

CHAPTER 3. WATER COLLECTION PROTOCOLS

Section A. Water Quality Sondes & Sensors: Calibration, Routine Maintenance, & Use

Overview

A sonde is a collection of multiple sensors and probes housed into one casing and designed to give readings on multiple parameters simultaneously (often referred to as a Multi-Parameter Sonde). Sondes can vary in length, diameter, and housing construction. The most common four sensors on sondes are Temperature, pH, Dissolved Oxygen, and Specific Conductance (typically housed in a 2-inch diameter casing). Larger sondes (e.g., 3.5 – 4-inch diameter casing) can be equipped with additional, larger sensors and probes (e.g., Depth, Chlorophyll-a, and Turbidity). On some sondes (e.g., YSI models) the sensors and probes can easily be changed or replaced by the user. On other sondes (e.g., Hydrolab models), the sensors and probes cannot be easily changed without opening the sonde housing and electronics (either by a very experienced user or by sending the instrument back to the manufacturer's service department).



Figure 3-1. Example of a YSI 660 XL Sonde (right) and a 650 MDS Display Unit (left).

Sensors and probes may utilize drastically contrasting technologies to measure a parameter. For example, one sonde may have a Dissolved Oxygen sensor that utilizes

the smaller Clark-cell technology (it has a membrane) with a stirrer; another sonde may use a similar Clark-cell technology and not have a stirrer; yet another sonde may use the larger Luminescence (LDO) technology (no membrane). In this case, the different sensor/probe technologies respectively offer pros and cons based on size the accuracy of the reading and size of the sonde casing required to house the sensor.

Many sensors are reliant on other sensors to take accurate readings. For example, the pH, Dissolved Oxygen, and Specific Conductance sensors require the Temperature sensor to be working and accurately reading to make temperature dependent corrections. The Dissolved Oxygen sensor is also dependent on the Specific Conductance sensor. Some manufacturers have the multiple sensors bundled into one probe (e.g., YSI's Temperature/Conductivity Probes).

The Watershed Assessment Branch utilizes multiple brands (e.g., YSI, Hydrolab, Eureka, Onset, etc.) and models (e.g., 600XL, DS5x, Quanta, Manta, Tidbit) of sondes. Not all the procedures described below will work or be applicable for all sondes (e.g., brand and/or model specific order in which buttons are pressed during calibration or operation). However, most of the procedures for calibration and maintenance (e.g., rinsing steps, calibration reagents and endpoints, QA/QC checks, and maintenance schedules) are universal across brands, models, and probes.

Additionally, the Watershed Assessment Branch utilizes sondes that are only capable of discrete, instantaneous readings as well as sondes/data loggers that are equipped to be programmed, deployed, and take time-series incremental or continuous readings. The Calibration and Maintenance procedures of both types are basically the same except for some data loggers (e.g., Temperature, Temperature/Light, and Temperature/Conductivity Data Loggers). For more specific information about the Calibration, Maintenance, and Programming of these deployable sondes/data loggers refer to **CHAPTER 13. CONTINUOUS WATER QUALITY MONITORING PROCEDURES starting on page 13-1.**

Sonde/Display Unit Manufacturer Manuals

For more complete descriptions of the care and operation of the various sondes and display units, consult the instruction manual provided by the manufacturer at the following locations:

YSI 6-Series (600 XL, 600 XLM, 6600) Multiparameter Water Quality Sondes

<https://www.ysi.com/File%20Library/Documents/Manuals/069300-YSI-6-Series-Manual-RevJ.pdf>

YSI 650 MDS Multiparameter Display System

<https://www.ysi.com/File%20Library/Documents/Manuals%20for%20Discontinued%20Products/655228-YSI-650-Operations-Manual-RevB.pdf>

YSI 556 MPS Sonde & Display Unit

<https://www.ysi.com/File%20Library/Documents/Manuals/655279-YSI-556-Operations-Manual-RevD.pdf>

YSI ProDSS Sonde & Display Unit	https://www.ysi.com/File%20Library/Documents/Manuals/YSI_ProDSS_User_Manual_English.pdf
Hydrolab Quanta and Quanta-G Sonde & Display Unit	http://www.ott.com/download/hydrolab-quanta-manual/
Hydrolab DS5X & MS5 Sondes	http://www.ott.com/en-us/products/download/user-manual-hydrolab-ds5x-ds5-and-ms5-water-quality-multiprobes/
Hydrolab Surveyor 4a Display Unit	http://www.ott.com/en-us/products/download/hydrolab-surveyor-4a-manual/
Hydrolab HL Sondes	http://www.ott.com/en-us/products/download/hl-series-sonde-bediensanleitung-user-manual-manuel-dutilisation-manual-de-usuario/
Hydrolab Surveyor HL Display Unit	http://www.ott.com/en-us/products/download/survey-hl-handheld-manual/

Any information provided in this SOP is not meant to supersede the instructions or guidance provided in the manual provided by the manufacturer.

Part 1. Sonde/Sensor Calibration, Maintenance, Diagnostics, and Accuracy

The following are a basic overview of the procedures for the calibration, maintenance, diagnostics and accuracy of for an YSI 600XL or 600XLM Sonde/650 MDS display combination and a Hydrolab Quanta G. These instructions are meant as a quick reference guide to the steps involved in calibrating a sonde and do not supplant the manufacturers' operation manual. Consult the owner's manuals for specifics or information on configurations other than these and for details on maintenance and trouble-shooting. Additional resources may be available on the internet (e.g., HachHydromet.com has calibration instructional videos for the Hydrolab models of sondes).

NOTE: The Hydrolab Quanta G directions are very similar to the older Scout 2 Hydrolab directions.

These procedures assume the user has a basic knowledge of the instrument. These directions are not intended for first-time users. Individuals with no prior experience should calibrate with the assistance of an experienced user.

All calibration adjustments as well as maintenance performed are documented on a permanent Sonde Calibration Sheet. The date and time of calibration, name of the calibrator, the identification number of the unit, battery voltage and all adjustments/maintenance must be documented (**see example in Figure 3-2 & Figure 3-3 on the following pages**).

Full Sonde Calibration Log Sheet

Sonde ID: _____ Date: _____ Time: _____ Calibrator's Initials: _____
 Battery Check (V): _____ Field User's Initials (if different from Calibrator): _____
 Temperature (°C): _____ *Temperature must be recorded for all Calibrations (even single probe calibrations)!*

IMPORTANT: *If any probe on the sonde needs to be replaced (e.g., does not calibrate correctly anymore, too old, etc.), YOU MUST FIRST complete the full calibration process on the old probes (filling out all of the applicable sections) before replacing it with a new probe. After the new probe is installed, fill out a second Calibration Log Sheet (in the applicable sections) for the new probe's calibration. Both sets of calibration data are necessary for quantifying the probe's quality during the period immediately before it was replaced.*

DO Probe Calibration

Routine Maintenance Checklist:

1. *Check the age of the DO probe. It should be no more than 2 years old for 600 XL YSIs (5-7 years for 556 YSIs). First 3 characters of Serial # _____
 Is it too old? Yes or No*
2. *Is the D.O. Membrane > 30 days old? Yes or No If so, it needs to be changed regardless of the amount of use it has seen.*
3. *For those sondes that have it, is the D.O. charge <100? Yes or No
 If not, then resurface the probe's electrodes with sandpaper.*

Atmospheric Pressure (mm Hg): _____ New DO Membrane Installed
 Initial % Sat: _____ Final % Sat: _____
 Initial DO (mg/L): _____ Final DO (mg/L): _____ DO Charge: _____

Specific Conductance Probe Calibration

Routine Maintenance Checklist:

1. *For best accuracy, Specific Conductivity should be calibrated according to the expectations of the streams/sites you will be sampling. It may be necessary to recalibrate between streams/sites due to extreme differences between streams/sites (e.g., 1000 vs. 10000 µmhos/cm). Was Specific Conductance calibrated accordingly? Yes or No*
2. *Be sure to check the age of the Specific Conductivity probe. It should be no more than 3 years old. First 3 characters of Serial # _____
 Is it too old? Yes or No*

Conductivity Solution (µmhos/cm): _____
 Initial Sp Cond (µmhos/cm): _____ Final Sp Cond (µmhos/cm): _____
 Low-End Sp Cond Check (i.e., <5 µmhos/cm)
 Solution: Deionized or Distilled Water Sp Cond (µmhos/cm): _____
 Monthly Mid-Range Sp Cond Check (e.g., 500 or 1000 µmhos/cm)
 Conductivity Solution (µmhos/cm): _____ Sp Cond (µmhos/cm): _____

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Figure 3-2. Example of Sonde Calibration Log Sheet (PAGE 1)

pH Probe Calibration

Routine Maintenance Checklist:

- 1. Be sure to check the age of the pH probe. It should be no more than 12 to 18 months old. First 3 characters of Serial # _____

Is it too old? Yes or No

- 2. If the pH probe has electrodes that can be refreshed with new Reference Solutions and Tablets, check them to see if they need refreshed. Was new pH Reference Solution & Tablet Installed? Yes or No

IMPORTANT: If the streams/sites you will be sampling are expected to fall within the same pH range (i.e., 4-7 vs. 7-10), pH should be calibrated using a two-point calibration for best possible accuracy. Should a stream site fall outside of the calibrated pH range, then on-site recalibration is necessary. If expectations are unknown, use a three-point calibration.

Initial pH (7): _____ Final pH (7): _____ mV (7): _____ (0 +/- 30 mV)

- 3. The pH 7 mV should be in a range of +/- 30 mV. Between +/- 30-50 mV, the probe is still useable, but should be monitored closely for irregularities with the ranges of mV on the 10 and/or 4 buffer solutions. After +/- 50mV, the probe should no longer be used. Is the pH 7 calibration showing an acceptable range? Yes or No

Initial pH (10): _____ Final pH (10): _____ mV (10): _____ (-180 +/- 30 mV)

Initial pH (4): _____ Final pH (4): _____ mV (4): _____ (+180 +/- 30 mV)

- 4. Is the Nernst Equation (mV ranges) OK for all the calibration points? Yes or No

Probe Maintenance Info

Probe Installed: New or Used Probe Type: pH DO Temp/Sp. Cond.

Probe Model #: _____ Probe S/N: _____

Calibration/Maintenance Notes: _____

Figure 3-3. Example of Sonde Calibration Log Sheet (PAGE 2)

NOTES ABOUT CALIBRATION:

- Rinsing the probe is a procedure that is frequently performed during calibration. To rinse the probe, install the calibration cup (which is the same as the storage cup on YSI and Quanta G sondes) and add about 1/2 cup of rinse solution, as specified in the directions (usually deionized (DI) or distilled water). Seal the open end of the calibration cup with the screw cap or rubber lid and shake the probe for 30 seconds. Discard rinse water and repeat per directions.
- All calibrations are performed with the probes pointing upward and at temperatures as close to room temperature as possible (25°C). If calibration does not occur at room temperature (e.g., a field calibration) then every attempt should be made to temperature adjust the calibration solutions according to the manufacturers' guidelines presented in Figure 3-4, Figure 3-5, & Figure 3-6 on pages 3-19, 3-20, & 3-21 respectively.

Display Unit Overview**YSI 6-Series (600XL or 600XLM) Sonde/650 MDS Display**

The YSI display unit uses a series of escapable menus in conjunction with several keys in the calibration process. Become familiar with the **Enter** key (which looks like a left arrow), escape, scroll, and alpha-numeric keys as these will be the most often used.

Maintenance of YSI Display Unit

The YSI display unit runs on a 4 alkaline C-cell battery system contained within the display unit. The battery power left is displayed on the screen.

Also, of importance is the fact that the results of calibration for YSI units are stored in the sonde itself, not in the display unit. Switching the sonde and display units will not affect calibration. This may be especially helpful as one can calibrate several sondes with only one display unit as others may be recharging.

The display unit also features a Date/Time and an auto-shutoff function, which may be modified by selecting "System Setup" in the Main Menu and then selecting the appropriate function to modify.

Hydrolab Quanta G

The Quanta G display unit uses a series of escapable menus in conjunction with several keys in the calibration process. Become familiar with the Enter key (which looks like a left arrow with a right angle), escape (Esc ∞), on/off (O | I), and arrow keys as these will be the most often used.

Maintenance of Quanta G Display

The Quanta G runs on 3 C batteries. Replace the C batteries as required. The Quanta G System provides at least 15 hours of continuous operation on one set of new batteries. A Battery Low icon will show the battery status.

Dissolved Oxygen Sensor

DO Sensor Overview

Two major technologies are used for DO Sensors: Clark-cell and LDO (Luminescence Dissolved Oxygen). Clark-cell sensors utilize a paired gold (Au) and silver (Ag) electrode immersed in a KCl electrolyte solution under a Teflon membrane. Dissolved oxygen diffuses across the membrane and measured by the electrical current between the two electrodes. One disadvantage to Clark-cell technology is that the process of measuring the dissolved oxygen consumes the oxygen. Therefore, Clark-cell sensors need to be used where there is adequate flow to replenish the oxygen. One way to get around this is the use of an external stirrer. For example, Hydrolab Clark-cell sensors have a stirrer that can be turned on if the water flow is less than 1ft/second. YSI Clark-cell sensors do not have a stirrer due to a slight variation; it is a pulse probe turns on and off rapidly so that oxygen depletion is prevented (whereas a Hydrolab Clark-cell is a steady-state probe). The main drawbacks with a Clark-cell are that the membrane is fragile and easily torn and can be fouled with biofilms and dirt quickly (especially during long-term deployment use).

LDO sensors utilize a luminescent material that is excited by light to measure the oxygen concentration. Specifically, a blue LED illuminates the chemical and it instantly becomes excited. As the material relaxes, it releases red light. The amount of red light is detected by a photodiode and the time it takes to relax is inversely proportional to the oxygen concentration in the water. LDO sensors have an advantage over Clark-cell sensors in that they give more stable and accurate readings, they do not consume oxygen, have longer sensor lives, and can be used in environments with little to no flow. Typically, they come with a wiper that will remove biofilms and dirt from the sensor cap. Because of this, an LDO sensors tend to be bulky and often need to be mounted on larger sonde casings (3.5 – 4-inch diameter), which is the technology's biggest drawbacks, at least when first introduced to the market.

DO Sensor Calibration

IMPORTANT: If a Clark-cell DO sensor will not calibrate, the membrane may be torn (including micro-tears not visible to the naked eye), wrinkled, dirty, damaged, or a bubble may be trapped in the probe. See DO Sensor Maintenance Clark-cell DO Sensor for information on how to change a membrane on a Clark-cell DO sensor.

YSI 600XL or 600XLM Sonde/650 MDS Display

NOTE: With some of the newer sondes (2004-Present), you need to run the sonde just as if it was in the stream to get the initial or pre-calibration DO readings and then go thru the following steps to calibrate DO and get the post-calibration readings.

1. Remove the threaded lid to the calibration cup. Unlike the Hydrolab sondes, it is not necessary to dry the membrane on the D.O. probe by blotting it with a soft cloth or tissue, but rather only make sure that the membrane is **not inundated with water**. Also, check the membrane for wrinkles, tears, bubbles, dirt, etc. and replace membrane, if necessary.

IMPORTANT: YSI recommends against touching DO membranes when replacing or servicing them. There is a potential for oils or dirt to affect O₂ diffusion through the membrane.

2. Reattach the calibration cup to the sonde and add no more than 1/8-inch of DI (deionized) or distilled water. Try not pour water on the membrane, but if it does get wet, just make sure that the membrane is not totally inundated with water. Make certain that the DO and Temperature probes are not immersed in water.
3. Cover the calibration cup with the lid and engage only 1 or 2 threads. An alternative to cover the calibration cup with a moist paper towel, then place the lid on upside down on top of the cup with a small weight on top of the lid.
4. Turn on the unit and let sit for about 10 minutes so that the air inside the cup will saturate with water and come to thermal equilibrium.

