New York City Department of Environmental Protection
Bureau of Water Supply

Stream Management Program
Second Biennial
Program Evaluation Report

April 27, 2006

Prepared in accordance with the United States Environmental Protection Agency's Filtration Avoidance Determination

This report evaluates the progress of the Stream Management Program in meeting its goals and objectives.

Prepared by: Stream Management Program
Division of Watershed Lands and Community Planning
Bureau of Water Supply

Preface

As a NYC Watershed Partnership Protection Program, the foundational goal of the DEP SMP is to protect and/or restore achievable levels of stream system stability and ecological integrity by providing for the long-term stewardship of streams and floodplains. The previous Program Evaluation Report was presented as final in April, 2004 as required by the EPA in the November 2002 Filtration Avoidance Determination (FAD). That report provided an evaluation of the DEP SMP structured around the goals and objectives identified in the DEP SMP's Five Year Plan and the Program Evaluation Strategy Outline:

1). Create an approach for stream management in the Catskill Region that is watershed scale, multi-objective, and community-based by promoting and applying the principles of fluvial geomorphology as the scientific basis of the approach.

2). Promote a stream stewardship ethic and develop an informed constituency of regional stream managers and community participants.

3). Prepare and implement Stream Management Plans in priority sub-basins.

4). Implement a range of stream restoration and protection projects demonstrating best management practices (BMPs) in priority sub-basins.

5). Develop and distribute regional stream morphology databases to support stream management decisions, stream design specifications, and program evaluation.

In this Program Evaluation we will address the successes and challenges DEP has encountered in meeting these programmatic goals. In late December 2005 we submitted a draft evaluation strategy to EPA that detailed the topics covered in this report. We also noted that we would have assistance in evaluating the restoration demonstrations (Goal 4) and research (Goal 5) components of the Program. Drs. Bruce Pruitt and Eric Somerville of Nutter and Associates, Inc, (NAI) were contracted to evaluate Goal 4. On February 23, 2006 Dr. Pruitt facilitated a meeting with DEP and our primary contract partners – the Soil and Water Conservation Districts (SWCD) and Dr. Craig Fischenich of the US Army Corp Engineer Research and Development Center (ERDC). The documented results of the NAI assessment and evaluation are enclosed as Attachment A of this report.

At this submittal, DEP is approximately four-fifths of the way through the term of the 2002 FAD. During this term, DEP has completed 6 stream management plans and 6 stream restoration demonstration projects (bringing the total to eleven) and made substantial progress in achieving its education/outreach and research milestones.

Progress has been made across the West of Hudson Watershed and its sub-basins in shifting the predominant paradigm regarding streams and their management. Program goals are sound and partnerships that have developed to date are enduring the test of time and the new partnerships essential to success are developing. Fulfillment of Program goals will take time because it is a long standing paradigm that DEP and its partners are working to shift. Fulfillment of goals and objectives will come from “staying the course” and with some enhanced education and outreach efforts with county partners.

In this report we review the program’s progress and efforts to overcome challenges it has faced as it sought to achieve its goals. The challenges related to goals one through three, education, outreach, planning and the extension of geomorphic restoration principles and practices are interrelated and therefore these issues will be discussed together in the first section of this report. Evaluation of our progress on demonstration restoration projects and our research initiatives will follow in sections two and three.

Section 1: An Integrated Review of Planning, Education, and Outreach Efforts

1.1 Introduction

Catskills streams are "managed" by many different agencies, groups and individuals. Each of these stakeholders has its own objectives, practices and policies intended to meet its objectives. These traditional management practices and policies are sometimes at cross-purposes—that is, single-objective and counter-productive with regard to other objectives-- and often ignore off-site causes and consequences for the larger stream system. In recognition of this, the Stream Management Program (SMP) developed an approach to encourage stakeholders to move away from these practices and policies and toward those better adapted to Catskill Mountain streams, stream process, geology, hydrology and, most importantly, those which address multiple objectives[1]. This approach has largely been extended through the stream management planning effort and the education and outreach activities both associated with the planning efforts and independently organized by DEP SMP.

In this section, discussion will focus on the challenges and progress to the preparation and implementation of stream management plans, establishment of an effective education and outreach effort, and the extension of fluvial geomorphic stream management principles and practices to relevant stakeholders.

1.2 Stream Management Plans

From the program's initiation, stream management plans have been advocated as the organizing framework to address stream-related issues sub-basin by sub-basin. The stream management planning process combines both technical components of stream condition assessment/process analysis with the social aspects of achieving popular support and "buy-in" to the eventual plan and its recommendations.

In the last two years DEP has completed additional stream management plans on the West Branch Delaware River, the West Kill and Stony Clove Creek and launched a new round of planning efforts on the Esopus Creek, the East Branch Delaware River and the Schoharie Creek. The area covered by stream management plans completed or under development has doubled and upon completion of East Branch and Schoharie plans in 2007, DEP will have fulfilled its stream management planning FAD commitments. (See Figure 1, Map of Stream Management Planning and Restoration Projects).

Challenges to plan creation, adoption and implementation include:

- Planning in larger watershed areas. DEP and its local partners are addressing more communities in larger watersheds including a wider range of stream-related issues.

[1] The systematic approach we developed was detailed in the 2004 Program Evaluation in the form of nine milestones and six additional measures of success. As most of these milestones were met, and as most of the measures of success documented that we largely accomplished Goal 1, they will not be repeated here.

- Inconsistent public participation. For some plans, public participation needs to be stronger to support successful adoption of stewardship practices.
- State agency participation in the planning process has been inconsistent across regional jurisdictions.
- Formal adoption of plans by municipalities continues although at a relatively slow pace as a result of a variety of factors.

The SMP and its partners have adapted the planning process to address these challenges and details follow.

The size of the average planning basin covered by a plan doubled during the current FAD. Despite the challenge of having to spread our resources over a wider area, DEP has fulfilled all of its plan deliverables under the FAD. This has successfully been accomplished by adopting "scoping" methods to guide plan development, refining stream assessment protocols to improve efficiency, and strengthening the capacity of the partnering agencies.

1.3 Scoping to Engage Public Participation and to Focus Assessments

Scoping efforts are now included to encourage communities to identify stream issues at the start of the planning process and avoid overlooking local concerns and to target future assessments. First utilized as part of the Esopus Creek SMP, the practice has been extended to the East Branch Delaware and will be included as part of the Schoharie SMP. Participation in the sessions has typically included local leaders, highway superintendents and key stakeholder representatives. DEP expects that the scoping effort will encourage long term local participation when the public finds that its concerns are studied and described within the plan. This scoping is viewed by DEP as integral to its program education and outreach efforts, for by successfully engaging landowners from the start of the stream management planning process, education and outreach have become a stated goal of the planning process itself.

A first essential step in achieving successful scoping has been reaching out to new partners experienced in undertaking such efforts. Examples of enhanced institutional cooperation in support of management planning and scoping include:

- For the Esopus Creek, a focus group in 2004 identified the critical stakeholder issues and became the core of the Project Advisory Committee (PAC). That focus group/PAC has met ten times since March 2004. The DEP selected Cornell Cooperative Extension of Ulster County (CCEUC) as a new project partner to lead the management planning effort. CCEUC's extension focus has been instrumental in mobilizing planning work groups, creating outreach materials and organizing public events.

- For the East Branch Delaware River: After limited involvement in the planning process for the West Branch Delaware River, the Delaware County SWCD joined with the Delaware County Planning Department to develop and lead a community visioning process before diving into assessment and planning. Three scoping and three visioning meetings have been very well attended and provided DCSWCD and DEP with a clear sense of priorities in the sub-basin.

- For the Schoharie/East Kill, DEP has hired a professional consultant to assist GCSWCD and DEP in forming a focus group that will provide scoping of stakeholder issues from the outset of the planning process.

1.4 Maintaining an Engaged Public during Plan Development

Attracting greater public participation in the planning process has required DEP to encourage its partnering agencies to place an equal emphasis on public outreach as to stream restoration activities. Where public involvement is significant during the planning process, stewardship activities will be more likely to occur. Engaging the public in planning, then, is critical to achieving the program's foundational goal.

The Esopus Creek planning effort, led by CCEUC, is the first planning sub-basin to have staff dedicated to education and outreach and to have a centrally located office within the watershed. As a result, the community educator leads an active Education and Outreach Working Group and watershed residents regularly stop by the project office to schedule a site visit by CCE or DEP staff or to express concerns or ideas. It is estimated that approximately100 people came to the office open house in February, 2006. The Working Group has developed a program including a speakers series, stream "neighborhood" meetings, a 4-H project on eradicating Japanese knotweed from an Esopus tributary, newsletters and an interactive website.

The Batavia Kill is an example of a watershed planning process where project partners have adapted their approach to achieve education and outreach goals associated with the preparation and implementation of stream management plans. The GCSWCD has revitalized the Batavia Kill PAC, inviting new representatives and growing the interest of past representatives. DEP and the District recently developed an Education and Outreach Strategy which includes a workshop series for key audiences and builds a new partnership with Cornell Cooperative Extension of Greene County's Agroforestry center to co-develop and co-sponsor the workshop series. The first workshop, hosted by GCSWCD in March 2006, targeted local, county and state highway departments about stream processes, how their actions affect stream health and alternatives to traditional highway management practices. A second workshop, "Banks and Buffers: Landscaping for Healthy Streams," will be held in April 2006.

Engaging the public means addressing head on the most controversial and difficult issues. Gravel management continues to be such an issue., Landowners and municipalities continue to pressure SWCDs, DEP and DEC to allow extensive gravel removal from Catskill streams as a means of improving flood conveyance and reducing pressure on streambanks. While some gravel management, carefully designed and conducted may be acceptable, poorly conceived gravel management activities are responsible for stream instability in many cases. The DCSWCD hosted a Gravel

Management Workshop in April 2006 to discuss the role of sediment transport in stable stream channels, the implications of gravel removal, and how to evaluate such decisions. The workshop was attended by more than 50 Delaware County municipal leaders and members of the public. Two town supervisors, one speaking on behalf of the Delaware County Board of Supervisors, reported that it had been the most informative session they had ever participated in and expressed their gratitude for the information. The session marked a first milestone in achieving an informed constituency on this topic.

The challenge still remains to transform public participation and interest in the planning process into broad support for individual and community stream stewardship actions. The stream management plans contain substantive information about stream processes and threats to stream stability at the stream reach scale as well as at the watershed scale. Most contain recommendations for public and individual action. Where reach specific recommendations have been prepared for the management plan the SWCDs have printed and mailed to each riparian landowner a copy of that landowner's stream reach condition description with an invitation to contact the District for additional assistance. These mailings have gone to riparian landowners on the Chestnut Creek (Rondout), the Broadstreet Hollow, the Stony Clove, the West Kill and the Batavia Kill to influence their stewardship actions.

Continued contact with individuals is a priority activity of the DEP and its county partners. In Greene County, the GCSWCD has recently established "Greene Streams," an electronic newsletter profiling the stream management activities of the District in the Batavia Kill, East Kill, Schoharie, West Kill, Stony Clove and Broadstreet Hollow streams. DCSWCD devoted a newsletter to stream process and uses this regularly in its education and outreach efforts. CCEUC publishes a quarterly 10-page newsletter for Esopus stakeholders.

Developing a better understanding our audience is a key element of both conducting education and outreach and evaluating the impact of those education and outreach efforts. On the Esopus Creek project, CCE is working with Cornell University faculty and Extension staff to design a survey that measures current state of knowledge for key sets of constituents. A follow-up survey is also planned to evaluate the effectiveness of the planning process.

Measuring our level of success in education and outreach is a challenging task because it often relies on anecdotal evidence. We frequently hear of positive examples of local landowner buy-in, such as a landowner in the West Kill, who, after receiving and reading a portion of the West Kill SMP, contacted DEP in order to incorporate natural channel design concepts into stream work on his property. A landowner on the Stony Clove used his management unit description to support an Article 15 stream disturbance permit application. A landowner along the Batavia Kill planted willow stakes along his property after learning about their use and success at our restoration projects. DEP does not compile these examples, but finds that they are related to us with increasing frequency.

