Batavia Kill Watershed

Results from July 20, 2006 Meeting on Stream Design Post-Construction Maintenance Protocol Evaluation

Greene County, New York

Prepared for GCSWCD and NYCDEP

Design Report Prepared by Buck Engineering
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and
New York City Department of Environmental Protection
Stream Management Program (NYCDEP – SMP)

Meeting on Stream Design Post-Construction Maintenance
Protocol Evaluation
Greene County, New York
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1. Introduction

The Greene County Soil and Water Conservation District (GCSWCD) and the New York City Department of Environmental Protection (NYCDEP) Stream Management Program (SMP) have worked together to implement several demonstration channel restoration projects in the Catskill Mountains of Greene County, NY. Each project was designed to satisfy specific long-term primary and secondary goals. Both the GCSWCD and the NYCDEP-SMP have participated in post-construction monitoring of these projects to assess the degree of success of each project in achieving its specific design goals and also to detect and repair any situations that may compromise the ability of the project to sustain its design goals over time.

It is the desire of both the GCSWCD and the NYCDEP-SMP to create a standard post-construction monitoring and maintenance activities protocol to optimize the efficiency of this post-construction process given the available resources. This initiative led to a meeting held at the GCSWCD office in Cario, NY on July 20, 2006, in which representatives of the GCSWCD and the NYCDEP-SMP met with members of the Buck Engineering team to discuss and reach an agreement on a general protocol for the post-construction monitoring and maintenance practice. This report summarizes the issues discussed and conclusions reached at this July 20, 2006 meeting.

2. Channel Restoration Project Goals

The GCSWCD and the NYCDEP-SMP offered a list of goals for channel restoration projects constructed in the Greene County area. A brief description of each goal was also provided. This information is summarized below:

- Reduce bank erosion –Bank erosion is a principal sediment supply in rivers. Reducing bank erosion reach-wide or on a watershed scale will reduce the amount of sediment available for transport by the stream, which will reduce turbidity and, in turn, improve water quality and aquatic habitat.
- Demonstrate natural channel design – Some part of the public remains unclear on the benefits of natural channel design restoration projects. When constructing these types of projects, cooperation from the landowners bordering the project site is essential for implementation of a successful stream design. Providing constructed projects through which the public can observe the benefits of stream design, and how these types of projects can provide a solution to problems they identify with, can make the public more receptive to them, this way facilitating their construction in the future.
- Verify Rosgen stream classification system –The Rosgen stream classification system categorizes streams into different types based on the value of specific measurable stream parameters. This classification system also relates each stream type to a different hydraulic and sediment transport pattern. In this manner, stream classification may serve to predict stream behavior. Stream

designs constructed as a certain Rosgen stream type may be used to confirm the relationship between stream type and stream behavior as defined by Rosgen holds true for streams in the Catskills Mountains area.

- Reduce channel maintenance cost – Unstable stream reaches may pose varying kinds of problems to surrounding areas, and substantial channel maintenance at a high cost is often required when the solution is localized channel stabilization, without addressing the source of destabilization. Implementation of natural channel design principles along these stream reaches may eliminate the condition causing destabilization and significantly reduce channel maintenance costs.

- Improve sediment transport and storage – Channel stability depends largely on its ability to transport and store sediment adequately. To help ensure channel stability, it is important to make sure the sediment transport and storage mechanisms along the channel are functioning properly.

- Improve ecological functions – The various aquatic species found in river systems each require different types of channel bedforms as habitat, such as riffles or pools, and others thrive along large woody debris present in the stream. In addition, the cooling shade of a riparian buffer is also vital for some species. In degraded channels displaying little variation in bed forms and lacking a vegetation buffer, many species cannot survive, and ecological functions are notably reduced. In cases where a channel has incised substantially, the ecological functions of the stream and its floodplain are also affected, as the incision may cause the water table to drop below the root mass of the floodplain vegetation. Stream restoration may re-introduce bedform diversity and large woody debris, re-establish a riparian buffer, and re-connect the root mass of the riparian vegetation to the water table, in this manner improving the ecological function of the stream.

