Community-Based Restoration Monitoring Protocol

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Project Partners

This project would not have been possible without collaborative partners and advisors. Thank you to the many voices that contributed to this protocol.

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"Developing an Integrated Community-based Monitoring Approach to Track Restoration"

Introduction

As jurisdictions continue to increase restoration efforts to achieve pollution reduction goals, it is essential to observe and collect data on projects to ensure their long-term success. Monitoring restoration project health and status can take many forms, from the indicators evaluated, to the diverse players collecting the data. With these questions in mind, it became clear there was a need to develop a standardized protocol to document observed changes resulting from the installed BMPS.

Project Background

In 2021, the National Fish and Wildlife Foundation (NFWF), partnered with the Chesapeake Monitoring Cooperative (CMC) and Stroud Water Research Center (Stroud) to develop a watershed-wide integrated community-based monitoring plan aimed at tracking changes in stream health conditions as a result of restoration projects implemented through NFWF's Chesapeake Bay Stewardship Fund (CBSF). Developing a consistent watershed-wide monitoring method not only meets NFWF's goals, but enhance the ability for diverse partners like local watershed groups, landowners, localities, and conservation districts to utilize the data and highlight the success of this investment.

The monitoring team for this project includes three CMC partner organizations (CMC Team) the Alliance for the Chesapeake Bay (Alliance), Dickinson College's Alliance for Aquatic Resource Monitoring (ALLARM), and the Izaak Walton League of America (IWLA) who work with organizations funded through the CBSF to select sites and conduct the monitoring activities across the Chesapeake Bay watershed. Stroud provides scientific oversight of the program and data analysis.

Protocol Overview

The outcome of this project is to engage volunteer monitors in collecting data to help assess the status of National Fish and Wildlife Foundation stream restoration sites (up to 2 years before implementation and up to 5 years after implementation). Specifically, this protocol aims to collect data in relationship to ten best BMPs that fall within four major categories:

- Dirt and gravel roads
- Riparian buffers
- Stream restoration (bank stabilization and floodplain reconnection)
- Cattle fencing

Monitoring restoration status and impact can take many forms ranging from the indicators evaluated to the diverse players collecting the data. It is important to acknowledge that measuring ecological lift can be difficult due to the lag times and complex variables across restoration sites. Therefore, this monitoring protocol has three goals:

1. Use biological, chemical, physical, and visual indicators to assess restoration project status and water quality impacts over time.
2. Educate and engage community members and community-based monitoring partners about Bay restoration activities and impacts.
3. Contribute to long-term water quality data collection and stream health understanding.

Data collected at the restoration location will be compiled into a site report to be shared with the landowner, project partners, and NFWF. Data will be used to inform maintenance needs to determine whether the BMPs continue to have the intended geomorphological and biological impact over time. Additionally, data will be used to develop standardized restoration case studies that NFWF can use to track projects.

Site Selection & Site Set Up

Prior to assessing a restoration site, preliminary work must take place to determine if the site is an appropriate and safe location for volunteer monitors. The Chesapeake Monitoring Cooperative (CMC) team will follow these steps to select monitoring sites, gather background information, and set up the site before monitoring can begin.

Select Monitoring Sites

Annually, the NFWF team will select a subset of approved grant applications with planned stream restoration, forest buffer, or cattle exclusion projects that may be suitable for monitoring. From that subset list of approved grant applications, the CMC team will work with on-the-ground Project Partners (NFWF Grantee or applicable Project Manager) to obtain and review site plans, fill out the background information, and conduct initial site visits to determine which projects/sites within each NFWF Grant are viable for monitoring (if more than one project is planned). The monitoring team will fill out the Project Documentation Form to identify which projects/sites within each grant are included in this monitoring protocol.

In order to be considered for monitoring activities, sites **must**:

1. Have a planned forest buffer, stream restoration, cattle fencing project, or gravel road improvements.
2. Be located on a 1-3 order perennial stream (1st order streams are preferable)
3. Have at least 100 meters of stream receiving treatment from the proposed project (except dirt/gravel roads). If the site is longer, the assessed reach will be in the most downstream portion of the project area.
4. Be safe, accessible, and wadable along the entire assessment reach (100m).
5. Be located within one property that has a landowner willing to allow access for at least 6 years.

Additional considerations to prioritize projects, if more than one project is being implemented within a grant:

1. Priority should be given to sites where additional structural or non-structural BMP's are being installed. All BMP's do not have to have NFWF funding to be included in the prioritization.
2. Priority should be given to sites with smaller upstream watersheds and watersheds that share multiple sites.
3. Dams, bridges, and other build infrastructure (e.g. exposed sewer pipelines) in the area should be considered and not included within the stream reach.

The Project Documentation Form will be submitted to NFWF prior to the start of monitoring activities and will indicate that a project is covered by the Quality Assurance Project Plan (QAPP) Community-based Restoration Monitoring to Track Progress of Restoration Projects Implemented through the NFWF Chesapeake Bay Stewardship Fund (approved 11/13/23). Only projects that follow this protocol exactly will be covered by the approved Project QAPP. If any additional monitoring is planned on site, a separate NFWF QAPP will be required and may include elements from this project.

Gather Background Information

The CMC team will gather background information for each project site selected. This can be done using the watershed delineation feature of Geographic Information Systems (GIS) or [Model My Watershed](), EPA Freshwater Explorer, and [How's My Waterway]() can be used if GIS is not available. The CMC team will fill out the first page of the [Site Background Template]() with all relevant background information. See the Site Background Instructions for more information.

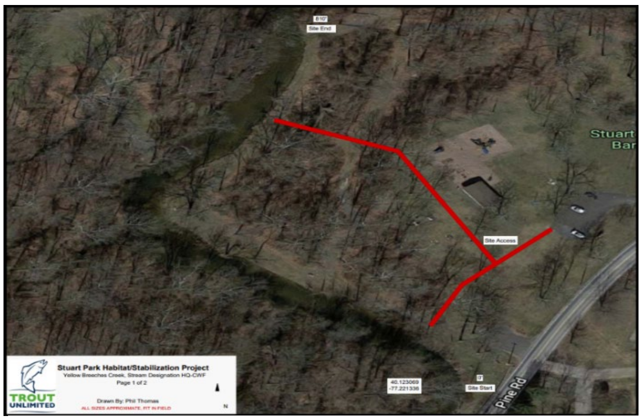


Figure 1: Stuart Park Site Reach. Image credit: Trout

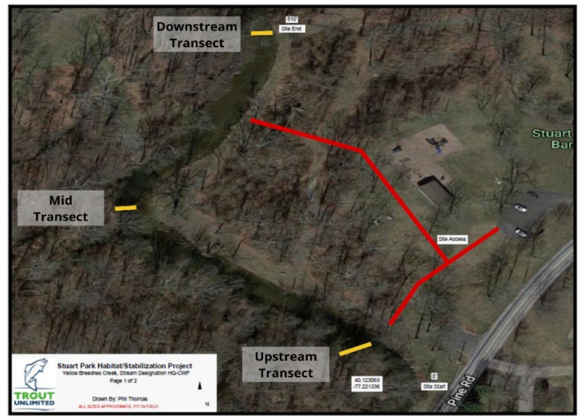


Figure 2: Establishing the three transects. Photo Credit: Trout Unlimited, with ALLARM modifications.

Site Visit and Assessment Setup

The CMC team will conduct an initial site visit with the Project Partner to determine if the site is viable for monitoring and identify the monitoring assessment reach within the proposed project area. The monitoring team will fill out the second page of the [Site Background Template]() to document the decisions made in the field.

1. Determine if the site is safe, accessible, and wadable along the entire assessment reach. Consideration for parking, stream access, electric fencing, and any access restrictions should be well documented.

2. Determine the length of the assessment reach based on stream order.
    a. Order 1 = 30m
    b. Order 2 = 60m
    c. Order 3 = 90m
3. Determine the location of the assessment reach within the proposed project area. If the project area is larger than 100m, the reach should be located at the most downstream area of the project. Take additional consideration for the following:
    a. The entire assessment reach should end or start at least 10m upstream or 20m downstream of a bridge so that no part of the reach is touching or being crossed by a bridge.
    b. The reach should be at least 10m downstream of a dam so that no part of the reach is touching or being crossed by a dam. Dams must be smaller than a couple of feet wide. If a site contains larger dams, it may not be suitable for this protocol. Ideally, there will be no dam near the monitoring site, as the dam effects will override any restoration impact other than riparian vegetation.
    c. If the project involves a dirt and gravel road BMP, the entire monitoring reach must be downstream of the BMP.

4. Identify three transect locations along the 30, 60, or 90-meter reach evenly distributed across the reach at the start, middle and end points. **Keep in mind safety and representative characteristics of the stream, and adjust the exact location of the transect accordingly.**
    a. Transect considerations:
        i. The three transects should represent different characteristics present throughout the stream reach (e.g. riffles, runs, shallow areas, and deep areas).
        ii. Water should be wadable across the entire transect (e.g. you can touch the bottom with your hand to pick up rocks). Avoid deep pools.
        iii. The banks must be accessible on both sides of the transect. Avoid areas with large overhanging vegetation (e.g. shrubs, trees, vines) that reduce access if there is a clear area close by.
        iv. Consider clearly defined natural markers (e.g. trees, fence posts, etc) to make the transect easy to identify.
    b. Place permanent reference markers at each transect location (pink flags or flagging tape labeled with the transect identifier).
        i. If there are trees/shrubs on site place pink flagging tape on the tree/shrub at the transect location.
        ii. If there is no vegetation prior to restoration, place pink flags in the ground on the bank. After the restoration practice is installed, mark the tree tubes with flagging tape.
    c. Record Lat/Long coordinates for each transect in decimal degrees (you can use the GPS on your phone), which bank the marker is located and any visual reference markers for each transect on the Site Background sheet.

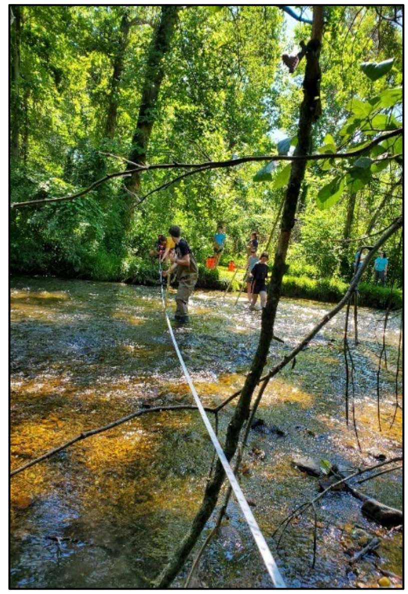


Figure 3: Setting up a transect. Photo credit: ALLARM

5. Identify the standard photo locations (25%, 50%, and 75% of the reach length). Place yellow flagging tape reference markers using the same techniques as the transects at the 25% and 75% reach length locations. Record specific instructions on the Site Background form for where the photos are taken (ie. 7.5 m upstream of the first transect marker on the left bank). Refer to the previous standardized photos found printed in the site binder.
    a. The 25% and 75% points are taken from the stream bank, so select the bank that is easiest to access and produces the most unobstructed photo.

