories: Proper functioning condition, Functional at risk/upward trend, Functional at risk/downward trend, Functional at risk/no apparent trend, Non-functional, and Unknown. There is no numeric scoring involved. Best professional judgment is used to determine the appropriate assessment category.

3.2 PROPER FUNCTIONING CONDITION WORKSHEET

INSTRUCTIONS: IF 75% OR MORE OF STREAM REACH IS PFC, CLASSIFY ENTIRE REACH AS PFC. "NO" ANSWERS MUST HAVE COMMENTS IN THE "PFC COMMENTS" SECTION. ANSWERS CAN GO ON THE LINE BETWEEN "YES" AND "NO", BUT CONSIDER IT A "NO" AND COMMENT IN NOTES SECTION. FILL OUT LAST AND AS A GROUP.

Yes	No	N/A	Description
			1) Floodplain is inundated in "relatively frequent" events (1-3 years) Bankfull indicators present. Bankfull events occur regularly can be identified from top of the point bars, changes in vegetation, topographic break in slope, change in size of bank materials, evidence of an inundation feature such as small benches, exposed root hairs below an intact soil layer indicating exposure to erosive flow, and bank undercuts. "NO" if channelization or entrenchment. "N/A" if a "V"-canyon without floodplain development (A & B stream types).
			2) Beaver dams are stable? Usually "N/A", but beaver have been documented in many places including the San Pedro River and at high altitude sites; also, consider the present environment (could they be present).
			3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, valley type) Based on the stream type expected within the current valley type (See SOP Section 7.4.1.1). All three features must indicate stability for a "YES". "NO" if straightness (G or F), excessive sediment (D), or entrenched channel (F)(eg. If there is a straightened "G" channel where there should be a "C" type channel in an alluvial basin valley type).
			4) Riparian area is expanding or has achieved potential extent Widening can mean woody or herbaceous plants encroaching on the channel as well as moving toward the terraces. The age of the vegetation is an indicator. "NO" if upland species encroaching on the floodplain or Kentucky bluegrass present. "YES" if recruitment of wetland/riparian species (seedlings or saplings). "N/A" if an A stream type or some B type channels with little woody riparian vegetation.
			5) Riparian impairment from the upstream/ upland watershed is absent. "YES" if no excess sediment (e.g. plants on pedestals, debris dams around plants, rills, gullies). "NO" if signs of excess sediment or erosion present (such as side channel and mid-channel bars, gullies, fan shaped deposits from tributaries, braided channels, overloading of point bars, or cementing of streambed).
			6) There is adequate diversity of stabilizing riparian vegetation for recovery/maintenance This is a presence/absence indicator. Maintenance means recruitment. Is it occurring? "YES" if several different species present (e.g. willows, rushes, sedges). However, it depends on the elevation and the potential natural community that might be present if all human stresses are removed. In alpine meadow streams, 2 herbaceous species could be a "YES". Usually "NO" if 1 species present, the exceptions are sometimes high meadow streams. Refer to → Section 2.18, Regeneration.
			7) There are adequate age classes of stabilizing riparian vegetation for recovery/maintenance. "YES" if 3 age classes (mature, young, saplings) present for a single species, or young and sapling classes if recruitment & replacement is occurring, or dense matting of herbaceous riparian/wetland plants in alpine meadow streams. "NO" if individual plants. "N/A" if A1 Stream Type. Refer to → Section 2.18 'Regeneration Potential of Riparian Trees'
			8) Species present indicate maintenance of riparian soil moisture characteristics Don't consider quantity. "YES" if sedges, rushes, willows, seep willows, alders, cottonwoods, etc. See 'Riparian Species' → Section 2.17.
			9) Stabilizing plant communities capable of withstanding moderately high streamflow events are present along streambank. Look for sufficient vegetation and root masses to protect banks from eroding during high flow events greater than bankfull. Q9 is similar to Q8, but you are now looking for quantity. "NO" if upland species are present within the bankfull channel. "YES" if willows, alder, aspen, birch, cottonwood, sedge, rush, bulrush, and wetland grasses.
			10) Riparian plants exhibit high vigor Are the plants healthy and dense? "NO" if yellow leaves, stunted plants, many dead stems and branches, a thin crown, infested with insects, diseased, or grazed down by browsers.
			11) An adequate amount of stabilizing riparian vegetation is present to protect banks and dissipate energy during moderately high flows. This is a quantity question. Use 80% cover as a guide. Look for riparian plants, herbaceous cover, salt cedar (tamarisk), seep willows, etc. "NO" if "NO" on Q9. If Q6-Q10 is "NO", this is probably a "NO".
			12) Plant communities are an adequate source of woody material for maintenance/recovery "YES" if any large woody vegetation or fallen trees present. Usually "N/A" for meadows, desert streams, and probably intermediate elevation streams, or sedge/grass community streams. "
			13) Floodplain and channel characteristics (i.e., rocks, woody material, vegetation, floodplain size, overflow channels) are adequate to dissipate energy "YES" if large boulders, roughness of the floodplain, large trees and dense vegetation along stream banks. "NO" if incision and no access of stream to floodplain.
			14) Point bars are revegetating with stabilizing riparian plants Applies mainly to "C" channel types. "YES" if sedge/rush components are present. Consider potential, height and newness of the point bar. Sandy soils don't hold water well and there may be no potential for revegetation. A Stream Type is "N/A". Recent drought or flood = between yes and no.
			15) Streambanks are laterally stable "YES" if single channel, stable banks (especially on straight segments), and natural deposition. "NO" if straight channel, not confined geologically, and if there is channel movement with every high flow event.
			16) Stream system is vertically stable (not incising) "NO" if incised banks, entrenchment, excessive aggradation (excess bar features, excess sand and fine particle sizes), unstable vertical banks. "YES" if streambed is armored with large rock, bedrock, large gravel. Don't consider old down cutting. If a bedrock stream then "N/A".
			17) Stream is in balance with the water and sediment that is being supplied by the drainage basin (i.e., no excessive erosion or deposition)? "NO" if excessive sediment from side drainages, excessive aggradation, mid-channel bars, braiding, or unstable banks. "NO" if Q5 is "NO".

Functional Rating	Current condition	Monitored Trend
☐ Proper Functioning Condition	☐ Upward	☐ Upward
☐ Functional at Risk	☐ Mid/Static	☐ Mid/Static
☐ Non-Functional	☐ Downward/Low	☐ Downward/Low

Rationale for Current rating:	
Rationale for Trend:	
Qualifiers: Natural factors preventing PFC (circle if present): Natural, Intermittent stream, Alpine stream	☐ Yes ☐ No
Stressors: Are there factors present that prevent achievement of PFC or affecting progress towards desired condition? (circle one))Regulated flow, mining activity, upstream channel condition, channelization, Road encroachment, Augmented flows, Other, list:	☐ Yes ☐ No

FIGURE 7.37. SEM Form. Proper Functioning Condition.

7.4.18 HABITAT ASSESSMENT

The habitat assessment focuses on stream substrates and bank stability, which are important for biotic communities such as periphyton, macroinvertebrates and fish. It is used in association with the macroinvertebrate index of biological integrity to identify habitat problems as potential stressors. The habitat condition parameters were extracted from USEPA's visual based habitat assessment protocols described in the Rapid Bioassessment Protocols (Barbour et al., 1999) and USEPA's Environmental Monitoring and Assessment Protocols (Lazorchak et al (eds.), 1998). **For an intermittent dry site this section can be skipped.**

7.4.18.1 Riffle Habitat Quality

Habitat quality within riffles is evaluated through a survey of the variety of natural structures within the stream reach, such as cobble, large rocks, woody debris, and undercut banks available for colonization by macroinvertebrates. A wide variety and abundance of submerged structures provides benthic macroinvertebrates with a large number of habitat niches, thus increasing community diversity. As the habitat structure becomes less complex, the variety and abundance of cover decreases. Habitat loss leads to a decrease in community diversity, and the potential for community recovery lessens.

Complete the Reach Habitat Quality portion of the SEM Form prior to conducting the habitat scoring. It is best to complete this form as one of the last tasks before leaving the study area. Walk the entire reach, identifying the relative abundance of each micro- and macro-habitat. For warm water streams, give an optimal score if there are 2-3 habitats in the common to abundant categories; suboptimal if there are 2+ habitats with 1 abundant; marginal if sand is common or abundant with 1 additional habitat; poor if the habitat is dominated by abundant sand with possible algae or macrophytes present. For cold water streams, give an optimal score if there are 3+ habitats in the common to abundant categories; suboptimal if there are 2+ habitats with 1 abundant; marginal if there are 2+ habitats that are rare or common; poor if the habitat is dominated by abundant sand with possible algae or macrophytes present.

7.4.18.2 Extent of Riffle Habitat

In addition to habitat quality, the quantity of the riffle habitat is an important factor for the support of healthy biological stream communities. Good riffle habitat covers the width of the streambed, extends twice the width in riffle length, and is populated with an abundance of cobble. When present, these factors provide abundant habitat for maintenance of the macroinvertebrate community and support of the aquatic food web. Where cobble substrate is lacking, riffles may also be lacking. In streams with excess sediment, the interstitial spaces around the rocks fill with sand which converts the riffle to a sandy run. The lack of habitat in sandy runs prevent macroinvertebrate communities from developing.

Complete the Riffle Geometry portion of the field form prior to conducting the habitat scoring. Mark the widths and lengths of three riffles in the study reach. Calculate the length to width ratios for each and then calculate the average ratio. Use these data to score the Extent of Riffle Habitat.

7.4.18.3 Embeddedness in Riffles

Embeddedness refers to the extent to which rocks (gravel, cobble, and boulders) and woody debris are covered or sunken into the silt, sand, or mud in stream riffles. As rocks become more embedded, the surface area available as habitat for macroinvertebrates decreases. Embeddedness is the result of an infusion of fine sediments from upland and stream bank erosion into stream substrates. Embeddedness is one of the primary measures of excess bottom deposits.

Note average the riffle embeddedness while doing the reachwide pebble count.

7.4.18.4 Sediment Deposition

This parameter measures the amount of sediment that has accumulated on the stream bottom and in pools throughout the reach, and for large-scale movement of sediment into a stream. Sediment deposition may cause the formation of side or mid-channel bars, enlargement of point bars, or may result in the filling of riffles and pools. Usually sediment deposition is evident in areas that are obstructed by natural or manmade debris and in areas where stream flow decreases, such as at bends. Large amounts of fine sediment deposition throughout the reach creates a homogenous, unstable, sandy substrate that is unsuitable for macroinvertebrate colonization.

Field staff should be familiar with Rosgen stream types (Rosgen, 1996) and be able to identify the stream type of the study reach. The stream type is required to evaluate whether excess sediment is present for that stream type and to determine whether the channel features conform to the model for a stream type.

7.4.18.5 Bank Stability

The bank stability parameter evaluates the active bankfull channel and is an indicator of the source and amount of sediment contributing to sediment deposition in the stream. Stable well vegetated banks with little erosion will maintain a stable geomorphic profile and adequate cobble habitat. Unstable banks are characterized by steep walls, banks devoid of vegetation, exposed tree roots, and exposed soil. Unstable banks will erode during moderate flows, contributing large amounts of sediment to the stream bed.

Bank stability is evaluated by visual estimation or measurement of the percent of bank erosion for each bank. Both bank scores are summed for the total bank stability score. A visual estimate of bank erosion for each bank is determined from markings on the site sketch. To measure bank erosion, the length of eroding banks can be paced off or measured with a tape measure, as a percentage of the total bank length.

7.4.18.6 Habitat Assessment Index Scoring

Scores for the five habitat parameters are summed for either a warm water or cold water habitat index score. The five in-stream and bank habitat parameters are scored on a scale of 1 to 4, with higher scores indicating better condition. The habitat scores are summed for a total habitat score ranging from 5-20, with habitat improving with increasing scores. The Habitat Assessment Index

score is then categorized as being good, impaired or very impaired; using the 25th percentile of ADEQ reference habitat assessment scores as the criterion. The 25th percentile of reference method was selected because it is a conservative scoring criterion and allows for the natural variance among reference site scores. The scoring criteria are the same for both the cold and warm water Habitat Assessment Indexes.

3.3 HABITAT ASSESSMENT

Habitat Parameter	Optimal	Sub-optimal	Marginal	Poor
Habitat Quality (use reach habitat quality table, →Section 2.4 and Section 2.14)	Large variety of habitats available for colonization which may include cobble, undercut banks, snags, submerged logs, leaf packs, root masses, macrophyte beds or other organic material.(WW – 2-3habitats; CW – 3+ habitats)	Moderate variety of habitats which may include cobble, leaf packs, root masses, macrophyte beds or other organic material.	Habitat has minimal variety, substrate dominated by one particle size, may have some cobble, macrophyte beds, or algae beds.	Homogeneous substrate dominated by sand, shallow with uniform velocity, no shade on riffles, may have extensive filamentous algae beds.
Score	**4**	**3**	**2**	**1**
Extent of Riffle Habitat (use riffle geometry table, →Section 2.3)	Well-developed riffle that is as wide as stream and its length extends 2x the wetted width of the stream.	Riffle is as wide as stream, but is less than 2x stream width; abundance of cobble; boulders and gravel are common.	Reduced riffle area does not extend across entire cross-section and is less than 2x width; gravel or large boulders and bedrock prevalent; cobble present.	Riffles virtually non-existent; sand, gravel, large boulders or bedrock prevalent; cobble lacking.
Score	**4**	**3**	**2**	**1**
Embeddedness of Riffles (use visual based embeddedness, in → Section 2.10)	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment (bedrock is 0% embedded).	Gravel, cobble, and boulder particles are 26-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 51-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment (sand is 100% embedded).
Score	**4**	**3**	**2**	**1**
Reach Sediment Deposition (use reach pebble count →Section 2.14)	Point bars in C type channel maintained, no mid-channel or side bars. No bimodal particle size distribution. No excess sediment in riffles and pools of A, B, or C type channels.	Point bars with few mid-channel bars or side bars in C type channels. No bimodal particle size distribution. Some filling in of pools in A, B, and C type channels.	Numerous mid-channel or diagonal bars in C type channels. Some loss of pool and riffle habitat in A, B, and C type channels. Bimodal distribution may be present with excess fines in the substrate.	Branched or braided C channel with numerous mid-channel bars and islands, some exceeding 2-3x channel width in length. Heavy deposits of fine material evident with bimodal particle distribution. Pools and riffles filled in, with run habitat dominating.
Score	**4**	**3**	**2**	**1**
Bank Stability within the active bankfull channel (score each bank)	Banks stable; no evidence of erosion or bank failure; <5% of bank length affected.	Banks moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank length in reach has areas of erosion.	Banks moderately unstable; 30-60% of bank length in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; 60-100% of bank length has erosional scars.
Score Left Bank	**2**	**1.5**	**1**	**0.5**
Score Right Bank	**2**	**1.5**	**1**	**0.5**

Sum of Habitat Scores		Rating Category		
		0 – 7	8 – 14	15 - 20
		☐ Very Impaired	☐ Impaired	☐ Good Condition

FIGURE 7.38. SEM Form. Habitat Assessment.

7.4.19 SITE SKETCH

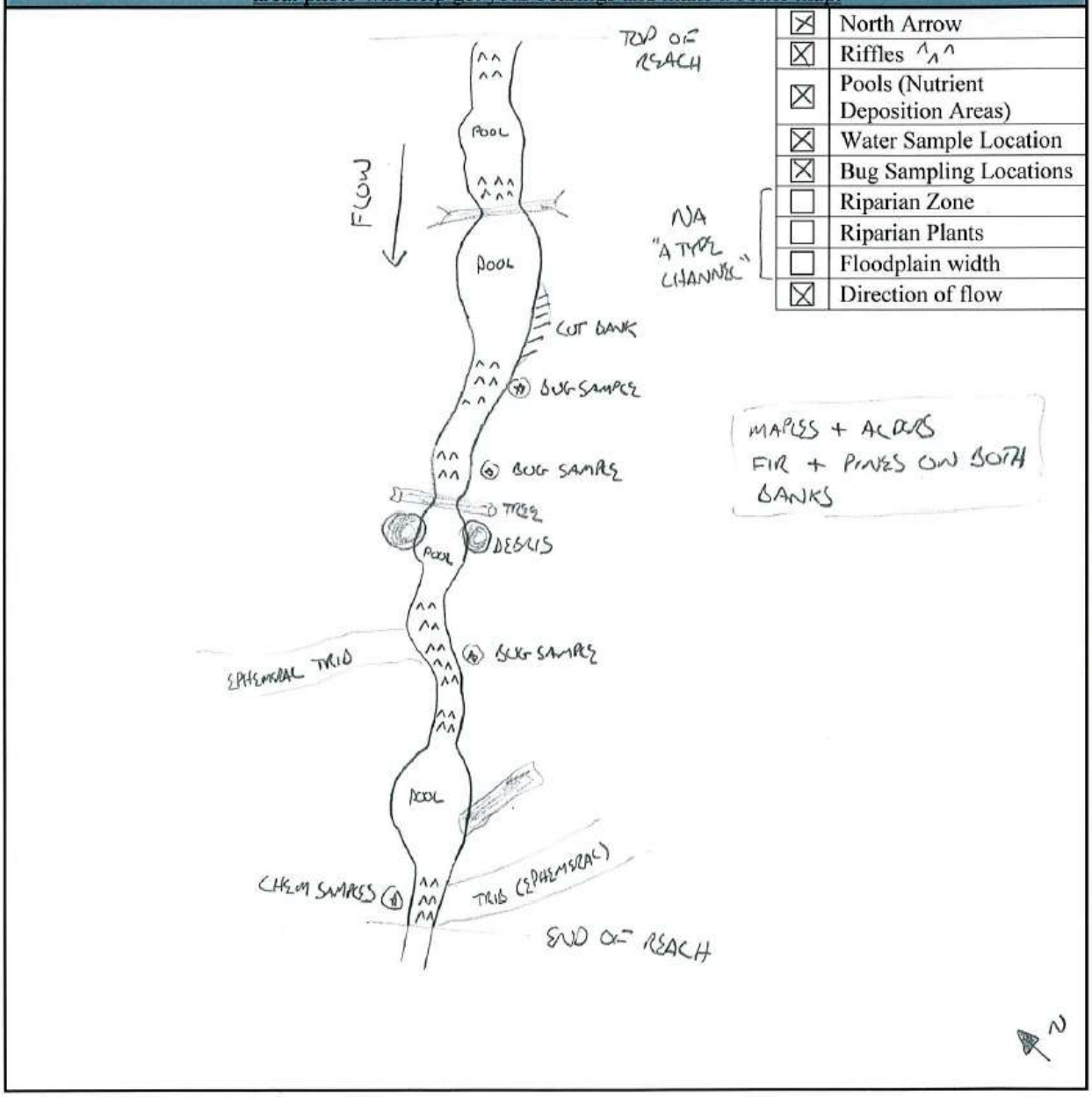
A sketch of the stream reach provides a visual representation of the general habitat available to the macroinvertebrate community. Map out the relative proportions riffles, runs, and pools by

recording number of paces in each habitat as you walk the reach on the sketch. Sum up the paces for each habitat and calculate the percentage of the entire reach length walked. Also noteany micro-habitats present, such as woody debris, leaf packs, macrophyte and algae beds, undercut banks, and riparian vegetation. Identify any potential sediment sources such as areas of bank erosion, and excess sediment in the form of side and mid-channel bars from cut banks or degraded tributaries. The map should be scaled to include the entire study reach, displaying floodplains, terraces, features such as trees, rocks or flood debris, the stream name, date, direction of stream flow, a north arrow, benchmarks, point bars, abandoned channels, and sample locations for water, bugs and pool deposits.

Print an aerial photo of the stream reach to provide the basic shape of the channel in your study reach. This will speed up your drawing and make your sketch more accurate.

3.4 SITE SKETCH

Instructions: Draw the sampling reach. Include the items in the upper right corner. Check boxes to verify that each item has been included. Also include items of interest such as snags, submerged logs, undercut banks, areas of stable cobble habitat, type of bar formations, and areas with cut or eroding banks. A GPS, topo map or areal photo will help get your bearings and make a better map.



☒	North Arrow
☒	Riffles ^^^
☒	Pools (Nutrient Deposition Areas)
☒	Water Sample Location
☒	Bug Sampling Locations
☐	Riparian Zone
☐	Riparian Plants
☐	Floodplain width
☒	Direction of flow

FIGURE 7.39. Site Sketch.

CHAPTER 8 INTERMITTENT STREAM SAMPLING

This chapter is meant to provide an overview of the intermittent stream program and focusses heavily on the time lapse cameras. Time lapse photography is used to collect daily flow data records for 365 days.

Stream Ecosystem Monitoring requirements for intermittent streams are located in Chapter 7.

8.1 TIME LAPSE CAMERA SETUP CONSTRUCTION, INSTALLATION, AND DATA COLLECTION

The time lapse camera is used to determine the number of days of flow per year for an intermittent stream. Both the motion sensor and time lapse functions are used to capture flow fluctuations within a stream. A solar panel and external 12v battery allow for long term deployment; however it's recommended to visit the camera set up quarterly to download images and check on the equipment.

The time lapse camera set up consists of 5 segments:

1. Solar panel/external battery
2. Time lapse camera test
3. Field installation and verification
4. Quarterly checks and downloads
5. Stream Ecosystem Monitoring (SEM) Protocols

8.2 SOLAR PANEL/EXTERNAL BATTERY

As of fall 2017, some of the intermittent streams have the Moultrie 12 volt game camera power panel deployed (See picture below). This solar panel battery combo decreases the work (ie. no soldering) and is substantially more cost effective.

FIGURE 8.1. Moultrie 12 volt solar panel and battery combination.

Some of the intermittent stream cameras deployed still have the Nature Panel semi-flex solar panels, this information will still be included in this document for that reason. Before field deployment, the power supply will need to be assembled for long term deployment. A solar panel is rewired to attach to a 12v external battery. The finished product is the solar panel with an adapter plug that fits into and charges the external battery to provide long term power to the time lapse camera.

FIGURE 8.2 Nature Power Semi-Flex Solar Panel.

Before field deployment, the power supply will need to be assembled for long term deployment. A solar panel is rewired to attach to a 12v external battery. The finished product is the solar panel with an adapter plug that fits into and charges the external battery to provide long term power to the time lapse camera.

Materials needed:
Solar panel: Nature Power 5 watt semi- flex 12volt
12V Battery box: Stealth Cam
Flux
Solder .032" (.813 mm) diameter
Heat shrink tubing sizes: one 1/8" and one 3/16" per setup
Butane

Tools Needed:
Soldering Iron
Heat Gun / Flame
Wire stripper/Wire Cutter
Helping hands with magnifier (a stand that holds wires)
Volt Meter

FIGURE 8.3. Equipment used for solar panel alteration.

8.2.1 POWER SUPPLY MODIFICATION PROCEDURE:

1. Start by setting up the necessary tools (FIGURE 8.3.). Add butane to the heat gun, plug in the soldering iron, and dampen the sponge on the helping hands/magnifier stand.
2. Using the wire cutter cut the 12V battery's charging cord 3" above the male/female terminal end. See image 1 for what the 12v charging cord terminal piece looks like.
3. Separate the "ground" (solid black coating) wire and the "positive" wire (identified by a thin white line on the wire coating) on the terminal. Strip the ends of both wire using the wire stripper (gauge 16) expose 0.5" of the wire.
4. Cut the 1/8" diameter heat shrink tubing in half resulting in two 1.5" lengths. Slip on the heat shrink segments to the separated ground and positive wires. Then slip on one 3/16" diameter heat shrink tube to the solar panel wire.

THIS MUST BE DONE BEFORE SOLDERING!

5. Place the 12V charging cord terminal end with attached wires on one side of the helping hands magnifier stand and the solar panel wire on the opposite side. (FIGURE 8.4).

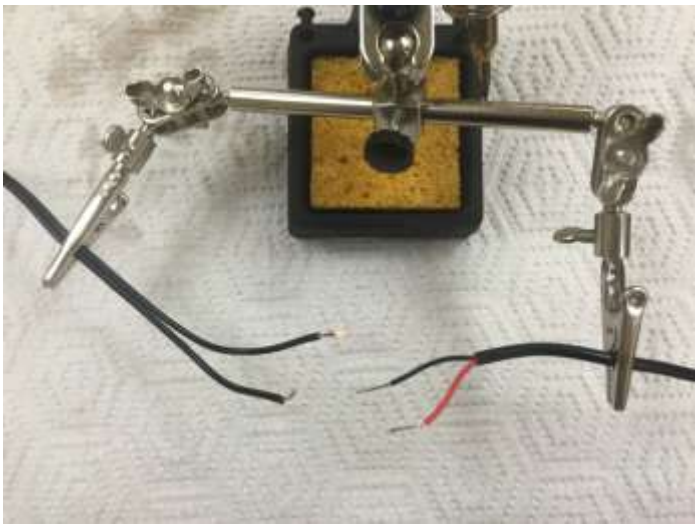


FIGURE 8.4. Lining up the wires to be soldered.

6. Using your fingers, connect the positive wires together (in the case of the specific equipment we used it would be the red wire from solar panel to the solid black wire from the charging cord terminal). Do this by twisting the exposed wires together. Do the same for the ground wires (solid black from the solar panel and black with a white dashed line from the charging terminal).

The positive and ground wires can be identified differently on different brands of equipment, as a rule of thumb the red wire on the solar panel is positive and should be soldered to the wire that ends at the male terminal of the charging cord from the external battery.

7. Add a small amount of flux to both of the exposed twisted wires.
8. Using the soldering iron, heat the wire until the flux melts into the wire and you see a slight color change of the wire. Do this by holding the solder in the opposite hand and simultaneously keep the soldering iron on the exposed wire and bring the tip of the solder to the now heated wire adjacent to tip of the iron (FIGURE 8.5). The solder will melt in and start to coat the exposed wire. Slowly run both the iron tip and the end of the solder together along the length of the joined exposed wire, coating the exposed portion of the wire with solder. Once finished, double check that there isn't any exposed wire or sharp points along the solder joint as this may rupture the heat shrink, possibly causing a short in the future. Often solder will ball up on the tip of the soldering iron, in this case use the wet sponge to help remove the solder by wiping the tip along the sponge.

FIGURE 8.5. Soldering and altering the solar panel to connect to the external battery.

9. Use a volt meter to confirm voltage through the soldered connection. This is done by placing the positive volt meter wand (red) into the male portion of the terminal and the black volt meter wand into the female end of the terminal. If reading voltage from the solar panel indoors, the volt meter should read around 6 volts. If reading voltage outside the meter will read around 18 volts (FIGURE 8.6).

FIGURE 8.6. Checking solar panel voltage.

10. Pull the 1/8" heat shrink tubing over the soldered wires and using the heat gun or flame, wave the heat underneath the wires in a fanning motion until the tubing shrinks down on the wire. The soldering area should be completely covered and all exposed wire should be covered by the shrink wrap. Do this process for both the positive and ground wires. Next

take the 3/16" heat shrink tubing and place it over BOTH of the soldered wires and the heat shrink tubing that was just done. Once again use the heat gun to shrink the tubing.

11. Use a volt meter to re-confirm voltage from the panel to the terminal end.
12. The finished product is the solar panel with the external male/female terminal that will directly plug in and charge the external battery and provide long term power to the time lapse camera.

8.3 TIME LAPSE CAMERA TEST

It's important to test the complete time lapse camera set up before field deployment to ensure all parts of the set up are working properly. The camera set up is comprised of multiple components including: a Moultrie M-550 game camera, metal housing for the camera, a solar panel, and an external battery.

At a minimum, a 24 hour test in the office is suggested to confirm that the soldered solar panel wires are carrying a charge, the external battery is holding a charge, and that the camera is collecting high quality data. Check that the solar panel reads 14V- 19V before connecting to the battery inside the battery box. This is what ensures the panel is charging the battery correctly.

Materials needed for 24 hour camera test:
Moultrie M-550 game camera
Moultrie metal housing
SD 32 GB card
Solar panel: Nature Power 5 watt semi- flex 12volt purchased from SRP
12V Battery box: Stealth Cam
Camera test datasheet
Pencil

Tools Needed
Volt Meter
Laptop/TabletSD card reader

8.3.1 24 HOUR TIME LAPSE CAMERA TEST

1. Label the camera, solar panel, and housing unit with the same equipment name (a unique identifier). A label maker works well for this. Identifying the various equipment parts will help keep equipment issues organized and trackable in the future.
2. Format the SD card on a computer prior to placing them in the game camera. This can be done by opening the SD card, right clicking on the icon, and pressing format. This can also be done within the camera itself under the "Memory Option" menu. Scroll Right and press "ok" to erase all images (FIGURE 8.7).

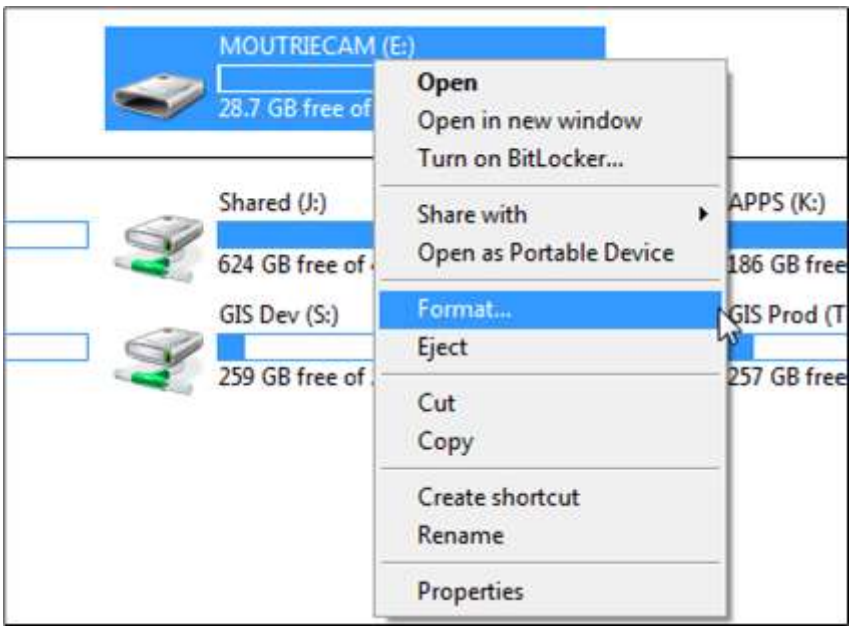


FIGURE 8.7. Formatting the SD card.

3. In the lab, configure the date & time and the camera name under the "infostrip" (use the same name that was placed on the set up with the label maker. Keep the camera connected to the external battery, all date and time information will erase when the power source is disconnected (FIGURE 8.8).

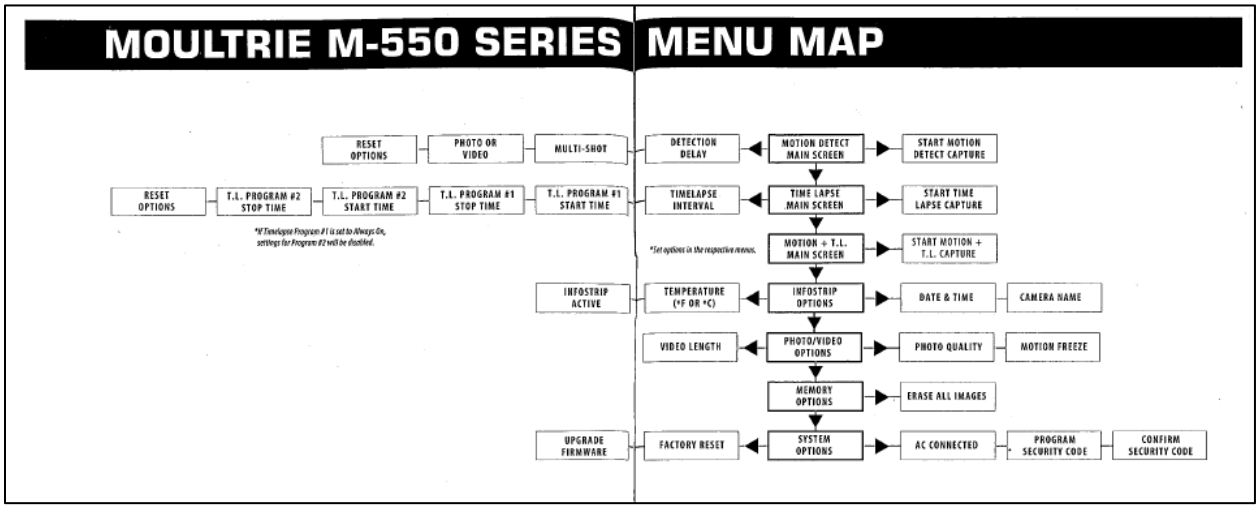


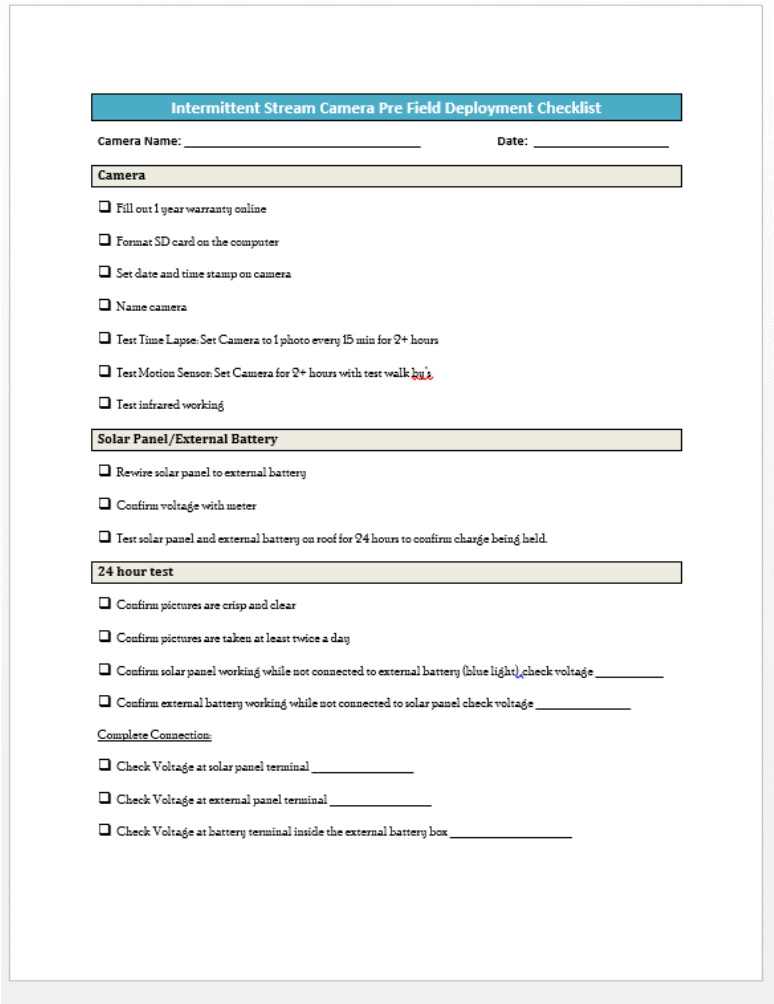
FIGURE 8.8. Moultrie M-550 Menu Map.

4. Update Time Lapse and Motion Sensor interval settings. For the 24 hour test it's recommended to push the camera/battery to its limit by triggering photos frequently so issues can be identified prior to deployment (TABLE 8.1).

	Program (TI)	Time	Time Frame	Example	Explanation
Time Lapse	Set to two program intervals per day (TI#1 and TI#2)	30 min	2 hours	TL#1 6-8 am TL#2 6-8 pm	This setting will take 1 picture every 30 min during the 6-8 am time frame and then will automatically trigger again during the 6-8 pm time frame.
Motion Detect	NA	10 sec	NA	NA	This setting will trigger a picture to be taken every 10 seconds if motion is detected.

TABLE 8.1. Time Lapse Camera Settings

5. Contact Dan Borns at ADEQ (or anyone from the property management company) to get approval and a key to the roof. The roof is a safe place for the cameras to be tested and provides direct sun light for the solar panels.
6. Print a copy of the Intermittent Stream Camera Pre Field Deployment Checklist located on the J drive (J:\WQD\Surface Water Section\Monitoring Unit\Intermittent Streams & Rec Monitoring\Forms and Checklists). Fill out the information and keep this in the site file (Figure 8.9).



Intermittent Stream Camera Pre Field Deployment Checklist

Camera Name: _____ Date: _____

Camera

- ❑ Fill out 1 year warranty online
- ❑ Format SD card on the computer
- ❑ Set date and time stamp on camera
- ❑ Name camera
- ❑ Test Time Lapse: Set Camera to 1 photo every 15 min for 2+ hours
- ❑ Test Motion Sensor: Set Camera for 2+ hours with test walk by's
- ❑ Test infrared working

Solar Panel/External Battery

- ❑ Rewire solar panel to external battery
- ❑ Confirm voltage with meter
- ❑ Test solar panel and external battery on roof for 24 hours to confirm charge being held.

24 hour test

- ❑ Confirm pictures are crisp and clear
- ❑ Confirm pictures are taken at least twice a day
- ❑ Confirm solar panel working while not connected to external battery (blue light), check voltage _____
- ❑ Confirm external battery working while not connected to solar panel check voltage _____

Complete Connection:

- ❑ Check Voltage at solar panel terminal _____
- ❑ Check Voltage at external panel terminal _____
- ❑ Check Voltage at battery terminal inside the external battery box _____

FIGURE 8.9. Pre field deployment checklist for time lapse camera.

7. Check the volt readings of the external battery and the solar panel. The external battery will read approximately12-13 volts (FIGURE 8.8) the solar panel will read approximately 17-18 volts in direct sun. It is important to plug the panel into the battery housing and check the voltage on the inside terminals that connect to the 12v battery itself. When the panel is in direct sunlight and plugged into the battery housing, the terminals inside should read around 13-14v. This ensures the voltage regulator, part of the battery housing, is actually stopping down the voltage from the panel and preventing the battery from over charging.

FIGURE 8.10. Checking the voltage on the external battery.

8. Double check the Time Lapse and Motion Sensor interval settings and then press start in the "Start Motion + T. L. Capture" (FIGURE 8.10). If you start the program in just the "Start Motion" or the "Start Time Lapse Capture", you will only trigger one of the functions and not both!

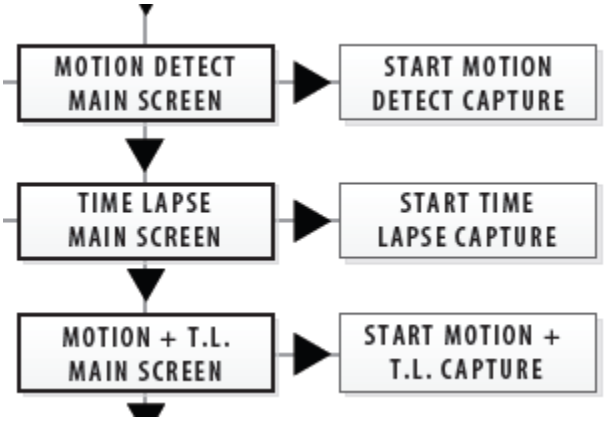


FIGURE 8.9. Press start in the "Start Motion + T. L Capture".

9. Leave the cameras out, overnight, for 24 hours. Once again check the volt readings of the external battery and the solar panel and record on the form
10. Download the images using an SD card reader and Tablet computer and make sure they are crisp and match the settings you programmed. If they are multi-colored and stripped it's most likely the SD card; reformat and try again. Complete the pre-deployment checklist and verify equipment is ready for field deployment.

8.4 FIELD INSTALLATION AND VERIFICATION

Now that the Moultrie M-550 game camera, metal housing, solar panel, and an external battery passed the 24 hour test the equipment is ready for field deployment.

Materials needed for the installation

- ☐ Moultrie Time-Lapse Camera (*make sure wing nut attached)
- ☐ SD card
- ☐ SD card reader
- ☐ Laptop or Tablet computer
- ☐ Metal Housing
- ☐ External Battery 12V
- ☐ Solar Panel (socket RAM mount and sleeving)
- ☐ Extra socket RAM mount
- ☐ Extra Complete camera set up (camera, panel, housing, external battery)
- ☐ Volt Meter
- ☐ Hose Clamps (3-5 per site, various sizes)
- ☐ 18-8 round head machine screws (1-1/2" length 8-32 thread)
- ☐ Steel Hex nut 8-32 thread
- ☐ Self-Tapping Screws, SPAX screws
- ☐ Drill (with a 5/16th hex driver and a T-20 torx bit)
- ☐ Fiberglass Solar Panel Pole
- ☐ Zip ties (large and small)
- ☐ Lock
- ☐ ADEQ stream survey laminated tag
- ☐ Spray Paint (Tan and Brown non glossy)
- ☐ Work Gloves
- ☐ Alcohol
- ☐ Utility Knife
- ☐ Step Ladder
- ☐ Trash Bag to cover camera while painting
- ☐ Drop cloth (to place small parts on while installing)
- ☐ Wire Cutter
- ☐ Field Datasheet
- ☐ Clipboard
- ☐ Pencil
- ☐ Nitrile Gloves

Tools Needed

- ☐ Volt Meter
- ☐ Laptop/Tablet
- ☐ Drill

8.4.1 OFFICE PREPERATION FOR FIELD INSTALLATION

1. Before field work, the RAM mount must be glued to the back of the solar panel. Using fine (80) sand paper on the **back** of the solar panel, gently sand a circle the diameter of the RAM mount base in the middle of the solar panel roughly ¼ of the way from the bottom (the bottom of the solar panel is identified by where the cord comes out). Sand the round base of the RAM as well. Wipe both sanded surfaces with a moist cloth/paper towel. This process roughs up the plastic surfaces and allows for better adhesion using the epoxy Mix two part epoxy specifically formulated for plastics and place a small amount on the round base of the plastic RAM mount. Place the panel upside down on a flat surface. Gently push the round base of the RAM mount down on the sanded portion of the solar panel and let dry for 24 hours (FIGURE 8.11).