- Improve fishing – Fishing is one of the major public uses of streams in the area. Stream design projects are able to improve aquatic habitat, which leads to increased fish populations, providing better fishing opportunities for the public.

- Improve riparian buffers – Riparian buffers substantially enhance stream stability as they are the principal protection against stream banks erosion. Improving riparian buffers will improve the overall stability of streams.

- Reduce bed incision, improve floodplain connectivity – When a channel is too incised for its high flow waters to reach and spread across the channel floodplain, shear stress along the channel increases, increasing channel erosion and furthering channel incision. In addition, it increases turbidity and decreases water quality and aquatic habitat. Reducing channel bed incision prevents many of the functions of a stream from being affected negatively.

- Protect infrastructure - There are cases in which the stability of a structure located near a stream bank - such as a house, a road, or a bridge abutment - is threatened by progressive erosion of the nearby stream bank. Implementation of natural channel design principles along these stream reaches may eliminate the bank erosion problem, providing a more long term solution to the problem of structure stability along river banks.

The GCSWCD and the NYCDEP-SMP stated that not all of the goals listed above apply to all of their various natural channel design projects. Each project may have one or several principal goals from the list above, with one or several of the other goals listed above as secondary project goals. In general, project goals align with the concerns of the source or agency funding the project.

3. Relating Design Goals and Post-Construction Monitoring

Post-construction monitoring is the process through which the results of the project are assessed and compared to certain pre-defined performance criteria in order to evaluate site conditions. These performance criteria stem directly from site design goals and define the long term standard for success of a project. For this reason, it is important to clearly identify what the primary and secondary goals of a channel restoration are in order to produce an effective post-construction monitoring plan.

The objectives of post-construction monitoring are to verify that the specific success criteria of a project are being met and identify any maintenance or repair necessary to keep a project on a track of its long term goals. Analysis of monitoring data provides a way to identify the source of any instability found during the principal monitoring activities.

It was agreed that for maximized efficiency, monitoring activities should focus on observation and recording of only those parameters that indicate if the specific goals of a project are being achieved. For this reason, a specific relationship should exist between the design goals of a project and the its post-construction monitoring activities.

Discussion among all meeting participants produced a table that shows how the level of priority of the various parameters that may be measured as part of the post-construction monitoring activities varies in relation to the principal goal of the project. This is presented in Table 1 below.

In Table 1, parameters classified as “primary” (“P”) under a specific principal project goal are those whose measurement should be of high priority in the post-construction monitoring plan, since they are necessary and required to assess whether the project is achieving that particular design goal. Parameters classified as “secondary” (“S”) under a specific principal project goal occupy a lower priority and provide complementary data to the “primary” data collected, allowing the monitoring team to further define project success for that particular principal project goal. Parameters without a priority ranking (blank space) under a particular project goal are those that may be left unmeasured without significantly affecting the degree to which one may assess whether the project is meeting the stated project goal.

There may be cases when the available budget or personnel for post-construction monitoring substantially limits the amount of data collection that may be obtained from each stream design project site during a monitoring season. This table allows the user to optimize the post-construction monitoring procedures with the available budget and manpower, since data collection is limited to only the high priority parameters presented in Table 1, while maintaining some level of monitoring on all important project aspects.

Table 1. Relation Between Stream Design Project Goals and Post-Construction Monitored Parameters.

