GEOMORPHIC MONITORING PROCEDURES FOR CHESAPEAKE AND ATLANTIC COASTAL BAYS TRUST FUND PROJECTS

Prepared for

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The Chesapeake and Atlantic Coastal Bays Trust Fund (Trust Fund) was created in 2007 in an effort to reduce nutrient and sediment pollution to these bays. The Trust Fund has focused its financial resources on the implementation of effective non-point (*i.e.*, diffuse) source pollution control projects in high priority watersheds. Examples of projects supported by the Trust Fund include stream channel restoration, stormwater retrofits, and cover crops. The Trust Fund provides a foundation for financing such restoration activities, and assessment of their efficacy. To standardize assessments, the Maryland Department of Natural Resources (DNR) is promoting the use of consistent monitoring protocols to assess projects funded through the Trust Fund. These include standard protocols for monitoring water quality, biology, flow, and geomorphology. DNR, in cooperation with the United States Fish and Wildlife Service (USFWS), has developed geomorphic stream monitoring protocols for use in assessing Trust Fund projects.

Monitoring of stream restoration projects will include assessments of a variety of parameters based on project goals, including parameters of interest to the Trust Fund. It is recognized that projects may have additional goals outside of the Trust Fund and that additional assessment methods and analyses may be necessary to address those goals. Trust Fund goals include the reduction of nutrients and sediment as a result of restoration and retrofit projects. To assess the success of traditional stream restoration projects (Natural Channel Design and Analytical Restoration) funded by the Trust Fund in achieving these goals, preferred methods are provided. These methods will ensure consistency and comparability between projects. In brief, the standard geomorphic protocols include a longitudinal profile, one riffle cross-section, one meander-bend cross section, a representative (weighted) pebble count, and a riffle (active-bed) pebble count within the project reach. This assessment should be done prior to restoration and following restoration. Following restoration, monitoring should be conducted for not less than 5 years.

Detailed protocols to complete this assessment follow. These include:

- 2010 Trust Fund Geomorphic Protocols: Cross Sections (February 20, 2013)
- 2010 Trust Fund Geomorphic Protocols: Longitudinal Profile (February 20, 2013)
- 2010 Trust Fund Geomorphic Protocols: Pebble Counts (February 20, 2013)

2010 Trust Fund Geomorphic Protocols: Cross Sections

Recommended Equipment

Cross-section datasheet printed on Rite-in-the-Rain paper
Clipboard
Pencil
Self-leveling laser level and audible receiver
Tripod
Top-setting, telescoping survey rod
300-foot measuring tape
Bank pins
Survey caps
Small sledgehammer
Wooden stakes
Flagging
Hammer and aluminum nails
Bright-colored spray paint
GPS unit
Digital camera
Hand shears

Cross-Section Instructions

1) Within the reach, choose a representative riffle area and representative meander bend/pool area to install the two cross-sections. The areas should be free from direct anthropogenic alterations and reflective of local geology such that the stream is able to adjust its banks under its current flow regime. The riffle location should be chosen along a relatively straight stretch of the stream when possible. Locate cross-sections across the middle of each feature. Establish the cross-sections perpendicular to the direction of flow.

2) Before measuring the cross-section, install and label rebar monuments and top with rubber survey caps. Monuments should be located sufficiently back from the top of bank to prevent them from being lost due to bank erosion. Monuments should be geo-referenced with GPS and flagged. Record GPS coordinates at the cross-section monuments on the cross-section data sheet. Flagged wooden stakes installed behind each pin enable location of monuments on re-visits.

3) Setup the surveying instrument in a location where the entire cross-section can be viewed. The instrument should be placed at an elevation higher than the highest feature required for the survey. Ideally, only one instrument setup will be required to survey the entire cross-section; however, determining the width of the flood-prone area may require multiple instrument setups due to dense foliage.

4) Stretch the tape across the channel (**zero on left bank facing downstream**) making sure the tape is perpendicular to the direction of flow. The zero end of the tape should be secured directly above the left bank pin and the tape should be taut and secured behind the right bank pin. If a survey of the reach longitudinal profile is also being conducted, record the station along the longitudinal profile where the cross section tape crosses the longitudinal profile tape.