NOTE: If the sonde is from a newer manufacture year (2004-Present), you may need to do one-time adjustment of the sonde settings so that it will give you the initial or pre-calibration readings before continuing the calibration procedure. The manufacture year can be determined by reading the first two digits of the sonde's serial number (e.g., 04=2004). If this is the case, this can be fixed by deactivating the Autosleep RS232 function in the following section of the menu: **Sonde Menu > Advanced > Setup > Auto sleep RS232**. Toggle the function off by pressing the enter button.

5. Turn on the unit and use the **Up** or **Down** keys to scroll to "Sonde Menu" and press **Enter**. Select "Calibrate" and press **Enter**.
6. Scroll to select "Dissolved Oxy" and press **Enter**.
7. Select "DO %", press **Enter**. One must keep in mind that this is calibrating based on O₂ air saturation, not water saturation.

8. Type in the Barometric Pressure displayed by the unit in the bottom right of the screen using the alpha-numeric pad; press **Enter**. Wait for both temperature and DO readings to stabilize; this may take up to 40 seconds (after waiting the initial 10 minutes for water vapor equilibration in the cup). The upper right of the screen should have the word "Calibrate". Record the initial or pre-calibration DO, temperature, and % air saturation on the Sonde Calibration Log Sheet. If the upper right of the screen has the word "Continue" instead of "Calibrate" then calibration has already occurred, and the readings given are the final or post-calibration readings. This can be avoided for future calibrations by deactivating the Autosleep RS232 function in the following section of the menu: Sonde Menu > Advanced > Setup > Auto sleep RS232. Toggle the function off by pressing the enter button. This will permanently allow the initial or pre-calibration readings will be available prior to calibration.
9. Press **Enter** to finish calibration. Record the final or calibrated DO and % air saturation in log book.
10. The final % air saturation should be within the range of 98% air saturation at the lowest WV elevations to 83% at the highest WV elevations (+/- 2 %). The probe should not read above 100% air saturation as this only occurs at sea level. A 100% reading may also be caused at low WV elevations by a high-pressure front or unusual weather in the area. Consult the attached sheet for air saturation values that should be found at different elevations or Appendix D (page 227) from the YSI operating manual (*see Table 3-1 on next page*). YSI probes may be calibrated at lower elevations and then brought to higher elevations and still be accurate (the percent air oxygen saturation should go down with an increase in elevation). However, calibration at an extreme elevation and transport to a lower elevation may require a recalibration at the lower elevation. If the barometer reading is extremely unusual for your local elevation, the internal barometer may require recalibration in the lab by a person familiar with that procedure.
11. The upper right of the screen will say "Continue". Press **Enter**. And it will take you back to the DO Calibration Menu.

Table 3-1. From Appendix D Table 2 of the YSI operating manual (page 227)

Pressure (mm Hg)	Altitude (ft.)	Expected % Saturation (+/- 2 %)
760	0	100
752	278	99
745	558	98
737	841	97
730	1126	96
722	1413	95
714	1703	94
707	1995	93
699	2290	92
692	2587	91
684	2887	90
676	3190	89
669	3496	88
661	3804	87
654	4115	86
646	4430	85
638	4747	84
631	5067	83

Elevation at Harpers Ferry=249 ft. and at Spruce Knob=4862 ft.

Hydrolab Quanta G

1. Remove calibration cup from probe and dry the membrane by blotting with a soft cloth or tissue. Check the membrane for wrinkles, tears, bubbles, dirt, *etc.* and replace membrane, if necessary.
2. Attach calibration cup to the Quanta and fill cup with room temperature tap water until the water surface is just level with O-ring on the D.O. probe. Do not pour water on the membrane. If the membrane gets wet, blot dry with a soft cloth or tissue.
3. Cover the calibration cup loosely using the black calibration cup cover placed upside down on the calibration cup.
4. Let the unit sit for about 10 minutes so that the air inside the cup will saturate with water.
5. Turn on the Quanta G using the **O | I** key and allow the D.O. reading to stabilize. If the circulator is on, press the **Esc** ∞ key to toggle the circulator off so that it doesn't splash the water in the cup onto the membrane. Record the initial or pre-calibration readings (mg/L) on the Sonde Calibration Log Sheet. Also, record the initial readout for temperature.
6. Press the **enter** key to toggle to the next screen and record the initial or pre-calibration % DO saturation on the Sonde Calibration Log Sheet.

7. After power-up the Display's "Screen" icon in the lower center of the screen is blinking. Press either of the **arrow** keys to cause the "Calib" icon to blink instead of "Screen". Press the **enter** key to select calibration. Use the **arrow** keys to cause "DO%" to blink and then press the **enter** key.
8. Determine the barometric pressure for entry as the calibration standard and record on the Sonde Calibration Log Sheet. *Use the local barometric pressure. Many local weather bureaus correct the barometric pressure to sea level. Consult the operating manual for formulas to convert from sea level barometric pressure to local barometric pressure.*
9. Press the **arrow** keys to raise or lower the barometric pressure to match the calibration standard.
10. Press the **enter** key to finish calibration of Dissolved Oxygen. If the unit rejects the calibration, the display will show "FAIL" before returning to the "Calib" screen.
11. Press the **Esc** ∞ key to return to the real-time data screen. Record the final or post-calibration D.O. readings on the Sonde Calibration Log Sheet. Press the **enter** key to toggle to the next screen and record the final or post-calibration % DO saturation on the Sonde Calibration Log Sheet.

Hydrolab LDO Sensor

See CHAPTER 13. CONTINUOUS WATER QUALITY MONITORING PROCEDURES Section D. Deployable Sonde Operation (Calibration, Programming, and Downloading Protocols) Part 1. Sonde Calibration Procedures Hydrolab Deployables on page 13-10 for example instructions on how to calibrate an LDO sensor.

DO Sensor Maintenance

Clark-cell DO Sensor

The Teflon membrane on the DO probe should be examined for fouling and bubbles before calibration and during use. Look to see if the membrane is torn, dirty or wrinkled, or if there are bubbles under the membrane. Whenever these conditions are observed, the membrane must be replaced. YSI recommends the membrane be replaced at least every 30 days. Frequent replacement of membranes can also lengthen the life of the probe.

To replace the membrane, remove the O-ring and old membrane and shake the remaining electrolyte (KCl solution) out of the probe. Check the silver and gold electrodes for excess tarnish (caused by contaminants that cross the membrane with the dissolved oxygen). The silver electrode will get dark (especially without maintenance) with use. If tarnish is excessive, use GoJo and a cotton swab or YSI sanding disk to remove tarnish (move clockwise on gold electrode gently with light

pressure...remember that the silver and gold electrodes are very malleable). If the silver electrode remains dark despite cleaning, then the sensor has reached the end of its lifespan. New KCl is available as an undissolved solid pre-aliquoted in a bottle and provided with each new DO sensor or in an YSI maintenance kit. This bottle should be filled with DI or distilled water to the **neck** to provide the proper working concentration. Add a few drops of fresh KCl solution to the sensor. The tip of the sensor should be filled to create a positive meniscus (looks like an "outie") and should be free of bubbles. If bubbles are present, tap the side of the sensor to get the surface tension to pop. Gently place the membrane onto the meniscus of the KCl solution and hold the new membrane between your fingers and the sensor body. Use your free hand to place the O-ring over the tip of the sensor on top of the membrane. Without overly touching the membrane with your fingers pull/push the O-ring down over the membrane and down the side of the sensor to the depression that holds the O-ring. Secure the loose ends with your forefinger and pull any wrinkles out. If any bubbles are present, you must start again. Cut off excess membrane. Document any membrane replacement on the Sonde Calibration Log Sheet.

WARNING: THE KCL SOLUTION USED UNDER THE DO MEMBRANE IS ESPECIALLY CORROSIVE TO THE ELECTRICAL CONTACT PINS ON THE SENSORS AND SHOULD NOT BE ALLOWED TO CONTACT THESE ELECTRODES OR COME IN CONTACT ANYWHERE NEAR OPEN SENSOR PORTS WHEN A SENSOR IS BEING REMOVED OR INSTALLED.

IMPORTANT: The membrane should be replaced 24 hours before use or calibration to allow time for the new membrane to relax. If, it is an emergency and the DO sensor must be used before the complete 24-hour relaxation period has lapsed, a minimum of 30 minutes must elapse prior to use. In addition, significant drift in its response should be expected due to shifting tension in the membrane. Therefore, the sensor should be calibrated every hour it is used until the full 24-hour relaxation period has passed. For most TMDL and other short-duration sampling events, this means the user will most likely need to recalibrate the DO sensor before every site.

LDO Sensor

Clean the exterior of the sensor with mild soap and a toothbrush or cotton swab. Inspect the LDO cap for excessive wear. This cap should be replaced every 1-2 years.

IMPORTANT: Do not expose the interior of the cap to sunlight as this will adversely affect the performance of the sensor. Exposure of the exterior of the cap to sunlight is to be expected and OK.

With the cap removed, examine the sensor lens. If water is visible under the lens, the sensor will need to be replaced. Be careful not to confuse water with oils that belong under the sensor lens.

ADDITIONAL NOTES ABOUT LDO SENSORS:

- **The Wiper Arm on Luminescence (e.g., LDO) or Fluorometric (e.g., Chlorophyll-a) sensors should be positioned over the temperature probe when installed and at rest on Hydrolab models. If they are showing excessive wear in one direction, you can remove the bristles and turn them the other direction. You can also replace the clip that attaches the bristles to the wiper arm.**
- **The Hydrolab LDO probe has two generations of caps. The first-generation cap is more tapered and was prone to water leakage. It needs to be upgraded to a second-generation cap (less tapered) that does not leak and the internal sonde software upgraded as well.**
- **Hydrolab LDO probes had a four-digit time stamp during manufacture. The first digit is the last digit of the year. The remaining three digits is the Julian Day. For example, 1074 is the 74th day of 2011 and 8329 is the 329th day of 2008.**

DO Sensor Diagnostic

YSI 600XL or 600XLM Sonde/650 MDS Display

To check the quality of the calibration or diagnose a potential problem with the DO sensor, an advanced function called DO charge may be used.

1. Press **Esc** to get the Main Menu.
2. Use the **Up** or **Down** keys to scroll and select "Report".
3. Scroll down and select "Dochrg" and press **Enter**. When this is done, the symbol to the left of "Dochrg" should change from an empty to a black circle.
4. Press **Esc** twice to get the 650 Main Menu. Scroll up to "Sonde Run" and press Enter.
5. A new parameter should be visible on the screen called "DOc". If the sensor is in adequate condition and calibrated successfully, the number should range from 25 - 75 with a score of 50 being optimum.
6. If the sensor reads in this range, then simply repeat this procedure to turn off the DO charge function (the black circle will change back into an empty circle).

If the DO charge is in the low end of the range or below this range, the KCl solution under the membrane may be contaminated with water. In this case the membrane and solution should be replaced.

If the DO charge is in the high end of the range several things may be wrong. First, the highly malleable gold electrode may be distorted or the silver-plating on the electrode may be “tarnished” and gray looking. In this case, the electrode may be reconditioned by buffing it using one of the **YSI provided buffing discs only**. *This should also be done only with strict adherence to the directions provided in the manual for using this buffing disc on the sensor surface. It may be necessary to consult with an YSI representative before attempting this action.* **YSI recommends running newly-buffed sensors for 10-15 minutes continuously to realize good stability.**

A second possible cause of a high DO charge reading are cracks around the electrodes because of drying and rewetting of the surface. If this is the case, then the DO sensor may need to be replaced.

YSI’s 6562 Clark-cell DO sensors have an expected lifetime of 3-5 years from the date of manufacture. The date of manufacture is stamped on the side of the sensor in the form of a 3-character code where the first two numeric digits indicate the year and the third character is a letter corresponding to the month (A = January, B = February and so on). If the sensor has passed its expected lifetime, it may simply be too old to give proper calibration and readings.

DO Sensor Accuracy

YSI Clark-cell

The DO sensor accuracy is +/- 0.2 mg/L (or ppm) O₂ or 2% of the reading (whichever is greater). The range for % saturation is or +/- 2 % or the reading or Air Saturation (whichever is greater).

Hydrolab Quanta Clark-cell

The DO sensor accuracy is +/- 0.2 mg/L (or ppm) O₂ at ≤ 20 mg/L or +/- 0.6 mg/L (or ppm) O₂ at >20 mg/L.

Hydrolab (Hach) LDO

The DO sensor accuracy is +/- 0.1 mg/L (or ppm) O₂ at ≤ 1 mg/L or +/- 0.2 mg/L (or ppm) O₂ at >1 mg/L.

Conductivity/Specific Conductance Sensor

Conductivity Sensor Overview

The Conductivity Sensor typically consists of a sensor with at least two or more holes that allows the flow water into an area of known volume with two electrodes. An electrical charge is applied between the electrodes and the conductivity of the known volume of

water is measured. The temperature reading is applied to correct the conductivity reading into a Specific Conductance reading.

Conductivity Sensor Calibration

YSI 600XL or 600XLM Sonde/650 MDS Display

1. Remove the lid on the calibration cup and use the special brush designed to fit inside the Conductivity Sensor's 2 end ports, vigorously scrub each port 5-10 times.
2. Rinse the sensor 3 times with DI or distilled water.
3. Dry the Conductivity Sensor using a paper towel. This will reduce the chances of diluting the conductivity standard.
4. Rinse the sensor 2 times with a small amount of **fresh** conductivity standard in the **1000-5000** microSiemens or μS (also known as micromhos or $\mu\text{mhos/cm}$) range. The exact concentration of the standard will be written on the bottle. The concentration of solution used should be dictated by the conductivities expected to be encountered during the use of the instrument during the week.
5. Fill cup with conductivity standard to within a centimeter of the top of the cup. Make sure that there are no bubbles in the measurement cell of the specific conductance sensor (e.g. gently inverting the sonde several times). Record the concentration of standard used to calibrate on the Sonde Calibration Log Sheet.
6. Press **Escape**. Scroll to **conductivity**; press **Enter**.
7. Scroll to **SpCond**; press **Enter**.
8. Type in concentration of standard in milliSiemens (not microSiemens). For example, 1000 microSiemens = 1.000 milliSiemens. Press **Enter**.
9. Allow the reading to stabilize, (a maximum of one minute, though the conductance sensor response time is usually the fastest of all sensors). Record the initial or pre-calibration readout on the Sonde Calibration Log Sheet. Press **Enter** to calibrate and record the final or calibrated readout on the Sonde Calibration Log Sheet. Press **Enter** again to continue back to the conductivity menu.
10. Now, after at least 3 rinses with DI or distilled water, exit from the calibration menu
11. Enter the discrete sampling mode (Sonde Run from the Main Menu) and conduct a **Low-End Specific Conductance Check** using either DI or distilled water (expected conductance ≤ 5 microSiemens). This Low-End Specific Conductance Check should be conducted at least once a week during calibration. Indicate the solution used and the Low-End conductivity solution reading on the Sonde

Calibration Log Sheet.

12. At least once a month, conduct a **Mid-Range Specific Conductance Check** using either a known 500 or 1000 microSiemens solution, depending on the solution used to calibrate the Conductivity Sensor. Indicate the conductivity of the solution used and the Mid-Range conductivity solution reading on the Sonde Calibration Log Sheet.