1.5 Refining Stream Assessments as part of Stream Management Plans

Stream assessment protocols have evolved considerably since our first planning efforts. The concept of a one-size-fits-all assessment approach has been replaced with a more flexible, phased approach that is adaptable to basin scale, schedule and other basin specific management issues. The factors driving this evolution are a response to:

- the increasing size of the river systems being assessed and
- the need to account for a broader range of conditions while still being able to address specific stream issues.

The change in assessment protocols also takes advantage of lessons learned from previous assessments and the availability of improved survey technologies and remotely sensed resource information.

As the size of the planning basins have increased, stream assessment protocols have been adjusted to focus more on the conditions observed while walking the river corridor (walkover survey). These walkover assessments are later supplemented by Rosgen level II and III assessments for priority sites. This approach was used on the West Branch Delaware and West Kill surveys conducted in 2002-2005. The walkover, made possible through the use of GPS technology, captured basic information about the location and condition of a wide variety of stream features and riparian characteristics. Characterization of the riparian land cover and buffer condition also evolved to support riparian buffer protection initiatives.

Further adaptation of the protocols occurred with the Esopus Creek. DEP and the contracted partner for assessment, U.S. Army Corp Engineer Research and Development Center (ERDC), are using a three-phased approach to assessing the 20 miles of stream along the mainstem. The first phase, adapted from published protocols developed by the Vermont River Management Program[2], is a watershed scale assessment using remote sensing techniques, limited field visits, and aerial reconnaissance with a helicopter to segregate the stream into reaches for further field-based study. Phase 2 includes a reach scale assessment and a sediment budget study based on a walkover reconnaissance with GPS to record various stream features and conditions. Phase 3 is a targeted site scale assessment that includes topographic surveys for BMP design or monitoring. Similar multi-phased assessments are either ongoing or planned for the East Branch of the Delaware and Schoharie Creek stream management planning projects.

1.6 Adoption and Implementation of Plans

DEP and its partners have presented the plans to local leaders and continue to seek their adoption by the Towns covered by the plans. The Delaware County Board of

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[2] The Vermont Agency of Natural Resources River Management Program has published a set of stream geomorphic assessment protocols that are available at the following website: http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassesspro.htm

Supervisors passed a resolution of support for the recommendations of the West Branch Delaware Stream Management Plan. The GCSWCD Board of Directors passed a resolution supporting adoption and implementation of the Batavia Kill stream management plan. GCSWCD then initiated acting as lead agency in coordinating SEQRA review of the Batavia Kill stream management plan for the Towns of Windham, Ashland and Prattsville. Upon completion of this review, GCSWCD will seek plan adoption by the three communities. GCSWCD has also initiated SEQRA review for the Stony Clove stream management plan for the Town of Hunter. Greater emphasis on the role of the PAC and involvement by local leaders on the PACs has increased buy-in to the planning process and resulting plans by the leaders. Additionally, DEP is considering how funding for future projects could be used as an incentive for plan adoption.

The implementation of recommendations has progressed and across the West of Hudson basins the foundation for future implementation is being established. DEP is strengthening its relationships with other watershed programs such as the CWC, WAP, DEP's Land Management and Land Acquisition programs. Training and educational opportunities, such as workshops and symposia, are being offered to key stakeholder groups in preparation of implementation of the plans.

Recommendations common to each plan have been the first to receive DEP support. For example, nearly every plan has contained recommendations for revision of existing flood plain maps. DEP has successfully negotiated a contract with DEC and the Natural Heritage Trust to fund DEC's restudy and remapping of FEMA flood insurance rate maps (FIRMs) for the floodplains in Delaware, Ulster, and Sullivan counties. DEP is actively supporting education and outreach to groups and individuals related to the control of Japanese knotweed and the modification of highway maintenance practices along stream corridors.

Continued guidance and support for stewardship actions are needed from both DEP and the local partners. In preparation for an expanded implementation effort in the next FAD, DEP is reviewing the recommendations of its stream management plans and considering a range of programs and projects which will both address water quality concerns and landowner needs and community interests.

1.7. Coordination with NYC Watershed Programs and Agencies

In addition to outreach designed to support the preparation and implementation of stream management plans, DEP has taken a lead role in organizing collaborative efforts to address stream management issues with other Watershed Programs. Bringing together multiple agencies and interest groups, DEP has sponsored efforts to develop strategies to protect and enhance riparian buffers, control of the spread of invasive plants like Japanese Knotweed, and prepare education materials promoting streamside landowner stewardship. Creating opportunities for collaboration has enabled the Stream Management Program to expand its contact with other agencies as well as within DEP, share our message with other agencies, learn from their experience, and further support their programs, policies and projects.

After contributing to the development of the DEP Riparian Buffer Report, DEP SMP sponsored and participated in a series of facilitated workshops with watershed agencies and organizations including the WAC, CWC, NRCS, SWCDs, TNC, and others to evaluate current riparian corridor condition in the watershed and chart a course for future efforts to protect and enhance riparian buffers. These workshops provided those working with riparian buffers the opportunity to share perspectives and prioritize a set of actions for expanding the protection of riparian areas through our existing programs. The results of these workshops reaffirmed our common support for buffer protection through programs like CREP, continued land acquisition and conservation easements, as well as the development of educational materials to support landowner stewardship in riparian areas. One priority put into immediate action is the development of an educational guide for riparian landowners. The DEP has helped coordinate and write this document, "Catskill Streams and You, Living Streamside in the Catskill Mountains," expected for publication and distribution in summer 2006.

DEP SMP helped organize a Regional Japanese Knotweed Manager's meeting during this evaluation period that continues to meet, exchange new information and collaborate on pilot studies. This group represents a multi-agency response to address the negative impacts on stream function caused by this non-native, competitive dominant riparian species, and has active representation from NYSDOT, The Nature Conservancy, National Park Service, DCSWCD, the Army Corps of Engineers, the Invasive Plants Council of NYS, and the Delaware River Foundation. The workshop sponsored by DEP and others brought together representatives of the cooperating organizations who shared their experience and agreed upon a set of future activities. This effort has resulted in the publication of a jointly published educational pamphlet "Knotweed: Spread the Word, Not the Weed." Additionally these interactions have expanded our network of cooperation and supported the delivery of a consistent message to stakeholders concerned about this invasive plant.

Extending technical assistance for project planning and review, on both FAD and non-FAD projects, has become a significant area of responsibility for the SMP during the past few years. DEP has stepped up to address this need because the number of professionals in our region with training and experience in river process-based project design is limited. This partnership has advanced institutional coordination significantly. In some cases, our local partners in the contracted development of management plans have invited us --outside the scope of those contracts— into other projects they were coordinating on behalf of their constituents, such as:

- the South Street and Terrace Avenue channel stabilization projects (DCSWCD, on behalf of the Village of Walton)
- Esopus Creek above McKenley Hollow (UCSWCD and NRCS)

In several projects, we were invited in by state agencies to provide technical assistance or review of work that they were initiating or reviewing:

- Herrick Hollow Creek at Richardson Hill Road Landfill Superfund Remediation Site (NYS Attorney General's office invitation)
- Lake Switzerland Dam removal (DEC Dam Safety, DCSWCD)
- NYS Route 214 / County Line stream work (NYSDOT invitation)
- Review of Emergency Watershed Protection projects (NRCS invitation)
- Andes Highway Garage, Tremper Kill (CWC and DCSWCD)

In our 2004 program evaluation report, DEP cited its improved coordination with other BWS Divisions as a major indicator of progress. During the past two years, this integration has continued as described below in the following ways.

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1) Greater involvement in DEP Engineering's review of NYSDEC Article 15 Stream Disturbance Permits applications which include a wide range of stream-related activities initiated by streamside landowners. Stream Management Program staff have:
   - Regularly provided comment on Stream Disturbance Permits and
   - Support the use of regional hydraulic geometry curves (See goal 5) by DEP Engineering staff as part of this review process.

2) Greater involvement in review of DEP Operation's stream-related infrastructure protection projects. These represented an opportunity to extend our approach to DEP Operations on agency projects, and included:
   - Chestnut Creek / Route 55 stabilization
   - Gooseberry Creek Sewer Line Crossing restoration
   - Allen Brook Sewer Line Crossing restoration
   - DEP bridge replacement contract (Bushkill Bridges)
   - Ashokan ReservoirWaste Channel Reactivation

3) Closer coordination within our the Division of Watershed Lands and Community Planning with the following projects and programs:
   Land Management
   - Stony Clove Creek Streamside Planting Project
   - Ashland connector stream restoration demonstration project
   - Lower West Kill DEP Property bank failure
   - Michellotti property on Esopus Creek
   - West Branch – Boyd's Corners Stormwater Remediation Project

   Community Planning
   - Tannersville Bike Path on Gooseberry Creek
   - Bull Run stormwater retrofit project

   Land Acquistion:
   - Red Falls stream restoration project

   Agriculture and Forestry
   - Coordination on the preparation of educational materials

- Review of CREP related stream bank projects

Another avenue of extension is the development of interagency MOUs that direct joint resources to implementation of recommendations in the plans during and following flood emergencies. In 2005, we began exploring with the NYS office of NRCS the development of an MOU to support post-flood stream projects –design and construction—that use multi-objective restoration practices.

Each of these are examples of the extension of our approach outside our previous programmatic areas. The Flood of April 2005, and our involvement in the response to it, illustrates other activities that have served for advocating our approach to stream management to other agencies, municipalities and individuals. At our initiation, we:

- Provided assistance with damage assessment reporting following the floods
- Conducted aerial flyovers of the Esopus, West Kill, Stony Clove, East Branch of the Delaware, Schoharie and Batavia Kill, and provided summaries of this reconnaissance to county and state agencies (SWCDs, DOT, NYSDEC)
- Participated on the SEMO/FEMA Stream Teams during site visits and facilitated local participation in hazard mitigation planning efforts
- Offered assistance to the towns, county and state on response to specific situations, including the contribution of a local match (12.5%) for federal emergency funding to remove a house that had been washed into the stream in the Town of Shandaken. DEP funding assistance ultimately was not needed to remove the house.