PARAMETERS	Primary Project Goals							
	Reduce Bank Erosion	Repair Bed Incision	Improve Sediment Transport	Improve Stream Habitat	Improve Riparian Buffers	Protect Infrastructure	Demonstrate Natural Channel Design	404 Permit Requirement
Qualitative Assessments								
Photographs	P	P	P	P	P	P	P	P
Visual Inspection	P	P	P	P	P	P	P	P
Aerial photography (if available)	S		P		P	S	S	
Channel Dimension (Cross-sections)								
Riffle Area, sq ft			P	P		P	P	P
Riffle Width, ft			P	P		P	P	P
Riffle mean depth, ft			P	P		P	P	P
Width to Depth Ratio, W/D	S	S	P	P		P	P	P
Riffle Max Depth Ratio, Dmax/Dbkf				P		P	P	
Bank Height Ratio, Dtob/Dmax (ft/ft)		S	P	S		P	P	
Pool Max Depth Ratio, Dmaxpool/Dbkf			S	P		S	P	
Pool Width Ratio, Wpool/Wbkf	S		S			S	P	
Pattern								
Meander Length Ratio, Lm/Wbkf	S		S			P	P	
Rc Ratio, Rc/Wbkf	S		S			P	P	
Meander Width Ratio, Wblt/Wbkf	S		P			P	P	
Sinuosity, K	S	S	P			P	P	P
Pool to pool spacing ratio	S		P	S		P	P	
Longitudinal Profile								
Thalweg Profile		S		P		P	P	
Water Surface Profile		S	P	P		S	P	P
Low Bank Profile		S	P			P	P	
Valley Slope, Sval (ft/ft)		S	P			P	P	
Riffle Slope Ratio, Srif/Schan		S	S	S		S	P	
Run Slope Ratio, Srun/Schan		S		S		S	P	
Glide Slope Ratio, Sglide/Schan		S		S		S	P	
Pool Slope Ratio, Spool/Schan	S	S		S		S	P	
Percent Riffle / Pool		S	S	P			P	

P = Principal parameter
S = Secondary parameter
(Blank field) = Irrelevant parameter

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Sediment Transport								
Bed material	S		P	P		P	P	P
Bank material	S		S		S	S	P	
Shear Stress		S	P	P		P	P	
Transport Capacity			P	P		P	P	
BEHI	S		S	S		P	P	
Total Suspended Solids			S					
Scour chains			S					
Tracer particles			S					
Biology								
Vegetation Plots	S	S		S	P		P	
Terrestrial habitat				S	S		S	
Benthos	S	S	S	P			S	
Fish Survey			S	P			S	
HSI Protocol		S	S	S			P	
Other								
Crest gage	S	S	S			S	P	
Water table wells		S			S	S		
Structure Survey	P	S	S	P		P	P	P
Survey available high water mark			P		S	P		
Wetland Delineation					S		S	P

P = Principal parameter
S = Secondary parameter
(Blank field) = Irrelevant parameter

A global post-construction monitoring activity which should be performed at all implemented stream design projects is the topographic survey of the as-built project conditions. Much of the information on the performance of a channel design and its success trend is obtained from the changes over time observed in the parameters listed in Table 1. For this reason, an as-built base of comparison is required for the interpretation of the data collected from these parameters. The information presented in Table 1 assumes the availability of an as-built survey.

In addition, all stream design projects should include as part of their monitoring plan the documentation of any design lessons learned from observation of the behavior of any of the components of the constructed project, such as:

- The most stable and functional way to build a specific structure type
- The optimal location along a stream to place a specific structure type
- The types of erosion/problem areas that have the ability to heal themselves without causing further instability along the channel
- The types of erosion/problem areas that will not heal themselves and will inevitably cause further channel instability if no maintenance intervention is offered.

This documentation will provide useful data for future design projects. The GCSWCD and the NYCDEP-SMP expressed that they are currently monitoring the Big Hollow, West Kill, and Broadstreet stream restoration projects using this approach.