5) Survey the top of the rebar pin installed on the left bank. Place the rod firmly on top of the pin and hold it as steady and vertical/plumb as possible while moving the receiver up/down until the audible tone indicates a proper reading. Once the elevation is determined, the rod operator should call out to the recorder the reading from the rod in hundredths of feet. Record this as station 0 (zero) and the corresponding elevation in hundredths of feet on the datasheet, making note that it is on top of the left end pin. Move the rod beside this pin level with the ground elevation and take another reading. Record this as station 0 as well, making note that it is beside the left end pin.

6) Continue surveying across the cross-section obtaining rod readings at major breaks in bed elevation. Typically, 15 to 20 points are necessary including key features such as top of left bank (TOB-L), left bankfull (LBF), left edge water (LEW), Thalweg (THL), right edge water (REW), right bankfull (RBF) and top of right bank (TOB-R). Other significant depositional features or breaks in slope should also be surveyed. Record the distance on the tape (station), the corresponding rod height and feature notes on the cross-section datasheet. Record station measurements in tenths of feet and rod heights in hundredths of feet. The difficulty of identifying the bankfull elevation in the field is recognized, particularly in non-forested and urbanizing conditions. While complete accuracy in bankfull identification is ideal, it is not an absolute necessity for these comparisons of pre- and post-restoration conditions, as they are not meant to be used as a basis for design work. Post-field survey corrections to field bankfull calls can be made during data analyses. See Rosgen (1996) and *Identifying Bankfull Stage in Forested Streams in the Eastern United States* video produced by the USDA Forest Service (2003) for additional guidance in determining bankfull elevation. Regional curves (e.g., McCandless 2003) and additional hydraulic analyses can also be useful to help identify or confirm bankfull dimensions, although dimensions of urbanizing streams may not always follow the regional curves.

7) If banks are severely undercut or slumping, an additional measuring device (e.g., measuring rod or yard stick equipped with a small level) can be used as a base for the main surveying rod. One person should hold the auxiliary rod horizontally against the bank at the first location of undercut, and perpendicular to the main survey rod, keeping it as level and steady as possible. A second person should rest the main survey rod on top of the auxiliary rod, making note of the distance of the base of the main rod along the auxiliary rod (reading 1) and the stationing of the main rod on the survey tape where they cross (reading 2). Move the receiver on the main rod up/down until the audible tone indicates a proper reading and record the elevation. Then determine stationing for the undercut by subtracting reading 1 from reading 2. Then move the entire setup down to the next point of measurement on the undercut bank and repeat until the bank is no longer undercut. Other methods for surveying the undercut portion can also be used, based on the surveyor's preference.

8) At the end of the cross-section, record an elevation reading beside the rebar pin installed on the right bank, making note that it is beside the right end pin. Move the rod on top of the pin and record the elevation of the pin (*keeping the station the same*), making note that it is on top of the right end pin. Top of pin elevations can be used in conjunction with or as benchmark elevations to match up survey data from year to year.

9) Determine the bankfull depth by subtracting the recorded bankfull elevation from the recorded thalweg elevation. Determine the flood-prone elevation by subtracting twice the

calculated bankfull depth from the recorded thalweg elevation. Use this elevation to measure the flood-prone area width (width of the channel at an elevation that is two times the maximum bankfull depth). If this elevation was covered during the cross-sectional survey on both the right and left side of the stream, measure the distance between the location of these two points, recording it as the width of the floodprone area. Else, move the rod upslope from both the left pin and right pin online with the cross section until this elevation is reached. Mark the locations on each bank and measure the distance between these two points, recording it as the width of the floodprone area.

10) Take four photographs of each cross section and record the photograph number, time stamp, and location information on the datasheet. Take one photograph from above the cross-section looking downstream, one from below the cross-section looking upstream, one from the left bank looking at the right bank, and one from the right bank looking at the left bank.

11) While the measuring tape is still deployed and level is still set up, the field QC Officer must make sure that all measurements have been recorded in the field and photographs taken. The field QC Officer must perform QC checks on all datasheets. All field datasheets should be filled out as accurately and completely as possible. Any errors found should be marked through with a single line, with a date and the corrector's initials noted beside the marked-out data.

12) Plot cross-section using the Ohio Department of Natural Resources Reference Reach Spreadsheet (available free from http://www.dnr.state.oh.us/tabid/24137/Default.aspx), or other transferable program.

