Volunteer Water Quality Sampling Guide for the Gills Creek Watershed

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Introduction to Sampling

Lakes and waterways are not only a beautiful and recreational part of nature but they are also extremely important for the health and wellbeing of the surrounding ecosystems. Since clean water is so essential for life, it is imperative to monitor the quality of water in the lakes and rivers as well as work to maintain its health. Unfortunately, comprehensive monitoring requires a great amount of resources and it is not always possible for local and state governments to reach all of the bodies of water that may be of interest to the local citizens. That is why the Gill Creek Watershed Association has developed this guide as a tool to help citizens understand more about water quality sampling, to teach them to sample for limited issues in their own backyard, and to have a greater understanding of water quality concerns.

Why should I sample the water in my area?

There are other important reasons as to why water should be consistently sampled in your area. Monitoring water quality over time allows a community to develop a reliable source of data to track water quality changes over time. It also allows communities to determine the impacts local facilities have on waterbodies and advocate for corrective action when necessary. Water in a river is not always swimmable or fishable. For example, high levels of mercury can accumulate in fish and cause harm to humans over time if that fish is consistently eaten. It is also imperative to know how much bacteria or other contaminants are in a water body before swimming since they can be accidentally ingested or absorbed through our skin.

With acquired knowledge of water body ecology and pollution levels, citizens will be better equipped to reach out to others in the community about the health of the rivers, lakes and streams in the Gills Creek watershed and to work to address and prevent local water quality problems. In addition, local legislators will be more likely to push for cleaner rivers and creeks if they see community efforts to keep local waterways clean.

What type of monitoring will I need to do?

There are many approaches to volunteer monitoring. Some volunteers use a State-approved scientific approach and are able to submit the data to government officials while others monitor for scientific research or educational purposes. This sampling guide will be used by GCWA volunteers to gather information for use by the GCWA and citizens of the watershed. At this point, the data received will not be used by any government entity for regulatory purposes or to justify stormwater projects. Additionally, the information will not be published as scientific research.

It is the goal of the GCWA to establish a volunteer base that has an interest in water quality sampling. Sample collection will initially be informal, but may lead to a more systematic and formal sampling effort if there is enough citizen interest. In the future, GCWA plans to work with the SC Department of Health and Environmental Control to create a Quality Assurance Project Plan and seek funding to establish scientifically accurate data to be used by local and state government.

At this point, the GCWA would like to address the concerns of many citizens that wish to know more about the quality of the water in their neighborhood. This document will guide citizens on how to sample for the following parameters using home test kits that citizens may purchase:

- Dissolved Oxygen
- E. Coli
- pH
- Temperature
- Turbidity

What is the role of the GCWA?

The GCWA is available to help homeowners get started with their sampling efforts. Representatives from the GCWA can conduct site visits; help homeowners determine what to sample and the appropriate sampling locations. Additionally, the GCWA can provide training on how to use the sampling equipment and interpret data. Unfortunately, the GCWA has no source of funding to reimburse or supplement the cost of sampling supplies at this time.

Citizens will submit the data they collect to the GCWA, where it will be mapped and tracked. By keeping record of each sample from around the watershed, the GCWA will be able to find potential water quality problems and public health concerns throughout the year. When water quality or public health concerns do arise, the GCWA will share this information with the proper government entity and work with the local neighborhood to address these concerns.

What is non-point source pollution?

There are two main types of pollution that have a significant impact on a river ecosystem. When a single pollution activity can be traced back to one or several specific sites such as a factory, a wastewater treatment plant, or even a local business or home, that is called *point source pollution*. It is typically easier to locate and address the entity responsible for the point source thus making it easier to find a solution. With *non-point source pollution*, there is no one specific contributor to the pollution activity. This kind of pollution can be created by agricultural runoff, storm water runoff, construction site runoff, and urban runoff from streets and parking lots. Since finding a single contributor to the pollution is almost impossible, creating a way to regulate this pollution can be far more difficult than point source pollution. Common non-point source pollutants in urban watersheds such as the Gills Creek Watershed include bacteria, oxygen demanding substances such as fertilizers and waste, and sediment.

Where should I sample?