4. Post-Construction Monitoring Procedures

The specific procedures that may be followed to satisfy post-construction monitoring objectives are presented in a previous report titled "Batavia Kill Watershed Stream Design Post-Construction Maintenance Protocol Evaluation, Greene County, NY" dated May 28, 2006. The GCSWCD and the NYCDEP-SMP desired further clarification on the application of some of these procedures, and the following was provided:

- Length of monitoring period – It is preferred for stream design projects to be actively monitored until good woody vegetation is established along the stream banks, a minimum of five years. If active monitoring of a project site has shown that for at least five years the project has remained relatively stable even though the project has not yet developed good woody vegetation along its banks, monitoring activity in subsequent years may be reduced to visual inspection to detect any maintenance or repair needs. Visual inspection should be performed yearly and after every major flood event, and should continue until sufficient woody vegetation has stabilized the stream banks. If a project has required re-design, the counting for the monitoring period should be reset, and a new five year period of active monitoring should be undergone for the re-constructed project.

- Bank erosion hazard index (BEHI) – A full cross-section is not required at each location where a BEHI assessment is to be performed. BEHI assessments are performed by walking the stream length and identifying stretches or lengths of uniform erosion condition along each streambank, assigning a BEHI score to each length of uniform erosion condition based on streambank angle, bank height ratio, ratio of root depth to bank height, percent of root density, and percent of bank surface protection. Each location is also assigned a degree of near bank stress (NBS): low, moderate, high, very high, or extreme. The known BEHI score and level of NBS of each area of uniform erosion condition are then used together to determine bank erosion rate, based on the relationship between BEHI, NBS, and erosion rate developed for Colorado (currently only location for which this relationship is available). It is important not to include areas of sediment deposition or areas of zero erosion (bedrock banks, for example) in the BEHI assessment or total erosion rate calculation. Rate of erosion from the project

The NYCDEP-SMP expressed that through the years, they have collected survey data with the purpose of eventually creating a local curve that relates BEHI, near bank shear stress, and bank erosion rate. Since preventing bank erosion is consistently one of the principal goals of the GCSWCD and the NYCDEP-SMP stream design projects, processing all the collected BEHI data to create the regional BEHI-NBS-band erosion rate curve should be made a top priority.

- Measuring bank erosion through survey data – If determining yearly erosion volumes from survey data, the survey must include data points to document the top of bank and toe of bank (breaklines) along the channel. This ensures that the correct bank areas are used in the calculation of bank erosion volumes from a digital terrain model (DTM).
- Photo monitoring of streams – Permanent pins or any other identifiable marker should be installed at locations from which photos shall be taken at each site on each monitoring occasion. A photo taken from exactly the same spot each time will provide a valuable record of changes over time. Photos should also always be taken following the same procedure on photo orientation and angle. When monitoring streams, photos may be taken from the location of permanent cross-sections, using their pins as permanent photo station to photograph the opposite stream bank, and upstream and downstream shots of the stream. For more specific procedures on photo monitoring, refer to:

  Harrelson, Cheryl C., C.L. Rawlins, and John P. Potyondy. 1994. *Stream Channel Reference Sites: An Illustrated Guide to Field Techniques*, United States Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-245, 61 p.
  (online at: www.stream.fs.fed.us/PDFs/RM245.PDF)
- Vegetation monitoring procedure – Riparian vegetation monitoring is used to determine if vegetation has been successfully established on a site. This process starts in the design phase where site specific conditions should be considered prior to planting. This may include soil testing to determine if soils need amending or creating separate planting zones with species that are tolerant to the conditions present in various areas of the site (i.e. floodplain verses upland or terrace zones).

For quantitative vegetation monitoring, a baseline should be established for the permanent vegetation monitoring plots (stem count of all planted trees, and species of each) once the site is planted so that stem mortality can be accurately calculated in subsequent years. Plots chosen should be representative of the site. Corners of each plot and trees within the plot should be clearly marked and mapped to facilitate locating plots and trees during the monitoring period. If desired, a sub-section of established monitoring plots may also be used to qualitatively or quantitatively assess percent cover of herbaceous plant material.

Observations within the monitoring plots and throughout the site should be used to assess competition from invasive or exotic species. These species may prevent native, desirable plant species from becoming established on site. If invasive, exotic species are a problem it may be necessary to treat them several times (both prior to and after construction). Once a healthy vegetative community has established, the focus of riparian monitoring may shift to evaluate the function of the vegetation in the ecological system, or may be discontinued if enhancement of the biological functions of the stream is not part of the project goals.