Related References

Anne Arundel County, MD. 2008. SOP for Stream Cross Sectional Measurement, Revision No. 1. Prepared by: Christopher J. Victoria. February 8, 2008. Annapolis, MD

McCandless, T. 2003. Maryland stream survey: Bankfull discharge and channel characteristics in the Coastal Plain hydrologic region. U.S. Fish and Wildlife Service, Annapolis, MD. CBFO-S03-02.

Ohio Department of Natural Resources (ODNR), Division of Soil and Water Resources – Stream Morphology. 2010. *STREAM Modules*. http://www.dnr.state.oh.us/tabid/24137/Default.aspx

Rosgen, D.L. 1996. *Applied River Morphology*. Wildland Hydrology, Pagosa Springs, CO.

Rosgen, D.L. 2008. *River Stability Field Guide*. Wildland Hydrology. Pagosa Springs, CO.

USDA Forest Service. 2003. Identifying Bankfull Stage in Forested Streams in the Eastern United States. Video available online http://www.stream.fs.fed.us/publications/bankfull_east.html

Recommended Equipment

Longitudinal Profile datasheet printed on Rite-in-the-Rain paper
Clipboard
Pencil
Self-leveling laser level and audible receiver
Tripod
Top-setting, telescoping survey rod
Two (2) 300-foot measuring tapes
Bank pins
Survey caps
Small sledgehammer
Wooden stakes
Flagging
Hammer and aluminum nails
Bright-colored spray paint
GPS unit
Digital camera
Hand shears

Longitudinal Profile Instructions

1) Locate the reach starting and ending points. Reach length should include at least two meander wavelengths, 20 bankfull widths, or a minimum of 300 feet. Reach must encompass locations chosen for riffle and meander bend/pool cross-sections. Reach should start and end at the top of a stable channel feature. If possible, the feature type of the start point should be the same as the feature type for the end point. For the best calculations of slope, the start and end points should be at the top of a riffle.

2) Before measuring the profile, install and label rebar or concrete monuments to serve as benchmarks (total of 3 monuments for longitudinal profile). Install 2 monuments (one on either bank) at the upstream end of the profile and top with rubber survey caps. Install at least 1 monument on a bank at the downstream end of the profile and top with rubber survey cap. Monuments should be located sufficiently back from the top of bank to prevent them from being lost due to bank erosion. Monumented benchmarks should be geo-referenced with GPS and flagged. Flagged wooden stakes installed behind each rebar pin enable location of monuments on re-visits.

3) Setup the instrument with a clear line of sight to both upstream monuments, and where as much of the monitoring reach as possible is visible. Choose instrument locations carefully to minimize the number of times you need to reposition. The instrument should be placed at an elevation higher than the highest feature required for the survey. Tripod legs should be spread sufficiently to ensure a stable base, and the feet should be pressed firmly into the ground.

4) At the upstream end of the reach, stretch a measuring tape across the channel between the upstream monuments so that the tape crosses the starting point. Record the locations of the

monuments on a datasheet using a site sketch and record the distance on the tape of both monuments and the start point.

5) Beginning at the upstream starting point, secure the end of a 300-foot measuring tape and position the tape along the centerline of the channel (if flow permits) or if flows do not permit, along edge of water to obtain stream length stationing, keeping the tape as tight as possible to eliminate slack. Record how the tape was laid out (center of channel versus water's edge) on datasheet to enable repeatability in future assessments. Subsequent tapes should be run in the same manner with the start point of the new tape matching up with the end point of the previous tape to ensure consistent stationing.

6) Place the rod firmly on top of each upstream benchmark and hold it as steady and vertical/plumb as possible while moving the receiver up/down until the audible tone indicates a proper reading. Once the elevation is determined, the rod operator should call out to the recorder the reading from the rod in hundredths of feet. Record the values in the backsight (BS) column on the datasheet.

7) Place the rod at the thalweg at station 0 on the tape. Place the rod firmly on the bed material and hold it as steady and vertical/plumb as possible while moving the receiver up/down until the audible tone indicates a proper reading. Once the elevation is determined, the rod operator should call out to the recorder the reading from the rod in hundredths of feet.