When looking for a sample site, there are several things to consider. Most importantly, the same sampling site should be used over time. You should determine a good way to keep track of your site so you can return to it throughout the year. You may want to take a picture or, where legal, leave a marker at the site so you'll know where to return to each month. Below is a list of other guidelines to consider when choosing a site:

- **How accessible is the site?** You'll want to find an area within close proximity to your home or workplace that you can get to easily and relatively quickly so you can take time consistent samples. Try to choose a site that you can access from your own or public property. However, if you need to access the site from someone else's property, be sure you have permission. Also, if you do not own a boat, choose sites that are easy to wade to, even when water levels are high.

- **Can I identify the site on a map and on the ground?** It is important to be able to identify the site of choice on a map for tracking purposes. This is also helpful if there is a waste spill in a river so that sites affected by the spill can be identified and monitored.

- **What type of water body should I sample?** You can sample any body of water as long as it is a part of the Gills Creek Watershed. There are some smaller streams that only get recharged with water at certain times of the year or only during a rain event. You can still take samples from these streams but you'll need to know when you will and will not be able to sample the site.

- **Is there another sampling site nearby?** If there is an established monitoring site nearby, you may be able to use that information for your personal use instead of collecting your own samples. If you are unsure if there is a nearby monitoring site, contact the GCWA.

- **Is there a storm drain or other discharge upstream of the sampling site?** If there is a storm drain discharge upstream it will likely affect the outcome of your sample. In this case we recommend that you sample upstream from the discharge as well as downstream to determine if the discharge is contributing to any pollution problems. This also goes for any additional water ways that enter upstream from where you are sampling. It will be beneficial for you to understand if any other body of water is impacting your waterway.

Frequency of sampling and monitoring

Certain pollutants are subject to seasonal variability. This means that at certain times during a year, you may find that levels of pollutants are higher or lower than at other times. Because of this, it is important that you sample monthly for at least a full year. Sampling for more than one year will provide an even more accurate prediction based upon the set of data. Monitoring at the same time during the day and at regular intervals (i.e. the first Saturday of every month) will also ensure more reliable comparable data for the future. For example, water temperature and dissolved oxygen change throughout the day because of sunlight.

What should I sample for?

What do you want to sample? Why do you want to sample the particular site? What is your main concern? If the water is used for recreational purposes, then your main concern may be the health of the people who use the water body. If there is a potential for point or non-point source pollution then identifying the pollutant is important for preserving the ecology of the stream. If you are concerned about the value of your property, pollutants in a water body will depreciate your property value. Once

you decide why you are sampling you can determine what type of sampling is best for you. Below are some example concerns and what you should sample for if you have these concerns.

- Recreation (i.e. swimming, boating) – sample for E. Coli
- Fishing, aquatic habitat – sample for Dissolved oxygen, pH, and Temperature
- Sedimentation – sample for turbidity

This guidance only addresses a few parameters that the GCWA felt were the simplest and some of the most common things to sample for. However, they may not be enough to address your concerns. If that is the case, contact the GCWA for further information.

How do I sample water?

The best way to sample a natural water body differs depending on the type of water body you choose. If it is a narrow and shallow creek you should be able to wade to the sampling site. The best place to sample would be in flowing water in the deepest part of the creek, which is likely to be in the middle. If you are sampling a wide river or a lake, there are several ways to measure. Here are a few ways:

- **With a Boat**
    - Upon reaching the site location, you can set the anchor. Do not re-position the anchor since doing so would stir up soil underwater thus effecting the outcome of your measurements.
    - Make sure you are able to find the location again either by setting a buoy at the location or by setting flags on the shore adjacent to the location.
    - Establish two landmarks perpendicular to the shore on each side of your sampling site that will allow you to easily find the location and plot the location on a map.
- **Without a Boat**
    - Wade to the site. Start downstream and wade upstream to the sample site to avoid kicking up soil that may affect the outcome of your sampling.
    - Stand on a bridge over the site. Attach a weight to your sampling gear and extend them on a rope or string into the water.

Stream Flow: Why is it Important?