FIGURE 8.11. The solar panel RAM mount attachment process.

2. Next add corrugated sleeving to the cord of the solar panel and secure using electrical tape and black zip ties along the length of the cord (FIGURE 8.12). Apply a thin amount of isopropyl alcohol to the outside of the tubing. This is done to help deter rodents from chewing on the wire.

FIGURE 8.12. Comparison of solar panel exposed wire vs. wire with sleeving.

3. Pack and keep the cameras, solar panels, and external batteries in the cab portion of the truck. Keep in mind that the solar panels need to be kept flat. While fairly durable and semi-flexible, if the panels become bent inside the photovoltaic portion of the panel, delicate wiring inside will likely break causing failure. It's recommended to keep the solar panels separate and well-padded while traveling in the vehicle, because larger equipment (camera and battery) can bounce around in transit and damage the panel.

Take care not to bend the solar panel, delicate wiring disturbance will cause failure of the solar panel.

8.4.2 FIELD

1. Before hiking to the site make sure to load all of the gear into the packs. Take care to keep the solar panel flat. Make sure you have a complete camera set with the same names (ie solar panel, camera, and battery box are all identified the same). If there is a long hike, consider laying out all of the necessary gear and brining two camera set-ups in case there is a malfunction (FIGURE 8.13).

FIGURE 8.13. Lay out gear prior to hiking into site.

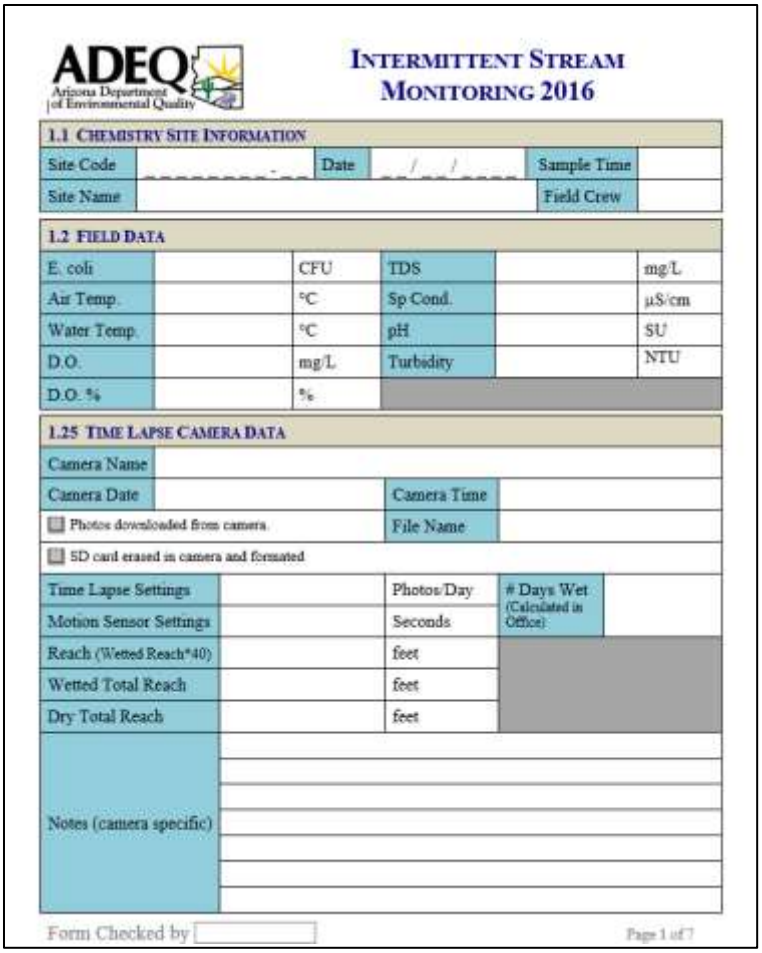
2. Once at the site take a moment to scan the trees nearby to install the camera set-up. Ideally, a tree will be close to the stream, somewhat hidden to people, and the location will be able to capture multiple stream habitats (riffle, run, pool). A riffle or run is preferred habitat to photograph, however a pool can be used if no other habitat is available. Keep in mind that the camera needs to be installed well above bankfull, use Arizona's regional curves can help properly identify bankfull. The camera does well in rain and snow, but if the camera is submerged under water it will break. Ideally place the camera facing upstream, unless there are factors preventing a good line of sight. Placing the camera facing upstream provides a better angle to see "flow" in the photos, but each site is different (FIGURE 8.14). To capture adequate detail the camera will have to be as close to the wetted channel as possible laterally. Use best professional judgement to choose what the best install location is at any given site.

FIGURE 8.14. Example of a unique camera set up.

3. Next perform a test shot. Before hose clamping or drilling, hold the camera in the metal housing at the desired location on the tree. Set the camera to 10 second intervals on the motion function. After a minute or so, take down the camera and download the images onto the computer to confirm the location and camera position is producing the desired results (FIGURE 8.15).

FIGURE 8.15. Checking photos in the field.

4. Once the installation location has been chosen, collect a GPS location and start filling out the necessary information on the Intermittent Stream Monitoring field form (Field form located: J:\WQD\Surface Water Section\Monitoring Unit\Forms and Letters\Field data sheets) (FIGURE 8.16). Provide detailed information regarding installation location. For example was the camera installed on the right or left bank? What type of tree? Looking upstream or downstream? What is the DBH? Any geological features nearby?



ADEQ Arizona Department of Environmental Quality

INTERMITTENT STREAM MONITORING 2016

1.1 CHEMISTRY SITE INFORMATION

Site Code	_ _ _ _ _ _ _ _ _ _ - _ _	Date	_ _ / _ _ / _ _ _ _	Sample Time	
Site Name				Field Crew	

1.2 FIELD DATA

E. coli		CFU	TDS		mg/L
Air Temp.		°C	Sp Cond.		µS/cm
Water Temp.		°C	pH		SU
D.O.		mg/L	Turbidity		NTU
D.O. %		%			

1.25 TIME LAPSE CAMERA DATA

Camera Name			
Camera Date		Camera Time	
☐ Photos downloaded from camera		File Name	
☐ SD card erased in camera and formated			
Time Lapse Settings		Photos/Day	# Days Wet (Calculated in Office)
Motion Sensor Settings		Seconds	
Reach (Wetted Reach*40)		feet	
Wetted Total Reach		feet	
Dry Total Reach		feet	
Notes (camera specific)			

Form Checked by

Page 1 of 7

FIGURE 8.16. Intermittent stream datasheet.

5. Make sure to liberally denude all branches, leaves, grasses, trees etc within view of the camera. Any vegetation left in view or left which can grow into the view of the camera over the deployment will move in windy conditions. This movement will cause the camera shutter to trigger when in motion phase. This will add work on the back end photo processing because thousands of photos may have to be reviewed. In the event more foliage around the camera is preferred for concealment of the camera, consider setting the motion sensor lag time to an appropriate setting greater than 5 min intervals.
6. Attach the camera metal housing to the tree with a hose clamp or screw depending on the size of the tree. Choose the correct hose clamp size based on the size of the tree. If a tree or branch is substantial in diameter (>7") it may be easier to install using self-tapping wood screws (FIGURE 8.17). The metal camera housings have two holes specifically for this installation method and comes with appropriate screws.
7. Install the external battery on the tree below the camera with a hose clamp. Take care not to over tighten the hose camps and cause too much tension on the plastic casing of the battery. If you see stress marks, loosen the clamp a little, readjust, and try again. Essentially you want to prevent the housing from sliding down the tree or branch, minimal looseness is acceptable and preferable to over tightening.

FIGURE 8.17. Installing time lapse camera set up.

8. The solar panel is last to be installed. Place the solar panel in an area that will receive the most amount of sun. There are two ways to attach the solar panel: 1) Attach the panel using a fiber glass pole or (rarely done only when installing under very dense canopy) 2) Attach the solar panel by fastening the diamond shaped base of the RAM mount directly to the tree or branch using self-tapping wood screws. If using the fiber glass pole, hold the diamond shaped base of the RAM mount in the desired location on the pole and using a sharpie trace where the two pilot holes will need to be drilled. Drill the holes and affix the diamond base to the pole using the 18-8 round head machine screws (1-1/2" length 8-32 thread). Attach the pole to the tree trying to expose the panel to as much sunlight as possible and using best professional judgement (hose camps, screw, etc.). Before attaching the solar panel to mount, check that the blue light is on and reading ~17 + volts in the desired position. Affix the panel to the pole and then the pole to the tree or branch.
9. Wrap the camera cord around the external battery box, then do the same with the solar panel corrugated sleeving. Rodents chew through cords, so the idea is to keep the majority of the cord tucked away.

FIGURE 8.18. External battery with solar panel wire wrapped around to avoid rodent chewing.

10. Set the camera settings as suggested below (TABLE 8.2). Double check the Time Lapse and Motion Sensor interval settings and then **press start in the "Start Motion + T. L. Capture".**

    If you start the program in just the "Start Motion" or the "Start Time Lapse Capture", you will only trigger one of the functions and not both (FIGURE 8.17).

	Time Lapse Settings	Time Frame	Motion	Explanation
Winter	TL #1 8-9 am TL #2 4-5 pm	**1 hour**	**5 min**	**This setting will take 1 picture at 8 am and another picture at 4 pm. Motion detect will occur every 5 min outside of the time lapse setting window.**
Summer	TL #1 6-7 am TL #2 5-6 pm	**1 hour**	**5 min**	**This setting will take 1 picture at 6 am and another picture at 5 pm. Motion detect will occur every 5 min outside of the time lapse setting window.**

TABLE 8.2. Time lapse camera settings

FIGURE 8.19. Testing the time lapse settings.

11. Add a lock with "612" as the code.
12. Place a small trash bag securely over the metal camera housing and spray paint any exposed black wires or metal like the hose clamps and lock (FIGURE 8.20). Use one or two shades of flat spray paint, preferably tan and olive. Gauge which color or combination of colors to use based on the surroundings the camera is mounted to. If the tree has lighter bark lightly streaking tan over the camera setup may be best where as if the bark is darker or the area is heavily vegetated olive may be best. The idea is to try and not have anything stick out or catch attention. In less remote locations the back of the solar panel can be dusted lightly with paint to break up the dark square profile of the panel in the tree. Do not get paint on the photovoltaic side of the panel.

FIGURE 8.20. Place a trash bag over the camera when using spray paint to camouflage the equipment.

13. Using a zip tie, add an ADEQ tag to the back of the hose clamp (FIGURE 8.21). Hopefully this will deter vandalism and provides the public with information to answer questions.

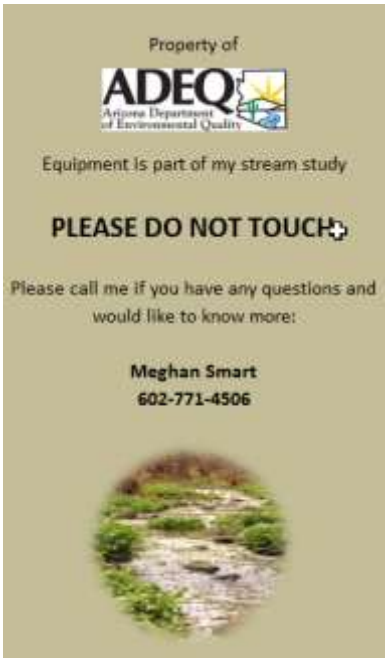


FIGURE 8.21. ADEQ's equipment tag

14. Using a point and shoot camera, collect photos of the camera install location and the stream from the camera's point of view (FIGURE 8.22). In addition take photos upstream and downstream from the stream channel.

FIGURE 8.22. ADEQ's stream photo from camera point of view.

15. If water is present collect water chemistry sample and field parameters. The rule of thumb is to collect a sample from flowing water or pools greater than 30ft long. That will eliminate sampling ephemeral pools.
16. In addition, if water is present collect wet/dry information for the reach. Multiply the wetted width by 40 to get the reach. Then pace out and record the information on the datasheet for the reach. This will help correlate possible chemistry issues and relate the data to more than the view of the camera.

8.5 QUARTERLY CHECKS AND DOWNLOADS

The images and water quality will need to be gathered on a quarterly basis. There are multiple reasons for this: 1) the SD card has a limited amount of space (we have yet come close to filling one, but it is a possibility). 2) The more often we download the less data we will use if the camera stops working (due to natural events like flooding, or vandalism). 3) The timing syncs up with the perennial stream sampling schedule.

1. Before hiking to the site make sure to load all of the gear into the packs including a GPS, good site map, and detailed directions to find the camera. Make sure you have a complete extra camera setup. It's a good idea to come prepared for anything, so make sure to bring extra screws, drills, hose clamps, etc. It's necessary to bring a laptop/tablet with an SD card reader every time when servicing the intermittent stream cameras.

Wear work gloves and open the camera housing away from your face. Make sure to pay attention to your surroundings, spiders, wasps, and scorpions have been found living in the camera housing.

2. Sampling intermittent streams can be broken down into five steps (FIGURE 8.23)
    1. Download Images
    2. Clean and Check Camera
    3. Reprogram Time Lapse Settings
    4. Collect Water Chemistry
    5. Wet Dry Mapping

FIGURE 8.23. Sampler cheat sheet for clipboard.

The infographic can be a useful tool for staff to print, add to personal clipboards, and use as a reference. The infographic is located on the J drive (J:\WQD\Surface Water Section\Monitoring Unit\Intermittent Streams\Forms and Checklists\How to Sample Intermittent Streams Infographic)

8.5.1 INTERMITTENT STREAM CAMERA SERVICING AND SAMPLE COLLECTION

1. Download the images from the SD card to the computer (FIGURE 8.24). Make a folder with the date and site ID, place the folder on the desktop of the laptop, and copy and paste the images from the camera's SD card to that folder.

FIGURE 8.24. Example download folder

Make sure to check that all images have been transferred over, then place the SD card back in the camera and erase all images inside the camera. Erasing the images this way ensures that the SD card gets properly formatted.

2. Clean and check the camera. Give an overall look and assessment to the camera set up. Is the blue light on the solar panel on? Are there any wires exposed? Has the camera been tampered with (wildlife or humans)?
    - Use a chem wipe to clean the residue and grit from the camera lens.
    - Check the battery readings of the solar panel. The solar panel should read ~14-19 volts. If it's lower, make an assessment as to why (low light, chewed wires, etc) and change out the solar panel if deemed necessary.
    - Check the voltage of the battery. The battery should read ~12 volts (a little higher is ok). If it's below 10 volts, change the battery out.
    - Add isopropyl alcohol to the sheath of the solar panel to help protect against rodent chewing of the wires.

3. Reprogram the camera settings as suggested below (TABLE 8.2). Double check the Time Lapse and Motion Sensor interval settings and then press start in the "Start Motion + T. L. Capture".

It's important to remember to start the camera in the "Motion +T. L Capture menu"! If you start the program in just the "Start Motion" or the "Start Time Lapse Capture", you will only trigger one of the functions and not both!

    - Using a point and shoot camera, collect photos of the camera install location and the stream from the cameras point of view. In addition take photos upstream and downstream from the stream channel.

4. If water is present collect water chemistry sample and field parameters.
    - Collect a water sample from flowing water or anything greater than 30ft long. This could include sampling a non-flowing pool.
    - Take care not to stir up the substrate on the bottom while collecting the sample.
    - Use appropriate data flags on the field forms. Commonly used flows would be "Low flow conditions, No active flow, pools or ponded water only, and Dissolved Oxygen value attributed to ground water upwelling."
    - Take detailed notes about field conditions.
5. If water is present collect wet/dry information for the reach.

- Take three widths of the stream and get an average. Next multiply the average wetted width of the stream by 40 to get the reach length.
- Walk the reach and record the wet and dry segments (feet) on the datasheet for the reach. This will help correlate possible chemistry issues and relate the data to more than the view of the camera.

8.6 PHOTO PROCESSING

Photo processing turns the time lapse photos into useable data points. Useful information like flow, weather events, wildlife and human encounters are documented in this process. Photo processing can take up to 45 min per site, per quarter, depending on how many motion pictures were triggered at the site.

1. 1. Upon returning to the office, place the photos on the J drive (J:\WQD\Surface Water Section\Monitoring Unit\Intermittent Streams\FLOW DATA FY16 & FY17\FY17 all sites flow photos) under the pertinent year and quarter of flow data (Q1, Q2, Q3, Q4). Keep this file open.
2. **Open the excel file FLOW DATA FY16 &FY17 folder** (J:\WQD\Surface Water Section\Monitoring Unit\Intermittent Streams\FLOW DATA FY16 & FY17). Ideally having 2 screens makes this process faster, one screen to view the photos and another screen to view the excel sheet (FIGURE 8.25)

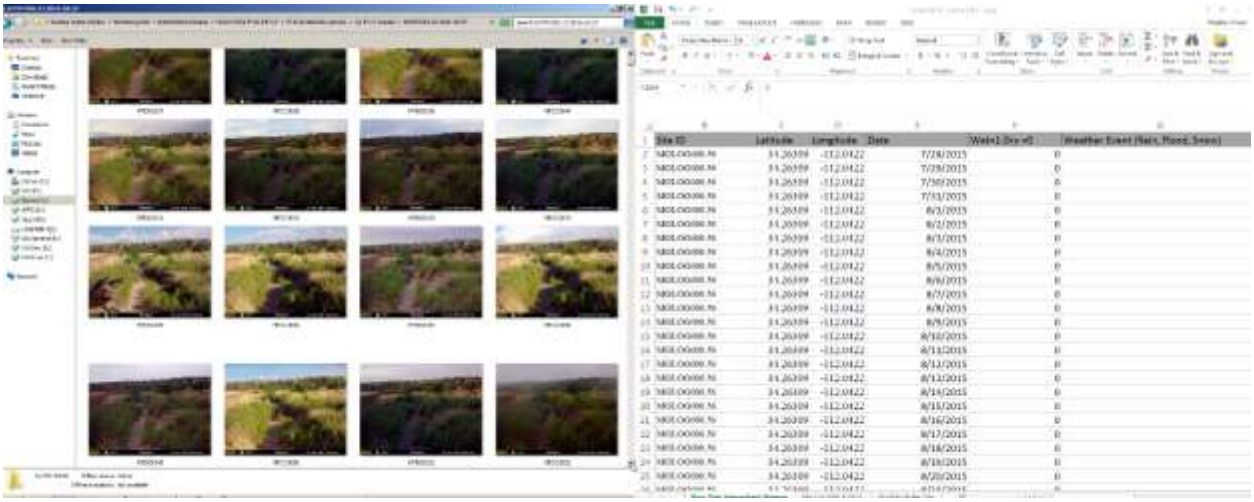


FIGURE 8.25. Viewing images on the left and the excel flow data table on the right helps expedite the photo processing process.

3. Scroll down to the end of the excel sheet and fill in the stream name, site id, and Lat/Long information.
4. Look at the date the first image was collected, this is easier to do when viewing the photos in the detail view, and add that date to the appropriate column. Next look at when the last image was taken. Using the drag option, autofill the dates. This provides the framework for the sites quarterly downloads and all relative information can be filled in.

5. Open the images for the specific date and determine if flow was present in two or more images taken at least 8 hours apart per day. **If flow or a wet reach (greater than 30 feet in length) was present in two or more images assign a value of "1" and if one or more images was dry assign a value of "0" to the appropriate column (FIGURE 8.26).** Keep in mind that we don't actually need to see flow in the image, the image can show that the stream is wet with a 30 foot stretch of water and still be assigned a "1" value.. If the images shows isolated small ponded pools assign a "0". Best professional judgement and prior knowledge of the site is used in this determination.

It's important to remember that the time lapse camera is set to capture two pictures a day, if flow is present in both pictures we will assign a value of "1", meaning the stream was wet that day.

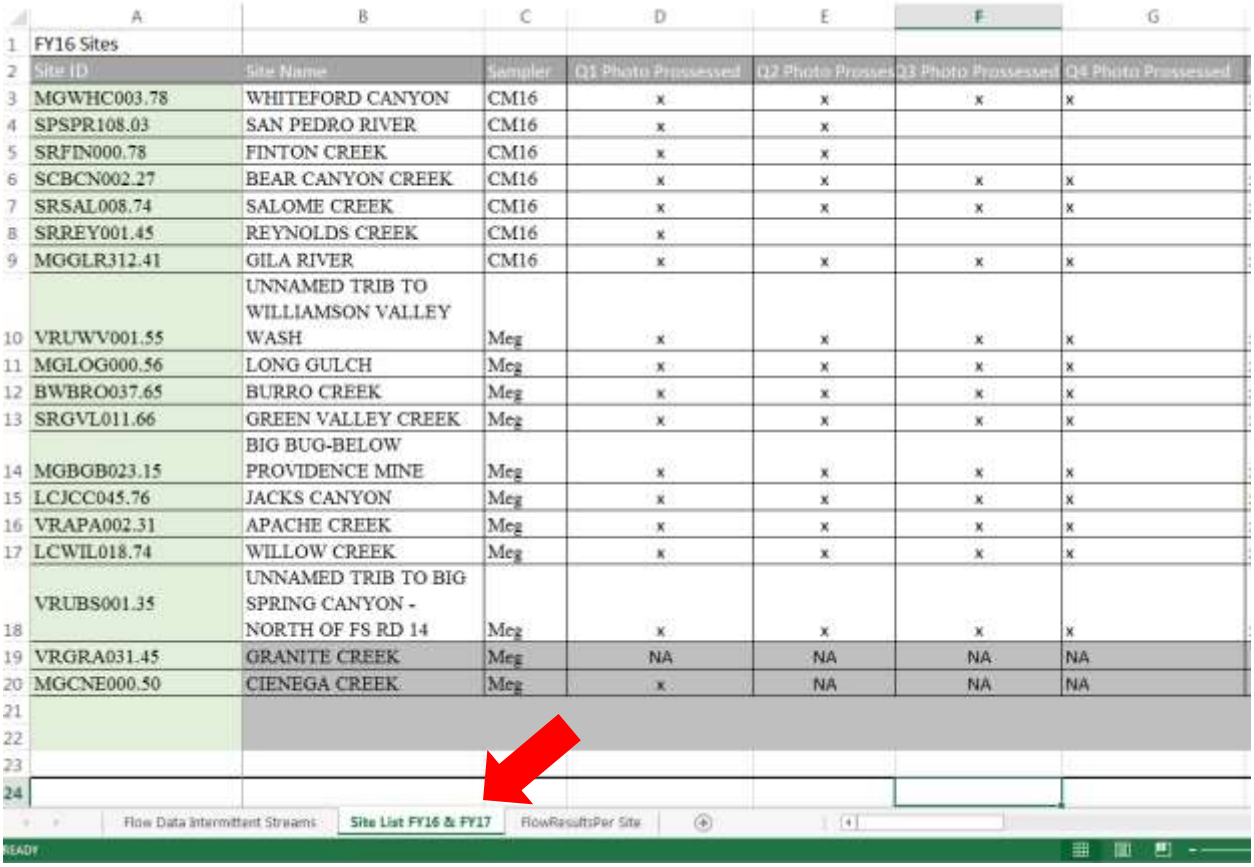
6. The motion triggered photos help capture the weather, wildlife, and human encounter data. While processing each photo make notes about weather: rain, snowing, flooding, etc. Make notes on wildlife present in the photos: "Elk, small mammal, and birds," but it's not necessary to count how many wildlife encounters occurred per day. Keep track of the number of humans present in the photos per day. Add any necessary comments regarding the photos from that day. FIGURE 8.24 shows an example of how the data is entered. All of these data points will help identify future reference sites and provide a better understanding of intermittent streams.

Date	Wet=1 Dry =0	Weather Event (Rain, Flood, Snow)	Wildlife	Human Encounter	Comments
8/20/2016	1			1	
8/21/2016	1			3	
8/22/2016	1		Mountain lion	0	
8/23/2016	1		3 MOUNTAIN LIONS	0	
8/24/2016	1			0	
8/25/2016	1			1	
8/26/2016	1			0	
8/27/2016	1			6	
8/28/2016	1			7	
8/29/2016	1			0	
8/30/2016	1			0	
8/31/2016	1			2	
9/1/2016	1			0	
9/2/2016	1			0	
9/3/2016	1			6	
9/4/2016	1			2	
9/5/2016	1			6	
9/6/2016	1			0	
9/7/2016	1	Rain		0	
9/8/2016	1	Large Flood		0	Tree debris in cha

FIGURE 8.26. An example of how the flow, weather, wildlife, and human data points are entered. Take note that the Stream name, Site ID, and Lat/Long info are not present in this images, but are located to columns on the left in the data sheet on the J drive.

Exercise caution when entering flow data and double check that duplicate dates aren't added. This can happen if staff forget to erase all previous quarters' images from the camera and can cause extra unnecessary work.

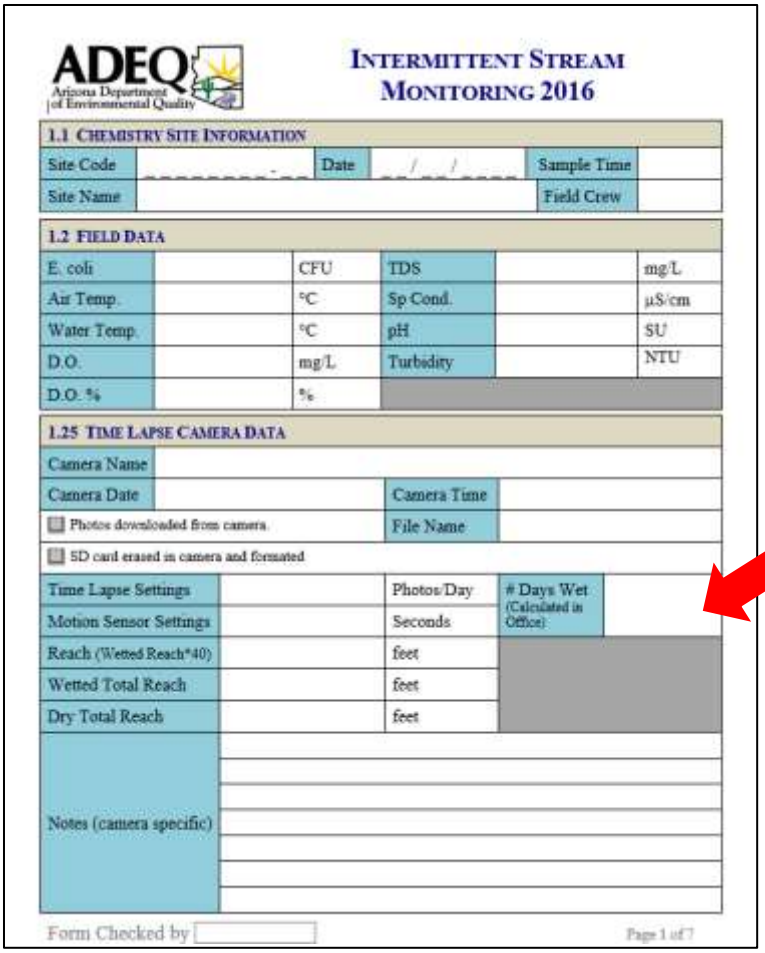
7. **After completing the photo processing for the site, add an "X" to the table located on the "Site List FY16 and FY17"** in the "Flow Data FY16 and FY 17" excel file (FIGURE 8.27). This prevents duplicated work.



	A	B	C	D	E	F	G
1	FY16 Sites						
2	Site ID	Site Name	Sampler	Q1 Photo Processed	Q2 Photo Processed	Q3 Photo Processed	Q4 Photo Processed
3	MGWHC003.78	WHITEFORD CANYON	CM16	x	x	x	x
4	SPSPR108.03	SAN PEDRO RIVER	CM16	x	x		
5	SRFIN000.78	FINTON CREEK	CM16	x	x		
6	SCBCN002.27	BEAR CANYON CREEK	CM16	x	x	x	x
7	SRSAL008.74	SALOME CREEK	CM16	x	x	x	x
8	SRREY001.45	REYNOLDS CREEK	CM16	x			
9	MGGLR312.41	GILA RIVER	CM16	x	x	x	x
10	VRUWV001.55	UNNAMED TRIB TO WILLIAMSON VALLEY WASH	Meg	x	x	x	x
11	MGLOG000.56	LONG GULCH	Meg	x	x	x	x
12	BWBRO037.65	BURRO CREEK	Meg	x	x	x	x
13	SRGVL011.66	GREEN VALLEY CREEK	Meg	x	x	x	x
14	MGBGB023.15	BIG BUG-BELOW PROVIDENCE MINE	Meg	x	x	x	x
15	LCJCC045.76	JACKS CANYON	Meg	x	x	x	x
16	VRAPA002.31	APACHE CREEK	Meg	x	x	x	x
17	LCWIL018.74	WILLOW CREEK	Meg	x	x	x	x
18	VRUBS001.35	UNNAMED TRIB TO BIG SPRING CANYON - NORTH OF FS RD 14	Meg	x	x	x	x
19	VRGRA031.45	GRANITE CREEK	Meg	NA	NA	NA	NA
20	MGCNE000.50	CIENEGA CREEK	Meg	x	NA	NA	NA
21							
22							
23							
24							

FIGURE 8.27. The red arrow shows the sheet within the Flow Data file where staff will add an "X" once quarterly photos have been processed.

8. Using an external hard drive, the intermittent stream lead will take backups of the photos and Flow Data worksheet quarterly to ensure that data is not lost.
9. On the field data form add the number of days wet in the box labeled # of days wet (FIGURE 8.28) by tallying all of the "1" in the wet column for that quarter. In the future the number of days wet will be added and stored in the WQDB.



ADEQ Arizona Department of Environmental Quality

INTERMITTENT STREAM MONITORING 2016

1.1 CHEMISTRY SITE INFORMATION

Site Code	_ _ _ _ _ _ _ _ _ _ _	Date	_ _ / _ _ / _ _ _ _	Sample Time	
Site Name				Field Crew	

1.2 FIELD DATA

E. coli		CFU	TDS		mg/L
Air Temp.		°C	Sp Cond.		µS/cm
Water Temp.		°C	pH		SU
D.O.		mg/L	Turbidity		NTU
D.O. %		%			

1.25 TIME LAPSE CAMERA DATA

Camera Name			
Camera Date		Camera Time	
☐ Photos downloaded from camera		File Name	
☐ SD card erased in camera and formated			
Time Lapse Settings		Photos/Day	# Days Wet (Calculated in Office)
Motion Sensor Settings		Seconds	
Reach (Wetted Reach*40)		feet	
Wetted Total Reach		feet	
Dry Total Reach		feet	
Notes (camera specific)			

Form Checked by

Page 1 of 7

FIGURE 8.26. Add number of days wet to the datasheet after flow data calculated.

10. Make sure to add field parameters, field notes, and chemistry data into the WQDB (same process as the perennial streams). **If the site was dry during a quarterly visit, make sure to still create a "visit" in the WQDB and add the three following pieces of information: 0 cfs under field parameters, "stream dry at the time of sampling"as an event code, and add field notes under comments.**

8.7 MACROINVERTEBRATE SAMPLE COLLECTION

The sampling index period for macroinvertebrates in intermittent streams is March-May when streamflow has been present for the longest duration and streams are wadeable.

A macroinvertebrate sample consists of a proportional multi-habitat composite of 10 sub-samples, collected using a D-frame dip net (FIGURE 8.27). Make a site sketch of stream habitats present in the sample reach, identifying the number of paces of riffle, run, and pool habitat present (Note your pace length in feet on the SEM form). Calculate the percentage of each habitat type in the reach. Divide each percentage by 10 to obtain the number of sub-samples to collect in each habitat type. For example, if the habitat in the sampling reach is 50% riffle, 30% run and 20% pool, the sampler

collects 5 sub-samples of riffle, 3 sub-samples of run, and 2 sub-samples in pools. The sub-samples are collected from selected representative habitats spanning the entire wetted reach. For example, the five riffle sub-samples are collected at five different riffles that encompass the variety of substrate sizes (large cobble to sand-gravel), velocities, depths, and habitats found within the reach. If needed, more than one sub-sample can be collected from a single habitat, such as a long pool. Edge macrophytes or filamentous algae beds may comprise a large percentage of habitat in runs and pools, especially in sandy streams. Sweep a $1ft^2$ area of macrophyte or algae beds within the habitat segment and make note of the number of macrophyte or algae subsamples that are collected on the SEM form.

Macroinvertebrate samples should be collected before pebble counts and before any disturbance to the stream channel by investigators. Sample collection begins at the downstream end of the assessment reach and proceeds upstream.

8.7.1 SUB-SAMPLING STEPS:

1. Fill a round 2-gallon spouted bucket half full with stream water.
2. Place the D-frame net on the stream bed in the path of flowing water, and agitate a one square foot area of substrate in front of the net, vigorously for 30 seconds. This is done by first hand-scrubbing all surfaces of cobbles, then kicking the one square foot area for 30 seconds to dislodge invertebrates and sediment in the sand-gravel matrix. Place the subsample into the bucket of water.
3. Repeat this sub-sampling procedure for the remaining 9 sub-samples, keeping count of how many riffle, run and pool substrates have been sampled.
4. After the last sub-sample, remove all macroinvertebrates from the net. Use forceps to remove organisms attached to the D-frame net.
5. Swirl the contents of the bucket and pour the non-sediment, organic matrix into a 500 µm mesh sieve. Add water again to the bucket, swirl and pour the contents into the sieve. Repeat this procedure several times until all insects and organic debris are emptied onto the sieve and only sediment remains.
6. Transfer the remaining sediment onto a dissecting tray and search the sediment for any remaining organisms, especially cased caddisflies, snails, and freshwater clams. Place any invertebrates into the sieve. Discard the remaining sediment.

7. Gently squeeze the sample to remove excess water from the sample matrix in the sieve, especially where filamentous algae are present. Using a plastic spoon or hands, gently place the sample from the sieve into a wide mouth, one-liter sample jar. Fill the jar only three-quarters full. If there is too much organic material for one jar, fill two jars. If there is too much material for two jars, then "field split" the sample. Rinse any leftover material in the sieve into a pile and spoon out as much as possible. Check the sieve for any remaining animals and use forceps to gently remove and place in the sample jar.
8. Preserve the sample with 99% isopropanol, filling the jar(s) full to the brim.
9. A field split consists of dividing and preserving half the collected organic matrix. To perform a one-half field split, evenly spread the entire sample in a white dissecting tray and divide the sample with your hands into two equal portions, being careful to divide the large and small organic matrix and any large/rare taxa equally. Place one half of the sample into the two sample jars and discard the other half into the stream. Note on the field form that the sample was "field split 1/2 or 50%" retained. A quarter split can be performed if a half-split still provides too much sample material to fit in two jars. Be sure to mark the field split check box and the quantity preserved in the "Biological Sampling" part of the SEM form.

FIGURE 8.26. Macroinvertebrate collection method using a D-frame dip net

10. Before leaving the site, rinse and scrub the D-frame dip net, bucket, and sieve to dislodge small invertebrates, egg masses, and organic material, so that it is not transferred to the next site. Spray the net and bucket with Quat-128 decontaminating solution before leaving the site.
11. Quality control measures:
    a. Collect a duplicate sample at 10% of sample sites for the sample season to evaluate sampling technique.
    b. Sample labels must be properly completed, including the site identification code, date, stream name & location, collector's name. One label should be placed into the sample container and the other on the outside of the container. Chain-of-custody forms, if needed, must include the same information as the sample container labels.
    c. Record the percentage of each habitat type in the reach. Note the sampling gear used, and comment on conditions of the sampling, e.g., high flows, treacherous rocks, difficult access to stream, or anything that would indicate adverse sampling conditions.
    d. Document observations of aquatic flora and fauna. Make qualitative estimates of macroinvertebrate composition and relative abundance as a cursory estimate of ecosystem health and to check adequacy of sampling.

CHAPTER 9 POST-TRIP PROCEDURES

9.1 CALCULATING DISCHARGE

After all flow measurements have been recorded on the field data sheet, discharge can be calculated using an excel spreadsheet (FIGURE 9.1). The "Calculating Discharge" template can be found at J:\WQD\Surface Water Section\Monitoring Unit\Streams

The completed form should be printed and included with the field data sheets in the site file.

	A	B	C	D	E	F	G	H
1								
2	Site Name:	SRBEV001.40						
3	Date:	4/22/2008						
4	Time:	1245						
5	Party:	JDJJOW						
6	Weather:							
7	Air Temp:	21.6						
8	Water Temp:	12.37						
9								
10	Shaded columns contain formulas; do not enter values in these columns.							
11	Distance From Initial Point	Width	Depth	Observation Depth Valid Entries: (0.2, 0.6, 0.8)	Velocity at point: Field Readings	Mean Velocity: Averages of 2 Point Velocities	Area	Discharge
12								
13								
14								
15	0.32808	0.16404	0		0			
16	0.65616	0.4101	0.4		0.09		0.16404	0.0147636
17	1.14828	0.49212	0.55		0.88		0.270666	0.23818808
18	1.6404	0.49212	0.6		1.33		0.295272	0.39271176
19	2.13252	0.49212	0.65		2		0.319878	0.639756
20	2.62464	0.49212	0.65		0.83		0.319878	0.26549874
21	3.11676	0.4101	0.5		0.98		0.20505	0.200949
22	3.44484	0.4101	0.55		2.26		0.225555	0.5142654
23	3.93696	0.65616	0.5		2.43		0.32808	0.7972344
24	4.75716	0.73818	0.85		2.34		0.627453	1.46824002
25	5.41332	0.65616	0.8		2.09		0.524928	1.09709952
26	6.08946	0.67414	0.7		1.98		0.401898	0.7957804
27	6.9516	0.49212	0.75		1.94		0.36909	0.7160346
28	7.05372	0.49212	0.8		2.16		0.393696	0.85036336
29	7.54584	0.57414	0.9		1.95		0.516726	1.0076157
30	8.202	0.73818	0.7		2.04		0.516726	1.05412104
31	9.0222	0.73818	0.65		1.54		0.480999	0.62523846
32	9.67836	0.65616	0.5		1.4		0.32808	0.459312
33	10.33452	0.8202	0.35		0.55		0.26707	0.1578885
34	11.31876	0.8202	0.1		0.2		0.08202	0.016404
35	11.97492	0.32808	0		0		0	0
61	Total Width	Sum of Widths	Average Depth		Average Velocity			
62	11.64984	11.64984	0.54		1.35	Total Area:	6.58	
63						Total Discharge:		11
64	Width:							
65	Method:							
66	# of Sections:							
67	Type of Meter:	Flow mate				No. of Sections:		20
68	Meter #:	2000						
69	Remarks:							
70								
71		Note: FSN Procedures include bank depths and velocities of 0 in the average velocity and average depth.						
72								

FIGURE 9.1. Discharge results from Excel template.

9.2 PEBBLE COUNTS

The median particle size (d50) can be calculated using the pebble count spreadsheet on the "J" drive. The 15th, 85th and 100th percentiles are also automatically calculated. Print out a copy of the completed data sheet and place it into the site file.

