West Branch of the Delaware River
Stream Corridor Management Plan

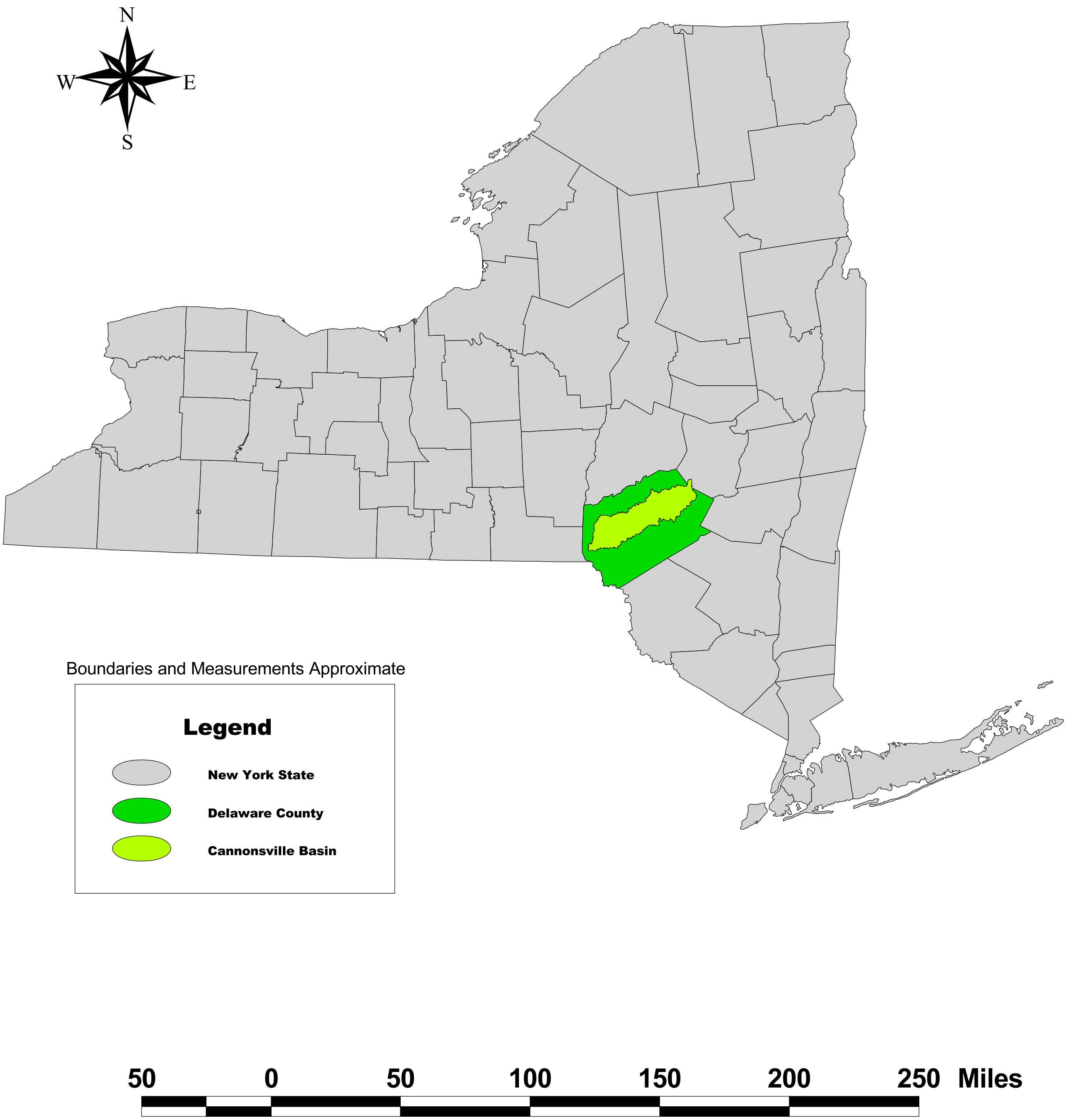
May 2006

Prepared by:
Delaware County Soil and Water Conservation District

In cooperation with:
New York City Department of Environmental Protection
Stream Management Program

West Branch of the Delaware River Stream Corridor Management Plan

Location Map



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Base Data Provided by NYCDEP

FOREWORD

The Board of Directors of the Delaware County Soil and Water Conservation District is pleased to present the following Stream Corridor Management Plan for the West Branch Delaware River above the Cannonsville Reservoir. This plan was prepared by and for the residents and communities in the watershed.

In *Reinventing Government*, David Osborne writes, "Entrepreneurial government pushes control of policies out of the bureaucracy and into the community to empower people rather than to simply serve them." We sincerely hope that this Plan will empower and inspire all stakeholders to comprehensively manage this valuable resource.

We encourage communities, residents, agencies and organizations to adopt this plan, not as a definitive action plan to resolve all issues and concerns for the river, but as a road map to guide and facilitate the future management of the West Branch Delaware River.

Rick Weidenbach,
Executive Director

Delaware County Stream Corridor Management Plan
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LIST OF ACRONYMS

Acronyms	Definition
BFE	Base Flood Elevation
BMP	Best Management Practices
CEAs	Critical Environmental Areas
CCE	Cornell Cooperative Extension
CREP	Conservation Reserve Enhancement Program
CRS	Community Rating System
CWC	Catskill Watershed Corporation
DCAP	Delaware County Action Plan
DCDES	Delaware County Department of Emergency Services
DCDPW	Delaware County Department of Public Works
DCPD	Delaware County Planning Department
DCSWCD	Delaware County Soil and Water Conservation District
DFIRMs	Digital Flood Insurance Rate Maps
DRIPP	Delaware River Invasive Plant Partnership
ECL	Environmental Conservation Law
FAD	Filtration Avoidance Determination
FEMA	Federal Emergency Management Agency
FIRMs	Flood Insurance Rate Maps
FPA	Fisherman-Parking Area
GCSWCD	Greene County Soil and Water Conservation District
GIS	Geographic Information Systems
GPS	Global Positioning System
HMGP	Hazard Mitigation Grant Program
MES	Munro Ecological Services
MOU	Memorandum of Understanding
NFIP	National Flood Insurance Program
NRCS	Natural Resources Conservation Service
NYCDEP	New York City Department of Environmental Protection
NYCRR	New York Code of Rules and Regulations
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOS	New York State Department of State
NYSDOT	New York State Department of Transportation
NYSEG	New York State Electric and Gas
PAC	Project Advisory Committee
PFR	Public Fishing Rights
SBA	Small Business Administration
SCMP	Stream Corridor Management Plan
SCMPr	Stream Corridor Management Program
SDWA	Safe Drinking Water Act
SEMO	State Emergency Management Office
SEQR	State Environmental Quality Review

SMP	Stream Management Program
SPDES	State Pollutant Discharge Elimination System
SPPP	Stormwater Pollution Prevention Plan
SWTR	Surface Water Treatment Rule
USACOE	U.S. Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WAC	Watershed Agricultural Council
WAP	Watershed Agricultural Program
WFP	Whole Farm Plans
WRDA	Water Resources Development Act
WRI	Water Resources Institute

1. Executive Summary

This Stream Corridor Management Plan provides a foundation for local residents, municipalities, interested organizations and cooperating agencies to enhance stewardship of the West Branch Delaware River and its tributaries. Funded by the New York City Department of Environmental Protection and the U. S. Army Corps of Engineers, this Plan is a culmination of four years of study and assessment in coordination with the Delaware County Action Plan (DCAP). Guided by a local Project Advisory Committee, this Stream Corridor Management Plan is representative of how both upstate and downstate stakeholders can work in partnership to protect and enhance a mutually beneficial resource.

The West Branch Delaware River and its tributaries are the source waters for the Cannonsville Reservoir, part of the Catskill/Delaware drinking water supply system for New York City. The watershed above the Cannonsville Reservoir encompasses an area of 353 square miles with approximately 662 linear miles of rivers and streams. This predominantly forested and agricultural watershed represents a sizeable and challenging resource to comprehensively manage. Stream walkover observations and assessments (presented in **Section 6**) suggest that the West Branch Delaware River has a tendency to become shallower and wider than is desirable due to increased sediment supply from excessive bank and bed erosion in the main river and its tributaries. While erosion and deposition are natural processes, many management activities can significantly increase erosion rates that in turn contribute to increases in sediment supply. These conditions demonstrate the need for comprehensive management and stewardship by all stakeholders.

This Plan was written in plain English to the extent possible. Clear understanding and involvement in the management of this resource by all stakeholders is crucial to its overall health. Although the entire document is lengthy, the reader will find that most sections provide informative reading. We encourage you at this time to review the Plan's Recommendations in **Section 2**, which we believe, provide a starting point for the long term stewardship of the West Branch Delaware River, its tributaries and associated riparian corridors.

Section 2 - Stream Corridor Plan Recommendations

2. Stream Corridor Management Plan Recommendations

Introduction

"The traditional engineering approach to river development has failed to incorporate the practical, physical, aesthetic and financial advantages of approaching river management as maintenance of natural tendencies in river channel behavior." Luna Leopold

Traditional stream management practices typically focus on single objectives such as bank stabilization or flood threat reduction. While dumped stone, riprap and other hard armoring techniques may achieve the goal of localized bank *stability* or protection, the application of these techniques generally does not consider potential causes or effects downstream, upstream or outside the immediate project area. Additionally, other stream processes such as channel and *floodplain* interaction and *sediment* transport are rarely considered. In many instances, ongoing evolutionary changes in stream form are interrupted by localized stabilization techniques. These interruptions may cause stream *instability* to shift upstream or downstream. Work undertaken to address one form of instability may create a domino effect of instability elsewhere.

One goal of this management plan is to create a better understanding of stream processes and encourage *riparian* landowners and managers to try and understand the potential causes of a particular problem, consider the potential effects of mitigation, and to seek technical guidance when needed. The following recommendations are suggested guidelines to aid and improve stream management in the West Branch basin.

Recommendations

RECOMMENDATION #1

Integration of the Stream Corridor Management Program and Watershed Agricultural Program

> ***The New York City Department of Environmental Protection (NYCDEP), Stream Corridor Management Program (SCMPr) and Watershed Agricultural Council (WAC) should develop and implement mechanisms to comprehensively integrate stream corridor management and stewardship into the Whole Farm Planning and implementation process.***

The Watershed Agricultural Council was formed in 1992 to assist the NYCDEP in the development and implementation of voluntary watershed protection programs that include agriculture and forestry, with the overall objective of safeguarding and improving source water quality in the New York City watershed.

The Watershed Agricultural Program (WAP) is a contractual partnership between WAC and the following agencies: Delaware County Soil & Water Conservation District (DCSWCD), United States Department of Agriculture (USDA) Natural Resources

Conservation Service (NRCS) and Cornell Cooperative Extension (CCE). These partner agencies develop and implement Whole Farm Plans (WFP) that address goals documented in the United States Environmental Protection Agency's Filtration Avoidance Determination (see **Section 4.2**) and the WAC contract with New York City. WAP program staff consists of NRCS planners, agronomists and engineers, DCSWCD civil engineering technicians and technicians, and CCE crop, livestock and nutrient management specialists. WAP teams work collectively to plan and implement agricultural Best Management Practices (BMPs) as an integrated system on each participating farm. BMPs are designed and constructed to NRCS standards and specifications. Other practices not covered by NRCS standards are designed and implemented by a team of WAC engineers and technicians.

Research indicates that approximately 62 percent of the land parcels in the West Branch watershed greater than one acre in size are under agricultural production[1]. With 662 miles of streams in the basin, it is obvious that many of these streams wind their way through agricultural land. Stream management issues exist on many of these farms, but the SCMPr staff, on its own, does not have time to assess all of these sites. WAP resource staff could be trained to identify and assess stream related issues on farms during the Whole Farm Planning process and work with SCMPr staff to develop solutions to the problems.

This training could be designed to:

- Identify stream reach issues, including Japanese knotweed problems (see **Section 5.10.4**), during the Environmental Review/Problem Diagnosis step of the Whole Farm Planning process.
- Describe and/or identify the problems and possible causes.
- Develop a "Stream Stewardship Plan" that outlines inexpensive measures for farmers to maintain stream stability.

WAP staff and SCMPr staff could then cooperate on identified issues such as riparian buffer enhancement, stream bank erosion, cattle access problems, debris jams, Japanese knotweed management or the need to consider other stream restoration measures.

Comprehensive integration of these programs will significantly enhance stream corridor management in the West Branch Delaware River watershed. The SCMPr, Watershed Agricultural Council and New York City Department of Environmental Protection should meet on a timely basis to develop and formulate the integration of these programs.

[1] Contract Task II-4 – Basin Demographics & Land Use. Report compiled by DCSWCD, 2003.

RECOMMENDATION #2

<u>Provide Technical Support to the USDA Conservation Reserve Enhancement Program (CREP)</u>

The Stream Corridor Management Program (SCMPr) and the NYCDEP should continue to fund and provide technical and design assistance for stream bank stabilization projects at potential CREP sites. The goal of this assistance is to stabilize stream banks so they are eligible for CREP participation.

From the results of the walkover assessment and the vegetation mapping exercise conducted during the planning effort, SCMPr staff found that protection and enhancement of the riparian forest buffer should be one of highest priorities for the future protection of the river's main stem, its tributaries and the lands adjacent to these streams.

Locally, vegetation and the streambanks at established CREP sites in the West Branch watershed have begun to recover. This initial recovery is due in large part to the exclusion of livestock from the stream, resulting in a reduction of hoof shear stress on the banks. Decreased erosion and the opportunity for vegetative growth on the streambanks reduce nutrient and pathogen-laden runoff from reaching streams, improving stream health throughout the basin.

Sixty-two percent of the parcels along the West Branch main stem are under agricultural production. Under federal rules, CREP cannot be implemented on unstable streambanks. SCMPr staff should prioritize and expand efforts to provide technical and design assistance to USDA and Watershed Agricultural Program staff for implementation of streambank stabilization projects at potential CREP sites. Funding sources for these projects should be explored and identified to facilitate CREP implementation.

As mentioned in **Section 6.3.2**, the United States Department of Agriculture (USDA) administers CREP. CREP authorization is currently scheduled to expire on September 30, 2007. SCMPr staff should work with USDA, Watershed Agricultural Council, and New York City Department of Environmental Protection staff to seek congressional re-authorization of the New York City watershed CREP beyond 2007.

RECOMMENDATION #3

<u>Enhance the Implementation of CREP on New York City Watershed Cropland and Explore Long-Term CREP Contracts</u>

The Stream Corridor Management Program (SCMPr) should work with the New York City Department of Environmental Protection, United States Department of Agriculture, US Environmental Protection Agency, Watershed Agricultural Council and other pertinent federal, state and local agencies and

organizations to enhance CREP implementation on cropland and explore long-term CREP contracts.

Cropland CREP

Currently, only 17% of CREP buffers implemented in Delaware County are on cropland demonstrating the need to enhance CREP participation on stream side cropland. Many producers do not opt for CREP buffers along cropland because:

- ♦ Quality cropland is in valley bottoms and available acreage is in short supply
- ♦ Crop values are significantly higher than CREP payments
- ♦ Necessitated enterprise changes make it too costly to produce crops on uplands

A review of LIDAR contour mapping and field verification reinforces that many runoff patterns are parallel to the stream. In these cases, *hydrologic delivery zones* should be identified where nutrients and sediments enter the stream. This may allow for narrower buffers along streams with parallel runoff patterns while shifting the main focus of a buffer in the hydrologic delivery zone areas or wider buffers with perpendicular runoff patterns.

An interagency Cropland Buffers Working Group should be established to:

- ♦ Assess cropland acres for CREP applicability under current program rules
- ♦ Develop a planning protocol to identify and address hydrologic delivery zones
- ♦ Develop applicable vegetation buffer standards for parallel runoff patterns
- ♦ Develop equitable incentive and payment protocols

Approximately 31 miles of cropland along the West Branch main stem are currently un-buffered, suggesting the need to review and enhance CREP rules on cropland.

Long-Term CREP

Under current program guidelines, CREP contracts are executed with either a ten or fifteen year life span. Landowners are required to follow an operation and maintenance plan during the life of the contract to ensure required plant survival rates and to protect the buffer area from destruction. Once the contract has expired, however, the commitment to maintaining the buffer will also expire.

There are documented improvements in stream health where CREP is currently implemented. The environmental benefits gained by extending existing CREP contracts and providing for longer-term future contracts would be an integral component of sound stream and land-use management.

RECOMMENDATION #4

Implement a Variable Width Riparian Buffer Pilot Program

The Delaware County Soil and Water Conservation District (DCSWCD) Stream Corridor Management Program (SCMPr) should work with the New York City Department of Environmental Protection (NYCDEP), New York State Department of Environmental Conservation, Watershed Agricultural Council, Catskill Watershed Corporation, Cornell Cooperative Extension and other pertinent federal, state and local agencies and organizations to develop and implement a pilot program to establish variable width riparian buffers along unstable stream reaches and monitor their effectiveness.

Mitigating unstable streambanks to facilitate the implementation of the USDA Comprehensive Reserve Enhancement Program (CREP - see **Section 6.3.2**) can be cost prohibitive. It is also important to recognize that mitigation measures may carry a high risk of failure if implemented within an improperly functioning stream reach. This is the case with three sites identified for mitigation along the West Branch Delaware River. These sites are located in a 4.35 mile reach of the river that is not properly functioning. Sections of this reach have become straightened, most of the reach has over widened and excessive deposition is occurring. Evidence suggests that this section of the river will continue to adjust and deposit sediment.

A need exists to develop criteria to facilitate riparian buffer implementation on agricultural lands along certain unstable streambanks. Since meandering is a natural stream function, the meander pattern can be reasonably predicted for a given reach of stream. Therefore, buffer limits could be established to allow a stream to naturally adjust within established limits. Buffer width could vary depending on site specific situations. Rock armoring could be planned at critical locations along a future streambank. If future needs were determined rock could be placed in dry conditions with reduced construction costs and minimal to no de-watering costs. Vegetative planting sequences could be phased over time as stream adjustment progresses.

Figure 2.1 Example of rapid lateral migration near Hamden resulting from the April 3, 2005 storm. This section of stream is one of the 3 sites located in the 4.35 mile stream reach.

The SCMPr and NYCDEP should work with all involved agencies and stakeholders to further advance the variable width riparian buffer concept, implement a pilot program to address identified needs and monitor program effectiveness.

RECOMMENDATION #5

Participation with the Catskill Watershed Corporation

The Stream Corridor Management Program (SCMPr) should cooperate with the Catskill Watershed Corporation (CWC) to explore the enhancement of existing CWC programs and explore the development of new CWC funding programs that address stream related stormwater issues, stream stewardship, public education and outreach, and stream stability issues.

The CWC, a local not-for-profit development corporation has a dual goal to protect the water resources of the New York City watershed west of the Hudson River while preserving and strengthening communities located within the region. CWC is a logical choice to fund stream corridor management projects and programs identified in each county's Stream Corridor Management Plan, thereby reducing the need to set up new funding mechanisms and governing boards.

The SCMPr and CWC, in cooperation with New York City Department of Environmental Protection, should:

1. Explore opportunities to enhance existing CWC stormwater programs to include the following:
   - Cooperative public outreach efforts to educate businesses, municipalities and residents regarding stormwater impacts on streams.
   - Enhanced public outreach efforts to include funding for stream management education and stream stewardship training, including Japanese knotweed identification and management (see **Section 5.10.4**), for landowners, local planning boards and highway departments, contractors, schools, community groups and other interested stakeholders.
   - Funding for retrofitting selected culverts that pose stormwater and fish passage issues.
   - Funding for storm flow solutions at bridges with problematic stormflows.

2. Explore new programs for stream/stormwater management to:
   - Fund a culvert sizing and design program for municipalities (see **Recommendation #9**).

Figure 2.2 Poorly designed culvert outfall along NYS Route 10 upstream of Bloomville. Note direct discharge into river with lack of energy dissipation and sediment control measures. This site could benefit from a stormwater retrofit.

- Fund stream stewardship activities which may include selective berm and/or debris removal.
- Fund future mitigation projects related to stream channel and streambank stability.

See **Section 4.7** for further information on the Catskill Watershed Corporation.

RECOMMENDATION #6

Stream Corridor Management Plans for Non-Agricultural Riparian Landowner Stewardship

The Stream Corridor Management Program (SCMPr) should seek funds to develop a program to provide non-agricultural riparian landowners with their own site specific Stream Corridor Management Plans.

The development of an individual Whole Farm Plan for agricultural production and a Forestry Plan for forest landowners has been essential to improving and maintaining water quality in the West Branch watershed. These plans inventory and assess soil, water and forest resources and provide a clear plan of action by recommending both structural and managerial Best Management Practices which meet both landowner and water quality objectives.

Figure 2.3 Example of site that could benefit from individual landowner stewardship.

Although 62% of the parcels in the basin over one acre are under agricultural production (see **Recommendation #1**), there remains a significant amount of riparian property that is non-agricultural land. As with agricultural and forestry practices, certain activities by riparian landowners may contribute to stream and riparian buffer degradation. Therefore, the SCMPr recommends development of a program to provide non-agricultural riparian landowners with an individual Stream Corridor Management Plan. This Plan would be provided at the request of the landowner free of charge. The Plan would address floodplain function, stream processes (including streambank and stream channel maintenance), invasive species control with Japanese knotweed management as a primary focus (**see Section 5.10.4**), and the importance of desirable native riparian vegetation and its function.

Riparian landowner stewardship is essential to proper stream corridor management. Efforts by individual riparian landowners to improve and maintain proper stream processes and riparian buffers can be very significant, especially with the control of invasive species and the management of desirable native vegetation. Well informed and educated riparian landowners can also be instrumental in maintaining floodplain function and stream channel and streambank functions. Many times streambank and stream channel unraveling begin as small problems that could have been mitigated or corrected without public funding assistance by a well educated riparian landowners. The preparation of individual Stream Corridor Management Plans will also provide SCMPr staff with opportunities to proactively monitor stream health, identify emerging issues and/or problems in the watershed, and develop greater rapport with riparian landowners.

RECOMMENDATION #7

Stream Gravel Deposition Issues

The Delaware County Soil and Water Conservation District (DCSWCD) Stream Corridor Management Program, New York City Department of Environmental Protection and Delaware County Department of Watershed Affairs will identify opportunities to work with the New York State Department of Environmental Conservation and U.S. Army Corps of Engineers for the purpose of identifying options pertaining to the management of deleterious gravel deposits within the West Branch of the Delaware River system.

Several members of the public and local government leaders have stated, throughout the public review process of this management plan, that they believe certain gravel deposits have had a deleterious effect on streambank stability and flooding over the years and have expressed their concern with current policies and regulations restricting their removal. The Stream Corridor Management Program has the responsibility to investigate these issues and respond to these concerns by advancing discussion with the appropriate regulatory agencies to identify what information is needed to determine if and where an appropriate level of response and intervention can or should be exercised. The DCSWCD wishes to create an informed dialog about gravel and stream processes in the West Branch Delaware River (WBDR) watershed, to improve both the professional manager's and general public's understanding of the mobilization, transport and deposition processes of both sediment and woody debris in the WBDR system. The DCSWCD recognizes that in order to successfully advocate a specific plan of action regarding gravel, it must both develop a science-based understanding of specific stream processes and secure the participation of the key regulatory agencies.

RECOMMENDATION #8

Streamline Stream Work Permitting

The Stream Corridor Management Program (SCMPr) proposes that the permitting process for stream work be simplified and streamlined. It is proposed that an interagency working group composed of representatives from the New York State Department of Environmental Conservation, U.S. Army Corps of Engineers, Delaware County Soil & Water Conservation District (DCSWCD), New York City Department of Environmental Protection, neighboring Soil & Water Conservation Districts, Delaware County Department of Public Works (DCDPW) and local community leaders identify ways to delegate, simplify and streamline the permitting process for the benefit of all agencies and stakeholders.

The purpose of this recommendation is to improve the permitting process so that necessary stream stabilization efforts may be made in a timely and efficient manner. As described in **Section 5.13**, the permitting process for stream disturbance is involved and lengthy, particularly for larger projects. Permitting can also be very costly. For example, administrative costs for SCMPr staff alone to prepare permit applications for the Town Brook demonstration project were nearly $2,850. The permitting process for emergency stream work in the aftermath of floods should also be reviewed.

One goal should be to enhance delegated permitting authority to the DCSWCD by NYSDEC for implementation of approved stream management practices under its current General Permit.

RECOMMENDATION #9

Assist Municipalities with Culvert Sizing and Design

The Stream Corridor Management Program (SCMPr), in cooperation with the Catskill Watershed Corporation, Delaware County Department of Public Works and NYCDEP should develop a program to provide technical assistance to Town Highway Superintendents for culvert design, sizing and placement.

Culverts are frequently used for highways crossing tributaries to the West Branch Delaware River, particularly in headwater areas where the tributaries are smaller and bridges are not required or economically practical. Culverts are also used under highways to drain roadside ditches, many of which create their own outfall watercourse to streams or wetlands.

While performing the walkover assessments in the watershed, SCMPr staff observed that road culverts often caused increased erosion below, and many exhibited increased deposition above the crossing. Typically these problems relate to the size or shape of the culvert selected or the installation of the culvert. Improper orientation, the lack of energy dissipation, and numerous other problems related to culvert installation reduce culvert efficiency, and impact stream channel and streambank stability. Additionally, incorrect culvert design/installation may have significant impacts on fish passage. The number of culverts in the watershed is quite large and therefore the total deleterious effect of improperly installed culverts could be significant.

Figure 2.4 Culvert installation that could benefit from improved alignment, fish passage, outfall dissipation, headwall installation and top cover.

The SCMPr should work in cooperation with other interested parties such as the CWC and DCDPW to develop a protocol to expand assessments of existing culverts to include geomorphic assessments, and work collectively where necessary in the prioritization of culverts for replacement and on the designs for retrofitting existing culverts. This technical assistance could be provided through recommendations made during the development of individual Town Highway Management Plans (HMPs) currently being developed by the DCDPW and Delaware County Planning Department (DCPD) Special Flood Hazard Areas as identified on Flood Rate Insurance Maps should also be included in this protocol (see **Section 5.14**).

RECOMMENDATION #10

<u>Participation with the Delaware County Action Plan (DCAP)</u>

The Stream Corridor Management Program will continue to work closely with all DCAP participants to integrate the West Branch Delaware River Stream Corridor Management Plan and its recommendations into all relevant components of the Delaware County Action Plan.

DCAP is a local initiative that comprehensively evaluates water quality issues and coordinates and facilitates local, state and federal initiatives to improve water quality in Delaware County (see **Section 4.6**). Integration of the Stream Corridor Management Plan and its recommendations into existing DCAP programs will ensure water quality benefits are maximized and/or enhanced.

RECOMMENDATION #11

Expand Public Education and Outreach Efforts

The Stream Corridor Management Program (SCMPr) should expand public education and outreach efforts to better inform and educate all stakeholders, including municipalities, regarding stream stewardship, the importance of floodplain function, stream processes and the importance of riparian vegetation. These efforts should be developed and implemented in cooperation with the Project Advisory Committee with funding from the Catskill Watershed Corporation.

Earlier outreach efforts by the SCMPr were largely limited to those that facilitated field work or helped formulate and direct the development of this Stream Corridor Management Plan. However, much more needs to be done. We must keep in mind that government programs, including this SCMPr, cannot take the place of stewardship by the general public and individual riparian landowners. Stream stewardship is the responsibility of everyone who lives in a watershed and participation from all stakeholders is the preferred objective.

To accomplish this objective, all stakeholders need to more fully understand stream processes such as stream bank erosion, sediment transport and the function of stream features such as riparian forest buffers, floodplains, and riparian wetlands. This understanding will guide stakeholders as they adopt practices that will protect the stream and improve its overall stability. Likewise, stream managers need to understand and account for the perspective and priorities of the stakeholders as they develop future stream management efforts.

Education and outreach efforts should be expanded to include, but not be limited to, the following:

- Development of a dialog with stakeholders on stream processes and the best management of stream features such as floodplains and riparian buffers.
- Facilitation of enhanced stormwater management.
- Promotion of action by new and existing watershed associations, stream management public interest groups and other groups and organizations interested in stream corridor management.
- Education of the public and municipalities regarding the importance of controlling invasive species, especially Japanese knotweed (see **Section 5.10.4**).
- Facilitation of public and municipal involvement in Flood Hazard Mitigation efforts (see **Section 5.14**).
- Support of landowners interested in furthering their understanding of streams through stream management education efforts such as field days and workshops.
- Development of brochures, presentations, exhibits, press releases and other educational materials for the public and stakeholder groups.

The DCSWCD and DCPD should initiate education and outreach with the local planning boards. When a planning board conducts a subdivision review or a site plan evaluation, they should be aware of the concerns of the DCSWCD in regards to the impact on streams in light of additional growth and development. The planning boards could then be used as a local engine to distribute information hosting workshops for private property owners that are current stakeholders or adjoining property owners.

The formation of local watershed associations should also be encouraged. These local stakeholders can be a valuable asset by contributing both historical and current stream reach information, sponsoring community based projects, and assisting in the procurement of project funding. Local planning boards could serve as the facilitator of these associations.

RECOMMENDATION #12

Geomorphic Assessments at Bridges and Culverts

> ***The Stream Corridor Management Program (SCMPr) and NYCDEP should develop a protocol and program to perform a full geomorphic assessment at prioritized bridges and large culverts. This program should be developed in cooperation with the New York City Department of Environmental Protection, Delaware County Department of Public Works, Delaware County Planning Department, Town and Village Highway Superintendents and New York State Department of Transportation.***

Stream assessment observations by SCMPr staff show that the West Branch main stem and a significant number of tributary crossings near their confluences with the river commonly exhibit signs of stress, such as gravel deposition near bridges and large culverts. These gravel deposits are generally a result of the inability of the stream to transport sediment during lower flows and can lead to decreased storm flow capacity through the structure and bank erosion and/or bed scour near the structure.

Figure 2.5 Gravel deposit under McMurdy Brook bridge on NYS Route 10 near Hobart. Note restriction of the waterway.

Geomorphic assessments at identified and prioritized structures, in conjunction with available historic hydraulic data, would result in a description of stream related issues at each site for incorporation into a set of initial recommendations for consideration in future maintenance, rehabilitation or replacement. As an example, considerations could include maintenance of low flow channels through structures and/or floodplain relief structures at elevated bridge approaches.

These assessments should be done as part of the environmental review process conducted during the design phase of a project in coordination with the municipality or agency having maintenance jurisdiction.

RECOMMENDATION #13

Flood Hazard Mitigation and Flood Recovery

> ***Work with Delaware County Planning Department and Emergency Services to develop a county-wide Hazard Mitigation Plan. Continue to work with the Delaware County Board of Supervisors, New York City Department of Environmental Protection (NYCDEP), New York State Department of Environmental Conservation (NYSDEC) and the State Emergency Management Office (SEMO) to revise the Federal Emergency Management Agency (FEMA) flood study and floodplain maps.***

Hazard mitigation is any sustained action that reduces or eliminates long-term risk to people and property from natural hazards and their effects. Flood recovery is federal and state assistance available through FEMA and SEMO, the agencies that administer their respective hazard mitigation programs for Presidential declared flood disasters. Flood Studies and Flood Insurance Rate Maps (FIRMs) provide vital information to communities considering flood hazard mitigation and stream management options.

The DCPD has substantially completed preparation of a county-wide Hazard Mitigation Plan which will enable communities to apply for funding through hazard mitigation programs. Plans are also under way in cooperation with the Delaware County Board of Supervisors, NYCDEP and NYSDEC to update current floodplain maps. Stream Corridor Management Program staff will continue to participate with and support both efforts.

See **Section 5.14** for more information.

RECOMMENDATION #14

Continuation of Geomorphic Research/Assessments

The Stream Corridor Management Program (SCMPr) and New York City Department of Environmental Protection, in consultation with the Project Advisory Committee, should continue Rosgen Level II assessments and perform Rosgen Level III and Level IV assessments at prioritized locations throughout the West Branch Delaware River watershed.

To more fully understand the problems facing the West Branch of the Delaware River basin, further investigation of the main stem and tributaries will be required. The original contract for the SCMPr outlined a process where Rosgen Level I through Level III assessments would be performed on the West Branch main stem, with Rosgen Level IV to be performed in restoration project reaches. Due to the size of the watershed, additional time is required to adequately perform necessary assessments to compile a complete data set of watershed conditions, their causes, and the potential effects of current and proposed management practices. Additional assessments will be necessary to reinforce preliminary determinations and validate assumptions.

Efforts should be made to seek funds and staff necessary to complete this work.

RECOMMENDATION #15

Seek Funds Necessary for Construction of Walton Streambank Stabilization Projects

The Stream Corridor Management Program (SCMPr) will continue to seek all funds necessary to implement two streambank stabilization projects located at Terrace Avenue and South Street in the Village of Walton.

In early 1999, two sites in the Village of Walton, approximately 5 miles upstream of the Cannonsville Reservoir, were identified for mitigation of severely eroding streambanks. Erosion at these two locations has been steadily increasing since the January 1996 flood resulting in significant risks to water quality, private property, public infrastructure and aquatic habitat. The upstream site is located at the eastern limit of the village adjacent to Terrace Avenue and consists of an actively-eroding streambank along the edge of a sandy terrace. The eroded section is approximately 600 feet in length and 30 feet high. Erosion has recently accelerated at this site due to the extremely wet conditions during 2003 and 2004. It is estimated that 10-12 lateral feet of embankment (approximately 7000 tons) has sloughed into the river during this period. The downstream site is located adjacent to Stockton Avenue and consists of a 25-foot-high bank that is eroded at its toe, and intermittent shallow translational failures of the upper bank for approximately 500 feet.

In August, 1999, the Delaware County Soil and Water Conservation District applied for $369,000 (75% of the original project cost estimate of $469,000) in state funding through the Clean Water/Clean Air Bond Act for State Fiscal Year 1999/2000. The New York State Department of Environmental Conservation (NYSDEC) awarded a Performance Partnership Grant (PPG) in November 2000 in the amount of $246,800 and a contract was executed for the work in September, 2001. Construction was originally planned for 2003.

Figure 2.6 View of relocated shed along severely eroding bank at the Terrace Avenue site. Note area near center of photo where upstream edge of shed was located (December, 2004).

Between the time of grant application and time of award, site conditions have worsened; it became apparent that the project needed to be increased in scope and magnitude. New cost estimates were projected and in May, 2002, a Letter of Interest was submitted to NYSDEC requesting additional funds through the Watershed Environmental Assistance Program (WEAP). Additional funds from this program are not expected. In April 2003, Fisch Engineering of Vicksburg, Mississippi was awarded a contract to develop a conceptual design for these sites with multiple alternatives considered. New cost estimates for the preferred alternatives at both sites total $1,222,000. To date all funds necessary to complete the projects have not become available. NYSDEC has issued a final contract extension for expenditure of the $246,800 in PPG grant funds through December 31, 2007, at which time the projects must be completed. At the time of the first draft of this document, an additional $975,200 was currently needed for completion. On April 15, 2005, it was announced that $916,500 in WRDA funds were earmarked for these sites. SCMPr, the Village of Walton and the Delaware County Department of Watershed Affairs are working within the following schedule to complete these projects:

Figure 2.7 Closer view of the unstable embankment at the Terrace Avenue site (December, 2004).

2005 – procure commitments for remainder of required funding
2006 – project survey, design and permitting
2007 – project implementation

Figure 2.8 South Street location showing condition of embankment (December, 2000).

RECOMMENDATION #16

Prioritization of Identified Stream Intervention Projects

The Stream Corridor Management Program, working with the Project Advisory Committee and New York City Department of Environmental Protection, will prioritize potential restoration reaches relative to the type and level of intervention needed.

Stream reaches in need of management action vary both in the magnitude of the problem and level of intervention needed. Water quality, property and aquatic habitat protection will be priorities for all reaches prioritized for intervention. The level of intervention will be based on the current need and condition of the stream as well as the type of existing and future land uses. Properties surrounding streams which have the potential for development based on location, accessibility, size, soils and local land use controls will be deemed as more critical for intervention.

Preservation – This intervention level should be considered when stream and surrounding floodplain are in excellent condition with low flooding and erosion threats, good water quality, and sustainable functioning aquatic and terrestrial habitat. These sections should be identified as valuable anchor points for stable stream morphology and good habitat, as well as helping to preserve and/or enhance water quality and flood dynamics.

Passive – Passive intervention should be considered when a stream reach and surrounding floodplain are in generally good condition, exhibiting apparent stability and sustainable function without further need for intensive management or changes. These reaches may not be in the most stable condition but may recover unassisted over time. Some visual monitoring or inspection of certain features or areas may be warranted, but generally no active management is recommended.

Assisted Recovery – Partial intervention, or "assisted recovery," involves direct management intervention on a small scale. Assisted recovery must be done carefully and with a good understanding of the stream type and setting to avoid further instability. Assisted recovery may be as simple as planting riparian vegetation to maintain bank stability or as complicated as designing comprehensive stormwater management retrofits or reconstructing sections of streambank.

Full Geomorphic Restoration – This intervention level, very costly and requiring the most intensive management, should be reserved for the most severe locations of stream instability with the greatest impact to management goals. This level of management requires much greater time and financial resources and technical expertise to ensure stability restoration is consistent with both management goals and the stream type and setting that will ensure project success and longevity.

RECOMMENDATION #17

Develop a Process for Updating the West Branch Delaware River Stream Corridor Management Plan

> ***In cooperation with the Project Advisory Committee and New York City Department of Environmental Protection, the Stream Corridor Management Program shall develop a process for updating the West Branch Delaware River Stream Corridor Management Plan.***

It is expected that as this plan and its recommendations are addressed and implemented, additional information and data will be collected and other management issues identified. In order to keep the plan a "living document" it should be updated as needed. The updates would track the implementation of the plan's recommendations, consider post-project monitoring, and compile and analyze new data, information, and management issues.

Section 3 – Introduction and Purpose

3. Introduction and Purpose

3.1. <u>Introduction</u>

"The rivers are our brothers. They quench our thirst. They carry our canoes and feed our children. You must give to the rivers the kindness you would give to any brother." Chief Seattle (1854)

Why develop a Stream Corridor Management Plan for the West Branch of the Delaware River? Stream management is an emerging discipline that recognizes the importance of our local streams to our overall quality of life, and seeks to coordinate decision-making around common goals we collectively identify for the stream.

Many generations of families have managed streams in the West Branch of the Delaware River *watershed*. Over the past several centuries we have used streams for transportation, learned to harness them for power, and used them for a source of food, recreation and water supply for both animals and humans. We have also installed *berms*, *rip rap* and various other types of *revetments* along their banks, altered their courses of flow, removed streamside vegetation, excavated un-wanted *gravel* deposits from their beds, and periodically stocked them with fish. These are all stream management activities.

Our past management activities have been relatively uncoordinated. Landowners have managed their own streambanks and *floodplains*, highway departments and railroads have managed road *embankments* and bridges, and *runoff* has at times been concentrated and given a more direct route to a stream. When there was major storm damage, state and federal agencies assisted to address immediate local needs. Those involved had their own objectives, areas of knowledge and expertise, and own ideas of what needed to be done to keep a stream healthy and protect property and infrastructure. Though all of our past efforts were well intentioned, there remain areas in the watershed that continue to unravel or seem to need continuous maintenance.

During the past few years efforts have started to focus on the management of the watershed as a whole. Through these efforts, we are trying to better understand stream function, the causes of *instability*, and the effects of management practices. This stream corridor management plan was created cooperatively through the efforts of local residents, local leaders and agency representatives involved in different aspects of stream management. It identifies management issues, common, shared and competing goals, and provides a "road map" for coordination among the many "stakeholders" (those who rely on, work with, or live by streams in the West Branch watershed). These stakeholders include local landowners, county, state and local highway departments, local agencies, anglers, canoeists, and the City of New York, whose residents drink some of these waters.

This plan also provides a description of stream function and dynamics, results of our continuing research, input from local residents, and management recommendations. Recommendations are tailored to specific sites and to generalized types of conditions.

Finally, the plan provides contact information for a variety of individuals, organizations and agencies involved in the various aspects of stream management, plus sources of technical and financial help for those seeking to implement plan recommendations.

3.2. <u>Purpose</u>

The West Branch of the Delaware River watershed is a major drainage area in the headwaters of the Delaware River system. Its streams impact how we live, providing both benefits and challenges. Increasingly, we are aware of the impacts that we have on the stream deriving from the way we live. From its headwater source in the Towns of Stamford and Harpersfield to the Cannonsville Reservoir (a source of water supply for New York City), the West Branch watershed encompasses an area of 353.5 square miles that contain 662.4 miles of stream.. The main stem of the West Branch is fed nineteen identified major tributaries. Land use is largely agricultural, and the West Branch watershed is home to approximately 2230 year round and seasonal residents. The Cannonsville Reservoir contributes nearly 25% of the drinking water to approximately 9 million people in the New York City metropolitan area.

Interest in developing a coordinated management strategy for the West Branch of the Delaware River emerged after the catastrophic January 19, 1996 flood event. After this flood, the dramatic stream and infrastructure damages that resulted, and subsequent emergency repair work, it was apparent that stream related activities in certain areas, although well-intentioned, had set the stage for excess damages during a flood. As a result, the condition of the West Branch significantly changed in many areas of the watershed. Small instability and *erosion* problems worsened, small eroding banks became larger failures and some stream courses were significantly altered.

This condition was noticed by *riparian* (streamside) landowners, anglers, resource agencies, and by the New York City Department of Environmental Protection (NYCDEP), who had been mandated by the United States Environmental Protection Agency (USEPA) to develop a strategy for stream management in its Catskill and Delaware watersheds that would address stream and riparian corridor-related water quality concerns. The NYCDEP Stream Management Program was charged with this responsibility and noted that local and City concerns dovetailed: local infrastructure and private property losses attributable to excessive rates of erosion were a concern to both, but to NYCDEP for water quality reasons. Excess streambank erosion can create "*turbidity*" in the Cannonsville Reservoir and contribute pollutants such as phosphorus as well. Excessive erosion can also degrade fisheries habitat and overall ecological health of the West Branch. Both the Delaware County Soil & Water Conservation District (DCSWCD) and NYCDEP acknowledge that biological health is an indicator of good water quality. This mutual interest in addressing stream instability laid the groundwork for a productive partnership between DCSWCD and NYCDEP.

Recognizing this, the NYCDEP initiated a voluntary planning effort with DCSWCD and the U. S. Army Corps of Engineers (USACOE). These core agencies agreed to work together to fund and coordinate the development of this management plan, and to construct a stream restoration *demonstration project*.

These agencies recognized the importance of local leadership for development of an effective management strategy for the West Branch of the Delaware River. As a result, the DCSWCD and NYCDEP convened local stakeholders living and working along the stream and formed a Project Advisory Committee (PAC) to develop, guide and implement the goals and objectives of the management plan.

This planning process has helped foster stronger partnerships among local, state, city and federal agencies, and landowners in the West Branch watershed. The plan is intended to facilitate cooperation and communication between the involved parties, build community relationships, aid in managing resources in the watershed, and support for stewardship of the stream as a vital natural resource.

3.3. Goals and Objectives

The scope of this project's goals and objectives are limited to the study areas ─ the main stem of the West Branch of the Delaware River and one of its headwater tributaries, the Town Brook sub-watershed. There are four primary goals for this management plan, each of which is described in more detail below. Note: Current progress towards each of these goals and objectives is at a varying state of completion

1) Document issues and local concerns and outline a plan to reduce damage to private property and public infrastructure (roads and bridges) from stream erosion and floodwaters;

2) Summarize known information and outline a plan to protect and improve water quality;

3) Document current conditions and outline a plan to protect and enhance the integrity of stream and floodplain ecosystems;

4) Provide a strategy for coordination of management activities among the various stakeholders, to ensure that no one of the above goals is achieved at the expense of another. Document partnerships with other water quality programs in the watershed.

3.3.1. Flooding and Erosion Threats

The risks associated with floods and their powerful erosive forces can affect an individual landowner or an entire community. To help reduce these risks, this plan has the following objectives:

1) Conduct a watershed-wide survey of landowners to assess the history of flood damages, concerns and interests in the stream;

2) Conduct a physical survey and analysis of the West Branch of the Delaware River and Town Brook main channels and their floodplains in order to better understand how each stream is likely to behave in future flood events, as indicated by its physical form (*stream morphology*);

3) Identify sites where stream stability exists, where the stream is functioning properly and how this information can be applied to unstable/impaired reaches;

4) Identify sites of bank erosion, monument and survey selected sites (for ongoing *monitoring*) prioritize sites in need of further assessment, and make prioritized recommendations for their treatment;

5) Identify those locations where developed or residential areas may be threatened by bank erosion, and make prioritized recommendations for their treatment;

6) Identify sites where bank conditions or bank location could exacerbate bank erosion problems, leading to high water quality risks, and make prioritized recommendations for their treatment;

7) Identify and assess bridge or *culvert* crossings that may be at risk from erosion of stream banks or streambeds, or otherwise *unstable* or threatened, and make prioritized recommendations for their treatment to the Town Highway Superintendents and County DPW; and

8) Provide this information to the Delaware County Hazard Mitigation Planning Grant administrator.

3.3.2. Water Quality

1) Potential impairments to water quality can come from both point sources (such as the outfall of a sewage treatment plant) and non-point sources (such as urban runoff, failing septic systems, etc.). Various methods are used to evaluate water quality, and many reputable studies have occurred and continue to monitor water quality in the West Branch basin. These studies are

summarized in **Section 5.12**. Erosion threats and their stream-related causes and effects are described in some detail in the Findings (**Section 6**).

2)

3.3.3. Ecological Health

The health of our stream and floodplain ecosystems is increasingly recognized as a key element in our quality of life. Healthy streams support a diversity of fish and insect species, and healthy floodplains support a variety of tree, shrub and grass species, as well as wildlife that can only thrive along healthy streams. Healthy streams provide higher recreation value, and increase property values for the individual landowner and the community as a whole. To achieve the goal of optimizing stream and floodplain ecosystem integrity, this plan has the following objectives:

1) Characterize the status of the stream ecosystem in general terms for the West Branch of the Delaware River main stem as a whole, using existing fish and insect population data as available;

2) Survey local resident's experience with the West Branch fishery, to determine perceived trends and document its management by local angling groups and the NYSDEC;

3) Monitor the response of fish community structure to *stream stability restoration* practices implemented during the course of the development and implementation of the management plan

4) Characterize current floodplain and riparian forest management practices on the West Branch and Town Brook main stems, and make prioritized recommendations for changes that can improve ecosystem integrity;

5) Conduct field surveys of selected riparian vegetation; make prioritized recommendations for further study and management of the riparian zone.

3.3.4. Coordination

Streams are currently "managed" by many different individuals, agencies and organizations. Each of these groups has its own perspective of the stream, including their specific goals and management practices they consider desirable. Sometimes the goals and practices of one group can be at cross-purposes with others, but through better communication and coordination, and by coming to agreement on a common strategy, these potential conflicts can be minimized or avoided. To promote the goal of effective coordination among the many stakeholders, this plan has the following objectives:

1) Establish a Project Advisory Committee consisting of representatives of all significant stakeholder groups to coordinate the development and implementation of the management plan;

2) Conduct a survey of the West Branch basin residents to determine their concerns, interests and stewardship practices;

3) Conduct a survey of highway superintendents about their concerns, interests and current management practices and priorities, and make recommendations to address these concerns;

4) Survey the needs of local stakeholders for information needed to promote land use that is consistent with the long-term, collective goals of the West Branch community, and make recommendations for strategies to acquire that information;

5) Determine the needs of various stakeholder groups for technical assistance, information and education, and make recommendations for the development of programs to meet those needs;

3.4. Guide to this Stream Corridor Management Plan

3.4.1. Plan Organization

This Stream Corridor Management Plan has been arranged by broad categories including: general watershed description, specific stakeholder information, and watershed and stream-specific recommendations. A review of the Table of Contents provides the best overview of how this material is organized. The plan is written in relatively easy-to-read format, because it would be of little use if people could not read and understand it. While modern stream studies do include some scientific jargon, concepts are explained as simply as possible, and a glossary is provided to define terminology.

The Findings section of this study (**Section 6**) summarizes thousands of hours of field time and scientific assessments. The Recommendations section (**Section 2**) contains summary recommendations, plus a variety of useful links and other guidance to facilitate future action. This section also contains suggestions for keeping this management plan up-to-date, which is important to ensuring the plan remains a viable and useful resource. The Appendix contains selected reference materials and other supporting documents. Additional material, much of which is in electronic format, is currently stored at the DCSWCD office.

3.4.2 Plan Application and Implementation

In summary, this Management Plan provides a framework for general stream management decision-making in the watershed. The plan provides documentation of current stream conditions along the West Branch and Town Brook main stems, private and public property issues, and a broad assessment of the condition of existing infrastructure. It will be useful when planning, permitting or providing advice and technical guidance to landowners and agencies within the West Branch watershed.

The plan also offers specific recommendations for expanding public outreach and prioritizing future assessments, work and maintenance activities in the watershed. The assessment data contained in the supporting documentation can aid projects and progress when state and federal agencies are assisting with flood emergencies. Highway departments can also use this information to help with the long-term maintenance of infrastructure projects.

A detailed, watershed wide assessment of fish populations and habitat quality was not undertaken as part of this effort. However, **Sections 5.11** and **5.15** provide useful and interesting reading about fish habitat.

The West Branch of the Delaware River watershed is a reasonably intact and healthy stream. However, the reader will find that some interesting trends were identified, existing and future issues pointed out, and in many cases these were mapped for the first time, as well. It is hoped that the plan's recommendations will serve as a guide for long-term stewardship for our river and its *tributary* streams.

Section 4 – Background

4. Background

4.1. Introduction

"A science of land health needs, first of all, a base datum of normality, a picture of how healthy land maintains itself as an organism." Aldo Leopold, A Sand County Alamanac

The New York City water supply system consists of unfiltered surface water sources (1,969 square miles) that supply an average of 1.3 billion gallons per day of drinking water to more than nine million people in the New York City metropolitan area. The West Branch Delaware River and the Cannonsville Reservoir *watershed* covers 455 square miles and accounts for 28% of the Catskill/Delaware Watersheds. This area (**Figure 4.1**) supplies approximately 50% of the city's drinking water. The New York City Department of Environmental Protection (NYCDEP) is the City agency with primary responsibility for oversight of the operation, maintenance and management of the water supply infrastructure and the protection of these watersheds.[1]

4.2. NYCDEP Filtration Avoidance Determination

The Safe Drinking Water Act (SDWA) amendments of 1986 required the United States Environmental Protection Agency (USEPA) to develop criteria under which filtration would be required for public surface drinking water supplies. In 1989, USEPA promulgated the Surface Water Treatment Rule (SWTR), which requires all public water supply systems supplied by unfiltered surface water sources to either provide filtration or meet a series of water quality, operational and watershed control criteria (filtration avoidance criteria).[2]

As a result, the NYCDEP filed for and received a conditional, renewable Filtration Avoidance Determination (FAD) in May 1997 (after a series of conditional waivers and a FAD beginning in 1993) under which the NYCDEP now operates its water supply system. The FAD is periodically reviewed and evaluated by the USEPA and the New York State Department of Health.

Central to maintaining the FAD are a series of partnership programs between New York City and the upstate communities, as well as a set of rules and regulations administered by the NYCDEP. As required in the FAD, this Stream Corridor Management Plan is being developed and implemented under the NYCDEP's Stream Management Program (SMP).

[1] New York City's 2001 Watershed Protection Program Summary, Assessment and Long-term Plan, December 2001. Section 1, pages 1-6. Also published on NYCDEP Website: http://www.ci.nyc.ny.us/html/dep/html/fadplan.html (Verified 8-26-04)

[2] Ibid. paraphrased.

Figure 4.1 Catskill/Delaware Watersheds of New York City Water Supply System

4.3. Stream Corridor Management Program Contract Development

Following the January 1996 flood event, which produced significant stream and infrastructure damage throughout the Catskills, it was recognized that a program to repair isolated streambanks would not effectively address the systemic causes of stream channel *instability* that exacerbate streambank *erosion*, compromise water quality and degrade *aquatic habitat*. In consultation with its watershed partners, the City of New York developed a stream management strategy to be implemented by its Stream Management Program (SMP). Its overall mission is to restore stream *stability* and stream ecological integrity by facilitating the long-term stewardship of Catskill streams and *floodplains*. As described in **Section 3**, local concerns about excessive stream erosion and flooding complement NYCDEP's concerns about water quality, making the partnership between NYCDEP and the Delaware County Soil & Water Conservation District (DCSWCD) a natural choice.

The main stem and tributaries of the West Branch were considered of significant priority by NYCDEP to be included in a first tier of projects to develop a comprehensive Stream Corridor Management Plan (SCMP) and DCSWCD was the appropriate agency with the legal mandate and experience to undertake this task. From 1999—2000, DCSWCD negotiated with NYCDEP to develop a SCMP contract for the West Branch of the Delaware River and its tributaries.

The contract was executed on 7/19/00 and an Order to Commence Work was issued to the DCSWCD on 9/12/00. The contract period was from 10/6/00 to 10/5/04, with funding (not to exceed $1,218,433) supplied by the NYCDEP and the US Army Corps of Engineers (USACOE). The primary tasks were to assess conditions of the entire main stem of the West Branch, and use the information gathered to develop a plan for the long-term stewardship of the basin. Two hundred thousand dollars of the contract sum would be used for construction and leveraging outside funds for one or more demonstration restoration projects.

A contract was executed in July 2000 and work commenced in December 2000, with a project term of December 2000 to December 2004. Subsequently, the project was extended to December 2005.),

4.4. Project Partners

When planning around any shared resource there are many different points of view, concerns, practices and regulations. To accomplish the goals and objectives described in **Section 3**, a communication network (advisory committee) was developed among the landowners and agencies that live, work near, or otherwise enjoy the streams and rivers in the basin.

4.4.1. <u>Project Advisory Committee</u>

In January of 2001 DCSWCD held a project information meeting to introduce the Stream Corridor Management Program (SCMPr) to prospective members of a Project Advisory Committee (PAC). Formed in March 2001, the committee has gradually expanded, each member bringing their own unique experiences and historical perspectives to the group. The PAC has met several times to review and discuss information collected by the SMP and to advise SCMPr as needed.

Early in the program, the staff and PAC identified stakeholders among the approximately 2,230 *riparian* landowners in the West Branch basin. This stakeholders list includes project partners, various categories of landowners and businesses, special interest groups, agencies, local municipal boards and highway departments, regulators, schools, media, and others interested in stream management. The PAC and Stakeholder lists are included at the end of this section.

4.4.2. <u>Initial Landowner Contact</u>

Initial landowner contact included a letter mailed to the 692 riparian landowners along the main stem of the West Branch, in early summer 2001, that briefly described the project and requested their support. This was followed by another letter and a release form sent to main stem landowners in the Towns of Stamford, Harpersfield and Kortright, seeking their permission to perform river assessments along their property. In early 2002, similar letters and release forms went out to West Branch main stem residents in the Towns of Delhi, Hamden and Walton. Landowners were overwhelmingly receptive in allowing the work to be performed. SCMPr maintained close contact with local landowners wherever stream data collection was being performed.

4.4.3. <u>Landowner Surveys</u>

Landowner perception of stream management issues was considered crucial to the success of the SCMP. Past and current management practices, the reasons for these practices and their successes and failures was considered valuable information for use with planned assessments, and would play an important role in future management recommendations. Important information was also gained as to where landowners were trapped into never ending cycles of stream maintenance, which would assist in the development of future management priorities and public outreach.

In May 2002 and again in April 2003, surveys addressing the perceptions of riparian landowners about their stream and its possible management alternatives were performed along the West Branch main stem and the main stems of the major sub-basin tributaries (see **Map 5.2**). The Town's of Harpersfield, Kortright, Stamford and the Kidd Brook *tributary* in the Town of Delhi were surveyed in 2002; Hamden, Bovina, Walton, Meredith and the remainder of Delhi were surveyed in 2003. Using two survey areas facilitated the survey process and coincided with the areas of the watershed being assessed during the 2002 and 2003 field seasons. The survey form was slightly modified for the 2003 survey to facilitate data compilation. The results of both surveys were combined and used to support efforts of the SCMPr, NYCDEP and the PAC to determine landowner concerns, target further research, and make plan recommendations.

Of 1037 surveys distributed, 230 were filled out and returned (a 22% return rate). Six land ownership classes were recognized for solicitation: permanent residence (44%), vacant/forested land (17%), agriculture (14% - representing 62% of the land base), seasonal residence (14%), business (7%), and government/public service (4%). Of the surveys returned, respondents were 50% permanent residents, 20% seasonal residents, 18% farmers, 6% businesses, 3% government/public servants, and 3% vacant/forested landowners. Of the permanent residents responding, 79% had lived in the basin 20 years or more, while 97% had 10 years or more of residency. 47% of the seasonal residents responding had lived here for 20 years or more, while 77% had 10 or more years of residency.

Of the agricultural respondents, 88% use their streams in their livelihood, and nearly 80% enjoy the stream view. Among all other residents, over 80% enjoy both their stream view and wildlife viewing. Nearly 70% felt that stream conditions are good to excellent. Respondents who enjoy fishing were about equally divided between those who felt stream conditions had improved, deteriorated or remained consistent over time. Their primary concern was with streambank erosion (over 60%). Moderate concerns include flooding of property and government regulation of private property rights (35% each). Minor concerns include the time required to obtain permits for stream-work, pollution from upstream, time and money required for proper stream care and washout of roads and bridges (20-26%). Over 40% indicated they had been affected by flooding multiple times, but only 27% indicated flooding as a frequent problem, while 44% thought flooding was a minor problem. 33% had never been affected by flooding. Some felt that *gravel* deposits need to be removed as a solution to flooding, while a few others felt that stream bank maintenance is necessary to maintain their streams. Over 30% felt that stream management decisions should be shared between landowners and local government, and 30% felt stream management decisions should rest with the local Soil & Water Conservation District. Survey forms, reports and summary tables are included in **Appendix 1**.

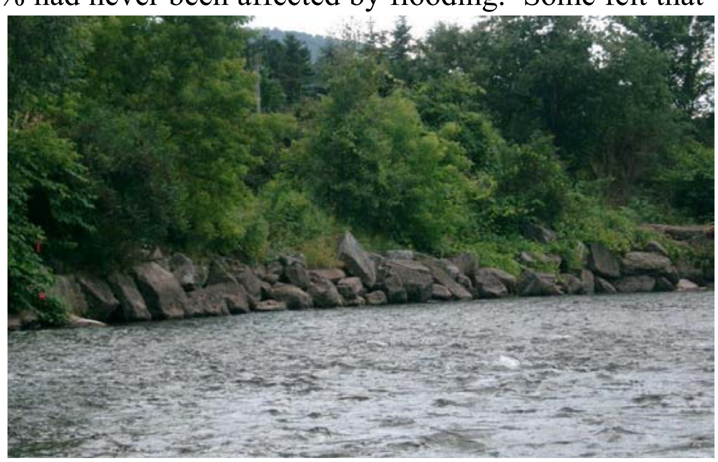

Figure 4.2 Example of streambank riprap above County Route 2 bridge in Delancey

The summary of responses listed above indicates that residents generally enjoy viewing their streams and stream conditions are good. Responding residents are genuinely concerned with erosion, and flooding is a moderate concern. Some respondents feel that some sort of maintenance is necessary to protect property and several have indicated concerns with obtaining permits and money to perform stream related work.

Additionally, several landowners with a long family history of living on the West Branch were asked to further share their experiences with living and working along the river. Due to the agricultural nature of the basin, most of these landowners were 3rd to 8th generation farmers. Approximately 80% of these respondents had experienced annual flooding with some indicating conditions have worsened since the January 1996 flood (see Section 3.8.3). Maintenance activities, generally consisting of the construction or maintenance of *berms* and/or dumped stone or riprap, were undertaken by 84% of the respondents. Generally, 30-40% of respondents had concerns with continuing erosion, widening of the river, increasing incidences of gravel bars, and difficulties with obtaining regulatory permits. An average of 36% of respondents appreciate the importance of floodplain function and natural river processes and have either natural or man-made buffers along at least some of their river frontage. Approximately 33% of the responding farmers prefer to mow or crop to the river's edge.

4.5. Watershed Agricultural Council

The Watershed Agricultural Council (WAC) was formed in 1992 to assist the NYCDEP in the development and implementation of voluntary watershed protection programs that include agriculture and forestry, with the overall objective of safeguarding and improving source water quality in the New York City watershed region through various conversation programs. Two programs pertinent to stream management are the Watershed Agricultural Program (WAP) and the Watershed Forestry Program, further described below. Further information is available on the WAC website: www.nycwatershed.org (Verified 12-07-04)

4.5.1. Watershed Agricultural Program

WAP is a contractual partnership between WAC and the following agencies: Delaware County Soil & Water Conservation District, USDA Natural Resources Conservation Service (NRCS) and Cornell Cooperative Extension (CCE). These partner agencies develop and implement Whole Farm Plans (WFP) that address goals documented in the United States Environmental Protection Agency's Filtration Avoidance Determination (see **Section 4.2**) and the WAC contract with New York City. WAP program staff consists of NRCS planners, agronomists and engineers, DCSWCD civil engineering technicians and technicians, and CCE crop, livestock, and nutrient management specialists.

WAP teams work collectively to plan and implement agricultural Best Management Practices (BMPs) as an integrated system on each participating farm in both large and small farm programs in the Catskill/Delaware Watersheds. These water quality BMPs are designed and constructed to NRCS standards and specifications and include: barnyard management systems, manure storage, roof runoff management, grazing systems, livestock water systems, livestock trails, comprehensive nutrient management, diversions, and crop rotation, to name a few. The Conservation Reserve Enhancement Program, implemented by USDA through WAP, is a very important riparian buffer program for land under agricultural production, further described in **Section 6.3.2**). Other practices not covered by NRCS standards are designed and implemented by a team of WAC engineers and technicians.

4.5.2. Watershed Forestry Program

WAC administers the Watershed Forestry Program with funding from the U. S. Forest Service and NYCDEP to address forestry needs within the Catskill/Delaware Watersheds. Community-based forestry groups and foresters provide technical support with the New York State Department of Environmental Conservation. The program encourages private forest landowners to actively manage their forests using sustainable best management practices and offers information and technical assistance to help them reach their goals, while observing practices that ensure the preservation of water quality.

The program offers training for consulting foresters and loggers and partners with the New York Logger Training's "Trained Logger Certification" program to help timber harvesters learn about a range of topics from safety and first aid to sustainable forestry to BMPs for water quality. The program also encourages forest land owners to develop and implement Forest Management Plans and provides technical assistance and some cost-sharing for implementation of forest management and riparian forest BMPs.

The Watershed Forestry Program also coordinates four model forests throughout the watershed that integrate research, demonstration, continuing education and public outreach. The Lennox Memorial Forest, the lone model forest in the Cannonsville basin, is a 140-acre site located south of Delhi and was completed in 2001. After viewing an educational kiosk that connects healthy forests to clean water, visitors travel a two-mile demonstration road with interpretive signs that highlight erosion control BMPs and fourteen silvicultural treatments. A number of deer "exclosures" are installed at the Lennox Forest to help research the effects of deer grazing on forest regeneration.

With funding from the USDA Forest Service Economic Action Program, eligible wood-based businesses in the NYC Watershed regions East and West of the Hudson River are awarded grants through the Forestry Grants Program to assist in a variety of projects ranging from web-site design and marketing to apprenticeship programs and new equipment. The results are improved safety and efficiency, cutting-edge wood technology and innovative marketing campaigns, all of which emphasize WAC's goal that forestry remain a viable enterprise to protect water and to bolster economic vitality in watershed communities.

4.6. Delaware County Action Plan

The Delaware County Action Plan (DCAP) was formulated in 1999 to address water quality issues in the New York City watershed. DCAP is a comprehensive strategy developed to meet the needs of Delaware County as a result of the Cannonsville basin being designated a phosphorus-restricted basin. DCAP coordinates with public and private agencies (listed below) to develop water quality initiatives and seek funding for implementation.

DCAP lead agencies include the DCSWCD and the following Delaware County Governmental Departments: Planning, Public Works, Watershed Affairs and Economic Development, and the New York State Water Resources Institute (WRI). Other DCAP participants include: Delaware County: Industrial Development Agency, Chamber of Commerce, and Cornell Cooperative Extension; Regional: Catskill Watershed Corporation, Watershed Agricultural Council and NYCDEP; New York State Departments: Environmental Conservation, Health, State, Agriculture and Markets, Soil and Water Conservation Committee, and Cornell University researchers. Federal Agencies: Environmental Protection Agency, Department of Agriculture, Natural Resources Conservation Service, and Army Corps of Engineers.

DCAP adopted a multiple barrier approach to address potential pollutants, particularly phosphorus. The barriers utilized are called the Initial Source Barrier, the Transport Barrier and the Stream Corridor Barrier. Current components of DCAP include management programs for stormwater and flooding, highway runoff, on-site septic systems, precision livestock feeding, forage management, SCMPr, and *monitoring* and modeling of best management practices to assess phosphorus reduction. By coordinating all water quality efforts under the DCAP umbrella, these programs are working together to collectively reduce pollutants entering watercourses and to improve overall water quality. The following categories demonstrate DCAP effectiveness to date:

Stream Corridor Management

The SCMPr has completed the following assessments:

- Rosgen Level II for the West Branch and Town Brook main stems.
- Evaluation of land use and riparian vegetation communities for the West Branch main stem.
- Cursory evaluation of stream conditions in proximity to road and bridge infrastructure.

The SCMPr has also implemented a full geomorphic demonstration restoration project to evaluate the effectiveness of natural stream channel design practices and principles. (see **Section 6, Findings** for a detailed description of the assessments and project)

This information is being integrated with other DCAP efforts, particularly the stormwater management and highway maintenance programs, to further enhance the effectiveness of these local water quality initiatives, further described below:

Stormwater Management

The Delaware County Planning Department (DCPD) has developed the following long-term management programs:

- Inventory, Assessment and Evaluation of Stormwater Sources and Infrastructure
  Goal: to identify all point and non-point sources of stormwater in village and hamlet areas and manage them to reduce their impact on water quality.

Work Completed:

- A detailed evaluation of stormwater sources and conveyance systems is underway in the Cannonsville basin using *GPS* to locate stormwater infrastructure and culvert outfalls in hamlets and villages. A *Geographic Information Systems* (GIS) database has been created combining this information with soils, land use and topographic datasets. (The local infrastructure in the Pepacton basin has been completed to date).
- Pilot projects of stormwater collection, conveyance and treatment methods have been implemented in the villages of Stamford, Delhi and Walton.

- Local Implementation and Municipal Plan Development

  Goals: to work with each municipality to develop local initiatives for water quality protection through stormwater management and demonstrate the role of water quality to community economic development; also, to develop Stormwater Management Plans consistent with the NYCDEP Watershed Regulations and Phase II EPA Stormwater Regulations.

  Work Completed:
  - Failing components of stormwater infrastructure in Bovina Center have been assessed and replaced.
  - Stormwater Management Plan finalized for the Village of Walton.
  - Stormwater Management Plan under way for the Village of Delhi.
  - Planning for source water protection.

Highway Management Activities

The Delaware County Department of Public Works (DCDPW) completed an inventory and assessment of storm drainage infrastructure along county highways in 1999 and continues to maintain a comprehensive inventory and assessment program for all pipes and their conditions. DCDPW has since evaluated alternative repair strategies for culverts that have reached the end of their useful life. These alternatives include culvert cut and cover practices; line inverts of existing pipes with concrete; and slip line existing pipes and fill interstitial space.

Ongoing management practices include: 1) Sediment removal from culverts and catch basins with a vacuum truck; made possible with the help of a 75% grant from the CWC 2) In-place road culvert stabilization, which includes slip lining failed culverts (when feasible) to minimize sedimentation caused by traditional excavation and replacement. 3) De-icing material control, which includes installation of modern control equipment on material spreaders to facilitate precise metering of de-icing materials. 4) All new structures (drop inlets) installed by DCDPW include sumps. These new structures are part of routine maintenance practices and capital improvement projects.

DCDPW currently has a stormwater retrofit project underway on County Route 6 in Bovina Center. Construction of this project is scheduled to be completed in 2005. DCDPW is also currently evaluating a retrofit project at the main DCDPW offices and shop complex on Page Avenue in the Village of Delhi. DCDPW has been working with the Village to continue two stormwater collection systems into one treatment system. For this project natural treatment systems are being evaluated, however there is currently no projected construction schedule.

DCDPW along with the assistance of DCPD has inventoried and cataloged all major drainage features on county highways using GPS and a GIS database. The databases are keep up to date with continual updates from DCDPW crews after maintenance and repairs to any infrastructure. DCPD maintains and houses the databases and provides continuous support to DCDPW on this program.

As a result of Delaware County's efforts to improve stormwater, DCPD along with DCDPW developed a town highway management program. DCPD has been successful at securing moneys from the New York State Department of State (NYSDOS) to inventory town highways and all associated infrastructure and drainage systems. Data has been collected using GPS in the towns of Davenport, Andes and Kortright. The inventories have been cataloged through a GIS database and all infrastructure in has been mapped. DCPD along with DCDPW has continued to seek funding to continue phase two of developing the town highway management plans. Phase two requires an engineer assessment and evaluation of the infrastructure and the development of a multi-year capital investment plan. There is currently a grant proposal into the NYS DOS to develop one complete highway management plan from inventory through assessment and including a capital investment plan for the Town of Walton.

Other activities include creation of *wetlands* towards the establishment of a mitigation bank on county-owned property in Walton, and research investigating the use of chipped passenger car tire chips as a medium to remove dissolved phosphorus from stormwater.

Additional information is available on the DCAP website:
http://www.co.delaware.ny.us/depts/h2o/dcap.htm (Verified 12-07-04)

4.7. Catskill Watershed Corporation

The Catskill Watershed Corporation (CWC) is a not-for-profit local development corporation with a dual goal: to protect the water resources of the New York City watershed west of the Hudson River, while preserving and strengthening communities located in the region. The CWC was formed in January 1997 with the signing of the New York City Memorandum of Agreement between City, State, federal, local and environmental entities. To help offset the costs and restrictions of increased regulations and land purchases by the city, CWC is charged with developing and implementing several city-funded programs including residential septic rehabilitation, replacement and maintenance, community wastewater management, planning and installation of stormwater controls, road salt storage, public education and economic development. CWC also consults on recreational uses of city lands, tax assessment issues, and wastewater treatment plants planned for several watershed communities. These programs are intended to protect the quality of the water which sustains 9 million residents of New York City and its suburbs, while at the same time preserving and strengthening the rural communities within the 5-county Catskill and Delaware Watersheds. Further information is available on the CWC website: www.cwconline.org (Verified 12-07-04).

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Delaware County Departments
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Planning
Public Works
Watershed Affairs
DCSWCD

Local Organizations
Catskill Revitalization Corporation
Chambers of Commerce

Business Entities
Campgrounds
Contractors
Developers
Farmers
Hunting and Fishing Guides
Foresters
Golf courses
Realtors
Ski slopes
Other local businesses

Local Governing/Planning Boards and Highway Departments
Bovina, Town of
Delhi, Town of
Franklin, Town of
Hamden, Town of
Harpersfield, Town of
Hobart, Village of
Kortright, Town of
Meredith, Town of
Stamford, Town of
Stamford, Village of
Walton, Town of
Walton, Village of

Regional Entities
Catskill Watershed Corporation
Catskill Center for Conservation and Development
Cornell Cooperative Extension
Delaware River Basin Commission
New York City Department of Environmental Protection
New York Farm Bureau
Watershed Resource Institute

State Entities
New York Department of State
New York State Department of Environmental Conservation
New York State Department of Transportation
New York State Emergency Management Office
New York State Office of Parks, Recreation, and Historic Preservation
New York State Soil and Water Conservation Committee
State University of New York at Delhi

Federal Entities
Federal Emergency Management Agency
National Oceanic and Atmospheric Administration
United States Department of Agriculture
Natural Resources Conservation Service

United States Forest Service
United States Army Corps of Engineers
United States Department of the Interior
United States Environmental Protection Agency
United States Fish and Wildlife Service
United States Geological Survey

Special Interest Groups
4-H clubs
Anglers
Canoers/boaters
Future Farmers of America groups
Scouting groups
Trout Unlimited

Other Interests
Allen Residential Center
Churches
Non-riparian landowners
Phoenix House
Public utilities
Riparian landowners
Schools
Seasonal riparian landowners
Water consumers (local, NYC)
Water recreation interests

Media
Catskill Mountain News
Country Folks
County Shopper
Delaware County Times
Deposit Courier
Hancock Herald
Local cable network – Delhi
Local cable network – Walton
Mirror Recorder
Mountain Eagle News
Stamfordword.com
The Daily Star
The Reporter Company
Tri-Town News
WBNG TV - Binghamton
WCDO Radio
WDHI Radio
WDLA Radio
WDOS Radio
WIYN Radio

Section 5 – Watershed Description and Characterization

LIST OF MAPS

5. Watershed Description and Characterization

Note: Maps 5.1 through 5.9 as described in the text are full page maps included at the end of this chapter.

5.1 Regional Setting

The West Branch of the Delaware River drains the central portion of Delaware County, NY (**Figure 5.1**). The river flows southwest into the Cannonsville Reservoir, the western most impoundment in the Catskill/Delaware water supply system for the City of New York. The project area *watershed* includes the river and its tributaries to the headwaters of the riverine system (its upper headwaters extend into the Utsayantha Lake drainage in Schoharie County). It should be noted that the defined project area is located in the headwaters of the Delaware River system together with its sister East Branch Delaware River to the south. These two streams join at the southwestern corner of the county to form the main Delaware River. The Delaware River flows to the Atlantic Ocean (Delaware Bay) between the states of Delaware and New Jersey. (Kaplewicz)

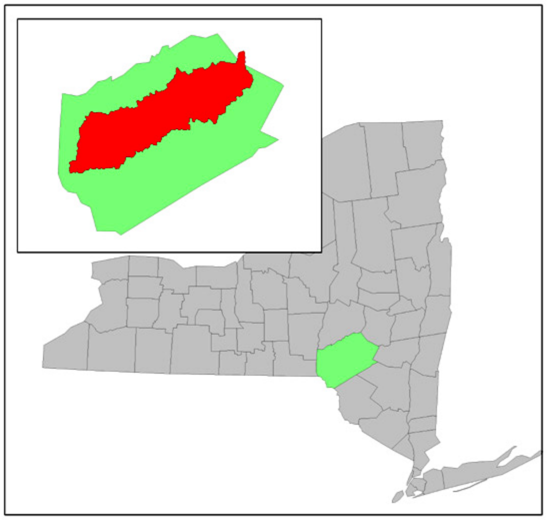

Figure 5.1 Cannonsville Watershed regional setting

As shown in **Map 5.1**, seven towns are largely within the project area: Walton, Hamden, Delhi, Kortright, Stamford, Harpersfield, and Bovina. These are all contiguous to the main stem of the West Branch of the Delaware River with the exception of the Town of Bovina, which is contiguous to the Little Delaware River, the largest *tributary* in the project area. Parts of the Towns of Meredith, Franklin, Andes, Roxbury and Sidney are located in tributary headwaters areas. The incorporated villages of Walton, Delhi, Hobart, and Stamford plus the five recognized hamlets of Hamden, Delancey, Bloomville, South Kortright, and Bovina Center are also included.

Due to its proximity to downstate population centers, the area has been popular for tourists and for development of seasonal homes for over a century. The watershed is largely rural, yet metropolitan New York and upper New Jersey are about a 3 hour drive and the Albany/Capitol District about a 1½ hour drive from the center of the watershed. New York State Route 10 parallels the West Branch and is the only east-west access through the area, Interstate 88 lies parallel and to the north, and the Route 17 "quick-way" is to the south.

Figure 5.1a Looking down the West Branch valley from atop Utsayantha Mountain near Stamford

5.2 Physiography

Physiography refers to the physical features of the earth's surface, including landforms, climate, currents of the atmosphere and ocean, and distribution of flora and fauna or the general "look" of the land. A physiographic province is a region in which all parts have similar geologic structure and climate, a unified geomorphic history and pattern of relief features or landforms that differ significantly from adjacent regions.

The watershed is located in the eastern portion of the Allegheny Plateau physiographic province, which is the northern part of the Appalachian Plateaus that extend from southern New York to central Alabama (**Figure 5.2**). Locally, the Allegheny Plateau extends throughout southern New York and includes the Catskill Mountains and southern sections of the Mohawk River basin (Isachsen, et al., 1991). Rivers and their tributaries have cut the originally level plateau into hilly uplands. The plateau surface is evident in the pattern of hilltops all tending to reach the same elevations in their respective locations in the watershed, creating a dissected plane that slopes gradually upward from northwest to southeast

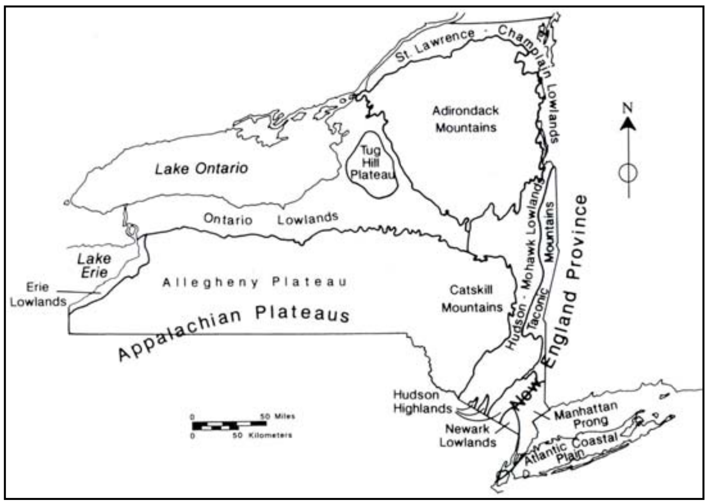

Figure 5.2 Physiographic regions in NY State

The West Branch of the Delaware River is the principal drainage channel for the basin and it delivers flows form northeast to southwest through a relatively narrow, flat floored valley. At its maximum, in the Village of Walton, the valley is about 1 mile across. Hillsides along the West Branch valley tend to be asymmetric, with steeper slopes facing north and gentler slopes facing south. Tributary streams typically occupy very narrow valleys, or "hollows", that generally intersect the West Branch at right angles.

5.3 Morphometry

Morphometry refers to the techniques used to measure the shape and form of something, in this case the watershed and its stream network. Such measurements form the foundation for understanding the current state of the river corridor in quantitative terms. This allows the design of practices that fit naturally within the watershed. Much of the remainder of this section of the stream corridor management plan describes information from scientific disciplines related to basin morphometry. A discussion of how this information is used in geomorphic stream design is given in **Section 5.9.2**.

The West Branch of the Delaware River drainage encompasses an area of 353.5 square miles. It contains 662.4 miles of streams, from the high-water mark of the Cannonsville Reservoir to the source of the West Branch. The minor portion of headwaters located in Schoharie County is not included in this management plan area, but does contribute to the overall watershed drainage area. **Map 5.2** shows the 20 major sub-basins delineated for the purpose of this plan. **Table 5.1** shows the drainage areas and stream lengths for each of these identified sub-basins.

Table 5.1 West Branch Delaware River sub-basins, drainage areas and stream lengths

Sub-basin (alphabetical)	**Watershed Area** (sq. mi.)	**Stream Miles**
Bagley Brook	15.64	25.60
Beers Brook	6.79	11.30
Betty Brook	9.14	15.20
East Brook	24.94	48.60
Elk Creek	14.50	27.10
Falls Creek	7.77	13.40
Kidd Brook	5.20	10.00
Lake Brook	6.91	13.40
Little Delaware River	52.26	97.50
Peak's Brook	7.80	13.20
Pines Brook	5.23	10.60
Platner Brook	13.99	26.40
Rose Brook	14.86	27.70
Steele Brook	6.73	10.80
Third Brook	5.52	9.20
Town Brook	16.08	27.00
West Branch Headwaters	15.64	26.30
West Brook	22.45	42.00
Wright Brook	12.03	22.40
Subtotal	**263.48**	**477.70**
West Branch Main Stem Basin	90.04	184.70
Total	**353.52**	**662.40**

From the outlet of Utsayantha Lake (1875 feet elevation above mean sea level), the West Branch of the Delaware River flows approximately 51 miles to the Cannonsville Reservoir (elevation of high-water mark 1150 feet). The river itself has an average slope of 0.58 %, while the average valley slope is 0.66%.

The West Branch watershed includes numerous ridges and peaks with elevations greater than 2000 feet. The highest elevations occur along the eastern edge of the basin, where the summit of Mount Pisgah reaches 3345 feet and Plattekill Mountain in the Little Delaware River sub-basin rises to over 3340 feet. Ridgetop elevations are slightly lower in the southwestern portion of the watershed, reaching just above 2500 feet along the southern divide between the West Branch main stem basin and the Beers Brook sub-basin. Ridgetop elevations in the northern portion of the watershed generally range from 2200 to 2300 feet, rising to over 2500 feet in the Wright Brook, Betty Brook and Lake Brook sub-basins, with the highest elevation of 2560 feet in the Wright Brook sub-basin. The sub-basins are generally drained by low to moderately steep tributaries that flow along U-shaped valleys. Tributary streams entering the West Branch main stem valley from the north and south have, in many places, truncated previously existing landforms and added their own *bedload* to form alluvial fan deposits (Day and Weidenbach, 1990).

5.4 <u>Climate</u>

5.4.1 Introduction

This section consists of two subsections that describe the general climate and the effects of physiography on the local economy. Climate conditions are variable both globally and in a given region. Climatic changes can noticeably affect seasonal rainfall and streamflow is derived form rainfall or snowmelt (Leopold, 1997). Varying rainfall amounts and soil moisture conditions prior to a rainfall event (or series of events) can have a direct effect on flooding frequency and magnitude. Therefore, it is necessary to have an understanding of climate to fully understand how stream systems function.

5.4.2 <u>General</u>

The climate of Delaware County is humid continental. Cool, dry air masses move generally eastward throughout the year, and warm, humid maritime air masses from the south move northeastward during the summer (Lumia, 1991). The summers are cool, with relatively few hot days. Cold winter temperatures prevail whenever Arctic air masses flow southward from central Canada. Mean daily temperatures range from the low 20's in winter to the upper 60's in summer. Rainfall is usually adequate during the growing season (May – September) but deficiencies of precipitation may occur from time to time.[1] Mean annual precipitation ranges from 46.69 inches in Walton to 41.40 inches in Stamford. **Map 5.3** shows the average annual rainfall distribution in the basin. Average snowfall in the valleys is near 65", with higher terrains receiving slightly more. **Table 5.2** shows the monthly averages for precipitation and temperature for the period of 1971 through 2000 (NOAA, 2002) (Note: water content in snowfall is computed by the National Weather Service and is included in the precipitation figures). Solar aspect, the orientation of a slope to the sun, also affects the local microclimatic conditions. South facing slopes are warmer and drier than the cool, often moist north facing slopes of the valley. A dramatic example of the effect of aspect on the watershed hydrology occurred during the January 19, 1996 flood event (see **Section 5.8.3**). Warm winds blowing against the south facing slopes of the watershed rapidly melted the 20 - 30 inch snow pack which contributed an estimated 3 inches of equivalent rainfall to approximately 2 ½ inches (average) of actual rainfall (Lumia, 1998, pages 8-13).

[1] The Climate of New York, Cornell University Website: http://nysc.eas.cornell.edu/climate_of_ny.html (Verified 7-27-04)

Table 5.2 Monthly average precipitation and temperature in the West Branch of the Delaware River basin.

	Precipitation Normals (Inches)*												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Walton	3.29	2.83	3.72	3.98	4.34	4.28	4.31	4.13	4.07	3.91	4.26	3.57	46.69
Delhi	2.95	2.35	3.39	3.90	4.26	4.47	3.86	3.29	3.97	3.70	3.87	3.19	43.20
Stamford	2.82	2.28	3.14	3.61	4.26	3.91	4.01	3.72	3.73	3.43	3.65	2.84	41.40
	Average Snowfall (Inches)												
Delhi	17.1	10.9	11.9	4.3	0.0	0.0	0.0	0.0	0.0	0.4	4.8	13.7	63.1
	Temperature Normals (Degrees Fahrenheit)												
Max	31.2	34.1	43.3	55.6	68.2	75.9	80.2	78.5	70.4	59.7	46.7	35.5	56.6
Mean	21.5	23.6	32.9	44.0	55.3	63.5	67.6	66.3	58.8	47.9	37.8	26.9	45.5
Min	11.7	13.1	22.4	32.2	42.3	50.9	55.0	54.1	47.1	36.0	28.8	18.3	34.3
	*Data from Climatography of the United States Nos. 20 & 81, 1971-2000, National Oceanic & Atmospheric Administration National Climatic Data Center												

5.4.3 Effects of Physiography on the Local Economy

Dairy farming and forestry are the most common and extensive land uses in the basin. Precipitation and temperature favor the growth of alfalfa and grasses for hay and corn for silage, except where limitations are imposed by soils and topography. Stands of sugar maple (*Acer saccharum*) are widely used for syrup production. Timber management is especially prevalent in the lower portion of the watershed where soils and slopes are less suitable for agriculture. Generally abundant snowfall supports snowmobiling for winter recreation. Spring and early summer flows provide a venue for water recreation by kayakers and canoers on the West Branch main stem. Combined with the local geology, the climate has resulted in the large number of springs that commonly occur near the base of hills. These cold water inputs to the river provide excellent fish habitat which attracts numerous anglers from the local community and the New York City metropolitan area. Spring water is also an important source of drinking water for some individual homes and some municipal water supplies.

5.5 Geology

5.5.1 Introduction

In landscapes unchanged by human activities, streams reflect the regional climate, biology and geology. Climate was discussed in the preceding section, while biology, especially streamside vegetation, will be discussed in **Section 5.10**. The following section describes the basic geology of Delaware County and the West Branch basin, how this affects the stream channel form or fluvial *morphology*, and water quality of the basin.

5.5.2 Bedrock Geology

The bedrock underlying all of Delaware County is of sedimentary origin. The *sediments* resulted from the *erosion* of a large mountain range that once existed to the east during the upper Devonian Period, some 370 million years ago. Westward flowing rivers deposited layers of *sand*, *silt* and *clay*, which eventually became the beds of sandstone, siltstone and shale rocks of today.

The regional dip of these otherwise flat lying rock layers is towards the south-southwest at angles less than 10 degrees, although steeply inclined, coarse crossbedding within individual rock units also occurs. Rock colors are shades of red or bluish gray due to deposition in environments of high oxygen (terrestrial) or low oxygen (tidal or alluvial plain), respectively. Fossils are typically few, poorly preserved plant fragments, trace fossils, and some marine fauna; the dominance and abundance of each varies between locations and individual beds. Studies of bedrock types, layer sequences and fossil records indicate ancient delta-like and shallow marine environments within a tropical climate that was alternately wet and dry.

Eventually, long periods of pressure from overlying sediments and cementation by mineral-carrying waters lithified sands into sandstones (or conglomerate, if gravelly) silts into siltstone and silty clays into shale. The thickest and most uniform beds of certain sandstones are now valuable for local "bluestone" quarries. As one travels from north to south across Delaware County, bedrock outcrops tend to expose progressively younger rocks. **Map 5.4** shows the occurrence of bedrock types in the watershed.

Important rock Groups and some of their component rock formations are, from oldest to youngest: the Genesee Group, which includes the Unadilla and Oneonta formations; the Sonyea Group, which includes the Lower Walton formation; and the West Falls Group, which includes the Slide Mountain and Upper Walton formations. None of these formations contain beds of limestone, but rather contain much silica; they are therefore considered to be "acidic" rocks, and spring water arising from bedrock cracks and fissures tends to be low in calcium and magnesium carbonates ("soft" water).

As mountain-building forces raised the Appalachian mountain chain to the south, this also created a smaller uplift of the Catskill region. As this occurred, long periods of erosion created the stream valleys of today, which probably originated along joints or fractures in the bedrock layers. Thus, the Catskill Mountains were created more by forces of erosion than those that build mountains upward. However, the shapes of the landscape have also been significantly remolded by glacial events, as described below (Isachsen, et al., 1991).

5.5.3 Glacial Geology

A number of major glaciations have occurred in North America. Geologic age dating techniques imply that the most recent glaciation to leave this area (the Wisconsin glaciation) did so only some 10 to 12 thousand years ago. At its furthest advance, glaciers covered the county with moving ice nearly one mile thick, extending hundreds of miles northward. This caused tremendous amounts of erosion by abrasion and bedrock "plucking", pressure melting and refreezing of the ice as it moved over hills. The generally rounded and smoothed profile of hills and the U-shaped cross section of larger valleys resulted. The processes of glacial erosion crushed and fragmented rocks into a slurry of *boulders*, angular stones and *gravel*, sand, silt and clay. This mixture was transported beneath, within and on top of the glacier, sometimes for many miles before being deposited by the ice or its meltwaters. When deposited in this form, i.e. a random mixture of particle sizes, this material is called glacial till, and most uplands are covered with till (**Map 5.5**)[2]. Because layers of sandstone and siltstone were continuously ripped up and incorporated into the till, upland soils are commonly stony (or very stony) throughout their depth. Till was deposited as a relatively thin layer (less than 40 inches thick) on many hilltops and north facing slopes, and in thicker layers over other areas. Certain south facing hillsides received unusually thick accumulations of till (over 50 feet thick) where they were on the lee side of hills that obstructed the flow of advancing ice.

After long periods of glaciation, the climate warmed again and the glaciers melted back northward faster than they were flowing southward. This melting created tremendous amounts of sediment-laden water in rivers and lakes. However, tongues or flows of ice tended to remain in the larger valleys long after the uplands were relatively ice-free. Eventually these valley ice masses stopped flowing and melted away, creating landforms and deposits that are distinctly different from those in the uplands. Large amounts of meltwater flowed along the sides of and beneath the stagnant valley ice masses, washing through the rocky and muddy debris. This tended to separate and remove the finer silt and clay from sand and gravel. In locations where washed and sorted debris was deposited, usually the margins of major valleys such as the West and East Branches of the Delaware River, gravelly terraces and kame deposits occur (**Map 5.5**). This gave these parts of the landscape a somewhat lumpy and bumpy appearance. Such deposits are often valuable sources of sand and gravel, although they typically contain more silt and clay than are desirable.

The stagnating remains of the valley glaciers blocked off the outlets of some meltwater streams, creating lakes until the dams of ice could melt, which took many years. In the quiet waters of deeper lakes, silts and clays settled out and accumulated while in shallower, more agitated lakes fine sand and silt was deposited. The finest-textured (clayey) sediments formed relatively small deposits (commonly a few acres each), as have been observed in excavations north and south of Walton (personal communication, Laurence Day, DCSWCD, 12/15/04). Coarser lake-laid deposits occur in the West Branch and other valleys, although more recent *floodplain* deposits often overlie them. The river itself winds through the relatively flat surface of accumulated sediments over the much deeper valley carved into the bedrock. Rich (1935) reported about 60 feet of sediment filling the valley floor at Bovina Center, and Day and Weidenbach (1990) reported numerous test wells in the Village of Walton were drilled more than 130 feet before bedrock was encountered.

Where relatively fast-flowing tributary streams enter major valleys, water *velocity* slows as they flow across the flatter river floodplain. The abrupt slowing of the stream's velocity causes it to drop its bedload of sand and gravel on the floodplains as a subtle fan or delta-shaped alluvial fan deposit. This process has been continuing since the waning stages of glaciation, and alluvial fans are commonplace in larger valleys. Because these deposits are fairly level and well drained, they make good farmland and building sites; the center of many villages and hamlets, including Walton and Delhi, are on alluvial fan landforms.

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[2] Isachsen and others (1991, pgs. 161-193) discuss the glacial epoch and its effects on NY landscapes. Titus (1996) and Rich (1935) give more in-depth descriptions of glacial landforms in the Catskills Region than the summary provided here. Map 3.5 is based in part on the work of Rich and others.

The glacial deposits described above are the parent materials in which the soils of today have developed. In terms of geology and soil formation, the Epoch since the glaciers left their deposits on the Delaware County landscape is a short period of time. Processes of erosion and sediment accumulation continue to affect the landscape, although their rates can be greatly accelerated by man's activities.

5.5.4 Applied Geology

An understanding of geology can be useful background to stream corridor management because bedrock and glacial deposits (see **Map 5.5**) influence the stream system within its drainage basin. Dendritic stream patterns, such as in this watershed, tend to develop where horizontally bedded, sedimentary bedrock had a gently sloping regional dip at the time the initial drainage channels began forming[3]. The bedrock jointing pattern (intersections of deep fractures) also influence stream pattern formation. Rates of stream channel downcutting, bank *stability* and lateral migration are dramatically reduced wherever the stream channel contacts bedrock instead of stream deposits. One example where the stream has cut down to bedrock is in Town Brook near the intersection of Clove Rd.

Thin soils typically cover fractured bedrock on the hilltops, while thicker deposits of glacial till occur at some distance downslope. As a result, precipitation infiltrates bedrock fractures on hilltops, creating and recharging the bedrock aquifer that is relied on for individual drinking water wells and springs. Small springs are quite common throughout the basin, and often are the places where tributary streams originate. Springs and other groundwater sources comprise the majority of stream base flow in drier, summer months. In general, the quality of this groundwater is soft (since the bedrock is low in limestone and other carbonate rocks), low in dissolved solids and chloride, but commonly contains considerable iron.[4]

The extensive areas of glacial till in the basin have developed permeable, upper soil layers, often 1 to 3 feet thick, that overlie relatively dense and slowly permeable subsoils. Abrupt changes in permeability create saturated zones (perched water tables) at the contact between the two materials. On lower portions of hillslopes, the upper soil layers often become saturated to the surface from the shallow throughflow. This in turn influences where erosive rills begin to form on a slope, and where new stream channels eventually begin to form.

The glacial till deposits tend to be relatively coarse textured, often including a substantial amount (15 to 35% by volume) of gravel- to boulder-sized rock fragments. This reduces soil erodibility by providing a sort of "armoring" effect[5], and physical stability of stream beds and banks may similarly be increased, especially where the rock fragments are firmly held within firm till deposits. The pervasive sandstone layers in local bedrock tend to form relatively flat clasts (rock fragments) in the till. In stream deposits, such as gravel bars, point bars and alluvial fans, flowing water often arranges these flat stones into a shingled or imbricate form, where one clast rests on a slight angle on top of another. Imbricated streambeds require a larger flow to move the bed material than do non-imbricated beds.

[3] Ritter, 1978, p. 171.
[4] Soren, 1963.
[5] McCormack, et al., 1984.

The main stem of the West Branch Delaware River flows mostly through alluvial soils (shown as "recent alluvium" on **Map 5.5**). Wherever eroding streambanks include deposits of relatively loose (non-cohesive) soil materials containing considerable fines, much sediment can be suspended in the water downstream. Such materials can include the "kame", "kame moraine" or "till moraine" deposits of **Map 5.5**, as well as recent alluvium. The tributaries of the main stem are more likely to contact the more cohesive glacial "till" in the uplands. Soils

Agriculture is a major land use in the West Branch watershed, and it is linked to the land use changes that may be needed in the future to enable successful stream corridor management. Many practices that limit the loss of excess *nutrients* and eroded sediments from farmland, and keep them from entering surface water, involve the consideration of soil type. While it is important to at least introduce the subject of soils, because the preceding section described glacial deposits in some detail, and since soils and the glacial deposits they develop in are closely linked, discussion about soils in the study area can be kept on a generalized level.

5.6 Soils

The character of soils reflects the various forces that have been weathering a geologic deposit over time. As described in the glacial history section, the most extensive geologic deposits in the watershed are the broad areas of glacial till in uplands, while sandy or gravelly materials are limited to relatively narrow floors and margins of valleys. The dominant soil types in these upland and valley settings strongly reflect the geologic deposit or "parent material" in which they are forming. Hence, the large proportion of angular-shaped stones incorporated into the till has produced the stony soils we see exposed in upland crop fields, and gravelly loam soils are common where villages have been built in the valleys, for example.

The USDA-Natural Resources Conservation Service has mapped soils in Delaware County through their soil survey program. **Map 5.6** shows a generalized view of soils mapping in the study area, using only four map units instead of the 129 recognized in the detailed soil survey. Reddish brown soils that occur in upland glacial tills are Lackawanna-Wellsboro (which occur at elevations below 1750 feet), and Willowemoc-Lewbeach-Onteora (similar soils but with a shorter growing season, mapped above 1750 ft). The more sandy and gravelly soils of the valleys (below 1750 ft.) comprise the Tunkhannock-Maplecrest-Barbour map unit. The West Branch main stem flows largely within this soil map unit. A small area of Mongaup-Willdin soils, which are brown-colored and occur above 1750 ft., occur in the northwest part of the study area. As illustrated, a distinct soil group trend occurs from lowland areas to the surrounding uplands. For readers that are interested, these soil groups are further described below, from lowest to highest elevations in the basin.[6]

The *Tunkhannock-Maplecrest-Barbour* soil group is found along the West Branch main stem and adjacent valley lowland areas from the Cannonsville Reservoir upstream nearly to the Schoharie County line. This soil group covers slightly less than 11% of the basin and is the predominant soil group in the stream corridor of the West Branch of the Delaware River. General characteristics include: very deep, more than 60 inches to bedrock; somewhat excessively drained (Tunkhannock) to well drained (Maplecrest and Barbour); medium to moderately

[6] USDA-NRCS, unpublished soil survey data, Delaware County, New York, 1998. *General Soil Map Units,* 16 pages.

coarse textured; found on nearly level to steep slopes in valleys, on valley sides, on terraces in mid-valley positions, and on low terraces and floodplains along streams.

The *Lackawanna-Wellsboro* soil group is adjacent to the Tunkhannock-Maplecrest-Barbour soil group in approximately the lower one-half of the basin, and extends substantially upstream into the Pines Brook, Third Brook, West Brook, East Brook, Platner Brook, Peaks Brook, and Steele Brook sub-basins. This soil group also encompasses significant portions of the main stem areas of Bagley Brook and Little Delaware River, and is present in the upper headwaters area. This soil group covers approximately 19.3% of the basin. General characteristics include: very deep, more than 60 inches to bedrock; well drained (Lackawanna) to moderately drained (Wellsboro); medium textured, with relatively dense subsoils; found on gently sloping to very steep hilltops and hillsides.

The *Willowemoc-Lewbeach-Onteora* soil group is found at the next general elevation level and is the predominant soil group, covering approximately 69.6% of the basin. General characteristics include: very deep, more than 60 inches to bedrock; moderately well drained (Willowemoc) to well drained (Lewbeach) to somewhat poorly drained (Onteora); medium textured, with relatively dense subsoils; found on nearly level to very steep hillsides and hilltops and along small drainageways.

The *Mongaup-Willdin* soil group is found in only a small area in the northwesterly portion of the West Brook sub-basin, covering less than 1% of the basin, and is primarily found in sub-basins outside of the project area. General characteristics include: moderately to very deep; moderately well drained (Willdin) to well drained (Mongaup); medium textured; found on gently sloping to very steep hillsides and broad hilltops. Willdin soils are found on gently sloping to moderately steep hillsides, have relatively dense subsoils and are more than 60 inches in depth to bedrock. Mongaup soils are found on the upper parts of hillsides and on bedrock-controlled hilltops and are 20 to 40 inches to bedrock.

Silty clay deposits are very few and of small size across the basin. Represented on the map by black dots, these are areas of less than 5 acres that have notably finer texture than the surrounding soil types and were noted when the soil survey was being performed in Delaware County.

In New York State, soils have been classified into four hydrologic soil groups based on *runoff* potential and infiltration rates. **Map 5.7** shows this information in the project area, which is useful for determining runoff characteristics in the basin. These four runoff groups are defined as follows:[7]

> Group A soils exhibit low runoff and high infiltration even when thoroughly wetted. They are chiefly sands and gravels that are deep and well drained to excessively well drained. Group A soils are found in 3.9% of the basin, generally occurring along the West Branch main stem and the main stems of larger tributaries.
>
> Group B soils exhibit moderate infiltration when thoroughly wetted. They are moderately deep to deep, moderately drained to well drained, and are moderately fine to coarse textured. Group B soils are found in 5.1% of the basin, again generally occurring along the West Branch main stem and the main stems of larger tributaries.
>
> Group C soils exhibit low infiltration rates when thoroughly wetted. They have a layer that impedes downward movement of water, such as hardpan subsoils or bedrock at 20 to 40 inch depths, and are moderately-fine to fine textured. This is the predominant

[7] National Engineer Handbook 649.00, United States Department of Agriculture Natural Resources Conservation Service. Chapter 2, page 2-2.

hydrologic soil group, covering 68.2% of the basin. These soils can contribute substantially to runoff.

Group D soils exhibit high runoff and very low infiltration when thoroughly wetted. They are chiefly clay soils with a permanent high water table, have a clay layer at or near the surface, and are shallow over nearly impervious material. Group D soils are found in less than 1% of the basin.

In many areas of the basin, dual hydrologic groups exist. These are Group A/D and Group C/D and are soils that can be adequately drained. The first letter applies to the drained condition and the second to the undrained condition. Group C/D soils are generally found where bedrock is close to the surface. If the bedrock is not fractured, the soils exhibit Group D characteristics. Where the bedrock is fractured, the soils exhibit Group C characteristics.[8] Group C/D soils are found in approximately 20.1% of the basin, generally in the higher upland areas. In Delaware County, Group A/D soils are quite permeable but are generally saturated, therefore exhibiting Group D characteristics. Group A/D soils are found in less than 0.1% of the basin

Two other soil types identified not previously mentioned are Fluvaquents and Udorthents. Fluvaquents are composed of many soils of varying textures along narrow stream channels. These soils flood frequently, resulting in both erosion and deposition. These soils are found in 1.4% of the basin, sporadically located along watercourses throughout the watershed. Udorthents consist of very shallow to deep, excessively drained to moderately well drained soils that have been altered for construction operations. They can also be found at landfill sites or may be former sand and gravel pits. Udorthents appear sporadically in developed areas and areas of excavation and/or filling and cover approximately 0.1% of the basin.

"Urban land" was mapped where 80% or more of the surface is covered with asphalt, concrete, other impervious materials or roofed buildings.[9] These impervious surfaces shed water very quickly, which can produce localized flash flooding. Less than 0.1% of the basin is mapped as urban land. Bodies of open water, which include larger streams, ponds, lakes and reservoirs, account for about 0.4% of the basin.

5.7 Land Use/Land Cover

Map 5.8 shows vegetative cover in the watershed as interpreted by remote sensing techniques. The dominant cover type throughout the basin is deciduous tree forest, with some north facing hill-slopes dominated by coniferous species. Deciduous tree species include maples, beech, birches, oaks, ash and cherries. Eastern hemlock (*Tsuga candensis*) is the predominant conifer; some eastern white pine (*Pinus strobus*) stands exist, as well as many fields that have been

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[8] Personal communication with Laurence Day, Soil and Groundwater Specialist, Delaware County Soil & Water Conservation District.

[9] Soil Survey Data, Delaware County, New York, 1998. *Non-Technical Descriptions*, USDA-NRCS, pages 7 and 27 of 34.

planted to various spruce and pine species. These forests encompass the majority of the upland area and the timber is frequently harvested. Along watercourses and the adjacent hillsides, cover types range from grass to a mix of grass and shrub, grass, corn and alfalfa. These cover types are indicative of the agricultural character of the basin. The grass and shrub component represents success ional land composed of grasses, forbs and woody plants, with hawthorns being common. The grass component includes turf, pasture and hayland. Tree species along the West Branch main stem include the species listed above, as well as American sycamore (*Platanus occidentalis)*, butternut (*Juglans cinera*) and willows. Urban areas appear to cover less than 0.1% of the basin.

As evidenced by remote sensing techniques, the primary land use in the West Branch of the Delaware River watershed is agriculture and forest lands, making up approximately 79 % of the overall land area. A more complete breakdown of land use/land cover is included in **Section 6.3**.

In the basin there are four villages and five hamlets which serve as the commercial centers for the larger towns. Village and hamlet parcels are primarily residential and commercial land uses and the lot sizes are substantially smaller. These smaller lots can be accommodated because of the use of municipal sewer and water systems. Of the nine villages and hamlets, eight of them are serviced by municipal water supplies, four have sewage treatment facilities.

The location of the villages and hamlets along the main stem of the Delaware River is significant due to the larger amount of impervious areas and more densely populated communities. The intensity of these uses can be a source of pollutants if not properly managed through local governmental tools. The communities have adopted local land laws including zoning, site plan review, subdivision review and floodplain management laws. These tools are used by the local municipalities to protect the safety, health and general welfare of the residents. This includes protecting the environment and all natural resources.

5.8 Hydrology

5.8.1 Introduction

"Between earth and earth's atmosphere, the amount of water remains constant; there is never a drop more, never a drop less. This is a story of circular infinity, of birthing itself." Linda Hogan

Understanding the hydrology of a drainage basin is important to stream management because *stream flow* patterns affect *aquatic habitat*, flood behavior, recreational use, and water supply and quality. Although it may not be obvious, the water flowing through the West Branch drainage system reflects the integrated net effect of all the watershed characteristics that influence the hydrologic cycle (**Figure 5.3**). These characteristics include the climate of the drainage basin (type and distribution patterns of precipitation and temperature regime), geology and land use/land cover (permeable vs. impermeable surfaces, materials affecting the timing and amount of runoff, constructed drainage systems), and vegetation (uptake of water by plants, protection against erosion, and influence on infiltration rates). These factors affect timing and amount of stream flow, referred to as the stream's hydrologic regime.

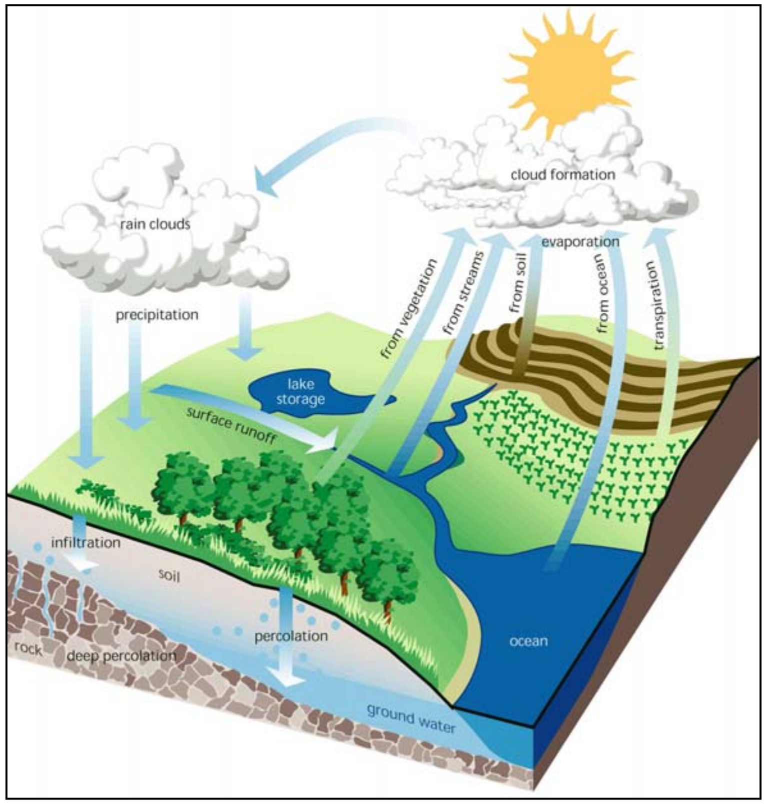

Figure 5.3 The Hydrologic Cycle

Streams in the West Branch watershed are primarily perennial streams—they flow year round except in smaller headwater streams or in extreme drought conditions. The drainage pattern is generally dendritic (a branching, tree-like form), which is typical of watersheds in the Catskill Mountain region uncontrolled geology (see **Map 5.2** for West Branch stream system).