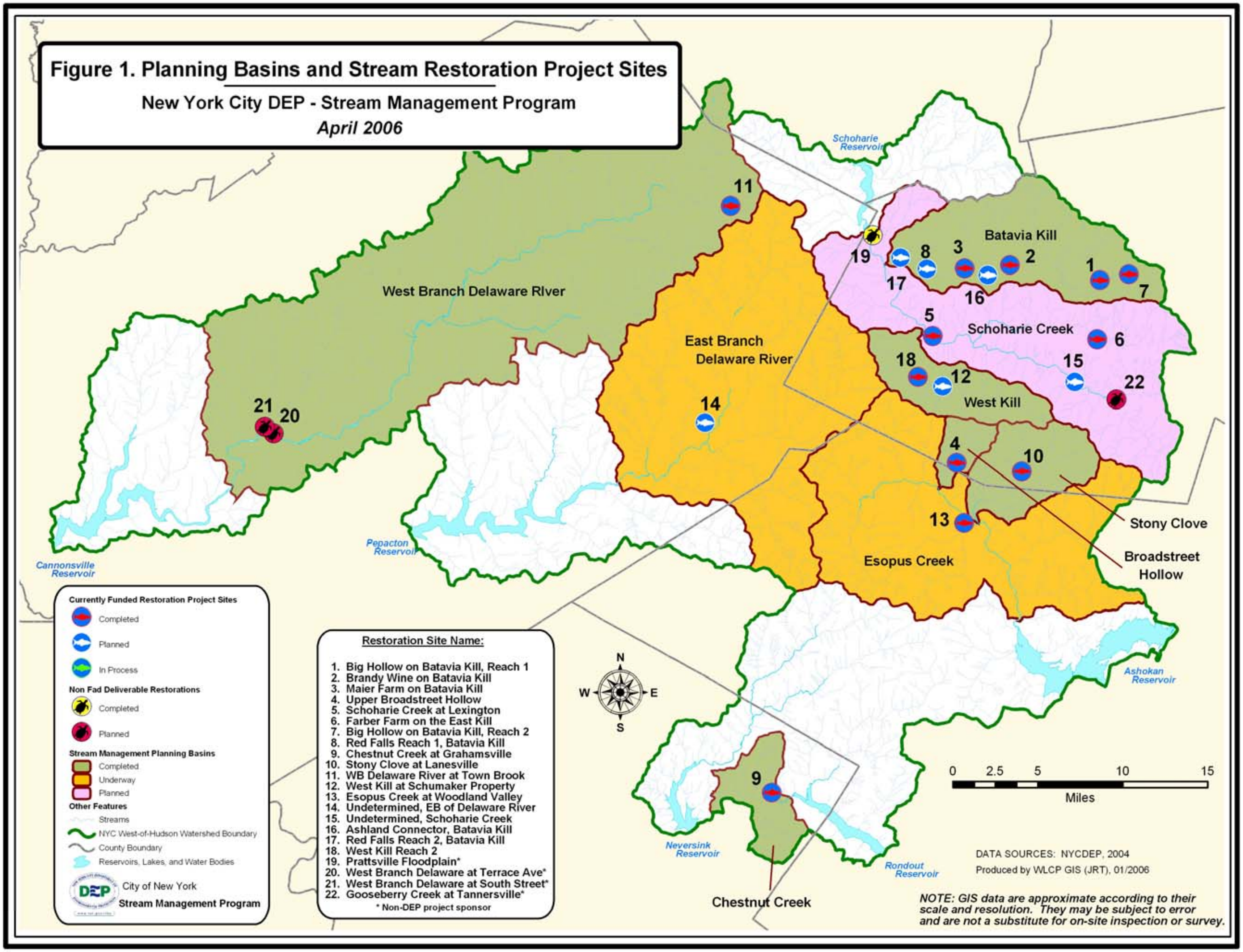
Figure 1. Planning Basins and Stream Restoration Project Sites
New York City DEP - Stream Management Program
April 2006
West Branch Delaware RIver
East Branch
Delaware River
Batavia Kill
Schoharie Creek
West Kill
Esopus Creek
Stony Clove
Broadstreet
Hollow
Chestnut Creek
Schoharie
Reservoir
Pepacton
Reservoir
Cannonsville
Reservoir
Ashokan
Reservoir
Neversink
Reservoir
Rondout
Reservoir
Currently Funded Restoration Project Sites
Completed
Planned
In Process
Non Fad Deliverable Restorations
Completed
Planned
Stream Management Planning Basins
Completed
Underway
Planned
Other Features
Streams
NYC West-of-Hudson Watershed Boundary
County Boundary
Reservoirs, Lakes, and Water Bodies
City of New York
Stream Management Program
Restoration Site Name:
1. Big Hollow on Batavia Kill, Reach 1
2. Brandy Wine on Batavia Kill
3. Maier Farm on Batavia Kill
4. Upper Broadstreet Hollow
5. Schoharie Creek at Lexington
6. Farber Farm on the East Kill
7. Big Hollow on Batavia Kill, Reach 2
8. Red Falls Reach 1, Batavia Kill
9. Chestnut Creek at Grahamsville
10. Stony Clove at Lanesville
11. WB Delaware River at Town Brook
12. West Kill at Schumaker Property
13. Esopus Creek at Woodland Valley
14. Undetermined, EB of Delaware River
15. Undetermined, Schoharie Creek
16. Ashland Connector, Batavia Kill
17. Red Falls Reach 2, Batavia Kill
18. West Kill Reach 2
19. Prattsville Floodplain*
20. West Branch Delaware at Terrace Ave*
21. West Branch Delaware at South Street*
22. Gooseberry Creek at Tannersville*
* Non-DEP project sponsor
N
W
E
S
0
2.5
5
10
15
Miles
DATA SOURCES: NYCDEP, 2004
Produced by WLCP GIS (JRT), 01/2006
NOTE: GIS data are approximate according to their scale and resolution. They may be subject to error and are not a substitute for on-site inspection or survey.

Section 2: Stream Restoration Demonstration Projects and their Evaluation

2.1 Introduction

DEP and our county partners have advocated use of natural channel design (NCD) as an important approach to restoring "stability" and proper functioning condition to a stream reach. The NCD approach is founded in the application of fluvial geomorphic (stream form and function) principles to stream channel restoration and stream bank stabilization. Primary goals of projects have included water quality improvement, infrastructure/property protection (flood hazard mitigation), and habitat enhancement. To date SMP and/or the SWCDs have implemented eleven stream restoration projects demonstrating NCD BMPs through 2006, employing over 40 individual techniques that serve over 20 specific project objectives (Table 4.1). Figure 1. depicts the stream restoration projects completed to date and their distribution. The most recent FAD Assessment Report (March 2006) includes an updated list of the 2002 FAD-required Stream Restoration Demonstration Projects.

There are multiple site specific goals and objectives for these projects, but as a whole two overarching objectives for this programmatic goal are:

1. Testing and evaluating a range of natural channel design (NCD) based approaches to stream work or protection projects that will help restore stream stability and ecologic integrity;
2. Creating a network of sites that can be used as education and outreach tools.

Ideally, the two objectives are mutually supportive, in that, the projects are suitably located, successfully implemented, monitored and documented so each project also functions as a resource for education and outreach. However, the ideal has not often been the case, and though largely successful in meeting these objectives, there have been challenges in implementing projects and utilizing all the projects as an educational network.

Evaluating the success of meeting this goal requires several distinct efforts. First, through various contracts with our SMP partners there are several assessments designed to evaluate the success of the projects at meeting specific project objectives: the sufficiency of monitoring, the necessity of maintenance, the extent of change in gross erosion rates, and the ecologic response. The references provided at the end of this section include papers and reports that examine and discuss the various aspects of selected assessments addressing the above objectives. In addition, the consulting firm Nutter and Associates, Inc (NAI) was hired to perform an independent evaluation of Goal 4 specifically. This report covers the suite of restoration projects undertaken by DEP and its county partners, with some analysis of four projects as case studies. These include Broadstreet Hollow, Esopus Creek at Woodland Valley, Stony Clove at Lanesville, and Town Brook at Post Farm. The NAI report is enclosed as Attachment A. All of this supplemental information and input from our project partners is used in evaluating the status of this goal and associated objectives.

2.2 Range and evaluation of projects and associated BMPs

Projects and individual BMPs have been chosen and implemented as a series of demonstration projects not intended to work together in the landscape, but rather as a program of demonstration of techniques and implementation. This approach allowed SMP and our partners the flexibility to research and apply many different BMPs in differing Catskill Mountain settings, and then to monitor and evaluate each project to determine its success individually. (Table 4.1 lists the range of BMPs used and the objectives served by each BMP.) Whereas this approach limits to some extent evaluation of the cumulative impact of a set of projects on a specific goal or set of objectives on a sub-basin scale, SMP and our partners have learned a great deal about individual BMP techniques, and have been able to apply this knowledge directly to adaptive management and restoration. For example, detailed monitoring of cross-vane structures at early project sites revealed subtle design parameters that resulted in greater amounts of scour than predicted. Slight adjustments in vane arm angles and the slope and height of vane sills in subsequent projects nearly completely solved this problem. Had detailed monitoring not been implemented, failure of selected structures may have been noted but the cause of the failure and the likely solution may not have been evident.

Extensive monitoring efforts focused on evaluating sets of objectives for each project have evolved over time as project goals, objectives and partners have changed. SMP and its partners have worked together toward development, testing and implementation of a set of standardized and repeatable protocols for monitoring and project evaluation.

Reference papers and reports pertaining directly to analysis and evaluation of performance of project reaches and/or BMPs used at these sites include Chen et al., 2005; Chen, et al., 2004; Buck Engineering PC, 2006; and Baldigo, et al., 2005. Work performed by Buck Engineering and USGS (Baldigo) was funded by DEP. Additional research by Chen, et al., was conducted in cooperation with DEP through GCSWCD.

Chen, et al., 2004 and 2005 focused on evaluation of erosion rates before and after restoration in comparison with unstable and stable reaches, and developed a multivariate predictive model for determining change in erosion rates that could be ascribed to restoration projects. Research focused on restoration sites at Big Hollow, Maier Farm, and Brandywine. This research showed that a number of explanatory variables (including bank angle, sinuosity, vegetative cover, mean depth and cross sectional area) are significantly correlated to erosion rates. Greater vegetative cover, and lower width to depth ratio were highly correlated with lower rates of erosion, whereas higher bank angle and lower mean depth were correlated with higher rates of erosion. Finally, applying the predictive model to restoration sites as if restoration were not completed showed significant reduction in bank erosion rate specifically related to the restoration intervention.

Reporting completed by Buck Engineering PC, 2006, summarized and analyzed more detailed and comprehensive morphological monitoring data for the same three restoration sites, with some comparison to pre-restoration condition but without comparison to other sites. This analysis covered both project-wide function as well as in-depth evaluation of specific structures with some recommendations for adjustment of design specifications. In general, the report concluded that overall project function is consistent with design for Maier Farm and Brandywine, with a few specific structural exceptions at individual bank or rock vane locations. Both sites showed variation in evaluated parameters (changes in cross section, bed sediment size distribution, longitudinal profile) within a level of natural variability. In contrast, though sections of the Big Hollow project site appeared to be functioning as designed, Buck found that stability issues that led to three channel avulsions (meander cutoffs during the April, 2005 flood event) were most likely related primarily to planform constraints (belt width was artificially constrained by land use) and sediment supply (very high bedload transport rates). This report did not analyze potential impact of floodplain morphology, though vegetation was noted as an important factor in encouraging further evolution toward a stable condition for this reach. The report also noted the importance of vegetation at Maier Farm and Brandywine, where additional vegetation will be needed to ensure longer term stability, particularly at Brandywine, which appeared to experience somewhat greater variation in sediment transport and localized bank instability, and which is heavily colonized by Japanese knotweed.

Reporting provided by USGS in conjunction with research studies in support of Goal 5, below, included an evaluation of three restoration project reaches with specific regard to fish and macroinvertebrate population dynamics and relation to physical habitat parameters. This analysis made use of comparison with pre-restoration data as well as reaches with reference (optimal or near optimal) condition and control (unstable and untreated) condition. Although this paper is in draft form, initial analysis and conclusions are presented. Findings indicate that biological integrity of resident fish communities in Catskill Mountain streams can be improved by NCD restorations.

2.3 Reach versus Watershed Scale Impacts on Suspended Sediment

Much progress was made during the reporting period in better understanding the relationship between reach scale restoration and suspended sediment loading. Some projects may be able to suppress sediment loading at low to moderate flows on a reach scale. The water quality problem with respect to suspended sediment however is watershed scale, as it is a function of the underlying glacial geology. The stream, in conveying its coarse bedload alternately scours, exposes, and covers the ancestral glacial deposits loaded with clay and silt.

Consider the Upper Esopus Creek watershed for an example of this challenge. In this watershed (and many Catskill watersheds) suspended sediment source location varies in space and time as the stream process continues transporting sediment downstream.

On April 3-4, 2006 the Catskills received the first significant precipitation in over a month (on negligible snowpack). Last year, there was a much more significant rainfall on a moderate snowpack during April 2-3. The resultant flooding last year was catastrophic given how high the antecedent streamflow was from a wet fall and winter. In that event, all but the Beaver Kill and Lower Beaver Kill of the major tributaries flowed in the red-brown of the classic Catskill turbidity. In this recent April runoff the Beaver Kill was a significant source of suspended sediment derived from streambank and hillslope exposures of glacial till and glacial lake deposits. The off/on sourcing is further evident in the case of the Esopus tributaries of Fox Hollow and Bushnellsville Creek. During, and for long after last year's April flood, these two streams ran red-brown where they scoured into the glacial lake silty clay. This year so far they are running relatively clear. Subsequent stream adjustments lead to "self-healing" and some stream maintenance activities worked to help suppress the sediment loading at the flows of the most recent runoff events. Throughout the watershed, the interceding year of several high water events readjusted the stream and adjacent hillslope landscape, modifying the suspended sediment source location magnitude and distribution. Several mapped locations of exposed turbidity sources following the April, 2005 flood have subsequently been covered by coarse sediment, while previously covered sources have been exposed. This "moving target" for suspended sediment sources is characteristic for the entire Schoharie and Ashokan watersheds and is related to how these streams have evolved since the post-glacial period.