The flow of water, also known as *discharge*, is defined as the total amount of water that is moved over an area of land in a certain amount of time and is highly dependent on seasons, weather, climate activity (droughts, wet periods, etc.) and land activity. Discharge is measured in cubic feet or cubic meters (volume) per a certain amount of time, usually measured in seconds (EPA, 1997).

There are multiple factors that increase or decrease discharge depending on land use in the watershed. The discharge may be impacted by agriculture, groundwater use, or industrial use. In the Gills Creek Watershed, rainfall is the main determining factor for discharge. Due to the amount of paved surfaces in the Gills Creek watershed, rainwater moves quickly from the roads and parking lots into waterbodies. This creates flash flood events that have a very high discharge in a short amount of time following the rain event. The first inch of rainfall usually carries the highest amount of non-point source pollution in the stormwater. This is called the *first flush*.

If the discharge remains high following the first flush, the pollutant of concern may be diluted thereby reducing its impact on the ecosystem. However, increased velocity (speed) associated with high discharges may also contribute to streambed scouring and streambank erosion, particularly in channelized (straightened) streams that are common in the Gills Creek Watershed. This erosion creates unstable banks and contributes to a buildup of downstream sediments in lakes and/or ponds.

The velocity at which the stream flows also affects the types of organisms living in the area. Since fast moving streams are consistently mixing and circulating, the level of dissolved oxygen is high. Animals that have a high oxygen demand end up thriving in areas with high water velocity and discharge. Slower moving water has a lower dissolved oxygen content allowing low oxygen demanding organisms to survive (Novotny, 2002).

How to measure discharge:

Discharge can be measured using a simple equation:

$$Q = \frac{A \times L \times C}{T}$$

In this equation:

Q = Discharge

A = Cross Section Area (Width of the stream × Average water depth)

L = Length of measured stream reach

C = The coefficient; 0.8 if the length of the stream has a rocky bottom and 0.9 if the length has a muddy bottom. This unit is necessary since water moves more quickly at the surface of the stream. This allows for a more accurate overall estimate for discharge.

T = Time in seconds. You can determine time by floating a device down the length of L and timing how long it takes to complete the stretch (EPA, 1997).

Necessary materials for measuring discharge:

- 20+ foot tape measure
- Yardstick (or meterstick) to measure water depth

- Heavy duty string
- Four stakes and a hammer to drive the stakes into the ground
- Twist ties for marking the string
- A floating devise and a fishing net to scoop out the floating devise
- A stopwatch for timing the floating device

Along with these items, be sure to wear proper clothing. Wear boots or shoes that can get wet and muddy. Also, make sure you have driving directions and take care to keep an eye on the weather.

Select a sampling site:

If your sample site is located on a lake it is not necessary to measure flow, however you should indicate this on the sample form. If your sample site is located on a stream, it is ideal to find an area on the stream that is straight and deep (at least 6 inches). Try to stay away from meanders (areas where the stream bends) and areas of still or slow moving water.

The length of your testing site, indicated by "L" in the discharge equation should be approximately ten feet. Using the string brought to the site, run the string (or a *transect* line) across the river perpendicular to the shore at the beginning and the end of the stretch of the stream chosen. The line can be anchored by the stakes and needs to be tight and close to the surface of the water (EPA, 1997).

Find the cross-sectional area:

By measuring the width of the stream in one specific spot and multiplying it by the average depth of the water, you can calculate the cross-sectional area. In order to find the average cross-sectional area of the stretch chosen, you must find the cross sectional area for your first transect and your second transect and then find the average by adding them and dividing by two. This calculation will be the "A" in the discharge equation.

To find the individual cross-sectional area for each transect line, begin by marking the line at three equal intervals with twist ties. At each mark, measure the depth of the stream using the yard (or meter) stick. To find the average, add each of the three depths and divide by four to account for the depth at the shores. Multiply the average depth by the length of the cross section of the stream. Use these cross-sectional areas to determine the average cross sectional area. (EPA, 1997)

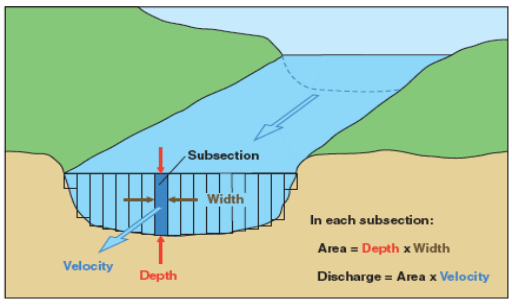


Diagram of cross-sectional area.