Figure 5.4 Stream Ordering (NRCS)

Streams in the West Branch basin form a connected system that can be classified by "stream order". Stream order identifies the position in a hierarchy of tributaries occupied by a stream segment. As described by Strahler (1964) and shown in **Figure 5.4**, below, any clearly defined (ephemeral) channel without tributaries is designated as a 1st order channel; where two 1st order channels join they form a 2nd order channel; where two 2nd order channels join they form a 3rd order channel, and so on. Tributary headwater streams are 1st and 2nd order streams. The lower main stems of the majority of the identified sub-basin tributaries are 3rd order streams. Using this system, the lower main stems of the Little Delaware River, Wright Brook, Platner Brook, East Brook and West Brook sub-basins are 4th order streams. The West Branch main stem is a 3rd order stream at the outlet of Utsayantha Lake. This information was not used in the research and analyses done for this management plan. It is described to show the reader that streams generally increase in size as smaller streams converge to form larger channel.

5.8.2 <u>Stream flow</u>

Streams flow at many different levels during the course of a year, ranging from a small trickle during a dry summer to a raging torrent during rapid thaw of a thick snow pack. Stream flow varies on several temporal scales. Throughout the course of a year we see a stream swell and shrink with seasons, or over the course of a single summer storm (hours to days) or a spring thaw (days to weeks) we can also watch a stream swell and subside.

There are essentially two basic types of stream flow: storm flow and base flow. Storm flow appears in the channel in direct response to precipitation and/or snowmelt, whereas base flow sustains stream flow during inter-storm (between storms), subfreezing or drought periods. Storm flow reaches a stream channel as channel interception, overland flow, or subsurface storm flow. Channel interception is simply the precipitation that falls directly into the water that is already in a stream channel; it enters the stream directly and its effect disappears as soon as the event is over. In the West Branch watershed it is a minor component of the stream flow.

Overland flow is one portion of storm flow that occurs over and slightly below the soil surface during a rain or snowmelt event. This surface runoff appears in a stream relatively quickly and recedes soon after the event. The role of overland flow in the West Branch watershed is variable and depends on the time of year, location, severity of storms, and soil conditions. Relatively impermeable areas (exposed bedrock, frozen ground, clayey soils) will generate more surface runoff to the stream than will relatively permeable areas (deep, coarse soils) or well-vegetated areas. Saturated well-drained soils can also contribute to increased runoff (in effect, they are already “full” and don’t allow additional infiltration). Generally, higher stream flows are more common during spring rains and snowmelt events, and during the fall hurricane season. During summer months, actively growing vegetation draws significant amounts of water from the soil and can intercept a significant portion of storm precipitation. This interception and demand for groundwater by vegetation can significantly delay and reduce the amount of runoff reaching streams during a rainstorm. During winter months, precipitation is held in the landscape as snow and ice so precipitation events do not generally result in significant runoff to streams. However, frozen ground may increase the amount of overland flow resulting from a rainstorm, especially in the absence of snow, which can absorb a certain amount of water.

In the northeastern US, shallow soils (less than 3 ft. deep to a restrictive layer) on sloping hillsides often have infiltration rates that are seldom exceeded by the rainfall rate (Goehring, et al., 2002). Instead, subsurface storm flow, or interflow, develops from rain or snowmelt after it has infiltrated the soil. It flows rapidly through permeable portions of the soil above restrictive layers until it reaches the soil surface, usually in saturated areas such as surface depressions or in the lower, concave sections of hillslopes. Nearly saturated soils can experience interflow during precipitation even before overland flow begins. Subsurface storm flow can also contribute to stream flow after the overland flow component has passed and as the stream recedes to base flow conditions. Interflow is becoming recognized as a transport mechanism for dissolved phosphorus compounds, which degrade water quality after entering streams and reservoirs (Akhtar, et al., 2003).

Base flow is water that drains slowly from the land, sustaining stream flow during dry periods and between storm events. The source of base flow is groundwater that has passed through the soil and entered deeper cracks or layers in bedrock, eventually being *discharge*d adjacent to or beneath a stream.

The distinction between base flow and subsurface storm flow is transitional – that is, there is no specific time period or exact flow magnitude at which a stream is clearly at storm flow or base flow *stage*. To get some idea of what might constitute base flow, hydrologists commonly utilize a graphical representation of the stream flow over some period of time, the hydrograph, which is created from data obtained from a stream gaging stations. The United States Geological Survey (USGS) maintains eight *continuous-recording stream gages* in the West Branch watershed (see **Map 5.9** and **Table 5.3**).

Table 5.3 Continuous Recording USGS Stream Gaging Stations in the West Branch of the Delaware River basin.

Station ID	Station Name	Drainage Area (Mi^2)	Period of Record
1421610	West Branch Delaware River at Hobart	15.50	Aug 2000 - present
1421614	Town Brook Tributary SE of Hobart	0.76	Oct 1998 - present
1421618	Town Brook SE of Hobart	14.30	Oct 1997 - present
1421900	West Branch Delaware River US of Delhi	134.00	Feb 1937 - Sept 1970, Dec 1996 - present
1422389	Coulter Brook Near Bovina Center	0.76	Oct 1997 - present
1422500	Little Delaware River Near Delhi	49.70	Oct 1937 - Sept 1970, Jan 1997 - present
1422747	East Brook East of Walton	24.70	Oct 1998 - present
1423000	West Branch Delaware River at Walton	332.00	Oct 1950 - present

These gages measure the stage, or height, of the water surface at a specific location, updating the measurement every 15 minutes. By knowing the stage, we can calculate the discharge (the volume of water flowing by that point every second) using a rating curve relationship developed by USGS. In this way, the discharge can be predicted for any stage of interest. We can also use the historic record of constantly changing stage values to evaluate stream response to rain storms, snow melt, extended periods of drought, to analyze seasonal patterns or flood characteristics.

The gages in the West Branch basin have long enough periods of record to prepare hydrographs for their individual streams. **Figure 5.5** is an annual hydrograph for the gage upstream from Delhi, showing the peaks and lows of stream flow over the course of the year. The rise and fall of the peaks are generally associated with storm flows, while minimum values are related to average annual base flow conditions. A review of the hydrograph reveals that the winter of 1998/1999 was a wet period that followed a dry fall, and that late spring/early summer was also dry. The smaller graph inserted within **Figure 5.5** is a close-up of the July 4, 1999 storm event. At the end of June, a small rainfall event brought the stream flow up slightly. Storm flow receded prior to the July 4, 1999 rainstorm. The response to this storm was rapid, presumably due to preceding conditions from the previous rainfall. Minor rainstorms followed, but eventually the landscape drained and the stream flow returned to lower base flow conditions.

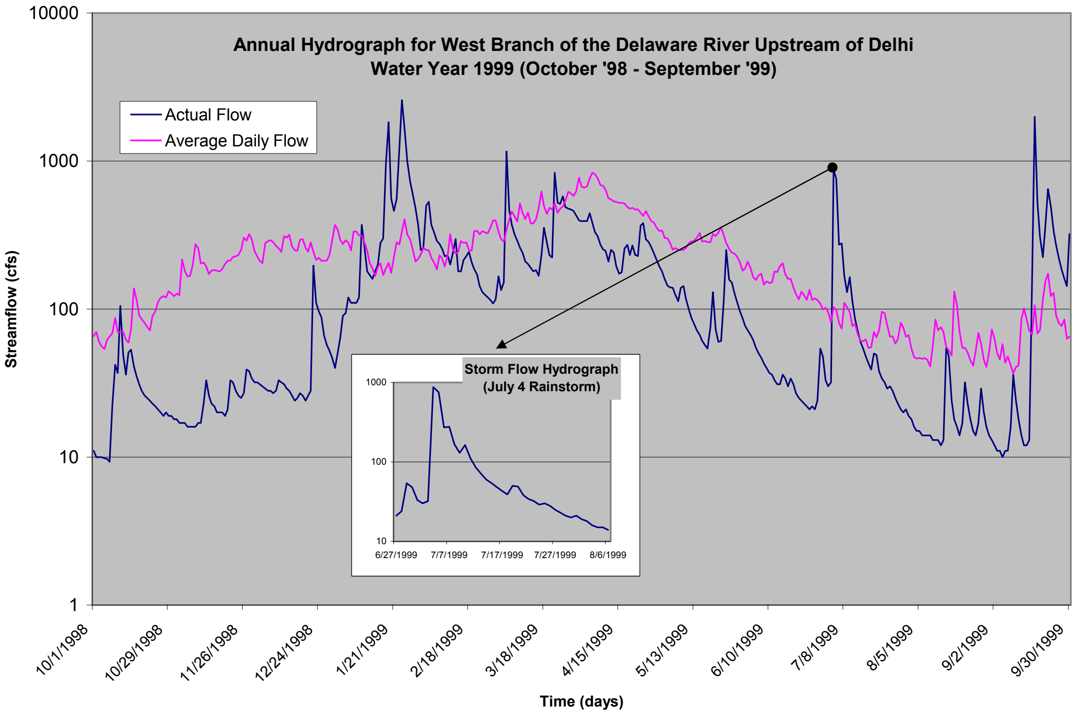

Figure 5.5 Annual Hydrograph for West Branch of the Delaware River upstream of Delhi for water year 1999.

We can also analyze longer time periods to see seasonal trends or long-term averages for any given period when the gage was in service. The record for the gage upstream from Delhi (**Figure 5.6**, below) shows higher flows in fall (hurricane season) compared to winter (when water is held in ice and snow), and higher flows in spring (snow and ice melt) compared to summer (drier conditions, with vegetation removing a lot of water). The highest flows of the year are generally associated with spring snowmelt. A spike from the July 4, 1999 storm is also noticeable.

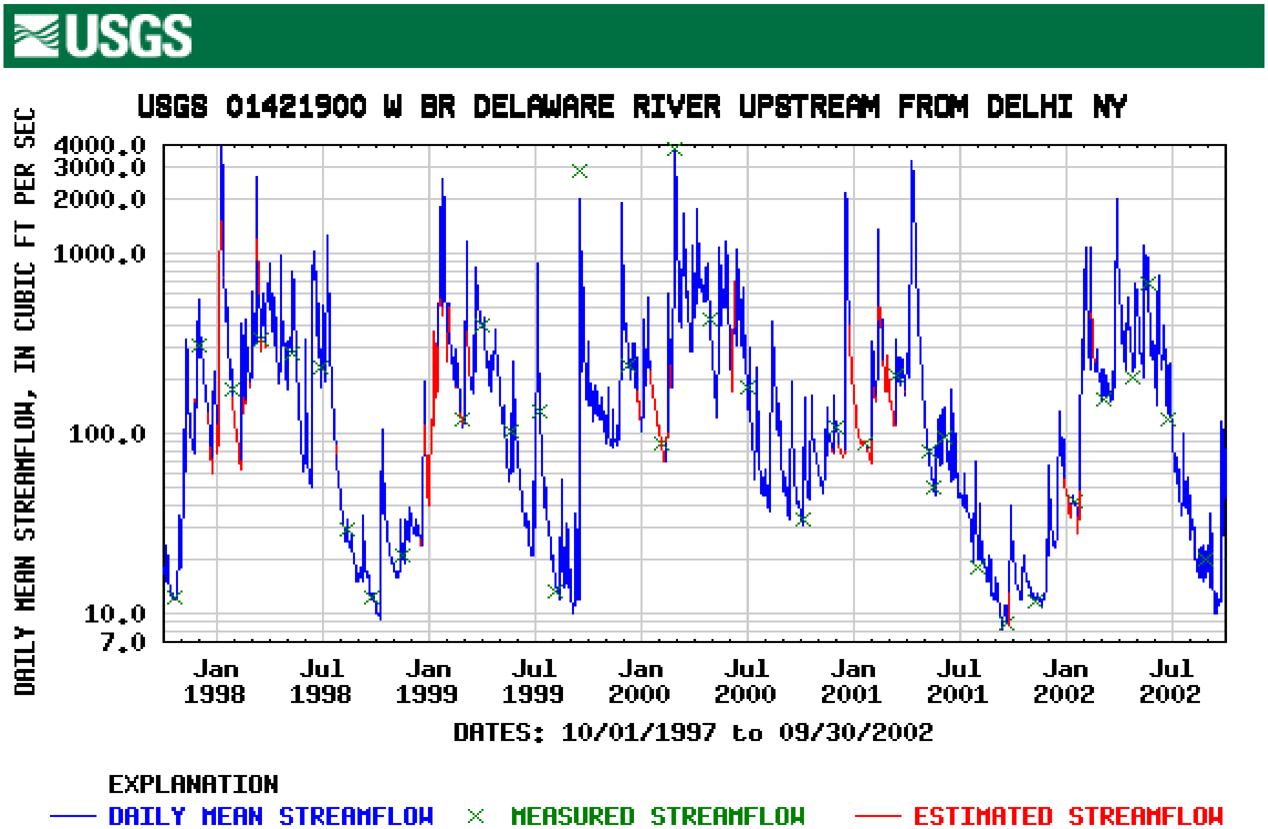

Figure 5.6 Hydrograph for a five-year period from the USGS Station upstream from Delhi, water years 1998 through 2002.

5.8.3 Flood History

Floods are events that occur whenever and wherever a defined stream stage is reached. They often result from runoff associated with spring snowmelt, summer thunderstorms, fall hurricanes, winter rain-on-snow events or from rainfall onto frozen or saturated ground. They may range in size from minor overbank events to the raging torrents that destroy bridges and carve new channels. In the West Branch basin, stream flows generally exceed channel capacity at the flood stage and then flow over their banks. (In contrast to this, highly *entrenched* streams may reach a defined flood stage long before their present channel capacity is reached.)

Examining the USGS records can help us evaluate the flooding history of a basin. The USGS publishes annual peak flow data for all stream gaging stations and calculates discharges (in cubic feet per second or cfs) for periodic flows at continuous record gaging stations (or peak flow only stations) with ten or more years of record. Annual peak stream flow is the highest stream flow recorded for a particular 12-month period (usually from October 1 through September 30 – the "hydrologic water year" as defined by USGS). A flood frequency distribution shows flood magnitudes for various degrees of probability (likelihood). These values are most often converted to a number of years, the "recurrence interval" or "return period". For example, the flood with 20% chance of occurring or being exceeded in any single year corresponds to what is commonly referred to as a "5 year flood" (1 divided by % probability equals the recurrence interval in years). This simply means that on average, for the period of record, this magnitude of flood will occur approximately once every 5 years. This probability is purely statistical; the probability remains the same from year to year over time for a particular size flood. Many years may go by without one or it may occur several times in one year. The calculated flows most often referred to by stream managers include the 1, 1.2, 2, 5, 10, 25, 50, 100, 200 and 500-year storms. Also, the greatest flow in any single year is not always a significant event, such as those recorded in the drought years of 1940, 1966, and 2002.

Table 5.4, below, shows the dates and flows for events greater than a 5-year recurrence interval for the three stream gaging stations in the watershed with ten or more years of record. The gage in the Village of Walton has the greatest number of years of record, the greatest number of events exceeding the five-year recurrence interval, and is also the downstream-most gage in the system.

Table 5.4 Flood flows exceeding the five-year recurrence interval at three stream stations

West Branch of the Delaware River at Walton			
Date	Flood Discharge (cfs)	Recurrence Interval (Years)	Flow (cfs)
12/11/1952	14,300	5	14,090
8/19/1955	15,100	10	17,210
1/22/1959	15,700	25	21,200
3/5/1964	15,800	50	24,190
6/29/1973	14,500	100	27,210
12/21/1973	14,700	200	34,350
3/14/1977	17,400		
1/9/1978	15,400		
2/11/1981	17,900		
3/15/1986	19,500		
4/5/1987	14,800		
1/19/1996	25,000		
11/9/1996	18,200		
9/18/2004	15,200		
4/3/2005	18,200		
West Branch of the Delaware River upstream from Delhi			
Date	Flood Discharge (cfs)	Recurrence Interval (Years)	Flow (cfs)
9/21/1938	8,940	5	5,551
3/31/1940	6,430	10	6,673
3/9/1942	6,090	25	8,126
11/26/1950	6,700	50	9,232
1/22/1959	5,500	100	10,360
3/5/1964	6,330	200	11,510
12/21/1973	6,070		
1/19/1996	13,000*		
11/9/1996	7,000*		
4/3/2005	5,700*		
Little Delaware River near Delhi			
Date	Flood Discharge (cfs)	Recurrence Interval (Years)	Flow (cfs)
9/21/1938	3,280	5	3,051
8/13/1953	4,530	10	3,688
1/22/1959	3,120	25	4,499
7/30/1974	3,260	50	5,105
1/19/1996	6,100*	100	5,713
11/9/1996	4,540	200	6,326
9/18/2004	3,210		
* Estimated flow	Highlighted cells indicate same flood event.		

Considering the flood events in **Table 5.4**, the largest recorded flood in the basin was a wintertime rain-on-snow event that occurred on January 19, 1996 and which has been well documented. Conditions preceding this event were as follows:

Figure 5.7 Washout on Chase Brook Road over Chase Brook near Cannonsville Reservoir, January 19, 1996

The fall of 1995 was wet and stream flows were above normal. Below normal temperatures from mid-December through mid-January reduced stream flows to much below normal during the period. Snowstorms in early to mid-January left up to two feet of snow on the ground. The first half of January was colder than normal; therefore, the snow pack lost little moisture and the ground was mostly frozen. Unseasonably warm air preceded the storm on January 18-19, with temperatures reaching the 60° F range. On January 19th, 2 to 2 ½ inches of rain fell on 20-30" of snow in the watershed (Lumia, 1998; The Reporter Company, 1996). The ensuing flood claimed six lives and was the worst flood since 1935 according to local residents (The Reporter Company, 1996). Delaware County damages were $30,000,000. This flow was generally either the flood of record (largest flood on record) or greater than the 100-year flood flow throughout the watershed, although the flow recorded at the Walton gaging station was closer to a 70-year recurrence interval event (Lumia, 1998).

The remainder of 1996 continued to be wet. Heavy rains falling on nearly saturated soils caused a smaller flood event on November 9, 1996 that exceeded the 10-year recurrence interval flow at all three gaging stations, as shown in **Table 5.4**.

The flood of July 1935 was the result of heavy rains and caused nearly $1,500,000 in damages throughout the county.[10] No gaging station records exist for this time period. **Figure 5.8** shows a view of Walton at that time.

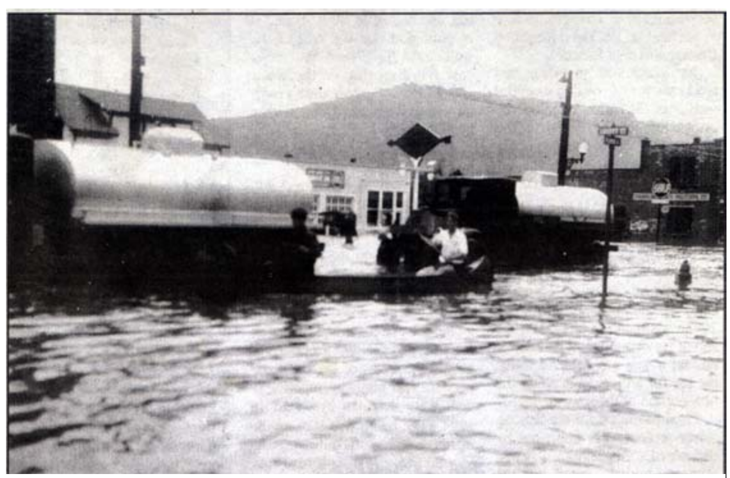

Figure 5.8 Scene from 1935 flood in Walton

The flood of September 1938 was also the result of heavy rains.[11] The hydrograph at the Delhi gaging station recorded a particularly wet year with several storm events throughout the spring and summer. A minor event just prior to the storm on September 21, which would have saturated the ground, created a rapid rise in the river.

[10] The Walton Reporter (weekly newspaper), Friday, July 12, 1935 and Friday, July 19, 1935.
[11] The Walton Reporter (weekly newspaper), Friday, September 23, 1938.

Figure 5.9 West Branch of the Delaware River looking upstream from County Bridge on County Route 2 in Delancey, January 1996

The March events in 1940 and 1942 are presumably associated with major snow melt events from either spring thaw or rain-on-snow events. 1942 was unusually wet during January and February.

The event of November 26, 1950 is presumably the result of a wet November. This event exceeded the 5-year recurrence interval at the Delhi station, but not at the Walton station (see **Table 5.4**), which may have been due to localized storm cells in certain parts of the watershed, or damping effects of the larger drainage area at Walton.

The hydrographs at the Delhi and Walton stations show two storm events close together, which caused the river to peak in Delhi on August 18, 1955 and a day later in Walton. The January 1959 event is presumably a rain-on-snow event, after a smaller preceding storm, following a wet fall with the river returning to winter base flow in late December. The March 1964 event is presumably a spring runoff event following a wet January and return to winter base flow near the end of February.

The June 29, 1973 event was the result above average flows following a wet May. Before the arrival of hurricane Alice (July 2-6, 1973) low-pressure systems existed in the eastern United States[12] that spawned preceding storms, resulting in the river system being unable to contain this storm. The December 21, 1973 flow is presumably a rain or rain-on-snow event following below-average flows in October and November, two storms in early December, followed by a return to approximate normal flow just prior to the recorded storm event.

In early March 1977, melting snows due to above average temperatures for several days placed stream levels above normal. A steady rain fell for more than a day with considerable snow still present at higher elevations[13], which resulted in an event slightly greater than the 10-year recurrence interval at the Walton station.

In January 1978 temperatures in the high 50's and heavy rains[14] following a wet November and December caused the flood flow of January 9, 1978. Another flow of nearly the same magnitude peaked on January 26, 1978 at the Walton station.

The event of February 11, 1981 is presumably a rain-on-snow event that following below average flows from mid-December through January. A storm in early February had not fully subsided when a second storm sent the West Branch to its second event exceeding the 10-year

[12] National Oceanic and Atmospheric Administration National Hurricane Center Website: ftp://ftp.nhc.noaa.gov/pub/storm_archives/atlantic/prelimat/atl1973/alice/ (Verified 12-22-04)

[13] The Walton Reporter (weekly newspaper), Wednesday, March 16, 1977.
[14] The Walton Reporter (weekly newspaper), Wednesday, January 11, 1978.

recurrence interval at the Walton station in four years (recurrence interval approximately 12.5 years).

Heavy rains and snow melt[15] following storm events in late January and late February resulted in heavy flooding on March 15, 1986. This is the second highest flow recorded at the Walton station, which significantly exceeded the 10-year recurrence interval (approximately an 18.5 year recurrence interval). The event of April 5, 1987 is a spring runoff event following a wet February and March with flows remaining above normal for that period. It is presumably the result of heavy rain.

A recent event on September 18, 2004 was the result of greater than 5 inches of rainfall (a 25 year rainfall event) throughout much of the West Branch basin. With soils saturated and most flows significantly greater than the annual mean daily flow for that time period, many streams significantly exceeded the 5-year recurrence interval flood. Of particular note was the flow in the Town Brook sub-basin, which is estimated to have been at or near the 25-year recurrence interval flow (The Town Brook station currently has 7 years of record. Therefore recurrence interval flows are estimated).

Over the last 67 years of record on the West Branch of the Delaware River there have been 18 events that have exceeded the 5-year recurrence interval flood. (Many other events exceeded *bankfull* discharge, but were less than the 5-year flood.) Approximately 33% of these 18 events have occurred in the winter and spring equally, 12% occurred in the summer and 20% in the fall. Of these 18 events, 6 have exceeded the 10-year recurrence interval flood. Although not evenly spaced within the 67 year period, one would expect the 10-year event to occur approximately 6 times during this period. In actuality, the record used to generate the flood frequency distribution would expect to closely show this pattern.

From the review of available stream gage data, it is apparent that most events at the bankfull stage and greater occur in late winter/early spring as the result of thaws and/or major rain-on-snow events. This is in large part due to the storage of available water as snow on the landscape, reduced infiltration capacity (if the ground is frozen) and the lack of evapotranspiration from vegetation during the dormant period.

Storm events can be unevenly spatially distributed across the basin. For example, an event exceeding the 5-year recurrence interval occurred in August 1953 at the Little Delaware River station (perhaps from an isolated thunderstorm) while all flows that year stayed within the streambanks at the Walton station. The July 4, 1999 storm, when over 6 inches of rain fell in a few hours, was estimated to be of "Biblical proportions" (as reported by a local farmer with respect to his conversation with USGS personnel during a mutual visit to the stream gaging station) on Town Brook near Hobart—yet this flow again stayed well within the banks at both the Delhi and Walton stations. During such storms, localized flash flooding may occur due to a sustained storm cell within isolated sub-basins of the West Branch; meanwhile, steady but light rainfall near the storm margins created only a moderate increase in stream flow elsewhere in the system.

[15] The Walton Reporter (weekly newspaper), Wednesday, March 19, 1986

Occasionally, a widespread storm/snow melt event results in a flow with a higher recurrence interval flood at upstream gaging stations than at the Walton station, such as happened in January 1996. This is probably due to flows from downstream tributaries, peaking and flushing through the system before water from upstream sources reaches the Walton station.

Figure 5.10 East Brook near the former Pierce farm, January 19, 1996

The recent years between 1998 and 2003 (not including 2003) were generally droughty with intervening wet conditions. Recorded high water events have been at or slightly above bankfull, although 2003 and 2004 were particularly wet and characterized with more than one such event on many streams. During these two years, USGS station records show that flows generally remained above the average base flows for a significant portion of each year.

See **Section 5.14** for additional information on flood protection and recovery.

5.9 Introduction to Stream Processes

5.9.1 Introductory Overview

"You cannot step twice into the same river; for other waters are ever flowing on to you."
- Heraclitus of Ephesus, 500 B.C.

Figure 5.10a Pettis Brook tributary just above NYS Route 10, near Delancey.

Ask anyone who lives by the streamside, and they'll tell you that living near a stream carries both benefits and risks; to enjoy the benefits we accept the risks. The pleasures and dangers of living near streams are part of their ever-changing nature. Icy spring flood-flows are exciting and beautiful as long as they don't creep up over their banks and run across your yard into the basement window, or suddenly tear out a streambank and begin flowing down the only access road to your house. For many reasons, the relatively flat land in the floodplain of a stream may be an inviting place to build a home or road — in fact it may be the only place — but as long-time residents of floodplains know only too well, it's not a matter of *if* they will see floodwaters, but of *when*.

As changeable as streams are, there remains something consistent about how they change through the seasons — or even through an individual storm. As unpredictable as streams can be, they are also predictable in many ways. If we take the time to observe them carefully, we begin to understand the patterns of stream behavior, what we might do in our individual roles as stream stewards and managers to increase their benefits to us, and to reduce the risks they pose.

This section of the management plan is provided to offer the reader a basic explanation of what stream scientists know about how streams "make themselves": why they take different forms in different settings, what makes them evolve, and how we can effectively manage them.

It's obvious that streams drain water off the landscape, but they also have to carry *bedload* - gravel, *cobble*, and even boulders - eroded from streambeds and banks upstream.

Figure 5.10b Town Brook reference reach

If you stand near the bank of a mountain stream during a large flood event, you can feel the ground beneath your feet vibrate as gravel, cobbles and boulders tumble against each other as the force of the floodwaters pushes them down the streambed. As the water begins to rise in the channel during a major storm, at some point the force of the water begins to move the channel bottom material. As the stormwaters recede, the force falls and the gravel and cobbles stop moving. The amount of water moving through the channel determines the amount of *bedload* moving through it as well.

To effectively manage the stream, managers first need to understand how much water is delivered from the landscape to the stream at any particular point in the system. The amount of water any stream will carry off the landscape is primarily determined by four characteristics of the region:

- climate, specifically the amount of rainfall and the temperatures the region typically sees throughout the course of a year;
- topography;
- soils and bedrock geology; and
- type of vegetation (or other land cover like roads and buildings) and its distribution across the landscape.

These characteristics also play key roles in determining the type and frequency of flood hazards in the region, the quality of the water, and the health of stream and floodplain ecosystems.

The shape and size of a stream channel adapts itself to the amount of water and bedload it needs to carry. Within certain limits, the form, or *morphology*, of a stream is self-adjusting, self-stabilizing, self-sustaining. If stream managers exceed those limits, however, the stream may remain unstable for a long time.

Over the period since the last glaciers retreated some 12,000 years ago, Catskills streams have adapted their size and shape to these regional conditions. Because the climate, topography, geology and vegetation of a region usually change very slowly over time, the amount of water moving through a stream from year to year, or stream flow regime, is fairly consistent at any given location.[16] This stream flow regime, in turn, defines when and how much bedload will move through the stream channel from year to year. Together, the movement of water and bedload carve the form of the stream channel into the landscape. Because the stream flow regime is fairly consistent year after year, the form of the stream channel changes relatively slowly, at least in the absence of human influence. Over the 120 centuries since glaciers covered the region, the stream and the landscape conditions have evolved into a dynamic balance.

However, as we made our mark on the landscape — clearing forests for pastures and cropland, or straightening a stream channel to accommodate agriculture and/or development — we unintentionally changed that balance between the stream and its landscape. We may notice that some parts of a stream seem to change very quickly, while others remain much the same year after year, even after great floods. Why is this? Streams that are in dynamic balance with their landscape adapt a form that can pass the water and bedload associated with both small and large floods, regaining their previous form after the flood passes. This is the definition of stability. In many situations, however, stream *reaches* become *unstable* when some management activity has upset that balance, altering the stream's ability to move its water and bedload effectively.

The amount of potential force that water has to move its bedload is determined by (1) slope — steeper slopes create more force; and (2) depth — deeper streams create more force. For example, if changes made to a *stable* reach of stream reduce its slope or depth, the stream may not be able to effectively move the bedload from an upstream supply. The likely result is the material will be deposited in that section, and the streambed will start building up, or *aggrading*.

On the other hand, when a stream is straightened, it becomes shorter in length; this means its slope is increased along with its potential force to move its bedload. Especially in the Catskill region, with its narrow and winding valleys, roads are commonly located close to streams. Road encroachment has narrowed and deepened many streams, with the same result: too much force, causing the bed of the stream to *degrade* and, ultimately, to become *incised,* like a gully in its valley. Both situations, aggrading and *degrading*, mean that the stream reach has become unstable, and both can lead to rapid bank erosion as well as impairment of water quality and stream health. Worse yet, these local changes can spread upstream and downstream, causing great lengths of stream to become unstable.

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[16]One exception is when the vegetation changes quickly, such as can happen during forest fires, catastrophic geologic events, or rapid commercial or residential development.

The lay of the land determines the pattern and grade of the stream, but the stream also shapes the lay of the land. The stable form for a particular stream depends on the larger form of the valley it flows through.

The stream pattern we now see throughout the Catskills is the result of millions of years of landscape evolution as previously discussed in **Section 5.5.4**.

As our climate warmed following the glacial period, grasses and then trees re-colonized the evolving valley floor. As vegetation returned to the floodplains, the conditions that determine the balance between stream shape and the landscape changed once again. Streambanks that have a dense network of tree and shrub roots adding strength to the soil can better resist the erosive power of flood flows, and consequently a new stable stream form emerges; a new balance is struck between resistive and erosive forces. A dense mat of woody roots is essential if we want to maintain a stable streambank. If streamside trees and shrubs are removed, we can expect the bank to soon begin eroding.

In the Catskills, a naturally stable stream will have trees and shrubs all along the streambank to help hold the soil together. If you remove the trees and shrubs, and mow right down to the edge of the stream, you may be risking big-time erosion problems.

The stable form that a stream takes where it is in balance with steep mountain notches will be different from the form it takes in medium-gradient valleys, and this will be different still from the stable form in a gently-sloping, broad floodplain like the West Branch of the Delaware. Stable streams are less likely to experience bank erosion, water quality and habitat problems. Since we want to maintain "healthy" and stable streams, we need to maintain a stable stream *morphology* and vigorous *riparian* (streamside) vegetation. The management developed by the Delaware County Stream Corridor Management Program (SCMPr) generally describes the current condition of the stream form and streamside vegetation throughout the watershed. The Stream Corridor Management Plan contains recommendations for protecting healthy sections and for restoration of sections at risk.

5.9.2 Stream Morphology and Classification

"The river is the carpenter of its own edifice" - Luna Leopold, 1994

For those interested, this section provides technical information about the relationship between stream *form* (or *morphology*) and physical stream *function* (e.g., flood behavior, sediment transport).

The last section described how a stream's form (slope and depth) determine its function — how much potential force the stream has to move the silt, sand, gravel, cobble and boulders that make up its *bedload*. Slope and depth were emphasized because they are often changed, intentionally or unintentionally, by stream managers. There are, however, many characteristics that come together to influence how a stream "makes itself", and whether it is stable or unstable in a given valley. These characteristics[17] include:

Stream flow (Q)

Usually represented as cubic feet or cubic meters per second, stream flow is also called stream *discharge*. Stream flow changes from hour to hour, from day to day, from season to season, and from year to year.

The typical pattern of stream flow over the course of a year is called the stream flow regime. Some stream flows play a more significant role than others in determining the shape of the stream. The "*bankfull flow*" is considered most responsible for defining the stream form. For this reason, bankfull flow is also sometimes called the *channel-forming flow*. This flow typically recurs every 1-2 years. It may seem surprising that very large floods aren't more important in forming the channel. While they may induce catastrophic changes in a stream—severely eroding banks and washing countless trees into the channel—these major floods are rarer, occurring on the average every decade or so. The flows that have the most effect on channel shape are those that come more frequently, but which are still powerful enough to mobilize the gravel and cobble on the streambed: the smaller, bankfull flows.

The height of the water in the channel is called the *stage*. When a stream overtops its banks, it is in *floodstage*. *Bankfull stage* — when the stream is just about to top its banks — is used as a benchmark for measuring stream dimensions for classifying different *stream types* (see *Rosgen Classification System*, below).

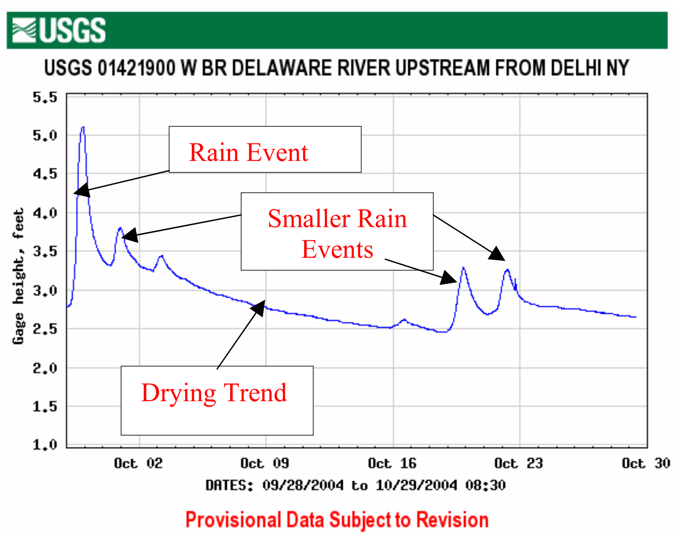


Figure 5.11 Hydrograph for one-month period showing storm events at the USGS station near Delhi

Slope (S)

Slope was already mentioned as one of the two main determinants of a stream's potential force for erosion of the streambed and banks. The slope of a stream usually refers to the average slope of the water surface when the stream is running at bankfull flow, though can be measured as a low flow water surface slope for use in stream classification.

Channel average depth (d)

Depth is the other primary determinant of potential force, and is measured from the streambed to the water's surface at the bankfull stage elevation. Again, this will depend on the level of the stream flow. When used to compare one stream reach to another in *stream classification systems*

[17] Each characteristic is followed (in parentheses) by the symbol commonly used to represent it in hydrology equations.

(see below), the average depth of the stream during a bankfull flow is used.

Channel width (W)

Together with average depth, channel *width* determines the *cross-sectional area* (Area (A) = width x depth). Channel width is measured from bank to bank at the bankfull elevation. One principle important to understanding stream morphology is that whenever outside influences change a stream's channel dimensions, the stream usually adjusts itself to maintain a cross-sectional area that will pass normal bankfull flows.

Channel roughness (n)

Although flowing water develops potential to erode streambeds and banks, other stream characteristics combine to slow the water down. One of these is the channel *roughness*: there is more resistance to flow where a stream reach contains boulders and cobbles than through a reach with a smooth, silt-bottomed bed and no obstructions. Similarly, water flows more slowly across a floodplain filled with trees and dense brush, and so is less likely to cause erosion, than it does across a smooth, newly mown lawn or parking lot. This characteristic is also referred to as *bed roughness*.

Sinuosity (k)

A different kind of roughness that slows water flow has to do with whether the channel runs straight, or curves. The flow of a stream is slowed as it moves around a bend as a result of *form roughness*. The overall "curviness" of a stream is called its *sinuosity*, and is measured as the stream length divided by the valley length. That is, if a stream runs completely straight down a mile long valley, both the valley and the stream are the same length, or 1 mile ÷ 1 mile = a sinuosity of 1. If the stream snakes, or *meanders*, down the same valley, it might be two miles long, or 2 miles / 1 mile = a sinuosity of 2. In natural channels we find that, as a rule of thumb, lower slopes produce more sinuous streams.

Radius of curvature (Rc*)*

Radius of curvature describes the "curviness" of the stream at a single curve, and is measured as shown in **Figure 5.12**.

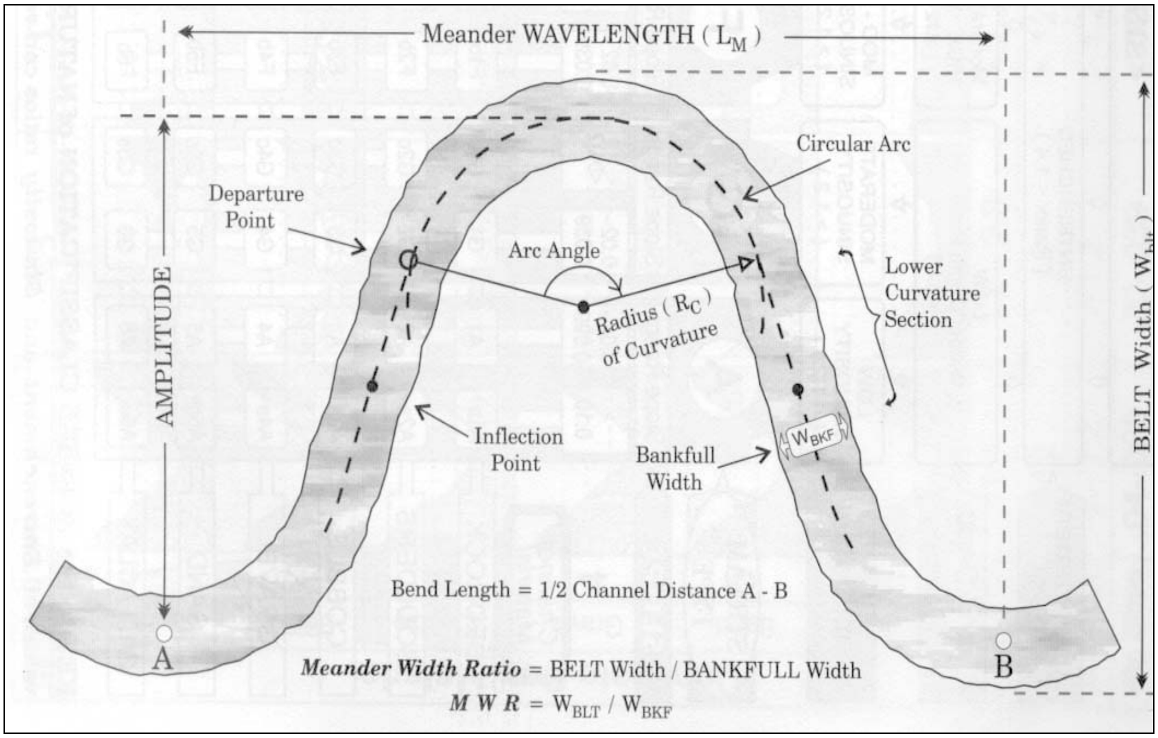


Figure 5.12 Radius of Curvature (Adapted from The Reference Reach Field Book, D. Rosgen.)

Beltwidth

Meander Beltwidth describes the width of a stream's meander through its valley (see figure above). It is measured from the outside of one meander to the outside of the next, perpendicular to valley fall. This is also sometimes referred to as the floodway, and during large floods, the entire meander beltwidth is often inundated, as the stream takes a "shortcut" on its way downvalley. Homes and roads in this region are at greater risk for flooding and damage from erosion.

Sediment size (D_{50})

Name	**Particle Size**	
Silt	< 0.062mm	< 0.002 in
Sand	0.062mm - 2mm	0.002 in - 0.08 in
Gravel	2mm - 64mm	0.08 in - 2.52 in
Cobble	64mm - 256 mm	2.25 in - 10.08 in
Boulder	256mm - 2048 mm	10.08 in - 80.63 in

It takes more force for a stream to move material on the streambed if it consists of large cobbles than if it is sand or silt; the smaller the particles, the more easily they will be moved. To characterize the sediment in a stream reach, 100-300 particles are randomly selected and measured, and the median size particle determined. Although a time-consuming task, this procedure determines the D_{50} of the reach: meaning that 50% of the particles in the stream are smaller, and 50% are larger.

Bed and Bank Cohesiveness

Due to the glacial history of the region, soils in the Catskills are extremely variable from place to place, and some soil types hold together better than others, or are more *cohesive*. Some streambeds have their gravel and cobbles bound together in a *matrix* of finer material that resists movement by stream flow; those that do not can erode more easily. The roots of trees and shrubs can reach deep into streambanks, and the web of fine root fibers can add much strength to otherwise erosive soils.

Over time, streams tend to develop a balance between the erosive forces of floodwaters, and the strength of the bed and banks to resist that erosive power. This balance develops because streams will keep eroding their banks until the lengthening of their meanders reduces stream slope, or the stream is widened and depth is decreased sufficiently, such that soil cohesion plus vegetative reinforcement equal the erosive potential of floodwaters. When changes in streambank vegetation change soil erosivity, stream morphology will change in response until a new *equilibrium* is reached. Also, if a streambank gradually migrates into an area with less cohesive soil, it may suddenly begin to erode this new area quite quickly.

Sediment discharge (Qs)

In general, the term "sediment" is used to describe the silt, sand, gravel, cobbles and even boulders that are moved by stream flow. *Sediment discharge* is the amount of sediment moving past a particular point over some interval of time, usually measured in tons per year. *Bedload* is sediment that moves along the bottom of the channel, while *washload* is sediment that is suspended within the water. Measuring sediment discharge helps determine if a stream reach is stable. If the amount of sediment entering a reach doesn't roughly equal the amount leaving it, the form of the reach is changing or unstable.

Entrenchment

When a reach of stream is either straightened or narrowed, the power of the stream flow is increased. The stream may then cut down into its bed, so that flood flows are less likely to spill out into the floodplain. When this happens, we say that the reach has incised, and that the channel has become *entrenched*, which can occur to varying degrees of severity. When large flood flows are confined to the narrow channel of an incised stream, the water becomes very deep and erosive; the stream may gully down even deeper into its bed. Eventually the banks may become so high and steep that they erode away on one or both sides, widening the channel. This in turn can change previously stable areas downstream, having a significant impact on our road and bridge infrastructure.

Entrenchment also occurs from *berms* built to prevent the stream from using its natural floodplain during large flows, and when the amount of water that the stream carries is increased significantly due added storm drainage associated with land development.

One method of measuring entrenchment was developed by hydrologist Dave Rosgen. His *Entrenchment Ratio* compares a stream's width at bankfull flow with its width at twice the maximum depth at bankfull flow: (The entrenchment ratio is a measure of stream incision).

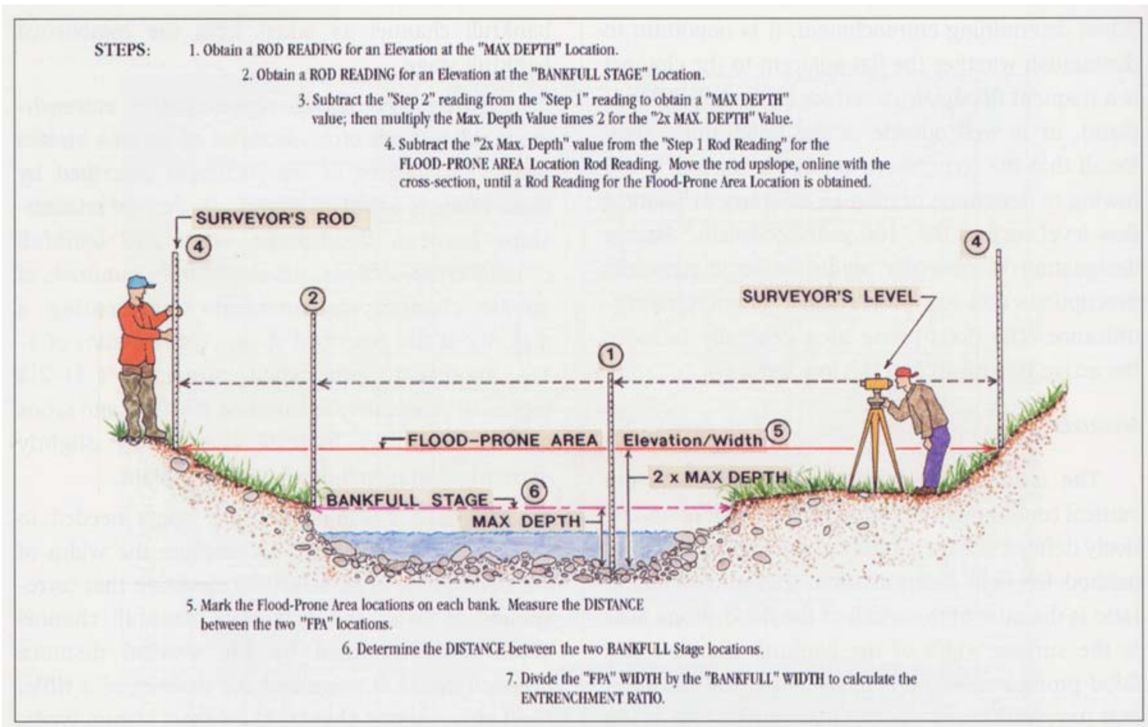


Figure 5.13 Rosgen method to measure stream entrenchment (Rosgen, 1996).

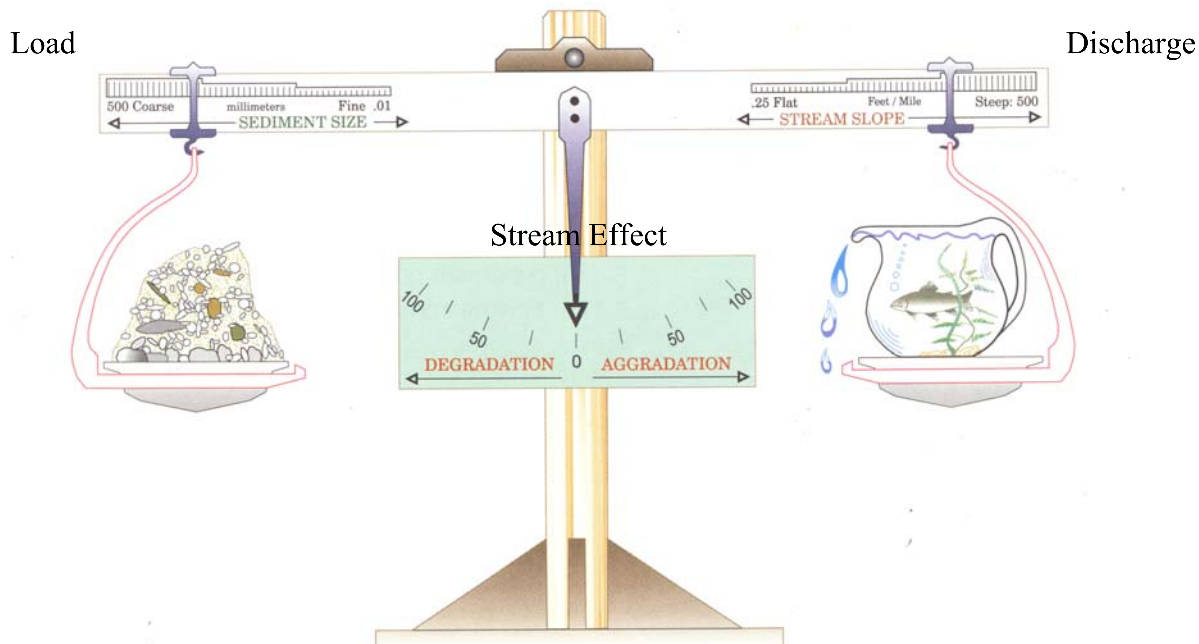
Sediment Balance

It must be emphasized that maintaining a sediment balance is essential to maintaining a stable stream. The following paragraph sums up the importance of sediment transport in the formation of rivers:

"Sediment transport processes have a major control on channel morphology since rivers can only develop if sediment is eroded and transported. Not only are the overall dimensions of the river influenced by sediment transport, but local temporal and spatial variations in transport capacity within a reach result in the formation and maintenance of *pools*, *riffles* and bar forms which are so characteristic of alluvial channels." (R. D. Hey, 2003).

It is the movement of bedload material that determines the characteristics of the stream channel. In the Catskills, the channel bottom is commonly made up of gravel or cobbles though can include sands, silts, clays and boulders in varying concentrations. When we speak of sediment transport we are typically referring to movement of small and medium sized rocks, though in some instances, we may refer to sediment transport of fine material in a habitat or water quality context.

Sediment discharge has long been recognized as one of the primary variables that determine the characteristics of a stream. **Figure 5.14** below symbolically illustrates the inversely proportional relationship between a set of four primary physical variables (sediment size, sediment load, stream discharge and stream slope) and two opposing processes (stream bed aggradation and *degradation*) that determine stream sediment and channel characteristics and balance. The figure suggests that a change in one of four physical variables will trigger a response in the two process variables. This in turn creates changes in river characteristics.



(Sediment LOAD) x (Sediment SIZE) is proportional to (Stream SLOPE) x (Stream DISCHARGE)

Figure 5.14 Sediment balance illustrative diagram (Rosgen, 1996).

If the supply of sediment decreases (for example, an impoundment leading to reduced sediment load downstream) or the supply of water increases (for example, increase in impervious area or decrease in vegetative cover in the watershed leading to increased runoff), the stream will begin to erode downward or *degrade*. The most noticeable manifestations of this will be incision (the stream depth will increase), and the stream slope will become less steep. Incision could lead to undermining of the streambanks as they become over-steepened and bank height ratio increases. As banks fail, this feedback mechanism provides additional sediment and results in a widening of the stream channel, bringing sediment transport capacity and sediment supply back into equilibrium. An increase in sediment transport capacity by increasing slope or decreasing width will have similar effects as increasing discharge or decreasing sediment supply (**Figure 5.14**).

Conversely, if the supply of sediment increases (for example, due to removal of bank vegetation causing increased erosion) or the supply of water decreases (for example due to water diversions or increasing vegetation on floodplain or watershed areas) the stream will begin to *aggrade* or fill in. Noticeable manifestations of this include a localized increase in stream slope and a reduction in stream depth often followed by further increase in stream width. Frequently the supply of sediment increases while the supply of water remains constant. This leads to a stream becoming too shallow from increased deposition, which can cause greater frequency of flooding due to a lack of channel capacity for its available water. Alternatively, the stream may erode its banks to become wider and achieve the necessary cross-sectional area to transport its available water. This process is temporary, because the increase in width encourages additional deposition. Eventually, the stream channel will develop a flow concentration between deposits, and a new channel will develop within the over-widened channel.

Channel Disturbance and Evolution

Channels that have been disturbed by dredging, incision, or channelization follow a systematic path to recovery. This process has been documented by Simon and Hupp (1992), and is illustrated in **Figure 5.15**.

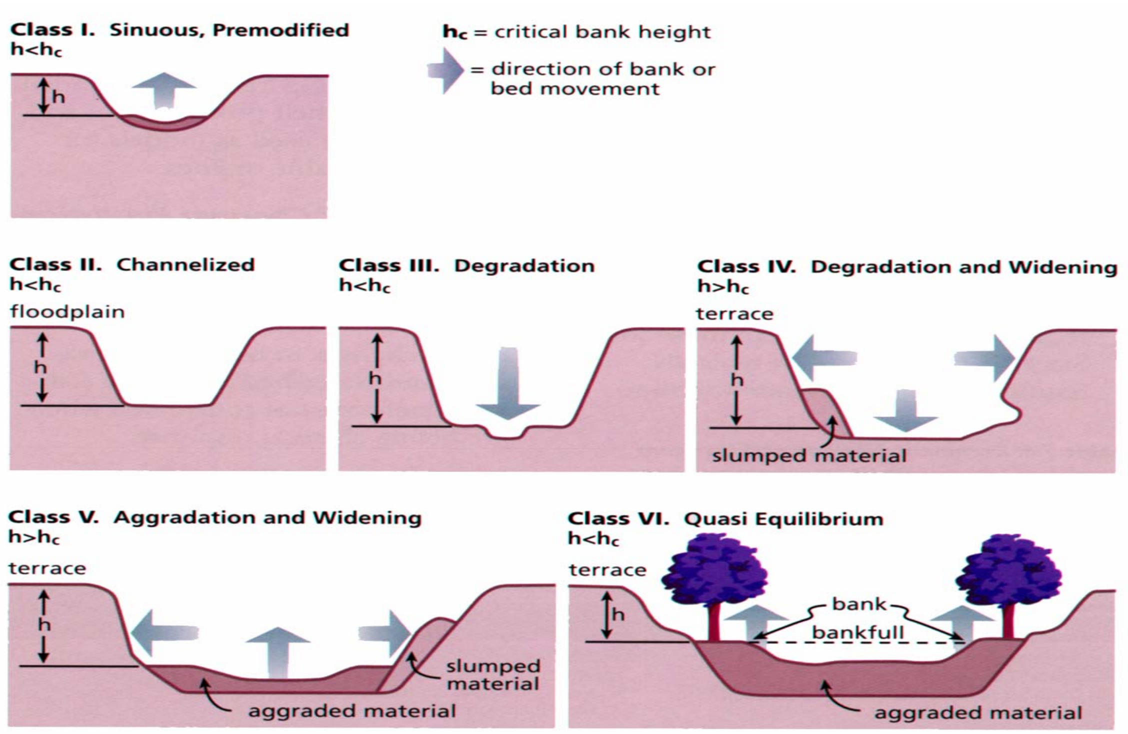


Figure 5.15 Channel evolution sequence in cross sectional view (Simon and Hupp, 1992).

- Class I, is the channel in its natural pre-disturbed state.
- Class II, is the channel immediately after being disturbed (in this case, channelized, presumably straightened and steepened in addition to over-widened).
- Class III, is the channel eroding down (degrading) due to the flood waters being confined because channel is lower and out of contact with the former floodplain.
- Class IV, the channel continues to degrade, the banks become unstable, and the channel erodes laterally.
- Class V, the channel begins to deposit eroded material in the over-wide channel, and the newly developing floodplain continues to widen.
- Class VI, and a new channel is established and becomes relatively stable. A new floodplain is established within the original channel, and the former floodplain becomes a *terrace* (abandoned or inactive floodplain).

The six classes would temporarily occur at a single cross-section, but they can be seen to occur spatially as well when viewed along the stream profile, most typically in the downstream direction from Class I at the headwaters to Class VI at the mouth.

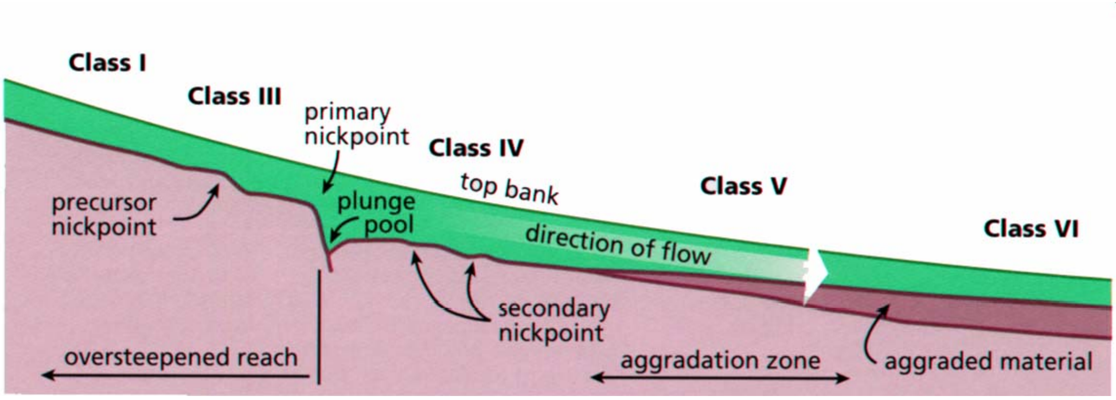


Figure 5.16 Channel evolution sequence in profile view (Simon and Hupp, 1992).

Figure 5.16 shows this process occurring along the stream profile. The profile view illustrates the changes a stream goes through in adjustment to disturbance or to natural stream processes over geologic time. Bank erosion is a symptom of change within the watershed. Focusing on stabilizing short reaches of eroding bank (*rip rap*) does not address the issue of change within the watershed. It ignores the effect that excess sediment form upstream will be deposited, and that this in turn triggers rapid channel migration and additional bank erosion. The causes of erosion must be addressed and this requires looking at the watershed as a whole.

Dave Rosgen (2001) has described nine evolutionary scenarios using his stream types which are illustrated below in **Figure 5.17**. These are not theoretical evolutionary scenarios; each has been observed by Rosgen in the field. A common evolutionary sequence in this region is number nine. A C type stream degrades to a G, then widens to an F. Eventually a new C is formed inside the wide F channel. Note that in this case a new floodplain has been created. The old floodplain is at a higher elevation relative to the streambed, and becomes a terrace.

The evolutionary sequence can be used on any particular stream to tell scientists, engineers, or hydrologists something about the stream's former and present state, or to determine what the stream's former condition (type) and what it should be to be in balance with the current setting.

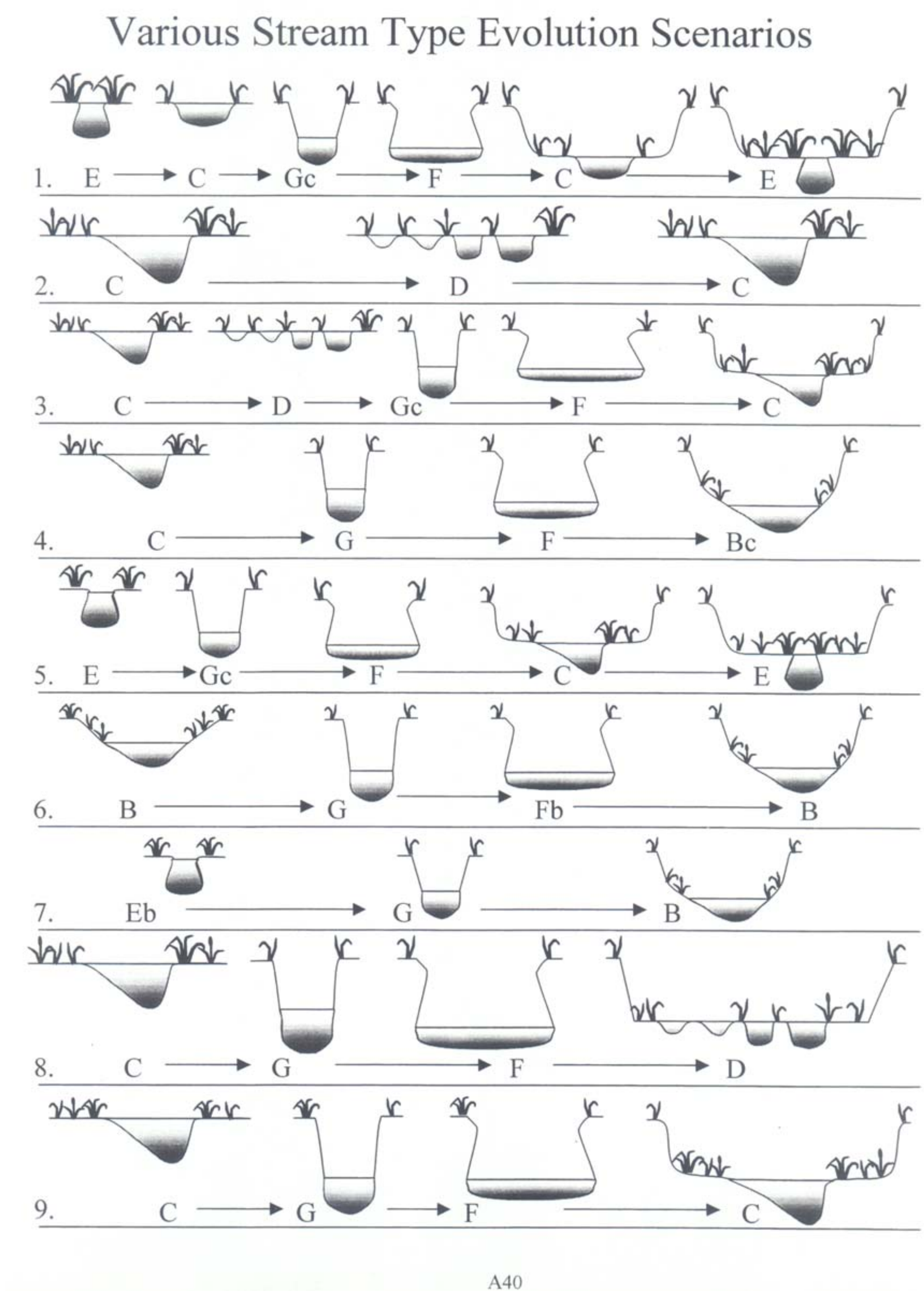
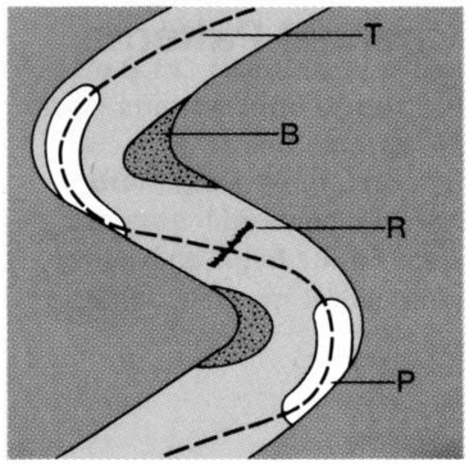


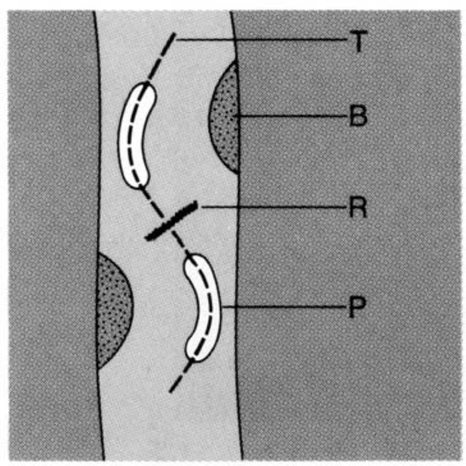
Figure 5.17 Stream Evolutionary Sequence from River Restoration and Channel Design (Rosgen, 2001)

Riffle-pool sequences

The channel form most commonly associated with rivers is that of a meandering channel. The figure below (Ritter 1978) shows the location of the principal features of a meandering channel where T is the *thalweg*, B is a point bar, R is the riffle section, and P is pools.



The following figure (Ritter 1978) shows these same features in a straight channel. The pool-pool spacing of a straight channel approximates the pool-pool spacing of a meandering channel.



Applying the Science of Stream Form and Function to Stream Management

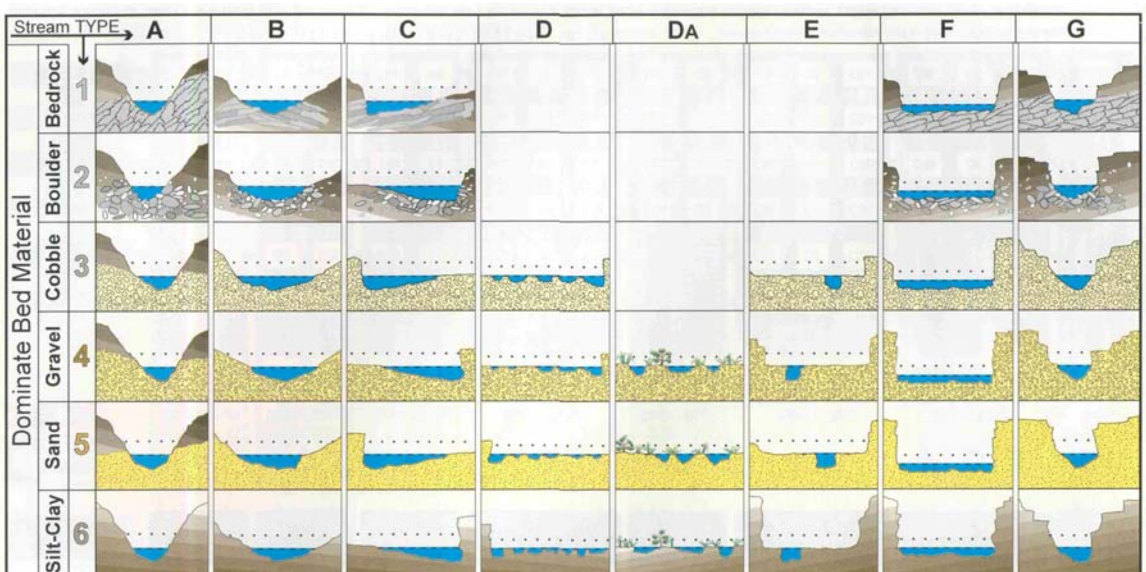
By carefully measuring the characteristics of stream form described above, stream managers can get a fairly good idea about the relative stability of a stream, reach by reach, over its whole length. By understanding the relationship between form and function, managers can prioritize severely unstable stream reaches for treatment, and can apply different management strategies appropriately and more cost effectively. Analysis of stream morphology can improve the success of stream restoration projects; designers identify and survey stable stream reaches *(reference reach*), and then use stable form characteristics as a design template for restoration projects.

Classifying Streams by their Form

One useful tool for stream managers, also developed by Dave Rosgen (1996), is a system for classification of different stream reaches based on their form. Rosgen's system gives letter and number designations to different stream types, depending on their combination of five bankfull channel characteristics:

1) Entrenchment ratio
2) Ratio of width to depth
3) Slope
4) Sinuosity
5) Bed material size (D_{50})

Different combinations of these characteristics result in a great number of different stream types, from A1 through G6 (see **Figure 5.18**; read letter designation across the top, particle size number down the left side). These letter/number designations provide a sort of shorthand for summing up the form of a stream reach.



Stream TYPE	A	B	C	D	DA	E	F	G
Entrchmnt.	< 1.4	1.4 - 2.2	> 2.2	n/a	> 4.0	> 2.2	< 1.4	< 1.4
W/D Ratio	< 12	> 12	> 12	> 40	< 40	< 12	> 12	< 12
Sinuosity	1 - 1.2	> 1.2	> 1.2	n/a	variable	>1.5	> 1.2	>1.2
Slope	.04-.099	.02-.039	< .02	< .04	< .005	< .02	< .02	.02-.039

Figure 5.18 Stream type delineative criteria, from Rosgen, 1996.

So, for example, a B3 stream type has a cobble dominated bed, has a moderate amount of accessible floodplain, is more than 12 times as wide as it is deep, is moderately sinuous, and drops between 2 and 4 feet for every 100 feet of stream length. How does a B3 differ from an F3? An F3 is more entrenched, so it can't spill out onto its floodplain during storm flows, and it's also less steep, dropping less than 2 feet for every 100 feet of stream length. How is a B3 different from a G4? Not only is the G4 more entrenched, like the F3, but also has a smaller width-to-depth ratio than a B3, and a finer, gravel-dominated bed.

As discussed above, each form functions a little differently from the next, especially with regard to the stream's ability to transport its sediment effectively. By classifying the different stream types in a watershed, then, different management strategies can be targeted to each section of stream. In **Table 5.5**, Rosgen (1996) has suggested how different stream forms can be interpreted with regard to various management issues.

Table 5.5 Management Interpretations of various stream types (Rosgen, 1996)

Stream type	Sensitivity to disturbance[a]	Recovery potential[b]	Sediment supply[c]	Streambank erosion potential	Vegetation controlling influence[d]
A1	very low	excellent	very low	very low	negligible
A2	very low	excellent	very low	very low	negligible
A3	very high	very poor	very high	very high	negligible
A4	extreme	very poor	very high	very high	negligible
A5	extreme	very poor	very high	very high	negligible
A6	high	poor	high	high	negligible
B1	very low	excellent	very low	very low	negligible
B2	very low	excellent	very low	very low	negligible
B3	low	excellent	low	low	moderate
B4	moderate	excellent	moderate	low	moderate
B5	moderate	excellent	moderate	moderate	moderate
B6	moderate	excellent	moderate	low	moderate
C1	low	very good	very low	low	moderate
C2	low	very good	low	low	moderate
C3	moderate	good	moderate	moderate	very high
C4	very high	good	high	very high	very high
C5	very high	fair	very high	very high	very high
C6	very high	good	high	high	very high
D3	very high	poor	very high	very high	moderate
D4	very high	poor	very high	very high	moderate
D5	very high	poor	very high	very high	moderate
D6	high	poor	high	high	moderate
Da4	moderate	good	very low	low	very high
DA5	moderate	good	low	low	very high
DA6	moderate	good	very low	very low	very high
E3	high	good	low	moderate	very high
E4	very high	good	moderate	high	very high
E5	very high	good	moderate	high	very high
E6	very high	good	low	moderate	very high
F1	low	fair	low	moderate	low
F2	low	fair	moderate	moderate	low
F3	moderate	poor	very high	very high	moderate
F4	extreme	poor	very high	very high	moderate
F5	very high	poor	very high	very high	moderate
F6	very high	fair	high	very high	moderate
G1	low	good	low	low	low
G2	moderate	fair	moderate	moderate	low
G3	very high	poor	very high	very high	high
G4	extreme	very poor	very high	very high	high
G5	extreme	very poor	very high	very high	high
G6	very high	poor	high	high	high

a Includes increases in streamflow magnitude and timing and/or sediment increases.
b Assumes natural recovery once cause of instability is corrected.
c Includes suspended and bedload from channel derived sources and/or from stream adjacent slopes.
d Vegetation that influences width/depth ratio-stability.

Throughout this management plan there are references to these stream types. It is important to emphasize that the above are only general management interpretations, and that stream types are used as a convenient "shorthand" summary of the morphology of a reach. To predict how a stream reach is likely to behave in the future, the surveyed conditions at each reach must be considered along with conditions of adjoining reaches upstream and downstream, historical information taken from aerial photography, field studies of soils, vegetation (adequate streamside vegetation of the proper species mix is important to stream function) and watershed land use.

5.10 Riparian Vegetation Issues in Stream Management

The condition and types of riparian vegetation play crucial roles in stream health, and thus are important to sound stream stewardship and management. This section discusses riparian vegetation in terms of general ecology, forest history of the West Branch basin, natural and human disturbances, and the effects of invasive plants on riparian vegetation (**Section 5.10.4**). A separate subsection focuses particularly Japanese knotweed (*Fallopia japonica*), an invasive plant that is gaining a strong foothold in the watershed.

5.10.1 General Concepts of Riparian Vegetation Ecology

Streamside vegetation provides numerous benefits to water quality, aquatic and terrestrial plants and animals, and local landowners. Vegetated *riparian zones* facilitate stream stability and function by providing rooted structure to protect against bank erosion and flood damage. Riparian buffers offer protection against pollution and the adverse impacts of human activities. Streamside forests also reduce nutrient and sediment runoff, provide food and shelter, and moderate fluctuations in stream temperature. Streamside vegetation also improves the aesthetic quality of the stream community.

The extent of benefits is proportional to the width of the riparian zone and its species diversity. For example, a narrow 25 foot buffer zone may offer only bank stabilization as a benefit while a buffer over 200 feet wide includes a diverse range of water quality and ecological benefits. A buffer containing a variety of species and types (trees, shrubs, grasses and forbs) offers the best protection **(Figure 5.19)**. An area with a diverse mix of native species of different ages and good regeneration will function more appropriately than a simpler community if disease or pests eliminated one or more species. Different types and species of plants also provide a variety of root depths and strength to help stabilize streambanks in both shallow and deep soils. Native plants in the riparian zone have the ability to resist or recover from disturbance, mainly from repeated inundation by floodwaters.

Figure 5.19 A healthy riparian community is densely vegetated, has a diverse age structure and is composed of plants that can resist disturbance. View of Town Brook Reference Reach.

The riparian forest community can be more extensive where a floodplain exists and valley walls are gently sloping. Where valley side slopes are steeper, the riparian community may occupy only a narrow corridor along a stream and transition to an upland forest community. Soils, ground water and solar aspect may create conditions allowing the riparian forest species to occupy steeper slopes along a stream, as in the case where Eastern hemlock (*Tsuga canadensis*) inhabits steep, north facing slopes along a watercourse.

5.10.2 Natural Disturbance and its Effects on Riparian Vegetation

Natural disturbances can greatly affect the vigor of streamside vegetation. These disturbances include floods, ice or debris floes, and to a lesser extent, high winds, pest and disease epidemics, drought and fire. Deer herds can also alter the composition and structure of vegetation due to their specific browse preferences.

The effect of flooding on healthy streamside vegetation is generally short term and the recovery/ disturbance regime can be cyclical. Following a large flood, the channel and adjacent floodplains can be littered with everything from woody debris to downed live trees. In following years, much of the vegetation recovers. Trees and shrubs flattened by floodwaters re-establish their form. In stable streams, gravel bars and sites disturbed in previous flood events become seedbeds for natural regeneration of grasses and forbs. However, if significant flood or ice floe events occur too frequently to allow adequate vegetation re-establishment, large trees do not have the opportunity to establish.

Figure 5.20 A channel-wide debris jam.

Springtime ice break-up, like floods, can damage established vegetation along streambanks and increase mortality of young tree and shrub regeneration. Ice floes can also cause channel blockages **(Figure 5.20)**, which result in erosion and scour associated with high flow channels and over-bank flow. This type of disturbance generally has a short recovery period.

When stream managers seek to expedite or augment the recovery process, the following local geology and stream morphology factors are important to consider before attempting restoration: hydraulics of flowing water, morphological evolution of the stream channel, geology of the streambank, and the requirements and growth capabilities of vegetation.

Pests and diseases that attack vegetation also impact the riparian area. In portions of the eastern United States, the hemlock wooly adelgid (*Adelges tsugae*) attacks eastern hemlock and can affect entire stands[18]. Currently, the adelgid is confined to the warmer southeastern section of New York State with no known infestations in the West Branch basin, although natural resource managers are aware of its potential to expand its impacted range. Hemlock stands have been delineated in the West Branch watershed to assist in future efforts to conserve this species.

5.10.3 Human Disturbance and its Effects on Riparian Vegetation

"When we try to pick out anything by itself, we find it hitched to everything else in the universe." - John Muir

The distinction between natural and human disturbances is important to understand. The effects of floods, ice floes, pests and disease can cause widespread damage to riparian vegetation but these effects are usually temporary. However, human activities often significantly alter natural conditions and can have a longer lasting impact on the capability of riparian vegetation to survive and function. These disturbances can include livestock overgrazing, cropping practices, construction and maintenance of highway infrastructure, real estate development and introduction of non-native species in the riparian zone.

Agriculture Influence

Figure 5.21 View of streambank significantly impacted by cattle activity.

Continuous access to streams by livestock has a significant impact on the vigor, mortality and diversity of riparian vegetation. Grazing can reach an intensity that keeps grasses and forbs at a height too low to effectively uptake nutrients and impede storm runoff, which increases environmental contamination and streambank erosion. Intensive riparian grazing also inhibits the growth, establishment and/or regeneration of shrubs and trees while hoof shear (cattle-eroded stream access points) on streambanks exacerbates erosion. Cultivating row crops and mowing haylands to the stream's edge or the top of the streambank also result in decreased species diversity and riparian buffer width. . The loss of riparian buffer as a result of these practices significantly increases surface erosion and stream bank erosion rates with an associated increase in the sediment and nutrient loads to the river system.

The United States Department of Agriculture's (USDA) Conservation Reserve Enhancement Program (CREP) is a voluntary program that protects environmentally sensitive agriculture land

[18] U.S. Forest Service, Morgantown office website: www.fs.fed.us/na/morgantown/fhp/hwa/hwasite.html (Verified 11-03-04)

with vegetative riparian buffers often associated with exclusionary livestock fencing. This program provides numerous environmental benefits and has met with great success in the West Branch of the Delaware River watershed. More information on CREP is included in **Section 6.3.2**.

Highway/Public Utility Infrastructure Influence

Use and maintenance of state and local highways also impacts the vigor of riparian vegetation where narrow buffers exist between roads and streams. These areas receive runoff containing sediment and road chemicals that stunt vegetative growth or increase stress and mortality. Accelerated storm runoff from these highways also contributes to increased streambank erosion. Highway maintenance activities that regularly disturb the soil along shoulders and cut banks can welcome undesirable *invasive plants*. In areas where public utility lines parallel or cross streams, riparian areas are disturbed by the practice of keeping vegetation trimmed to near ground level. This is another contributor to accelerated runoff and increased streambank erosion.

Residential Development Influence

Residential land use and development of new homes can have a significant impact on the watershed and ecology of the riparian area. Houses require access roads and utility lines that often have to cross streams. Homeowners who enjoy their stream and desire to be close to it may clear all the trees and shrubs along it to provide access and views. They may replace natural conditions with an un-natural mowed lawn that provides little benefit to stream health or local wildlife. These practices can lead to new streambank erosion or increase existing erosion.

Many people live close to a stream and have access to the water without destabilizing the bank. Careful selection of a route to the stream and locating access where the water's force on the bank is lower, a landowner can minimize disturbance to riparian vegetation and the streambank. Minimizing disturbance in the flood prone area and promoting a dense natural buffer provide property protection, aesthetic value and wildlife habitat. Riparian gardeners must know which riparian species are appropriate for planting. A list of native trees and shrubs is included in **Appendix 2.** More information can be obtained by contacting the Delaware County Soil & Water Conservation District, 44 West Street, Suite 1, Walton, New York, 13856, (607) 865-7162. The following websites also offer information on riparian buffers:

USDA Natural Resources Conservation Service backyard tree planting -
http://www.nrcs.usda.gov/feature/backyard/TreePtg.html (Verified 11-05-04)

USDA Natural Resources Conservation Service wildlife habitat -
http://www.nrcs.usda.gov/feature/backyard/WildHab.html (Verified 11-05-04)

Connecticut River Joint Commission, Inc. - http://www.crjc.org/riparianbuffers.htm
(Verified 11-05-04)

The National Wildlife Federation - http://www.nwf.org/backyardwildlifehabitat/ (Verified 11-05-04)

5.10.4 Invasive Plants and Riparian Vegetation

Sometimes attempts to beautify a property with new and different plants will introduce a plant that aggressively spreads out of control. These "invasive" plants present a threat when they alter the ecology of the native plant community. Their impact may even alter the landscape should the invasive plant destabilize the geomorphology of the watershed (Malanson, 1993). Japanese knotweed, an invasive plant gaining a notable foothold in the West Branch basin, is an example of a plant capable of causing such a disruption. Although others exist, additional invasive plants of note along the West Branch corridor include multiflora rose (*Rosa multiflora*), purple loosestrife (*Lythrum salicaria*).

All three of these plants are not native to the United States and are termed "exotic species". Because exotic species are often transported without the associated plants and animals that normally keep them in check, they can become *invasive* species. Invasive species earn this categorization by out-competing local, native species and may alter the ecosystem and its functions. Invasive plants can often survive under less than perfect conditions – from high and low soil pH levels, full sun to much shade, or wet to dry soils. The following text briefly describes multiflora rose and purple loosestrife, followed by an in-depth description of Japanese knotweed, its traits as an invasive species, what people can do about it and resources for additional information.

5.10.4.1 Multiflora Rose

Multiflora rose is native to Japan, Korea and eastern China and was introduced to the eastern United States in 1866 as rootstock for ornamental roses. Beginning in the 1930s, the U.S. Soil Conservation Service (now Natural Resources Conservation Service) promoted it for use in erosion control and as "living fences" to confine livestock. State conservation departments recommended multiflora rose as cover for wildlife.

Figure 5.22 Multiflora rose

Multiflora rose grows aggressively and produces large numbers of fruits (hips) that are eaten and dispersed by a variety of birds. It tolerates a wide range of soil, moisture and light conditions and is able to invade fields, forests, streamsides, some wetlands and many other habitats. Dense thickets of multiflora rose exclude most native shrubs and herbs from establishing and may be detrimental to nesting native birds. It has been recognized as a problem on pastures and unplowed lands where it has disrupted cattle grazing, and more recently as a pest of natural ecosystems.

Figure 5.23 Purple loosestrife

Multiflora rose may be controlled by hand pulling. Mature plants can be controlled through frequent repeated cutting or mowing. Several contact and systemic herbicides are also effective in controlling multiflora rose. Follow-up treatments are likely to be needed.[19]

5.10.4.2 Purple Loosestrife

Purple loosestrife is native to Eurasia and was introduced to the northeastern United States and Canada in the 1800's for ornamental and medicinal uses. It is still widely sold as an ornamental. Purple loosestrife adapts readily to natural and disturbed areas and is capable of invading wetlands, river and stream banks, pond edges, reservoirs and ditches. Under favorable conditions, loosestrife is able to rapidly establish and replace native vegetation with a dense, homogenous stand that reduces local biodiversity, endangers rare species and provides little value to wildlife.

Small infestations of purple loosestrife plants may be pulled by hand, preferably before seed set. For older plants, spot treatment with a glyphosate herbicide may be effective. Biological control using USDA approved beetle species is probably the most effective method for long-term control of large infestations.[20]

For further information on invasive species in New York visit the Invasive Council of New York State website: http://www.ipcnys.org/.

[19] National Park Service, U.S. Fish and Wildlife Service, *Plant Invaders of Mid-Atlantic Natural Areas,* July 2004, pages 40-41.
[20] National Park Service, U.S. Fish and Wildlife Service, *Plant Invaders of Mid-Atlantic Natural Areas,* July 2004, pages 26-27.

5.10.4.3 Japanese Knotweed, an invader of the Catskills

A plant whose presence within the Catskill region has become much more prevalent in the last few years, Japanese knotweed is an invasive plant that is often referred to by Catskill residents as bamboo or Japanese bamboo. Although bamboo and Japanese knotweed are two different plants, they do have a couple of similarities. Both have tall, hollow stems, but more importantly, neither belong in the United States. As implied by its name, Japanese knotweed originates from Asia. This categorizes knotweed as an *exotic* plant, one that evolved in another area of the world with different plants and animals.

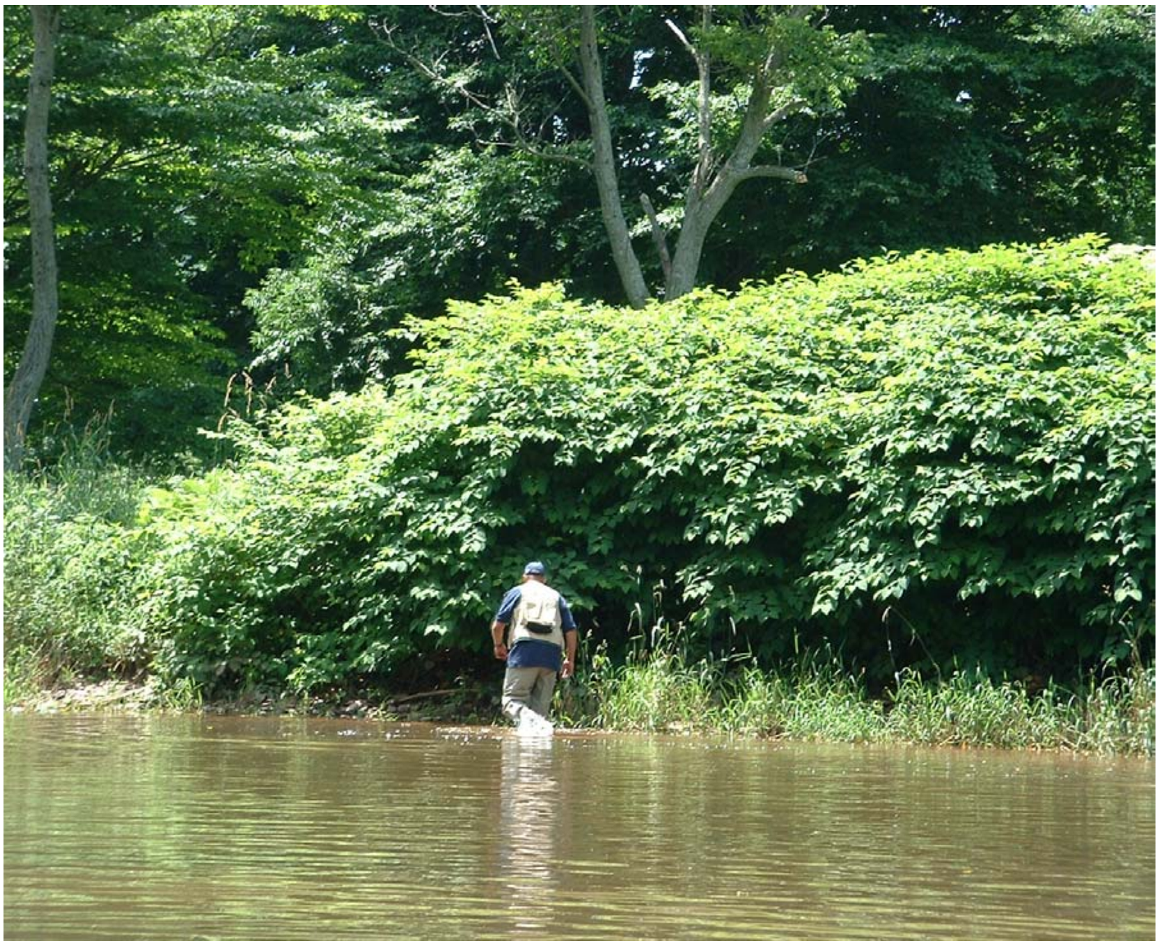


Figure 5.24 Japanese knotweed along the West Branch of the Delaware, summer 2003

Characteristics of Japanese knotweed

Fortunately, Japanese knotweed is quite recognizable throughout the year. The photographs on this page illustrate different stages of Japanese knotweed's growth throughout each season. This herbaceous, or non-woody, perennial goes through these cycles every year.

In the spring (generally late April, early May), new red, asparagus-like shoots sprout from last year's crown or from underground roots (*rhizomes*).

By July individual stems may reach as tall as 11 feet. Many thick, hollow stems are based at a crown. The upper areas of the stems form a few branches that reach out like an umbrella from the crown. Each main stem and branch holds several large, nearly-triangular leaves that shade out most of summer's sunlight.

In August knotweed dons abundant clusters of small, white flowers that attract several pollinators, such as bees, wasps and Japanese beetles.

The numerous flowers turn into buckwheat-like seeds by late September, early October. Although some seeds may create small seedlings, knotweed spreads more by their *rhizomes*.

Cold weather halts the growth of knotweed; once frost covers the land, knotweed drops its leaves and turns an auburn hue. These dead stems often remain standing for one or two years and then cover the ground, decaying slowly.

Problems associated with Japanese knotweed

As previously mentioned knotweed is an exotic, invasive species. Some texts explain that knotweed was brought to Great Britain as early as 1825 where it won accolades as an ornamental plant. By the late 1800s immigrants to the U.S. brought their prized garden plant. Knotweed has escaped personal gardens and spread into lawns, farm fields (**Figure 5.25**), along roadsides and railroads, along streambanks and onto floodplains. It is found in five Canadian provinces and all but ten states in the US.

Figure 5.25 A farmer in the Batavia Kill valley explained how a tractor barely caught a knotweed stem and pulled it into his cornfield and now it's growing amongst the corn.

Knotweed spreads vegetatively from portions of the roots or shoots. This vegetative propagation characteristic explains how it has expanded into such a wide variety of environments. The rhizomes begin new colonies of knotweed by spreading up to 20 feet from an existing plant. For this reason people may transport knotweed unknowingly by digging up rhizome-contaminated soils and dumping them elsewhere. Even a very small piece of this rhizome can sprout a new plant.

When kept moist, other plant parts, such as the stem, can also sprout new plants. Stems and rhizomes float downstream after breaking off during floods (knotweed is actually a very brittle plant and breaks easily) or from beaver damage. These fragments then come into contact with disturbed or eroded soils lacking vegetation and begin more new colonies. This is why streams host such dense stands of knotweed.

Knotweed can also be unwittingly introduced to new areas by highway departments and contractors through soil transported from gravel and sand pits contaminated with knotweed. *Stream assessment* teams have noted several instances where knotweed stands have developed in the new soil where a *culvert* or bridge has been renovated. Once established near the waterway, the knotweed is able to spread downstream after disturbance associated with a storm event.

Figure 5.26 From left to right: knotweed flattened by high flow event in Greene County, a stream bank *slump* where only grass and knotweed bordered streambank, and the shade created by dense canopy of broad knotweed leaves.

Why is this rapid invasion such a concern? Knotweed's traits pose a broad array of concerns. Some of these concerns include:

- Knotweed appears to be less effective at stabilizing streambanks than deeper-rooted shrubs and trees, possibly resulting in more rapid bank erosion (**Figure 5.26**).
- The shade of its broad leaves and the cover by its dead litter limit the growth of native plants that provide food and shelter for associated native animals (**Figure 5.26**).
- Dead knotweed leaves (*detritus*) may alter food webs and impact the food supply for terrestrial and aquatic life.
- Large stands of knotweed impede access to waterways for fishing.

Knotweed on the West Branch of the Delaware River

As part of the stream assessment for this plan, the field team used GPS to map the location of Japanese knotweed colonies along the river. This mapping effort began in 2003 and was completed in 2004. The mapping effort began within the Town of Delhi because, despite its presence, knotweed was not identified as a major component of the riparian vegetation in the upper portion of the watershed. The team mapped colonies that could be observed from within the stream channel, therefore the resulting mapping effort may not have captured colonies that are distant from the channel (but may be within the floodplain or flood fringe). Colonies were mapped as isolated points, or as a line with the beginning and end of a continuous stretch of colony identified along a bank.

The resulting map of colony locations (**Figure 5.27**, page 53, below) shows that the plant has extensively colonized the banks of the river from above Delhi to the Cannonsville Reservoir. Of the 26.8 miles of river within the mapping area, Japanese knotweed had colonized approximately 13.5 miles of streambank. Over 300 colonies were identified and the longest single colony stretched over 2400 feet along one stream bank. The median size colony was 61 feet long. The small median size relative to an average of over 200 feet suggests that a number of the colonies may be small and capable of being controlled.

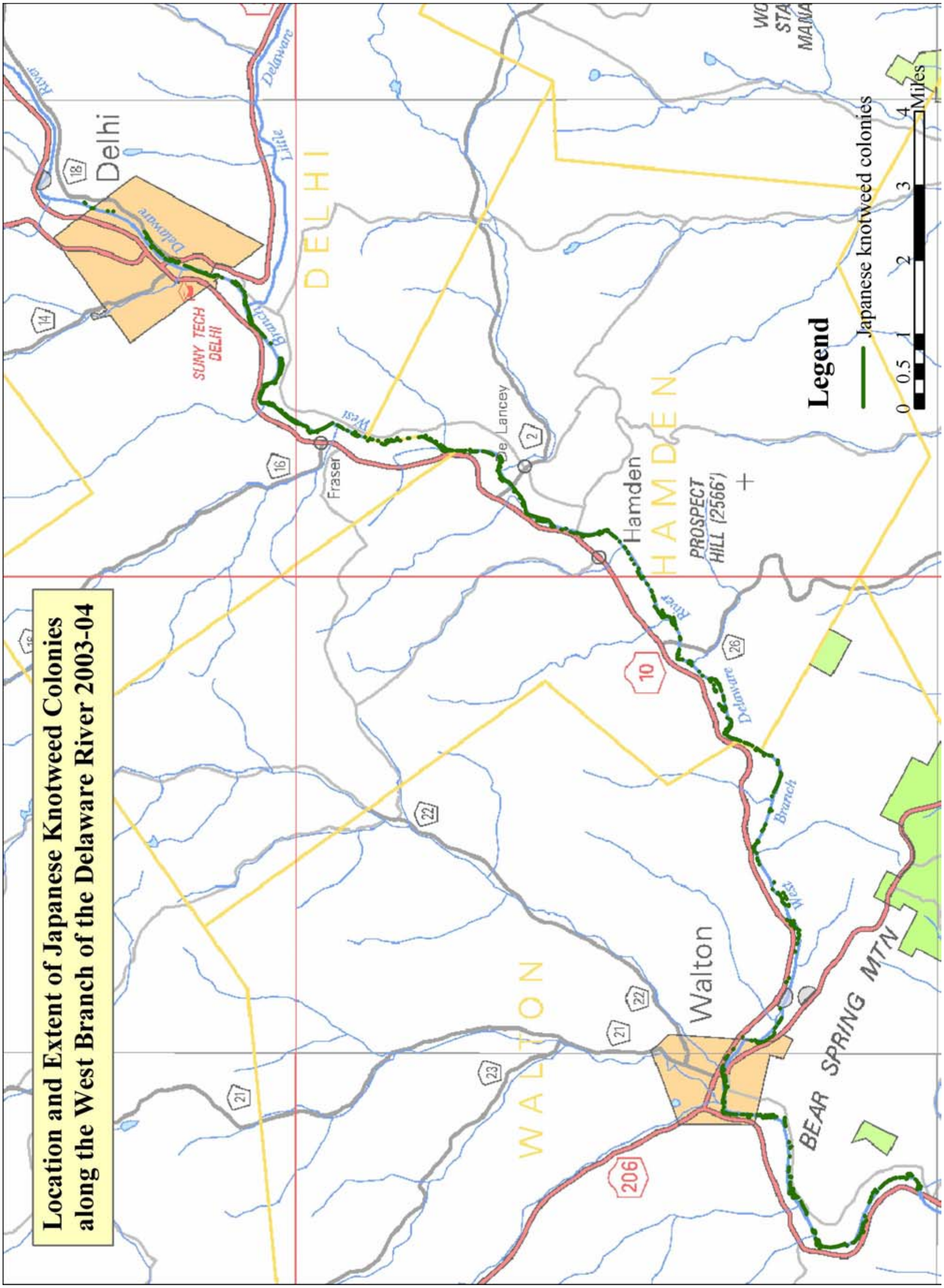


Figure 5.27 Japanese knotweed colonies along the West Branch from Delhi to Beerston

What to know before treating knotweed

Besides understanding key characteristics about knotweed (e.g. how it spreads, what environments it prefers), it is also essential to recognize a few key concepts that actually apply to most invasive species.

First and foremost,

Prevention is the best policy

No knotweed is the best knotweed

Preventing its spread is the best, most cost effective and time efficient approach to take.

Prevention may be in the form of:

1). Telling others about knotweed and warning them of its associated problems,
2). Keeping stream banks stable by allowing native trees and shrubs to grow and mature, and
3). Testing transported soil and sources for any knotweed colonies and plant fragments.

Unfortunately, the West Branch of the Delaware River has a knotweed problem and some level of treatment is necessary. It is critical to recognize that knotweed grows under diverse conditions and in varying locations, so there are different ways to approach its control. Before simply mowing down all the knotweed or spraying herbicides everywhere, one should first ask:

- How large is the stand of knotweed?
- Is it located near a waterway?
- What native plants exist nearby?

With answers to the above questions, a customized approach may be taken, saving time and money by applying the most appropriate techniques.

Finally, someone wanting to control knotweed should understand that:

- A disposal plan for all knotweed material is a must; otherwise a new colony will just sprout somewhere else. This might include burning the material, burying it more than 6 ft. deep or letting it completely dry out.
- Most treatments require multiple applications. A one-time cutting or mowing of knotweed will not do anything except stunt it temporarily and cause the rhizomes to extend underground faster towards more nutrients, possibly causing a higher rate of spread. Be prepared to make follow-up visits to past treatment sites to ensure complete control of knotweed.
- Re-vegetation with native species after treatment is necessary. Leaving bare ground only promotes the reinvasion of knotweed. Rapid-growing, native trees and shrubs must be planted soon after removing knotweed in order to affect the most beneficial change.

What to do about knotweed

Getting involved is as simple as 1, 2, 3:

1. Check your property. Locate any knotweed or areas of bare soil to know where you may need to remove knotweed or add more native trees or shrubs.
2. Become informed & spread the word. Since knotweed can travel anywhere, via stream or dump truck, let your neighbors know about it. *Spread the word, not the weed.*
3. Ask for help. Contact the Delaware County Soil & Water Conservation District for assistance with assessment or control.

Below are various treatment prescriptions depending on size of the knotweed stand, its proximity to a waterway, and amount of surrounding vegetation. Please note that where bare ground exists after removing knotweed stems and roots, it is essential to re-vegetate the area with competitive (fast-growing) native trees and shrubs. This is especially critical if surrounding vegetation is limited or nonexistent. Otherwise, reestablishment of knotweed is likely and control efforts may be futile.

For *small* stands (less than $3ft^2$):
Cover with dark plastic.
Frequent cutting, grubbing or pulling with safe disposal of knotweed stems.
Herbicide injection of stems. **PLEASE READ CAUTION BELOW**.

For *medium* stands ($3ft^2$ to $25ft^2$):
Frequent mowing (do not allow cut material to leave site).

For *large* stands ($25ft^2$+):
In some cases, the extent of a knotweed colony is so extensive that more harm (e.g. damage to soils) would be done in trying to eliminate the entire stand. For this reason control of expansion is the appropriate action.
Frequent mowing around edges of stand (do not allow cut material to leave site).
Herbicide injection of stems in edges of stand. **PLEASE READ CAUTION BELOW**.

Herbicide Caution: Glyphosate (e.g. Rodeo, Roundup, Aquamaster) is the recommended active agent. When used with care and according to product labels, this herbicide does NOT negatively affect *un*touched plants and animals. Using an injection method is highly recommended, because knotweed material is not cut therefore requiring no disposal. Also this method eliminates drift and targets only injected stems. Only certain herbicides, such as Rodeo and Aquamaster, can be safely used near a waterway.

Please take care to wear appropriate protective equipment. Check with Cornell Cooperative Extension of Delaware County at (607) 865-6531 for information about the proper, safe and legal use of herbicides.

Current research

Batavia Kill, Greene County

In summer 2003, Hudsonia, DEP SMP and the Greene County Soil & Water Conservation District (GCSWCD) established a number of permanent plots for long-term research. These included *monitoring* plots, which measure the rate of spread of Japanese knotweed under various conditions, and treatment plots, which will provide the setting for testing various management techniques. While setting up the different plots, the research partners gathered baseline data about knotweed, including average height and diameter of individual stems, percent canopy & litter cover and associated vegetation. Another element of last year's research included mapping Japanese knotweed and general vegetation categories along the main stem of the Batavia Kill. GCSWCD and Hudsonia hope to expand this research effort to increase community involvement in the management of Japanese knotweed. In addition to continuing to monitor the established research plots, the knotweed management team will focus on education and outreach about the prevention of knotweed expansion and its proper management and disposal. In the near future GCSWCD will be posting a literature review conducted by Hudsonia in 2002 on its website (see **Table 5.6** below)

Stony Clove, Greene & Ulster Counties

In conjunction with the Stony Clove Stream Management Plan, developed by GCSWCD and NYCDEP Stream Management Program, the partners developed the Stony Clove Planting Project to address the vegetation of private properties adjacent to over-widened sections of the creek. GCSWCD received a grant from the Watershed Agricultural Program (WAC) Forestry to treat eight sites. This money enabled contracting with Munro Ecological Services (MES), a consultant specializing in ecological restoration of floodplains, to produce designs and installation specifications. These designs included recommendations for the eradication of Japanese knotweed that exists on a couple properties. Implementation of MES recommendations is scheduled for the growing season of 2005.

Delaware River, Delaware & Sullivan Counties

The Delaware River Invasive Plant Partnership (DRIPP) was formed to increase public awareness and understanding of invasive plants and their impacts, facilitate the exchange of information regarding invasive plant management, and help coordinate public and private efforts to control these weeds in the Delaware River watershed. Recently the director of DRIPP, in partnership with the National Park Service, established a Knotweed Initiative working group that meets periodically to coordinate efforts to address knotweed management.

Catskill Region, Delaware, Greene, Sullivan & Ulster Counties

Through matching funds from WAC Forestry, The Nature Conservancy's Catskill Mountain Chapter began a study in summer 2004 of the distribution of nine exotic, invasive species, including Japanese knotweed, in seven forest matrix blocks in the Catskills – Beaverkill, Cannonsville, Panther Mountain, Sugarloaf, Catskill Escarpment, Westkill and Bear Pen Vly.

Resources for more information

While scientists and resource managers throughout the U.S. and the United Kingdom are conducting useful research and experiments on knotweed, various agencies within the Catskill region are making their own efforts to address this problem plant. Learning from the experience of others has greatly informed the above text and will continue to inform future practices. **Table 5.6** below shows summaries of these local efforts, including contact information.

Table 5.6 Regional agencies and organizations for Japanese knotweed information

Regional Agencies & Organizations		
NYCDEP Stream Management Program	845-340-7515	http://www.ci.nyc.ny.us/html/dep/watershed/html/streams.html
Greene County Soil & Water Conservation District	518-622-3620	www.gcswcd.com
Hudsonia, Ltd.	845-758-7053	www.hudsonia.org
Delaware River Invasive Plant Partnership (DRIPP)	570-643-7922 x12	http://www.upenn.edu/paflora/DRIPP%20mission%20statement.htm
Adirondack Park Invasive Plant Partnership (APIPP)	518-576-2082 x 131	http://www.adkinvasives.com/terrestrial/Program/Program.html
The Nature Conservancy-Catskill Mountain Program	845-586-1002	
National Park Service-Upper Delaware Scenic & Recreational River	570-729-7842	
Other Japanese Knotweed resources		
The Nature Conservancy-UC Davis		http://tncweeds.ucdavis.edu/esadocs/polycusp.html
The Nature Conservancy-Oregon	503-230-1221	http://tncweeds.ucdavis.edu/success/or002.html
The Knotweed Page		http://www.knottybits.com/Knotweed/
Japanese Knotweed Control Forum of Cornwall		http://www.ex.ac.uk/knotweed
The Invasive Plant Council of New York State	518-271-0346	http://www.ipcnys.org/

5.10.5 Forest History and Composition in the West Branch Delaware River Basin

Catskill region forests evolved since the last ice age, reflecting changes in climate, competition and human land use. As ice melted, plants adapted to warmer temperatures and migrated north, replacing species with a colder climate preference. The forests of the West Branch basin gradually re-established and evolved from boreal spruce-fir dominated forests (examples of which can presently be found in Canada) to maple-beech-birch forests (typical northern hardwood forests of the Adirondacks and northern New England) with a final transition in some areas to oak-hickory-ash dominated southern hardwood forests typical of the northern Appalachians (Kudish, 2000). The forests of the western Catskills and West Branch of the Delaware River basin are the eastern most extension of the Allegany Highlands forests, a broadleaf, temperate, mixed forest ecozone. The pre-settlement forests in this ecozone consisted largely of American beech (*Fagus grandifolia*) and Eastern hemlock (*Tsuga canadensis*). Sugar maple (*Acer saccharum*) later replaced hemlock as a major component of the forest on drier sites as fire controlled hemlock. Red maple (*Acer rubrum*), white ash (*Fraxinus americana*), black cherry (*Prunus serotina*), yellow birch (*Betula alleghaniensis*) and black birch (*Betula lenta*) were and continue to be associates of the beech-maple and beech-hemlock forests. Eastern white pine (*Pinus strobus*) established nearly pure stands after fire or wind impacted the previous stands[21]. One of the earliest recorded natural disturbances was the March 20th blowdown in 1797. Regional high winds felled trees around Delaware and surrounding counties (Kudish, 2000). There have also been several significant floods that have altered the landscape over the years. Hemlock has remained an important species in riparian forests along the north facing slopes of the West Branch of the Delaware River. Because of its dense overstory and allelopahtic characteristics, hemlock may have been able to preserve its dominance by regulating the diversity and abundance of ground cover vegetation in riparian zones (Williams and Moriarity, 1999).

Human activities have affected forests through manipulation of regeneration for desirable species maintenance, exploitation for wood and wood products and through clearing for development. Native American land management practices included the use of prescribed burning as a means of enabling nut bearing oaks to remain dominant in the forest. In response to a rising industrial economy, European settlers altered the landscape and forest cover through land clearing for agriculture, harvesting for construction materials, and hemlock bark harvesting for tannin extraction. These activities may have allowed the migration of some southern hardwood species (e.g. American sycamore (*Platanus occidentalis*) and shagbark hickory (*Carya ovata*)). Land cover in the basin began to revert back to forest with the local collapse of these economies in the 20th century (Kudish, 2000).

5.10.6 Summary

Changes in the composition, vigor and density of riparian vegetation produce corresponding changes in rooting depth and density, shading, water temperature, physical protection from bank erosion processes, terrestrial insect habitat and contribution of detritus to the channel. Adverse changes in riparian vegetation generally sets in motion a series of channel adjustments seen as

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[21] 2001, World Wildlife website: http://.www.worldwildlife.org/wildworld/profiles/terrestrial/na/na0401_full.html (Verified 12-22-04)

increased sediment deposition, bank erosion, sediment supply, channel slope, and degradation of aquatic habitat. Eventually stream alignment may change and begin to cause stream migration affecting downstream landowners. Streambanks in this region require a mix of vegetation having a range of rooting depths. Grasses alone are insufficient to maintain bank stability in most cases (Rosgen, 1996).

If adverse changes to riparian vegetation are allowed to continue, where occurring without intervention to maintain or improve vigor and density, there is an increased potential for further degradation to the stream system. More than likely, lateral migration and excessive erosion and deposition will either continue at the current rate or increase, depending on climatological factors. The Conservation Reserve Enhancement Program (see **Section 2, Recommendation #2** and **Section 4.5** and **6.3.2)** and the Watershed Agricultural Council's Watershed Forestry Program (**Section 4.5**) are two programs that implement managed riparian forest buffers along streams for land under agricultural and forestry production, respectively. **Section 2, Recommendation #4** outlines the need for riparian management on non-agricultural and non-forestry land.

5.11 Fisheries and Wildlife

Streams, riparian lowlands and adjoining upland areas in the West Branch Delaware River watershed support a diverse fish and wildlife community. Their presence is influenced by land cover, the intensity of land use, and ecosystem health. This section highlights fisheries management and the species that are found in the basin and briefly describes wildlife species that are present.

5.11.1 Fisheries Management[22]

Management of the fisheries of the West Branch of the Delaware River above the Cannonsville Reservoir, and all waters of the state, is the responsibility of the Division of Fish, Wildlife and Marine Resources of the New York State Department of Environmental Conservation (NYSDEC). (Note: NYSDEC internally designates this portion of the river as the Upper West Branch for management purposes; this is the same basin delineation used for this management plan). Delaware County and the entire Upper West Branch basin are located in DEC Region IV. Fittingly the NYSDEC Region IV Fisheries Unit is located in Stamford DEC Sub-Office, only several hundred yards from the West Branch main stem.

The majority of the fisheries management activities associated with the West Branch fishery include provisions for public use, management of fish species and fish habitat protection.

Fishery Designations and Habitat Components

The designations cold-water fishery, cool-water fishery and warm-water fishery are arbitrarily given relative to the types of fish that a water body supports. While it is true that trout, representative of a cold-water fishery, can be found to live in most any water during the winter,

[22] This section has been contributed by Walt Keller, a local resident and avid fisherman who retired in 1999 as the Regional Fisheries Manager for NYSDEC Region IV.

they will not be able to survive water temperatures that support a healthy bass population during the summer months. Generally, cold-water rivers have trout of varying ages and warm-water rivers have warm-water species of varying ages. Chain pickerel (*Esox niger*) and yellow perch (*Perca flavescens*) are representatives of cool-water species.