There are obvious reaches where stream restoration can have a significant reach scale suspended sediment reduction at low and possibly moderate flows, however, it is important for all to remember that this will be an ongoing watershed scale management issue. Stream restoration practices may help suppress sediment loading at low to moderate flows but given the geology of the watershed, during extreme flood events both stable and unstable reaches contribute, and several new short and long-term sources will be exposed and continue to cause episodic excessive turbidity.

2.4 Use of demonstration projects as education/outreach tools

As stated throughout the discussion on this goal, these projects are intended to demonstrate alternative BMPs that address multiple objectives (Table 2.1). They do this in part by incorporating stream system process into the design. By constructing these projects and monitoring them to evaluate their performance with respect to the project specific goals we endeavor to demonstrate to the public and to stream management agencies an approach that can be used to meet traditional concerns (property and infrastructure protection and bank stabilization) as well as improving the ecologic integrity of the stream corridor. Clearly the key audience for these demonstrations is a diverse group of stream management practitioners that includes state and local agency personnel, state and local highway departments, contractors, and landowners. Each of these audiences has a set of mandates and methods, so education and outreach efforts should be tailored to each audience to achieve the greatest benefits.

Several of these projects are commonly used as organized field trip sites though project location and accessibility for visits has not been a selective criterion to date. Several of the projects are well suited for this purpose (Esopus Creek, West Kill, Big Hollow, Broadstreet Hollow) while others are not (Stony Clove, Maier Farm, Brandywine, and Post Farm). DEP and its project partners have conducted numerous site tours and/or workshops for multiple government agencies, academic institutions, special interest groups, and paper and electronic media.

The primary challenge for public demonstrative use is that most (if not all) of these projects are on private property. In order to fully examine sites like Broadstreet Hollow and Big Hollow, visitors need to traverse several properties. Given that project selection is largely based on addressing concerns that do not factor in accessibility this is a natural outcome.

Another method employed to enable transfer of knowledge and information using these sites includes presentations at meetings of Town Boards, Landowner Associations, Sporting or Conservation Clubs, Project Advisory Committees, and local and regional Workshops and Conferences. The presentations often include extensive use of photo-documentation to show structure and function of different project sites and BMPs. This method is very successful, providing a discrete forum for each group or interest to get a lot of spatial and temporal information very quickly, and to have space and time to ask questions. An additional benefit to this method is that presentation can be made any time of year in any weather conditions, and remote sites or those on private property can be "visited" easily by large numbers of people.

Another key demonstrative aspect of these projects has been the project documentation through websites, project reports, and journal papers. The GCSWCD website provides information on several of the projects they have constructed. Similarly, GCSWCD has sponsored research on some of their projects that has been published in journal articles that reach a nationwide and international audience (Chen, et al, 2004; 2005).

Finally, DEP developed a pilot version of a Stream Restoration Project Database. This database summarizes each of 11 projects, including objectives of each project, location, extent and funding statistics, all BMPs employed with design specifications or other details, permits and agreements required or procured, project partners involved, photographs, and references or links to additional information.

In conclusion, DEP and its project partners believe these demonstration projects have not only been largely successful in meeting project goals and objectives but have laid the foundation for a successful ongoing educational program that can be built upon as this Program goes forward.

List of numbered Project Objectives for use with Table 2.1:

Goal: Habitat Improvement

1 Increase DO
2 Increase instream cover
3 reduce water temperature
4 increase aquatic habitat complexity/cover
5 increase riparian habitat complexity/cover
6 control invasive exotics
7 provide riparian forest habitat
8 provide riparian wetland habitat

Goal: Water Quality

9 reduce fine sediment input
10 pollutant filtering
11 nutrient uptake
12 increase infiltration

Goal: Infrastructure/Property

13 control grade
14 direct flow
15 reduce/control bed scour
16 reduce bank erosion
17 minimize surface erosion (soil loss)
18 reduce flood stage/timing
19 control slope failure
20 preserve/enhance aesthetic values

Table 2.1 Goals, Objectives and Best Management Practices Used in Stream Restoration Projects. Refer to list above for numbered Project Objectives under each Project Goal to match objectives to each BMP.

List of BMPs used, and Objectives each BMP serves

Best Management Practice (BMP)	Objectives that apply to each BMP
cross vanes	1.2.4.13.14.15.16
live fascines	5.7.9.10.11.12.16.17.18
live post	5.7.10.11.16
relief wells	3.20
steel sheet pile wall	13.16.20
clay removal	9
rock vane	1.2.4.14.15.16
w-weir	1.2.4.13.14.15.16
root-wad	2.4
shrub planting	2.3.5.7.10.11.12.16.18
tree planting	2.3.5.7.10.11.12.16.18
dry seeding with annual grasses/Rye	9.10.11.12.17
Mulching	9.17
stacked rock wall	2.4.13.16.19.20
culvert installation	9.14.17
Brush layering	5.7.9.10.11.12.16.17.18
live stakes	5.7.10.11.16
Hydroseeding	9.10.11.12.17
floodplain ponds	8.21
dry conservation seeding	9.10.11.12.17
Willow clumps	2.3.5.7.10.11.12.16.18
sod mats	5.9.10.11.12.16.17
Single MES structural fascine with treated "sleeper" and bank plantings	2.3.5.7.9.10.11.12.16.17.18
Single MES structural fascine with soil tube	2.3.5.7.9.10.11.12.16.17.18
Single MES structural fascine with soil pouch	2.3.5.7.9.10.11.12.16.17.18
joint plantings	21
grassland preparation and planting	2.3.5.9.10.11.18
herbicide treatment and eradication of Japanese Knotweed	6
VRSS	2.3.5.7.9.10.11.12.16.17.18.19.20
Berm Removal	7.12.16.18
Single MES Structural Fascine	5.7.9.10.11.12.16.17.18
Double Cross Vane	1.2.4.13.14.15.16
Cattle Crossing	9.13.15
Keyways	
seeding with native warm season grasses	9.10.11.12.17
wetland construction	8.10.11.18
dumped rip-rap	9.16.17
paved rip-rap	9.16.17.19
floodplain drains	12.19
reconstructed natural channel morphology	2.4.9.13.14.15.16.18.20
grassed swale	9.10.11.12.17

Section 3: Development and Distribution of Stream Morphology Databases to Support Decisions, Designs and Project Evaluation

3.1 Introduction

The long-term strategy of the research and data development efforts of the Stream Management Program is summarized in DEP's Long-Term Watershed Protection Program (2002 FAD). In 1996, following reactive regional response to flooding, the DEP initiated a multi-year effort to develop and distribute regional stream morphology databases to support stream management decisions, stream restoration design, and program and project evaluation. This effort is composed of the following set of coordinated data development projects including development of Catskill regional bankfull discharge and hydraulic geometry relationships, reference reach design geometry and fluvial processes database, and monitoring effectiveness of stream restoration demonstration sites. Specific sites and elements of the projects are summarized in Tables presented in past FAD annual reports as well as FAD Assessment reports and will not be repeated here.

The geographic extent of these projects covers the entire Catskill and Delaware watersheds, with monitoring sites in all six reservoir basins, and including three sites outside the NYC watershed (shown in Figures 2 and 3) summarizing reference reach and stream restoration monitoring sites; see also summary map of Stream Management Program Planning Basins and Stream Restoration Project Sites located in this report; see also Miller and Davis, 2003, for regional curve study sites). Specifics of study elements applied to each site are summarized in text sections below.

Reference papers and reports pertaining directly to summary and analysis of data collected in support of this research effort include Miller and Davis, 2003; Baldigo, et al., in press; and more detailed summary of most of the research efforts in NYCDEP, 2005. Work performed by USGS (Baldigo) was funded by DEP through Safe Drinking Water Act, Grant 3. Additional work performed in support of research efforts pertaining to development of regional curves, reference reach databases and evaluation of selected stream restoration project sites was also partially funded through the SDWA.

3.2 Regional Regression Curves of Bankfull Discharge and Associated Hydraulic Geometry

Relationships developed through this study are used to help identify and confirm field indicators of bankfull stage, a necessary first step in any geomorphic stream assessment. SMP's objectives for development of regional curves included distribution within and outside the agency, with the ultimate goal of encouraging widespread use of the curves in reach assessment, project design review, site visits, restoration project design and monitoring. Paper publication of this work was completed 2003 (Miller and Davis, 2003). Additional data were added and reported on in 2005.

Out of the research and database development initiatives to date, DEP has achieved the greatest success in development, distribution and training in regional curve use within and outside the agency. Regional curves were used in watershed assessments by SWCDs in Ulster, Sullivan, Greene, Delaware Counties in support of stream management plan development. Regional curves have also been used in ongoing SMP BMP monitoring; Reference Reach database development; individual landowner site visits; permit and project review; and as one tool in BMP design by project partners.

Outside the agency DEP has encouraged use of regional curves, particularly among partnering agencies, to some level of success. Limited numbers of requests have been received for the curves, most of which occur shortly following workshop presentations or meetings focused on regional curve development and use. Organizations and agencies outside the DEP have requested regional curve information, project technical assistance in stream-related projects, or additional information to incorporate into stream management projects or programs, including the Villages of Margaretville, Fleischmanns and Tannersville; Westchester County, Stormwater Management Planning; Environmental Design & Research, P.C., Syracuse, NY (referred by Dave Rosgen); Lu Engineers, Penfield, NY; and Upstate Freshwater Institute, Syracuse, NY. Cooperative projects led from outside the agency, including Catskill Railroad in Arkville (Bushkill and Dry Brook confluence, led by Village of Arkville), Tannersville Bike Path (Gooseberry Creek landslide remediation, led by Village of Tannersville), Prattsville (Schoharie Creek, led by Village of Prattsville) Stream Restoration, and Lake Switzerland Dam removal and site remediation (Vly Creek, led by Village of Fleischmanns), Richardson Hill Road Landfill (Herrick Hollow Creek, led by USEPA) have made use of this information to advise and adjust stream-related projects to accommodate geomorphic principles.

Unfortunately, the DEC regional stream disturbance permitting staff have not begun to use the regional curves for their project reviews. The curves are ideally suited for this purpose and their use by DEC would represent one of the most significant advancements possible in mitigating stream bed and bank disturbances in the Watershed, and would also represent needed advancement in institutional coordination.

Use of regional curves in permit review and project assessment and design work within the DEP has had limited success. Groups within DEP that have requested stream database or regional curve information to inform projects or programs, include EOH and WOH Engineering Design and Review, DWQC Wetlands, WLCP Land Acquisition, Land Management, Community Planning, and Forestry Programs.

Use of regional curve information is still not widespread through all agencies in the watershed, though partnering SWCDs are using regional curve information routinely in project design even without DEP partnership. Even so, these data remain primarily in use within the SMP or in projects with other agencies or groups in which SMP staff are involved. Regional curves have not reached a level of practicability due in large part to lack of sufficient education, outreach and distribution of curve materials to appropriate practical personnel.

3.3 Reference Reach Design and Fluvial Process Database Development

This overarching project seeks to create design geometry and fluvial processes data for up to 15 reference stream reaches and monitor biological and aquatic habitat at the study sites (set currently includes nine sites). Documenting both physical and biological form and function will provide a valuable set of templates for Catskill regional stream stability restoration designs and assessments. This database will also provide the start of an understanding of sediment transport and hydraulic characteristics for stable streams for comparison with unstable streams and project sites. Study of fish population dynamics, associated aquatic habitat, detailed morphology and sediment transport measurements enable better understanding of variability range we can expect in stable stream settings. Reference Reach Design Geometry and Fluvial Process Study final report is due in 2007. Interim reporting with initial data analysis and findings was completed in 2005 in a paper with USGS (SDWA, 2005). Although the USGS paper is in draft format, initial analysis and conclusions regarding habitat conditions and fish population studies confirm reference reaches appear to maintain relatively low variability and high function, suggesting a level of “stability” in these reaches year to year.