Hydrolab Quanta G

1. Remove the lid on the calibration cup and rinse the sensor 3 times with DI or distilled water.
2. Dry the Conductivity Sensor using a paper towel. This will reduce the chances of diluting the conductivity standard.
3. Rinse the sensor 2 times with a small amount of **fresh** conductivity standard in the **1000-5000** microSiemens or μS (also known as micromhos or $\mu\text{mhos/cm}$) range. The exact concentration of the standard will be written on the bottle. The concentration of solution used should be dictated by the conductivities expected to be encountered during the use of the instrument during the week.
4. Fill cup with conductivity standard to within a centimeter of the top of the cup. Make sure that there are no bubbles in the measurement cell of the specific conductance sensor. Wait for the readings to stabilize. Record the concentration of calibration standard used and the initial or pre-calibration specific conductance readings on the Sonde Calibration Log Sheet.
5. Press either of the **arrow** keys to cause the “Calib” icon to blink instead of “Screen”. Press the **enter** key to select calibration. Use the **arrow** keys to cause “SpC” to blink and then press the **enter** key.
6. Press the **arrow** keys to raise or lower the specific conductance to match the calibration standard in mS/cm.
7. Press the **enter** key to finish calibration of specific conductance. If the unit rejects the calibration, the display will show “FAIL” before returning to the “Calib” screen.
8. Press the **Esc** ∞ key to return to the real-time data screen. Record the final or post-calibration specific conductance readings on the Sonde Calibration Log Sheet.
9. Rinse at least 3 times with DI or distilled water.
10. Conduct a **Low-End Specific Conductance Check** using either DI or distilled water (expected conductance ≤ 5 microSiemens). This Low-End Specific

Conductance Check should be conducted at least once a week during calibration. Indicate the solution used and the Low-End conductivity solution reading on the Sonde Calibration Log Sheet.

11. At least once a month, conduct a **Mid-Range Specific Conductance Check** using either a known 500 or 1000 microSiemens solution, depending on the solution used to calibrate the Conductivity Sensor. This is also known as a Linearity Test. Indicate the conductivity of the solution used and the Mid-Range conductivity solution reading on the Sonde Calibration Log Sheet. The Mid-range check should vary less than 10% from the Mid-Range solution.

NOTE: The Hydrolab deployable sondes (e.g., DS5x, DS5, or MS5 sondes) can do a 0-point calibration. The Quanta sonde models do not have this ability.

Conductivity Sensor Maintenance

Air bubbles in the Conductivity sensor's openings will affect the accuracy of the reading (*i.e.*, air bubbles will change the volume of water in the sensor's void. Biofilms and dirt often help trap air bubbles and contribute to inaccuracy as well. Because of this, the openings that allow fluids to access the conductivity electrodes should be cleaned regularly (once a month at least) using mild soap and the small acrylic brush included in the YSI calibration kit, a soft toothbrush, or cotton swabs. Dip the brush in mild soap and water and insert it into each hole 20-30 times. The electrodes should also be inspected and cleaned. Rinse with plenty of water to remove the debris and soap.

Excessive scratches Conductivity sensor's openings will also affect the accuracy of the reading and are an indication that the sensor should be replaced. YSI's Temperature/Conductivity Sensors have an expected lifetime of 2-3 years from the date of manufacture. The date of manufacture is stamped on the side of the sensor in the form of a 3-character code where the first two numeric digits indicate the year and the third character is a letter corresponding to the month (A = January, B = February and so on). If the sensor has passed its expected lifetime, it may simply be too old to give proper calibration and readings.

NOTE: YSI 556 sondes have Conductivity Sensors that are not interchangeable with the YSI 600 series.

Conductivity Sensor Diagnostic

YSI 600XL or 600XLM Sonde/650 MDS Display

The Conductivity Sensor on an YSI sonde can be checked using a function called Cal Constants.

1. Press **Esc** to get the Main Menu.

2. Scroll down and select “Advanced” and press **Enter**.
3. Scroll down and select “Cal Constants” and press **Enter**. The reading next to the “Cond:” should range from 4.5 – 5.5. If the reading is not within this range consult the YSI operation manual or an YSI representative.
4. To escape from this screen, press Esc repeatedly until the Main Menu appears.

Conductivity Sensor Accuracy

YSI 600XL or 600XLM Sonde/650 MDS Display

The Conductivity Sensor accuracy is +/- 0.5% +/- 1 μ S/cm. For example, a solution that is 1000 microSiemens, the range would be 1000 x 0.005 +/- 1 microSiemen or 5 +/- 1 microSiemen.

Hydrolab Quanta G

The Conductivity Sensor accuracy is +/- 1% +/- 1 μ S/cm. For example, a solution that is 1000 MicroSiemens, the range would be 1000 x 0.01 +/- 1 MicroSiemen or 10 +/- 1 MicroSiemen.

pH Sensor

pH Sensor Overview

A basic pH sensor generally has two components: the pH bulb or “voltage provider” and the reference junction or “ground” that create a complete circuit via a salt bridge in the water. YSI pH sensors house both components into one self-contained probe. By contrast Hydrolab sensors house these components in two separate probes.

pH Sensor Calibration

The pH Sensor on a sonde can usually be calibrated using one three methods:

- ✓ One-Point
- ✓ Two-Point=Preferred Calibration Method
- ✓ Three-Point

If you know what side of neutral (*i.e.*, pH=7) most the streams you are going to be sampling will be on, it is recommended that you use a Two-Point calibration. A Three-Point Calibration may seem to be advantageous since it covers both sides of neutral (*i.e.*, acidic and alkaline), but it has been observed that accuracy can suffer, especially near or beyond the two endpoints (*i.e.*, 4 and 10 pH). Since the Three-Point calibration covers all three pH buffers, we will describe it below as an example.

YSI 600XL or 600XLM Sonde/650 MDS Display (Three-Point calibration example)

1. Press **Escape** to get to Calibration mode.
2. Rinse probe three times with DI or distilled water.

3. Scroll down to **ISE1 pH**; press **Enter**.
4. Scroll down to **3 Point**; press **Enter**.
5. Rinse probe twice with DI or distilled water and once with 7.0 buffer solution.
6. Fill calibration cup with 7.0 buffer solution to within a centimeter of the top of the cup.
7. Because the exact pH of a buffer varies (depending on its constituents) with its temperature, a table provided by the manufacturer must be used to determine the exact current pH of the buffer solution. **Refer to Figure 3-4 below or the chart hanging in the lab for the exact pH of a given buffer solution at the current temperature of the room.**

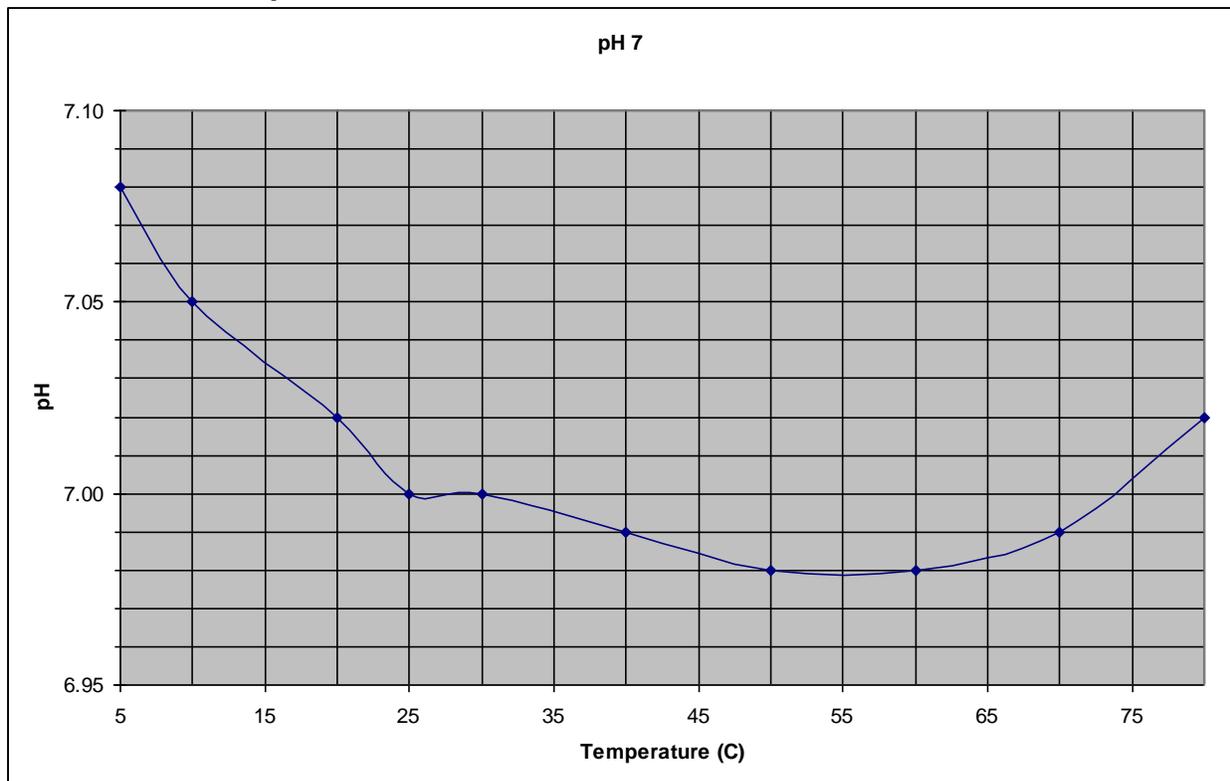


Figure 3-4. Temperature/pH curve for pH 7 Buffer Solution

8. Type in the exact pH for the 7.00 buffer solution for the current temperature; press **Enter**. Allow readout to stabilize (approximately one minute).
9. Record the initial or pre-calibration readout. Press **Enter** to calibrate.
10. Record the final or calibration readout and press **Enter** again.
11. Rinse probe 2 times with DI or distilled water and once with pH 10.00 buffer solution.

12. Fill calibration cup with 10.00 buffer solution to within a centimeter of the top of the cup.
13. Determine the exact current pH of the 10.00 buffer solution from the table provided by the manufacturer or in **Figure 3-5 below** as in Step 7 above.

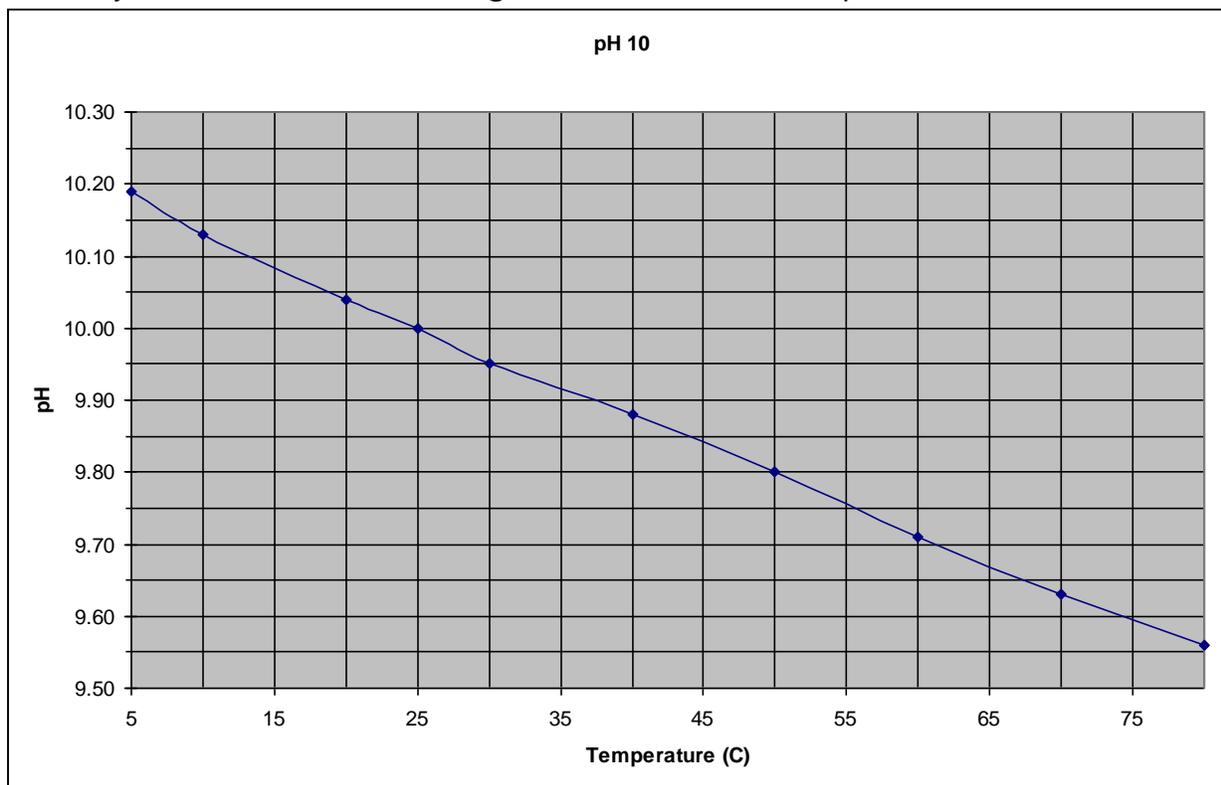


Figure 3-5. Temperature/pH curve for pH 10 Buffer Solution

14. Type in the exact pH for the 10.00 buffer solution given the current room temperature; press **Enter**. Allow readout to stabilize (approximately one minute).
15. Record the initial or pre-calibration readout; press **Enter** to calibrate.
16. Record the final or calibration readout and press **Enter** again.
17. Rinse probe 2 times with DI or distilled water and once with pH 4.00 buffer solution.
18. Fill calibration cup with 4.00 buffer solution to within a centimeter of the top of the cup.
19. Determine the exact current pH of the 4.00 buffer solution from the table provided by the manufacturer or in **Figure 3-6 below** as in Step 7 above.

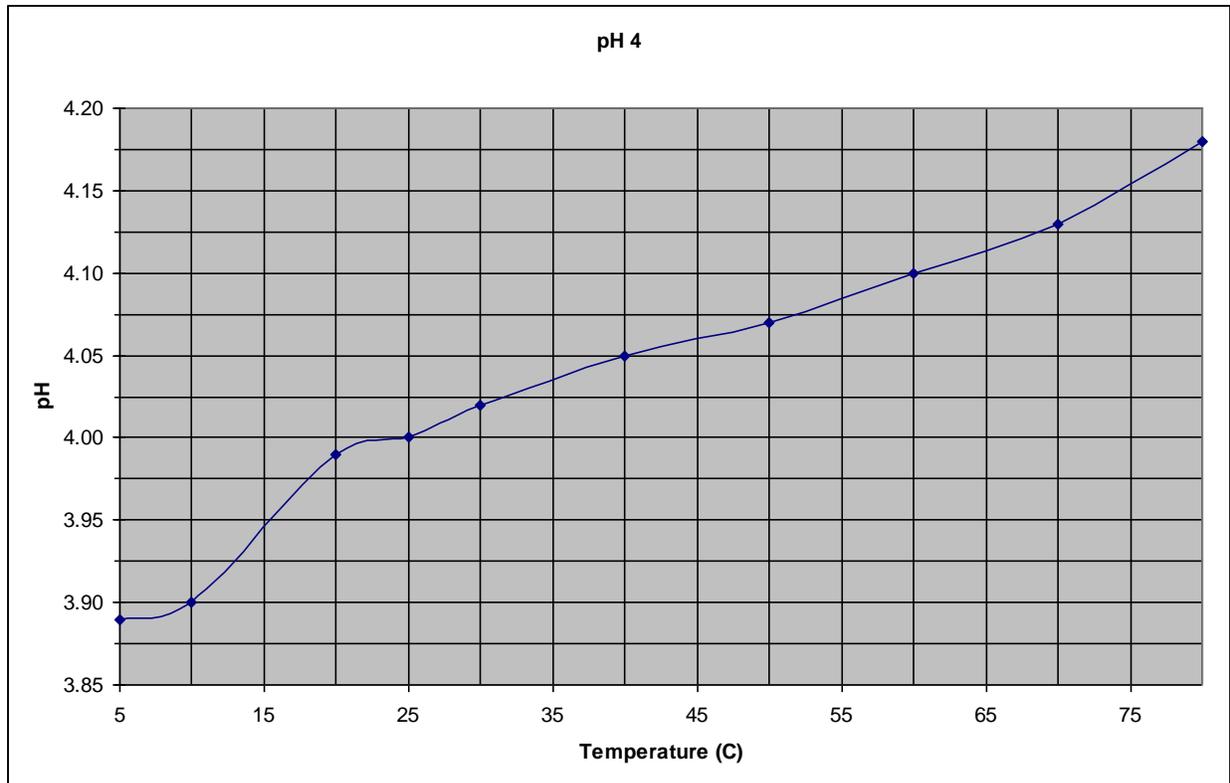


Figure 3-6. Temperature/pH curve for pH 4 Buffer Solution

20. Type in exact pH for the 4.00 buffer solution given the current room temperature; press **Enter**. Allow reading to stabilize (approximately one minute).
21. Record the initial or pre-calibration readout; press **Enter** to calibrate. Record the final or calibrated readout. Press enter to return to the pH calibration menu.
22. Pour out some of the 4.00 buffer solution from the calibration cup, leaving some behind to keep the air inside the cup moist. Preferably, the sonde should always be stored in some sort of high ionic solution (such as the pH buffer solutions) as this will prevent leaching of ions from the pH Sensor and prevent degradation to the probe's expected lifespan. Should you spill the buffer out of the calibration cup while in the field, add an *extremely small* amount of stream water (just enough to keep the air inside the cup moist) to the storage cup. **THE WATER SHOULD NOT COVER THE PH OR DO PROBE WHEN THE SONDE IS HORIZONTAL.** This water should be replaced by buffer solution as soon as possible to prevent the degradation of the pH Sensor.