Components of fish habitat that are essential to maximize fish population size are water of temperatures at which the fish best function, cover where fish may go to escape detection, predation or to avoid the current, and places to spawn having the necessary substrate. Additionally, habitat for food species is necessary for fish growth and reproduction. Attempts at riverine fish habitat alteration have addressed all of the above except water temperatures as influenced by spring seeps. Physical structures have been placed and continue to be located without regard to ground water influences.

Management of Fish Species

The Upper West Branch is a cold-water stream managed as a trout fishery. It is home to wild trout spawned in the stream and tributaries whose numbers are supplemented with trout raised in New York State fish hatcheries. In 1993 D.K. Sanford updated the trout stocking policy for the Upper West Branch. The trout stocking objectives for the basin are catch-rate-based, with trout stocked in numbers adequate to provide an average catch rate of one trout for every two hours fished and an average creel rate of one pound of trout (the equivalent weight of a two-year old hatchery brown trout (*Salmo trutta*) at stocking) for every ten hours fished. The number of trout stocked to achieve those rates is based on estimates of fishing pressure, wild trout biomass, angler accessibility to the fishery and the abundance of trout forage and aquatic competitors of trout.

The Upper West Branch is usually stocked with brown trout in mid-April, and again in mid-May with about 50 percent of the brown trout stocked in each increment. As with most other DEC Region IV streams, only brown trout are included in the trout stocking policy. The 1993 stocking policy considered only spring yearling trout, but this has been modified in recent years to make use of two-year old fish to supplement the yearling brown trout. Two-year old hatchery brown trout average about 13.5 inches, weigh about a pound each and are equivalent to four yearling hatchery brown trout. The NYSDEC fish hatchery diet includes supplements that enhance the color of trout, particularly the two-year olds, to more closely match that of their wild, stream grown counterparts. During 2004, about 17,570 brown trout were stocked in the Upper West Branch above the Cannonsville Reservoir, including 3,340 two year old fish with a total weight of approximately 6,900 pounds. The number of trout stocked each year may vary due to fish hatchery shortfalls. Any shortfall in hatchery production is shared across the state. At the time the two-year old fish stocking program was initiated New York State, hatchery brown trout cost about four dollars per pound.

Sanford (1989) reported that Upper West Branch wild brown trout at age 4 and older were about 15 inches long (**Figure 5.28,** below). Consider the fact that anglers who know the river are able to catch wild brown trout in excess of 20 inches on a fairly regular basis (colorful, riverine brown trout, unlike those that migrate up from Cannonsville Reservoir to spawn). In fact, one wild Upper West Branch riverine brown trout, caught on a recent April 1st, weighed over seven pounds was pictured in the Oneonta Daily Star (a local daily newspaper). An abundance of cool ground water entering the streambed is necessary to keep such fish alive and healthy long enough to attain the ages and sizes that they do. Because the Upper West Branch can produce and hold large trout, special fishing regulations require that trout be at least nine inches long before they are harvested. Also, the trout fishing season is closed from October 1st ─ April 1st to protect resident brown trout, plus those migrating up from Cannonsville Reservoir, during their spawning season.

Figure 5.28 Brown trout (*Salmo trutta*)

In addition to brown trout, wild brook trout (*Salvelinus fontinalis*) also contribute to anglers' catches from the Upper West Branch and its tributaries. Brook trout, however, are neither as abundant nor do they grow as large as the brown trout in the basin. Warm water and cool water game fish in the Upper West Branch, including chain pickerel and largemouth and smallmouth bass (*Micropterus salmoides* and *M. dolomieu*), are managed with statewide fishing regulations. No non-trout species are stocked in the river.

There is nothing unique about the fish fauna of the Upper West Branch relative to that of other Catskill waters. Its fishes comprise nine families, including fish that are native and introduced. More species of minnows are present than fishes in any other family. Minnows include common carp (*Cyprinus carpio*) ─ the largest fish found in the Upper West Branch; gold fish (*Carassius auratus*) and rudd (*Scardinius erytrophthalmus*), both exotic species; native minnows, including fallfish (*Semotilus corporalis*), creek chub (*Semotilus atromaculatus*), blacknose dace (*Rhinichthys atratulus*), longnose dace (*Rhinichthys cataractae*), common shiner (*Luxilus cornutus*), and golden shiner (*Notemigonus crysoleucas*). White suckers (*Catostomus commersoni*), closely related to minnows, are also present. The catfish family is represented by the brown bullhead (*Ameiurus nebulosus*). Chain pickerel are the lone member of the pike family present in the Upper West Branch. Slimy sculpins (*Cottus cognatus*), primitive looking but nevertheless highly evolved, are the lone sculpin species present in the watershed. Yellow perch and the tessellated darter (*Etheostoma olmstedi*) are the two members of the perch family inhabiting the Upper West Branch. Members of the sunfish family include largemouth and smallmouth bass, black crappie (*Pomoxis nigromaculatus*), pumpkinseed (*Lepomis gibbosus*), bluegill (*Lepomis macrochrius*) and rock bass (*Ambloplites rupestris*), all of which are more likely to be found in impoundments, but nevertheless are in the river. The alewife (*Alosa pseudoharengus*), a herring native to the lower main-stem Delaware and its tributaries, was introduced into the Cannonsville Reservoir by bait pail. Finally, brook trout and brown trout both occur in the watershed, but only brook trout are native to the system.

This list is probably not exhaustive, as one never knows whether all the species present have been collected or noted, and additional species become introduced into the watershed, such as the rudd most recently. Noticeably absent from the list is the American eel (*Anguilla rostrata*), whose migratory passage upriver was impeded by the Cannonsville Reservoir, particularly the dam. Eels do inhabit the West Branch of the Delaware River downstream of the reservoir, as do sea lamprey (*Petromyzon marinus*).

Public Use

Twenty-two equivalent miles (44 bank miles) of Public Fishing Rights (PFR) have been purchased by the NYSDEC on about 95 proposals along the 51 miles of the Upper West Branch in Delaware County. (A small portion of the West Branch, the very headwater portion, is located in Schoharie County.)

Figure 5.29 Public Fishing Stream poster

The purchase of PFR is ongoing and property owners on the Upper West Branch are currently being paid $16,800 per two miles of streambank. Sale of PFR easements is for perpetuity and is recorded on property deeds, but only obligates the landowner to allow fishermen access to fish. In years past PFR was one chain (66 feet) wide, but in recent years it is two rods (33 feet) wide along the streambank. Purchase of PFR on the Upper West Branch began around 1948. PFR is marked with signs printed with dark lettering on a yellow background and posted on trees facing the stream from the bank. Additional, non-formal access to the river is allowed by the generosity of some landowners who have chosen not to sell PFR but have no problem allowing fishermen to fish from their property.

PFR is mapped, by proposal, on letter-sized paper in a format and at a scale that does not currently lend itself to public use. These maps reside in the NYSDEC Regional Fisheries Office in Stamford and in the NYSDEC Central Office in Albany. A *Global Positioning System* (GPS) mapping project of PFR is nearly complete in NYSDEC Region IV and those maps should be available on the NYSDEC web site in the near future.

Five formal Fisherman-Parking Areas (FPAs), also purchased by the NYSDEC with public funds, have been developed and are maintained along the river. Four are situated between New York State Route 10 and the river. From upstream the locations of those five are: at McMurdy Brook, 0.5 miles upstream of South Kortright; immediately downstream of Bloomville; upstream of Delhi across from Falls Mills Road; and downstream of Delhi on Sherwood Road. FPAs are identified roadside by large, brown stained wooden signs lettered in yellow, and suspended from similarly stained, rustic standards. Originally, the parking areas were bounded with log barriers, but those are being or have been replaced with large rocks as barriers. During the summer, a NYSDEC field crew mows the grassed areas, maintains the signs, standards and barriers, and picks up trash at each of the sites. Some of the FPAs are removed from the road on the stream and are linked to the stream by either a fisherman footpath or a gravel road, which also require maintenance. Each FPA has a small birdhouse backing board on a small standard, displaying rules and regulations regarding use of the FPA. More parking is available at pull-offs along NYS Route 10 and other roads paralleling the river.

Fish Habitat Protection

Laws are currently in effect that provide some protection to the bed and banks of the Upper West Branch, and also to its water quality. Permits are required for any work on the banks or in the bed of the stream, and for any discharge from a point source (see Section 3.13). Those laws do not change the fact that many years of abuse have altered the physical form of the river, and accidents do occasionally happen that result in fish kills. Despite this, the aquatic community of the Upper West Branch appears to be in good shape. A quote from a report of a 2000 biological assessment of the Upper West Branch (Bode, et al, 2001) reads, "Overall, the West Branch Delaware River appears heavily enriched by nutrients, but still supportive of a healthy, productive invertebrate fauna."

That the Upper West Branch runs reddish brown during and after rainstorms is also indicative of the serious erosion that occurs in the watershed. That erosion is not all mineral and contributes heavily to the enrichment mentioned in the above quoted report.

Two major fish habitat issues need to be addressed. They are the continuation of riparian buffer planting and ground water protection. Riparian vegetation provides shading of the stream which results in more optimal water temperatures for trout and cover for both aquatic and upland species. Riparian buffer planting is actively progressing and appears to be a widely accepted practice along the Upper West Branch stream corridor (see **Section 6.3.2**). Although ground water is recognized as important to keep the fishery in great condition, protection efforts are only starting to be discussed. Studies on spring seeps have been conducted by researchers at the State University of New York College of Environmental Science and Forestry in Syracuse, New York, and Cornell University in Ithaca, New York. Studies treating groundwater on a much larger scale, relating groundwater to landforms have been proposed. The determination of the location of spring seeps prior to stream re-alignment can be as indicated by localized water temperature changes and the presence of blue-green algae. Protection of groundwater inputs, especially on the inside of meander bends is critical to the maintenance of trout habitat.

The trout fishery of the Upper West Branch of the Delaware River, My Opinion, by Walt Keller.

The trout fishery of the Upper West Branch is outstanding for many reasons. It is easily accessible for most of its length. It grows very large stream brown trout and gets stocked with brown trout that provide instant gratification to anglers of all ages and levels of skill for short periods of time in the spring. Its cool ground water keeps trout spread out during times of drought and warm ambient stream temperatures, precluding easy predation on them and reducing the risk of disease that can result from crowding. The stream has an

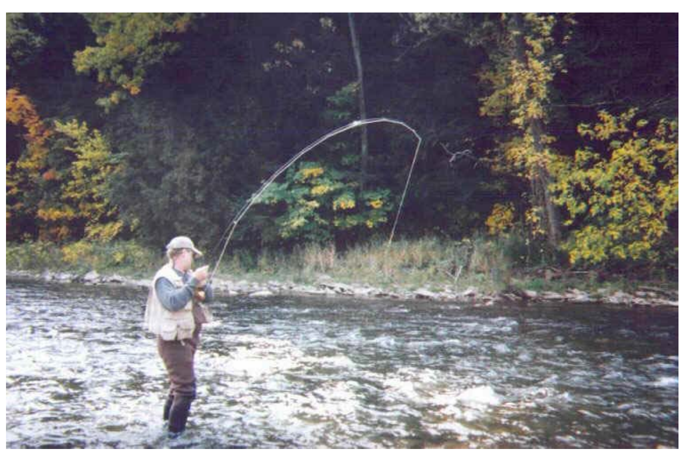

Figure 5.30 Fisherman playing a fish

abundance of trout forage for fish of all sizes, including insects, fish and crayfish for the larger trout. The only limitation is that the stream gets un-fishable during and just after rainstorms due to rapidly rising water levels and serious *turbidity*, as do many streams in agricultural watersheds and watersheds with fine or exposed soil. My recommendations for fisheries management of the UWB include that groundwater impacts are a design consideration for projects, riparian buffer planting be encouraged and continued, and useable maps of PFR be made available to the angling public.

5.11.2 Wildlife

Riparian corridors in the West Branch basin support a diverse community of wildlife species. Species mix ranges from predator to prey and commonly includes: white-tailed deer (*Odocoileus virginanus*), eastern wild turkey (*Meleagris gallopavo*), ruffed grouse (*Bonasa unbellus*), eastern coyote (*Canis latrans*), red and gray foxes (*Vulpes vulpes* and *Urocyon cinereoargenteus*), eastern cottontailed rabbit (*Sylvilagus floridanus*), muskrat (*Ondatra zibethicus*), beaver (*Castor canadensis*), porcupine (*Erethizon dorsatum*), mink (*Mustela vison*), striped skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*), Great blue heron (*Ardea herodias*), turkey vulture (*Cathartes aura*), American crow (*Corvus brachyrhynchos*), Canada goose (*Branta canadensis*), and various ducks, songbirds, hawks, owls, gulls, snakes, frogs, toads, salamanders, turtles, squirrels, chipmunks, mice, voles, bats, weasels, shrews, woodchucks, and an occasional black bear (*Ursus americanus*), bald eagle (*Haliaeetus leucocephalus*) (**Figure 5.31**), bobcat (*Lynx rufus*).

Figure 5.31 Bald Eagle
(Photo by Joel Fisk, DCSWCD)

All these species depend on the stream and/or the floodplain and adjacent uplands for food, cover and shelter. Many of these species are managed as game species under jurisdiction of the NYSDEC Division of Fish, Wildlife and Marine Resources, while others are permanently protected by state and federal legislation (migratory birds that are game species are additionally managed through the federal Migratory Bird Treaty Act).

5.12 Water Quality

There are numerous approaches for evaluating the quality of water bodies. The preferred method for any study depends upon the time and funds available and on the research focus (chemistry, biology, etc.). Because the Cannonsville Reservoir is important as a drinking water source, there have been many water quality studies of the reservoir, and there are ongoing studies along the West Branch. These studies tend to be complex, but only a summary of representative information is appropriate for this report.

All waters in the State of New York are assigned a letter classification by the NYS-DEC that denotes their "best usages". These are: AA and A – source of drinking water, culinary or food processing purposes (reservoirs, direct tributaries to reservoirs); B – swimming and other contact recreation and fishing (ponds, lakes and some streams); C – waters supporting fisheries and fish propagation; D – waters supporting fishing but not fish propagation. Waters may also have a standard designation or specification. These are: (T) – supports a trout population or (TS) – supports trout spawning.[23] For example, the Lake Brook tributary to the West Branch of the Delaware River is designated C (TS) indicating it supports fisheries and fish propagation, and is a designated trout spawning stream.

The West Branch main stem is predominantly a C (T) stream with the section between the southerly bounds of the Village of Walton to the Cannonsville Reservoir being designated B (T). Most tributary streams are classified as C, with some classified as A or AA (most of which are local water supplies and are also protected by rules and regulations approved by the NYS Department of Health) and a few classified as B. Most tributary streams also carry a (T) or (TS) designation.[24] Primarily, the West Branch river system is trout habitat.

One method to assess the overall biological health of water, in addition to evaluating fish populations as mentioned previously, is to sample and evaluate smaller life forms ─ macroinvertebrates and diatoms. The NYSDEC's Stream Biomonitoring Unit performed this kind of study at selected locations along the West Branch in September, 2000 (Bode, et al., 2001). Their results and conclusions included the following:

> "Water quality in the West Branch Delaware River was assessed as non-impacted at Stamford, and slightly impacted for the remaining 43 miles from Hobart to Beerston, based on combined assessments of macroinvertebrate and diatom communities. Nonpoint nutrient enrichment was likely the major source of impact."
>
> "Overall, the West Branch Delaware River is considered heavily enriched by nutrients, but still supportive of a healthy, productive invertebrate fauna. Water quality in this reach may be vulnerable to added sources of enrichment, so that seemingly minor nonpoint source discharges could result in substantial changes is the ecosystem."
>
> Based on diatom assessments alone, which are considered a sensitive indicator of nonpoint runoff, a moderate impact was noticed between Hobart and Beerston, with "a sharp decline in water quality between Stamford and Hobart".

Annual macroinvertebrate studies in the West Branch main stem, beside the county Solid Waste Management Center in Walton during 1998-2002 (also performed by R. Bode), found similar results. Water quality was generally nonimpacted, with slight impacts noted in some parameters during 2000 and 2002 (personal communication, S. McIntyre, Delaware Co. DPW, 12/1/04).

Water quality in the West Branch has been routinely monitored for a number of years as part of the NYCDEP watershed monitoring program at nine sampling locations within the watershed.

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[23] Official Compilation of Codes, Rules and Regulations of the State of New York, Title 6, Chapter X, Parts 701, 703 and 815 (6 NYCRR Parts 701, 703 and 815)
[24] 6 NYCRR Part 815.

There are three on the West Branch main stem (above Hobart, near Delhi and at the NYS Route 10 bridge just above the Cannonsville Reservoir) and two each on three tributaries (Town Brook, Little Delaware River and East Brook, one each in the headwaters and near their *confluences* with the West Branch)[25]. Analytes chosen to be the most important for the City water supply for streams are turbidity, coliform bacteria[26] and total phosphorus.

Although streams in the basin are turbid during significant storm events (which implies erosion and suspension of sediments), average turbidity levels for 2003 were generally near normal values and below the maximum accepted water quality value. Coliform levels remained well below the maximum accepted water quality value. Phosphorus levels tend to be greater than desirable but have been decreasing; the Cannonsville Reservoir has remained off the list of phosphorus-restricted water bodies for the third consecutive year[27]. (When negotiations first began to develop this management plan, the Cannonsville was classified as a phosphorus-restricted basin. Hence, the West Branch received top priority for creating a SCMP).

The Delaware County Action Plan (DCAP) was formulated in 1999 by a contingent of county departments and agencies to address water quality issues in the New York City watershed. Current components of DCAP include management programs for stormwater, highway runoff, on-site septic systems, precision livestock feeding, stream corridors and monitoring and modeling of best management practices to assess phosphorus reduction. More detailed information regarding DCAP is included in **Section 4.6**.

5.13 Permitting Requirements for Stream Related Activities

Work in any stream in New York State requires a permit or series of permits, depending on the nature of the project. This section briefly describes the requirements of the permitting agencies, and Stormwater Pollution Prevention Plans that are typically required in order to receive these permits.

5.13.1 NYSDEC Permit Requirements

The NYSDEC regulates activities in and around the water resources of New York State pursuant to the Environmental Conservation Law (ECL) Article 15, Title 5, Protection of Waters Program. This is known as an Article 15 Permit, and is issued to applicants at no charge.

A Protection of Waters Permit is required for temporary or permanent disturbances to the bed or banks of a stream with a classification and standard of C(T) or higher. Examples of activities requiring this permit are:

- Placement of structures in or across a stream (i.e., bridges, culverts or pipelines);

[25] New York City Department of Environmental Protection, *Integrated Monitoring Report*, October 2003, Section 2, pages 9-17.
[26] New York City Department of Environmental Protection, *2003 Watershed Water Quality Annual Report*, July 2004, Section 3, pages 29-40.
[27] Ibid.

- Fill placement for bank stabilization or to isolate a work area (i.e., riprap or other forms of *revetment*);
- Excavations for gravel removal or as part of a construction activity;
- Lowering streambanks to establish a stream crossing;
- Use of heavy equipment in a stream to remove debris or to assist in-stream construction.

Some stream disturbance activities are exempt from the requirements of an Article 15 Permit. The most common of these are:

- Disturbance of a protected stream by a town or county government that enters into a written agreement with NYSDEC for specified categories of work, undertaken in compliance with performance criteria that are protective of stream resources.
- Agricultural activities involving the crossing and re-crossing of a stream by livestock or farm equipment at an established crossing.
- Removal of fallen tree limbs or tree trunks where material can be cabled and pulled from the stream without disruption of the streambed or banks, utilizing equipment placed on or above the streambank.

Projects are classified as minor or major for the purposes of review by NYSDEC. Maximum allowable review periods are different for "minor" and "major" projects under the Uniform Procedures Act requirements (6 New York Code of Rules and Regulation (NYCRR) Part 621). Minor projects include: 1) repair or in-kind replacement of existing structures; and 2) disturbances of less than 50 linear feet along any 1,000 feet of watercourse. All other activities are considered major projects for the purposes of review and public notice, as required by the Uniform Procedures Act. For minor projects, NYSDEC must make a permit decision within 45 days of determining the application complete. For major projects: 1) if no hearing is held, NYSDEC makes its final decision on the application within 90 days of its determination that the application is complete; and 2) if a hearing is held, NYSDEC notifies the applicant and the public of a hearing within 60 days of the completeness of determination. The hearing must commence within 90 days of the completeness determination. Once the hearing ends, NYSDEC must issue a final decision on the application within 60 days after receiving the final hearing record.
For permit applications and any questions regarding the permit process contact the Deputy Regional Permit Administrator at:

NYS Department of Environmental Conservation
Division of Environmental Permits, Region 4
65561 State Highway 10, Suite 1
Stamford, NY 12167-9503
(607) 652-7141

Protection of Waters permit information is also available on the NYSDEC website: http://www.dec.state.ny.us/website/dcs/streamprotection/protwater05.html (verified 11-17-04).

5.13.2 U. S. Army Corps of Engineers Permit Requirements

Under Section 404 of the Clean Water Act, any activities where placing fill or undertaking activities resulting in a discharge to waters of the United States[28] also require a Nationwide permit from the U. S. Army Corps of Engineers (USACOE). Minor projects include those projects that will not exceed the minor project thresholds for NYSDEC Article 15 permits, and which do not involve the approval of construction and operation of hydroelectric generating facilities. All other projects are major projects and require USACOE review.
Currently, applications are a one form joint application available from the NYSDEC, which forwards a copy of the application package to the regional USACOE office. USACE will contact the applicant if additional information is required. Information is also available from the regional USACE office at:

Department of the Army
New York District, Corps of Engineers
Albany Field Office
1 Bond Street
Troy, NY 12180
(518) 270-0588

[28] The term **"waters of the United States"** means

1. All waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;
2. All interstate waters including interstate wetlands;
3. All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation or destruction of which could affect interstate or foreign commerce including any such waters:
   - **i.** Which are or could be used by interstate or foreign travelers for recreational or other purposes; or
   - **ii.** From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or
   - iii. Which are used or could be used for industrial purpose by industries in interstate commerce;
4. All impoundments of waters otherwise defined as waters of the United States under the definition;
5. Tributaries of waters identified in paragraphs (1)-(4) of this definition;
6. The territorial seas;
7. Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (1)-(6) of this section.

5.13.3 Erosion and Sediment Control

Stormwater Pollution Prevention Plan

A Stormwater Pollution Prevention Plan (SPPP) documents how erosion will be controlled during construction, and the project's likely effects on the rate and quality of stormwater leaving the site. An SPPP consists of a narrative report, plans, details and specifications.

NYSDEC Requirements

Generally, construction activities in the West Branch watershed that involve one acre or more of land disturbance must obtain a State Pollutant Discharge Elimination System (SPDES) permit, which includes the development of an Erosion and Sediment Control Plan and an SPPP. Operators of potential construction activities should contact the local NYSDEC office in Stamford (see **Section 5.13.1**) for a determination whether or not a SPDES permit is required. Additional information is available from the NYSDEC website: http://www.dec.state.ny.us/website/dow/mainpage.htm (Verified 11-18-04).

Implementation of certain agricultural Best Management Practices are exempt from SPDES permitting requirements pursuant to a Memorandum of Understanding (MOU) between the NYSDEC, NYS Department of Agriculture and Markets and the NYS Soil and Water Conservation Committee dated March 25, 2004. A copy of this MOU is included in **Appendix 3.**

New York City Requirements

The New York City Department of Environmental Protection (NYCDEP) requires an SPPP to be submitted and approved prior to implementation of any of the following activities:

- Development or sale of land that will result in the disturbance of five or more acres of land.
- Construction of a subdivision.
- Construction of a new industrial, municipal, commercial or multi-family residential project that will result in creation of an impervious surface totaling over 40,000 square feet in size.
- A land clearing or land grading project, involving two or more acres, located at least in part within the limiting distance of 100 feet of a watercourse or *wetland*, or within the limiting distance of 300 feet of a reservoir, reservoir stem or controlled lake or on a slope exceeding 15%.
- Construction or alteration of a solid waste management facility within 300 feet of a watercourse or wetland or within 500 feet of a reservoir, reservoir stem or controlled lake.
- Construction of a gasoline station.
- Construction of an impervious surface for a new road within certain limiting distances from various watercourses.

- Construction of an impervious surface within a village, hamlet, village extension or area zoned for commercial or industrial uses.
- Up to a 25% expansion of an existing impervious surface at an existing commercial or industrial facility which is within the limiting distance of 100 feet of a watercourse or wetland.

Generally, installation of culverts, stream diversions and bridges or stream crossings within 100 feet of a stream or wetland, or within 300 feet of a reservoir , reservoir stem or controlled lake also require NYCDEP approval. For applications and any questions regarding this process contact the Deputy Chief, Engineering Section at:

NYCDEP
71 Smith Avenue
Kingston, NY 12401
(845) 657-2390

5.13.4 Local Requirements

It should be recognized that since New York is a "home rule" state, the authority to regulate development rests with the local municipalities. Communities that participate in the National Flood Insurance Program (NFIP) have adopted local laws for Flood Damage Prevention that incorporates Federal Emergency Management Agency (FEMA) minimum standards for development in a Special Flood Hazard Area. Participating communities appoint a local floodplain administrator, typically the Building Inspector or Code Enforcement Officer, to administer the program within the community. The intent of the program is, at least in part, to reduce flood risk to new development, and to prevent an increase in flood risk to the existing community from development proposed in the future. It should be noted that development as defined in the local law is: "… any man-made change to improved or unimproved real estate, including but not limited to, buildings or other structures, mining, dredging, filling, paving, excavation or drilling operations, or storage of equipment or materials." As such, proposed stream corridor management projects should be assessed by the affected communities, and floodplain development permits should be issued or denied as appropriate.

5.14 Flood Protection and Recovery

5.14.1 Introduction

As protection is a principal function of government, and floods and the potential resulting loss of life and property are a serious threat to those living along the West Branch of the Delaware River, it is the role of all levels of government to assist the public in securing itself from the threats associated with flooding. Policy for protecting the public from flooding and programs for assisting the public in the event of a flood, flow from the federal level to the state and local levels of government. FEMA, within the Department of Homeland Security, establishes flood programs enabling communities to plan and respond to flood events, minimize or mitigate against flood hazards, and recover from flood disasters. The State Emergency Management Office (SEMO) generally mirrors FEMA policies and programs and helps to administer flood planning, mitigation and coordinate state resources for recovery efforts. Within Delaware County, the Director of Emergency Services coordinates emergency response and recovery, while efforts to plan for mitigating against flood hazards is shared across county agencies such as the Department of Public Works and Planning Department. As a tool for individuals and communities living along the river, this Stream Corridor Management Plan provides a general background on the programs and policies that will enable the community to avoid, mitigate against, or recover from a flood. This section is written for home owners, local leaders and the general public to help increase their knowledge of steps they can take to reduce flood losses and facilitate disaster recovery.

5.14.2 Avoiding Flood Losses

Flood waters are very destructive and while losses in terms of property or life cannot be totally avoided, with good information and wise decisions, individuals and communities can reduce their losses. Information is the most important tool available. Local knowledge, timely communications and accurate maps of where flood waters are likely to have their greatest impact are only some of the information that can help the community with decisions as they seek to avoid flood losses.

Communicating with local experts is critical to avoiding flood losses. A very important and often overlooked individual is the local *floodplain administrator.* (per DEC) or floodplain regulation enforcement officer. Many municipalities employ a person in this position to inform the public about floodplain regulations and help landowners make wise decisions about their development projects. The floodplain administrator develops an understanding of the regulations, the best practices and the location of floodprone areas for their community. Making use of their knowledge can save time and money by avoiding red tape and otherwise avoidable flood damages. Often, the floodplain administrator is also the building code enforcement officer, so it is likely to meet this person in more than one capacity when a construction project be undertaken in or around a floodplain. Training courses are available through NYSDEC and FEMA to keep the local floodplain administrator current with the latest best management practices and regulations.

Flood Insurance Rate Maps (FIRMs) are available for most communities in the United States and provide a guide to where flood waters of larger floods are likely to inundate the lands surrounding a water body. Before buying or building a house or buying property near a body of water, whether stream, river, lake or wetland[29], an individual should consult their floodplain map or FIRM "community panel" to find out where the waters will be likely to rise during a major storm event. FIRMs are produced and maintained as part of the National Flood Insurance Program, which provides flood insurance to home owners and businesses living in a participating community. Because properties located outside of Special Flood Hazard Areas are assumed to have a lower risk, they benefit by qualifying for lower insurance premiums. The most recently updated FIRMs for Delaware County were created through engineering studies which based the estimated extent of the floodplain on local topography, channel shape and slope, hydrology and

[29] The National Wetland Inventory (NWI) maps produced by the U.S. Fish and Wildlife Service provide a good reference for the location of wetlands. These maps are available for inspection through the local planning board, the Delaware County Planning Department or the DCSWCD.

hydraulic conditions for a range of flood return probabilities. Typically, the maps show the one percent annual chance flood (also called the base flood or 100 year flood) extent or the Special Flood Hazard Area. An example of this generation of maps includes the Village of Walton, Delhi and Stamford. These maps are of reasonable accuracy but could be improved with current mapping technologies. Older maps, such as the FIRM map for the Town of Hamden, created in the late 1960's at the start of the NFIP, only show the "flood hazard boundary" based on approximate studies of the floodprone area for the 100 year flood event. Care should be exercised in using these maps if one is considering a development anywhere near this map zone. When an area is suspected as being within the floodplain, but the limits and depth of the base flood are not known for a location, a flood study should be required of the applicant by the local code officer or planning board. Not all areas at risk of flooding have been mapped by FEMA, so at a minimum, each property owner should evaluate the flood risk for themselves and decide whether they need to purchase flood insurance.

Should an older map be of questionable accuracy, the individual should obtain an engineer's estimate of the floodprone area or the *Base Flood Elevation* (BFE) for the development site prior to any construction. Before securing financing to purchase or build a home within a known floodprone area with an established Base Flood Elevation (BFE) a lender will require the purchase of flood insurance and have a surveyor define the elevation of the structure's first floor for use in estimating your flood insurance premium. Building in a floodplain can result in thousands of dollars of losses, especially if the construction is not compliant with the NYS Building Code and NFIP requirements. Not only does the individual risk personal losses, but building within the floodplain or floodway can seriously impact the neighboring property owners by causing flood elevations to rise or flood routes and velocities to change. The local Code Enforcement Officer can inform individual of the requirements before they begin planning a project. Individuals that are buying land with the intent to build should avoid floodprone areas. FIRM maps are available for inspection through the Delaware County Planning Department and should be available for viewing at the Town or Village Hall. Copies of the maps can also be purchased from FEMA through their web site or by mail.

Recent advances in remote sensing, hydraulic modeling and computer mapping technology have greatly improved the ability of engineers to accurately estimate the flood extent and elevation for a range of floods. FEMA, together with the NYSDEC have established procedures for revising the current **flood studies** around New York State. NYSDEC and Schoharie County have completed a new flood study and set of revised paper floodplain maps and Digital FIRMs (DFIRMs) for the entire county. Similar efforts in Delaware County could improve the information available to landowners about the development potential of their property, their risk of flood losses, and help prevent future threats to life and property throughout the area. This information could also improve the community's rating and minimize the need for individuals to bear the expense of site specific flood studies.

NFIP was established by Congress in 1968 to reduce the cost of taxpayer funded disaster relief. The Mitigation Division, within FEMA, manages the NFIP, and oversees the floodplain management and mapping components of the Program.

Nearly 20,000 communities across the United States, (including all municipalities within Delaware County), participate in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. In exchange, the NFIP makes Federally backed flood insurance available to homeowners, renters, and business owners in these communities. Flood insurance can be purchased through a local insurance agent and covers the cost of structural damage to a home. If an insurance agent is unable to write a flood policy, call 1-800-638-6620 for information. The contents of a home, such as appliances, furniture and clothing are typically insured at additional cost. There is a 30 day waiting period for new policies.

Flood damage is reduced by nearly $1 billion a year through partnerships with communities and the insurance and lending industries. Further, buildings constructed in compliance with NFIP building standards suffer approximately 80 percent less damage annually than those not built in compliance. And, every $3 paid in flood insurance claims saves $1 in disaster assistance payments (FEMA, 2004). Flood Insurance rates for individual policyholders of a community can be reduced if the community improves its "*community rating*" by participating in flood disaster planning efforts and takes action to reduce or avoid flood losses. The NYSDEC Flood Bureau within the Division of Water, together with SEMO can help the community identify ways to improve the community's rating under the Community Rating System (CRS). Additional information is available at: http://www.fema.gov/fima/nfip.shtm (Verified 12-08-04).

For those who live in a floodprone area, there are several practical steps that can be taken to protect a home or business in preparation for a flood. Irreplaceable valuables should be moved out of the cellar and first floor. If an oil tank exists in the basement, it should be securely anchored according to code to prevent it from floating and spilling during a flood. Electrical components, including the washer and dryer, within the house should be raised above the level of potential flood waters. Consideration should be given whether to raise the furnace and water heater above the level of potential flood waters. These suggested actions could help avoid the common repairs homeowners may have to undertake after a flood.

In the event of a flood, FEMA recommends the following actions to make sure a family stays safe until the water levels recede:

- Fill bathtubs, sinks, and jugs with clean water in case water becomes contaminated.
- Listen to a battery-operated radio for the latest storm information.
- If local authorities instruct the community to do so, turn off all utilities at the main power switch and close the main gas valve.
- If told to evacuate your home, do so immediately.
- If the waters start to rise inside a house before evacuation, retreat to the second floor, the attic, and if necessary, the roof.
- Floodwaters may carry raw sewage, chemical waste and other disease-spreading substances, wash hands with soap and disinfected water.
- Avoid walking through floodwaters. As little as six inches of moving water can knock a person off their feet.
- Don't drive through a flooded area. If you come upon a flooded road, turn around and go another way. A car can be carried away by just 2 feet of flood water which is very hard to judge.

- Electric current passes easily through water, so stay away from downed power lines and electrical wires.

Following a flood, individuals should take special care to document their damages and losses. Receipts for repairs and materials as well as photographs of damages should all be kept by home and business owners.

5.14.3 Flood Response

On July 21, 2004, the Delaware County Comprehensive Emergency Management Plan was adopted by the Delaware County Board of Supervisors. This plan results from the recognition on the part of local government and state officials that a comprehensive plan is needed to enhance the County's ability to manage emergency/disaster situations. It was prepared by County officials working as a team in a planning effort recommended by SEMO. This plan constitutes an integral part of a statewide emergency program and contributes to its effectiveness. Authority to undertake this effort was provided by both Article 2-B of the State Executive Law and New York State Defense Emergency Act. The development of this plan included an analysis of potential hazards that could affect the county and an assessment of the capabilities existing in the county to deal with potential problems.

Dealing with disasters is an ongoing and complex undertaking. However, lives can be saved and property damage minimized by reducing before the flood emergency occurs, timely and effective response during the event, and providing both short and long term recovery assistance afterwards.

This process is called Comprehensive Emergency Management to emphasize the interrelationship of activities, functions, and expertise necessary to deal with emergencies. The plan contains three sections to deal separately with each part of this ongoing process.

County department's and agencies emergency management responsibilities are outlined in this plan. Assignments are made within the framework of the present County capability and existing organizational responsibilities. The Department of Emergency Services is designated to coordinate all emergency management activities of the County.

Delaware County intends to use the Incident Command System (ICS) to respond to emergencies. ICS is a management tool for the command, control and coordination of resources and personnel in an emergency.

County responsibilities are closely related to the responsibility of the local levels of government within the County (cities, towns and villages) to manage all phases of an emergency. The County has the responsibility to assist the local governments in the event that they have fully committed their resources and are still unable to cope with any disaster. Similarly, New York State is obligated to provide assistance to the county after resources have been exhausted and the County is unable to cope with the disaster.

The plan describes in detail the centralized direction of requests for assistance and the understanding that the governmental jurisdiction most affected by an emergency is required to involve itself prior to requesting assistance.

Specific emergency management guidance for situations requiring special knowledge, technical expertise, and resources may be addressed in separate annexes attached to the plan. Examples of this type of situation are emergencies resulting from floods, hazardous chemical releases, dam failure, and power outage.

The plan provides a general all-hazards management guidance, using existing organizations, to allow the County to meet is responsibilities before, during and after an emergency.[30]

Although this plan addresses all emergency/disaster situations, flooding has been the most prevalent in the West Branch watershed. During major flood events and other disasters that can cause road and bridge closures, the Delaware County Department of Emergency Services activates its emergency operations center and ICS. All emergency response agencies including FEMA, SEMO, NYS Office of Fire Prevention Control, law enforcement agencies, and fire departments are contacted and put on alert. Department of Emergency Services monitors all emergency situations and provides for emergency evacuations, if necessary.

5.14.4 Flood Recovery

Following a flood that has been declared as a Presidential disaster, several forms of assistance become available to individuals and communities. There can be both Public Assistance and Individual Assistance programs depending upon the severity of the flood event. Declarations are made on a county by county basis. Less severe events may only trigger a declaration enacting Public Assistance programs to assist with infrastructure recovery, such as the repair of roads and public facilities. If a disaster is declared for Individual Assistance, then programs are deployed to address the property losses of individuals, farmers and other businesses.

Public Assistance is managed by the state through the Emergency Services Coordinator and local government representatives. A SEMO team will organize initial contact meetings to inform local government representatives of the assistance process and initiate project identification. It is important to document all actions taken to repair damages to a flood and carefully track the use of materials, equipment and labor for later reimbursement. Attendance at these meetings is critical especially if local leadership has changed and the new leadership has not experienced a flood event. Documents regarding flood recovery efforts should be held and shared with those considering flood hazard mitigation planning. The SEMO website is an excellent resource for obtaining the latest information on the status of a disaster recovery effort or finding out who to contact for more information: http://www.nysemo.state.ny.us (Verified 12-08-04).

Individual Assistance is typically made available following a flood where there has been widespread damage to homes and businesses. The American Red Cross is a first responder helping flood victims with their immediate needs for food, shelter, medical attention and clean

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[30] Delaware County, *Delaware County Comprehensive Emergency Management Plan*, July 2004, pages i-ii, paraphrased.

up provisions. Within 12-36 hours of an event, FEMA deploys its staff of inspectors to assess the damage and meet with state and local officials. Once the declaration is made, FEMA will announce an 800 telephone number for individuals to seek assistance and file claims. One of the primary forms of individual assistance is the Assistance for Individuals and Households Program which can help with lodging or temporary housing, home repair grants, and other personal needs. The Small Business Administration (SBA) offers low interest loans to eligible individuals, farmers and businesses to repair or replace damaged property and belongings not covered by insurance. Other assistance is available as tax rebates, veterans benefits and unemployment benefits. Following a flood, individuals should take special care to document their damages and losses. Receipts for repairs and materials as well as photographs of damages should all be kept by home and business owners. If individuals have flood insurance they should initiate a claim immediately.

5.14.5 Flood Hazard Mitigation

Hazard Mitigation is any sustained action taken to reduce or eliminate long-term risk to people and property from natural hazards and their effects. Examples of hazard mitigation are the acquisition and removal of hazard prone property, retrofitting of existing buildings and facilities, elevation of floodprone structures, and infrastructure protection measures. The federal government provides funding for hazard mitigation following disasters through two programs; the 404 Hazard Mitigation Program and the 406 Hazard Mitigation Program.

FEMA provides funding to States under section 404 of the Stafford Act for the Hazard Mitigation Grant Program (HMGP). The funds are to provide state and local government, certain private non-profit organizations and Native American tribes with the incentive and capacity to take critical mitigation measures during the flood recovery and reconstruction process to protect life and property from future disasters (FEMA, 2001). The eligibility of a community requires a community to have prepared and filed with the SEMO, a Hazard Mitigation Plan which describes the local priorities for mitigation. Funding is competitive with other communities around the State, and will be ranked by the results of a benefit-cost analysis with others possible projects for having the greatest potential to reduce future losses. Delaware County received significant levels of funding through this program following the January 1996 flood disaster for the Flood Property Buyout Program and other mitigation projects. Delaware County Planning Department is currently preparing a Hazard Mitigation Plan for the county to enable any community within the county to apply for funding under this program. HMGP funds require a 25 percent local commitment in cash or in kind for total project costs. For more information about this program contact the Delaware County Planning Department or the Hazard Mitigation Program Director within SEMO. The web site for the state program is: http://www.nysemo.state.ny.us/MITIGATION/mitigation.html (Verified 12-08-04).

The Section 406 Hazard Mitigation program is available for public assistance projects (those dedicated to the recovery and reconstruction efforts of local government) for the reduction or elimination of future damages to a facility damaged during a disaster. Hazard mitigation funding can be sought for infrastructure damage where the funds would enable the applicant to upgrade the structure to a standard that will avoid future flood damages. Undamaged structures would not be eligible under this program. 406 Hazard mitigation funds are added to the reconstruction costs normally used to return a structure to its pre-flood condition. Typically, there is a 25% local cost share for the mitigation activity. This program is not cost competitive and can be very useful in preventing future flood damages, especially where recurrent flood losses are avoidable through a retrofit. Questions about this and other flood recovery programs should be directed to:

New York State Emergency Management Office
1220 Washington Avenue
Building 22, Suite 101
Albany, New York 12226-2713 Telephone: (518) 485-2713

5.15 Recreational Opportunities

"I have never seen a river that I could not love. Moving water…has a fascinating vitality. It has power and grace and associations. It has a thousand colors and a thousand shapes, yet it follows laws so definite that the tiniest streamlet is an exact replica of a great river."

- Roderick Haig-Brown, fisherman and conservationist

The West Branch basin, located in a transitional area between the Catskill high peaks and the rolling hills of central New York has a uniqueness all its own. Its verdant springs, warm summers, cool and colorful falls, and snowy winters offer four season recreational opportunities for the outdoor enthusiast.

5.15.1 Fishing, Hunting, Canoeing & Hiking

Fishing

Fishing is perhaps the most popular sport enjoyed along the river and its tributaries and is a great recreational activity for all age groups and genders. Fishing in the West Branch attracts people from across New York and neighboring states. As mentioned in **Section 5.11.1** the NYSDEC puts forth considerable effort in managing the trout fishery in the basin. With its roots in the Catskills, fly fishing is an ever popular means of pursuing West Branch trout. Local tackle shops supply flies that match the hatches found on the river. Other methods include the use of live bait and artificial spinning lures. Although the NYSDEC has purchased public fishing rights on much of the West Branch main stem and some tributary reaches, most riparian property is under private ownership and anglers are requested to seek permission to access anyone's stream. Trout season is generally from April 1 – October 15, although seasons, fish size and creel limits vary between water bodies, with some waters having additional regulations. Ice fishing is a popular winter sport for species that have an open season during that time of the year, particularly on lakes and ponds. Fishing is also permitted on the Cannonsville Reservoir and is described in **Section 5.15.2.** Information for special trout regulations and specific information for seasons and creel limits on other fish species are found in the New York State Fishing Regulations Guide. The guide and a required New York State fishing license are available from town clerk's offices and most sporting goods stores in the area. The Delaware County Chamber of Commerce and the NYSDEC have compiled a fishing map of Delaware County which is available at the Chambers' website: http://www.delawarecounty.org/fishing/fishing.pdf (Verified 11-23-04).

Hunting

Hunting is another popular outdoor activity in the West Branch watershed, the fall white-tailed deer hunt being the most popular. Many residents, both permanent and seasonal, eagerly participate in the pursuit of this sought-after game species. Wild turkey hunters enjoy both a spring and fall season, with the spring bearded-only season the more popular of the two. Both these species are currently present in good numbers in the watershed, and have an affinity for the many acres of land under agricultural production. Other species of interest include black bear, grouse, other wildfowl, rabbit, squirrel, fox and coyote (the latter two may also be taken by trapping, as may beaver, mink and muskrat). Seasons for species that may be hunted *or* trapped are fall and winter seasons. As with fishing, a license is required. This can be issued in combination with a fishing license, and can be obtained from the sources listed in the above paragraph. Permission should also be requested prior to entering on private land. Public lands open to hunting (other than NYCDEP lands, see **Section 5.15.2**) include the 7,186 acre Bear Spring Mountain Wildlife Management Area, which is maintained by the NYSDEC and is partially located in the West Branch watershed. Specific season information and bag limits are listed in the New York State Hunting and Trapping Regulations guide. Additional information on fishing and hunting in New York State can also be found on the DEC website: http://www.dec.state.ny.us/ (Verified 11-23-04)

Canoeing and Kayaking

Canoeing, kayaking and tubing are summer season activities that begin around the Memorial Day weekend and usually end in October, when water temperatures begin to cool. This activity offers scenic views of the West Branch its surroundings, often with a glimpse of riparian wildlife including the bald eagle, and some canoeists also enjoy fishing. Many residents own their own watercraft, while some participants rent them from local businesses. According to Ken Landry, owner of Catskill Outfitters in Walton, the West Branch is classified according to seasonal water flow: In the spring or during other periods of higher flow the river is considered to be "intermediate" class, while the lower flows are classified as "beginner". The frequency of equipment leasing can vary from year to year depending on water levels. The higher flows during the wet 2003 and 2004 summers reduced canoeing/kayaking activities.

Hiking

Hiking can be a four season activity along four managed trail systems in the West Branch basin. Each trail system offers its own unique vista, and plant and wildlife viewing opportunities.

The Catskill Scenic Trail lies atop the former Ulster and Delaware railroad bed. The 19 miles of trail extends from Bloomville to Grand Gorge (near the headwaters of the East Branch of the Delaware River). A unique feature of this trail is the very gentle grade. It parallels the West Branch, crossing it at several points. Several access points along its path offer hikers of all ages an enjoyable trek. Along the trail are several resting benches and fishing access points. The trail is open year-round for hiking, biking, horseback riding, cross-country skiing and snowmobiling.

The Utsayantha Trail System is another picturesque trail located in the mountains surrounding Stamford. Several places along the marked trail provide a stunning view of the West Branch and neighboring valleys and their surrounding mountaintops. Accepted uses are hiking, horseback riding, cross-country skiing, and snowmobiling.

The West Branch preserve is a 446 acre site in the Town of Hamden donated to the Nature Conservancy in 1973 by Dr. Charles Jones and his family. There are two trails, a 0.7 mile trail with a moderate ascent and marked in blue, and a 2.0 mile trail marked in orange. The latter trail has a steep climb and should be attempted only by experience hikers.

Additional information on these trail systems is available from the Delaware County Chamber of Commerce website: http://www.delawarecounty.org/hiking (Verified 11-23-04)

The Bear Spring Mountain Wildlife Management Area is state owned land which is maintained by the NYSDEC. A network of trails of various degrees of difficulty are marked and maintained for hiking, horseback riding, mountain biking and snowmobiling. Additional information is available from the NYSDEC Regional office in Stamford at (607) 652-7365.

5.15.2 NYCDEP Lands

New York City owns considerable acreage around the Cannonsville Reservoir. The DEP has begun purchasing additional watershed properties in its efforts at water supply protection under its Land Acquisition and Stewardship Program. Many of these lands are open to the public for low-impact recreational activities where compatible with water supply protection. To responsibly provide recreation access to city property, NYCDEP issues a comprehensive Access Permit that allows for fishing and hiking. Access Permit holders may also obtain a NYCDEP hunting tag for deer hunting in designated areas and a NYCDEP boat tag for keeping a rowboat at the reservoir for fishing.

Fishing on the Cannonsville Reservoir has long been a popular activity enjoyed by permanent and seasonal residents alike. Properly tagged boats may be moored at specific locations designated by NYCDEP. Boats may be stored above the high water mark over winter, which most boat owners take advantage of. In order to preclude Zebra mussels (*Dreissena polymorpha*) and other "hitchhiking" species from entering the reservoir, all fishing boats must be steam cleaned and inspected by the DEP before being moved onto the reservoir or its shores. The reservoir is home to popular fish species including brown trout, smallmouth and largemouth bass, yellow perch and brown bullhead. Brown trout are much sought after and many weigh-in well over five pounds, with some even topping ten pounds. Special fishing regulations for the Cannonsville Reservoir are found in the New York State Fishing Regulations Guide.

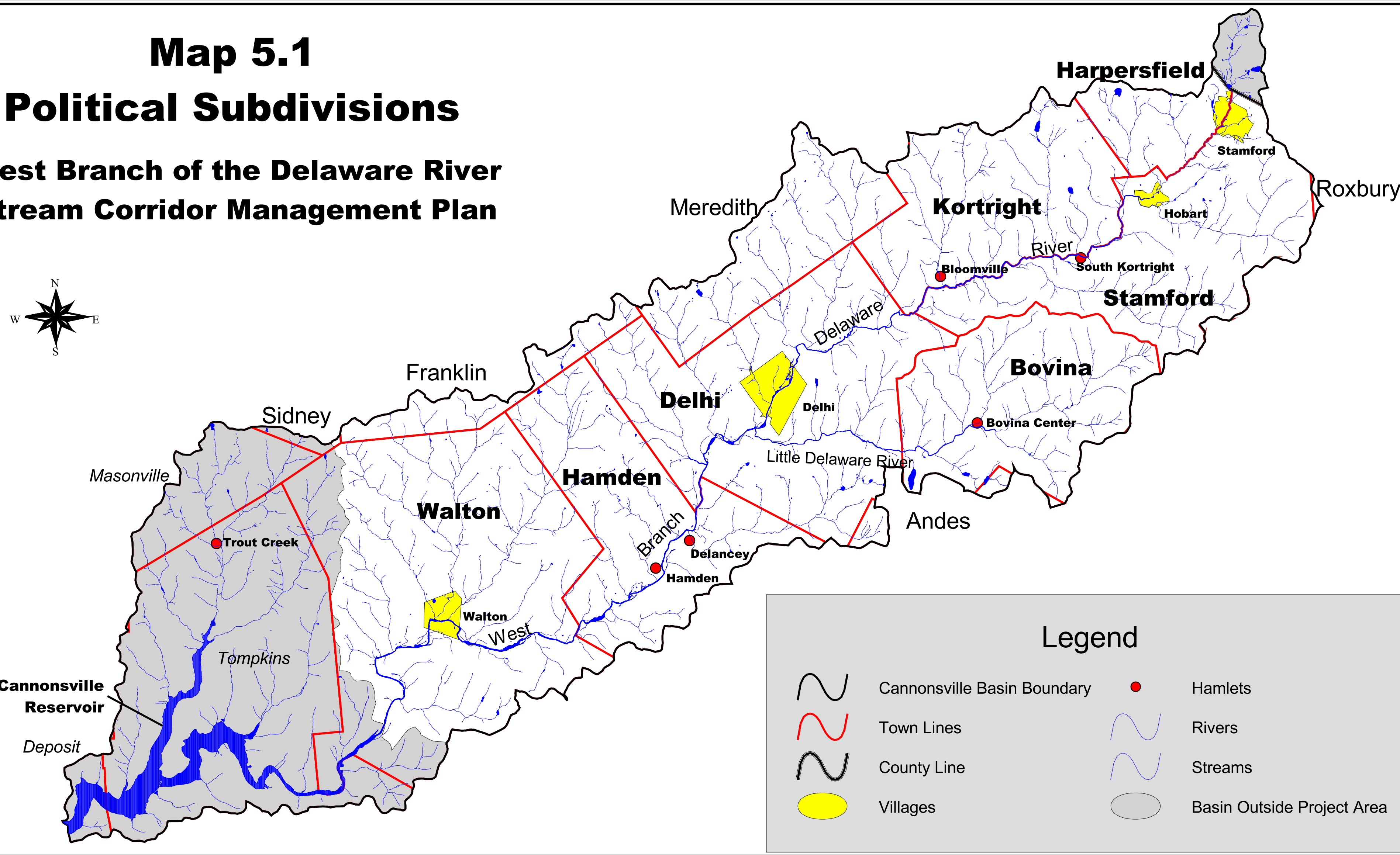
Hiking is not allowed at or around the Cannonsville Reservoir, but a number of other City properties throughout the watershed are open for hiking year round. People must have a valid Access Permit in order to enter these areas and they must agree to abide by the permit conditions.

Deer hunting is allowed under the Access Permit system on designated City water supply lands. NYCDEP Hunting Tags are issued annually to valid Access Permit holders who apply or who complete the prior year's hunting survey by the due date. NYCDEP Access Permit holders who wish to apply for the current season's DEP Hunting Tag may do so starting in late summer of each year by mailing a completed NYCDEP Hunting Tag application or sending an e-mail request including their Access Permit number to the NYCDEP Access Permit Office. Hunters must also possess a valid New York State hunting license for deer.

Additional information, regulations, permit conditions, maps, Access Permit applications and applications for hunting and boating tags are available at local NYCDEP offices, by calling 1-800-575-LAND, or on the NYCDEP website:
http://www.ci.nyc.ny.us/html/dep/watershed/html/wsrecreation.html (Verified 11-23-04).

Map 5.1
Political Subdivisions

West Branch of the Delaware River
Stream Corridor Management Plan



Base data provided by NYCDEP
Map data provided in NAD 27 UTM Zone 18 North
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

Scale
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1"=25000'

25000 0 25000 50000 75000 100000 125000 Feet

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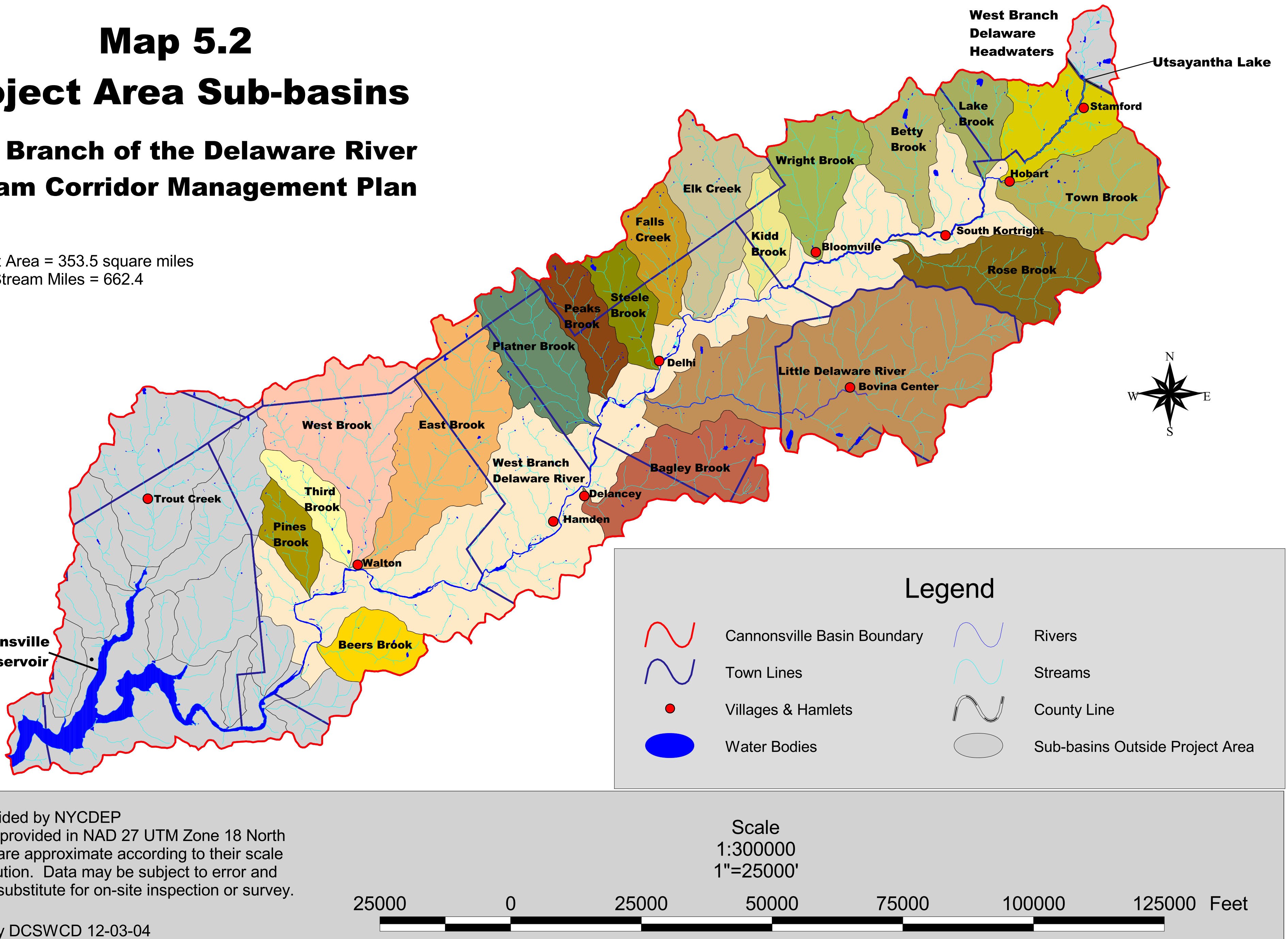
archive\Nad27\gisprojects\Management_Plan\pol_subdiv.apr

Map 5.2
Project Area Sub-basins

West Branch of the Delaware River Stream Corridor Management Plan

Project Area = 353.5 square miles
Total Stream Miles = 662.4



Data provided by NYCDEP
Map data provided in NAD 27 UTM Zone 18 North
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

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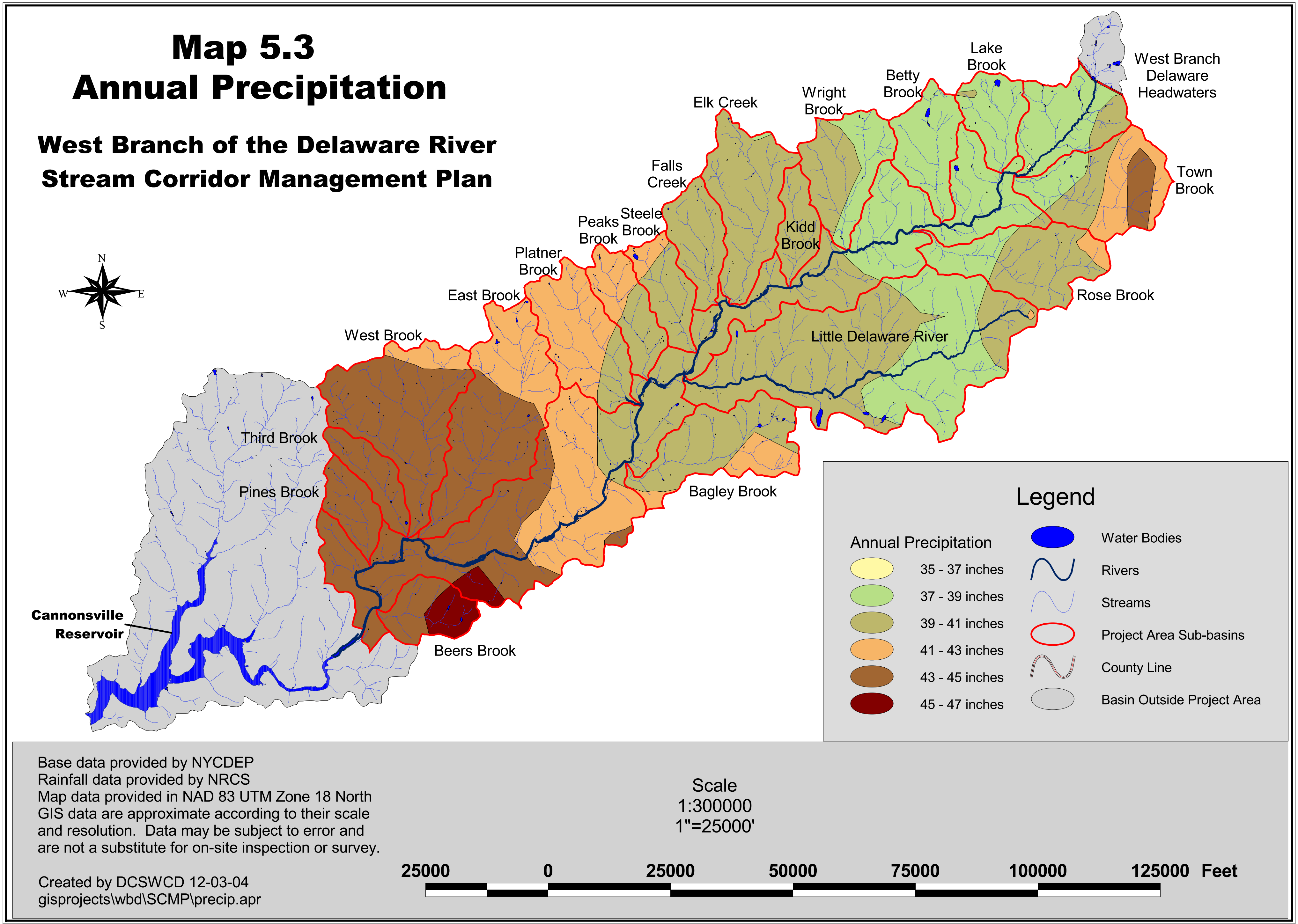
Map 5.3
Annual Precipitation
West Branch of the Delaware River
Stream Corridor Management Plan
N
W
E
S
West Branch Delaware Headwaters
Lake Brook
Betty Brook
Wright Brook
Elk Creek
Falls Creek
Steele Brook
Peaks Brook
Kidd Brook
Platner Brook
East Brook
West Brook
Town Brook
Rose Brook
Little Delaware River
Third Brook
Pines Brook
Bagley Brook
Beers Brook
Cannonsville Reservoir
Legend
Annual Precipitation
35 - 37 inches
37 - 39 inches
39 - 41 inches
41 - 43 inches
43 - 45 inches
45 - 47 inches
Water Bodies
Rivers
Streams
Project Area Sub-basins
County Line
Basin Outside Project Area
Base data provided by NYCDEP
Rainfall data provided by NRCS
Map data provided in NAD 83 UTM Zone 18 North
GIS data are approximate according to their scale
and resolution. Data may be subject to error and
are not a substitute for on-site inspection or survey.
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Scale
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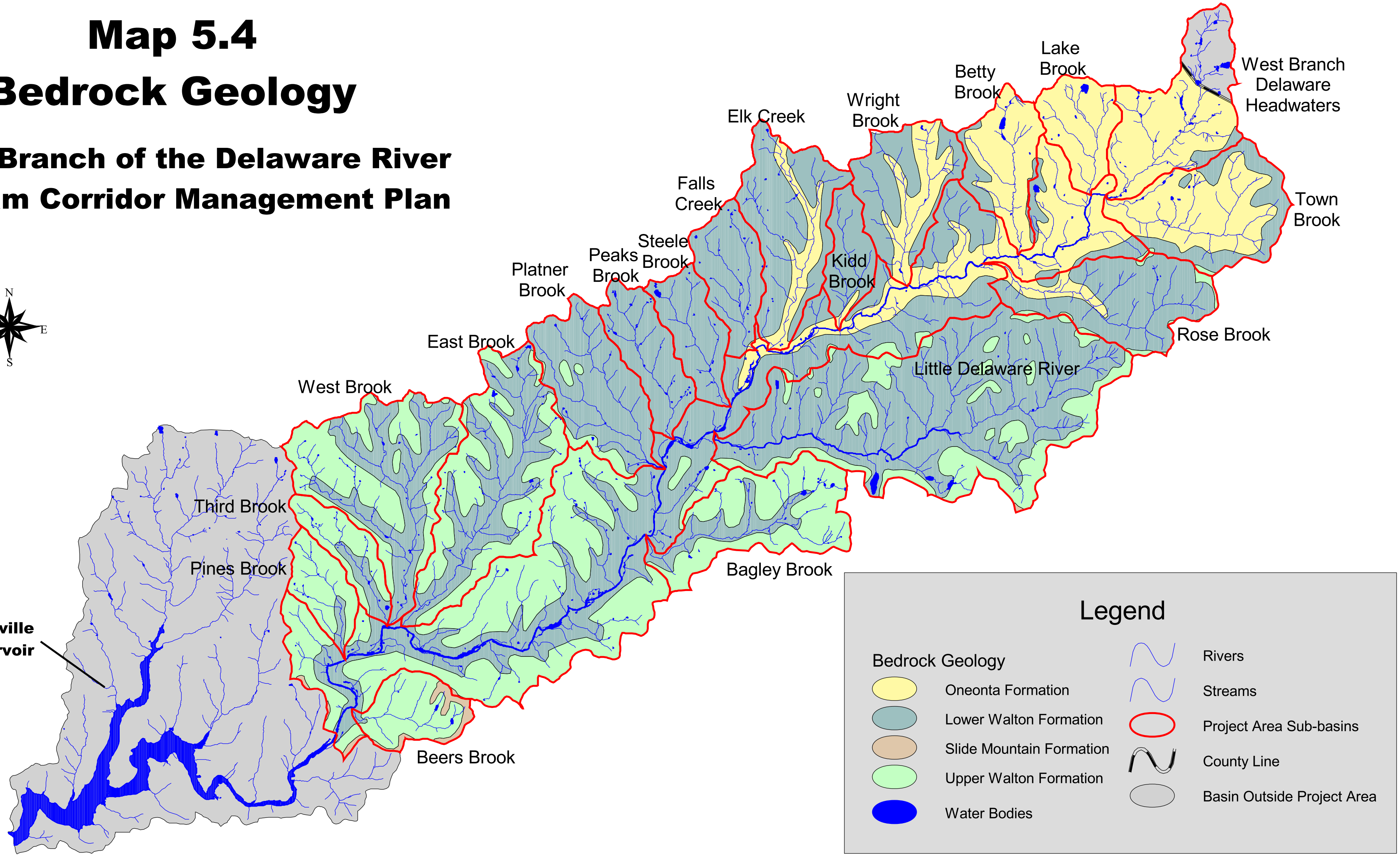
1"=25000'
25000
0
25000
50000
75000
100000
125000
Feet

Map 5.4
Bedrock Geology

West Branch of the Delaware River Stream Corridor Management Plan



Base Data Provided By NYCDEP
GIS bedrock geology coverage provided by NYSGS
Map data provided in NAD 27 UTM Zone 18 North
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a subsitute for on-site inspection or survey.

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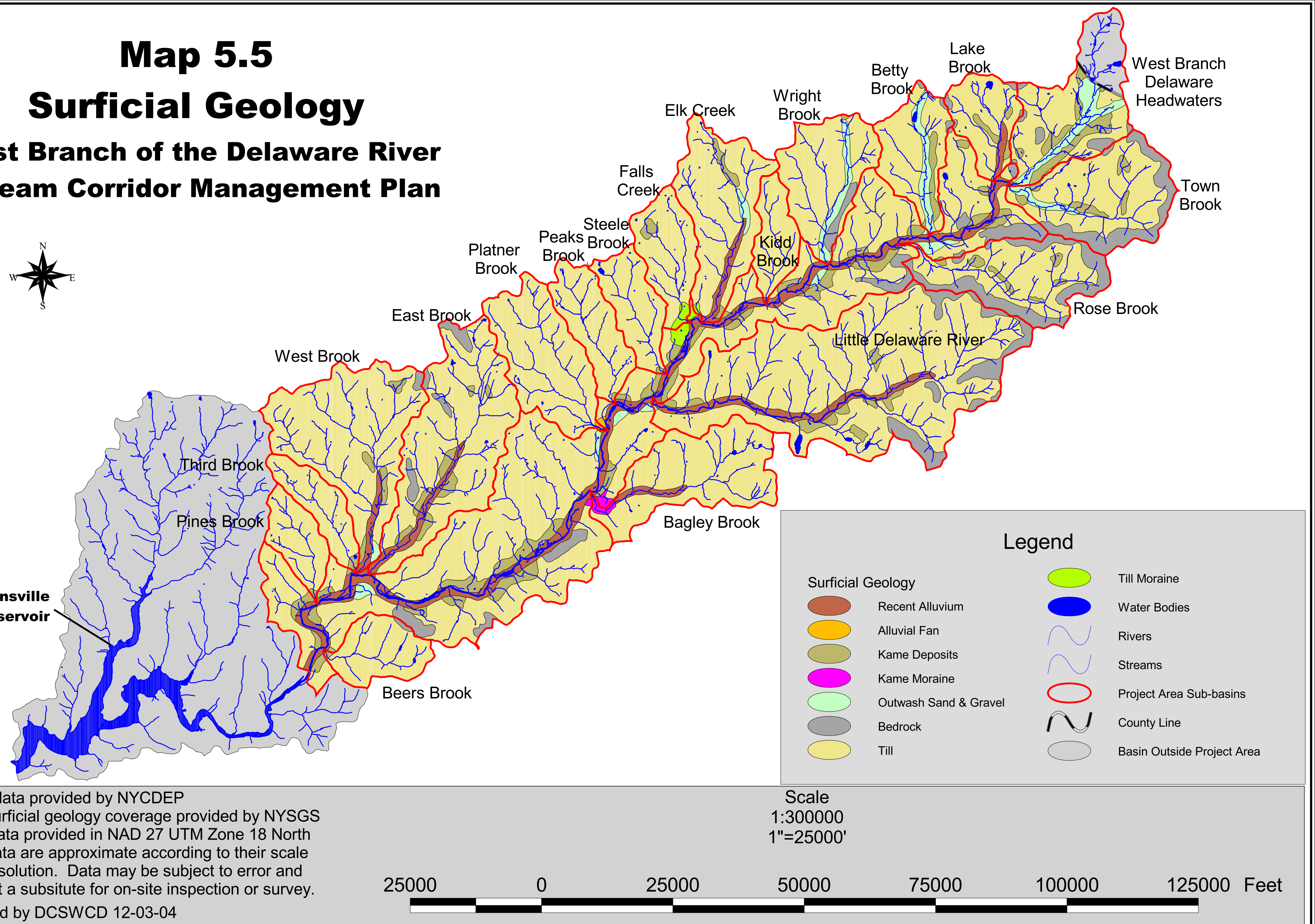
25000 0 25000 50000 75000 100000 125000 Feet

Map 5.5
Surficial Geology
West Branch of the Delaware River
Stream Corridor Management Plan



Base data provided by NYCDEP
GIS surficial geology coverage provided by NYSGS
Map data provided in NAD 27 UTM Zone 18 North
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a subsitute for on-site inspection or survey.

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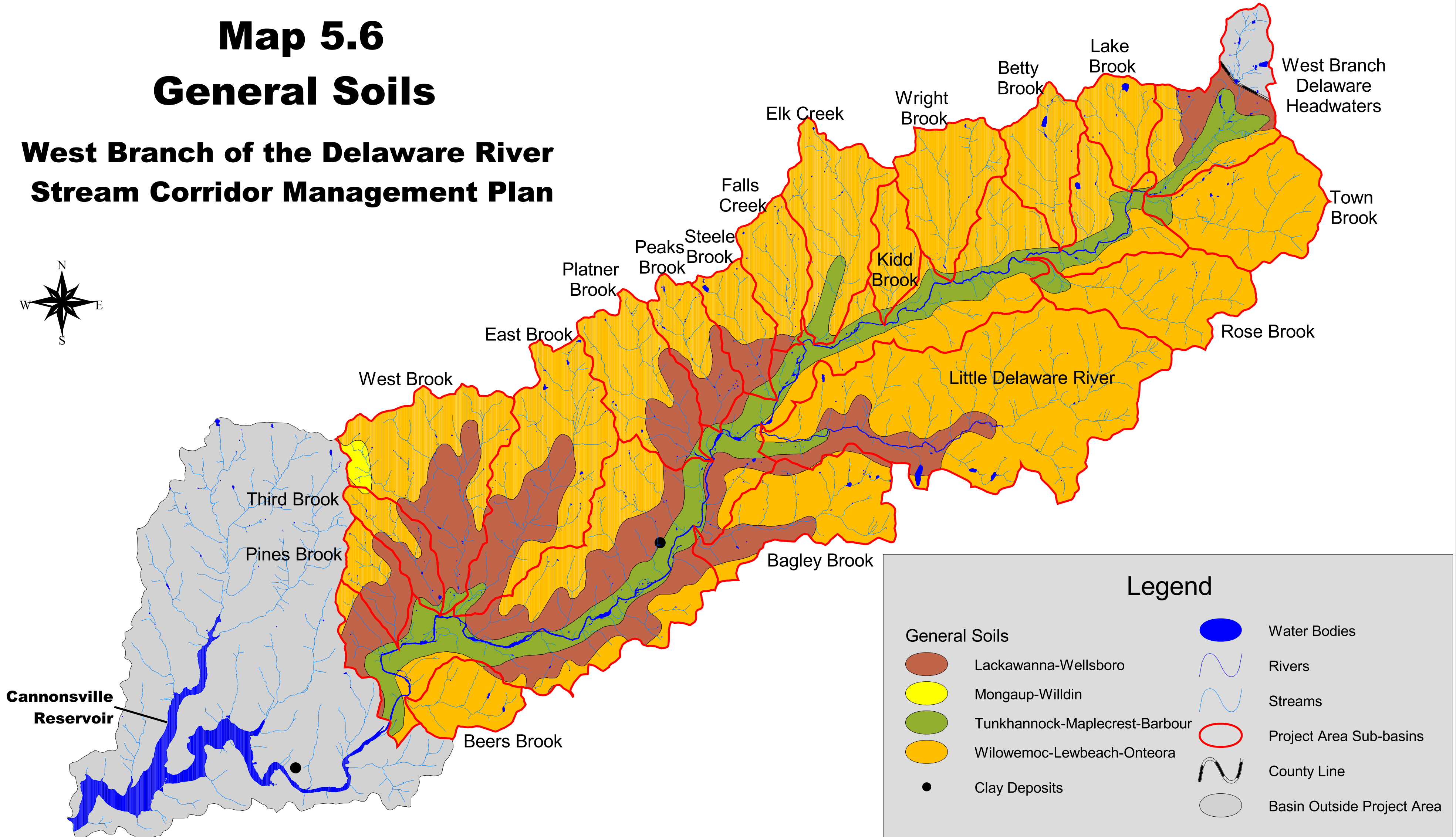
Map 5.6
General Soils

West Branch of the Delaware River
Stream Corridor Management Plan



Base data provided by NYCDEP
GIS soil type coverage provided by NRCS
Map data provided in NAD 27 UTM Zone 18 North
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substiture for on-site inspection or survey.

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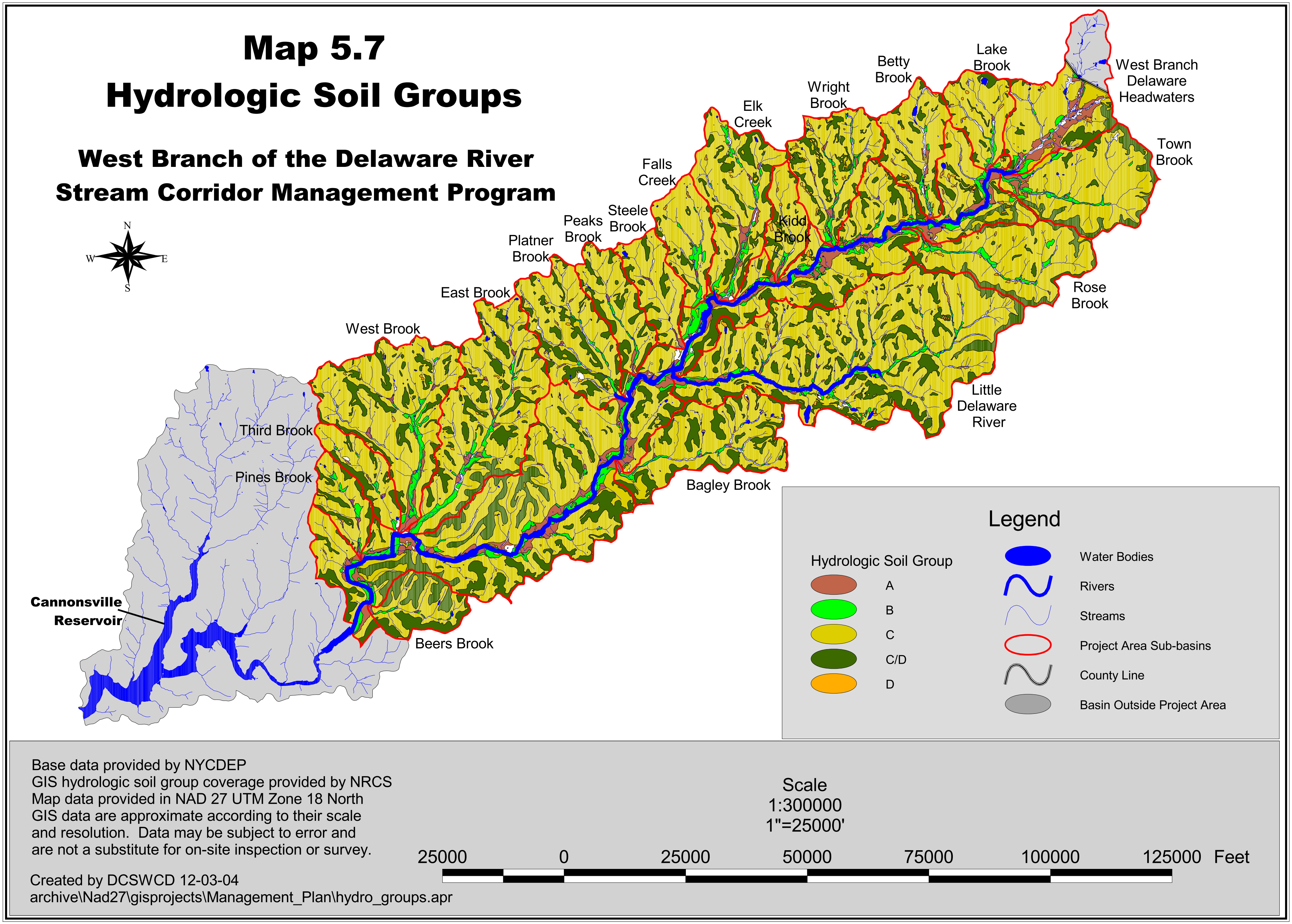

Map 5.7
Hydrologic Soil Groups
West Branch of the Delaware River
Stream Corridor Management Program
N
W
E
S
West Branch Delaware Headwaters
Lake Brook
Betty Brook
Wright Brook
Elk Creek
Town Brook
Falls Creek
Steele Brook
Kidd Brook
Peaks Brook
Platner Brook
East Brook
West Brook
Rose Brook
Little Delaware River
Third Brook
Pines Brook
Bagley Brook
Cannonsville Reservoir
Beers Brook
Legend
Hydrologic Soil Group
A
B
C
C/D
D
Water Bodies
Rivers
Streams
Project Area Sub-basins
County Line
Basin Outside Project Area
Base data provided by NYCDEP
GIS hydrologic soil group coverage provided by NRCS
Map data provided in NAD 27 UTM Zone 18 North
GIS data are approximate according to their scale
and resolution. Data may be subject to error and
are not a substitute for on-site inspection or survey.
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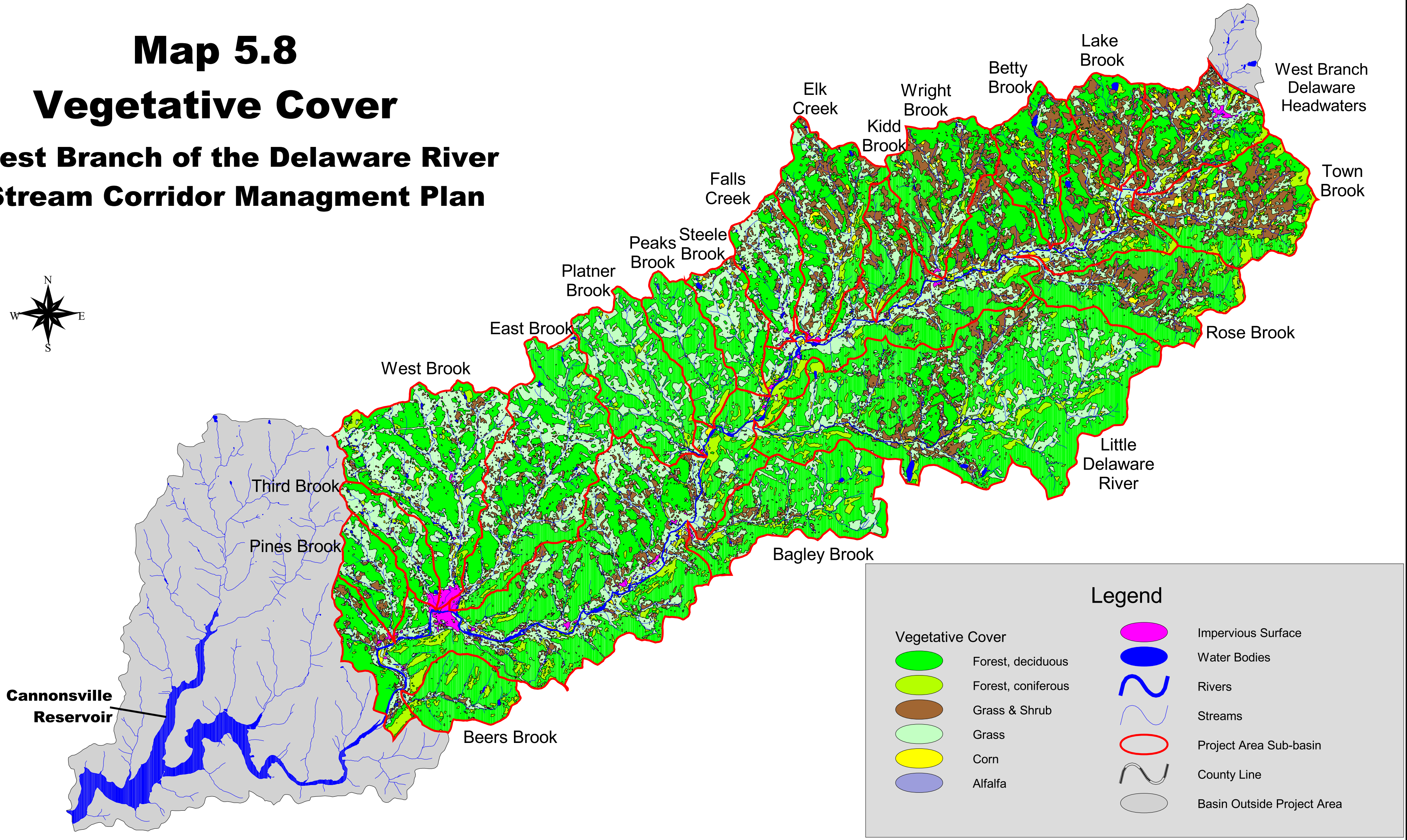
Map 5.8
Vegetative Cover

West Branch of the Delaware River
Stream Corridor Managment Plan



Data provided by NYCDEP from July 1992 & May 1993 datasets
Updated January 1999
Map data provided in NAD 27 UTM Zone 18 North
GIS data are approximate according to their scale
and resolution. Data may be subject to error and
are not a substitute for on-site inspection or survey.

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1"=25000'

30000 0 30000 60000 90000 120000 Feet

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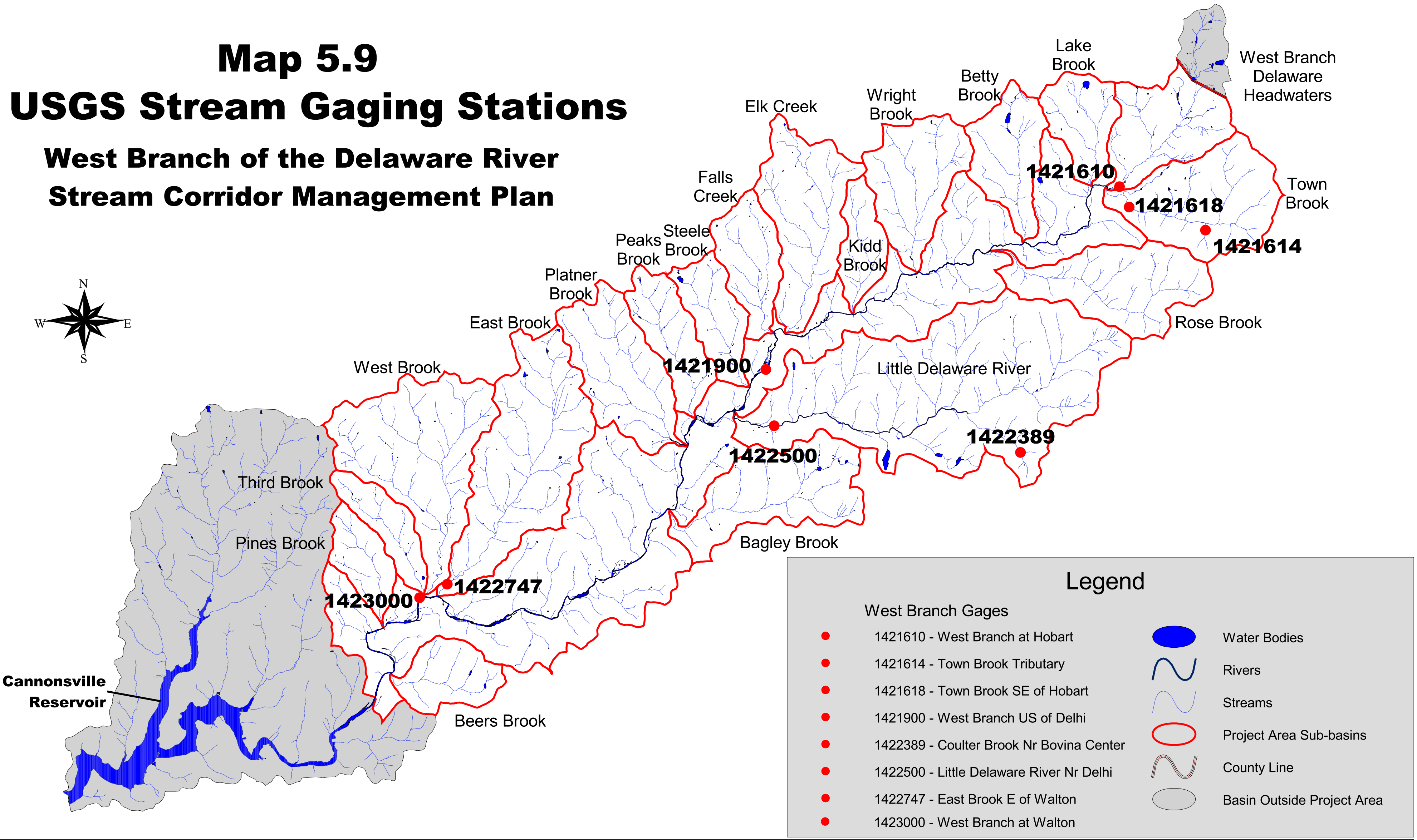
Map 5.9
USGS Stream Gaging Stations

West Branch of the Delaware River
Stream Corridor Management Plan



Base data provided by NYCDEP
USGS Gage data provided by USGS
Map data provided in NAD 83 UTM Zone 18 North
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

Created by DCSWCD 12-03-04
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Scale
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30000 0 30000 60000 90000 120000 Feet

Section 6 – Findings

6. Findings

6.1. Introduction

"Comparisons between streams of unknown characteristics must thus be of little help in understanding river process." Fahnstock and Bradley (1973)

This section presents the results of investigations performed to gather data for determination of physical conditions and problems with the stream corridor, and to provide guidance for future research and management recommendations. The geomorphic condition of the West Branch is the primary data group in these findings. Information on vegetation characteristics, public infrastructure, from public outreach efforts and a demonstration restoration project are also included in this section.

6.2. Geomorphic Condition of the West Branch

6.2.1. Introduction

A multiple objective *watershed* assessment protocol was followed to support the development of this plan. This watershed assessment protocol was prepared by Mark Vian with the NYCDEP stream management Program in 2001. These objectives, as modified through work during the Stoney Clove Stream Management Program were:

1. Provide the Stream Corridor Management Program (SCMPr) team with a general, baseline inventory of stream conditions on the West Branch main stem which included:
   - Conditions affecting hydraulic function, particularly *sediment* transport, including: cultural and natural grade controls, *berms*, riprap or other *revetment*;
   - Potential sources of water quality impairment, especially eroding banks, *clay exposures* or other hazards;
   - *Riparian* vegetation, including locations of functioning riparian communities, changes in riparian vegetation management, and occurrences of invasive exotic vegetation of significant consequence to stream *stability* and ecosystem function (primarily *Japanese Knotweed*);
   - Locations of *cross-sections* to be surveyed for characterization of channel *morphology*;
   - Infrastructure, including road crossings, bridges, *culverts* and outfalls and other features such as *tributary confluences*, springs or diversions.

2. The field protocol was meant to support the characterization of channel form, or *morphology*, throughout the West Branch main stem. Because sediment transport function and the stability of stream beds and banks is highly influenced by channel morphology, characterization of this morphology was key to the identification of *reaches* that were likely to present *erosion*, water quality or habitat problems, either in themselves or in the context of adjoining reaches and the system as a whole. The methods chosen for this characterization employed

Rosgen's natural channels classification system (Rosgen, 1996), described in **Section 5.9.2**. This classification system supports (but does not provide) general management interpretations regarding channel morphology on a watershed-wide basis. The morphological variables measured to classify reaches with the Rosgen approach can inform the interpretation of process beyond classification of Rosgen *stream types*.

3. To support analysis that would determine, for certain reaches and conditions identified during the stream feature inventory, the extent to which channel geometry and stream bank stability departs from a potential *stable* form[1]. This allowed determination of locations for which restoration of stable channel geometry was required, or alternatively where bioengineered bank stabilization would be sufficient to reasonably assure future stability. In this regard, the protocol represented a "first cut" to identify where further assessment is warranted, both of potential stable *reference reaches* and reaches where *instability* is indicated. Reference reaches will subsequently be surveyed in greater detail and over time to verify their stability and to provide data on the range of values they exhibit in variables such as facet dimensions, measures of bed *aggradation* and *degradation*, bank erosion rates, and substrate distribution. Stable channel geometry derived from these reaches can be used in the design of channel stability restoration projects. *Unstable* reaches will be subsequently surveyed in greater detail to allow comparison to the stable ranges of these same variables exhibited by reference reaches, and among themselves to characterize their relative severity and support the prioritization of their remediation.

The first step in the watershed assessment was production of a set of stream corridor maps which featured:

- Digital Orthographic Photography (Emerge, 2001)
- Identification of drainage area above and below each tributary confluence by using NYCDEP measuring watershed area and predicting hydraulic geometry protocol and at bridge crossing, and anticipated *bankfull* cross-sectional area at these points, using regional hydraulic geometry curves developed for the Catskills by NYCDEP.
- Contour lines (USGS, 20 foot contours, 1995 is from DEP GIS coverage).
- Property boundaries and owners names from 1993 Delaware County tax parcel data.
- Historical channel alignments, from 1938, 1963, 1971 and 1983 aerial photography.

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[1] This approach assumes that for any valley setting a variety of channel morphologies might be found, and that some of these forms, in that setting, convey the range of water and sediment discharges supplied by the landscape in a manner which allows them to maintain their morphology with relatively little change form year to year (stable forms), while others are less effective and are likely to evolve relatively rapidly though a sequence of channel forms due to vertical and/or lateral adjustments (unstable forms). For any valley setting, there is a discrete range of potentially stable forms.

Fieldwork proceeded in three passes over three years as follows: 2002 – 24.6 miles from Utsayantha Lake to above Delhi; 2003 – 17.5 miles from above Delhi to Oxbow Hollow; 2003 – 13.4 miles from above Oxbow Hollow to the NYS Route 10 bridge near the Cannonsville Reservoir. The first pass used a *Global Positioning System* (GPS) receiver to map locations of features identified in the stream inventory summarized below, Section 6.2.2). Photographs were taken of each feature, and upstream and downstream at cross-section locations. Selected eroding banks were later *monumented* and surveyed for the purpose of long-term *monitoring*. These were severely eroding banks randomly selected during the walkover as it progressed.

The second pass involved elevation survey of the longitudinal profile of current water surface and field identified bankfull *stage* at 47 selected cross-sections out of 73 identified cross sections, numbered sequentially downstream from the headwaters. Following this survey, a stream-specific hydraulic geometry curve was developed for 29 of these cross-sections (selection of these sections is further described below) to support determination of bankfull stage at other locations in the watershed. Modified Wolman pebble counts were conducted for each of the 47 cross-sections. These data were used to classify the stream reaches to Rosgen Level II, and to perform hydraulic calculations at these reaches.

A third pass involved the collection of bulk samples (stream bed particle analysis) at the 29 selected cross-sections. This information was used to validate sediment transport estimates and whether or not the stream reach is in an *aggrading*, *degrading* or stable condition.

The locations of features described in the tables and charts in this section are available as maps. However, due to the overwhelming number needed to cover the entire West Branch main stem, only a few maps are included in this plan for illustrative purposes (see **Section 7**). Upon request, maps can be provided for another section of the river not included here.

6.2.2. <u>Data Collection/Analysis</u>

Geomorphic data were collected as described above during the summers of 2002, 2003, and 2004 using a GPS receiver (see **Figure 6.1**). These data were incorporated into a *Geographic Information System* (GIS) and then located on aerial photos for mapping and analysis. The data collected included:

Figure 6.1 Using a hand held GPS receiver to locate a debris jam downstream of South Kortright.

- The location and surface area of eroded banks.
- The location of headcuts,

natural or cultural grade control, and other evidence of stream bed erosion.

- The location and extent of revetments, *rip-rap*, and other similar erosion control measures.
- The location and extent of unstable depositional features such as side bars and center bars. See **Table 6.2** below.

Rosgen Level II surveys were performed at 29 locations. Information collected included:

- Surveyed stream bed elevation.
- Pebble counts at the surveyed cross-sections.
- Documentation of bankfull indicators.
- *Thalweg* and water surface profiles.

Cross sections were chosen at locations where bankfull stage indicators were readily or reasonably identifiable, to create a localized hydraulic geometry curve to assist in the description of channel geometry. This is used to assist in determining stream hydraulic geometry properties where stream instability or other conditions obscure bankfull indicators. Since good indicators are required for development of a reliable hydraulic geometry curve, these 29 sections are at locations that are typically more stable than other sections in that particular reach. Thus, the data generated by the Level II analysis is reflective of a selection of cross-sections with characteristics that tend to be hydraulically and geomorphically more stable than the surrounding reaches and the river as a whole.

For mapped location of the 29 cross-sections see the Stream Segment maps in **Section 7**. No cross sections were taken below Hamden due to time constraints. The summers of 2003 and 2004 were extremely wet, and consequently the water depth in the river precluded any surveys being done.

Visual observation by trained DCSWCD personnel and GIS data were used to supplement the cross section data. Where no cross sections were surveyed, visual observation and GIS data form the basis of descriptions, conclusions and recommendations made in this report.

6.2.3. Current Conditions of the West Branch

Note: The scope of this project was limited to surveying, cataloging and analyzing the physical condition of the West Branch main stem, including the form and functions of its streambed and banks. In this section, perceived problems with the river will be limited to a discussion of the effects of erosion and deposition, and suggested strategies to effectively manage these concerns. Flood management issues are mentioned in **Sections 5.8.3** and **5.14**, but determining causes and solutions to flooding problems was largely beyond the scope of this project.

Figure 6.2 Measuring erosion loss using the bank-pin method at cross-section 53 just upstream of Delhi.

Anyone making a casual review of conditions along the West Branch of the Delaware River main stem might find the following:

- Widespread streambank erosion
- Widespread repairs along previously-eroding streambanks
- Widespread and common depositional features (i.e. *gravel* bars in various forms)

When stream surveys of the main stem were completed and GIS and Rosgen Level II data were analyzed, the above features were confirmed repeatedly. After careful documentation and review, the following problems became apparent:

- A general aggrading trend exists along the length of the river, that is, there are more sections aggrading than degrading.
- There are many eroding banks.
- Overly large Width/Depth ratios are common.
- Fine-textured sediments are being deposited in noticeably greater quantity at the downstream reaches near the Village of Walton.

Taken together, this pattern of erosion and deposition runs the length of the West Branch Delaware River, from its headwaters to the Cannonsville Reservoir.

The processes of stream erosion and deposition go together. If the stream cannot carry the available sediment load, then some sediment will drop out — *raising the streambed*. The stream widens in response to this — causing bank erosion — since it needs a certain cross sectional area to convey its *discharge*. As a result of aggradation and widening more of the stream bank is exposed to flood flows. Especially in the absence of riparian vegetation that could otherwise hold banks in place, this encourages further erosion and increases the sediment load that the stream must move. A spiral of events begin, the result of which is the destabilization of the stream. While in theory a stream will stabilize or reach a new *equilibrium* condition over time, the time required may be very long, and the stream will not stabilize if the disturbance that caused the destabilization persists.

The following human activities have an effect on streams and can initiate the erosion/deposition cycle. Evidence of all these activities can be found in the watershed.

- Deforestation. This increases peak *runoff*. For further discussion see **Section 5.10.5**.
- Building development. This increases impervious area, which increases peak runoff. This leads to an increase in erosion. For further discussion see **Section 5.10.3**.
- Agricultural practices. Certain agricultural practices can increase bank erosion and increase peak runoff. For example, the lack of a riparian buffer or cattle having direct access to the stream leads to an increase in erosion. For further discussion see **Section 5.10.3**.
- Stream realignment. Generally, when this happens the stream is straightened. This increases the slope of the stream, which in turn increases erosion. For further discussion see **Section 5.9.2**, especially **Figure 5.15**.
- Bulldozing streams. This is often done in conjunction with realignment. Usually the motive is to increase the capacity of the channel for purposes of flood control. If the stream channel is deepened this increases erosion. If it is widened it increases deposition. It frequently occurs in the vicinity of bridges in an attempt to achieve the desired capacity for floods or to align the stream at a right angle to the bridge.
- Bridges located on alluvial fans or at confluence areas. Typically, this means that the stream has been realigned, and the channel has usually been widened and deepened to get the capacity to pass the required design flood. The effect is the same as bulldozing streams.

Table 6.1, below, lists various physical properties of the West Branch as measured at 29 cross-sections along its 49.5-mile length. Cross-sections were taken from the top of the watershed down and are listed as such in the table. (Note: In the following text, use of adjectives such as “good”, “undesirable”, or “preferred” when referring to the river’s condition indicate comparisons to streams that are in balance or relatively stable ─ a goal for stream management purposes.)

Approximately 95% of the West Branch is a C stream type. Other reaches included type D, Type DA, and type F. Cross sections were not surveyed for these types because they were not considered stable reaches (note: DA is a stable type. Cross-sections were not taken in this reach due to time constraints). (For a description of stream types see **Section 5.9.2,** and **Figure 5.18**).

All of the surveyed cross sections are a Type C. The following description of a Type C4 also largely applies to a type C3 except that the C3 has a *cobble*-dominated bed. While no cross sections were taken south of Hamden, observation and GPS data indicate that the river is primarily a C type through out its entire length, excepting where multiple channels or highly *entrenched* conditions were observed.

> The C4 stream type is a slightly entrenched, *meandering*, gravel-dominated *riffle*/*pool* channel with a well developed *floodplain*. The C4 stream type is found in U-shaped glacial valleys; valleys bordered by glacial and Holocene terraces; and in very broad coarse alluvial valleys typical of the plains areas. Some of the C4 stream types occur in glacial outwash terrain, closer to the lobe where gravel material is present. The C4 stream channels are found in Valley Types IV, V, VI, VIII, IX, and X (the predominant valley type in the West Branch is Valley Type VIII). C4 stream channels have gentle gradients of less than 2%, display a high width/depth ratio, are slightly more sinuous and have a higher meander width ratio than the C1, C2, and C3 stream types. The riffle/pool sequence for the C4 stream type average 5-7 bankfull channel widths in length. **The stream banks are generally composed of unconsolidated, heterogenous, non-cohesive, alluvial materials that are finer than the gravel-dominated bed material. Consequently, the stream is susceptible to accelerated bank erosion. Rates of lateral adjustment are influenced by the presence and condition of riparian vegetation**. Sediment supply is moderate to high, unless stream banks are in a very low erodibility condition. **The C4 stream type** characterized by the presence of point bars and other depositional features, **is very susceptible to shifts in both lateral and vertical stability caused by direct channel disturbance and changes in the flow and sediment regimes of the contributing watershed**. (Rosgen, 1996) (Emphasis added).

Table 6.1 Summary of various physical properties for 29 cross-sections in the West Branch Delaware River

1	2	3	4	5	6	7	8	9	10	11	12	13
Cross-section #	Stream Type	Drainage Area (mi^2)	Bankfull Width W_{bf} (ft)	Bankfull Depth d_{bf} (ft)	Bankfull Area A_{bf} (ft^2)	Width/ Depth ratio (W_{bf}/d_{bf})	Entrenchment Ratio	D84 (mm)	Aggrading/De-grading/Stable	Sinuosity	Stream Slope (%)	Profile Length (ft)
2	C3	3.96	30.3	1.1	33.5	27.5	2.0	223	A	1.15	0.66	617
7.9	C4	8.35	20.2	1.7	33.5	11.9	14.8	142	D	1.20	1.13	746
8	C4	8.35	29.0	1.4	40.3	20.7	8.6	152	D	1.20	1.13	746
14	C4	9.13	46.0	1.7	76.9	27.1	1.3	158	A	1.15	0.44	1542
15	C4	9.19	44.8	1.5	67.9	29.9	2.3	169	A	1.15	0.78	1542
16	C4	9.36	31.8	1.8	58.2	17.7	8.0	136	A	1.15	0.52	1542
16.8	C4	9.61	52.4	1.3	65.8	40.3	4.8	233	A	1.15	1.16	1355
16.9	C4	9.61	31.3	1.8	55.4	17.4	7.5	172	A	1.15	1.02	1355
17	C4	9.61	74.1	1.1	78.0	67.4	2.0	155	A	1.20	0.90	1355
19.5	C4	13.54	96.8	1.1	107.8	88.0	2.6	173	A	1.15	0.80	719
20	C4	13.54	55.6	1.4	79.6	39.7	9.0	165	A	1.15	0.82	719
21	C3	13.85	46.9	2.0	94.2	23.5	2.3	198	A	1.20	0.57	1035
22	C3	13.85	48.0	2.0	96.2	24.0	3.6	154	A	1.20	0.50	1035
23	C3	13.85	51.0	2.1	105.0	24.3	2.7	207	A	1.20	0.44	1035
24	C4	31.97	57.3	2.2	121.2	26.0	8.7	138	D	1.20	0.68	970
26	C3	39.17	52.1	3.2	169.3	16.3	7.7	167	S	1.10	0.62	748
29	C4	44.33	80.2	2.8	222.4	28.6	6.2	198	A	1.15	0.55	1240
35	C4	75.23	58.6	4.3	254.2	13.6	4.2	137	A	1.15	0.43	622
38	C4	81.20	98.0	3.9	377.5	25.1	8.2	109	A	1.15	0.36	2073
38.5	C3	81.20	83.4	4.5	373.4	18.5	9.6	168	S	1.15	0.35	2073
40	C3	94.96	83.0	5.2	428.7	16.0	5.4	157	A	1.15	0.22	5914
41	C3	94.96	155.0	5.2	483.1	29.8	4.5	90	A	1.15	0.27	5914
41.2	C3	94.96	139.5	4.0	552.3	34.9	5.0	132	A	1.15	0.27	5914
42	C3	94.96	103.8	4.4	460.9	23.6	2.9	118	A	1.15	0.25	5914
46	C4	99.07	106.4	3.4	362.7	31.3	3.3	100	D	1.42	0.41	610
48	C4	106.81	83.0	5.1	424.0	16.3	3.4	62	D	1.42	0.21	992
56	C4	197.35	122.5	6.0	738.3	20.4	3.6	47	S	1.15	0.25	1302
61	C4	242.31	123.0	5.9	721.9	20.8	4.1	107	A	1.15	0.12	1205
63	C4	247.19	147.7	4.3	637.6	34.3	3.4	80	A	1.15	0.25	1690
	Gray hi-lighted cells indicate width/depth ratio exceeds 24											
	Yellow hi-lighted cells indicate entrenchment ratio is less than 2.2											
	Red/green hi-lighted cells indicate cross sections that are on the same profile (reach)											

- As a general rule a width/depth ratio of 24:1[2] is about the maximum that we would like to see on a stable Type C stream. However, as shown in column 7, 15 of the 29 cross sections have a width/depth ratio greater than 24. These cross sections are highlighted in the table. A width/depth ratio not over 20[3] would be preferable. In this case, 21 of the 29 cross sections would be too wide.

[2] Class note, River Restoration and Natural Channel Design, Wildland Hydrology, 2001

[3] Class note, River Restoration and Natural Channel Design, Wildland Hydrology, 2001

While a large width/depth ratio does not by itself indicate an unstable stream, any stream that has a width/depth ratio wider than preferred should be considered to be at risk. Recall that C type streams are very sensitive to accelerated bank erosion especially if the riparian vegetation is inadequate. Note that just over 50% (15 of 29) cross sections have a width/depth ratio greater than 24. This indicates that while the stream is not over-wide everywhere it has tendency to become wider than should be expected to maintain stability. Also, referring to **Table 6.1,** the sum of the profile length of the shaded (wide) cross sections is 27,295 feet, the total length of all the profiles is 52,524 feet, so 52% of the surveyed profile exhibits signs of tending to be over-wide.

Two cross sections have a width/depth ratio between 30 and 40, while two others have ratios greater than 50. Any time the width/depth ratio exceeds 40- 50[4], channel braiding can occur (potentially becoming a D type). While factors besides width/depth ratio can influence a stream's tendency to braid, anywhere the ratio approaches 50 should serve as a "red flag" indicator.

Cross sections 2, 7.9, 8, 14, 15, 16, 16.8, 16.9, 21, 24, 38, 38.5, 41, 41.2, 42, 48, 61, and 63 had bulk (bar) samples taken from the stream bed. They were judged to be aggrading, degrading, or stable by calculating critical dimensionless shear stress and then determining if the existing mean depth and/or water surface slope at bankfull were sufficient to move the largest particle from the bar (bulk) sample. (See Entrainment Calculation Form in **Appendix 7**).

It was not possible to gather bulk samples at the other cross sections, due to persistent high water in the river during the summers of 2003 and 2004. For cross sections which had no bulk samples taken we compared the bankfull shear stress to that shear stress required to move the D84 and D90 of the surface particles in a riffle. If the shear stress fell between that required to move the D84 and D90 we judged the cross section to be stable. If it was not great enough to move the D84 we judged the section to be aggrading. If it was larger than the shear stress required to move the D90 we judged it to be degrading. This approach will yield only approximate results, but provided a useful measure of bed stability to compare with locations in which we were able to obtain bed samples.

Again referring to **Table 6.1**, 21 out of the 29 cross sections, or 72%, are listed as aggrading. Taking only the cross sections that were bulk sampled, 13 of the 18 were judged to be aggrading, also 72%.

Totaling up profile lengths for the 29 cross sections: 18,102 feet aggrading, 3,318 feet degrading, and 4,122 feet stable; for 71% aggrading. Totaling up profile lengths for the 18 cross sections that got bulk sampled: 15,431 feet aggrading, 2,708 feet degrading, 2,073 feet stable; for 76% aggrading. Note: 2,073 feet (cross sections 38 and 38.5) was included in both aggrading and stable summations because both sections are on the same reach and one section is aggrading and one is stable.

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[4] Rosgen 1996 especially Figure 5-3. And, Knighton 1998, pg 231.

Our initial survey indicates that the river has a tendency toward aggradation.

While no cross sections were surveyed below Hamden, observation and GIS indicate that this same tendency towards aggrading and widening appears to persist the length of the river to the Cannonsville reservoir as indicated by comparing historic aerial photographs with current images, observation, and conversations with longtime residents.

- The entrenchment ratio is good (consistent for a stable C type) for most of the stream (see **Table 6.1**, column 8). In only 3 locations is it below 2.2. This means that the stream is generally not *incised* and still has access to its floodplain. Two locations have an entrenchment ratio of 2.0 which is still at the low limit of acceptability for a type C stream. Only one cross section (14) exhibits signs of incision outside the acceptable range for a type C stream in an otherwise C type reach. If a reach on a type C stream has an entrenchment ratio of 2.0 or less. It should be observed closely and regularly. A low entrenchment ratio (< 2.0) could be indicative of the stream entrenching itself. This could be warning that the system is destabilizing.