6. Measure bankfull width in meters at each transect. Determine riparian zone transect length in meters based on bankfull width at each transect (round to the nearest meter).

7. Determine macroinvertebrate collection approach (muddy bottom or rocky bottom). Use the Muddy Bottom vs. Rocky Bottom decision tree. **There are a limited number of sites where macroinvertebrates will be collected, and laboratory analyzed to the family level. All other sites will use either the EPA Volunteer Monitoring or the Virginia Save Our Streams order level protocol*.

Landowner Expectations

This monitoring requires site access for a minimum of five years, and in some cases, monitoring may occur for seven years (two years prior to the restoration and five years after). It is important to set up communication expectations so that the landowner knows when the monitoring team (including volunteers) will be visiting the site. The Project Partner will be responsible for working with each landowner to ensure they understand the expectations and timelines for monitoring. Project Partners will give each landowner the Community-Based Restoration Landowner Packet document to ensure they understand the requirements.

Figure 4: T. Wagner's Goat Farm. Photo Credit: ALLARM

The landowner must sign a Landowner Expectation Agreement prior to the start of monitoring activities. It is also recommended that the names of the people who will be on site (if known) be shared with the landowner.

Once monitoring is established on site, the monitoring team can take over communications with the landowner to coordinate and schedule monitoring visits. The Project Partner is responsible for sending a reminder to the landowner within a week of the monitoring day to ensure they turn off any electric fences, unlock gates, and relocate any farm animals by the section of stream that will be monitored.

Assessment Teams

It is recommended that each assessment team consists of 4-6 people. Each assessment team may contain CMC staff, NFWF grantee staff, or volunteers. The CMC team provides the quality assurance and monitoring oversight of all data collected. Any additional monitors who participate (grantee staff or volunteers) must complete the following steps to become certified:

1. Attend the program orientation (virtual or in-person).
2. Attend a protocol training (virtual or in-person) - each group of volunteers will be provided all necessary equipment at the training workshop.
3. Attend a monitoring day for in-field training.

Figure 5: Stuart Park Assessment Crew. Photo credit: ALLARM

For sites that are located on a farm, the CMC team will provide a brief Farm 101 training to educate monitors on the best practices for being on site to make sure everyone is respectfully engaging with the site and to ensure safety of everyone participating. Annually, monitors will attend a refresher course to review program materials and any site-specific requirements to make sure they are up to date.

The CMC team will work with the NFWF grantee organization and local partners to recruit and train volunteers as needed.

Community-Based Restoration Monitoring Protocol

Overview

This protocol uses four components to assess restoration site status: visual-physical assessment, physical water quality indicators, biological water quality indicators (benthic macroinvertebrates), and photos. Integrating these data will help the NFWF and CMC teams determine the status of restoration projects and assess whether site follow up or additional maintenance is required.

The visual-physical assessment, physical water quality indicators, and photos will always be assessed together in the Spring (March – May) and/or Fall (September – October) following the monitoring frequency in **Table 1**. At least one survey will be conducted prior to restoration and can occur in the same season as installation. Two surveys are conducted in the Spring and Fall prior to restoration. Post-restoration surveys will start the season after implementation and occur every Spring and Fall for 2 years. After two years, surveys will be conducted once a year in either the spring or fall.

Benthic macroinvertebrate samples will follow the monitoring frequency in **Table 1** and only be collected in the Spring. At least one sample will be collected prior to restoration and can occur in the same season as Spring installations. Post-restoration samples will be collected once during the spring after a practice is installed (for practices installed in the spring the first post-restoration benthic sample will be taken 1 year later) and every other year thereafter.

Table 1: Monitoring frequency overview.

Monitoring Type	**Pre-Restoration** (up to 2 years prior)	**Post-Restoration** (Year 1 and 2 after install)	**Post-Restoration** (Year 3-5 after install)
• Visual-Physical Assessment • Physical Water Quality Indicators • Pictures	Minimum 1 survey before installation (Spring or Fall). Can occur the same season the installation occurs.	Twice annually (Spring and Fall), starting the season after implementation.	Once annually (Spring or Fall depending on when the practice is installed).
Benthic Macroinvertebrates	Minimum 1 sample before installation (Spring). Can occur the same season the installation occurs.	Once (Spring) in Year 1 after installation.	Every other year (Spring) in Years 3 and 5 after installation.

Arrival on Site/Set up

Before arriving on site, review all of your site paperwork to familiarize yourself with the project, the sampling reach, parking, and site logistics. Upon arrival:

1. Check all of the transect reference markers (pink flags) and confirm the latitude and longitude coordinates of each transect location. If a transect has lost its marking, replace the marker at the location of the recorded coordinates.
2. Assess stream crossing and entry points throughout the reach.
3. Assess your photo locations and check the reference markers (yellow flags). Replace any missing photo location markers.
4. Assess the benthic sample collection locations throughout the reach (spring only).

Note! *Take caution to not walk directly across the transect lines during setup.*

Plan out your monitoring approach. Monitors can break up into teams if needed. A typical data collection approach is as follows, but may vary depending on your site and monitoring team:

1. Start at the downstream transect.
2. Collect water temperature and turbidity tube measurements.

Note! *It is important to collect turbidity tube measurements before the sediment is disturbed for the benthic sample or cross section observations.*

3. In spring, if you have enough monitors to split into two teams, start benthic sample collection below the first transect.
4. Collect the downstream transect measurements following the order on the datasheet.
5. Take 2 stream reach photos (downstream and upstream) between the downstream and mid-transect.
6. Collect the mid-transect measurements following the order on the datasheet and the mid-stream reach photo.
7. Take the 2 stream reach photos between the mid- and upstream transect.
8. Collect the upstream transect measurements following the order on the datasheet.

Clean Up/Leaving the Site

As you are leaving the site, double check to make sure you have all of your equipment, water bottles, and any trash you brought with you. Check to make sure all necessary forms are fully completed.

- Clean all equipment (e.g. nets, bucket, and boots), before leaving the site by rinsing them off in the stream.

- Dry your equipment and boots and allow to sit dry for at least 48 hours prior to another sampling event. This drying happens in the sun which can act as an excellent disinfectant.

If you are visiting another site within 72 hours or are visiting a farm, please follow the additional biosecurity protocol.

In-stream Measurements

AIR AND WATER TEMPERATURE

A thermometer measures water temperature, or the amount of heat present in water. Temperature is an important indicator as it affects both the biological and physical characteristics of an ecosystem. When the sun heats shallow freshwater streams and surface waters, warmer water temperatures stimulate growth, reproduction, and decomposition of plants and animals. The warmer the water, the less oxygen in the water to sustain aquatic animals. As trees mature along the stream banks from restoration projects, the increased shade they provide is expected to lower water temperature.

Air and water temperature are recorded in degrees Celsius (°C) using a Hanna Digital Thermometer.

Air temperature will be taken once near the downstream transect.

Water temperature will be taken once at the downstream transect and once at the upstream transect. ***Note!*** *Always take air temperature before water temperature.*

Measure the Air Temperature

1. Locate a place near your first transect that is out of the direct sun.
2. Hold the thermometer by the white plastic cover and wait for the thermometer temperature reading to stabilize.
3. Record your reading in Celsius to the nearest 0.1°C on your datasheet.

Measure the Water Temperature

1. Enter the stream above or below the downstream transect and move to the middle of the stream.
2. Place the tip of your thermometer beneath the surface of the water. Do not submerge the display!
3. Allow the water temperature reading to stabilize.
4. Record your reading in Celsius to the nearest 0.1°C on your datasheet.

Figure 6: Water Temperature reading.

Measure the Replicate

1. Remove the thermometer from the stream, wait 30 seconds, and then reinsert it into the water. Record the second value.
2. The values of the two replicates must be within ± 0.5 °C of each other. If the values are outside of the range, measure additional replicates until two values are within the range.

EXAMPLE

Replicate #1	Replicate #2
13.1 °C	13.3 °C

WATER CLARITY

Water clarity, or transparency, is a measure of how much light passes through water – a function of light that is scattered by particles and absorbed by dissolved substances. These particles reduce the depth that sunlight can penetrate a stream and affect the growth of aquatic plants. Very high concentrations of fine sediment can also detrimental to fish and macroinvertebrates. Water clarity is measured using a turbidity tube and recorded in centimeters (cm).

You will only take a water clarity measurement at the **downstream transect**. Collect the turbidity tube measurements before starting the benthic sample collection process.

Rinse the Equipment

1. Move to the center of the waterway just below the downstream transect.
2. Rinse the transparency tube 3 times with stream water: face upstream, hold the tube horizontally in the middle of the stream, mid-depth, and allow the tube to fill and rinse all sides.
3. Empty the rinse water downstream.

Measure Water Clarity

1. Close the drain tube by squeezing the crimp.
2. Hold the tube horizontally in the middle of the stream, mid-depth, and allow the tube to fill with water.
3. Once the tube is full, lift out of the water, and carefully exit the waterway.
4. Stand with your back to the sun so that the tube is shaded and remove sunglasses if you are wearing them.
5. Look straight down through the opening of the tube. If the secchi disk is visible (you can see two white and two black triangles), record the water level as > 60 cm on your datasheet.
6. If you cannot see the secchi disk, partially open the drain clamp to drain the sample slowly. When the secchi disk faintly appears, immediately close the clamp.
7. Read the scale on the side of the tube and record the water level on your datasheet in cm.

Measure the Replicate

1. Swirl the transparency tube to resuspend any settled sediment and then pour the water out of the transparency tube. Repeat the above section "Measure Water Clarity" for replicate #2.
2. The values of the two replicates must be within ± 10 cm of each other. If the values are outside of the range, measure additional replicates until two values are within the range.

EXAMPLE

Replicate #1	Replicate #2
52 cm	56 cm

Clean Up

Empty the water from the transparency tube. Rinse the tube to remove any sediment.

Channel Geometry Measurements

Start your measurements at the downstream transect and work your way upstream as you move through the protocol. Take caution when wading across the stream to not disturb the potential cross section points where you will be observing the substrate. Techniques #2-7 can be carried out together at a transect before moving on to the next transect.