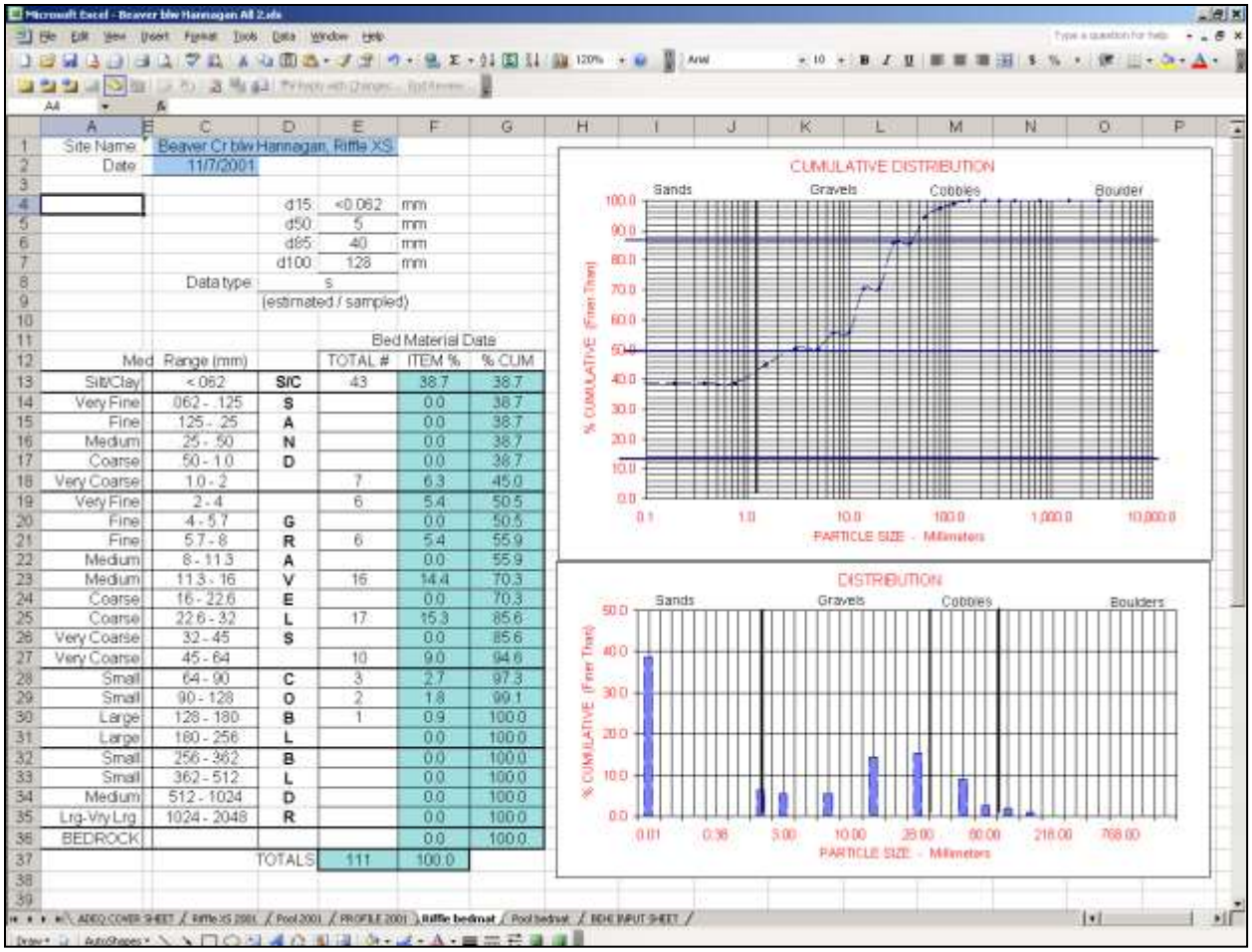


FIGURE 9.2. Pebble count excel sheet.

9.3 WATER QUALITY METER POST-TRIP CHECK

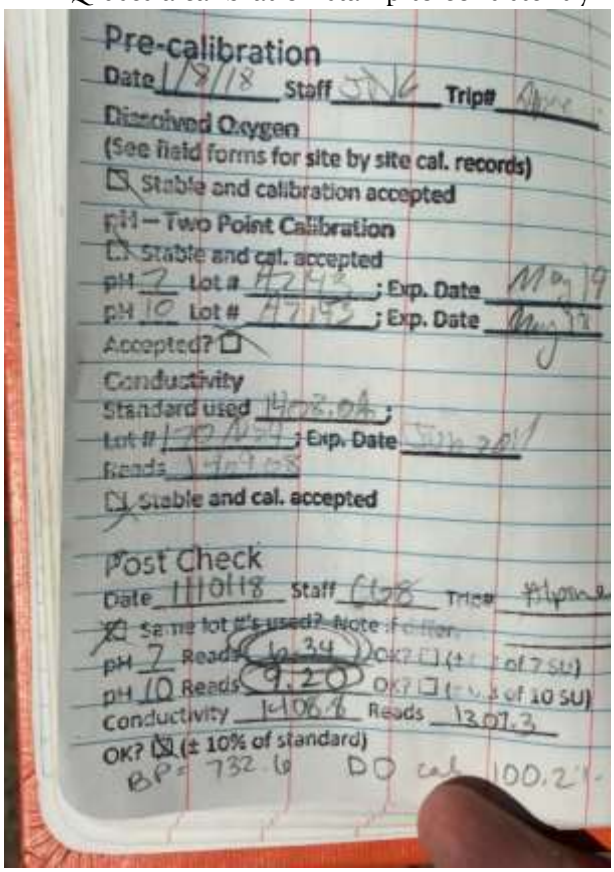
Upon returning from the field, the calibration standards used to calibrate the equipment are read to determine if the instruments values are with-in range and have not drifted. Read each standard for pH (7 and 10) and conductivity and record each value. Values should agree with the precalibration results within the following limits.

Parameter	Acceptable Range
pH	Post-trip reading should be within 0.3 standard units of the pre-trip readings for each buffer solution used. Hydrolab instrument specifications specify an instrument tolerance of +/- 0.2 SU, and additional 0.1 SU is permitted for minor environmental differences (temperature, etc.).
Conductivity	EC readings shall be within 10% of pre-trip post-calibration values.
Dissolved Oxygen	Dissolved oxygen saturation values will be evaluated site by site according to calibration performance in the field. Readings will be evaluated after site calibration by stabilization time (should be within 2 minutes) and adherence to a full 100% calibration for YSI. Hydrolab measurements should be within 10%.

TABLE 9.1 Post-trip calibrations.

If the field meter post trip checks are out of the ranges identified below, the following steps must be done:

ADEQ uses a calibration stamp to consistently record calibration information.



What to do if the calibration value is outside the "Acceptable Range".

1. If the post-trip check results in readings that deviated outside of the acceptable range, the data will not be acceptable for assessment or compliance purposes and should be flagged QA-R to reject all samples within that trip/run. Add comments about what the post-calibration value was and suspected reason why it was out of range. Be sure to on the field form that the parameter was rejected.
3. Determine when, if possible, any problems occurred in the field. If this can be determined, the readings taken before the problem occurred may be acceptable. Any values obtained after the problem occurred must be flagged.
4. If the problem resulted in large differences between meter readings and stated solution values, try to isolate the problem and correct it as outlined in the Pre-Trip Equipment Calibration Procedures. If the problem cannot be corrected satisfactorily, tag the meter for repair.

9.4 ROUTINE MAINTENANCE

Maintenance of active multiprobes should be conducted every quarter. Equipment that is not being regularly used should be maintained every six months. This section covers both YSI and Hydrolab multiprobes. The maintenance is the same for both units unless otherwise noted.

Record what maintenance was performed, the date, who performed the maintenance and any problems encountered in the equipment log book.

9.4.1 MULTIPROBE CALIBRATION

9.4.1.1 Hydrolab Maintenance

9.4.1.1.1 Specific Electrical Conductivity

1. Prepare the unit by attaching the cable and transmitter. On older sonde units and on some older minisondes, the EC probe consists of a set of nickel electrodes covered by a hard plastic conductivity cell block. When working with this type of probe, first remove the conductivity cell block with a screwdriver and then remove the rubber o-rings from the electrodes.
2. Newer units will probably be equipped with a four electrode graphite conductivity sensor (FIGURE 9.3). This type of sensor should never be cleaned with abrasive material of any type. When cleaning the electrodes, use cotton and a solvent such as methanol or isopropyl alcohol to remove any residue that may present. The sensor can also be cleaned using warm soapy water. Rinse with deionized water when finished.

FIGURE 9.3. New graphite conductivity sensor (left). Old nickle conductivity electrodes (rig ht). Both are combined with the DO probe.

3. For older units, polish all exposed surfaces of the nickel electrodes including the ends with the emery strips (#400 wet/dry sandpaper) found in the maintenance kit. Do not to touch the other probes with the sandpaper (especially the pH and redox); protect them with wet cotton. Rinse with deionized water and then replace the o-rings and the conductivity cell block.

9.4.1.1.2 pH

1. Clean the glass probe with a cotton ball or Q-tip saturated with methanol or isopropyl alcohol. Rinse the probe thoroughly with deionized water.
2. If the response time of the pH probe does not produce 95% of the calibration reading within 90 seconds, then shock the probe with a weak HCl solution or pH 4.0 buffer.
3. Wrap the probe with cotton saturated with 0.1M HCl and leave for 5 minutes. Remove the cotton and rinse with deionized water. Soak the probe in pH 7.0 buffer for 10 minutes before calibrating.

4. The reference electrolyte is replaced in the older sonde units by inverting the entire unit and gently pulling off the white cylindrical sleeve. Empty the remaining electrolyte and rinse the sleeve with a small amount of fresh pH reference electrolyte. After rinsing, refill the sleeve to the top with standard pH electrolyte and push sleeve back about half-way onto its mount. At this point, turn the sonde unit so the probes are pointing upwards, allowing any air bubbles in the electrolyte to move up towards the porous Teflon junction. Push the sleeve down the rest of the way, purging any air within the chamber and flushing the porous junction on the tip of the sleeve with fresh reference solution. In most cases the fresh reference solution can be seen coming through the pores in the junction. In the newer minisonde units, the porous Teflon junction is located at the top of the probe next to the pH electrode. A screw driver is used to remove it so that the old reference solution can be dispensed and replaced with new solution. Use a syringe to replace the solution in the probe. When the porous junction is replaced, the fresh solution is flushed thru the junction.
5. The porous junction of the electrolyte sleeve can become clogged with impurities over time. A new junction may be required if air bubbles are obstructing the flow of electrolyte to pass through the junction during the process described in step #4.

9.4.1.1.3 Dissolved Oxygen

1. To change the DO membrane, remove the DO sensor guard (older sonde units) and o-ring securing the membrane. The membrane should be replaced each time the unit is serviced. The membrane should be replaced if air bubbles are under the membrane, the membrane is damaged, or if the membrane is wrinkled.
2. To replace the DO electrolyte solution, tip the probe until the old solution is dispensed. Slowly refill with the squeeze bottle of KCL electrolyte provided in the kit. Empty the probe a second time. Refill the probe again being careful not to induce any bubbles into the cylinder. Gently tap the cylinder to remove any bubbles and let the unit sit for 5-10 minutes to allow gases to escape. Add a few more drops of solution to form a meniscus if needed.
3. To replace the standard membrane, secure the membrane on one side of the top of the sleeve with the thumb, and with a smooth firm motion, stretch the other end of the membrane over the sensor surface and hold it in place with the index finger. Secure the membrane with the o-ring and trim the excess membrane below the o-ring. There should be no wrinkles in the membrane or bubbles in the electrolyte under the membrane. Avoid overstretching the membrane. Do not touch any of the internal parts of the DO sensor.
4. Test the unit for bubbles by gently tapping the sonde cylinder and by inverting the probe a few times.
5. The DO sensor should be allowed to sit overnight to allow the membrane to relax before calibrating.

9.4.1.1.4 Temperature

The temperature portion of the probe requires no maintenance. Temperature should be verified to a NIST traceable thermometer at least once a year.

9.4.1.2 YSI Maintenance

9.4.1.2.1 Conductivity

The openings that allow fluid access to the conductivity electrodes must be cleaned regularly. The small cleaning brush included in the 6570 Maintenance Kit is ideal for this purpose. Dip the brush in clean water and insert it into each hole 15-20 times. In the event that deposits have formed on the electrodes, it may be necessary to use a mild detergent with the brush. After cleaning, check the response and accuracy of the conductivity cell with a calibration standard.

If this procedure is unsuccessful, or if probe performance is impaired, it may be necessary to return the probe to an authorized dealer.

9.4.1.2.2 pH

Cleaning is required whenever deposits or contaminants appear on the glass and/or platinum surfaces of these probes or when the response of the probe becomes slow.

Remove the probe from the sonde. Initially, simply use clean water and a soft clean cloth, lens cleaning tissue, or cotton swab to remove all foreign material from the glass bulb and platinum button. Then use a moistened cotton swab to carefully remove any material that may be blocking the reference electrode junction of the sensor.

When using a cotton swab, be careful NOT to wedge the swab tip between the guard and the glass sensor. If necessary, remove cotton from the swab tip, so that the cotton can reach all parts of the sensor tip without stress. You can also use a pipe cleaner for this operation if more convenient.

If good pH and/or ORP response is not restored by the above procedure, perform the following additional procedure:

1. Soak the probe for 10-15 minutes in clean water containing a few drops of commercial dishwashing liquid.
2. GENTLY clean the glass bulb and platinum button by rubbing with a cotton swab soaked in the cleaning solution.
3. Rinse the probe in clean water, wipe with a cotton swab saturated with clean water, and then rerinse with clean water.

If good pH and/or ORP response is still not restored by the above procedure, perform the following additional procedure:

1. Soak the probe for 30-60 minutes in one molar (1 M) hydrochloric acid (HCl). This reagent can be purchased from most distributors. Be sure to follow the safety instructions included with the acid.
2. Rinse the probe in clean water, wipe with a cotton swab saturated with clean water, and then rerinse with clean water. To be certain that all traces of the acid are removed from the probe crevices, soak the probe in clean water for about an hour with occasional stirring.

If biological contamination of the reference junction is suspected or if good response is not restored by the above procedures, perform the following additional cleaning step:

1. Soak the probe for approximately 1 hour in a 1 to 1 dilution of commercially-available chlorine bleach.
2. Rinse the probe with clean water and then soak for at least 1 hour in clean water with occasional stirring to remove residual bleach from the junction. (If possible, soak the probe for period of time longer than 1 hour in order to be certain that all traces of chlorine bleach are removed.) Then rerinse the probe with clean water and retest.

Dry the sonde port and probe connector with compressed air and apply a very thin coat of O-ring lubricant to all O-rings before re-installation.

9.4.1.2.3 Dissolved Oxygen

The KCl solution and the Teflon membrane at the tip of the probe should be changed prior to each sonde deployment and at least once every 30 days during the use of the sonde in sampling studies. In addition, the KCl solution and membrane should be changed if (a) bubbles are visible under the membrane; (b) significant deposits of dried electrolyte are visible on the membrane or the O-ring; and (c) if the probe shows unstable readings or other probe-related symptoms.

After removing the used membrane from the tip of the probe, examine the electrodes at the tip of the probe. If either or both of the silver electrodes are black in color, the probe should be resurfaced using fine sanding disks.

To resurface the probe using the fine sanding disk, follow the instructions below. First dry the probe tip completely with lens cleaning tissue. Next, hold the probe in a vertical position, place one of the sanding disks under your thumb, and stroke the probe face in a direction parallel to the gold electrode (located between the two silver electrodes). The motion is similar to that used in striking a match. Usually 10-15 strokes of the sanding disk are sufficient to remove black deposits on the silver electrodes. However, in extreme cases, more sanding may be required to regenerate the original silver surface.

After completing the sanding procedure, repeatedly rinse the probe face with clean water and wipe with lens cleaning tissue to remove any grit left by the sanding disk. After cleaning, thoroughly rinse the entire tip of the probe with distilled or deionized water and install a new membrane.

Be sure to: (1) Use only the fine sanding disks in the resurfacing operation and (2) Sand in a direction parallel to the gold electrode. Not adhering to either of these instructions can seriously damage the electrodes.

If this procedure is unsuccessful, as indicated by improper probe performance, it may be necessary to return the probe to an authorized service center.

9.4.1.2.4 Temperature

The temperature portion of the probe requires no maintenance. Temperature should be verified to a NIST traceable thermometer at least once a year.

9.4.1.3 Insitu Maintenance

RDO Fast Sensor Cap Replacement:
The RDO Fast Sensor Cap has a 1 year typical life (15 mo. of total useage) after the sensor takes its first reading, or 36 monthsfrom the date of manufacture. Follow the instructions included in the RDO Sensor Cap Replacement Kit.

pH/ORP Sensor Replacement:
To replace the pH/ORP sensor or to refill the reference junction, follow the instructions in the pH/ORP Sensor Instruction Sheet that is included with the replacement sensor.

9.4.1.3.1 Cleaning the pH/ORP Sensor

Begin with the gentlest cleaning method and continue to the other methods only if necessary. Do not directly touch or wipe the glass bulb.

To clean the pH sensor, gently rinse with cold water. If further cleaning is required consider the nature of the debris.

Remove Crystalline deposits

- Clean sensor with warm water and mild soap.
- Soak sensor in 5% HCl solution for 10 to 30 minutes
- If deposits persist, alternate soaking in 5% HCl and 5%NaOH solutions.

Remove Oily or Greasy Residue

- Clean sensor with warm water and mild soap.
- Methanol or isopropyl alcohol may be used for short soaking periods up to 1 hour.
- Do not soak the sensor in strong solvents such as chlorinated solvents, ethers, or ketones, including acetone.

Remove Protein Like Material or Slimy Film

- Clean sensor with warm water and mild soap.
- Soak the sensor in 0.1M HCl solution for 10 minutes and then rinse with deionized water

When performing any of these methods rinse the sensor with water and soak overnight in pH 4 buffer.

9.4.1.3.2 Cleaning the RDO Sensor

Cleaning the Sensor Cap

1. Leave the cap on the sensor.
2. Rinse the sensor with clean water from a squirt bottle or spray bottle.
3. Gently wipe with a soft cloth or brush if biofouling present.

4. If extensive fouling or mineral build-up is present, soak the RDO cap end (while the cap is still installed on the sensor) in commercially available household vinegar for 15 minutes, then soak in deionized water for 15 minutes.
5. After cleaning the sensor cap, perform a 2 point calibration

Cleaning the optical window
1. Perform this task only once per year when you replace the sensor cap.
2. Pull to remove the sensor cap.
3. Gently wipe the optical window with the supplied lens wipe.

Do not wet the interior lense area with water or any solution

9.4.1.3.3 Cleaning the Conductivity Sensor

1. Before you begin, ensure that the RDO Cap and the pH/ORP sensor are in place. Rinse the conductivity sensor under running water to remove loose material.
2. Follow cleaning procedure 1. If debris is still present, progress to the next cleaning procedure. If the debris is removed, skip to the last step.

Cleaning Procedure 1
Avoid damaging the plastic material of the conductivity cell. Gently scrub the conductivity cell with a soft swab and mild soap such as a dilute solution of dish detergent. The probe is shipped with polyurethane foam swabs for this purpose. You can also achieve good results using a gentle back-and-forth motion with a thin cotton pipe cleaner. If debris is still present, continue to Cleaning Procedure 2. If the sensor is clean, skip to the last step.

Cleaning Procedure 2
Avoid damaging the plastic material of the conductivity cell. Gently scrub the conductivity cell with a foam swab and an aggressive soap such as Alconox cleaner. If debris is still present, continue to Cleaning Procedure 3. If the sensor is clean, skip to the last step.

Cleaning Procedure 3
Soak the sensor with dilute acetic acid (10:1 solution) or commercially available household vinegar to pre-soften calcium deposits. Follow this with Cleaning Procedure 1 or Cleaning Procedure 2, depending on the degree of residual contamination. The probe can soak for any length of time in household vinegar. If debris is still present, continue to Cleaning Procedure 4. If the sensor is clean, skip to the last step.

Cleaning Procedure 4
Topically apply dilute phosphoric acid (< 27 %) or the consumer product LIME-A-WAY with a soft swab to remove iron or calcium deposits that remain after using Process 3. Do not allow the cleaner to be in contact with the sensor for more than 10 minutes. Rinse well with clean water and continue to the last step. Check the sensor calibration before redeployment. Recalibrate the sensor when necessary.

9.4.2 TURBIDITY

The Hach 2100 Turbidity meter should be calibrated with the primary standard every quarter. The primary reference standard is different from the secondary gel standards that travel with the unit.

FIGURE 9.4. Turbidity primary reference standards.

Turbidity Maintenance

- Check batteries (takes 4 AA)
- Clean unit including sample cells
- Replace velvet cloth if dirty
- Replace secondary standards or sample vials if scratched
- Add label with calibration results and date

Be sure to check the expiration date of the primary standards and keep them refrigerated. Warm to room temperature and mix the standards well before calibrating.

Quarterly Calibration Procedure

1. Insert the 0.1 NTU primary reference standard in the cell compartment (the one in the refriderator). Shake/mix well. Be sure to align the arrow on the cell with the arrow on the cell compartment. Close the lid and press I/O button to turn the machine on.
2. Press the CAL button and then the arrow key → to get a numerical value.
3. Then press READ. The instrument will count back from 60 seconds and then ask for the next Gelex Primary Standard.
4. Insert the 20 NTU primary reference standard in the cell compartment and press the READ button. The instrument will count back from 60 seconds and then ask for the next Gelex Primary Standard.
5. Insert the 100 NTU primary reference standard in the cell compartment and press the READ button. The instrument will count back from 60 seconds and then ask for the next Gelex Primary Standard.
6. Insert the 800 NTU primary reference standard in the cell compartment and press the READ button. The instrument will count back from 60 seconds.
7. Remove the cell from the compartment and press CAL to accept the calibration. The instrument will return to the measurement mode automatically.
8. If the calibration is not accepted start back at step one and try it again.
9. Next, insert the 0-10 gel standard (the one that is used in the field) and press READ. Do this three times to obtain an average that will become the calibration value. Write this value down on a label that will be placed on the instrument.

Press the 'RANGE' button if you see a blinking 9.99 value.

10. Insert the 0-100 gel standard and press READ. Do this three times to obtain an average that will become the calibration value. Write this value down on a label that will be placed on the instrument.
11. Insert the 0-1000 gel standard and press READ. Do this three times to obtain an average that will become the calibration value. Write this value down on a label that will be placed on the instrument.

9.4.3 FLOW METER

Maintenance for the flow meter basically consists of checking the batteries and calibrating using the bucket test.

Flow Meter Maintenance

- Check Batteries (takes 2 D)
- Add label with calibration date and noting that batteries were good

Flow Meter Quarterly Calibration

1. Fill a 5 gallon bucket of water half full of water. Clean sensor with liquinox soap and water.
2. Attach the probe to a wading rod and insert the probe into the bucket so that it is 3" away from the sides and bottom of the bucket. Let the probe sit for at least 5 minutes until the water is no longer moving before calibrating.
3. Turn on the unit and press RCL and STO at the same time. The number "3" will be displayed. Quickly press ↓ until "0" is displayed. The number 32 will be displayed and the unit will decrement itself to zero and turn off. The unit is now zeroed.

If you are not quick enough you may need to power down the unit and start over.

9.4.4 SEM MONITORING

Maintenance for SEM monitoring should include verifying that all the needed equipment is present and in good repair before the spring sampling event.

9.5 MACROINVERTEBRATE SHIPPING

9.5.1 SAMPLE PREPARATION FOR SHIPPING TO TAXONOMY LABORATORY

This protocol outlines the procedures for preparing macroinvertebrate samples for batch shipping to the out of state taxonomy laboratory. The procedure covers packing, marking, labeling and shipping as per the Hazardous Materials shipping guide for Fedex ground shipment. A DEQ employee who is certified to ship hazardous materials must oversee the packaging and shipping preparations. Certification is obtained via an online training course sponsored by Fedex Ground Ship Safe Ship Smart course, costing $150 (www.shipsafeshipsmart.com). The certification is valid for one year, but is automatically renewed annually unless terminated by Fedex. Questions can be directed to the Fedex hotline at 1-800-463-3339; the ADEQ account # and shipper # are needed and can be obtained from the ADEQ Mailroom staff. The procedure for packaging and preparing macroinvertebrate samples for shipping is as follows:

1. The macroinvertebrate samples should be preserved with 99% isopropanol, completely filled, and contained in 1L Nalgene bottles. The lids should be tightly closed and wrapped securely in black electrical tape or parafilm for transport.
2. Samples should be packaged in ice chests, preferably without spigots or with spigots taped. Ice chest should be in good condition without cracks or leaks. Secure and tape the drain plug with reinforced fiber tape inside and outside.
3. Line the ice chest with a large heavy duty plastic bag.
4. Place cushioning/absorbent material in the bottom of the cooler (ie, layered absorbent cloths or pet absorbent pads) and place the sample containers in the cooler with sufficient space to allow for additional cushioning materials between the containers.
5. Place paper cushions around the edges of the package and packing peanuts between the sample bottles, as well as additional packing materials on top, to absorb shock in transport.
6. Securely fasten the top of the large plastic bag with a ziptie or tape.
7. Place a copy of the chain of custody form/inventory form in a gallon Ziploc bag and tape to the inside lid of the cooler.
8. Weigh the box using one of the lab scales. The total per box/cooler weight must be <30kg/66lbs.
9. Close the cooler and securely tape with reinforced fiber strapping tape around each end of the cooler, wrapping around the cooler twice.
10. Attach the "limited quantity" (Ltd. Qty) label to the cooler/box and mark it with "this side up" symbol on two opposite sides of the package.
11. A normal Fedex Ground shipping label is used along with a Limited Quantity label (FIGURE 9.5). No Hazardous material labelling is required for isopropanol preserved bug samples if they meet Fedex "limited quantity" regulations. A package is considered "limited quantity" if each sample bottle contains <1Liter of isopropanol and the overall weight of the cooler/box is <30kg/66lbs.
12. Deliver sample coolers to mailroom staff for Fedex pickup.

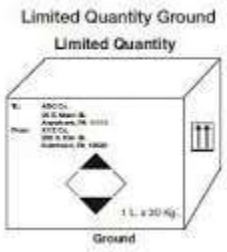


FIGURE 9.5. Labeling of shipping container for macroinvertebrate samples

All macroinvertebrate samples from a spring sample event are shipped as one batch to the taxonomy laboratory in July of each year or as soon as practical after sampling.

CHAPTER 10 DATA MANAGEMENT

This chapter is meant to provide clear data entry methods that encourage uniformity and accuracy in surface water quality data management. It is to be used by anyone who enters surface water data into the Water Quality Database (WQDB). For the purposes of this manual, WQDB will reference the surface water portion of the database.

10.1 WQDB BASICS

Chemistry, macroinvertebrate, algae, fish, and habitat data are all stored in the WQDB. The WQDB is a relational database that makes the task of storing hundreds of thousands of water quality records easier. The WQDB has three main levels as illustrated by FIGURE 10.1.

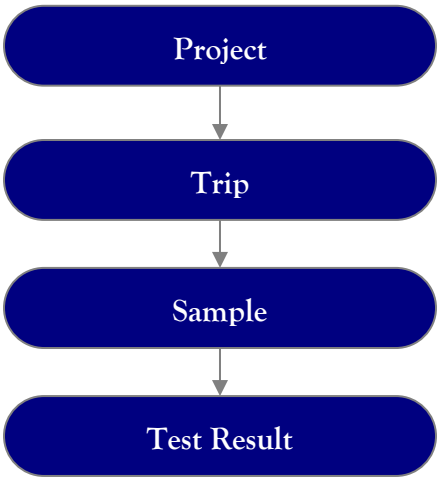


FIGURE 10.1. WQDB table hierarchy. One site is related to many trip. One trip is related to many samples etc.

The water quality database currently has over 5 million records from internal and external sources. It includes both surface water and groundwater data. A record is a defined as a discrete parameter at a particular location at a particular time. For example, an alkalinity concentration of 123 mg/L at Roosevelt Lake 15 feet below the surface on March 23, 2008 would be one record.

10.1.1 ACCESSING THE WQDB

This section will focus on how to move from screen to screen in the WQDB.

10.1.1.1 Logging into the Database

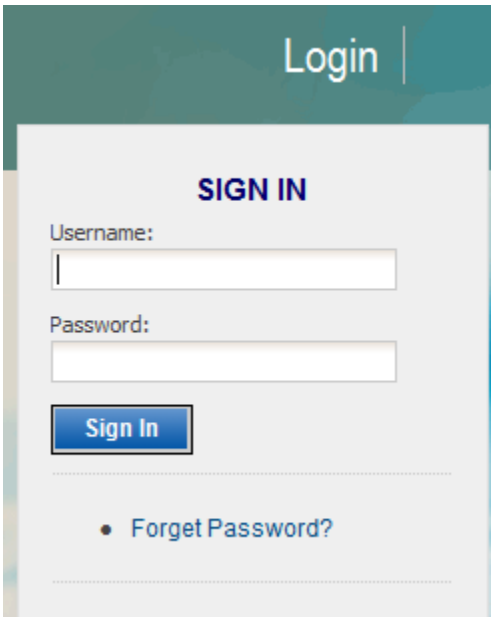
Production Database Link: http://eaqua-prd-01/AZWQDB/Pages/Login

1. Click 'login'

2. Enter User = [Your LAN ID]

New users will need an account, which is managed by administrators under 'Manage Users'

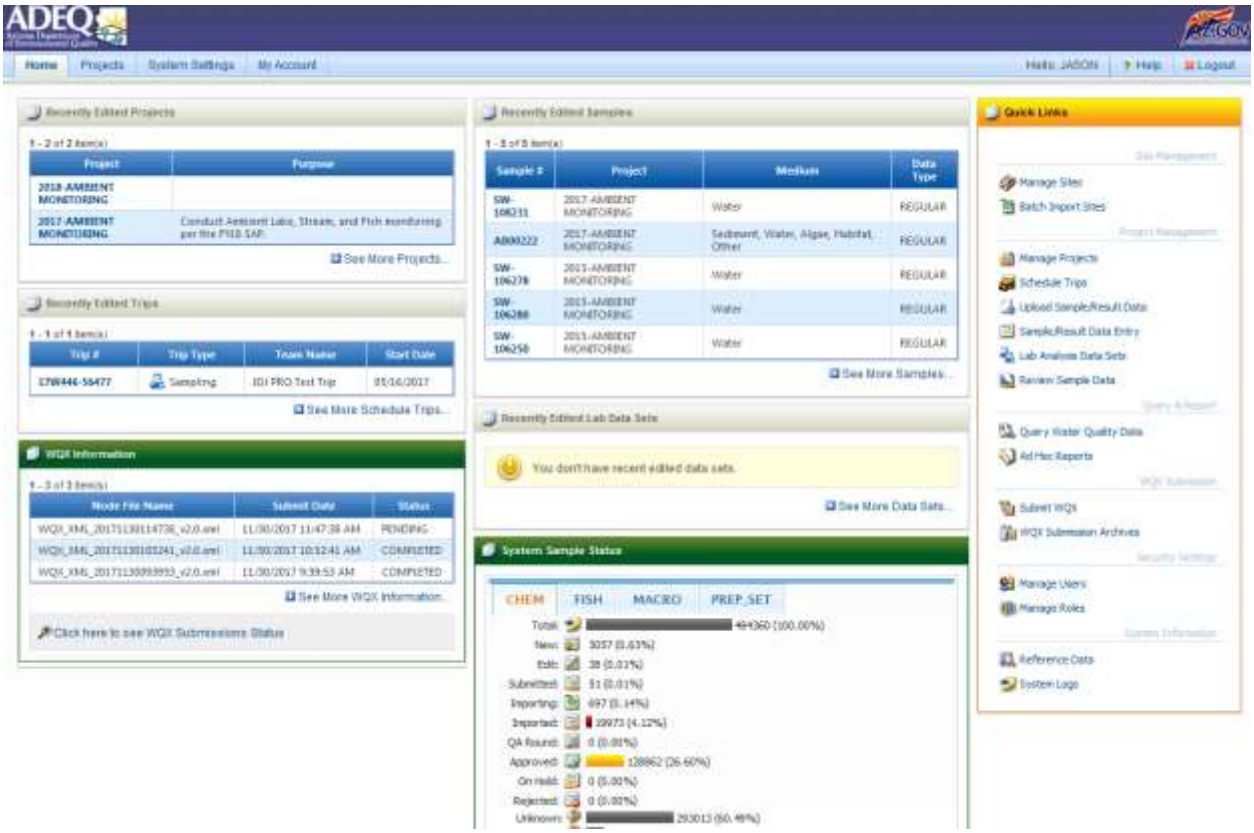
3. Enter Password = [Enter your password]



10.1.2 NAVIGATION

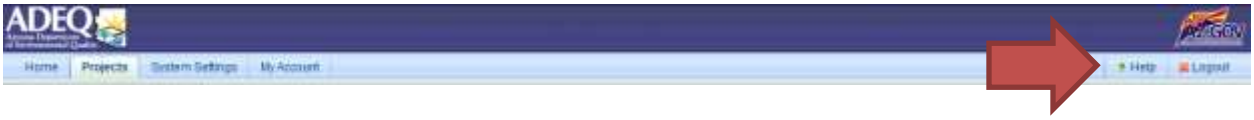
After logging in, the user is taken to a dashboard showing recent projects, trips, samples, data sets and WQX submissions. Quick links to all parts of the database are available on the right hand side.

The quick links are always available to the user to navigate around the database but will be on the lefthand side once you leave the dashboard.



10.1.3 THE COMPLETE WQDB HELP MANUAL

This manual is meant to cover the basics of what samplers will need to enter, review, and approve data. <u>The full WQDB User Guide can be accessed by clicking help</u>.



The user guide is the comprehensive source of information and will cover everything related to the database.

- Manage projects
- Add sites
- Add fish data
- Add algae data
- Add bug data
- Upload data
- Manage and add users (see administrative user guide; contact current administrators for access)
- Update reference data (see administrative user guide; contact current administrators for access)

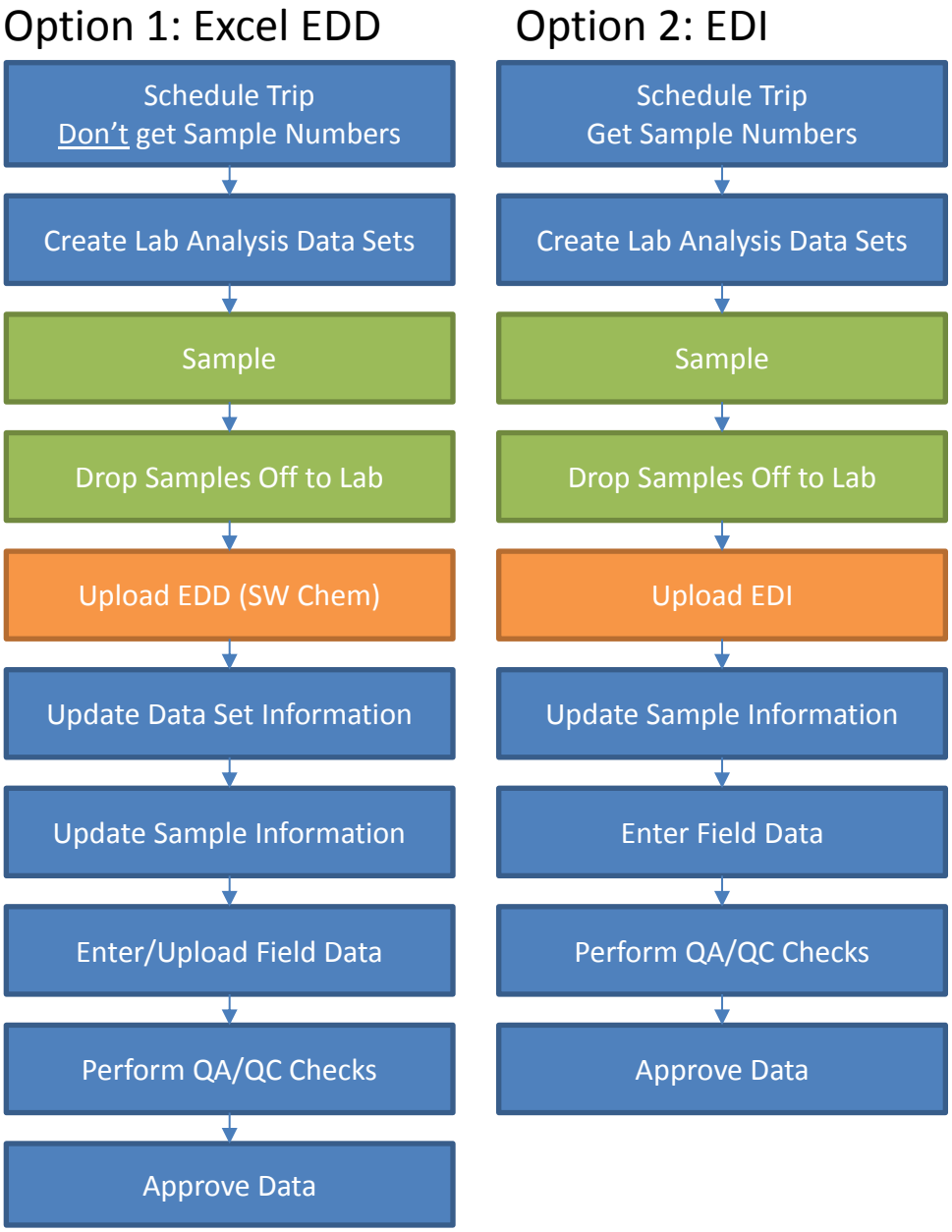
This chapter includes items that may touch on some of the same procedures as the user's guide but will focus more on the business process for how surface water data is entered in general.

A quick reference guide for the public is also available by clicking 'help' from http://waterdata.azdeq.gov/AZWQDB

10.2 GENERAL WORKFLOW

Most data collected by ADEQ is a combination of field and lab data. For lab data, there are two main ways that data can quickly be entered into the database.

- Option 1: Electronic Data Deliverable – Excel Format. The lab supplies data in excel using a predefined format.
- Option 2: Electronic Data Deliverable – EDI Format. This is a preferred way. The lab supplies data in a pipe-delimited text file. This predefined format also tells the data where to be loaded in the database and includes lab QA/QC data.

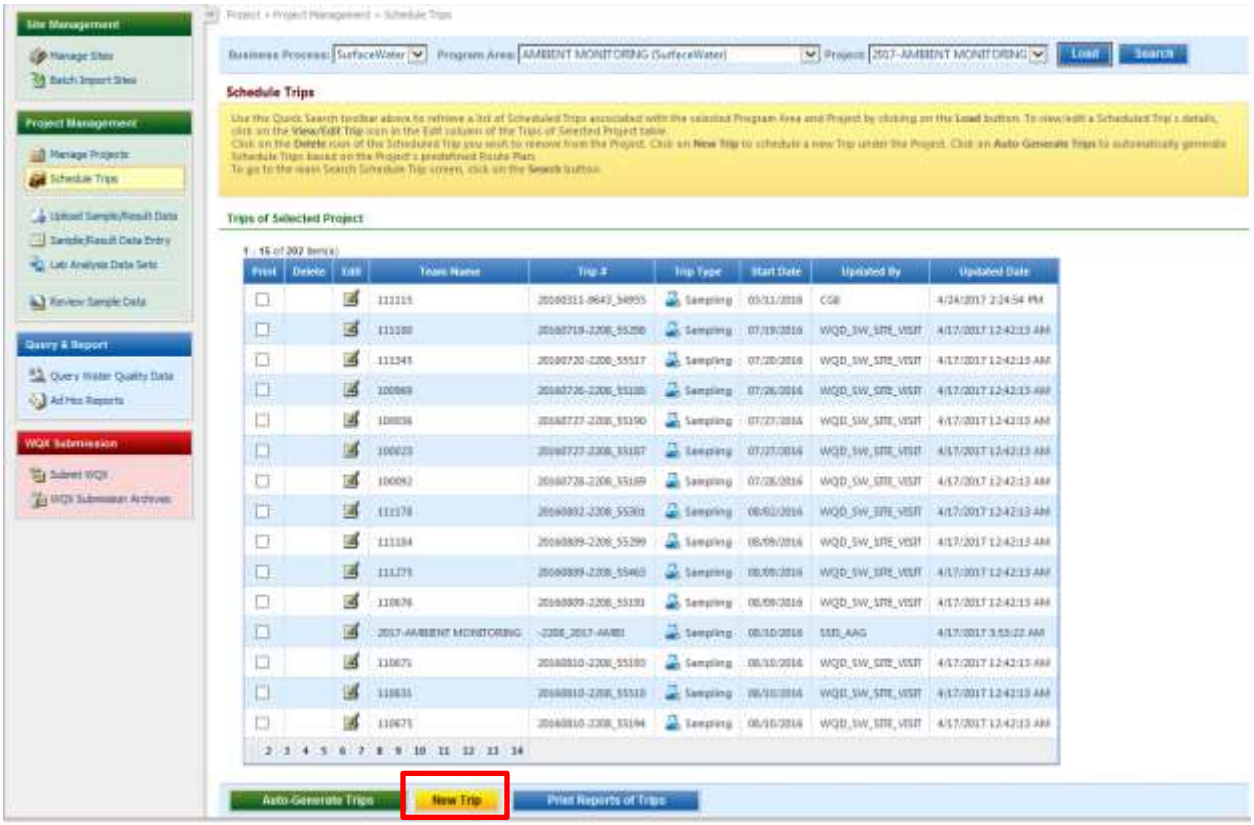


10.2.1 SCHEDULE THE TRIP

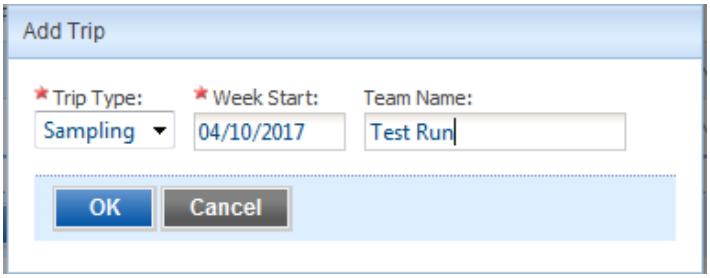
A trip is the group of sites that a sampler plans on sampling. Trips should be scheduled before an actual sampling event.