- Sinuosity is generally about 1.15 (see **Table 6.1**, column 11). This is slightly less than the preferred value of 1.2 or greater for a C type stream with a stable meander pattern, but is within the acceptable range.

What is not apparent in **Table 6.1** is that the river has long reaches of planar bed, which came to be referred to as "long runs" by DCSWCD personnel (see **Figure 6.3**). The cause of these long runs is not known, but they have been observed by our personnel on other streams in the northeast where they appear to be quite common. They are devoid of features (riffles, pools), cross-sections tend to be nearly rectangular and the bed is usually flat and level. In this sense, they interrupt the pool-riffle sequence; they have been observed occupying a length that would normally be occupied in similar reaches by one or more pool-riffle sequences. They can be stable, especially if the riparian vegetative buffer is thick, with a good root mass to hold the banks in place (see **Figure 6.3**). Their significance is unclear. As a working hypothesis, since they do interrupt the normal pool-riffle sequence, it is assumed that they are most likely a response by the stream to a past disturbance, but it remains unclear whether long runs represent a current problem.

Figure 6.3 Example of a long run just below Bloomville at cross-section 43.

The location and surface area of eroded banks, and the location of unstable depositional features such as side bars, center bars, transverse bars and emergent gravel bars were located by GPS. For a summary of these features see **Table 6.2**, below. **Table 6.2** lists the number of erosional and depositional features per mile for each management unit. (See maps in **Section 7**).

Table 6.2 Erosion and depositional features per mile by Management Unit

Segment Number	Management Unit	Length (mi)	Linear Feet Erosion	Surface Area (sq.ft.)	# Erosion Features	# Deposition Features	Linear Feet Erosion per Mile	# Erosion Features per Mile	# Deposition Features per Mile
1	1	0.57	52	26	1	1	91.23	1.75	1.75
	2	0.70	255	951	6	4	364.29	8.57	5.71
	3	0.59	87	193	2	2	147.46	3.39	3.39
	4	0.37	140	729	2	0	378.38	5.41	0.00
2	5	2.55	905	1901	14	19	354.90	5.49	7.45
	6	0.76	417	2703	5	13	548.68	6.58	17.11
	7	0.38	0	0	0	0	0.00	0.00	0.00
	8	0.39	521	3502	5	7	1335.90	12.82	17.95
	9	1.99	1936	9498	18	12	972.86	9.05	6.03
	10	1.65	2562	10511	15	14	1552.73	9.09	8.48
	11	0.96	1131	7954	6	3	1178.13	6.25	3.13
	12	4.89	9054	47441	61	54	1851.53	12.47	11.04
	13	1.20	1433	7702	6	6	1194.17	5.00	5.00
3	14	4.60	8377	41689	50	32	1821.09	10.87	6.96
	15	1.67	3282	12718	10	6	1965.27	5.99	3.59
	16	1.27	3499	16548	23	18	2755.12	18.11	14.17
	17	0.87	1081	3998	7	4	1242.53	8.05	4.60
	18	1.12	3953	15705	19	11	3529.46	16.96	9.82
	19	2.84	7605	26247	32	22	2677.82	11.27	7.75
4	20	1.75	7739	31315	25	15	4422.29	14.29	8.57
	21	2.97	8307	27497	38	23	2796.97	12.79	7.74
	22	1.03	3234	7658	13	7	3139.81	12.62	6.80
	23	0.64	2236	9432	12	15	3493.75	18.75	23.44
	24	2.35	4970	19346	34	31	2114.89	14.47	13.19
5	25	2.21	3600	11054	26	5	1628.96	11.76	2.26
	26	0.84	2824	14770	14	15	3361.90	16.67	17.86
	27	1.58	2120	8283	24	13	1341.77	15.19	8.23
	28	1.86	6204	40272	31	10	3335.48	16.67	5.38
	29	4.44	9554	36808	54	46	2151.80	12.16	10.36
Total			**97078**	**416451**	**553**	**408**			

There are about 1,961 feet of eroded bank for each mile of stream. This works out to 18.5% of the stream banks being eroded. There are approximately 19 erosion features per mile of stream. There are approximately 8.2 depositional features per mile of stream.

Chart 6.1 below graphically illustrates the linear feet of erosion per mile per management unit. Note that there is less erosion in the upstream units. This is probably due to:

- The river being small and lacking erosive power, especially in reaches with low slope.
- The river is channelized and hardened within the Village of Stamford.
- A lack of West Branch and sub-basin development and agriculture in the upper portions of the watershed.
- Healthier riparian vegetative communities to hold stream banks in place.

Chart 6.1 Linear Feet of Erosion per Mile by Management Unit

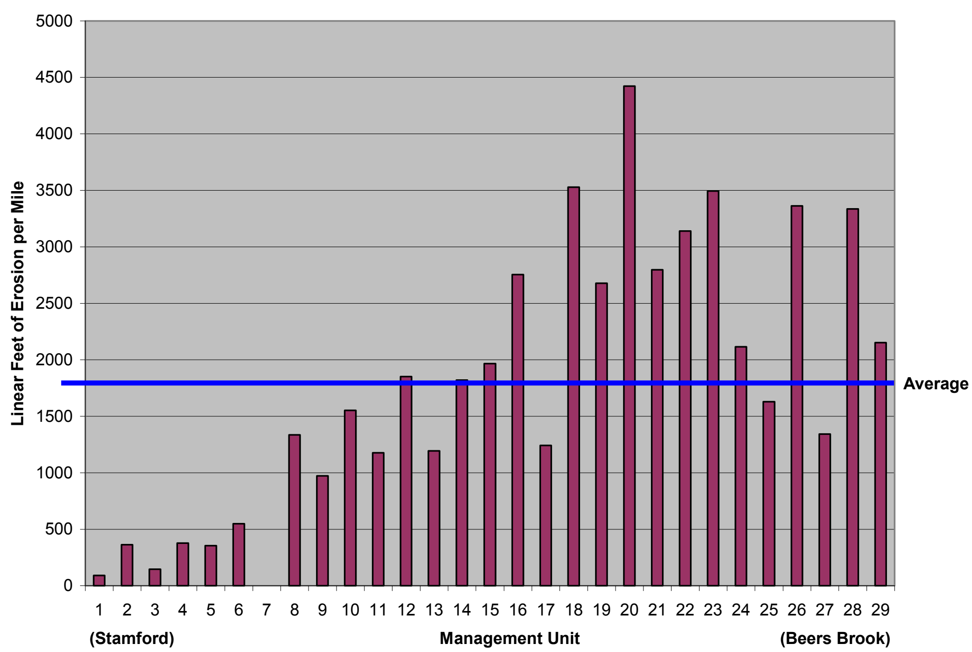

Chart 6.2, below, graphically illustrates the rate of depositional features per mile per management unit. Note that the rate of depositional features tends to increase in the downstream direction. This is particularly true from management unit 23 to management unit 29. This is probably due to:

- Excessive sediment load being contributed by the tributaries along the length of the main stem.
- The total sediment entering the stream from the upstream eroded banks being more than the stream can move.
- Stream slope decreasing to the point that it can no longer transport the sediment being made available to it.
- Stream depth decreasing and/or stream width increasing to the point that it can no longer transport the sediment being made available to it.
- Some combination of the above factors.

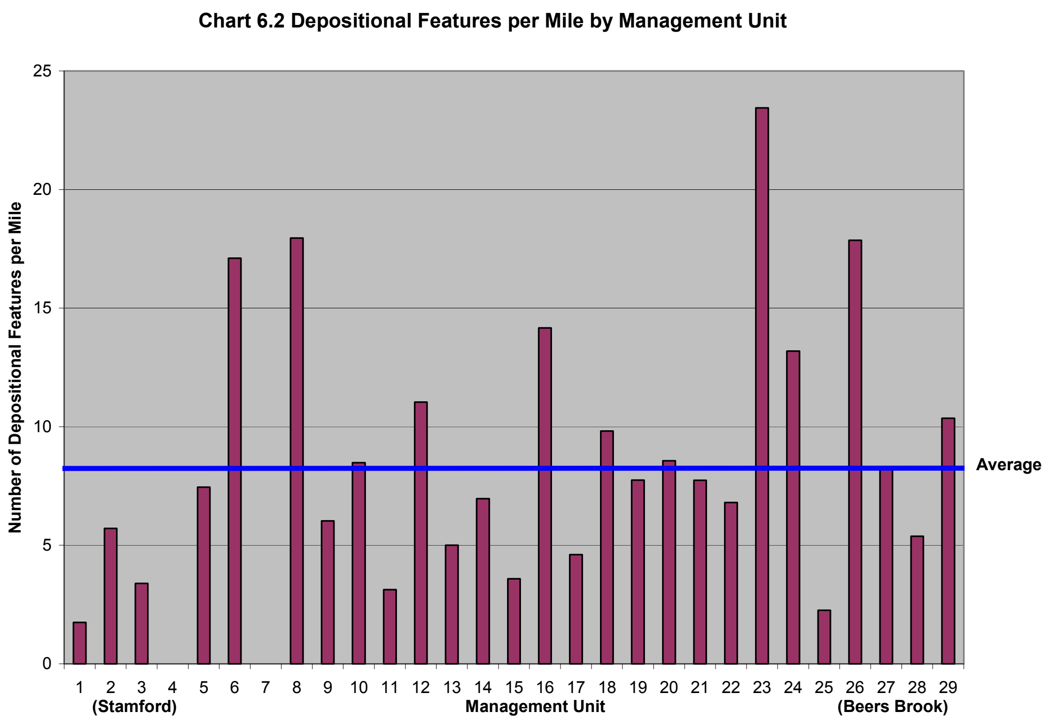

Chart 6.3, below, graphically illustrates the depositional features by type for each management unit. Note that center bars and side bars are the most common depositional features.

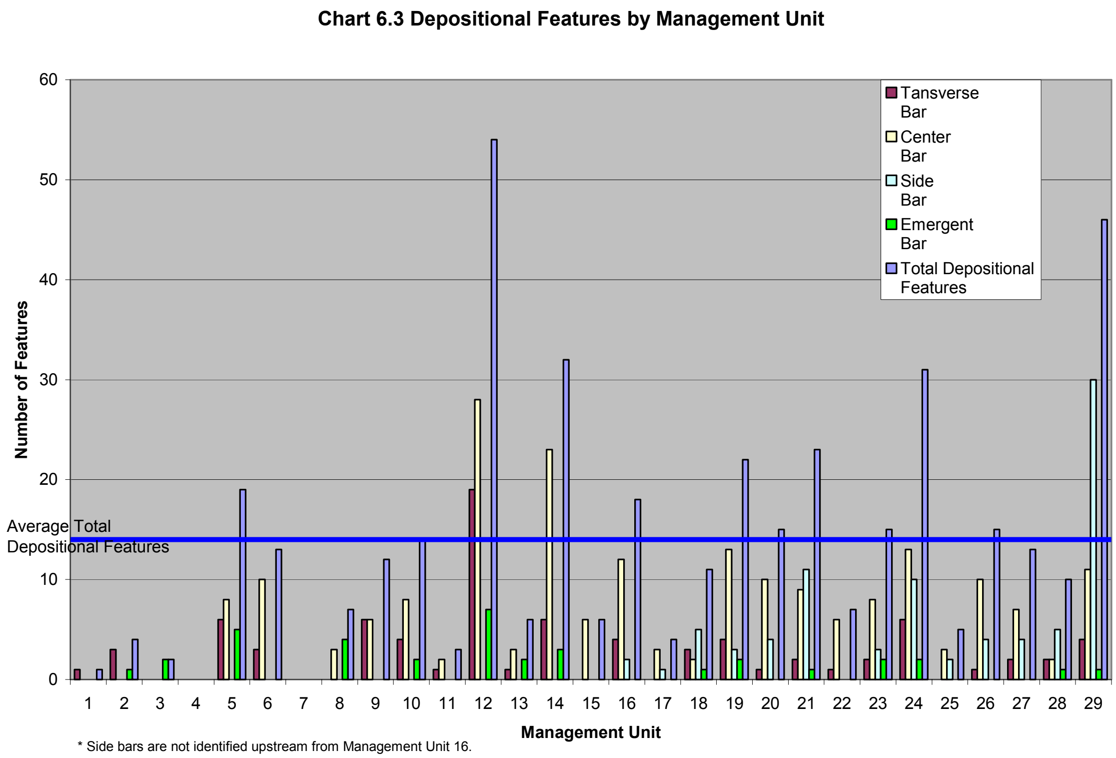

Table 6.3, below, lists the number and type of depositional features recorded during the river survey. The river averages 8.2 depositional features per mile. Note that point bars, being a normal feature of type C streams, are *not* counted as depositional features. The features that were noted in the table below are only those features which are or can be indicative of a high *bedload*.

Table 6.3 Depositional Features Found in the West Branch

Type of Deposition	Number
Center Bar	206
Side Bar	84
Transverse Bar	82
Emergent Gravel Bars	36
Total	**408**

Table 6.4, below, lists the erosion as measured at bank pins. There are 553 located erosion features on the West Branch. Their total length is 97,078 feet, and their total area is 416,451 square feet. Over the length of the river this equals about 1,961 linear feet of eroded bank per stream mile, or, about 18.5% of the length of the stream banks being eroded. Cubic yards (CY) is determined by measuring the eroded banks length, height and length of exposed bank pin.

Table 6.4 Measured Erosion at Bank Pins

Bank Pin Number	Installed	2003		2004		Notes
		Exposed (ft)	Soil Lost (CY)	Exposed (ft)	Soil Lost (CY)	
8.90	2004	-	-	-	-	New pin 2004
16.90	2004	-	-	-	-	New pin 2004
33.40	2004	-	-	-	-	New pin 2004
33.50	2004	-	-	-	-	New pin 2004
34.30	2002	2.75	125	2.2	150	
34.80	2003	-	-	5.1	188	New pin 2003
36.20	2002	0	0	2.3	43	Pin may have slumped with sod & was still flush with bank
38.50	2002	-	-	-	-	Not inventoried
44.40	2002	Assume 5	218			Bank pin 44.40 missing in 2003,
44.41	2003	-	-	4.5	115	New pin to replaced 44.40.
47.20	2002	1	21	1	21	
51.50	2002	0	0	0	0	Not inventoried
53.00	2002	1.55	3	3	32	
Total			367		549	
Average		2.57		3.02		Avg. for 2003-2004 = 2.80

*Note: (-) data has not been collected at this time.

Ongoing monitoring, of existing and new pins to represent additional erosion sites, will be required before any firm conclusion can be drawn regarding the rate of erosion along the West Branch. However, to get an idea of the magnitude of the total sediment eroded away each year, if only one foot of erosion occurs at each erosion feature, this equates to 23,946 tons of sediment entering the stream each year [416,451 sq. ft.[5] x 1 ft x 115 lbs/cu ft x (1T/2,000 lbs) = 23, 946 T]. The actual number could be higher or lower, and only monitoring over time will give us an accurate number.

The following is taken from the report entitled *Assessment and Conceptual Design: West Branch Delaware River, Walton New York*, by Fisch Engineering, November 12, 2003. (This report was prepared under a contract with Fisch Engineering to assess conditions and make recommendations for restoration of two significantly eroding streambanks in the Village of Walton where private property and public infrastructure are at risk).

[5] See **Table 6.2**

> **"However, bank erosion in agricultural areas along the stream is likely higher than reference conditions, and areas devoid of good stands of riparian vegetation contribute a large amount of fine sediments to the stream.** (Emphasis added) These sediments are of concern not because they alter the channel stability, but because they contribute to water quality degradation for the system. Embeddedness is moderate and consists mainly of fine clays and *silts*[6]. **This condition is not unique to the mainstem of the West Branch of the Delaware, but was found to be true for virtually every tributary evaluated within the system, and is consistent with the glacial influence upon the landscape."** (Emphasis added)
>
> "No explicit assessment of the environmental character of the West Branch of the Delaware was conducted, but observation of the fish and macro invertebrate communities suggest that the system is healthy. Algal and aquatic plant growth suggest a high *nutrient* content, and the Upper West Branch of the Delaware was listed as impaired by the State of New York due to high phosphorous levels. **Continued erosion of the banks along reaches of the stream lacking riparian vegetation appears to be the primary contributor to the input of fine sediments and phosphorous."** (Emphasis added)

These remarks from Fisch Engineering's report are consistent with the visual observations made by DCSWCD personnel as they located features using GPS along the stream. Fine sediment is noticeable throughout the West Branch of the Delaware, increasing in the downstream direction. This is logical, as one would expect the fines to drop out as the river slope decreases and sediment transport capacity is reduced. The sources of the fine sediment could include the exposed and eroded river banks, overland runoff, drainage ditches, and remobilized sediment from the stream bed itself. Tributaries could also be a significant source of fines.

Of all the West Branch main stem's tributaries, only Town Brook was assessed. As was noted in the Geomorphic report for Town Brook (see **Section 6.6**), a conservative estimate would be 2,836 tons of gravel and sediment entering the main stem from this source each year. There are 18 identified tributary watersheds, which may be in better or worse condition than Town Brook. So, it is likely that these tributaries are also significant contributors of sediment and gravel, including the fines that were evident in the West Branch of the Delaware River. It cannot be definitively stated at the present time why there is a noticeable increase in fines coating the channel bottom on the reaches near Walton. However, this phenomenon is noticeable as one moves down the West Branch. The presence of fines coating the channel bottom not only adversely affects water quality but also negatively impacts fish propagation by smothering their eggs.

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[6] Editor's note: Clay material in the West Branch system generally doesn't settle out in the stream channel, and therefore does not significantly contribute to embeddedness of larger bed sediments. However, near Walton there is a noticeable increase of fines on the channel bottom. To date, the reason for this occurring has not been explained.

Another group of features that illustrate the erosion problem along this river is the amount of revetments that have been installed on its banks. **Table 6.5**, below, summarizes this information.

Table 6.5 Revetments/Repairs

Type	Number	Total Length (ft)
Stone Structures		
Dumped Stone	296	5262
Rip Rap	128	18110
Laid-up Stone	47	5364
Stacked Rock Wall	21	2963
Gabions	17	1730
Subtotal Stone Structures	509	33429
Berms	46	20722
Log Cribwall	30	4139
Concrete	23	1035
Sheet Piling	2	159
Other	8	1704
Log Deflectors	23	660
Total	**641**	**61848**

For the purpose of this assessment, revetments are considered to be maintenance and/or repair structures placed along the streambank to prevent erosion. Most revetments along the West Branch are of some sort of stone structure, with dumped stone predominating. This feature largely consists of field stone and cobbles dumped along the river bank; the intent is to decrease erosion. Rip rap is large stone that has been dumped or machine-placed. Laid-up stone is generally field stone that was hand-placed along the streambank, while *stacked rock walls* are larger rock, usually blockier in shape than ordinary field stone. *Gabions* are cuboid shaped wire baskets that are filled with stone, and the basket top wired shut. They are then stacked along the river bank.

Note that 46 berms have been constructed. Berms are ridge-like structures along streambanks, usually constructed of earth and stones. Their purpose is to raise the bank elevation to prevent the stream from overflowing. (They may also be called levees). These contribute to erosion because they deny the river access to its floodplain. Constraining flood waters increases the speed of flowing water, producing more shear stress and resulting streambank erosion. Since berms confine and increase floodwater velocities, they increase the damaging effects of floods downstream. This situation does not develop when the stream has access to its floodplain.

Log cribwalls are log structures constructed along the river bank and backfilled with stone. These structures were installed by the NYS Department of Environmental Conservation as part of a maintenance program over the last 40-50 years. The log deflectors were also installed during the same time period. These structures protrude into the stream channel and were designed to create streambed scour for fish habitat. Although technically not a revetment, they were inventoried as such for ease in assessment.

The remaining revetment or repair structures consist of concrete, both in the form of poured walls and concrete slabs dumped along the river bank. Sheet piling consists of long sheets of steel driven vertically into the riverbed along the bank. The remaining eight structures represent miscellaneous efforts at erosion control.

Stream length surveyed was 49.5 miles, or 99 miles of river bank. So, there has been an average of 6 structures made per mile of riverbank, which equals about one repair every 880 feet of riverbank or one repair approximately every 6 (average) bank full widths. The average revetment is 96.5 feet long, and 12% of the river bank has been revetted. This certainly illustrates the magnitude of the erosion problem that riverbank property owners have been trying to cope with. **Table 6.6**, below, shows the number of, type of, and length of revetment and repairs for each management unit.

Table 6.6 Revetment and Repair by Management Unit.

Segment	Management Units	Length (mi)	Dumped Stone	Rip Rap	Laid-up Stone	Stacked Rock Wall	Gabions	Log Cribwall	Concrete	Sheet Piling	Other	Log Deflectors	Total Revetment Length (ft)	Revetment Length per mile	Berms	Berm Length (ft)
1	1	0.57	-	-	2	-	-	-	-	-	-	-	58	102	1	146
	2	0.70	1	13	10	-	3	-	4	-	1	-	2663	3804	4	385
	3	0.59	-	3	2	-	-	-	-	-	-	-	107	181	-	-
	4	0.37	5	5	2	-	-	-	1	-	-	-	1485	4014	-	-
2	5	2.55	3	8	4	4	-	-	1	-	-	-	2438	956	-	-
	6	0.76	2	5	4	-	-	-	-	-	-	-	1154	1518	-	-
	7	0.38	-	3	3	-	13	-	2	-	-	-	2403	6324	-	-
	8	0.39	1	3	1	-	-	-	-	-	-	-	381	977	-	-
	9	1.99	10	26	2	-	-	4	2	-	-	10	5146	2586	9	3155
	10	1.65	7	12	3	-	-	5	-	-	-	10	3884	2354	3	2079
	11	0.96	4	3	4	-	1	1	-	1	-	-	1690	1760	1	105
	12	4.89	34	18	3	-	-	14	2	-	-	3	11124	2275	5	1211
	13	1.20	2	1	-	-	-	-	-	-	-	-	1413	1178	4	3464
3	14	4.60	33	3	1	-	-	3	-	-	-	-	8646	1880	8	4924
	15	1.67	10	5	1	-	-	-	-	1	-	-	3988	2388	3	1922
	16	1.27	6	2	-	1	-	-	1	-	-	-	794	625	-	-
	17	0.87	11	1	-	11	-	-	4	-	-	-	3118	3584	-	-
	18	1.12	10	3	-	-	-	-	-	-	-	-	1563	1396	1	448
	19	2.84	10	1	1	1	-	2	1	-	-	-	3271	1152	-	-
4	20	1.75	5	-	-	1	-	-	-	-	-	-	190	109	1	836
	21	2.97	29	5	-	1	-	1	2	-	1	-	6625	2231	3	980
	22	1.03	6	-	-	-	-	-	-	-	1	-	976	948	-	-
	23	0.64	10	-	-	-	-	-	-	-	-	-	1275	1992	-	-
	24	2.35	21	2	-	-	-	-	1	-	2	-	5433	2312	1	159
5	25	2.21	21	-	-	2	-	-	-	-	1	-	3772	1707	1	399
	26	0.84	10	-	-	-	-	-	-	-	-	-	1808	2152	-	-
	27	1.58	14	-	-	-	-	-	-	-	-	-	3272	2071	-	-
	28	1.86	11	5	-	3	-	-	-	-	-	-	5324	2862	-	-
	29	4.44	28	1	-	1	-	-	3	-	-	-	3681	829	1	509

Japanese knotweed may be a contributing factor to streambank erosion. Considered an undesirable and *invasive plant* species, knotweed colonizes river banks and grows in thick stands that out-compete indigenous riparian vegetation. Knotweed may facilitate erosion of stream banks, especially during winter months when it provides little or no soil surface protection. During the 2003 and 2004 field seasons 70,115 linear feet of knotweed stands were documented on both river banks over a distance along the river of 165,502 feet. Approximately 20,000 linear feet of erosion was noted at knotweed stands that were located at the water's edge. Research is continuing, but at the present time it is not known if knotweed establishes itself at banks that are already eroded, or if it establishes itself and then erosion begins. What is known is that wherever knotweed is established, there is erosion. Japanese knotweed will not provide a sufficient vegetative barrier to prevent erosion and stabilize banks (see **Section 5.10.4** for additional information concerning Japanese knotweed).

6.2.4. Summary of Geomorphic Condition of the West Branch

Overall, the following can be said about the main stem of the West Branch of the Delaware River:

- The stream exhibits a tendency to be wider than is desirable. This could be due to lateral erosion, excess sediment load, or a combination of management approaches that leads to erosion and a reduced sediment transport ability.

- The stream exhibits a tendency to aggrade. Sources of sediment include exposed and eroded river banks and the river's tributaries.

Fine sediment that coats the rocks on the channel bottom becomes particularly noticeable near Walton. Its exact cause is unknown, but it is probably due to some combination of fine sediments entering the stream from eroding banks, the upper main stem or tributaries, low energy gradients, and wide channels.

- Bank erosion is widespread throughout the whole length of the river. Recall that type C streams are susceptible to lateral erosion particularly if riparian vegetation is inadequate.

- Review of aerial photographs from 1938, 1961, 1971, and 1983 show that plan form has remained relatively unchanged since 1938. Over the entire length of the river, sinuosity is slightly low (1.15) for the stream type and valley setting but is not considered a problem. Straight stretches of stream do exist and are readily identifiable from aerial photographs. Presumably, some of these straight reaches are due to alteration to the stream's natural winding course. The stream at these locations was probably moved for the construction of railroads or highways, or to form contiguous acreage for planting or pasture. It appears that most stream relocation and straightening took place in the 19th to the early 20th century prior to 1938.

Figure 6.4 Severely eroding bank in the Village of Walton (December 2004).

6.3. West Branch Vegetation

6.3.1. Evaluation of Land Use and Riparian Vegetation Communities

Section 5.10.1 reviewed the importance of forest land in regulating the hydrology of a watershed, and the role of riparian vegetation in maintaining the stability of river as well as providing for *aquatic habitat*, and other benefits. This section provides a summary of the findings of two sets of analyses conducted to provide: an overview of land use/cover within the West Branch of the Delaware River and examine the structure of riparian vegetation along the river. The general analysis for the entire watershed was based on a land use classification derived largely from satellite imagery of the entire Cannonsville basin, while the analysis of riparian vegetation involved the mapping and classification of ecologic communities within a 300 foot buffer of the river between Stamford and the Cannonsville Reservoir.

Watershed Land Use/Land Cover Analysis

Section 5.7 generally describes the land use and land cover for the West Branch of the Delaware River watershed. **Map 5.8** provides a map of land cover based upon a classification of 1992 Landsat imagery for the project area. Recent efforts by the NYCDEP have produced updated maps and a set of statistics for the current land use/land cover in the basin under the New York City Watersheds 2001 Land Use/Land Cover Classification Project. The maps and underlying database for this project were derived by selectively merging data from various imagery and GIS datasets.[7]

As with the 1992 Land use classification and as shown in **Figure 6.5**, below, deciduous forests dominate the watershed landscape, comprising approximately 68 percent of the area. As shown in **Map 5.8**, the bulk of the forest land covers the higher elevations and steeper slopes. Brushland or successional land (11%) typically occurs in the mid-elevations to lower slopes, or upper portions of sub-watersheds. Agricultural land (10%) is commonly on the level flats of the river bottom lands. Urban or built up lands make up only about 6% of the watershed area, and are chiefly found on the alluvial fans and *terraces* along the mainstem and principal tributary valleys. The large proportion of successional land indicates a transition from agriculture to new forests, a trend over the last several decades.

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[7] These included: 2001 Landsat Enhanced Thematic Mapper Plus (ETM+) satellite imagery (5 April, 2001; 8 June, 2001; 10 July, 2001, and 12 September, 2001), April 2001 color infrared orthoimagery (NYS 1 foot resolution) and Emerge 0.3 meter resolution, Tax Parcel Data, and National Wetland Inventory polygon data. These data were used to produce a land use/land cover classification based upon a slightly modified version of the USGS Anderson Level II-IV standard. This is the result of a classification of land use using a modified version of Anderson land use classification system (Anderson et. al., 1976). The Anderson system was devised by the USGS to update existing widely used classification systems and provide Federal, State and local government agencies with a standard system of defining land use from remotely sensed imagery. The system allows the user the flexibility to define increasingly detailed categories of land use as it progresses from Level I through Level IV. For the purpose of this plan, the summary will provide the statistics in the more general categorization of the Anderson Level I and Level II standards.

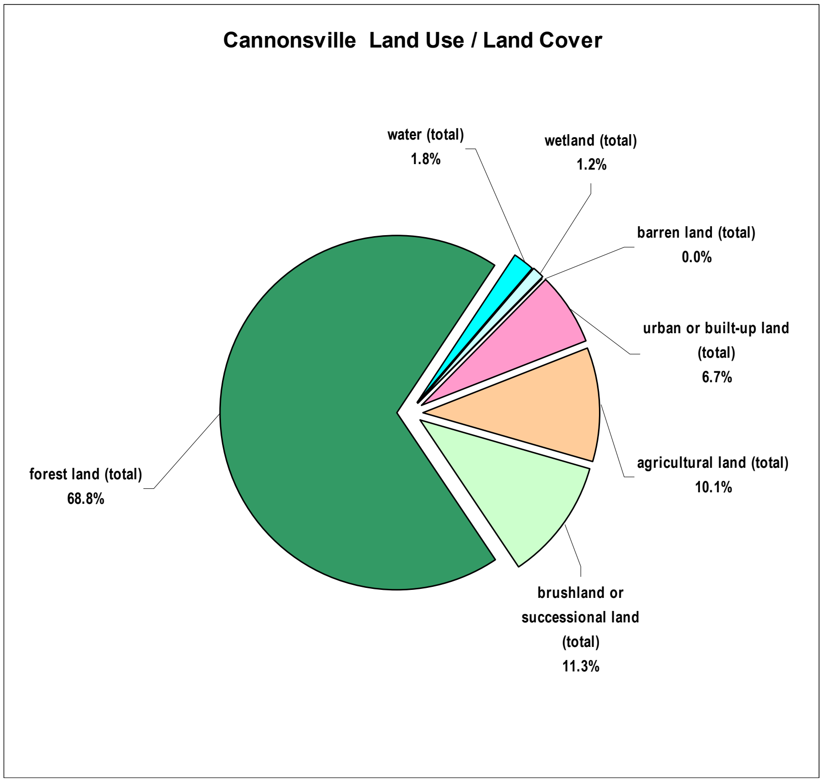


Figure 6.5 Cannonsville Land Use/Land Cover in percentages

When examining land cover in the valley along the river corridor (i.e., not the entire watershed), the intensity of land use increases; less land was left as forest while more land is actively farmed. For land use within 1000 feet of the river, the mix is approximately 33 percent forested, 23 percent agricultural and 14 percent shrubland or transitional. *Wetlands* (7%) also are a significant portion of the land cover in this principally riparian zone.

A Closer Look

The presence of riparian forest vegetation acts as a "buffer" or shock-absorbing feature, adding to stream corridor stability. As the streamside buffer lands were of primary concern, detailed mapping was performed on the riparian corridor and near adjoining upland areas within 300 feet of the main stem's riverbanks. The purpose was to develop information on the condition of the riparian buffer and to identify locations where additional vegetation could be established to improve buffer function. A greater level of detail was needed to assess the condition of the riparian buffer, so high-resolution Digital Ortho Quarter Quadrangle (DOQQ) aerial photographs were used to produce a map. Mapping included the approximate delineation of ecological communities through the photo interpretation of "Emerge" digital orthophotography acquired by New York State in 2000.[8] Later, a similar assessment was made for the riparian zone along Town Brook.

[8] The classification of the land cover by ecological community based upon the New York Natural Heritage Program's (Reschke, et al. 2000) definitions was created as a GIS data layer using heads-up digitizing techniques with ESRI's Arcview and Image Analyst softwares. Photo interpretation was field checked with class boundaries and classification amended based upon field observations. The classification was then translated in to an Anderson Level II land use/land cover classification comparison with other datasets and analysis for this report.

The land use/land cover maps resulting from this process accompany each management unit, but a summary table of land use/land cover is found below (**Table 6.6**), and a map of a portion of the main stem (**Figure 6.6**) is displayed on the following page.

The table below summarizes the land use/land cover distribution for lands within 300 feet of the mainstem between Lake Utsayantha and the Cannonsville Reservoir.

Table 6.6 Land Use/Land Cover within 300 ft. buffer width along West Branch main stem

Riparian Land Use/Land Cover Distribution

Anderson Level II	Acreage	%
Cropland and Pasture	1052.3	28.8%
Mixed Forest Land	661.7	18.1%
Herbaceous	447.1	12.2%
Mixed Brush	428.9	11.7%
Deciduous Forest Land	405.9	11.1%
Transportation, Communications and Utilities	129.3	3.5%
Residential	119.3	3.3%
Wetland	115.5	3.2%
Commercial and Services	72.3	2.0%
Shrub and Brush	64.5	1.8%
Water	63.4	1.7%
Coniferous Forest Land	54.6	1.5%
Strip Mine, Quarries and Gravel Pits	30.0	0.8%
Exposed Bare Rock	5.9	0.2%
Other Urban or Built Up Land	1.8	0.1%
Grand Total	**3652.5**	**100%**

Compared with the watershed-wide statistics, the amount of land in forest is significantly less (approximately 30%), with agriculture comprising approximately 40 % of the riparian zone.

The most serious issue with the riparian buffer for the West Branch of the Delaware appears to be its structure. A functional riparian buffer needs to be both sufficiently wide and continuous to minimize channel migration, and to insure adequate capacity for trapping nutrients, pollutants and sediment from surface runoff. A narrow buffer or a buffer with gaps is easily breached by the river during flood events. The river then scours out high flow channels and erodes open land behind the buffer. A narrow buffer allows bank erosion to strip away whole chunks of the bank along with individual trees and shrubs. A narrow vegetative buffer also does not adequately trap nutrients or meet cover requirements of aquatic life.

Along the West Branch Delaware where agriculture is most intense, the riparian buffer is especially narrow, and in many places is absent. Where it does exist, its width is commonly about 50 feet wide. Areas where it is wider are typically either not tillable, subject to inundation, or include steep slopes that preclude development.

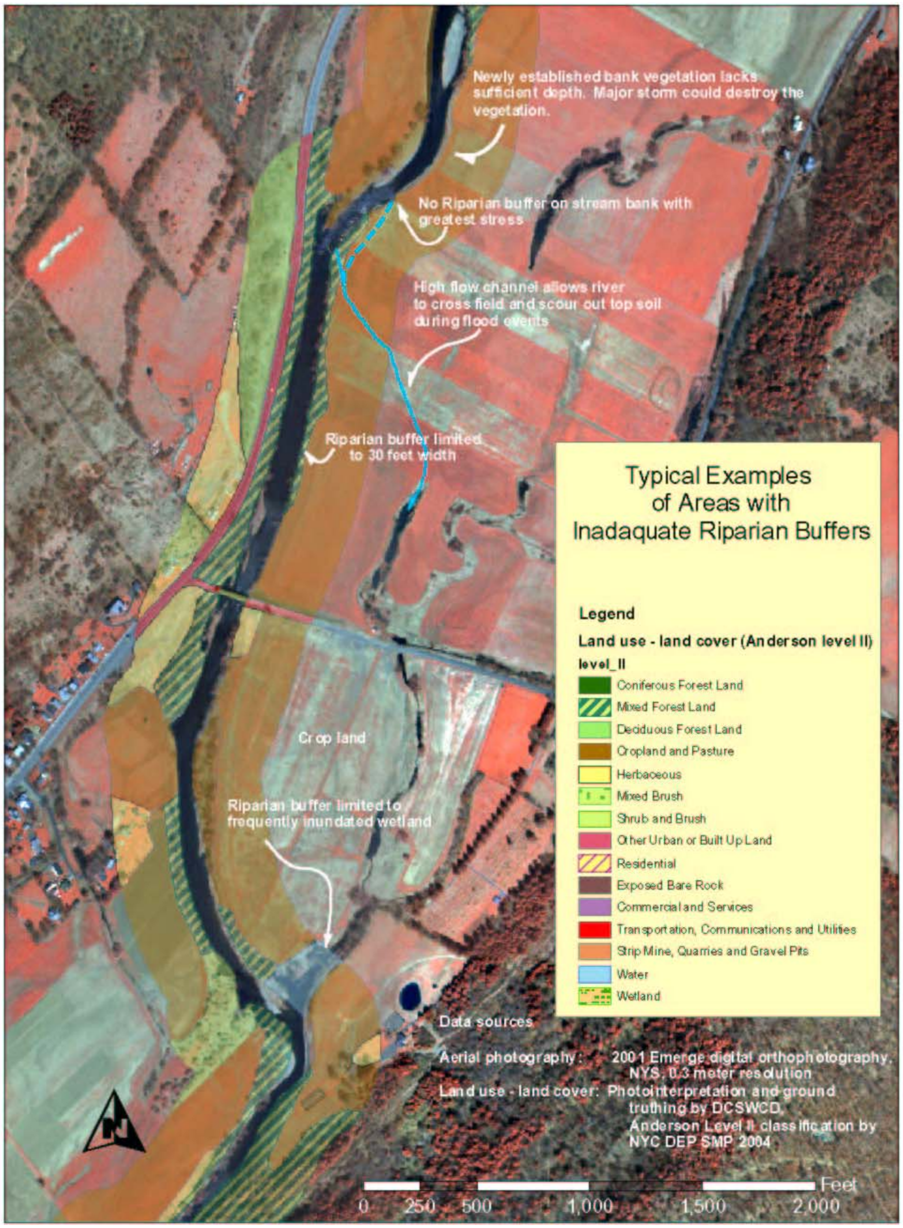


Figure 6.6 Photo of portion of West Branch main stem showing various land use/land cover characteristics.

NYCDEP's minimum recommended width for riparian forest buffers should be 100 feet, with wider buffers established where the river has historically attempted to utilize secondary channels or where stress and *erosion potential* on meander bends would warrant additional protection.

Using the 2000 high resolution aerial photography for the watershed, a map was created to indicate locations that would benefit from riparian forest buffer establishment or where additional land should be set aside and reforested to augment existing buffers. This review identifies areas where either no buffer exists or the existing buffer is inadequate. Relative adequacy was defined by width of the riparian buffer (< 100 ft = inadequate), type and density of vegetation (herbaceous or sparse tree and shrub cover = inadequate). The maps shown in **Section 7** are simply a cursory review of the buffer condition. **Table 6.7**, below, provides an estimate of the length of land fronting on the river that should receive consideration for riparian buffer establishment, enhancement or protection. Given that the total length exceeds 10 miles, it is clear that the size of the task is enormous and that additional prioritization based upon erosion threat, channel and floodplain considerations, runoff and nutrient sequestration concerns is required. From this cursory review, active agricultural land, which constitutes 44% of the inadequately buffered land, should be the primary target for riparian buffer establishment efforts –as under the Conservation Reserve Enhancement Program (CREP, see **Section 6.3.2**). Land that is already in a successional shrub stage or floodplain forest (30% of the inadequately buffered land) should also be considered for buffer enhancement/protection efforts. Landowners with mowed lawns (11% of the total) typically associated with residential property should be included as a target audience for riparian buffer efforts.

Figure 6.7 Natural riparian forest buffer near the Village of Stamford. Note abundance of vegetation and lack of erosion. Stream also has noticeable natural riffle-pool sequence.

Table 6.7 Estimated length of riparian buffer requiring establishment or enhancement (un-prioritized)

Ecological Community	Length ft.	Percentage
Cropland/field crops	15935	28%
Floodplain Forest	8783	15%
Successional Old Field	7070	12%
Cropland/row crops	5417	9%
Pastureland	4268	7%
Mowed Lawn	4121	7%
Shrub Swamp	2575	5%
Successional Shrubland	1883	3%
C.R.E.P.	1847	3%
Mowed Lawn w/ trees	1020	2%
Residential	889	2%
Closed Northern Hardwood	794	1%
Hemlock-Northern Hardwood	646	1%
Successional Northern Hardwood	495	1%
Shallow Emergent Marsh	430	1%
Open Northern Hardwood	305	1%
Commercial	194	0%
Unpaved road/path	174	0%
Conifer Plantation	75	0%
Paved road/path	59	0%
Brushy Cleared Land	43	0%
Gravel Mine	33	0%
Mixed Open Tree Canopy	30	0%
Riprap/erosion control roadside	30	0%
Backwater Slough	13	0%
Pine-Northern Hardwood	10	0%
Grand Total	57139	100%

Although CREP is making a significant contribution to improving riparian buffers in the watershed, additional programs that address non-agricultural land or abandoned agricultural land should be considered as possible outcomes of this planning process.

6.3.2. Conservation Reserve Enhancement Program

On August 26, 1998, New York City entered into a Memorandum of Agreement (MOA) with the United States Department of Agriculture (USDA) and New York State to implement a Conservation Reserve Enhancement Program in the Catskill and Delaware Watersheds. This MOA allows watershed landowners to enter into 10 to 15 year contracts with the USDA to retire environmentally-sensitive agricultural lands from production. CREP helps establish forested or grass riparian buffers adjacent to watercourses and provides for fencing watercourses to exclude livestock. The USDA pays the producer an annual rental rate per acre of retired land and 50 percent of the cost of all CREP Best Management Practices (BMPs) associated with establishing the riparian buffers, permanent grass and/or exclusionary livestock fencing, (which usually include alternative water systems). USDA also provides for signup incentive and practice incentive payments. New York City pays the remaining 50 percent of BMP costs for participating farms and technical and administrative assistance costs through its agreement with the Watershed Agricultural Council (WAC)[9] located in Walton, New York.

Figure 6.8 CREP buffer with fencing. Note brush mats and tree tubes (lower right) to protect seedlings and facilitate growth.

Most CREP implementation in the West Branch watershed consists of the establishment of riparian forest buffers through tree and shrub plantings and exclusionary livestock fencing, both of which are CREP priorities (**Figure 6.8**). Riparian forest buffers of sufficient width intercept sediment, nutrients, pesticides and other materials in surface runoff and reduce nutrients and other pollutants in shallow subsurface flow. Woody vegetation in buffers provides food and cover for upland wildlife, helps lower water temperatures by shading the stream, and slows out-of-bank flows. The vegetation closest to the stream provides litter fall and large woody debris important to aquatic organisms. Woody roots also increase the resistance of streambanks to erosion. A riparian forest buffer consists of 2 or 3 vegetation zones as shown and described in **Figure 6.9** below.

[9] The WAC is a non-profit organization funded by New York City, USDA Forest Service and other federal and foundation sources. Their mission is to support the economic viability of agricultural and forestry through the protection of water quality and the promotion of land conservation in the New York City watershed region through various conversation programs. See **Section 4.5** for additional information.

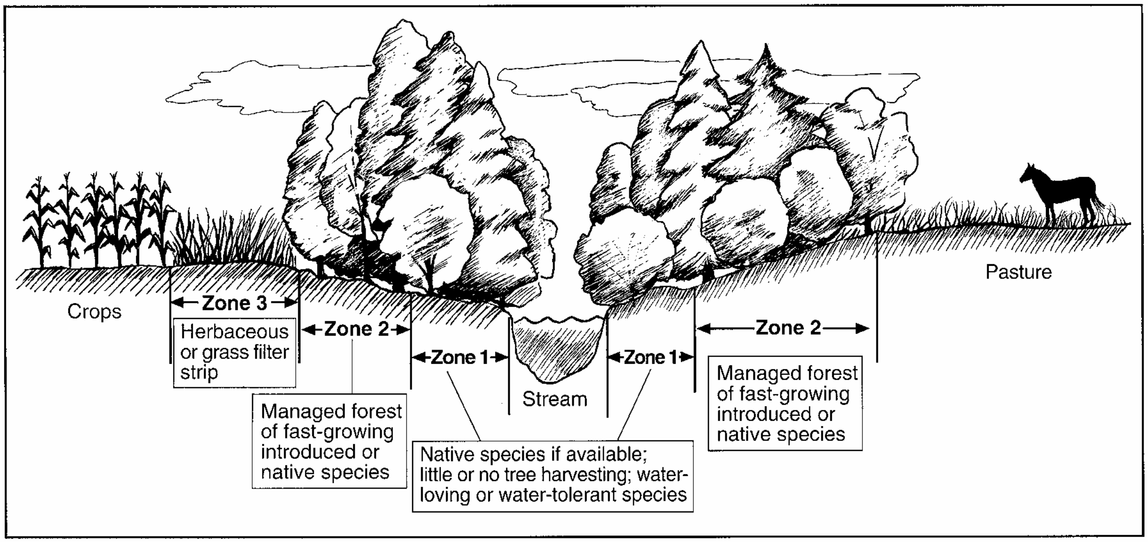


Figure 6.9 Illustration of riparian forest buffer zones

A riparian forest buffer zone includes zone 1, the area closet to the stream, and zone 2 the area adjacent to and up gradient of zone 1. Trees (67%) and shrubs (33%) in zone 1 help stabilize streambanks and provide habitat and shading. Shrubs (67%) and trees (33%) in zone 2 intercept sediment, nutrients and other pollutants. A third zone, zone 3, is established if periodic and excessive water flows, erosion, and sediment from upslope fields are anticipated. Zone 3 is usually herbaceous plants or grass. This zone provides a "first defense" to assure proper functioning of zones 1 and 2. The allowable minimum buffer width is 35 feet from the top of the streambank.

Figure 6.10 Fenced livestock crossing with animal walkway.

Since streams have long been the primary source of water for livestock, alternative water supplies, usually from on-site springs, are developed where streams are fenced out. In many instances, a dedicated livestock crossing is constructed with a fenced animal walkway through the CREP area. Crossings usually consist of specially designed concrete slabs placed at grade in the streambed, which provides a stable base for livestock traffic (**Figure 6.10**). Animal walkways usually consist of a gravel surface placed over filter fabric material. All CREP BMP's are planned, designed and constructed by New York City's Watershed Agricultural Program (WAP)[10] and according to USDA Natural Resources Conservation Service (NRCS) standards and

[10] This program is responsible for Whole Farm Planning on volunteer farms in the West Branch and surrounding New York City water supply watersheds. See **Section 4.5** for additional WAP information.

have operation and maintenance requirements. Other requirements include a sixty percent survival rate of planted woody vegetation after the first year. This is to ensure that the remaining tree and shrub vegetation will meet the intent of the riparian forest buffer standard as designed to enhance water quality.

To date, approximately 1100 acres of CREP have been implemented on 79 farms in the West Branch basin. It is important to note CREP cannot be implemented on unstable streambanks. Consequently, there are areas identified and prioritized in the watershed that require some form of bank stabilization to facilitate CREP implementation. The current CREP authorization expires September 30, 2007. Currently, the Stream Corridor Management Program and the WAP are working together to further prioritize and plan bank stabilization projects for areas in greatest need of CREP implementation. See **Section 2, Recommendations**, for future recommendations.

Figure 6.11 Newly implemented riparian forest buffer system, with exclusionary fencing, and newly planted trees in brush mats.

6.4. Public Infrastructure[11]

Within the boundaries of the West Branch basin exists a network of highways and bridges under three separate ownership and maintenance categories: New York State, Delaware County, and townships. They are all part of an infrastructure system on an inventory maintained by the New York State Department of Transportation (NYSDOT). Highways are inventoried according to political jurisdiction with subcategories including pavement type. All bridge structures with a span of 20 feet and greater are inventoried, numbered, rated, and periodically inspected for condition and safety by NYSDOT. In Delaware County, bridges on town highways with a 20 foot span and greater are inventoried, numbered (in addition to the NYSDOT inventory and numbering system), maintained, and periodically inspected for maintenance or repair scheduling by the county. On county highways, all structures with a span of 5 feet or greater are managed as bridge structures. Structures on town highways with less than 20 feet of span are the individual town's responsibility and are not inventoried by the county or state.

Note: **Map 6.1,** a map of the highway system in the watershed, is included at the end of this section. Following is a brief description of this highway system.

The three state highways are NYS Route 10, which parallels the West Branch main stem on the north for the entire length of the watershed; NYS Route 28, which runs in a general north-south direction through the towns of Meredith, Delhi and Bovina, intersecting NYS Route 10 in the Village of Delhi; and NYS Route 23, which runs in a general northwest-southeast direction through the towns of Kortright, Harpersfield and Stamford, intersecting NYS Route 10 in the Village of Stamford. These are major routes in the watershed and are constructed and maintained according to strict NYSDOT standards. State highways are owned in fee by the State of New York.

Portions of nine county highways traverse the watershed and three lie completely within the basin. County Route 18 runs from the Village of Delhi to the Village of Stamford and parallels the West Branch main stem to the south. The remaining county highways are located along tributary streams and with the exception of County Routes 5 and 22, traverse into neighboring watersheds. County highways are all paved, most with oil and stone surface and a few with bituminous concrete (blacktop). Some county highways have been constructed to NYSDOT standards. Some county highway mileage is owned in fee by the County of Delaware and some is public right-of-way by usage according the New York State Highway Law.

Most of the highway mileage in the watershed is divided among the jurisdictions of nine townships (the Town of Andes has negligible mileage in the basin and Roxbury has none). These roads run along streams, over mountaintops and connect with each other and the state and county highways. The roads that parallel the West Branch main stem to the south between Delhi and Hamden, and Hawleys' Station and Walton are town roads (there are no roads along the river between Hamden and Hawley's Station). Town highways are constructed to various standards, with many having been constructed or rehabilitated to the Erwin and Donovan standards developed and financially supplemented by New York State from the period of 1952 through 1982. Town highways feature a variety of surfaces including improved dirt, gravel, or oil and stone. Most town highway mileage is public right-of-way by usage according the NYS Highway Law.

[11] This section has been contributed to in part by Phil Pierce, P.E., Deputy Public Works Commissioner and John Reynolds, Senior Engineer, both with the Delaware County Department of Public Works.

Many of these highways are in close proximity to streams and rivers, often crossing them. Highway maintenance can affect stream dynamics and water quality as a result of roadside drainage management, road surface repairs, bridge rehabilitation or replacement, snow and ice removal, and bank stabilization (which may be between the road and the stream).

Many reaches of streambanks in proximity to roads have been stabilized primarily with dumped stone or riprap. Stacked rock walls and gabion baskets filled with stone are also fairly common along highway streambanks. Although there are 641 revetments along the West Branch main stem (see **Table 6.5, Section 6.2.2**), many of them are not the result of highway maintenance since highways paralleling the West Branch are generally not close to the river. Most highway related revetments are in the narrower tributary valleys along town highways or where streams (including the West Branch main stem) flow through villages. Most revetments along county highways are associated with bridge crossings. It is important to note that many revetments where streams and roads share a common slope were constructed or repaired during the aftermath of the January 1996 flood event.

Along some reaches, roadside drainage management impacts stream dynamics and water quality. Ditching practices and culvert sizing, placement and outfall protection all have drawn recent attention to highway and stream managers. The Delaware County Action Plan (DCAP) is currently developing and implementing programs for better management of highway infrastructure related to drainage and stormwater management (see **Section 4.6**).

Bridges are perhaps the key management issue between highway infrastructure and stream management. Of the 117 bridges in the West Branch watershed, thirty-one are on state highways (22 on NYS Route10, 3 on NYS Route 28 and 1 on NYS Route 23). Forty-six are county bridges on county roads, thirty-four are county bridges on town roads, and six are county bridges on village streets. Fifteen of these structures cross the West Branch main stem: five state bridges and ten county bridges (3 on county roads, 5 on town roads, and 2 on village streets).

Figure 6.12 Wide and shallow flow around a gravel bar downstream of county bridge 33-1 on County Route 33, just north of Bloomville

Stream flow through many bridges during periods of low flow exhibit the characteristics of a stream that is too wide and too shallow, resulting in lack of adequate energy to effectively transport its sediment (see **Section 5.9.2** for description of width/depth relationship and sediment transport). This can result in deposition downstream of or inside the structure, which in turn creates further flow issues (**Figure 6.12** above). Other bridges exhibit deposition upstream of the structure which is indicative of a backwater effect. Woody debris accumulations are another common concern at bridge crossings.

Figure 6.13 Floodplain relief culverts installed at County Bridge 2-1 in Delancey. Photo taken looking upstream, March 21, 2003

At some bridge crossings the highway approaches are elevated above the floodplain elevation. This creates an obstruction to floodplain flow, forces overbank flows under the bridge, and can create flood debris accumulation under the bridge. One solution that is being evaluated is the placement of culverts under the approaches to allow for some continuity of flood flow across the floodplain. This method has been applied where County Route 2 crosses the West Branch in Delancey (County Bridge 2-1, **Figure 6.13**). Although this application has met with some success, the practice is still being evaluated to determine its effectiveness.

On the town level, common concerns focus on culvert design and permitting to work within streams that are close to the roads. Most towns have some sort of ditch maintenance policy in place. There is interest in financial and technical assistance with drainage maintenance, and protection of roads close to streams.

6.5. <u>Public Outreach</u>

Outreach efforts consisted of a series of presentations and tours outlining the program goals, objectives and status updates of our ongoing research. The initial informational meeting was held on January 18, 2001 to introduce prospective Project Advisory Committee members to the program. A series of presentations were made to various agencies and organizations throughout the remainder of 2001.

In 2002 and 2003 a number of presentations were made in each of the major towns along the West Branch main stem and to the Delaware County Board of Supervisors. An additional presentation was made to a contingent of watershed farmers in November, 2002. This meeting was especially valuable because it featured a Pennsylvania farmer who had developed a good understanding of stream processes and the geomorphic approach and changed many management practices on his farm accordingly, with positive results.

In addition to presentations to agencies and organizations, efforts in 2004 included two tours of the David Post *demonstration project* site, further described in **Section 6.7** below.

A list of presentations and tours follows:

Program Outreach Efforts
(Presentations unless otherwise noted)

Date	**Audience**
2001	
January 18	Program introduction meeting, invited attendees
March 7	Delaware County Phosphorus Study Group (includes Delaware County Board of Supervisors)
March 14	Trout Unlimited, Susquehanna Chapter
April 4	Cornell University class field trip to Richard Latourette project (restoration project done through the Watershed Agricultural Program prior to inception of the Stream Corridor Management Program)
July 11	US Army Corps of Engineers representatives
July 19	NYS Attorney General's office representatives
September 21	NYS Departments Health and Environmental Conservation (DEC) US Environmental Protection Agency (EPA), and NYC Department of Environmental Protection (NYCDEP) (the Stream Corridor Management Program was a venue on Cannonsville watershed tour hosted by Delaware County Department of Watershed Affairs)
December 20	NYS DEC Division of Water representatives
2002	
April 1	Town of Harpersfield board
April 15	Town of Kortright board
April 30	Board of Cooperative Educational Services class - Masonville campus
May 9	Town of Stamford board
July 2	Town of Middletown board (East Branch basin, requested by supervisor)
October 8	Delaware County Phosphorus Study Group
November 6	Watershed farmers

2003	
May 7	Town of Hamden board
May 13	Town of Delhi board
May 21	Delaware County Board of Supervisors
November 13	Cannonsville watershed tour for NYCDEP Stream Program Advisory Board, West Branch Project Advisory Committee (PAC), and neighboring Soil and Water Conservation Districts

Date	**Audience**
2004	
January 29	Hobart Rotary Club
March 5	Delaware County Board of Supervisors
July 7	US EPA representatives
August 5	Watershed Agricultural Program staff
August 18	David Post project site tour (PAC and agencies)
September 2	O'Connor Foundation (local funding entity)
October 20	David Post project site tour (DEC Division of Water Representatives)

Education on the Importance of Floodplain Function

During the development of this plan, it has become apparent that further education is necessary on the importance of floodplain function (see **Section 2, Recommendations**). Following is a brief discussion on floodplain function.

"The floodplain is defined as the flat area bordering a stream, constructed by the river in the present climate and inundated during periods of high flow." (Leopold, 1997). The floodplain has key roles in stream function, perhaps the most important being energy dissipation during overbank flows. The normal elevation for the floodplain is the bankfull elevation. Water flows that are higher than bankfull will flow across the floodplain with a much lower velocity than in the main channel in a properly functioning riverine system (**Figure 6.14**). The floodplain also acts as a storage area for floodwaters. Another important function of the floodplain is for deposition of fine sediments during high flows – in other words, a sediment trap. These sediments facilitate seed generation on the floodplain. Another way to state the relationship between the channel and floodplain is that the floodplain, like the channel, ***is part of*** the stream.

Figure 6.14 Photo of overbank flow taken just downstream of the Village of Stamford, March 21, 2003.

Assessments identified numerous locations where attempts to protect lands along the stream through the construction of berms and walls limited the river's access to its floodplain. Other channel modifications that are commonly advocated, but can disconnect the floodplain or reduce its function include deepening the channel and widening the channel

Development within the floodplain also restricts its function. Constructing buildings in the floodplain, especially large complexes, reduce the capacity of the floodplain. Further, flow around floodplain obstructions causes scour, which in turn introduces additional sediment into the system. Aside from damage to the floodplain and the structure, this additional sediment becomes deposition further downstream.

Misunderstanding or ignoring the importance of the floodplain can result in actions which reduce sediment transport capacity, accelerate erosion or shifts problems from one location to other sections of the river system. An education effort highlighting the importance of preserving floodplain function will promote expanded stewardship of the river and ultimately result in greater stream stability.

6.6. Geomorphic Condition of Town Brook

6.6.1. Introduction and Overview of Drainage Basin

The summer of 2003 was extremely wet. Unseasonably high water levels in the West Branch prevented much Rosgen Level II work from being performed but it did seem possible to assess a tributary stream instead. Since NYCDEP, NYSDEC, Cornell University and the Watershed Agricultural Program had various research projects ongoing in the Town Brook sub-basin, a Global Positioning System (GPS) walkover and Rosgen Level II surveys were performed during the 2003 field season.

Town Brook is 7.58 miles long with a drainage area, upstream of the gage near Hobart, of 14.3 square miles. The stream begins at an elevation of 2400 feet and joins the West Branch Delaware River at 1600 feet. The overall stream slope is 0.02 ft/ft (2.0%). The valley that it runs through is a Type V valley. The uppermost 0.9 miles of town Brook is a Type B stream, and where it crosses under Davis road it begins to transition to a Type C stream. Ten tributaries to Town Brook are identified on USGS topographic maps. There are also numerous intermittent swales that direct flow to the stream during rainstorms, but are not mapped as streams. The watershed is primarily used for farming, and about 20% is forested. There is very little urbanization, and what there is tends to be concentrated in the Village of Hobart at the lowest end of the watershed. Some residential development is occurring along Town Brook Road between the Village of Hobart and the upstream reaches of the watershed.

6.6.2. Data Collection

Geomorphic data were collected along 6.2 miles of stream during 2003 using a Global Positioning System receiver. The data was incorporated into a Geographic Information system (GIS) and then located on aerial photos for mapping and analysis. No data were collected along one reach near the midpoint of Town Brook, because we were denied access by the landowner. The data collected included:

- The location of and the degree of severity of eroded banks.
- The location of *head-cuts* and other evidence of erosion.
- The location of revetments, rip-rap, and other similar erosion control measures.
- The location of depositional features such as side bars and center bars.

Rosgen Level II surveys were performed at selected locations. Information collected included:

- Surveyed stream cross sections.
- Pebble counts at the surveyed cross sections.
- Documentation of bankfull indicators.
- Bulk gravel samples (bar samples).

6.6.3. <u>Current Conditions of Town Brook</u>

When the GIS and Rosgen Level II data were analyzed, the following problems became apparent:

- Un-vegetated and clearly eroded banks.
- High banks, which indicate that the stream is incised.
- Existing revetments and erosion repairs.
- Head cuts.
- Transverse bars.
- Mid-channel bars and side bars.
- Channel widths that are too wide for their depth.

As described in **Section 6.2.2**, the processes of stream erosion and deposition go together. A spiral of erosional and depositional events can occur, the result of which is the destabilization of the stream.

Figure 6.15 High eroding bank on Town Brook just below cross-section 10.

Table 6.8 Summary of various physical properties for 14 cross-sections in Town Brook

1	2	3	4	5	6	7	8	9	10	11	12	13
Cross-section #	Stream Type	Drainage Area (mi^2)	Bankfull Width W_{bf} (ft)	Bankfull Depth d_{bf} (ft)	Bankfull Area A_{bf} (ft^2)	Width/Depth Ratio (W_{bf}/d_{bf})	Entrenchment Ratio	D84 (mm)	Aggrading/ Degrading/Stable	Sinuosity	Stream Slope (%)	Profile Length (ft)
1	B4	1.30	12.1	0.8	10.0	15.1	1.65	146	A	1.1	2.50	225
2	B4	1.60	18.4	1.0	17.8	18.4	1.58	152	A	1.1	2.90	1317
3	C4	3.12	37.9	0.9	33.2	42.1	1.16	142	D	1.2	1.75	432
3.1	C4	3.12	30.1	0.8	25.3	37.6	1.63	140	A	1.2	1.47	432
4	C4	3.20	35.1	0.8	29.8	43.9	8.55	109	A	1.1	1.30	494
4.1	C4	3.20	29.4	1.1	30.9	26.7	10.20	125	A	1.1	1.30	494
5	C4	7.80	22.4	1.4	32.3	16.0	13.39	140	A	1.2	0.97	482
6	C4	7.80	30.8	1.3	40.6	23.7	8.12	108	A	1.2	0.42	482
7	C4	9.18	43.5	1.0	43.8	43.5	4.14	156		1.1	1.82	484
8	C4	9.18	37.4	2.9	60.1	12.9	5.35	175		1.1	1.56	484
9	C3	12.50	35.4	1.9	66.3	18.6	5.08	237		1.1	1.25	735
10	C3	12.50	30.9	1.8	56.2	17.2	5.82	180		1.1	1.30	735
11	C4	13.50	27.3	2.0	55.9	13.7	4.21	176		1.1	0.93	935
12	C4	13.50	47.0	2.0	94.3	23.5	6.38	195	A	1.1	0.93	935
	Shaded cells exceed acceptable width/depth ratio 24											
	Red/green hi-lighted cells indicate cross sections that are on the same profile (reach)											

*Note: No bulk samples were taken at X-sections 7, 8,9,10 and 11. However comparison of shear stress to D84 suggests that they are all aggrading.

Reference to **Table 6.8** above shows that Town Brook is aggrading. Note that 7 of the 14 cross sections exceed the allowable width depth ratio for a stream in regime. This commonly happens when a steam is aggrading and is further evidence of excessive bedload. While sediment is eroded away and must be transported downstream by Town Brook, the tributaries were not surveyed; yet it was noted that many of them tend to be steep and show obvious signs of erosion (severe down cutting, exposed banks, bars at their mouth). They are a major source of sediment that overloads the system.

Table 6.9, below, summarizes the eroded bank data. The worst location is the Lamport farm site, as almost the entire reach there is badly eroded. Approximately 20% of the *bank* length of Town Brook (inclusive of both sides) is eroded. Assuming that one foot of earth is eroded each year (a *very* conservative estimate) in one year's time 2826 tons of gravel and sediment is eroded and must be transported downstream by Town Brook, where it then enters the West Branch main stem.

Table 6.9 Eroding Bank Summary

Number	Total Length (ft)	Total Area (Sq. Ft.)
166	12,928	49,400

This high bedload should show up as depositional features. **Table 6.10**, below, summarizes the depositional features found.

Table 6.10 Depositional Features found in Town Brook

Type of Deposition	Number
Transverse Bar	31
Center Bar	18
Emergent Gravel Bar	27
Side Bar	9
Total	**85**

There are a considerable number of features. 85 features over 6.2 miles of stream works out to one feature every 385 feet or approximately one feature every 12 *bankfull widths*. This is further proof that the stream carries an excessive bedload.

Table 6.11 summarizes the number and types of revetments and erosion repair features. Each site has probably experienced previous erosion. Thus, erosion problems are and have been wide spread along Town Brook. We also noted the presence of berms. As was explained in **Section 6.2.2**, berms prevent the stream from accessing its floodplain and they increase erosion.

Table 6.11 Revetments/Repairs along Town Brook

Type	Number	Total Length (ft)
Stone Structures		
Dumped Stone	34	3073
Rip Rap	15	1489
Stacked Rock Wall	4	250
Subtotal Stone Structures	53	4812
Berms	14	5918
Concrete	1	81
Other	1	97
Total	**69**	**10908**

6.6.4. <u>Summary of Geomorphic Condition of Town Brook</u>

Overall Town Brook exhibits the following characteristics:

- The stream is or should be a type C stream over most of its length; it is or should be a Type B stream in its upper reaches.
- The stream tends to too wide for its depth.
- It exhibits symptoms of both erosion and deposition.
- Its defects are due to excessive bedload.

6.7. Demonstration Project

6.7.1. Introduction

The Contract Scope required the design and construction of a natural stream channel (or fluvial geomorphic) demonstration restoration project. Many sites along the West Branch main stem were originally given consideration. However, *reference reach* information was not obtainable for the larger watersheds of main stem project sites. Subsequently, the decision was made to implement the initial demonstration project on a reach with a watershed size compatible with the limits of available stable reach information. Further discussion led to a decision to prioritize three potential sites in the Town Brook sub-basin. This decision was based on 1) a geomorphic assessment had been performed in the sub-basin and a reference reach had been located, as well as a "sister" reference reach in a watershed of similar characteristics (Pettis Brook in the Town of Hamden), 2) erosion at these sites was significant, and 3) two of the three sites were currently ineligible for CREP due to unstable streambank conditions.

The merits of these three sites were compared by developing a *matrix* (a table with varying weights given to characteristics) to prioritize potential sites in the West Branch watershed (see **Appendix 4**)[12]. The project selected was a 1200 foot long reach on the David Post farm, located just below the point where Town Brook crosses Davis Road in the Town of Stamford (see **Map 6.2** attached at the end of this section).

The project was let to public bid and a contract was awarded to T. C. Briggs Construction and Supply, Inc., Prattsville, New York in the amount of $213,745.00. Total project cost including all construction modifications was $222,035.50.

6.7.2. Existing Stream Conditions

Note: Photographs cited below are at the end of this section, arranged to emphasize before and after views of locations. Their identifying numbers do not follow in consecutive order.

Problems exhibited by the selected stream, as it existed before the project began, included:

- Incision: The stream was incised; banks were vertical, and the stream could not properly access its floodplain (photos 6.17, 6.23 & 6.24).
- Over width: The stream was too wide for its proper stream type (photo 6.29).
- There were very few pools, and they tended to be quite shallow.
- Four headcuts were observed in the project reach, also indicating stream incision (photo 6.29).
- Severe bank erosion: This was due to incision and the absence of a sound riparian buffer on the overbanks.

[12] Pending comments from involved individuals and agencies, the prioritization matrix is considered to be in draft form.

- A large gravel deposit had formed in 1999, when the stream burst its banks during a record flood. (This flood was the result of a localized storm in which over 6 inches of rain fell in approximately a 4-hour period on July 4, 1999. The resulting flow from this storm was significantly higher than the January 1996 event) (photos 6.27, 6.29).
- The existing stream on the Post farm was trending heavily toward a Type F (photo 6.31).

The effect of these problems was that this stream reach was not the proper type for its setting, and was not functioning properly. Specific failures to function properly included:

- Inadequate trout habitat.
- A major source of sediment due to the eroding banks. This was probably affecting the downstream portions of Town Brook, and causing increased deposition downstream.
- Large gravel deposits in the project reach. As previously mentioned, some of this was due to the flood of 1999.

6.7.3. Design

Note: **Map 6.3**, the proposed construction plus the existing stream's alignment, is included in at the end of this section.

The techniques used to design a stream channel that is in balance with its surrounding landscape (its watershed) involve a unique synthesis of hydrology, engineering and fluvial geomorphology.

There are two main methods of designing streams using the above principles:

- The Rosgen reference reach method: This is an analog design method. A *reference reach* (stable reach of the same stream type in a similar geomorphic setting) is used as the template to design the particular stream in question.
- Regime equations based on stable streams. Care must be taken to insure that the regime equations used are based on similar stream types in similar geomorphic settings. In this case, the Hey-Thorne equations were known to be acceptable for use in this setting.

A third method is to duplicate a previous stream alignment. This is usually done by using old aerial photos to design the plan form. However, these photos would not show the stream's cross-sectional area or shape. Care must also be taken to insure that the plan form being duplicated is, in fact, stable.

For this project, a combination of all three methods was used. It should be noted that this reach is in a transitional area in the valley. Valley and stream slope begin to flatten and stream type transitions from a B Type to a C Type.

The proposed alignment was based on the location and shape of the stream as it appeared on the aerial photos taken in 1943. The bend radii were generally in agreement with the

1943 photos. However, the Hey-Thorne equations were also used to determine arc length and radii. The two sets of radii were compared and the larger of the two were used for each bend. This was done because of concerns that, for a period of time immediately after construction, the new channel may have banks that are not “stiff” enough to resist floods. Also, while it was easy to determine the plan form of the stream from on the 1943 photos, scaling off the radii of the bends was more problematic due the graininess or fuzziness of the photo images. Therefore, it was preferable to use the conservative solution and use the slightly larger radius. Furthermore, it seemed wiser to use a computed value from accepted equations, than to scale off the radius from the old photos, which were somewhat difficult to interpret.

The shape and depth of the riffles and pools were computed from two reference reaches and the Hey-Thorne equations. The two reference reaches used were: 1) a reach from Pettis Brook and 2) a reach from Town Brook, downstream of the project site. The Town Brook reference reach gave values that were clearly too large. Results from the Pettis Brook reference reach and the Hey-Thorne equations were quite comparable. The design of the riffle was based on these two similar values. The riffle was also designed to both provide the required shear stress at bankfull flow and to convey the bankfull flow.

In natural streams, pools tend to occur at bends or meanders. However, natural stream design principles required more pools on this reach than the number of bends would allow. To maintain the proper pool-to-pool spacing, we designed pools to be built at drop structures (cross vanes) on straight stretches of the stream. Thus, two “pool types” were designed; one occurs at bends and the other occurs at the drop structures on the straight reaches. For this project, these pools were referred to as C and B type pools respectively. This pool type nomenclature refers to the stream type that they are usually found on.

The bankfull slope of the stream was selected based on: 1) providing the necessary shear stress, 2) conveying the bankfull flow, and 3) being in agreement with the stream length and sinuosity.

The width of the floodplain was set by being at least 2.2 times the bankfull width. This is in agreement with the entrenchment ratio for a Rosgen type C stream (*entrenchment ratio* 2.2 or greater).

Finally, the stream profile and plan form were adjusted to achieve an economical balance between cut and fill earthwork quantity. After adjustment for this, all the above-listed stream performance criteria still had to be met, which required further design adjustment.

The most obvious feature of the new stream is the rock vane structures (photos 6.21, 6.22, 6.25, 6.26, 6.28, 6.30, 6.33). These serve 4 purposes:

- Act as grade control structures.
- Create pools.
- Redirect the flow of water.
- Take stress off the channel banks.

There are three types of rock vanes on this project:

- Cross vanes that form a kind of u-shaped structure across the full width of the channel.
- Single vanes that direct the flow water.
- A double vane structure. It can be thought of as two cross vanes stacked up on top of each other. It is based on bedrock vanes found in natural streams. Its primary function is to serve as grade control. The vertical drop through the structure is about 4 feet, and this allows the design slope of 0.013 feet/foot to be maintained.

It should be noted here that almost 9 feet of vertical drop had to be made up in only 1200 lineal feet of project. The rock vanes were instrumental in allowing this to be done. Rocks for the vanes were sized using the bank shear/rock size curve from Rosgen.

There is a single log cross vane structure on the project (photos 6.20, 6.34). It is located at the outlet of a small brook (tributary), just a few feet from the bank of Town Brook. This log cross vane was intended to concentrate flow from the small brook and prevent a delta from being formed where it enters Town Brook.

Other significant design features were:

- A "rock lined riffle" at the culvert outlet, which was lined with medium stone fill to prevent erosion from the high *velocity* water leaving the culvert outlet during large storms (photo 6.18).
- Excelsior matting on the floodplain banks near the culvert outlet.
- Excelsior matting on the top of the channel bank as a temporary erosion control measure until vegetation became established (upper left corner of photo 6.22).
- Live willow stakes at the top of the vane arms. When grown the willows will reinforce the bank at the top of vane arms and help prevent the bank being eroded during major floods.

The following dimensions were used for the reconstruction of this stream (all dimensions refer to the bankfull condition). Keep in mind that all dimensions are based on fluvial geomorphological principles, and reflect the shape and size of natural stable streams in similar settings.

- Riffle Width 17.34'
- Riffle Depth 1.97'
- Riffle Cross-sectional Area 21.44 sf
- Pool Width 16.26' (B Pool) 14.81' (C Pool)
- Pool Depth 3.24' (B Pool) 2.62' (C Pool)
- Pool Cross-sectional Area 28.52sf (B Pool) 24.83sf (C Pool)
- Bankfull Slope 1.3%

A cattle crossing consisting of pre-cast concrete slats was constructed across the new stream in coordination with the Watershed Agricultural Program CREP project (photo 6.30). The cattle crossing was designed in coordination with the stream reconstruction to insure that the crossing did not interfere with the hydraulic properties of the new stream.

This effort was a "first" for both programs, and all participants were pleased with the outcome.

6.7.4. <u>Construction</u>

Generally speaking, construction proceeded smoothly. We did experience three major storms, and one that was smaller but still significant. If not for the inclement weather, the project could have been completed much sooner that it was. The stream was dewatered, then construction began upstream and proceeded downstream. We had to describe to the contractor's workforce not just *what* to do but *how* and *why* it was to be done. Unless the contractor has experience on stream restoration projects, this is necessary to obtain a good product. After viewing how well the partially-completed project weathered the first flood, the construction crew took a real interest in the project. They asked more questions and checked their own work more diligently.

During construction, we experienced the following problems:

- The rocks delivered by the quarries tended to be too large. The required minimum diameter was 3'. This should be interpreted as a cube 3' on each side, or 27 cubic feet. Rocks often exceeded this volume by 50% or more. One rock even displaced 98 cubic feet. Repeated trips to the quarry helped, but the situation was never completely resolved.

- This portion of Town Brook is a very small stream, with a design riffle width of only 17.34 feet. Working in a stream this small is always difficult. The equipment can be "too large" for the stream, and proper rock placement is more difficult in a small stream. Since so many of the rocks were overly large, the difficulties only increased. In future projects, consideration should be given to using log vanes instead of rock vanes on streams this small.

- Flooding: We experienced four major storms while building this project. The first was estimated to be about a "five-year" storm event. Work had just begun, there was no vegetation started, and the floodplain was raw earth. Fortunately, there was virtually no damage and the floodplain withstood the flood with essentially no damage. This gave us confidence that our design judgments were correct. Two smaller but still significant events followed. Work had to be suspended briefly, and when it resumed the ground was saturated, making earth-work difficult. When the channel and floodplain were about 80% completed, we had a 25- year event (estimated). There was no damage to the floodplain to speak of, as only some seed was washed off. The structures handled it well (photos 6.33-6.36), reaffirming that our design was adequate.

- We installed excelsior matting on the terrace slope near the culvert outlet. We did this to ensure that we had adequate mulching on an area that we judged to be sensitive to flood flows exiting the culvert pipe with high velocity. The matting performed well ─ it stayed in place on the slopes, and vegetative growth was rapid.

- For similar reasons, we installed excelsior matting at the top of the channel bank on the very edge of the floodplain. During the 25-year event, this material came loose and piled together, usually at the top of vane arms. These resulting balls of excelsior matting prevented flowing water from plunging back down over the vane arm and into the channel, or at higher flow from flowing properly out onto the floodplain. This caused erosion at the very top of the channel bank. This was the only erosion we experienced during the 25-year event.

- Mechanical breakdowns: The contractor used mechanical thumbs on his excavators (to lift and place the rocks). Several times, they broke loose from the boom arm, and had to be welded back on. Naturally, work on the vane arms had to stop while the thumbs were being repaired.

6.7.5. Design Changes

During the construction process, it is important to remain flexible to any design adjustments that appear necessary. We experienced four major storm events, which resulted in three design changes. During these events, water ran down the channel and onto the newly constructed floodplain (remember that the channel had been dewatered for construction purposes). At these times the stream was "operating". When carrying water, the stream provides clues as to how it will operate, and what design features, if any, should be changed or modified.

- Fish passage became a concern at some of the cross-vane structures. NYSDEC recommended pool dimensions of a maximum one-foot jump height, with a two-foot minimum pool depth. At the time this information became available, it was no longer feasible to reconstruct the rock vanes. With DEC cooperation and after further discussion, it was decided to cut notches in the "throat rocks" of the cross vanes where necessary, to lower the jump height to an acceptable limit. At the same time, in an attempt to deepen the pools, we removed some large stones from the bottom of certain pools. If this notching technique works, it will provide a low-cost way to open up stream reaches otherwise closed to spawning or migrating trout. For example, tall bedrock steps on natural streams could be notched, and this would allow the trout to move up the stream.

- During one large storm event the water scoured out a deep pool at cross vane number 7. Construction of this vane had already been completed, but the channel downstream of it was not. The pool formed by this event was deeper than the designed pool. It also permitted fish passage without the need to notch the throat rocks. We surveyed this and all constructed pools (i.e. for cross vanes 8-13), readjusting our design to mimic this "natural" pool.

- The alignment was changed between station 9+50 to 12+00. Bends at 9+75 and 10+50 were eliminated. This was done because:

- Our experience with the reconstructed stream during the storms showed that the normal pool spacing (5-7 channel widths apart) worked fine.
- The three bends at the end of the project taken from the 1943 aerial photographs were very tight and were closer than the normal 5-7 channel widths.
- The stream in the 1943 photos also displayed bends greater than 5-7 channel widths apart, i.e. there was a long straight section between bends.
- Field observation has shown that on natural stable streams of the type being constructed there is commonly a long straight reach between bends. Usually there is a drop pool on this long straight section. This takes the place of the pools at the bends.
- The design stream is a "hybrid" Type C/Type B. Therefore, bends further apart than the usual 5-7 channel widths were acceptable. However, the pool-to-pool spacing of 5-7 channel widths should be maintained.
- The straightened channel reach, while having no bends, would maintain the proper pool spacing by the use of cross vanes.
- The riffle length between the bends would have been shorter than the designed riffle length. Experience from the three storms indicated that the design riffle length was correct.
- A grove of apple trees would have been destroyed by constructing the stream in the original design location. This would destroy existing riparian habitat.
- Overall, it seemed wiser to adjust the stream and eliminate two of the tight bends (bends at 9+75 and 10+50).
- Subsequent operation of the stream has shown that these adjustments were appropriate.

6.7.6. <u>Project Summation</u>

- The constructed stream is a hybrid TypeB/TypeC.
- The stream is functioning as designed.
- All design modifications are functioning.
- The high, eroded banks that were contributing to sediment load have been eliminated.
- Access to the floodplain has been restored.
- The restored reach withstood a 25-year flood with essentially no damage or instability.
- In regard to fish passage:
    - At the flows at which fish passage ordinarily occurs, jump height appears adequate.
    - Fish have already been observed moving upstream
    - Bio-mass and fish monitoring will continue to ensure that steps already taken to insure fish passage are functioning properly.

Figure 6.16 Photo taken during construction showing newly excavated channel and layout for a vane structure.

6.7.7. <u>Lessons Learned</u>

This section is intended to summarize the lessons learned on this project: what went right, what went wrong, and where we can improve.

- Using the 1943 aerial photos to design the alignment worked well. For future projects use should be made of old aerial photos if they are available. Care must be taken to insure that the old alignment was stable.

- Non-technical people have trouble interpreting engineering plans. Therefore at the time that the design is 80-90% complete the design team should walk over the project with the property owner.

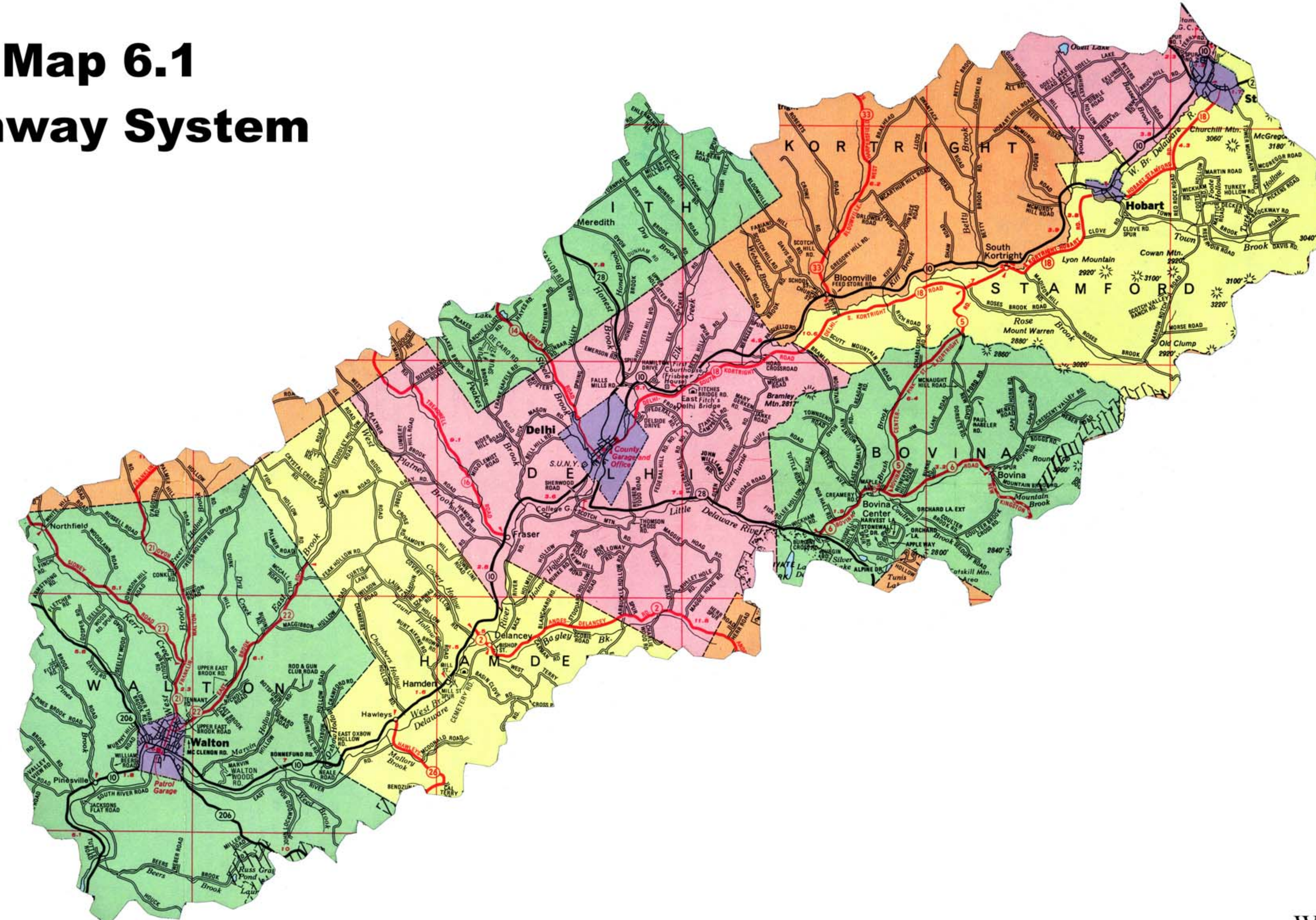
- The delivered rock was some times larger than called for by the specification. A new specification and close coordination before construction begins between the design team, the contractor, and the quarry is recommended.

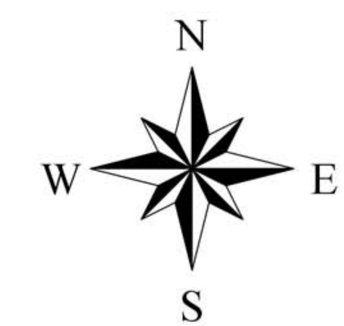
- Coordinating the stream reconstruction, with CREP and the cattle crossing was a success. The two programs are mutually beneficial.

- Rocks of the size required are difficult to work with on a small stream like this. We should seriously consider using log vanes on small streams.

- Full geomorphic project construction contracts should be of 2 year duration. The project would be built in the summer, and then there are 6-9 months of water running in the channel. The stream then has a chance to shape it self and "polish off the rough spots". The next summer the contractor comes back and makes any necessary changes or modifications. This second season work would typically not be extensive. It would be reasonable to assume that a vane or two may be repaired or adjusted, and there could be minor repairs to the flood plain (it there has been a major flood before the vegetation establishes).

Map 6.1
Highway System

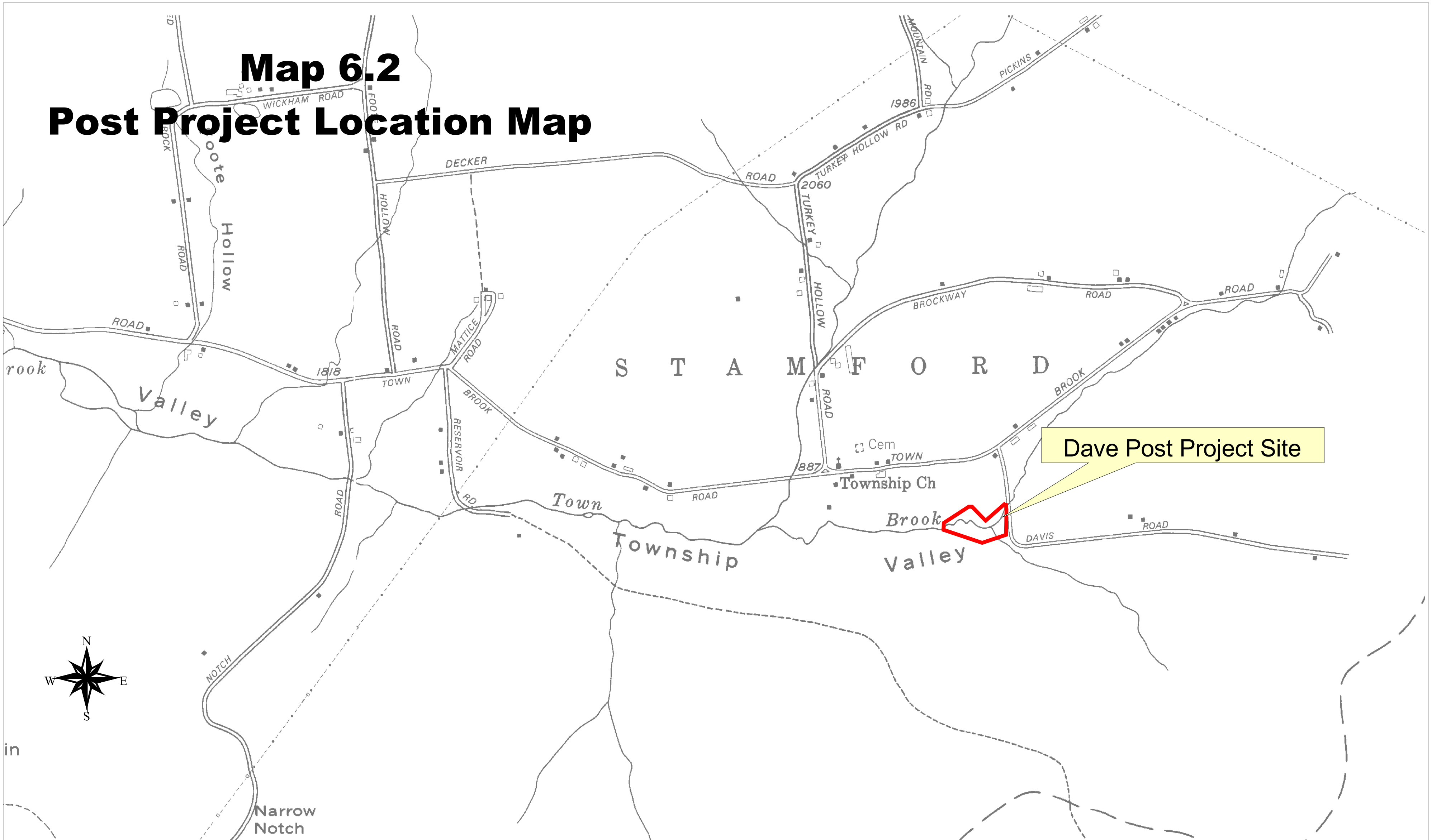




Scale
1:190080
1"=3 miles

Scanned from Map of Delaware County, New York
Copyright, The National Survey, 1984, Chester VT.
Data may be subject to error and are not a substitute
for on-site inspection or survey.
Created by DCSWCD 1-06-05
H:\Working Data\WestBranch SCMP\Stream Corridor Mgt Plan\A -A_Final Documents\Section 6 (4)\Map_6.1

Map 6.2
Post Project Location Map



Based data provided by NYCDEP
Map data provided in NAD 83 UTM Zone 18 North
GIS data are approximate according to their scale
and resolution. Data may be subject to error and
are not a substitute for on-site inspection of survey.

Scale
1:24000
1"=2000

2000 0 2000 4000 6000 8000 10000 Feet

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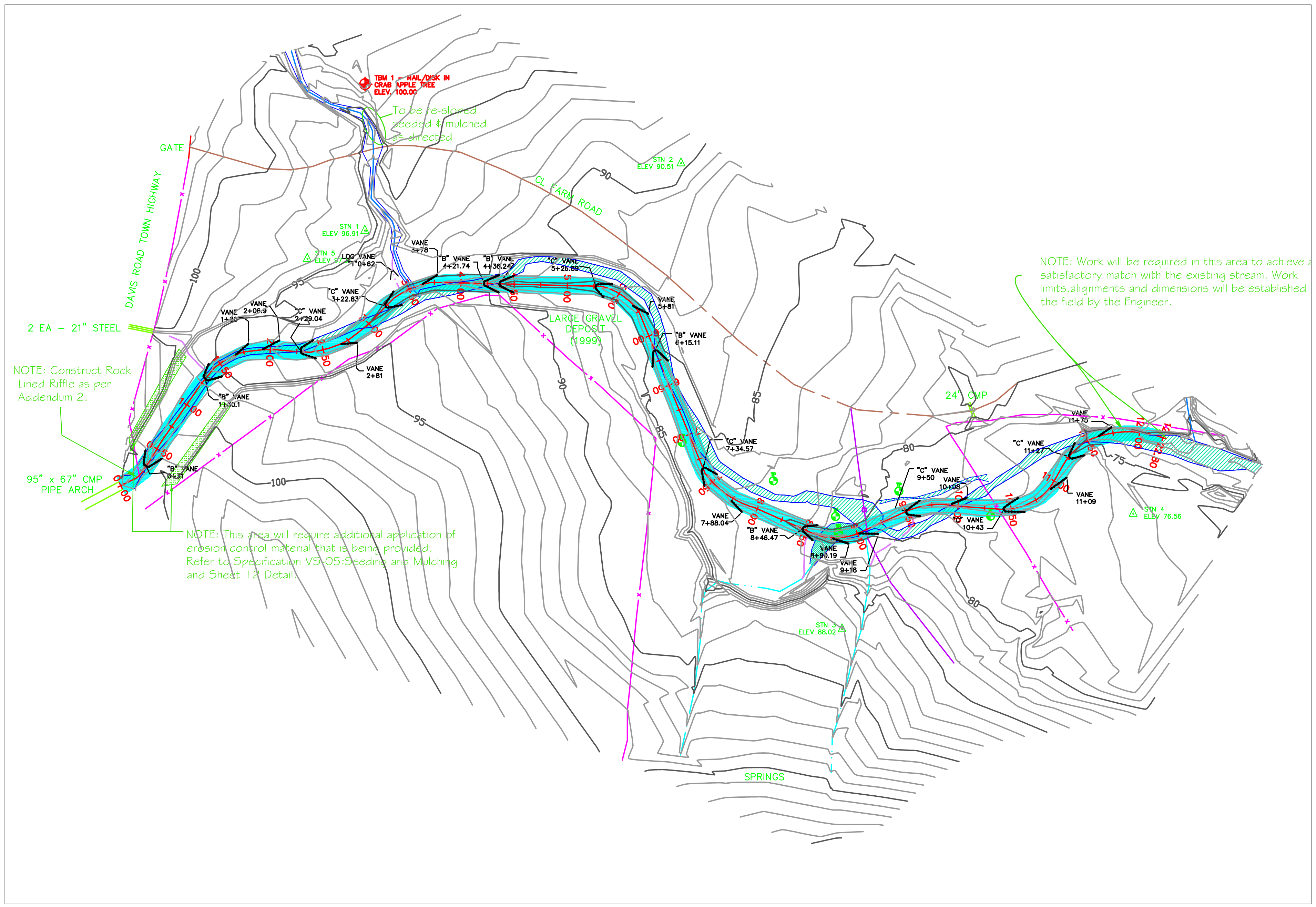
D:gisproject\wbd\scmp\post_proj_loc.apr

Map 6.3
Post Project Proposed Plan View



LEGEND

- MAJOR CONTOURS
- MINOR CONTOURS
- BARBED WIRE FENCE
- EXISTING CATTLE CROSSING
- CL FARM ROAD
- SPRING RUN
- TRIBUTARY
- PROPOSED TRIB. REALIGNMENT
- PROPOSED STREAM THALWEG
- PROPOSED STREAM @ BANKFULL WIDTH
- EXISTING STREAM
- CLAY DEPOSITS
- TEST PIT
- TRAVERSE POINT
- TBM 1 - NAIL/DISK IN CRAB APPLE TREE ELEV. - 100.00
- CROSS VANE
- SINGLE ARM VANE
- EXCELSIOR MAT

NOT TO SCALE

David Post
Stream Restoration
Proposed Plan View
Delaware Co. Stream Corridor Management Program
Delaware Co., NY

Delaware County Soil & Water Conservation District
44 West Street
Walton, NY 13856

Designed		Approved by
Drawn JMF	2-04	Title
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Checked		Sheet No. 1 of 1 — Drawing No. DE-C-SCMP-001

Photo 6.17: Just below culvert, 10-31-03. Stream entrenched with no floodplain.

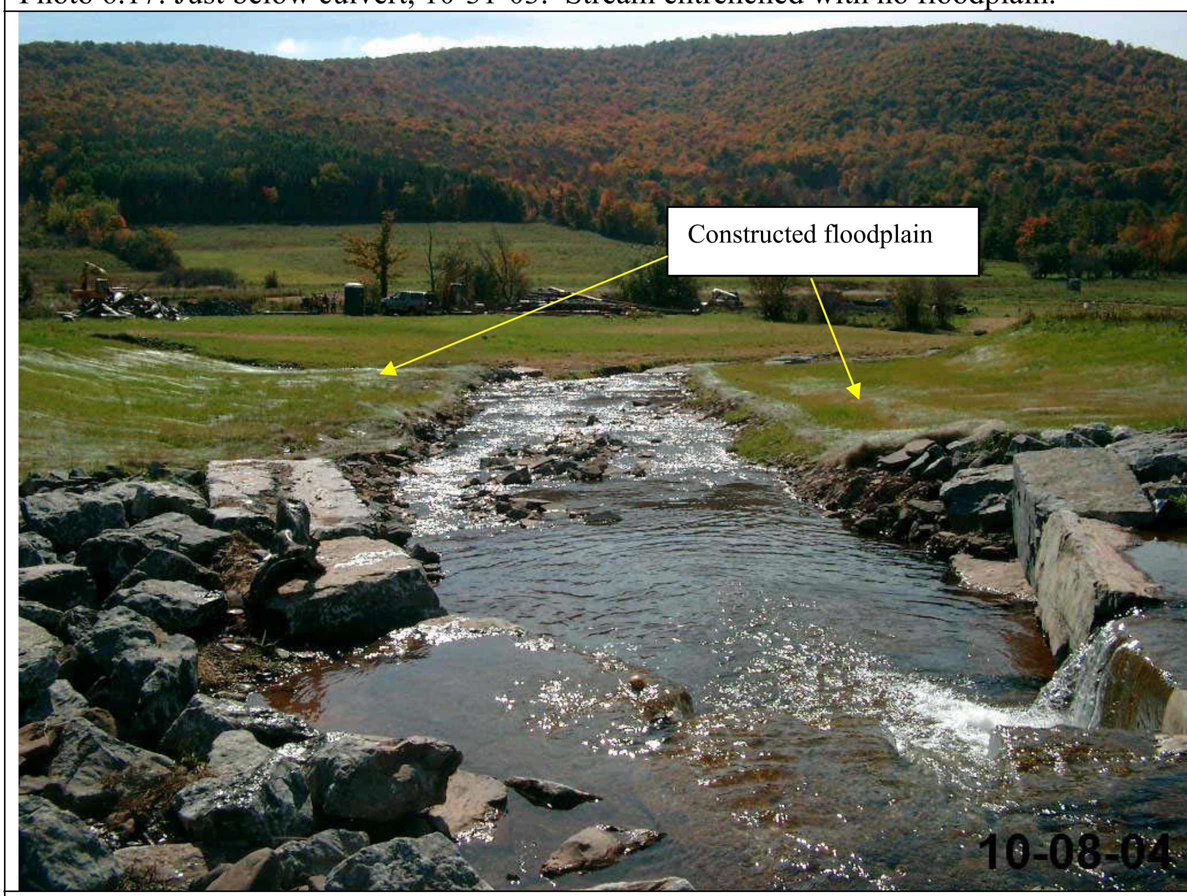


Photo 6.18: Just below the culvert with a newly constructed floodplain, 10-08-04.

Dave Post Project Site – Before/After Construction

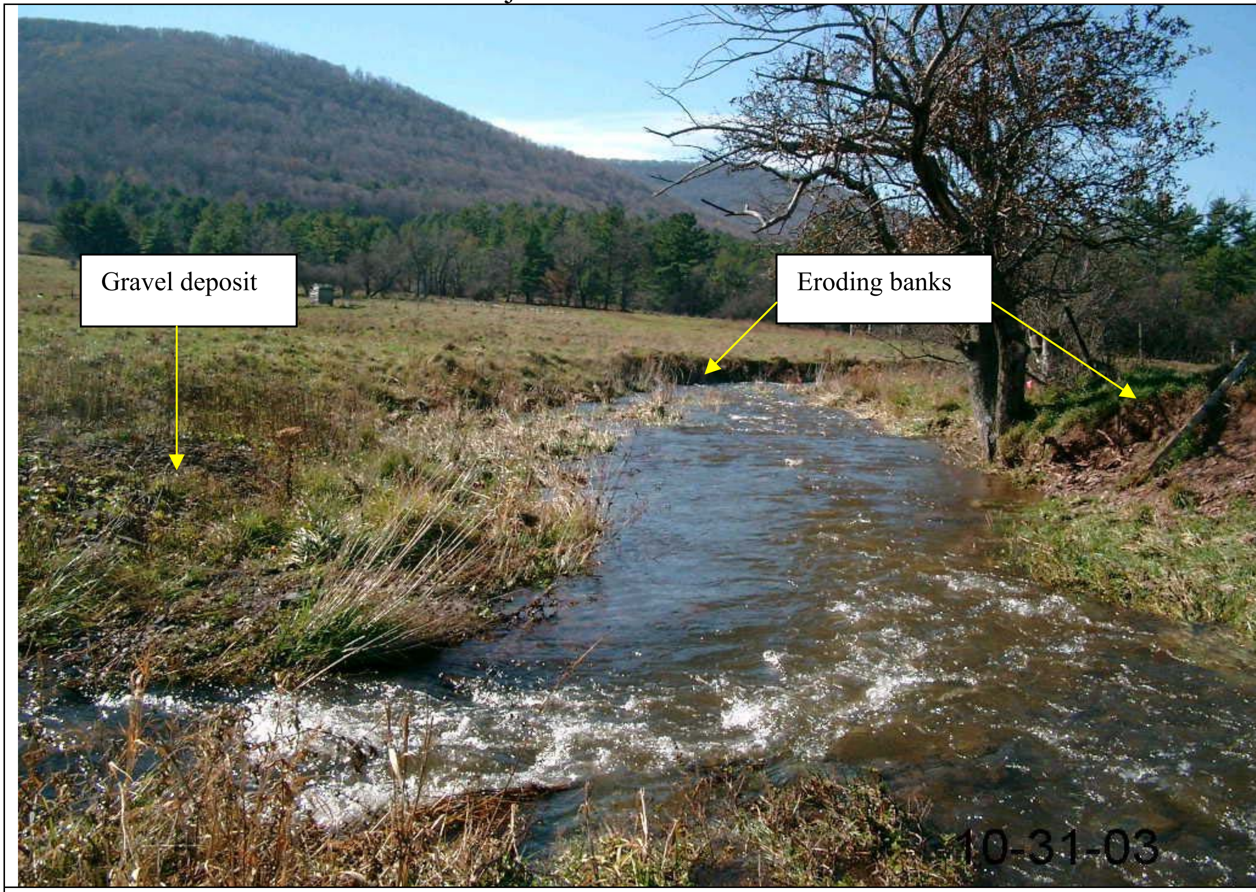


Photo 6.19: At tributary confluence (trib. on left). Lack of adequate floodplain. 10-31-03

Photo 6.20: Tributary on the left with log vane enters town brook at cross-vane.

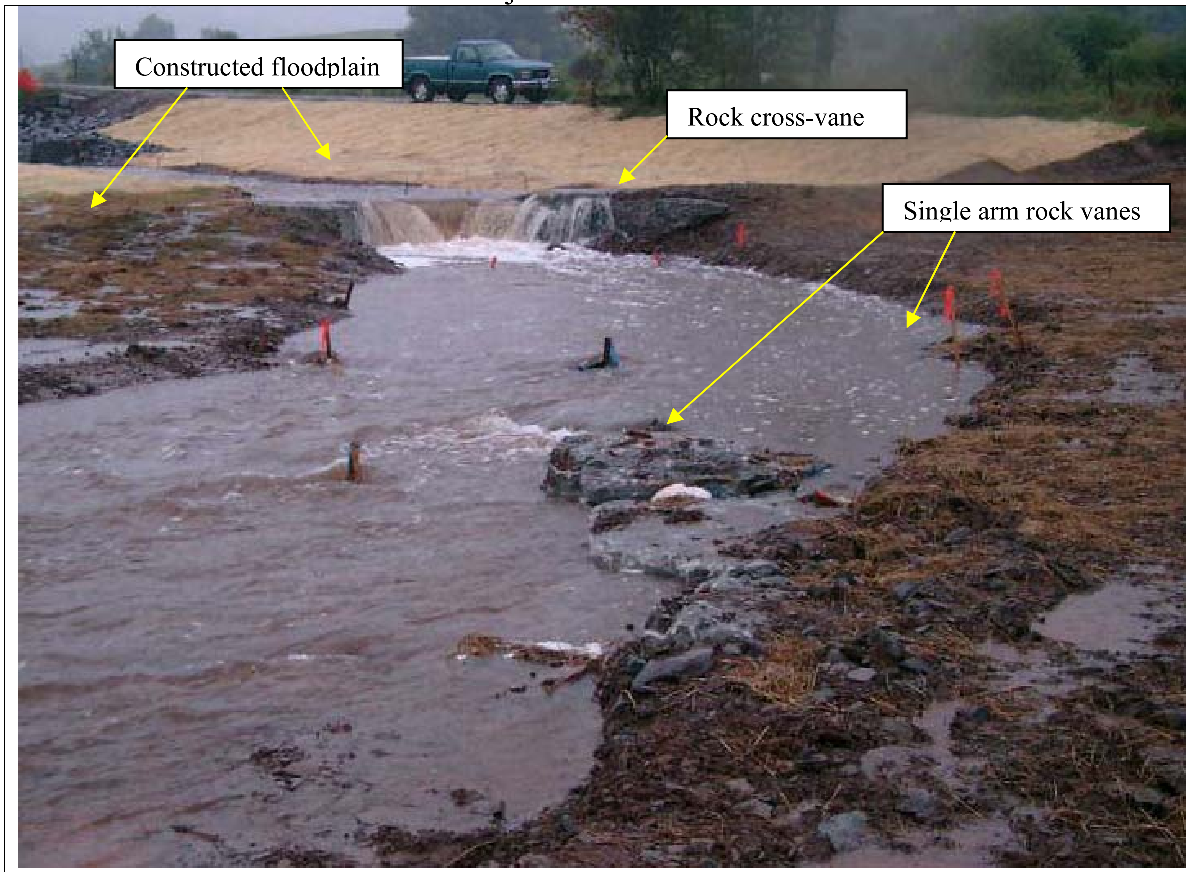


Photo 6.21: Looking U.S. at near bankfull flow across three structures, 8-13-04.

Photo 6.22: Looking U.S. the same three structures in photo 7 during construction, 8-04-04.

Dave Post Project Site – Before/After Construction

Photo 6.23: Approximate area of lower rock vane structure in photos 5 & 6, 6-05-03

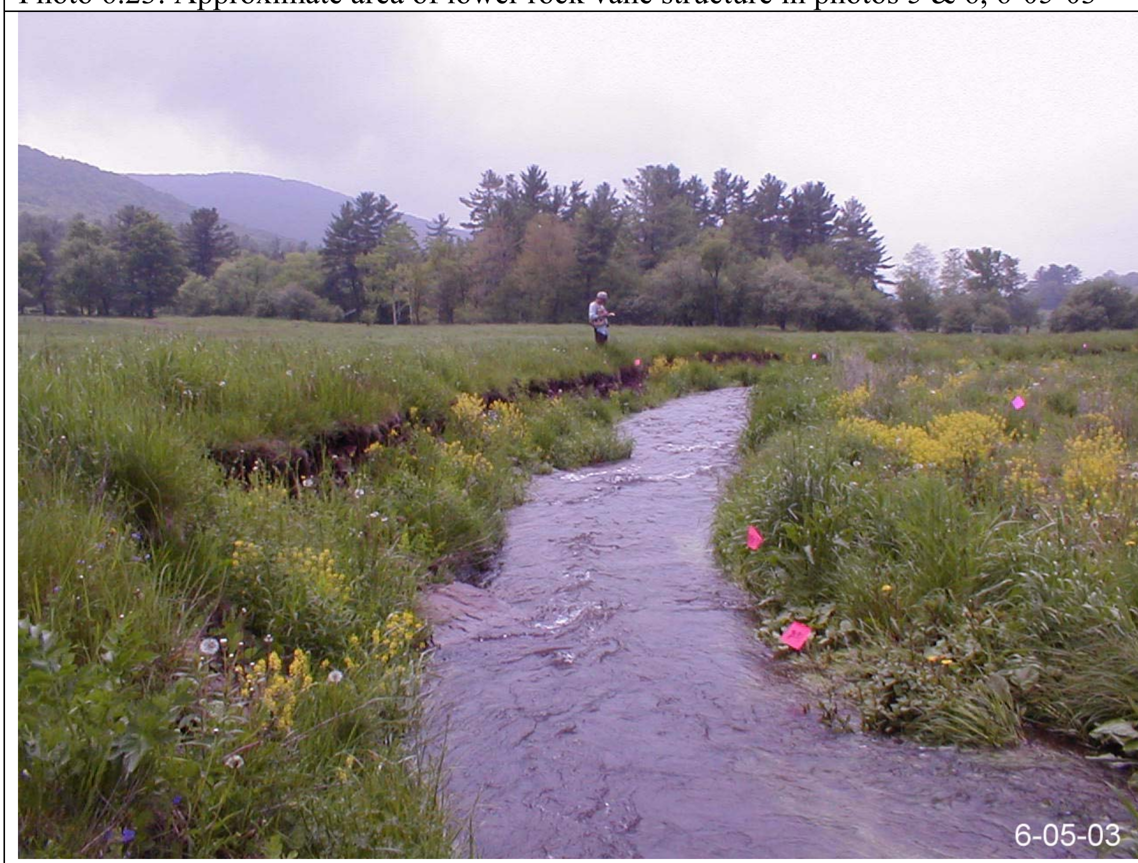


Photo 6.24: Approximate location of double cross-vane structure shown in next 2 photos.