Collectively, changes in bank height, bankfull width, and bank angle can reflect the adjustment of the stream to changes in hydrology, sediment load, and vegetation on the stream banks. Restoration practices that reduce intense storm runoff and reduce sediment load may, over the course of many years, lead to a shallow, wider, and less rapidly migrating stream channel. It is difficult to interpret stream dynamics, watershed impacts, or the influence of restoration from any one of these three metrics by itself.

Grab you gage sticks, measuring tape, protractor, and level to take the following measurements on the left and right banks of the stream along the transect. **Channel geometry measurements can be taken within 4 meters (2 meters each side of transect)** to determine the most representative spot along the bank.

Note! *Carry the gage stick upright to avoid accidentally hitting other monitors.*

BANK HEIGHT

Bank height is the point along the stream bank where a rising stream would expand beyond its channel into the floodplain. The bank height may be different on each side of the stream.

1. Stand the gage stick on the stream bed at the base of the bank so that it stands completely vertical. Be careful not to let the gage stick sink into the streambed, especially in highly silted streams.
    a. If the bank is sloped (Example 1, Figure 7), take a second gage stick and your level, and create a flat extension from the top of the bank until it meets your gage stick.
    b. If the bank is vertical (Example 2, Figure 7) or undercut (Example 3, Figure 7), read the measurement on your gage stick where it touches the top of the bank.
2. Record the measurement on your datasheet in meters.

If the bank is taller than your gage stick, use the measuring tape.

Example 1: Sloped bank **Example 2**: Vertical bank **Example 3**: Undercut bank

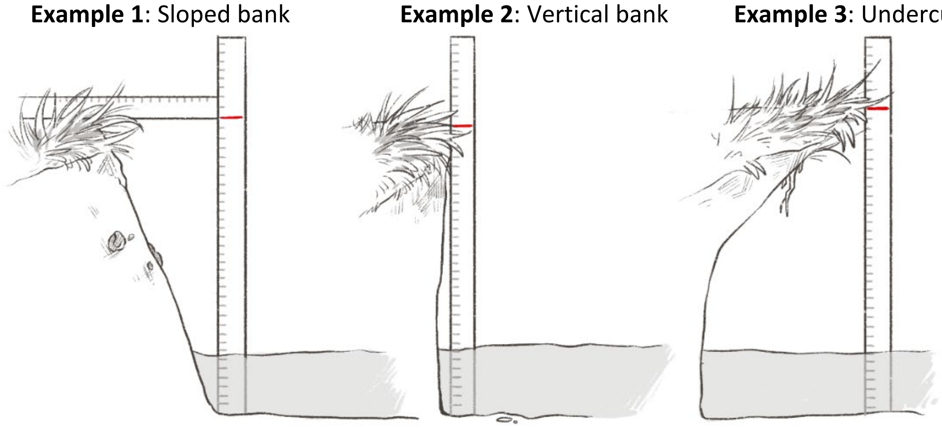


Figure 7: Measuring the bank height using a gage stick. Image credit: ALLARM

BANKFULL WIDTH

Bankfull width is the distance between the two banks from the point at which the channel, if full of water, would spill out over one or both banks. There are many field indicators of bankfull including change in bank slope (top of the stream bank), vegetation changes, and scour features.

1. Based on your bank height measurements, determine whether the left or right bank is shorter.
2. Place the tape measure on top of the **shorter** bank at the same location bank height was measured and stretch it across the stream to the other bank. Make sure the tape measure is level and above the water, it may touch the second bank well below bank height (but should be in the same area as bank height measurement). Consider the following scenarios:
    a. Banks are even (Figure 9): measure from the top of one bank to the top of the other.
    b. One bank is lower than the other (Figure 8 and 10): use the height of the lower bank to match the same spot on the higher bank and measure that distance.
    c. There is a step on one or both banks (Figure 11): measure the width from the top of the true bank, not at the step.
    d. The stream is within a ravine or has no floodplain (Figure 12): look for flood debris, an absence of soil, or vegetation changes to determine bankfull. The bankfull may be just below a line of flood debris, a line where the plant community changes from one kind to another, or a scoured away line where soil was eroded.

    Note! *You can use the previous bankfull widths and cross section diagrams as reference.*

3. Measure your determined bankfull width and record on your datasheet in meters.

Bankfull width will look different for every stream. Below are examples of what to look for depending on the type of stream you are assessing.

Note! *Keep the measuring tape above the water. The current will pull the tape away if it is in the water, making it hard to measure bankfull.*

Examples of bankfull height measurements

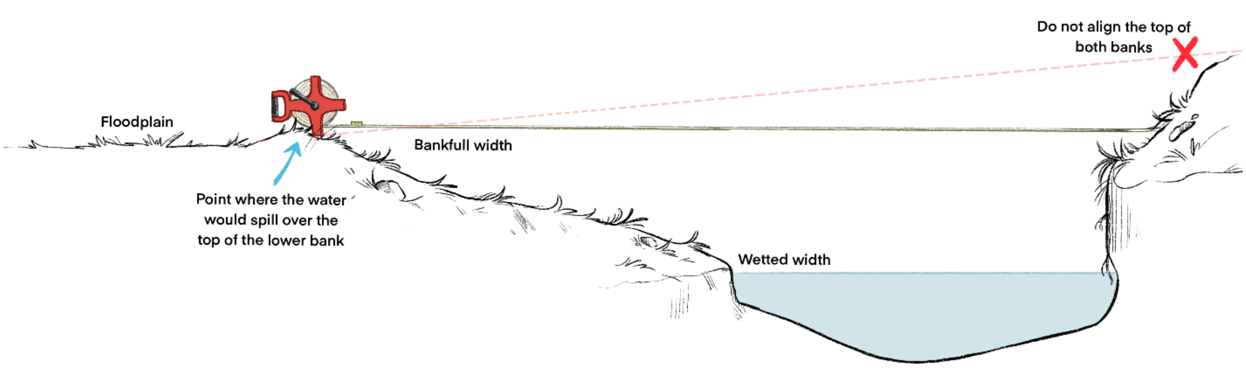


Figure 8: Measure bankfull width using a measuring tape that measures the distance between the two banks. If the banks are different heights, measure across the channel from the bank that is the lowest, keeping the tape measure level with the lower bank height. Look for where the water would spill over into the floodplain and place your measuring tape at that point.

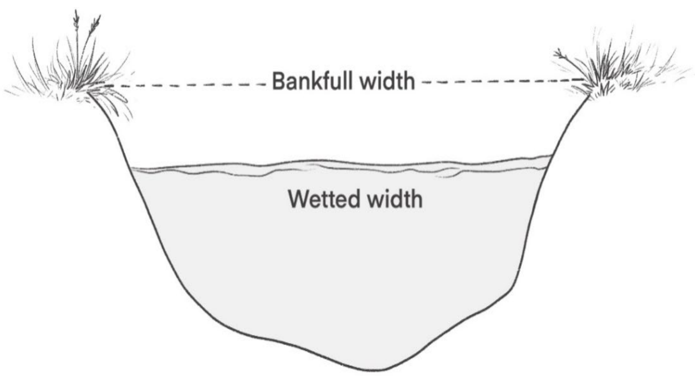


Figure 9: Measuring bankfull from the top of the stream bank on each side. Image credit: ALLARM

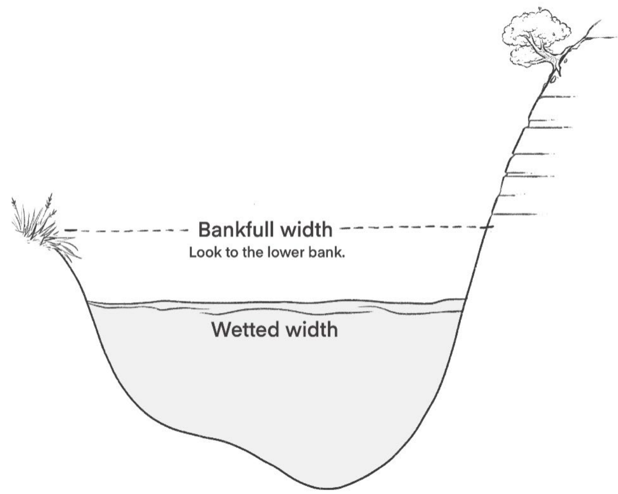


Figure 10. Using the lower bank as the reference for bankfull. Image credit ALLARM

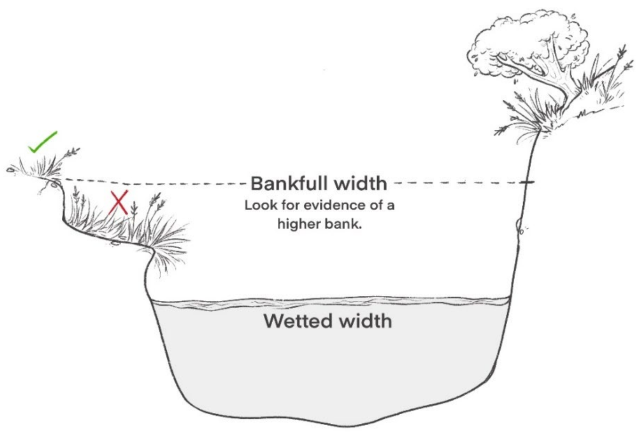


Figure 11: Measuring bankfull at the top of the bank steps/bench. Image credit: ALLARM

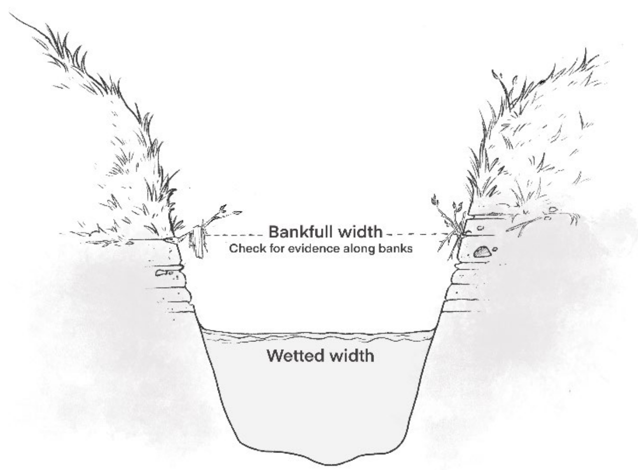


Figure 12: Use depositional and vegetation indicators (absence of soil, flood debris, etc.) to determine bankfull. Occasionally seen in first-order streams. Image credit ALLARM

BANK ANGLE

Finding the bank angle involves measuring the angle of the bank relative to the stream, documenting whether the bank is undercut (less than a 90-degree angle) or set-back (greater than a 90-degree angle). To measure bank angle, look at the entire bank height and assess the bank angle that encompasses the majority of the bank.