3.4 Monitoring Effectiveness of Stream Restoration Projects

This research project seeks to monitor the effectiveness of stream restoration demonstration projects installed on three unstable stream reaches, and compare findings to the same monitored information at six control sites (three stable and three unstable sites), over a five year period. Evaluation includes analysis and comparison of post-construction adjustment of its fish population, geomorphic stability and aquatic habitat. A total of five construction projects with unstable and stable control and reference reaches have been monitored and analyzed throughout the last 4 years (total of 15 sites). This project was scoped to provide an Interim Report in 2007. Interim reporting has been provided in part through Batavia Kill Post-April Flood Reports and USGS papers documenting preliminary results of fish and habitat data related to restoration and control sites (SDWA, 2005). Although USGS papers are in draft form, initial analysis and conclusions are presented. Findings indicate that biological integrity of resident fish communities in Catskill Mountain streams can be improved by NCD restorations.

This spatially complex study design has required an intensive data collection effort. Locating stable reference reaches has proven problematic; so, reference reaches used in BMP comparisons have largely been limited to a biological reference. These biological reference reaches demonstrate reference fishery and habitat conditions but do not necessarily represent a geomorphic stable reference match for the project site. Unstable, untreated control reaches have been easier to find, however one of the control reaches appears to be in recovery, potentially skewing the results. Similar logistical issues as described above for reference reaches apply to measurements for this set of monitoring sites. Additionally, recovery periods for project sites (required time for sediment to reach a stable bed form and vegetation to become established and selfsustaining) have been longer than anticipated, and have been exacerbated by a series of extreme flooding events following construction. Perhaps the biggest challenge to putting together this database has been delay in completion of construction projects due to weather (floods) and regulatory (de-watering requirements) constraints. Two of the projects included in the study were just completed in 2005 (Stony Clove and West Kill), so will require two additional years of monitoring beyond the anticipated completion date.

3.5 Erosion and Scour Monitoring

This research project seeks to monitor rates of streambank erosion and stream bed scour at up to 11 stream reaches in support of projects described above. This project is not a separate project as originally scoped in 2001. As an alternative and at the advice of the Advisory Board, the SMP decided to scale the study back to a monitoring effort at five of the reference reaches and three treatment and three associated control reaches. SMP has developed and piloted methods to measure scour and fill activity at these reaches starting in 2002. This project is currently scoped to provide detailed interim reporting with data analysis and interpretation in 2006.

The biggest challenge to implementing a scour measurement protocol has been tailoring a scour chain installation and harvest procedure in coarse sediment typical in Catskill streams. Scour chain procedures employed in other regions of the US are typically used to study scour and fill dynamics in sand or gravel streams. Most Catskill streams are cobble- to boulder-bedded, requiring an entirely new set of equipment and techniques. Following an initial trial period, SMP staff developed and designed an innovative installation apparatus tailored to cobble-bed streams. This methodology was a breakthrough in conducting this type of monitoring with hand labor at remote sites, but remains labor-intensive even while being relatively inexpensive.

3.6 Data Management and Distribution

DEP with support from PAR Government Technologies under SDWA funding are creating a unified database for the storage, maintenance and distribution of regional stream morphology data collected by the Stream Management Program and its program partners. Stream Data Management Project is integrating data collected during the stream assessments, stream morphology surveys and restoration BMP evaluation survey efforts. PAR has designed a geodatabase for use in ArcGIS as well as a set of software tools for loading field survey data into the geodatabase. Additional tools have been created to help organize, analyze and provide reports of the data. DEP has begun loading data into the geodatabase, preparing instructional documents for the users and introducing program partners in Greene and Delaware Counties on its use. The project will enable stream managers to readily access their information from a single, secure repository and conduct analysis spatial and temporal analysis of the data. Additional benefits of the project include the standardization of data management practices amongst the partners and further development of data collection protocols.

DEP's 2004/5Student Conservation Association (SCA) member designed and populated two additional pilot databases. The first is a comprehensive library database including all printed resources maintained by SMP including books, technical journals, video tapes, protocols, conference proceedings and other reference materials. The second includes a detailed summary of 11 completed SMP-partnered stream restoration projects. Details included project summary, goals and objectives, design and structural details, monitoring data, permits required, landowner information, photos and web and other references to project documents. Initial outreach to outside agencies for review, comment and submittal of additional projects for the database, intended to eventually become a sharable tool for agency and public use, was only partially successful and remains the biggest challenge to expanding and distributing this information.

Management plans represent a direct application of principles, methods and data gathered as part of study goals and objectives. As such, public circulation of these documents represents an important venue for distribution of study findings with clear applications. DEP, District partners and USGS make presentations at workshops and conferences based on data and information gathered through DEP projects and programs. Just in the last few years, SMP staff have presented preliminary results and/or applications of regional curve development, watershed and reach assessments, or BMP monitoring methods, at inter-disciplinary forums, meetings and conferences across the country. Additional efforts will continue to be needed to update and distribute data and databases to the appropriate audiences to ensure our information is recognized and used to maximum benefit.

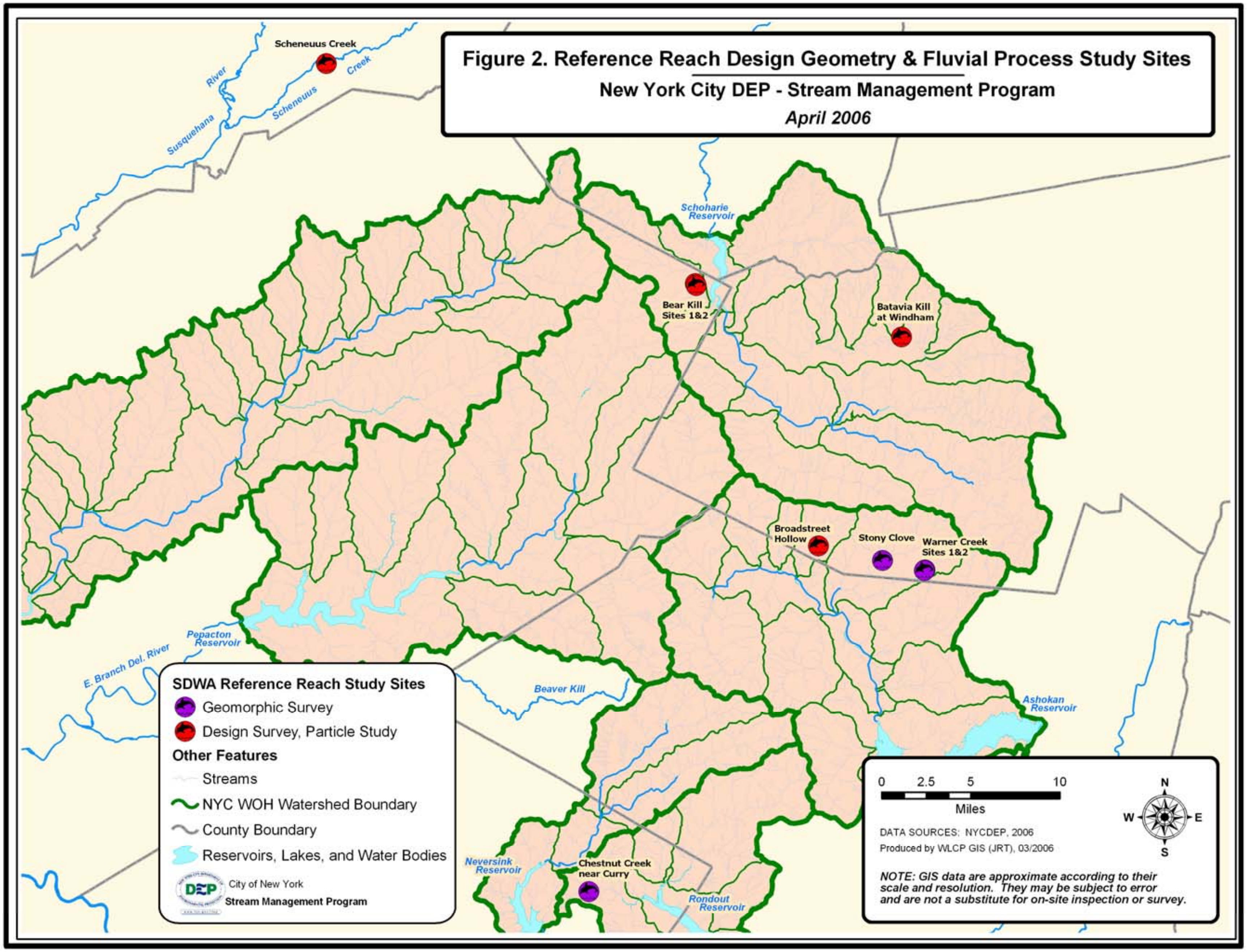
Figure 2. Reference Reach Design Geometry & Fluvial Process Study Sites
New York City DEP - Stream Management Program
April 2006
Scheneuus Creek
Susquehana River
Scheneuus Creek
Schoharie Reservoir
Bear Kill Sites 1&2
Batavia Kill at Windham
Broadstreet Hollow
Stony Clove
Warner Creek Sites 1&2
Pepacton Reservoir
E. Branch Del. River
Beaver Kill
Ashokan Reservoir
Neversink Reservoir
Chestnut Creek near Curry
Rondout Reservoir
SDWA Reference Reach Study Sites
Geomorphic Survey
Design Survey, Particle Study
Other Features
Streams
NYC WOH Watershed Boundary
County Boundary
Reservoirs, Lakes, and Water Bodies
City of New York
Stream Management Program
0 2.5 5 10
Miles
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DATA SOURCES: NYCDEP, 2006
Produced by WLCP GIS (JRT), 03/2006
NOTE: GIS data are approximate according to their scale and resolution. They may be subject to error and are not a substitute for on-site inspection or survey.