Photo 6.25: Near bankfull flow through the double cross-vane structure, 8-13-04.

Photo 6.26: The double cross-vane structure during construction, 8-10-04.

Dave Post Project Site – Before/After Construction

Photo 6.27: Approximately at the middle of the project reach, 10-31-03.

Photo 6.28: Looking D.S. at cross-vane approximate area as the above picture, 10-08-04.

Dave Post Project Site – Before/After Construction

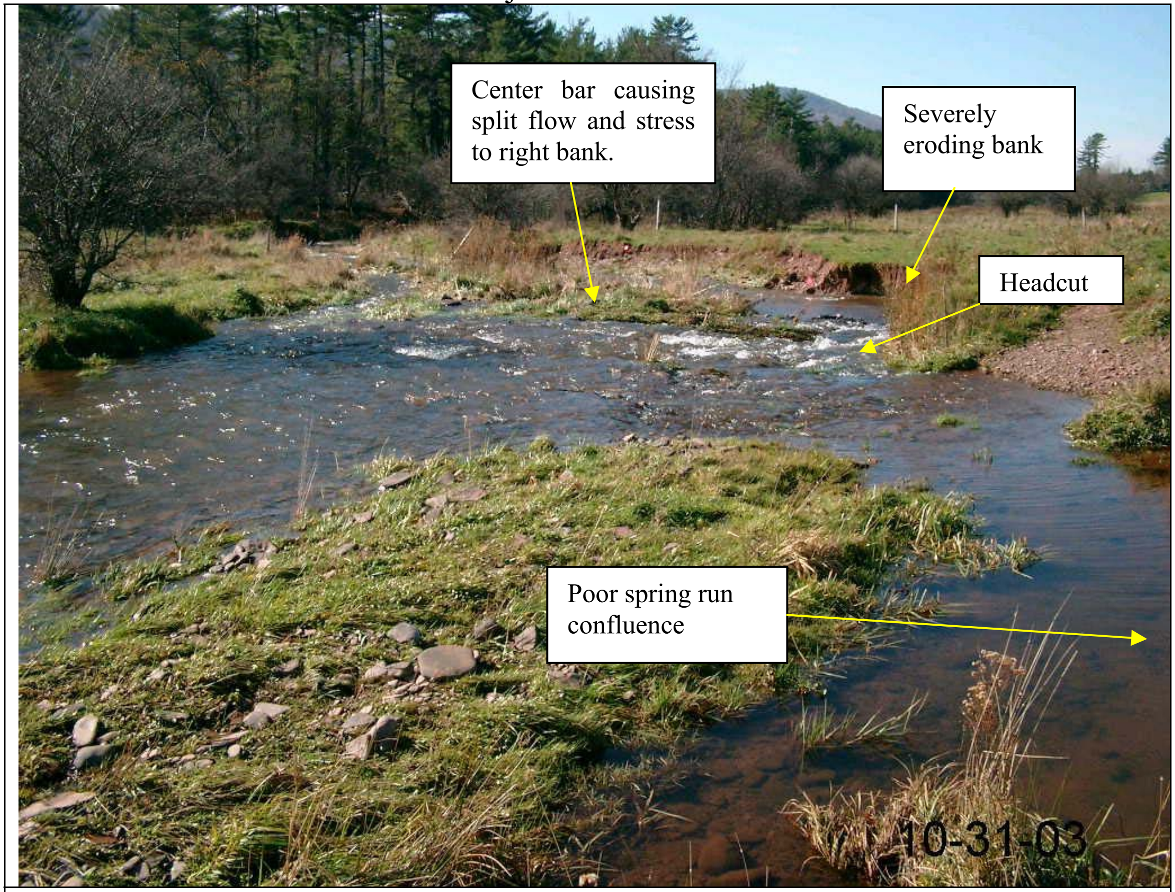


Photo 6.29: At existing cattle crossing, 10-31-03. Stream over-widened with split flow.

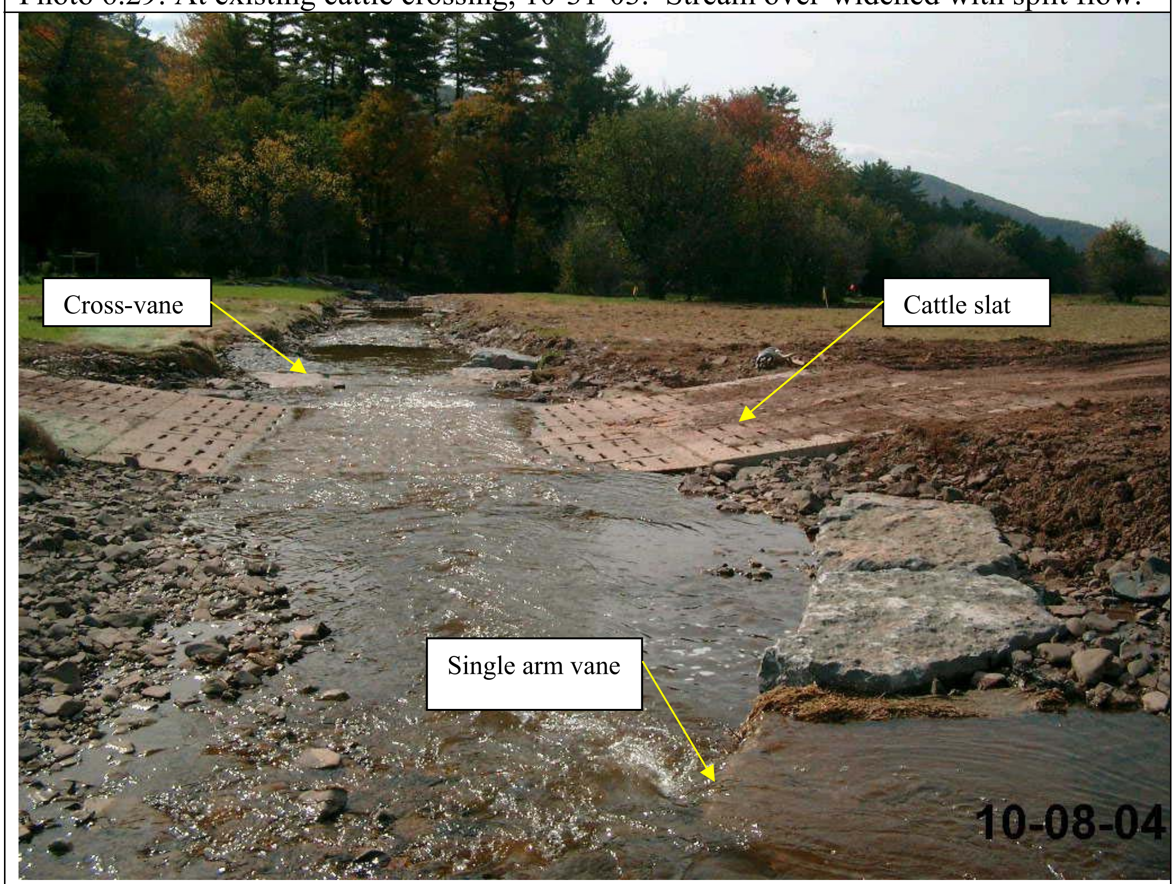


Photo 6.30: Looking D.S. at cattle slat, 10-08-04

Photo 6.31: Lower end of project reach, 10-31-03.

Photo 6.32: Looking U.S. at the end of the project, 10-08-04.

Dave Post Project Site – High Flow Event 9-18-04

Photo 6.33: Looking U.S. at the beginning of the project, 9-18-04.

Photo 6.34: Looking U.S. of the tributary with log vane, 9-18-04.

Dave Post Project Site – High Flow Event 9-18-04

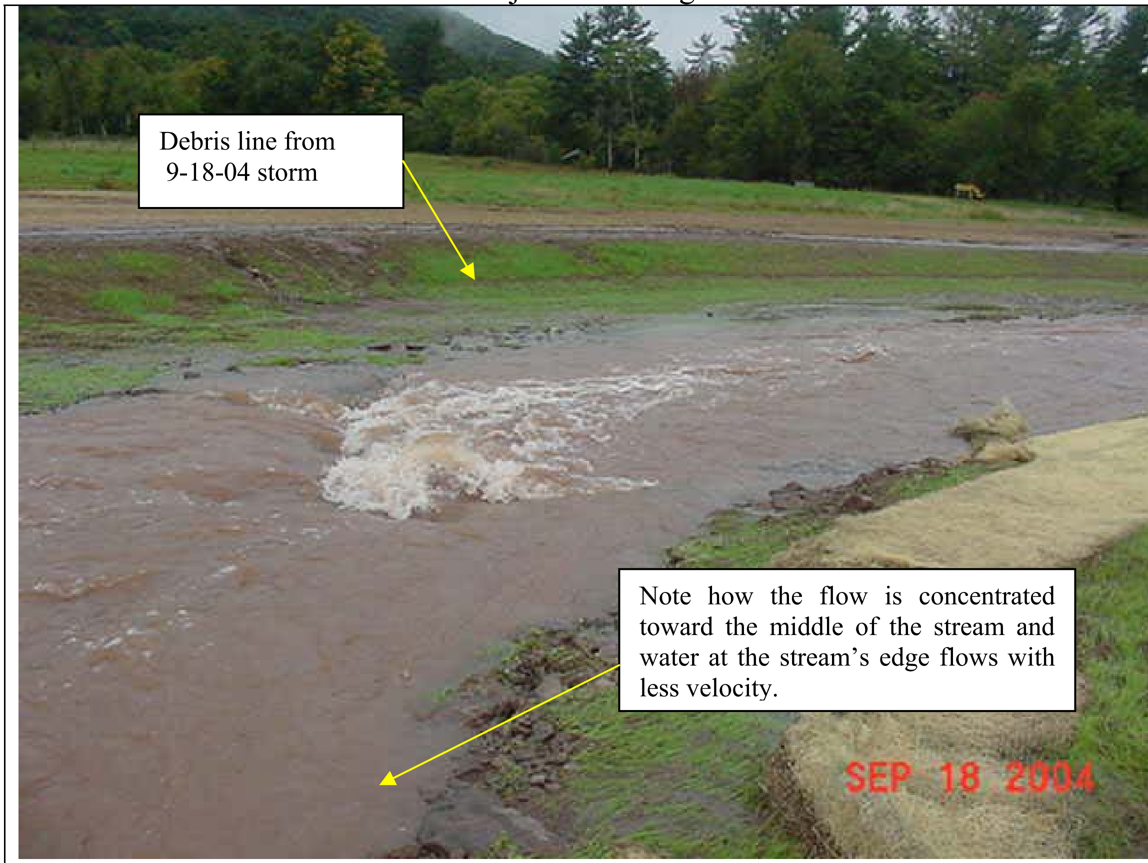


Photo 6.35: Looking D.S. at cross vane at debris line from 9-18-04 storm.

Photo 6.36: Looking U.S. at cross vane and cattle slat, 9-18-04.

Section 7 – West Branch of the Delaware River Stream Segments and Management Units

7. West Branch of the Delaware River Stream Segments and Management Units

7.1 Introduction

This section of the plan presents the observations of the condition of the West Branch of the Delaware River made during the walkover assessment that was conducted in the summers of 2002-2004. During the assessment, teams walked the entire length of the main stem from Lake Utsayantha to the Cannonsville Reservoir inventorying and mapping stream features, man-made structures, and conditions influencing the stream's function. The purpose of this assessment was to inventory and characterize the condition of the river, identify and describe problem areas, and where possible, provide an indication of the source(s) of the problem(s). This assessment is the Stream Corridor Management Program's first look at the river as a whole. The best use of the assessment is to document where the problems are located and the extent of the problem. Other surveys employed after the walkover assessment have been analyzed and were used to clearly identify a stream's departure from the *stable* condition and capture the information needed for designing a solution.

The following is a list of conditions that were measured or estimated:

- Eroding bank lengths and heights
- *Cross-section* dimensions including *bankfull* elevation, *bankfull width*, *bankfull depth*, and floodprone zone width and depth
- Bed material size distribution at cross-sections
- Bed and bankfull slope through cross-sections

The following is a list of some of the features that were mapped:

- Stream alignment including the start of *pools* and *riffles*
- Eroding banks
- Eroding beds (or *head-cuts*)
- Depositional bars – point, side, transverse (or diagonal), center bars
- Debris or log jams
- *Culvert* outfalls
- *Revetment* types – *berm*s, walls, riprap, dumped stone, log cribbing
- Cross-section locations
- Grade control features – including bedrock outcrops and dams
- *Japanese knotweed* colony locations
- Bridges and their abutments
- *Clay exposures* in the banks
- Spring seeps
- Tributaries

These features were mapped with a handheld *Global Positioning System (GPS)* unit with a 3-5 meter accuracy and in addition to GPS database entries, notes where written on 1:100 scale copies of the 2000 Emerge digital orthophotographs for the Cannonsville basin. Photographs were taken of significant features including eroding banks, bars, bridges, etc. The information from this assessment was compiled within a series of Arcview *Geographic Information Systems (GIS)* software shapefiles, which will be maintained by Delaware County Soil and Water Conservation District (DCSWCD) and New York City Department of Environmental Protection (NYCDEP). Inquiries as to the content or availability of this information can be directed to the DCSWCD Project Coordinator or NYCDEP Project Manager.

Characterization of the river is broken into two levels of specificity; a more general description of a larger area or "**segment**" description and a more detailed description of a smaller reach or "**management unit**" description. There are several management units within each segment. Segment descriptions are divided by municipal boundaries. This delineation enables readers to consider the condition and relevant issues regarding the river within the context of local decision making and local history. To some extent, the river within the five different segments may have a character that is physically unique to that town. For example the river through Segment 1, Village of Stamford, is a steeper, narrower, headwaters stream that is physically different than the river in Segment 2, Town of Stamford and Kortright, where the river transitions to a mid-valley stream with its broader *floodplains* and lower slope. But, for the most part, the segment division is made for purposes of reporting to individual communities. A map showing stream type, management unit limits, cross-section locations and bank pin locations within a segment is provided at the beginning of each segment description.

The management unit boundaries are much more specific to stream characteristics that change or evolve from one unit to the next. As rivers are complex systems, the use of a management unit description which focuses more on the stream "*reach*" scale, is an attempt to describe the processes occurring within smaller part of the stream. The problems within a management unit may be related and therefore might be addressed by a common action or set of actions. For example, a sequence of three failing banks within a management unit might be addressed through a restoration project and a concerted *riparian* buffer enhancement effort. The solution will require knowledge of system-wide processes, but the application of a solution will be made for a specific reach of the river.

A set of sample maps for a representative management unit is provided for each segment. Hardcopy of the management units maps are available upon request for the entire mainstem from the Soil and Water District office. Due to the size of the *watershed* and the number of maps required for the entire watershed, a complete set is not included in the hardcopy version of the plan. Digital versions contain copies of all the management unit maps and can be obtained from the Soil and Water District office.

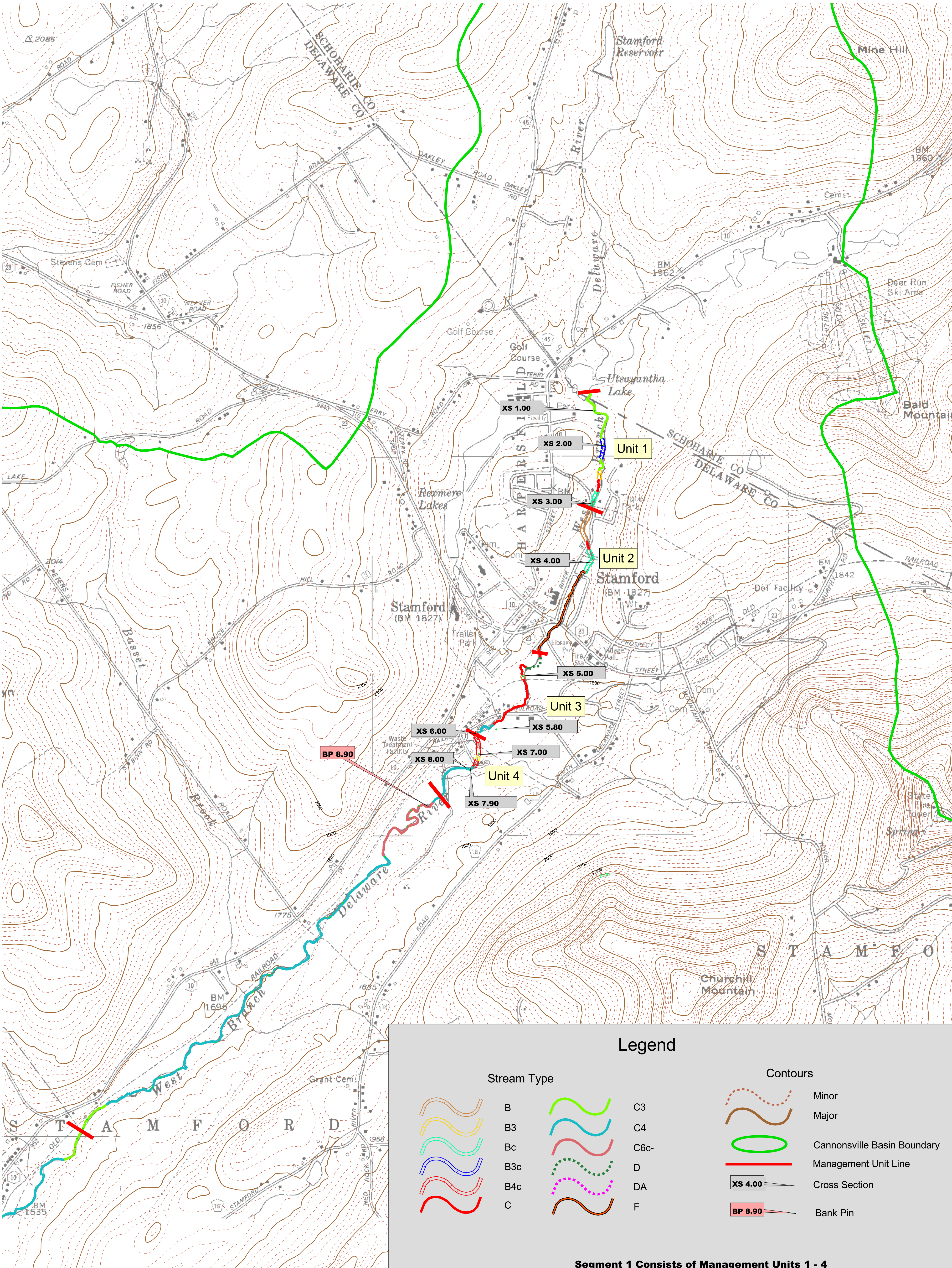
In the management unit descriptions any description of process where a situation exists is to call attention to the obvious relationship. For example, you might read that a center bar is directing flow toward an eroding stream bank and that it is suggested that the center bar may have formed because the stream is too wide. From a walkover assessment we cannot state what caused the over-wide condition or without a series of cross-section surveys that the reach is actually over-wide. We can only identify that there are bars and eroding banks present as indicators of an *unstable* condition. Therefore, this plan recommends that an additional survey should be conducted before attempting certain remedial actions. Taking action without understanding the cause and effect is a recipe for more problems when working with rivers and streams.

Having made a warning about taking action, it is important to differentiate that some action will improve conditions with little potential for negative impact. Riparian forest buffers play an important role in protecting stream banks and improving water quality. Efforts to expand the size of the riparian forest buffer will not only help the individual landowner, but also the entire river system. It is important to give the river room to move and adjust and a buffer provides that room while knitting together the stream bank.

In this description, the river in a management unit will be rated as to its *stability*. A management unit may be rated as: unstable, moderately stable, moderately stable with unstable reaches, or stable. At this stage, this description is largely based upon the extent of the eroding banks and other indicators of *instability*. The actual level of instability can only be determined with additional survey. The Stream Corridor Management Program will continue to refine this assessment to enable further definition of priorities for remedial action. For other terms and concepts used within these descriptions, see **Section 5.9.**, Introduction to Stream Processes.

Segment 1

Segment 1 - Map 1
Stream Types and Management Unit Locations



Base Data Provided by NYCDEP
Map data provided in NAD 83 UTM Zone 18 North
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7.2 Segment 1 - Village of Stamford

General Description of Segment One

This description of stream segment one covers the section of river from the outlet of Lake Utsayantha above the Village of Stamford to a point below the wastewater treatment plant downstream from the village (see **Segment 1 – Map 1**). The watershed area at the top of this segment is approximately 4.9 square miles and is approximately 13.4 square miles at the bottom of the segment with a total surveyed segment length of 12,057 feet. This segment represents the headwaters for the West Branch of the Delaware River and as such, the stream is narrow, relatively stable and with good feature characteristics. The stream channel dimensions such as its width and depth are generally within expected dimensions, pool and riffle lengths are consistent, and although there are areas with some problems, there is no evidence of significant or systemic *erosion* of the stream banks or stream bed within this segment. Historically, the channel and floodplains have been significantly modified through the Village of Stamford to allow for development, provide stormwater drainage, and protect the banks from the resulting stress that accompanies channelized conditions. The riparian vegetation is very good above the village near the lake, somewhat lacking through the village and then improves as the stream is allowed to reestablish its floodplain below the village. Several residences upstream from the central commercial district along River Street are located within the historic floodplain for the stream and as such are subject to frequent basement flooding and water approaching the first floor elevation.

This segment is composed of Management Units 1 through 4. The table below summarizes the erosion and depositional features that are within this segment by management unit.

Table 7.2.1 – Summary of Erosion and Depositional Features

Management unit	Length (mi)	Linear Feet of Erosion	Surface Area (sq.ft.)	# Erosion Features	# Deposition Features	LF Erosion per Mile	# Erosion Features/mi	# Deposition Features/mi
1	0.57	52	26	1	1	91.23	1.75	1.75
2	0.70	255	951	6	4	364.29	8.57	5.71
3	0.59	87	193	2	3	147.46	3.39	5.08
4	0.37	140	729	2	0	378.38	5.41	0.00

Geomorphology and Geology:

Lake Utsayantha and this headwater segment of the West Branch of the Delaware lie atop and cut through outwash *sands* and *gravels* deposited during the Wisconsin glacial retreat over 10 thousand years ago. The lake, controlled by a low dam, collects water from surrounding Bald Mountain, Woodchuck Hill and Mount Jefferson, and may be the remnants of a glacial kettle lake. The outwash sands and gravels layers with a thickness of 6-60 feet which form the bottom of the valley are bounded in places by deposits of larger gravel dumped as “kames” or *terraces* along the valley wall. Under the Rosgen classification, the valley along this segment most closely resembles valley type VIII with its wide gentle sloping valley with terraces at the margins of the floodplain. The valley width varies between 2 and 4 hundred feet. As expected for a headwater location, the valley slope, which varies between 2.2 and 1.3 percent through this segment, is the steepest for the entire length of the river. Stream channel slope varied between 2.0 and 1.1 percent and the stream *sinuosity* was about 1.1. Sinuosity is very high (1.4) through one section of Management Unit 3 where channel flattens out after passing through the village. There are several locations above the village where red shale bedrock controls either the bed and/or a bank of the stream.

The river through this segment is predominantly B stream types above the village, C stream types below the village, F channels within the village with a short section of D stream found below the village. Typically only the F channels would present a major management issue, but since these are constructed channels largely lined with *rip rap* or concrete, their stability is not an issue at this time. These revetted sections of stream through the village will continue to require maintenance and may become a problem on private land. A site behind the Great Union grocery store in Stamford was, in particular, noted as a site that may cause problems. Of the three cross-sections located within this segment, at one cross-section the stream is over wide and appears to be *aggrading* (cross-section 2), another cross-section is *entrenched* and may be *degrading* (cross-section 7.9), and the third cross-section (cross-section 8) appears stable.

<u>Stream Orders, Floodplains, and Wetlands:</u>

The river below Lake Utsayantha is a third order stream until it receives waters from Lake Rexmere. Lake Utsayantha and other upland ponds above the lake provide a limited degree of regulation for the flows received from the surrounding hills. Fringed by emergent and forested *wetlands*, Lake Utsayantha also supports wildlife habitat and acts to improve the quality of the waters before they are *discharged* over the low dam at the south end of the lake. Below the dam, the river flows through a C channel with a well forested floodplain to the remnants of an old mill pond which also supports a wetland community. Once beyond the mill pond, the stream has been channelized and bermed to control erosion and flooding through the residential neighborhoods and the commercial district of Stamford. In response to repeat flooding along River Street and through Main Street, the U.S. Army Corps of Engineers conducted a reconnaissance flood control study in 1996, which suggested that additional channelization and bridge replacement would be an alternative solution to the flooding worthy of additional study. Below South Street, the river flows through a small wetland that receives water from an unnamed *tributary* with its source above Lake Rexmere. Continuing downstream from Stamford, *runoff* is buffered through riverine wetlands and well vegetated floodplains. Below the South Street, the stream is able to access the floodplain in most locations except where recent development in the floodplain has occurred such as at the wastewater treatment facility. Protection of the integrity of these vegetated floodplains and wetlands are essential to the maintenance of water quality and stream stability in this section of the river. Conversion of the wetland or floodplains to impervious surface or channelization of the stream to enable development will greatly impact rates of runoff, stream bank erosion and water quality *degradation*.

Land Use/Land Cover:

Above the Village of Stamford, the dominant land use is a mix of forested land with abandoned agricultural land. Once within the limits of the village, residential and commercial land uses associated with impervious and semi-impervious surfaces are the primary land cover. A light industrial and commercial district is found downstream from where the river crosses NYS Route 23, but runoff from these businesses is currently buffered by a vegetated zone before it reaches the stream.

The Village of Stamford historically has supported a tourist industry attracting downstate residents to moderate sized hotels in this Catskill community. Despite the demise of the hotel industry, the economy of Stamford continues to support a stable population and investment in small businesses, light industry and tourism based businesses. Growth in the area has occurred largely east and north of the village along NYS Route 23 and 10, away from the river. While the stream and adjoining lands are not currently threatened by development, protection of the riparian buffer, even in urban areas should be a priority as land use planning options are considered.

Below the village limits, the stream passes through a mix of residential areas gradually changing to agricultural areas as the principle land use. In the past century, the amount of land under agriculture has declined with areas at higher elevations abandoned first and more recently, areas within the central valley converted to residential development or reverting to forest through old field as known as forest succession. In the reaches below the Village of Stamford, development along the stream corridor in this segment has not reached the critical point where floodplain encroachment would begin to dramatically affect stream stability. The maintenance of a continuous riparian buffer of adequate belt width to allow for stream alignment adjustments should be a major objective of landowners and those reviewing plans for development in this area. This buffer would help reduce nitrogen and phosphorus pollution from overland sources including agriculture.

Infrastructure:

At the intersection of NYS Route 10 and 23, the Village of Stamford has numerous smaller stream crossings over the West Branch headwaters including 1 county, 4 towns, 1 state, and 5 privately owned bridges (including 1 railroad bridge). All of these crossings are small and typically allow flood elevations to rise about 5 feet before the structure is overtopped. While there was no significant evidence of bank erosion at any of these bridges, gravel bars were associated with three of the bridges, including the Route 23 Bridge. While the presence of gravel bars can indicate a *sediment* transport constraint, at the time of assessment the condition of the bars did not suggest that there was a problem worthy of corrective action.

Within this segment few if any of the roads critically impair the ability of the river to access its floodplain. No major highways parallel the stream within the historic floodplain. Only River Road in the village parallels the stream, but the road's influence on the floodplain is minimal as it is constructed at grade with the floodplain and therefore allows for the unrestricted access of high flows to the floodplain.

The Delaware and Ulster Rail Trail crosses the river in Stamford below South Street and upstream from Railroad Ave. This bridge and its approach bisect the floodplain through this reach and limit the stream to a 10.5 ft. wide bridge opening. The stream maybe slightly entrenched through this reach with a short length of eroding bank downstream from the bridge. While the bridge may contribute to the entrenched condition and erosion, the impact is minor and only requires occasional visual *monitoring*.

Sediment Transport and Channel Evolution:

Knowing where a stream lacks the ability to move its sediment is a key indicator of where problems with stream could be expected. If a stream fails to move its sediment, central and transverse gravel bars form and stress grows on the banks resulting in accelerated erosion and bank failure. A process of channel evolution can begin which will require years before the stream is able to return to its stable form. In the Stamford segment of the West Branch of the Delaware, the presence of gravel bars is limited to areas where the stream's capacity to transport its sediment has been altered by bridges and channelization. Transverse bars are the most prevalent of the four bars found in this segment, only one is associated with notable bank erosion. Overall, the sediment appears to be moved adequately by the stream though this segment.

Comparison of stream alignments mapped from a time series of aerial photographs including photographs from 1963, 1971, and 1987 show little change in the stream's current course except where it has been most likely altered by development.

Although the stream management program is sampling *bedload* at point bars on the West Branch Delaware River as part of this planning process, no samples were taken within this stream segment as visual inspection of conditions did not indicate the presence of a sediment transport problem.

Aquatic Habitat Conditions:

In general, the condition of the *aquatic habitats* in this segment were good, with areas of concern found in the urban areas of Stamford which is channelized and may be impaired by inputs of warm water, fine sediment and pollutants associated with runoff from roads and other impervious surfaces in the village. The forested area below Lake Utsayantha provided inputs of woody debris and low overhanging branches for cover, with some of the pool depths adequate to provide refuge for the warmer months. The wetland below South Street with its deep and narrow channel provide good habitat with plenty of vegetative cover. Just above Railroad Ave, a long deep pool provided excellent habitat for summer refuge, but a series of man made waterfalls above the road culvert could limit fish passage. Protection of the riparian vegetation, especially the avoidance of mowing lawns down to the edge of the stream will help improve the habitat, as well as protect the banks from the erosive force of flood waters.

Water Quality Concerns:

The principle concern for water quality within this segment is stormwater runoff from streets and parking areas in the Village of Stamford. An increase in impervious ground cover can cause an increase in stormwater runoff that contains more contaminants. Without a sufficient riparian buffer zone in place these contaminants are dumped directly into the main stem increasing the risk of *nutrient* overload and/or pollution into the water system.

History of Stream Management:

The construction of a dam in at the mouth of Lake Utsayantha increased the size and provided additional depth to the lake. The dam found above River Street appears to be the remains of a mill. The construction of residences along River Street in the village also probably resulted in a degree of channel modification to protect the homes from flooding. This effort is supported in the Army Corps study of 1996; however the project would only improve flood protection for events with greater than a 4 percent probability of occurrence in any given year (less than the 25 year storm)[1]. Besides the urban channelized reach, there has been little attempt to create berms along the channel to prevent flooding and the use of revetments, such as rock walls and gabion baskets are limited outside the Village of Stamford. **Table 7.2.2** summarizes the quantity of revetments and repairs that have been established within each management unit in this segment.

Table 7.2.2 – Revetment and Repair

Management Units	Length (mi)	Dumped Stone	Rip Rap	Laid-up Stone	Stacked Rock Wall	Gabions	Log Cribwall	Concrete	Sheet Piling	Other	Log Deflectors	Total Revetment Length (ft)	Revetment Length per mile	Berms	Berm Length (ft)
1	0.57	-	-	2	-	-	-	-	-	-	-	58	102	1	146
2	0.70	1	13	10	-	3	-	4	-	1	-	2663	3804	4	385
3	0.59	-	3	2	-	-	-	-	-	-	-	107	181	-	-
4	0.37	5	5	2	-	-	-	1	-	-	-	1485	4014	-	-

Special Concerns:

In addition to the repeat flood damages experienced by home owners along River Street, there has been repeated concern with local flooding in a manufactured home park on a

[1] U.S. Army Corps of Engineers, September 1996, West Branch Delaware River – Flood Control Study (Section 205), Final Reconnaissance Report, Philadelphia District, Philadelphia, Pennsylvania, 19107-3390. 56pgs.

tributary below Lake Rexmere. Spillage over the dam at the lake passes through the park as it is conveyed through a system of culverts and ditches to the West Branch below Horner Street. The damages include the loss of access resulting from damages to driveways and parking areas and minor damages to homes and landscaping. Current stormwater management programs of Catskill Watershed Corporation may be a source of funding for addressing such problems.

7.2.1 Management Unit 1

Management Unit 1 is in good condition with a well forested floodplain and wetland areas protecting the stream's stability. The reach is relatively undeveloped, or has returned to a largely undisturbed condition. There are a few low stream banks with evidence of minor erosion and a short section of undercut bank. There are a few short sections that appear slightly over wide, with one small central bar. Cross-Section 2 is located in the middle of the reach and has a width/depth ratio of 27 compared with an upper limit for a C stream type of 24 (see **Figure 7.2.1**). This management unit is rated stable and contains monitored cross-sections 1, 2, and 3.

Figure 7.2.1 Typical scene in Management Unit 1 looking downstream located approximately 1,320 feet from Lake Utsayantha.

There is one small private bridge and an old dam at the bottom of the reach. The Lake Utsayantha dam, a bedrock outcrop just above the mill dam and the old mill dam provide grade controls through this reach (see **Figure 7.2.2**).

Figure 7.2.2 Remains of the old mill dam located approximately 375 feet upstream from River Street stone arch bridge.

The vegetation density, species diversity and width of the riparian buffer is excellent, and could provide a reference of an indigenous riparian forest community. The landowners should ensure that conditions on this reach are conserved as it provides an example of a healthy headwater stream. Above the reach, a Japanese knotweed colony has become established on the shore of Lake Utsayantha. This colony could be a source of material for invasive colonies downstream and should be controlled.

There are three areas of wetlands and they are all classified as shrub swamp. The first area of wetland is located approximately 200 feet downstream of Lake Utsayantha, the second area is located approximately 300 feet upstream from River Street Bridge, and the third area is located approximately 670 feet upstream from River Street Bridge.

<u>7.2.2 Management Unit 2</u>

Figure 7.2.3 Deposition at the upstream end of the box culvert located on River Street.

Management Unit 2 is rated moderately stable and contains monitored cross-section 4. Management Unit 2 is largely influenced by the development that has occurred in the Village of Stamford. Below the old mill dam, the river loses much of its floodplain and becomes a B stream as it passes under the first of two bridges on River Street. There rip rap and a berm have been constructed to control and confine the stream as it enters the residential neighborhood along the street. The first bridge shows evidence of deposition at its entrance suggesting that there may be a backwater effect at the mouth of the box culvert (see **Figure 7.2.3**). A constriction at this point in the channel enables flow during flood events to jump the *right bank* and run down River Street through the residential neighborhood.

Figure 7.2.4 Looking downstream at NYS Route 23 Bridge.

Other private driveway bridges/culverts allow driveways to cross the channel through this reach before the channel becomes revetted for the last 300 ft before crossing under NYS Route 23 (**Figure 7.2.4**). The landowners living along this section of the river have been plagued with flooding, but the river's low slope and the intensity of land use through this 1700 foot reach provide few options for alleviating this condition. Reestablishment of a limited floodplain (converting the channel from an F to an entrenched E channel) may provide some relief, but would require that landowners along the stream be willing to move their activities away from the channel.

Below Route 23, the stream is channelized. It is tightly squeezed between buildings, first with formed concrete walls, and then rip rap and laid-up stone. Some of the stone walls are aging and may soon need repair. The culvert at South Street is in fair condition. The management unit ends below South Street as the stream enters a wetland and changes from an F channel to a multiple thread D stream type. There are no wetlands located within this unit.

7.2.3 Management Unit 3

Management Unit 3 is rated stable with monitored cross-sections 5, 5.8, and 6. In Management Unit 3, the stream flows through a wetland and through a forested section at the railroad crossing before entering another wetland above Railroad Avenue. The first wetland receives water not only from upstream, but also runoff from surrounding parking areas. Its function and conservation is likely to be very important to water quality along this reach. This multiple thread channel is a well vegetated D channel, before transitioning to a C4 with fairly deep pools and later a B stream type. The riparian vegetation is healthy throughout with a dense grass and shrub community dominating the wetland before transitioning to a forested riparian community in the C and B sections of the stream.

Figure 7.2.5 Typical C stream type located approximately 450 feet upstream from Rail Trail

After passing under the rail trail bridge, the stream returns to a C stream type although the flat slope of the stream is maintained by a small dam at the end of a long pool just upstream from the culvert on Railroad Avenue. In this reach, the riparian buffer on the right bank is weakened by the maintenance of a lawn up to the edge of the water (see **Figure 7.2.6**). Integration of shrubs and a few trees would increase bank stability and help ensure that the river does not circumvent the check dam above the Railroad Avenue culvert.

Figure 7.2.6 Lawn maintained to edge of water located approximately 350 feet upstream from Railroad Avenue culvert.

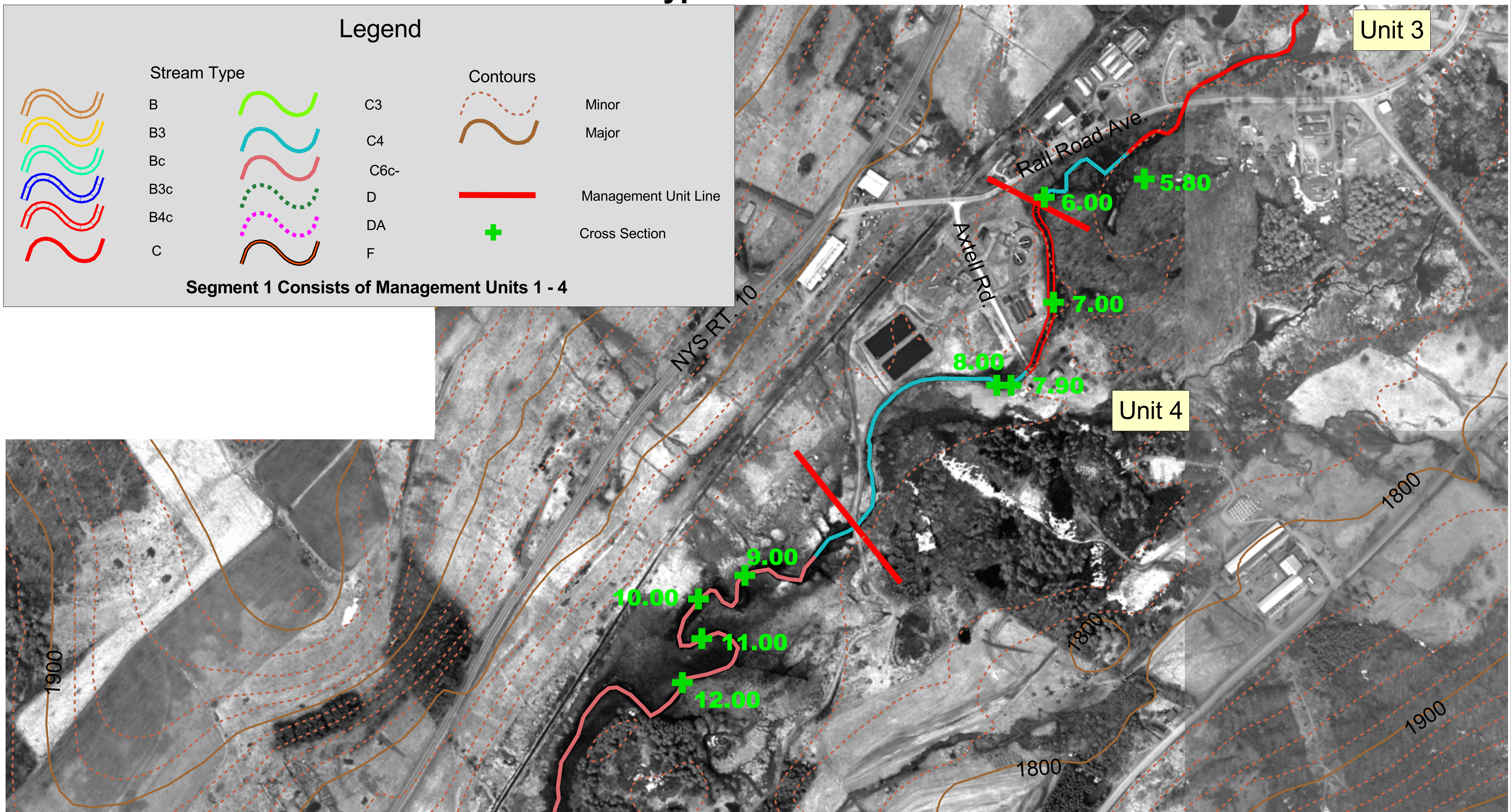
Below Railroad Avenue the river enters a forested wetland, which has a debris jam that splits and reroutes flow through the wetland. This area is not impacted by local development and the strong riparian vegetation community maintains the stream bank stability at the margin of the wetland. Removal of the debris jam is not needed at this time. The wetland and the riparian forest community warrant protection from future potential development.

7.2.4 Management Unit 4

Management Unit 4 is rated moderately stable with unstable reaches and contains monitored cross-sections 7, 7.9 and 8. See **Management Unit 4 - Map 1** through **Map 6** at the end of this unit description. Below the wetland, the river enters a long sweeping bend around the village waste water treatment plant. To protect this facility, the right bank has been armored with dumped stone and rip rap. Also, the stream may have been realigned sometime between 1971 and 1983. This realignment may have been related to a previous aerator/settling tank upgrade to the treatment plant. The entire reach along the treatment plant shows evidence of instability with the frequent use of rip rap indicating the repeated need to strengthen the banks. Even the two residential properties at the end of Axtell Rd have had to rip rap their stream banks. Additional vegetation at key points along the stream bank would help improve the riparian buffer and reduce the need for rip rap maintenance. The stream type below the wetland changes from C4 to B4 and then back to a C4 at the bottom of the reach near the treatment plant outlet. The change is due to the rip rap placement which confines the stream and minimizes its access to a floodplain.

Figure 7.2.7 Typical scene in Management Unit 4 looking downstream located approximately 160 feet upstream from Axtell Road.

Management Unit 4 - Map 1
Stream Types and Cross Sections



Base Data Provided by NYCDEP
Map data provided in NAD 83 UTM Zone 18 North
Contour Interval 20 feet
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

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Management Unit 4 - Map 2
Channel State and By-Pass Flow

Legend

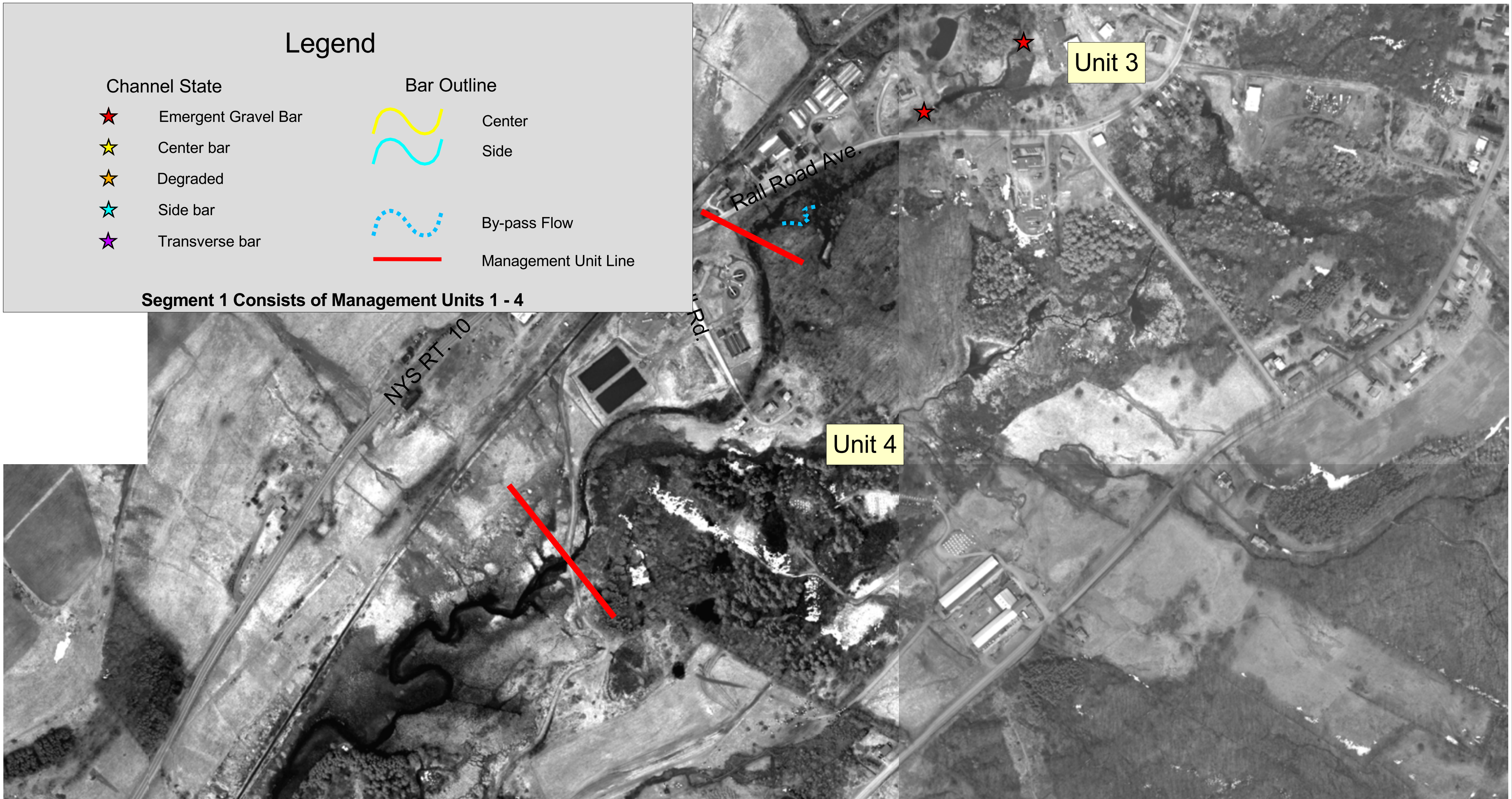
Channel State

- ★ Emergent Gravel Bar
- ★ Center bar
- ★ Degraded
- ★ Side bar
- ★ Transverse bar

Bar Outline

- Center
- Side
- By-pass Flow
- Management Unit Line

Segment 1 Consists of Management Units 1 - 4



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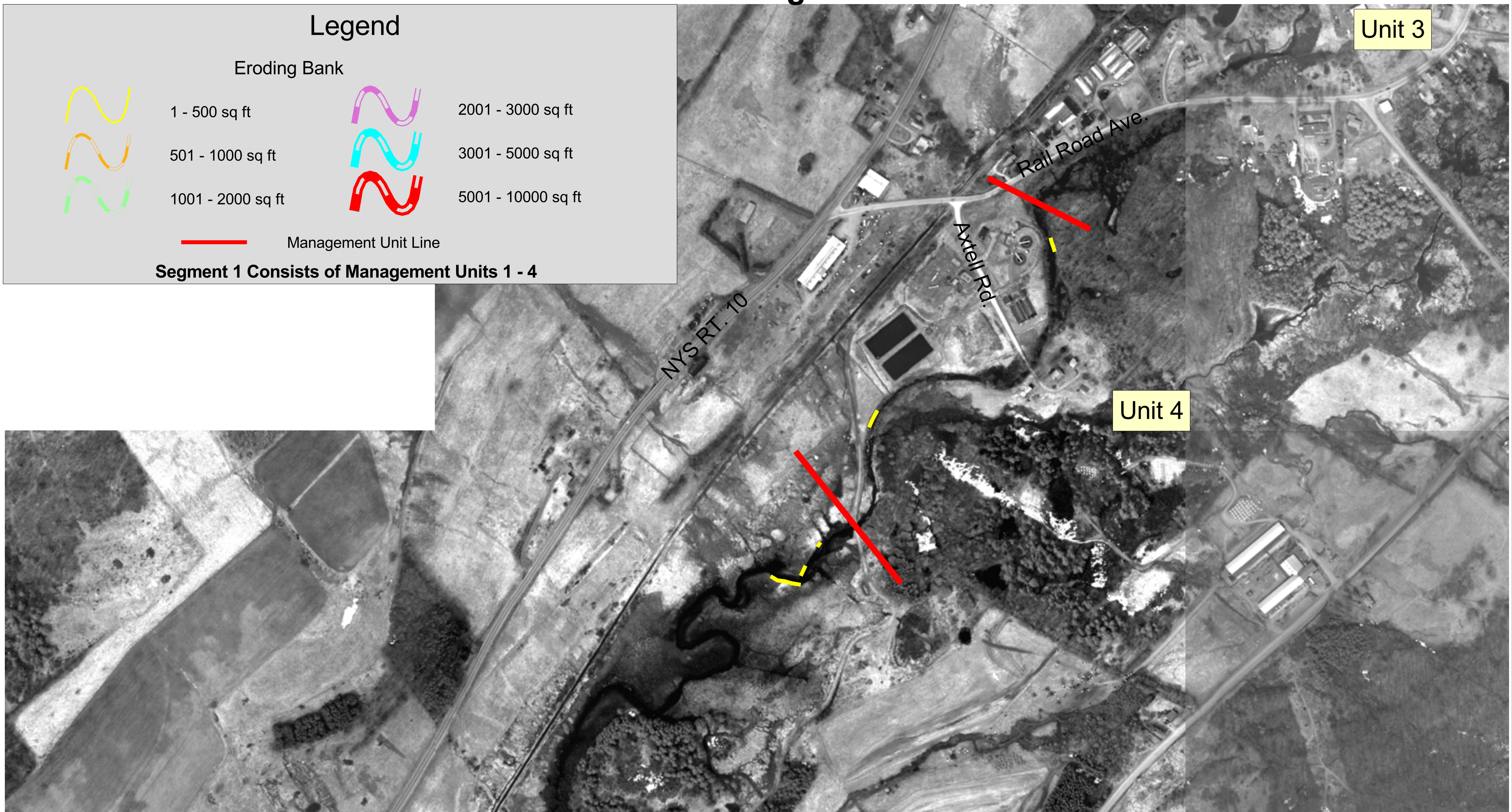
Management Unit 4 - Map 3
Eroding Banks

Legend

Eroding Bank

- 1 - 500 sq ft
- 501 - 1000 sq ft
- 1001 - 2000 sq ft
- 2001 - 3000 sq ft
- 3001 - 5000 sq ft
- 5001 - 10000 sq ft
- Management Unit Line

Segment 1 Consists of Management Units 1 - 4



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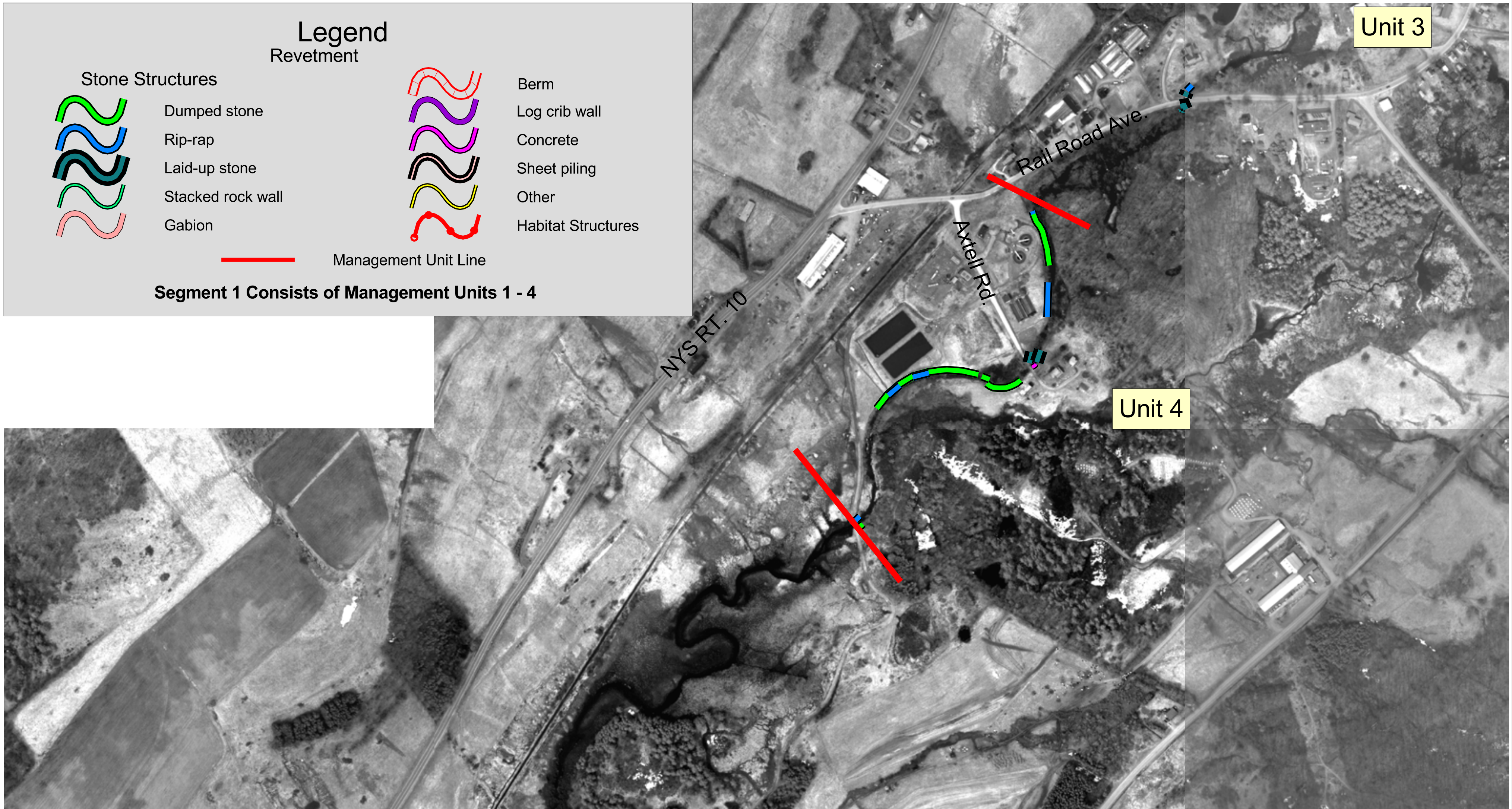
Management Unit 4 - Map 4
Revetment



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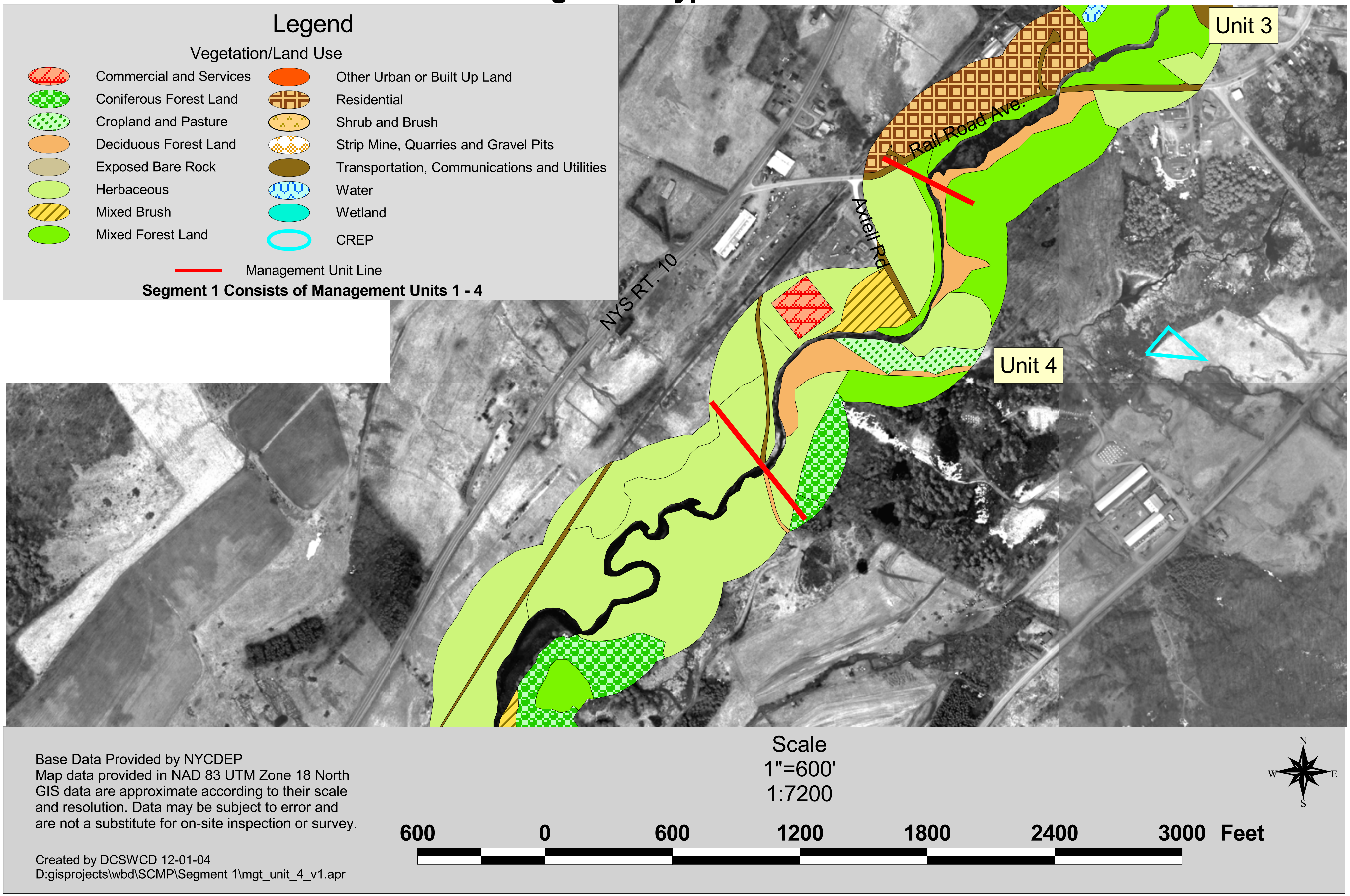
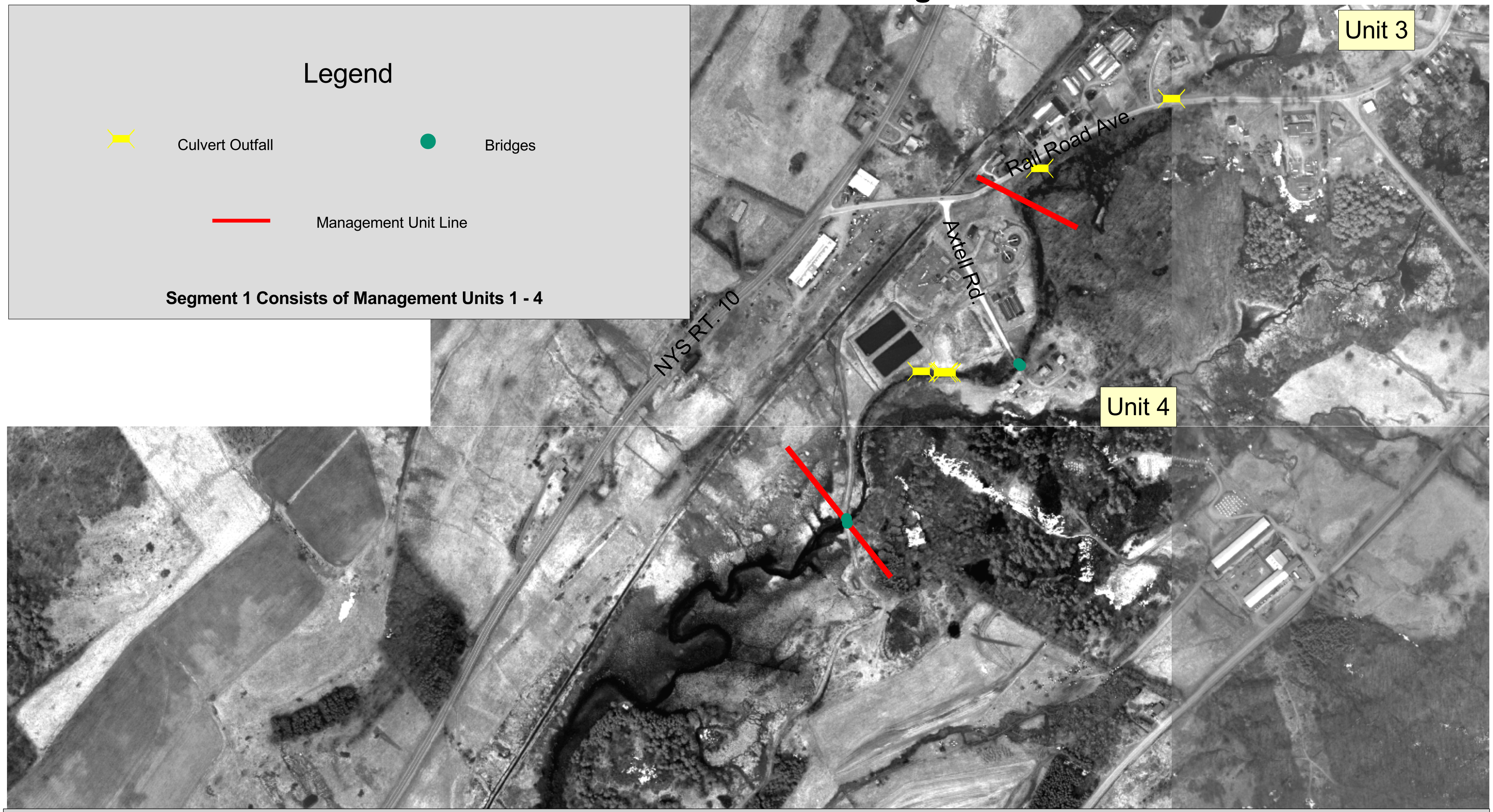
N W E S

Management Unit 4 - Map 5
VegetationTypes/Land Use



Management Unit 4 - Map 6
Culvert Outfalls and Bridges



Base Data Provided by NYCDEP
Map data provided in NAD 83 UTM Zone 18 North
GIS data are approximate according to their scale
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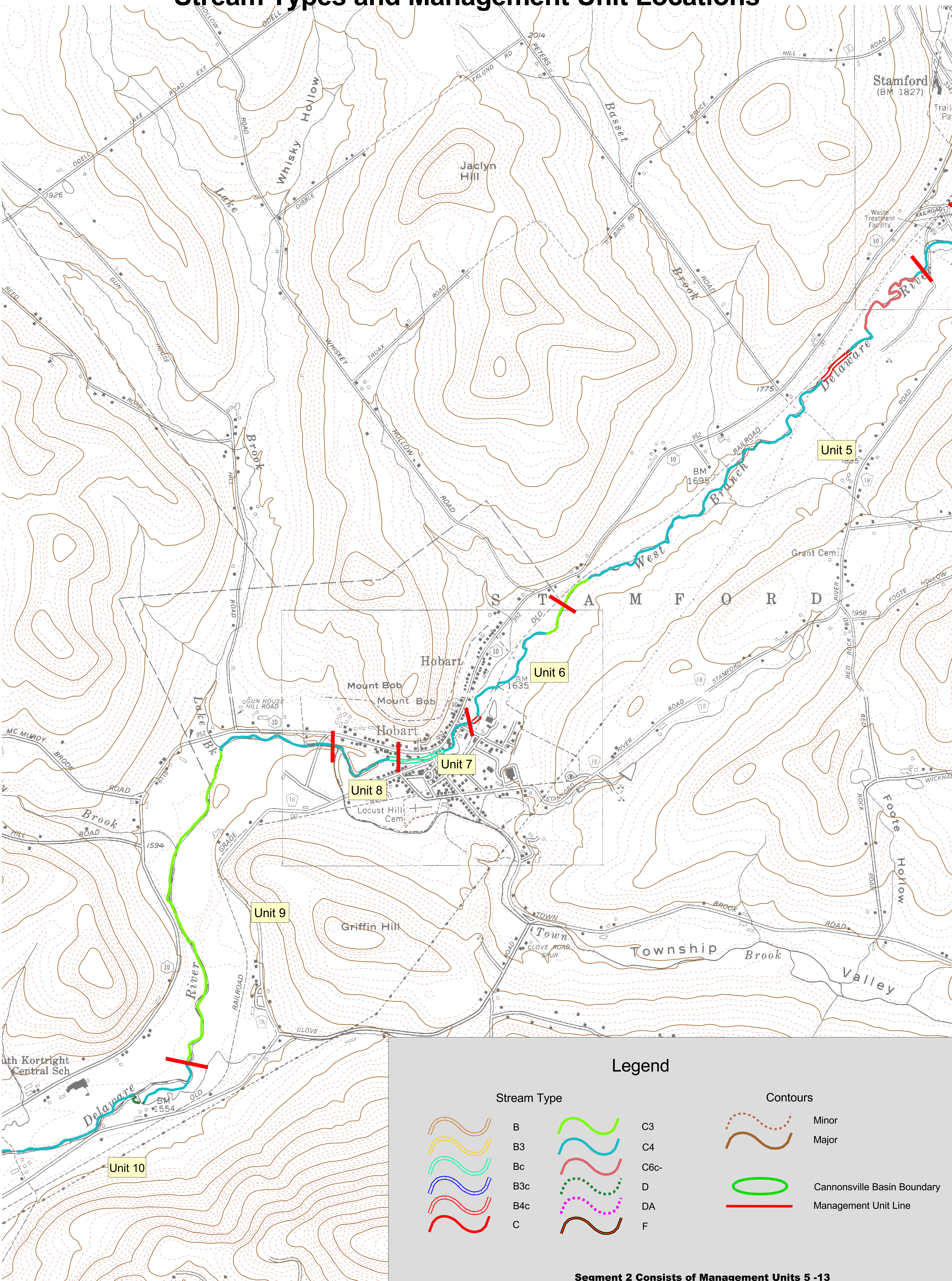
N W E S

Segment 2

Segment 2 - Map 1
Stream Types and Management Unit Locations



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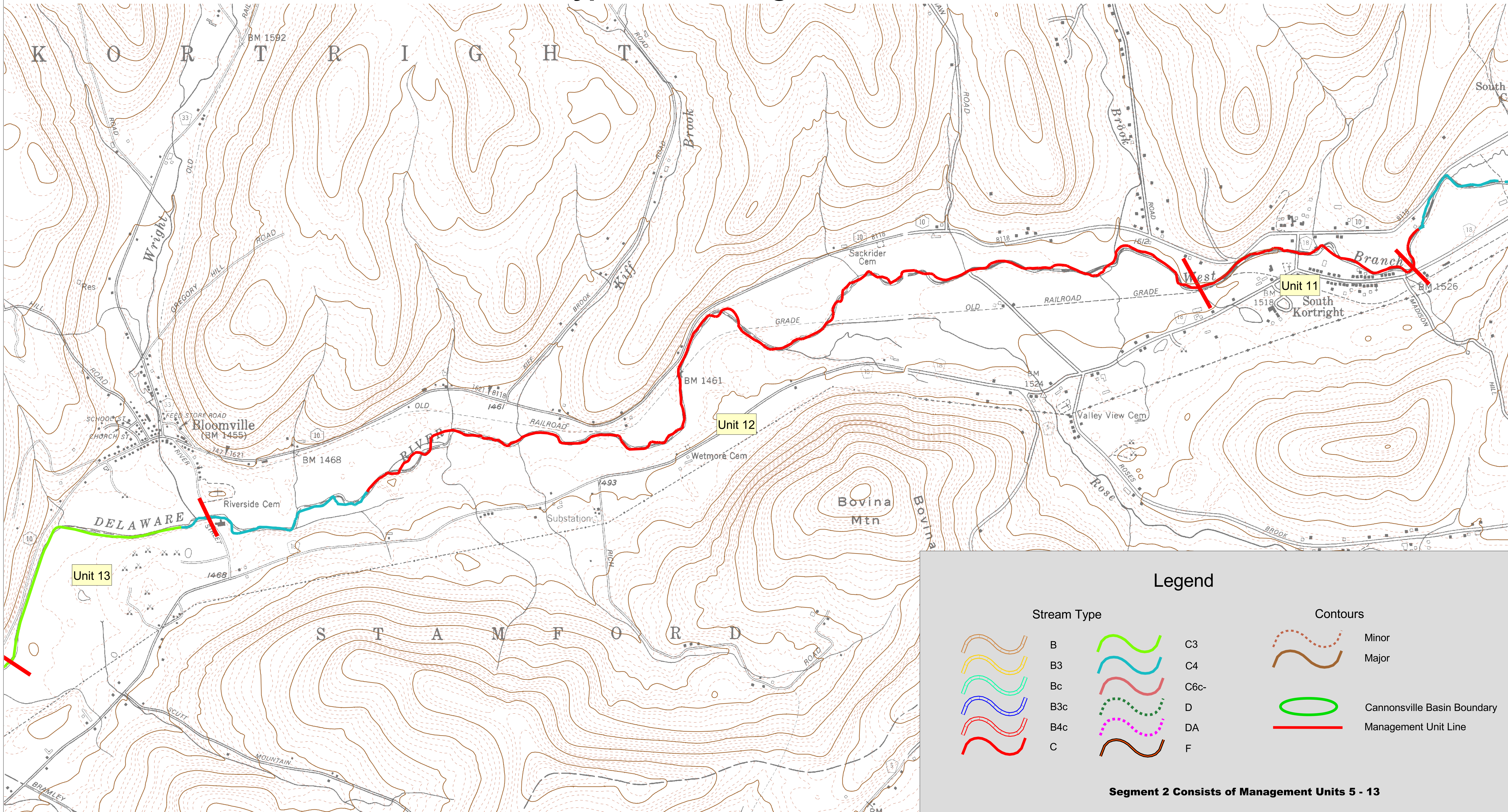
Segment 2 - Map 2
Stream Types and Management Unit Locations



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7.3. Segment 2 – Towns of Stamford and Kortright

General Description of Segment Two

This description of stream segment two covers the section of river from a point below the Village of Stamford wastewater treatment plant to a point just upstream of the Kortright-Delhi town line. The watershed area at the top of the segment is approximately 13.4 square miles and 97 square miles at the bottom of the segment with a total surveyed segment length of 82,441 feet. This segment represents the transition from the headwaters for the West Branch of the Delaware River to the mid valley river stream types. Numerous tributaries, including Town Brook, Lake Brook, Betty Brook, Rose Brook and Wright Brook increase the watershed area and the additional drainage area requires a larger channel to effectively move the water and sediment. As the river valley and channel widens and the slope is reduced, the sinuosity of the river increases. These changes are accompanied by an increase in bank erosion. The land use transitions from urban residential and commercial to rural agriculture with interspersed residential properties.

The stream channel dimensions such as its width and depth and the size of the floodplain varies within this transitional zone. Within this segment of the river, the floodplain widens and plays a more significant role in reducing the energy of the river during flood events. In numerous places, less than bankfull flows break out from the primary river channel and create secondary channels across the floodplain. This situation may be evidence that the river is aggrading and is unable to move its sediment through the primary channel. Frequently, where secondary channels are present, landowners have constructed berms and rock walls to contain the river within its primary channel and protect their property. In an attempt to protect the stream banks, landowners have lined the bank with rip rap and dumped stone. The presence of one or more of these revetments along the stream bank is most prevalent where land use is most intense, the riparian vegetation has been removed and the alignment of the river places extreme stress on the stream bank, such as on a the outside bank of a sharp bend in the river.

Flooding is not a major problem along this segment of the river as most houses and developments are located well outside the floodplain.

This segment is composed of Management Units 5 through 13. The table below summarizes the erosion and depositional features that are within this segment by management unit.

Table 7.3.1 – Summary of Erosion and Depositional Features

Management unit	Length (mi)	Linear Feet of Erosion	Surface Area (sq.ft.)	# Erosion Features	# Deposition Features	LF Erosion per Mile	# Erosion Features/mi	# Deposition Features/mi
5	2.55	905	1901	14	18	354.90	5.49	7.06
6	0.76	417	2703	5	10	548.68	6.58	13.16
7	0.38	0	0	0	0	0.00	0.00	0.00
8	0.39	521	3502	5	7	1335.90	12.82	17.95
9	1.99	1936	9498	18	12	972.86	9.05	6.03
10	1.65	2562	10511	15	11	1552.73	9.09	6.67
11	0.96	1311	7954	6	3	1365.63	6.25	3.13
12	4.89	9054	47441	61	11	1851.53	12.47	2.25
13	1.20	1433	7702	6	5	1194.17	5.00	4.17

Geomorphology and Geology:

The outwash sands and gravel plain deposited during the Wisconsin glacial retreat are the most significant elements of the surficial geology affecting *morphology* of the river in this segment. As with segment one, the sands and gravels layers with a thickness of 6-60 feet at the bottom of the valley are bounded in places by deposits of larger gravel dumped as "kames" or terraces along the valley wall. As tributaries enter the main stem of the West Branch, alluvial fans have formed in the delta. The fans are elevated over the valley floor and provide a site that has been attractive to development as in the case of the hamlets of Hobart and Bloomville. The observation of the geometry of the main stem suggests that the river will migrate to the valley wall opposite the alluvial fan as the river seeks to flow around the fan. On top of the fan, the tributary may migrate back and forth across the delta area as it attempts to move its bedload down through the channel and avoid clogging with sediment. This migration can be troublesome in times of flood for communities that have built on the fan. During flood events, debris from up channel sources is deposited in the delta channel and clogs the channel. The flow will rise over the banks and may create new, *braided* channels across the fan, in the process spreading debris and inundating low areas away from the primary channel.

The valley continues to be a Rosgen valley type VIII with wide gentle sloping valley with terraces at the margins of the floodplain. Based upon approximated measurements from USGS 7.5' quadrangle sheets, the width of the valley floor increases to between 400 and 900 feet as the watershed source area increases. The valley slope decreases from about 1.3 percent in segment one to about 1.0 percent at the top of segment two to about 0.5 percent at the bottom of segment two. Stream channel slope declines from 1.0 percent at the top of the segment to about 0.4 percent at the bottom of the segment. Sinuosity varies between 1.1 and 1.4, with most sections around 1.2. There are three locations (one above South Kortright and two below South Kortright) along the north side of the river along NYS Route 10 where bedrock controls the stream alignment. The bedrock at only one location (approximately 1000 feet below South Kortright) acts as a grade control.

The river through this segment is predominantly C stream type with the exception of small sections of Bc stream. These C stream reaches are typically, somewhat over-wide and have pools that are shallower than should be expected. The bed pavement material is largely *cobble* and gravel, with the exception of the highly sinuous C6c- (*silt*/sand bed) reach below the Village of Stamford waste water treatment plant. This tortuously *meandering* reach is the mythical section of the river where legend tells of Hiawatha shooting an arrow seven times across the Delaware. It is likely that this reach was previously an E6 channel with a lower width to depth ratio, but recent grazing practices have resulted in the cattle damaging the stream banks and altering the character of the stream.

The assessment team identified ten locations along this segment with exposed clay lenses in either the stream bed or bank. These clays are a significant concern for water quality as disturbance and introduction of the material into the river increases *turbidity*. These clays while not as abundant as found in the central Catskill rivers such as the Schoharie and Esopus, still pose a threat and the exposures should be monitored. Prior to any future stream work in these areas, the presence or absence of clays should be ascertained as part of the survey and design process.

Stream Orders, Floodplains, and Wetlands:

The stream is a fourth order stream in this segment. There are eight tributaries that enter the river in this segment: Basset Brook, Town Brook, Lake Brook, McMurdy Brook, Dry Brook, Betty Brook, Rose Brook, and Kiff Brook. Town Brook is a major source of sediment. McMurdy Brook, Rose Brook, and Kiff Brook are moderate sources of sediment. Basset Brook, Lake Brook, Dry Brook, and Betty Brook contribute minimal amounts of sediment to the river.

Upstream of Hobart the floodplain is typically used for agriculture. There is some riparian buffer except for the C6c- reach which has no riparian buffer. The stream has good access to its floodplain.

In the Village of Hobart, due to the man-made conditions which prevail, the river has no access to its floodplain.

Downstream of Hobart the floodplain is used for agriculture, and generally it has a narrower riparian buffer than is found upstream. The river has good access to its floodplain.

There are 12 areas of wetland in this segment. Two areas are shallow emergent marsh and ten areas are shrub swamp.

Land Use/Land Cover:

Below the Village of Stamford, the dominant land use is agricultural land with forested land at the higher elevations and on steeper slopes. Scattered residences are located along the alluvial terraces and lower side slopes of the hills where access roads can be constructed. Within the riverine lands, cropland and pasture dominate with hayland (herbaceous) the principal land uses/land covers. Forests and mixed shrub as a percentage of riparian land cover is similar to segment one with about 42% of the land cover forest or shrub within 300 feet of the river. This proportion of forested land drops to 36% of the land cover if the analysis is limited to a 100 feet buffer of the river. Herbaceous land cover increases from 15% to 24% as the buffer analysis changes from 300 feet to 100 feet of the river. To improve stream bank stability it would be preferable to reverse this trend and have woody vegetation dominate the area within 100 feet of the river. Within this segment, greater efforts are needed to enhance the woody component of the riparian buffer along the river.

The hamlets of Hobart and South Kortright are stable communities that have not experienced significant growth. In Hobart, Tyco International, a major employer and landowner within the village, directs runoff from its impervious surfaces through stormwater detention ponds located above the floodplain. The O'Connor Foundation sponsored project at the old mill dam has secured the river banks through much of the hamlet. A few older retaining walls above the project area will need continued reinforcement to protect the older structures along the river. Where possible, opportunities to remove or relocate structures should be sought to reduce repetitive flood damages and the cost of maintaining the walls. Commercial and residential development in South Kortright is largely located outside of the floodplain and therefore is not threatened by flooding nor does it impact the river's stability. In both South Kortright and particularly in Hobart, stormwater runoff planning would aid in protecting water quality and facilitating future development. A Japanese knotweed colony was detected on the upstream *left bank* at South Kortright and was probably established from a garden dump. This colony is one of the farthest upstream colony found on the West Branch and should be controlled before it spreads into the floodplain.

Development along the stream corridor in this segment has not reached the critical point where floodplain encroachment would begin to dramatically affect stream stability. The maintenance of a continuous riparian buffer of adequate belt width (at least 100 feet wide) to allow for stream alignment adjustments should be a major objective of landowners and those reviewing plans for development in this area. This buffer would help reduce nitrogen and phosphorus pollution from overland sources including agriculture.

<u>Infrastructure</u>:

The river is paralleled by New York State Route 10 and County Route 18 with bridges in Hobart at Cornell and Maple Avenue, South Kortright and Bloomville. None of these bridges present a problem for stream stability at this time. There are several locations where stormwater drains installed to remove runoff from NYS Route 10, now direct flow over the high stream bank with insufficient protection for the stream bank. Highway construction planners and inspectors need to ensure that stormwater is directed toward the river in a way that does not destabilize the riverbanks and allows for sufficient filtering/detention.

Sediment Transport and Channel Evolution

The percentage of stream length that had eroding stream bank increased from 4 percent on Segment One to 21 percent in Segment Two. The increase in erosion is correlated with the decrease in the size and decline in quality of the riparian forest buffer.

Nearly half of the river length along segment two has some form of revetment constructed to either retain flows within the channel (berms and walls) or protect the banks (rip rap, stonewall and dumped stone). Berms make up about 12% of total length, rip rap and dumped stone each comprise a similar percentage of the length. Although anglers familiar with this segment are knowledgeable of the log cribbing revetment constructed by the Department of Environmental Conservation, these revetments are generally in disrepair and only make up 4 percent of the total stream length. The willow trees planted in conjunction with the log revetment continue to hold the banks together even though the revetment structures have failed.

There are numerous side channels throughout the segments, particularly in Management Units 9, 11 and 12. These channels reduce the sediment transport capacity of the primary channel and exacerbate the aggradational condition. In some locations, the presence of side channels together with a general aggrading trend could be an indicator that the stream is evolving from a type C to a type D (braided channels). Type D's are generally highly unstable, erosive, and provide very poor habitat.

Aquatic Habitat Conditions:

In general, the condition of the aquatic habitats in this segment were good, with areas of concern found where the riparian vegetation was lacking and provided no cover or woody debris. In some locations the channel was over wide and the shallow conditions may increase in water temperatures during low flow periods. Pool depths through the segment are somewhat shallow due to the process of aggradation which is occurring along this reach. The gravel and small cobble channel substrate are good for spawning. This segment is known as a productive reach by local anglers.

History of Stream Management:

Throughout this segment there is extensive revetment largely constructed by farmers in an effort to protect their fields from bank erosion and flood scour out on the floodplain. **Table 7.3.2** summarizes the quantity of revetments and repairs that have been established within each management unit in this segment.

Table 7.3.2 – Revetment and Repairs

Management Units	Length (mi)	Dumped Stone	Rip Rap	Laid-up Stone	Stacked Rock Wall	Gabions	Log Cribwall	Concrete	Sheet Piling	Other	Log Deflectors	Total Revetment Length (ft)	Revetment Length per mile	Berms	Berm Length (ft)
5	2.55	3	8	4	4	-	-	1	-	-	-	2438	956	-	-
6	0.76	2	5	4	-	-	-	-	-	-	-	1154	1518	-	-
7	0.38	-	3	3	-	13	-	2	-	-	-	2403	6324	-	-
8	0.39	1	3	1	-	-	-	-	-	-	-	381	977	-	-
9	1.99	10	26	2	-	-	4	2	-	-	10	5146	2586	9	3155
10	1.65	7	12	3	-	-	5	-	-	-	10	3884	2354	3	2079
11	0.96	4	3	4	-	1	1	-	1	-	-	1690	1760.4	1	105
12	4.89	34	18	3	-	-	14	2	-	-	3	11124	2275	5	1211
13	1.20	2	1	-	-	-	-	-	-	-	-	1413	1178	4	3464

Special Concerns:

Riparian buffers throughout this segment need to be either established or enhanced to reduce bank erosion, limit nutrient enrichment of river and provide greater cover for aquatic life. Controlling grazing and keeping cattle out of the stream are also management controls that will improve water quality and reduce bank erosion. Control of Japanese knotweed is vital along the river and roadsides to prevent this *invasive plant* from replacing the existing riparian vegetation. Monitoring and further assessment of the distribution of clay lenses in the stream banks may be warranted.

7.3.1 Management Unit 5

Management Unit 5 is a mixture of wooded riparian lands with some agricultural fields. Bank erosion is not serious in this unit. There are about 900 feet of eroding banks with most of the exposures having a bank height of less than two feet. There is about 2400 linear feet of revetment of which almost half is old stone wall. This unit is moderately stable and contains 16 monitored cross-sections (9 through 16, 16.8, 16.9, 17, 19, 19.5, and 20 through 22).

Figure 7.3.1 Typical scene in Management Unit 5 located approximately 3,500 feet upstream from Basset Brook Confluence.

This reach has a private bridge that is in poor condition but there is no evidence of aggradation downstream from the bridge. There are three areas of wetlands within this unit. One wetland that is classified as a shrub swamp is located 2,500 feet upstream from Basset Brook, another wetland is classified as a shrub swamp located at the *confluence* of Basset Brook, and the third wetland, located 3,000 feet downstream from Basset Brook, is a shallow emergent marsh.

Figure 7.3.2 C6c- stream type that is located at the top of Management Unit 5 downstream of bridge.

The top portion of this unit is classified as a C6c- stream type. It is very sinuous, with a low width to depth ratio. The C6c- section may have evolved from an E6 type stream. It is currently destabilizing as a result of recent cattle access to the stream and destabilization of the banks by hoof shear. **Figure 7.3.2** provides an example of the C6c- stream type with its broad shallow floodplain. Removal of the cattle may enable the stream to regain its stream bank vegetation, maintain its sinuosity, and remain a stable C6c-.

The results from the surveyed cross-sections suggest the stream is generally over wide. Several of the surveyed cross-sections had width/depth ratios near or over 40. The degree of entrenchment was typically low, with the entrenchment ratio was between 2.3 and 9 for most of the cross-sections. Below the C6c- section, the river transitions to C4 stream type. Numerous high flow or secondary channels divert some of the flow out of the main channel during near bankfull events. Fortunately through this unit, most of these secondary channels flow through well vegetated buffer lands. Maintenance of this land as forested buffer will help ensure that the channel does not migrate to the route of the secondary channel.

7.3.2 Management Unit 6

In Management Unit 6 the river flows through a large wet meadow/pasture above the Village of Hobart. Cattle have access to the stream through much of this reach. At several locations, the stream banks showed signs of erosion caused by farm animals. There are two sections with revetment, a stone wall along a field and rip rap protection that was placed at the approaches to the rail trail bridge just upstream from the village.

Figure 7.3.3 Typical scene of the river located at the top of Management Unit 6.

There are several center bar deposits in the lower part of this unit before the river enters the village. This management unit is moderately stable and contains monitored cross-section 23. There is one area of wetland within this unit located approximately 600 feet upstream from Cornell Avenue Bridge (County Bridge 69).

7.3.3 Management Unit 7

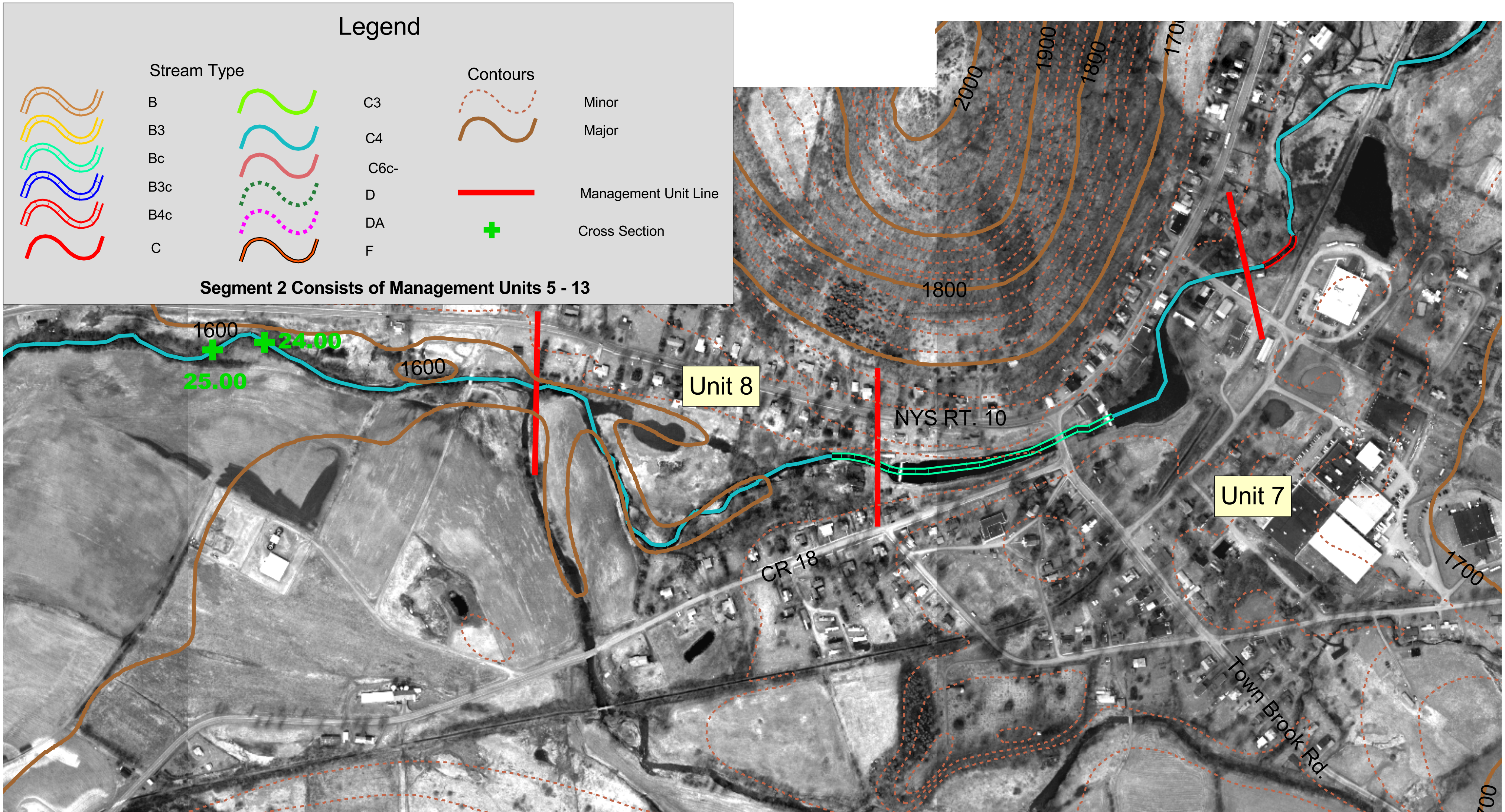
Management Unit 7 is within the Village of Hobart where there are several structures and roads that are in close proximity to the river. New York State Highway 10 runs parallel to the river. See **Management Unit 7 – Map 1** through **Map 6** at the end of this unit description.

This reach contains two dammed ponds connected by a manmade stream. Gabion baskets are found in the river bed and along the banks which continues downstream through Maple Avenue Bridge. **Figure 7.3.4** shows the upper dam from Maple Avenue Bridge. The outfall of the lower pond is of similar construction. These structures trap sediment behind the dams.

Figure 7.3.4 Looking upstream at one of the dams in Hobart from Maple Avenue Bridge.

This unit is in stable condition and has no *monitoring cross-sections* at this time. There is USGS gage station 01421610 (West Branch Delaware River at Hobart NY) which is located at the dam of the upper pond. County Bridge 69 on Cornell Avenue has no evidence of aggradation downstream. The County Bridge has concrete and laid-up stone revetments on both sides of the riverbanks. There are old stone walls above Cornell Avenue that may require maintenance.

Management Unit 7 - Map 1
Stream Types and Cross Sections



Base Data Provided by NYCDEP
Map data provided in NAD 83 UTM Zone 18 North
Contour Interval 20 feet
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

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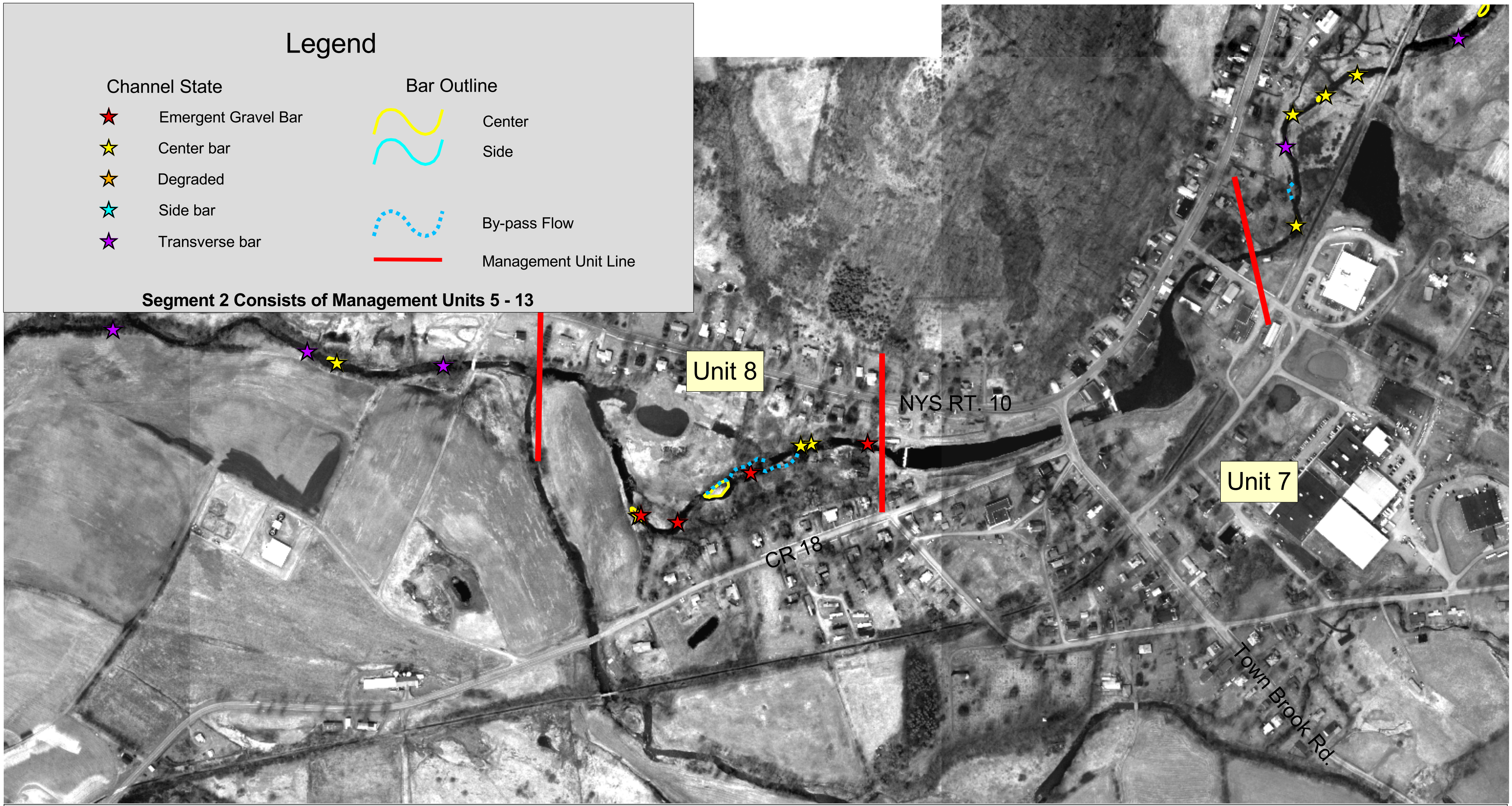
Management Unit 7 - Map 2
Channel State and By-Pass Flow



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Management Unit 7 - Map 3
Eroding Banks

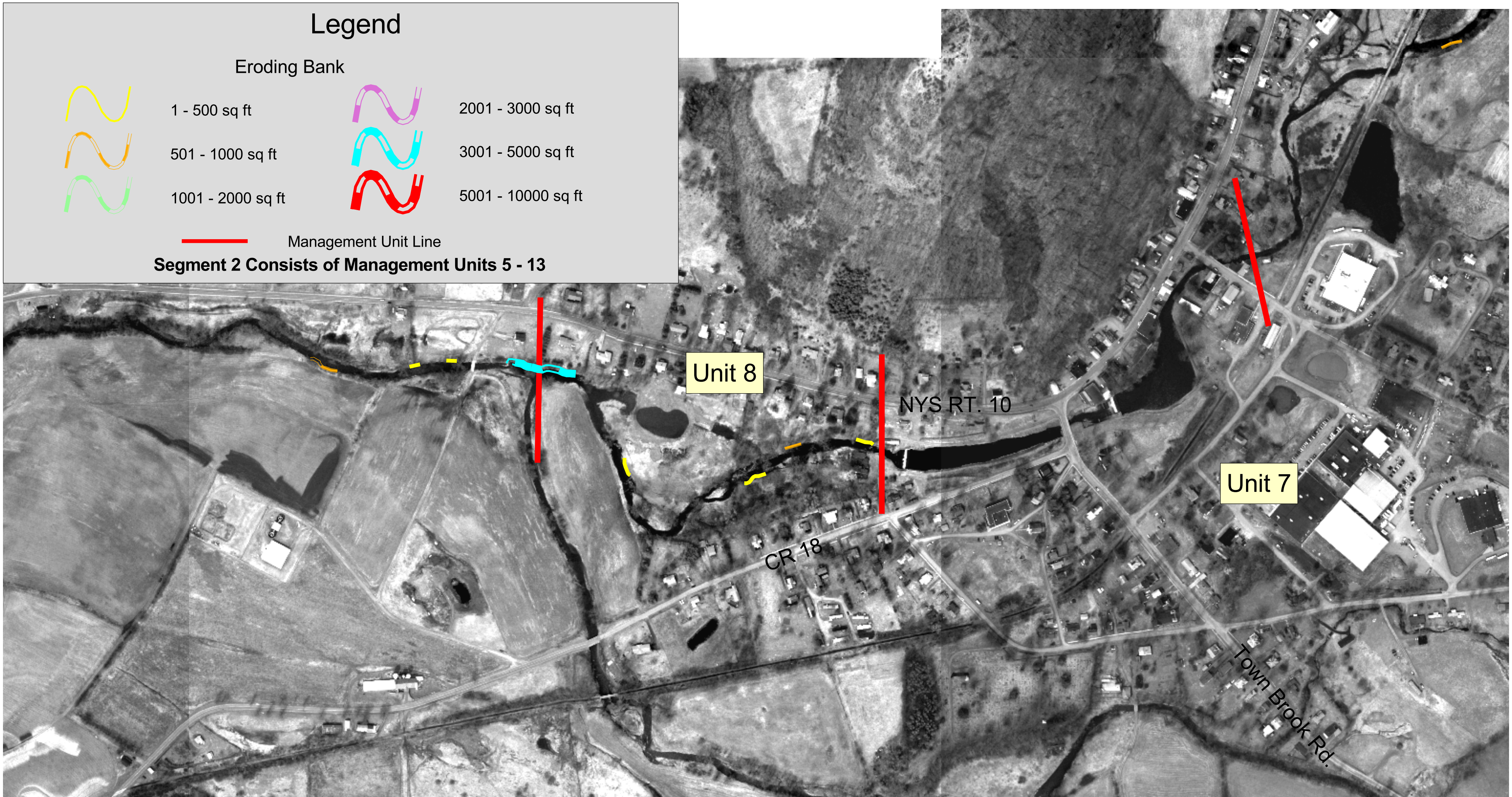
Legend

Eroding Bank

- 1 - 500 sq ft
- 501 - 1000 sq ft
- 1001 - 2000 sq ft
- 2001 - 3000 sq ft
- 3001 - 5000 sq ft
- 5001 - 10000 sq ft

Management Unit Line

Segment 2 Consists of Management Units 5 - 13



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N W E S

Management Unit 7 - Map 4
Revetment

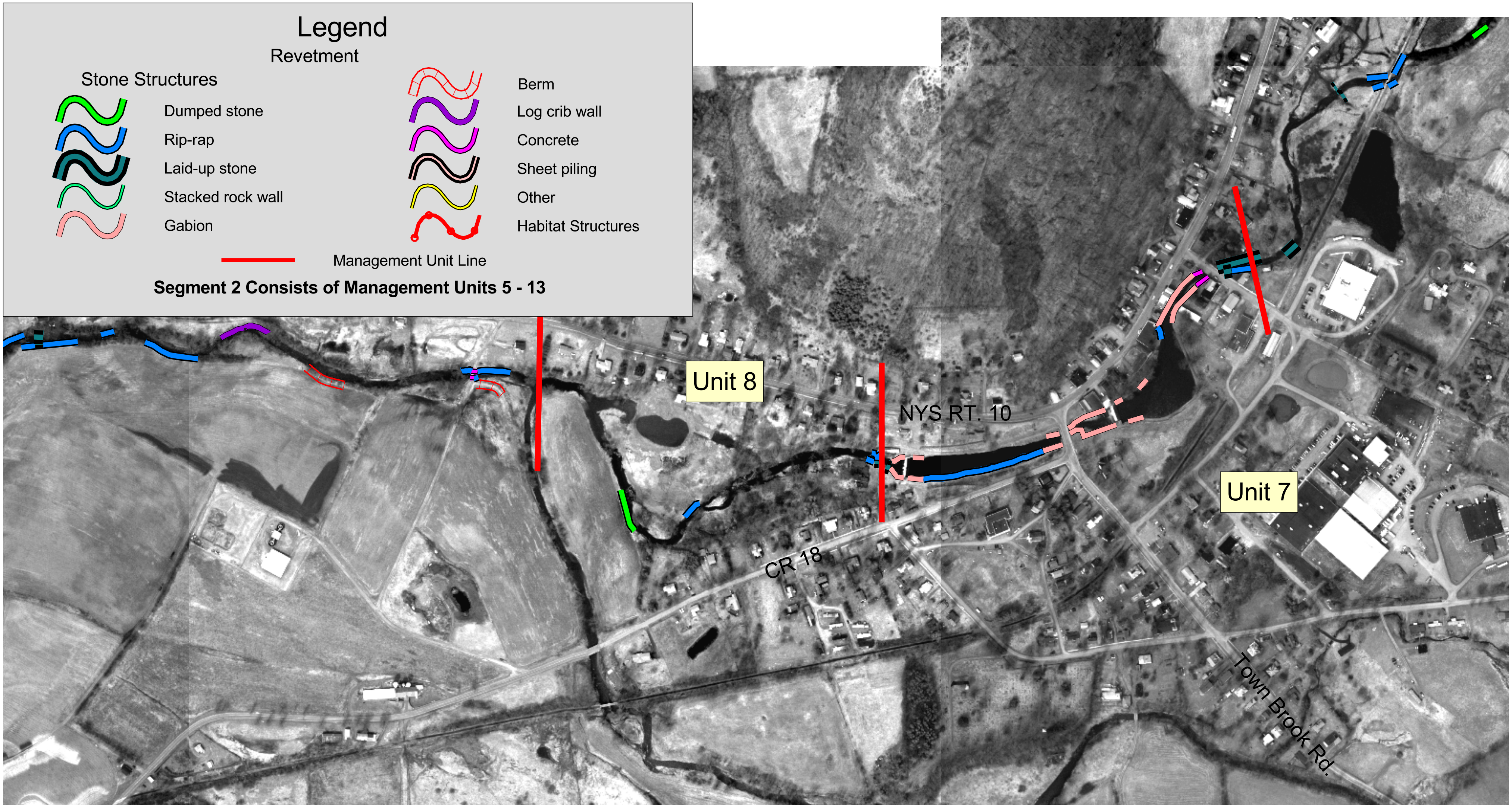
Legend
Revetment

Stone Structures
- Dumped stone
- Rip-rap
- Laid-up stone
- Stacked rock wall
- Gabion

- Berm
- Log crib wall
- Concrete
- Sheet piling
- Other
- Habitat Structures

Management Unit Line

Segment 2 Consists of Management Units 5 - 13



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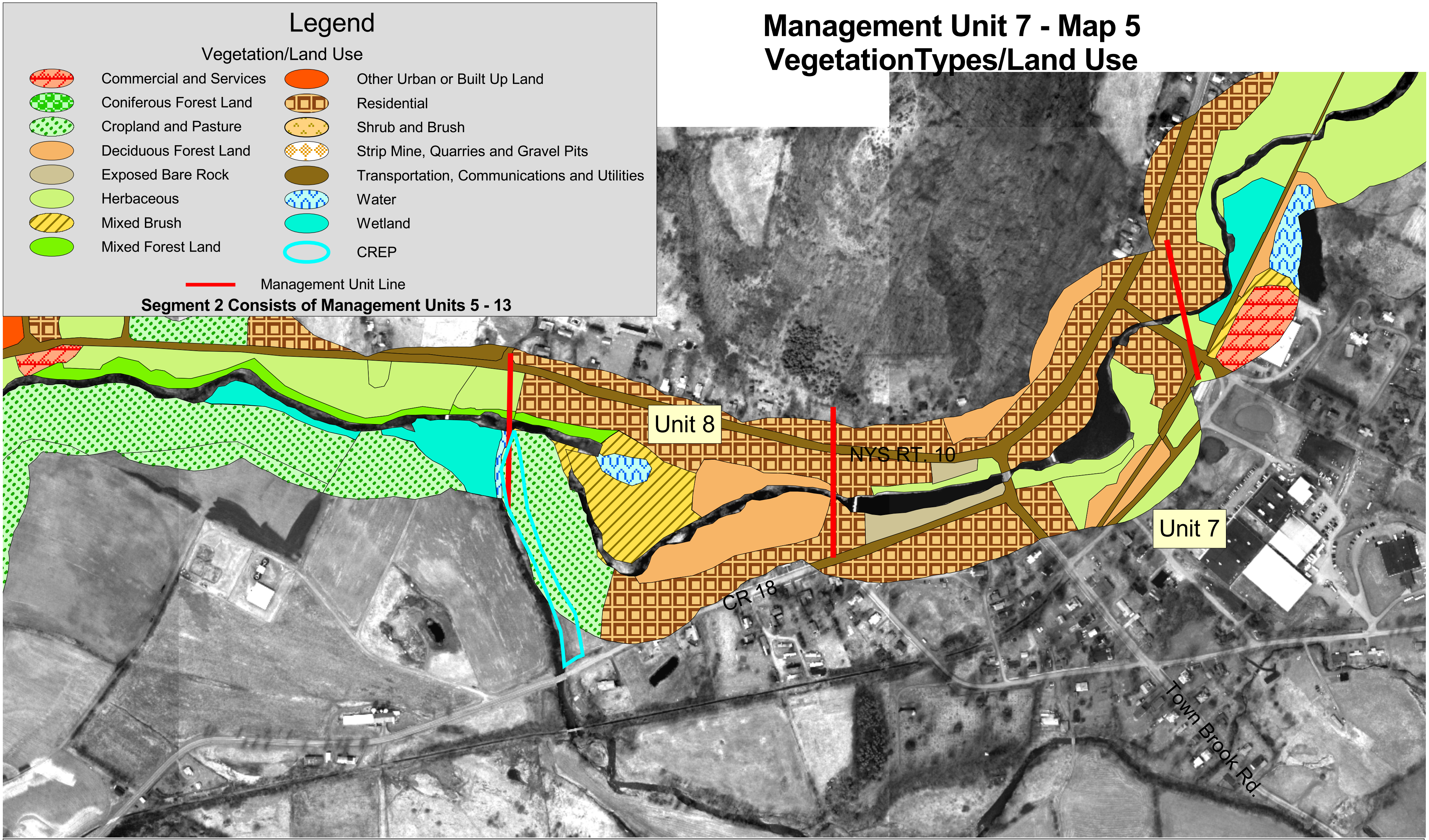
N W E S

Management Unit 7 - Map 5
VegetationTypes/Land Use



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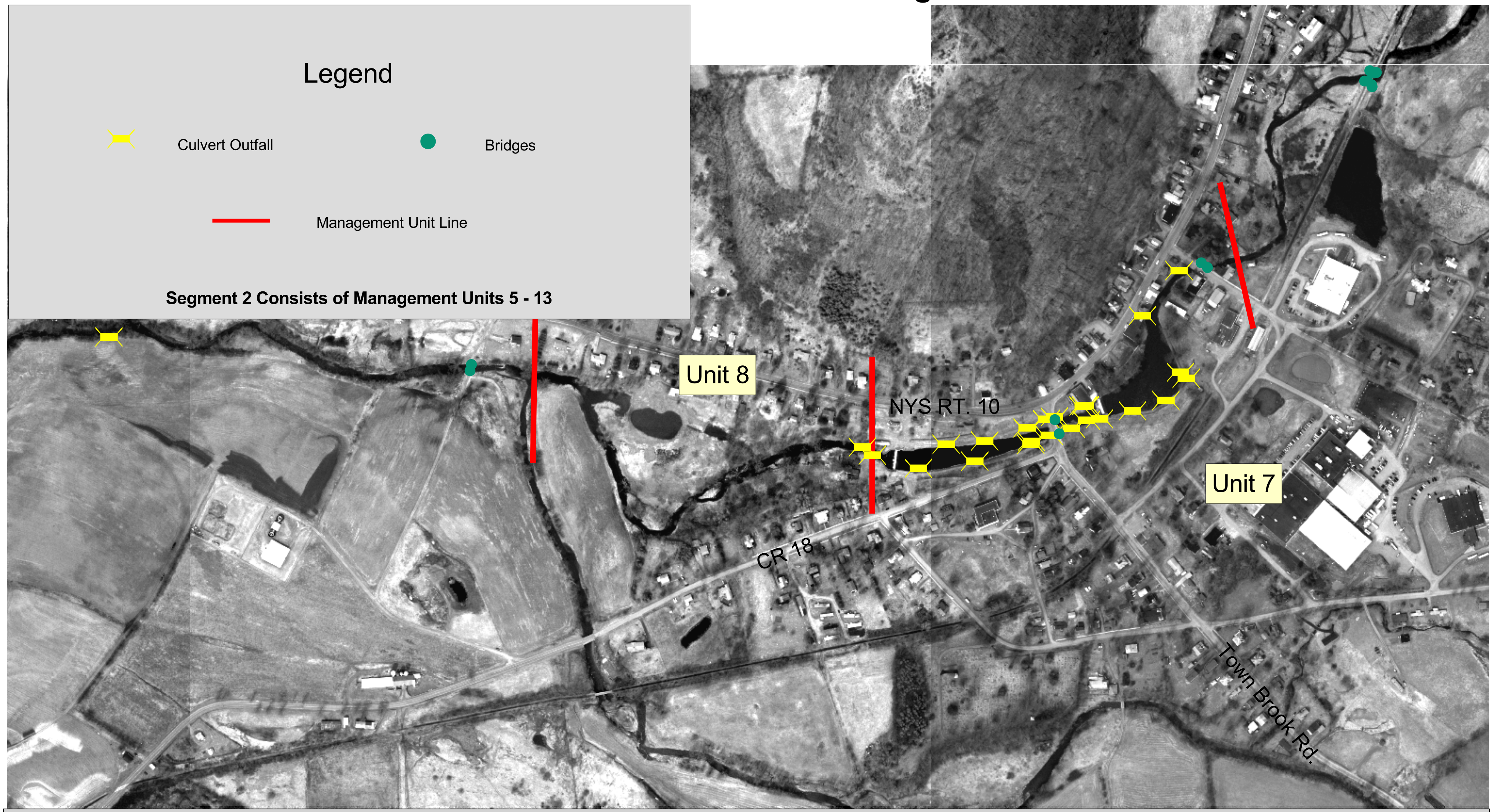
Management Unit 8 - Map 6
Culvert Outfalls and Bridges



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7.3.4 Management Unit 8

Management Unit 8 is a short but unstable reach. There is a short section below the dam, where the flow is confined within a narrow channel with steep banks. It has a high eroding bank at two locations. The eroding bank is a source of material for deposition downstream. Some of the material is deposited before the meander bend where the river takes an abrupt turn to the north before turning again southwest and combining with Town Brook

Figure 7.3.5 Looking downstream at a long, shallow, overly wide pool just upstream of Town Brook confluence.