TMDL, lakes and groundwater often do not know exactly what sites/depths they will be able to sample before a trip. Go ahead and schedule a trip without adding sites/samples. Return to the office and then log in every sample you collected in the WQDB and get your sample # as described below and then add this information to the COC. Alternatively, submit the samples to the lab without logging the samples in the database and request an Excel EDD.

1. Click on Schedule Trips on the side navigation bar.
2. Select Business Process, Program Area and Project. Click 'Load' then click on 'New Trip'.



3. Add Week Start date (e.g., first sample date) and Team Name (e.g., name of your run) and hit OK.



4. Add Team Member and Role on the General Information page (**at a minimum, add trip lead as Survey Crew Chief - otherwise the sampler name will not show up as Crew Chief on the sample page**) and click Save Trip Info.
5. Click on the Team's Sampling Sites tab and add scheduled sites. This is where you obtain the sample numbers for your samples. You need sample numbers to label your bottles and fill out the Chain of Custody for EDI reporting. Check appropriate Collection Type boxes (you may need to uncheck some). Click Save Sampling Trips.

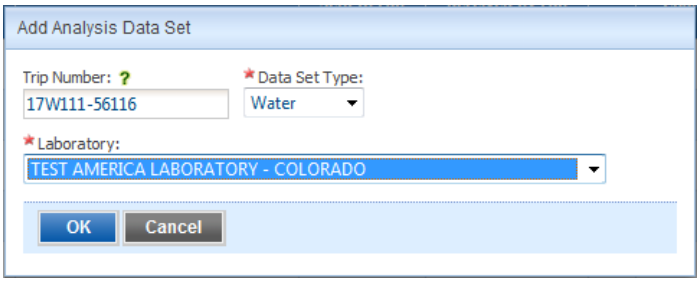
Enter your sites faster by using a comma between each site identification number. Station ID: bwbro, vrver15. **This example will pull all Burro Creek sites and all Verde River sites with a river mile starting with 15.**

Sites can be changed later. If you have a new site, assign any site to obtain a sample number and change the site later.

10.2.2 CREATE A LAB ANALYSIS DATA SET

A lab analysis data set is the set of parameters for a particular sample to a particular lab. Create a lab analysis data set to obtain a data set number (lab tracking number), which is required for EDI upload.

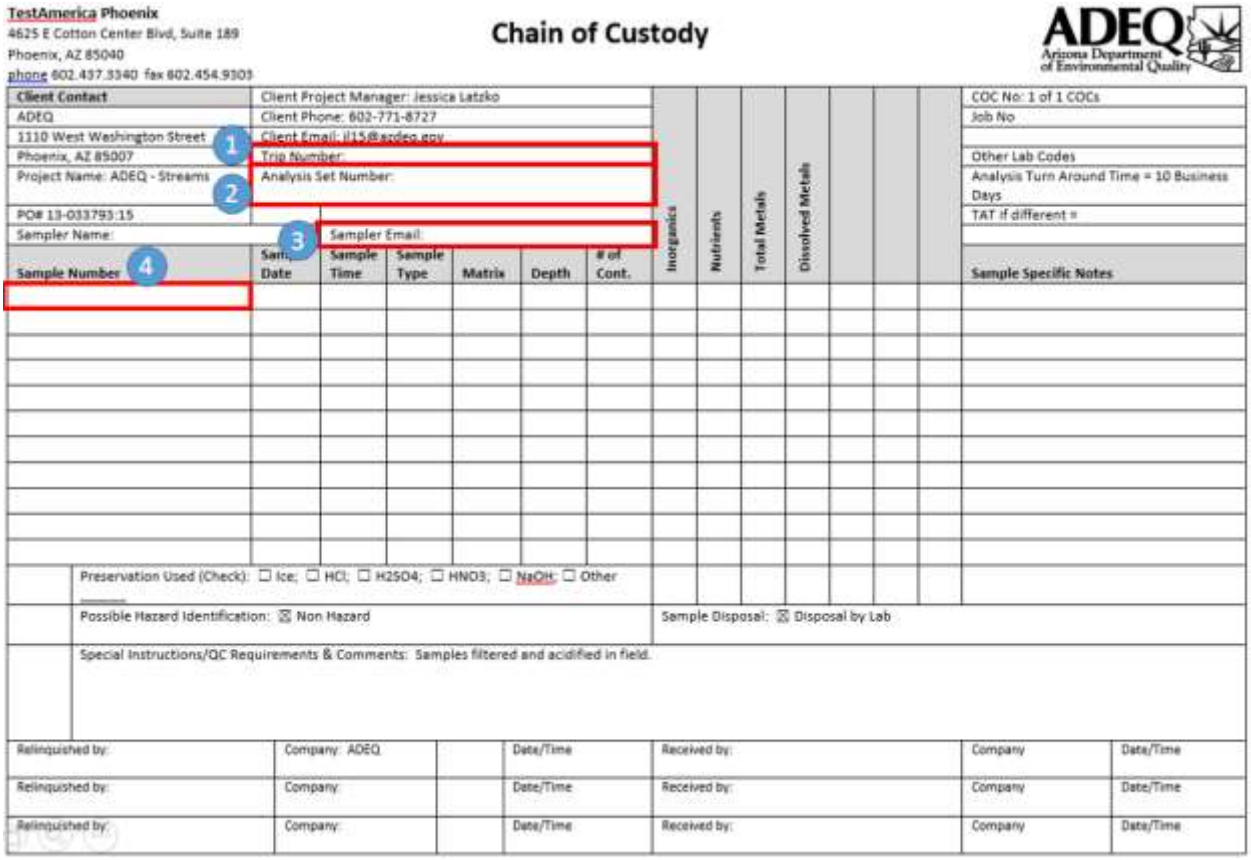
1. Click on Lab Analysis Data Sets on the side navigation bar.
2. Check Program Area and Project are correct (if not, select the correct Project). Click on New Data Set.
3. Enter Trip Number (this will associate your samples to the data set), Data Set Type and Laboratory. Hit OK.



4. Click Save Data Set to get a unique data set number.
5. Note the Data Set Number. This is your lab tracking number and must be on the Chain of Custody form.
6. Go back to the Data Sets List and repeat the steps to obtain another tracking number for additional labs.

10.2.2.1 How to Fill Out the Chain of Custody for EDI Samples

The Chain of Custody form in the database is currently under development. The example below only applies to Test America.



TestAmerica Phoenix
4625 E Cotton Center Blvd, Suite 189
Phoenix, AZ 85040
phone 602.437.3340 fax 602.454.9303

Chain of Custody

ADEQ Arizona Department of Environmental Quality

Client Contact	Client Project Manager: Jessica Latzko													COC No: 1 of 1 COCs
ADEQ	Client Phone: 602-771-8727													Job No
1110 West Washington Street (1)	Client Email: jl15@azdeq.gov													
Phoenix, AZ 85007	Trip Number:													Other Lab Codes
Project Name: ADEQ - Streams (2)	Analysis Set Number:													Analysis Turn Around Time = 10 Business Days
PO# 13-033793:15														TAT if different =
Sampler Name:	(3) Sampler Email:													
Sample Number (4)	Sample Date	Sample Time	Sample Type	Matrix	Depth	# of Cont.	Inorganics	Nutrients	Total Metals	Dissolved Metals				Sample Specific Notes

Preservation Used (Check): ☐ Ice; ☐ HCl; ☐ H2SO4; ☐ HNO3; ☐ NaOH; ☐ Other

Possible Hazard Identification: ☒ Non Hazard — Sample Disposal: ☒ Disposal by Lab

Special Instructions/QC Requirements & Comments: Samples filtered and acidified in field.

Relinquished by:	Company: ADEQ		Date/Time	Received by:	Company	Date/Time
Relinquished by:	Company:		Date/Time	Received by:	Company	Date/Time
Relinquished by:	Company:		Date/Time	Received by:	Company	Date/Time

FIGURE 10.2. Test America COC with new fields.

The highlighted items in FIGURE 10.2 are critical telling the data where to go in the database and where the lab should send the data.

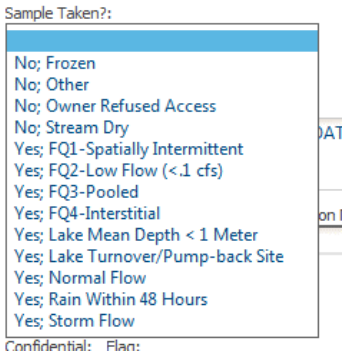
10.2.3 UPDATE THE WQDB

After your trip fill out the following information.

10.2.3.1 Sample Information

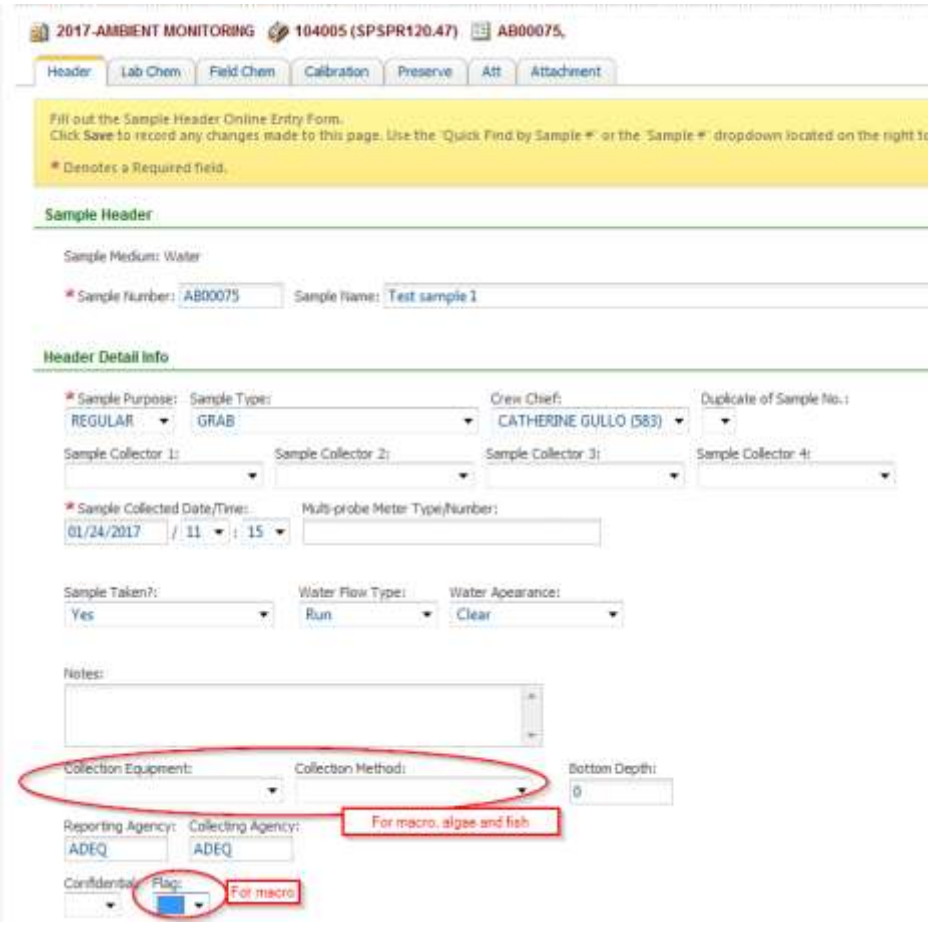
1. Click on Sample/Result Data Entry on the side navigation bar.
2. Select Business Process, Program Area, Project and Trip and hit Load.
3. Click on the Edit icon next to the sample number.
4. Fill in as much information as possible on the Header page. **Required fields** are:
   - Sample Purpose (Regular, blank, duplicate)
   - Sample Type (Grab, autosampler, etc).
   - Crew Chief (who is the lead)
   - Duplicate of Sample Number (if duplicate taken)
   - Sample collector 1 (other people on trip)
   - Sample Date
   - Time
   - Sample Taken (**critical for identifying storm flow samples!**)

  - Note if 'No; Stream Dry' selected also add a single record to the field tab for FLOW equal to 0 cfs.
  - Interstitial means surface water is interrupted between habitat units such that the majority of streambed cobbles in riffle habitats are exposed. Interstitial flow is evident as trickles flowing between stones or visible at the tail and heads of pools.
  - Spatially intermittent means a river with alternating wet and dry reaches and fluctuating stream flow rates.
- **The Sample Taken field is also used to automate exceedance flagging for assessments as follows:**
  - SSC exceedances – flagged if rain within 48 hours or storm flow, excluded from median calculations
  - Chronic exceedances – flagged if rain within 48 hours or storm flow, excluded from listing determinations
  - DO exceedances – flagged if low flow, excluded from listing determinations
-



- Depth (for lakes)
- Reporting Agency
- Collecting Agency

The database only requires that sample purpose and date/time be filled out to save. Sample type, crew chief, duplicate of Sample number, sample collector, sample taken, depth, reporting agency and collecting agency must all be filled out.

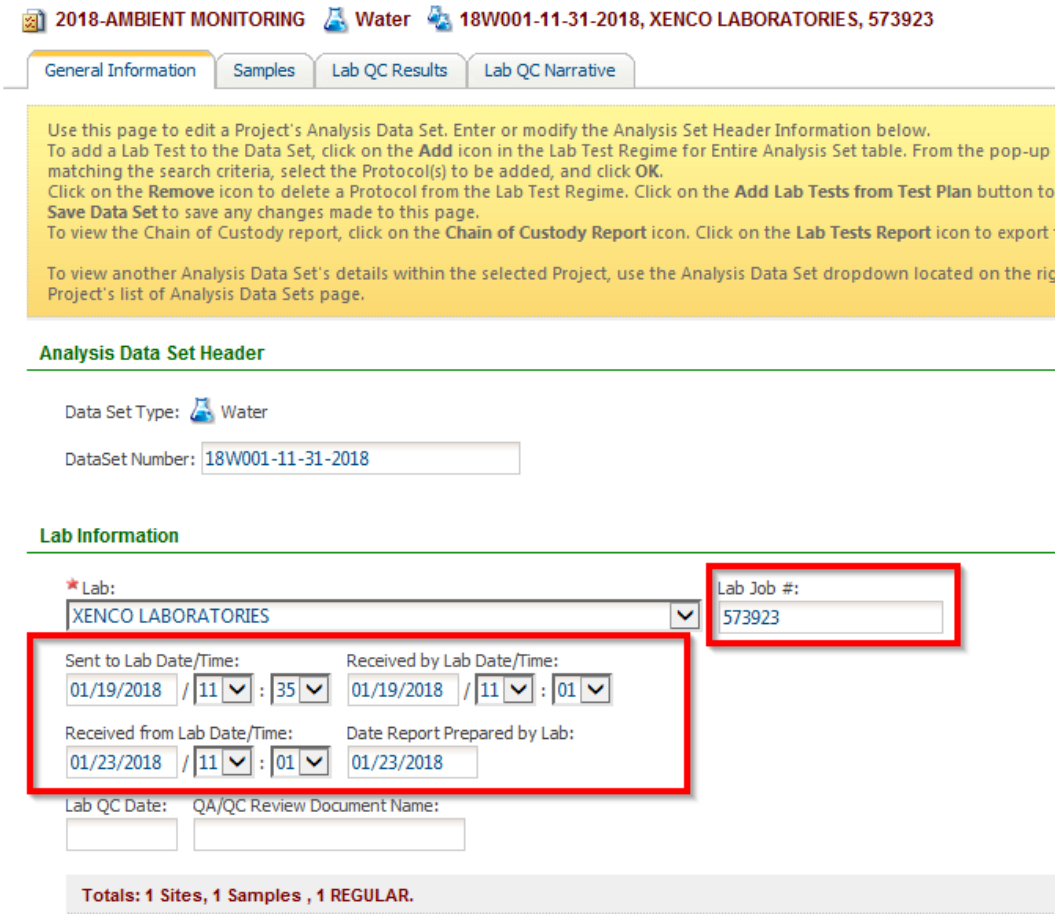


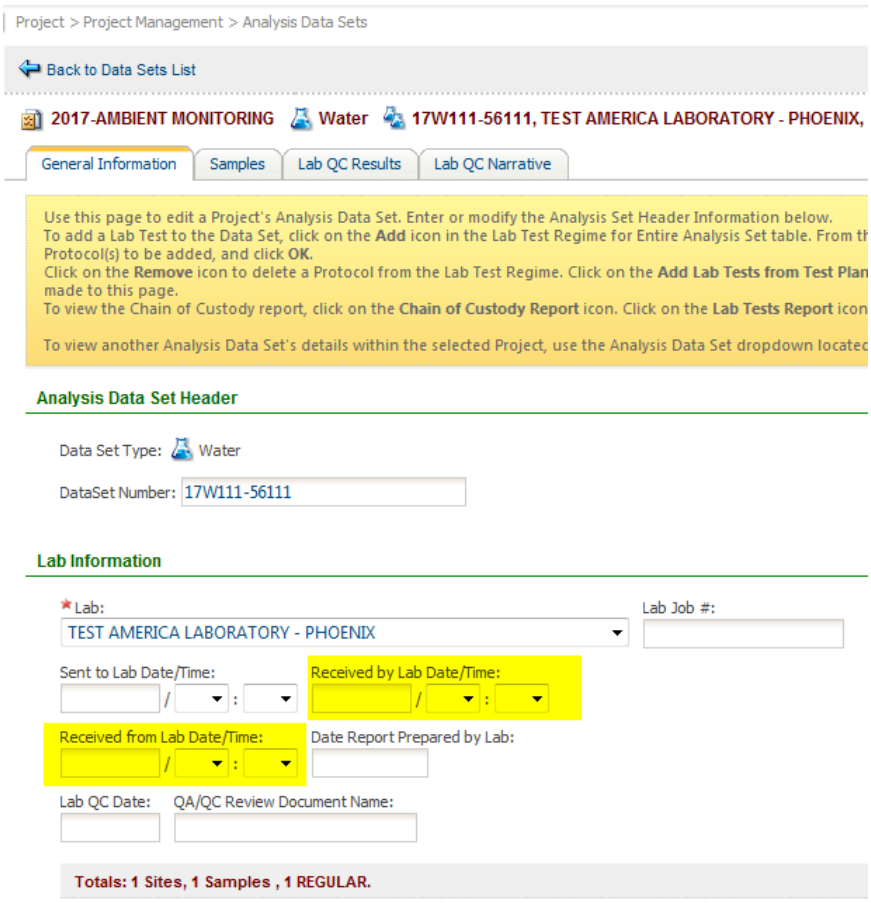
5. Click Save

10.2.3.2 Update Lab Analysis Data Set

Lab Date/Time and Received from Lab Date/Time are filled out automatically for edi files. This protocol only applied to EDD Excel reporting.

1. Click on Lab Analysis Data Sets on the side navigation bar.
2. Select Business Process (surface water or groundwater), Program Area and Project and click Load.
3. Click on the Edit icon next to your data set number.
4. Enter Sent to Lab and Received by Lab Date/Time. After the results are uploaded, enter Received from Lab Date/Time and Date Report Prepared by Lab as well as Lab Job Number.
5. Click Save Data Set


2018-AMBIENT MONITORING
Water
18W001-11-31-2018, XENCO LABORATORIES, 573923
General Information
Samples
Lab QC Results
Lab QC Narrative
Use this page to edit a Project's Analysis Data Set. Enter or modify the Analysis Set Header Information below.
To add a Lab Test to the Data Set, click on the Add icon in the Lab Test Regime for Entire Analysis Set table. From the pop-up
matching the search criteria, select the Protocol(s) to be added, and click OK.
Click on the Remove icon to delete a Protocol from the Lab Test Regime. Click on the Add Lab Tests from Test Plan button to
Save Data Set to save any changes made to this page.
To view the Chain of Custody report, click on the Chain of Custody Report icon. Click on the Lab Tests Report icon to export
To view another Analysis Data Set's details within the selected Project, use the Analysis Data Set dropdown located on the rig
Project's list of Analysis Data Sets page.
Analysis Data Set Header
Data Set Type: Water
DataSet Number: 18W001-11-31-2018
Lab Information
*Lab:
XENCO LABORATORIES
Lab Job #:
573923
Sent to Lab Date/Time:
01/19/2018 / 11 : 35
Received by Lab Date/Time:
01/19/2018 / 11 : 01
Received from Lab Date/Time:
01/23/2018 / 11 : 01
Date Report Prepared by Lab:
01/23/2018
Lab QC Date:
QA/QC Review Document Name:
Totals: 1 Sites, 1 Samples , 1 REGULAR.



10.2.3.3 Enter Field Data and Update Event Conditions

1. Click on Sample/Result Data Entry on the side navigation bar.
2. Select Business Process, Program Area, Project and Trip and click Load.
3. Click on the Edit icon next to the sample number.
4. Click on the Field Chem tab to manually enter field data. Note: Lab data is electronically loaded but could be manually entered by clicking the lab data tab.
5. Select a Test Plan as a template or click 'new result'.
6. Add "Event conditions":
   a. From the Field Chem tab at bottom of page, select "new result" which opens a new screen.
   b. Select "Event Condition" from the "Substance" dropdown, then click "Protocol" field and select "Event condition". Then click in the "Lookup result" field and select an event condition from the Lookup Result dropdown list.
   c. Add event specific comments in the comment box if needed. Comments that apply to the entire sample should be added on the sample page under comments.

When you use a Test Plan template to add results, make sure to delete the ones you don't need.

For lake field data, you will need to go back to the Schedule Trips section and add additional samples (i.e., field measurements) collected at different depths.

7. Enter the lab notation if needed. ND or 'not detected' is the most common lab notation. When the lab notation is present the results should be blank and vice versa.

If bacteria counts are reported as "too numerous to count," then enter GT for the lab notation. A rough estimate of the upper detection limit should also be entered. This may be an educated guess. The upper limit for Colilert analysis is 2419.6 CFU per 100 mL (unless dilutions are preformed). Also enter the A1 data qualifier indicating that the bacteria is too numerous to count.

Bacterial results are not recorded as "0" as this number will interfere with automated geometric mean calculations (Chapter 4 has additional information regarding bacteria).

Code	Lab Notation
ND	Not detected
GT	Greater than quantification level
LT	Less than
PR	Compound is present
AB	Compound is absent
NR	Not reported

TABLE 10.3. Lab notation descriptions.

8. Enter the results and units. Results are entered using the units provided by the laboratory. Be sure that the units and results match. Incorrect units are one of the most common errors. You will seldom report a result of "0." Instead you will report that it was measured below the lower reporting or detection limit – even with field equipment. The Sampling and Analysis Plan contains the default detection limits for the laboratory analysis as well as the lowest reliable range for all field equipment.
9. Enter the reporting limit and reporting limit units and MDL and MDL units if provided. Lab results can be reported between the Method Detection Limit and the MRL. These results will be flagged with one of the "Estimate" qualifiers in TABLE 10.4.

Samples that are analyzed at a detection limit above any applicable water quality criterion do not tell us if the standard was exceeded. Such analysis should be avoided. For example, the chronic selenium criterion is 2.0 µg/L; therefore, a lab result reported as <5 µg/L will not provide any information about if the standard was exceeded.

10. Enter applicable lab data qualifiers. Lab qualifiers provide a wealth of information concerning the lab analysis that also needs to be documented with the data. Choose one or more Laboratory Data Qualifiers from the drop down list provided. TABLE 10.4 lists the most current lab qualifiers.

B1-7 Method blank Lab Qualifiers. Do not record the "B" qualifier for test results where analyte results are ND but have a method blank qualifier in the QC Summary portion of the lab report. The water quality results are still valid where the value is ND.

Code	Short Name	Description	Type	Decision	For 303d List
A1	BACTERIA - TOO NUMBEROUS TO COUNT	MICROBIOLOGY: TOO NUMEROUS TO COUNT.	ELAC		
A2	BACTERIA - INCUBATION PERIOD EXCEEDED	MICROBIOLOGY: SAMPLE INCUBATION PERIOD EXCEEDED METHOD REQUIREMENT.	ELAC		
A3	BACTERIA - INCUBATION PERIOD SHORTER THAN REQUIRED.	MICROBIOLOGY: SAMPLE INCUBATION PERIOD WAS SHORTER THAN METHOD REQUIREMENT.	ELAC		
A4	BACTERIA - DETECTED IN METHOD BLANK.	MICROBIOLOGY: TARGET ORGANISM DETECTED IN ASSOCIATED METHOD BLANK.	ELAC	Reject	No
A5	BACTERIA - INCUBATOR/WATER BATH TEMP OUTSIDE REQUIREMENTS	MICROBIOLOGY: INCUBATOR/WATER BATH TEMPERATURE WAS OUTSIDE METHOD REQUIREMENTS.	ELAC		
A6	BACTERIA - NOT DETECTED IN POSITIVE CONTROL	MICROBIOLOGY: TARGET ORGANISM NOT DETECTED IN ASSOCIATED POSITIVE CONTROL.	ELAC	Reject	No
A7	BACTERIA - SAMPLE HAD INADEQUATE HEADSPACE	MICRO SAMPLE RECEIVED WITHOUT ADEQUATE HEADSPACE.	ELAC		
A8	BACTERIA - PLATE COUNT WAS OUTSIDE THE METHOD'S REPORTING RANGE.	MICROBIOLOGY: PLATE COUNT WAS OUTSIDE THE METHOD'S REPORTING RANGE. REPORTED VALUE IS ESTIMATED.	ELAC		
B1	BLANK - ANALYTE IN METHOD BLANK DETECTED AT OR ABOVE METHOD REPORTING LIMIT	METHOD BLANK: TARGET ANALYTE DETECTED IN METHOD BLANK AT OR ABOVE THE METHOD REPORTING LIMIT.	ELAC		No
B2	BLANK - NON-TARGET ANALYTE DETECTED IN METHOD BLANK AND SAMPLE PRODUCING INTERFERENCE	METHOD BLANK: NON-TARGET ANALYTE DETECTED IN METHOD BLANK AND SAMPLE, PRODUCING INTERFERENCE.	ELAC		No
B3	BLANK - ANALYTE IN CALIBRATION BLANK AT OR ABOVE THE METHOD REPORTING LIMIT.	METHOD BLANK: TARGET ANALYTE DETECTED IN CALIBRATION BLANK AT OR ABOVE THE METHOD REPORTING LIMIT.	ELAC		No
B4	BLANK - ANALYTE IN BLANK AT OR ABOVE METHOD ACCEPTANCE CRITERIA.	METHOD BLANK: TARGET ANALYTE DETECTED IN BLANK AT OR ABOVE METHOD ACCEPTANCE CRITERIA.	ELAC		No
B5	BLANK - ANALYTE IN METHOD BLANK AT OR ABOVE THE METHOD REPORTING LIMIT, BUT BELOW STANDARD.	METHOD BLANK: TARGET ANALYTE DETECTED IN METHOD BLANK AT OR ABOVE THE METHOD REPORTING LIMIT, BUT BELOW TRIGGER LEVEL OR MCL.	ELAC		No
B6	BLANK - ANALYTE IN CALIBRATION BLANK AT OR ABOVE THE METHOD REPORTING LIMIT, BUT BELOW STANDARD	METHOD BLANK: TARGET ANALYTE DETECTED IN CALIBRATION BLANK AT OR ABOVE THE METHOD REPORTING LIMIT, BUT BELOW TRIGGER LEVEL OR MCL.	ELAC		No

Code	Short Name	Description	Type	Decision	For 303d List
B7	BLANK - ANALYTE IN METHOD BLANK AT OR ABOVE MRL, BUT CONC. IN SAMPLE IS 10X ABOVE CONC IN BLANK	MEHTOD BLANK: TARGET ANALYTE DETECTED IN METHOD BLANK AT OR ABOVE METHOD REPORTING LIMIT.CONCENTRATION FOUND IN THE SMP WAS 10 TIMES ABOVE THE CONCENTRATION FOUND IN THE MTHD BLK.	ELAC		No
B8	BLANK - ANALYTE FOUND IN BOTH THE TRAVEL BLANK AND SAMPLE	TRIP BLANK: ANALYTE FOUND IN BOTH THE TRAVEL BLANK AND SAMPLE.	ELAC		No
C1	CONFIRMATION - ANALYSIS NOT PERFORMED AS REQUIRED.	CONFIRMATION: CONFIRMATORY ANALYSIS NOT PERFORMED AS REQUIRED BY THE METHOD.	ELAC		
C3	CONFIRMATION - QUALITATIVE CONFIRMATION PERFORMED.	CONFIRMATION: QUALITATIVE CONFIRMATION PERFORMED.	ELAC		
C4	CONFIRMATION - PAST HOLDING TIME.	CONFIRMATION: CONFIRMATORY ANALYSIS WAS PAST HOLDING TIME.	ELAC		
C5	CONFIRMATION - NOT CONFIRMED, PAST HOLDING TIME.	CONFIRMATION. CONFIRMATORY ANALYSIS WAS PAST HOLDING TIME. ORIGINAL RESULT NOT CONFIRMED.	ELAC		
C8	SAMPLE RPD BETWEEN THE PRIMARY AND CONFIRMATORY ANALYSIS EXCEEDED 40%. PER EPA METHOD 8000C, THE LOWER VALUE WAS REPORTED AS THERE WAS NO EVIDENCE OF CHROMATOGRAPHIC PROBLEMS.	SAMPLE RPD BETWEEN THE PRIMARY AND CONFIRMATORY ANALYSIS EXCEEDED 40%. PER EPA METHOD 8000C, THE LOWER VALUE WAS REPORTED AS THERE WAS NO EVIDENCE OF CHROMATOGRAPHIC PROBLEMS.	ELAC		
D1	DILUTION - REQUIRED DUE TO MATRIX INTERFERENCE.	DILUTION: SAMPLE REQUIRED DILUTION DUE TO MATRIX.	ELAC		
D2	DILUTION - REQUIRED DUE TO HIGH CONCENTRATION OF ANALYTE.	DILUTION: SAMPLE REQUIRED DILUTION DUE TO HIGH CONCENTRATION OF TARGET ANALYTE. SEE CASE NARRATIVE.	ELAC		
D3	ARCHIVED FOR HISTORICAL DATA ON 20080128 NOT AVAILABLE FOR USE: DILUTION: SAMPLE DILUTION REQUIRED DUE TO INSUFFICIENT SAMPLE	ARCHIVED FOR HISTORICAL DATA ON 20080128 NOT AVAILABLE FOR USE: DILUTION: SAMPLE DILUTION REQUIRED DUE TO INSUFFICIENT SAMPLE	ELAC		
D4	DILUTION - MINIMUM REPORTING LEVEL ADJUSTED DUE TO SAMPLE AMOUNT.	DILUTION: MINIMUM REPORTING LEVEL (MRL) ADJUSTED TO REFLECT SAMPLE AMOUNT RECEIVED AND ANALYZED.	ELAC		
D5	DILUTION - MINIMUM REPORTING LIMIT ADUSTED DUE TO SAMPLE DILUTION; ANALYTE NONDETECT IN SAMPLE.	DILUTION - MINIMUM REPORTING LIMIT ADUSTED DUE TO SAMPLE DILUTION; ANALYTE NONDETECT IN SAMPLE.	ELAC		
D6	DILUTION: MINIMUM REPORTING LIMIT ADJUSTED DUE TO AN AUTOMATIC 10X DILUTION PERFORMED ON THIS SAMPLE FOR THE PURPOSE OF REPORTING TRADITIONAL DRINKING WATER ANALYTES FOR WW REQUIREMENTS.	DILUTION: MINIMUM REPORTING LIMIT ADJUSTED DUE TO AN AUTOMATIC 10X DILUTION PERFORMED ON THIS SAMPLE FOR THE PURPOSE OF REPORTING TRADITIONAL DRINKING WATER ANALYTES FOR WW REQUIREMENTS.	ELAC		

Code	Short Name	Description	Type	Decision	For 303d List
D7	DILUTION - MINIMUM REPORTING LIMIT ADJUSTED TO REFLECT SAMPLE DILUTION.	DILUTION: MINIMUM REPORTING LIMIT ADJUSTED TO REFLECT SAMPLE DILUTION.	ELAC		
E1	ESTIMATE - ANALYTE EXCEEDED CALIBRATION RANGE. INSUFFICIENT SAMPLE TO REANALYZE.	ESTIMATED CONCENTRATION: CONCENTRATION ESTIMATED. ANALYTE EXCEEDED CALIBRATION RANGE. REANALYSIS NOT POSSIBLE DUE TO INSUFFICIENT SAMPLE.	ELAC		No
E2	ESTIMATE - ANALYTE EXCEEDED CALIBRATION RANGE. NOT REANALYSED DUE TO MATRIX PROBLEMS.	ESTIMATED CONCENTRATION: CONCENTRATION ESTIMATED. ANALYTE EXCEEDED CALIBRATION RANGE. REANALYSIS NOT PERFORMED DUE TO SAMPLE MATRIX.	ELAC		No
E3	ESTIMATE - ANALYTE EXCEEDED CALIBRATION RANGE. NOT REANALYSED DUE TO HOLDING TIMES.	ESTIMATED CONCENTRATION: CONCENTRATION ESTIMATED. ANALYTE EXCEEDED CALIBRATION RANGE. REANALYSIS NOT PERFORMED DUE TO HOLDING TIME REQUIREMENTS.	ELAC		No
E4	ESTIMATE - ANALYTE BELOW LAB REPORTING LEVEL BUT ABOVE MDL	ESTIMATED - ANALYTE WAS DETECTED BELOW LABORATORY MINIMUM REPORTING LIMIT (MRL) BUT ABOVE MDL.	ELAC		No
E5	ESTIMATE - ANALYTE DETECTED BELOW LAB REPORTING LEVEL. NOT CONFIRMED BY ALT ANALYSIS.	ESTIMATED CONCENTRATION: CONCENTRATION ESTIMATED. ANALYTE WAS DETECTED BELOW LABORATORY MINIMUM REPORTING LEVEL (MRL), BUT NOT CONFIRMED BY ALTERNATE ANALYSIS.	ELAC		No
E6	ESTIMATE - INTERNAL STANDARD RECOVERIES DID NOT MEET METHOD ACCEPTANCE CRITERIA.	ESTIMATED CONCENTRATION: CONCENTRATION ESTIMATED. INTERNAL STANDARD RECOVERIES DID NOT MEET METHOD ACCEPTANCE CRITERIA.	ELAC	Reject	No
E7	ESTIMATE - INTERNAL STANDARD RECOVERIES DID NOT MEET LAB ACCEPTANCE CRITERIA.	ESTIMATED CONCENTRAITON: CONCENTRATION ESTIMATED. INTERNAL STANDARD RECOVERIES DID NOT MEET LABORATORY ACCEPTANCE CRITERIA.	ELAC	Reject	No
E8	ESTIMATE - ANALYTE WAS NOT DETECTED; REPORTED TO MDL PER PROJECT SPECIFICATION.	ANALYTE REPORTED TO MDL PER PROJECT SPECIFICATION. TARGET ANALYTE WAS NOT DETECTED IN THE SAMPLE.	ELAC		No
EXC	ADEQ - EXCEEDANCE AT TIME OF SAMPLING	ADEQ - EXCEEDANCE AT TIME OF SAMPLING	ADEQ		
FB1	ADEQ - FIELD BLANK TAKEN: NO CONTAMINATION	ADEQ - FIELD BLANK TAKEN FOR ANALYTE: NON-DETECT REPORTED, NO CONTAMINATION.	ADEQ		
FB2	ADEQ - FIELD BLANK TAKEN, MINOR CONTAMINATION	ADEQ - FIELD BLANK TAKEN FOR ANALYTE: MINOR CONTAMINATION REPORTED AT LEVELS BETWEEN MRL AND MDL. ASSOCIATED DATA CONSIDERED USABLE FOR LIMITED PURPOSES.	ADEQ		No

Code	Short Name	Description	Type	Decision	For 303d List
FB3	ADEQ - Field Blank taken, result above MRL	ADEQ - Field Blank result is above MRL	ADEQ	Reject	No
H1	HOLDING TIME - ANALYSIS PERFORMED PAST HOLDING TIME	HOLD TIME: SAMPLE ANALYSIS PERFORMED PAST HOLDING TIME.	ELAC		No, except E. coli
H2	HOLDING TIME - REANALYSIS FOR DILUTION WAS PAST HOLDING TIME	HOLD TIME: INITIAL ANALYSIS WITHIN HOLDING TIME. REANALYSIS FOR THE REQUIRED DILUTION WAS PAST HOLDING TIME.	ELAC		No
H3	HOLDING TIME - SAMPLE RECEIVED AND/ OR ANALYSIS REQUESTED PAST HOLDING TIME.	HOLD TIME: SAMPLE WAS RECEIVED AND/ OR ANALYSIS REQUESTED PAST HOLDING TIME.	ELAC		No
H4	HOLDING TIME - EXCEEDED SAMPLE EXTRACTION HOLDING TIME, BUT ANAL HOLDING TIME OK	HOLD TIME: SAMPLE WAS EXTRACTED PAST REQUIRED EXTRACTION HOLDING TIME, BUT ANALYZED WITHIN ANALYSIS HOLDING TIME.	ELAC		
H5	HOLDING TIME - FIELD TEST: 15 MINUTES HT. SAMPLE RECEIVED & ANALYZED PAST HOLDING TIME.	HOLDING TIME: THIS TEST IS SPECIFIED TO BE PERFORMED IN THE FIELD WITHIN 15 MINUTES OF SAMPLING; SAMPLE WAS RECEIVED AND ANALYZED PAST THE REGULATORY HOLDING TIME.	ELAC		No
H6	HOLDING TIME - FILTRATION NOT DONE WITHIN 15 MINUTES OF SAMPLING.	HOLD TIME: THE FILTRATION WAS NOT DONE WITHIN THE REQUIRED 15 MINUTES OF SAMPLING, THE SAMPLE WAS FILTERED IN THE LABORATORY.	ELAC		
K1	BOD - DILUTIONS DID NOT MEET THE OXYGEN DEPLETION CRITERIA (2 MG/L)	BOD: THE SAMLE DILUTIONS SET-UP FOR THE BOD ANALYSIS DID NOT MEET THE OXYGEN DEPLETION CRITERIA OF AT LEAST 2 MG/L. THE REPORTED RESULT IS AN ESTIMATED VALUE.	ELAC		
K10	BOD - SEED CONTROL SAMPLES DO NOT DEPLETE AT LEAST 2.0 MG/L.	BOD: SEED CONTROL SAMPLES DO NOT DEPLETE AT LEAST 2.0 MG/L, WITH A RETENTION OF AT LEAST 1.0 MG/L DO CRITERIA IN ALL SAMPLES.	ELAC		
K11	BOD - MINIMUM DO IS LESS THAN 1.0 MG/L IN ALL DILUTIONS.	BOD: MINIMUM DO IS LESS THAN 1.0 MG/L IN ALL DILUTIONS.	ELAC		
K2	BOD - DILUTIONS DID NOT MEET THE RESIDUAL D.O. CRITERIA (1 MG/L)	BOD: THE SAMPLE DILUTIONS SET UP FOR THE BOD ANALYSIS FAILED TO MEET THE CRITERIA OF A RESIDUAL DISSOLVED LXYGEN OF AT LEAST 1 MG/L. THE REPORTED RESULT IS AN ESTIMATED VALUE.	ELAC		
K5	BOD - DILUTION WATER D.O. DEPLETION WAS > 0.2 MG/L.	BOD: THE DILUTION WATER D.O. DEPLETION WAS > 0.2 MG/L.	ELAC		
K6	BOD - GLUCOSE / GLUTAMIC ACID BOD BELOW METHOD ACCEPTANCE CRITERIA.	BOD: GLUCOSE/GLUTAMIC ACID BOD WAS BELOW METHOD ACCEPTANCE CRITERIA.	ELAC		
K7	BOD - DISCREPANCY BETWEEN THE BOD AND COD. RESULTS VERIFIED BY REANALYSIS OF COD.	BOD: A DISCREPANCY BETWEEN THE BOD AND COD RESULTS HAS BEEN VERIFIED BY REANALYSIS OF THE SAMPLE FOR COD.	ELAC		