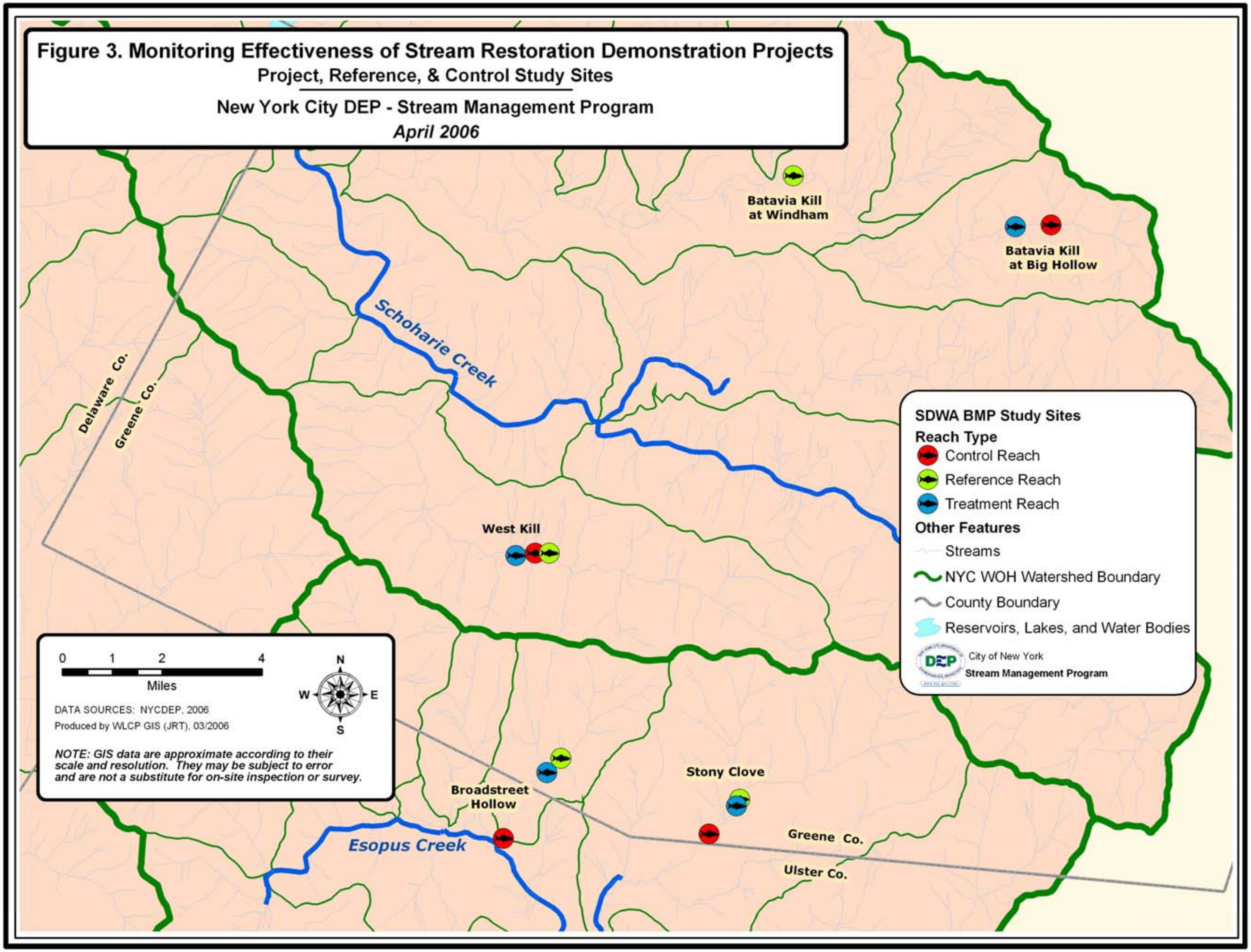

Figure 3. Monitoring Effectiveness of Stream Restoration Demonstration Projects
Project, Reference, & Control Study Sites
New York City DEP - Stream Management Program
April 2006

Conclusion

The DEP Stream Management Program is successfully working to influence the overall approach to stream and floodplain management by engaging stakeholders and managers, demonstrating alternative management practices and communicating results of ongoing research. Although climate and geology are out of our control, given the support of our local partners and the growing strength of the PAC-based approach to management, the Stream Management Program model is demonstratively working.

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TECHNICAL MEMORANDUM NO. 06-005.01

PREPARED FOR: Beth Reichheld
Program Manager, Stream Management Program
NYC DEP

PREPARED BY: Bruce A. Pruitt, Ph.D., P.W.S.
D. Eric Somerville

DATE: April 26, 2006

SUBJECT: EVALUATE AND REPORT ON THE STREAM MANAGEMENT PROGRAM OF NYC DEP

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1.0 INTRODUCTION

1.1 General Overview of Stream Management Program

1.2 Purpose

As stated in the 2002 New York City Filtration Avoidance Determination (FAD), the overall objective of the SMP is to increase stream system stability through the development and implementation of stream management plans and demonstration projects, and to enhance long-term stream stewardship through increased community participation (USEPA 2002, pg. 38).

1.3 SMP Objective

As stated in the FAD, the Stream Management Program (SMP) is to address areas of stream system degradation that has contributed to streambank and bed erosion, and the loss of riparian buffers (all of which contribute to increased turbidity). An overarching goal of the program is to restore stream stability by providing for the long-term stewardship of streams and floodplains (USEPA, 2002, pg. 10). According to the New

York City's 2001 Long-Term Watershed Protection Program, the City is committed to protect, in part, the Catskill/Delaware water supply:

> Through the implementation of more stream restoration projects and the completion of a number of stream management plans. Upon completion of Stream Management Plans, NYCDEP will identify which riparian areas, if any, covered by such Plans are critical to the protection of water quality, and to provide funding and/or other resources to ensure their long-term protection. The City will also conduct a quantitative assessment of its overall efforts to protect riparian buffer areas and develop recommendations and a plan for any needed enhancements or additions to ongoing riparian buffer protection initiatives. The City will coordinate the implementation of the SMP with local Soil and Water Conservation Districts, county planning agencies and other watershed partners which will implement various aspects of this program (USEPA, 2002, pg. 11).

The reader is referred to New York City's 2001 Long-Term Watershed Protection Program for additional information on the multiple goals and objectives of the SMP.

1.4 Objective, This Report

In December 2002, the NYC DEP Stream Management Program developed a Draft Program Evaluation Strategy Outline. The outline identified four programmatic goals supportive of SMP's mission to provide long-term stewardship of streams and floodplains in the West of Hudson Watershed. Following three meetings of the Stream Management Program Advisory Board, a fifth goal was added to the Outline, and the document was finalized in April 2004. The subject of this report is directly related to Program Goal IV of the finalized Outline and is stated as follows:

> Program Goal IV. Implement a range of stream restoration and protection projects demonstrating and evaluating best management practices (BMPs) in priority sub-basins.

Webster's New Universal Unabridged Dictionary defines demonstration as: 1) the act, process, or means of making evident or proving; 2) an explanation by example or experiment; or 3) a practical showing of how something works or is used. Evaluate is defined as: to determine the worth of; to find the amount or value of; to appraise. The following questions are fundamental to the aforementioned goal and definitions: 1) Has a range of both stream restoration and protection projects been demonstrated or made evident or proven by example?; 2) Has a range of both stream restoration and protection projects been adequately evaluated or appraised"?; 3) Have the demonstration projects been adequately utilized for education and outreach (Aa practical showing of how something works or is used)? Fundamental to addressing questions 1 and 2 is to identify the range or limits of natural and anthropogenic variation that currently exists at multiple scales including stream reach, valley reach, watershed, and basin-wide (Catskills).

Consequently, the objectives of this report are two-fold: 1) evaluate whether the range of variation has been adequately addressed; and 2) assess if the demonstration projects satisfactory provide evidence or proof that BMPs can be employed to support the objective of the SMP as stated above in paragraph 1.2.

2.0 RANGE OF DEMONSTRATION PROJECTS

A complete suite of examples of best management projects including demonstration projects has been constructed or such projects are in the planning stages in the Catskill Mountains. Table 1 is a tabulation of those projects included whether the projects were required as part of the FAD or not. Geographically, the projects span several NYC reservoir basins, including the Schoharie, Ashokan, Rondout, Cannonsville, and Pepacton. From a watershed position perspective, representative demonstration projects have been constructed at critical headwater areas to mid-watershed to near watershed outlets. At the valley scale, the projects have been constructed from the steep, V-shaped valleys (Rosgen Type I and II) of the Schoharie and Esopus to the U-shaped, glacial trough valleys (Rosgen Type V) of the Delaware. At the stream reach scale, natural channel design integrated with traditional engineering design and soil bioengineering has been successfully demonstrated in a range of bed material types and sizes, hydraulics, channel slopes, and extreme dynamism associated with stream confluences and high stream power and sediment yield.

Endemic vegetation has been established in stream management zones adjacent to restored stream reaches. Studies have been funded to address the spread of non-native, invasive plants such as Japanese knotweed (*Polygonum cuspidatum*). Geo-technical studies have been funded to address the occurrence, cause and possible remediation of naturally occurring phenomena such as highly dispersive, glacial silt-clay deposits which cause hillslope instability, elevated turbidity, embeddedness and aquatic habitat loss.

3.0 SELECTED DEMONSTRATION PROJECTS

The objective of this report was not to provide a critique of each individual demonstration project completed in the Catskill Mountains, but to identify the range of demonstration projects across watersheds, stream and valley types, and restoration methods. However, the following projects were selected to provide a general synopsis of the problems identified, the variability of specific project opportunities and challenges, restoration design, and monitoring and contingencies.

3.1 Woodland Esopus Demonstration Restoration Project, Ulster County (Construction Dates: August 2003 - December 2003)

3.1.1 Statement of Problem

Erosion, bank failure and subsequent accelerated sedimentation was occurring along approximately 500 feet of the left stream bank on the Esopus Creek immediately upstream of the confluence of Woodland Creek near Phoenicia, Ulster County, New York. Apparently, bank erosion was initiated with an avulsion as a result of the flood of 1996. Prior to restoration, bank erosion was estimated to be 3 feet per year on average and was projected to accelerate if not corrected.

3.1.2 Project Uniqueness and Challenges

The project site posed several natural and anthropogenic challenges. The site was located at the confluence of two streams, Esopus and Woodland Creeks. Generally, confluences are considered the most dynamic of all stream reaches with an increase in active belt width and high potential for lateral migration between stream channels. However, lateral migration had been artificially confined with the construction of Herdman Road, Woodland Valley Road, High Street, Old Route 28, and various residential roads such as Lilly Avenue, Center Street, and East and West Streets. In addition, the Esopus and Woodland Valley bridges have constricted channel flow especially at discharges equal to and greater than the 25-year recurrence interval. The project was further complicated by the construction near the left bank of residential structures which were considered threatened by accelerated stream lateral migration causing bank erosion and failure. The 25-foot high eroding bank was composed of clay rich glacial till overlain with glaciofluvial deposits that hosted septic systems. The till was an episodic source of turbidity and the septic systems were starting which were in danger of compromise from the accelerated bank erosion. In addition to site specific challenges, surface water is discharged to the Esopus approximately 3 miles upstream of the project site from a trans-basin diversion from the Schoharie Reservoir. Consequently, the hydrologic and hydraulic design of the project required an accurate account of discharges from not only the Esopus and Woodland Creeks but also variation from the trans-basin diversion. In addition to stream stability objectives, the project reach provides recreational opportunities for fishing, boating, and aesthetics as a viewscape.

3.1.3 Stream Assessment

Prior to restoration design, several studies were undertaken including interpretation of historic aerial photography, a qualitative sediment and source assessment, hydrologic analyses of USGS gage records, and a modified Rapid Bioassessment Protocol(USEPA) at the watershed scale. At the reach scale, twelve cross-sections and a longitudinal profile were surveyed, Wolman pebble counts were conducted, and hydraulic regional curves developed by NYC DEP were utilized and confirmed. Hydrologic and hydraulic data and sediment data reduction, analyses, and interpretation included flood frequency and flow duration analyses, resistance coefficients, shear stress, sediment transport, and HEC-RAS modeling to conduct current and projected backwater analyses prior to and following restoration.

3.1.4 General Restoration Design and Corrective Actions

Four alternatives were considered to reduce bank erosion and failure along a 500-foot stream reach including: 1) no action; 2) stabilization using a retaining wall; 3) stabilization using a rip-rap section; and 4) reach restoration. The feasibility, risk and effect of the alternatives were compared and as the preferred alternative, a complete reach restoration (alternative 4) was selected. Alternative 4 represented an integration of natural channel design with traditional engineering and soil bioengineering. Alternative 4 also included reconstruction of an active floodplain. Probably the most aggressive bioengineering method utilized during bank stabilization was the construction of a Vegetation Reinforced Soil System (VRSS) along the left bank adjacent to residential structures. Conventional methods were used to restore the stream channel including two rock weirs and three rock vanes, along with intermittent bioengineering techniques including live fascines and posts.

3.1.5 Post-Construction Monitoring and Contingencies

A comprehensive monitoring protocol was developed to measure the anticipated response of the stream system following restoration. The objective of the monitoring protocol is to evaluate the effectiveness of the restoration in providing stream channel stability. Quarterly visual inspections are conducted during low flow conditions using a standardized form which included hydrologic and channel conditions, structural integrity of in-channel structures, floodplain status (scour or deposition), rip-rap condition, soil bioengineered slope conditions and vigor (VRSS), and growth and vigor of fascines, live stakes, and container-grown plantings. Traditional channel geomorphological measurements are routinely conducted to characterize changes in planform, bedforms and cross-sectional geometry. It was also recommended that topographic maps be generated from total station land surveying. A photographic record is also maintained.