The pools within this unit are long, shallow and overly wide and the riffles are short and steep. A long pool shallow follows the bend for almost 500 feet before Town Brook confluences with the river.

Short sections of stone structure revetments are found in this unit. This reach does not contain any monitored cross-sections at this time. There are no wetlands within this unit, but a backwater slough is located just above the confluence with Town Brook.

7.3.5 Management Unit 9

Management unit 9 is predominately agricultural lands with a narrow riparian buffer zone along the river bank. There are 23 acres of agricultural land that are enrolled in Conservation Resource Enhancement Program. This management unit is moderately unstable, and contains monitored cross-sections 24, 25, 26, 26.4, 27, and 28.

Figure 7.3.6 Typical scene looking downstream in Management Unit 9 located approximately 1,450 feet downstream from Town Brook.

There are 4 areas of wetlands located within this unit and they are all classified as shrub swamp. One of the wetlands is located approximately 1,350 feet downstream of Lake Brook confluence, another wetland is located 500 feet downstream of McMurdy Brook confluence, and the last two areas are located on each side of the river 4,000 feet downstream of McMurdy Brook confluence.

Figure 7.3.7 Looking upstream at the confluence of Town Brook.

Lake Brook, Town Brook and McMurdy Brook enter the main stem in this unit. The watershed area of the West Branch Delaware River more than doubles within this mile long reach. McMurdy Brook and Town Brook contribute a large amount of sediment load to the river. Aggradation features appear primarily in the upper half of this unit due to these three tributaries that enter the main stem.

Large sections (8312 ft. total) along the river bank contain revetments such as berms, old log cribbing, rip rap or dumped stone. Numerous Department of Environmental Conservation structures are found in this reach, including log cribbing, log deflectors and fish habitat structures. **Figure 7.3.8** shows log cribbing along the right bank. Bank erosion is common at the downstream ends of these revetments. There was over 2100 feet of bank erosion along this 10,500 foot reach. Over 50% of this eroded bank length had an average bank height of 4.5 feet or greater.

Figure 7.3.8 Log cribwall on the right bank located approximately 1,200 feet downstream from Town Brook confluence.

Despite previous efforts by the DEC and the significant achievements to date under CREP, additional land in this management unit needs to be conserved along the river as riparian buffer.

7.3.6 Management Unit 10

In Management Unit 10, the river continues to flow through primarily agricultural and fallow land.

The uppermost portion of the unit has a significantly aggraded section with a series of long pools and short riffles. Within the first 2,000 feet of the uppermost portion of this unit contains a section of the river that has many by-pass channels and is classified as unstable. This area runs through a low swampy section of wetland classified as shrub swamp on left bank and shallow emergent swamp on the right bank.

Figure 7.3.9 Typical scene in Management Unit 10 located downstream at a Department of Environmental Conservation pool digger located approximately 1,350 feet upstream of the Post private bridge near DEC fishing access parking lot.

Figure 7.3.10 High eroding bank located approximately 3,300 feet upstream from private bridge.

The shallow rooted bank vegetation and the aggradation result in substantial bank erosion in the uppermost 2,000 feet of this unit. Of the 2500 feet of eroding bank in the entire management unit, 1500 feet occurs in the upper 2000 feet of the unit. As this reach is not entrenched, the average heights of these banks are generally less than 4.5 feet high. The remainder of this unit is largely bermed and rip rap. There is a significant amount of dumped stone on the banks which has been used to repair eroding sites. In the lower 4000 feet of the unit, the riparian buffer is less than 50 feet wide in most places. As there are no Conservation Resource Enhancement Program sites in this area at this time, this reach should be a priority for CREP and other riparian buffer enhancement efforts.

This management unit contains monitored cross-section 29.

7.3.7 Management Unit 11

The river in Management Unit 11 flows through the hamlet of South Kortright and is bounded by residential land use fronting on County Route 18. The land on the right bank of the river is predominately agricultural fields. The unit is approximately 5050 feet long and is primarily a C stream type.

Figure 7.3.12 Looking downstream at County Bridge 18-6.

Just upstream from the Dry Brook tributary there is a grade control consisting of massive flat stones set into the streambed. This structure is the remnants of an old dam. The County Route 18 Bridge (18-6) crosses the river in the hamlet. The bridge has two arches with the right arch acting as a high flow by-pass channel. This feature enables the river to function through this reach without significant aggradation or scour. There are only a few bars found downstream of the bridge.

This reach contains a Japanese knotweed colony located below the meander bend on the left bank as the river enters the hamlet. This colony is the furthest upstream knotweed stand found by our survey on the West Branch main stem.

Figure 7.3.13 Looking downstream at an eroding bank located approximately 1,750 feet upstream from County Bridge 18-6.

This management unit has some moderately stable with unstable sections above and below the bridge. **Figure 7.3.13** shows the most significant eroding bank upstream from the bridge. Another high eroding bank is located below the bridge where the river sweeps up against the right valley wall below Route 10. This management unit contains monitored cross-sections 30 and 31. There is a shrub swamp wetland located at the bottom of this management.

7.3.8 Management Unit 12

Management Unit 12 is a long (27,400 feet) reach that receives water from several tributaries including Betty Brook, Roses Brook, Kiff Brook and several unnamed tributaries. Management Unit 12 has been significantly affected by both farming practices and the maintenance of the railroad grade though the river's floodplain. The rail grade crosses the floodplain three times and agricultural land bounds much of the river as it flows through this reach. This management unit is rated unstable with over 12300 feet of revetted bank and 9054 feet of eroding stream bank. Over 50% of this length of eroded stream bank has an average exposed height of greater than 4.5 feet. There are many long by-pass channels throughout the management unit, with 24 center bars and 20 transverse bars on the reach. Kiff Brook and the unnamed tributary contribute sediment load resulting in the formation of some of the central bars found on the reach. Several bars are located above and below the three railroad bridges that cross the river

Figure 7.3.14 Monitor bank pin located in the eroding bank that is shown in the **Figure 7.3.15**.

The assessment team established monitoring cross-sections 32, 33, 35, 36, 37, 38, 38.3 and 38.5.

Poorly vegetated banks along the agricultural lands create unstable banks conditions. There is approximately 9200 feet of stream bank with little to no woody vegetative buffer along agricultural land on this reach. This means that 17% of the stream bank in this reach has no natural protection. Many areas where a riparian forest buffer is present, the buffer are less than 50 feet wide. Greater participation in buffer programs is needed from the landowners in this management unit.

Figure 7.3. 15 An eroding bank downstream of railroad bridge where bank pin #34.3 is located.

The assessment team established two bar erosion monitoring pins on the lower section of this reach. The data gathered from these bank pins will provide information on the amount of river bank that is lost within a year. **Figure 7.3.14** shows bank pin #34.3 which lost 2.2 feet of bank in the spring of 2004.

The upstream portion of the stream contains stone structure revetments such as dumped stone which can be found along agricultural fields. These revetments are used in an attempt to reduce the erosion and to get rid of stone in the fields.

In this unit there are four bridges where 3 of them are railroad bridges and the last bridge is the County Bridge 82 on River Street in Bloomville. There are no wetlands that were identified within this unit.

7.3.9 Management Unit 13

In Management Unit 13 the river flows past the hamlet of Bloomville and receives the Wright Brook tributary. The surrounding land use is primarily agricultural, but there is a steep, wooded *embankment* along of New York State Highway 10 where the river comes in contact with the valley wall. Opposite this embankment, on the left bank, an old earthen berm forces this section of the unit into a very straight channel as shown in **Figure 7.3.16**. This straight stretch has a poor riffle and pool sequence which is inconsistent with the morphology of this stream. The whole embankment along New York State highway 10 has rip rap along the river bank.

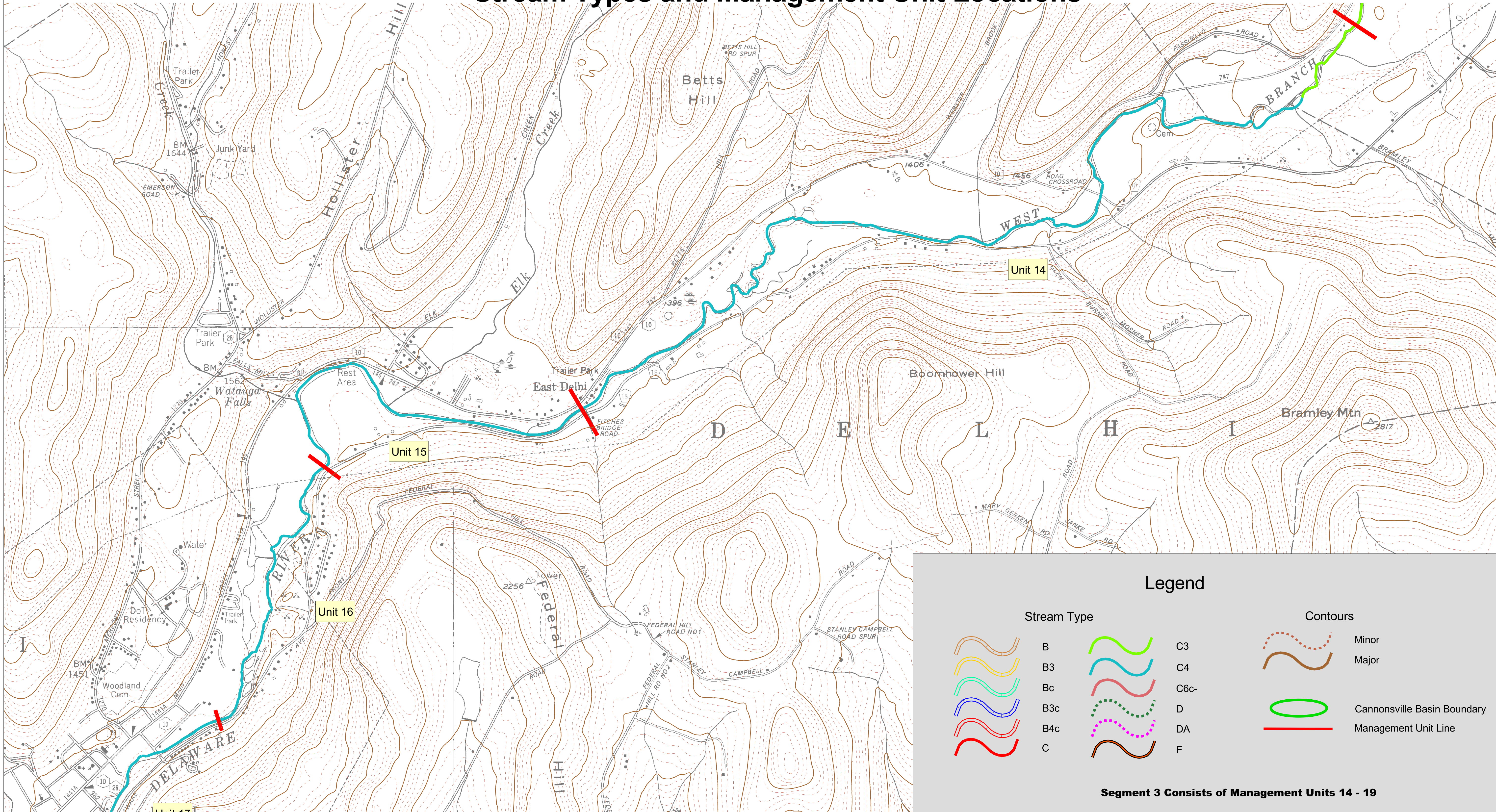
Figure 7.3.16 Typical scene in Management Unit 13 located approximately 4,500 feet downstream from County Bridge 82.

A large center bar located at the downstream end of Management Unit 13 is associated with the very long pool along Route 10. It forms below the point where the berm on the left bank ends and the river is able to again access its full floodplain. This management unit is rated moderately stable and contains monitor cross-sections in this unit include 40, 41, 41.2, 42 and 43. Monitor bank pin #41.3 is also located within this unit.

Wright Brook tributary enters this unit downstream of County Bridge 82 and is not a major source of sediment as much of the sediment is captured above the mill dam in the hamlet. Downstream of County Bridge 82 a large center bar is forming. There is minimal bank erosion occurring within this unit. There are no wetlands located in this unit.

Segment 3

Segment 3 - Map 1
Stream Types and Management Unit Locations



Base Data Provided by NYCDEP
Map data provided in NAD 83 UTM Zone 18 North
Contour Interval 20 feet
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

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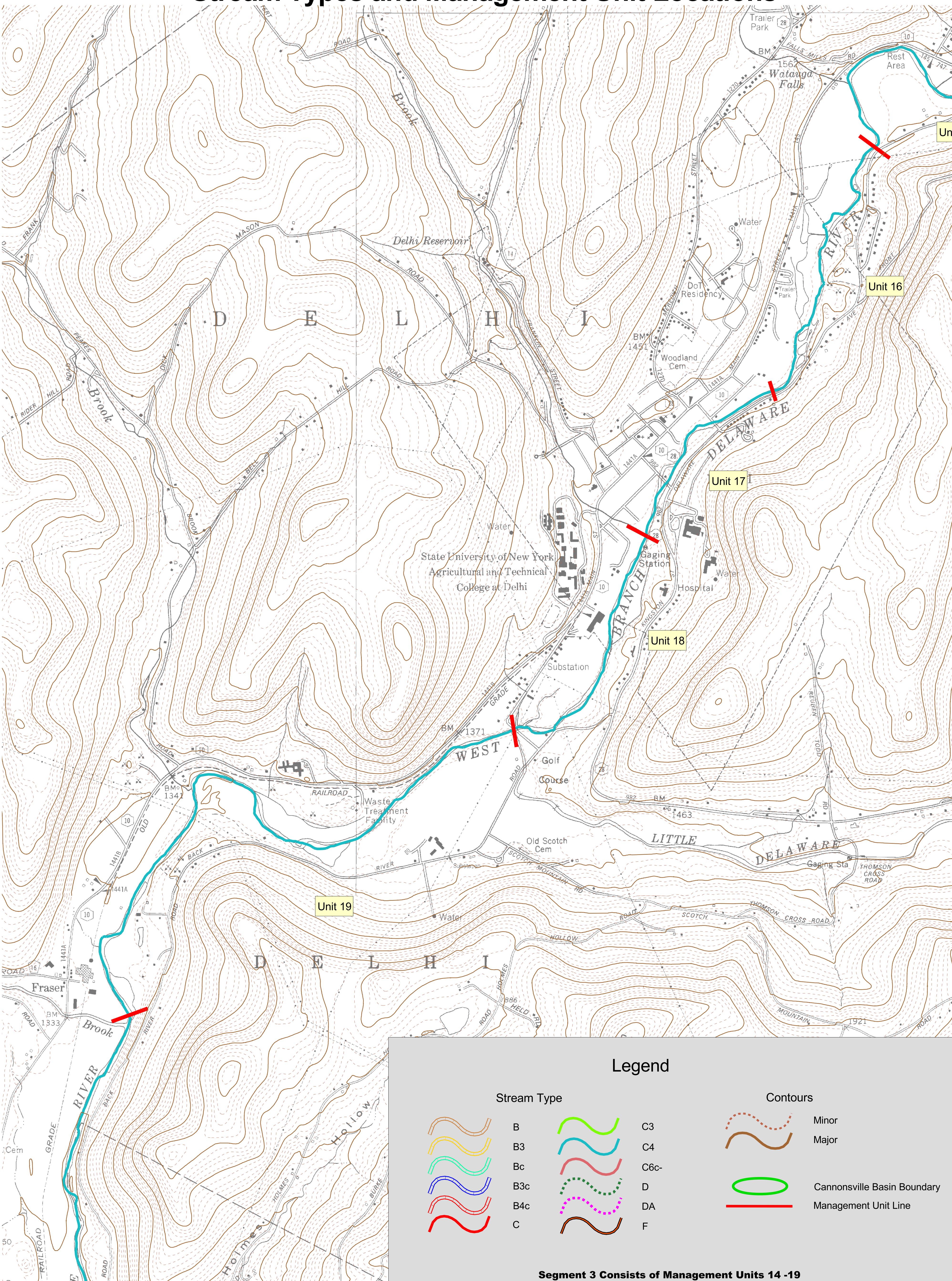
Segment 3 - Map 2
Stream Types and Management Unit Locations



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GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

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7.4 Segment 3 – Town and Village of Delhi

General Description of Segment Three

Segment three is generally delineated based on the Delhi town lines, beginning upstream approximately 2,100 feet from the Delhi town line and ending at the confluence of Platner Brook with a total surveyed stream length of 65,310 feet (see **Segment 3 – Map 1** and **Map 2**). It is composed of Management Units 14-19. The Village of Delhi is the only population center in this segment. The drainage area at the top of this segment is approximately 97 square miles and approximately 206 square miles at the bottom. The valley slope in this area is 0.0019 and the majority of the West Branch Delaware River in this section is classified as a C4 stream type with some C3 sections.

The Village of Delhi, a major population center within the county, straddles the river. The first settlers arrived in the Delhi area after 1784, with the Town lands taken from Franklin, Kortright, and Walton towns in the 1790s and the Village of Delhi incorporated in 1821. The some of the first villagers built homesteads along Main Street and Second streets which are located on the Steele Brook alluvial fan. The village has been a commercial center and the county seat since its settlement. This area above and below the village is predominately agricultural, but there has been significant development along the floodplain both within and below the Village of Delhi. This includes two industrial factories downstream of Delhi at Fraser, which are Ultra Dairy: Morning Star and DMV International Nutritionals. The wastewater treatment facility serving the village and the dairies is also located downstream from the village. Two education centers on either side of the valley, Delaware Academy and Central School on one side, and SUNY Delhi College of Technology on the other, support the local economy and cover large tracks of land along the valley's terraces and mid slopes. The college farm, now partially occupied by the College golf course, is also located on an alluvial fan for the Little Delaware River. The buildings along Main Street including the County Offices (Delhi is the County seat) Department of Public Works and local telephone company all back on the river are subjected to basement and some first floor flooding in larger storm events. The population of Delhi in the 2000 census is 3324, which does not include the approximately 2200 students seasonally resident at SUNY Delhi.

Stream Orders, Floodplains, and Wetlands:

The river is a fifth order stream throughout this segment. The tributaries that enter the watershed are Webster Brook, Falls Creek, Elk Creek, Kidd Brook, Steele Brook, Little Delaware River, Peakes Brook and several unnamed tributaries.

The river below Hoag's Crossing is able to access its floodplain through the long straight reach opposite confluence with Webster Brook and then becomes highly sinuous just above East Delhi. Below Fitches' Bridge the river looses much of its flood plain and sinuosity as the valley is pinched between Federal Hill and Betts Hill. After flowing around the large glacial outwash terrace at the mouth of Elk Creek and receiving the Falls

Creek tributary, the river temporarily reestablishes its floodplain before it becomes confined again as it enters the village. Through the village the river is confined by the narrow valley, local development and stone retaining walls through the village. Parts of the village were built on the alluvial fan for Steele Brook which keeps the river positioned against the southeast side of the valley until the confluence and fan associated with the Little Delaware force the river to the opposite valley wall at Sherwoods Bridge. The river crosses the valley diagonally from the foot of Bell Hill to the north to the foot of Arbor Hill to the south. This means that the floodplain moves from the right of to the left of the stream as the river moves diagonally across the valley. From the confluence of Peakes Brook to Fraser, the floodplain is once again wide.

There are eleven areas of wetlands located within this segment which includes three types: shrub swamp, shallow emergent marsh, and backwater slough. Wetlands are a very important part in this segment because they help to absorb the nutrients from agricultural and road runoff. Wetlands help to reduce the impact of nutrient overload in the water system. Too much phosphorus and nitrogen in the aquatic ecosystems can cause severe problems such as an increase in algae and plant growth. This is a concern because the increase in plant growth will deplete dissolved oxygen levels within the water system affecting aquatic habitat survival. Other benefits of wetlands consist of sediment control, reduced flood impact, and wildlife habitat.

Land Use/Land Cover:

The predominant land use is forest on the hills and agriculture in the valley except near the Village of Delhi where residential and commercial land uses are dominant. The development in and around the village is stable and regulated by zoning both within the Village and Town. The impervious surfaces associated with streets, large parking areas, and building rooftops pose a concern for stormwater management. Recent reconstruction of Route 10 through the village provided for an upgrade in the stormwater drainage system, but there is little room within the village for catchments to detain the stormwater before it reaches the river.

The riparian buffer is lacking throughout this segment and could be improved both on agricultural lands upstream and downstream of the village. Starting just above the village, Japanese knotweed is a significant and growing problem. Large colonies now exist below Falls Creek all the way through the village and down across the college farm flats through Fraser to the end of the segment. The colonies are rapidly crowding out the native vegetation and may already be causing bank destabilization below the village.

Infrastructure:

The main roads that run parallel to the river are NYS Route 10 and County Route 18, and Arbor Hill Road. These roads have a minimum negative impact on the floodplain. Downstream of Fitches covered bridge is a short section of County Highway 18 road that floods during high flow events that are greater than bankfull. Culverts carry stormwater runoff away from the roads without sufficient protection against additional sediment and nutrient that input into the water system. Stormwater runoff is recognized as a significant water quality concern as overland flow from impervious surfaces such as roads and parking areas contains contaminants and nutrients that are delivered directly into river. In addition to the stormwater associated with Main Street and the activity of the commercial district of the village, Town and County road ditches can deliver contaminated stormwater to the river. Ditch cleaning without reseeding can also increase the turbidity within the river system

The bridges that are within this segment includes: County Bridge 33, Fitches covered bridge (County Bridge 94), Bridge Street Bridge (County Bridge 31), NYS Route 28, and Sherwood road bridge (County Bridge 10). County Bridge 33, Fitches, and Bridge Street bridges all have minor impact on sediment transportation. State Highway 28 and Sherwood bridges have deposition bars forming upstream and downstream of the structures.

Sediment Transport and Channel Evolution:

The Stream Corridor Management program has surveyed ten cross-sections in this segment. Only one of these cross-sections has a bar sample completed but the rest of the cross-sections have only pebble counts completed. The results from the collected data indicate that the bed material is coarse gravel.

The main stem of the Delaware River has not changed its course according to comparison of aerial photographs from 1938, 1963, 1971, and 1983. Interpretation of the aerial photographs indicates that most of the tributaries seem to have been straightened before the 1938 aerial photos were taken based on their direct route from the State Highway 10 to the main stem Delaware River. Historically these tributaries have been bermed, straightened and maintained as the slope of the stream decreases across their alluvial fans. These channelized reaches frequently become clogged with bedload following storm events and maintenance is required to keep the stream bed from aggrading to the point where flows easily overtop the berms. This straightening may only temporarily improve sediment transport load until the channel becomes laden with deposits following the next major storm event. Steele Brook, which runs through the Village of Delhi, is a good example of a tributary that was straightened and channelized. Outside of the village the tributaries were frequently straightened so that farmers could either avoid damage to their agricultural lands or extend their productive land up to the edge of the stream. Most of the tributaries have small riparian buffer zones as agricultural fields and pastures are cultivated and mowed close to the river banks.

Gravel side bars often form on the West Branch below the confluence of a tributary as the main river attempts to move the tributary sediment downstream. These bars can affect bank stability as the river attempts to move around these depositional features. The location of sediment bars at the mouths of the tributaries indicates that either the tributaries are moving large amounts of sediment or the river is having difficulty moving the added sediment load. Generally, if a type C stream experiences difficulty moving sediments it tends to evolve to a G stream type and then to a F type, or directly from a C to an F. G and F types are less desirable types than a type C due to their marked tendency towards severe erosion and instability.

The table below summarizes the erosion and depositional features that are within this segment by management unit.

Table 7.4.1 - Summary of Erosion and Depositional Features

Management unit	Length (mi)	Linear Feet of Erosion	Surface Area (sq.ft.)	# Erosion Features	# Deposition Features	LF Erosion per Mile	# Erosion Features/mi	# Deposition Features/mi
14	4.60	8377	41689	50	31	1821.09	10.87	6.74
15	1.67	3282	12718	10	1	1965.27	5.99	0.60
16	1.27	3499	16548	23	10	2755.12	18.11	7.87
17	0.87	1081	3998	7	2	1242.53	8.05	2.30
18	1.12	3953	15705	19	6	3529.46	16.96	5.36
19	2.84	7665	26247	32	8	2698.94	11.27	2.82

History of Stream Management:

The majority of the revetments in this segment consist of dumped stone which are commonly found along agricultural fields. In this segment there seems to be more berms along agricultural fields than in other segments. **Table 7.4.2** shows the extent and types of revetments and length of berms within each management unit. Behind the Ames Plaza there is a long section of berm that continues along the bank into the adjacent crop field. In the village there are several sections of *stacked rock walls* and rip rap along the banks. Most of the revetment is well maintained especially in the Village of Delhi.

Table 7.4.2 Revetment and Repairs

Management Units	Length (mi)	Dumped Stone	Rip Rap	Laid-up Stone	Stacked Rock Wall	Gabions	Log Cribwall	Concrete	Sheet Piling	Other	Log Deflectors	Total Revetment Length (ft)	Revetment Length per mile	Berms	Berm Length (ft)
14	4.60	33	3	1	-	-	3	-	-	-	-	8646	1880	8	4924
15	1.67	10	5	1	-	-	-	-	1	-	-	3988	2388	3	1922
16	1.27	6	2	-	1	-	-	1	-	-	-	794	625	-	-
17	0.87	11	1	-	11	-	-	4	-	-	-	3118	3584	-	-
18	1.12	10	3	-	-	-	-	-	-	-	-	1563	1396	1	448
19	2.84	10	1	1	1	-	2	1	-	-	-	3271	1152	-	-

7.4.1 Management Unit 14

Figure 7.4.1 is a picture of a stretch of the West Branch Delaware River within Management Unit 14. This management unit is rated unstable. There are two locations where the West Branch comes in contact with the valley wall. This section of the West Branch should have wider floodplains where agricultural fields are located. Some of the agricultural lands have extensive berms along their fields that prohibit floodplain access.

Figure 7.4.1 Typical scene in Management Unit 14 located approximately 6,500 feet downstream from County Bridge 33.

The tributaries that enter the West Branch are Kidd Brook and Glen Burnie. Gravel bars downstream from the confluence of the Glen Burnie tributary indicate that it contributes a high sediment load, whereas Kidd Brook contributes less sediment.

There are two bridges located on Hoag's Crossroad (County Bridge 33) and Fitches Road (County Bridge 94).

Figure 7.4.2 High eroding right bank located approximately 2,600 feet upstream from County Bridge 33.

Location and extent of bank or bed erosion is mainly along agricultural fields with no riparian buffer, but there are some areas where the river hugs the valley wall or scours the base of glacial alluvial deposits. Above Hoag's Crossing, the river winds its way around several small hills on the valley floor that are the likely remnants of glacial moraines. **Figure 7.4.2** shows a high eroding bank just downstream of a meander bend where the river is undermining even the deep rooted vegetation. The agricultural land on the opposite bank has been bermed which confines the river and increases the stress on the stream banks. Removing or setting back the berms could improve bank stability and reduce the need for additional revetments.

There is one section approximately one mile upstream from Fitches Bridge where the river becomes very sinuous and unstable. The vegetation has shallow roots and cannot effectively protect the banks.

There are numerous by-pass channels and areas of aggradation located within this unit. The by-pass channels are a special concern because they could indicate that the river is unable to adequately move its sediment.

Figure 7.4.3 Typical rip rap installation approximately ½ mile upstream of County Bridge 94.

Revetments such as rip rap as shown in **Figure 7.4.3** are used to help protect the stream banks from erosion, but the excessive use of rip rap can accelerate the stream's *velocity* along the bank and result in additional erosion downstream.

Two areas of wetland are located upstream from Fitches Bridge and both are classified as shrub swamps.

Monitoring bank pins where placed in stream banks that have been actively eroding. This unit contains two monitoring pins. Bank pin number 44.40 is located approximately 6,000 feet upstream of Hoag's crossing (County Bridge 33). This bank pin was lost in this reach and was replaced in June 2003 with bank pin number 44.41. Another monitoring bank pin number 47.20 is located downstream of Hoag's Crossing Bridge (County Bridge 33). This unit contains monitored cross-sections 45, 46, 47, and 48.

7.4.2 Management Unit 15

Figure 7.4.4 shows a typical scene that is within Management Unit 15. Most of the river in this unit is bounded by agricultural land with little riparian buffer. Management Unit 15 is moderately stable.

Figure 7.4.4 Typical scene in Management Unit 15 near the Elk Creek tributary.

Tributaries that enter this unit are Elk Creek and Falls Creek. Below Fitches Bridge the river valley is pinched between the two hills and the river loses much of its floodplain. The confluence of Elk Creek is significantly aggraded and may create the long pool found upstream of the confluence. The length of this pool and its silty bottom are unusual morphologic features of this system.

Figure 7.4.5 Eroding bank on the left bank located at the end of Management Unit 15.

Downstream of Elk Creek confluence the reach appears to be entrenched for approximately 700 feet. This may be due to an area of fill on the right bank associated with the construction of NYS Route 10 and a high glacial outwash terrace on the left bank. This creates some erosion on the left bank and the right bank has been armored with rip rap. The river regains its floodplain further downstream and becomes fairly stable. Some bedrock can be found along the right bank near the Route 10 rest area. Falls Creek confluence appears to be slightly aggraded. Downstream of Falls Creek confluence, the banks are experiencing moderate erosion due to shallow rooted vegetation along agricultural lands which can be seen in **Figure 7.4.5**.

One area of wetland within this unit is located approximately 3,000 feet upstream from Elk Creek confluence. This wetland is classified as a shrub swamp.

There are no measured cross-sections within this management unit at this time. This unit contains two monitoring pins. Bank pin number 51.5 is located downstream of Elk Creek confluence and bank pin number 53.0 is located at the end of Management Unit 15.

Management Unit 16:

Management Unit 16 is unstable with a significant number of center bars, islands and by-pass channels. There are numerous clay/silt exposures on the banks and an increase in the amount of Japanese knotweed through this reach.

Figure 7.4.6 High eroding bank on the left side of the river near the top of this management unit.

The river has historically been unstable and has had problems moving sediment through this reach as evidenced by the numerous by-pass channels, center bars, eroding banks and

Figure 7.4.7 Poorly vegetated eroding bank on the right side approximately 100 feet downstream of **Figure 7.4.6**.

cut-off meander bends. **Figure 7.4.6 and Figure 7.4.7** shows the examples of the erosion within the upper portion of this management unit. There is nearly 3500 feet of eroding bank along the 6670 feet of river in unit 16. Approximately 30 percent of the eroding banks have an average bank height 4.5 feet high or greater.

There are two areas of wetlands within this management unit which are located approximately 3,000 feet and 5,000 feet upstream from the Bridge Street Bridge (County Bridge 31). Both of these wetlands are classified as shrub swamp.

There are no monitoring cross-sections or bank pins within this unit at this time.

7.4.4 Management Unit 17

This management unit runs through the Village of Delhi. See **Management Unit 17 – Map 1** through **Map 6** at the end of this unit description. Development along the banks limits the river's access to its floodplain. The land use in the middle section of this unit is primarily residential and commercial. Delhi has three major bridges that cross the river. One bridge is County bridge 31 located on Bridge Street and two New York State Department of Transportation bridges located on Kingston Street. Within this unit is a USGS gage station 01421900 (West Branch Delaware River Upstream from Delhi NY) which is located upstream from Bridge Street (County bridge 31).

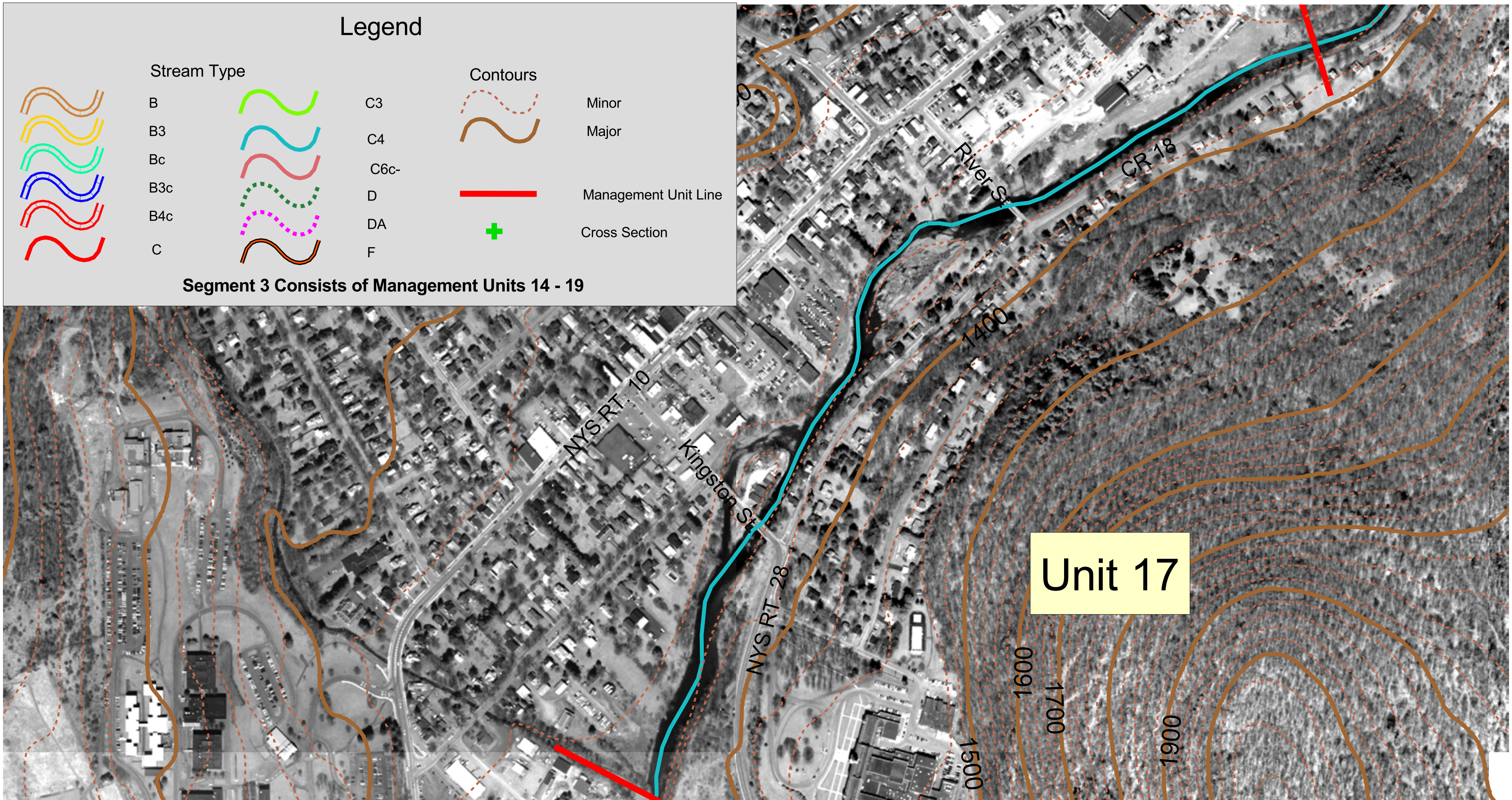
Figure 7.4.8 Rip rap along the island upstream from Kingston Street Bridge.

There are noticeably more revetments along the banks (3110 feet of revetment over 4500 feet of stream) and a decrease of eroding banks (1081 feet). **Figure 7.4.8** shows rip rap along the island upstream from Kingston Street Bridge.

There are few depositional bars possibly due to the confinement of the channel and absence of any tributaries above Steele Brook. This management unit is stable, therefore monitoring cross-sections have not been set at this time. There are no wetlands located within this management unit, however the large vegetated point bar below Bridge Street is an important riparian feature. It provides both habitat, and the wider stream width at this bar provides relief to the stress associated with the confined channel conditions through the village

There is a significant amount of Japanese knotweed colonizing the stream banks through the village. Landowners should exercise caution in attempting to manage the plant (see **Section 5.10.4**).

Management Unit 17- Map 1
Stream Types and Cross Sections



Base Data Provided by NYCDEP
Map data provided in NAD 83 UTM Zone 18 North
Contour Interval 20 feet
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

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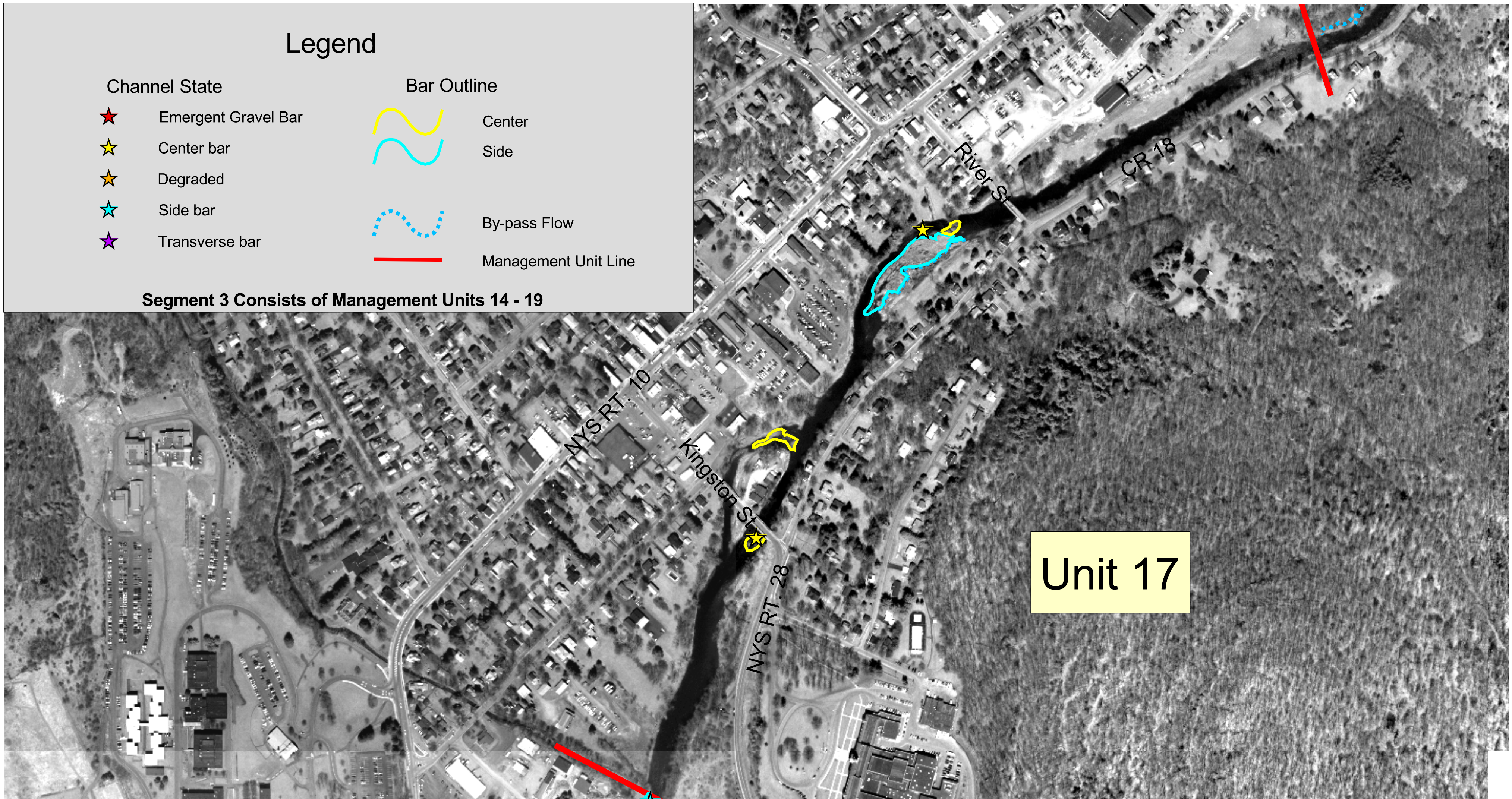
Management Unit 17 - Map 2
Channel State and By-Pass Flow



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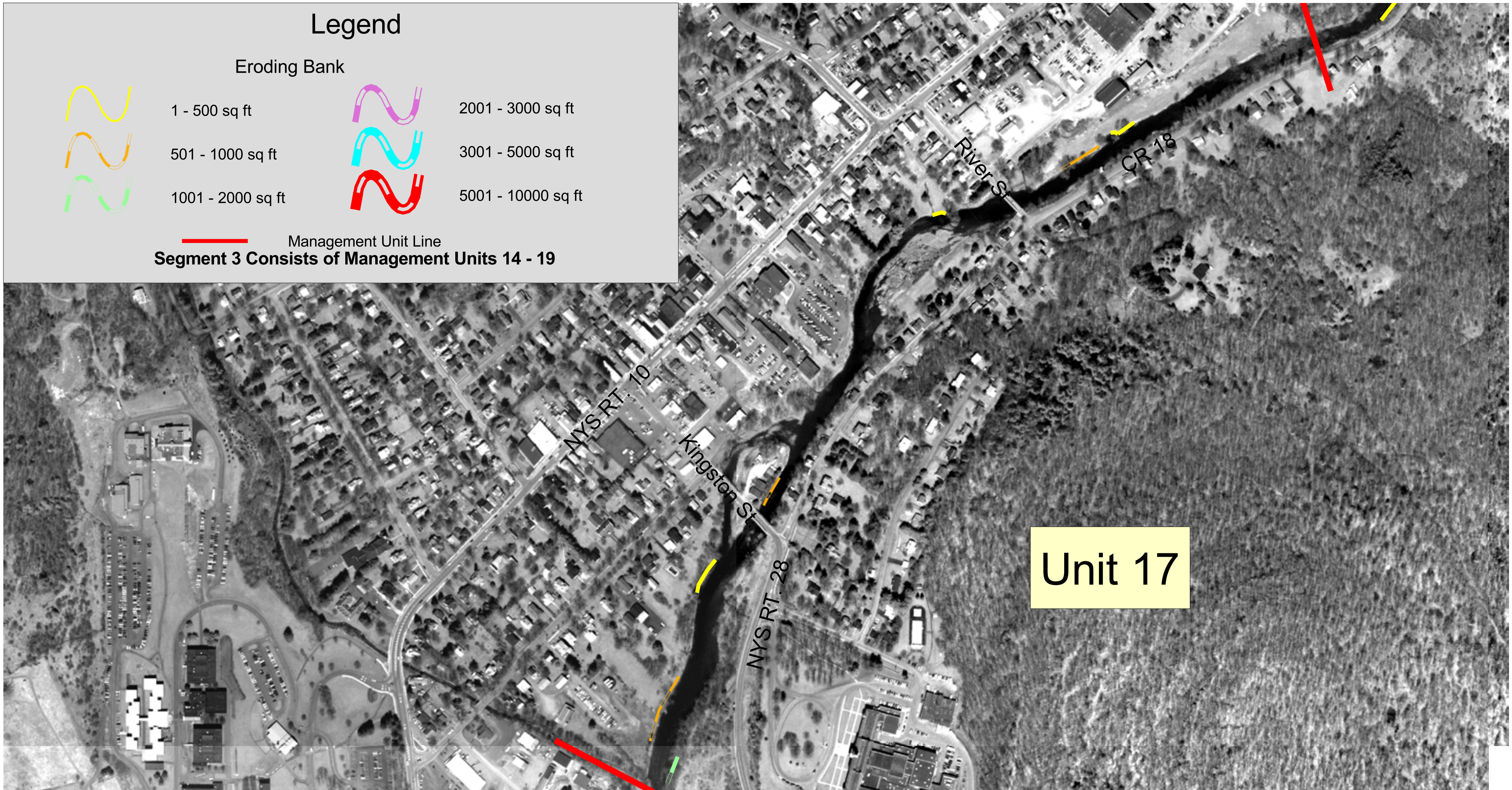
Management Unit 17 - Map 3
Eroding Banks



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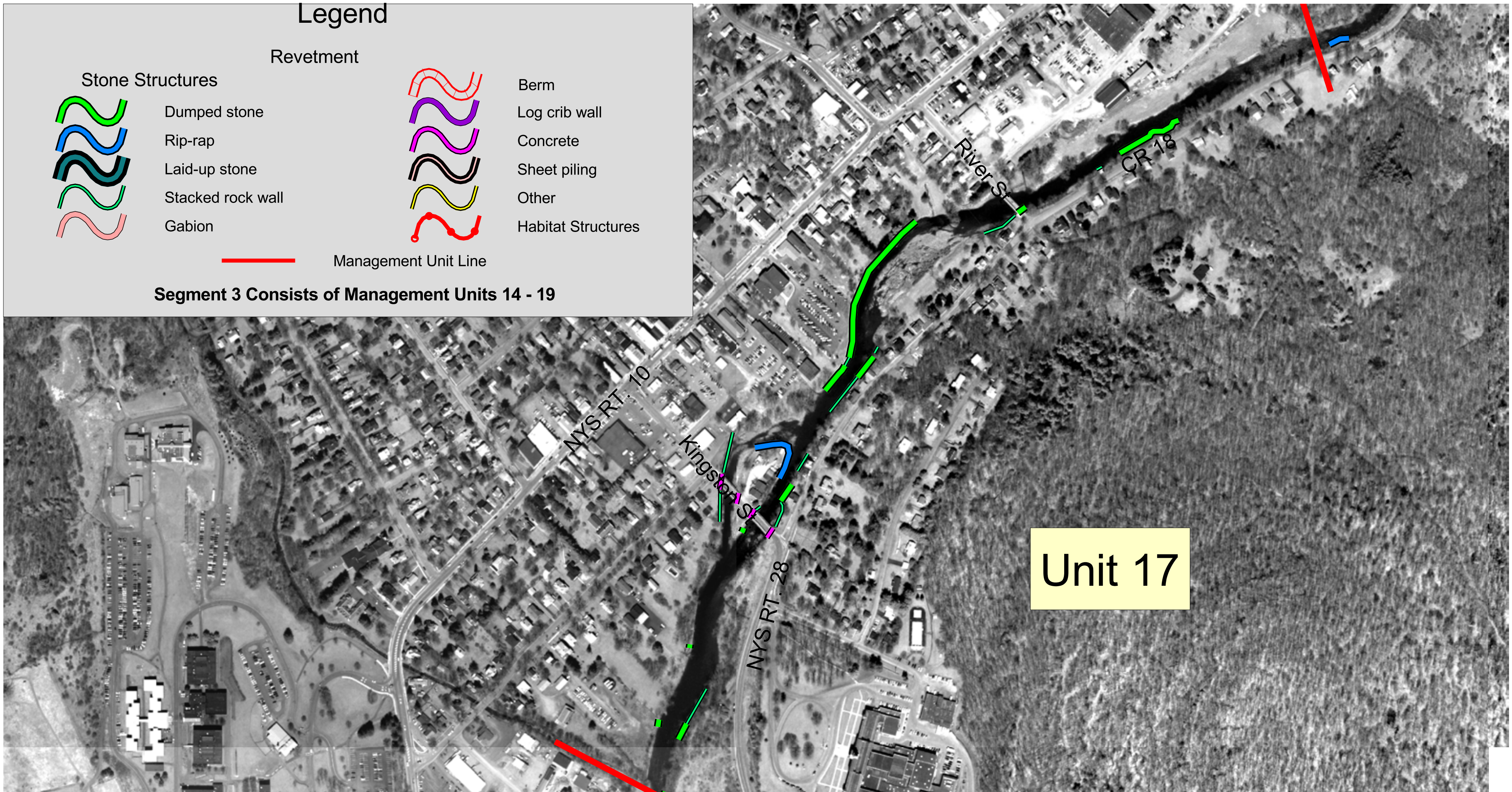
Management Unit 17 - Map 4
Revetment



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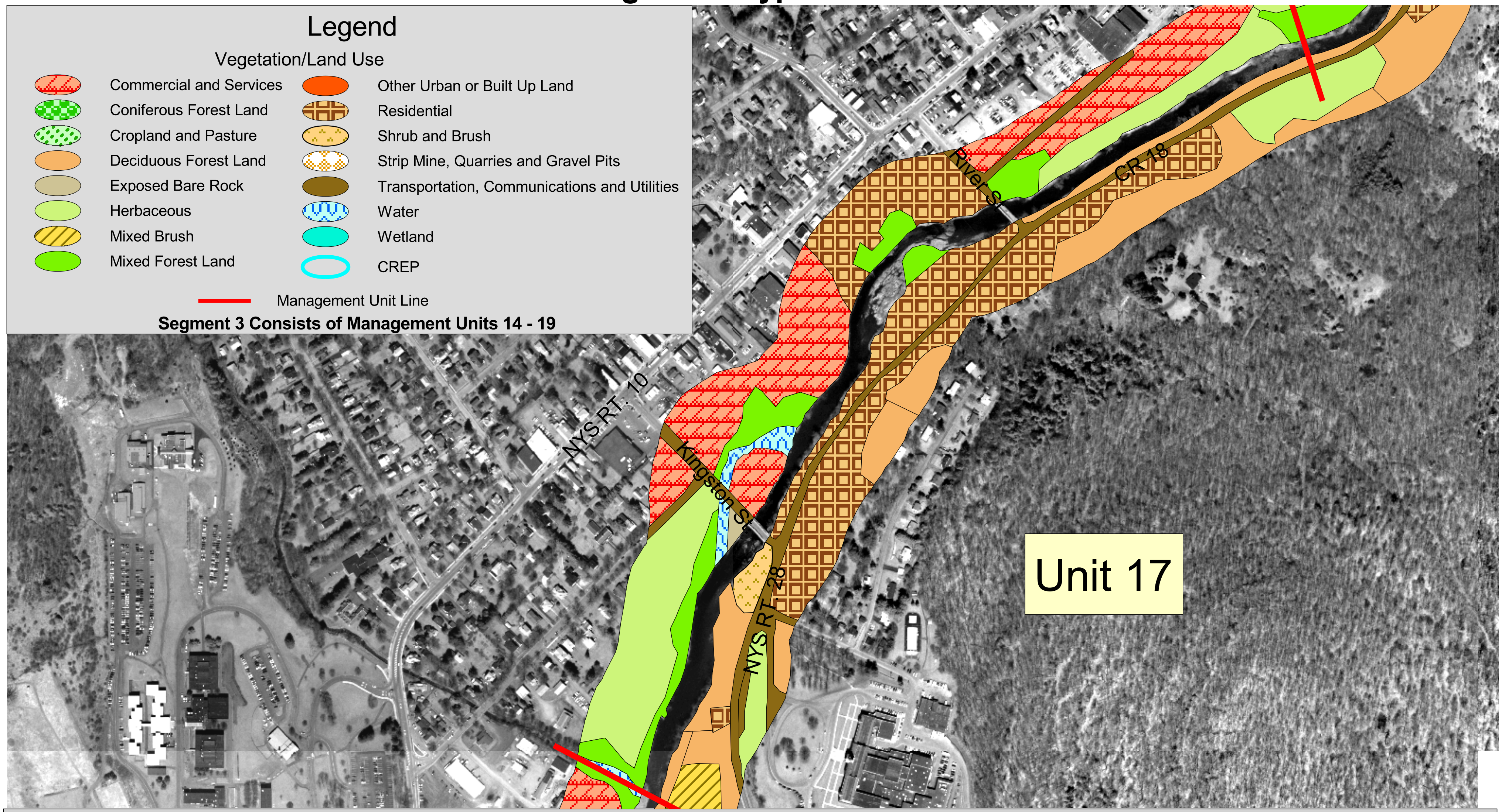
Management Unit 17 - Map 5
VegetationTypes/Land Use



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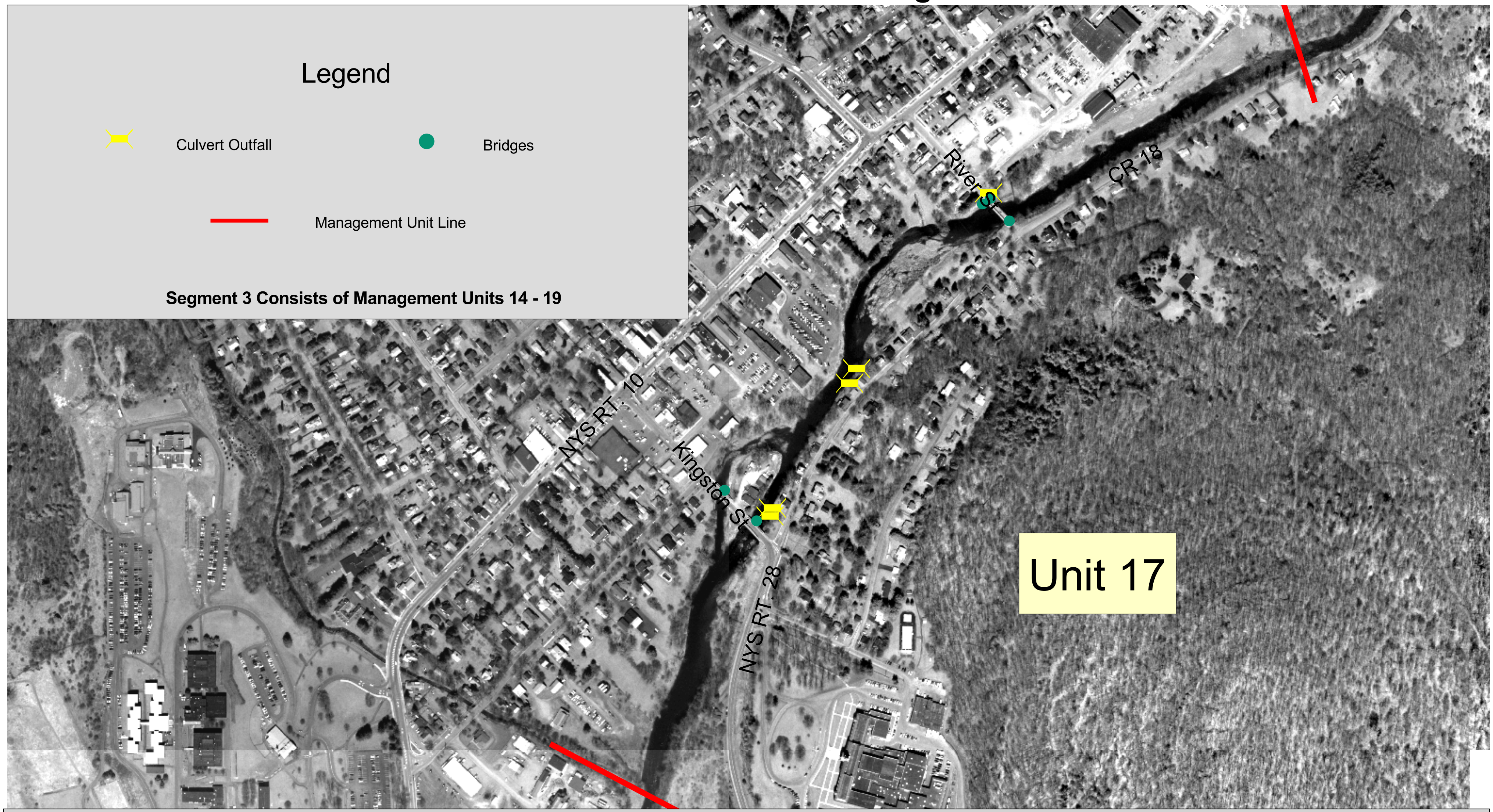
N W E S

Management Unit 17 - Map 6
Culvert Outfalls and Bridges



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7.4.5 Management Unit 18

Management Unit 18 begins at the confluence of Steele Brook. The land use along the river through this unit is commercial along the right bank and mixed deciduous forest and successional shrubland along the left bank. The reach is 5,893 feet long, has 3,953 feet of eroding bank (28% is 4.5 feet or more in average bank height) and over 2,000 feet of revetment.

Steele Brook tributary contributes a high sediment load which is forming side, transverse and center bars downstream of its confluence. This excess sediment from Steele Brook is forming a center bar downstream of the outflow forcing the river toward the opposite bank. An old gage station was located just downstream of Steele Brook confluence and now the high bank is presently eroding as shown in **Figure 7.4.9**.

Figure 7.4.9 High eroding bank opposite of Steele Brook confluence.

A large transverse bar on the lower portion of the reach directs flows into the left bank which poses a threat to Arbor Hill Road. The property owner has rip-rapped the bank. The County Department of Public Works has re-enforced the banks where the Delhi sewage plant pipelines run underneath the river just upstream of Sherwood Bridge (County Bridge 10).

Figure 7.4.10 Poorly vegetated bank and a section of Japanese knotweed located approximately 2,000 feet upstream from County Bridge 10.

This management unit is unstable and highly erosive. There are no cross-sections in this unit at this time. Of special concern are the expanding colonies of Japanese knotweed found along the banks. **Figure 7.4.10** shows a section of knotweed along an eroding bank that is poorly vegetated.

7.4.6 Management Unit 19:

Figure 7.4.11 Typical scene in Management Unit 19 located downstream of County Bridge 10.

Management Unit 19 is 14,780 feet long reach where the West Branch Delaware River valley becomes wider as it accepts flows from the Little Delaware River watershed. Long pools and short riffles are typical through this reach. The river remains a C4 stream type below the confluence with the Little Delaware. The Little Delaware River contributes a moderate amount of sediment to the West Branch main stem. Gravel bars are found both at the confluence and further downstream along the long straight reach which lies at the base of the alluvial fan of the Little Delaware.

Figure 7.4.12 Section of Japanese knotweed and eroding bank found near the Delhi college agricultural land.

The land along the river is predominately used for agriculture. Forest land on steep banks are frequently found opposite the agricultural fields as the river hugs the valley walls along the Delhi College farm and at the base of Arbor Hill. The College's agricultural lands also have long stretches of knotweed along banks often associated with bank erosion as shown in **Figure 7.4.12**. Another large colony is found behind the 4-H camp opposite DMV Nutritionals.

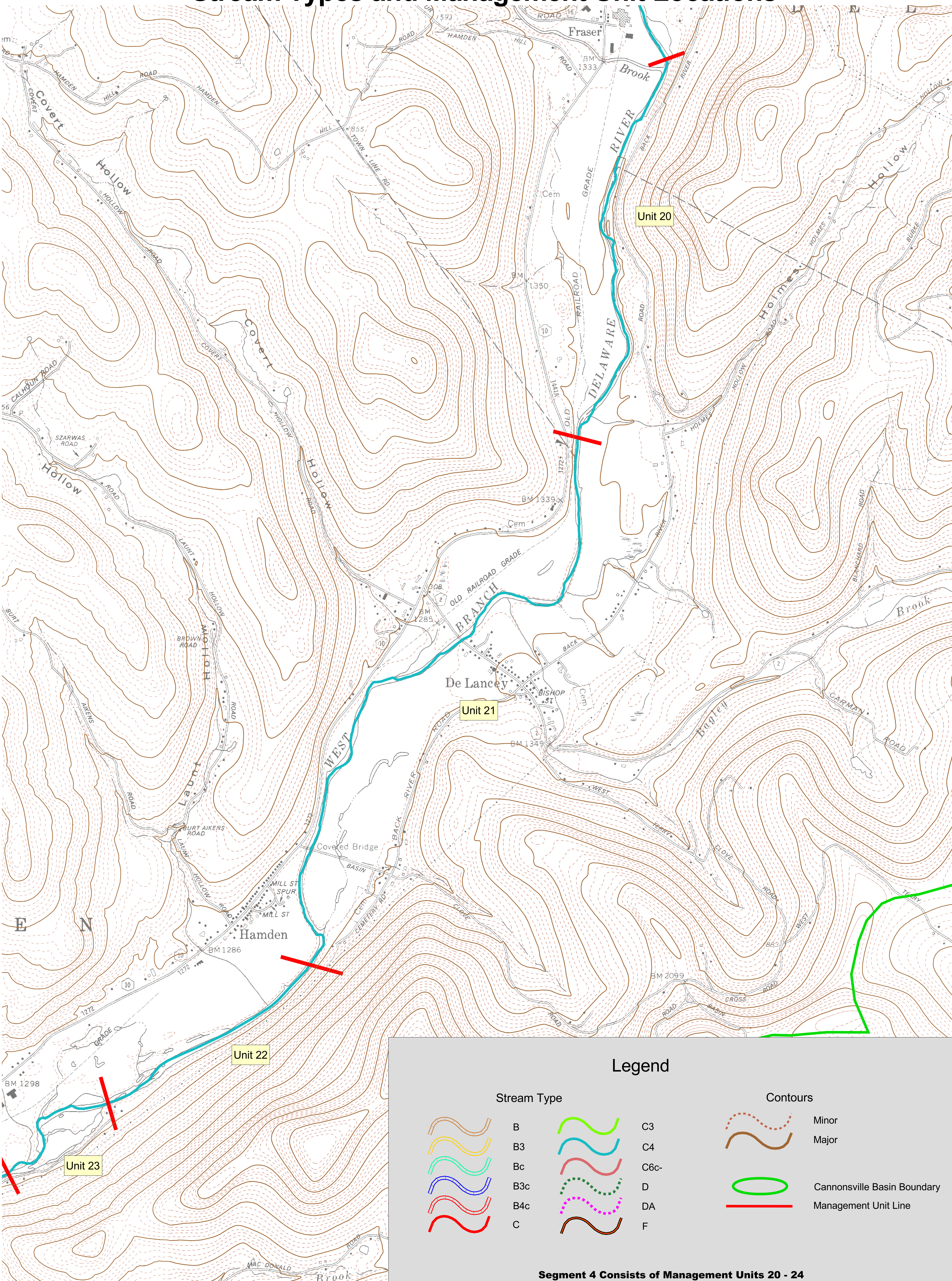
Figure 7.4.13 Poorly vegetated eroding bank located upstream from Peaks Brook confluence.

The majority of erosion occurs along agricultural fields with poorly vegetated banks as illustrated in **Figure 7.4.13**. There were over 7,600 feet of total eroding stream bank in this unit. This management unit is moderately stable with unstable reaches and contains monitored cross-sections 54, 55, 56, 57, 57.9, and 58.

There are three areas of wetlands; including one shallow emergent marsh and two backwater sloughs.

Segment 4

Segment 4 - Map 1
Stream Types and Management Unit Locations



Base Data Provided by NYCDEP
Map data provided in NAD 83 UTM Zone 18 North
Contour Interval 20 feet
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

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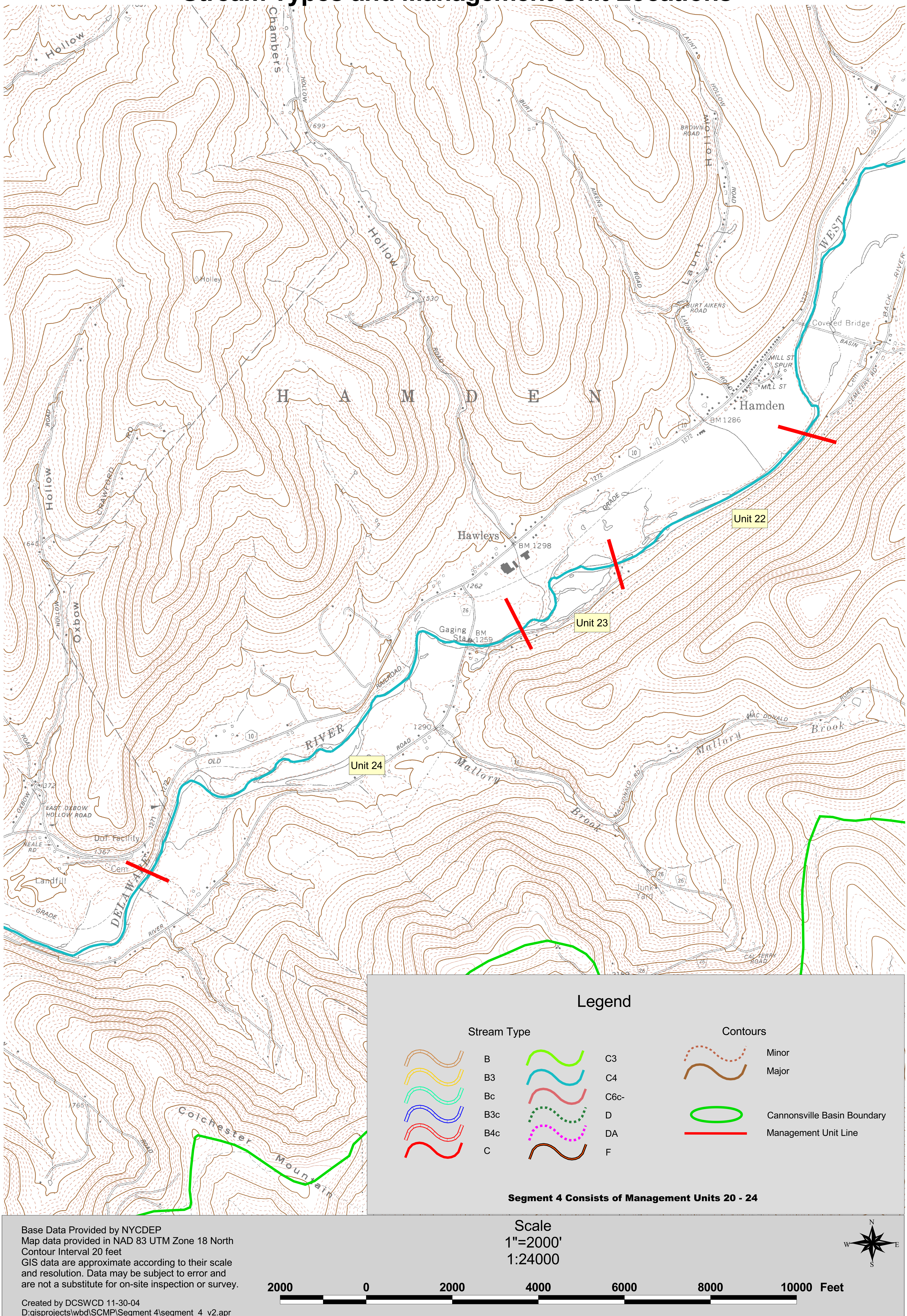
Segment 4 - Map 2
Stream Types and Management Unit Locations



7.5 Segment 4 - Town of Hamden

General Description of Segment Four

Segment four begins at the confluence of Platner Brook and ends at the Hamden/Walton town line (see **Segment 4 – Map 1** and **Map 2**). The total surveyed stream length of this segment is 46,142 feet long. Two population centers are within this segment: the hamlets of Delancey and Hamden. The drainage area at the top of this segment is approximately 206 square miles and approximately 263 square miles at the bottom. The valley slope in this area is 0.0019 and the stream type is classified as a C4. The channel features are mainly long pools and short riffles.

The Town of Hamden was originally settled in the 1700's and incorporated in 1825. Historically, agriculture led the economy of the community and the productive river bottom lands were prized by local farmers. Fields along the banks of the river have been mowed or cropped fields close to the river banks which have reduced the size of the riparian forest buffer. This practice has reduced the protection provided to the stream bank and resulted in accelerated stream bank erosion. To alleviate this problem many farmers have dumped stone along the banks in an attempt to reduce water's impact on the banks.

This segment is broken up into Management Units 20 through 24. The table below summarizes the erosion and depositional features that are within this segment by management unit.

Table 7.5.1 - Summary of Erosion and Depositional Features

Management unit	Length (mi)	Linear Feet of Erosion	Surface Area (sq.ft.)	# Erosion Features	# Deposition Features	LF Erosion per Mile	# Erosion Features/mi	# Deposition Features/mi
20	1.75	7739	31315	25	10	4422.29	14.29	5.71
21	2.97	8307	27497	38	14	2796.97	12.79	4.71
22	1.03	3234	7658	13	4	3139.81	12.62	3.88
23	0.64	2236	9432	12	12	3493.75	18.75	18.75
24	2.35	4970	19346	34	30	2114.89	14.47	12.77

Stream Orders, Floodplains, and Wetlands:

The West Branch Delaware River continues to be a fifth order stream. Tributaries that enter the West Branch of the Delaware River are Bagley Brook, Pettis Brook, Launt Hollow, Chambers Hollow, and Mallory Brook.

Throughout this segment the broad floodplains are used for agriculture. There has been limited development along the margin of the floodplain, typically on alluvial fans for streams flowing from the sides of the valley. The hamlet of Delancey is on the alluvial fan from Bagley Brook and portions of the West Branch floodplain. The hamlet of Hamden is located on the alluvial fan from Launt Hollow. The county office building and New York State Electric and Gas (NYSEG) offices near Chambers Hollow are built on an alluvial fan at the edge of the floodplain for the West Branch. The location and extent of the regulatory floodplain for the Town of Hamden is not well defined by the community's outdated flood insurance rate maps.

There are only three areas of wetlands along the river including a shallow emergent marsh, a shrub swamp, and a backwater slough. Wetlands in this segment help to absorb some of the nutrients from agricultural and storm water runoff and reduce the impact of nutrient inputs into the river system. Excess phosphorus and nitrogen in the aquatic ecosystems can increase algae and plant growth resulting in the depletion of dissolved oxygen levels. Wetlands also function to trap sediment, store flood waters and provide wildlife habitat.

Land Use/Land Cover:

Agriculture remains the dominant land use within this segment. There are a few residential structures in the floodplain in Delancey and Hamden which are affected by major flood events. To date, there has been little commercial development in the flood plain area. Some of the agricultural land is under Conservation Resource Enhancement Program (CREP) to help create a riparian buffer along the river banks on agricultural fields. Still there are some agricultural lands that have little to no riparian buffer because the farmers mow up to the river banks. The riparian buffer is very important because the vegetation helps to stabilize banks and the buffer absorbs nutrients such as nitrogen and phosphorus and keeps them from entering the river.

Infrastructure:

The roads that bridge the river in this segment include County Highway 2, County Highway 26 and the covered bridge on Basin Clove road. The major roads that run parallel to the Delaware River are State Highway 10 and Back River road which have minimal influence on the stream floodplain. The old railway bed travels through the floodplain on occasion, but has limited effect where it encroaches on the floodplain near Delancey and the Chambers Hollow tributary.

Traditionally bridges have been designed and built to allow the passage of major floods under the bridge and with little regard for the natural processes of rivers. This often results in severe upstream aggradation, bed and bank scour through the constriction, and bank erosion below the structure. Delaware County Department of Public Work (DPW) has recognized these problems and working to improve its bridge designs to reduce the stress to the bed and banks and improve sediment transport through the bridge. The County Highway 2 Bridge was re-built in 2002 and includes floodplain culverts. These culverts allow the river to access its floodplain and reduce the constriction previously responsible for undermining the bridge's abutments and destroying approach to the bridge.

Sediment Transport and Channel Evolution:

Bagley Brook and Chambers Hollow Brook yield large quantities of bedload which contributes to channel instability near their confluence with the West Branch. As it enters the hamlet of Delancey, Bagley Brook has been realigned to a location upstream of the hamlet. Its current alignment reduces its slope and does not enable it to effectively move its bedload, as a result the channel must be maintained to prevent it from clogging with bedload. Both Launt Hollow and Pettis Brook appear to be stable.

The Stream Corridor Management Program has sampled bed material along three cross-sections within this segment. The results indicate that the bed material consist of very coarse gravel to cobble material. There are several depositional bars within this segment that have influence on bank erosion where the water is being forced around the bars and into the banks. Some of the banks are poorly vegetated due to agricultural fields or lawns being mowed to the river banks. Generally, if a type C stream experiences difficulty moving sediments it tends to evolve to type G and then to a type F, or directly from a C to an F. G and F types are less desirable types than a type C due to their marked tendency towards severe erosion and instability.

The West Branch Delaware stream alignment has not changed in most of this segment when compared to aerial photographs from 1938, 1963, 1971, and 1983. Many of the tributaries entering the West Branch had been straightened prior to 1938. Historically these tributaries have been straightened, entrenched, and bermed across their alluvial fans from roads that parallel the West Branch until they enter the main stem. The river's alignment continues to change upstream and downstream of Chambers Hollow and Bagley Brook in response to sediment inputs from those tributaries. Depositional bars at the mouths of Chambers Hollow and Bagley Brook are evidence of a high volume of sediment from these tributaries and that the river is having difficulty moving this sediment.

Aquatic habitat Conditions:

Throughout this section there are at least 6 significant spring seeps that contribute cold water to the stream. These cold water inputs help keep the stream temperature lower and provide refuge for the fish, such as trout in the summer months. Long reaches of the river flow along the south valley wall shaded by the overhanging cover of hemlock trees. This forest type prefers the cool, moist site conditions typically found on north facing slopes of the valley. The lack of tree cover along agricultural fields limits the quality of the habitat.

History of Stream Management:

Landowners and construction agencies have extensively utilized revetments to maintain the position of the river and protect land and facilities from the river. **Table 7.5.2** shows the extent and types of revetments and length of berms within each management unit. There is nearly 14200 feet of bank revetment along the river in this segment. Most of the revetment is dumped stone placed along stream banks near agricultural fields. There are several berms in this segment that limit floodplain access. A berm just above the land fill is constructed of old vehicles.

Table 7.5.2 – Revetment and Repairs

Management Units	Length (mi)	Dumped Stone	Rip Rap	Laid-up Stone	Stacked Rock Wall	Gabions	Log Cribwall	Concrete	Sheet Piling	Other	Log Deflectors	Total Revetment Length (ft)	Revetment Length per mile	Berms	Berm Length (ft)
20	1.75	5	-	-	1	-	-	-	-	-	-	190	109	1	836
21	2.97	29	5	-	1	-	1	2	-	1	-	6625	2231	3	980
22	1.03	6	-	-	-	-	-	-	-	1	-	976	948	-	-
23	0.64	10	-	-	-	-	-	-	-	-	-	1275	1992	-	-
24	2.35	21	2	-	-	-	-	1	-	2	-	5433	2312	1	159

7.5.1 Management Unit 20

Management Unit 20 is predominately agricultural land except for where the river runs close to the south valley wall exposing bedrock on the left bank. Tributaries that enter this unit are Holmes Hollow and Platner Brook. These tributaries contribute sediment load to the main stem resulting in the formation of numerous depositional bars downstream from their confluences. These bars are causing additional bank erosion. This management unit is unstable and is being monitored with cross-sections 59 and 60.

Figure 7.5.1 Typical eroding bank along agricultural field with no riparian buffer approximately 4,000 feet downstream of Platner Brook.

The significant number of eroding banks in the vicinity of aggradation areas suggests that the river is attempting to alter its alignment to enable it to move around the deposits. As many of these banks have little to no vegetation as shown in **Figure 7.5.1**, the river is able to rapidly remove huge sections of bank with each storm event. The riparian buffer width should be increased for almost all of the agricultural fields along the river in this management unit. The stream program should also continue to review stable or "reference" stream alignments for large C streams in an effort to provide recommendations for channel realignment as needed by stream bank stabilization and river restoration efforts.

There are two areas of wetlands located 3,500 feet downstream of Platner Brook. These wetlands are classified as shrub swamp and shallow emergent marsh.

7.5.2 Management Unit 21

Although the land along the stream is primarily agricultural land in Management Unit 21, the unit also includes the Hamlets of Delancey and Hamden. Hamden Covered Bridge (County Bridge 54) and Delaware County Route 2 Bridge (County Bridge 2-1) are within this unit.

Figure 7.5.2 Typical scene of the West Branch in Management Unit 21 located approximately 4,000 feet upstream from Bagley Brook confluence.

Tributaries that enter this unit are Bagley Brook and Pettis Brook and both of these tributaries have high sediment load. Pettis Brook sediment load has been noted near New York State Route 10, but the majority of this excess load has not reached the main stem. Deposition is found in the vicinity of bridges and at the confluence of Bagley Brook. This management unit is classified as moderately stable. The monitored with cross-sections 62 and 63 are located in this reach.

Figure 7.5.3 Eroding bank upstream from Bagley Brook confluence.

Erosion is mainly in the upper portion of this unit along agricultural fields with little to no riparian buffer. An old vehicle revetment (partially buried) can be found just downstream of Bagley Brook confluence. There are fewer revetments located within this unit, with most of the revetment associated with the bridges, New York State Highway Route 10 and some of the agricultural fields.

There is one small area of wetland located 1,600 feet upstream of the County Bridge 2-1. This wetland is classified as a backwater slough.

Other features to observe are the Willow planting project upstream of Bagley Brook confluence and the floodplain culverts at the County Bridge 2-1.

7.5.3 Management Unit 22

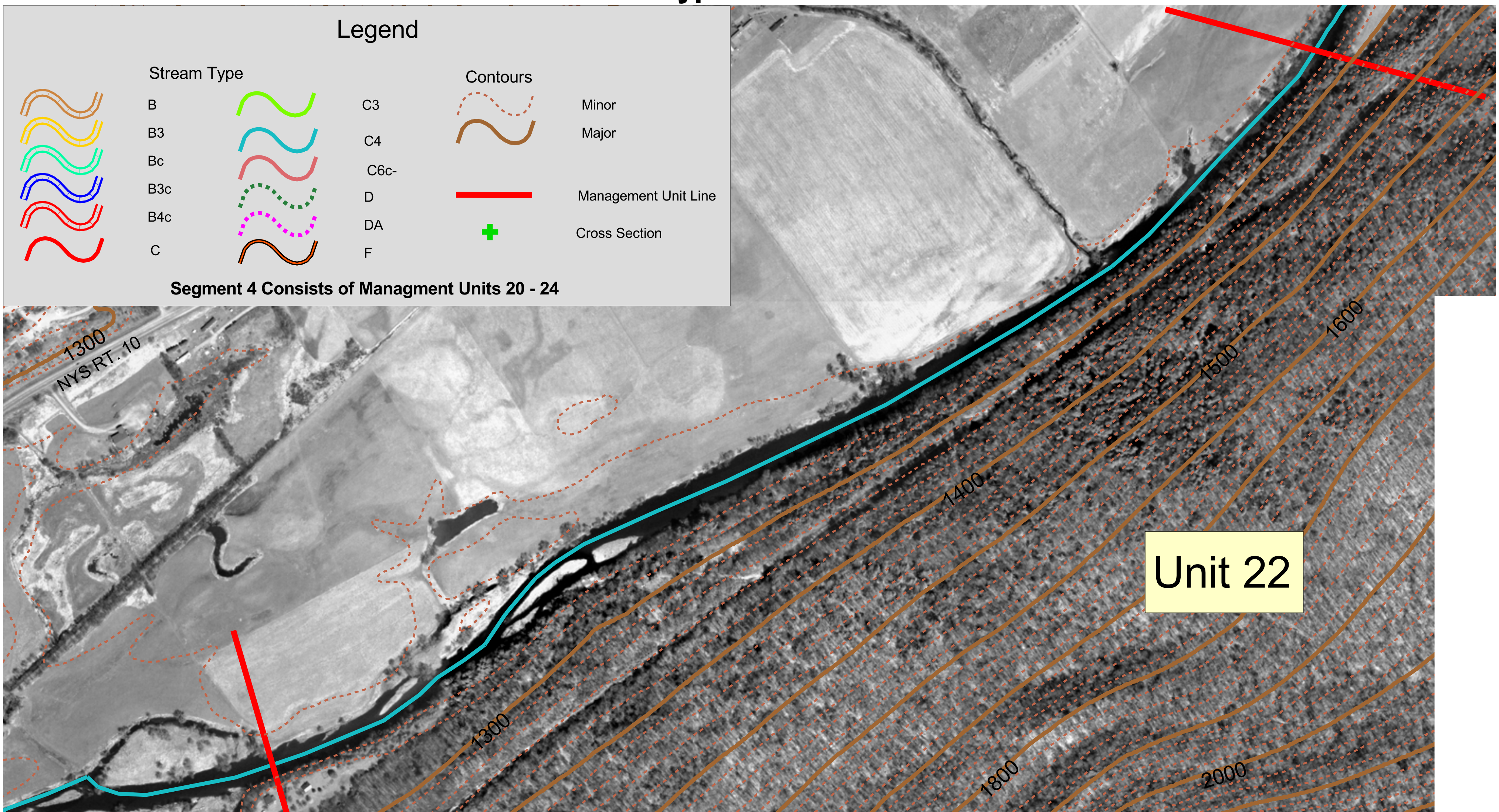
In this management unit the river runs along a steep side hill on the left bank. See **Management Unit 22 – Map 1** through **Map 6** at the end of this unit description. All the floodplain is located on the right side and it has no riparian buffer. Launt Hollow tributary enters the West Branch downstream of the Hamlet of Hamden and has formed a center bar at its confluence which can be seen in **Figure 7.5.5**. There are additional center bars 2,000 feet downstream of Launt Hollow. Bank erosion is mainly occurring in the areas of this group of center bars.

This management unit is moderately stable and contains no monitored cross-section at this time. There are no wetlands located within this unit.

Figure 7.5.4 Typical scene in Management Unit 22 and is located 1,600 feet downstream from Launt Hollow.

Figure 7.5.5 Confluence of Launt Hollow.

Management Unit 22 - Map 1
Stream Types and Cross Sections



Base Data Provided by NYCDEP
Map data provided in NAD 83 UTM Zone 18 North
Contour Interval 20 feet
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

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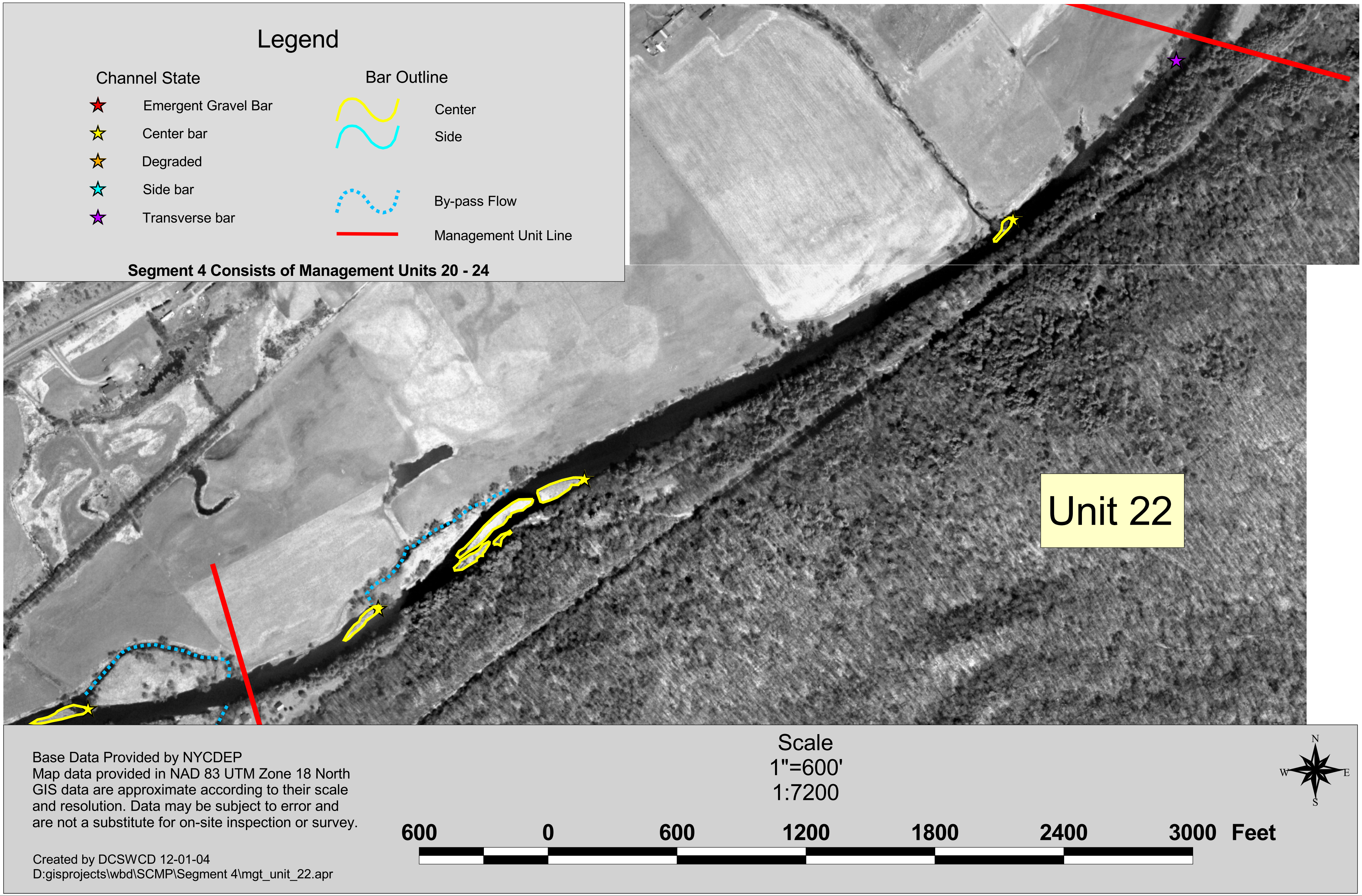
N W E S

Management Unit 22 - Map 2
Channel State and By-Pass Flow



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GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

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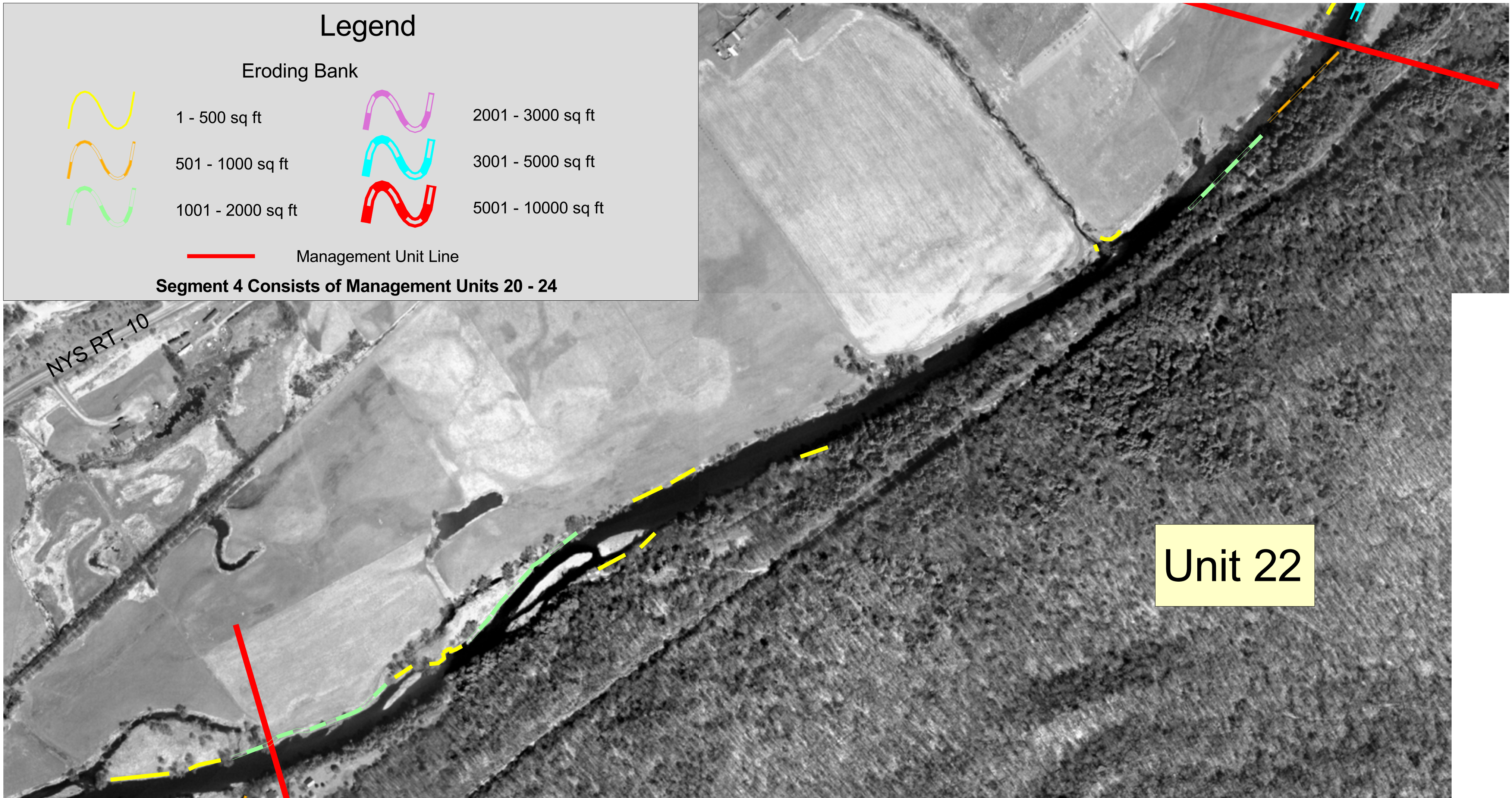
Management Unit 22 - Map 3
Eroding Banks



Base Data Provided by NYCDEP
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N
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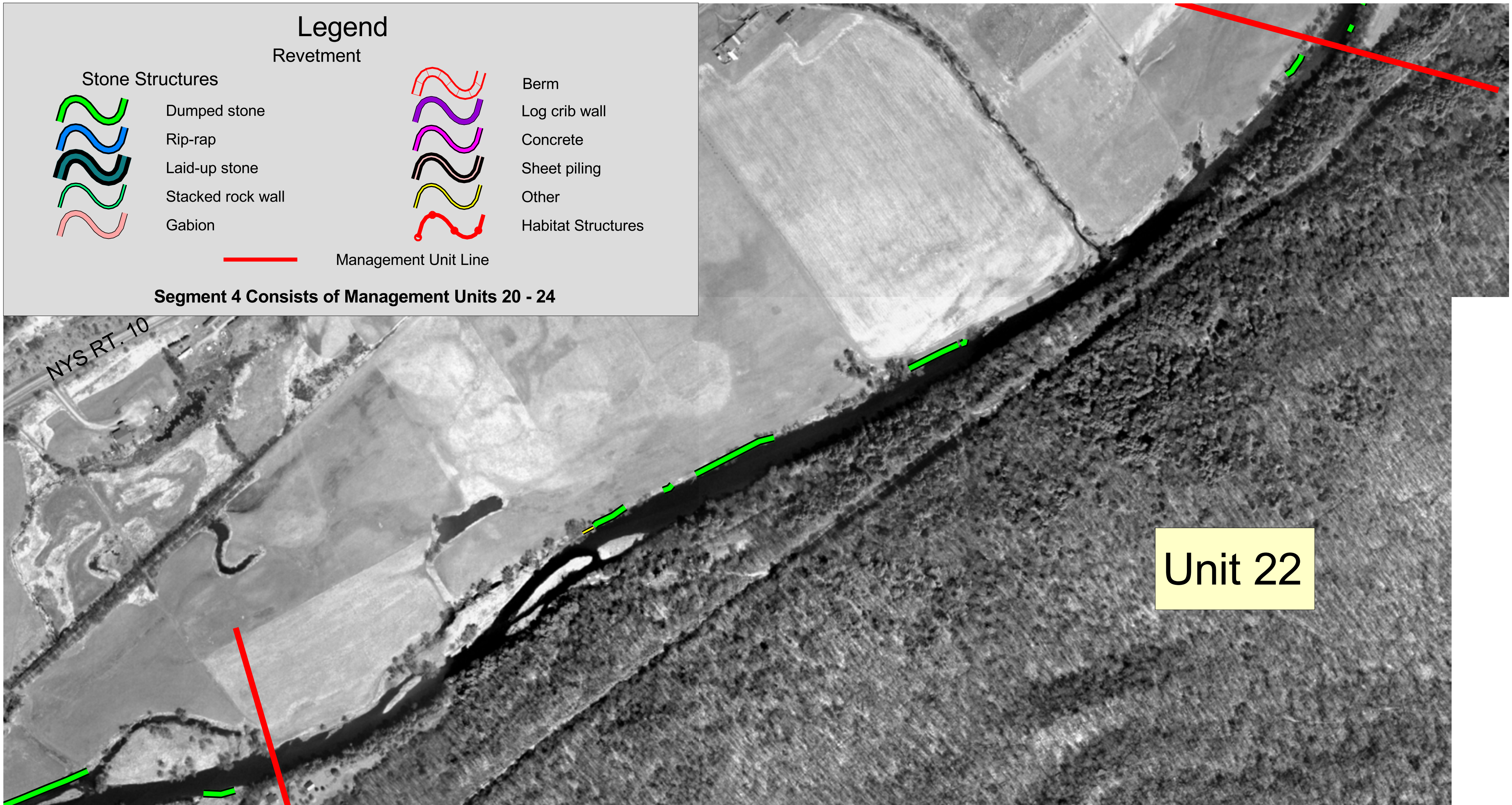
Management Unit 22 - Map 4
Revetment



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N W E S

Management Unit 22 - Map 5
VegetationTypes/Land Use

Legend

Vegetation/Land Use

- Commercial and Services
- Coniferous Forest Land
- Cropland and Pasture
- Deciduous Forest Land
- Exposed Bare Rock
- Herbaceous
- Mixed Brush
- Mixed Forest Land
- Other Urban or Built Up Land
- Residential
- Shrub and Brush
- Strip Mine, Quarries and Gravel Pits
- Transportation, Communications and Utilities
- Water
- Wetland
- CREP

Management Unit Line

Segment 4 Consists of Management Units 20 - 24

Base Data Provided by NYCDEP
Map data provided in NAD 83 UTM Zone 18 North
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

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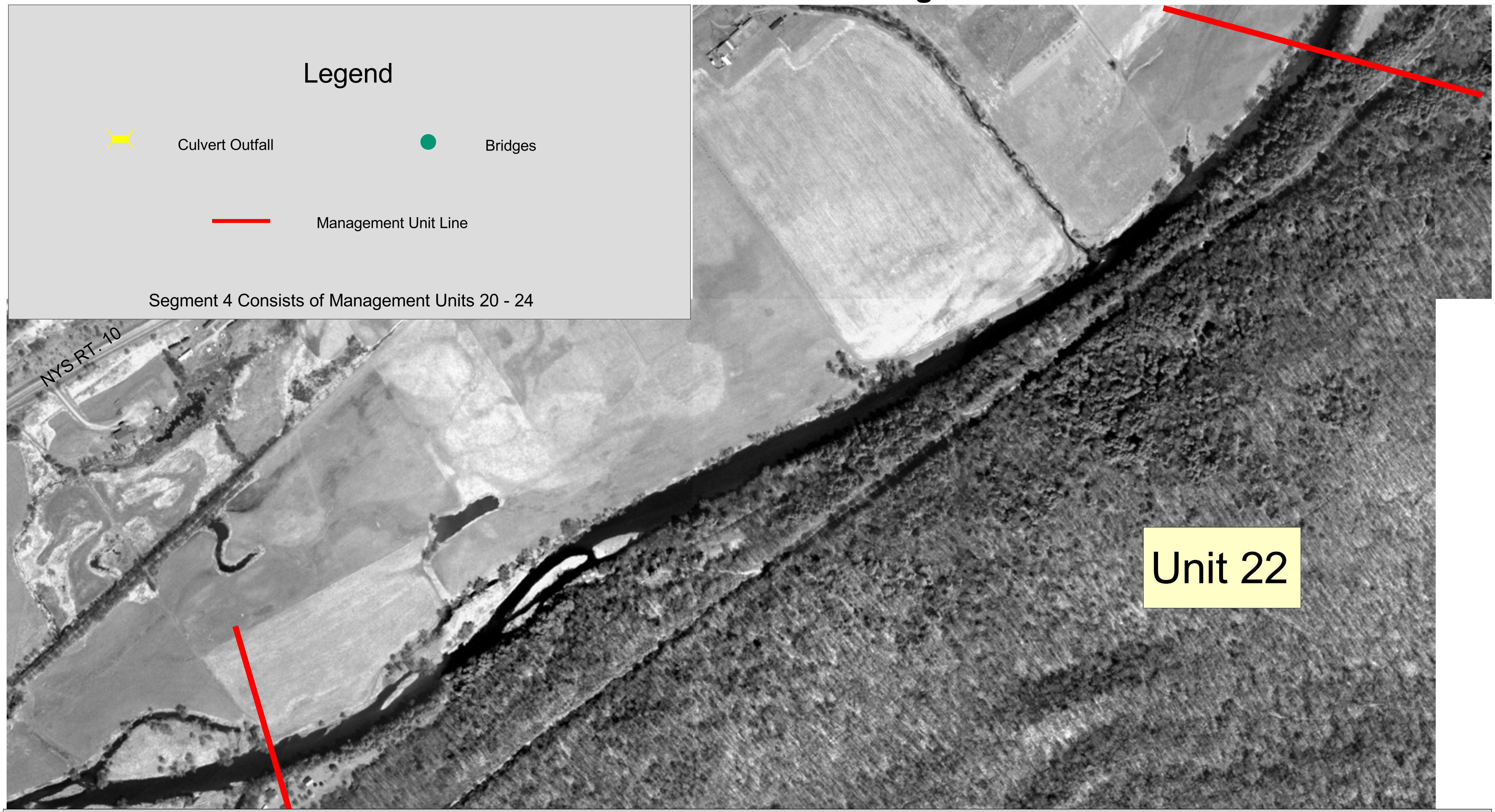
Management Unit 22 - Map 6
Culvert Outfalls and Bridges



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are not a substitute for on-site inspection or survey.

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N W E S

7.5.4 Management Unit 23

This management unit is unstable. In the upper portion of this unit there is a by-pass channel on each sides of the river. Approximately 700 feet downstream is a large gravel deposit that forced water around it creating a second new channel approximately 800 feet long. Chambers Hollow supplies large amounts of sediment to the river system which is shown in **Figure 7.5.6**.

Figure 7.5.6 Confluence of Chambers Hollow tributary with high sediment load.

This area is primarily agricultural lands and there is a significant amount of erosion on poorly vegetated banks. **Figure 7.5.7** shows an eroding bank with poorly vegetated banks.

This unit contains aggraded deposition and many sections of dumped stone revetments. There are no wetlands located in this unit.

Figure 7.5.7 Poorly vegetated eroding bank that is associated with a transverse bar located 350 feet downstream of the confluence with Chambers Hollow.

There are no established monitoring sections within this unit at this time. The entire reach was topographically surveyed in 2001.

7.5.5 Management Unit 24

This management unit is moderately stable. The main stem of the Delaware River makes two very tight radius curves within this unit. County Bridge number 26-6 on County Route 26 is in this unit.

The northwest unnamed tributary across from Mallory Brook confluence contributes large amounts of sediment to the main stem. Mallory Brook does not contribute a significant sediment load.

Figure 7.5.8 Typical scene in Management Unit 24 located 900 feet downstream of Mallory Brook confluence.

Figure 7.5.9 Vehicle revetment that is located approximately 7,400 feet downstream of County Bridge 26-6.

Figure 7.5.10 Poorly vegetated bank that is easily eroded on the island.

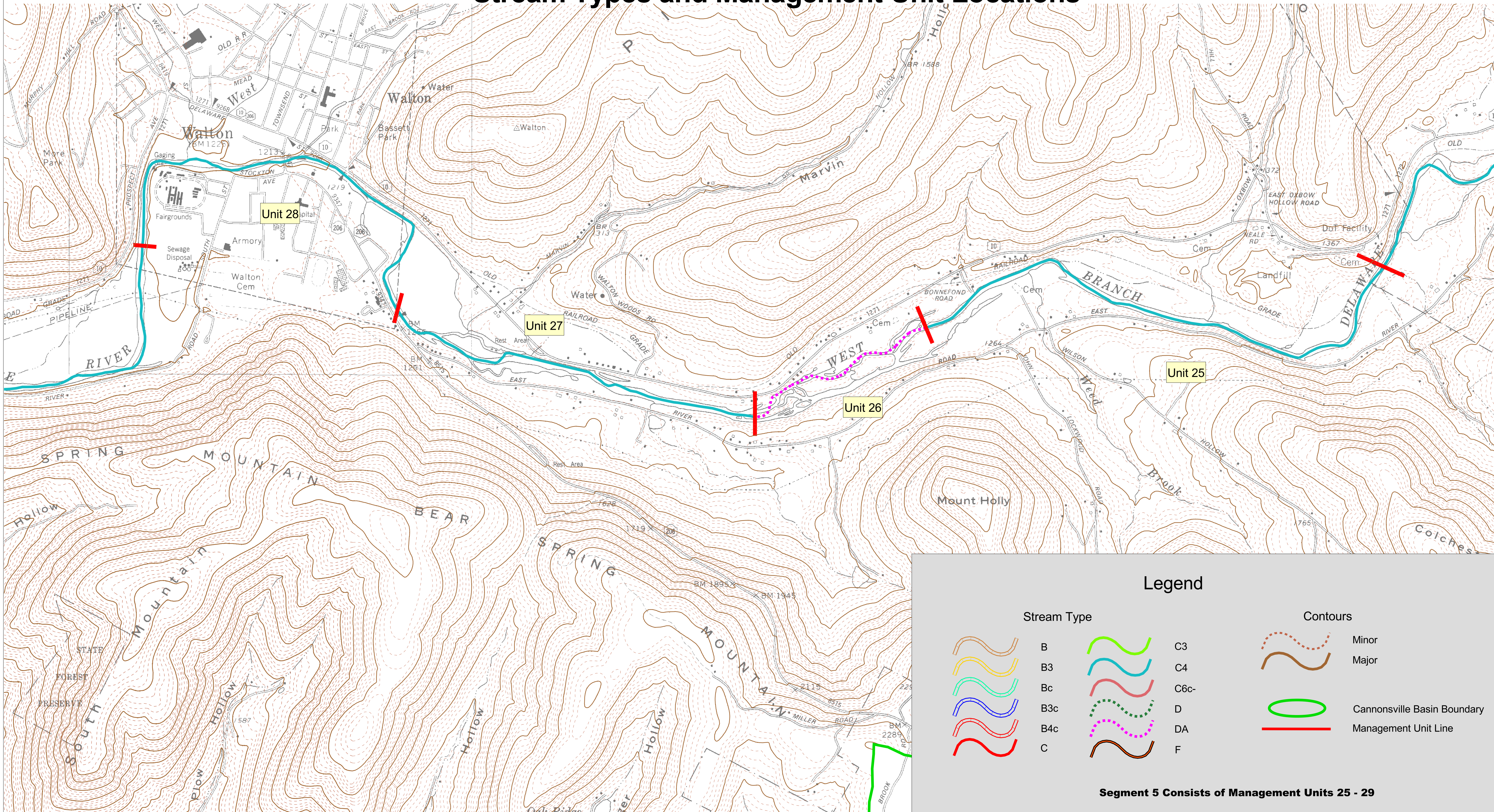
In the lower part of the unit there is a berm constructed of cars and school bus bodies along the left bank approximately 1,100 feet long which can be seen in **Figure 7.5.9**. This revetment is an ill-advised attempt to protect agricultural land during flooding events.

The entire reach seems to have minimal erosion. The most significant erosion is located on an island where there are several aggradation deposits directing water into the banks. These river banks are poorly vegetated and are easily eroded under high flow conditions. See **Figure 7.5.10**.

Management Unit 24 has no monitored cross-sections at this time. There are no wetlands located in this unit.

Segment 5

Segment 5 - Map 1
Stream Types and Management Unit Locations



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GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

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Segment 5 - Map 2
Stream Types and Management Unit Locations

Base Data Provided by NYCDEP
Map data provided in NAD 83 UTM Zone 18 North
Contour Interval 20 feet
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

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7.6 Segment 5 – Town and Village of Walton

General Description of Segment Five

Segment five begins at the Hamden/Walton town line and ends near Beers Brook Bridge (see **Segment 5 - Map 1** and **Map 2**). The total surveyed stream length of this segment is 57,743 feet. The drainage area at the top of this segment is approximately 263 square miles and approximately 352 square miles at the bottom. The Village of Walton is the only population center within this segment. The valley slope through this segment is 0.0013 and the West Branch Delaware River is mainly a C4 stream type with a small section of DA stream type.

The Village of Walton was formed from the Town of Franklin on March 17, 1797. This area was well known for its tanning and lumbering industries. The south bank of the river is mainly a steep sloped, rocky, mountainous region with conditions that are unsuitable for cultivation and grazing and the north bank is hilly, but generally better adapted to agriculture. The Village of Walton, which was established on the alluvial fans of East and West Brooks, historically floods during high water events. The south side of Walton sits atop a glacially deposited terrace. Although properties on the south bank near the river are still within the 100 year floodplain, the south bank is slightly higher with respect to the floodplain and typically receives less flood damage than properties on the north side of the river.

This segment has more residential development along the floodplain than previous segments. Floodplain development and the filling to raise sites above the *base flood elevation* has the effect of reducing the net effective capacity of the floodplain to convey out-of-bank discharges. This increases the stress on the banks within the channel which results in bank scour and erosion. Development along the river also results in the loss of riparian buffer to lawns and parking areas which do not protect the river banks

The regions above and below the village are used for agriculture with residential/mixed use along the NYS Route 10 corridor.

This segment consists of Management Unit 25 through 29. The table below summarizes the erosion and depositional features that are within this segment by management unit.

Table 7.6.1 - Summary of Erosion and Depositional Features

Management unit	Length (mi)	Linear Feet of Erosion	Surface Area (sq.ft.)	# Erosion Features	# Deposition Features	LF Erosion per Mile	# Erosion Features/mi	# Deposition Features/mi
25	2.21	3600	11054	26	3	1628.96	11.76	1.36
26	0.84	2824	14770	14	19	3361.90	16.67	22.62
27	1.58	2120	8283	24	14	1341.77	15.19	8.86
28	1.86	6204	40272	31	12	3335.48	16.67	6.45
29	4.44	9554	36808	54	49	2151.80	12.16	11.04

Stream Orders, Floodplains, and Wetlands:

The stream remains a fifth order stream until it reaches the Cannonsville reservoir. Tributaries in this segment are Oxbow Hollow, Marvin Hollow, East Brook, West Brook, Third Brook, Pines Brook, Bobs Brook and Beers Brook. East Brook, Third Brook, and West Brook are channelized through the Village of Walton to the main stem. Many of the tributaries carry large amounts of sediment that is deposited in bars at their confluences with the main stem. Where the main stem cannot carry the excessive sediment load from the tributaries and the sediment begins to fill the pools or form aggradation bars. These deposits can create more stress on the river banks and result in banks erosion or failure.

At bankfull flows, the river is generally able to access its floodplain except in the Village of Walton. Outside of the village, the floodplains are typically used for agriculture although land use pressure has grown to where commercial businesses could be expected to expand into the fringe areas of the floodplain. Two sections of berms located in this segment outside the village that are approximately 904 feet in total length also impede floodplain access.