Hydrolab Quanta G (a Two-Point calibration)

The pH Sensors on a Hydrolab sonde only offer one type of calibration: Two-Point.

1. Rinse the probe 3 times with DI or distilled water.

2. Rinse the probe 2 times with a small amount of the 7.0 pH standard.
3. Fill cup with 7.0 pH standard to within a centimeter of the top of the cup. Wait for the readings to stabilize. Record initial or pre-calibration specific conductance readings on the Sonde Calibration Log Sheet.
4. Press either of the **arrow** keys to cause the “Calib” icon to blink instead of “Screen”. Press the **enter** key to select calibration. Use the **arrow** keys to cause “pH” to blink and then press the **enter** key.
5. Press the **arrow** keys to raise or lower the pH to match the calibration standard for the given room temperature (**See Figure 3-4 on page 3-19 under YSI 6-Series (600XL or 600XLM) Sonde/650 MDS pH**).
6. Press the **enter** key to finish the calibration of pH. If the unit rejects the calibration, the display will show “FAIL” before returning to the “Calib” screen.
7. Press the **Esc** ∞ key to return to the real-time data screen. Record the final or post-calibration pH readings on the Sonde Calibration Log Sheet.
8. Repeat steps 1-7 for the second pH standard. This pH standard will depend on the types of streams that will be encountered. Use the 4.0 pH buffer if mainly acid streams will be encountered and use the 10.0 pH buffer if mainly alkaline streams will be encountered. The calibration standards exact pH at the given temperature can be found in **Figure 3-5 and Figure 3-6 (See pages 3-20 & 3-21 under YSI 6-Series (600XL or 600XLM) Sonde/650 MDS pH)**.
9. When finished with the second pH standard, add a *very* small amount of tap water (just enough to keep the air inside the cup moist) to the storage cup. THE STORAGE WATER SHOULD NOT COVER THE PH OR DO PROBE WHEN THE SONDE IS HORIZONTAL.

pH Sensor Maintenance and Troubleshooting

YSI 600XL or 600XLM Sonde/650 MDS Display

Sometimes slow response times or instability with the values (jumping as much as +/- 1.0 unit during calibration or field measurements) are observed with the pH readings. This may be caused by several factors and may or may not be indicative of a bad probe.

One consideration is the age of the probe. YSI's pH Sensors have an expected use lifetime of about 18 months. This is mainly because the pH Sensor on an YSI sonde operates using a polypropylene wick from the water (or sampling) side to a concentrated KCl side sealed inside the probe. The reference electrolyte solution (KCl) in the probe is sealed in and cannot be recharged (unlike a Hydrolab pH Sensor). Therefore, depending on the amount and types of usage over time (*i.e.*, long-term vs.

short-term submersion in water and dilute vs. concentrated dissolved ions in the water column), the reference electrolyte will eventually be leached out of the probe. The date of manufacture is stamped on the side of the probe in the form of a 3-character code where the first two numeric digits indicate the year and the third character is a letter corresponding to the month (A = January, B = February and so on). If the probe is 18 months or older, then it is likely that it has passed its expected lifetime and it may simply be too old to give proper calibration and readings.

Another factor to consider is the temperature probe. The calculation of pH by the sonde is a temperature dependent calculation. If the temperature probe is malfunctioning, then it may appear as if the pH Sensor isn't working right. Be sure to check the temperature to see if it is returning a reasonable value. If it is not, then the temperature sensor may need to be replaced.

Water or sealant grease can also get in the connector when replacing a probe and can cause malfunctions and erratic readings. When replacing a pH Sensor, dry off the probe and sonde as much as you can before removing the probe to make sure water doesn't enter the fitting. Also, remove the pH Sensor with the sonde upside down so that water cannot run into the connections. Once removed, look inside the connector end of the probe and sonde to see if there is any water or grease in the fitting. If so, remove it with a can of compressed air and/or a paper towel. The important thing is to dry it out as much as possible. If there is excessive grease, then try to remove it with a towel. If the grease cannot be removed, an YSI maintenance expert may need to use a solvent for to break up the grease. Once dry, reconnect the probe using very little grease around the upper O-ring near the threads. A very thin coat making the O-ring look wet is sufficient for a proper seal.

pH Sensor Cleaning is required should be done monthly or when response becomes slow or when deposits build up on the surfaces. To clean the glass bulb, remove the probe and use a mild soap, soft cloth, tissue, soft toothbrush, or cotton swab to wipe foreign material from the glass bulb and platinum button. Then use a moisten cotton swab to GENTLY remove any material blocking the reference electrode junction. *Do not wedge the swab tip between the guard and the glass sensor.*

If response is still slow, soak the probe 10-15 minutes in clean water containing mild soap. Then wipe the probes gently with a cotton swab moistened with the cleaning liquid. Rinse in clean water, wipe once more with a clean swab and rinse again.

If response times continue to be slow, the probe may be cleaned in a 1:1 chlorine bleach solution for 1 hour. YSI recommends this procedure ever 6 – 12 months if the probe does not work well. This is usually as result of extreme conditions in which fouling of the probe is more probable.

Finally, if the probe still does not respond well, it may be soaked in one molar HCl for 30-60 minutes. *This should be used as a last resort method only. Refer to the YSI*

operating and maintenance manual for details on these procedures or consult an YSI representative.

Hydrolab Quanta G

Two electrodes are used to measure pH: one inside of a glass pH probe and a reference electrode enclosed in a reference sleeve. If the response time for pH seems slow then the probes may need to be cleaned.

Glass pH probe: The surface of the glass pH bulb acts as the voltage provider in a circuit with the reference electrode. Little maintenance is required. Check the tip of the probe to make sure the glass is not broken or dirty. If the pH sensor is obviously coated with oil, sediment, or biological growth, clean the glass with a very clean, soft, non-scratching cloth wet with mild soap (a cotton swab or soft toothbrush will also do). Rinse with tap water.

Reference electrode: The reference electrode acts as a ground for the salt bridge to the glass pH bulb. Gently pull the reference sleeve away from the probe. The reference sleeve is the black tube with a porous Teflon Reference Junction attached. Discard the old electrolyte from the reference sleeve. Clean the metal electrode at the bottom with mild soap and a cotton swab. Refill the sleeve to the top with a reference electrolyte tablet and solution. With the probe pointed toward the floor, push the full reference sleeve back onto its mount until the sleeve has just covered the first O-ring located on the mount (just behind the silver electrode). Turn the probe so that the sensors point toward the ceiling and push the sleeve the rest of the way onto its mount. Rinse with tap water. The porous Teflon Reference Junction is the most important part of the pH performance. Make sure it is clean and passes electrolyte readily. A sure sign that it is clogged is that the readings look good in buffer (not a dilute solution, therefore a good salt bridge is established) but do not look good in the field (a more dilute solution, and a salt bridge is not established). Another sign is if the inside of the Teflon junction looks clean (white) and the outside look dirty (gray). If these are the case, replace it. Since this Teflon Reference Junction cannot be cleaned, it should be replaced once every 1-2 years. When seating the reference sleeve, trapped air and excess electrolyte is purged. This purging flushes the porous Teflon Reference Junction.

pH Sensor Diagnostic (Nernst Equation)

pH Sensors operate using the Nernst Equation (*see Figure 3-7 below*). Simply put, it is a line running from 4 to 7 (or 7 to 10) pH on the x-axis should increase 180 mV (or 60 mV/pH unit) from 7 to 4 or (decrease 180 mV from 7 to 10) pH on the y-axis as in the illustration below. If this slope flattens, the pH Sensor will lose resolution. This slope is a result of the probe condition as well as the quality of the calibration. If the sonde is capable, a parameter called pH mV may be used to check this slope.

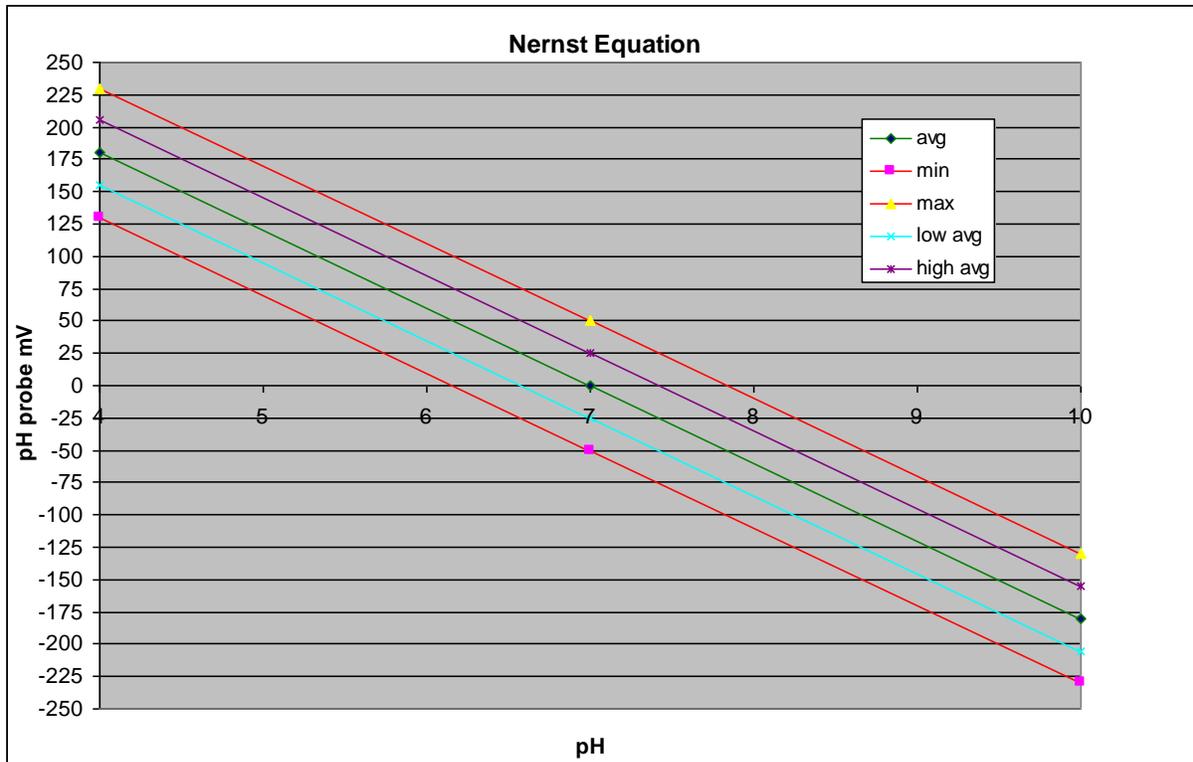


Figure 3-7. The Nernst Equation

YSI 600XL or 600XLM Sonde/650 MDS Display

The Nernst Equation may be checked and calculated on an YSI sonde by following the steps below. Alternatively, it can be checked during calibration if the pH mV parameter on the display is turned on.

1. Press **Esc** to get the Main Menu.
2. Use the **Up** or **Down** keys to scroll to Report and press Enter.
3. Scroll down and select "pH mV" and press **Enter**. When this is done, the symbol to the left of "pH mV" should change from an empty to a black circle.
4. Press **Esc** twice to get the 650 Main Menu. Scroll up to "Sonde Run" and press Enter.
5. A new, second parameter called "pH mV" should be visible on the screen that reads well beyond 14 and may be positive or negative.
6. Use the rinse procedures from the pH calibration above to introduce the 7.00 buffer solution to the probe. Write down the second "pH" reading for the 7.00 buffer solution. It should be between -30 and 30 but may be slightly more (-50 to 50). The reading should stabilize within the values in less than 30 seconds.

7. Repeat the rinse procedures for either 4.00 or 10.00 buffer solution. For either solution, the new reading should have a difference of 180 from the initial 7.00 buffer solution reading.

For example, if an initial reading at 7.00 was -20.0, then the second reading at 4.00 should be around 160 (+/- 30) or, if using 10.00, the second reading should be around -200 (+/- 30).

8. If the probe reads in this range within 30 seconds, then the probe is OK and simply repeat this procedure to turn off the pH mV function (the black circle will change back into a –). If the probe reads outside this range or takes longer than 30 seconds, two things may be wrong. First, the calibration may be off, and the calibration procedure should be repeated to check for this. Unfortunately, if recalibration does not correct the problem, this is an indication that the KCl solution inside the probe is contaminated with water and the whole probe will need to be replaced. **See *Sonde Storage on page 3-30 for prevention of contamination of the KCl solution inside the pH Sensor.***

pH Sensor Accuracy

YSI 600XL or 600XLM Sonde/650 MDS Display

The pH Sensor accuracy is +/- 0.2 pH units (*i.e.*, 6.8-7.2 is an acceptable reading for 7.0 buffer solution).

Hydrolab Quanta G

The pH Sensor accuracy is +/- 0.2 pH units (*i.e.*, 6.8-7.2 is an acceptable reading for 7.0 buffer solution).

Temperature Sensor

Temperature Sensor Maintenance and Troubleshooting

The Temperature probe needs to be cleaned with mild soap and a toothbrush or cotton swab monthly. After cleaning, the metal should be checked for signs of rust as this is a warning sign that the probe is potentially compromised and needs to be replaced.

The temperature reading should be checked against a NIST certified thermometer yearly for accuracy in water baths set at several temperatures. If the difference in the readings is outside of the probe's accuracy rating, then the probe should be replaced. YSI has suggested that their Temperature probe's lifespan can be up to 5 years before it has drifted out of range.

Note: Some brands (*e.g.*, YSI) have the Temperature and Conductivity Sensors bundled into one probe.

Temperature Sensor Accuracy

The Temperature probe accuracy is +/- 0.15⁰ C.

Additional Sensors

Additional sensors that may be installed on certain models of sondes include:

Depth Sensor or Pressure Transducer

Ion Probes (e.g., Chloride, Ammonium, Nitrate)

Fluorometers (e.g., Chlorophyll-a, Rotomine, Blue-Green Algae)

Total Dissolved Gasses

Light Penetration

Turbidity

Oxidization Reduction Potential (ORP)

Part 2. Sonde Routine Maintenance & Storage

Maintenance Kit Contents

At all times, each field crew should have with them in the field a Sonde Maintenance Kit consisting of items necessary to perform routine/basic maintenance and cleaning of the sonde. **See Table 3-2 below** for the contents of a maintenance kit and each item's function.