8) At the same location, record the water depth reading off the rod in hundredths of feet. Also record the station and feature type in the notes column. Features should be recorded as follows: Top of Pool (TOP), Maximum Depth of Pool (MDP), Top of Glide (TOG), Top of Riffle (TOR), Top of Run (TON).

9) Continue the same sequence moving downstream to the top of major bed features (e.g. pool, glide, riffle, run) and to the deepest part of pools and repeat the same measurements at the new stations. When compound features occur (double/triple pools, etc.) they should be noted accordingly. Location along the profile (station) should be recorded in hundreds of feet + tens of feet. tenths of feet (for example, the station one-hundred ninety five and five-tenths (195.5) should be recorded as 1+95.5).

10) At the top of each riffle and at any other locations where bankfull features are confidently recognizable, place the rod at a bankfull indicator and determine the elevation recording it on datasheet as BKF. The difficulty of identifying the bankfull elevation in the field is recognized, particularly in non-forested and urbanizing conditions. While complete accuracy in bankfull identification is ideal, it is not an absolute necessity for these comparisons of pre- and post-restoration conditions, as they are not meant to be used as a basis for design work. Post-field survey corrections to field bankfull calls can be made during data analyses. See Rosgen (1996) and *Identifying Bankfull Stage in Forested Streams in the Eastern United States* video produced by the USDA Forest Service (2003) for additional guidance in determining bankfull elevation. Regional curves (e.g., McCandless 2003) and additional hydraulic analyses can also be useful to help identify or confirm bankfull dimensions, although dimensions of urbanizing streams may not always follow the regional curves.

11) Also, whenever a bankfull elevation is recorded, record a corresponding top of low bank elevation. Place the rod on top of the lowest bank (i.e., the bank that would overtop first in the event of an out of bank flow) and determine the elevation recording it as TOB-R (for right bank) or TOB-L (for left bank). (Note that all language referring to bank location within the survey reach are oriented facing downstream (i.e., “left bank” is the bank on the left side when facing the downstream direction and vice versa). If the top of the low bank is slumping due to partial bank collapse or other reason, the TOB reading should be taken further back where the bank is stable.

12) At cross-section intersection locations, note the distance (station) on the longitudinal profile tape in tenths of feet. Take a measurement on top of both cross-section end point monuments to obtain common elevations of the cross-section and longitudinal profile.

13) If the entire profile is not able to be surveyed from the initial location of the level due to distance and/or visual obstructions, a turning point will be needed, and must be taken prior to moving and re-setting the laser. The turning point should be taken from a location that provides a stable elevation that will not shift between shots (e.g., large rock boulder, tree stump, concrete benchmark, firmly packed soil, etc.). The point collected using the first laser setup is recorded as the foresight (FS). Repeat Step 3 for laser setup at a new location with clear views of the turning point and the next section of stream to survey, then re-shoot the turning point. This will be recorded as the backsight (BS).

14) To complete the survey at the bottom end of the reach, record the feature, thalweg elevation and water depth at the last station. Then place the rod firmly on top of the downstream monumented benchmark and hold it as steady and vertical/plumb as possible while moving the receiver up/down until the audible tone indicates a proper reading. Once the elevation is determined, the rod operator should call out to the recorder the reading from the rod in hundredths of feet. Record this value on the datasheet. Top of pin elevations from the upstream and downstream monuments can be used to match up survey data from year to year.

15) While the measuring tape is still deployed, take photographs moving along the reach, recording the profile stations (in feet) where photographs are taken, the photograph number and time stamp, and a description of the photograph as well.

16) While the measuring tape is still deployed and level is still set up, the field QC Officer must make sure that all measurements have been recorded in the field and photographs taken. The field QC Officer must perform QC checks on all datasheets. All field datasheets should be filled out as accurately and completely as possible. Any errors found should be marked through with a single line, with a date and the corrector’s initials noted beside the marked-out data.

17) Enter the data and plot the longitudinal profile using the Ohio Department of Natural Resources Reference Reach Spreadsheet (available free from online), or other transferable program.