Code	Short Name	Description	Type	Decision	For 303d List
K8	BOD - GLUCOSE / GLUTAMIC ACID BOD ABOVE METHOD ACCEPTANCE LEVELS.	BOD: GLUCOSE / GLUTAMIC ACID BOD WAS ABOVE METHOD ACCEPTANCE LEVELS.	ELAC		
K9	BOD - TEST REPLICATES MORE THAN 30% DIFFERENCE.	BOD: TEST REPLICATES SHOW MORE THAN 30% DIFFERENCE BETWEEN HIGH AND LOW VALUES.	ELAC		
L1	SPIKE - BLANK SPIKE RECOVERY ABOVE LAB ACCEPTANCE LIMITS.	LABORATORY FORTIFIED BLANK/BLANK SPIKE: THE ASSOCIATED BLANK SPIKE RECOVERY WAS ABOVE LABORATORY ACCEPTANCE LIMITS.	ELAC	Reject	No
L2	SPIKE - BLANK SPIKE RECOVERY BELOW LAB ACCEPTANCE LIMITS.	LABORATORY FORTIFIED BLANK/BLANK SPIKE: THE ASSOCIATED BLANK SPIKE RECOVERY WAS BELOW LABORATORY ACCEPTANCE LIMITS.	ELAC	Reject	No
L3	SPIKE - BLANK SPIKE RECOVERY ABOVE METHOD ACCEPTANCE LIMITS.	THE ASSOCIATED BLANK SPIKE RECOVERY WAS ABOVE METHOD ACCEPTANCE LIMITS.	ELAC	Reject	No
L4	SPIKE - BLANK SPIKE RECOVERY BELOW METHOD ACCEPTANCE LIMITS.	LABORATORY FORTIFIED BLANK/BLANK SPIKE: THE ASSOCIATED BLANK SPIKE RECOVERY WAS BELOW METHOD ACCEPTANCE LIMITS.	ELAC	Reject	No
L5	SPIKE - BLANK SPIKE RECOVERY ABOVE METHOD ACCEPTANCE LIMITS. NO ANALYTE DETECTED IN SAMPLE.	LABORATORY FORTIFIED BLANK/BLANK SPIKE: THE ASSOCIATED BLANK SPIKE RECOVERY WAS ABOVE LABORATORY/METHOD ACCEPTANCE LIMITS. THIS ANALYTE WAS NOT DETECTED IN THE SAMPLE.	ELAC		No
M1	SPIKE - MATRIX SPIKE - RECOVERY WAS HIGH. ACCEPTABLE METHOD CONTROL SAMPLE RECOVERY.	MATRIX SPIKE: MATRIX SPIKE RECOVERY WAS HIGH, THE METHOD CONTROL SAMPLE RECOVERY WAS ACCEPTABLE.	ELAC		
M2	SPIKE - MATRIX SPIKE - RECOVERY WAS LOW. ACCEPTABLE METHOD CONTROL SAMPLE RECOVERY.	MATRIX SPIKE: MATRIX SPIKE RECOVERY WAS LOW, THE METHOD CONTROL SAMPLE RECOVERY WAS ACCEPTABLE.	ELAC		
M3	SPIKE - MATRIX SPIKE - ACCURACY REDUCED AS CONC IS DISPROPORTIONATE TO SPIKE CONC.	MATRIX SPIKE: THE ACCURACY OF THE SPIKE RECOVERY VALUE IS REDUCED SINCE THE ANALYTE CONCENTRATION IN THE SAMPLE IS DISPROPORTIONATE TO SPIKE LEVEL. THE METHOD CONTROL SMPLE RECOV	ELAC		
M4	SPIKE - MATRIX SPIKE - CONC DILUTED BELOW REPORT LIMIT. METHOD CONTROL SAMPLE RECOVERY OK	MATRIX SPIKE: THE ANALYSIS OF THE SPIKED SAMPLE REQUIRED A DILUTION SUCH THAT THE SPIKE CONCENTRATION WAS DILUTED BELOW THE REPORTING LIMIT. THE METHOD CONTROL SAMPLE RECOVERY WA	ELAC		
M5	SPIKE - MATRIX SPIKE - ANALYTE CONC. DETERMINED BY THE	MATRIX SPIKE: ANALYTE CONCENTRATION WAS DETERMINED	ELAC		

Code	Short Name	Description	Type	Decision	For 303d List
	METHOD OF STANDARD ADDITION (MSA).	BY THE METHOD OF STANDARD ADDITION (MSA).			
M6	SPIKE - MATRIX SPIKE - RECOVERY WAS HIGH (ADEQ POLICY 0154).	MATRIX SPIKE: MATRIX SPIKE RECOVERY WAS HIGH. DATA REPORTED PER ADEQ POLICY 0154.000. MATRIX INTERFERENCE WAS CONFIRMED.	ELAC		No
M7	SPIKE - MATRIX SPIKE - RECOVERY WAS LOW (ADEQ POLICY 0154.000).	MATRIX SPIKE: MATRIX SPIKE RECOVERY WAS LOW. DATA REPORTED PER ADEQ POLICY 0154.000. MATRIX INTERFERENCE WAS CONFIRMED.	ELAC		No
MX1	ADEQ - MATRIX INTERFERENCE PRESENT FOR METALS	ADEQ - SERIAL DILUTION DETERMINED MATRIX INTERFERENCE WAS PRESENT FOR METAL ANALYTES	ADEQ		
MX2	ADEQ - MATRIX INTERFERENCE, ALL LAB CRITERIA MET	ADEQ - MATRIX INTERFERENCE WAS PRESENT, BUT LAB WAS ABLE TO COMPLETE THE ANALYSIS AND REPORT THE RESULT.	ADEQ		
N1	ANALYTE - SEE LAB CASE NARRATIVE.	SEE CASE NARRATIVE.	ELAC		
N2	ANALYTE - SEE LAB CORRECTIVE ACTION REPORT	SEE CORRECTIVE ACTION REPORT.	ELAC		
N3	METHOD - ALL METHOD REQUIREMENTS MET.	THE ANALYSIS MEETS ALL METHOD REQUIREMENTS. SEE CASE NARRATIVE. DELETED IN REVISION 4.0 9/5/12.	ELAC		
N4	THE MINIMUM REPORTING LIMIT VERIFICATION CHECK DID NOT MEET THE LABORATORY ACCEPTANCE LIMIT.	SV1	ELAC	Reject	No
N5	GENERAL - MINIMUM REPORTING LIMIT VERIFICATION CHECK DID NOT MEET THE METHOD ACCEPTANCE LIMIT.	GENERAL: THE MINIMUM REPORTING LIMIT (MRL) VERIFICATION CHECK DID NOT MEET THE METHOD ACCEPTANCE LIMIT.	ELAC	Reject	No
N6	GENERAL - DATA SUSPECT DUE TO QUALITY CONTROL FAILURE, REPORTED PER DATA USER'S REQUEST.	GENERAL: DATA SUSPECT DUE TO QUALITY CONTROL FAILURE, REPORTED PER DATA USER'S REQUEST.	ELAC	Reject	No
N7	GENERAL - ADDITIONAL ANALYSIS WAS NOT PERFORMED BASED ON THE "TOTAL" RESULT.	GENERAL: ADDITIONAL ANALYSIS WAS NOT PERFORMED BASED ON THE "TOTAL" RESULT WHICH WAS BELOW THE REQUESTED ANALYTE'S MCL/ACTION LEVEL/TRIGGER LEVEL.	ELAC		
Q1	QC - SAMPLE INTEGRITY WAS NOT MAINTAINED.	SAMPLE QUALITY: SAMPLE INTEGRITY WAS NOT MAINTAINED. SEE CASE NARRATIVE.	ELAC	Reject	No
Q10	QC - SAMPLE IN INAPPROPRIATE SAMPLE CONTAINER.	SAMPLE QUALITY: SAMPLE RECEIVED IN INAPPROPRIATE SAMPLE CONTAINER.	ELAC	Reject	No
Q11	QC - SAMPLE IS HETEROGENEOUS. SAMPLE HOMOGENEITY COULD NOT BE ACHIEVED.	SAMPLE QUALITY: SAMPLE IS METEROGENEOUS. SAMPLE HOMOGENEITY COULD NOT BE READILY ACHIEVED USING ROUTINE LABORATORY PRACTICES.	ELAC		No

Code	Short Name	Description	Type	Decision	For 303d List
Q2	QC - SAMPLE RECEIVED WITH HEAD SPACE.	SAMPLE QUALITY: SAMPLE RECEIVED WITH HEAD SPACE.	ELAC		
Q3	QC - SAMPLE RECEIVED WITH IMPROPER CHEMICAL PRESERVATION.	SAMPLE QUALITY: SAMPLE RECEIVED WITH IMPROPER CHEMICAL PRESERVATION.	ELAC	Reject	No
Q4	QC - SAMPLE RECEIVED AND ANALYZED WITHOUT CHEMICAL PRESERVATION.	SAMPLE QUALITY: SAMPLE RECEIVED AND ANALYZED WITHOUT CHEMICAL PRESERVATION	ELAC	Reject	No
Q5	QC - SAMPLE RECEIVED WITHOUT CHEM PRESERVATION,. PRESERVED BY THE LAB.	SAMPLE QUALITY: SAMPLE RECEIVED WITHOUT CHEMICAL PRESERVATION, BUT PRESERVED BY THE LABORATORY.	ELAC	Reject	No
Q6	QC - SAMPLE RECEIVED ABOVE RECOMMENDED TEMPERATURE.	SAMPLE QUALITY: SAMPLE WAS RECEIVED ABOVE RECOMMENDED TEMPERATURE.	ELAC		
Q7	QC - SAMPLE INADEQUATELY DECHLORINATED.	SAMPLE QUALITY: SAMPLE INADEQUATELY DECHLORINATED.	ELAC	Reject	No
Q8	QC - INSUFFICIENT SAMPLE TO MEET METHOD QC REQUIREMENTS, BUT BATCH QC REQUIREMENTS MET.	SAMPLE QUALITY: INSUFFICIENT SAMPLE RECEIVED TO MEET METHOD QC REQUIREMENTS. BATCH QC REQUIREMENTS SATISFY ADEQ POLICY 0154.000.	ELAC		
Q9	QC - INSUFFICIENT SAMPLE TO MEET METHOD QC REQUIREMENTS.	SAMPLE QUALITY: INSUFFICIENT SAMPLE RECEIVED TO MEET METHOD QC REQUIREMENTS.	ELAC		
QA-NFL	Not For 303(d) Listing	ADEQ - Not for 303(d) listing	ADEQ		No
QA-R	Reject Data	ADEQ - Data rejected due because acceptance criteria not met.	ADEQ	Reject	No
R1	DUPLICATES - RPD EXCEEDED THE METHOD CONTROL LIMIT.	DUPLICATES: RPD EXCEEDED THE METHOD CONTROL LIMIT. SEE CASE NARRATIVE.	ELAC	Reject	No
R11	DUPLICATES - THE RPD CALCULATION FOR MS/MSD NOT USEFUL DUE TO THE VARYING SAMPLE WEIGHTS.	DUPLICATES: THE RPD CALCULATION FOR MS/MSD DOES NOT PROVIDE USEFUL INFORMATION DUE TO THE VARYING SAMPLE WEIGHTS WHEN ENCORE SAMPLERS / METHANOL FIELD PRESERVED SAMPLES ARE USED.	ELAC		
R12	DUPLICATES - RPD/RSD EXCEEDED THE METHOD ACCEPTANCE LIMIT. RESULT LESS THAN 5 TIMES THE PQL.	DUPLICATES: RPD/RSD EXCEEDED THE METHOD ACCEPTANCE LIMIT. RESULT LESS THAN 5 TIMES THE PQL.	ELAC	Reject	No
R13	DUPLICATES - MS/MSD RPD EXCEEDED METHOD ACCEPTANCE LIMIT.	DUPLICATES: MS/MSD RPD EXCEEDED METHOD ACCEPTANCE LIMIT. MATRIX SPIKE RECOVERY WAS OUTSIDE ACCEPTANCE CRITERIA. BATCH PRECISION AND ACCURACY WERE DEMONSTRATED.	ELAC	Reject	No
R2	DUPLICATES - RPD EXCEEDED THE LAB CONTROL LIMIT	DUPLICATES: RPD EXCEEDED THE LABORATORY CONTROL LIMIT	ELAC	Reject	No
R4	DUPLICATES - RPD > METHOD CONTROL LIMIT, BUT RECOVERY MET ACCEPTANCE CRITERIA.	DUPLICATES: RPD EXCEEDED THE METHOD CONTROL LIMIT. RECOVERY MET ACCEPTANCE CRITERIA.	ELAC	Reject	No

Code	Short Name	Description	Type	Decision	For 303d List
R5	DUPLICATES - RPD > LAB CONTROL LIMIT, BUT RECOVERY MET ACCEPTANCE CRITERIA.	DUPLICATES: RPD EXCEEDED THE LABORATORY CONTROL LIMIT. RECOVERY MET ACCEPTANCE CRITERIA.	ELAC	Reject	No
R6	DUPLICATES - LFB/LFBD RPD > METHOD CONTROL LIMIT, BUT RECOVERY MET ACCEPTANCE CRITERIA.	DUPLICATES: LFB/LFBD RPD EXCEEDED THE METHOD CONTROL LIMIT. RECOVERY MET ACCEPTANCE CRITERIA.	ELAC	Reject	No
R7	DUPLICATES - LFB/LFBD RPD > LAB CONTROL LIMIT, BUT RECOVERY MET ACCEPTANCE CRITERIA.	DUPLICATES: LFB/LFBD RPD EXCEEDED THE LABORATORY CONTROL LIMIT. RECOVERY MET ACCEPTANCE CRITERIA.	ELAC	Reject	No
R8	DUPLICATES - SAMPLE RPD EXCEEDED THE METHOD ACCEPTANCE LIMIT.	DUPLICATES: SAMPLE RPD EXCEEDED THE METHOD ACCEPTANCE LIMIT.	ELAC	Reject	No
R9	DUPLICATES - SAMPLE RPD EXCEEDED THE LABORATORY ACCEPTANCE LIMIT.	DUPLICATES: SAMPLE RPD EXCEEDED THE LABORATORY ACCEPTANCE LIMIT.	ELAC	Reject	No
RPD	ADEQ - RPD EXCEEDED CRITERIA	ADEQ - RELATIVE PERCENT DIFFERENCE EXCEEDED CRITERIA	ADEQ	Reject	No
RR1	ADEQ - Rerun Result Confirmed	ADEQ - The lab confirmed the rerun analysis.	ADEQ		
RR2	ADEQ - Rerun different than original. Result ok.	ADEQ - Rerun value was different from the original result. Rerun value meets the QC criterion (such as %RPD, blank contamination, SM ratio, etc). Essentially DEQ agrees with the lab that the rerun result is acceptable.	ADEQ		
RR3	ADEQ - Rerun different than original. Not ok.	ADEQ - Rerun value was different from the original result. Rerun value does not meet the QC criterion (such as %RPD, blank contamination, SM ratio, etc). Essentially DEQ does not agree with the lab that the rerun result is acceptable.	ADEQ		
S1	SUR RECOV - ABOVE LAB ACCEPT LIMITS. METHOD ACCEPTANCE LIMITS OK.	SURROGATE: SURROGATE RECOVERY WAS ABOVE LABORATORY ACCEPTANCE LIMITS, BUT WITHIN METHOD ACCEPTANCE LIMITS.	ELAC		No
S10	SUR RECOV - WAS ABOVE LAB & METHOD ACCEPTANCE LIMITS.	SURROGATE: SURROGATE RECOVERY WAS ABOVE LABORATORY AND METHOD ACCEPTANCE LIMITS. SEE CASE MARRATIVE (NI).	ELAC		No
S11	SUR RECOV - WAS HIGH (ADEQ POLICY 0154.000).	SURROGATE: SURROGATE RECOVERY WAS HIGH. DATA REPORTED PER ADEQ POLICY 0154.000.	ELAC		No
S12	SUR RECOV - WAS LOW (ADEQ POLICY 0154.000).	SURROGATE: SURROGATE RECOVERY WAS LOW. DATA REPORTED PER ADEQ POLICY 0154.000.	ELAC		No
S3	SUR RECOV - ABOVE LAB ACCEPT LIMITS. METHOD ACCEPTANCE LIMITS OK. TARGET ANALYTE NOT DETECT	SURROGATE: SURROGATE RECOVERY WAS ABOVE LABORATORY ACCEPTANCE LIMITS, BUT WITHIN METHOD ACCEPTANCE LIMITS. NO TARGET ANALYTES WERE DETECTED IN THE SAMPLE.	ELAC		No

Code	Short Name	Description	Type	Decision	For 303d List
S4	SUR RECOV - ABOVE LAB AND METHOD ACCEPTANCE LIMITS. TARGET ANALYTES NOT DETECTED	SURROGATE: SURROGATE RECOVERY WAS ABOVE LABORATORY AND METHOD ACCEPTANCE LIMITS. NO TARGET ANALYTES WERE DETECTED IN THE SAMPLE.	ELAC		No
S5	SUR RECOV - BELOW LAB ACCEPTANCE LIMITS, BUT WITHIN METHOD ACCEPTANCE LIMITS.	SURROGATE: SURROGATE RECOVERY WAS BELOW LABORATORY ACCEPTANCE LIMITS, BUT WITHIN METHOD ACCEPTANCE LIMITS.	ELAC		No
S6	SUR RECOV - BELOW LAB & METHOD ACCEPT LIMITS. REANALYSIS LOW RECOV DUE MATRIX EFFECT	SURROGATE: SURROGATE RECOVERY WAS BELOW LABORATORY AND METHOD ACCEPTANCE LIMITS. REEXTRACTION AND/OR REANALYSIS CONFIRMS LOW RECOVERY CAUSED BY MATRIX EFFECT.	ELAC		
S7	SUR RECOV - BELOW LAB & METHOD ACCEPTANCE LIMITS. UNABLE TO CONFIRM MATRIX EFFECT.	SURROGATE: SURROGATE RECOVERY WAS BELOW LABORATORY AND METHOD ACCEPTANCE LIMITS. UNABLE TO CONFIRM MATRIX EFFECT.	ELAC		
S8	SUR RECOV - CALC NOT USEFUL DUE SAMPLE DILUTION. METHOD CONTROL SAMP RECOV ACCEPTABLE.	SURROGATE: THE ANALYSIS OF THE SAMPLE REQUIRED A DILUTION SUCH THAT THE SURROGATE RECOVERY CALCULATION DOES NOT PROVIDE ANY USEFUL INFORMATION. THE METHOD CONTROL SAMPLE RECOVE	ELAC		
SM1	ADEQ - F/L PH RATIO OUTSIDE IDEAL RANGE	ADEQ - QC RATIO OUTSIDE IDEAL RANGE - F/L PH	ADEQ		
SM2	ADEQ - F/L EC OUTSIDE IDEAL RANGE	ADEQ - QC RATIO OUTSIDE IDEAL RANGE - F/L EC	ADEQ		
SM3	ADEQ - TDS/EC OUTSIDE IDEAL RANGE	ADEQ - QC RATIO OUTSIDE IDEAL RANGE - TDS / EC	ADEQ		
SM4	ADEQ - TDS/CALC. SUM OUTSIDE IDEAL RANGE	ADEQ - QC RATIO OUTSIDE IDEAL RANGE - TDS / CALC. SUM	ADEQ		
SM5	ADEQ - CATION/ANION BALANCE OUTSIDE IDEAL RANGE	ADEQ - QC RATIO OUTSIDE IDEAL RANGE - CATION / ANION BALANCE	ADEQ		
SOP	ADEQ - DEVIATIONS FROM FIELD SOP	ADEQ - DEVIATIONS FROM STANDARD FIELD OPERATING PROCEDURES, ANALYTE-SPECIFIC	ADEQ		
T1	METHOD - APPROVED BY EPA, BUT NOT YET LICENCED BY ADHS.	METHOD/ANALYTE DISCREPANCIES: METHOD APPROVED BY EPA, BUT NOT YET LICENSED BY ADHS.	ELAC		
T2	METHOD - APPROVED METHOD, BUT ANALYTE NOT INCLUDED IN THE METHOD COUMPOUND LIST.	METHOD/ANALYTE DISCREPANCIES: CITED ADHS LICENSED METHOD DOES NOT CONTAIN THIS ANALYTE AS PART OF METHOD COUMPOUND LIST.	ELAC		
T3	METHOD - NOT PROMULGATED EITHER BY EPA OR ADHS.	METHOD/ANALYTE DISCREPANCIES: METHOD NOT PROMULGATED EITHER BY EPA OR ADHS.	ELAC		
T4	ESTIMATE - TENTATIVELY IDENTIFIED COMPOUND. CONCENTRATION ESTIMATED.	METHOD/ANALYTE DISCREPANCIES: TENTATIVELY IDENTIFIED COMPOUND. CONCENTRATION IS ESTIMATED AND BASED ON TEH CLOSEST INTERNAL STANDARD.	ELAC		

Code	Short Name	Description	Type	Decision	For 303d List
T5	METHOD - LABORATORY NOT LICENSED FOR THIS PARAMETER.	METHOD/ANALYTE DISCREPANCIES: LABORATORY NOT LICENSED FOR THIS PARAMETER.	ELAC		
T6	METHOD - THE REPORTED RESULT CANNOT BE USED FOR COMPLIANCE PURPOSES.	METHOD/ANALYTE DISCREPANCIES: THE REPORTED RESULT CANNOT BE USED FOR COMPLIANCE PURPOSES.	ELAC		
T7	METHOD - INCUBATOR/OVEN TEMPERATURES NOT MONITORED DURING ALL DAYS OF USE.	METHOD/ANALYTE DISCREPANCIES: INCUBATOR/OVEN TEMPERATURES WERE NOT MONITORED AS REQUIRED DURING ALL DAYS OF USE.	ELAC		
T8	METHOD - METHOD USED NOT LISTED IN 40 CFR 136; ALTERNATE METHOD CHOSEN PER PERMIT.	METHOD/ANALYTE DISCREPANCIES: METHOD USED NOT LISTED IN 40 CFR 136; ALTERNATE METHOD CHOSEN AS ACCEPTABLE PER PERMIT.	ELAC		
T9	METHOD - LESS THAN THE PRESCRIBED SAMPLE AMOUNT WAS AVAILABLE FOR THE LEACHATE EXTRACTION.	METHOD/ANALYTE DISCREPANCIES: LESS THAN THE PRESCRIBED SAMPLE AMOUNT WAS AVAILABLE TO PERFORM THE LEACHATE EXTRACTION. THE VOLUME OF EXTRACTION FLUID WAS ADJUSTED PROPORTIONATELY BASED ON THE METHOD PRESCRIBED RATIO OF EXTRACTION FLUID TO SAMPLE WEIGHT.	ELAC		
V1	CALIBRATION - RECOV ABOVE METHOD ACCEPT LIMITS. TARGET ANALYTE NOT DETECTED.	CALIBRATION VERIFICATION: CCV RECOVERY WAS ABOVE METHOD ACCEPTANCE LIMITS. THIS TARGET ANALYTE WAS NOT DETECTED IN THE SAMPLE.	ELAC		
V2	CALIBRATION - RECOV ABOVE METHOD ACCEPT LIMITS. ANALYTE DET. INSUFFICIENT SAMPLE 2 CONFIRM	CALIBRATION VERIFICATION: CCV RECOVERY WAS ABOVE METHOD ACCEPTANCE LIMITS. THIS TARGET ANALYRTE WAS DETECTED IN THE SAMPLE. THE SAMPLE COULD NOT BE REANALYZED DUE TO INSUFICIENT	ELAC		
V3	CALIBRATION - RECOV ABOVE METHOD ACCEPT LIMITS. ANALYTE DET. SAMPLE NOT REANALYZED.	CALIBRATION VERIFICATION: CCV RECOVERY WAS ABOVE METHOD ACCEPTANCE LIMITS. THIS TARGET ANALYTE WAS DETECTED IN THE SAMPLE, BUT THE SAMPLE WAS NOT REANALYZED. SEE CASE NARRATIVE.	ELAC		
V5	CALIBRATION - RECOV AFTER GROUP OF SAMPLES ABOVE ACCEPT LIMITS. TARGET ANALYTE NOT DET.	CALIBRATION VERIFICATION: CCV RECOVERY AFTER A GROUP OF SAMPLES WAS ABOVE ACCEPTANCE LIMITS. THIS TARGET ANALYTE WAS NOT DETECTED IN THE SAMPLE. ACCEPTABLE PER PEA METHOD 8000B.	ELAC		
V6	CALIBRATION - DATA FROM ONE-POINT CALIBRATION CRITERIA	CALIBRATION VERIFICATION: DATA REPORTED FROM ONE-POINT CALIBRATION CRITERIA.	ELAC		
V9	CALIBRATION VERIFICATION: CCV RECOVERY WAS BELOW METHOD ACCEPTANCE LIMITS.	CALIBRATION VERIFICATION: CCV RECOVERY WAS BELOW METHOD ACCEPTANCE LIMITS.	ELAC		

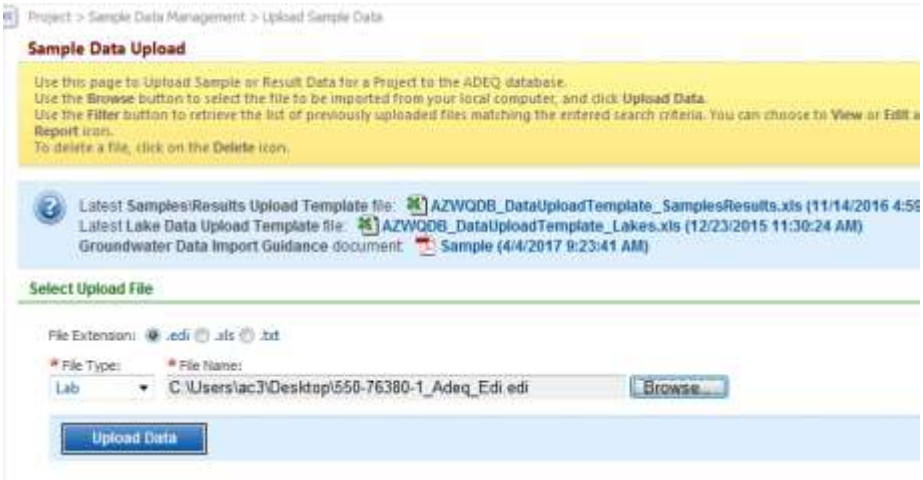
TABLE 10.4 ADEQ Laboratory data qualifiers. Only 'actively' used qualifiers are listed. The type column includes Arizona approved qualifiers from the Environmental Laboratory Advisory Committee (ELAC) and also qualifiers that ADEQ uses internally.

10.2.4 UPLOADING LAB DATA

10.2.4.1 EDI Upload Process

EDI files are directly uploaded to the database by the lab. Samplers should get an email notifying them that their results are in. Once notified complete the following steps to upload an EDI file.

1. Click on Upload Sample/Result Data on the side navigation bar. (For Test America data, find your file on the Uploaded File List, and skip to step 5)
2. Click on Browse and find the EDI file.
3. Click Upload Data

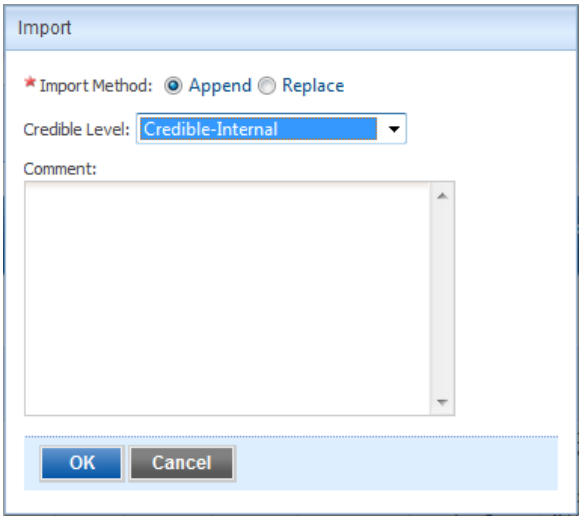


4. If you encounter errors and are unsure what to do, contact the system administrator. You'll see the Upload Successful message if the upload was successful.

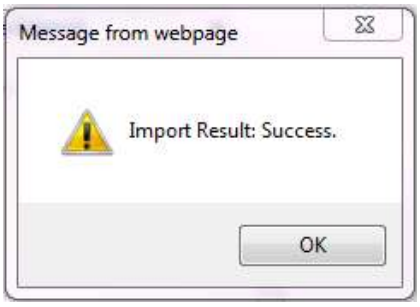
Known Issue: If you receive the following unique constraint error, just ignore it and click on Upload Data again.

5. Click 'Import to Live'.
6. Accept the default option selected for "Append".
7. Select Credible-Internal and hit OK.

Note all data collected by ADEQ should be credible internal. When you pick credible for the lab data, the field data for the same sample is associated as 'credible internal' as well. Do not change the 'credible' status by parameter. If you have bad data use the reject and other qualifiers/quality assurance flags.



8. You should receive this message when the file was imported successfully. If not, contact the system administrator.



10.2.4.2 Excel Upload Process

1. Process the Excel file received from the lab (add missing values and rename worksheet to Sheet1).
2. Click on Upload Sample/Result Data on the side navigation bar.
3. Click on the radio button for ".xls"
4. Select Business Process, Program Area, Project, and Trip
5. For File Type, select SW Chem from the drop down list
6. Click on Browse and select the Excel EDD file.
7. Click on Upload Data
8. If you encounter errors and are unsure what to do, contact the system administrator. You'll see the Upload Successful message if the upload was successful.
9. Click on the "Import to Live" icon for your file.
10. Accept the default option selected for "Append".

11. Select Credible-Internal and hit OK.
12. Update Lab analysis data set information: Date/Time Received from Lab and Date Report Prepared by Lab as well as Lab Job #.

Excel (SW Chem) files should be uploaded by trained staff since it requires data processing prior to upload.

10.2.5 DATA QUALITY ASSURANCE AND QUALITY CONTROL CHECKS

Quality assurance is achieved by a myriad of activites, described in the Surface Water Quality Assurance Program Plan (ADEQ, 2015). A large portion of the QAPP focuses on checking field and lab data quality before 'approving' the data for use in the Clean Water Act Assessment and by the public.

ADEQ has automated much of the quality assurance review process, which includes:

- Checking for exceedances
- Comparing regular samples to splits and duplicates
- Determining if field blanks are clean
- Determine if standard method checks are within acceptable limits

Staff will still need to do the following checks which will be outlined in detail in this section using the Quality Control Checklist in Appendix A.

- Verify that the automated checks for exceedances, duplicates/splits, and blanks are working correctly
- Manually check exceedances that are not yet automatically calculated by the WQDB such as site specific nutrients.
- Verify that lab data and field data were imported correctly with appropriate qualifiers
- Add event codes, QA flags and descriptive information to explain the data to a third parties
- Review the lab quality control data package

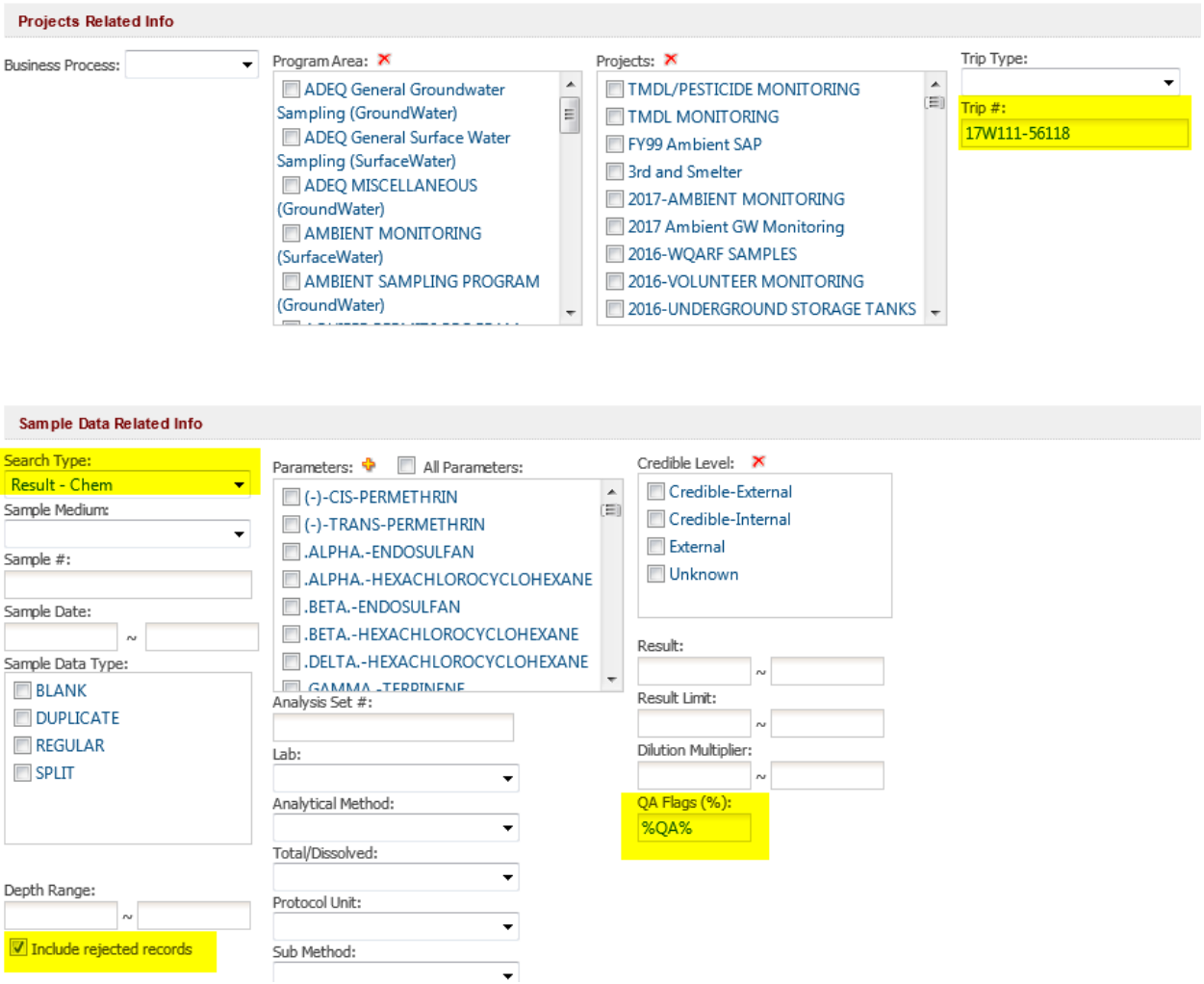
10.2.5.1 Run the Automated Quality Assurance Flagging

1. Click on Schedule Trips on the side navigation bar
2. Select Business Process, Program Area and Project and hit Load
3. Click on the Edit icon next to your trip
4. Click on Run QA Flagging Process
5. You should receive a "SUCCESS!" message

Results for almost every parameter is automatically compared against <u>almost all</u> standards for each designated use. The WQDB does not calculate every exceedance. Currently statistical standards (geomeans for example), site specific standards and ammonia are not automatically calculated.

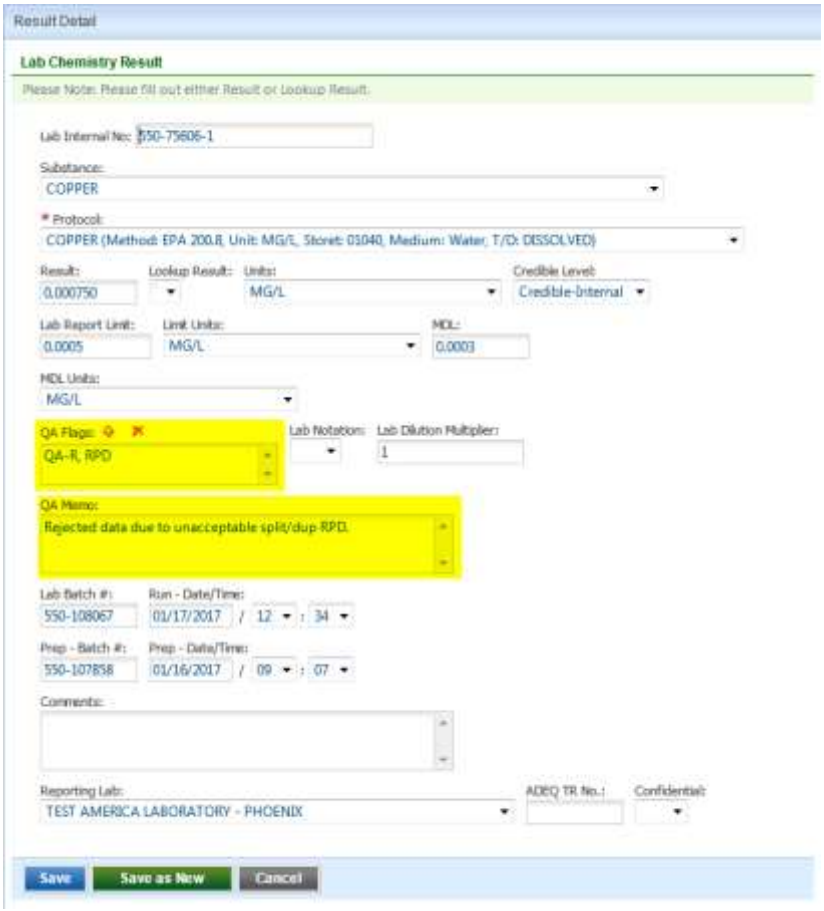
In order for ammonia standards to be calculated, the pH and temperature measurements must be in the same sample as the ammonia result. For lakes, check ammonia exceedances manually if field data were uploaded into separate samples.

6. You can review QA flags on the All Trip Data tab.
   a. Click on the All Trip Data tab.
   b. For "Contain QA Flag", select "Yes" from the drop down list and click on the Filter button.
   c. Review each flag carefully.



- Manually update/delete/add QA flags in the Data Entry section if QA flags need added or changed.
- If you need to clear many QA flags, contact an administrator (currently Aiko, Jason, Jade).
- Where the DB adds an FB3 qualifier, but your sample results are ND, then remove the FB3 and QA-R and add a comment that data is OK for Assessment.

Add QA comments to the Comment box, not the QA Memo box. QA memo is used for auto-generated comments by the QA flagging procedure and will not be exported to WQX or used in assessments.



10.2.5.2 Determine and Report Surface Water Quality Standard Exceedances

Field and Lab water quality data should be reviewed and compared to surface water quality standards as soon as practical to determine whether there are any exceedances of surface water quality standards. A "Notice of Exceedance Letter" should be prepared and sent to the Director of the County Health Department of the county where the sampling site is located, the property owner, and ADEQ managers as soon as possible to notify when human health standards have been exceeded. The "Notice of Exceedance" form letter is found at: J:\WQD\Surface Water Section\Monitoring Unit\Forms and Letters\Exceedance Letters.

Do not send notices to the County Health Director when the exceedance is for a water quality standard to protect aquatic life.

Call the property owner and county health department if there is an exceedance of a standard that is an immediate human health concern such as high *E. coli* values in a highly recreated waterbody. Calls should be placed as soon as you receive/read the results. Use best professional judgement to determine if a site is highly recreated enough

and if the value warrants immediate contact with the land owner and county health department.

Procedure to determine if there has been a Surface Water Quality Exceedance

1. Exceedances are automatically identified with a EXE QA flag after running the QA flagging process (See section 10.2.5.1).
2. If an exceedance is of a surface water quality standard intended to protect human health (i.e., the domestic water source (DWS), fish consumption (FC), full body contact recreation (FBC) or the partial body contact recreation (PBC) designated uses) a Notice of Exceedance letter should be prepared and sent to the Director of the County Health Department of the county where the sampling site is located and the property owner. Add a comment in the letter for exceedances that are due to "natural background" causes or storm events. If the exceedance occurred at a site that is with-in one mile of an AZPDES outfall, the exceedance letter should also be sent to ADEQ compliance (koester.andy@azdeq.gov). A list of the sites that are with-in one mile of an outfall are listed at J:*WQD**Surface Water Section**SAMPLING**2016_azpdes*.
3. File a copy of the Notice of Exceedance in the site file and Unit reading file (FIGURE 10.3). Add the event "Exceedance at Time of Sampling" to the sample page for E.coli, pH or DO exceedances in the WQDB.

Surface water quality standards are located in Title 18, Chapter 11, Article 1 of the Arizona Administrative Code (A.A.C.). Standards are available on the internet at http://www.azsos.gov/public_services/Table_of_Contents.htm.

NOTE TO STAFF: PLEASE COPY THE FOLLOWING TEXT INTO THE CURRENT LETTERHEAD TEMPLATE in WORD, WHICH CONTAINS OUR CURRENT DIRECTOR AND GOVERNOR'S NAMES, THEN COMPLETE IT WITH YOUR TEST RESULTS PER THE SOP.