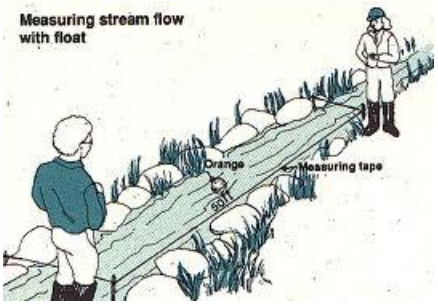
Source: www.usgs.gov

Measuring stream flow.

Source: www.usda.gov

Measure flow time:

Find the flow time by using a stopwatch and a small, light floating device such as a ping pong ball or orange peel. Hold the device at the upstream transect line then, release the device into the fastest current and start the timer. When the floating device reaches the second transect line, stop the timer and record the time. Do this three times and record the average. Every time the device gets caught up in something in the river, restart the trial. After finding the average time, use it as "T" in the discharge equation.



Measuring flow time.

Now that you have received all of your data needed, place your numbers into the discharge equation and record your numbers.

Dissolved Oxygen

Measuring dissolved oxygen (DO) is a good way to determine the health of a water body. Oxygen plays an important role in determining the types of organisms that live in a water body. Since water in a stream is constantly churning and mixing, oxygen is consistently fed into the water allowing organisms to survive. Oxygen is also naturally supplied by photosynthesis from aquatic organisms and algae. Organisms in the water consume the oxygen to survive or to decompose. Some species like trout need a consistently high DO levels to survive while other species can tolerate lower or fluctuating dissolved oxygen levels.

Low DO (usually called hypoxic) levels usually indicate pollution or some type of human-caused change, of which there are several major categories:

- Addition of organic waste in the form of sewage and animal manure, organic fibers from textile and paper processing, and food wastes. These organic materials are decomposed by microorganisms that use up oxygen.
- Addition of nutrients from fertilizers and agricultural runoff as well as through sewage. This causes lots of plants and algae to grow and then decay. The bacteria that decompose the plants consume oxygen during the decay process.
- Changing the flow of the water through dams and water withdrawal (for irrigation, snowmaking, water supply, or cooling systems of electric or nuclear power plants). The reservoirs created through a dam may increase the temperature and reduce the amount of dissolved oxygen.

- Raising the water temperature through the removal of vegetation from stream banks, which increases the water temperature and therefore decreases the dissolved oxygen levels. Another way that temperature can be affected is through the release of heated water that was used to cool an industrial plant (Cary, 2009).

Natural processes also affect the dissolved oxygen levels:

- Warm water holds less dissolved oxygen than cold water.
- The lowest levels of DO usually occur in the morning, because photosynthesis stops at night while respiration continues.
- Water at higher altitudes holds less oxygen.
- Fast-moving water generally has more oxygen than still water, because the movement mixes the air into the water. However, if the water is very turbulent, it may hold too much oxygen, causing stress to the aquatic organisms.
- Water with lots of aquatic plants have higher levels of dissolved oxygen, since submerged plants produce oxygen through photosynthesis. Also, as mentioned above, too many plants will ultimately reduce the DO levels, because of either night-time oxygen use by plants or the decay process that consumes oxygen (Cary, 2009).

Dissolved oxygen is often measured in parts per million (ppm) or milligrams per liter (mg/L). When measuring DO, concentrations range from 0 to 14 ppm or mg/L (they measure the same thing, but sometimes your test kit will use only one of the measurements).

Interpretation of data:

0-2 mg/L: not enough oxygen to support most animals
2-4 mg/L: only a few kinds of fish and insects can survive
4-7 mg/L: good for most kinds of pond animals
7-11 mg/L: very good for most stream fish (Cary, 2009)

Dissolved Oxygen kits can be purchased online: http://www.chemetrics.com/Oxygen+%28dissolved%29 Instrumental and visual kits are available at this website and both types are accurate enough for volunteer data. While instrumental kits are more accurate, they are also more costly. The kit that would be most useful is 1-12ppm visual kits for $50. It comes with everything you need to test for dissolved oxygen including directions. Instructions can also be found online at: http://www.chemetrics.com/products/i7512.pdf

E. coli

E. coli, short for *Escherichia coli*, is a type of fecal coliform bacteria that is found in the intestines of humans and animals. Therefore, E. coli in the water indicates that sewage or animal waste has contaminated the water. Most strains of E. coli are harmless but E. coli O157:H7 can cause severe illness.