Qualitative vegetation monitoring may also be conducted through visual inspection of the site, by a monitoring team with knowledge on both the desired and undesired vegetation species.

Further details on riparian vegetation monitoring including several suggested methodologies may be found in the following reports:

> Lee, M. T., R. K. Peet, S. D. Roberts, T. R. Wentworth. 2006. CVS-EEP Protocol for Recording Vegetation.
> Online at:
> http://www.nceep.net/business/monitoring/veg/cvs-eep-manual-v4_lev1-2.pdf.
>
> Harris, R.R., S.D. Kocher, J.M. Gerstein and C. Olson. 2005. *Monitoring the Effectiveness of Riparian Vegetation Restoration*. University of California, Center for Forestry, Berkeley, CA. 33 pp. Online at: http://forestry.berkeley.edu/comp_proj/DFG/Monitoring%20the%20Effectiveness%20of%20Riparian%20Vegetation%20Restorat.pdf.

- Visual assessment – When conducting a visual assessment, a monitoring team should look for and take note of the following items:
  - Physical stability of any in-stream structures
  - Erosion along stream banks
  - Areas of channel bed incision, e.g. head cuts
  - Areas of channel bed deposition, e.g. mid channel bars, gravel deposition on the floodplain
  - Particle size found along channel bed
  - Bedforms present and bar development
  - Any changes in channel alignment, e.g. avulsions

    - Valley type and slope, and how this influences channel pattern
    - Vegetation density and type
    - Condition of aquatic habitat/presence of wildlife.

  The visual assessment should incorporate photographic recording of all portions of the project inspected.

  The visual assessment is the principal way through which a monitoring team may assess needs for repair, and determine whether an observed problem area along a project reach (localized erosion, shifted rocks on structure, etc.) is an indicator of progressive instability that requires remedial action or if the situation is one that will heal itself. The visual assessment should include a technical memo that records the observations. The observations and photographs should refer to station numbers from the as-built surveys.

- Selection of cross-section locations – Monitoring cross-sections are used to represent in a discrete location the behavior of a homogeneous portion of the stream reach. For this reason, cross-sections should be located at places along a stream that are representative of the reach one wishes to examine. A single stream design project site may have several distinct reaches where channel behavior may differ due to change in slope, stream type, inflow of a tributary, etc. In meandering streams, each of those reaches will have both riffles and pools. For this reason, at least two cross-sections are necessary to represent each stream reach in a meandering stream: one across a riffle and one across a pool. It is preferable for the cross-section pair representing a stream reach to be a selected at a pool and the riffle immediately downstream of that pool (these two will be working together as the riffle is the grade control of the pool immediately upstream). For sediment transport analysis, a cross-section should be completed in a stable riffle with bank height ratios near 1.0 if possible. Pavement and subpavement samples should be taken from this same riffle.

5. Post-Construction Monitoring Planning

It was recognized that monitoring activities and length of monitoring period varies by project. Since different situations may arise at each project site during each monitoring year, the monitoring plan for each project must be revisited periodically to ensure that any pending issues from previous monitoring years are addressed. In addition, revisiting the monitoring plan for a project just before the monitoring season can eliminate any procedures that may not be necessary during that particular monitoring year.

Both the GCSWCD and the NYCDEP-SMP agreed that a very effective way to improve the efficiency of annual monitoring activities is to have yearly pre-monitoring season meetings between the GCSWCD and the NYCDEP-SMP to review each projects and perform visual inspections of the projects to tailor the monitoring strategy for the year to the needs of each individual project based on the findings from the visual inspection. This meeting should also be used to define and/or restate the question that the monitoring activities are supposed to answer, and determine what actions will be taken based on the monitoring results. In addition, it was agreed that yearly post-monitoring season