Related References

Anne Arundel County, MD. 2012. Picture Spring Branch Longitudinal Profile Procedure, Revision No. 0. Prepared by: Christopher J. Victoria. April 10, 2012. Annapolis, MD

McCandless, T. 2003. Maryland stream survey: Bankfull discharge and channel characteristics in the Coastal Plain hydrologic region. U.S. Fish and Wildlife Service, Annapolis, MD. CBFO-S03-02.

Ohio Department of Natural Resources (ODNR), Division of Soil and Water Resources – Stream Morphology. 2010. *STREAM Modules*. http://www.dnr.state.oh.us/tabid/24137/Default.aspx

Rosgen, D.L. 1996. *Applied River Morphology*. Wildland Hydrology, Pagosa Springs, CO.

Rosgen, D.L. 2008. *River Stability Field Guide*. Wildland Hydrology. Pagosa Springs, CO.

USDA Forest Service. 2003. Identifying Bankfull Stage in Forested Streams in the Eastern United States. Video available online http://www.stream.fs.fed.us/publications /bankfull_east.html

2010 Trust Fund Geomorphic Protocols: Pebble Counts

Recommended Equipment

Representative pebble count datasheet printed on Rite-in-the-Rain paper
Active bed riffle pebble count datasheet printed on Rite-in-the-Rain paper
Sand gauge reference cards (1 per surveyor)
Metric ruler (with mm markings) (1 per surveyor)
Metal hand tally counter (clicker) (1 per surveyor)
Clipboard
Pencil

Representative Pebble Count Instructions

1) Walk the entire study reach, paying attention to the distribution and lengths of riffles, runs, pools, and glides within the reach
2) 10 transects (perpendicular to flow) within the reach will be sampled for pebbles. Determine the number of riffle, run, pool and glide transects needed based on the proportion of the reach they occupy (for example, if the reach is 40% riffle, 20% run, 30% pool, and 10% glide, one would sample 4 transects in riffles, 2 in runs, 3 in pools, and 1 in a glide). Data collected from the longitudinal profile survey can provide the proportion of bed features within the reach.
3) Identify bankfull on both sides of the channel at your first transect location and determine the sampling interval (sample at equal increments across the entire bankfull channel).
4) Begin the pebble count below the bankfull elevation. No more than 5% (one sample every other transect) of materials should be selected from particles between the bankfull and wetted elevations. To avoid bias of selecting larger particles, the observer should look away from the channel bed and select the first particle touched by the tip of index finger at observer's toe.
5) Measure the length of the intermediate axis in millimeters and mark a dot in the correct column and row on the data sheet. (The intermediate axis is neither the longest nor the shortest of the three mutually perpendicular sides of the particle). If the particle is linear-shaped, average the axes. If the particle is very small and a measurement cannot be taken (e.g., sand or silt), sand gauge reference cards can help the surveyor classify the particle appropriately.
6) Sample each transect moving perpendicular to the stream banks until 10 random particles equally spaced across the transect have been measured. Repeat this procedure until 10 random particles at each of 10 different transects have been measured in proportion to the bed features of the reach for a total of 100 particles assessed. A metal hand tally counter/clicker can be used to help keep track of counts.
7) The field QC Officer must perform QC checks on all datasheets. The field QC officer should tally up counts in each cell of the datasheet to ensure that a total of at least 100 particles were measured and recorded.

8) Record data using the Ohio Department of Natural Resources Reference Reach Spreadsheet (available free from http://www.dnr.state.oh.us/tabid/24137/Default.aspx), or other transferable program.

Active Bed Riffle Pebble Count Instructions

1) Repeat Steps 5-8 from the Representative Pebble Count Instructions (above), only sampling on the active bed of the riffle cross-section (100 particle counts). Distribute transects for the active bed riffle counts evenly along the riffle feature.

Related References

Harrelson, C.C, C.L. Rawlins, and J.P. Potyondy. 1994. Stream channel reference sites: An illustrated guide to field technique. Gen. Tech. Rep. RM-245. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Ohio Department of Natural Resources (ODNR), Division of Soil and Water Resources – Stream Morphology. 2010. *STREAM Modules*. http://www.dnr.state.oh.us/tabid/24137/Default.aspx

Rosgen, D.L. 2008. River Stability Field Guide. Wildland Hydrology. Pagosa Springs, CO.

Wolman, M.G. 1954. A method of sampling coarse river-bed material. Transactions of American Geophysical Union.