1. Move to one bank along the transect. If you have enough monitors, you can have two teams measuring each bank at the same time.
2. Place the gage stick so that it rests on the bank, touching as much of the bank as possible along the entire bank height. Long grasses and plants may need to be pushed to the side to get an accurate bank angle.
    a. For severely undercut banks, place the bottom of the gage stick at the base of the undercut (avoid placing it on the rising back wall) and rest the upper end of the gage stick against the edge of the overhanging bank and measure that angle (see Figure 13 below).
3. Take a second gage stick, with a level attached, and place it level with the top of the bank.
4. Face downstream and align your protractor where the two gage sticks meet. Keep the center point (vertex) on the streamside edge of the gage stick.
5. Read the angle on the streamside of the protractor and record it on your datasheet for each bank

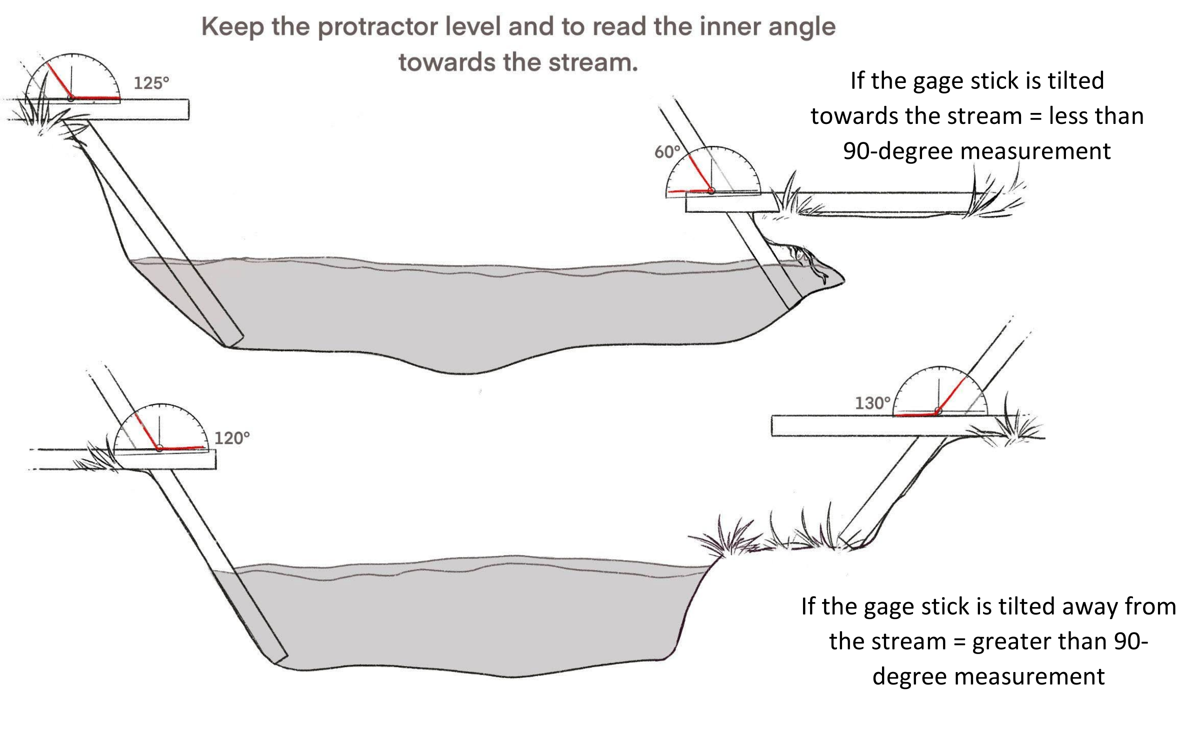


Figure 13: Using a gage stick and protractor to determine bank angle. If the gage stick is tilted towards the stream the angle is less than 90-degrees, if the gage stick is tiled away from the stream the angle is greater than 90-degrees. Image credit: AL

WETTED WIDTH

Wetted width is a measurement of the stream from water's edge to water's edge and is expected to increase during the decades following riparian forest planting. Wetted width is measured using a tape measure in meters.

1. Hold the end of the tape measure to the water's edge on one bank while another individual carefully wades across the stream to the edge of the water at the opposite bank.
    a. If possible, wade across the stream **below** where you will be taking depth and stream viewer measurements so as to not disturb the substrate/sampling area.
2. Record this distance on your datasheet in meters.

Cross-Section Measurements

CROSS-SECTION POINTS

You will measure water level and use the stream viewer at three points along the transect. Using the wetted width measurement, determine the 25%, 50%, and 75% measurement points going from the left bank (looking downstream) to the right bank.

Example: If your wetted width is 3.6m, your 25% point will be 0.9 meters off the left bank, your 50% point will be at 1.8 meters (mid-channel), and your 75% point will be 2.7m off the left bank. The exact locations of your cross-section points may vary over time as the stream widens or narrows.

Place a gage stick at each cross-section point to mark its location, then assess water depth and stream viewer observations at each cross-section point.

Figure 14: Marking the cross-section points.
Image credit: Alliance.

WATER DEPTH

Water depth is expected to decrease during the decades following riparian forest buffers establishment because the channel is also expected to widen. A gage stick is a measuring tool that is calibrated in centimeters. You will be measuring water depth using a gage stick at all three points along the transect, 25%, 50%, and 75% of the wetted width.

1. Use the gage used to mark the 25%, 50%, and 75% point along the transect.
2. With your gage stick resting on top of the streambed, turn the calibrated side of the stick **downstream** and read the stage of the water at all three cross-section points.
3. Record the three values on your datasheet in centimeters.

Note! *It is acceptable to record the water depth as zero if the cross-section measurement point falls on a sediment deposit (e.g. sandbar, island) in the stream.*

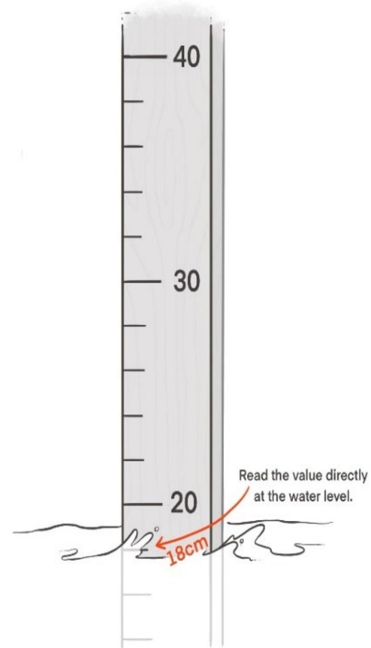


Figure 15: Recording water depth
Image credit: ALLARM.

STREAM VIEWER MEASUREMENTS

Stream viewers enable us to break the water surface and obtain an underwater view of the stream bed. This unique view allows us to evaluate four categories:

- Substrate size and composition
- Periphyton % coverage
- Periphyton thickness
- Embeddedness (percentage of rocks surrounded by fine sediment)

Figure 16: Using stream viewers at 3 cross-section points along the transect.
Photo credit: ALLARM

You will be using the stream viewers at all three cross-section points along the transect at 25%, 50%, and 75% of the wetted width (Figure 16). If your stream is not wide enough to take three cross-section measurements across the transect without the stream viewer areas overlapping, take one measurement along the transect and then move up or downstream to take the second and third measurements. Be sure to note this change on your site diagram on the Datasheet.

Note! *We recommend at least a team of two at each point to work together and crowd-source these measurements.*

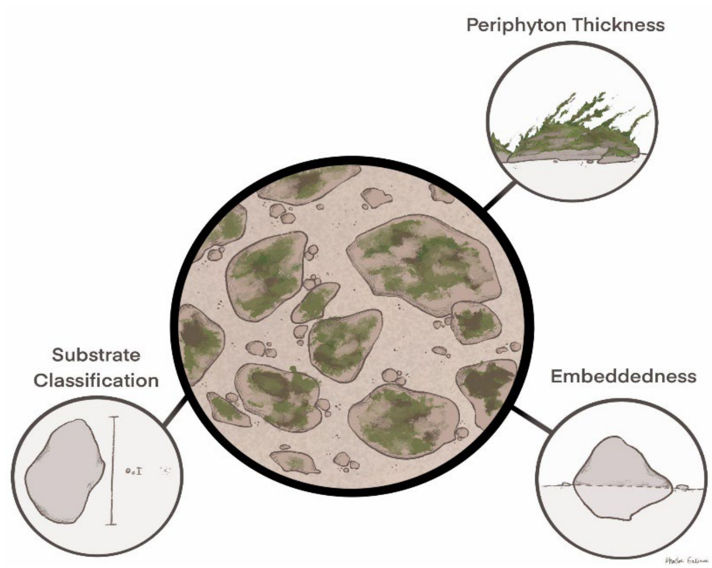


Figure 17: Using the stream viewers to obtain substrate size-type-percentage; embeddedness; and periphyton thickness
Image credit: ALLARM

If you are assessing a stream with a deposit within the transect, you can still measure embeddedness and substrate on that dry ground. ***Note!*** *Do not measure periphyton****.***

Find the Stream Viewer Location

Center the stream viewer over the point where you used the gage stick to record water depth. Look through the stream viewer and note if any obstructions exist (ie. large woody debris, leaf pack, rooted aquatic plants). **Do not** remove any obstructions as that can disturb the matrix of the stream bed. If an obstruction exists follow these steps to determine where to collect your observations.

1. If aquatic plants are present, gently redirect them (don't remove) away from the stream viewer area to get a clear view of the substrate. If you can successfully clear the viewer window, take all measurements as directed.
2. If there is an obstruction that cannot be redirected, look to move the stream viewer to an adjacent undisturbed area (typically upstream or sideways direction) as close to the original location as possible that is not obstructed. Take all measurements as directed and note on the field datasheet that the stream viewer was moved.
3. If you cannot find an area in close proximity to the original location that is unobstructed, find a location that is least obstructed. Take all measurements as directed and note % of obstructed view on the datasheet and account for the portion obstructed in the total percentage for substrate classification (e.g., 50% obstructed, 10% gravel, 30% silt, 20% sand).
4. If you cannot find an area with an unobstructed view (for example, if the entire left side of the stream is covered with macrophytes) record "not possible to measure due to obstruction".
5. If the water is too cloudy or dark to see the substrate with and without the stream viewer, you will need to feel around the bottom of the streambed with your hands and feet estimate substrate measurements. Please add a note in the field datasheet under the Comments and Concerns section, if you are unable to see the bottom of the stream.

Take Photos Through the Stream Viewers

Take at least 1 photo of the stream viewer view across each transect, you may take more photos if there are questions or unusual attributes. Take the photo **before** taking any measurement to ensure clean views before streambed disturbance.