Table 3-2. Sonde Maintenance Kit Basic Contents

Item	Function
Soft Toothbrush	Light cleaning of all probe surfaces
Mild Soap (e.g., Simple Green Pro 3)	Light cleaning of all probe surfaces; note that the Simple Green contains an anti-bacterial component that will help prevent the growth of biofilms on the sensors. Never clean sensors with alcohol or other organic solvents. This will degrade the probe materials.
Long Cotton Swabs	Cleaning in small tight spaces (e.g., conductivity ports)
YSI Acrylic Cleaning Brush	Used to clean probe surfaces (especially the conductivity ports); Provided in an YSI maintenance kit.
GoJo & Cotton Swab	Pumice helps clean tarnished electrodes on Clark-cell DO sensor.
YSI Electrode Sanding Pad	Used to clean tarnished electrodes; Provided in an YSI maintenance kit.
KCl Electrolyte Solution	Required for Clark-cell DO membrane replacement; Provided in an YSI maintenance kit.
Teflon DO Membranes	Required for Clark-cell DO membrane replacement; Provided in an YSI maintenance kit.
pH KCl Reference Tablets/Solution	To recharge the reference pH probe on Hydrolab or other capable sondes.
Mini-Allen Wrench	To remove the wiper arm on Luminescence (e.g., LDO) or Fluorometric (e.g., Chlorophyll-a) sensors for cleaning.

Maintenance Schedule

Provided **below in Table 3-3** is a brief outline of the regular maintenance schedule (beyond calibration) that needs to be performed on the sondes. Each of these actions are more thoroughly discussed **above in Part 1. Sonde/Sensor Calibration, Maintenance, Diagnostics, and Accuracy on pages 3-3 to 3-28.**

Table 3-3. Routine Sonde Maintenance Schedules for the Basic Sensors

Probe	Action	Frequency
All Probes	Clean all probe surfaces with mild soap, toothbrush, and cotton swabs.	Monthly
Temperature	Clean and check Metal Temperature Probe for Rust (Not applicable on Data Loggers).	Monthly
	Check Temperature against a NIST Certified Thermometer in several water baths.	Yearly
pH	Clean glass bulb on pH probe.	Monthly
	Replace Reference pH Tablet/Solution (Hydrolab models).	
	Replace Reference pH Teflon Junction Cap every 1-2 years (Hydrolab models).	Yearly
DO	If Clark-cell type probe, clean electrodes with GoJo and cotton swab (Hydrolab) or sanding disc (YSI) to remove tarnish; Add new KCl electrolyte solution and Teflon membrane.	Monthly
	If LDO, check the Cap for material loss/wear and look under the LDO lens for leakage; if so replace.	
	Replace LDO Cap every 1-2 years (Hydrolab models only)	Yearly
Conductivity	Clean Conductivity Ports and electrodes with cotton swab or YSI acrylic cleaning brush. Check for scratches.	Monthly

Miscellaneous Sonde Maintenance

Sonde Storage

With any sonde, certain storage procedures (both short and long-term) must be observed to prevent damage to the sensors and probes.

1. Never store the sensors in DI water. This will deplete the reference pH electrolytes and the surface of the pH bulb. To increase the life of a probe, proper storage of the probe must be implemented.

For **short-term storage** (e.g., between sites and over the weekend), the sensors only need to remain moist. Place only a minute amount of water (1/8th of an inch is probably too much) in the cup for storage making sure that no water will inundate the pH Sensor. The other probes (e.g., the DO probe) require only moist air to maintain proper function. A small damp sponge inside the cup would be adequate for such storage.

For **longer-term storage** (e.g., over winter), use pH 4 solution or clean tap water (between 1 Tablespoon and ¼ cup depending on the size of the sonde cup). YSI recommends that the cup be filled with a concentrated KCl solution. Alternatively, the pH probe can be uninstalled and put into its original shipping container with the KCl solution. This will lengthen the life of the probe and help maintain the concentration of KCl inside of the pH Sensor. *To obtain the concentration of KCl solution, consult the YSI operating manual or an YSI representative.*

2. Remove all batteries for long-term storage. If the batteries should leak, the acid may destroy the sonde housing. The exception to this are any Lithium Ion batteries found connected the sonde electronics that maintain the internal clock; these types of batteries are not supposed to leak and typically last 2-5 years.
3. Install all connector covers and cable plugs to protect the sonde's electronic connection pins.
4. Do not store sonde in freezing temperatures. Even though the sondes may have just a small amount of liquid in the storage cup to keep the sensors moist, many sondes have sensors that contain liquid inside the probe (e.g., pH reference probe). Additionally, the freezing action of just the small amount of liquid inside of the storage cup can cause damage to the housing and probe connections.

Part 3. Sonde Use (Field Procedures)

The readings from a water quality sonde are often referred to as instantaneous readings as they are taking immediately and directly from the water column.

While weekly calibration should be adequate to take care of most the probes, the DO probe should be calibrated daily. In some cases, when travel to sites are greatly varying elevations, DO should be calibrated in each new elevation.

In the case of the Hydrolab Quanta, the pH should be recalibrated if the pH regime of the stream changes (e.g., the Quanta was calibrated for 4.0 to 7.0 and the streams you are sampling are above 7.0 pH).

Setting up the Water Quality Sample Site

1. Attempt to locate a good sampling location with adequate depth and flow near mid-stream. If mid-stream is not available due to high flows or deep water, you may deploy the sonde from the bank if you are sure that there are no plumes from pollution sources or tributaries that may be flowing along either bank (*see Figure 3-8 below*).

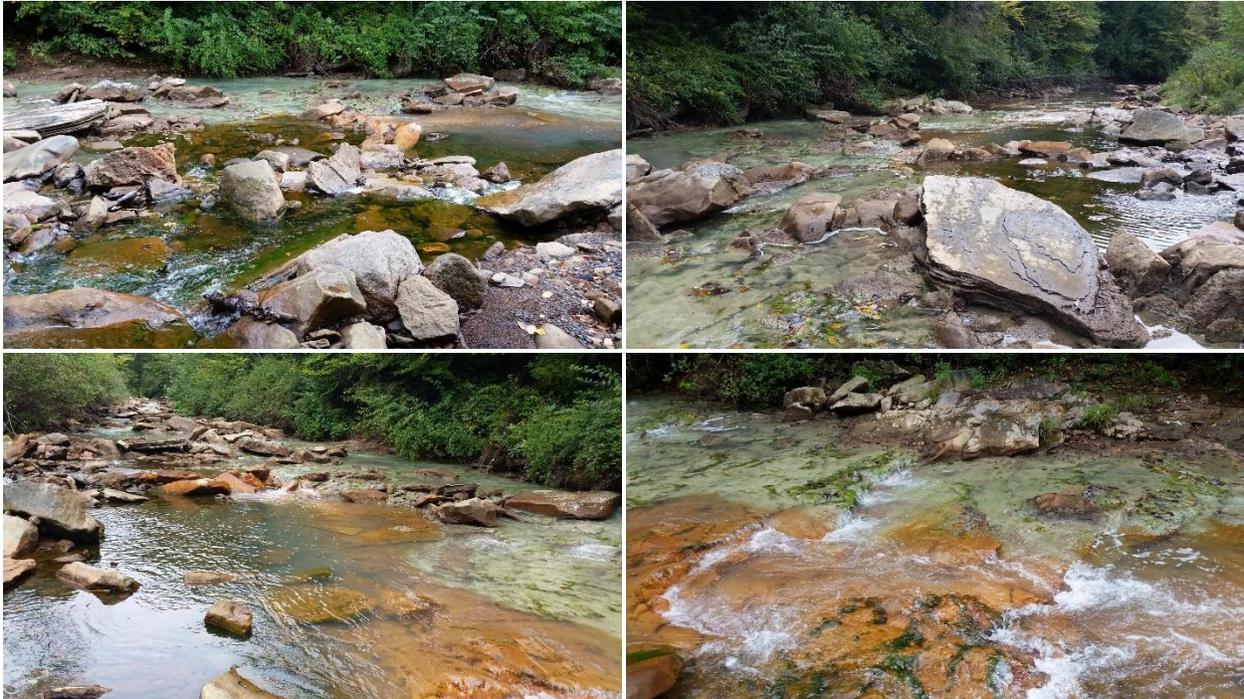


Figure 3-8. Example of an obvious plume of pollution in a stream.

The white-green areas are deposits of aluminum hydroxide that are precipitating out of solution. This water is chemically different from the water in the foreground (which is underlain by orange iron hydroxides) and originates from a polluted tributary on that side of the stream.

Additionally, if the cord of your sonde is long enough, you could attempt to deploy the sonde from a bridge. Another alternative is to deploy the sonde into a proxy like a bucket or sample tube that was lowered off a bridge to collect water. In any case, be sure to document where and how you sampled on the habitat form.

IMPORTANT: If you are collecting water for analysis at a lab, directly from the stream, you must place the sonde in the same flow vector as the water sample collection.

2. Remove the calibration cup from the end of the sonde, screw on the deployment guard, and deploy the sonde into the water column. **Be sure to not disturb the substrate above this point until all water data collection is completed.**

NOTE: When deploying a sonde into the water, give it a little tap or shake once submerged. This will help dislodge any air bubbles inside the Conductivity Sensor that will bias a reading. Make sure that all probes are submerged adequately.

3. Once fully submerged in the water turn the unit on. For YSI, turn on the unit with the power key and press **Enter** twice. For the Hydrolab Quanta, turn on the unit using the **O | I** key. Press the **Esc** ∞ key to toggle the circulator on and off if necessary.
4. Let the sonde run for at least ten minutes to stabilize.

Reading stabilization is typically based on the sonde's chemical parameter sensors (*i.e.*, pH, DO, and Specific Conductance). If the individual readings do not change over the course of three reading intervals (minutes) by more than the sensor's accuracy (pH = +/- 0.2 pH units, DO = +/- 0.2 mg/L (or ppm), Specific Conductance = +/- 5 µS), then the sensors are assumed to have stabilized to the water.

Note that it has been observed that the pH readings take upwards of 20-30 minutes to stabilize under extremely low temperature or low conductivity situations. In addition, the age of the sonde/probes also can play a role in how long it takes for the readings to stabilize. This time could be used to fill out parts of the habitat form, collect water samples, or check on the GPS coordinates.

5. Record the readings onto the habitat form and turn the sonde off. Take off the deployment guard and replace the calibration cup. Always make sure sand and other particles are kept clear of the threads on the sampling weight, cap, storage cup, and sonde itself. These threads are plastic and will strip if sand is caught in the treads while screwing these parts on and off.
6. Store the sonde securely for future use. When storing the sonde between sites or sampling events, only a small amount of liquid (preferable pH 4 buffer) inside the cup is necessary to keep the air (and membranes) moist. If the pH buffer is spilled at the site, you can get away with a few drops of water inside the cup until you can replace it back at a vehicle or the lab.

IMPORTANT: Do not store the sonde with a full cup of water, as this will lessen the life of the pH sensor.

TIPS FOR USAGE OF SONDES IN THE FIELD:

- If taking readings from an intermediate water container (e.g., a bucket), make sure to keep the hole on the Conductivity Sensor away from the edges of the container as this may cause stray signals from the probe and result in an inaccurate reading. Also, attempt to keep the sample as sealed and isolated as possible to maintain the temperature and DO concentrations. It also may be necessary to swirl the sonde around to keep the water circulating.
- If a DO probe is suspected of being out of calibration, check the DO charge reading as well as the % air saturation. If the air saturation is not within an expected range for your current elevation, recalibration at that elevation may be necessary. It is also possible that the internal barometer, if equipped, needs recalibration (a manufacturer repair).

Sonde Quality Assurance/Quality Control

Before use, each sonde and probe should be examined for wear (e.g., breakage, air bubbles, membrane tears or wrinkles) and adjustments should be made as required.

Sonde Calibration Log Sheets are used for any calibration or maintenance performed on an instrument and entered into the database weekly and examined for patterns that indicate potential or imminent probe failure. Any instrument failing to meet calibration requirements is repaired in house or shipped to the manufacturer. Meters are calibrated weekly, prior to sampling, and are recalibrated in the field, if conditions warrant. For example, if a Hydrolab has been calibrated for pH using the 7 and 10 buffers, recalibration is performed if a stream pH of 3 is encountered. Dissolved Oxygen is calibrated daily. In addition, all sondes and probes are frequently cross-checked against each other in variable water bath solutions for accuracy and stabilization speed.

Each meter has an identification number, which is recorded on the habitat assessment sheet each time the meter is used. Should any instrument fail to calibrate, readings taken prior to the failed calibration will be examined for reliability and accuracy. Documentation of the instrument used at each site will help to keep data loss to a minimum. All repairs to sondes and probes are documented in a repair log including the serial numbers and manufacture dates of any replacement probes.

Duplication of sonde data is only possible if two different sondes are present during the sampling event. If this is the case, then the sampler should be all means document the duplication of sonde data.

Once a year, all field participants in the WAB attend mandatory training sessions. The purpose of these sessions is to ensure that all field personnel are familiar with habitat sampling protocols and calibrated to sampling standards. A hands-on session concerning the calibration, maintenance, and collection of water quality sonde data is included.

Individuals who are more experienced in using water quality sondes will be teamed up with the less experienced to ensure reinforcement of training and accurate results before they can use the sondes. This document is also provided to all program personnel for review and use in the field. Additional training provided by the Sonde manufacturer may also occur as available.

Section B. Water Quality Sample Collection and Preservation

The water quality monitoring is the centerpiece of the Watershed Assessment Branch's (WAB) efforts to assess streams. It is extremely important that these methods are followed to maintain comparability between samplers and sampling events.

Materials and Reagents

1. Analysis Request Form with Chain-of-Custody (COC) - for sample identification and tracking of samples from the field to lab and results from the lab back to us.
2. Water Quality Sample Labels-featuring the unique WQ Sample ID for each distinct water sample.
3. Waterproof pen or sharpie - for labeling sample bottles.
4. Sterile Fecal bottles with Sodium thiosulfate tablet - for collecting bacteria samples.
5. Plastic Containers (e.g., cubitainers with Lids) - for collecting other water quality samples, except phenols.
6. Cooler - for sample preservation.
7. Wet Ice - for sample preservation.
8. Fixatives (nitric acid, sulfuric acid, and sodium hydroxide) - for sample preservation.
9. Waterproof plastic bags or other suitable container - for holding bacteria sample bottles during transport.
10. Filtration Apparatus (either Peristaltic or Vacuum type) – for sample preservation.

IMPORTANT: Storage of sampling containers (e.g., cubitainers and fecal bottles) needs to be as tidy and clean as possible:

- ***Do not store anything that is dirty (e.g., waders, food, backpacks, Thalweg poles, etc.) on top or near an open box of cubitainers.***
- ***Keep the lid to box closed between sites and only open a sealed box as needed.***
- ***All loose cubitainer lids and fecal bottles should be kept in a clean/new Ziploc bag or clean, sealable container and only opened when needed.***
- ***Do not handle sampling containers and lids with dirty hands.***
- ***Make sure all the sample lids are secured tightly to prevent leakage/cross-contamination.***

Water Quality Safety Precautions

Rubber gloves and protective eyewear should be available to be worn during sample collection to avoid bacterial contamination and for personal health protection as many

streams may have sharp objects embedded in the substrate (e.g., glass, metal, wire, etc.). They should also be worn during sample preservation or at any time while handling the fixatives, which are concentrated acids. Bottles containing fixatives should be stably seated inside a lidded container to prevent breakage and leakage.

WARNING: SOME FIXATIVES ARE CORROSIVE, AND MAY EMIT TOXIC FUMES. BE SURE TO USE THE APPROPRIATE SAFETY GEAR AND PRESEVE SAMPLES IN A WELL VENTILIATED AREA. DO NOT FIX SAMPLES IN THE VEHICLE, AS ACCIDENTAL SPILLS CAN OCCUR.