In August 2-3, 2005, a greater than 50-year recurrence interval flood event occurred (estimated at 35,000 cfs) and resulted in several changes to the project reach. However, the primary objectives of the stabilizing the stream into one channel and protecting the eroding bank were sustained. Below the confluence with Woodland Valley Creek, the channel alignment changed by shifting to the right bank which resulted in the total loss of one of the rock vanes and weirs. In August 2005, additional rock was placed at three locations: rip-rap on the lower left bank, paved stone and chinking rock on the upper left bank, and additional rock for the stone channel block.

3.2 Stony Clove Demonstration Restoration Project (Greene County) (Construction Dates: July 2003 - November 2005)

3.2.1 Statement of Problem

The left backslope of Stony Clove Creek was severely eroding due to high near bank shear stress exacerbated by a mid-channel bar. The bank was over sixty feet high, composed of highly erodible fine material, and extended for approximately 1,700 feet. Mass wasting combined with surficial hydraulic erosion had contributed to high erosion, bank failure, and ultimately, accelerated sedimentation and downstream transport of fines. Following the flood of January 1996, a landowner had bermed, to a maximum height of 15 feet, approximately 800 linear feet of the right floodplain opposite the falling hillslope, confining flood flows and further increasing local shear stresses at the toeslope. Consequently, water quality in the form of increased suspended load and sediment yield had threatened downstream habitat and the natural form and pattern of downstream river reaches. Based on pre-project observations, if corrective actions were not performed, slope failure would have continued both laterally and longitudinally both upstream and downstream.

3.2.2 Project Uniqueness and Challenges

This restoration project offered a unique opportunity to restore a highly cut and eroded backslope along a relatively short stream reach. The challenge was related to the height of the backslope and the reduced channel capacity due to floodplain modification on the right valley.

3.2.3 Stream Assessment

Fluvial geomorphic methods and protocols were utilized for restoration design including cross-sectional and longitudinal profiles, channel planform, Wolman pebble counts, and critical dimensionless shear stress calculations on both the reference and project reaches. In addition for comparison and evaluation, bankfull discharge was calculated using several regional hydraulic curves including the southeast Pennsylvania curves (Leopold reported in Rosgen, 1998), the Catskill Mountains (complete data set and stratified subsets), and USGS full and short regression equations (90-4197, Lumia).

3.2.4 General Restoration Design and Corrective Actions

In order to stabilize the stream channel and severely-cut, left backslope, four cross vanes and five rock vanes (deflectors) were constructed at predetermined locations to reduce near bank shear stress, provide grade control, and improve bedforms and habitat diversity. In addition, the stream channel was re-aligned and an active floodplain was constructed along the edge of the left backslope. Stream channel capacity was designed at various recurrence intervals and discharges along gently sloped banks stabilized with native cobble and small boulders to increase roughness. Approximately 20,000 cubic yards of material was removed from the active channel and replaced with coarser material. Vegetative treatments included 3,200 linear feet of willow fascines, 1,500 live willow posts, and >4,000 potted trees of several dozen species. Experimental treatments of the fascines included three mulch treatments applied with a hydroseeder into the fascine trenches to improve moisture retention.

3.2.5 Post-Construction Monitoring and Contingencies

As-built cross-sections were established at nine monumented stations, from which a thalweg profile was derived to monitor changes in the longitudinal profile. A monitoring plan and protocol was established for sampling survival and growth of planted vegetation.

3.3 Town Brook (Post Farm) Demonstration Restoration Project (Delaware County) (Construction Dates: 2004)

3.3.1 Statement of Problem

The stream channel was deeply incised with vertical banks (F channel) and severe erosion and evidently, bankfull discharge was decoupled from its historic floodplain. Bedforms and subsequently aquatic habitat diversity were limited to runs and riffles with very few shallow pools. The severe erosion and inadequate aquatic habitat resulted in poor trout production and degraded water quality downstream due to increased suspended sediment yield and accelerated sedimentation.

3.3.2 Project Uniqueness and Challenges

The demonstration project provided a unique opportunity to integrate stream restoration with riparian buffer enhancement in an agricultural (dairy farm) setting. The project required coordination with the Watershed Agricultural Program for the establishment of a riparian buffer and livestock exclusion under the Conservation Reserve Enhancement Program (CREP). Livestock exclusion required the integration of stream restoration BMPs with a concrete cattle crossing. In addition, the project sought to improve fish habitat for a landowner who was interested in granting public fishing access to the property.

3.3.3 Stream Assessment

Traditional methods and protocols were utilized for restoration design including cross-sectional and longitudinal profiles, channel planform, and Wolman pebble counts on both the reference and project reaches.

3.3.4 General Restoration Design and Corrective Actions

The project is approximately 1,200 linear feet with nearly nine feet of vertical fall. Two local reference reaches were identified and measured for comparison against empirical equations. In general, the planform design was based on the historic alignment as it appeared on 1943 aerial photography. However, design meander arc and radii and the shape and depth of the riffles and pools were calculated using the Hey-Thorne equations. Three types of rock vanes were constructed on the project: cross vanes, single vanes, and a double vane structure. In addition, a single log cross vane was constructed at the outlet of a small unnamed tributary to Town Brook. The design also included a rock lined riffle and excelsior matting near the culvert outlet, excelsior matting for erosion control on the top of the bank, and live willow stakes at the top of the vane arms. A series of pre-cast concrete slats were installed for a cattle crossing across the constructed stream channel and fencing was designed with adequate setbacks from the belt width of the stream corridor.

3.3.5 Post-Construction Monitoring and Contingencies

During the construction phase, NYSDEC raised concerns about fish passage in regard to the excessive height of several of the cross vanes constructed on the project. In order to accommodate fish passage over the vanes, notches were cut into the throat rocks to lower the jump height to an acceptable limit.

DCSWCD sought to correct the design for subsequent vanes constructed later in the project by increasing pool depth below the vanes and improving pool spacing between vanes. DCSWCD believes this design modification has improved fish migration. Additional adjustments, involving the construction of horseshoe vanes below four of the vanes to accommodate fish passage are currently being considered pursuant to recent requests from the DEC and ACOE.

3.4 Broadstreet Hollow Demonstration Restoration Project (Greene County) (Construction Dates: 2000-2001)

3.4.1 Statement of Problem

Severe channel instability and property loss resulted from a major flood in 1996. In places, the channel migrated laterally over 30 feet and the channel incised considerably. The problem was aggravated by grading activities during emergency repairs exposing glacial clays. Headward downcutting and degradation of the stream channel continued causing additional erosion and bank failure. The adjacent hillslope was exhibiting movement apparently in association with an "artesian mud boil" that formed at a groundwater discharge point in the stream channel. High concentrations of dispersive, glacial clays were discharged to the stream through this boil.

3.4.2 Project Uniqueness and Challenges

The project site posed several natural and anthropogenic challenges. The Broadstreet Hollow Demonstration Project was a unique undertaking to not only restore the natural planform and dimension of the stream but also to conduct geo-technical investigations on artesian mud boil and unstable adjacent hillslope. The results of the investigation could have application and ramifications to exposed glacial clays elsewhere in the Catskill Mountains. The challenge was to restore the stream channel in a belt width which was confined by residential structures while addressing the highly dispersive glacial clays entering the stream.

3.4.3 Stream Assessment

Fluvial geomorphic methods and protocols were utilized for restoration design including cross-sectional and longitudinal profiles, channel planform, and Wolman pebble counts on both the reference and project reaches. In addition, a geo-technical investigation was conducted on the local groundwater adjacent to the artesian mud boil.

3.4.4 General Restoration Design and Corrective Actions

Based on reference and historic conditions, the stream channel was re-aligned to a more natural planform and dimension. Grade control and reduction in near bank shear stress was accomplished by a series of rock vane (deflectors) and cross vanes. In an attempt to relieve the potentiometric head differential, groundwater relief wells were installed at strategic locations immediately upgradient of the mud boil. A stream riparian zone was developed by planting various trees, shrubs, and deep rooted grasses. A short section of sheet piling was required near the project's terminus to protect a home on the stream bank.

3.4.5 Post-Construction Monitoring and Contingencies

As part of a larger research and data development contract, the USGS has been conducting detailed physical habitat and biomonitoring studies at this project reach, at a stable reach used during project design, and an unstable control reach in a similar setting. DEP and Greene County SWCD have maintained a yearly monitoring program, including re-surveys of cross-sections and longitudinal profiles through the same set of reaches. In addition, the Greene County SWCD and DEP have completed a brief flood monitoring report following the April 2005 storm flood event. The report included a detailed damage report and recommended remediation.

4.0 PROGRAM EVALUATION

4.1 General

Partnering with the SWCDs and other stakeholders, the SMP has successfully participated in and overseen the construction of stable reaches within several basins in the Catskill Mountains. The SMP, SWCDs, and other participating stakeholders and collaborators should be commended on successfully demonstrating their ability to work cooperatively as a team in exceeding the requirements of the FAD and Goal IV with respect to the demonstration of stream restoration projects including streambank stability, best management practices, riparian zone restoration, and enhancement of aquatic refugia. The successful completion of several demonstration projects in the Catskill Mountains has been "made evident or proven by example" by the aforementioned unique and challenging projects. The demonstration projects represent a range of riverine settings across the Catskills including various watershed positions, valley types and slopes, geology, soil associations and bed materials, riparian vegetation, restoration methods, soil bioengineering, and multi-objective management strategies. Future demonstration projects could include innovative stream channel design and restoration at transportation corridors at bridge and culvert crossings. In addition, new and innovative methods could be directed at reducing stream bank erosion at the reach scale which would include cooperation with local landowners.

Pre- and post-restoration data acquisition at reference and project sites has been extensive including, but not limited to, interpretation of aerial and on ground photohistory, cross-sectional and longitudinal profiles, use of GIS coverage, LiDAR coverage and contouring, AutoCAD generated construction drawings, details and schedule of materials, use of regional and subregional hydraulic curves, erosion and scour rates, GPS walkovers, full Level II Rosgen assessments, geo-technical investigations, and sediment yield and loading rates.

4.2 Specific Evaluation and Recommendations

4.2.1 Restoration Methods

Considering the magnitude and frequency of intense storm events over the past decade in the Catskills, stream channel design and restoration should not only accommodate the bankfull event, but should also be capable of withstanding peak discharges during 25-year and higher storm events. In narrow V-shaped valleys, instream structures should not only be designed to accommodate the bankfull discharge and channel dimensions, but also should consider critical low flow for fish passage and peak discharges, as well. For instance, cross vanes and seals should be designed to withstand a minimum 25-year storm event even if it necessitates extension of the cross vane arms to the backslopes to prevent flanking. In essence, the channel capacity and associated floodplain should be designed to accommodate two and sometimes three discharges:

baseflow, bankfull, and peak flows. Presently, research studies in the Catskills are underway to address future design considerations related to peak discharges and bank erosion problems that may or may not be related to size and orientation of cross vanes as discussed below.

Currently bank erosion is occurring immediately upstream of some cross vanes. Has the bank erosion and failure problem been translocated upstream? Is the effect related to the orientation of the cross vane (see discussion below)? If the assumption is made that the channel capacity at the cross vane is not able to withstand storm events greater than the bankfull event, then the vane itself is contributing to a backwater, eddy effect and bank erosion immediately upstream during peak storm events. Future designs should account for the displacement of surface water by the large rocks being using in cross vane construction. In addition, while cut, cubic rocks obtained from rock quarries may be ideal for use as footers, they are inappropriate for deflectors in most cases. In other words, the "A" and "B" surfaces of the BFR (Big Flat Rock) can be in paralleling planes. However, the preferred deflector rock should have "C" surfaces in multiple, non-parallel planes to improve the functional efficacy in redirecting flow and fish passage. The practice of utilizing native rocks that exhibit natural subangular blocky structure should continue, and native rock also provides ancillary aesthetic value. Finally, future restoration design within high energy/high stream power valleys and stream reaches could include an integration of natural channel design with traditional engineering practices and aggressive soil bioengineering, as appropriate. Such flexible hybrid approaches to stream restoration based on site specific conditions, aggressive vegetation implementation both within the stream channel and in the riparian corridor, and adaptive management will further progress program goals.