1. Rest the camera on the top edge of the stream viewer so the lens is centered in the middle of the window and the entire streambed is visible through the camera.
2. Make sure the camera is focused on the view of the streambed. Let the view fill most of the screen. It can be helpful to cover the stream viewer with a jacket or paper to reduce glare.
3. Name the photo using the appropriate naming convention listed below

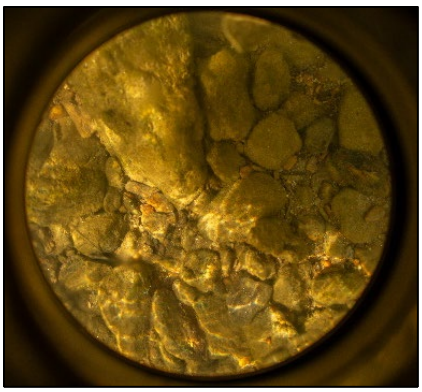


Figure 18: Example of a good stream viewer photo.
Photo credit: Alliance

Figure 19: Example of a bad stream viewer photo.
Photo credit: Alliance

Nomenclature for Stream Viewer Photos:

- Stream Viewer: SV
- Transect Location: Up(upstream transect)/Mid(midstream transect)/Down(downstream transect)
- Cross-Section Marker: 25/50/75 across wetted width
- **Example: SVDown25**

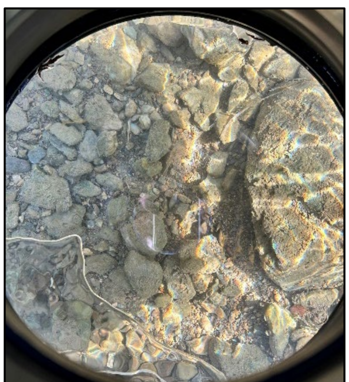
Evaluate Substrate Material

After taking the photo, assess the substrate size and classifications using the guidelines in **Table 3**.

Table 3: Size metric to evaluate substrate sizes within the stream viewer

Boulder	Cobble	Gravel	Sand	Silt/Mud
>25 cm (>Basketball)	5 – 24 cm (basketball to golf ball)	0.5 – 4 cm (golf ball to sesame seed)	<0.5 cm (gritty)	<0.5cm (Slimy)

1. Looking through the stream viewer window, estimate the percentage of different substrates sizes using the size metric in **Table 3**. Start with the largest size and work your way down to the smallest size. All of the percentages added together must equal 100% (see Figure 20 for examples).
2. To assess sand versus silt/mud you will need to pick up the fine sediment and rub between two fingers. Sand will feel gritty and silt/mud will feel slimy/slippery.
3. If any of the view is obstructed by aquatic vegetation or logs, include the percent obstructed under "Other" on your datasheet. Refer to page 19 for more information.
4. It is helpful to have a second person review the estimates and average the two assessments.



Cobble = 30%
Gravel = 50%
Sand = 10%

Gravel = 40%
Sand = 50%
Silt/Mud = 10%

Gravel = 5%
Sand = 50%
Silt/Mud = 15%
Other (SAV) = 30%

Figure 20: Examples of evaluated percent substrate classifications. Photo credit: ALLARM and Alliance

Evaluate Periphyton Percent Coverage

There could be diverse forms of vegetated growth along the transect. Periphyton is the mixture of algae and other organisms **growing on the surface of rocks** (not to be confused with rooted aquatic plants or lichen). Periphyton are a source of food for many stream organisms and are a critical component of stream ecosystems.

1. Looking through the stream viewer window, estimate the percent coverage of only the periphyton growing on the substrate.
2. You may need to pick up a rock to look at and feel the type of growth present. Periphyton will feel soft, furry or even gelatinous. Lichen on the other hand will feel hard and crusty.

Figure 21: Example of 25% periphyton coverage (the green growth on the rocks).

Evaluate Periphyton Thickness

Evaluate the thickness of only the periphyton at each stream viewer location. Thick growth of periphyton can occur where sunlight is intense, phosphorus concentration is high, and grazers are scarce; it's anticipated that riparian tree cover and phosphorus control may reduce very thick growth of periphyton. If there is no periphyton present, record "bare". If periphyton is present, compare the periphyton thickness on the surface of the rock to the width of your finger.

1. Pick up a rock that contains periphyton growth.
2. While holding the rock underwater (if you bring the rock out of the water the periphyton will flatten) assess the periphyton thickness (vertical growth) using your finger as a guide.
3. Wiggle your finger in between the growth and assess whether the periphyton growth is thicker or thinner than the width of your finger.
    a. If the periphyton is all thinner than your finger width, record the thickness as <2 cm, if **any** of the periphyton strands are thicker than your finger width, record the thickness as >2 cm.

Evaluate Embeddedness

Embeddedness measures the extent to which rocks (gravel, cobble, and boulders) are surrounded by, covered, or sunken into the silt, sand, or mud of the stream bed. High embeddedness reduces habitat for macroinvertebrates and restricts the healthy shallow subsurface stream flow through the stream bed. Streams with high fine sediment loads are expected to have higher embeddedness, thus restoration practices that reduce sediment load may reduce embeddedness over a period of many years.

Note! *Embeddedness can only be evaluated if the dominant substrate type is gravel (0.5-4cm) or larger.*

1. Swish the water above the substrate to remove newly settled fines. Take note of how much of the larger substrate you can see above the fine sediment.

a. If you swish the water above the substrate to remove settled fines and it doesn't reveal rocks below, do not measure embeddedness and record "all fine substrate; no rock".

2. Pick up an average sized rock – look for the clean/transition/oxidation line ("Clean Line" in Figure 22) that provides evidence that the rock was embedded. The portion of rock buried in fine substrate will typically have minimal to no growth on it (diatoms, periphyton). As a result, it can appear to have a different color.
3. Estimate the percentage of the rock that was buried in fine substrate by looking at the "cleaner" portion of the rock.

Figure 22: A clean line on a rock pulled from the stream bed, indicating it is 75% embedded. Photo credit: Alliance

CANOPY COVER

Canopy cover is a critical measurement of how well riparian forest regrowth following buffer plantings can reduce light intensity to the stream bed. Measure the canopy cover **only** if the trees have leafed out.

1. From the 50% cross-section point of each transect, look up and assess the percent of canopy covering the stream.
2. If there are no trees in sight, record 0% canopy cover.
3. If it is completely covered, record 100% canopy cover.
4. If canopy cover has NOT leafed out record N/A.

Figure 23: Example of a stream with an 80% canopy cover.

Assess Biological Habitat

Healthy streams contain a variety of structure and different types of habitat for macroinvertebrates, fish, amphibians, and other riparian animals. Check all of the biological habitats that are present along the transect line. Evaluate the biological habitat within a 4-meter corridor along the length of the transect (total of 4 meters, 2 meters on each side of transect).

Assess the following:

Logs/Large Woody debris

Fallen trees or parts of trees that are thicker than an arm.

Small Woody debris

Small twigs and sticks that have fallen off of bushes or trees.

Leaf Packs

Clumps of dead leaves frequently caught between stones, sticks, and roots along the banks.

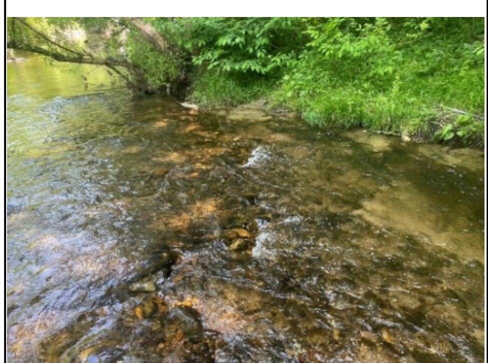
Cobble

Rocks that are tennis ball sized to basketball sized.

Boulders

Rocks that are basketball sized and larger.

Riffles



Area characterized by broken water surface, moderate or swift current, and relatively shallow depth (usually less than 18 inches).

Tree Root Wad

Dense mats of roots at or beneath the water.

Overhanging Vegetation

Trees, shrubs, etc. that hang over the stream surface providing shade and cover. Does not include grass or vines.

Aquatic Vegetation

Beds or patches of rooted aquatic plants (not algae or periphyton; should be rooted in the streambed).

Undercut Banks with Roots

Banks that have eroded so that roots of surrounding shrubs and trees emerge from the bottom of the overhanging bank.

Bank Slumps

Parts of the streambank can side down a slope towards the wetted width.

Bank Cracks

Bank cracks are visible breaks in the streambank.

Assess Riparian Areas

A healthy stream is dependent on a naturally vegetated, hydrologically and ecologically connected riparian zone. Riparian restoration practices are intended to re-establish these connections. Each transect will extend two bankfull widths from the bank height into the riparian area to assess riparian health. Evaluate riparian health within a 4-meter transect corridor (2 meters on each side of the transect along the full transect length).

1. Review bankfull width at each transect reach and multiply it by two to determine the riparian transect length. Your riparian transect must be a minimum of 10m and a maximum of 30m. Example:
    a. Bankfull width of 11m = Riparian transect length of 22m
    b. Bankfull width of 3m = Riparian transect length of 6m, but we have a 10m minimum so the transect will be 10m.
2. Record the transect length on your datasheet in meters for each bank.
3. Take your tape measure and measure the riparian transect from the left and right bank (start from where you measured bank height/bankfull width) onto the adjacent land to the calculated length.
4. Measure two meters on each side of the transect line to create a riparian corridor four meters wide. You can use pieces of equipment to temporarily mark the edges of the corridor if needed.
5. Count the number of trees within the corridor. Tree counts will distinguish between pre-existing/established trees and trees planted with the restoration project. Each time this assessment occurs you will:
    a. Count the number of pre-existing/established trees (trees that were present prior to restoration).
        i. Count just the total number of trees (with a single trunk) that are taller than your gage stick.
        ii. Do not count shrubs (multi-trunk) or other vegetation.
    b. Evaluate the Planted Buffer (trees or shrubs that are planted as part of the restoration project that have a stake, tree tube or other evidence of being planted). ***Note!*** *This is only done during the post-restoration sampling events.*
        i. Count the number of trees with less than 5 cm in diameter at breast height (your gage sticks have been made to this height).
        ii. Count the number of trees with greater than 5 cm in diameter at breast height.
        iii. Count the number of dead (empty tree tubes) or fallen trees.
6. Draw a sketch of the riparian area on the site diagram.
7. Make note of and photograph any concerns and whether maintenance is required. Concerns could include invasive species present (note if you can ID any), tree tubes removed or down, dead trees, etc.