February 1, 2018

[To]
[Agency]
[Address]
[City, State, Zip]

RE: NOTIFICATION OF EXCEEDANCE; STATE SURFACE WATER QUALITY STANDARDS

Dear [Salutation]:

This letter is to notify your office that the ADEQ Monitoring Unit collected a surface water sample that is exceeding water quality standards from [Monitoring Site Name (SITEID)] on [Sample date] as part of our routine ambient monitoring program. Analyses determined the limit(s) for State Surface Water Quality Standards (Arizona Administrative Code Title 18 Chapter 11) were exceeded as follows:

Water Quality Parameter	State Limit	Reported Value	Reporting Lab	Comment

All other surface water parameters were meeting standards. All surface water sample results are available on request. Feel free to call me should you have any questions at 602-771-XXXX.

Sincerely,

Your Name Here,
Surface Water Quality Specialist
Monitoring & Assessment Unit

cc: Krista Osterberg, Section Manager, Surface Water Section
Richard Gay, Supervisor, Monitoring & Assessment Unit
Jade Dickens, Manager, Watershed Protection Unit
[Applicable County Health Department]

Main Office
1110 W. Washington Street • Phoenix, AZ 85007
(602) 771-2300

Southern Regional Office
400 W. Congress Street • Suite 433 • Tucson, AZ 85701
(520) 628-6733

www.azdeq.gov
printed on recycled paper

FIGURE 10.3. Notice of Exceedance.

10.2.5.3 Compare Results from Split and Duplicate Samples

In general, acceptable relative percent difference between split or duplicate samples is 20 % or less if the value of the results of the duplicate samples are greater than 2 times the method reporting limit (MRL). Values at or near the detection limit may have a RPD greater than 20% and still be acceptable.

Exceptions:

- Do not use RPD for *E. Coli* duplicates. See Section 4.1.3.2 for instructions on determining if duplicate results are acceptable.
- Trace metals,

- Analytes whose averages are less than two times the MRL, and
- Splits/duplicates where one result is reported as a non-detect and the other value is above the detection limit.

Precision for split and duplicate samples is determined by calculating a Relative Percent Difference (RPD), or coefficient of variation, of the duplicate samples. The smaller the RPD, the more precise the measurement is. The relative percent difference is calculated using the following equation:

$$RPD = \frac{(X_1 - X_2)}{(X_1 + X_2)/2} \times 100$$

Where X1 is the larger of the two values and X2 is the smaller of the two values.

The trace metal values are reported in µg/L and are generally small. Therefore, a slight variation in numbers may cause a one-hundred percent difference which would be non-indicative of a real problem. A five-hundred percent difference may be more indicative of a true problem. Use professional judgment.

Analytes close to the detection limit are also more likely to show a large percentage difference when the absolute magnitude of the difference is small. In these cases, the 20% rule of thumb should be disregarded.

Where one duplicate or split is reported as a non-detect, and the other a value above the detection limit, ADEQ has adopted the ADHS protocol of acceptance of the duplicate or split results if the reported value in such a case is less than two times the detection limit.

As discussed above, a much larger variation is acceptable when working with trace metals, analytes whose averages are less than two times the detection level, and splits or duplicates where one is reported as a non-detect.

Rerun the duplicate/split and regular sample if the results have widely-differing results.

Procedure to determine if Duplicates or Splits are within Acceptable Limits

1. Run the QA Flagging process to automatically flag unacceptable data due to relative percent difference (See Section 10.2.5.1). The database will also flag/reject all parameters within the same trip.
2. Make sure the database also automatically rejected the data with the QA-R flag.

10.2.5.4 Determine if Field Blanks were "Clean."

Field blanks are used to confirm that lab and field process are not introducing contaminants into the sample. Blanks should not have detections of any parameter excluding detectable parameters like TDS, pH and conductivity.

Procedure to determine if Blanks are Clean

1. Run the QA Flagging process to automatically flag data with blank contamination (See Section 10.2.5.1). The database will also flag all parameters within the same trip.
2. The database will apply the following qualifiers to the data.
   - FB1 – The test result is non-detect for the parameter found in the field blank. The data is not impacted
   - FB2 – There is a numeric test result and the field blank has contamination at levels between the Method Detection Limit (MDL) and the Method Reporting Limit (MRL).
   - FB3 –There is a numeric test result and the field blank contamination is greater than the MRL; data is rejected.
3. Make sure the database also automatically rejected the data with the QA-R flag.

10.2.5.5 Standard Methods Quality Control Ratios

The WQDB uses five different quality control tests adopted from the Standard Methods for the Examination of Wastewater to identify potential problems with data. The QA flagging process automatically determines if each of the five standard method quality control ratio tests are met. Each is identified with a qualifier of SM1 to SM5. Unlike the previous checks these test are more informational and should not be used to reject data by themselves.

What to do when a ratio or balance is outside the "acceptable" value

- Check to be sure that all the parameters needed to run the QC check are present.
- Check historic ratios at this site to determine if the ratio is normal for this site. Long-term sites have a compilation sheet showing historic QC values in the site file. Refer to the sheet for a determination of historic trend data.
- Check to see if the sample was collected under unusual conditions (i.e. flood, drought, incoming pollutants, high algae content, etc). This can potentially throw ion balances out of the acceptable range.
- For the TDS/Conductivity ratio check bicarbonate and sulfate values to see if they are exceedingly high or low compared to past data at the site.
- Calculate the values by hand and see if the WQDB report is reporting the right value.

Lab and Field pH Ratio (QA Flag SM1)

The ratio between the field pH and lab pH = field pH ÷ lab pH

- Unacceptable Below 0.90
- Qualified Between 0.90 to 0.95
- Acceptable Between 0.95 to 1.05
- Qualified Between 1.05 to 1.10
- Unacceptable Above 1.10

For example, if the field pH is 7.6 and the Lab pH is 7.1, then the ration is 7.6 ÷ 7.1 = 1.07. This ratio is within the qualified range. The pH values should be investigated more closely, as a difference of 0.5 standard units represents a sizable shift in the acidic-basic character of the water. Further investigation is advised.

Effluent dominated waters, industrial sewage, and other highly polluted samples will have more problems with the pH ratio than ambient water samples. The pH of a sample may change very rapidly if the sample contains large amounts of algae, microbes or air bubbles. Over-zealous churning of the churn splitter can also cause a change in pH by aerating a sample that may have been anaerobic when field measurements were taken. Floods or drought have little negative impact on this QA/QC ratio.

Lab and Field Specific Conductivity Ratio (QA Flag SM2)

The ratio between the field and lab specific conductivity = field conductivity ÷ lab conductivity.

- Unacceptable Below 0.90
- Acceptable Between 0.90 and 1.10
- Unacceptable Above 1.10

TDS and Specific Conductivity Ratio (QA Flag SM3)

The TDS and Specific Conductivity Ratio = lab TDS ÷ lab conductivity. This ratio should range from 0.55 to 0.75 (Hem, 1998). The reason this ratio is not equal to 1.0 is that some constituents that are reflected in the lab EC are not detected in the lab TDS.

For example, if TDS is 388 and lab EC is 439, the ratio is 388 ÷ 439 = 0.88. Since the acceptable range is between 0.55 to 0.75, this value is not acceptable without additional investigation.

Some ambient waters in the state will consistently have values that fall outside this ratio. This is acceptable if the trend is established and obvious as observed in historic sample results.

TDS and Calculated Sum of Constituent Ratios (QA Flag SM4)

The TDS and calculated sum of constituent ratios = lab TDS ÷ the sum of the major constituents (lab values for Ca, Mg, Na, K, SO_4, F, NO_3+NO_2 and Cl in mg/L plus total alkalinity as $CaCO_3$ at 0.6 times its reported value). An acceptable ratio is 1.0 to 1.2.

For example:
The sum of Ca+Mg+Na+K+F+(NO_2+NO_3) +SO_4+Cl = 108.5 mg/L,
Hardness as $CaCO_3$ = 350 mg/L
Sum of major constituents = 108.5 + (0.6 * 350) = 318.5
TDS = 388
Therefore the ratio is 388 ÷ 318.5 = 1.2

This value falls at the limit of the range and is acceptable.

Cation and Anion Balance (QA Flag SM5)

The sum of five major cations should be roughly equivalent to the sum of six major anions in a sample, when measured in milliequivalents per liter (meq/L).

Cations: calcium, magnesium, sodium, potassium, and ammonia.

Anions: fluoride, carbonate, bicarbonate, sulfate, chloride, and nitrate-nitrite.

The cation/anion values are converted from mg/L (milligrams per liter) to meq/L by using the following conversion factors obtained from Standard Methods for the Examination of Water and Wastewater - 20th Edition.

Standard Methods outlines the following acceptance criteria for ion balance calculations:

Anion Sum (meq/l)	Acceptable Difference
0 - 3.0 meq	+/- 0.2 meq/l (Absolute Difference)
3.0 - 10.0	+/- 2% (Percent Difference)
10.0 – 800	+/- 5% (Percent Difference)

TABLE 10.6. Acceptable differences for cation/anion ratios.

10.2.5.6 Errors & Completeness

Compare the data entered to the hard copy files to be sure that the entries are accurate and complete. Contact the lab to verify data if necessary. Check to make sure that all parameters and all sites requested by the lab are present in the laboratory data submittal.

Data review includes checking that:

- Sample times and dates are formatted correctly and lab and field data match (date, time, sites).
- Lab data are complete and no tests are missing.
- Correct decimal placement.
- No missing data.
- No erroneous values.
- All pertinent field comments were entered, using appropriate event codes and comments.
- All pertinent lab comments were entered, using appropriate lab data qualifiers.
- Appropriate "lab notations" were used and lab reporting limits and units were provided.
- Compared to prior records, no unusual or dubious data.
- Field measurements that are not representative of surface water conditions.
- Field measurements on equipment that was not functioning properly.

Dubious or questionable data values are more easily identified when the data reviewer has familiarity with past analytical results from the sample site. All results are scrutinized and any dubious or questionable values that are found are tracked back to the lab or field sheets for possible transcription errors or misreported values. Conversations with laboratory personnel may be necessary to resolve the problem.

Review field measurements collected with equipment that was not functioning properly or didn't field calibrate. Adding a comment that the equipment was not functioning properly is not adequate if the standards were not met. You reject this data with the QA-R flag and add a comment.

When the pH or dissolved oxygen probes will not calibrate in the field, be sure to apply the "E3" data qualifier (Concentration estimated. Analyte exceeded calibration range) when entering the results into the WQDB.

In select cases, where unusual values are present have the test rerun. Keep a written record of any values or comments that need further verification on the QC checklist. You will need to follow up on these items before the review is complete. Keeping and rejecting data requires best professional judgment. Recognize that such decisions will affect other programs and agencies that depend on our quality data.

10.2.5.7 Review of Lab QC Data Package / Lab Internal QC

Lab reports have a section for quality control to demonstrate that the various checks that the lab performs to ensure that ADEQ receives quality data (FIGURE 10.4).

Labs do not typically send results that do not meet their own internal checks.

Samplers need to check the QC Sample Result Section to verify there are not qualifiers that would limit the use of the data. The case narrative should explain when data is acceptable or not. Contact the lab if you are unsure about the meaning of a particular qualifier in this section.

QC Sample Results

Client: Arizona Dept of Environmental Quality
Project/Site: 17W446-75-109-2017

TestAmerica Job ID: 550-88578-1
SDG: ADEQ - Streams

Method: SM 2320B - Alkalinity

Lab Sample ID: MB 550-125992/7
Matrix: Water
Analysis Batch: 125992

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Alkalinity as CaCO3	ND		6.0		mg/L			08/28/17 11:20	1
Bicarbonate Alkalinity as CaCO3	ND		6.0		mg/L			08/28/17 11:20	1
Carbonate Alkalinity as CaCO3	ND		6.0		mg/L			08/28/17 11:20	1
Alkalinity, Phenolphthalein	ND		6.0		mg/L			08/28/17 11:20	1
Hydroxide Alkalinity as CaCO3	ND		6.0		mg/L			08/28/17 11:20	1

Lab Sample ID: LCS 550-125992/6
Matrix: Water
Analysis Batch: 125992

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Alkalinity as CaCO3			250	254		mg/L		102	90 - 110		

Lab Sample ID: LCSD 550-125992/20
Matrix: Water
Analysis Batch: 125992

Client Sample ID: Lab Control Sample Dup
Prep Type: Total/NA

Analyte			Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Alkalinity as CaCO3			250	256		mg/L		102	90 - 110	1	20

Lab Sample ID: 550-88469-A-2 DU
Matrix: Water
Analysis Batch: 125992

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Alkalinity as CaCO3	39			39.7		mg/L				1	20
Bicarbonate Alkalinity as CaCO3	39			39.7		mg/L				1	20
Carbonate Alkalinity as CaCO3	ND			ND		mg/L				NC	20
Alkalinity, Phenolphthalein	ND			ND		mg/L				NC	20
Hydroxide Alkalinity as CaCO3	ND			ND		mg/L				NC	20

Method: SM 2510B - Conductivity, Specific Conductance

Lab Sample ID: MB 550-125993/7
Matrix: Water
Analysis Batch: 125993

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Specific Conductance	ND		2.0		umhos/cm			08/28/17 11:20	1

Lab Sample ID: LCS 550-125993/5
Matrix: Water
Analysis Batch: 125993

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Specific Conductance			1000	986		umhos/cm		98	90 - 110		

TestAmerica Phoenix

Page 18 of 36

9/19/2017 (Rev. 1)

FIGURE 10.4. Example page from the lab QC sample results.

10.2.5.8 What to Do with Rerun Data

It is the lead sampler's responsibility to decide if a sample need to be rerun or not. Instances where a sample might need to be rerun include:

- High RPD between regular and duplicate samples
- Contamination in blank
- Out of range QC ratios (does not automatically warrant a rerun; use best professional judgement)
- Data that is unusually high or low for a particular site.

Reruns are tracked using QA Flags. These can be added under the 'Sample Result Data Entry' form under the 'lab' or 'field' tabs.

- **RR1 -** If the lab confirms the original data, add a RR1 qualifier to the original record (Result value confirmed by rerun analysis). Don't add the rerun result to the database.
- **RR2 -** If the rerun value is different from the original value and meets the QC criterion, reject the original record with a QA-R qualifier and add your comment in the QA Memo box. Add the rerun record with a RR2 qualifier in the database (Rerun value was different from the original result. Rerun value meets the QC criterion).
- **RR3 -** If the rerun value is different from the original value and still does not meet the QC criterion, add a RR3 qualifier to the original record (Result value could not be confirmed by rerun analysis. Rerun value is not acceptable). Don't add the rerun result to the database.
- Remember you may need to update qualifiers for other samples in your trip (field dup, blank and split apply to all samples in a trip).

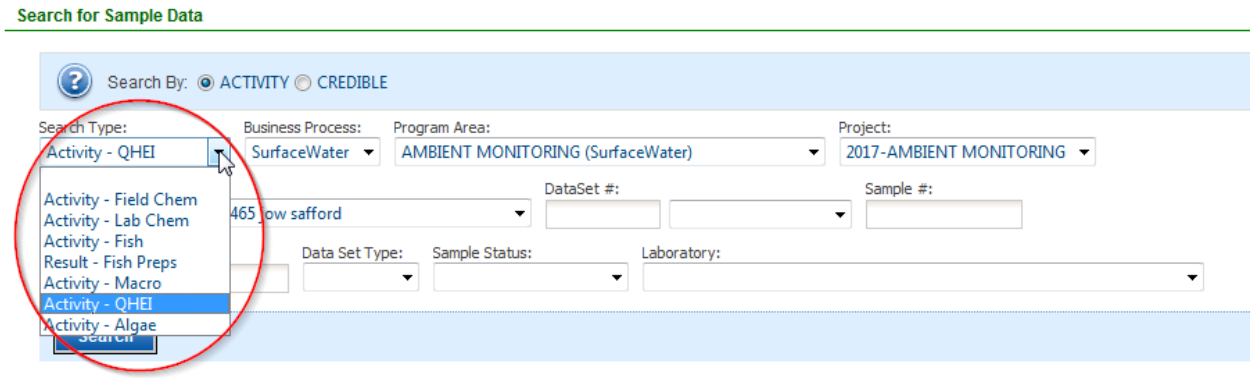
10.2.6 DATA APPROVAL

Clicking the approval button is a statement by the reviewer that the data is ready to be sent on to WQX, used for assessments, listing decisions, or TMDL development. Clicking the approve button also means the following:

- The data has been checked for exceedances.
- The data has been reviewed for errors, omissions and dubious or unusual data
- Results from duplicates and splits were compared.
- Results from blanks were assessed.
- The QA flagging was run
- All the appropriate EVENTS and QA Flags have been added.

Approving data means that the sampler believes that the data quality is sound and ready for the public to view.

1. Click on Review Sample Data on the side navigation bar
2. Select Business Process, Program Area, Project and Trip (may be slow to load trip #s) and hit Search **If you have more than one media type, you can use the Search Type box to choose between Lab and Field Chem, Fish Preps, Fish Prep Chem, QHEI (Habitat), Macro and Algae.



3. Click on the Edit icon next to the sample you want to approve, or on the Batch Update Status button
4. In the Popup window, select "Approved" from the drop down list and click Save.

To un-approve data, select another status (e.g., Imported) from the drop down list. Indicate why you are unapproving the data using the comments box.

If you select "Rejected", the data will be excluded from the query, WQX and assessment.

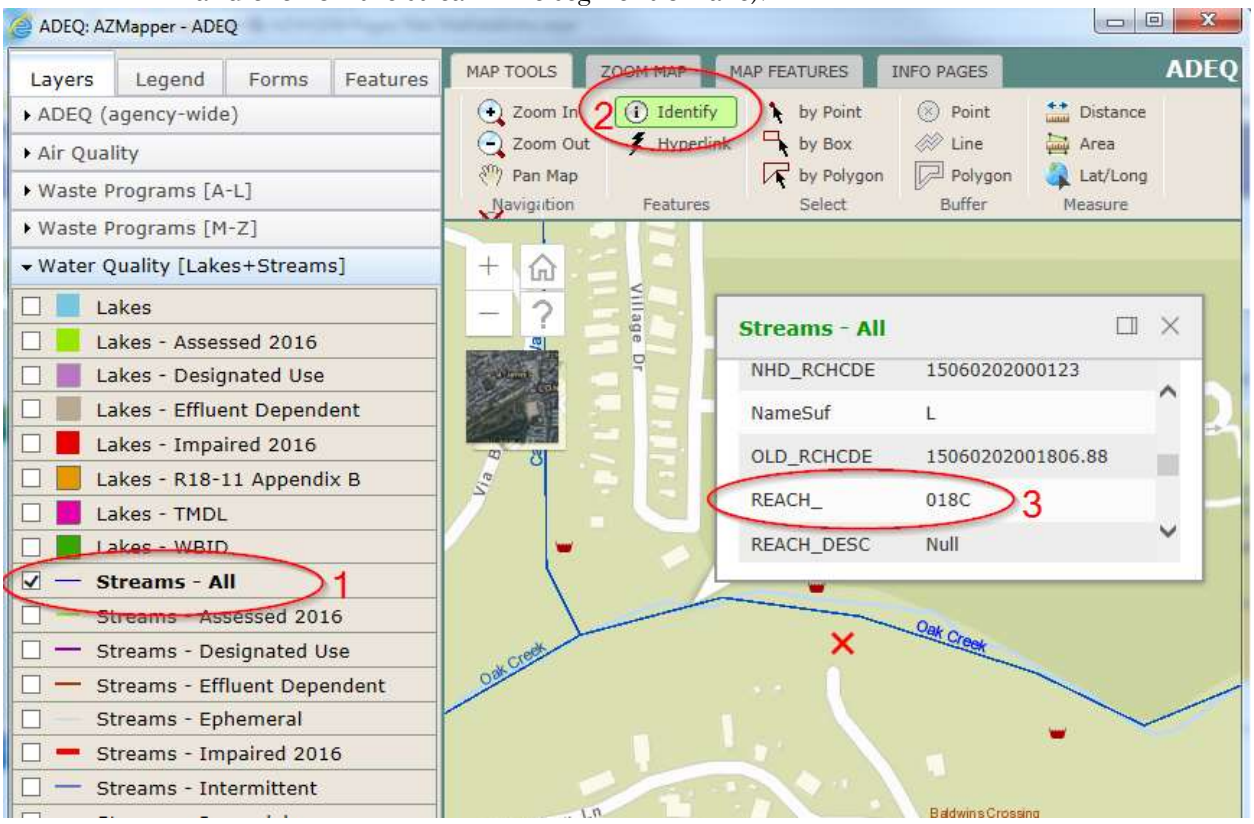
Use the comments note to identify why approval out of range (ex. waiting on SSC from a different lab).

10.3 CREATING NEW SITES

A new site should be established when it is hydrologically distinct from existing sites. In general, a new site can be created if it is more than 200 meters or 660 feet apart from an existing site on a stream. Sites can be less than 200 meters apart if they are established to characterize the effect of an intervening tributary, outfall or other pollution source, or significant hydrographic or hydrologic change. The database has a site proximity check, which runs automatically when you try to save a new site and lets you know if there are any existing sites within 660 feet of the new site.

Use the 200 meter rule with a best professional judgement when creating a new site. Data aggregation in assessment is based on the assumption that all sites are spatially independent in the database.

1. Click on Manage Sites on the side navigation bar
2. Click on Create New Site
3. Skip Site ID and DEQ Site Number and fill in the rest of Site Type and Coordinates section.
   a. Required fields are indicated by *.
   b. Don't forget to type in "-" for longitude, as all western hemisphere longitudes in the database are negative numbers.
   c. Site Name – The convention is to include the waterbody name followed by "–" and site location, e.g., Oak Creek – Below Red Rock Crossing.
4. Add Monitoring Point Distance (add site location for Lake; e.g., –A)
   a. If stream, click on Map it to start AZMapper (click OK on the pop-up window)
   b. On AZMapper, under Forms, select River Miles. Click Find Streams. Enter the value next to "Along Stream to Mouth" into the Monitoring Point Distance box (14.6 miles should be entered as 014.60). The River Mile tool reports mileages both ways (to headwaters and mouth), so ensure you've selected the correct one.
5. Fill in the Other Information section.
   a. DEQ number, Basin, County, HUC, and Watershed will be automatically populated when you save site.
   b. The reach number/lake number is also required. You can obtain the number in AZMapper (Activate the Stream-All or Lake layer, click on Identify under Map Tools, and click on the stream line segment or lake).



6. Click Save Site to auto-fill DEQ number, Basin, County, HUC, and Watershed.

a. If a site proximity check finds any existing site(s) within 660 feet, make a best professional judgement as to whether to proceed with the new site creation or to use the existing site.

7. Click Generate Site ID (see notes below) for stream sites. Lakes and canal sites should be manually entered for now according to established protocols. Check the Site ID generated carefully to ensure it adheres to the correct format (Mileages should always be reported to 5 digits including 2 decimal places for streams in the site ID code). If incorrectly generated, make necessary manual corrections before saving.
8. Click Save Site again to save Site ID
9. Exit the screen (click on Back to Site List)
10. Click on Edit icon next to your newly created site. Scroll down to the Designated Uses section and make sure Origin, Terminus, Designated Uses are populated.

10.3.2 HOW SITES ARE NAMED

The Site Identification Number (a.k.a. SITEID) is also used to identify a site. It has a distinct advantage over the DEQ number by using a naming convention that describes a particular site. Lake and stream sites are each identified a little differently.

10.3.2.1 Stream Code Abbreviations

Each surface water code abbreviation is unique within the watershed and within the surface water type. For instance, "RED" can only be used for one stream in the Bill Williams Watershed. However, RED could also be used for a lake in the Bill Williams, and RED could be used for another stream in the Santa Cruz Watershed.

If the site is on a stream or canal, the monitoring point is the "river mile" distance calculated from the streams mouth point (confluence with another stream or lake) up to the monitoring site, measured in miles. The river miles are shown as a 5-digit number with a decimal point to 100ths (e.g., 001.32).

A stream site code contains a numeric river mile, along with the watershed and stream code. For example: VREVR012.21, is the East Verde River at 12.21 miles upstream from its confluence with the Verde River.

The three letter stream code is primarily derived from the first three letters of the name, except as stated below or to avoid duplications (e.g., Aluminum Creek might be ALU)

- The third letter is dedicated for the following stream names endings
  - C is dedicated to names ending in "Canyon." It is not used for names ending in Creek (e.g., Chevelon Canyon = CHC) (C is also used for canals, see canal abbreviations below)
  - W is dedicated to names ending in "Wash" (Indian Bend Wash = IBW);
  - R is dedicated to names ending in "River" or "Run" (e.g., San Pedro River = SPR)
  - G is dedicated to names ending in "Gulch" (e.g., Alum Gulch = ALG);
  - S is dedicated to names ending in "Spring" (e.g., Tontozona Spring = TOS)
- Use only the first letter of a common name (East, San, Little) (e.g., East Clear Creek = ECL)

- Ignore the word "Fork" (e.g., East Fork Black River = EBR)
- Use first letters of each word if three or more words (e.g., Copper Camp Wash = CCW)
- Use the number in the name (e.g., 3-Mile Creek = 3MI)

Unnamed Streams – These are assigned codes on an as-needed basis (when sampling sites).

- The first code is always a "U" for unnamed stream.
- The next two letters are taken from the first two code letter used for the stream or lake it is draining to.
- If unnamed tributary to an unnamed tributary, use "UU" and then a letter for the stream or lake it is draining into.

For example: If Bitter Creek's code is BTR, then the first unnamed tributary would be UBT. The next unnamed tributary would be UB1, then UB2, etc. If samples are collected on an unnamed tributary to an unnamed tributary to Bitter Creek, the code would be UUB.

Duplicate Codes – If the abbreviation is already used for a stream within the watershed, do the following in order, until a unique code is derived:

- Use the next consonant until all consonants in the name have been used,
- Use the next vowel until all vowels in the name have been used,
- Use a number

For example, multiple unnamed tributaries to Pinto Creek became: UP1, UP2, UP3, UP4....

10.3.2.2 Lake Code Abbreviations

Lake monitoring points are created by adding a dash and up to a 5 letter code abbreviation. The most common lake sites are routinely given the following abbreviations:

- A = Dam site
- B = Mid lake
- MAR = Marina or -BR = Boat Ramp

Lake sites can also be given descriptive abbreviations. For example, a site on Roosevelt Lake near Pitney Picnic Grounds might be "- PIT."

The three letter lake code is primarily derived from the first three letters of the name, except as stated below or to avoid duplications (e.g., Alamo Lake = ALA).

- Ignore the word "Lake" if it is the first name of the lake (e.g., Lake Havasu = HAV)
- Use the first letter of the second name if multiple words (e.g., Soldier's Annex Lake = SAL)

If the abbreviation is already used for a lake within the watershed, do the following to derive a unique code:

- Use the next letter in the name or
- Use a number (last resort).

10.3.2.3 Canal ID and Code Abbreviations

Canals are special cases requiring unique protocols to identify monitoring points. River mile monitoring points cannot properly be applied to canals because the conventions associated with rivers are not consistent with canals. Consequently, a convention has been adopted for canal IDs that uses a special descriptor with a mix of both text and integers for the monitoring point to distinguish canals from both streams and lakes.

Watershed codes are applied to canal monitoring points as with any other site in the database. Codes are assigned to canals or their laterals. Canals codes are a composite of:

- The first code is a letter – generally the first letter of the name,
- The second code is a number from 1-9, and
- The letter C for canal.

Example: Atwater Canal = A1C

The monitoring point for any canal follows the following protocol:

Determine the cadastral section number the monitoring point falls within from a USGS quadrangle or other map source. The section number comprises the second and third characters of the monitoring point (single digit section numbers shall be prefaced with a "0").

Determine the quarter (Q), the quarter-quarter (QQ), and the quarter-quarter-quarter (QQQ) section designation for the part of the section the monitoring point falls within. AZMapper has a tool to assist with this operation. Generally, each successively smaller quarter is designated as follows:

"A" – Northeast quarter
"B" – Northwest quarter
"C" – Southwest quarter
"D" – Southeast quarter

These three characters (for the quarter, quarter-quarter, quarter-quarter-quarter respectively) comprise the fourth, fifth, and sixth characters of the monitoring point.

If the site is the first or only site within a unique QQQ for the canal water body ID and watershed, preface the monitoring point designation with an "X". If the site is the second within the same QQQ, preface the monitoring point with a "Q". Either of these letters will occupy the first character of the monitoring point.

For example, a fictitious monitoring point associated with the example code above might be developed in the following fashion. If the monitoring point is the first in the extreme northwest QQQ of section 22 for the Middle Gila watershed, its code would be MG-A1C-X22BBB (dashes added for illustration purposes only). A site on the Middle Gila's portion of the Arizona Canal

falling just to the southwest of the center of Section 9 and the second one within the QQQ would be MG-AZC-Q09CAA

While it is theoretically possible that codes could be duplicated with this protocol, the likelihood is not high that this would occur. Following the protocol will yield unique and identifiable site ID codes with inherent locational information content that differ in format from both stream codes and lake codes.

10.3.2.4 Non-network Sites

Occasionally we need to create a new site that is off the natural hydrologic network (stand-alone site). For non-network sites, the site code is always NSW, and the syntax for auto-generated Site ID is NSW latitude/longitude (NSWddmmss/-dddmmss).

10.4 SITE FILES

Monitoring site information and data from the Surface Water Monitoring and the TMDL Units are contained in individual files for each sampling site. Sites are grouped by watershed. Individual site files are housed on the 5th Floor at the central Phoenix office. Lateral file cabinets are dedicated to housing the site files.

10.4.1 SITE FILE CONTENTS

Each site file should contain the following information starting with the inside cover of the file.

Site Information sheet

The Site Information sheet can be printed from the Water Quality Database. It will have information regarding the site, such as the name of the site, DEQ Database number, site location, and, if applicable, a signed written permission form from the property owner to enter the property and collect samples. Ownership of the land should not be assumed to be public land and should be investigated during the reconnaissance stage of site selection.

Road Log and Map

A detail road log should be written during the reconnaissance stage of site selection. In addition, any special comments such as locked gates, 4x4 roads, or other access issues need to be attached to the log.

Correspondence/Exceedances

- Any miscellaneous correspondence with the property owner
- All correspondence on Surface Water Quality Standards exceedances that apply to the site
- Any contractual or sampling agreements pertaining to the site
- All internal and external correspondence regarding the site

Photographs

Archive-quality slides, prints or digital images of site taken at each site visit. For sites with a lot of photos, consider taking a few representative photos and storing the rest on a CD.

Biological Data
All field and taxonomy laboratory data sheets pertaining to macroinvertebrate or other biological collections.

Stream Channel Physical Assessments
Habitat Assessment Field Data Sheet for Cold and Warm Water Streams, Stream Ecosystem Monitoring Data Sheets and any other data sheets describing the physical condition of the stream channel. Use the WQDB to print out the habitat data for each site.

Field Notes
- Field data sheets and field measurements from each site visit
- A flow calculation sheet
- Any historic copies of field notes from each site visit
- Sketches or diagrams representing the site

Water Quality Chemical Data
- Located on inside back cover of site file
- All analytical laboratory data from each site visit
- Water Quality Standards Exceedance and QA/QC check off sheet
- Cation/Anion report

10.4.2 FILING SYSTEM
There are three separate filing systems for streams, lakes, and TMDL.

Stream site files are filed in the lateral file cabinets by hydrologic basin. There are ten major basins:
1. Colorado-Grand canyon (CG)
2. Colorado-Lower Gila (CL)
3. Little Colorado River Basin (LC)
4. Verde River Basin (VR)
5. Salt River Basin (SR)
6. Upper Gila River Basin (UG)
7. Middle Gila River Basin (MG)
8. San Pedro River Basin (SP)
9. Santa Cruz River Basin (SC)
10. Bill Williams River Basin (BW)

Site files are sorted within each file cabinet drawer in alphabetical order by a 2 character basin code (e.g. UG for Upper Gila River) and a 3-character stream identification code (e.g. ETK). Sort streams with the same name numerically by the river mile.

Lake site files are organized by basin and then by lake.

10.4.3 SITE FILE SECURITY

Site files contain unique and irreplaceable information, thus are kept in locked lateral file cabinets to provide security against loss. The lateral file cabinets are located on the west wall on the 5th Floor. Access to the SWS site file cabinets is limited to SWS personnel and all others by special arrangement. SWS staff is responsible for site files that are removed to their work areas. They must be returned and properly filed in alphanumeric order after usage.

It is recommended that site files be returned to the file cabinet after one week. If files need to be used for a longer period of time, an "OUT CARD" should be placed in the file with the user's name and cubicle number.

10.4.4 SIGNING OUT FILES

Non-SWS staff may check out site files to their work areas for an 8-hour work day, but the files must not be removed from the 5th floor and must be returned by 5:00 p.m. Files may be signed out from the Surface Water Section secretary or TMDL or Monitoring unit manager. An "OUT CARD" must be filled out with the date, name, telephone extension and cubicle number where the file will be kept during the work day.

10.4.5 PUBLIC REVIEW OF SITE FILES

The data and information in SWS site files are public records and they may be viewed by members of the public upon request during regular business hours. Members of the public who wish to review a site file must make arrangements with the ADEQ Records Center.

10.4.6 RECORDS RETENTION AND ARCHIVING FILES

Monitoring site files (chemistry and biocriteria) do not have a "destruction date" in accordance with our retention schedule (FIGURE 10.5). This means that facility data should be kept with the file throughout time. Old data can be shipped to the State Archives. See the section secretary for the appropriate forms and instructions for archiving files.

Division WQD **Office** Surface Water Section

Records Series	Ret Total	Ret Remarks
1. Macroinvertebrates and Fish Tissue Sample Data Records	Permanent	Permanent
2. 305 305(b) Assessment and 303(d) Listing Report (including supporting documentation)	05	After completed
3. 208 Consistency Reviews	05	After Completed
4. 208 Areawide Water Quality Management Plans	-	Keep until superseded
5. Complaint Investigation Files	05	After Resolved
6. Monitoring Site Files (including biocriteria files)	15	from date generated
7. Triennial review (separate from rulemaking)	10	date of report
8. Surface Water Monitoring Program Files (sample plans, annual data reports, guidance)	05	after fiscal year that monitoring program ends
9. AZPDES individual & general permits (except construction) approvals (RS Replaced WS)	05	After permit expires or is superseded
11. Construction General Permit (NOI, NOT & SWPPP) (WL RS Replaced)	02	From NOT or from new permit

FIGURE 10.5. Records retention schedule.

APPENDIX A CHECKLISTS

AMBIENT STREAMS

Equipment List

LAB/OFFICE

Meters

- ❑ Hydrolab/YSI (need barometer?)
- ❑ Dissolved Oxygen Titration Kit
- ❑ Chlorine Meter
- ❑ Thermometer

Sample Equipment

- ❑ Sample Bottles : per site
  - ~1 wide mouth
  - ~3 one liter small mouth
  - ~2 500ml small mouth
- ❑ Bottles for a Duplicate or Blank (blanks need DI water)
- ❑ Tubing
- ❑ Filters
- ❑ Gloves
- ❑ Nitric Acid and Stickers
- ❑ Sulfuric Acid and Stickers
- ❑ Tape

Bacteria

- ❑ Incubator
- ❑ Sealer
- ❑ Bottles
- ❑ Trays
- ❑ Reagents
- ❑ Black Light

Office Supplies

- ❑ Clipboard (Pens and Pencils)
- ❑ Field Forms
- ❑ Camera (Extra AA Batteries)
- ❑ Truck Keys/ Bluebook/Gas Card
- ❑ Maps
- ❑ Lab Forms and Tracking Number
- ❑ GPS (Extra AA Batteries)
- ❑ Sample Plan and SOPs

CAGE

Meters

- ❑ Turbidity
- ❑ Flow Meter

Sample Equipment

- ❑ Wading Rod
- ❑ Measuring Tape
- ❑ DH-81 Rod and Nozzle
- ❑ Chain Pins
- ❑ Float Bottle
- ❑ Flagging
- ❑ Ice Chests
- ❑ Churn Splitter
- ❑ Backpack, Bucket, or Duffel Bag
- ❑ Waders, Hip Boots, or Irrigation Boots

First Aid/ Safety

- ❑ First Aid Kit
- ❑ Shovel
- ❑ Drinking Water
- ❑ Bug Repellant
- ❑ Cell or Satellite Phone

SEM Supplies

- ❑ 250 mL Bottle (for Periphyton ID)
- ❑ 500 mL Graduated Composite Bottle,
- ❑ 2" delimeter, angled toothbrush, 1L Wash bottle, 60mL syringe w/ tube, 1" stickon sample labels Lugols, DI Wash bottle.
- ❑ Whatman GF/F 0.7um glass fiber filter
- ❑ Filtration apparatus (Millipore) & Pump
- ❑ Large Funnel
- ❑ 30 mL amber bottle ~ 2 per site
- ❑ 250/50 mL Gradulated cylinder
- ❑ Forceps (reuse)
- ❑ Bug Net
- ❑ Bucket and Sieve
- ❑ 2nd Bucket for Bug Duplicate
- ❑ Wide Mouth Bug Jars
- ❑ Alcohol
- ❑ Bug Bag (pebble count ruler, densito-meter, watch, spoon, tape, and labels)

Lakes

Office

- ☐ Determine depth of lake, if possible, so you can decide which length of rope to bring
- ☐ Current or historical problems at the lake?
- ☐ Lake map
- ☐ List of site ID names and GPS locations
- ☐ Plan # of samples to take at each site and order bottles
- ☐ Reserve truck
- ☐ Make reservations

Paperwork and Logistics

- ☐ Clipboard
- ☐ Site files/maps
- ☐ Field forms
- ☐ Truck logbook
- ☐ Truck keys and Gas card
- ☐ Pontoon keys
- ☐ Routing form/float plan
- ☐ Chain of custody and lab forms
- ☐ Tracking, PCA, and Index #s
- ☐ Permission Forms
- ☐ AZ Atlas
- ☐ Forest Service maps
- ☐ Labels
- ☐ Table for DO/elevation
- ☐ Tape for labels
- ☐ Extra pencils, pens and sharpies
- ☐ SOPs

Personal Gear

- ☐ Hip or chest waders
- ☐ Seal skin gloves
- ☐ Hand sanitizer

Safety

- ☐ First Aid kit
- ☐ Life jackets
- ☐ Sunscreen
- ☐ Bug repellant
- ☐ Drinking water
- ☐ Rain gear
- ☐ Squincher drink
- ☐ Satellite phone
- ☐ VHF radio
- ☐ Flashlight
- ☐ Tool box
- ☐ Fire extinguisher

Filtered metals

- ☐ Tubing
- ☐ Capsule filters
- ☐ Geopump
- ☐ Battery if using geopump

Meters

- ☐ YSI
- ☐ YSI cable
- ☐ Barometer if using the Hydrolab

Sampling Equipment

- ☐ Secchi disk with sufficient rope
- ☐ Depth finder
- ☐ Beta bottle with sufficient rope
- ☐ Sediment corer or Eckman dredge with sufficient rope
- ☐ Sediment scoops
- ☐ Sediment glass container
- ☐ Sediment noses pieces
- ☐ Sediment catchers
- ☐ GPS
- ☐ Camera
- ☐ Ice chests with ice
- ☐ Bacteria incubator
- ☐ Bacteria sealer
- ☐ Bacteria bottles
- ☐ Bacteria additive
- ☐ Bacteria trays
- ☐ Black light
- ☐ Whirlpacks
- ☐ Plastic bags for sample bottles
- ☐ Garbage bags

- ☐ Sampling bottles
- ☐ Duplicate sampling bottles
- ☐ Acid stickers
- ☐ Acid
- ☐ Measuring tape
- ☐ Extra batteries

Boat Equipment

- ☐ Anchor
- ☐ Extra rope
- ☐ Adapter
- ☐ Boat lock
- ☐ Bleach for de-contamination
- ☐ Oars
- ☐ Motor flush
- ☐ Inflatable Raft

Pump
Seat
trawling motor
Battery and battery cover
Battery charger

- ☐ Aluminum boat

2" ball hitch
2 stroke Outboard motor oil

- ☐ Pontoon

Keys
Get gas
Hitch with 2" drop if taking a Ford 250, 2" ball

TMDL - GENERAL

Office and Paperwork

- ☐ Field data sheets
- ☐ Cell/satellite phone
- ☐ Field notebook
- ☐ Laptop (with necessary cables)
- ☐ Keys (equipment and access)
- ☐ SAP (site maps, safety plan)
- ☐ Digital Camera
- ☐ Clipboard (pens, Sharpies)
- ☐ GPS
- ☐ Equipment manuals
- ☐ Weather radio
- ☐ Copies of routing form
- ☐ Tracking # _____
- ☐ P.O #_____
- ☐ Index #_____

Personal Gear

- ☐ Hip or chest waders
- ☐ Irrigation boots
- ☐ Seal skin gloves
- ☐ Rain Gear
- ☐ PFD

Safety

- ☐ First Aid kit

- ☐ Sunscreen
- ☐ Bug repellant
- ☐ Drinking water
- ☐ Squincher drink
- ☐ Tool box
- ☐ Hand sanitizer

Filtered metals

- ☐ Tubing
- ☐ Capsule filters
- ☐ Nitric acid vials

Sample Bottles

- ☐ 1-liter bottles
- ☐ SSC bottles
- ☐ Specialty bottles
- ☐ Clean metals
- ☐ Autosampler bottles

Equipment from Cage

- ☐ Shovel
- ☐ 5-gal bucket
- ☐ Flow Meter (SN_____)
- ☐ Wading rod
- ☐ Hydrolab (SN_____)
- ☐ Turbidity Meter (SN_____)
- ☐ DH-81 rod, nozzle, and cap
- ☐ Geopump
- ☐ Ice chest(s)
- ☐ Tape measure
- ☐ Steel Arrows
- ☐ Rope
- ☐ Backpack(s)

Water Laboratory Supplies

- ☐ DI Carboy
- ☐ Field Box
  - ☐ Gloves
  - ☐ Buffer solutions
  - ☐ Batteries
  - ☐ Ziploc Bags
  - ☐ Garbage bags
  - ☐ Cubitaners
- ☐ Sulfuric acid vials

☐ Autosampler batteries

Bacteria

☐ Bacteria incubator
☐ Bacteria sealer
☐ Bacteria bottles
☐ Bacteria additive
☐ Bacteria trays
☐ Black light
☐ Inverter

☐ Ice

TMDL - AUTOSAMPLER

Pre-trip - Make sure equipment to install is functioning properly before leaving ADEQ

- Tools
- Drill with appropriate drill bits
- Generator with extension cord and gas
- Tool kit
- Anchor bolts
- Clamps (2" fence post for 2" well casing/float switch, 1" PVC U or C-clamps for securing 1" PVC tubing)
- Saws
- Sledgehammer
- Wire crimpers
- Wire nuts
- Electrical tape
- Wire cable, ferrules, and swag
- Extra wire

Autosampler specific

- Autosampler
- New pump and distributor arm tubing installed for each deployment
- Bottles (Bottle racks and bags if using disposable bottle packs)
- Intake tubing
- Charged Battery(ies)
- Bottle retaining ring
- Intake strainer
- ½ cables if needed for float switches
- Padlock
- Cable to lock autosampler to tree, etc.
- Cable(s) to secure autosampler
- Ceramic knife

- Autosampler program
- 1” PVC pipe (glue, caps, elbows)
- Float switch
- Level/Stage Logger specific
- Level logger
- Laptop to program logger
- 2” PVC well screen (caps, elbows)
- 1” PVC pipe (glue, caps, elbows)
- Equipment Enclosure (outdoor electrical box, etc.)
- Camera
- GPS, unless existing site

SURVEYING EQUIPMENT

- Laser level
- Extendable Rod
- Laser receiving unit
- Tripod
- Rolls of flagging
- Stake flags
- Field data sheets
- GPS-Garmin
- GPS-GeoExplorer
- Auto Levels
- Rods & rod levels
- Measuring tape reel , 1/10 ft
- Cross-section and caps
- Short & long-handled sledgehammers
- Machetes
- Tightening strap and chaining pin
- Bank pins
- Toe pins and caps
- Scour chains, duckbills, and driver
- Boltcutters DH-76 or DH-74 SSC sampler w/ glass jars
- 3" Helly Smith bedload sampler w/ 500micron mesh bag
- Bedload jars or bags
- 6" Helly Smith bedload sampler w/ 500micron mesh bag
- A" and "B" reels for use on cableways
- Shovels, monuments, galvanized steel pipe and concrete
- Bucket setup for bar samples
- Set of sieves and scale
- Lathe stakes
- BEHI equipment (16' rod, meter stick w/ line level, angle measure or calculator)
- Metal tags

- Walkie talkies
- Clipboards w/ reference documents
- Digital camera or 35mm Camera

FISH

Field Sampling Equipment and Supplies:

_____Collecting Permit
_____Copy of this SOP
_____GPS Unit
_____Fish weigh scale
_____Paper tags and zip ties
_____Plastic bags
_____Coolers with dry ice or regular ice
_____Field data sheet
_____Fish sample labels
_____Nitrile gloves
_____Heavy duty aluminum foil
_____Fish collection gear (nets, electro-shocker, etc.)
_____Fish measuring board
_____Clear and masking tape
_____Waterproof pen
_____Scale

Laboratory processing supplies

_____Copy of this SOP
_____Cooler(s) containing fish to be processed
_____Cooler containing ice only (for processed samples)
_____Nitrile gloves
_____Ceramic knife
_____PTFE cutting board
_____6mm biopsy punch
_____Porcelain mortar and pestle
_____10 percent nitric acid rinse made from ultra-pure certified trace-metal grade
_____Laboratory-grade deionized water
_____Teflon wash bottles (fill with the 10% nitric acid solution before beginning procedure)
_____400 ml beakers
_____50ml PTFE sample bottles
_____Sample Analysis Lab Request forms for State Laboratory or Chain of Custody forms and seals for EPA Laboratory

QUALITY CONTROL CHECKLIST

Water Quality Data QC Checklist	
SiteID:	**Date/Time sampled:**

Manage Sites - Enter/update all locational information:

- ☐ Elevation, drainage area, site access directions, current site type (ref, nonref, stressed) if known, biocriteria exemption (eg. intermittent or edw), GIS slope, Stream order, Flow Regime (P, I, E or Edw). Check that Designated uses match WQS and are correct (report to Aiko if incorrect)

Lab DataSet Info:

- ☐ Update "Received by Lab Date/Time". Update "Received from Lab Date/Time" for Labs other than Test America.