Do not place liquid acid or base into sample bottles prior to sample collection. Always add fixatives to sample.

WARNING: NEVER ADD SAMPLE WATER TO LIQUID ACIDS OR BASES, AS A STRONG CHEMICAL EXOTHERMIC REACTION CAN OCCUR.

Part 1. Procedures for Collecting Water Quality Samples

Labeling Sample Containers

Label each sample container with a sharpie. The following information must be included: Agency Name (WVDEP), Project Name (e.g., WAB, TMDL, Deploy, AWQN, LTMS, Lakes, etc.), WQ Sample ID (this is a unique number for each water sample that is taken from the Water Quality Sample Labels), Stream Name, AN-code and Mile Point, Date/Time (Military) collected, Random # (if applicable) and type of fixative/preservation used (**see Figure 3-9 on the next page**). In addition, any distinct sub-sample descriptions (e.g., Top vs. Bottom, Left Bank vs. Right Bank, etc.) should be indicated in parenthesis following the Stream Name and recorded on all paperwork so it can be associated with the correct WQ Sample ID. Blind Duplicate samples (usually Dup #2 on the Habitat form) should be labeled with false Stream Names and AN-Code to disguise the fact that it is a duplicate. Replicate samples should be distinguished by a Rep #1 vs. Rep #2. The WQ Sample ID should be put on the lids as the sides of the containers can be abraded easily and lose their labels. This additional identifying mark can be the WQ

NOTE: The Water Quality Sample Labels do not stick well to any surface that is not smooth. Therefore, if a fecal coliform/bacteria sample is being collected, use the label on that bottle/container as it has a smooth surface. If no fecal sample (or other sample that has a container with a smooth surface) is being collected, then copy the WQ Sample ID to other containers and discard the unused label.

Sample ID, Random #, or something as simple as the time of collection.

Direct Dip/Grab Method

1. At the selected water quality sampling location, (X-site for random sites), attempt to locate a sampling location with adequate depth and flow near mid-stream. If mid-stream is not available due to high flows or deep water, you may take the sample from the bank if you are sure that there are no plumes or influences from pollution sources or tributaries that may be flowing along either bank (*see Figure 3-8 on page 3-31*). Be sure to document where you sampled on the habitat form. **Be sure not to disturb the stream bottom above this point until all water sampling is completed.**



Figure 3-9. Example of Sample Containers Labeled with sample information.

IMPORTANT: Take water samples at lower end of reach for Non- Random targeted sites. Take water samples at X-site for random sites regardless of the location of the lower end of 100-m assessment reach.

2. Place the water quality sonde downstream in the same flow vector as your grab sample point and turn it on so that it can begin to take readings (*see Section A. Water Quality Sondes & Sensors: Calibration, Routine Maintenance, & Use. Part 3. Sonde Use (Field Procedures) starting on page 3-28 for more information on how to use the water quality sonde in the field*).

NOTE: The definitive order of sample container filling is as follows:

- A. Fecal Coliform Sample
- B. Unfixed Cubitainer
- C. Nutrient (H₂SO₄) Cubitainer
- D. Total Metals (HNO₃) Cubitainer
- E. X-Bottle/Dissolved Metals (to be Filtered/HNO₃) Cubitainer

3. Collect the water samples upstream of the sonde as follows:

A. Fecal Coliform Sample:

- Use pre-sterilized bottle with Sodium thiosulfate tablet. Keep the bottle closed until you are ready to collect the sample.
- Open bottle and handle carefully to avoid contamination. Do not touch the inside of the lid or bottle.
- Using a quick upstream-dipping motion, submerge below the surface of the water (6 inches if possible) and fill the bottle to the 100-mL mark (**see Figure 3-10 on right**). Do not rinse or refill the bottle.
- If the bottle is too full, slowly decant the excess until the 100 mL line is approximated. *The head-space is necessary in a fecal coliform sample to provide oxygen to the bacteria until the sample can be analyzed.*
- Place cap tightly on bottle and secure cap lock.



Figure 3-10. Example of a Fecal Sample being taken from a stream.

B. Other Water Samples (e.g., Unfixed, Total Metals, Dissolved Metals, Nutrient cubitainer samples):

- All remaining water quality samples are collected in containers (e.g., cubitainers) provided by the analytical lab (per the state analytical contract).

IMPORTANT: *DO NOT expand cubitainers (or other such collapsible-type container) by blowing into them. The sample can become contaminated by your breath (e.g., Phosphoric acid effervescing from your mouth after drinking a cola and contaminate the Phosphorus readings).*



Figure 3-11. Example of Cubitainer being filled and emptied (i.e., rinsed with stream water).

- Rinse the sample container by filling it with approximately 500 mL (**one-half full**) of stream water. Secure the lid and shake vigorously for at least 5 seconds. Empty the contents downstream and repeat two more times for a total of **three rinses** (*see Figure 3-11 above*).
- Submerge below the surface of the water (6 inches if possible) and completely fill the containers with an upstream motion with sample water (1000 mL).
- Make sure to limit pieces of organic matter in the sample container as much as possible as these can cause contamination.
- When sealing the container, expunge as much air as possible from the sample container to avoid contamination (*i.e.*, no head-space).

NOTE: If water depth is limiting the ability to submerge the container opening without stirring up sediment and organic debris:

- 1) Cut the top off a fresh, unused cubitainer.
- 2) Thoroughly rinse with stream water as normal (three times).
- 3) Use the cut cubitainer to carefully collect water and pour into an intact cubitainer labeled for sample collection.
- 4) Discard the cut cubitainer after filling up all cubitainers for the site.

Indirect Methods

In some cases, water levels (high or low) or strong flows will not permit direct water sampling. In these cases, it is necessary to use special equipment to get the sample. The use of such equipment is explained in **CHAPTER 11. Section A. Part 2. Bridge Method starting on page 11-5 and CHAPTER 12. Section D. Part 3. Van Dorn Sampler Method for Depth Profiles on page 12-21.**

Part 2. Sample Preservation (Filtration, Fixation, & Holding)

Preserve the sample as indicated on the Analysis Request Form. **See Figure 3-16 on page 3-50 for an example of an Analysis Request Form with COC.**

IMPORTANT: Preservation must occur within 15 minutes of sample collection, even if you must pack bags of wet ice and the filtration equipment in on a 6-mile hike. NO EXCEPTIONS!

The preservation methods and holding times are summarized in Table 3-4 in the Holding section on page 3-48.

Samples should be preserved in the following order:

- 1) Unfixed or Iced (Wet Ice) Samples (e.g., Fecal Coliform, Unfixed container)
- 2) Filtered Samples (e.g., Dissolved Metals or Nutrients)
- 3) Fixed Samples (e.g., Total Metals or Nutrients).

The fecal coliform sample should be double bagged in plastic Ziploc-type bags before being put on wet ice to prevent accidental contamination of other samples should the sample container become compromised. Do not submerge the fecal sample in ice water! The samples that only need to be cooled on ice (commonly referred to as Unfixed or No Fix) can also be placed on wet ice as well.

IMPORTANT: If Alkalinity is being analyzed, 100% of the air must be expunged from the unfixed containers to avoid contamination. If nutrients (i.e., Nitrogen or Phosphorus) are being analyzed, avoid water samples with visible organic debris in the container.

Filtration

A net minimum of 500 mL of filtered sample should be turned in for dissolved metal analysis at most labs. Once enough water is filtered for the dissolved metal analysis, the total metal container can be reduced in volume (from 1000 to 500 mL) by pouring out the excess water. This will keep the volumes of the Total and Dissolved metal containers approximately equal for **Fixation (see page 3-46)**.

Protocols for Sample Filtration with Peristaltic Pump/Drill Apparatus (Dissolved Metals & Dissolved Nutrients)

The components of the filtering apparatus are:

1. Peristaltic Pump mounted on Stabilizing Board
2. Power Drill with Pump Adaptor Bit
3. Tygon Tubing
4. Filters (50 mm cellulose acetate membranes with a 0.45-micron pore size); two varieties: Flat Disc or Cartridge.

5. Two sample containers (one for the stream sample-labeled with an X; one to receive the filtered water-labeled fully for delivery to the lab).



Figure 3-12. Example of Peristaltic Pump/Drill Apparatus for Sample Filtration being used under the tailgate of a vehicle.

It is important to keep the filtering equipment and area around the equipment clean. Try to handle all parts by the exterior components. Fingerprints and other dirt can contaminate samples. The tubing and filters should be kept in sealed plastic bags until time of use to reduce exposure to dust and other contaminants.

Ideally, the filtering process would occur streamside by taking the filtered samples (e.g., dissolved metals and dissolved orthophosphate) directly from the water column. However, this is highly dependent upon there being a flat, streamside surface to work on and no precipitation/moisture that could short the drill. Because of these impracticalities, the sample water to be filtered is collected in a clean container that is rinsed three times with stream water and transported to a suitable area for filtration and preservation within 15 minutes of collection (*see Figure 3-12 above*).

IMPORTANT: This container should be the only one that will be exposed to the Tygon tubing and not reused from site to site. Do not filter from the Total Metals sample container as the insertion of the Tygon tubing may contaminate the sample.

Procedure:

The Peristaltic Pump is setup in a manner so that the water is being vacuumed through the filter(s) rather than being pushed through. This is accomplished by placing filter between the peristaltic pump and the unfiltered (or source) water (**See Figure 3-13 below** for a diagram of how to setup the peristaltic pump filtration unit).

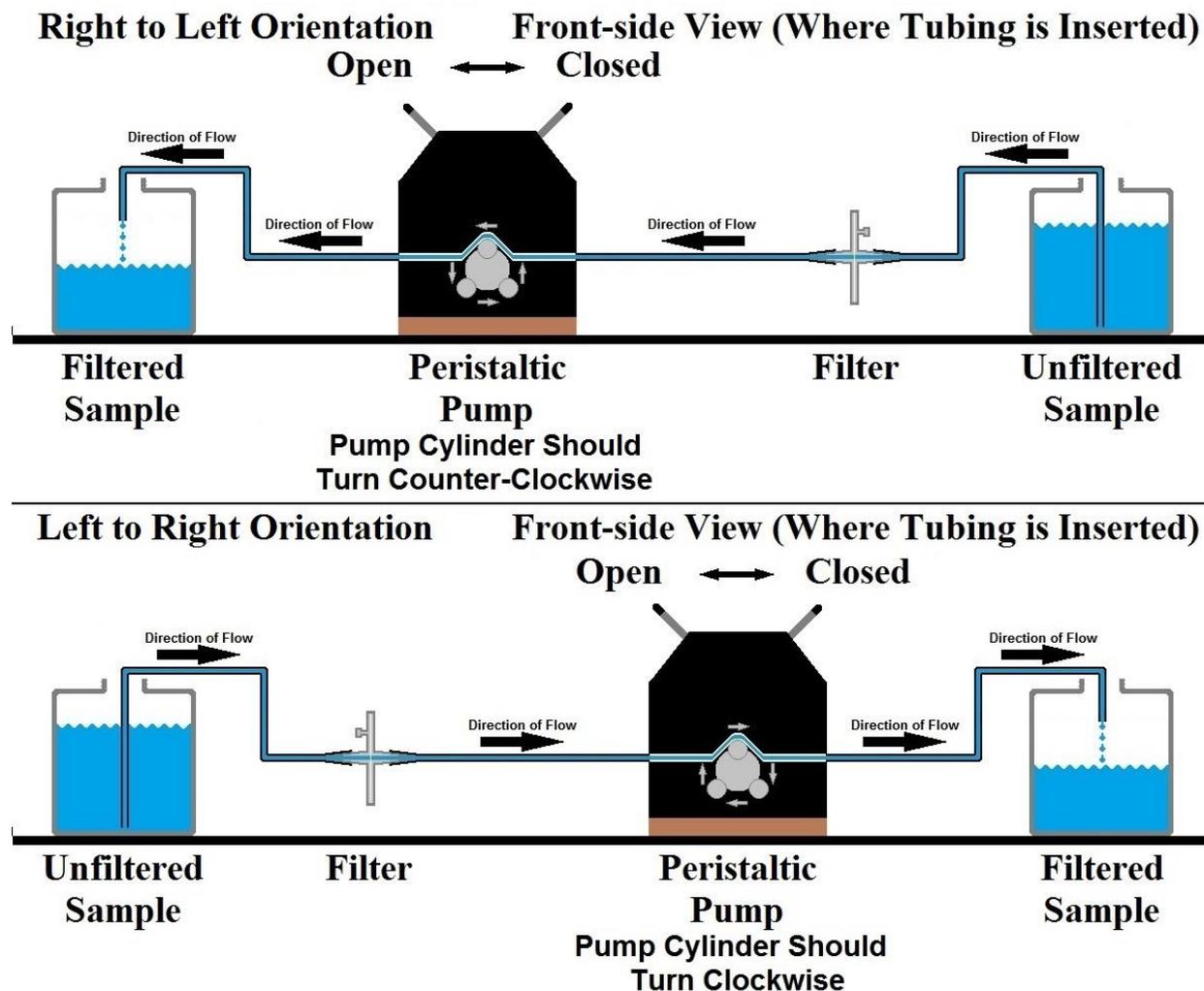


Figure 3-13. Diagram depicting the setup of a Peristaltic Pump. Note that the filter is situated between the Unfiltered Sample and the Peristaltic Pump.

In situations with high turbidity, the pump setup can be modified to include two filters: a large cartridge filter as a primary (first in direction of flow) and a disk filter as a secondary. The cartridge filter will be situated between the Unfiltered Sample Container and Peristaltic Pump as normal, but the disk filter will be situated between the Peristaltic Pump and Filtered Sample Container (**see on Figure 3-14 next page**). The larger surface area of the cartridge filter will accommodate more suspended solids before clogging and the second disk filter acts as a redundancy in case small particles perforate the cartridge filter. There is no steadfast rule for when to utilize a two-filter setup and generally it is up to the person filtering to decide when to do so based on experience.



Figure 3-14. Example of Filtration Setup with a Cartridge and Disk Filterer

NOTE: Keep in mind that using three disk filters (i.e., changing the disk filter when it becomes clogged) is more expensive than using one cartridge filter and one disk filter. Additionally, each filter change increases the chances for the filtered sample to become accidentally contaminated.

1. Assemble the filtration unit (See Figure 3-13 on page 3-41 for a diagram of how to setup the peristaltic pump filtration unit):
 - Attach the drill to the peristaltic pump by carefully inserting the drill bit into the back of the pump. The drill will either be upside down or laying on its side.
 - The drill bit may need to be rotated slightly to line up with the receiving shaft and engage fully.
 - Open the pump clamp by lifting the lever.
 - Place the unfiltered stream sample container near the pump and remove the cap.
 - Open the sealed tubing bag and pull out one end of the smaller length of tubing.
 - Attach one end of the smaller length of tubing to the inflow side of the filter (or primary filter):
 - ❖ For disk filters, the side with the pressure release valve is the inflow.
 - ❖ For cartridge filters, an arrow indicates the direction of flow.
 - Carefully remove the remainder of the small length of tubing and feed it into the unfiltered stream sample container so that the end is near the bottom of the container.

- If a two-filter setup is being used, a second small length of tubing will be needed to connect the outflow of the primary filter (cartridge) to the inlet of the secondary filter (disk).
- Attach the longer piece of tubing to the outflow side of the filter (or secondary filter) and thread the tubing through the pump and close the clamp.
 - If filtering directly from stream be sure to:
 - Place the stream end of the tubing so that sediment is not being collected from streambed.
 - Make sure not to touch the end of the filter that will be discharging towards the filtered sample container.
- 2. Flush the filter and tubing briefly with sample water by engaging drill slowly for five seconds.
 - Do not collect the flushed water in the filtered container. Discard elsewhere.
- 3. Rinse the fully-labeled container that will receive the filtered water:

NOTE: This is done to remove any contaminants from the fresh filter that may bias the sample (positive bias).