Wetlands are very important because they help reduce the amount of nutrients entering the river from upland sources. In this segment, there are eight wetland areas, classified as shallow emergent marshes and backwater sloughs. These wetlands play an important role in taking up phosphorus and nitrogen before it enters the aquatic ecosystems. These nutrients in the system can cause increase in algae and plant growth and deplete dissolved oxygen levels needed by aquatic life. Other benefits of wetlands consist of sediment control, increase flood storage, and wildlife habitat.

Land Use/Land Cover:

The land use has been and is predominantly agricultural land with more forested areas than the other four segments. The majority of the agricultural lands have only a narrow vegetated riparian buffer to protect the banks. The fields are still cropped close to the river banks which restrict the buffer vegetation to shrubs and shallow rooted herbaceous vegetation. Little or no riparian buffer zone increases the possibility of eroding banks and also allows a greater amount of nutrients from agriculture to enter the water system.

This segment is experiencing residential development encroachment as the Village of Walton continues to develop. Residential and mixed use developments are increasingly filling in along the Route 10 corridor and the floodplain fringe. Increased storm water runoff associated with the expansion of impervious surfaces is also a concern. This can cause more overland flow that contains more contaminants. Without a sufficient riparian buffer zone established in the village, these contaminants are dumped directly into the main stem increasing nutrient load and/or pollution into the water system. Another concern is restricted floodplain access with more development encroaching on the floodplain.

This segment contains Delaware County Solid Waste Management Center (formerly the Delaware County Landfill) which was originally established in 1974. Concern over the possibility of ground water contamination requires the facility to constantly monitor several wells. Surface runoff is controlled through catchment basins such as wetlands to absorb excess nutrient runoff. Water quality and micro-invertebrates are frequently tested above and below the waste facility.

Infrastructure:

The major roadways in this segment are State Highway 10, East River Road, and South River Road which run parallel to the river and have minimal impact on the floodplain. The old railway road runs parallel to the river except at one location where it crosses the river. The railroad bridge has long been removed, but remnants of the abutments are still present. The railway has only a very limited impact on the floodplain function as the elevated grade has been breeched in numerous locations.

The major bridges in this segment are on State Highway 206 and 10. Both bridges have sidebars that have formed near their abutments. However, neither bridge has a significant negative impact on *stream flow*. The State Highway 206 Bridge in the village can be inundated in major flood events which complicates the task of emergency service providers during floods.

Storm water runoff into road way ditches and from impervious ground are a major concern because of the potential problems of added sediment and nutrient supply to the river system without adequate protection.

Sediment Transport and Channel Evolution:

The Stream Management Program has not yet taken any samples of bed material from this segment because there are no monitoring cross-sections that have been established in this region. Since the summers of 2003 and 2004 were exceptionally wet, and water depths were deep it was not possible to survey cross-sections or take bed material samples. Visual inspection of this area shows that the riffles in this segment are poorly spaced and there are shallow long pools. There is a noticeable increase in fines on the river bottom in this segment. Gravel bars occur at the mouths of the tributaries. In particular, there is a long deposit at the mouth of West Brook tributary in the Village of Walton. Generally, if a type C stream experiences difficulty moving sediments it tends to evolve to type G and then to a type F, or directly from a C to an F. G and F types are less desirable types than a type C due to their marked tendency towards severe erosion and instability.

The main stem of the Delaware River has not changed based on the aerial photographs from 1938, 1963, 1971, and 1983. The tributaries seem to have been straightened before 1938.

History of Stream Management:

When the banks begin to fail and property is lost, property owners typically attempt to protect the banks by placing a revetment along the bank, such as a stone wall, rip rap or simply dumping cobble sized stone from the floodplain into the eroded bank. The majority of the revetments in this segment consist of dumped stone which are commonly found along agricultural fields. Revetments found within the village are mainly stonewalls or rip rap along the banks. Most of the revetment is well maintained especially in the Village of Walton. **Table 7.6.2** summarizes the quantity of revetments and repairs that have been established within each management unit in this segment.

Table 7.6.2 - Revetment and Repairs

Management Units	Length (mi)	Dumped Stone	Rip Rap	Laid-up Stone	Stacked Rock Wall	Gabions	Log Cribwall	Concrete	Sheet Piling	Other	Log Deflectors	Total Revetment Length (ft)	Revetment Length per mile	Berms	Berm Length (ft)
25	2.21	21	-	-	2	-	-	-	-	1	-	3772	1707	1	399
26	0.84	10	-	-	-	-	-	-	-	-	-	1808	2152	-	-
27	1.58	14	-	-	-	-	-	-	-	-	-	3272	2071	-	-
28	1.86	11	5	-	3	-	-	-	-	-	-	5324	2862	-	-
29	4.44	28	1	-	1	-	-	3	-	-	-	3681	829	1	509

7.6.1 Management Unit 25

Figure 7.6.1 Typical scene in Management Unit 25 located at the top of this unit.

This management unit consists of lands that are mainly agricultural fields with some forested areas. Delaware County Solid Waste Management Center is located within this unit. Oxbow Hollow tributary enters the West Branch downstream of the waste management center. This management unit is considered to be stable. **Figure 7.6.1** is a picture taken within Management Unit 25.

The only significant depositional feature in this unit is a center bar located 2,900 feet downstream from the Oxbow Hollow tributary at a sharp bend where the stream is obviously too wide.

Figure 7.6.2 Root wad revetment that is located near the Delaware County Solid Waste Management Center.

There are fewer erosion features in this management unit than most of the other management units. The erosion that does exist ranges from 1.5 feet to 5 feet in height. As usual, it can be found along banks without an adequate riparian buffer.

This management unit is not as highly revetted as most of the other units. Most of the revetments consist of dumped stone placed along the banks. The lack of berms helps ensure that the river can access its floodplain. **Figure 7.6.2** is a picture of root wad revetment constructed by Delaware County Department of Public Works to help protect the bank from erosion located near the Solid Waste facility.

There is one small section of wetland located approximately 300 feet upstream from Oxbow Hollow confluence, which classified as a shallow emergent marsh. There are no monitored cross-sections or bank pins at this time.

7.6.2 Management Unit 26

In this management unit the principal land use along the river continues to be agricultural fields with some forested areas on the left bank of the river. This unit contains four islands with several side and bypass channels. It is rated unstable. See **Management Unit 26 – Map 1** through **Map 6** at the end of this unit description.

This management unit is unique in that the entire reach is a DA (braided – *anastomosed*) stream type under the Rosgen classification. As a DA, the stream consists of multi-channels around vegetated "islands". In addition to the "islands" there are several side, center, and transverse bars, all of which are evidence of major deposition.

Figure 7.6.3 Poorly vegetated right bank that is eroding located approximately 1,500 feet downstream from Bonnefond Road.

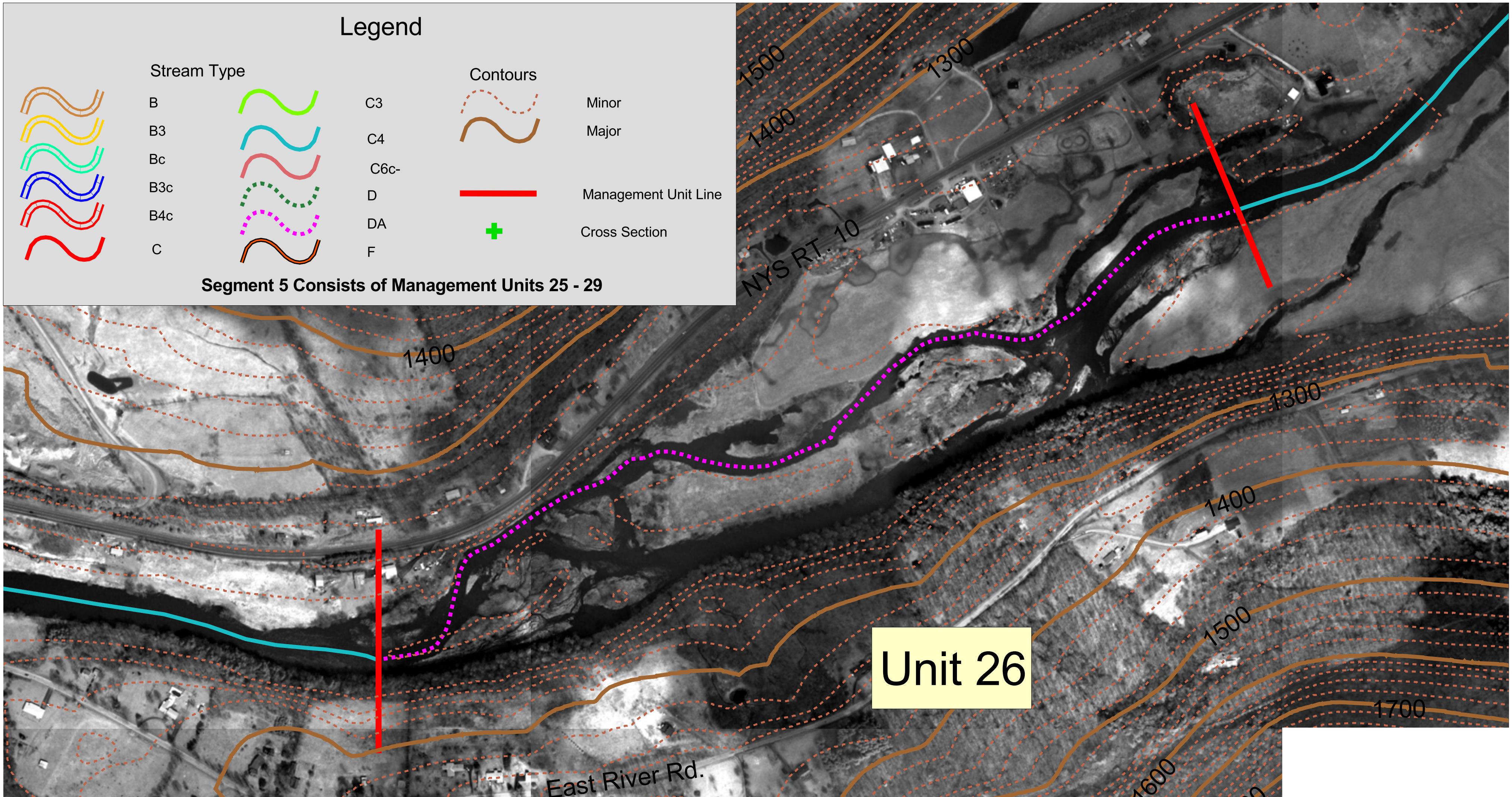
There is a total of 4,054 feet of eroding bank along this 8,545 foot long management unit. The height of the eroding banks varies from about 2 feet to about 8 feet, with about 30 percent of the eroding bank length having an average bank height of greater than 4 feet. It is likely that the stream banks in this management unit contribute a significant amount of sediment to the river.

Given the extent of the erosion in this unit, there is, as one would expect, considerable revetment placed along the banks. There is over 3,700 feet of dumped stone along this reach. Adjacent to NYS Route 10 about 1,200 feet of rock has been placed along the highway.

There is one area of wetland located approximately 3,500 feet downstream from Bonnefond Road and is classified as a shallow emergent marsh.

This is an important management unit given the stream classification and the river processes occurring here. Special consideration should be given to this multi-channel reach in an effort to understand why it is occurring at this location within the river valley and the cause of the extensive erosion. This is of special concern when considering the implications for the stable reach upstream. Further investigation and monitoring is required to determine why this unit exhibits such a morphologically extreme form for this watershed. At the present time there are no monitored cross-sections or bank erosion pins in this management unit.

Management Unit 26 - Map 1
Stream Types and Cross Sections



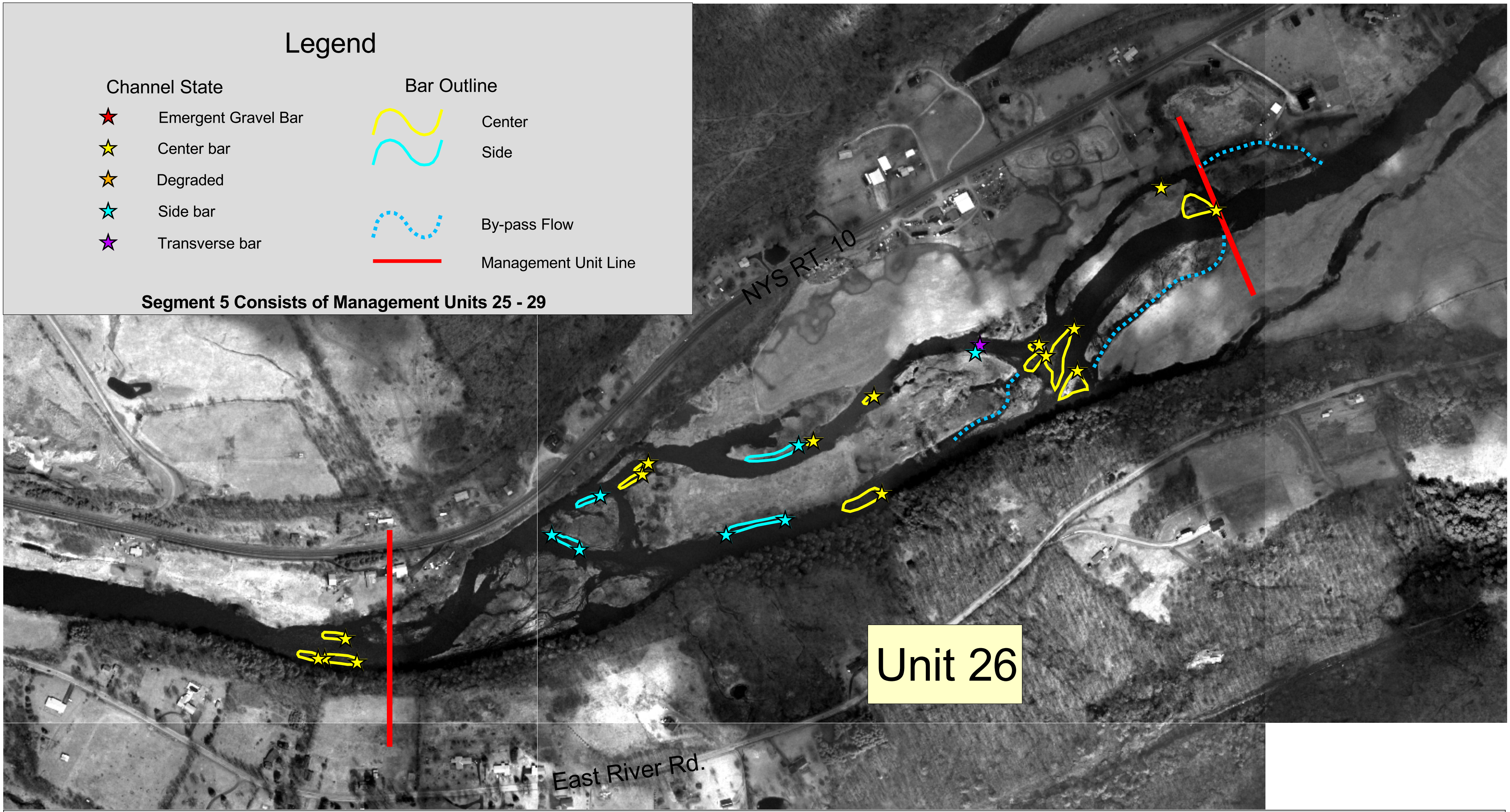
Base Data Provided by NYCDEP
Map data provided in NAD 83 UTM Zone 18 North
Contour Interval 20 feet
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

Created by DCSWCD 12-01-04
D:gisprojects\wbd\SCMP\Segment 5\mgt_unit_26.apr

Scale
1"=600'
1:7200

600 0 600 1200 1800 2400 3000 Feet

Management Unit 26 - Map 2
Channel State and By-Pass Flow



Base Data Provided by NYCDEP
Map data provided in NAD 83 UTM Zone 18 North
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

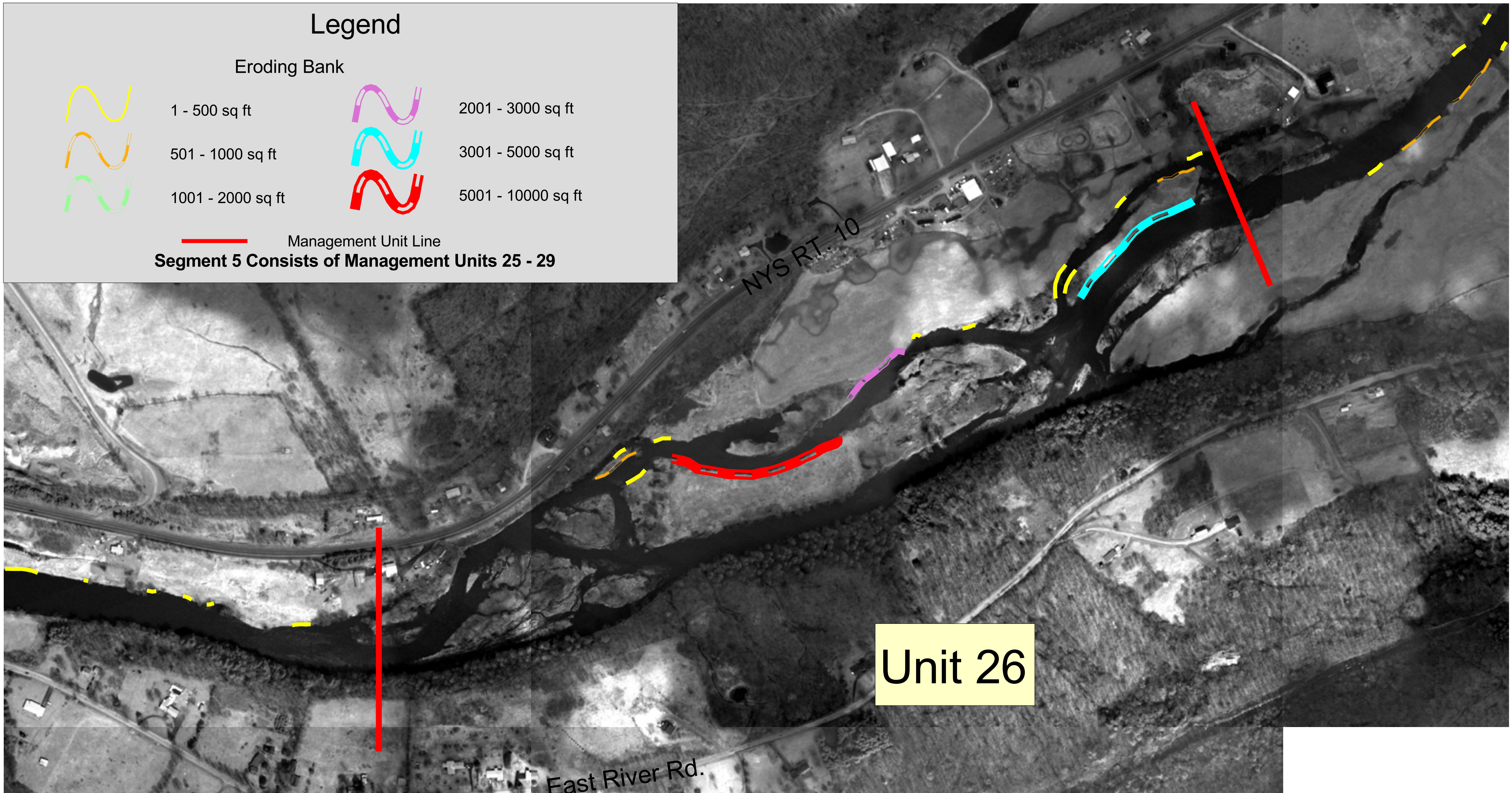
Created by DCSWCD 12-01-04
D:gisprojects\wbd\SCMP\Segment 5\mgt_unit_26.apr

Scale
1"=600'
1:7200

600 0 600 1200 1800 2400 3000 Feet

N S W E

Management Units 26 - Map 3
Eroding Banks



Base Data Provided by NYCDEP
Map data provided in NAD 83 UTM Zone 18 North
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

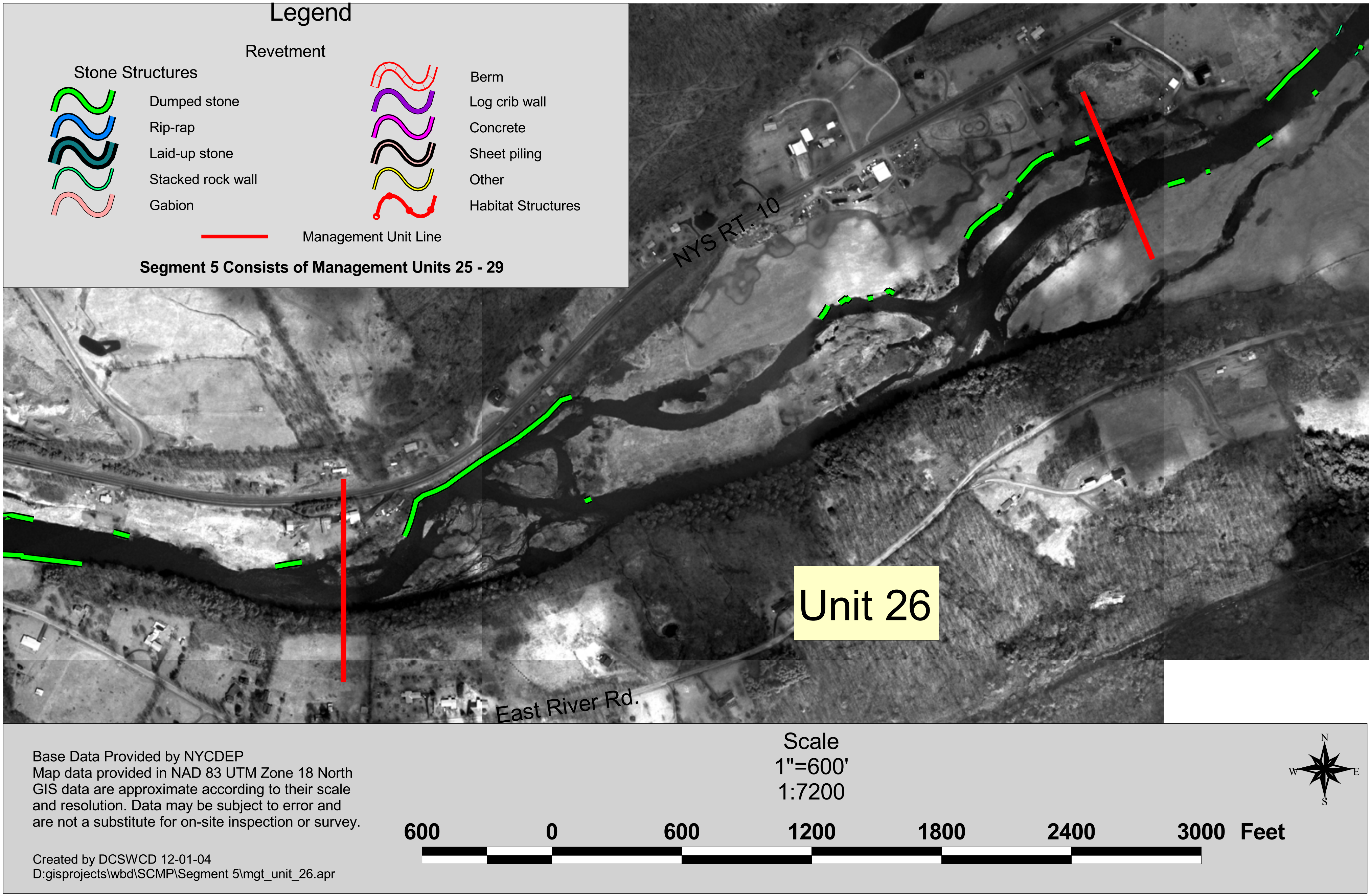
Created by DCSWCD 12-01-04
D:gisprojects\wbd\SCMP\Segment 5\mgt_unit_26.apr

Scale
1"=600'
1:7200

600 0 600 1200 1800 2400 3000 Feet

N E S W

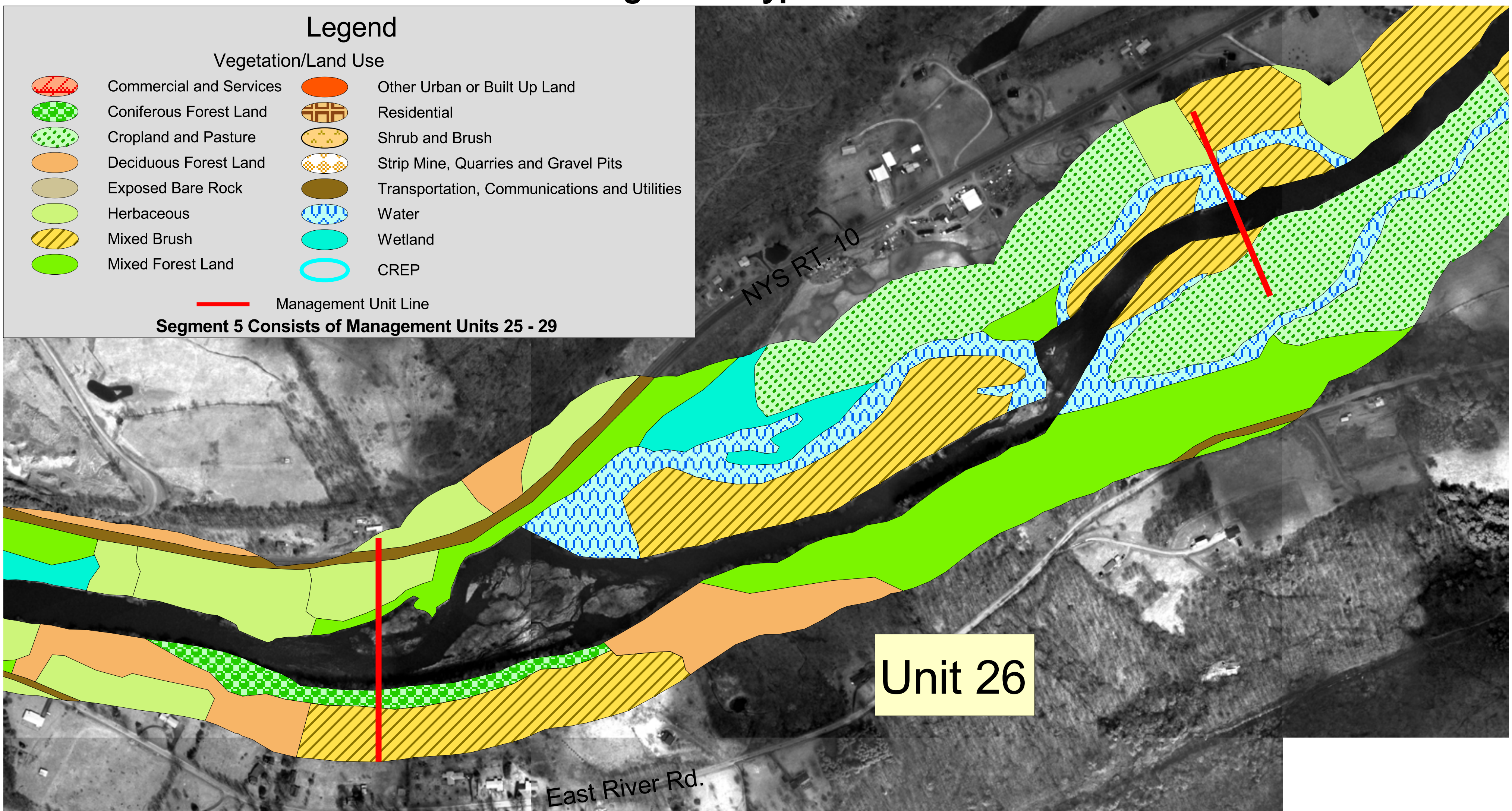
Management Unit 26 - Map 4
Revetment



Base Data Provided by NYCDEP
Map data provided in NAD 83 UTM Zone 18 North
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

Created by DCSWCD 12-01-04
D:gisprojects\wbd\SCMP\Segment 5\mgt_unit_26.apr

Management Unit 26 - Map 5
VegetationTypes/Land Use



Base Data Provided by NYCDEP
Map data provided in NAD 83 UTM Zone 18 North
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

Created by DCSWCD 12-01-04
D:gisprojects\wbd\SCMP\Segment 5\mgt_unit_26.apr

Scale
1"=600'
1:7200

600 0 600 1200 1800 2400 3000 Feet

N W E S

Management Unit 26 - Map 6
Culvert Outfalls and Bridges

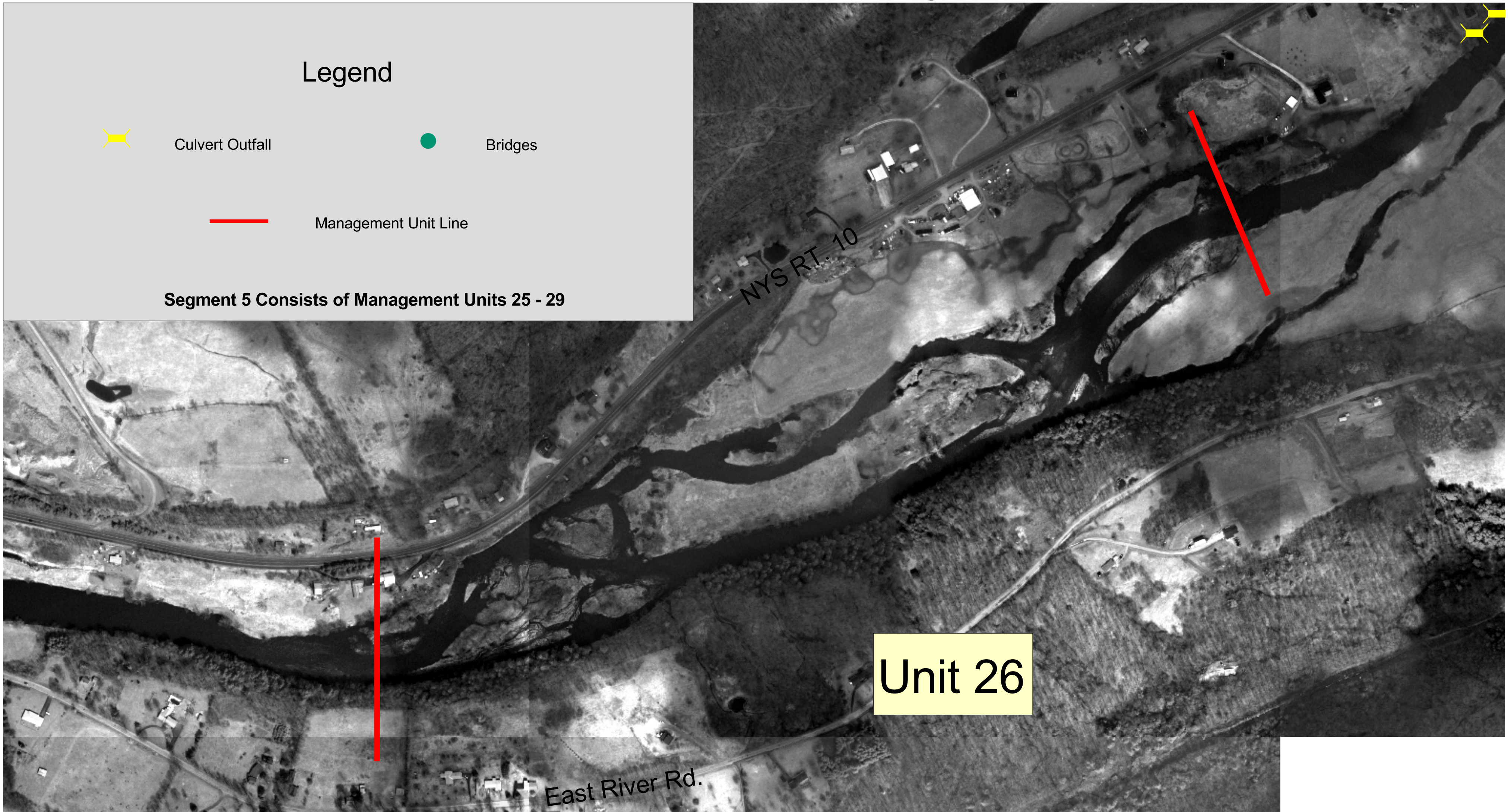
Legend

Culvert Outfall

Bridges

Management Unit Line

Segment 5 Consists of Management Units 25 - 29



Base Data Provided by NYCDEP
Map data provided in NAD 83 UTM Zone 18 North
GIS data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey.

Created by DCSWCD 12-01-04
D:gisprojects\wbd\SCMP\Segment 5\mgt_unit_26.apr

Scale
1"=600'
1:7200

600 0 600 1200 1800 2400 3000 Feet

N W E S

7.6.3 Management Unit 27

This unit consists of lands that are mainly agricultural fields and is on the outskirts of the Village of Walton. Marvin Hollow tributary enters the West Branch upstream from the village line. This unit is rated moderately stable with unstable reaches. **Figure 7.6.4** is a picture taken in this unit.

Figure 7.6.4 Typical scene in Management Unit 27 looking downstream at the top of this management unit.

Aggradation is not a serious concern in this unit. The number of depositional features is consistent with the average number of features per mile for the river. The depositional features are side bars and center bars.

Figure 7.6.5 Poorly vegetated left eroding bank located approximately 1,500 feet upstream from Marvin Hollow confluence.

There are approximately 4,800 feet of eroding banks in this management unit. Eroded banks in this unit range from 1 to 8 feet in height, with nearly half of the eroding bank length (2,322 ft.) having an average bank height between 4' to 8' in height. The height of several of these eroding banks exceeds 10 feet.

There are no berms in this management unit. There are a considerable number of dumped stone revetments. This indicates that the property owners have an ongoing problem with erosion.

There are two small areas of wetlands located upstream approximately 3,600 and 4,900 feet from Marvin Hollow confluence. The wetlands are classified as shallow emergent marsh and backwater slough. At the present time there are no monitored cross-sections or bank erosion pins in this management unit.

7.6.4 Management Unit 28

This management unit is rated unstable. This unit includes the Village of Walton with residential and commercial buildings near the stream banks. The river does not have access to its floodplain at bankfull in the village due to development, fill, and revetment. NYS Highway Route 206 Bridge crosses the river in the Village of Walton. It spans the entire river in the Village of Walton and is not a restriction. Tributaries in this unit are East Brook, Third Brook and West Brook.

Figure 7.6.6 Looking at a high eroding bank on the left side at Terrace Avenue potential project site.

Two sites with serious failing banks include the meander bend near Terrace Avenue and the left bank below the NYS Route 206 Bridge along South Street. Severe erosion has undermined these banks and the adjacent houses and residential properties are threatened by further bank loss. **Figure 5.6.6** shows the Terrace Avenue eroding bank which lost approximately 5 feet of bank during the flood of September 18, 2004. The Terrace Avenue bank is approximately 30 feet high, and South Street is about 25 feet high. These sites are thought to contribute a large amount of sediment to the river during storm events. There is a large center bar downstream from the Terrace Avenue bank that receives material from and may have a role in the process that is undermining the bank. Both of these sites were studied by a consultancy coordinated by the Soil and Water Conservation District with conceptual designs created for addressing the problem.

In addition to these two sites, there is a higher than average number of erosion sites in this unit.

There are 19 revetments (mostly dumped stone) in this unit; further evidence of the ongoing struggle against erosion in this unit. There are relatively few depositional features in this unit. The most outstanding depositional feature is the large gravel deposit at the mouth of West Brook. In recent years, fill has been dumped in sections of the floodplain on the left bank below the NYS Route 206 Bridge. Such activities can reduce the floodplain's capacity to reduce the energy associated with flood flows. Filling of floodplains can result in greater erosion causing sheer stress on stream banks.

At the present time there are no cross-sections or bank erosion pins in this management unit. Within this unit is a USGS gage station 01423000 (West Branch Delaware River at Walton NY) which is located near the Delaware County fairgrounds. This gage was surveyed as part of an effort by NYC DEP's Stream Management Program to create regional regression curves of hydraulic geometry for streams in the Catskill region.

There are no wetlands located in this management unit.

Management Unit 29:

This is the last management unit and consists mainly of agricultural land with few forested areas. Tributaries that are within this unit are Bob's Brook, Pines Brook, and Beers Brook. These tributaries contribute a large amount of sediment load into the main stem which can not be transported effectively resulting in depositional bars downstream.

This unit has a higher than average number of depositional features. Most of these features are side bars and center bars. There is a 2,000 foot long section within this unit that consists of multiple channels. This same reach has severe erosion along its banks. At the very end of this unit there is a 4,000 foot long reach with a large number of depositional and erosional features concentrated together.

Figure 7.6.7 Poorly vegetated right bank located approximately 1,700 feet upstream from Pines Brook confluence.

In addition to these two specific locations this unit also has a large number of erosion features over its entire length. Taken together with the large number of deposition features, this unit is rated moderately stable with unstable reaches.

There are four areas of wetlands classified as either shallow emergent marsh or backwater slough. The first area of wetland is located approximately 4,200 feet downstream from Walton stream gage, second area is located approximately 3,600 feet upstream from Pines Brook, third is located approximately 2,000 feet upstream from Beers Brook confluence and the forth is located approximately 300 feet from Beers Brook confluence.

There are currently no monitored cross-section or bank pins in this management unit at this time.

Appendix 1

Landowner Survey Information

Delaware County
Soil and Water Conservation District
44 West Street, Suite 1 Walton, New York 13856
Phone 607-865-7161
FAX 607-865-5535

May 2002

Dear Resident and/or Landowner

WE NEED YOUR OPINION

As you may know, the Delaware County Soil & Water Conservation District (SWCD) is working on the development of a Stream Corridor Management Plan (SCMP) for the West Branch of the Delaware River and its tributaries. Funding is provided by a contract with the New York City Department of Environmental Protection (NYC DEP)as a part of the Memorandum of Agreement between the DEP and the watershed communities. The SWCD is a local conservation service agency based in Walton, New York.

The purpose of the SCMP is to identify the current problems and issues relating to stream management in the basin as well as unstable areas for future remediation. This shall form the framework for potential solutions and management strategies in the final Stream Management Plan. Our goal is to develop a practical plan with crucial input from you and local and state agencies. Hopefully, by working together, we can succeed in leveraging the money needed for future stream restoration projects and making the current regulatory process more user friendly.

Enclosed please find a survey that we would like you to complete and return to us by June 28, 2002. This survey is important to us to understand your thoughts and concerns with current and future management of the river and its tributaries and also to develop an understanding of historic and current land uses. The results of this survey will be compiled and made publicly available at a date to be announced.

I encourage you to call me with any questions, comments, suggestions, or requests for additional information and look forward to your reply to this survey. Thank you in advance for your time and participation.

Sincerely,

Scotty R. Gladstone
Stream Program Coordinator

SRG:sg
encl.

WEST BRANCH OF THE DELAWARE RIVER
STREAM CORRIDOR MANAGEMENT PROGRAM

LANDOWNER SURVEY ANALYSIS & RESULTS
AREA 1

INTRODUCTION

In May 2002, the Stream Corridor Management Program surveyed riparian landowners along the West Branch main stem and the main stems major tributaries. The survey area included the Towns of Harpersfield, Kortright, and Stamford, and that part of the Kidd Brook watershed and the West Branch main stem to its confluence with Kidd Brook in the Town of Delhi, as shown on Map 1 in **Attachment A**. This area was chosen for initial distribution to keep the survey at a manageable level for our first solicitation and also because it was the area of focus for the 2002 field season. The purpose of the survey was to gain a general idea of the values they place on the river or tributary and the concerns they feel may need to be addressed.

METHODS

There are several diverse land uses and types of property along the West Branch and its tributaries. To make it possible to view trends among the different types of landowners, the survey forms were color coded and categorized by the type of land classifications identified in the Delaware County Tax database. The definitions of each property type classification and ownership codes may be obtained from the New York State Board of Real Property Services. A cover letter accompanied the survey and self-addressed return envelopes were included with the survey for the convenience of the respondents. After the surveys were returned, the data were compiled and used to create the summary tables in the next section of this report. A copy of the cover letter and survey may be found in **Attachment B**.

RESULTS

Table 1 on the following page summarizes the number of surveys distributed versus those received.

TABLE 1. RESPONSE TO AREA 1 LANDOWNER SURVEY

Landowner Survey- May 2002				
Category	**Color**	**Number of Surveys Distributed**	**Number of Surveys Received**	**Number Returned As Non Deliverable**
Agricultural	Green	66	20	
Commercial	Blue	22	5	
Gov't/Public Service	White	11	3	
Permanent Resident (Non-Ag)	Yellow	182	30	3
Seasonal Resident	Pink	43	24	8
Vacant Land/Forested	Purple	105	4	5
Total mailed 5/31/02		429		
Total Rec'd by 7/19/02			86	
Total Returned				16
Percent surveys received (of total mailed)		20.05		
Percent surveys returned		3.73		
Percent surveys received (adjusted for returns)		20.82		

Table 1 shows that 86 landowners responded which indicates an overall response rate of 20.05%. From the total number of surveys received, the table also shows that the most significant number of responses came from the agricultural community, seasonal residents, and permanent residents. Within these three categories of respondents, it is shown that 30.30% of the agricultural community responded, 16.48% of the non-agricultural permanent residents responded, and 55.81% of the seasonal residents responded.

For each respondent the length and type of residency was determined. The results are included in **Table 2**.

TABLE 2. LENGTH & TYPE OF RESIDENCY

Residency	Q	% Of total
Year-round:	56	65
0-5 yrs	1	2
6-10 yrs	2	4
11-20 yrs	12	21
Over 20 yrs	40	71
Mostly weekends:	16	19
0-5 yrs	3	19
6-10 yrs	2	13
11-20 yrs	3	19
Over 20 yrs	6	38
Summer:	9	10
0-5 yrs	0	0
6-10 yrs	1	11
11-20 yrs	3	33
Over 20 yrs	4	44
Other:	4	5
No response	1	<1

* 9 landowners did not respond to # years lived here.

Table 2 shows that 65% of the responses came from permanent residents. Furthermore, in each category of residency type, the number of respondents that have lived on the West Branch for more than 20 years represents the most significant portion. Conversely, the number of responses from the 0-5 year category was significantly low.

To illustrate the multiple benefits of the West Branch to riparian landowners, the survey asked residents what they enjoyed most about the river on their property. The results are presented in **Table 3** on the next page.

TABLE 3. FREQUENCY & PERCENTAGE OF RESPONSES TO QUESTION 4 BY LANDOWNER TYPE.

"I enjoy the West Branch on my property for…"					
Agriculture (20):	**Q**	**%**	**Business (5):**	**Q**	**%**
-agricultural livelihood	17	85	-agricultural livelihood	0	0
-hiking along river	5	25	-hiking along river	1	20
-camping along river	4	20	-camping along river	1	20
-the view	13	65	-the view	3	60
-wildlife viewing	9	45	-wildlife viewing	2	40
-hunting	9	45	-hunting	0	0
-fishing	10	50	-fishing	2	40
-swimming	3	15	-swimming	1	20
-canoeing/kayaking	2	10	-canoeing/kayaking	0	0
-other (written response)	1	5	-other (written response)	2	40
Gov't (3):			**Part-Time Res.(24):**		
-agricultural livelihood	0	0	-agricultural livelihood	4	17
-hiking along river	1	33	-hiking along river	12	50
-camping along river	1	33	-camping along river	3	13
-the view	3	100	-the view	18	75
-wildlife viewing	2	67	-wildlife viewing	19	79
-hunting	0	0	-hunting	8	33
-fishing	1	33	-fishing	13	54
-swimming	1	33	-swimming	6	25
-canoeing/kayaking	1	33	-canoeing/kayaking	2	8
-other (written response)	0	0	-other (written response)	1	4
Year-Round Res.- Non-Ag. (30):			**Vacant (4):**		
-agricultural livelihood	4	13	-agricultural livelihood	0	0
-hiking along river	10	33	-hiking along river	1	25
-camping along river	3	10	-camping along river	0	0
-the view	24	80	-the view	2	50
-wildlife viewing	24	80	-wildlife viewing	3	75
-hunting	11	37	-hunting	1	25
-fishing	14	47	-fishing	2	50
-swimming	10	33	-swimming	1	25
-canoeing/kayaking	3	10	-canoeing/kayaking	0	0
-other (written response)	5	17	-other (written response)	0	0

When considering the three most significant demographic groups based on the number of responses, the survey results can be evaluated by the trends viewed in each. **Table 3** shows that the agricultural community considered the primary benefits of living on the West Branch to be agricultural livelihood (85%), aesthetics (65%), and fishing (50%) respectively. Permanent, non-agricultural residents were split between aesthetics and wildlife viewing (80%), but also considered fishing (47%) as a major benefit. Similarly, part-time residents listed aesthetics (75%), wildlife viewing (79%), and fishing (54%) as the primary benefits of the river on their property. Among all types of demographic groups, the aesthetics of the West Branch is the main benefit to having property along the river.

The landowner class and the years of residence analyzed landowner opinions about the condition of the West Branch on their property. The results are shown in **Table 4**.

TABLE 4. FREQUENCY & PERCENTAGE OF LANDOWNER RESPONSES TO QUESTION 5: "CONDITIONS ON THE WEST BRANCH ARE…"

"Conditions on the West Branch" by landowner type & years lived here						
Agriculture (20):	**Q**	**%**	**0-5**	**6-10**	**11-20 (4)**	**Over 20 (16)**
-excellent	3	15				19%
-good	11	55			50%	56%
-fair	2	10			25%	6%
-poor	4	20			25%	19%
Business (5):			**0-5**	**6-10**	**11-20 (1)**	**Over 20 (3)**
-excellent	1	20				33%
-good	4	80			100%	67%
-fair	0	0				
-poor	0	0				
Gov't (3):			**0-5**	**6-10**	**11-20**	**Over 20 (3)**
-excellent	0	0				
-good	1	33				33%
-fair	0	0				
-poor	2	67				67%
Part-Time Res.(24):			**0-5 (3)**	**6-10 (3)**	**11-20 (6)**	**Over 20 (8)**
-excellent	9	38	33%	33%	67%	38%
-good	12	50	67%	67%	17%	50%
-fair	2	8			17%	13%
-poor	0	0				
Year-Round Res.– Non-Ag (30):			**0-5 (1)**	**6-10 (2)**	**11-20 (7)**	**Over 20 (19)**
-excellent	12	40	100%	100%	29%	37%
-good	11	37			57%	32%
-fair	3	10			14%	11%
-poor	4	13				21%
Vacant (4):			**0-5**	**6-10**	**11-20**	**Over 20**
-excellent	0	0				
-good	1	25		*not applicable		
-fair	1	25				
-poor	0	0				

Table 4 shows that in general, landowners who have lived on the West Branch for at least 11 years consider the conditions on the river to be good, but there could be some improved management. 55% of the agricultural community and 50% of seasonal residents believe that conditions are good. Permanent (non-ag) residents however were split closely between feeling that conditions are excellent and in no need of a change (40%), and that conditions are good (37%). Collectively, the remaining portions of landowners (government, businesses, and vacant landowners) represent a small percentage of responses. However, their responses may also help to gain a better understanding of landowner opinion.

Table 5 shows the frequency and percentage of total responses to the question regarding landowner's main concerns about the West Branch.

TABLE 5. SUMMARY OF LANDOWNER'S MAIN CONCERNS

"Main Concerns are…"		
Problem	**Q**	**% of total**
-bank erosion	50	58
-flooding of property	33	38
-gov't regs of private property	32	37
-obtaining permits	25	29
-time and money required for proper stream care	23	27
-pollution from upstream runoff, dumping	19	22
-impaired fishing	17	20
-trespassing	16	19
-how it affects my livelihood	14	16
-washouts	13	15
-other (written response)	11	13
-groundwater connection to my well	4	5

Table 5 shows that the top three concerns of landowners are bank erosion, flooding, and government regulations of private property. The results were categorized further in **Table 6** to show trends between main concerns and the type of landownership.

TABLE 6. MAIN CONCERNS ABOUT THE RIVER BY LANDOWNER TYPE.

Main Concerns About The River	**Agriculture (20):**		**Business (5):**		**Gov't (3):**		**Part-Time Res.(24):**		**Year-Round Res. (30):**		**Vacant (4):**	
	Q	%	Q	%	Q	%	Q	%	Q	%	Q	%
-bank erosion	16	80	2	40	2	67	10	42	17	57	3	75
-flooding of property	10	50	3	60			9	38	11	37	1	25
-impaired fishing	1	5					7	29	8	27	1	25
-groundwater connection to my well							2	8	2	7		
-pollution from upstream runoff, dumping	4	20			1	33	10	42	3	10	1	25
-trespassing	4	20	2	40			4	17	6	20		
-obtaining permits	10	50	2	40	2	67	4	17	7	23		
-time and money required for proper stream care	12	60	1	20	1	33	2	8	7	23		
-gov't regs of private property	11	55	3	60	1	33	8	33	9	30		
-washouts	2	10			1	33	3	13	6	20	1	25
-how it affects my livelihood	7	35	2	40					5	17		
-other (written response)	2	10	1	20			2	8	3	10	3	75

Table 6 illustrates that the majority of respondents in each landowner type indicated bank erosion as their main concern. Flooding of property also seemed to be of universal

importance to landowners. However, compared to other types of landowners, the agricultural community has the highest degree of concern for bank erosion. The agricultural community is also more concerned with the time and money required for proper stream care than the other types of landowners. On the other hand, the table shows that farmers are much less concerned about impaired fishing than permanent (non-ag) and seasonal residents, who exhibit a relatively high degree of concern. Furthermore, seasonal residents show a high level of concern for pollution, while for the other landowner types, the level of response is not as significant.

The survey asked landowners to rate the severity of flooding along the West Branch. **Table 7** is a summary of the results.

TABLE 7. SUMMARY OF RESPONSES TO FLOODING PROBLEM

Flooding Problem		
Response	**Q**	**% of total**
-relatively minor problem	40	47
-frequent problem	20	23
-has never been a problem	18	21
-has worsened	3	3
-no response	2	2
-other (written response)	2	2
-has improved	0	0

Table 7 shows that the majority of respondents believe that flooding along the West Branch is a relatively minor problem.

The responses to the flooding problem were also categorized by the type of landowner and the years they have lived on the West Branch. The most significant trends may be seen in the portion of respondents that have lived on the river for more than twenty years. Of the sixteen farmers residing on the West Branch for over twenty years, 50% felt that flooding has been a relatively minor problem. The highest percentages of seasonal and permanent residents living on the river for over twenty years feel the same. In addition, none of the seasonal residents feels that flooding is a frequent problem, but a small portion of farmers and permanent residents feel that it is a frequent problem.

The next question in the survey sought to gain an understanding of how landowners have been affected by floods. **Table 8** is a summary of the total responses to the question.

TABLE 8. SUMMARY OF RESPONSES TO
“I HAVE BEEN AFFECTED BY FLOODING…”

"Affected by flooding…" Total Responses		
Response	**Q**	**%**
Never	37	43
A number of times	32	37
Blank	7	8
Once	6	7
Extensively	4	5

Table 8 shows that the majority of respondents have either never been affected by flooding or have been affected a number of times. The results were further categorized in the table below to show possible trends based on length of residency and landowner type.

TABLE 9. RESPONSES TO QUESTION 9 BASED ON LENGTH OF RESIDENCY & LANDOWNER TYPE

Responses to "I have been affected by flooding…"

	Expressed as a %					
Type & Length of Residency	**Never**	**Once**	**A number of times**	**Extensively**	**Blank**	**Total**
Agriculture (20):						
11-20 yrs		25	50	25		4
Over 20 yrs	19		44	13	25	16
Business (5):						
11-20 yrs	100					1
Over 20 yrs	67		33			3
No response	100					1
Gov't (3):						
Over 20 yrs	33		67			3
Part-Time Res.(24):						
0-5 yrs	67		33			3
6-10 yrs	67	33				3
11-20 yrs	33	33			33	6
Over 20 yrs	44		56			9
No response	67	33				3
Year-Round Res.- Non-Ag. (30):						
0-5 yrs	33					1
6-10 yrs	50		50			2
11-20 yrs	57		43			7
Over 20 yrs	53		42	5		19
No response			100			1
Vacant (4):						
No response	50		25		25	4

The most significant trend seen in **Table 9** is that the largest proportion of landowners who said that they had never been affected by flooding were permanent residents with at least 11 years of residence on the West Branch. A majority of the agricultural community responded that they had been affected by flooding a number of times, while part-time residents seem to have had less of a problem with flooding on their property. A trend in the data is much less obvious for the other types of landowners, due to the relatively low number of responses.

Next, landowners were asked to describe how floods have affected them. **Table 10** on the following page is a summary of the results. Additional descriptions of damage may be found in **Attachment C**.

TABLE 10. TYPES OF DAMAGE BASED ON FLOOD FREQUENCY

Type of Damage per Frequency of Flooding Response									
	Expressed as a %								
Response	**water damage to my house**	**washout of road/private bridge**	**washout of bridge access(public)**	**erosion of river banks**	**loss of cropland**	**loss of cropland**	**no response**	**Total (Q)**	**%**
Never							100	37	43
Once		17	50				33	6	7
A number of times	9	47	16	63		16	3	32	37
Extensively				25		100		4	5
Blank (no response)		43		43		14	14	7	8

Of those who said that they had been affected a number of times, bank erosion (63%) and road/private bridge washout (47%) were the number one responses. This trend also correlates with the question regarding landowner's main concerns where bank erosion was also indicated as a major problem for landowners.

The survey then asked landowners what they felt was the best solution to flooding problems. To obtain the most unbiased response from landowners, the question did not provide any opportunities to check an answer box but rather left the question open-ended so that respondents would be free to make any suggestions they wished. The responses to this question may be found in **Attachment D**.

Many landowners indicated that they enjoy fishing on the West Branch. The respondents that indicated fishing as a major benefit (49%) were then further categorized by their opinions of the fishing conditions on the river. The results are presented in **Table 11** on the next page.

TABLE 11. SUMMARY OF LANDOWNER OPINIONS ABOUT FISHING CONDITIONS ON THE WEST BRANCH.

Condition has…	**Q**	**%**	**Reasons/ Comments**
Improved:	7	17	Clean. Increased stocking return of holes after 95 flood.
Deteriorated:	14	33	Too many beaver dams. Do not know- but class of people has changed they leave all their garbage where they fish. Soil erosion from runoff. Do not know. Cannonsville Dam killed off most warm water species and prevents shad migration. No management. Flooding Reason unknown to me.
Remained Consistent::	13	31	
No response:	8	19	

Table 11 illustrates that most landowners who enjoy fishing on the West Branch feel that the conditions have either deteriorated or remained the same. The comment section further displays what the respondents feel are the reasons for the decline in conditions.

Table 12 below examines who landowners feel should make decisions regarding stream management.

TABLE 12. SUMMARY OF LANDOWNER OPINIONS ABOUT WHO SHOULD MAKE STREAM MANAGEMENT DECISIONS.

Decisions should…	**Q**	**%**	**Full-Time Res (56)**	**Part-Time Res (24)**
be shared b/t landowners and local gov't	35	41	43%	36%
rest w/ landowners	25	29	27	36
don't know	12	14	20	4
blank	5	6	5	8
other	4	5	4	4
rest w/ SWCD's	2	2	2	4
rest w/ state gov't	2	2	0	4
rest w/ fed. gov't	1	1	0	4
rest w/ town gov't	0	0	0	0
rest w/ county gov't	0	0	0	0

Table 12 shows that the majority of respondents believe that stream management decisions be shared between local government and the landowner. 43-percent of those responses came from full-time residents. Part-time residents on the other hand, are split between thinking that solely the landowners should make decisions and that decisions be shared with local government.

The results were categorized further to show how different types of landowners with different lengths of residency felt about stream management decision-making. The results are shown in **Table 13**.

TABLE 13. LANDOWNER OPINION OF DECISION-MAKING BASED ON LENGTH OF RESIDENCY & LANDOWNER TYPE

"Decisions should…" Based on Landowner Type & Years of Residence											
	Expressed as a%										
Type & Length of Residency	**rest w/ landowners**	**be shared b/t landowners and local gov't**	**rest w/ SWCD's**	**rest w/ town gov't**	**rest w/ county gov't**	**rest w/ state gov't**	**rest w/ fed. Gov't**	**don't know**	**other**	**blank**	**Total Responses**
Agriculture (20):											
11-20 yrs		100									4
Over 20 yrs	38	50						6	6		16
Business (5):											
11-20 yrs	100										1
Over 20 yrs		33								67	3
No response		100									1
Gov't (3):											
Over 20 yrs		100									3
Part-Time Res.(24):											
0-5 yrs		67								33	3
6-10 yrs	67	33									3
11-20 yrs	17	33				17	17		17		6
Over 20 yrs	33	44						11		11	9
No response	67		33								3
Year-Round Res.- Non-Ag (30):											
0-5 yrs	100										1
6-10 yrs								100			2
11-20 yrs		57	14					29			7
Over 20 yrs	37	21	5					26	5	5	19
No response										100	1
Vacant (4):											
No response	25	25				25			25		4

Table 13 further illustrates that the majority of respondents felt that decisions about stream management should be shared between landowners and local governments. There does not appear to be any significant trends with landowner types or length of residency.

The next question in the survey asked landowners what they would like changed about the West Branch. A list of the responses may be found in **Attachment E**.

The remaining question posed to landowners dealt with who they believe should have primary financial responsibility of stream management on private property. The results are summarized in **Table 14**.

TABLE 14. SUMMARY OF LANDOWNER OPINIONS ABOUT FINANCIAL RESPONSIBILITY OF STREAM MANAGEMENT

Primary Financial Responsibility should…	**Q**	**%**
be shared b/t landowners and local gov't	26	33
don't know	16	20
rest w/ SWCD's	15	19
rest w/ state gov't	9	11
no response	7	9
rest w/ landowners	6	8
rest w/ fed. gov't*	4	5
other	3	4
blank	0	0
rest w/ town highway dept.	0	0
rest w/ county highway dept.	0	0

* 1FEMA, 2 NRCS, 1USF&W

The results of **Table 14** show correlation between the results in **Table 12**. The majority of responses for both indicate that landowners feel that decision-making as well as the primary financial responsibility for stream management should be shared between landowners and local government. The distinct difference between the results is that while a relatively large number stated that decisions should be made by landowners, only a small fraction felt that they should bear the financial responsibility alone. Furthermore, a much higher percentage felt that County Soil & Water Districts should be financially responsible, whereas the number of responses for the same category in **Table 12** was much less. A list of the written responses to this question may be found in **Attachment F**.

CONCLUSIONS

During the process of tabulating the responses, several portions of the survey were identified as areas that could be improved upon before the next mailing in Spring 2003. The proposed improvements would simplify the task of summarizing the results and allow trends in the data to be viewed much easier. The following suggestions are:

- Group “mostly on weekends” and “primarily in the summer” into one category entitled “Part-time” with a short description in parenthesis. i.e. (seasonal, weekend, other).
- Instruct respondents to check only one box for the type of property.

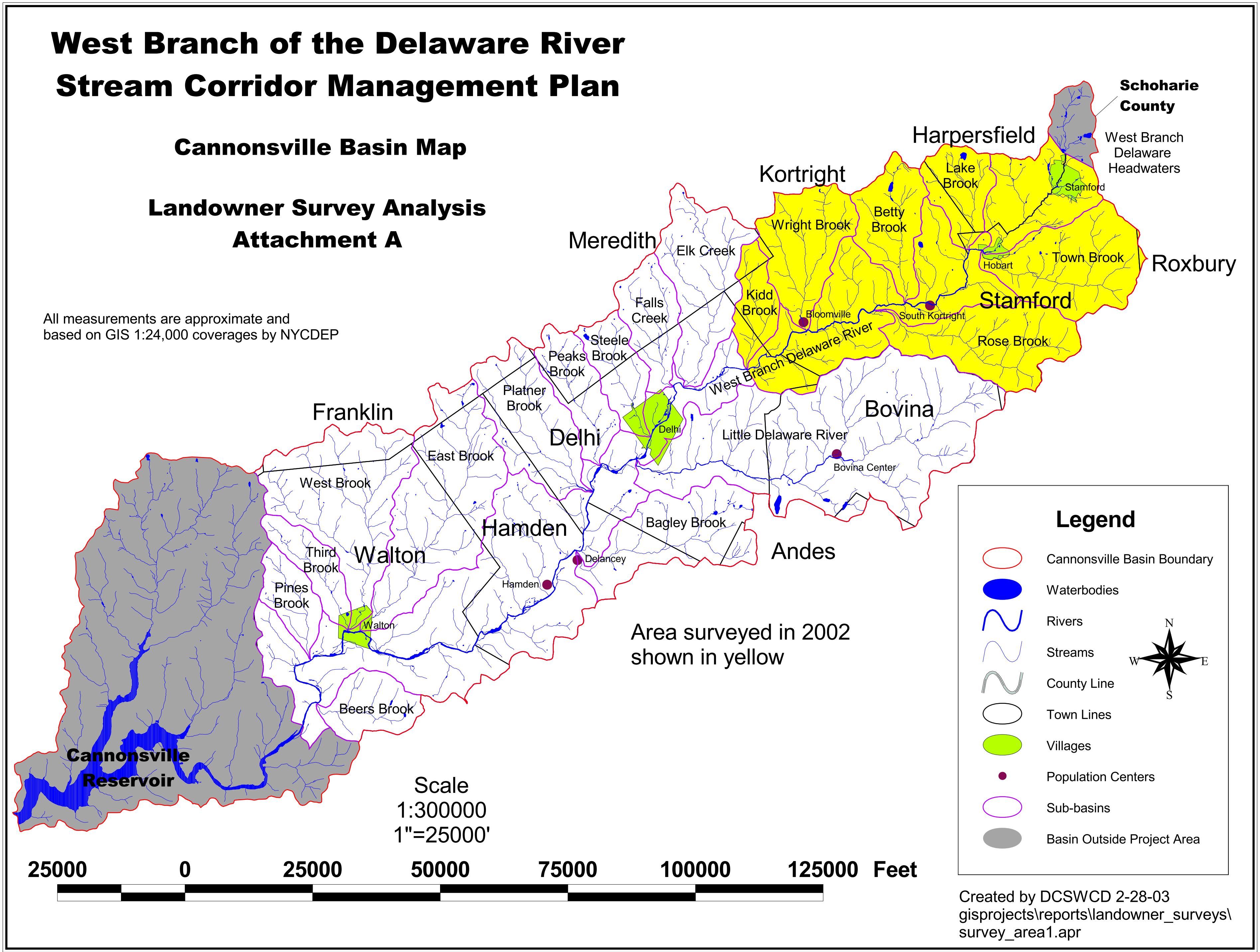
- In each question that refers to the "West Branch", change the phrasing of the question to read "West Branch or tributary".

- Change questions 12 and 14 by instructing respondents to check only one box OR to rank their responses, i.e. top 3 choices in order of importance.

- Mixing the current order of choices in Questions 12 and 14 so as not to bias the response and to encourage respondents to look at all the choices rather than those at the top of the list.

The changes suggested will alleviate difficulty in generating results from landowner surveys in the future.

It has also been suggested that we get the Town Supervisors to sign the cover letter accompanying the survey. This may generate a greater response.


West Branch of the Delaware River
Stream Corridor Management Plan
Cannonsville Basin Map
Landowner Survey Analysis
Attachment A
All measurements are approximate and
based on GIS 1:24,000 coverages by NYCDEP
Schoharie County
West Branch Delaware Headwaters
Harpersfield
Kortright
Meredith
Roxbury
Stamford
Franklin
Delhi
Bovina
Hamden
Walton
Andes
Lake Brook
Betty Brook
Wright Brook
Town Brook
Kidd Brook
Rose Brook
Elk Creek
Falls Creek
Steele Brook
Peaks Brook
Platner Brook
East Brook
West Brook
Third Brook
Pines Brook
Beers Brook
Bagley Brook
Little Delaware River
West Branch Delaware River
Stamford
Hobart
Bloomville
South Kortright
Delhi
Bovina Center
Delancey
Hamden
Walton
Cannonsville Reservoir
Area surveyed in 2002
shown in yellow
Scale
1:300000
1"=25000'
25000
0
25000
50000
75000
100000
125000
Feet
Legend
Cannonsville Basin Boundary
Waterbodies
Rivers
Streams
County Line
Town Lines
Villages
Population Centers
Sub-basins
Basin Outside Project Area
N
S
E
W
Created by DCSWCD 2-28-03
gisprojects\reports\landowner_surveys\
survey_area1.apr

ATTACHMENT B:

West Branch – Delaware River Stream Management Program
Landowner Survey Form

Please take a few minutes to complete the following survey questions. This survey is designed to give the Stream Corridor Management Program Team at the Delaware County SWCD a general idea of the importance of the West Branch of the Delaware River to the landowners, and what values you place on the river. Please include additional information on a separate sheet of paper and return with this form. Thank you for your assistance with this project.

I live in the West Branch river valley

❑ Year round ⑥ Mostly on weekends
❑ Primarily in the summer

I've lived here ________ years

My property is:

❑ Agricultural ❑ Residential ❑ Non-Profit
❑ Business ❑ Agency/Goverment

I enjoy the West Branch river on my property for
(check all that apply)

❑ Agricultural livelihood
❑ Hiking along the river
❑ Camping along the river
❑ The view
❑ Watching the wildlife, birds
❑ Hunting along the river
❑ Fishing
❑ Swimming
❑ Canoeing/Kayaking
❑ Other (please explain)

____
____

Conditions on the West Branch in my area are generally

❑ Excellent, needs no change in management
❑ Good, but could use some improved management
❑ Fair, needs much more management
❑ Poor, needs urgent management

My main concerns about the river include
(check all that apply)

❑ Bank erosion
❑ Flooding of property
❑ Impaired fishing
❑ Groundwater connection to my well
❑ Pollution from upstream runoff, dumping
❑ Trespassing
❑ Obtaining permits for stream work
❑ Time and money required for proper stream care
❑ Government regulation of private property rights
❑ Washout of roads and bridges
❑ How it affects my livelihood
❑ Other (please explain)

____
____
____

While I've lived here, flooding along the West Branch

❑ Has been a frequent problem
❑ Has been a relatively minor problem
❑ Has never been a problem
❑ Has worsened
❑ Has improved
❑ Other (please explain)

____
____
____

I personally have been affected by flooding
(check all that apply)

❑ Never ❑ Once ❑ A number of times ❑ Extensively
❑ Water damage to my house
❑ Washout of road access or private bridge
❑ Washout of bridge access (public bridge)
❑ Erosion of river banks ❑ Loss of cropland

Describe Damages: ______________________________
____
____
____

The best way to solve flooding problems is to:
Please explain:

____
____
____
____
____
____
____
____
____
____
____
____
____
____
____

Fishing on the West Branch has generally

- ❑ Improved in recent years. The reason is:
- ❑ Deteriorated in recent years. The reason is:
- ❑ Remained consistent

Decisions about how streams are managed on private property should

- ❑ Rest with landowners
- ❑ Be shared between landowners and local government
- ❑ Rest with the County Soil and Water Districts
- ❑ Rest with the Town government
- ❑ Rest with the County government
- ❑ Rest with the State government
- ❑ Rest with the Federal government
  - ❑ FEMA
  - ❑ Army Corps of Engineers
  - ❑ Natural Resources Conservation Service
  - ❑ U.S. Fish and Wildlife
- ❑ Don't know
- ❑ Other (please explain)

I would be willing to participate on the West Branch Project Advisory Committee for the development of the management plan. ❑ Yes ❑ No

What would you like changed about the West Branch?

The primary financial responsibility for management of streams on private property should

- ❑ Rest with landowners
- ❑ Be shared between landowners and government
- ❑ Rest with the County Soil and Water Districts
- ❑ Rest with the Town highway department
- ❑ Rest with the County highway department
- ❑ Rest with the State government
- ❑ Rest with the Federal government
  - ❑ FEMA
  - ❑ Army Corps of Engineers
  - ❑ Natural Resources Conservation Service
  - ❑ U.S. Fish and Wildlife
- ❑ Don't know
- ❑ Other (please explain)

Optional Information

Name

Address

Phone

E-Mail

Thank You for Your Assistance

Return address optional

STAMP

Delaware County Soil & Water Conservation District
44 West Street, Suite 1
Walton, NY 13856

Please fold & seal with tape or staple

ATTACHMENT C:

FLOOD DAMAGE DESCRIPTIONS

AGRICULTURE COMMENTS:

1. Flooding pasture, stranded animals and washed out fences.
2. Logs and debris left on cropland after water recedes.
3. a) Water took out our water line from spring to barn
   b) Took out our passage way so that our machinery cannot cross over to our pastures.
4. 3 Acre lot had to be re-soiled after major washout.
5. Needed to fill back around culverts.
6. River becomes blocked by debris from above deserted land. Water floods over one of the main meadows on my farm.
7. Flooding on fields.
8. Cuts into banks, general flooding of my field.
9. Have had to do major repair work due to wash outs several times.

BUSINESS COMMENTS:

1. No damage to house came up into driveway.

SEASONAL RESIDENT COMMENTS:

1. In 1995, the wing walls to my bridge were washed away and bank damage occurred.
2. They were working on the main road and redirected overflow. We had a rainstorm and our lower field flooded and our road washed out and the bridge was damaged.
3. Soil washout from field.

YEAR ROUND (NON-AG) RESIDENT COMMENTS:

1. Roof needed replacing loss of all personal items in basement including: a pool table, needed a new water heater, etc.
2. Water completely took out end of driveway (access to road) and washed out all and part of road.
3. Since 1989, I have lost approximately a 6'x20' amount of soil.
4. Several washouts have cause access to be limited.
5. You've seen them!
6. Road washed out and public bridge destroyed.
7. 5 ft. of water in my cellar. My driveway washed out. My riverbanks eroded more and more.
8. Have replaced bridge and pond in low area also got flood debris in it.
9. Washed out driveway, water in cellar, damaged sheet rock and some furniture.

VACANT COMMENTS:

1. Washed out road to camp twice in last 10 years.

ATTACHMENT D:

QUESTION # 10
LANDOWNER OPINIONS OF POTENTIAL FLOODING SOLUTIONS

AGRICULTURE

1. Cannot be solved, natural phenomenon. Stabilizing stream banks would certainly be a plus and removing gravel bars.
2. I have not a clue-hope you do!
3. Maintain riverbanks, clean out gravel deposits and fallen trees.
4. Plant trees to slow down erosion. Flooding is in God's hands. We can only slow down the results of flooding by preventive measures.
5. Use large rocks if available to slow water force.
6. Let landowners clean stream banks when needed.
7. Clean out the existing river and clean debris out on above vacant land owned by city people.
8. River bank management with rock!
9. Rip rap, clean out gravel bars, deepen and narrow the streams.

GOV'T

1. Maintain floodwater plains and stabilize banks.

SEASONAL RESIDENTS

1. I thought that's what you fellas did.
2. As I understand it, flooding is a problem when structures are built in a flood zone. If building in the flood zone is restricted, the floods can occur naturally without interfering with activities.
3. Need bridge over stream instead of pipe under driveway on my property. In general, large overflow basins in strategic flood areas may help minimize the occasional flooding. The basins require good drainage so they empty soon after filling.
4. My property is raised so no problems like neighbors.
5. Have a program to rebuild bank in the summer. A log framework backfilled with rocks from the river bottom works best.
6. They fixed the overflow and it hasn't happened since then.
7. By dredging the river bottom
8. Reinforce bulkhead, replace broken rotted out beams.

YEAR-ROUND RESIDENTS

1. Bank is too high for property to flood here.
2. There isn't a flooding problem this far up stream. In this case, leave Mother Nature alone!!!
3. Bank the riverbanks.

ATTACHMENT D:

4. Build up the bank on both side of stream.
5. Dig riverbeds deeper and town to make and maintain ditches and other water escape ways. Ditches on Kiff Brook Road have not been cleaned in about 2-3 years.
6. Repair Banks. A wall next to me made from railroad ties is washing out.
7. I may try to place naturally occurring local stone on a bulkhead along the erosion line (can I do this?)
8. Is proper drainage sizes calculated by water flow that can be substantial better management of washouts that happens at least every three years cause by rain snow melt and the like.
9. Make channel deeper clean all debris, cut brush, etc.
10. Spend money wisely.
11. Have clean up of brush and fallen trees.
12. The stream comes over the banks by Gregory's garage then down the street into my yard and cellar. Deepen the stream to accept extra water. Down stream put up a floodwall where it comes over the banks.
13. Cleaning of riverbed trees and gravel bars. Planting trees to hold stream banks. Also the DEC use to reinforce the banks with stone wire and treated logs. This hasn't been done since the mid 1960's.
14. Walk the entire watercourse and design remedies with qualified technicians. Provide funding for remedies.

ATTACHMENT E:

QUESTION 13
WHAT WOULD YOU LIKE CHANGED ABOUT THE WEST BRANCH?

AGRICULTURE COMMUNITY

1. Easier permit process to remove gravel bars.
2. Gravel bars removed.
3. Increase fish population.
4. See file "additional Survey Comments" Survey #10
5. It would do me no good to give my opinion because the other organization would only disagree-I have tried.
6. Stream bank improvement without a lot of hassle.
7. See file "additional survey comments" #21

BUSINESS COMMUNITY

1. Garbage removed and better entrance and fines to people who leave it.

PART-TIME RESIDENTS

1. Stock more fish.
2. More public fishing access parking areas.
3. Stabile banks and stream improvement for recreational fishing.
4. Rebuild banks where erosion has occurred.
5. Property owners get some rights back (example being able to construct a bridge over a stream without going broke from cost of regulations)
6. Old abandoned farms have dumped old machinery and all kinds of junk along the banks. It is an eyesore, yet it remains to set there.

YEAR-ROUND RESIDENTS

1. Nothing.
2. Nothing except governmental intervention remove the governmental intervention.
3. Build up banks.
4. Cleaned up
5. To remove NY City’s regulation of it and turn it back to DEC.
6. Better access & WS management.
7. Eliminate pollution completely now!
8. More bank erosion protection offered.
9. I would like the dead trees removed which cause obstructions.
10. Clean up of river beds, banks re-do the DEC reinforcement on the banks that need it.
11. Get it out from under the thumb of N.Y. City.
12. Restoration of DEC installed pool diggers, cribbing and other structures. Stabilization of severely eroding bank areas, which are adding much of the "silt" to the water during floods.
13. Clear fallen river trees and debris.
14. Nothing
15. No change.

QUESTION 14
RESPONSES TO "PRIMARY FINANCIAL RESPONSIBILITY FOR STREAM MANAGEMENT SHOULD…"

Written Responses:
1. We need to access every and all agencies for financial assistance and man power.
2. NYCDEP too because of NYC watershed regulatory burden.
3. Let NYC pay for it. They had a free ride for too long!!!!
4. NYC
5. At the upper river area there is no need for any agency to be financial responsible because there is no need to manage it.
6. If stream needs improvements the government should pay for it without the landowner giving up his rights.

Delaware County
Soil and Water Conservation District
44 West Street, Suite 1 Walton, New York 13856
Phone 607-865-7161
FAX 607-865-5535

April 2003

Dear Resident and/or Landowner

WE NEED YOUR OPINION

Enclosed is a survey that we would like you to complete and return by May 30, 2003. This survey is important to understand your thoughts and concerns with current and future management of the West Branch of the Delaware River and its tributaries, and to develop an understanding of historic and current land uses.

This survey is a component of a Stream Corridor Management Plan (SCMP) for the West Branch of the Delaware River and its tributaries being developed by the Delaware County Soil & Water Conservation District. Funding is provided by a contract with the New York City Department of Environmental Protection (DEP) as a part of the Memorandum of Agreement between the DEP and watershed communities.

The purpose of the Stream Corridor Management Program is to identify the current problems and issues relating to stream management in the basin, and to identify unstable areas for future remediation. This shall form the framework for potential solutions and management strategies in the final SCMP. The goal is to develop a practical plan with crucial input from you and local and state agencies. Hopefully, by working together, we can succeed in leveraging the money needed for future stream restoration projects and making the current regulatory process more user friendly.

I encourage you to call with your questions, comments, suggestions, or requests for additional information, and look forward to your reply. Thank you in advance for your time and participation.

Sincerely,

Scotty R. Gladstone
Stream Program Coordinator

SRG:sg
encl.

WEST BRANCH OF THE DELAWARE RIVER
STREAM CORRIDOR MANAGEMENT PROGRAM

LANDOWNER SURVEY ANALYSIS & RESULTS
AREA 2

INTRODUCTION

In April 2003, the Stream Corridor Management Program (SCMP) surveyed riparian landowners along the main stem of the West Branch and each of the major tributaries in the lower half of the Cannonsville watershed. The survey area included the Town and Village of Delhi, Town of Meredith, Town of Hamden, Town of Bovina, and the Town and Village of Walton as illustrated on Map 1 in **Attachment A**. The purpose of the survey was to gain a general idea of the importance of the river or tributary in the landowner's lives and to gain insight into problems or concerns they feel may need attention.

METHODS

There are several diverse land uses and types of property along the West Branch and its tributaries. To make it possible to view trends among the different types of landowners, the survey forms were color coded and categorized by the type of land classifications identified in the Delaware County Tax database. The definitions of each property type classification and ownership codes may be obtained from the New York State Board of Real Property Services. A cover letter accompanied the survey and self-addressed return envelopes were included for the convenience of the respondents. A copy of the cover letter and survey may be found in **Attachment B**.

The survey mailed to Area 2 riparian landowners had some minor differences from the original survey that Area 1 residents received. The changes made are as follows:

- The first question was shortened to only two available responses: Year-round or Part-time.
- Different lengths of time were provided in a check box format as opposed to the write-in response in the Area 1 survey.
- All references made to the West Branch in the Area 1 survey were changed to include tributaries so as not to limit a response from a landowner who may not live on the main stem.
- If the landowner lives on a tributary of the West Branch, the Area 2 survey asked residents to please indicate which one.
- Questions 12 and 14 were changed so that the list of possible responses was scrambled so as not to bias the results. Furthermore, the questions were altered from the original format of "check all that apply" to a ranking system whereby respondents were asked to rate their top three choices by placing a number next to their selection.

For use as a basis for comparison, a copy of the original Area 1 survey can be found in Attachment **C**.

After the surveys were returned, the data were compiled and used to create the summary tables in the next section of this report. The data and landowner comments will then be considered during the process of drafting a comprehensive Stream Corridor Management Plan for the West Branch basin.

RESULTS

Table 1 summarizes the number of surveys distributed versus those received as well as the percent response for each land use classification.

TABLE 1. RESPONSE TO AREA 2 LANDOWNER SURVEY.

Landowner Survey April 2003						
Land Type	**Color**	**Number of Surveys Distributed**	**Number of Surveys Received**	**Number Returned As Non Deliverable**	**% of Total Received by Land Type**	**% of Total Received**
Agricultural	Green	90	21	2	23	15
Commercial	Blue	55	9	5	18	6
Gov't/Public Service	White	28	4	0	14	3
Permanent Residence	Yellow	306	84	17	29	58
Seasonal Residence	Pink	114	21	15	21	15
Vacant Land/Forested	Purple	80	5	10	7	3
Total mailed:04/12/03		673				
Total Rec'd by:06/17/03			144			
Total Returned				49		
Percent surveys received (of total mailed)		21				
Percent surveys returned		7				
Percent surveys received (adjusted for returns)		23				

Table 1 shows that 144 landowners responded which indicates an overall response rate of 21%. From the total number of surveys received, the table also shows that the most significant number of responses came from the permanent residents, the agricultural community, and seasonal residents respectively. Within these three categories of respondents, it is shown that 29% of permanent residents responded, 23% of the agricultural community responded, and 21% of the seasonal residents responded.

Table 2 on the following page shows the percentage of respondents who indicated that they live on a tributary of the West Branch.

TABLE 2. PERCENATGE OF TOTAL RESPONDENTS LIVING ON A WEST BRANCH TRIBUTARY.

Tributary	Q	% of Total
Bagley Brook	3	2.1
Brush Brook	1	0.7
East Brook	12	8.3
Elk Creek	3	2.1
Freer Hollow	1	0.7
Honest Brook	2	1.4
Little Delaware River	13	9.0
Oxbow Brook	1	0.7
Peake's Brook	2	1.4
Pines Brook	1	0.7
Platner Brook	5	3.5
Steele Brook	7	4.9
Third Brook	3	2.1
West Brook	7	4.9
TOTALS	61	42.7

Table 2 shows that almost 43 percent of riparian landowners that responded to the survey own property along a tributary of the West Branch. Furthermore, responses from riparian landowners along a tributary accounted for nearly 10 percent of the total surveys mailed. The highest level of response came from the Little Delaware River, which comprised over 9 percent of the total 144 responses.

For each respondent the length and type of residency was determined. The results are included in **Table 3**.

TABLE 3. LENGTH & TYPE OF RESIDENCY

Residency		
	Q	% Of total
Year-round:	97	82
0-5 yrs	3	3
6-10 yrs	2	2
11-20 yrs	16	14
Over 20 yrs	71	62
Part-time:	22	18
0-5 yrs	2	2
6-10 yrs	0	0
11-20 yrs	8	7
Over 20 yrs	12	10

* 5 landowners did not respond to # years lived here.

Table 3 shows that 82% of the responses came from permanent residents. Furthermore, in each category of residency type, the number of respondents that have lived on the West Branch or tributary for more than 20 years represents the most significant portion. Conversely, the number of responses from the 0-5 and 6-10 year category was significantly low.

To illustrate the multiple benefits of the West Branch to riparian landowners, the survey asked residents what they enjoyed most about the river on their property. The results are presented in **Table 4** shown below.

TABLE 4. FREQUENCY & PERCENTAGE OF RESPONSES TO QUESTION 4 BY LANDOWNER TYPE.

"I enjoy the West Branch on my property for…"					
Agriculture (20):	**Q**	**%**	**Business (9):**	**Q**	**%**
-agricultural livelihood	19	95	-agricultural livelihood	1	11
-hiking along river	8	40	-hiking along river	0	0
-camping along river	2	10	-camping along river	1	11
-the view	15	75	-the view	9	100
-wildlife viewing	16	80	-wildlife viewing	6	67
-hunting	7	35	-hunting	2	22
-fishing	11	55	-fishing	3	33
-swimming	4	20	-swimming	1	11
-canoeing/kayaking	5	25	-canoeing/kayaking	1	11
-other (written response)	1	5	-other (written response)	1	11
Gov't (4):			**Part-Time Resident (21):**		
-agricultural livelihood	0	0	-agricultural livelihood	0	0
-hiking along river	2	50	-hiking along river	10	48
-camping along river	1	25	-camping along river	1	5
-the view	2	50	-the view	20	95
-wildlife viewing	2	50	-wildlife viewing	19	90
-hunting	0	0	-hunting	3	14
-fishing	2	50	-fishing	12	57
-swimming	0	0	-swimming	6	29
-canoeing/kayaking	2	50	-canoeing/kayaking	8	38
-other (written response)	0	0	-other (written response)	2	10
Residential (85*):			**Vacant (4):**		
-agricultural livelihood	7	9	-agricultural livelihood	2	40
-hiking along river	27	35	-hiking along river	3	60
-camping along river	9	12	-camping along river	2	40
-the view	61	78	-the view	3	60
-wildlife viewing	73	94	-wildlife viewing	5	100
-hunting	16	21	-hunting	3	60
-fishing	49	63	-fishing	3	60
-swimming	24	31	-swimming	4	80
-canoeing/kayaking	21	27	-canoeing/kayaking	3	60
-other (written response)	5	6	-other (written response)	0	0

*7 people from this group did not respond.

When considering the three most significant demographic groups based on the number of responses, the survey results can be evaluated by the trends viewed in each. **Table 4** shows that the agricultural community considered the primary benefits of living on the West Branch or tributary to be agricultural livelihood (95%), wildlife viewing (80%), and aesthetics (75%) respectively. Permanent residents considered wildlife viewing (94%), aesthetics (78%) and fishing (63%) as major benefits. Similarly, part-time residents listed aesthetics (95%), wildlife viewing (90%), and fishing (57%) as the primary benefits owning riparian land. Among all types of demographic groups in Area 2, watching birds and other wildlife is regarded as the number one overall benefit to owning property along a stream.

The landowner class and the years of residence analyzed landowner opinions about the condition of the West Branch on their property. The results are shown in **Table 5**.

TABLE 5. FREQUENCY & PERCENTAGE OF LANDOWNER RESPONSES TO QUESTION 5: "CONDITIONS ON THE WEST BRANCH ARE…"

"Conditions on the West Branch" by landowner type & years lived here						
Agriculture (21):	**Q**	**%**	**0-5**	**6-10**	**11-20**	**Over 20**
-excellent	4	19				100%
-good	7	33	14%		29%	57%
-fair	8	38				88%
-poor	2	10				100%
No response	1	10				
Business (9):			**0-5**	**6-10**	**11-20**	**Over 20**
-excellent	1	11				100
-good	5	56			20	80
-fair	2	22				100
-poor	1	11			100	
Gov't (4):			**0-5**	**6-10**	**11-20**	**Over 20**
-excellent	1	25				100
-good	1	25				100
-fair	1	25				100
-poor	1	25				100
Part-Time Res.(21):			**0-5**	**6-10**	**11-20**	**Over 20**
-excellent	4	19			75	25
-good	10	48			30	50
-fair	4	19			50	50
-poor	2	10				100
* 1 "don't know" response						
Year-Round Res. (84):			**0-5**	**6-10**	**11-20**	**Over 20**
-excellent	13	15			23	77
-good	43	51	2	2	16	72
-fair	7	8			14	71
-poor	13	15		8	8	77
No response	9	11				
Vacant (5):			**0-5**	**6-10**	**11-20**	**Over 20**
-excellent	1	20				100
-good	1	20				100
-fair						
-poor	3	60			33	66

Table 5 shows that in general, riparian landowners who live in the West Branch basin consider the conditions on the river to be good, but there could be some improved management. The majority of two of the largest landowner types have indicated that conditions are good (48-percent of part-time residents and 57-percent of full-time residents). The agricultural community was closely split between feeling that conditions were either good or fair. Collectively, the remaining portions of landowners (government, businesses, and vacant landowners) represent a small percentage of responses. However, their responses will help to gain a better understanding of landowner opinion.

Table 6 shows the frequency and percentage of total responses to the question regarding landowner's main concerns about the West Branch.

TABLE 6. LANDOWNER'S TOP 3 MAIN CONCERNS ABOUT THE RIVER OR TRIBUTARY.

Concern	**1**		**2**		**3**	
(out of 139 responses)	**Q**	**%**	**Q**	**%**	**Q**	**%**
Bank erosion	52	37	22	16	19	14
Don't know	1	.7	-		-	
Flooding of property	18	13	10	7	20	14
Gov't regulation of private property rights	21	15	10	7	18	13
Groundwater connection to my well	5	4	2	1	2	1
How it affects my livelihood	-		4	3	4	3
Impaired fishing	4	3	7	5	7	5
No response	5	4	23	17	29	21
Obtaining permits for stream work	8	6	15	11	7	5
Pollution from upstream runoff, dumping	11	8	19	14	11	8
Time and money required for proper stream care	3	2	10	7	10	7
Trespassing	9	6	6	4	5	4
Washout of roads and bridges	7	5	16	12	9	6

Other response: *It is a main route for 4-wheelers and snowmobilers and they wear the grass down to nothing which sends silt down slope.
** Debris and beaver dams.

Table 6 shows that bank erosion is the number one concern of the respondents from Area 2 (36-percent). Furthermore, it appears that government regulations and flooding are major concerns as well. Unfortunately, a majority of the respondents did not indicate their second and third concerns about the river or tributaries. However, a significant portion of the second and third responses indicates that bank erosion is a main concern for riparian landowners. The results were categorized further in **Table 7** to show trends between main concerns and the type of landownership.

TABLE 7. MAIN CONCERNS ABOUT THE RIVER BY LANDOWNER TYPE.

Main Concerns About The River	**Agriculture (21):**		**Business (9):**		**Gov't (4):**		**Part-Time Res.(21):**		**Year-Round Res.(84):**		**Vacant (5)**	
	Q	%	Q	%	Q	%	Q	%	Q	%	Q	%
Bank erosion	12	57	2	22	1	25	10	48	25	30	2	40
Don't know							1	5				
Flooding of property	3	14	2	22	1	25	3	14	9	11		
Gov't regulation of private property rights	2	10	1	11			1	5	16	19	1	20
Groundwater connection to my well							2	10	3	4		
Impaired fishing			1	11			2	10	1	1		
No response									5	6		
Obtaining permits for stream work			3	33					4	5	1	20
Pollution from upstream runoff, dumping	2	10					2	10	7	8		
Time and money required for proper stream care	2	10							1	1		
Trespassing											1	20
Washout of roads and bridges					2	50			5	6		

Table 7 illustrates that the majority of respondents in each landowner type indicated bank erosion as their main concern with the exception of the business community, which were slightly more concerned with obtaining permits. Flooding of property also seemed to be of universal importance to landowners. However, compared to other types of landowners, the agricultural community has the highest degree of concern for bank erosion. The agricultural community is also more concerned with the time and money required for proper stream care than the other types of landowners. For year-round residents, government regulation of private property rights seems to be of secondary importance behind bank erosion. However, it still represents a significant portion of the demographic.

The survey asked landowners to rate the severity of flooding along the West Branch or tributary. **Table 8** is a summary of the results.

TABLE 8. SUMMARY OF RESPONSES TO FLOODING PROBLEM

Flooding Problem		
Response	**Q**	**% of total**
-relatively minor problem	61	43
-frequent problem	42	30
-has never been a problem	12	8
-has worsened	16	4
-no response	-	
-other (written response)	9	6
-has improved	5	4

Table 8 shows that the majority of respondents believe that flooding along the West Branch is a relatively minor problem. The full written responses will be found in **Attachment C**.

The responses to the flooding problem were also categorized by the type of landowner and the years they have lived on the West Branch. The most significant trends may be seen in the portion of respondents that have lived on the river for more than twenty years. Of the sixteen farmers residing on the West Branch for over twenty years, 50% felt that flooding has been a relatively minor problem. The highest percentages of seasonal and permanent residents living on the river for over twenty years feel the same. In addition, none of the seasonal residents feels that flooding is a frequent problem, but a small portion of farmers and permanent residents feel that it is a frequent problem.

The next question in the survey sought to gain an understanding of how landowners have been affected by floods. **Table 9** is a summary of the total responses to the question.

TABLE 9. SUMMARY OF RESPONSES TO
"I HAVE BEEN AFFECTED BY FLOODING…"

"Affected by flooding…" Total Responses		
Response	**Q**	**%**
Never	38	28
A number of times	60	43
Blank	4	3
Once	25	18
Extensively	10	7
Other	1	1

Table 9 shows that the majority of respondents have either never been affected by flooding or have been affected a number of times. The results were further categorized in the table below to show possible trends based on length of residency and landowner type.

TABLE 10. RESPONSES TO QUESTION 9 BASED ON LENGTH OF RESIDENCY & LANDOWNER TYPE

Responses to "I have been affected by flooding…"

	Expressed as a %					
Type & Length of Residency	**Never**	**Once**	**A number of times**	**Extensively**	**Blank**	**Total**
Agriculture (21):						
0-5 yrs	50		50			2
11-20 yrs	33	33	33			3
Over 20 yrs	13	13	53	20	7	15
Business (9):						
11-20 yrs		50	50			2
Over 20 yrs	14	29	57			7
Gov't (4):						
Over 20 yrs		25	75			4
Part-Time Res.(21):						
0-5 yrs	100					2
11-20 yrs	38	25	25		13	8
Over 20 yrs	9	18	64	9		11
Year-Round Res. (84):						
0-5 yrs		50			50	2
6-10 yrs	50		50			2
11-20 yrs	38	23	31		8	13
Over 20 yrs	33	14	37	8	8	63
No response	50		50			4
Vacant (4):						
11-20 yrs			100			1
Over 20 yrs	25	25	25	25		4

Table 10 shows that a large majority of riparian landowners has been affected by flooding a number of times. As one might expect, landowners with 20 or more years of residence are the most significant faction of respondents that indicated being affected by flooding multiple times. A lesser number of respondents said that they had been affected only once or extensively. It is also important to note that a significant portion of residents of all types in the 11-20 year category stated that they have never been affected by flooding.

Next, landowners were asked to describe how floods have affected them. **Table 11** on the following page is a summary of the results. Additional descriptions of damages are located in **Attachment D**.

TABLE 11. TYPES OF DAMAGE BASED ON FLOOD FREQUENCY

Type of Damage per Frequency of Flooding Response								
	Expressed as a %							
Response	water damage to my house	washout of road/private bridge	washout of bridge access(public)	erosion of river banks	loss of cropland	no response	Total (Q)	%
Never				66		33	3	3
Once	25	55	15	45	5		20	22
A number of times	38	13	30	72	21		53	57
Extensively	40	50	10	90	40		10	11
Blank (no response)	14	14		100	29		7	8

Of those who said that they had been affected a number of times, bank erosion (72%) and water damage (38%) were the number one responses. This trend also correlates with the question regarding landowner's main concerns where bank erosion was also indicated as a major problem for landowners. Residents who claimed that that they had only been affected once, appear to have been affected the most by a washout of a private road/bridge.

The survey then asked landowners what they felt was the best solution to flooding problems. To obtain the most unbiased response from landowners, the question did not provide any opportunities to check an answer box but rather left the question open-ended so that respondents would be free to make any suggestions they wished. The responses to this question are found in **Attachment E**.

Many landowners indicated that they enjoy fishing on the West Branch. The respondents that indicated fishing as a major benefit (49%) were then further categorized by their opinions of the fishing conditions on the river. The results are presented in **Table 12** on the next page.

TABLE 12. SUMMARY OF LANDOWNER OPINIONS ABOUT FISHING CONDITIONS ON THE WEST BRANCH.

Condition has…	Q	%	Reasons/ Comments
Improved:	28		More attention by public to the stream Has improved last couple of years but not up to level of 15-20 years ago. Stocking of stream, clearing of debris from riverbed. Stocking by private club. Better control of business and residential pollution. Installation of sewer plants Cleaner water Stocking More fish stocked, larger fish stocked, I have become a better fisherman. Cleaner water. Less silt and salt runoff from roads DEC releasing larger trout in rivers. Also we don't have the pollution we had in the 1970's. Cleaner water. Fewer fishermen. * 7 people stated that stocking was the reason for the improved conditions.
Deteriorated:	32		Lack of water in late summer. Bank erosion and loss of cover. DEC doesn't stock tributary. Gravel bars. Dry summers Flooding has changed the course and the brook is not stocked with trout any longer. Flooding near bridges changed river flow pattern in Delancey at Hawley's Station. Improper stocking of fish and pollution. Upstream pollutants. Not getting enough native trout…stockers don't count! Believe frequent high water has washed out pools. Low water, no pools in brooks. Fishing holes have filled in, water line has been affected, and temperature of water discourages trout. I think it is because of carp overrun and eating everything. Not restocked. Less environmental condition favorable to fish habitat. I.E. waterpools Don't know Erosion, lack of fish habitat due to poor stream maintenance. Carp…they are like hogs rooting up the river bottom. Always turbidity in the stream. Stream bank erosion Absence of Rock Bass, sunfish, bullheads, pickerel. Easy fish for kids to catch. Lack of stream and road drainage maintenance. To my knowledge, are not stocking it with fish anymore. Dirty water Erosion of fishing holes. Too many city fishers.
Remained Consistent::	40		don't know
No response/don't know/don't fish	44		

Table 12 shows that riparian landowners feel that fishing conditions on the West Branch and its tributaries have remained consistent. More informative though are the responses that suggest that conditions either have deteriorated or have improved. The comment

section further displays what the respondents feel are the reasons for the decline or improvement in conditions. It is apparent that the respondents feel that a major reason behind improved fishing conditions is more stocking and that the most common reasons behind deteriorated conditions are a lack of stocking and erosion.

Table 13 below examines who landowners feel should make decisions regarding stream management.

TABLE 13. SUMMARY OF LANDOWNER OPINIONS ABOUT WHO SHOULD MAKE STREAM MANAGEMENT DECISIONS.

	Full-Time Res* (123)						**Part-Time Res (21)**					
Decisions should…	**1**		**2**		**3**		**1**		**2**		**3**	
	Q	**%**	**Q**	**%**	**Q**	**%**	**Q**	**%**	**Q**	**%**	**Q**	**%**
be shared b/t landowners and local gov't	49	43	22	27	4	6	5	24	5	38	1	10
rest w/ landowners	23	20	8	10	6	9	6	29	-	-	1	10
don't know	7	6	1	1	2	3	2	10	-	-	-	-
other	1	.8	-		2	3	-	-	-	-	-	-
rest w/ SWCD's	16	14	29	35	14	21	4	19	1	8	2	20
rest w/ state gov't	7	6	5	6	6	9	2	10	1	8	-	-
rest w/ fed. gov't	-	-	-	-	2	3	-	-	-	-	-	-
rest w/ fed. gov't-FEMA	1	.8	1	1	2	3	-	-	-	-	1	10
rest w/ fed. gov't-USFW	3	3	3	4	4	6	-	-	3	23	1	10
rest w/ fed. gov't-COE	2	2	1	1	1	1	1	5	2	10	-	-
rest w/ fed. gov't-NRCS	1	.8	4	5	5	7	1	5	1	8	-	-
rest w/ town gov't	1	.8	4	5	8	12	-	-	-	-	2	20
rest w/ county gov't	-	-	3	4	8	12	-	-	-	-	2	20
Blank (% of total)	8	7	40	33	56	46	-	-	8	38	11	52

In **Table 13**, 43-percent of full-time riparian landowners indicated that they should be included with local government in the decision-making process of how streams should be managed. 35-percent of full-time landowner's second choice and 21-percent of their third choice was that decisions about how streams are managed should be made by the County Soil and Water Conservation District.

On the other hand, 29-percent of residents' indicated in their first choice that stream management decisions should rest solely with the landowner. However, 38-percent of second choice responses illustrate that decisions be shared between landowners and local government. **Table 13** also shows that the number of responses to the question decreased exponentially with each level of ranking after the first choice.

The results were categorized further to show how different types of landowners with different lengths of residency felt about stream management decision-making. The results are shown in **Table 14** on the next page.

TABLE 14. LANDOWNER OPINION OF DECISION-MAKING BASED ON LENGTH OF RESIDENCY & LANDOWNER TYPE*

"Decisions should…" Based on Landowner Type & Years of Residence

	Expressed as a %										
Type & Length of Residency	**rest w/ landowners**	**be shared b/t landowners and local gov't**	**rest w/ SWCD's**	**rest w/ town gov't**	**rest w/ county gov't**	**rest w/ state gov't**	**rest w/ fed. Gov't**	**don't know**	**other**	**blank**	**Total Responses**
Agriculture (21):											
0-5 yrs			100								1
11-20 yrs		100									2
Over 20 yrs	35	24	24	6					6	6	17
No response		100									1
Business (9):											
11-20 yrs		100									2
Over 20 yrs	14	57					14			14	7
Gov't (4):											
Over 20 yrs			25			25		25		25	4
Part-Time Res. (21):											
0-5 yrs	50						50				2
11-20 yrs	13	38	13			25		13			8
Over 20 yrs	40	20	30				10				10
Year-Round Res. (84):											
0-5 yrs		100									2
6-10 yrs	100										2
11-20 yrs	15	46	8			23				8	13
Over 20 yrs	16	43	13	2		2	14	8		3	63
No response		50						25		25	4
Vacant (5):											
11-20 yrs	100										1
Over 20 yrs	25		25			50					4

*only the respondents' first choices were considered

Table 14 further illustrates that the majority of riparian landowners with 11 or more years of residency in the West Branch watershed feel that decisions about streams should be shared between landowners and local government. The exception is the response from the agricultural community and some part-time residents who felt that stream management decisions should rest solely with the landowner. Due to the small number of responses in some categories, the percentages are somewhat suspect.

The next question in the survey asked landowners what they would like changed about the West Branch or tributary. A list of the responses may be found in **Attachment F**.

The remaining question posed to landowners dealt with who they believe should have primary financial responsibility of stream management on private property. The results are summarized in **Table 15**.

TABLE 15. SUMMARY OF LANDOWNER OPINIONS ABOUT FINANCIAL RESPONSIBILITY OF STREAM MANAGEMENT

Primary Financial Responsibility should…	Q	%
be shared b/t landowners and local gov't	24	19
don't know	11	9
rest w/ SWCD's	27	22
rest w/ state gov't	11	9
rest w/ landowners	9	7
rest w/ fed. gov't*	22	18
rest w/ town gov't	2	2
rest w/ county gov't	10	8
no response	17	12
other	7	6

* 6 FEMA, 5 COE, 5 NRCS, 3 USF&W

The results of **Table 15** show that there are significant differences between the results found in **Table 13**. Although the majority of respondents felt that decisions about how streams are managed should be shared between local government and landowners, they felt that the financial burden should rest with the Soil and Water Conservation District. However, a large portion of respondents did feel that the financial responsibility be shared. The distinct difference between the results is that while a relatively large number stated that decisions should be made by landowners, only a small fraction felt that they should bear the financial responsibility alone. Many felt that the Federal government should be involved in the financing of stream management activities.

CONCLUSION

In general, the response to the Area 2 survey was better than that of Area 1 by almost 2.5 – percent. Furthermore, the changes that were made to the Area 1 survey helped to simplify the responses thereby making them easier to analyze. For example, it was especially helpful to the Stream Corridor Management Program (SCMP) Team to know whether a response came from a riparian landowner along a tributary versus one along the West Branch main stem. If a landowner describes an erosion problem, it helps to know that the tributary where the erosion occurs is a source of sediment to the main stem and a potential area for restoration.

It is important to note that each question had a certain portion that did not answer and left the response section blank. These were omitted from the total number of responses to maintain accurate calculations.

The open-ended questions where respondents were free to write in their opinions, suggestions, or concerns were also very beneficial to the SCMP Team. Due to the responses, the SCMP Team can gain specific information for potential areas to target for restoration projects as well as how to better focus landowner education programs. Furthermore, the open-ended questions can also show a high frequency of similar responses thus indicating a trend in the data.

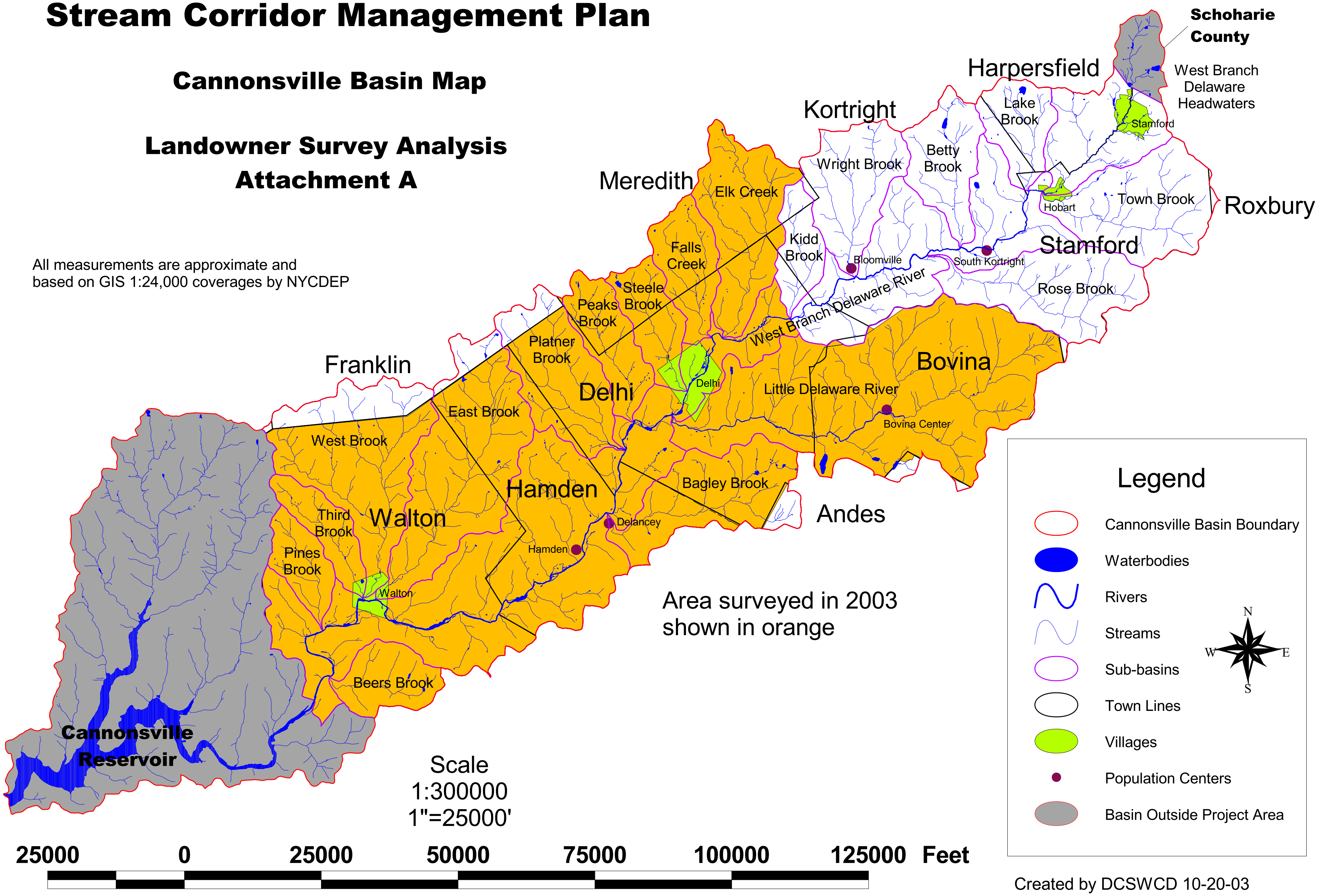
The only portion of the Area 2 survey where the changes made may have complicated the responses was in Questions 12 and 14. Requesting the respondents to rank their choices appeared either too confusing or too involved for many. This was made evident in the low numbers of responses to the second and third selections. However, it was definitely more helpful to know which response the landowners felt was the most important. Therefore, it is recommended that no changes be made to the current format of this survey.

West Branch of the Delaware River
Stream Corridor Management Plan

Cannonsville Basin Map

Landowner Survey Analysis
Attachment A

All measurements are approximate and
based on GIS 1:24,000 coverages by NYCDEP



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West Branch – Delaware River Stream Management Program

Landowner Survey Form

April 2003

Please take a few minutes to complete the following survey questions. This survey is designed to give the Stream Corridor Management Program Team at the Delaware County SWCD a general idea of the importance of the West Branch of the Delaware River to the landowners, and what values you place on stream. Please include additional information on a separate sheet of paper and return with this form. Thank you for your assistance with this project.

I live in the West Branch river valley:

- ❑ Year-round
- ❑ Part-time (seasonal, weekend, or other)

I've lived here ❑ 0-5 ❑ 6-10 ❑ 11-20 ❑ 20+ **years**

If you live on a tributary, please indicate which one.