Upload Sample/Result Data:

- ☐ Upload edi dataset, following WQDB Transition Plan guidance.

Sample/Result Data Entry - Sample Header:

- ☐ Fill in all Sample information fields possible.
- ☐ Select appropriate Flow Condition in the "Sample Taken?" field (This is a requirement for Assessments)
- ☐ Select collection equipment and Method (eg. Chem-01 is the standard one for water chemistry samples, ADEQ Riffle bugs for perennial stream bug samples)
- ☐ Enter "ADEQ" for Reporting and collecting agency

Sample/Result Data Entry – Field Chem

- ☐ Enter Field data (select test plan & pre-populate fields)
- ☐ Double check data entry records for 100% correct entry
- ☐ E.coli dups – Click Edit button for E.coli parameter, enter new result, place "DUP" in comments box, then "Save as New" to add a 2nd Ecoli value
- ☐ Add "Event conditions" for Weather, algae blooms, equipment problems, QC samples collected, ect. by adding a parameter for each Event, following Transition Plan Doc. Do not add an Event for flow conditions; this is captured on the Header Tab.

Sample/Result Data Entry – Lab Chem

- ☐ Is Dataset complete? Check for SSC, dissolved Ca & Mg, reruns updated.
- ☐ Spot check that uploaded lab values are correct
- ☐ Equipment blanks Clean? If not, request rerun by Lab. If detections still a problem, flag analytes as rejected (QA-R) in the QA Flags field, for all samples on the run.
  List Rejected Analytes:_____
- ☐ Splits/Dups within Limits for chem analytes (RPD<20% where results are >2x MRL)? (Request rerun and/or Flag for all samples on the run)
- ☐ E.coli Dups are within limits (Confidence intervals overlap- IDEXX calculator)?
- ☐ Field/Lab ratios calculated and qualifiers applied? (run "QA Flagging" procedure in "Schedule trips" page). Check for rejected analytes (see Transition Plan doc) and list above.
- ☐ Lab qualifiers correctly applied?

○ Check that all flags in Lab report pdf copy are listed in Lab Chem tab ○ Scan Lab Report –QC Sample Results for any dilutions or qualifiers that apply to your sample. ○ Reruns: follow Transition Plan guidance for entering qualifier RR1, RR2, or RR3	
Sample/Result Data Entry – Exceedances? ☐ Check Standards: Field pH, DO, E.coli & Lab metals, nutrients (if standard applies), and SSC [use Metals calculator spreadsheet for any dissolved metals detections, using dissolved Ca/Mg Hardness value & check Standards tables for Ammonia] List Here: _____ ☐ Exceedance letter for Human health Standards sent to Landowner & County Health Dept? ☐ Exceedance letter filed in Site File?	
Date Lab data uploaded	
Due date for field data entry into AZWQDB (+10 days)	
Due date for Approval in AZWQDB (+20 days)	
Comments:	

APPENDIX B MACROINVERTEBRATE LAB REQUIREMENTS

The procedures followed at the consultant taxonomic laboratory are not part of the field procedures for collecting and preserving macroinvertebrate samples. However, this section is included to explain practices and requirements for documentation and future reference.

SAMPLE RECEIPT

Upon receipt of the samples, the laboratory will check and adjust the preservation in each sample, catalog the samples, check the attached inventory for accuracy, and sign the chain of custody papers. The consultant will then notify ADEQ of the receipt of samples, any damaged samples, or discrepancies between the inventory and actual sample labels.

SAMPLE PROCESSING

Samples must be sorted to separate the invertebrates from the sample matrix. The entire sample should be floated in water in a white plastic tray. Large debris is rinsed and removed from the sample until all organic matter and invertebrates are floated off the mineral residue. The mineral residue is then searched for stone-cased caddisflies and mollusks.

SUB-SAMPLING

Arizona samples typically contain thousands of invertebrates and must be sub-sampled into equal squares for results to meet a minimum count of 500 organisms. A Caton Tray is be used to randomly obtain fractions of the total sample from which all the invertebrates are removed and counted. Additional fractions are selected until the 500 target level is reached after which the number of squares subsampled are recorded. Terrestrial insects and non-benthic insects (e.g. corixidae, other swimmers, mosquitoes, or surface tension dwellers) should not be included in the count. Additional fractions are examined if one fraction is dominated by a single species. After the target number of specimens has been achieved, the entire unsorted sample is scanned for large or rare taxa, which may aid in identification of smaller instars or may expand the taxa list for that sample. The remaining unsorted sample is re-preserved with 70% ethanol in individual containers and archived at the laboratory for one year from the date of sample receipt, after which time the laboratory will contact ADEQ prior to disposal.

SORTING

The sorting of invertebrates from the sample matrix shall be performed by trained technicians, using dissecting scopes with a minimum magnification of 6X. After identifications have been made, the sorted specimens, including the separated Chironomidae, should be archived for one year or incorporated into the reference or voucher specimen set. The laboratory shall keep logs for each sample sorted, the fraction sorted, sample matrix problems, etc. in addition to bench sheets of the taxa identified in each sample.

SORTING EFFICACY

The laboratory shall check the sample residues to insure a sorting efficacy of 95% or better. A statement of sorting efficacy for the ADEQ batch of samples should be presented in the laboratory report.

TAXONOMIC IDENTIFICATION

Invertebrate identifications shall be performed by a trained and experienced taxonomist. The taxonomy contractor is responsible for obtaining the most accurate, consistently achievable identifications for ADEQ samples. Specialists are used as needed to obtain identifications to the general taxonomic levels listed in TABLE B.1.

Invertebrate Group	Level of taxonomy required
Aquatic insects	Genus or species, where consistently identifiable
Chironomidae	Genus level
Semi-aquatic insects	Family
Arachnida (Mites)	Class
Cladocera, Copepoda, Ostracoda	Class
Amphipoda, Decapoda, Isopoda	Class
Nematoda, Nematomorpha	Phylum
Turbellaria	Class
Annelida	Class
Mollusca	Family or Genus

TABLE B.1. ADEQ Taxonomic levels of identification for macroinvertebrates

REFERENCE COLLECTION AND STORAGE

A set of reference or voucher specimens shall be prepared from the batch of samples each year for incorporation into ADEQ's reference specimen collection. The reference specimen collection is maintained for several reasons: 1) the voucher collection supports all research conducted by the Department, 2) for performing interlaboratory taxonomy QC checks on voucher specimens, and 3) for training and in-house taxonomic identifications. Several specimens shall be preserved for each new taxon and the best or largest larval instars of other taxa shall be preserved to represent the taxa found that year and to update the historic reference collection at ADEQ. The Contractor shall make recommendations for archiving any important specimens, if verification of identification by national specialists is required.

REPORTING

Laboratory reports containing taxonomic identifications and counts for all samples for that year shall be submitted to ADEQ in electronic format. The electronic data shall be submitted in ACCESS database format or Excel spreadsheets formatted for database uploading. The Contractor shall perform quality control checks on the electronic data prior to submittal to ADEQ. The data set should contain at a minimum the Station Identification (ID), waterbody name and location, habitat, collection date, laboratory tracking number, complete taxa ID from phylum to lowest level ID, raw number of individuals, and the portion of sample analyzed including field splits where applicable, and adjusted final counts, which are corrected for sub-sample size and field splits. Other attribute data should also be provided for any new taxa which are not currently in ADEQ's database, such as tolerance value, functional feeding group, and habit.

QUALITY CONTROL TASKS

ADEQ may conduct Laboratory audits as needed. ADEQ may also periodically request the laboratory to examine quality control reconstituted samples or voucher specimens from another lab and produce a short letter regarding the accuracy of identifications.

QUALITY CONTROL FIELD AND LABORATORY PROCEDURES

Quality control procedures for macroinvertebrate sample collection consist of controls in equipment type, sampling methodology, selection of appropriate sampling habitats and timeframes, replicate sampling, detailed sorting and subsampling lab methods, use of taxonomy specialists for macroinvertebrate identifications, and re-identification of samples in the lab. A detailed list of these biological field and laboratory quality control procedures and performance characteristics is provided in TABLE B.2.

In addition to these QC procedures, a decontamination protocol for macroinvertebrate field collection equipment has now been added to this document to prevent transport of biological agents among streams. The D-frame dip net, bucket, and sieve should be rinsed and scrubbed with a brush to dislodge small invertebrates, egg masses, and organic material, prior to leaving any given site and all sampling equipment should be sprayed with an acetic acid (vinegar) or bleach solution to decontaminate equipment.

Procedure	Performance Characteristic	Description
Sampling device	Precision - repeatability in a habitat	The D-frame dip net is a good choice for use in Arizona streams, as it can be used in riffle habitats with virtually all substrate sizes. The precision of sampling with this net is repeatable because a timed sampling effort is used which applies across different stream substrate types.
	Bias - exclusion of certain taxa (mesh size)	The D-frame sampler is outfitted with a 500Φ mesh size net opening, which retains organisms of a consistent size for identification.
	Interferences - matrix/physical limitations	Excess filamentous algae can foul a sample, but it is considered part of the organic matter of a sample and is packaged with the biological sample.

Procedure	Performance Characteristic	Description
Sampling method	Precision - variable metrics or measures among replicate samples at a site	Measurement error is quantified by replicate sampling at 10% of our sampling sites each year. Samples are processed and analyzed separately and their metrics and IBI score compared to obtain a measure of the method precision. This is an estimate of the precision of the entire method which includes variability due to small-scale spatial variability within a site, operator consistency and bias, and laboratory consistency.
	Bias - exclusion of certain taxa or habitats	Riffle only, 500Φ mesh size
	Performance range - limitations in certain habitats or substrates	Riffle only, sample edge vegetation for sandy substrates riffles
	Interferences - high river flows, training of personnel	Sampling not performed during high flows for safety reasons. The method has only been tested on a limited basis for large river sampling.
Field Sample Processing	Bias - efficiency of locating small organisms in sample transfer	The sieve is carefully rinsed after straining a sample. The sieve is washed prior to leaving a sample site.
	Performance range - sample preservation and holding time	Sample preserved with isopropanol and capful of formalin for better preservation in Arizona heat. Formalin also allows longer holding time.
	Interferences - Weather conditions	Sample taking maybe performed during light rains and slightly elevated flows, but not during bankfull or greater flows.
	Accuracy - of sample transfer process and labeling	There is a standard format for sample labels which includes stream name, site id, date, habitat sampled, collector info, whether sample was field split and # of jars in sample.

TABLE B.2. Biological field quality control procedures and performance characteristics.

BIOASSESSMENTS AS APPLIED TO PROJECTS BY OTHER ENTITIES (NPDES PERMITS)

The application of bioassessments to projects by other entities than ADEQ must adhere to the following requirements:

- A bioassessment should occur concurrently with ambient water monitoring
- A bioassessment survey plan should be completed and submitted to ADEQ by December 31st of each year. The plan should contain sample dates, locations of background and study sites, sampling personnel and qualifications, name and location of contract laboratory, biological and habitat sampling protocols and method of analysis
- ADEQ sampling and analysis protocols should be followed as closely as possible while using the most updated Quality Assurance Program Plan
- Laboratory protocols should follow ADEQ recommendations in TABLE B.3
- The bioassessment report should be submitted to ADEQ for review. The report should contain: an executive summary, introduction, study area description table, including maps and photos, methods, results and discussion, literature cited, and appendices with complete taxa lists and copies of completed field forms for each site. The results and discussion section should cover a physical characterization of the sites, a habitat assessment, water quality, fish and wildlife, macroinvertebrates, and long term trends at the study sites.

- Macroinvertebrate analyses should contain: a list of taxa and abundances, the calculated warm or cold water IBI score, the benthic habitat score, and graphs indicating a comparison of reference and study site IBI scores for the current year, changes in the reference and study IBI scores over a permit period and changes in the reference and study site habitat scores or habitat values over the permit period.
- The first bioassessment shall be subject to a quality assurance review to be conducted by ADEQ. The voucher specimens from the laboratory should be submitted to ADEQ for a quality control review of the taxonomic identifications by the ADEQ contract taxonomist. Major revisions should be incorporated into the final bioassessment report.

Procedure	Performance Characteristic	Description
Laboratory sample processing	Precision - split samples	Duplicate samples are collected at the rate of 10% of the total # of samples during each year's index period. This is a test of the labs ability to create consistent IDs.
	Bias - sorting certain taxonomic groups or organism size	Large specimens are removed first from the sample. All organisms, regardless of size are sorted for ID from each 1/32 section of the sample.
	Interferences - distractions, equipment	Field and lab equipment, such as sieves and nets, are thoroughly washed between sites and samples.
	Accuracy - sorting method, lab equipment	Caton Tray used for consistent method of sorting samples, especially where thousands of insects per sample are found.
Taxonomic enumeration	Precision - split samples	The similarity of duplicate samples is verified using the Arizona warm water and cold water IBI's, rather than the individual taxonomic identifications.
	Bias - counts and identifications for certain taxonomic groups	Our taxonomist offers 500 counts of insects per sample, which exceeds the number of specimens counted by many other states. Where a particular taxa is dominant in the sample, that taxon is not included in the 500 count. Our laboratory has used a number of nationally recognized specialists to provide confirmed identifications of specimens for our reference/voucher collection.
	Interferences - appropriateness of taxonomic keys	List of taxonomic keys used by our laboratory is included in our SOP's.
	Sensitivity - level of taxonomy related to type of stressor	Our standard taxonomic effort (identifications to genus in most cases, with midges at family level) is generally used for all samples. Identification of Chironomidae to genus can be done on an as-needed basis for samples/sites found to be impaired.
	Accuracy - identification and counts	Use of nationally recognized specialists to create the Arizona reference collection, by which all other samples are identified.

TABLE B.3. Biological laboratory quality control procedures and performance characteristics.

APPENDIX C WATERSHED DELINEATIONS

There are several ways to delineate watersheds. The USGS stream stats tool is the easiest to use but users may also use ArcMap

USGS STREAM STATS

USGS has an online tool for creating watersheds, which is a good back up option if the Arc Map tool isn't available or deals with watersheds outside of Arizona http://water.usgs.gov/osw/streamstats/ssonline.html

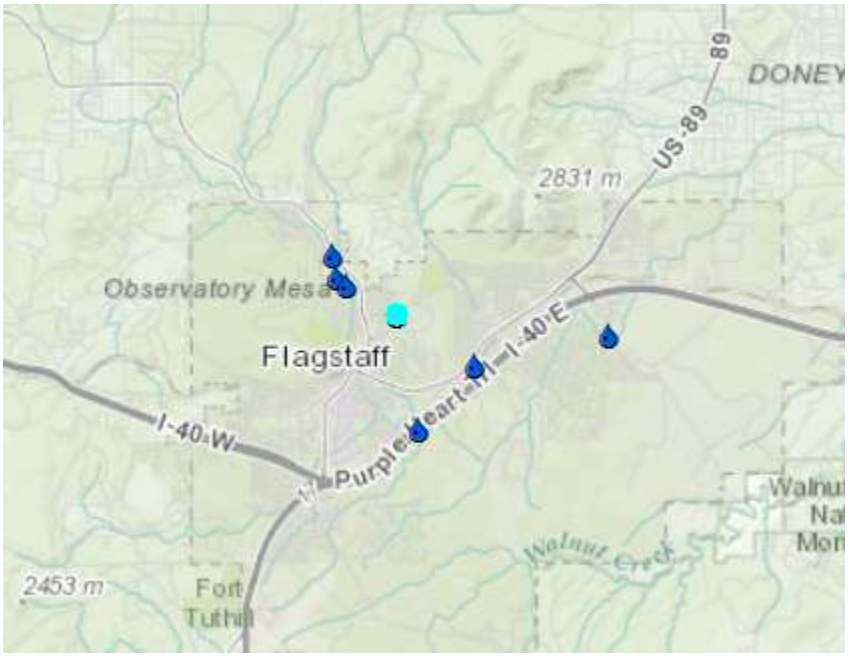
ARCMAP

This tool allows the user to calculate watershed delinations based on a point feature class.

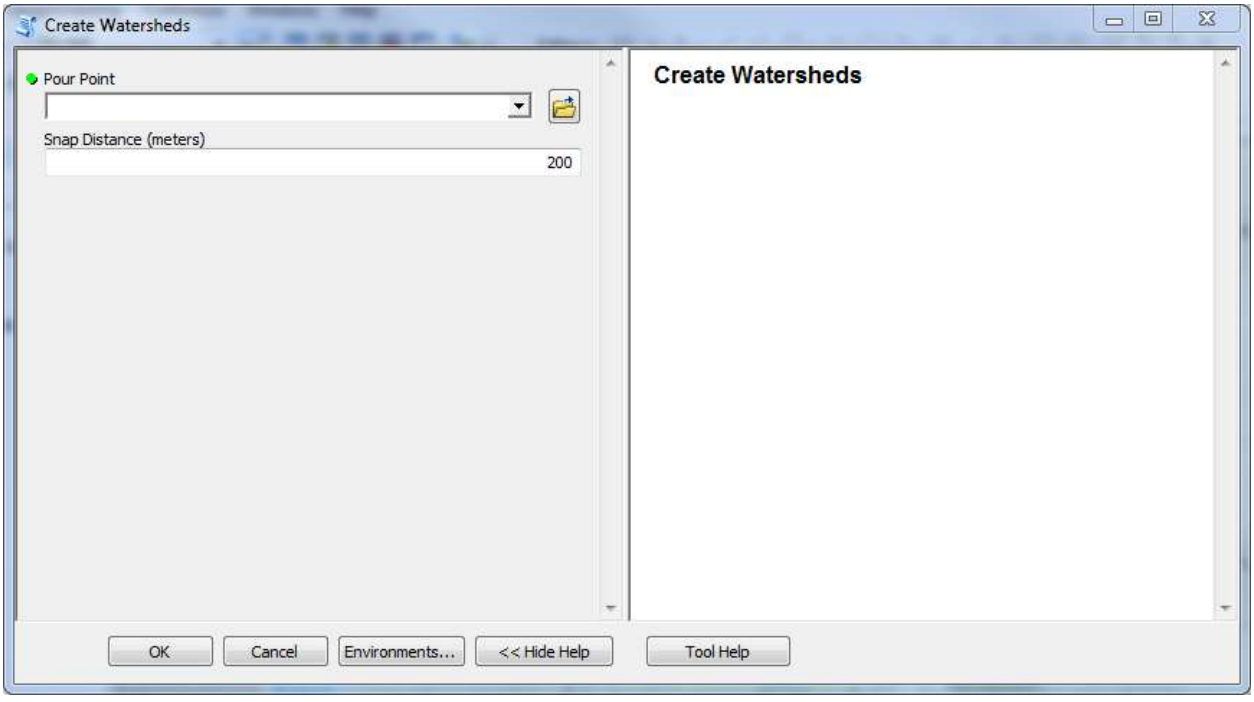
1. To load the tool, open arcToolBox, right click "ArcToolbox" at the top of the Toolbox pane, select Add Toolbox, navigate to r:\common\ADEQ Tools and select the ADEQ Tools.tbx toolbox.

2. Once you've selected the toolbox, you can save it permanently by right clicking the top of the ArcToolbox again and selecting Save Settings\To Default.

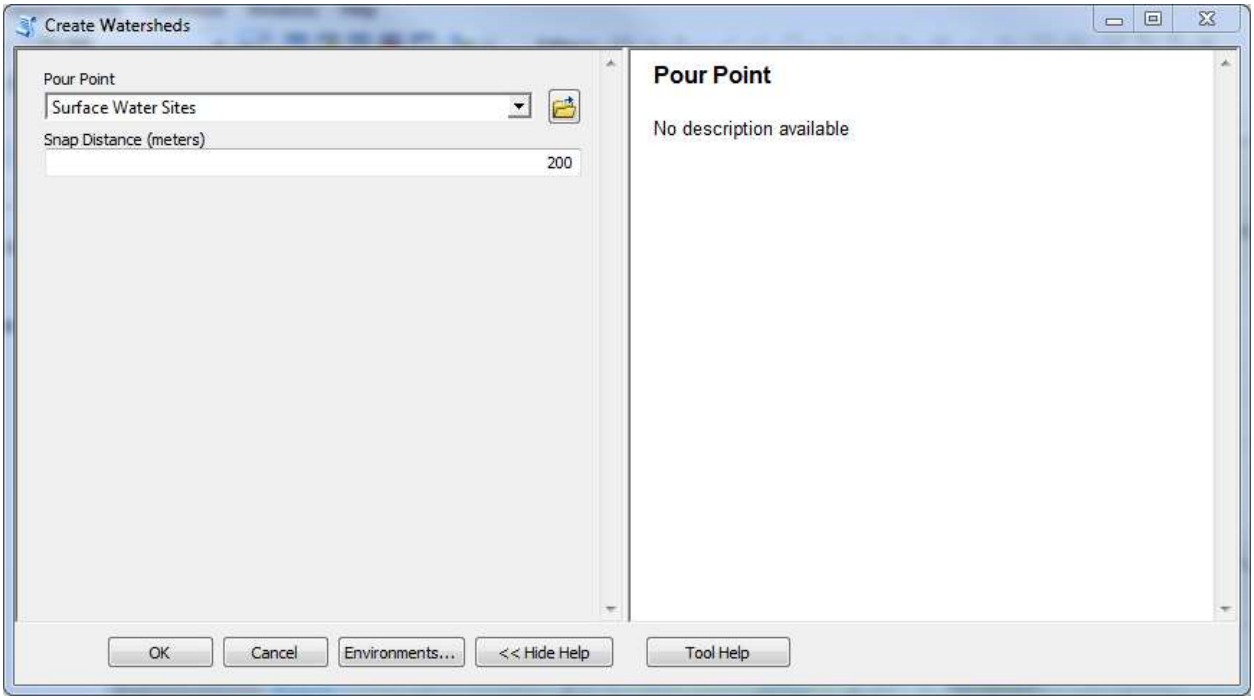
3. To use the tool, open a point layer consisting of points you want to use as a pour point(s). This layer can be any existing point layer such as the Surface Water Sites layer or a point file that you create yourself. Select one or more points from the layer with the select tool (see below). If you select more than one point, all points need to be in the same watershed (The tool will know if you've select points from different watersheds and will not run).



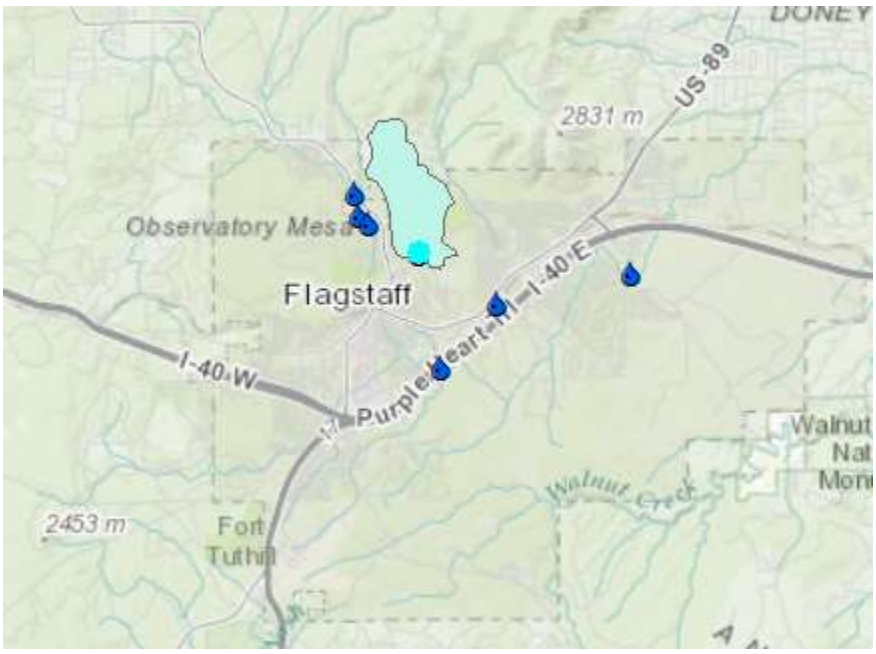
4. From the ADEQ Tools toolbox, double-click on the "Create Watersheds" script to run the tool. You'll see the following:



5. Select the name of the layer you want to use for the pour points and a Snap Distance (the default is 200 meters). The Snap Distance is the distance you want the program to search to determine the best location for the pour point. You can vary this distance if you're not happy with the watershed that is created.



6. In this case I'm using the Surface Water Sites layer to use as pour points. Click OK to run the script.



7. A polygon representing the watershed will be added to the map. It will be named something like NewWSPoly_Layer… (1,2,3, etc.). This polygon layer only exists in the ArcGIS memory, because you may not be happy with the result and may want to modify the model parameters (snap distance) to produce a better watershed. Once you are happy with the result, save the polygon layer to a Feature Class of your choice by right clicking on the layer name and selecting Data/Export Data. If you quit ArcMap before saving the polygon layer, you will lose it.

APPENDIX D BORDER AREA CONTACT INFORMATION

TUCSON SECTOR STATIONS

Ajo Station
850 North Highway 85
Ajo, AZ 85321-9634
Phone: (520) 387-7002
Fax: (520) 387-6620
Area of Responsibility: The Ajo Station is located nine miles south of Ajo, Arizona, along State Route 85, and approximately 120 miles west of the Tucson Sector headquarters. The international border and the Lukeville Port of Entry lie approximately 27 miles south of the station.
The Ajo area of responsibility encompasses a total of 64.3 miles along the international border and nearly 7000 square miles of operational area. The border area begins at the Papago Farms on the Tohono O'Odham Nation, continuing west through the Organ Pipe Cactus National Monument and the Lukeville Port of Entry, and ends south of the Granite Mountains on the Cabeza Prieta National Wildlife Refuge at the Pima County / Yuma County line.

Casa Grande Station
396 Camino Mercado
Casa Grande, AZ 85222
Phone: (520) 836-7812
Fax: (520) 423-2341
Area of Responsibility: Currently (April, 2007), the Casa Grande Station patrols 44.2 miles of linear border on the Tohono O'odham Nation. Casa Grande Agents also patrol the Eloy and Phoenix metropolitan areas. Agents are assigned to Sky Harbor Airport and the Phoenix Metro bus stations and respond to other Arizona cities such as Globe, Apache Junction, Oracle Junction, and San Manuel.

Douglas Station
1608 S. Kings Highway
Douglas, AZ 85607
Phone: (520) 805-6900
Fax: (520) 805-8080
Area of Responsibility: The Douglas Station is one of eight stations in the Tucson Sector that ensures the successful implementation of the service's Southwest Border Strategy. The Douglas Station's area of responsibility (AOR) covers 40.5 linear miles of the International Border with Mexico and includes over 1450 square miles of mountainous terrain, with a few small valleys to the north of the International Border.

Naco Station
2136 South Naco Highway
Bisbee, AZ 85603

Phone: (520) 432-5121
Fax: (520) 432-5219
Area of Responsibility: The Naco Border Patrol Station's area of responsibility (AOR) is located within Cochise County in south east Arizona covering approximately 1,175 square miles. This includes 32.5 miles of International Boundary with the areas of Agua Prieta, Sonora, Mexico, Naco, Sonora, Mexico, and Cananea, Sonora, Mexico. The station's AOR commences near Paul Spur west of Douglas, Arizona, continuing west through the San Pedro River Valley to the crest of the Huachuca Mountains in the Coronado National Forest. The AOR includes the cities and towns of Sierra Vista, Arizona, Hereford, Arizona, Palominas, Arizona, Huachuca City, Arizona, Whetstone, Arizona, Tombstone, Arizona, Bisbee, Arizona and Naco, Arizona. The Naco Border Patrol Station is also responsible for sections of Arizona State Highways 92, 80, 90, and 82 with a temporary highway checkpoint near milepost 304 on Highway 90.

Nogales Station
1500 West La Quinta Road
Nogales, AZ 85621
Phone: (520) 761-2400
Fax: (520) 761-2628
Area of Responsibility: As of May, 2007, the Nogales Border Patrol Station has become the largest Border Patrol Station in the United States. Agents are tasked to patrol 1,100 square miles of rough terrain, including 32 miles of International Border. Nogales Station's area encompasses many urban areas like Nogales, Rio Rico, Tubac, Patagonia, Amado, and Green Valley. The Coronado National Forest is also a large part of the western sector of Nogales area of responsibility.

Sonoita Station
PO Box 37 (mailing)
3225 Highway 82
Sonoita, AZ 85637
Phone: (520) 455-5051
Fax: (520) 455-5807
Area of Responsibility: The Sonoita Station is located near the junction of State Routes 82 and 83 in Santa Cruz County. The station lies approximately 25 miles north of the international border and about 49 miles southeast of the Tucson Sector Headquarters. The Station is responsible for patrolling 24.3 linear miles of international border and an overall area that encompasses nearly 1,000 square miles. This area stretches from the Patagonia Mountains in the west, to the Huachuca Mountains in the east, and near Interstate 10 to the north.

Tucson Station
2430 S. Swan Road
Tucson, AZ 85711
Phone: (520) 514-4700
Fax: (520) 514-4760
Area of Responsibility: The Tucson Station is a very unique station. It is considered a linewatch station, responsible to patrol the border east and west of Sasabe, Arizona. Because it is located 68

miles north of the international border, it is also considered an interior station with responsibility for the vast majority of Pima County.

Willcox Station
530 East Grant Street
P.O. Box 909 (For mail)
Willcox, AZ 85643
Phone: (520) 384-4424
Fax: (520) 384-4092
Area of Responsibility: The Willcox Station does not have responsibility for a border area but is located in a geographically strategic position to conduct traffic operations on a variety of routes of egress throughout the corridor. U.S. Interstate 10, Highways 80, 191, and 90 all travel through the Willcox AOR. Willcox also conducts sign-cutting, sensor response, night scope operations, and ranch patrol.

YUMA SECTOR

Yuma Station
4151 S. Avenue A
Yuma, AZ 85365
Phone: (928) 341-2800
Fax: (928) 344-1184
Area of Responsibility
The station has 48 miles of Sonora land border, 10.75 miles of Baja California land border, and 15.25 miles of Baja California river border, for a total of 74 miles.

CORONADO NATIONAL FOREST

Douglas Ranger District
1192 West Saddleview Road
Douglas, AZ 85607
(520) 364-3468
(520) 364-6667 FAX

Nogales Ranger District
303 Old Tucson Rd.
Nogales, AZ 85621
(520) 281-2296
(520) 281-2396 FAX

Safford Ranger District
711 14th Avenue, Suite D
Safford, AZ 85546
(928) 428-4150

(928) 428-2393 FAX

Santa Catalina Ranger District
5700 N. Sabino Canyon Rd.
Tucson, AZ 85750
(520) 749-8700
(520) 749-7723 FAX

Sierra Vista Ranger District
5990 S. Hwy. 92
Hereford, AZ 85615
(520) 378-0311
(520) 378-0519 FAX

COUNTY SHERIFFS

Cochise County
Benson Patrol District
126 West 5th Street
Benson, Arizona 85602
(520) 586-8150

Bisbee Patrol District
205 North Judd Drive
Bisbee, Arizona 85603
(520) 432-9500

Douglas Patrol District
661 G Avenue
Douglas, Arizona 85607
(520) 805-5670

Sierra Vista Patrol District
100 Colonia De Salud, Suite 106
Sierra Vista, Arizona 85635
(520) 803-3850

Willcox Patrol District
450 South Haskell Avenue
Willcox, Arizona 85603
(520) 384-7050

Pima County
Green Valley District Office
601 N. La Canada Drive

Green Valley, Arizona 85614-3440
Phone (520) 351-6711

Santa Cruz
1250 N Hohokam Dr
Nogales, AZ 85621
Tel: (928) 761-7869

Yuma
District 1 – Foothills
13190 E. South Frontage Road
Yuma, AZ 85367
Tel: (928) 342-1477
Fax: (928) 345-1164

District 2 – Westside
3620 W. 8th Street
Yuma, AZ 85364-2585
Tel: (928) 782-3192

BUREAU OF LAND MANAGEMENT

Safford Field Office
711 14th Avenue
Safford, AZ 85546-3337
Phone: (928) 348-4400
Fax: (928) 348-4450

Tucson Field Office
12661 East Broadway
Tucson, AZ 85748-7208
Phone: (520) 258-7200
Fax: (520) 258-7238

Yuma Field Office
2555 East Gila Ridge Road
Yuma, AZ 85365-2240
Phone: (928) 317-3200
Fax: (928) 317-3250

Lower Sonoran Field Office
21605 North 7th Avenue
Phoenix, AZ 85027-2929
623-580-5500
Fax: 623-580-5580

APPENDIX E QUERYING DATA USING MICROSOFT ACCESS

This procedure will enable you to query any field in any combination and filter data to get the results you want.

A FEW IMPORTANT THINGS TO KNOW

The relationships and some basic queries are already set up in the "New Live WQDB.accdb" project in access. The linked WQDB tables are located under the "Tables" object on the left. Relationships between the tables can be viewed by clicking the relationship button .  .

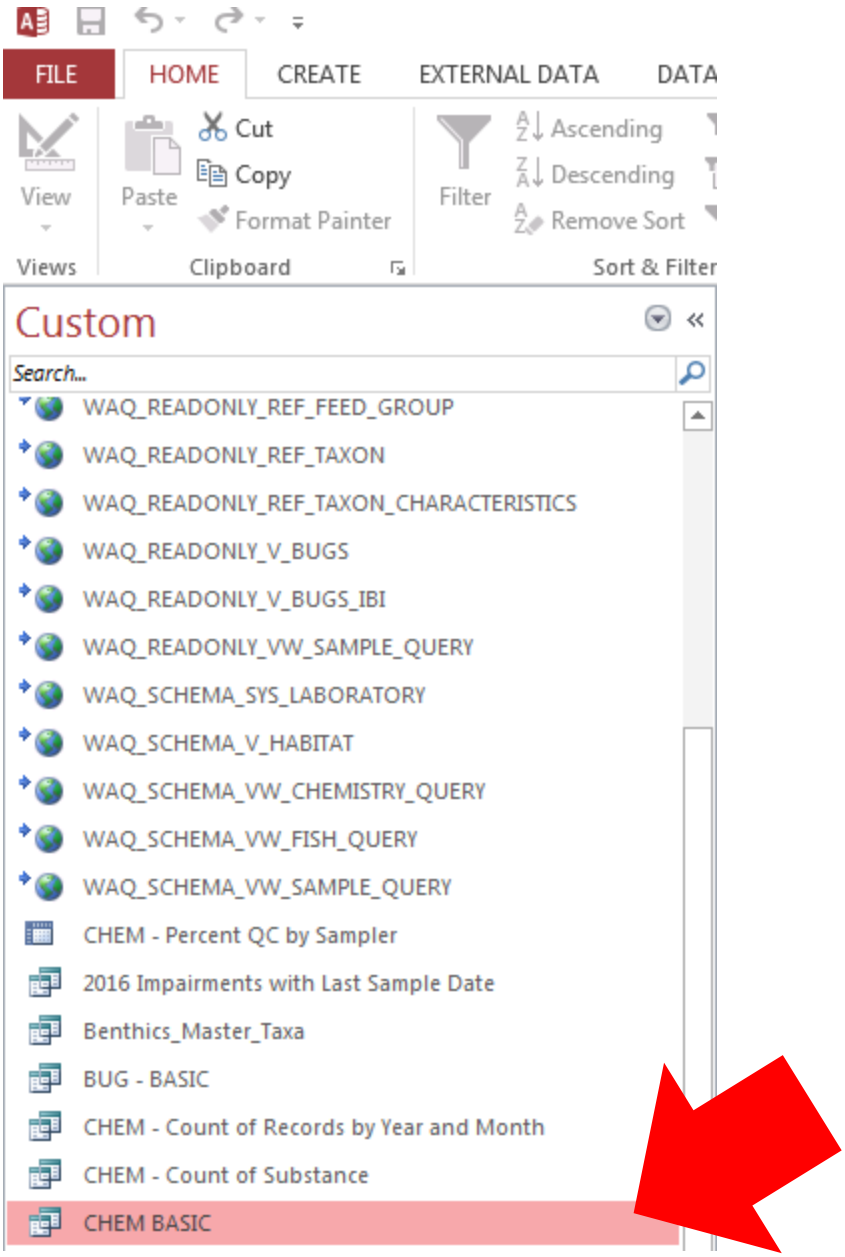
Many of the existing queries are based off of the query called CHEM-BASIC.