- Hold the outflow end of the tubing at an angle above the mouth of the receiving (filtered water) container at the point of where the tubing is attached.
- Engage the drill slowly and fill the receiving container with about 50 mL of water.

IMPORTANT: Although the vacuum pressure is less than that required to rupture the filter, do not open the drill full throttle!

- Cap the container, shake vigorously for 5 seconds and discard the filtered rinsate.
 - Repeat the rinse two more times for a total of three rinses.
4. Filtering the sample:
- Engage the drill and fill the receiving container with at least 500 mL, unless otherwise directed. On one-liter cubitainers, this location is near the first character on the long diagonal bar on the side of the cubitainer.
 - Use slow drill speeds (never full throttle) to filter the sample, especially when approaching the desired sample amount.
5. Changing filters:
- Sometimes it becomes necessary to change the filter while in the middle of processing a water sample. This is usually due to the filter membrane becoming overwhelmed with small particles of silt, which causes the sample to filter slowly. The filter can also become clogged with seemingly clear water due to unseen microscopic algae. This will also require the filter to be changed. If the field personnel feel that it is necessary to change the filter to achieve the minimum amount of sample necessary, the following steps should be taken:
- Cap the receiving container, relieve the pressure in the tube by reversing the drill momentarily or unlocking the clamp, and remove the clogged filter.

- Replace with a clean filter as before in Step 1 being careful not to touch ends of filter.
 - Flush the new filter as in Step 2 and resume filtering.
- Repeat these steps until a sufficient sample is collected.
6. Record on the lab analysis form how many and what type of filters were used.
 7. You must discard and restart the sample if:
 - Sediment is collected directly from bottom of stream.
 - The filter is cracked or split during use.
 - The filter is dislodged from tubing while filtering and the unfiltered water contaminates the filtered sample during use.

NOTE: The tubing and filters are disposable and should only be used once. Discard each filter after one use and discard the tubing after each sample. Obtain a clean set for the next sampling event.

Protocols for Sample Filtration using a Vacuum Pump (Dissolved Metals & Dissolved Nutrients)

The components of the filtering apparatus are:

1. Filter Flask – Receptacle for the filtered sample.
2. Filter Funnel – Consists of two parts: A cup to hold the unfiltered sample and the funnel itself.
3. Filters – Cellulose Nitrate membranes with a 0.45-micron pore size.
4. Vacuum Pump – A variety of hand operated pumps are available.

It is important to keep the filtering apparatus clean. Handle all parts by the exterior components or by the stopper. Fingerprints and other dirt can contaminate samples. The Filter Funnel & Filter Flask should be stored in a Zip Lock bag or other container (even when driving from one site to another) to reduce exposure to dust and other contaminants.

Procedure:

The water for the filtered sample must be taken from a portion of the total metals sample.

1. Rinse off the filter apparatus (cup, funnel and flask) with DI or distilled water.
 - Be careful not to get water into the nipple on the flask.
 - Rinse each part separately. Do not let rinse water from cup drip into either the funnel or flask. Do not let rinse water from the funnel drip into the flask.
2. Assemble the filtration unit:
 - Attach the funnel to the flask.
 - Place a filter on the funnel.
 - Handle the filter by the edges only.

- Make sure the filter is centered on the funnel's screen.
- Attach cup, be sure to get a good seal.

3. Initial Rinse:

- Pour a small amount (e.g., 50 mL) of sample into cup.
- Filter sample, making sure all the water has passed through.
- Depressurize the pump.
- Dry any water drops from exterior of cup & funnel and remove from flask without disassembling cup from funnel.
- Rinse the flask with a swirling motion and discard filtered rinsate (be careful to avoid getting filtered rinsate in the flask nipple).

4. Filtering the sample:

- Place cup & funnel assembly back into flask.
- Pour a larger amount (e.g., 100 mL) of the sample into the cup.
 - If water is turbid, use small amounts; filter may clog and need to be changed.
 - Do not put too much sample into the cup since this may exceed the capacity of the flask, causing water to be drawn into the pump.
 - Wipe off any spills outside of the cup.
- Filter sample using full strokes on the pump.
- Depressurize pump after sample has been filtered and before changing filters.

5. Changing filters:

Sometimes it becomes necessary to change the filter while in the middle of processing a water sample. This is usually due to the filter membrane becoming overwhelmed with small particles of silt which causes filtering to become extremely slow. If the field personnel feel that it is necessary to change the filter to achieve the minimum amount of sample necessary, the following steps should be taken:

- If there is any left, pour off the excess water out of the cup by turning the filter apparatus on its side with the siphon arm up so that no filtered water can escape from the flask or enter the vacuum tube. One should support both the cup and the lower funnel so that the two do not break the magnetic seal and separate.
- Filter off any excess water until the filter is dry.
- Remove the cup from the funnel.
- Holding funnel sideways, remove old filter. Start from the top of the filter and pull downward.
- If there is any question that unfiltered water may have dripped into the funnel or into the flask, assume that the sample has been contaminated and the filtering process must be reinitiated from the beginning.
- Install a fresh filter handling only by edges.
- Replace the cup and continue filtering.

- Repeat these steps until sufficient sample (usually a net of 500 mL of sample after rinsing the cubitainer 3 times but check with lab beforehand). It is also a good idea to put on the lab analysis form how many filters were used.
8. You must discard and restart the sample if:
 - Filter is cracked or split during use.
 - Sediment on filter is off-center (no white ring around entire edge).
 9. End of week cleaning:
 - Rinse cup, funnel and flask with tap water; wipe off scum.
 - Use a brush to lightly clean the funnel's screen.
 - Rinse cup, funnel and flask thoroughly with DI or distilled water and shake off excess droplets.
 - Place a filter on the funnel's screen and store cup/funnel assembled in a zip lock bag.
 - Rinse only the glass flask with 10% HCl (a desorbing agent). The plastic portions (funnel and cup) may only be rinsed with DI or distilled water and lightly rubbed with a paper towel.
 - Do not touch inside surfaces of filtration apparatus.

Fixation

As outlined in **Table 3-4 on page 3-48 in the Holding section**, certain sample containers will need to be fixed with acids before being stored (**see Figure 3-15 on page 3-47**). To fix properly, the designated containers need to be acidified down to a pH just below 2.0. Metal sample containers (total and dissolved) should be preserved with Nitric Acid only. Nutrient sample containers (total and dissolved) should be preserved with Sulfuric Acid only.

Sample containers that are preserved with Sulfuric Acid should always be preserved before samples that are preserved with Nitric Acid. This is because the volatile Nitric Acid vapors may contaminate Nutrient samples and give false Nitrogen results. If you do accidentally preserve the Nitric Acid sample first, then move away from that area when fixing the Sulfuric Acid sample (e.g., the opposite end of the vehicle or 20 feet away).

When fixing a sample with acids, careful consideration must be given to the ambient chemistry of the stream (*i.e.*, pH and conductivity) and volume of sample being preserved. A given vial (ampule) of acid is designed to preserve 1 liter of normal water (*i.e.*, pH near neutral and normal conductivities (approximately 200 $\mu\text{mhos/cm}$). If a stream has a low pH and/or low conductivity, one ampule of acid may over preserve the sample. Conversely, if a stream has a high pH and/or high conductivity, one ampule of acid may not be enough to adequately preserve the sample. A larger volume of sample water would also require more acid; a smaller volume less. Less experienced individuals could use pH test strips to gauge how much acid to add to adequately fix sample (**see Testing a sample with a pH test strip on page 3-47**).

As a guideline, one vial of Nitric Acid provided by the lab contains 2 mL, enough preservative to fix a 500mL metals sample. Therefore, use one vial of Nitric Acid per metals bottle (Total and Dissolved Metals containers, ~500mL each). One vial of Sulfuric Acid provided by the lab contains 5 mL, enough preservative to fix a 1000mL nutrient sample.



Figure 3-15. Example of sample being preserved with Nitric Acid.

Testing a sample with a pH test strip

1. First add a small amount of acid to the sample (maybe half of an ampule).
2. Seal the sample and shake it to mix in the acid.
3. Open the sample and tap a small amount (droplet) from the lid onto a pH test strip.

IMPORTANT: Never dip the pH test strips into the sample!

4. Compare the pH test strip color to the color key on the pH test strip package. The target pH is just below 2.
5. If more acid needs to be added, then add more accordingly. Otherwise, remove the headspace, seal the sample, and put it on wet ice if necessary.

Holding

With the exception of fecal coliform, all samples should be delivered to the lab within the holding times specified in "Standard Methods for the Examination of Water and Wastewater", 18th Edition and as outlined in **Table 3-4 Preservation Methods and Holding Times on the next page.**

The holding time for fecal coliform sample has been expanded by the WAB from 6 hours to 24 hours because the six-hour holding time places severe limitations on the amount of time a crew can spend in the field. **However, fecal coliform samples collected for the TMDL program may need to comply with the six-hour holding time depending on the specific instructions given for that watershed.**

Table 3-4. Preservation Methods and Holding Times

Parameter	Preservation	Max. Holding Time
Fecal Coliform	Cool <10 °C, 0.0008% Na ₂ S ₂ O ₃	6 hours. (24 hours for TMDL/WAB samples)
Acidity	Cool ≤4 °C	14 days.
Alkalinity	Cool ≤4 °C	14 days.
Ammonia	Cool ≤4 °C, H ₂ SO ₄ to pH<2	28 days.
Chloride	None required	28 days.
Kjeldahl (TKN) and Organic N	Cool ≤4 °C, H ₂ SO ₄ to pH<2	28 days.
Chromium VI	Cool ≤4 °C, pH = 9.3–9.7	28 days.
Mercury (CVAA)	HNO ₃ to pH<2	28 days.
Mercury (CVAFS)	5 mL/L 12N HCl or 5 mL/L BrCl	90 days.
Total Metals (except Chromium VI and Mercury)	HNO ₃ to pH<2	6 months
Dissolved Metals (except Chromium VI and Mercury)	Filtered, HNO ₃ to pH<2	6 months
Nitrate	Cool ≤4 °C	48 hours.
Nitrite	Cool ≤4 °C	48 hours.
Nitrate-Nitrite (NO ₂ -NO ₃ -N)	Cool ≤4 °C, H ₂ SO ₄ to pH<2	28 days.
Total Orthophosphate	Cool ≤4 °C	48 hours.
Dissolved Orthophosphate	Filtered, Cool ≤4 °C	Filter within 15 minutes; 48 hours.
Phosphorous, Total	Cool ≤4 °C, H ₂ SO ₄ to pH<2	28 days.
Total Solids, Total Suspended Solids (TSS), Total Dissolved Solids (TDS)	Cool ≤4 °C	7 days.
Sulfate	Cool ≤4 °C	28 days.

Documentation

Using a black or blue permanent ink pen, fill out an Analysis Request Form/COC for each water sample. If multiple samples are taken at a given site/station during the sampling event, you will need a separate form for each distinct sub-sample (e.g., Top, Middle, and Bottom Lake samples; Left Bank, Middle, and Right Bank cross-section samples). In addition, you will need to fill out an Analysis Request Form for each laboratory. For example, if the fecal coliform sample will be delivered to one laboratory and the other samples to another, complete a request form for each lab unique to the parameters that they will be analyzing. The person who collected the sample must be the person indicated on the form and the one who signs the chain-of-custody (COC).

IMPORTANT: All samples COCs for a sample event must be filled out as soon as the sample is placed in the cooler.

A completed Analysis Request Form includes: *Project, Laboratory Name, Stream Name* (followed by a *Subsample Description*, in parentheses if applicable), *Watershed Name, AN-Code, WQ Lab ID, Random #* (if applicable), *Sampled By, Filtered By, # of Containers, Sample Type, Acid Type Lot #s, Sample Date & Time (Military), Field Values* (i.e., Temperature, pH, DO, and Conductivity if taken), *Parameters Requested & Fraction* (i.e., Total or Dissolved, if applicable), *Volume of Total Metals and Dissolved Metals Samples, Type & # of Filters Used, and Relinquished By*. Blind Duplicate samples (usually Dup #2 on the Habitat form) should be labeled with false Stream Names and An-Code to disguise the fact that it is a duplicate. Replicate samples should be distinguished by a Rep #1 vs. Rep #2.

IMPORTANT: Make sure that vehicles containing samples are always locked when unattended!

After the sample has been turned over to a WVDEP certified analytical laboratory (**see page 3-57 for more details about the WVDEP Laboratory Quality Assurance Program**), the Date and Military Time, Received By, and Lab name must be filled out on the COC portion at the bottom of the Analysis Request Form. **See Figure 3-16 on the next page for an example of a fully completed Analysis Request Form with COC.** Keep the white copy for WAB records and give the yellow copy to the lab.

WV DEPARTMENT OF ENVIRONMENTAL PROTECTION - WATERSHED ASSESSMENT BRANCH

General Analysis Request Form, Rev. 07/17

Circle Project(s): TMDL LTMS WAB **RANDOM** AWQN DEPLOY. LAKES FISH OTHER _____

Laboratory Name: Pace

Stream Name: Little Green Shoals Fork Watershed Name: Lower Guyandotte

AN-Code: OG-45-A-(2.7) WQ Lab ID: 101931 Random #: _____

Sampled By: SJM Filtered By: SJM # of Containers 5

Sample Type: Water Sediment _____ Other _____ Specified Method: 40 CFR 136

Acid Lot #, Nitric: 177935 Sulfuric: _____ HCl: _____

Sample Date: 2/5/18 Time: 1100

Field Values¹: Temp. 0.1 pH 6.59 D.O. 13.73 Cond. 110.4

Bold type/Cell Border = Random Parameter Suite (Total & Dissolved Al & Fe, Diss. Only Cu, Zn & Pb)

Pres.	Analysis / Item #*	Pres.	Analysis / Item #*	Pres.	Analysis / Item #	Tot	Diss ⁺	Preservation Code
3	Acidity (Hot)	3	Tot. Diss. Solids	5	Aluminum Al	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	1. None - Determined on-site 2. None 3. Iced immediately 4. H ₂ SO ₄ to pH <2, iced immediately 5. HNO ₃ to pH <2 6. Sterile + 0.008% Na ₂ S ₂ O ₃ , iced immediately 7. Filtered immediately, iced immediately 8. HCl to pH <2, iced immediately 9. MgCO ₃ & Ice, _____ ml sample 10. Other (Specify) 11. Filter, H ₂ SO ₄ to pH <2, iced immediately +Dissolved metals are to be filtered immediately, and nitric acid added to pH <2 * Item # specifies method, MDL, & PQL required in current WQ Analytical Contract REMARKS: 5°C Total Metals Vol <u>500</u> ml Dis Metals Vol <u>500</u> ml Filter type (circle): Disc Cartridge Disc # used <u>1</u> Cart. # used: <u>1</u>
3	Alkalinity	3	Tot. Susp. Solids	5	Iron Fe	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
3	Sulfate	4	T. Phosphorus-P	5	Manganese Mn	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
2	Chloride	4	TKN	5	Selenium Se	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
6	Fecal Coli., MF 24 hour holding	4	NO₂-NO₃-N	5	Copper Cu	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
6	Fecal Coli., MF 6 hour holding	4	Low level T. Phosphorus-P	5	Zinc Zn	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
2	Bromide	11	Diss. Phosphorus	5	Magnesium Mg	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
5	Hardness	4	TKN	5	Calcium Ca	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
3	Acidity (Cold)	4	Ammonia-N	5	Potassium K	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
3	Bicarbonate	3	Tot. Ortho PO ₄	5	Sodium Na	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
3	BOD	7	Diss. Ortho PO ₄	5	Beryllium Be	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
4	COD	9	Chlorophyl a	5	Barium Ba	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
4	TOC	3	NO ₃ -N (Nitrate)	5	Strontium Sr	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
3	pH (lab)	3	NO ₂ -N (Nitrite)	5	Boron B	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
3	Cond. (lab)	3	Semi-Vol. Organics	5	Cadmium Cd	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
6	E. Coli 6 hour holding	8	Volatile Organics	5	Lead Pb	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
6	E. Coli 24 hour holding			5	Nickel Ni	<input type="checkbox"/>	<input type="checkbox"/>	
				5	Arsenic As	<input type="checkbox"/>	<input type="checkbox"/>	
				5	Silver Ag	<input type="checkbox"/>	<input type="checkbox"/>	
				3	Hex. Chromium	<input type="checkbox"/>	<input type="checkbox"/>	
				5	Mercury Hg	<input type="checkbox"/>	<input type="checkbox"/>	
				5	LL Mercury	<input type="checkbox"/>	<input type="checkbox"/>	
				5	Thallium Ti	<input type="checkbox"/>	<input type="checkbox"/>	

Relinquished by: <u>Sony Mills</u>	Date & Time <u>2/6/18</u> <u>9:25am</u>	Received by: <u>Carissa Turley</u> Lab: <u>Pace</u>	Relinquished by:	Date & Time	Received by:
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Mail Results to: WVDEP - DWWM - Watershed Assessment Branch ATTN: Janice Smithson
601 57th Street SE, Charleston, WV 25304 Phone (304) 926-0499 ex. 1051

WHITE - DEP Copy

CANARY -Laboratory Copy

Figure 3-16. Example of a fully completed Analysis Request Form with Chain-of-Custody (COC) at bottom

Part 3. Common Water Quality Parameter Suites & Detection Limits

Take Field (Sonde) readings at every site!