Impervious surfaces in urban areas (paved roads, sidewalks, etc.) tend to allow water to runoff very rapidly. Since the runoff is moving at such a high rate, it picks up fecal matter and other bacteria carrying entities and carries them to the river. Animal waste (including waste from pets), septic systems, wastewater pipes and discharge areas are all sources of this type of pollution and all have the potential

of carrying a dangerous strand of E. coli. This is why an increase in rain water directly increases the amount of bacteria concentration in the local waterways (USGS, 1998). If you are concerned about the levels of E. coli in the waterways near you, it is important to test for it.

E. coli is usually measured as Most Probable Number (MPN) which is a technique that measures microbial populations in liquid. According to the EPA, the criterion for *E. coli* for primary contact recreation activities such as swimming is 235 MPN/100mL. The criterion for secondary contact recreation activities such as boating is 406 MPN.

Coliscan Easygel which tests for E.coli can be bought for approximately $25 for ten tests online at: http://www.micrologylabs.com/.cWcustom/php/catalog.php3?CAT=1. The kit will come with easy to follow instructions and interpretation guidelines for sampling at home.

pH

pH is measured on a scale from 0 to 14. Values below 7 are more acidic and values above 7 are basic. A value of 7 indicates a neutral sample. Acid rain has a pH range of 4.0 to 4.5 and a lake has a natural pH range of 6 to 9. The majority of aquatic life prefers a pH range of 6.5-8.0 pH (EPA, 1997). A pH outside this range, whether acidic or basic, reduces the diversity in the water body because it can stress the physiological system of an organism and can reduce reproduction. An acidic pH can cause toxins in the water to become available for uptake by aquatic organisms. Meters and solution can be bought for around $17 at http://www.benmeadows.com/store/Water_Testing_and_Sampling/Water_Testing/.

Temperature

Aquatic organisms are dependent on certain temperature ranges for their optimal health. Certain organisms survive best in cold water while others survive best in warm water. If, for any long period of time, these fragile organisms remain out of their temperature range, they will die. The main reason water temperature affects these organisms is because oxygen levels change according to the temperature. Warm water carries less oxygen while cold water carries more oxygen. The main causes of temperature change are weather, changes in stream bank vegetation, storm water discharge, industrial cooling water discharge, and pools formed from barriers or dams. Temperature can also depend on the distance from the bank and variation of water elevation.

At the same time of day and location, measure temperature by placing the thermometer directly into the water body, allow the thermometer to come to equilibrium and record the temperature. For sites where this isn't possible, allow the sample container to cool in the sample water before collecting the sample. If at all possible, take temperature samples at different depths and horizontal positions in the river since it varies with both of these factors. Immediately record the temperature of the sample once it is collected.

Aquatic field thermometers can be bought in degrees Fahrenheit or Celsius for approximately $20 online at: http://www.acornnaturalists.com/Water-Quality-Kits-Thermometers-Plankton-Nets-C70.aspx

Turbidity

A body of water is said to be turbid when it has a high dissolved and suspended load. The dissolved load is the micro materials within the river that are dissolved within the water. This material is physically bonded with the water molecules and does not settle out easily. Suspended load is the material that is not bonded with the water molecules, is carried by the water itself, and can settle out easily. The load consists of clay, silt, sand, and larger particles as well as algae, plankton, and other micro and macro organisms. You can tell the level of turbidity by how much light passes through the water (EPA, 1997).