Given that several large cross vanes have been constructed along stream reaches, the orientation of the cross vane with respect to not only the realigned constructed channel but also the valley needs further exploration and research. For example, how does the orientation of the cross vane with respect to the valley effect natural lateral migration of the stream within its belt width? How does the orientation effect surface water hydraulics both upstream and downstream during peak storm events? Currently, the Greene County SWCD is conducting research studies related to the size and orientation of cross vanes in regards to the effects of bankfull and higher discharges on bank stability upstream and downstream of cross vanes.

The first step in a holistic approach to riverine corridor restoration is re-coupling bankfull and higher discharges to the historic floodplain and restoring riverine ecosystem integrity. A suite of riverine and floodplain/wetland functions related to hydrology, water quality, food chain support, and habitat should be identified during the planning stages of riverine ecosystem restoration. Even in steep, V-shaped valleys that exhibit limited valley flats, the upland riparian zone provides numerous terrestrial functions and export to aquatic systems. River restorationists and practitioners should recognize functions and values related to riverine ecosystem integrity and evaluate improvements in ecosystem functions. When appropriate, the SMP should collaborate with regional wetland scientists, as well as other stakeholders, to form riverine ecosystem management committees or teams committed to restoring, protecting and managing whole riverine ecosystems and corridors. Consideration should be given not only to the wetted surface of the stream channel and its banks, but also adjacent upslope terraces and valley backslopes.

In areas where the valley flat is adequately sized, several projects have incorporated use of existing or constructed floodplains with the stream channel design. However, floodplain construction should also include construction of a levee that sets the grade at bankfull or a design overflow supportive of specific functions or goals. Levee refers to the top of the channel bank where incipient flooding of the adjacent active floodplain occurs during bankfull events. A levee is not a berm. Berms decouple bankfull discharge from the active floodplain and generally reduce overbank flood events. A properly designed levee not only stabilizes the bank and prevents flanking around in stream structures such as rock vanes and cross vanes, but it also is supportive of hydrologic processes on the adjacent valley flat, such as short-term and long-term surface water storage important in water quality and aquatic biota functions. For example, the Conine project planned on the Batavia Kill will provide an excellent opportunity to construct an active floodplain along the right stream channel and valley.

Many of the restored reaches have inadequate coarse wood debris in various stages of decomposition. Coarse woody debris provides several functions including a niche and habitat for a wide variety of aquatic macroinvertebrates and periphyton, not to mention fish. Mature, intact riparian zones naturally contribute coarse woody debris to adjacent stream systems in the eastern United States. However, this process may be interrupted for decades on restored streams where riparian zones are often immature. When appropriate, future stream designs should include the incorporation of large woody debris (LWD) such as root wads, log J-hooks, log weirs, and in limited situations, log revetments.

Considering entrainment, mobilization and transport of high dispersive, glacial clays is contributing high concentrations of suspended sediment and embeddedness, research funds should be directed toward addressing this chronic problem (e.g., observations made on the Esopus River and Woodland Valley Creek). Nutter & Associates hypothesize that on the long-term, these naturally occurring clays may be contributing upwards of 70 percent of the suspended load (annual basis) in Catskill mountain watersheds where glacial till clays have been exposed. Sediment yield studies could be conducted in representative watersheds (e.g., Woodland Creek, Batavia Kill) during baseflow and near bankfull conditions. Clear and concise objectives and statistical analysis should be established. However, a study design that addresses relative contributions of suspended sediment originating from upslope sources including mass wasting and road ditches versus in channel sources should be a priority. Currently, a study is underway in the Esopus Creek watershed to address various contributions of fluvial sediment and deposition.

Based on past and ongoing studies, an aggressive Japanese knotweed (*Polygonum cuspidatum*) control program, based on a feasibility investigation, needs to be initiated. On the short-term, knotweed could be controlled by utilizing an EPA-labeled herbicide for use around surface waters. However, previous studies suggest that there is a direct relationship between knotweed invasion and disturbed stream bank and riparian zones. Consequently, once this cause and effect relationship is fully understood, a long-term eradication strategy should be developed that concentrates on treating the problem not the symptoms. For instance, we recommend expanding the planting of riparian buffers to include stream management zones that are not necessarily experiencing large-scale erosion and bank failure. In other words, effort and resources should be devoted to fixing small problems before they become big ones. Obviously, this passive method of stream bank and riparian zone restoration provides a fantastic opportunity for public involvement and education. The SMP and its partners should continue developing an aggressive Japanese knotweed control and management strategy.

4.2.2 Education and Outreach (Stewardship Evaluation)

Undoubtedly, word of mouth can be your best friend or worst enemy, especially in the small townships and villages in the Catskills. Brochures, partnership publications, and internet sites provide an important means of informing the general public on the values and benefits associated with stream restoration and river ethics. In addition, the value and goodwill generated by meeting an individual or group streamside cannot be overemphasized. The SMP, SWCDs, and other stakeholders should continue and expand upon fostering and maintaining a strong and active relationship with the general public.

Now that several stream restoration projects are complete, restoration projects that are located in highly visible areas or viewsheds should be equipped with self-guided interpretative trails along greenways with kiosks at strategic locations. The SMP, SWCDs, and other stakeholders should coordinate frequent group excursions including school groups to these streamside trails. Once properly trained, science teachers from local schools and adjacent property owners should be encouraged to lead the guided tours.

The SMP and SWCDs should coordinate and design a multi-objective and multi-use “riverine recreation park” that integrates interpretative trails, a snorkeling area with a kiosk that describes fish and herptiles that may be viewed underwater, a boat launch, and an ice skating rink in a borrow pit within the floodplain with an E channel inlet and outlet. The ice skating rink could be equipped with a sediment detention and removal basin designed to capture stormwater runoff. The participating village or township could provide matching funds and hold the conservation easement on the facility.

The SMP and SWCDs should continue to partner with property owners and encourage them to attend public meetings and share their testimonies with neighbors. The DEP should continue to provide financial support for education and stormwater programs in the watershed. The SMP should provide priority areas (sensitive riparian zones) to the Land Acquisition and Stewardship Program (NYC Watershed MOA, 1997).

Table 1. Summary of BMP projects associated with the Stream Management Program. Prepared by DEP SMP, March, 2006.

BMP	FAD REQ'D?	DATE	DESCRIPTION
DEP funded and sponsored projects in partnership with SWCDs, other DEP Programs, Villages or Towns			
1. Schoharie Creek at Lexington (Schoharie Basin)	No	1997	Streambank Stabilization using floodplain bench, W-weir, rock vanes and willow vegetation. 500 linear feet of main stem Schoharie Creek.
2. Maier Farm on Batavia Kill (Schoharie Basin)	No	1999	Full natural channel restoration of approximately 1800 linear feet.
3. Brandywine on Batavia Kill (Schoharie Basin)	No	1999	Full natural channel restoration of approximately 3500 feet.
4. Farber Farm on East Kill (Schoharie Basin)	No	2001	Full natural channel restoration of approximately 3000 feet as part on a participating farm to the Watershed Agricultural Program (WAP)
5. Big Hollow on Batavia Kill (Schoharie Basin)	Yes	2001, 2002	Full natural channel restoration of approximately 5200 feet.
6. Broadstreet Hollow (Esopus Basin)	No	2001	Full natural channel restoration of headwater reach, 1300 linear feet.
7. Esopus Creek at Woodland Valley (Esopus Basin)	Yes	2003	Full natural channel restoration of confluence area, approximately 1000 linear feet.
8. Stony Clove at Lanesville (Esopus Basin)	Yes	2005	Full natural channel restoration on Stony Clove, approximately 1800 linear feet.
9. West Kill at Shoemaker (Schoharie Basin)	Yes	2005	Full natural channel restoration on the West Kill, approximately 3100 linear feet.
10. Chestnut Creek at Town Hall Site (Rondout Basin)	Yes	2004	Riparian restoration to enhance bank stability and enhance stormwater runoff infiltration of approximately 300 linear feet.
11. Post Farm on Town Brook (Cannonsville Basin)	Yes	2004	Full natural channel restoration of 1200 linear feet on participating farm in WAP; cattle crossing, CREP, sale of public fishing rights.
12. Beaverkill/Sickler Road planting (Esopus Basin)	No	2002 & Ongoing	Annual planting of riparian buffer and invasive plant removal on DEP lands in Town of Woodstock using students from an educational Upstate-Downstate partnership.
13. Riparian Plantings on Stony Clove (Esopus Basin)	No	2004	Riparian restoration on 3 key properties thought to be able to succeed with vegetation alone that were identified through Stony Clove stream assessment process.

Table 1. Summary of BMP projects associated with the Stream Management Program. Prepared by DEP SMP, March, 2006.

BMP	FAD REQ'D?	DATE	DESCRIPTION
14. Pepacton Hollow on Chestnut Creek (Rondout Basin)	No	2004	Culvert replacement and realignment to account for river process and sediment transport.
Non-DEP Sponsored Projects (DEP advised and in some cases partially funded)			
15. Prattsville Project (Schoharie Basin)	No	2004	Removal of ACOE flood control berm to restore floodplain function below Prattsville to mitigate ice jamming and consequent flooding in Prattsville.
16. Drainage ditch seeding	No	Ongoing	GCSWCD procured hydroseeder under grant from CWC for this purpose & to seed road and stream restoration projects – some seeding of ditches in Batavia Kill watershed has been done and more is proposed by GCSWCD for implementation phase of stream management plans.
17. Gooseberry Creek (Schoharie Basin)	No	2005	Streambank stabilization using hybrid approach – stacked rock wall, cross vanes, rock vanes.
18. Terrace Avenue, West Branch Delaware River (Cannonsville Basin)	No	Future	Streambank stabilization
19. South Street, West Branch Delaware River (Cannonsville)	No	Future	Streambank stabilization and potentially floodplain restoration
Upcoming DEP Projects			
20. Rama Project (Cannonsville)	No	2006	Stabilize streambanks on Rama Farm, a participating farm in the WAP, to provide eligibility for participation in CREP
21. West Kill at RCH Stables	Yes	2006	Hybrid natural channel design and bank stabilization on eroding bank of horse pasture.
22. Ashland Connector on Batavia Kill (Schoharie Basin)	Yes	2006	Full natural channel restoration on approximately 3600 linear feet.
23. Red Falls on Batavia Kill (Schoharie Basin)	Yes	?	Geotechnically, archaeologically complex project. City is attempting to purchase land to streamline geotechnical assessment and restoration process.
24. Conine on Batavia Kill	Yes	2007	Design yet to be developed; likely to be a full natural channel restoration addressing complex

Table 1. Summary of BMP projects associated with the Stream Management Program. Prepared by DEP SMP, March, 2006.

BMP	FAD REQ'D?	DATE	DESCRIPTION
(Schoharie Basin)			geotechnical issues on adjacent hillslope.
25. East Branch Delaware River Demo Project (Pepacton Basin)	Yes	2007	Project is yet to be determined.
26. Schoharie Creek/East Kill Demo Project (Schoharie Basin)	Yes	2007	Project is yet to be determined.
27 ~ 30. CREP-Eligibility Projects (Cannonsville Basin)	No	Ongoing	As per project 20 (Rama), DCSWCD is funded by DEP-SMP to bring a handful of farms into eligibility for CREP by stabilizing streambanks using river process principles.
31. Grahamsville Little League Park Planting Project (Rondout Basin)	No	2006	DEP-SMP and DEP-Land Management partnership to plant riparian borders along the Rondout Creek adjacent to a little league park that DEP owns but the Town of Neversink is licensed to use and maintain. Plantings by student partnership and town labor.
32. Chestnut Creek Route 55 -- Streambank Stabilization (Rondout Basin)	No	2008	DEP may partner with DOT to address a failing bank on DEP property where DEP infrastructure is also threatened.