BASIC NAVIGATION

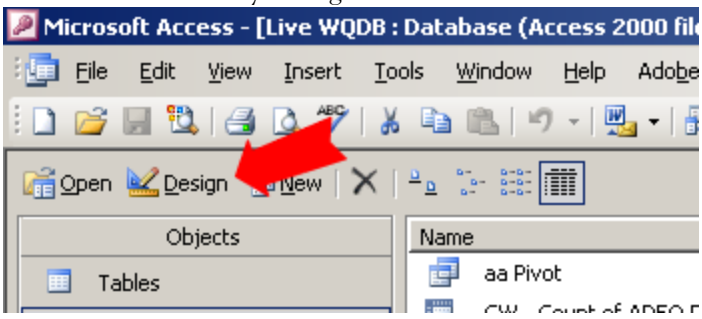
1. Navigate to "New Live WQDB.mdb" located at J:\WQD\Surface Water Section\New WQDB

Save a copy of the New Live WQDB.mdb to your computer so that you don't mess things up things for other users.

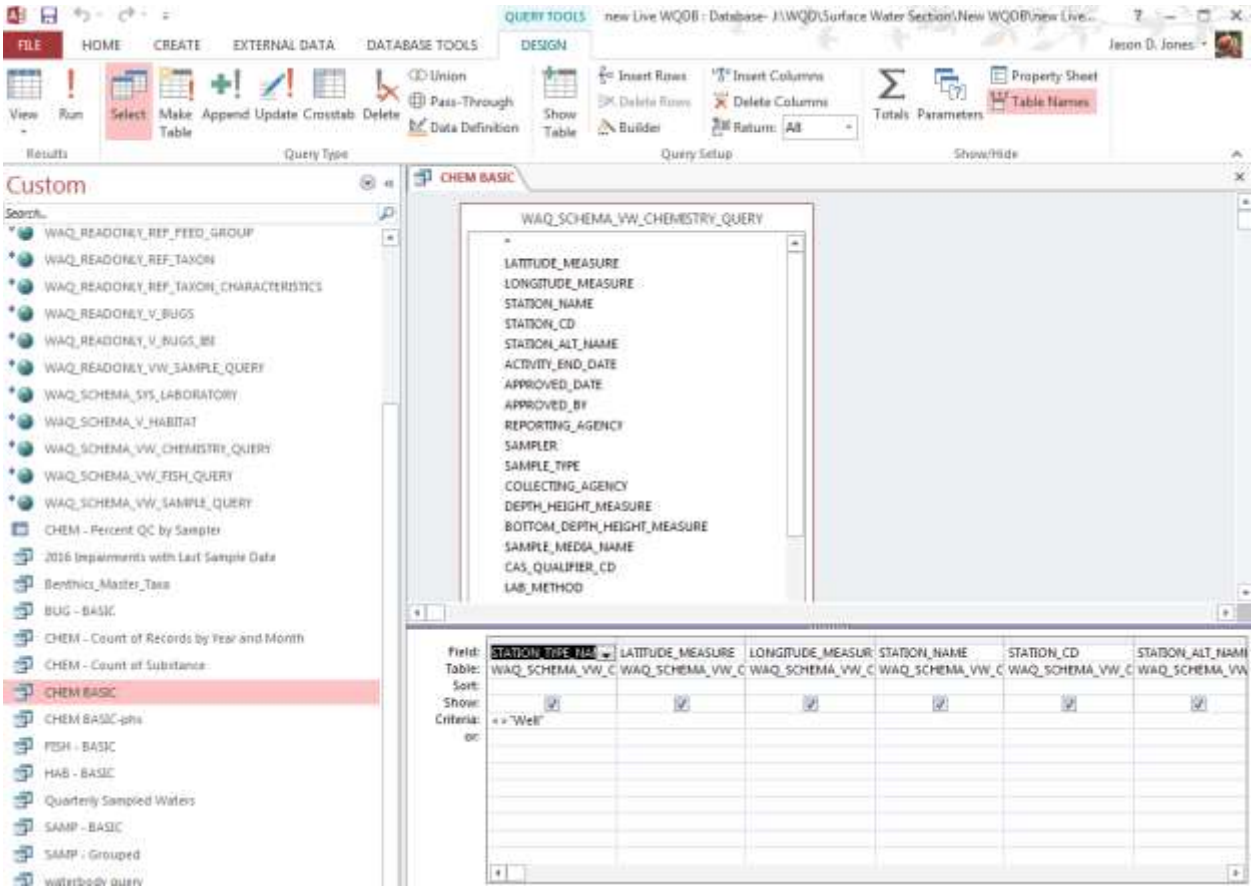
3. Click the "Queries" object on the left.



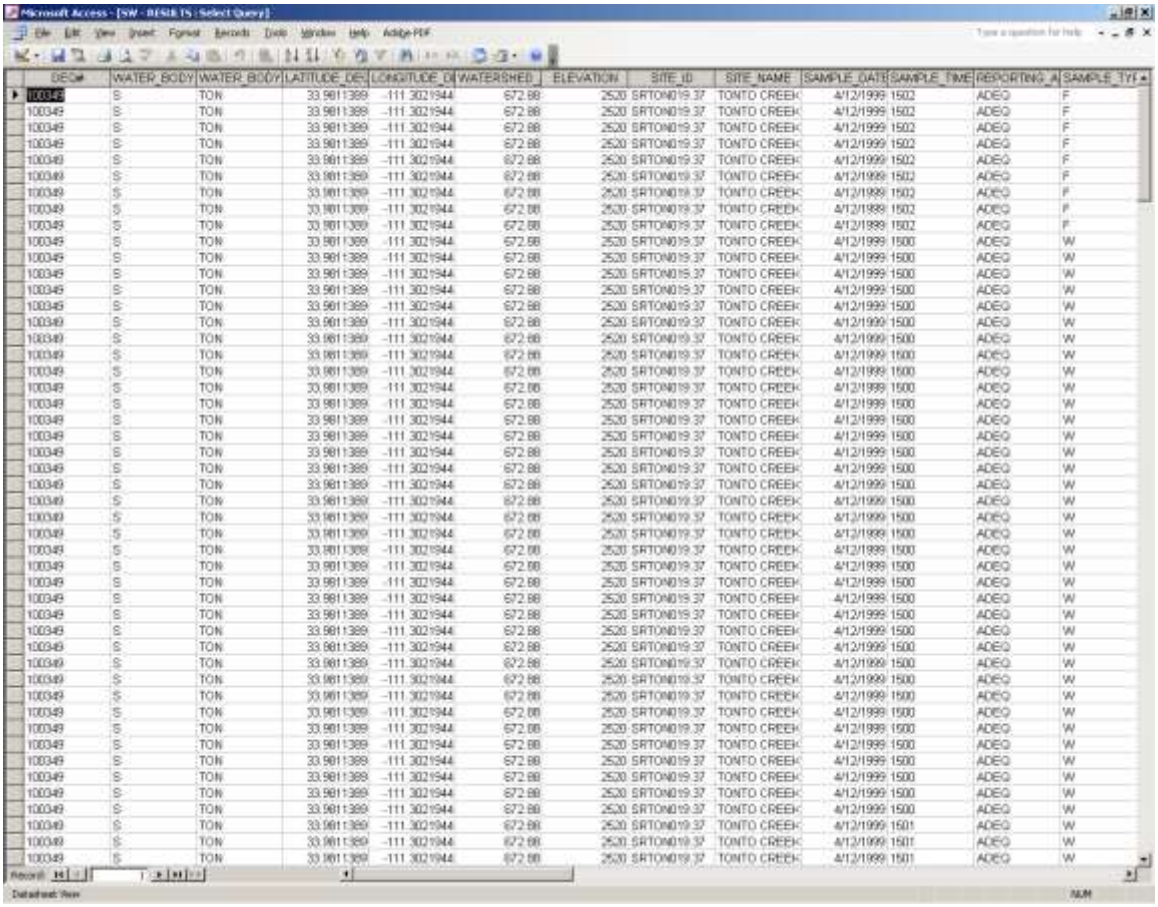
4. Single Click the CHEM – BASIC for surface water data.
5. Click Design. This allows you to specify criteria. If you double clicked you run the query. Not to worry though. You can still click the design button (upper left).



6. Access takes you here.

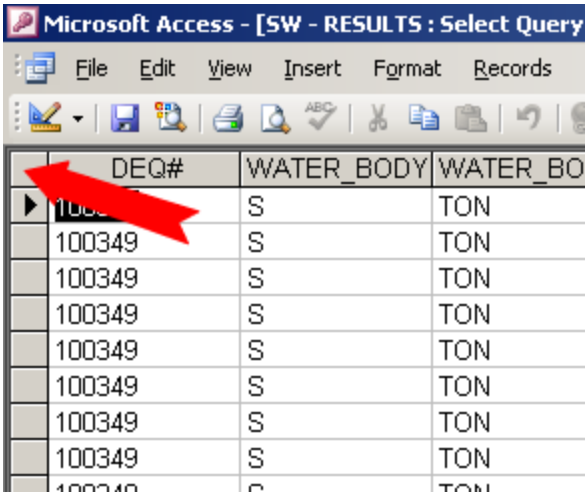


7. This is what you see when you run your query.



8. To return to your query you can click the design button  .
9. To export your data to excel select all the records by clicking on the upper left hand cell.

Don't do this if you have more than 66,000 records. Excel can't easily handle that much data on one sheet.



10. Copy the data by hitting CTRL+C. Depending on the amount of data selected this may take a minute or two.
11. Paste it into excel CTRL+V.

Always check your query against the WQDB and make sure that the records match up. If your relationships are wrong, your query will be too.

APPENDIX F BASIC DATA MANIPULATION

The WQDB, Microsoft Query and the Water Quality data warehouse will give you data in a row format such as:

SITE_ID	Date	LN	Result	RESULT	UNIT	CHEMICAL_NAME
LCBEN002.57	11/15/2006	ND				ALKALINITY, PHENOLPHTHALEIN
LCBEN002.57	11/15/2006		0.039	0.039	MG/L	AMMONIA AS NITROGEN
LCBEN002.57	11/15/2006	ND				ANTIMONY - TOTAL
LCBEN002.57	11/15/2006	ND				ANTIMONY - DISSOLVED
LCBEN002.57	11/15/2006	ND				ARSENIC, INORGANIC
LCECL021.13	11/14/2006		137	137	UMHOS/CM	LAB SPECIFIC CONDUCTIVITY
LCECL021.13	11/14/2006		160	160	UMHOS/CM	FIELD SPECIFIC CONDUCTIVITY
LCECL021.13	11/14/2006		44	44	FT	STREAM WIDTH
LCECL021.13	11/14/2006	ND				SULFATE
LCECL021.13	11/14/2006		6	6	MG/L	SUSPENDED SOLIDS / SEDIMENTS

TABLE F.1. Unformatted data from the WQDB in a row format.

It is helpful to manipulate this kind of data into a tabular format so that each column is a different parameter. This enables easy analysis using programs such as Arc Map and SYSTAT (TABLE F.2).

SITEID	SAMPDATE	HARDCACO3 (mg/L)	ALKCACO3 (mg/L)	CA-T (mg/L)	CHLORIDE (mg/L)	DO- (mg?l)	DO- (%)
LCBEN002.57	11/15/2006	85.0	110.0	21.0	ND	9.00	79.9
LCBEN002.57	4/5/2007	64.0	77.0	15.0	ND	8.29	75.6
LCBEN002.57	5/9/2007	58.0	73.0	13.0	ND	9.33	73.2
LCBRB000.27	11/14/2006	58.0	57.0	11.0	0.5	10.03	106.3
LCBRB000.27	5/1/2007	39.0	37.0	8.3	ND	11.41	107.1
LCBRB000.27	5/16/2007	50.0	52.0	11.0	ND	7.39	89.4
LCBRB006.74	11/28/2006	77.0	76.0	16.0	0.5	8.90	88.3
LCBRB006.74	6/18/2007	43.0	46.0	9.0	ND	8.83	93.2
LCCHC060.61	11/15/2006	120.0	130.0	30.0	0.5	9.46	97.3
LCCHC060.61	4/25/2007	81.0	87.0	20.0	12	11.15	117.0
LCCHC081.26	11/15/2006	120.0	130.0	29.0	0.5	7.37	71.9

TABLE F.2. Formatted data in a tabular or columnar format after it has been manipulated.

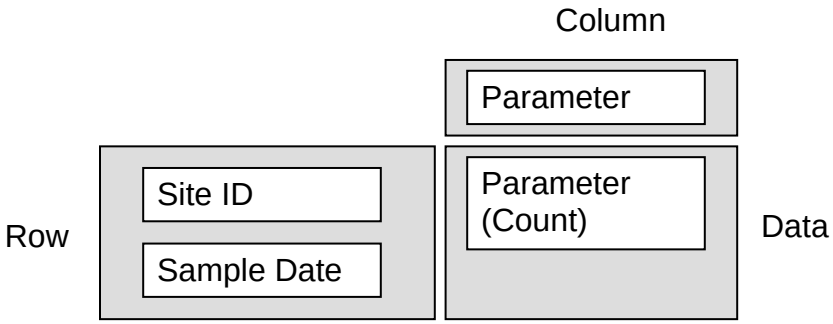
GETTING THE DATA INTO THE "RIGHT" FORMAT

Excel has a powerful tool called a Pivot Table. This tool enables you to organize large quantities of data quickly. One limitation of a Pivot Table is that it really wants to summarize data, which isn't something we want when it comes to displaying results for water chemistry. In order to work around this issue each parameter must be made to be unique. For example, you must distinguish between total and dissolved antimony or field and lab specific conductivity to make this transformation work. We could use STORET numbers to accomplish this, but the problem is that no one knows what

that number means without looking it up in a table. This method gives you a descriptive name for each parameter that we'll use later.

MAKING EACH PARAMETER UNIQUE

1) In Excel, add a new column to the right of "CHEMICAL NAME" and call it "Parameter".
2) Sort by lab method code.
3) Add the formula =CONCATENATE(N2, " ",H2). This should combine the "chemical name" field with the "analysis type". This solves problems with total and dissolved metals.
4) Use the fill down function (CTRL+D) to add to all selected records. Select the column Parameter. CTRL+C. Right Click. Paste Special. Check "values". Paste. This gets rid of the formula.
5) Sort by "EVAL_PURPOSE_TYPE".
6) Concatenate "Parameter" with "Eval_Purpose_Type". This solves duplicate versus regular samples.
7) Use the fill down function (CTRL+D) to add to all selected records. Select the column Parameter. CTRL+C. Right Click. Paste Special. Check "values". Paste. This gets rid of the formula.
8) Concatenate "Parameter" with "Lab_Method_Code".
9) The goal is to verify that each chemical name is unique. Create a pivot table from your data by going to "Data" → "Pivot Table and Pivot Chart Report". Go through the wizard using the default settings (as long as all of your data is selected you should be ok). Set up the pivot table the following way. **All the numbers should be 1**. If not then double click on the number greater than one to see what the problem is. If you are not very familiar with how pivot tables work, you can get up to speed at: http://office.microsoft.com/en-us/training/CR061831141033.aspx



ADDING A NEGATIVE TO THE LONGITUDE FIELD

ArcMap likes to have a negative value for the longitude field.

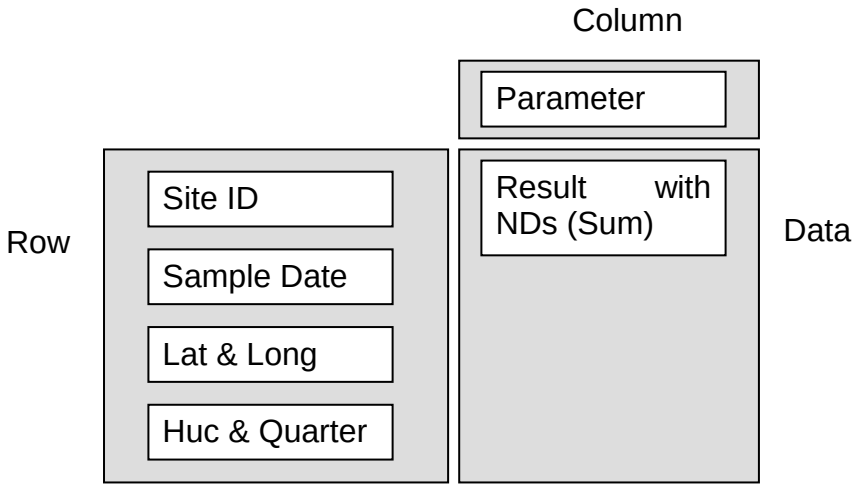
1) Add a column to the right of "LONGITUDE_DEGREES". Call it "Longitude"
2) Insert the formula "=-B2". Fill down. Replace formulas with values.
3) Delete the "LONGITUDE_DEGREES" column.

If you are going to use the data for statistical analysis you should consider how to handle your non-detect values now. Some people use 50% of the detection limit and place use that value when running statistical tests. USGS has developed a more complicated

procedure for dealing with this problem. Statistical analysis is beyond the scope of this procedures manual.

CREATE A PIVOT TABLE TO DISPLAY YOUR RESULTS

1) Select all records.
2) Create a pivot table from your data by going to "Data" → "Pivot Table and Pivot Chart Report". Go through the wizard using the default settings (as long as all of your data is selected you should be ok). Set up the pivot table the following way. We use the "sum" function because there is only one value in each cell, which is why it was important to create unique records earlier. You could also use the average function.



3) Hide all totals and grand totals by right clicking on them and clicking "hide".

PREPARING TO IMPORT YOUR DATA

1) Copy the values in the Pivot Table to a new sheet. CTRL+A, CTRL+C, go to new workbook. Right click, Paste Special. Check Values (this is the important part). Paste.
2) Delete extra rows (rows 1 to 3).
3) Format the cells for each column and pick the maximum number of decimal points displayed for each column. Format the date as a number with no decimals.
4) Fill down all the site_IDs, dates, lat and longs for each site.
5) Change each parameter name to something simple and short such as in TABLE 3. Note all Duplicates with DUP as a suffix. Pick shorter names for all habitat values.

From WQDB and Excel	Change to:
LATITUDE_DEGREES	Latitude
Longitude	Longitude
SAMPLE_DATE	SampleDate
ALKALINITY, PHENOLPHTHALEIN TOTAL	Alk-Pheno
AMMONIA AS NITROGEN TOTAL	NH3
ANTIMONY DISSOLVED	SbD
ANTIMONY TOTAL	SbT
ARSENIC, INORGANIC DISSOLVED	AsD
ARSENIC, INORGANIC TOTAL	AsT
BERYLLIUM AND COMPOUNDS DISSOLVED	BeD
BERYLLIUM AND COMPOUNDS TOTAL	BeT

From WQDB and Excel	Change to:
BORON (BORON AND BORATES ONLY) TOTAL	BT
CADMIUM DISSOLVED	CdD
CADMIUM TOTAL	CdT
CALCIUM CARBONATE STANDARD	HardCOCO3
CALCIUM CARBONATE TOTAL	AlkCOCO3
CALCIUM TOTAL	CaT
CARBONATE TOTAL	CO3
CHLORIDE TOTAL	Cl
CHROMIUM TOTAL	CRT
COPPER DISSOLVED	CuD
COPPER TOTAL	CuT
FLUORIDE TOTAL	FT
HARDNESS (CACO3 + MGCO3) CALCULATED	HardCal
HYDROGEN CARBONATE TOTAL	HCO3
KJELDAHL NITROGEN TOTAL	TKN
LEAD AND COMPOUNDS (INORGANIC) DISSOLVED	PbD
LEAD AND COMPOUNDS (INORGANIC) TOTAL	PbT
MAGNESIUM TOTAL	MgT
MANGANESE TOTAL	MnT
MERCURY, ELEMENTAL DISSOLVED	HgD
MERCURY, ELEMENTAL TOTAL	HgT
NITRATE + NITRITE TOTAL	NitrateNitrite
NITRATE AS N TOTAL	Nitrate
NITRITE AS N TOTAL	Nitrite
PH TOTAL	pHLab
PHOSPHORUS TOTAL	PT
POTASSIUM TOTAL	KT
SELENIUM AND COMPOUNDS TOTAL	SeT
SODIUM TOTAL	NaT
SPECIFIC CONDUCTIVITY STANDARD	SpCondLab
SULFATE TOTAL	SO4
SUSPENDED SOLIDS / SEDIMENTS SUSPENDED	SSC
SUSPENDED SOLIDS / SEDIMENTS SUSPENDED - COARSE FRACTION	SSCCourse
SUSPENDED SOLIDS / SEDIMENTS SUSPENDED - FINE FRACTION	SSCFine
TOTAL DISSOLVED SOLIDS DISSOLVED	TDSLab
ZINC DISSOLVED	ZnD
ZINC TOTAL	ZnT
E. COLI FIELD	Ecoli
STREAM WIDTH FIELD	StreamWidth
DEPTH FIELD	StreamDepth
FLOW FIELD	Flow-ft/s
CROSS-SECTIONAL AREA FIELD	Crossarea
E. COLI FIELD TOTAL	Ecoli
TEMPERATURE FIELD STANDARD	Temp-Air
TEMPERATURE FIELD TOTAL	Temp-Water
DISSOLVED OXYGEN FIELD DISSOLVED	DO-mg/l
DISSOLVED OXYGEN FIELD STANDARD	DO-%

From WQDB and Excel	Change to:
TOTAL DISSOLVED SOLIDS FIELD DISSOLVED	TDS-Field
SPECIFIC CONDUCTIVITY FIELD STANDARD	SpCond-Field
PH FIELD TOTAL	Ph-Field
TURBIDITY FIELD STANDARD	Turbidity

6) Maximize all column widths.

IMPORTING DATA INTO ARCMAP

1) Select the Latitude and Longitude columns.
2) Select all the data you want to export.
3) Save the file as a DBF4 file. DBF's are very picky. Here are some things to keep in mind:
   A) Maximize all columns and make sure your column names are unique and under 8 characters
   B) Make sure you specify the number of decimal places for each column.
   C) Make sure all results are displayed as numbers
   D) If you are importing a column that has a blank value at the top and it is supposed to be numeric you will need to put a "0" at the top. Otherwise it will be converted into a text file. You will need to remember a "0" is equivalent to a blank when displaying your data. In other words, only values with a nonzero number were sampled.
4) Open your map in ArcMap. Be sure you already have stuff loaded such as the watersheds. This establishes the datum in NAD83.
5) Using Arc Catalog, import the DBF file into arcmap by dragging and dropping into the layers panel.
6) Right click on the table in the layer panel in ArcMap and select "Display X Y Data". Longitude should be in the x field, latitude in the y field.
7) All of our data is in NAD83. Under "Coordinate System of Input Coordinates" select Edit. Click Geographic Coordinates → North America → North American Datum 1983. Click OK on all screens.
8) Your data should be displayed on the map. If not you may need to readjust column names in the DBF table or format the lat/long fields correctly. Sometime you need to tinker with it to get it to load properly.
9) Once you get it loaded you should create a shapefile and make it permanent. To do this right click on the newly displayed cover. Select Export Data. Chose a great place on your computer and name the shapefile. You can now remove the DBF table from your map.

IMPORTING DATA INTO SYSTAT

1) Open SYSTAT. Make sure your Excel file is closed or SYSTAT won't be able to open it.
2) Go to "File" > "Open" > Data.
3) Select "excel" for the file type. Pick the excel file you saved earlier. Pick the sheet with the formatted data. Remember don't try and import the pivot table. You want to import the table with the data already formatted.

APPENDIX G SEPTIC SYSTEM DETECTION USING OPTICAL BRIGHTENERS

Monitoring for optical brighteners can be used to determine whether inadequate septic systems or other domestic wastewater discharges are impacting surface water quality. Optical brighteners are fluorescent white dyes that are added to almost all laundry soaps and detergents and are therefore found in domestic wastewaters that include laundry effluent. When optical brighteners are applied to cotton fabrics, they absorb ultraviolet rays in sunlight and release them as blue rays. These blue rays interact with the natural yellowish color of cotton to give the appearance of being "whiter than white."

Optical brighteners are removed from surface water by absorption onto soil and organic materials and by photo decay (exposure to sunlight). The recovery of optical brighteners in surface water or ground water is direct evidence that the cleansing of wastewater is ineffective.

It is recommended that discharge measurements be taken when deploying the sample kits.

EQUIPMENT

The following equipment is needed to collect optical brightener samples:

Equipment	Use
Rigid, non-metal or vinyl coated racks	Holds cotton pad in the water
Stakes and ties	Secure racks in the stream and secure pad in the rack
Cotton pads	Collects optical brighteners
Hammer	Pound stakes into stream bed
Disposable gloves	When handling racks and pads
Waders or rubber boots (optional)	
Flagging	Mark sites – have to locate a week later
Knife	Remove ties or fishing line
Plastic bags	For cotton pads once collected
Waterproof marker	Label plastic bags with sample site info
Black plastic lined box or other darkened container	Transportation of samples back to lab
Monofilament line (fishing line) and pins	Drying cotton pads
Ultra-violet light, darkened room (Colilert reading equipment works well)	Look for fluorescence

Before going in the field, check that equipment is clean and that the cotton pads and equipment do not fluoresce under ultra-violet light conditions.

PLACEMENT

Optical brightener sampling is best suited for small streams and drainages under base flow conditions (primarily ground water). Larger volumes of water (ponds, lakes, rivers, or runoff conditions) will likely dilute the concentration of optical brighteners to such a degree that it cannot be qualitatively detected. This is a presence / absence test.

Use disposable plastic gloves to secure a cotton pad in a clean wire rack using plastic ties.

Use metal stake, ties, or monofilament fishing line so the sampling rack holding the cotton pad will remain:

- Securely in place while allowing water to easily pass through it.
- Submerged within the flow of water for the next week.
- In a shaded location (sunlight naturally decays the brighteners).
- Almost invisible to a casual passerby.

Mark the site with flagging tape so you will be able to find it in a week. Avoid placing the kits where a passerby may notice it, as they may tamper with the equipment.

The optical brightener sample is generally exposed for seven (7) days to allow sufficient time for contact with optical brighteners. If background interference (sediment, algae, rust) or drying conditions occur, the exposure time can be shortened. The exposure time can also be lengthened.

SUPPORTING DATA

The reliability and sensitivity of this testing procedure, and conditions needed to detect optical brighteners in Arizona's surface waters, are still being evaluated; therefore, other supporting data and information will be needed to properly interpret the optical brightener positive/negative tests. Collect and record the following additional information:

- Flow data at each site when placing the sample kits.
- *E. coli* bacteria samples.
- Total nitrogen (TKN + nitrite/nitrate) and total phosphorus.
- Weather conditions when setting and information concerning weather during the time the kits were exposed.
- Change in flow during the week (qualitative only).
- Field observations concerning sources.

If this is a new site, record latitude and longitude and other site access information needed to locate the site.

Photo document the site, taking upstream and downstream photos when setting out and when collecting the samples.

SAMPLE RETRIEVAL AND PROCESSING

Use single use gloves when handling the samples. Rinse the pads in the surface water to remove excess sediment. If pads have become frail, rinse them while they remain in the rack.

Gently remove the cotton pads, place them in plastic bags, and label the bags with site information. Label should show location, day of placement, and day of removal.

Place pads in a dark place during transportation (remember sun will degrade the brighteners).

Directions indicate that pads should be dried overnight on monofilament line. Be sure that pads remain labeled. Watch out for cross-contamination as most labeling papers and cotton string contain whiteners.

DATA ANALYSES AND INTERPRETATION

View each pad under ultra-violet fluorescent light in a dark room on a clean table. Turn off lights, close doors, and take all measure possible to prevent ambient light from entering the analyses room.

Compare each pad to a non-exposed sampling pad and a pad exposed to optical brighteners as a control.

Report results as:

- Positive (fluorescence – it glows),
- Negative (no fluorescence – just like the control), or
- Inconclusive.

In some instances only a portion of the pad will fluoresce. This is usually due to uneven exposure of the pad to the dye in the watercourse. It should be considered positive.

Specks or spots of fluorescence on the sample or control pads are likely due to paper or cotton dust and do not indicate a positive result.

When in doubt, call it “inconclusive”.

Record results on the Optical Brightener Data Sheet.

The presence or absence of optical brighteners in a stream can be used to determine TMDL implementation or Water Quality Improvement Grant Project effectiveness.

However, the absence of optical brighteners should be interpreted based on supporting evidence such as flow conditions, bacteria samples, potential sources, and precipitation. For example, higher stream flows could have diluted dyes, resulting in negative tests.

ADEQ Optical Brightener Data Sheet

Monitoring Project Name: _____
Surface Water(s): _____
Date Equipment Placed: _____ Date Equipment Retrieved: _____ Days in Stream _____
Method of flow: _____ NAD for Lat/Long _____
Monitoring Staff: _____
Comments: _____

Site Name	Site IDs	Latitude Longitude	Flow (cfs)	Bacteria Results (CFU)	Optical Brightener (Pos/Neg/Inconclusive)	Field Observations

APPENDIX H SWITCH CONSTRUCTION

Section 1.

FLOAT SWITCH CONSTRUCTION

The current basic float switch design used to trigger deployed autosamplers is outlined below, see FIGURE H.1 for complete float switched housed on two-inch well casing. The design is open to refinement and redesign based on specific project needs.

Materials needed for one float switch

Float Switch (Grainger part number 4YM35)
2" PVC slotted well screen (1.5-2' length)
1" PVC cap
5/32" drill bit
3/8" drill bit
#6 1.5" length screw with nut, wing nut, and washer

Tools Needed

Drill
Radial saw
Screwdriver
Pliers

Construction

Float switch assembly
Drill 3/8" hole in bottom of 1" PVC cap;
Thread float switch into hole- should screw in; if loose use glue/caulking/sealant to affix to cap;
Drill 5/32" hole into upper third of 1" PVC cap;
Insert #6 screw through hole so that the threads are exposed on the outside of the cap; and
Tighten nut onto screw- if loose the wing nut will not tighten properly.

Well Casing

Use a radial or circular saw to cut slot in solid portion of well casing leaving approximately 2-3" on both sides of the slot.

Complete Assembly

Insert float switch assembly into well casing by placing exposed screw threads through the slot in the well casing; and
Place washer and wing nut onto screw threads and tighten.

FIGURE H.1. Float switch assembly installed into well screen PVC pipe

Section 2.

CONDUCTIVITY SWITCH CONSTRUCTION

Conductivity switches have been designed to circumvent a common problem with float switches of debris in the stormflow pulse clogging the float and preventing functional enablement of the autosampler. The main advantage conductivity switches have over float switches is that there are no moving parts in the switch mechanism. Water in a stormflow pulse completes the circuit across switch leads, thereby enabling an autosampler or a microcontroller.

Materials needed for one conductivity switch

Standard household plug, 120V 2 prong
6" length of standard lamp cord, 2-wire
2" PVC slotted well screen (1.5-2' length)
1" PVC cap (or 1 ¼" PVC plug)
#6 1.5" length screw with nut, wing nut, and washer
Plumbers/silicone caulk

Tools Needed

Drill
1/4" drill bit
1/8" drill bit
Radial saw
Screwdriver
Pliers
Vise
Caulk gun (optional)

Construction

Conductivity switch assembly

- Drill 1/4" hole in bottom of 1" PVC cap or 1 ¼" PVC plug;
- Drill 1/8" hole into upper third of cap or plug;
- Insert #6 screw through the 1/8" hole so that the threads are exposed on the outside of the cap; and tighten nut onto screw- if loose the wing nut will not tighten properly.
- Disassemble the plug and attach the electrical cord to the plug as called for by the design; some plugs have screw terminals; these will require 1/8" to ¼" stripping of the ends of the cord for attachment. Others rely upon a folding/jackknife construction that penetrates the wire insulation with metal prongs/contacts in the plug casing. These require no prior stripping.
- Reassemble the plug; thread the wire through the ¼" hole so the plug is pulled into the cap. It may be necessary to leave the outer plug housing off for some models to fit into the PVC cap.
- Fill spaces in the PVC cap with plumbers caulk or silicone clear caulk. The cap should be filled to its rim level, and the plug face should be even with the rim and centered in the cap.
- Allow the cap to cure for 24 to 48 hours before use.

If desired, the switch can be mounted in well screen, as outlined below, for adjustable stage settings. Alternatively, the mounting screw and wingnut may be omitted from construction and the switch mounted by other means, e.g. hose clamps on rebar, etc. The design may be modified using smaller caps and electrical pins for use with first flush samplers and microcontrollers.

Well Casing

Use a radial or circular saw to cut slot in solid portion of well casing leaving approximately 2-3" on both sides of the slot.

Complete Assembly

Insert conductivity switch assembly into well casing by placing exposed screw threads through the slot in the well casing; and

Place washer and wing nut onto screw threads and tighten.

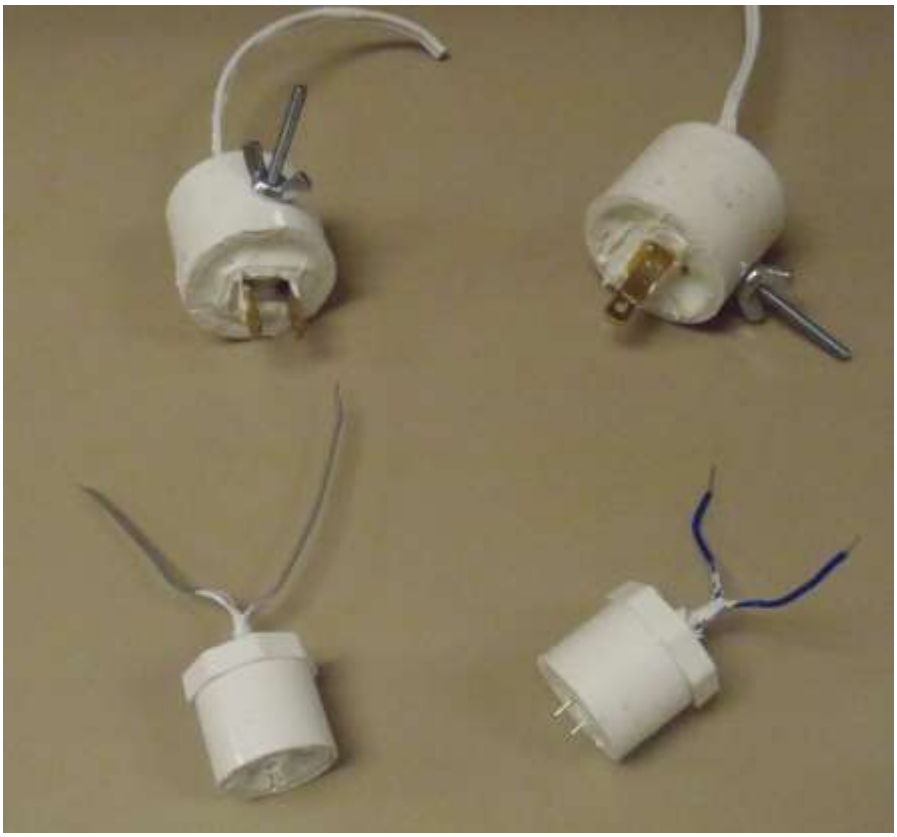


Figure H.1. Conductivity switches, large with screw attachment and small without.

SWITCH INSTALLATION

Switches are intended to trigger microcontrollers in the event of flow or enable autosampler programs as water levels rise, causing either a float or a direct water-medium contact to complete the circuit. The switches are connected to the autosamplers via half cables (ISCO part # 790 and Sigma part #541), normally 25' in length. The half cables are connected directly to the float switch wires or via a two-wire junction wire. The ISCO half cables consist of only two wires whereas the Sigmas contain six (6). It does not matter how the ISCO half cables are connected to the two wires on the switch. However, when using the Sigma half cables, the blue and black wires must be connected to the switch wires.

The float switch consists of a donut-shaped float that moves up and down a rod with a retaining clip on the bottom. The ISCO and Sigma autosampler programs are triggered when the circuit created by the half cable and float switch is either opened (ISCO) or closed (Sigma). In order to change whether the circuit is opened or closed under "dry" conditions, the donut-shaped float can be removed, reversed and reinstalled. A test trigger should be conducted to ensure that the float switch is functioning properly prior to final installation and during maintenance events.

Both types of switches are placed in the stream bottom and set to trigger an autosampler or microcontroller when the water level rises sufficiently to activate the switch. The switch assembly can be mounted on either a bedrock outcrop (preferred) or on a masonry brick or garden paver using

2" fence post mounting brackets. Ideally, access to the switch assembly will be unobstructed after installation. Periodic cleaning and maintenance may be needed. Mounting to rock or brick requires a hammer drill, masonry drill bit, generator, sledge hammer, anchor bolts and nuts, and an appropriately sized wrench. Prior to installation proper authorization shall be received in writing from the land owner or managing entity.

APPENDIX I GENERAL LEVEL LOGGER MAINTENANCE FIELD PROCEDURES

Needed items

- Laptop
- Communication cable
- Extra battery
- Equipment keys
- Field notebook
- Calibration check pipe

Download/maintenance instructions

- Update laptop clock to cellular phone or GPS unit
- Open appropriate program
- Record device serial number in field notebook
- Note time difference between logger and laptop in field notebook
- Download historical data, note number of records in field notebook
- Save data to file, note file path in field notebook
- Check file; verify it contains data
- Delete historical data from logger
- Clear memory and resynchronize clock
- Check and note real-time reading in field notebook
- If needed change battery and note in field notebook, reconnect to laptop and verify proper operation

Upon return to office

- Transfer files to desktop or data disk
- Delete data from laptop

Notes to make in field notebook include:

- Device serial number
- Time difference of equipment to laptop
- Number of records in memory
- Data file name
- Note actions taken: Memory cleared, resynchronize clock
- Battery status (if equipped)
- Real-time reading
- General notes- changed battery, observations, etc.

APPENDIX J AUTOSAMPLER DEFAULT AND RECOMMENDED PROGRAM SETTINGS FOR TMDL STORM SAMPLING

The following values are presented as provisionally-recommended program settings for Sigma 900 and ISCO 6712 samplers used in storm water sample collection. Site and/or project-specific objectives may differ from the assumptions underlying this template; consequently, site or project-specific settings may need to deviate from the settings presented here. The sampler is advised to use this guide as a generic template from which a sampling collection program may be constructed consistent with the sampler's objectives.

Sigma 900 Max
Main Menu → Setup → Modify All Items →

Number of Bottles:	24
Bottle Volume:	1000 ml
Intake Tube Length:	Set for project site location
Intake Tube Type:	3/8" Vinyl
Program Lock:	Disabled
Program Delay:	Disabled
Sample Collection:	Time proportional
Interval:	1 hr 00 min- determined by project needs
Take First Sample:	Immediately
Deliver Each Sample to All Bottles?:	No (or Set for project objectives)

Choose a Method of Distribution: Bottles per Sample (or Set for project objectives)

Bottles per Sample:	2
Liquid Sensors:	Enabled
Sample Volume:	1000 ml
Intake Rinses:	1 (variable)
Sample Retries:	3 (variable)
Site ID:	Not Necessary / Bypass

Do you wish to access the Advanced Sampling Features?: Yes
↓ to Setpoint Sampling and Select

Setpoint Sampling:	Enabled
Type of Control:	Start on Setpoint
Input Channel:	External Control
Delay when input becomes active:	00:01 (hrs:min) (or Set for project objectives)

Loaded Program:	1
RS232 Baud Rate:	Not Necessary / Bypass

External Control: Delay: 1 minute
Installed Memory: Not Necessary / Bypass
External Power: Not Necessary / Bypass
Memory Mode: Not Necessary / Bypass
Program Complete Output: Not Necessary / Bypass
Special Output: Not Necessary / Bypass
Upset Sampling: Not Necessary / Bypass

ISCO 6712 Program
Program Name: Not necessary / Bypass
Length Units: ft
Number of Bottles: 24
Bottle Volume: 1000 ml
Suction Line Length: Set for project site location
Auto Suction Head: Keep as default
Number of Rinses: Set from 1-3
Number of Retries: Set from 1-3
One-part Program: Yes
Time Paced/Flow Paced:

Time paced
Distribution: Sequential
Sample Volume: 1000 ml
Enable: None programmed
Enable: Once enabled stay enabled
Enable: 0 pauses and resumes
No delay to start: Keep as default

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