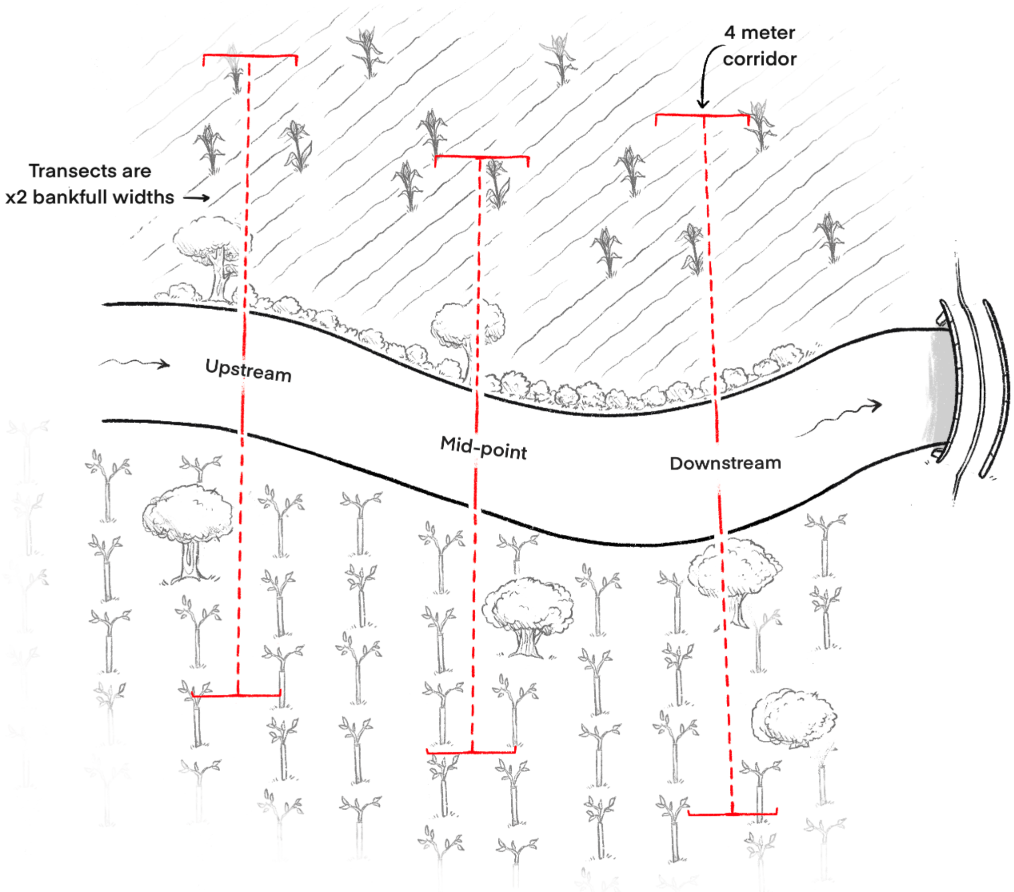


Figure 24: Evaluated riparian health on either side of the stream. Image credit: ALLARM

Standardized Stream Reach Photos

Standardized photos are crucial to contextualizing the additional information and data gathered at the restoration site and may help capture change over time. Monitors will take photos each time they conduct a visual-physical assessment. In total, monitors will take 12 standardized photos along the stream reach. Six photos will include a white board description of the type of photo and upstream/downstream indicators and six photos will be the photo used to document the site conditions.

Nomenclature for Stream Reach Photos:

- (25/50/75) Reach length information
- Orientation with streamflow - are you looking downstream (Down) or upstream (Up)? Always take the downstream looking photo first, then the upstream looking photo.
- Photo number (1-6)
- **Example:** 25Down1 for the 25% reach point, facing downstream, and photo 1

Additionally, record on the white board where the left or right bank (L/R) are located and the monitoring date. If you are not using the white board, you can annotate the photos on your phone using the appropriate nomenclature.

Finding the Locations for the Standardized Stream Reach Photos

Review and find the reference markers (yellow flags) for the 25%, 50% and 75% reach length points working downstream to upstream. If needed (ie. the marker is missing), use your tape measure to find the photo location from the instructions on the Site Background sheet. Mark where the photos are taken on your site diagram.

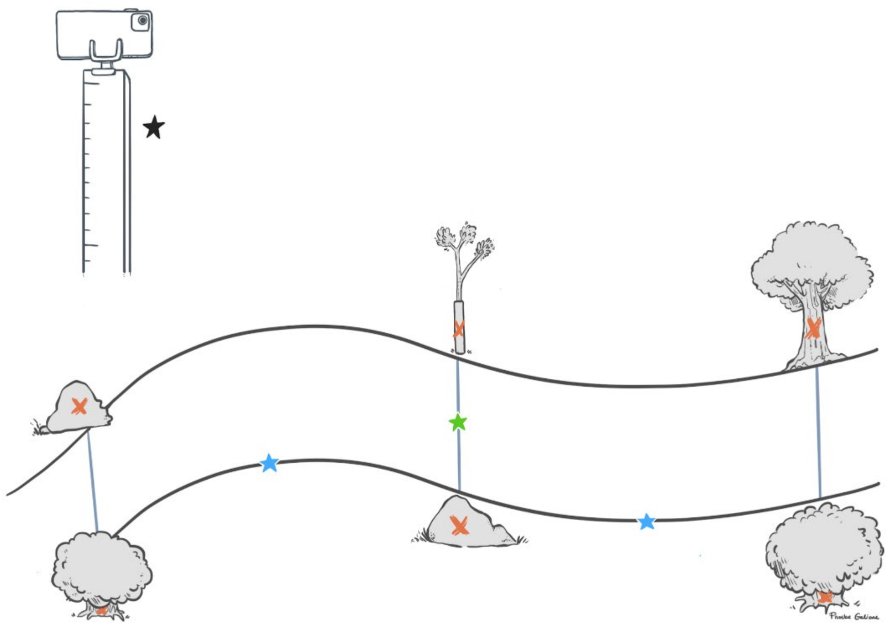


Figure 25: Standardized photo should be taken on top of the gage stick. Image Credit: ALLARM

25% Standardized Photo Point

Start at the 25% point, which should be located between the downstream transect and the mid transect.

1. Locate the 25% point along the bank and, look downstream.
2. Place the gage stick phone holder on the marker. Use the widest angle possible on your camera or device. Position yourself so that the transect markers are in the center of the photo's field of view. Frame the photo using the downstream transect markers and align the bank along the edge of the photo.
3. Fill out your whiteboard, with the photo ID (25Down1), label the left and right banks, and the date.
4. Place the whiteboard in the photo, close enough to the camera so you can read the writing, and take the first photo.
5. Remove the whiteboard but do not move the camera or gage stick. Take another, unobstructed photo of the same view. ***Note!*** *Only take one photo to reduce the confusion. If you take multiple photos, delete the unnecessary ones immediately.*
6. Turn to face upstream and repeat the above process, naming the photo 25Up2 on the whiteboard, or on the photo on your phone, and updating the bank labels.

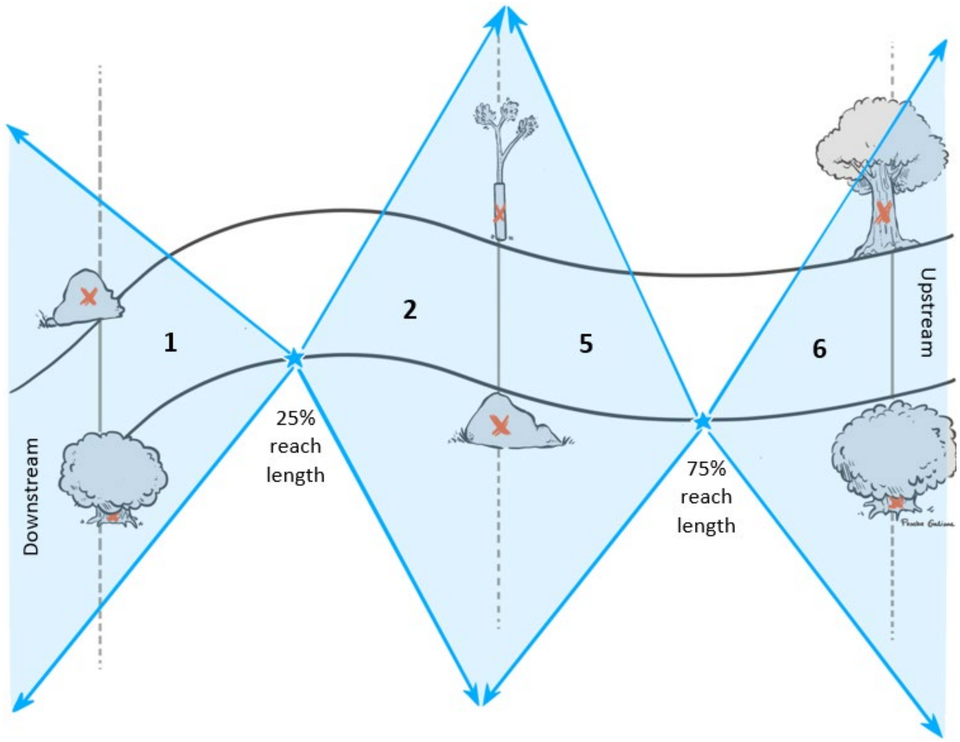


Figure 26: Identify the 25% and 75% points and take 4 photos from the bank. Image Credit ALLARM

50% Standardized Photo Point

The 50% photo point should be located along the mid transect. Since this is in the same location as the cross-section measurements, this photo should be done **after** the cross-section measurements are completed.