The effects of turbidity can include several things. First, it increases the temperature of the water since the particles that make up the load are able to trap and absorb higher amounts of heat. This directly impacts the DO levels in the water and causes fish to have to endure low DO levels. Second, high turbidity also decreases the level of penetrating light which directly reduces photosynthesis and oxygen produced by plants and algae. Finally, a high sediment load will clog the gills of fish, reduce the resistance to disease for fish, expose the fish to more harmful diseases and in turn lowering growth rates, and smother fish eggs and larval development by settling along the bottom of the stream (EPA, 2008).

Some common causes of turbidity:

- Construction
- Storm water and urban runoff
- Quarrying, and mining
- Stream bank erosion
- Soil erosion
- Waste discharge
- Excessive algal growth
- Bottom feeders stirring up sediment (EPA, 1997).

Turbidity is measured in NTUs (Nephelometric Turbidity Units) which is a measure of light penetration through the sediment. Turbidity can be measured several different ways. The most accurate way to measure turbidity is with a turbidity meter. However, these can be very expensive and not necessary for a volunteer monitoring program. Many people use a secchi disk which is a very simple and inexpensive tool, but not very accurate and difficult to use in streams. A turbidity tube is the recommended method to use for volunteer groups. Turbidity tubes can be purchased or homemade. Once you have your turbidity tube, follow the instructions below for using it.

Using a Turbidity Tube

Before You Begin:

• Be sure to use a clean bucket or other container to collect water samples.

• Measurements should be taken in daylight, but not direct sunlight. Cast a shadow on the tube by placing yourself between the sun and the tube.

• Do not wear sunglasses when reading the tube.

• If possible, work with a partner to help verify measurements and disk visibility.

Turbidity Tube
Source: www.lakeaccess.org

When Measuring, Remember:

- Highly colored water will register as having a higher turbidity than it actually does.
- The turbidity scale is logarithmic, so it cannot be linearly interpolated.

Measuring Procedure:

1. Dip the container into the water. Be careful not to include sediment from the bottom of the body of water.
2. Rinse the tube with the water that is going to be tested and pour it out.
3. Stir or swirl the water sample in the container vigorously until it is homogenous, introducing as little air as possible.
4. Place your head 10 to 20 centimeters directly over the tube so that you can see the viewing disk while the sample is being poured into the tube.
5. Slowly pour water into the tube. Try not to form bubbles as you pour. *If bubbles do form*: Stop pouring and allow any bubbles to rise and the surface of the water to become still.
6. Keep slowly adding water until the pattern on the disc becomes hard to see.
7. Watch the viewing disk closely and add water even more slowly. Stop pouring as soon as the pattern on the disk can no longer be seen. If you can still see the viewing disk pattern when the tube is full, record the turbidity value as less than the final measuring mark. (Example: If your tube is full and your highest mark is 5 NTU, write down that the turbidity is "<5 NTU".)
8. Read the turbidity from the scale on the side of the tube. If your turbidity tube does not have turbidity values marked on the tube side, simply measure the water level with a ruler or tape measure and find the corresponding turbidity value in the table below (Myre, 2006).

Table 1: Converting Centimeters to NTU (Myer, 2006).

Centimeters	NTU	Centimeters	NTU
6.7	240	38.2	17
7.3	200	40.7	15
8.9	150	43.3	14
11.5	100	45.8	13
17.9	50	48.3	12
20.4	40	50.9	11
25.5	30	53.4	10
33.1	21	85.4	5

The state standard for turbidity according to the South Carolina Department of Health and Environmental Control is not to exceed 25 NTUs for lakes and 50 NTUs for all other waterbodies.

For instructions on making your own turbidity tube, refer to this website : http://www.cee.mtu.edu/sustainable_engineering/resources/technical/Turbidity-Myre_Shaw.pdf

Turbidity tubes can be purchased for approximately $40-50 from a variety of websites. http://www.forestry-suppliers.com/product_pages/view_Catalog_Page.asp?id=5073 or http://www.carolina.com/product/earth+and+environmental+science/environmental+systems/water/carolina%26%23153-+turbidity+tube.do are some example websites.

Submitting the data

The data forms can be filled out on site, then the information can be entered into a fillable PDF found on our website at: www.gillscreekwatershed.org or you can mail the forms to:

Gills Creek Watershed Association
712 Main St., EWS 603
Columbia, SC 29208

Thank you for your intensive volunteer work. Everything you do is very much appreciated!

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