Because of the susceptibility of the pH and Conductivity Sensors to infrequent failure, it is important to have redundant information to corroborate the sonde readings. Therefore, always order Lab pH or Lab Specific Conductivity under either of the two following circumstances:

- A. The site you are visiting is a single or infrequent visit site (e.g., Random or Target Sites, LTMS, Lakes) and the instantaneous pH reading (i.e., sonde) indicates a violation of the pH WQ standards (i.e., <6 or >9)

Or

- B. The site you are visiting is a multiple visit site (e.g., TMDL, Deployable, Ambient, Special Projects) and the instantaneous pH reading (i.e., sonde) is outside of normal historic ranges as indicated on user-maintained pH/Conductivity log sheets. For example, if the site has a pH reading of 5.5 and has been visited X times in the past year and normally has a pH between 6.5 and 8.0.

Although Lab pH and Lab Specific Conductance readings are not the same as instantaneous readings due to a lag in analysis time, the lab readings may give us the ability to confirm if there is a failure with the sonde's probes.

NOTE: Internal testing (Spring 2017) has confirmed that Lab pH readings from samples held for a day or two before being given to the lab are usually quite different from the field pH reading (using a sonde that was not indicating any issues). Photosynthetic related pH changes are the likely cause of this pH shift in normal, circumneutral samples. However, the Lab pH from AMD or Acid Deposition stream samples do not change significantly from the field pH reading. This is mostly likely because these lower pH streams limit or inhibit any photosynthetic organisms, therefore limiting photosynthetic related pH shifts.

The Parameters in the Lab Parameter Suites below are listed in order of appearance on the COC in Figure 3-16 on Page 3-50.

Random & Potential Reference Sites

- Acidity (Hot), Alkalinity, Sulfate, Chloride, Fecal coli., Bromide, TDS, TSS, Tot. & Dis. Phos., TKN, NO₂-NO₃-N, Al (Tot. & Dis.), Fe (Tot. & Dis.), Mn (Tot.), Se (Tot.-Low Level), Cu (Dis.), Zn (Dis.), Mg (Tot.), Ca (Tot.), K (Tot.), Na (Tot.), Be (Tot.), Ba (Tot.), Sr (Tot.) & Pb (Tot.).

5 containers (wet iced, HNO₃, filtered HNO₃, & H₂SO₄) & fecal bottle

Acid Rain Parameters

Take when: 1) pH <6.0 & conductivity is <50, 2) if stream is on the 303(d) list for pH unrelated to mining, or 2) if for any reason you suspect acid rain deposition impacting the stream:

- Acidity (Hot), Alkalinity, Sulfate, Fecal coli., Acidity (Cold), TSS, Al (Tot. & Dis.), Fe (Tot. & Dis.), Mn (Tot.), Mg (Tot.), & Ca (Tot.).

3 containers (wet iced, HNO₃, & filtered HNO₃) & fecal bottle

AMD Parameters

Take when: 1) conductivity alone is >500, 2) pH <6.0 & conductivity is >200, 3) if stream is on the 303(d) list for AMD, or 4) if for any reason you suspect mine drainage:

- Acidity (Hot), Alkalinity, Sulfate, Chloride, Fecal coli., TDS, TSS, Al (Tot. & Dis.), Fe (Tot. & Dis.), Mn (Tot.), Se (Tot. & Dis.), Mg (Tot.), & Ca (Tot.). Take Ammonia-N (NH₃) if it is suspected that Ammonia is being used to treat the stream water.

3 containers (wet iced, HNO₃, & filtered HNO₃) & fecal bottle

Nutrient Enrichment

Take within 24 hours of a significant rain or when animal waste, straight pipes, STP outfalls, etc., may be impacting the stream:

- Fecal coli, TSS, Tot. & Dis. Phos., TKN, & NO₂-NO₃-N, Total Orthophosphate (PO₄-P). Take Ammonia-N (NH₃) if cattle or other livestock have direct access to stream or if there is evidence of possible ammonia input.

3 containers (wet iced, H₂SO₄) & fecal bottle

Large River Algae/Nutrient Enrichment

Take in large rivers that are experiencing exceptionally excessive algal blooms (e.g., Greenbrier River, Tygart River):

- Alkalinity, Fecal coli, TSS, Tot. & Dis. Phos., TKN, NO₂-NO₃-N, Total Orthophosphate (PO₄-P), Mg (Tot.), & Ca (Tot.). Take Ammonia-N (NH₃) if cattle or other livestock have direct access to stream or if there is evidence of possible ammonia input.

4 containers (wet iced, HNO₃, H₂SO₄) & fecal bottle

TDS Ions

Take anywhere in Monongahela Basin (Dunkard, Monongahela, West Fork, Tygart, Youghiogheny, & Cheat):

- Alkalinity, Sulfate, Chloride, Bromide, Fecal coli, TDS, TSS, Mg (Tot.), Ca (Tot.), K (Tot.), & Na (Tot.).

2 containers (wet iced & HNO₃) & fecal bottle

Oil & Gas

Take if oil or gas activities are evident & cond. >200 in absence of other sources like AMD:

- Alkalinity, Sulfate, Chloride, Fecal coli, TDS, TSS, Mg (Tot.), Ca (Tot.), K (Tot.), Na (Tot.), Ba (Tot.), Sr (Tot.).

2 containers (wet iced & HNO₃) & fecal bottle

Sediment

Typically, only used during WQ only sampling events (e.g., TMDL sampling). Take anywhere where it is suspected that Suspended Solids are contributing solely to the Iron load in the stream bed during precipitations events:

- Fecal coli, TSS, & Fe (Tot.).

3 containers (wet iced & HNO₃) & fecal bottle

Target analytical method detection limits are displayed in Table 3-5 on page 3-54.

Current Water Quality Analyte Method Detection Limits**Table 3-5. Current Water Quality Analyte MDLs**

Analyte	Method Detection Level	Analyte	Method Detection Level
Alkalinity	5 mg/L	Kjeldahl Nitrogen	0.1 mg/L
Aluminum	0.005 mg/L	Lead	0.001 mg/L
Ammonia Nitrogen	0.1 mg/L	Magnesium	0.05 mg/L
Antimony	0.005 mg/L	Manganese	0.005 mg/L
Arsenic	0.005 mg/L	MBAS	0.05 mg/L
Barium	0.005 mg/L	Mercury	0.0001 mg/L
Beryllium	0.001 mg/L	Mercury / Method 1631E	0.5 ng/L
Bicarbonate (Standard Methods)	1 mg/L	Mineral Acidity	1 mg/L
BOD	1 mg/L	Molybdenum	0.005 mg/L
BOD-carbonaceous	1 mg/L	Nickel	0.005 mg/L
Boron	0.02 mg/L	Nitrate-Nitrogen	0.05 mg/L
Bromide	1 mg/L	Nitrite-Nitrate	0.05 mg/L
Bromide Alt. Method	0.1 mg/L	Nitrite-Nitrogen	0.05 mg/L
Cadmium	0.0002 mg/L	Oil-Grease	2 mg/L
Calcium	0.02 mg/L	Organic Nitrogen	0.5 mg/L
Chloride	5 mg/L	Orthophosphate	0.01 mg/L
Chlorophyll A	0.5 mg/L	Percent Solids	1%
Chromium	0.001 mg/L	Phenolics	0.01 mg/L
Cobalt	0.001 mg/L	Potassium	0.05 mg/L
COD	0.5 mg/L	Selenium	0.001 mg/L
Color (ADMI)	10 ADMI value	Silver	0.0002 mg/L
Color (APHA)	5 color units	Sodium	0.05 mg/L
Copper	0.001 mg/L	Specific Conductance	3 uS/cm ²
Cyanide, Amenable	0.005 mg/L	Sulfate	5 mg/L
Cyanide, Free (ASTM)	0.01 mg/L	Sulfide	1 mg/L
Dissolved Organic Carbon	1 mg/L	Suspended Solids (TSS)	3 mg/L
Dissolved Solids (TDS)	1 mg/L	Thallium	0.001 mg/L
Escherichia Coli (Numeric Result)	1 col/100 mL	Tin	0.02 mg/L
Fecal Coliform (MF)	4 col/100 mL	TOC	1 mg/L
Fecal Coliform (MPN)	4 col/100 mL	Tot Petroleum Hydrocarbons GRO/DRO (8015)	0.5 mg/L
Fecal Streptococci	4 col/100 mL	Total Acidity	1 mg/L
Ferrous Iron (Standard Methods)	0.05 mg/L	Total Cyanide	0.005 mg/L
Fluoride	0.2 mg/L	Total Phosphate	0.01 mg/L
Hardness	1 mg/L	Total Phosphorus	0.005 mg/L
Hexavalent Chromium	0.005 mg/L	Total Solids	1 mg/L
Hot Acidity	5 mg/l	Turbidity	1 NTU (higher OK if highly turbid)
Hot Acidity Alt. Method	*	Vanadium	0.005 mg/L
Iron	0.01 mg/L	Volatile Solids	1 mg/L
		Zinc	0.002 mg/L

Water Sample Collection Quality Assurance/Quality Control

Once a year, all field participants in the WAB attend mandatory training sessions. The purpose of these sessions is to ensure that all field personnel are familiar with water quality sampling protocols and calibrated to sampling standards. A hands-on session concerning the collection and handling of water quality samples is included. In the field, biological sampling teams will consist of two people. Individuals who are more experienced in collecting water quality will be teamed up with the less experienced to ensure reinforcement of training and accurate results before they can collect water quality. This document is also provided to all program personnel for review and use in the field.

Sample labels are to be accurate and complete and contain all the information discussed above. Sampling equipment will be checked for contaminants and excess dirt or moisture cleaned before and after each sampling event. Lot numbers of all preservatives are recorded on the Analysis Request Form for each sample submitted and entered into the database to allow for easy tracking. Sample transfer to the lab shall also be documented using the Chain-of-Custody (COC) portion of the Analysis Request Form.

Duplicate sampling and field blanks must be performed at a minimum of 2.5% and 5% of our sites respectively. To ensure we meet these requirements, each team list will have a designated duplicate and field blank. The field blank and duplicate data are looked at by Watershed Assessment Branch staff and scrutinized to find any possible discrepancies, contamination, or faults in the sampling methods and techniques. Any problems are brought to the attention of the program management and steps are made to immediately correct the problem. Data that is related to the problem are flagged with notes concerning the details of the situation so that decisions can be made whether to include the data in any further assessments or analysis. Procedures for performing field blanks and duplicates are presented in **CHAPTER 14. Section A. Blanks and Duplicates starting on page 14-1.**

Field Blanks

Field blanks are simply samples of clean water that are handled (i.e., collected, filtered, and preserved) in the field. The purpose of the field blank is to detect onsite contamination in sample handling (i.e., parameter detections). Additionally, the field blanks can be used to verify the purity of sample fixatives and identify potential lab contamination issues. Trends in parameter detects in field blanks can be traced to a specific lab, preservative (e.g., supplier and lot number), vehicle, methodology, or field collector. Ideally, a field blank would be collected each week per team deployed in the field.

The preparation of field blanks is required by each field team on a **weekly basis**. DI or distilled water is used as the blank "sample" and is purchased in sealed one-gallon containers for transport to the field. During the designated sampling event, a set of sample containers are prepared as field blanks with one container for each type of preservation method. The blanks are disguised as a normal sample per the water collection protocols described starting on **page 3-35**. These containers are rinsed and filled with the DI or distilled water and are preserved and stored in the same manner as the actual samples. A QC Blank Form field sheet (**see Figure 14-1 on page 14-4**) and separate Analysis Request Form with Chain-of-Custody (COC) is completed for the field blanks and the samples are submitted to the laboratory.

IMPORTANT: Field blanks are to be prepared in the field only and not in the laboratory or garage. A stream location is sometimes designated on the sample list for a field blank. If you miss the exact location indicated on the sheet, prepare a field blank at the next location. The reason why field blanks are indicated on your list is to remind you to do it AND to ensure that field blanks are prepared at random locations and times.

IMPORTANT: Do not prepare a field blank for fecal samples, as the DI or distilled water is not sterile.

Duplicate Samples (Blind Duplicates)

Blind duplicate samples are collected at the same date and time and side by side by different individuals. If the sampling team consists of one person, as is often the case during a TMDL assessment, the duplicate is still performed by the one sampler. Bottles intended for the same analytes should be collected side by side.

Duplication must include the full list of parameters sampled during the week. Duplicates for lists that have varying water analysis suites should be conducted at sites where the most parameters on the list are collected (if such sites exist on the list) and, if repeated, should be rotated to different sites each sampling event.

During repeat sampling efforts, (e.g., TMDL and Ambient), field crews should not repeatedly duplicate the same site.

Results of the duplicates are compared and any samples not falling within an acceptable range are examined for sampling error. The duplicate data will be analyzed to ensure precision and repeatability of the sampling technique. Every effort is made to ensure that different teams perform the duplicate sampling throughout the sampling season to ensure that all variability is being captured. The variances between individual techniques will be documented and used in future training sessions or individual re-training.

NOTE: If two people are involved in collecting a duplicate, each person should filter his or her own sample and not filter the other person's sample.

WVDEP Laboratory Quality Assurance Program

All water quality samples must be analyzed by a laboratory that has been approved through the WVDEP Laboratory Quality Assurance Program. The Quality Assurance Program is responsible for certifying environmental laboratories to ensure that the DEP receives accurate and reliable analytical data. Laboratories are certified when they follow approved methods, employ well-trained capable staff, and use equipment and instrumentation suited to the work they perform.

Certified laboratories are grouped into **three** categories:

1. **Commercial** – stand-alone laboratories testing samples for a fee.
2. **Municipal** - laboratories associated with publicly owned treatment works operated by cities or public service districts.
3. **Industrial** - manufacturing company owned and operated laboratories.

Most water quality samples collected by the Watershed Assessment Branch will be analyzed by certified commercial laboratories. However, sometimes it may be necessary to use a certified municipal laboratory due to holding times combined with distance to a commercial lab (e.g., fecal coliform samples). In addition, industrial laboratories may be used when cooperating with industry partners in certain studies.

The WVDEP maintains an up-to-date list of approved laboratories on the web located at: <http://www.dep.wv.gov/WWE/Programs/lab/Pages/default.aspx>

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