1. Step to the midpoint of the stream along the transect line and look downstream.
2. On your whiteboard, label the photo ID (50Down3) and update the bank labels.
3. Use the gage stick phone holder and frame the photo using the downstream transect markers.
4. Take a whiteboard and unobstructed photo following the same procedure as above.
5. Turn to face upstream and frame the photo using the upstream transect markers.
6. Take your final two photos, writing 50Up4 on the whiteboard or on the photo on your phone,

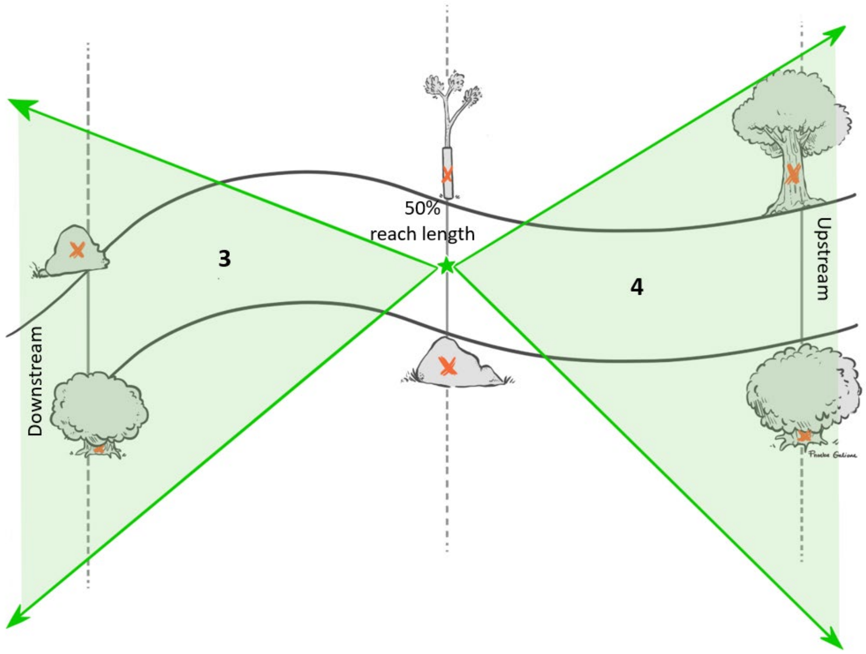


Figure 27: Take two photos from the middle transect looking upstream and downstream. Image Credit: ALLARM

75% Standardized Photo Point

The 75% photo point should be located between the mid transect and the upstream transect. Take the photo from the bank and be sure to indicate from which bank this photo was taken on your site diagram. See figure 7 for photo reference points.

1. Move to the 75% point along the bank (use a tape measure if needed), look downstream.
2. On your whiteboard, label the photo ID (75Down5) and update the bank labels.
3. Using the gage stick phone holder and frame the photo using the mid transect markers.
4. Take a whiteboard and unobstructed photo following the same procedure as above.
5. Turn to face upstream and frame the photo using the upstream transect markers.
6. Take your final two photos, writing 75Up6 on the whiteboard or on the photo on your phone,

Total Photo Coverage

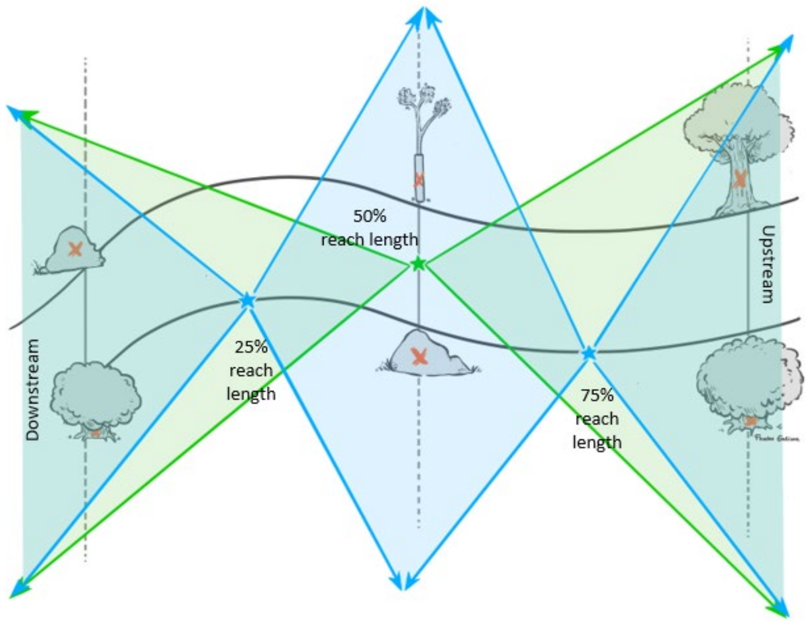


Figure 28: Capture 6 photos from the prescribed angles. Image Credit: ALLARM

In total you will take twelve standardized site pictures, 6 with a labeled whiteboard and 6 corresponding unobstructed photos (Table 2).

Table 2: Summary of site photos taken throughout the stream assessment reach.

Photo Number	Nomenclature	Description of Photo
	25Down1_WB	whiteboard photo from 25% looking downstream
1	25Down1	unobstructed photo from 25% looking downstream
	25Up2_WB	whiteboard photo from 25% looking upstream
2	25Up2	unobstructed photo from 25% looking upstream
	50Down3_WB	whiteboard photo from 50% looking downstream
3	50Down3	unobstructed photo from 50% looking downstream
	50Up4_WB	whiteboard photo from 50% looking upstream
4	50Up4	unobstructed photo from 50% looking upstream
	75Down5_WB	whiteboard photo from 75% looking downstream
5	75 Down5	unobstructed photo from 75% looking downstream
	75Up6_WB	whiteboard photo from 75% looking upstream
6	75Up6	unobstructed photo from 75% looking upstream

General Characteristics of the Reach

All of these observations will summarize the entire length of the assessment reach (30, 60 or 90m) for your site. It is helpful to assess these characteristics with the entire monitoring team and "crowd-source" your responses from the team. For example, the team may walk back downstream after finishing Transect #3, to review the characteristics along the entire reach. These observations provide a broader context to help scientists interpret the data you provide throughout the rest of this survey.

REACH CATEGORIZATION

1. Estimate the surface area covered in riffles, pools, and runs across the reach. The total percentage should add up to 100.
2. While estimating the percent riffle coverage, also count the number of separate riffles and add that number to the datasheet.

AQUATIC VEGETATION CLASSIFICATION

1. Assess water color. If it is difficult to determine color by looking into the water, fill your turbidity tube and view the water color through the side. Examples include clear, brown, pea green, hint of green, milky, and chalky.
2. Estimate the percentage of aquatic vegetation along the stream reach or the percentage of the area within the stream channel that looks "green".
    a. Aquatic vegetation Includes: aquatic plants, macrophytes, filamentous algae (thin green or brown clumps of algae longer than your finger), and periphyton.

BANK CONDITION

For each of the listed categories estimate the percent of both left and right bank that the bank condition covers. Only assess the actual bank (where the bank angle was measured) and not into the floodplain or riparian zone. If there are trees along the bank and grasses behind those trees, you would label it as trees not grass.

1. Grasses/herbaceous plants
2. Trees/Shrubs
3. Soil
4. Bedrock
5. Fortified bank with artificial materials - Concrete/rip-rap/Lumbar
    a. Concrete: Smooth solid panels/blocks, or entire walls.
    b. Rip-rap: Large jagged rocks/boulders that are not naturally occurring. Often rip rap along the stream is construction leftovers.
    c. Lumber: big framed timbers to fortify a bank and held in place with rebar.
6. Bank impacts (animal/human/vehicle tracks).

Figure 29: Example of a fortified bank with rip-rap.

FLOODPLAIN INUNDATION

1. Look for evidence of floodplain inundation above bankfull. This may include:
    a. Water rings or stains around trees.
    b. Flattened vegetation.
    c. Lines of leaves, twigs, or trash carried and deposited by flooding.

Figure 30: Water Ring as a sign of floodplain inundation.

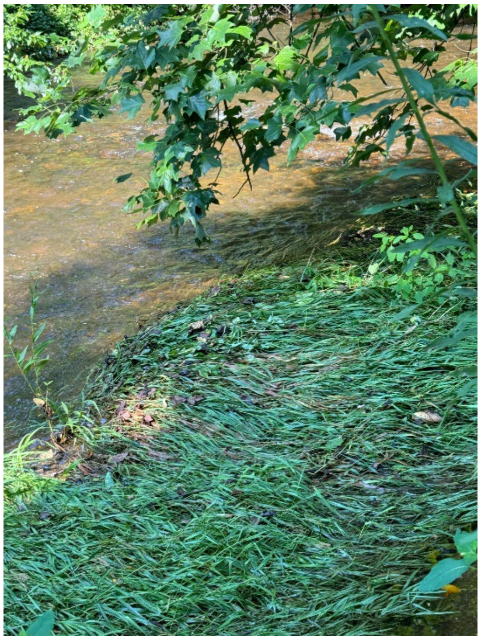


Figure 31: Flattened vegetation as a sign of floodplain inundation.

Figure 32: Debris caught on understory vegetation indicative of the depth of the floodplain inundation.

2. Record whether evidence exists on both the right bank and the left bank, circling yes or no.

IMPACTS OF ANIMALS

1. Observe the assessment area and identify where, if any, animals are present and answer the following questions on your datasheet.

a. Are they fenced out of the stream?

b. Is the fence keeping animals out of the stream?

Benthic Macroinvertebrate Sample Collection

Benthic Macroinvertebrates are a key indicator of stream health and an important metric to track the ecological uplift from restoration practices. This protocol was modified from the Chesapeake Bay Program Macroinvertebrate Sample Collection Protocol, developed to fill in gaps in the Chesapeake Index of Biotic Integrity (IBI). The sampling process requires the collection and retention of the macroinvertebrates in the sample. The entire sample (not picked) will be preserved for later processing in a lab. Importantly, these samples will be evaluated down to the family level taxonomy (at a minimum).

During this process you are going to collect twelve sub-samples that will be combined to yield one sample. The twelve sub-samples should be collected by completing six double-wide kicks within the assessment reach (30 m, 60 m, or 90 m) of the selected stream within the installation area of the BMP. If there are not enough riffles within the assessment reach, the sampling reach can be extended to up to 100m total. ***Note!*** *The six sub-samples should not be collected along the transect lines.*

Monitors should use the Rocky Bottom method if possible, within the assessment reach at the site. Should the site not be viable for Rocky Bottom sampling, Muddy Bottom sampling can be done in its place. If the Muddy Bottom protocol is selected it will be used for all samples collected.

Check your paperwork to confirm which method you will be using on site. Then follow either the Rocky Bottom or Muddy Bottom method below.

If you have enough volunteer monitors, you can have two teams of people, one collecting the visual-physical data, while the other team collects the benthic sample. If this occurs, be sure to collect your turbidity tube measurements before the sediment is disturbed for the benthic sample.

ROCKY BOTTOM METHOD

Assess the Valuable Habitat

You will first need to assess the viable habitat (riffles) to collect the sample from across the stream reach (30 m, 60 m, or 90 m). If you do not have enough riffles within the stream assessment reach, you can extend the reach upstream up to 100 m total. Use the following considerations to find your six sub-sampling locations with a Rocky Bottom reach:

- Make sure there are at least six viable locations (you will complete two kicks at each location for a total of 12 kicks) within at least two different riffles along the 100m reach where you will be able to rub cobbles with your hands and disturb the substrate beneath the cobbles (i.e. does not have bedrock).
- Look for a variety of riffle-run habitats including different velocities and stone sizes as these microhabitats are important to different species. Kicks on the 100m reach should be distributed and representative of the riffle-run habitat (slow flowing shallow riffles and fast-flowing deeper riffles).
- Look for locations throughout the width of the stream to include left middle and right areas.
- If there are not six viable locations for sub-sampling within a riffle, Muddy Bottom monitoring may be done in its place. Follow the protocol for Muddy Bottom Sampling at the end of this document (Appendix A) in lieu of following sections below.

Collect your First Sub-Sample

Start at the downstream end of your reach and work upstream sub-sampling the riffle-run habitat when collecting your sample. Check your net and bucket to make sure there are no holes or tears in the mesh.

1. The collection process used is referred to as a "kick". A kick is done to disturb the sample area 2–4 inches down into the substrate. The sample area for a single kick is one width of the net and two net widths upstream. Properly place the D-net—one partner should rest the D-net along the bottom of the stream facing upstream while the other stands directly in front of the net. Ensure that there are no gaps underneath the net where the sample could be lost.
2. When everyone is set, start the timer for 60 seconds and start the kick process. One kick is done for 60 seconds total.
    a. For the first **40 seconds**, use your hands to pick up and rub rocks in the sampling area (white section in Figure 31) to dislodge macros clinging to them. The timer will indicate when 40 seconds is up.
    b. For the last **20 seconds**, gently disturb the substrate in front of the net down 2-4 inches using a flat stone or handheld shovel/rake, trying to get the water to run a muddy brown. DO NOT use your feet, since people often grind down, instead of kick up—a flat rock is easier to use correctly. The targeted area should be the width of the net across, and two net widths upstream.

Figure 33: For a double-wide kick, after a location is monitored, place the net directly adjacent to the location and begin again.

3. Once the 60 seconds are over, <u>move the net directly beside where you just sampled and repeat the process</u> (Blue area in Figure 33). These two samples combined constitute the "double-wide" kick.
4. Carefully lift the D-net out of the water, ensuring that the opening in the net is facing upwards.
5. To complete a double wide kick, repeat this process directly adjacent to the first spot.

Emptying the Net into the Bucket

Empty the contents of the net into the bucket after every double-wide kick. If there isn't a lot of debris in the sample, you may be able to empty the contents after two or three kicks.

1. Sit the bucket into the stream so that it is half full of water. You can use a pool in between the riffles, just be sure to go to a pool downstream if you have not finished your kicks within the current riffle.
2. Carefully dump the contents of the net into the sieve bucket.
3. Turn the net inside out and rinse any missed part of the collection into the bucket.
4. With a squirt bottle filled with stream water, rinse net into the sieve bucket to get any last clinging part of the sample.
5. Double check the net to make sure you didn't miss any organisms, hand pick or rinse any additional organisms into the bucket.

Once the net is cleaned, **repeat this process five more times** moving upstream with each kick to get 6 double-wide kicks (12 total kicks). Remember, these kicks should be done in at least two different riffles within your reach and should cover the left, middle, and right of the stream, as well as slow and fast moving riffles. Keep your bucket with you and continue to empty the contents of the net into the bucket as you move along.

Final Rinse and Bucket Check

1. Once all of your kicks have been completed, do a final rinse of your net into the bucket and check the sample bucket for large debris and species that should not be included in the sample.
2. All large stones, debris, leaves etc., should be carefully washed, inspected for organisms and discarded. Try to put as little material as possible into the sample bucket.
    a. **Remove:** fish, mussels, salamanders, turtles, large sticks, stones over 3 cm, and any trash.
    b. **Keep:** Crayfish, all leaf litter, and small sticks and pebbles.
3. Once you have your final sample, gently wash the sides of the sieve bucket with stream water to get everything to the bottom of the bucket.
4. Dump the remaining water out of your spray/squirt bottles, take all your equipment and your bucket and move out of the stream.

Transfer Your Sample

1. Move to an easily accessible place, such as the shore of the stream or to a parking lot area, in order to transfer your sampling to the sample jar.
2. Before any organisms are placed into the collection container, fill out and insert the waterproof label into the collection container to avoid harming the sample later on. **Using a pencil,** fill out the label provided to you with your sampling kits (should be a small piece of rite-in-the-rain paper) with the following information.

Station ID MOURUN1	Date (m/d/yyyy) 9/26/2021
Latitude (decimal degrees) 37.874	Longitude (decimal degrees) -79.379
Certified Monitor(s) Sophie Stern and Liz Chudoba	

Example Label: Everything on the label should match your data sheet exactly. The Station ID is provided by your CMC service provider.

3. Using a sharpie, write the same information on the lid of the sample jar.
4. Fill your squirt bottle with stream water.
5. Dump the contents of the bucket into the white bin provided with your sampling kit. Use the bottle of water to rinse the contents of the bag or bucket into the bin - this can be done several times until the bag or bucket are totally clean.
6. The bin, now a mix of water and the sample, can be tipped and run through the 500 micron sieve. It is easier if the sieve is held at an angle so the sample is collected in a corner that can easily be transferred into the sample jar.
7. Water can be run back and forth between the bin and sieve several times to get all remaining contents available for the sample jar.
8. Dump the water out of the squirt bottle and fill with ethanol.
9. Carefully transfer the sample from the sieve to the sample jar. Use the ethanol squirt bottle to wash all contents from the sieve into the sample jar.
10. Check to make sure the label is still in the container, then add more ethanol until you have double the volume of the solids alone.
11. Close the lid well. If needed for transport, secure the jar with duct tape and place in a plastic bag.

Fill Out the Datasheet

Fill out the front and back of your datasheet before you leave your location. On the front, fill out all of the information about your sampling day. On the back, include a stream diagram. Be sure to label the riffles, each kick location, and the length of stream reached.

Clean Up

Gather all of your supplies and equipment. Clean all equipment—nets, bucket, boots, etc.— by washing them off in the stream. If you're not going to another stream that day, your equipment and boots just need to be dry for 48+ hours prior to another sampling event. This drying happens in the sun which can act as an excellent disinfectant. If you're going to another stream that same day, you must decontaminate your equipment before leaving the site using either a 10% bleach solution (nine parts water to one part bleach in a spray bottle) or Alconox (a biodegradable soap product dissolved in water in a spray bottle). Spray down boots, nets, and all other gear at least 50 feet away from the stream, and scrub with a bristled scrub brush. Dry gear with a towel before entering the next stream site.

Storage and Return

Store samples in a cool dry place away from direct sunlight or flammable materials. Bring your sample(s) and all equipment to your CMC Service Provider.

MUDDY BOTTOM METHOD

Should the site not be viable for Rocky Bottom sampling, Muddy Bottom sampling can be done in its place. Sampling is conducted from downstream to upstream by jabbing the D-frame net into productive and stable habitats 20 times.

Assess Viable Habitat

Different types of habitat should be sampled in rough proportion to their frequency within the reach. Unique habitat types (i.e., those consisting of less than 5 percent of stable habitat within the sampling reach) should not be sampled.
Use the following considerations to identify proportional representation of habitat types.

1. Stream-bottom:
    - *Riffles* have relatively fast velocity, shallow steam depth, steep surface gradient, and a straight to convex channel profile. Riffles are usually topographic high areas produced by the accumulation of coarse materials. A reminder - if there are enough riffles to perform six subsamples, the Rocky Bottom protocol should be used.
    - *Non-riffle* encompasses all other forms (i.e., pools, runs, and slack areas) and generally contain intermediate to fine particle substrate.
    - *Submerged aquatic vegetation* serves as habitat for macroinvertebrates and may constitute large areas of the available substrate.
2. Stream-edge:
    - *Overhanging vegetation* includes terrestrial shore-zone plant material that is living, submerged, and provides in-stream cover for aquatic organisms.
    - *Submerged tree roots* include living root material from shoreline or overhanging vegetation that is submerged and provides in-stream cover for aquatic organisms.
    - *Woody debris* includes other woody material beyond living tree roots (such as logs, branches, and snags).

Collect Your Sub-Sample

Proportionally allocate sampling effort (20 total jabs/sweeps/kicks) to the different habitat types. A single jab consists of thrusting the net into a productive habitat for a distance of 1m, followed by 2-3 sweeps of the same area to collect dislodged organisms for 20 seconds. The collected sample is washed by running clean stream water through the net 2-3 times.

Empty the Net into the Bucket

Samples should be cleaned and transferred to the sieve bucket at least every five jabs/kicks, more often if necessary. Do not let the net become so clogged with debris that it results in the diversion of water around the net rather than through the net. If clogging occurs, discard the sample that is in the net and redo that portion of the sample in a different location.

1. Sit the bucket into the stream so that it is half full of water. You can use a pool in between the riffles, just be sure to go to a pool downstream if you have not finished your kicks within the current riffle.
2. Carefully dump the contents of the net into the sieve bucket.
3. Turn the net inside out and rinse any missed part of the collection into the bucket.
4. With a squirt bottle filled with stream water, rinse net into the sieve bucket to get any last clinging part of the sample.
5. Double check the net to make sure you didn’t miss any organisms, and hand pick or rinse any additional organisms into the bucket.

Move to the Next Location

Once the net is cleaned, continue collecting your sample while moving upstream. Keep your bucket with you and continue to empty the contents of the net into the bucket as you move along.

After completing the 20 jabs and transferring to the sieve bucket, continue at **the section “Collect Your First Sub-Sample”** in the Rocky Bottom Protocol above.

Monitoring Packing List

General Items

- Datasheets (visual and benthic) – one for each team member, keep one clean until the end to record final results
- Field Manual
- Volunteer binder
- Site binder
- Clipboard
- Pens, pencils, sharpie marker
- Paint and/or field tape
- 100-meter field tape measure
- Gloves
- Hand sanitizer or wipes
- Bug spray/Sunscreen
- Old shoes, waders, or hip waders
- Life jacket (optional)
- Camera / phone
- Large trash bag
- Water cooler
- binder clips (in case it is windy)
- Towel
- First aid kit

Visual-Physical Items

- Gage stick (x3), one with cell phone holder
- Protractor with arm and level
- Transparency tube
- DBH tape
- Thermometer
- Stream viewer
- Ruler, metric
- Level
- Whiteboard and whiteboard marker

Biosecurity

- Boot Covers (optional)
- Soap (Dawn or Alconox)
- Lysol spray
- Spray bottle
- Containers of fresh water
- Scrubbing brush
- Bucket

Benthic Items

- D-net with 500 um mesh
- Sieve bucket with 500 um mesh or DIY equivalent
- Collection container
- 95% ethanol preservative
- Spray/squirt bottle (x2)
- Forceps
- Duct tape or gallon plastic bags
- Waterproof labels for sample jars
- Decontamination supplies - scrub brush, bleach solution, and alconox
- Fishing license(s)