____

My property is *(check one)*:

❑ Agricultural ❑ Residential ❑ Non-Profit
❑ Business ❑ Agency/Government

I enjoy West Branch or tributary on my property for *(check all that apply)*:

- ❑ Agricultural livelihood
- ❑ Hiking along the river
- ❑ Camping along the river
- ❑ The view
- ❑ Watching the wildlife, birds
- ❑ Hunting along the river
- ❑ Fishing
- ❑ Swimming
- ❑ Canoeing/Kayaking
- ❑ Other (please explain)

____

____

Conditions on the West Branch or tributary in my area are generally:

- ❑ Excellent, needs no change in management
- ❑ Good, but could use some improved management
- ❑ Fair, needs much more management
- ❑ Poor, needs urgent management

My main concerns about the river or tributary include *(rank your top three selections by placing a 1,2 or 3 next to your choice)*:

- ❑ Trespassing
- ❑ Washout of roads and bridges
- ❑ Impaired fishing
- ❑ Groundwater connection to my well
- ❑ Pollution from upstream runoff, dumping
- ❑ Bank erosion
- ❑ Obtaining permits for stream work
- ❑ Time and money required for proper stream care
- ❑ Government regulation of private property rights
- ❑ Flooding of property
- ❑ How it affects my livelihood
- ❑ Other concerns about the stream (please explain)

____

____

____

____

While I've lived here, flooding along West Branch or tributary:

- ❑ Has been a frequent problem
- ❑ Has been a relatively minor problem
- ❑ Has never been a problem
- ❑ Has worsened
- ❑ Has improved
- ❑ Other (please explain)

____

____

____

I personally have been affected by flooding:

❑ Never ❑ Once ❑ A number of times ❑ Extensively

(check all that apply)

- ❑ Water damage to my house
- ❑ Washout of road access or private bridge
- ❑ Washout of bridge access (public bridge)
- ❑ Erosion of river banks
- ❑ Loss of cropland

Describe Damages: ____________________________

____

____

The best way to solve flooding problems is to:

Please explain:

____

____

____

____

____

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____

____

____

Fishing on the West Branch or tributary has generally:

- ❑ Improved in recent years. The reason is:

____
____
____

- ❑ Deteriorated in recent years. The reason is:

____
____
____

- ❑ Remained consistent

Decisions about how streams are managed on private property should *(rank the top three selections by placing a 1,2 or 3 next to your choice)*:

- ❑ Rest with the State government
- ❑ Rest with the Federal government
  (if selected, choose one of the federal agencies below)
  - ❑ FEMA
  - ❑ Army Corps of Engineers
  - ❑ Natural Resources Conservation Service
  - ❑ U.S. Fish and Wildlife
- ❑ Be shared between landowners and local government
- ❑ Rest with the County Soil and Water Districts
- ❑ Rest with the County government
- ❑ Rest with landowners
- ❑ Rest with the Town government
- ❑ Don't know
- ❑ Other (please explain)

____
____
____

I would be willing to participate on the West Branch Project Advisory Committee for the development of the management plan. ❑ Yes ❑ No

What would you like changed about the West Branch or tributary?

____
____
____
____
____
____

The primary financial responsibility for management of streams on private property should *(rank the top three selections by placing a 1,2 or 3 next to your choice)*:

- ❑ Rest with the County government
- ❑ Don't know
- ❑ Rest with the County Soil and Water Districts
- ❑ Be shared between landowners and local government
- ❑ Rest with the Federal government
  (if selected, choose one of the federal agencies below)
  - ❑ FEMA
  - ❑ Army Corps of Engineers
  - ❑ Natural Resources Conservation Service
  - ❑ U.S. Fish and Wildlife
- ❑ Rest with landowners
- ❑ Rest with the Town Highway department
- ❑ Rest with the State government
- ❑ Other (please explain)

____
____
____

Optional Information

Name ______________________________________
Address ____________________________________
____
Phone ______________________________________
E-Mail _____________________________________

Thank You for Your Assistance

____
____
____
Return address optional

STAMP

Delaware County Soil & Water Conservation District
44 West Street, Suite 1
Walton, NY 13856

Please fold & seal with tape or staple

ATTACHMENT C:

LANDOWNER RESPONSES TO FLOODING PROBLEMS

AGRICULTURE:

1. The stream work after the '96 flood worsened bank erosion and now large trees are undermined and falling.
2. A serious concern for us, requiring care to keep soil covered in winter and spring.
3. Brings and leaves a lot of flood trash.
4. That's nature.

BUSINESS:

1. By "prevent" I mean once every five to ten years.
2. Its part of nature.

GOVERNMENT:

1. Has happened once.
2. Has been a periodic problem.

SEASONAL RESIDENTS:

1. Don't know.
2. Three times in 10 years.
3. Has improved after the flood of '96
4. I have heard of one time, a few years ago when it was a major flood problem- I myself have not seen a problem.
5. In Jan 1996- we had to totally rebuild, lose major bank, all due to poor management of tributary across the river.
6. Beaver have added to loss of fields to expanded wetlands.

FULL-TIME RESIDENTS:

1. Constant erosion.
2. Has been a problem on the southeast side.
3. Flooding has been eliminated but high water keep eating my rear yard away due too erosion.
4. Have had three serious floods. 1935, the '40 and 1973. Ice jam also.
5. My home has improved thanks to retaining walls.
6. Has happened – West Branch not Third Brook.
7. Major problem during and after flood of '96. Severe undercutting of large steep bank needs major corrective project – beyond my means.
8. The flood of 1996 eroded 10 feet of bank which has never been reclaimed.

VACANT PARCEL LANDOWNERS:

1. Haven't observed.

ATTACHMENT D:

<u>FLOOD DAMAGE DESCRIPTIONS</u>

<u>AGRICULTURE:</u>

1. We lost all the high tensile fencing in '96.
2. Stream bank damage for 11/2 of frontage, erosion of topsoil from flooding.
3. Water runs thru our tree/shrub planting when water is high.
4. Delaware St office bldg. 1/19/96
5. Flood washed my topsoil into binnacle. It needs to be dredged and put back on field- isolated 4 acres of land I can no longer use.
6. We get sheet erosion on unprotected soil and gullies in swift areas.
7. Erosion eats away at pastures and cropland. Develops gravel bars that we cannot legally remove.
8. Flooding of fields, deep gullies formed.
9. Gravel bars forming, diverting water into banks.
10. Minor erosion of banks.
11. Water in basement.
12. Flooded our septic system.

<u>BUSINESS:</u>

1. Bridge replacement; stream bank erosion. I.e. muddy water.
2. Lower stream bottom in areas where needed to control large increases in water flow.
3. Live with it.
4. Let responsible landowners take care of problems-than when help is needed it is given freely!
5. Ground damage.
6. Our buildings have experienced flooding several times in the past 100 years.

<u>GOVERNMENT:</u>

1. Water damage to the school. Jan '96.
2. Do not build in floodplain.
3. Water damage to homes, disruption of municipal service, cost associated with cleanup and repair.

<u>SEASONAL RESIDENTS:</u>

1. Water seepage in my basement from hill behind the house…not from East Brook water.
2. Every high water, I lose property. If I lose two willows, my house is a goner!
3. In 1996 we had to totally rebuild, lose major bank, all due to poor management of tributary across the river.

4. Beavers have added to loss and fields to expanded wetland.

FULL-TIME RESIDENTS:

1. Minor in flood of '96.
2. $10,000 worth of damage in the '96 flood.
3. Lost approximately 1.5 ft this year.
4. Minor washout of banks.
5. Loss of bank at rear of home.
6. House foundation, 3x major driveway damage, erosion at any point not protected by a grass root system.
7. Unable to get across East Brook to home or Park St or sometimes from home to other areas.
8. Bank erosion, but in 1973, I lost two Holstein calves, their shelter, apple trees, dog house and my home was evacuated at 2:30 am. The Brook was re-routed to the front yard.
9. Water heater-furnace, small amount of erosion on foundation.
10. Lost a building and damaged yard.
11. Flooding of my business in Village of Walton.
12. Lost 10-12 large maple trees and over 4,000 square feet of land (40' x 100')
13. Flooding in house of 3-5 feet.
14. Lawn washed away, bridge washed out, house undermined. My home has improved thanks to retaining wall.
15. Lost firewood.
16. Loss of personal possessions.
17. Furnace damage in basement, severe erosion (4'deep gullies, exposed gas line washed out driveway.)
18. Debris left behind on my river flat.
19. Peake's Brook in yard; Water in cellar. (minor continuous erosion each year; minor water in cellar)
20. Water in cellar 1996
21. 2 feet of water in house, foundation damaged. Loss of personal property.
22. About 100 feet of gravel road eroded by floodwaters. 90% of damage repaired by simply collecting lost gravel from adjacent field and filling in the holes.
23. While some landowners were able to reclaim their land, I don't feel they were consistent with people who live outside the village.
24. Water damage to the foundation of my garage. Flooding of my basement.
25. I have lost over $10,000 in property.

ATTACHMENT E:

LANDOWNER OPINIONS
OF POTENTIAL FLOODING SOLUTIONS

AGRICULTURE:

1. Strike a balance between natural wetlands on floodplain and some intervention to mitigate yearly flood damage.
2. Changes of cropping practices for soil erosion, continued effort with various gov't departments and Agriculture-related groups to solve the flooding effects to the farm.
3. Let us clean where needed in the creek. One or two places.
4. Excavate the riverbed.
5. Dredge the whole river. Open up a clear channel and remove gravel bars that direct current towards my field instead of down the river channel.
6. Do not use iron tubes for roads…use span bridges. Use riprap to prevent stream bank erosion. The stream thru our property is in pretty good shape with good fishing and limited erosion due to work done by my grandfather 50 or more years ago.
7. I think flooding is a natural function of the river given the narrowness of the valley and the size of seasonal melt. Therefore, protection of flood plain soils is our aim. Flood "control" approaches usually change rivers and would, in my opinion, be detrimental to the W. Branch.
8. Can't really stop flooding-but stable stream banks would prevent damage.
9. Deeper stream channel.
10. Consult and hire qualified personnel.
11. Do not know the answer to that.
12. Flooding is a natural process-the banks should be protected from erosion. CREP program is excellent.
13. Being able to clean streambeds occasionally.
14. Clean out gravel bars, slope banks.
15. Clean out brook in certain spots and build up bank where needed.
16. Lower the streambed.
17. No possible way. Fitch's bridge acts as a dam.
18. Rip rap/ clear channels where practical.

BUSINESS:

1. I don't know.
2. Dredge sandbars, build up riverbanks, removal of tree trunks that have fallen into river and floated down stream causing a dam effect.
3. Issue stream disturbance permits to remove gravel bars or deposits and replace riprap on eroding slopes.
4. Keep the transition smooth and flowing-erosion pile up.

5. Eliminate construction along rivers-especially in flood plains-unfortunately, most of the construction was completed years ago and it is not practical, or economically possible to relocate.
6. Clean the gravel bars out of rivers and streams.

GOVERNMENT:

1. Rechannel river and do bank stabilization project.
2. Maintain/improve wetlands and soil cover and limit paved surfaces up stream.

SEASONAL RESIDENTS:

1. Build log retaining walls and backfill with stone at badly eroded river edges. As a child in the 50's by town or county crews (see sketch). Work can be done by prisoners (it will give them badly needed job skills) or by summer gov't crews.
2. Don't know.
3. Contain erosion by changing East Brook flow. 1999 berms have been abandoned, unfinished.
4. Keep streams free of trees, brush and beavers.
5. Repair banks.
6. Let us dig the brook deeper and secure banks with big rocks.
7. Clean out main river.
8. …not build on the floodplain!
9. Keep loose banks covered with plantings or riprap, build berms, and pray for less rain!!!
10. Please help us with the bank and tributary across the river from us. We lost major bank from Jan. 1996.

FULL-TIME RESIDENTS:

1. Build small berms or dikes along the river in flood areas.
2. Keep rivers unobstructed by excessive build-up of silt, dirt etc. Also, maintain banks along rivers and streams to prevent erosion.
3. Stop people from building in or filling in the floodplain. Removing areas that have been filled in such as the alliance church, Breakey Motors, etc.
4. Don't know if we can be ready for the winter melt floods, such as the one five or six Januaries ago. This winter saw some flooding, which caused little damage.
5. I don't know the score of the problem. Total elimination can't be expected, perhaps just reduced.
6. Identify problem areas and engineer proper hydrologic remedies.
7. Don't strip away soil holding vegetation. Don't encourage building around waterways known to flood. Expect that it will happen and stop complaining. Be thankful we have water.
8. a) As pointed out by the NYSDEC Region 4 Richard Pop, one tree in the wrong place can cause water to change course.

b) Dikes/berms are expensive ways to keep a river in check. I did an estimate on a 4" high x 32' x 1500' dike down on my property years ago and I think I came up with a figure of about 75000 complete with a clay core/keyway.

9. Clean out brooks from silt over the years. Widen certain areas water runs under the rocks.
10. There has been a lot of development on the municipalities along the river and on Main St in Delhi that has affected the water on the East Side of the Village of Delhi.
11. After '73 flood, Delaware Co. Soil and Water helped by re-directing the brook out where it used to run, but erosion of bank has been a problem since. At one point, we let Soil and Water District store riprap on our lot so they could fix erosion problems but they used it south of us and never fixed our problem.
12. Clean out riverbanks and culverts.
13. Clean out fallen trees and clean up riverbanks.
14. Plan-respect property rights, keep the GD trees! Make sure you are planning for people, not some politician's resume.
15. Keep brook cleaned out.
16. Reinforce the stream bank.
17. Remove gravel and debris in West Branch within Village limits.
18. I believe a reverse weir in the river would work best.
19. Channel wide shallow areas, narrow the stream banks, and install barriers to prevent bank erosion. Plant trees-but not like the city program. When this many trees mature, they suck too much water.
20. Plant trees along the river.
21. Improve riverbanks.
22. Clean channel when and where sand bars form causing a change in present waterway and perform bank repairs when necessary. Bank repair decreases erosion and flooding-decreases need for channel dredging.
23. Plant basket willows to prevent erosion. Place pool diggers in stream to slow water. Simple ones log and cable. Do not restrict the floodplain by filling that narrows it, causing damage.
24. Clean out gravel bars at end of Steel Brook.
25. Raise banks to protect residential area and to protect Agricultural areas.
26. Dredging at river basin between Bridge St and US28 in Delhi.
27. Address storm water and flashy nature of streams from direct piping of runoff to streams. Avoid building structures (including roads near streams.
28. Removal of silt and gravel that has washed in over the years.
29. Maintain riverbank stability and allow clear river to flow.
30. Getting into stream and removing gravel bars.
31. Stop building along rivers and floodplains.
32. Maintain proper river management.
33. Properly manage stream channels. A lot lots of $$ for stabilization projects. Co-coordinated efforts of gob's, landowners and other agencies (DEP,DEC,COE)
34. Dredge river at regular intervals, it will not hurt anything. But will help with build up in streams.
35. Clean debris from river.

36. Needs extensive work on banks and better drainage from road runoff. Presently very poorly controlled.
37. Not build in flood prone areas.
38. Loss of land and peril to buildings
39. To clean out creeks of washed stones in pile and tree debris.
40. Wooded buffer zones along streams.
41. Monitor debris and ice dams from the head of the river to Cannonsville bridge in streams and rivers. Volunteer (landowners) would be least costly than or will help reduce the cost of patrolling.
42. Reforest tributaries will also solve pollution problems eg. Silt run-off and cattle waste.
43. I don't know.
44. Selectively remove slip off slope runoff from main channel and straighten river. Clearance of channel. Build levees in village areas where flooding prevails.
45. In my opinion, the riverbeds should be cleaned out occasionally at intersections of larger brooks that feed into the river, especially in the Village of Walton. There are large deposits of dirt, rocks, etc at these intersections. Huge deposits at the area of the bridge in Walton, which crosses. Several years ago NYSDOT cleaned this area out yearly or semi-yearly however, nothing has been done in I would say the past 15-20 years. At some point, I believe we have to realize that humans are more important than fish. Fish will survive-they have in the past.

VACANT PARCEL LANDOWNERS:

1. Let private maintain their own streams.
2. Allow concerned professionals plan.

ATTACHMENT F:

WHAT WOULD YOU LIKE CHANGED ABOUT THE WEST BRANCH?

AGRICULTURE:

1. Less government.
2. Drain the reservoir and return the land to farming
3. Improvements to stream banks.
4. I am glad this survey is being done. I think the need for changes (or not) will come out in this process.
5. More emphasis on stream bank stabilization and improving fish and wildlife habitat.
6. Nothing.
7. Stop erosion where soil is washed away. Clear of fallen trees. Remove gravel bars. Cleanup trash.
8. Remove gravel bars.
9. OK
10. Would like some solution to downed trees. Most landowners don't wish to spend money to snag the trees-they cause problem for other owners and damage to canoeists.
11. More attention paid to flood damage.

BUSINESS:

1. More active SCS in stream management and funding of stream repair projects. Take some of the burden off landowner.
2. To take NYC out of the management picture.
3. Ability to maintain with responsibility to environment and river condition.
4. Keep sluices clear. Keep bridges clear.

GOVERNMENT:

1. Bank stabilization.

SEASONAL RESIDENTS:

1. More stocking of fish including trout and salmon to improve fishing.
2. Don't know
3. Bank erosion control. Finish work from last two floods.
4. Better, flood control.
5. More access for fishing and to stock bigger fish.
6. Nothing much that I can see.
7. Paths and trails that allow people from all over to enjoy our natural resource. Perhaps these paths and parks could serve the dual purpose of bank stabilization and recreation.

8. To be clean up, remove all debris, dump along it over many years. Help increase fishing, hunting and more beautification.
9. Banks need to be restored-deep pools for trout or swimming no longer exists. Banks becoming overgrown limiting creek access.

<u>FULL-TIME RESIDENTS:</u>

1. More fish stocking.
2. Reduce seasonal flooding.
3. More stocking of side streams
4. Stop bank erosion in Walton area
5. Better beaver management. Fallen trees into the river are a problem.
6. Reduce the problem if possible.
7. There should be fishing and hiking access along the riverbanks over private property.
8. Not a thing.
9. All watercourses need management. Trout unlimited if they had their way would never touch a stream. I feel that if a tree or rock needs to be removed along a watercourse because it is in the best interest of the "public" then, with proper planning, it should be done.
10. Banks and pools to be maintained
11. Perhaps walls built along banks of brooks where erosion is a problem.
12. Repair washed out areas from flooding
13. Nothing.
14. Clean out of gravel bars.
15. Repair gabions along East Brook before serious erosion or highway damage occurs.
16. Nothing
17. Needs to be cleaned, but it seems the fish have more rights than landowners.
18. My bank is severely eroding and I would like to have the Conservation District Management take measures to stabilize my bank. Large amounts of soil are falling into the river each year and the bank is moving towards my house.
19. Clean out gravel lays and narrow up the channels, repair banks, and install hole diggers to create trout habitat.
20. More trees
21. Continued effort to keep it clean.
22. More stream bank repair.
23. Kill all carp in stream and put a falls in river to prevent up stream return. Restock with native fish.
24. The gravel bank removed from end of Steele Brook
25. Stop flooding of my property.
26. Address stream bank erosion and storm water issues.
27. More easily accessible from which to launch canoes, etc.
28. Bank restoration with plan to help minimize erosion.
29. Have all trash, stoves, tires, and irrigators, cleaned up.Want to see a dike put in to stop the erosion. I am 81 years old and will do anything to save my property.

30. Better flood control and maintenance.
31. Less NY City regulation.
32. Have streams cleaned out because when there are heavy rains it floods on fields and pasture lands.
33. Riparian owners need to understand the issues of water conservation.
34. Clean out the old Walton Village reservoir on Third Brook filled with sediment. Then open to public for picnic area and fishing.
35. Fertilizer, field and barn wastewater should be collected in ponds and purified of silt and chemicals similar to industrial waste.
36. The county is a big contributor to pollution of the river. The parking lot id ugly and a source of pollution. A park next to the river could improve these conditions.
37. Selectively remove slip off slope runoff from main channel and straighten river. Clearance of channel. Build levees in village areas where flooding prevails.
38. Cleaning of the riverbed.

<u>VACANT PARCEL LANDOWNERS:</u>

1. Need maintenance of erosion control. So far nothing has been done. Still pay same taxes on untaxable land.
2. Stop the water from flooding the meadow.
3. Let landowners do own maintaining.
4. Absolutely certain not polluted. Water levels such to allow canoeing.

The following tables are a compilation of the results of both landowner surveys.

TABLE 1. RESPONSE TO WEST BRANCH LANDOWNER SURVEY.

Land Type	Color	Number of Surveys Distributed	Number of Surveys Received	Number Returned As Non Deliverable	% of Total Received by Land Type	% of Total Received
		Landowner Survey				
Agricultural	Green	156	41	2	26	18
Business	Blue	77	14	5	18	6
Gov't/Public Service	White	39	7	0	18	3
Permanent Residence	Yellow	488	114	20	23	50
Seasonal Residence	Pink	157	45	23	29	20
Vacant Land/Forested	Purple	185	9	15	5	4
Total mailed		1102				
Total Received			230			
Total Returned				65		
Percent surveys received (of total mailed)		21				
Percent surveys returned		6				
Percent surveys received (adjusted for returns)		22				

Table 1. Constructed by adding numbers in area 1 table 1 and area 2 table 1 Landowner survey report.

TABLE 2. PERCENATGE OF TOTAL RESPONDENTS LIVING ON A WEST BRANCH TRIBUTARY.

Tributary	Q	% of Total
Bagley Brook	3	2.1
Brush Brook	1	0.7
East Brook	12	8.3
Elk Creek	3	2.1
Freer Hollow	1	0.7
Honest Brook	2	1.4
Little Delaware River	13	9.0
Oxbow Brook	1	0.7
Peake's Brook	2	1.4
Pines Brook	1	0.7
Platner Brook	5	3.5
Steele Brook	7	4.9
Third Brook	3	2.1
West Brook	7	4.9
TOTALS	61	42.7

Table 2. Taken directly from Area 2 Table 2.

TABLE 3. LENGTH & TYPE OF RESIDENCY

Residency			
	Q	% year-round	% Of total surveyed
Year-round:	153		67
0-5 yrs	4	3	
6-10 yrs	4	3	
11-20 yrs	28	18	
Over 20 yrs	121	79	
		% part-time	
Part-time:	47		20
0-5 yrs	5	11	
6-10 yrs	3	6	
11-20 yrs	14	30	
Over 20 yrs	22	47	
Other	4		2
No response	1		<1
* 14 landowners did not respond to # years lived here.			

Table 3. Numbers for this table came from Area 1 table 2 and Area 2 table 3. The percent of total surveyed is out of 230.

TABLE 4. FREQUENCY & PERCENTAGE OF RESPONSES TO QUESTION 4 BY LANDOWNER TYPE.

"I enjoy the West Branch on my property for…"					
Agriculture (41):	**Q**	**%**	**Business (14):**	**Q**	**%**
-agricultural livelihood	36	88	-agricultural livelihood	1	7
-hiking along river	13	32	-hiking along river	1	7
-camping along river	6	15	-camping along river	2	14
-the view	28	68	-the view	12	86
-wildlife viewing	25	61	-wildlife viewing	8	57
-hunting	16	39	-hunting	2	14
-fishing	21	51	-fishing	5	36
-swimming	7	17	-swimming	2	14
-canoeing/kayaking	7	17	-canoeing/kayaking	1	7
-other (written response)	2	5	-other (written response)	3	21
Government (7):			**Part-Time Resident (45):**		
-agricultural livelihood	0	0	-agricultural livelihood	4	9
-hiking along river	3	43	-hiking along river	22	49
-camping along river	2	29	-camping along river	4	9
-the view	5	71	-the view	38	84
-wildlife viewing	4	57	-wildlife viewing	38	84
-hunting	0	0	-hunting	11	24
-fishing	3	43	-fishing	25	56
-swimming	3	43	-swimming	12	27
-canoeing/kayaking	3	43	-canoeing/kayaking	10	22
-other (written response)	0	0	-other (written response)	3	7
Residential (114):			**Vacant (9):**		
-agricultural livelihood	11	10	-agricultural livelihood	2	22
-hiking along river	37	32	-hiking along river	4	44
-camping along river	12	11	-camping along river	2	22
-the view	85	75	-the view	5	56
-wildlife viewing	97	85	-wildlife viewing	8	89
-hunting	27	24	-hunting	4	44
-fishing	63	55	-fishing	5	56
-swimming	34	30	-swimming	5	56
-canoeing/kayaking	24	21	-canoeing/kayaking	3	33
-other (written response)	10	9	-other (written response)	0	0

*7 people from this group did not respond.

Table 4. Data is from Area 1 table 3 and Area 2 table 4. All percentages are land use per landowner type. Landowner type totals are in parentheses next to landowner type headings.

TABLE 5. FREQUENCY & PERCENTAGE OF LANDOWNER RESPONSES TO QUESTION 5: “CONDITIONS ON THE WEST BRANCH ARE…”

"Conditions on the West Branch" by landowner type & years lived here

			Expressed as a %			
Agriculture (41):	**Q**	**%**	**0-5 yrs**	**6-10 yrs**	**11-20 yrs**	**Over 20 yrs**
-excellent	7	17				100
-good	18	44	6		22	72
-fair	10	24			10	80
-poor	6	15			17	83
No response	1	2				
Business (14):			**0-5 yrs**	**6-10 yrs**	**11-20 yrs**	**Over 20 yrs**
-excellent	2	14				100
-good	9	64			22	67
-fair	2	14				100
-poor	1	7			100	
Government (7):			**0-5 yrs**	**6-10 yrs**	**11-20 yrs**	**Over 20 yrs**
-excellent	1	14				100
-good	2	29				100
-fair	1	14				100
-poor	3	43				100
Part-Time Residents (45):			**0-5 yrs**	**6-10 yrs**	**11-20 yrs**	**Over 20 yrs**
-excellent	13	29	8	8	54	31
-good	22	49	9	9	18	41
-fair	6	13			50	50
-poor	2	4				100
* 1 “don’t know” response	1	2				
Year-Round Residents (114):			**0-5 yrs**	**6-10 yrs**	**11-20 yrs**	**Over 20 yrs**
-excellent	25	22	4	8	20	68
-good	54	47	2	2	20	67
-fair	10	9			20	70
-poor	17	15		6	6	82
No response	9	8				
Vacant (9):			**0-5 yrs**	**6-10 yrs**	**11-20 yrs**	**Over 20 yrs**
-excellent	1	11				100
-good	2	22				
-fair	1	11				
-poor	3	33			33	66
No response	2	22				

Table 5. Data for this table was taken from Area 1 table 4 and Area 2 table 5. Qs from the two tables were added. The percent column was gotten by dividing land owner response by the total landowners in that specific group. All other percentages represent the number surveyed in each landowner group, who think the river is in a certain condition and have lived in the area a specified number of years.

TABLE 6. LANDOWNER'S MAIN CONCERNS

ABOUT THE RIVER OR TRIBUTARY.

Total Q = 688	Q	% of Total surveyed
Bank erosion	143	62
Don't know	1	<1
Flooding of property	81	35
Gov't regulation of private property rights	81	35
Groundwater connection to my well	13	6
How it affects my livelihood	22	10
Impaired fishing	35	15
No response	57	25
Obtaining permits for stream work	55	24
Pollution from upstream runoff, dumping	60	26
Time and money required for proper stream care	46	20
Trespassing	36	16
Washout of roads and bridges	45	20
Other (written response)	13	6

Other response: *It is a main route for 4-wheelers and snowmobilers and they wear the grass down to nothing which sends silt down slope.

** Debris and beaver dams.

Table 6. Numbers are from Area 1 table 5 and Area2 table 6. Percents are landowner concern divided by total numbered surveyed (230).

TABLE 7. MAIN CONCERNS ABOUT THE RIVER BY LANDOWNER TYPE.

Main Concerns About The River	**Agriculture (41):**		**Business (14):**		**Gov't (7):**		**Part-Time Res.(45):**		**Year-Round Res.(114):**		**Vacant (9)**	
	Q	%	Q	%	Q	%	Q	%	Q	%	Q	%
Bank erosion	28	68	4	29	3	43	20	44	42	37	5	56
Don't know							1	2				
Flooding of property	13	32	5	36	1	14	12	27	20	17	1	11
Gov't regulation of private property rights	13	32	4	29	1	14	9	20	25	22	1	11
Groundwater connection to my well							4	9	5	4		
Impaired fishing	1	2	1	7			9	20	9	8	1	11
No response									5	4		
Obtaining permits for stream work	10	24	5	36	2	29	4	9	11	10	1	11
Pollution from upstream runoff, dumping	6	15			1	14	12	27	10	9	1	11
Time and money required for proper stream care	14	34	1	7	1	14	2	4	8	7		
Trespassing	4	10	2	14			4	9	6	5	1	11
Washout of roads and bridges	2	5			3	43	3	7	11	10	1	11
How it affects my livelihood	7	17	2	14					5	4		
Other (written response)	2	5	1	7			2	4	3	3	3	33

Table 7. Numbers from Area 1 table 6 and Area 2 table 7. The Q's were added together with respect to landowner type and concern. Percents are type of concern divided by total landowner type. Each total landowner type is given in parentheses after the landowner type.

TABLE 8. SUMMARY OF RESPONSES TO FLOODING PROBLEM

Flooding Problem		
Response	**Q**	**% of total**
-relatively minor problem	101	44
-frequent problem	62	27
-has never been a problem	30	13
-has worsened	19	8
-no response	2	1
-other (written response)	11	5
-has improved	5	2

Table 8. Q's were gotten from adding Area 1 table 7 and Area 2 table 8. Percents are response divided by total surveyed (230).

TABLE 9. SUMMARY OF RESPONSES TO
“I HAVE BEEN AFFECTED BY FLOODING…”

“Affected by flooding…” Total Responses		
Response	**Q**	**%**
Never	75	33
A number of times	92	40
Blank	17	7
Once	31	13
Extensively	14	6
Other	1	<1

Table 9. Q’s were obtained by adding Area 1 table 8 and Area 2 table 9. Percents are response divided by total surveyed (230).

TABLE 10. RESPONSES TO QUESTION 9 BASED ON LENGTH OF RESIDENCY & LANDOWNER TYPE

Responses to "I have been affected by flooding…"						
	Expressed as a %					
Type & Length of Residency	**Never**	**Once**	**A number of times**	**Extensively**	**Blank**	**Total**
Agriculture:						**41**
0-5 yrs	50		50			2
11-20 yrs	14	29	43	14		7
Over 20 yrs	16	6	45	16	16	31
No response					100	1
Business:						**14**
11-20 yrs	33	33	33			3
Over 20 yrs	30	20	50			10
No Response	100					1
Government:						**7**
Over 20 yrs	14	14	71			7
Part-Time Residents:						**45**
0-5 yrs	80		20			5
6-10 yrs	67	33				3
11-20 yrs	36	29	14		21	14
Over 20 yrs	25	10	60	5		20
No Response	67	33				3
Year-Round Residents:						**114**
0-5 yrs	33	33			33	3
6-10 yrs	50		50			4
11-20 yrs	45	15	35		5	20
Over 20 yrs	38	11	38	7	6	82
No response	40		60			5
Vacant:						**9**
11-20 yrs			100			1
Over 20 yrs	25	25	25	25		4
No response	50		25	25		4

Table 10. Totals were gotten by adding numbers from area 1 table 9 and area 2 table10 based on landowner type and length of residence. The percents indicate the amount of people in a specific landowner type and length of residency to have a certain type of flooding problem.

TABLE 11. TYPES OF DAMAGE BASED ON FLOOD FREQUENCY

Type of Damage per Frequency of Flooding Response								
	Expressed as a %							
Response	**water damage to my house**	**washout of road/private bridge**	**washout of bridge access(public)**	**erosion of river banks**	**loss of cropland**	**no response**	**Total (Q)**	**%**
Never				5		95	40	17
Once	19	46	23	35	4	8	26	11
A number of times	27	26	25	68	19	1	85	37
Extensively	29	36	7	71	57		14	6
Blank (no response)	7	29		71	21	7	14	6

Table 11. Data retrieved from Area 1 table 10 and Area 2 table 11. Percents were calculated by dividing the response by the total surveyed (230).

TABLE 13. SUMMARY OF LANDOWNER OPINIONS ABOUT WHO SHOULD MAKE STREAM MANAGEMENT DECISIONS

	Full-Time Res* (179)		**Part-Time Res (45)**		**Total**	
Decisions should…	**Q**	**%**	**Q**	**%**	**Q**	**%**
be shared b/t landowners and local gov't	99	55	20	44	121	37
rest w/ landowners	52	29	16	36	69	19
don't know	21	12	3	7	24	5
other	5	3	1	2	7	1
rest w/ SWCD's	60	34	8	18	69	29
rest w/ state gov't	18	10	4	9	23	9
rest w/ fed. gov't	30	17	11	24	41	17
rest w/ town gov't	13	7	2	4	15	7
rest w/ county gov't	11	6	2	4	13	6
Blank	11	6	2	4	13	6

Table 13. Total is all responses that were given. The rank of one, two and three from the area 2 survey was disregarded in order to combine with area 1 survey. Total percents are out of the total number of surveys received (230). The other percents were obtained by dividing the number of people, in the full-time residents or the part-time residents group who had a certain opinion, by the total number in that specific group.

TABLE 14. LANDOWNER OPINION OF DECISION-MAKING BASED ON LENGTH OF RESIDENCY & LANDOWNER TYPE*

“Decisions should…” Based on Landowner Type & Years of Residence											
	Expressed as a %										
Type & Length of Residency	**rest w/ landowners**	**be shared b/t landowners and local gov't**	**rest w/ SWCD's**	**rest w/ town gov't**	**rest w/ county gov't**	**rest w/ state gov't**	**rest w/ fed. Gov't**	**don't know**	**other**	**blank**	**Total Responses**
Agriculture (41):											
0-5 yrs			100								1
11-20 yrs		100									6
Over 20 yrs	36	36	12	3				3	6	3	33
No response		100									1
Business (14):											
11-20 yrs	33	67									3
Over 20 yrs	10	50					10			30	10
No Response		100									1
Gov't (7):											
Over 20 yrs		43	14			14		14		14	7
Part-Time Res. (45):											
0-5 yrs	20	40					20			20	5
6-10 yrs	67	33									3
11-20 yrs	14	36	7		7	21		7	7		14
Over 20 yrs	37	32	16				5	5		5	19
No Response	67	33									3
Year-Round Res. (114):											
0-5 yrs	33	67									3
6-10 yrs	50							50			4
11-20 yrs	10	50	10			15		10		5	20
Over 20 yrs	21	38	11	1		1	11	12	1	4	82
No response		40						20		40	5
Vacant (9):											
11-20 yrs	100										1
Over 20 yrs	25		25			50					4
No Response	25	25				25			25		4

*only the respondents’ first choices were considered

Table 14. Data compiled from Area 1 table 13 and Area 2 table 14. Percents were calculated by dividing the number of people with a certain opinion by the total responses in that specific landowner group and length of residency.

TABLE 15. SUMMARY OF LANDOWNER OPINIONS ABOUT FINANCIAL RESPONSIBILITY OF STREAM MANAGEMENT

Primary Financial Responsibility should…	**Q**	**%**
be shared b/t landowners and local gov't	50	22
don't know	27	12
rest w/ SWCD's	42	18
rest w/ state gov't	20	9
rest w/ landowners	15	6
rest w/ fed. gov't*	26	11
rest w/ town gov’t	2	1
rest w/ county gov’t	10	4
no response	24	10
other	10	4

* 7 FEMA, 5 COE, 2 NRCS, 4 USF&W

Table 15. Data for this table was gotten from Area1 table 14 and Area 2 table15. Percents were calculated by dividing by the total number surveyed (230).

Appendix 2
Riparian Buffer Information

Maintaining a Healthy Streambank Using Riparian Forest Buffers

Conservation buffers can be a key to maintaining stream health and protecting water quality. They slow water run-off, trap sediment, and enhance infiltration within the buffer. They also trap fertilizers, pesticides, pathogens, and cut down on blowing soil in areas with strong winds and help to stabilize streambank erosion caused by high water flows. In addition, they protect livestock and wildlife from harsh weather and buildings from wind damage.

What is a Riparian Forest Buffer?

A riparian forest buffer is an area along flowing water which is maintained in a healthy vegetative state.

Trees and shrubs are allowed to grow along the stream to provide shade, nutrient uptake, and sediment and erosion control.

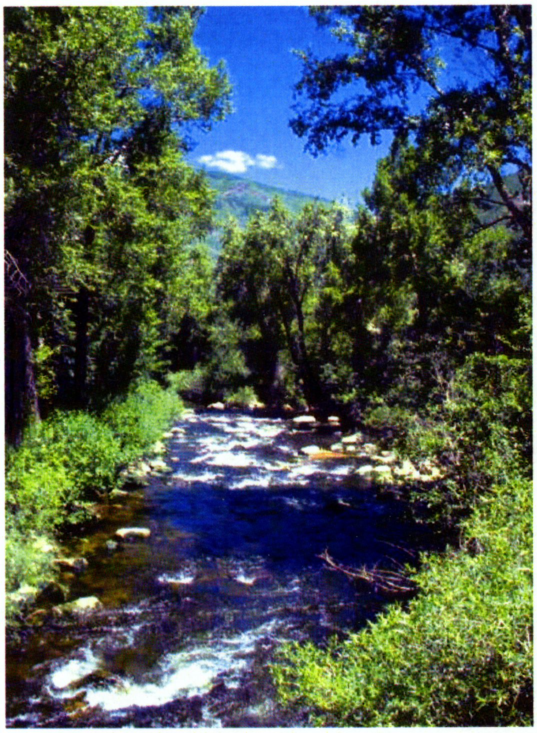
For urban backyards, buffers should average 10 feet in width.

For mid-sized streams in larger backyards the buffer average should be 25 feet wide.

Along agricultural lands, the buffer should average 35-180 feet.

For very large streams, a 150 foot buffer is ideal.

The buffer should not be a mowed lawn and trash should be removed.



What Healthy Buffers Do?

If properly installed and maintained, buffers have the capacity to:

- Stabilize streambanks and reduce erosion.
- Provide wildlife habitat.
- Provide shade to keep stream water at cooler temperatures for healthy plants and animals and less algae growth.
- Remove up to 75% or more of sediment.
- Remove up to 50% or more of nutrients and pesticides.
- Remove up to 60% or more of certain pathogens from rainwater runoff.

The more miles of streams and tributaries that are protected by buffers, the greater the overall benefit to water quality and stream health.Conservation buffers are also a visual showcase of the conservation ethics of a landowner. This fact sheet will help you evaluate and maintain a healthy buffer along your stream. For more information, contact the Delaware County Soil & Water Conservation District at 865-7161, or your local soil & water conservation district.

"Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our waters is the principal measure of how we live on the land."
Luna Leopold

References

Nurseries that stock Native Plants:

- Annie Miller
  Salem, NY
  (518) 692-7839
  (woody species only)
- The Flower Co.
  Altamont, NY
  (518) 869-8000
- Saratoga State Tree Nursery
  Saratoga Springs, NY
  (518) 581-1439
- Northern Nurseries
  Wholesale
  Schenectady, NY
  (518) 382-1600

Soil and Water Conservation Districts (SWCD):

- You can also purchase native trees from your local SWCD
- Delaware County SWCD
  Walton, NY
  (607) 865-7161
- Greene County SWCD
  Cairo, NY
  (518) 622-3620
- Sullivan County SWCD
  Liberty, NY
  (845) 292-6552
- Ulster County SWCD
  Highland, NY
  (914) 883-7162

For Further information on Riparian Buffers, Bioengineering, and Natives vs. Exotics, visit:

www.ipcnys.org
www.crjc.org/riparianbuffers.htm
www.chesapeakebay.net/info/forestbuff.cfm
www.nhq.nrcs.usda.gov/CCS/Buffers.html
www.epa.gov/glnpo/greenacres/nativeplants/index.html
www.nynjtc.org/committees/science/native.html
www.hort.cornell.edu/gardening
www.ianr.unl.edu/pubs/soil

For permit information, contact:

- NYS Dept. of Environmental Conservation
  Region 4 SUB – Office
  65561 State Hwy 10
  Stamford, NY 12167-9503
  (607) 652-7741

Riparian Buffers

Why Do I Care?

- Everyone lives downstream from someone else.
- What you do or don't do will affect others, therefore what your neighbor does or does not do, will affect **you**.

Riparian Buffers

Help to:

- Stabilize stream banks
- Reduce erosion, sediment, nutrient and chemical runoff
- Improve or provide aquatic and wildlife habitat
- Provide shade for you and the stream
- Increase aesthetics

What Can I Do?

- One of the easiest and most inexpensive methods is to let nature take care of itself. Allow the grass to grow along the land stream bank. Eventually, shrub and tree seeds will land and grow.
- Please read pesticide and fertilizer directions carefully. Applying the appropriate amount will decrease chemical and nutrient runoff.
- Create a Riparian Buffer

Creating a Riparian Buffer

Step 1: Contact your local Soil and Water Conservation District to find out if there are any stream stabilization or restoration projects ongoing in your area.

Step 2: Spend time outside during a heavy rainstorm and watch how the water flows along your property. A buffer will spread out runoff, rather than allowing it to flow straight into the stream like a channel. If the latter is the case you can:

- Re-grade, use stones or landscape timber to divert runoff into flatter areas where it can be absorbed.
- If your land receives storm water runoff from a road, consult your local highway department or appropriate authority.

Step 3: Talk with your neighbors. (What are they doing or what have they done?) Then assess your stream edge:

- Steepness of bank?
- Frequent water level changes?
- Type of soil? Well drained or saturated?
- Active erosion?
- Existing plant cover? Type?
- Human access desired?

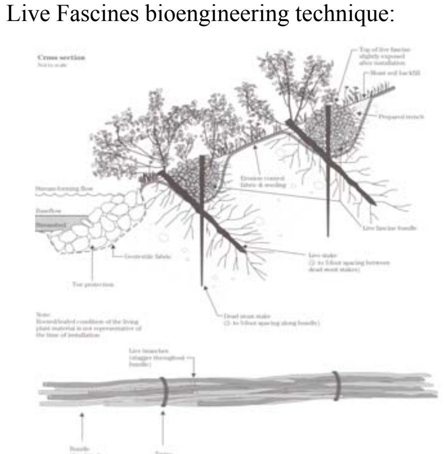
Step 4: Once you have assessed your stream edge, consult your regional Dept. of Environmental Conservation Office about permits and planting advice.

a. If your bank is severely eroding and professional help is not an option, there are two simple bioengineering techniques you can do:

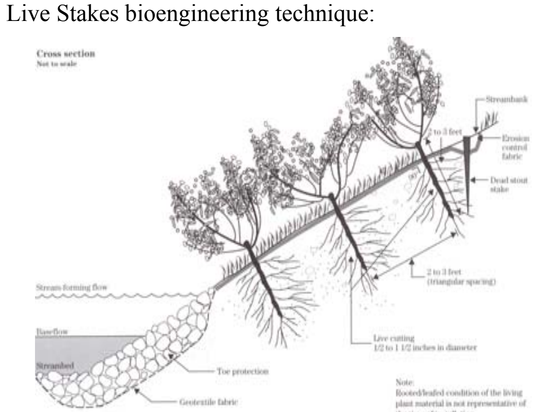
- Live Fascines: An oblong, cylindrical bundle of live cut branches from a species that roots easily from cuttings, typically willows.
- Live Stakes: Live cut branches that root easily. A system of stakes will stabilize and dry out the bank soon after installation.

b. If your bank is not severely eroding, you can plant grass, shrubs, and trees by following steps 5 – 9.

Live Fascines bioengineering technique:



Live Stakes bioengineering technique:



Bioengineering pictures and corresponding descriptions modified from the U.S. Department of Agriculture engineering field handbook

Step 5: Determine Buffer Width

- The width of your buffer depends on your reason (s) for creating a buffer.
- The basic buffer is 50 ft. from the top of the bank. You get more water protection with every foot (see figure below).

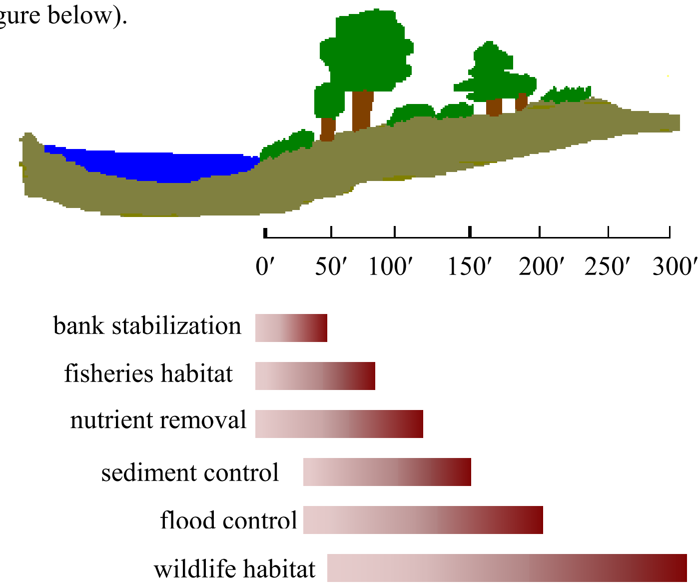


Figure modified from the Connecticut River Joint Commissions, Living with the River series no.1

Step 6: Determine how many plants you will need based on your buffer width. Be sure there are enough to be effective. See the table below for determining plant types.

- You will want to space shrubs 3′ – 5' apart, small trees (25' at maturity) 15' apart, large trees 25' apart, and ground covers 1′ - 3' apart.
- Wider spacing will still provide water quality protection, but allow more stream view.

Effectiveness of Different Vegetation Types for Specific Buffer Benefits

Benefits	grass	shrubs	trees
stabilize streambank	Low	High	High
filter sediment and the nutrients, pesticides, & pathogens bound to it	High	Moderate	High
filter nutrients, pesticides, and microbes from surface water	Moderate	Low	Moderate
protect groundwater and drinking water supplies	Low	Moderate	High
improve aquatic habitat	Low	Moderate	High
improve wildlife habitat for field animals	High	Moderate	Low
improve wildlife habitat for forest animals	Low	Moderate	High
provide economically valued products	Moderate	Moderate	High
provide visual interest	Low	Moderate	High
protect against flooding	Low	Moderate	High

Low Moderate High

Table modified from the Connecticut River Joint Commissions, Living with the River series no.8

Step 7: Plant Selection

- In general, native plants are the best choice for your riparian buffer because they require less care than non-native plants and are compatible with native soils and wildlife.
- Keep in mind that you want to select the most **appropriate** species for your site. The most **appropriate** species are those thriving in the area near your buffer site. Walk up and down stream of your site, taking note of the most common species.
- In general, plant selection is based on soil type (saturated, well drained), slope and buffer width.
- Try to include deciduous plants since their leaf litter traps nitrogen. Too much nitrogen in a stream can cause algal blooms, which reduce the amount of dissolved oxygen available for fish and invertebrates.
- Favor plants that have multiple values, such as erosion control, timber, nesting, fruit.
- You want to avoid invasive species. Those that reproduce quickly, displacing many of the other species in their domain and are difficult to eradicate (often exotic or non-native species).
- Note that nursery catalogues frequently do not use the term invasive or exotic, rather use phrases like "a very vigorous grower." For example, Japanese Knotweed.
- Lastly, confirm all plant sources and check their quality.

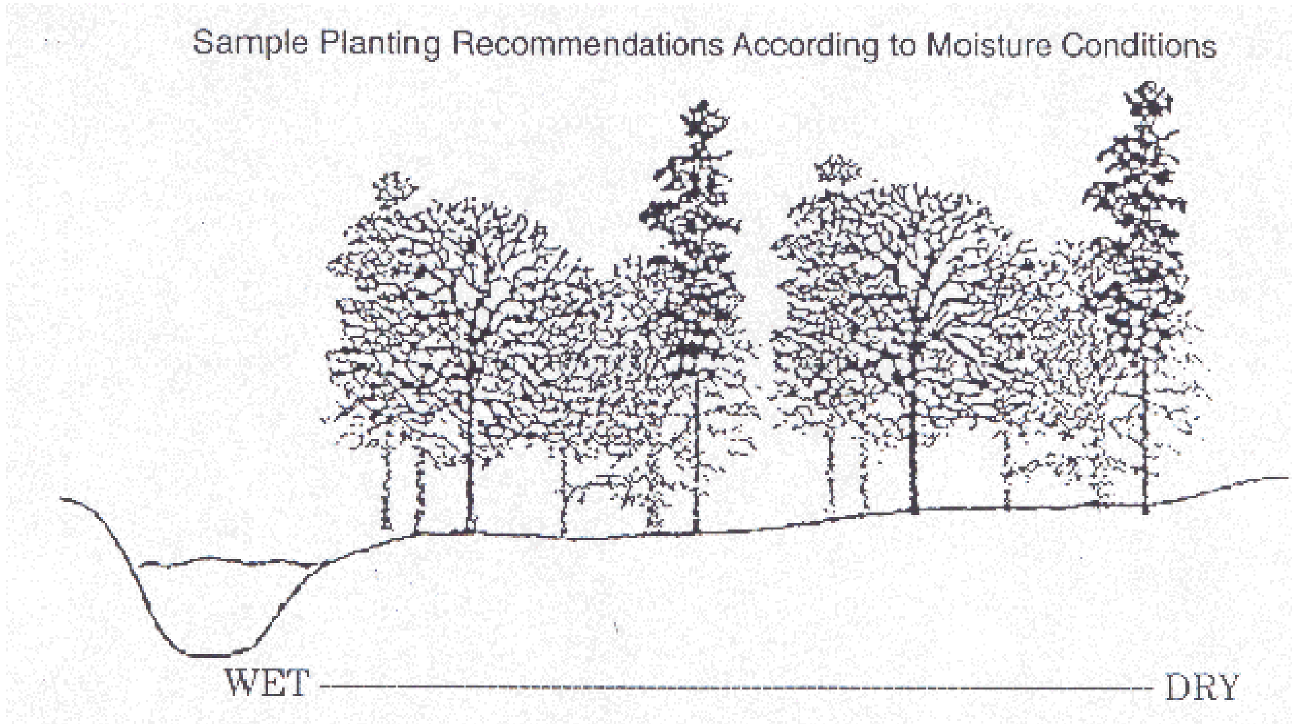
Step 8: Planting a Riparian Buffer

- Plant trees and shrubs when they are dormant (early spring or in autumn after leaf fall).
- Arrange plantings to create a gradual edge rather than an abrupt one, for a more natural appearance and for blowdown protection.
- For woody cuttings or live posts:
  Drive them deeply into the soil allowing a foot or so to remain exposed.
- For rooted plants:
  Prune any large roots before planting. Set plant in a hole 2 –3 times as wide but only as deep as the root ball. Plant at the same depth it was growing in the container or before transplanting. Fill hole gently but firmly with the original soil , watering to settle soil.
- Water once a week through the first growing season. Take care not to start gullies or erosion.
- Use only lime or wood ash to fertilize in your buffer zone.
- Mulching limits surface erosion, suppresses weeds and retains soil moisture. Use organic mulches such as leaf humus, wood chips, pine mulch or other shredded bark. Avoid redwood or cedar, since they are toxic to some seedlings and their chemistry interferes with buffer function.
- Stockpile fresh wood chips for at least 6 months before using, to avoid introducing disease and other troubles.
- Fencing is useful to control grazers, equipment, onlookers and vandals. To deter small mammals from girdling saplings, surround individual plants with simple fine wire mesh or use below ground collars. Deer require robust fencing until well-chosen plants are established. Use temporary fences on flood plains; permanent fences can be used elsewhere.

Step 9: Maintenance

- Inspect plantings and erosion control after rainstorms and regularly every 2 weeks for the first 2 months; then once a month for 6 months; then every 6 months for 2 years.
- Look for stressed or failed plants, invasives, weed competition, deer or beaver browsing, ineffective erosion control, debris accumulation and encroachments.
- Anticipate the need to replant if the buffer is subjected to prolonged high water, drought or ice damage before plants are fully established.

Steps 8-9 modified from the Connecticut River Joint Commissions, Living with the River series no. 8



TREES

- Silver maple
- Swamp white oak
- Green ash
- Sycamore ÿ
- Japanese larch ÿ
- Tamarack
- River Birch

SHRUBS

- Dogwood, Red osier & Silky
- Winterberry ÿ
- Inkberry ÿ
- Highbush blueberry ÿ
- N. Arrowwood (Viburnum)
- Willow, Basket/Stream-Co., Dwarf or Pussy
- Elderberry ÿ
- Button bush ÿ

TREES

- [2] Red maple ÿ
- [2] White ash ÿ
- Blackgum ÿ
- [2] Pin oak ÿ
- [2] Shellbark hickory ÿ
- [2] Bitternut hickory ÿ
- [2] Butternut ÿ
- [2] Eastern/Canadian Hemlock ÿ
- [2] Spruce, White & Norway ÿ
- [2] E. White pine ÿ
- N. White cedar/Arborvitae ÿ
- [2] Hornbeam ÿ
- Hackberry ÿ

SHRUBS

- [2] Gray dogwood ÿ
- American Filbert / Hazelnut ÿ
- [2] Spicebush ÿ
- [2] Ninebark ÿ
- Northern Bayberry ÿ
- [2] Highbush cranberry (Viburnum) ÿ
- [2] Nannyberry ÿ

TREES

- Sugar maple
- White oak
- [2] Red oak
- Black walnut
- [2] Black cherry

SHRUBS

- [2] Snowberry
- [2] Am. Red Raspberry
- [2] Chokecherry

Arrows denote that certain species can tolerate either a wetter or drier environment.

Appendix 3
SPDES Memorandum of Understanding

NEW YORK STATE
SOIL AND WATER CONSERVATION COMMITTEE
I Winners Circle, Albany, NY 12235

MEMORANDUM

TO: Soil and Water Conservation Districts

FROM: Ronald T. Kaplewicz

DATE: September 24, 2003

SUBJECT: MOU for Implementation of Agricultural Best Management Practices - SPDES General Permit for Stormwater Discharges from Construction Activity, GP-02-01

Attached is a copy of the executed MOU between NYS DEC, NYS Ag. & Mkts. and the NYS Soil and Water Conservation Committee for the implementation of agricultural best management practices as it relates to the general permit for stormwater discharge.

If you have any questions, please contact your Associate Environmental Analyst or Regional Water Quality Specialist.

RTK:cj
Encl.
cc: Staff
State Committee Voting
and Advisory Members

MEMORANDUM OF UNDERSTANDING
BETWEEN
NYS DEPARTMENT OF ENVIRONMENTAL CONSERVATION
AND
NYS DEPARTMENT OF AGRICULTURE AND MARKETS
AND
NYS SOIL AND WATER CONSERVATION COMMITTEE
FOR
IMPLEMENTATION OF AGRICULTURAL BEST MANAGEMENT PRACTICES
IN CONFORMANCE WITH
THE SPDES GENERAL PERMIT FOR STORMWATER
DISCHARGES FROM CONSTRUCTION ACTIVITY, GP-02-01

Background

The New York State Department of Environmental Conservation (NYSDEC), the New York State Department of Agriculture and Markets (NYSDA&M), and the New York State Soil and Water Conservation Committee (NYSSWCC) have worked cooperatively to support implementation of agricultural best management practices (AgBMP's). The implementation of these AgBMP's result in improved soil management and water quality.

However, some of the AgBMP's could be required to obtain coverage under the SPDES General Permit for Stormwater Discharges from Construction Activity (GP-02-01). This Memorandum of Understanding clarifies which AgBMP's must be authorized by SPDES permit and which may proceed without such permitting.

Clarification

1. Operational and vegetative agricultural best management practices (BMP's), as identified in Table II (attached) of the "Agricultural Management Practices Catalog for Nonpoint Source Pollution in New York State" are agricultural activities exempt from requirements to obtain authorization to discharge construction stormwater under a SPDES permit.

2. Practices that are structural as identified in Table II in the "Agricultural Management Practices Catalogue for Nonpoint Source Pollution in New York State" are agricultural activities exempt from requirements to obtain authorization to discharge construction stormwater under a SPDES permit provided that such practice:

a. improves water quality or reduces soil erosion,
b. does not degrade water quality or substantially exacerbate water quantity fluctuations,
c. has been planned and designed to USDA/NRCS standards and specifications,
d. is constructed in a manner consistent with the current version of the "New York Standards and Specifications for Erosion and Sediment Control", as prepared by the Urban Erosion and Sediment Control Committee, and
e. disturbs less than 5 acres.

3. Wetland reconstruction projects installed in a manner consistent with the current version of the "New York Standards and Specifications for Erosion and Sediment Control", as prepared by the Urban Erosion and Sediment Control Committee, are agricultural activities exempt from requirements to obtain authorization to discharge construction stormwater under a SPDES permit.

4. Construction activities not set forth in clarification one, two, or three, such as construction of a barn or other agricultural building, silo, stock yard or pen, are not exempt by virtue of their status as agricultural activities.

Sandra Allen, Director, Division of Water
NYS Department of Environmental Conservation

dated: SEP 10, 2003

Dennis Hill, Chair
NYS Soil and Water Conservation Committee

dated: 9/16/03, 2003

Ruth Moore, First Deputy Commissioner
NYS Department of Agriculture and Markets

dated: September 15, 2003

Table II. Agricultural Management Practices by Category and Lifespan

Management Practices	Management Practice Categories			Management Practice
	Operational	Vegetative	Structural	Lifespan
Access Road Improvement		●	●	Permanent
Alternative Water Supply	●		●	Temporary/Permanent
Barnyard Runoff Management System	●	●	●	Permanent
Conservation Tillage:				
- Minimum-Till	●	●		Temporary
- No-Till	●	●		Temporary
Constructed Wetlands		●	●	Permanent
Contour Farming	●			Temporary
Cover and Green Manure Crop	●	●		Temporary
Critical Area Protection:				
- Permanent Vegetative Cover		●		Permanent
- Streambank and Shoreline Protection	●	●	●	Permanent
Crop Rotation	●	●		Temporary
Diversions		●	●	Permanent
Fencing			●	Permanent

Table II. Agricultural Management Practices by Category and Lifespan (Continued)

Management Practices	Management Practice Categories: Operational	Vegetative	Structural	Management Practice Lifespan
Filter Strips		●		Permanent
Grassed Waterway		●	●	Permanent
Integrated Pest Management (IPM):				
- Biological Controls	●			Temporary
- Cultural Practices	●	●		Temporary
- Resistant Crop Varieties		●		Temporary
- Scouting	●			Temporary
- Trap Crops	●	●		Temporary
Irrigation Water Management:				
- Scheduling	●			Temporary
- Trickle Irrigation	●		●	Permanent
Nutrient Management:	●		●	Temporary/Permanent
- Anaerobic Digestion	●		●	Temporary/Permanent
- Composting	●			Temporary
- Fertilizer Management	●			Temporary
- Land Application of Manure	●			Temporary
- Manure Nutrient Analysis	●		●	Permanent
- Manure Storage System	●			Temporary
- Soil Testing				
Nutruent/Sediment Control System		●	●	Permanent

Table II. **Agricultural Management Practices by Category and Lifespan (Continued)**

Management Practices	Management Practice Categories: Operational	Management Practice Categories: Vegetative	Management Practice Categories: Structural	Management Practice Lifespan
Pathogen Management	●			Temporary/Permanent
Pasture Management: Short-Duration Grazing Systems		●	●	Permanent
Pesticide Management				
- Computerized Precision Application	●			Temporary
- Evaluation of Site-Specific Leaching and Surface Loss Potential	●			Temporary
- Pesticide Application Education and Training	●			Temporary
- Pesticide Handling Facility	●		●	Permanent
- Proper Equipment Calibration	●			Temporary
- Proper Timing of Pesticide Application	●			Temporary
- Read and Follow the Label Directions	●			Temporary
Petroleum Product Storage, Spill Prevention and Containment	●		●	Temporary/Permanent
Riparian Forest Buffer		●		Permanent
Silo Leachate Control	●	●	●	Temporary/Permanent
Stripcropping	●	●		Temporary
Terraces			●	Permanent

Appendix 4

Project Site Prioritization Protocol/Matrix

Delaware County Soil & Water Conservation District
West Branch Delaware River
Stream Corridor Management Program

Project Site Prioritization Protocol/Matrix

This prioritization procedure is intended to be used on a pilot basis for initial demonstration stream restoration projects in the Town Brook sub-basin. Future modifications will be made as deemed necessary by the Program staff, Project Advisory Committee, and Soil & Water Conservation District Board.

Data used as the basis for this procedure include field measurements of streams using survey equipment, collection and analysis of stream sediment, documented observation including digital photographs, Global Positioning System (GPS) points associated with field flagged features, historic and current (digital) aerial photography, and contact with riparian landowners. Collection and analysis procedures include the Rosgen system of stream classification and assessment, Mecklenburg Stream Assessment software, and various protocols developed by the New York City Department of Environmental Protection. It should be noted that data were collected and analyzed to date for the main-stem of the Town Brook sub-basin including the impacted (proposed project) reaches. Proposed project reaches were initially selected by field observation and review of GPS data after processing through the Geographic Information System (GIS) mapping database.

Ranking criteria were also developed based on tasks that can be completed with current staffing, available funding, and geomorphic approach. The tasks include data collection and analysis, project site survey, project design, and construction supervision and documentation. This protocol is designed that more difficult projects, particularly those with a higher risk in the event of failure (see Natural Resources Conservation Service Hazard Class criterion), will receive a lower score. Such projects will require a higher level of assessment, complicated designs, and will exceed available funding. These projects would need to be contracted to professional consultants having considerable experience with larger geomorphic based projects until later program phases. High risk sites may be selected from the list of all sites and prioritized with a modified protocol designed to determine the site in greatest need of restoration. Any such projects could be bid out pending availability of funding.

Following are the criteria to be used for establishment of the objective (rank) matrix component:
Ranking: 1 = Low Priority, 2 = Medium Priority, 3 = High Priority

Criteria 1 through 4 will be used to initially identify potential project reaches. Once a list of reaches are identified, the reaches will be re-ranked using criteria 5 through 9. Criteria 10-16 will be used to assist in the final project reach selection. Criterion 17 will currently **only** be used when public infrastructure is an issue and **only** when outside resources are available. In those instances Criterion 17 will be a Phase 1 Criterion.

Phase 1 Criteria

1 Eroding Banks (sediment contribution)

Data have been collected and analyzed on eroding banks to evaluate severity and potential for continued or increased sediment contribution to the stream system. Sediment loading greater than a stream's natural transport capacity results in degradation of water quality, increased nutrient loading, and degradation of aquatic habitat. Bank erosion can also result in damage to or loss of agricultural land; residential, commercial and public property and/or structures; and damage to public infrastructure.

A. Surface Area
- 1 = <1000 sq. ft./1000 ft. of stream length
- 2 = 1001 sq. ft. - 3000 sq. ft./ 1000 ft. of stream length
- 3 = >3000 sq. ft./ 1000 ft. of stream length

B. Eroded length (total) vs. reach length (stream centerline)
- 1 =Eroded/Reach < 25%
- 2 =Eroded/Reach 25% - 50%
- 3 =Eroded/Reach > 50%

C. Bank materials
- 1 =Bank clay materials none
- 2 =Bank clay materials slight to moderate
- 3 =Bank clay materials significant (glacial lake clays)

D. Proximity to residence, business, or public building
- 1 =< 30 ft. (higher risk site, requires higher level expertise)
- 2 =31 ft - 100 ft. (moderate risk site, may require further evaluation)
- 3 => 100 ft. (lower risk site)

E. Proximity to public infrastructure
- 1 =< 30 ft. (higher risk site, requires higher level expertise)
- 2 =31 ft - 100 ft. (moderate risk site, may require further evaluation)
- 3 => 100 ft. (lower risk site)

2 Channel Conditions

Certain channel conditions indicate that a stream's capacity to transport sediment is out of balance. Stream bed aggradation (deposition) indicates an excessive sediment supply, usually upstream. Stream bed degradation (cutting of the bed) indicates sediment starvation usually due to upstream aggradation. Center bars, side bars, and transverse bars are forms of aggradation and are given additional consideration since these formations further alter desirable stream flow conditions and can compound erosion problems.

A. Aggraded areas
- 1 = None to slight
- 2 = Moderate
- 3 = Significant

B. Degraded areas
- 1 = None to slight
- 2 = Moderate
- 3 = Significant

C. Center bars, side bars, transverse bars
- 1 = Not present
- 2 = Moderately present (# 3 points per 1000 feet of reach)
- 3 = Significantly present ($5 points per 1000 feet of reach)

D. Incision
- 1 = None to slight
- 2 = Moderate incision
- 3 = Significantly incised

E. Debris
- 1 = Not present, or beneficial
- 3 = Debris present, creating flow problems present

3. Lateral Migration

Lateral migration is a natural stream phenomenon. However, excessive migration can be destructive to property, aquatic habitat, and has serious consequences with respect to sediment transport regimes. Excessive migration can be the result of past practices and intervention.

A Lateral migration
- 1 = Migration minimal
- 2 = Migration moderate
- 3 = Migration significant

4. Soil Conditions

For a site to be considered for restoration, soils must exhibit favorable characteristics for re-vegetation and with enough structure to support heavy equipment. Although offsite soils may be brought in for re-vegetative purposes, this is costly and is not considered a favorable option.

A. Soil conditions
- 1 = Soils inadequate for both re-vegetation and equipment access
- 2 = Soils adequate for equipment access but not re-vegetation
- 3 = Soils adequate for both re-vegetation and equipment access

Phase 2 Criteria

5 NRCS Hazard Class

The Natural Resource Conservation Service (NRCS) Conservation Practice Standard 580 - Streambank and Shoreline Protection, contains criteria for assessing the design standards that must be used in any streambank stabilization project. These criteria include a hazard classification. The standard states, "A hazard classification shall be assigned each site to establish the level of design for streambank protection measure. Hazard classes are:

A. Low Hazard - sites where failure of measure would result in damage to cropland, woodland, pastureland, or other lands.

B Medium Hazard - sites where failure of measure would result in damage to uninhabited structures, farm buildings, limited access roads and their appurtenances, parks, and other improved properties.

C. High Hazard - sites where failure of measure would result in damage to residences, businesses, state and local highways and their appurtenances, or other structures which if imperiled would threaten the life and safety of the people."

- 1 = Hazard Class C
- 2 = Hazard Class B
- 3 = Hazard Class A

6 Stream Bank Maintenance

Many stream reaches have historically been maintained. Most of this maintenance takes the form of some sort of revetment including berms, log crib-walls, rip-rap, dumped stone, stacked rock walls, concrete slabs, and other various structures of varying degrees of integrity. All revetments affect stream hydraulics and some restrict stream access to the floodplain. Some revetments have been continually maintained, some somewhat maintained, while others were placed and rarely or never maintained. Some revetments have had a positive effect decreasing bank erosion with some enhancing aquatic habitat while others have created and/or compounded bank erosion at their locations and/or further downstream. No revetment is not necessarily indicative of a stable or unstable reach but could be an indicator that past maintenance was not deemed necessary, or that the stream could adequately access its floodplain.

A. Revetments
- 1 = Not present (if no revetment present, skip next three categories)
- 2 = Present, in good condition
- 3 = Present, in fair to poor condition

B. Revetment effectiveness (erosion, floodplain access, habitat)
- 1 = Beneficial or no detected adverse effects
- 2 = Moderate adverse effects
- 3 = Significant adverse effects

C. Revetment length (total) vs. reach length (stream centerline)
- 1 = Revetment/Reach <25%
- 2 = Revetment/Reach 25% - 50%
- 3 = Revetment/Reach >50%

D. Proximity to public infrastructure
- 1 =< 30 ft. (higher risk site, requires higher level expertise)
- 2 =31 ft - 100 ft. (moderate risk site, may require further evaluation)
- 3 => 100 ft. (lower risk site)

7 Riparian Buffers

The presence or lack of riparian buffers can affect the rate at which a bank is eroding or the potential for either increased or decreased erosion. Absence of buffers results in increased runoff thereby increasing erosion and nutrient loading. As buffers reach their full potential, nutrients are assimilated, sediments are trapped, and the energy of overland water flow is decreased while infiltration of water is increased.

A. Presence of riparian buffer (minimum width of 35 ft. from top of bank)
- 1 =Established buffer
- 2 =Newly created (CREP) or narrow established buffer
- 3 =No buffer

8 Proximity to Natural/Cultural Resources

Potential sites in close proximity to public parks, New York State Department of Environmental Conservation (NYSDEC) Reforestation Areas, NYSDEC Wildlife Management Areas, NYSDEC Significant Habitats, critical ecological areas, cemeteries, and nationally or State registered districts and buildings will require special permitting or may be precluded from any work at all. Therefore this criterion is included to identify a potential deterrent to restoration.

A. Proximity to Natural/Cultural Resources
- 1 = Resources within potential project footprint
- 3 = No resources within potential project footprint

9 Program Goals are Defined and Achieved (Conceptually)

Restoration projects must meet the goals of the Stream Corridor Management Program. Conceptual plans will assess and define how these goals will be achieved. These goals are listed as follows: 1) Protection or enhancement of water quality; 2) Protection of private and/or public property; 3) Increased stream reach stability; 4) Improved aquatic habitat; 5) Other goals as defined.

A. Program goals defined and achieved
- 1 = 2 or less goals will be achieved
- 2 = At least 3 goals will be achieved
- 3 = All goals will be achieved

Phase 3 Criteria

10 Program Partnering

Partnering programs exist for some project phases such as riparian buffers, agricultural crossings, etc. Projects with potential for government funding and established deadlines should be a higher priority.

A. Project partnering available
- 1 = No program partnering available
- 3 = Program partnering available

11 Dewatering Potential

Current NYSDEC regulations require stream projects to be dewatered. This can be a costly process on sites where dewatering options are difficult.

A. Dewatering
- 1 = Site dewatering will be costly and difficult
- 3 = Site can be effectively and economically dewatered

12 Complicating Factors

It is advisable to keep initial demonstration projects uncomplicated. Tributaries within a project reach may need to be included in a restoration plan which could greatly increase both the scope of work and cost. Tributaries can also create hydraulic challenges at their confluences, especially where a main stream may require realignment. It is also advisable to address unstable reaches from upstream to downstream.

A. Tributaries within proposed project reach (storm drains & springs not included)
- 1 = Tributaries present
- 3 = No tributaries (if no tributaries, then skip category B)

B. Sediment load from tributaries if tributaries present
- 1 = Significant sediment load
- 2 = Moderate sediment loading
- 3 = Minimal to no sediment loading

C. Unstable upstream reaches
- 1 = Unstable upstream reaches present
- 3 = No unstable upstream reaches

D. Unstable downstream reaches (within reasonable proximity to project reach that could affect project success)
- 1 = Unstable downstream reaches present
- 3 = No unstable downstream reaches

13 Survey, Design, and Construction Supervision

It is desirable to reserve initial demonstration projects requiring complicated survey, design, and construction supervision be reserved for later program phases. These tasks must be within the capabilities of current staffing and time constraints. Larger, more complicated projects that may require outside resources could result in projects not being completed before current contract deadlines.

A. Survey, design, and construction supervision
- 1 = Complicated, lengthy, outside resources required
- 2 = Moderately complicated, may be lengthy, outside resources not required
- 3 = Uncomplicated, fits within time constraints, outside resources not required

14 Geomorphic Approach is Used

The Stream Corridor Management Program's fundamental approach to classification, assessment, and restoration is the fluvial geomorphology, or natural stream channel design approach (Rosgen approach). This methodology seeks to identify and solve an adverse stream condition. It is dependent on the data collection, analysis, and surveys of the project site watershed, as well as the data collection, analysis, and survey of a suitable stable reference reach (stream reach with same stream type and morphology). Designs need to be compatible with Rosgen's channel evolution sequencing. Strong consideration will be given to integration with other watershed protection programs. Objectives could include bringing stream back to acceptable range of width to depth ratio, pool/riffle length and depth, adjust slope or sinuosity, or reconnect the stream with its floodplain.

A. Geomorphic approach is used
- 1 = Project approach has limited geomorphic objectives
- 2 = Project approach addresses several geomorphic objectives
- 3 = Project approach addresses several geomorphic objectives and has program partnering

15 Estimated Restoration Costs

Funding is currently limited and is a significant factor in scoping potential projects. Initial projects need to fall within the limits of existing funding. Reasonably priced projects would better enable similar projects to be funded in the future and allow funds to be reserved for future operation and maintenance. Additionally, time and types of funding available may not allow for procurement of funds and completion of construction before current contract deadlines.

A. Estimated restoration costs
- 1 = Estimated costs exceed available funding
- 2 = Estimated costs may exceed available funding

- 3 = Estimated costs within limits of available funding

16 Post Project Monitoring

It is necessary for initial demonstration projects to be visible and accessible. Completed projects must be monitored to measure success and will provide valuable data for use in future projects where similar solutions might be applied. This is to build expertise and test solutions. Project sites will be visited by program staff and other agencies and stakeholders for various monitoring and educational purposes. Strong consideration will be given to sites where access easement is likely to be given.

A. Project site visibility
- 1 = Site not visible
- 2 = Site partially visible
- 3 = Site highly visible

B. Project site accessibility
- 1 = Easement not attainable
- 2 = Easement attainable, site somewhat difficult to access
- 3 = Easement attainable, site offers good access

Public Infrastructure Criterion

17 Public Infrastructure (use only when adequate outside resources available)

Streams and roads exist in close proximity throughout much of the basin, existing parallel to each other and/or often crossing. As a result, they both affect each other. In some instances, the effects are not mutually beneficial. Although every potential project reach will not involve public infrastructure, many will. There will also be potential project sites where infrastructure will be the main focus. Therefore this criterion is being included but is designated for use only when roads and bridges are an issue. The eroding bank and revetment criteria address proximity to infrastructure and are the criteria most likely to have mutual impacts. This score for this criterion will be added to the rest of the criterion after initial prioritization of all potential sites to prevent bias toward only those sites where roads and bridges are an issue: 1) where the road or bridge is deemed important to or for a project; and 2) adequate outside resources are available.

A. Scour condition at a road embankment or bridge
- 1 = None to slight
- 2 = Moderate
- 3 = Significant

B. Aggradation condition at a bridge
- 1 = None to slight
- 2 = Moderate
- 3 = Significant

Following is the initial subjective (weight) matrix component.

1. Eroding Banks (sediment contribution)
2. Channel Conditions
3. Lateral Migration
4. Soil Conditions

5. NRCS Hazard Class
6. Stream Bank Maintenance
7. Riparian Buffers
8. Proximity to Natural/Cultural Resources
9. Program Goals are Defined and Achieved

10. Program Partnering Available
11. Dewatering Potential
12. Complicating Factors
13. Survey, Design, and Construction Supervision
14. Geomorphic Approach is Used
15. Estimated Restoration Costs
16. Post Project Monitoring

17. Public Infrastructure*

* Use only when adequate outside resources available)

Delaware County Soil & Water Conservation District
West Branch Delaware River
Stream Corridor Management Program

Project Site Prioritization Matrix

Location	Criterion	1A	1B	1C	1D	1E	2A	2B	2C	2D	2E	3A	4A	17A*	17B*	Phase 1 Score	5A	6A	6B	6C	6D	7A	8A	9A	Phase 2 Score	10A	11A	12A	12B	12C	12D	13A	14A	15A	16A	16B	Phase 3 Score	Total Score
	Weight	3	3	3	3	3	2	2	2	2	2	2	2	1	1		3	1	1	1	1	2	1	2		3	3	2	2	2	2	2	2	3	3	3		
	Rank																																					
	Score	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Weight	3	3	3	3	3	2	2	2	2	2	2	2	1	1		3	1	1	1	1	2	1	2		3	3	2	2	2	2	2	2	3	3	3		
	Rank																																					
	Score	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Weight	3	3	3	3	3	2	2	2	2	2	2	2	1	1		3	1	1	1	1	2	1	2		3	3	2	2	2	2	2	2	3	3	3		
	Rank																																					
	Score	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Weight	3	3	3	3	3	2	2	2	2	2	2	2	1	1		3	1	1	1	1	2	1	2		3	3	2	2	2	2	2	2	3	3	3		
	Rank																																					
	Score	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Weight	3	3	3	3	3	2	2	2	2	2	2	2	1	1		3	1	1	1	1	2	1	2		3	3	2	2	2	2	2	2	3	3	3		
	Rank																																					
	Score	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Weight	3	3	3	3	3	2	2	2	2	2	2	2	1	1		3	1	1	1	1	2	1	2		3	3	2	2	2	2	2	2	3	3	3		
	Rank																																					
	Score	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Weight	3	3	3	3	3	2	2	2	2	2	2	2	1	1		3	1	1	1	1	2	1	2		3	3	2	2	2	2	2	2	3	3	3		
	Rank																																					
	Score	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* Public Infrastructure Criterion when applicable

Appendix 5
DCSWCD Board Stream Policy

APPENDIX C

Delaware County Soil and Water Conservation District Technical Standard to Address the Issue of Livestock in Streams, Rivers and Hydrologically Sensitive Areas

~~When reviewing Whole Farm Plans for technical content, the SWCD Board of Directors~~ requires that each Whole Farm Plan provide for the exclusion of livestock from all streams, rivers and HSAs following one or more of the following methods.

These methods include:

1) Conservation Reserve Enhanced Program (CREP) – The Landowner/Producer agrees to utilize the CREP Program.

2) Fencing – The Landowner/Producer agrees to use Watershed Agricultural Program funds to fence cattle from streams, rivers and HSAs.

3) Behavioral Changes – When options 1 and 2 above are not practical, the Landowner/Producer agrees to use Watershed Agricultural Program funds to implement BMP's that will provide limited livestock access to streams, rivers and HSAs. BMP's may include but are not limited to the development of alternative water sources, location of alternative feeding areas and prescribed grazing.

A__.oved by SWCD Board 6/15/04

Appendix 6

GPS Data Dictionary

```
West Branch Assess
Updated 6/12/03 SRG

Bankfull               Point Feature, Label 1 = location, Label 2 = text
   location            Menu, Required, Required
      left bank
      right bank
   text                Text, Maximum Length = 30
                       Normal, Normal
   camera #            Text, Maximum Length = 30
                       Normal, Normal

Beaver Dam P           Point Feature, Label 1 = text, Label 2 = camera #
   text                Text, Maximum Length = 30
                       Normal, Normal
   camera #            Text, Maximum Length = 30
                       Normal, Normal

Beaver Dam L           Line Feature, Label 1 = text, Label 2 = camera #
   text                Text, Maximum Length = 30
                       Normal, Normal
   camera #            Text, Maximum Length = 30
                       Normal, Normal

Bedrock P              Point Feature, Label 1 = location, Label 2 = grade control
   location            Menu, Required, Required
      all (bed,both banks)
      bed
      bank rt
      bank lt
      bed rt
      bed lt
   grade control       Menu, Normal, Normal
      yes
      no
   text                Text, Maximum Length = 30
                       Normal, Normal
   camera #            Text, Maximum Length = 30
                       Normal, Normal

Bedrock L              Line Feature, Label 1 = location, Label 2 = grade control
   location            Menu, Required, Required
      all (bed,both banks)
      bed
      bank rt
      bank lt
      bed rt
      bed lt
   grade control       Menu, Normal, Normal
      yes
      no
   text                Text, Maximum Length = 30
                       Normal, Normal
   camera #            Text, Maximum Length = 30
                       Normal, Normal

BEHI Pin               Point Feature, Label 1 = location, Label 2 = camera #
   location            Menu, Required, Required
      left
      right
      left upper
      right upper
      left lower
      right lower
   camera #            Text, Maximum Length = 30
                       Normal, Normal
   text                Text, Maximum Length = 30
                       Normal, Normal

Benchmark              Point Feature, Label 1 = location, Label 2 = description
   location            Text, Maximum Length = 30
                       Normal, Normal
   description         Text, Maximum Length = 30
                       Normal, Normal
   camera #            Text, Maximum Length = 30
                       Normal, Normal
```

```
Bridge                 Point Feature, Label 1 = type, Label 2 = bridge #
   type                Menu, Required, Required
      state
      county
      town
      village
      private
   bridge #            Text, Maximum Length = 30
                       Normal, Normal
   road name           Text, Maximum Length = 30
                       Normal, Normal
   wing wall           Menu, Normal, Normal
      us left
      us right
      ds left
      ds right
   text                Text, Maximum Length = 30
                       Normal, Normal
   camera #            Text, Maximum Length = 30
                       Normal, Normal

Camera                 Point Feature, Label 1 = text, Label 2 = camera #
   text                Text, Maximum Length = 30
                       Normal, Normal
   camera #            Text, Maximum Length = 30
                       Normal, Normal

Channel                Point Feature, Label 1 = state, Label 2 = bed material
   state               Menu, Normal, Normal
      aggraded
      high bed load
      degraded
      transverse bar
      center bar
      side bar
      divergence
      convergence
   bed material        Menu, Normal, Normal
      clay
      sand
      gravel
      cobble
      boulder
   text                Text, Maximum Length = 30
                       Normal, Normal
   camera #            Text, Maximum Length = 30
                       Normal, Normal

Clay Exposure P        Point Feature, Label 1 = location, Label 2 = text
   location            Menu, Required, Required
      left bank
      right bank
      bed,all
      bed,left
      bed,right
   text                Text, Maximum Length = 30
                       Normal, Normal
   camera #            Text, Maximum Length = 30
                       Normal, Normal
   type                Menu, Normal, Normal
      glacial lake
      glacial till
   behi #              Numeric, Decimal Places = 2
                       Minimum = 0, Maximum = 30, Default Value = 0
                       Normal, Normal

Clay Exposure L        Line Feature, Label 1 = location, Label 2 = text
   location            Menu, Required, Required
      left bank
      right bank
      bed
   text                Text, Maximum Length = 30
                       Normal, Normal
   camera #            Text, Maximum Length = 30
                       Normal, Normal
```

```
   type                 Menu, Normal, Normal
      glacial lake
      glacial till
   behi #               Numeric, Decimal Places = 2
                        Minimum = 0, Maximum = 30, Default Value = 0
                        Normal, Normal

Control Pin             Point Feature, Label 1 = type, Label 2 = location
   type                 Menu, Required, Required
      behi
      erosion
      surv sta
      x-section
      DOT marker
      USGS marker
   location             Menu, Required, Required
      control pin
      right pin
      left pin
      trav pt
   text                 Text, Maximum Length = 30
                        Normal, Normal
   local elevation      Numeric, Decimal Places = 3
                        Minimum = 0, Maximum = 50000, Default Value = 0
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Culverts                Point Feature, Label 1 = size, Label 2 = material
   size                 Menu, Required, Required
      4"
      6''
      8''
      10''
      12''
      15''
      18''
      21''
      24''
      30''
      36''
      42''
      48''
      54''
      60''
      66''
      72''
      84''
      other
   material             Menu, Required, Required
      corrugated
      smooth steel
      plastic
      concrete
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal
   flow status          Menu, Normal, Normal
      dry
      wet
      running

Debris                  Point Feature, Label 1 = location, Label 2 = material
   location             Menu, Required, Required
      bank right
      bank left
      across stream
      in stream
   material             Menu, Required, Required
      tree, log
      other
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera#              Text, Maximum Length = 30
                        Normal, Normal
```

```
Dump                    Point Feature, Label 1 = location, Label 2 = materials
   location             Menu, Required, Required
      bank right
      bank left
      hillside right
      hillside left
      other
   materials            Menu, Normal, Normal
      glass
      metal
      wood
      mixed
      toxic, dangerous
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera#              Text, Maximum Length = 30
                        Normal, Normal

Edge Water P            Point Feature, Label 1 = location, Label 2 = text
   location             Menu, Required, Required
      left
      right
      island
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Edge Water L            Line Feature, Label 1 = location, Label 2 = text
   location             Menu, Required, Required
      left
      right
      island
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Eroding Bank P          Point Feature, Label 1 = location, Label 2 = height
   location             Menu, Required, Required
      left
      right
      left lower
      right lower
      left upper
      right upper
   height               Numeric, Decimal Places = 1
                        Minimum = 0, Maximum = 100, Default Value = 0
                        Required, Required
   text                 Text, Maximum Length = 30
                        Normal, Normal
   behi #               Numeric, Decimal Places = 1
                        Minimum = 0, Maximum = 200, Default Value = 0
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Eroding Bank L          Line Feature, Label 1 = location, Label 2 = text
   location             Menu, Required, Required
      left
      right
      left lower
      right lower
      left upper
      right upper
   text                 Text, Maximum Length = 30
                        Normal, Normal
   behi #               Numeric, Decimal Places = 1
                        Minimum = 0, Maximum = 200, Default Value = 0
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Gage                    Point Feature, Label 1 = gage ID #, Label 2 = gage plate reading
   gage ID #            Text, Maximum Length = 30
```

```
                       Normal, Normal
   gage plate reading  Text, Maximum Length = 30
                       Normal, Normal
   camera #            Text, Maximum Length = 30
                       Normal, Normal

Grade Control P        Point Feature, Label 1 = type, Label 2 = text
   type                Menu, Normal, Normal
      check dam
      mill dam
      flood dam
      habitat structures
      sheet piling
      handworked
      concrete
      log sill
      cross-vane
      earthen
      other
   text                Text, Maximum Length = 30
                       Normal, Normal
   camera #            Text, Maximum Length = 30
                       Normal, Normal

Grade Control L        Line Feature, Label 1 = type, Label 2 = text
   type                Menu, Normal, Normal
      check dams
      mill dam
      flood dam
      log-jam, lwd
      habitat structures
      sheet piling
      handworked
      concrete
      log sill
      bedrock sill
      cross-vane
      earthen
      other
   text                Text, Maximum Length = 30
                       Normal, Normal
   camera #            Text, Maximum Length = 30
                       Normal, Normal

Headcut                Point Feature, Label 1 = height, Label 2 = text
   height              Numeric, Decimal Places = 1
                       Minimum = 0, Maximum = 50, Default Value = 0
                       Required, Required
   text                Text, Maximum Length = 30
                       Normal, Normal
   camera #            Text, Maximum Length = 30
                       Normal, Normal

HWM Flag               Point Feature, Label 1 = type, Label 2 = location
   type                Menu, Required, Required
      high water mark
      bankfull
      water surface
   location            Menu, Required, Required
      left bank
      right bank
   date                Date, Month-Day-Year Format
                       Required, Required
   text                Text, Maximum Length = 30
                       Normal, Normal
   camera #            Text, Maximum Length = 30
                       Normal, Normal

Information            Point Feature, Label 1 = contact, Label 2 = hydrology
   contact             Text, Maximum Length = 30
                       Normal, Normal
   hydrology           Text, Maximum Length = 30
                       Normal, Normal
   misc.               Text, Maximum Length = 30
                       Normal, Normal
```

```
Land Use P              Point Feature, Label 1 = type, Label 2 = buffer
   type                 Menu, Normal, Normal
      Forest/decid, heavy
      Forest/decid, light
      Forest/coniferous
      Agricultual/crops
      Agricultural/grass
      Agricultural/pasture
      Residential
      Commercial
      Other
   buffer               Menu, Normal, Normal
      CREP
      Trees/Brush
      Grade/Berm
      Other
   buffer  width        Text, Maximum Length = 30
                        Normal, Normal
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Land Use L              Line Feature, Label 1 = type, Label 2 = buffer
   type                 Menu, Normal, Normal
      Forest/decid, heavy
      Forest/decid, light
      Forest/coniferous
      Agricultual/crops
      Agricultural/grass
      Agricultural/pasture
      Residential
      Commercial
      Other
   buffer               Menu, Normal, Normal
      CREP
      Trees/Brush
      Grade/Berm
      Other
   buffer  width        Text, Maximum Length = 30
                        Normal, Normal
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Revetment P             Point Feature, Label 1 = location, Label 2 = type
   location             Menu, Required, Required
      left
      right
   type                 Menu, Normal, Normal
      berm
      log cribwall
      habitat structures
      gabion
      old abutment
      rip-rap
      sheet piling
      stacked rock wall
      other
      concrete
      laid-up stone
      dumped stone
      bankrun - bare
      bank run, seed&mulch
      concrete slabs
      poured concrete
      brush/lwd
   Description          Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Revetment L             Line Feature, Label 1 = location, Label 2 = type
   location             Menu, Required, Required
      left
```

```
      right
   type                 Menu, Normal, Normal
      berm
      log cribwall
      habitat structures
      gabion
      old abutment
      rip-rap
      sheet piling
      stacked rock wall
      other
      concrete
      laid-up stone
      dumped rock fill
      bankrun - bare
      bank run, seed&mulch
      concrete slabs
      poured concrete
      brush/lwd
   Description          Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Reference Reach         Point Feature, Label 1 = location, Label 2 = Classification
   location             Menu, Normal, Normal
      top
      middle
      bottom
   Classification       Menu, Normal, Normal
      Aa
      A
      B
      C
      D
      E
      F
      G
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Road                    Line Feature, Label 1 = feature, Label 2 = materials
   feature              Menu, Normal, Normal
      guiderail
      ditch - bare
      ditch - veg
      ditch - hardened
      edge - uphill
      edge - downhill
      centerline
      hillside staywall
   materials            Menu, Normal, Normal
      blacktop
      gravel
      crushed stone
      grass/veg
      concrete
      other
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Stream Channel TW P     Point Feature, Label 1 = text
   text                 Text, Maximum Length = 30
                        Normal, Normal

Stream Channel TW L     Line Feature, Label 1 = text
   text                 Text, Maximum Length = 30
                        Normal, Normal

Stream Crossing         Point Feature, Label 1 = type, Label 2 = text
   type                 Menu, Required, Required
      farm equip
```

```
      cattle
      recreational
      other
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Stream Feature          Point Feature, Label 1 = feature, Label 2 = chan type
   feature              Menu, Required, Required
      top riffle
      run
      top pool
      glide
      step pools
      point bar
      spring seep
      trout area
   chan type            Menu, Required, Required
      MC
      SC1
      SC2
      BP
   text                 Text, Maximum Length = 30
                        Normal, Normal
   Rosgen Class         Menu, Normal, Normal
      Aa
      A
      B
      C
      D
      E
      F
      G
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Stream Type Change      Point Feature, Label 1 = top of, Label 2 = bottom of
   top of               Menu, Normal, Normal
      Aa?
      A?
      B?
      C?
      D?
      E?
      F?
      G?
   bottom of            Menu, Normal, Normal
      Aa?
      A?
      B?
      C?
      D?
      E?
      F?
      G?
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Terrace                 Point Feature, Label 1 = location, Label 2 = text
   location             Menu, Required, Required
      left bank
      right bank
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Tributary               Point Feature, Label 1 = location, Label 2 = type
   location             Menu, Required, Required
      left bank
      right bank
      thalweg
   type                 Menu, Required, Required
```

```
      perennial
      intermittent
      spring
      storm drain
      binnekill
   name                 Text, Maximum Length = 30
                        Normal, Normal
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Utilities               Point Feature, Label 1 = type, Label 2 = pole #
   type                 Menu, Normal, Normal
      electric
      phone
      sewer
      well
      water supply
      cable
   pole #               Text, Maximum Length = 30
                        Normal, Normal
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Undercut Bank P         Point Feature, Label 1 = location, Label 2 = height
   location             Menu, Required, Required
      left
      right
   height               Numeric, Decimal Places = 1
                        Minimum = 0, Maximum = 100, Default Value = 0
                        Required, Required
   depth into bank      Numeric, Decimal Places = 1
                        Minimum = 0, Maximum = 100, Default Value = 0
                        Required, Required
   vegetation           Menu, Normal, Normal
      none
      tree roots
      woody
      other
      grasses,etc
   text                 Text, Maximum Length = 30
                        Normal, Normal
   behi #               Numeric, Decimal Places = 1
                        Minimum = 0, Maximum = 200, Default Value = 0
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Undercut Bank L         Line Feature, Label 1 = location, Label 2 = height
   location             Menu, Required, Required
      left
      right
   height               Numeric, Decimal Places = 1
                        Minimum = 0, Maximum = 100, Default Value = 0
                        Required, Required
   depth into bank      Numeric, Decimal Places = 1
                        Minimum = 0, Maximum = 100, Default Value = 0
                        Required, Required
   vegetation           Menu, Normal, Normal
      none
      tree roots
      woody
      other
      grasses,etc
   text                 Text, Maximum Length = 30
                        Normal, Normal
   behi #               Numeric, Decimal Places = 1
                        Minimum = 0, Maximum = 200, Default Value = 0
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Valley Type             Point Feature, Label 1 = Types, Label 2 = text
```

```
   Types                Menu, Normal, Normal
      1
      2
      3
      4
      5
      6
      7
      8
      9
      10
      11
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Vegetation P            Point Feature, Label 1 = type, Label 2 = text
   type                 Menu, Normal, Normal
      brush
      knotweed
      multiflora rose
      other invasive
      other non-invasive
      sparse/stressed
      lawn
      other
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Vegetation L            Line Feature, Label 1 = type, Label 2 = text
   type                 Menu, Normal, Normal
      brush
      knotweed
      multiflora rose
      other invasive
      other non-invasive
      sparse/stressed
      lawn
      other
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

X-Section               Point Feature, Label 1 = location, Label 2 = Type
   location             Menu, Required, Required
      bankfull flag LB
      bankfull location LB
      thalweg
      bankfull flag RB
      Bankfull location RB
   Type                 Menu, Required, Required
      existing
      proposed
      reference
      classification
      BEHI
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Point Generic           Point Feature, Label 1 = text, Label 2 = camera #
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal

Line Generic            Line Feature, Label 1 = text, Label 2 = camera #
   text                 Text, Maximum Length = 30
                        Normal, Normal
   camera #             Text, Maximum Length = 30
                        Normal, Normal
```

Area Generic	Area Feature, Label 1 = text, Label 2 = camera #
text	Text, Maximum Length = 30
	Normal, Normal
camera #	Text, Maximum Length = 30
	Normal, Normal

Appendix 7

Entrainment Calculation Form

Entrainment Calculation Form (Andrews)

Stream:			Reach:		
Date:			Observers:		
	D_{50} Riffle bed material D_{50} (mm)				
	$\hat{D}_{50}$ Bar sample D_{50} (mm)				
	$\hat{D}_{100}$ (mm) Largest particle from bar sample		0.000	(ft)	304.8 mm/ft
	S Existing bankfull water surface slope (ft/ft)				
	d Existing bankfull mean depth (ft)				
1.65	G_s Submerged specific gravity of sediment				
$D_{50riffle}$	$\hat{D}_{50bar/subpave.}$	Ratio 1: $D_{50riffle}/D_{50bar/subpavement}$			
0	0	#DIV/0!	If between 0.3 & 4.2, use Eq.1. If outside range, calculate Ratio 2		
$\hat{D}_{100}$	$D_{50riffle}$	Ratio 2: $\hat{D}_{100(bar/subpave.)}/D_{50riffle}$			
0	0	#DIV/0!	If not between 0.3 and 4.2, use Equation 2		
If ratios are outside either of the above ranges, use Shields relationship.					
Use Equation 1? (1=yes, blank=no)			Use Equation 2? (1=yes, blank=no)		

Critical Dimensionless Shear Stress (Equation 1)

$$\tau_{ci} = 0.0834(D_{50riffle}/\hat{D}_{50bar/subpave.})^{-0.872}$$

Value	Variable	Definition
0	D_{50} (mm)	D_{50} Bed Material (D_{50} from riffle pebble count)
0	$\hat{D}_{50}$ (mm)	Bar Sample D_{50} or Sub-pavement D_{50}
0.000	τ_{ci}	**Critical Dimensionless Shear Stress**

Critical Dimensionless Shear Stress (Equation 2)

$$\tau_{ci} = 0.0384(\hat{D}_{100bar/subpave.}/D_{50riffle})^{-0.887}$$

Value	Variable	Definition
0	$\hat{D}_{100}$(mm)	Largest Particle from Bar/Sub-pavement Sample
0	D_{50} (mm)	D_{50} Bed Material (D_{50} from riffle pebble count)
0.000	τ_{ci}	**Critical Dimensionless Shear Stress**

Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample:

$$d_r = (\tau_{ci}*1.65*\hat{D}_{100})/S_e \quad \text{(Equation 3)}$$

1.65 = submerged specific weight of sediment

Value	Variable	Definition
	τ_{ci}	Critical Dimensionless Shear Stress (input value)
0.000	$\hat{D}_{100}$ (ft)	Largest particle from Bar/Sub-pavement sample $(D_{(mm)}/304.8)=D_{(ft)}$
0.0000	S_e (ft/ft)	Existing Bankfull Water Surface Slope
#DIV/0!	d_r (ft)	**Bankfull Mean Depth Required**
0	d_e (ft)	**Existing Bankfull Mean Depth (from riffle cross section)**
#DIV/0!	d_e/d_r	Ratio of Existing Mean Depth to Required Mean Depth

Check one: ☐ Stable (de/dr = 1) ☐ Aggrading (de/dr < 1) ☐ Degrading (de/dr > 1)

Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample:

$$S_r = (\tau_{ci}*1.65*\hat{D}_{100})/d_e \quad \text{(Equation 4)}$$

1.65 = submerged specific weight of sediment

Updated by DCSWCD 10/15/03

Value	Variable	Definition
	τ_{ci}	Critical Dimensionless Shear Stress (input value)
0.000	$\hat{D}_{100}$ (ft)	Largest particle from Bar/Sub-pavement sample $(D_{(mm)}/304.8)=D_{(ft)}$
0	d_e (ft)	Existing Bankfull Mean Depth (from riffle cross section)
0.0000	S_e (ft/ft)	Existing Bankfull Water Surface Slope
#DIV/0!	S_r (ft/ft)	Bankfull Water Surface Slope Required
#DIV/0!	S_e/S_r	Ratio of Existing Slope to Required Slope
Check one:	☐ Stable (Se/Sr = 1)	☐ Aggrading (Se/Sr < 1) ☐ Degrading (Se/Sr > 1)

Sediment Transport Validation	
0	Largest Particle in Bar Sample $\hat{D}_{100}$ (mm)
	Hydraulic Radius (ft) (input value)
0.00	Bankfull Shear Stress $\tau_c=\gamma RS$ (lb/ft^2) $\gamma = 62.4$ R=Hydraulic Radius S=Slope
0	Moveable particle size (mm) at bankfull shear stress (predicted by the Shields Diagram: Blue field book: p238, Red field book: p190)
0	Predicted shear stress required to initiate movement of $\hat{D}_{100}$ (mm) (see Shields Diagram: Blue field book: p238, Red field book: p190)
	Input value in light blue cells
	Yellow cells contain formulas, value will be calculated

After Wildland Hydrology 2001

Appendix 8

Agency Contacts and Funding Sources

Appendix 8 - Agency Contacts and Funding Sources

Technical Assistance

A wealth of information and assistance is available to local municipalities, landowners, and businesses in the West Branch watershed. Services are wide ranging through a variety of programs. Although funding and grant opportunities may not always be a possibility, the organizations listed below offer a variety of solutions for water quality, infrastructure, and property protection. Please do not hesitate to contact these resources with questions and requests. Many of these organizations also offer grant and other funding opportunities. Please see the grant resources list for more information on monetary support.

<u>Delaware County Soil & Water Conservation District</u>

With a soil and water conservation district in each upstate county in New York State, these local entities provide a variety of services to its local constituency. Most districts focus on offering agricultural assistance with best management practices (BMPs) through design, installation, and oversight. These BMPs include water management such as diversions, barnyard management systems, manure storages, grazing systems, and livestock water systems. Other services provided by DCSWCD include stream management, nutrient management, riparian buffer management and environmental education. DCSWCD is often a good starting place for information and assistance. If they cannot help, they can most likely point you in the right direction.

Delaware County SWCD 44 West Street, Suite 1 Walton, NY 13856 (607) 865-7161/7090 (607) 865-5535 Fax	Rick Weidenbach, Executive Director rick-weidenbach@ny.nacdnet.org Scotty Gladstone, Stream Program Coordinator scott-gladstone@ny.nacdnet.org Elaine Hitt, Watershed Ag Program Manager Elaine-hitt@ny.nacdnet.org

<u>New York City Department of Environmental Protection (NYCDEP)</u>

www.nyc.gov/dep

The Bureau of Water Supply works closely with landowners to achieve goals in an environmentally sensitive manner. NYCDEP has a variety of programs that assist landowners with the management of their property and streams. Please see below for a brief description of the various programs.

Land Acquisition: In 1997, the New York State Department of Environmental Conservation (NYSDEC) issued a permit that allowed the NYCDEP to acquire land for the purpose of watershed protection. The acquisition of land is one of the best ways to ensure the ongoing prevention of pollution and to prevent future water quality problems from occurring as a result of adverse development close to critical natural features and reservoir intakes. Purchase of land at fair market value or placement in an easement is negotiated only from willing sellers. Interested parties should contact Dave Tobias dtobias@dep.nyc.gov, or the Land Acquisition Program at (845) 340-7540**.**

Stream Management: NYCDEP's Stream Management Program was established after the 1996-snowmelt flood to address the systemic challenges to overall water quality in the Catskill/Delaware watershed. Its mission is to establish long-term stewardship of the streams through a watershed-scale, community-based, geomorphic approach. Essential to achieving this goal is the provision of technical assistance to local municipalities, landowners, and businesses within the watershed. The stream management staff is available for consultation on property and infrastructure protection through natural channel design. Staff members also offer training and educational programs regarding these topics. Concerns or requests for service should be made to Beth Reichheld at ereichheld@dep.nyc.gov or call the Stream Management Program at (845) 340-7517.

Land Management: This program aims towards good stewardship of the natural resources in the West of Hudson watershed. Providing good stewardship is critical to the success of any water quality protection program. The Land Management Program develops land resource management plans for NYCDEP properties, conducts a recreational review, and develops basin plan, incorporating specific property by property uses and stewardship. In addition, the NYCDEP has implemented a public access program, making 50% of acquired lands available for recreational purposes like hiking, hunting, and fishing. For additional information contact John Potter at jpotter@dep.nyc.gov or call (845) 340-7541.

The DEP also oversees a number of other programs like the watershed agricultural and watershed forestry programs, sewer and septic maintenance, economic development, and watershed education through the Catskill Watershed Corporation (CWC). Please see the CWC description below for more details.

<u>New York State Department of Environmental Conservation (NYSDEC)</u>
www.dec.state.ny.us (Verified 12-07-04)
Many water related programs are offered by the NYSDEC. The agency has various divisions, which handle watershed assessment and management, environmental education, fisheries, and flood protection. Information about the NYSDEC stocking schedule, fishing licenses, and access points is available at http://www.dec.state.ny.us/website/dfwmr/fish/index.html (Verified 12-07-04) or by calling (607) 652-7366.

To receive information regarding any flooding issues and the National Flood Insurance Program, see http://www.dec.state.ny.us/website/dow/bfp/gisfpm/index.htm (Verified 12-07-04) or call (518) 402-8141 about flood control projects, or (518) 402-8146 about flood plain management.

In addition to the above services, the NYSDEC is also the regulatory agency for the state of New York's waterways. Having classified Catskill streams, the NYSDEC requires a

Protection of Waters Permit for disturbing the bed or banks of a stream. Please contact the following individual for direction and advice.

NYS Department of Environmental Conservation
Bureau of Habitat
65561 State Hwy 10
Stamford, NY 12167
(607) 652-2645

U.S. Army Corps of Engineers (USACOE) New York District
www.nan.usace.army.mil/index.htm (Verified 12-07-04)
The U.S. Army Corps of Engineers has a variety of duties related to stream management. If a municipality or landowner wishes to install a water-related structure, dredge or fill a stream, or affect a wetland area, USACOE will often assign a field technician to visit the sight in order to evaluate the need for a federal permit. USACOE also offers engineering designs and other technical expertise. In addition, they are available for planning, designing, and constructing flood control projects. For a field technician contact the office listed below:

Department of the Army
New York District, Corps of Engineers
Albany Field Office
1 Bond Street
Troy, NY 12180
(518) 270-0588

Catskill Watershed Corporation
www.cwconline.org (Verified 12-07-04)
The CWC is a not-for-profit corporation with a dual goal: to protect the water resources of the New York City Watershed west of the Hudson River, while preserving and strengthening communities located in the region. Although the CWC is mainly a source of funding (see grant information section below), they can also provide technical assistance. Pertinent programs for Catskill/Delaware stream stakeholders include the Stormwater Controls for New Construction, Stormwater Retrofit, Septic System Rehabilitation and Replacement, and Alternate Design Septic Program. For more information call (845) 586-1400. See also **Section 4.7**.

Watershed Agricultural Council (WAC)
www.nycwatershed.org (Verified 12-07-04)
WAC offers the Watershed Agricultural Program and the Watershed Forestry Program. WAC subcontracts with local, state, and federal agricultural assistance agencies, Cornell University, and the private sector to provide planning, education, training, engineering, scientific, and administrative support. See also **Section 4.5**.

National Rural Water Association

www.nrwa.org (Verified 12-07-04)

The National Rural Water Association is a non-profit federation of State Rural Water Associations. Their mission is to provide support services to State Associations who have more than 22,000 water and wastewater systems as members. Please see description below for New York state contact information.

New York Rural Water Association

www.nyruralwater.org/tech_assistance.shtml (Verified 12-07-04)

New York Rural Water Association (NYRWA) is a not-for-profit group organized in 1979 with the goal of promoting the development, improvement, and sound operation of rural drinking water and wastewater systems throughout New York State. New York Rural Water Association recently expanded its scope to offer training, technical, and administrative assistance to rural communities on solid waste management matters as well. Contact (518) 828-3155, or e-mail nyruralwater.org

Federal Emergency Management Association (FEMA)

http://www.fema.gov/ (Verified 12-08-04)

FEMA is the federal government agency responsible for administering emergency and disaster relief, recovery, planning and preparedness programs across the United States and territories. While FEMA's most apparent role is emergency response and recovery, its role in risk reduction through the establishment of building codes and administration of insurance programs like the national flood insurance program provide protection against losses of life and property in the case of an emergency or natural disaster. Based in Washington, FEMA operates regional offices across the United States including the Region II office in New York City, covering New York State. FEMA works in cooperation with other federal agencies and State and local emergency response entities such as the State Emergency Management Office (SEMO) and county Emergency Management officials (please see below). FEMA provides training to state and local officials on most aspects of their work including emergency response, disaster response planning, hazard mitigation planning, code interpretation and enforcement. Following a Presidentially declared disaster, FEMA's assistance can be available to state and local government, private individuals, and businesses. See also **Section 5.14**.

To contact the FEMA Region II office, please call (212) 680-3600.

New York State Emergency Management Office (SEMO)

www.nysemo.state.ny.us (Verified 12-08-04)

As stated above, the New York State Emergency Management Office is the state entity for pre- and post disaster assistance. Like FEMA, the state office provides planning and resources through cooperation with local governments, volunteer organizations like Red Cross, and the private sector. Where FEMA is primarily involved immediately after a disaster event, SEMO provides long-term recovery solutions. The state agency is more involved in the day to day planning and preparation for disaster response. Below are summaries of some of SEMO's major programs. See also **Section 5.14**.

Mitigation: This may be one of SEMO's most influential programs by providing preventative assistance to communities within the Catskills. Mitigation efforts intend to reduce negative impacts of floods and other major disasters by preparing predisaster planning. This program also aims to identify potential threats and repeatedly damaged structures and to offer positive solutions to reduce future losses and protect against the loss of life and property. It is the intention that preventative efforts will greatly reduce the cost of recovery and will also reduce the loss of property. SEMO manages a Hazard Mitigation Grant program available to communities that prepare hazard mitigation plans. Communities preparing the plan are eligible for grant program funds to implement hazard mitigation projects following Presidentially declared disasters within New York State. Individuals living in communities with plans may benefit from the program through the reduction in flood insurance rates.

Disaster Recovery Assistance: Recognizing that not all disasters can be prevented, this program aims to provide local assistance for faster recovery by coordinating public assistance funds, disaster housing assistance, individual family grants, and small business administration assistance.

Other Emergency Assistance: SEMO also provides a variety of services during times of emergency. These services include state of the art communications, information dissemination, and emergency operation coordination.

Call the Emergency Coordination Center at (518) 457-2200 with questions or requests.

Cornell Cooperative Extension (CCE)
http://www.cce.cornell.edu/ (Verified 12-08-04)
Cooperative Extension builds partnerships and coalitions with individuals, communities, organizations, government agencies, and businesses around issues of mutual concern; develops local leaders who use CCE knowledge to inform decisions; promotes youth development through 4-H clubs and other experiences; strives to help participants make informed choices using the best knowledge available; connects learners with educational resources found in locations throughout the world; consults with individuals and groups on multiple topics; provides resources via technologies such as the World Wide Web, satellite, and compressed video.

(607) 865-6531 e-mail: delaware@cornell.edu

Natural Resources Conservation Service (NRCS)
www.nrcs.usda.gov/ (Verified 12-08-04)
NRCS puts nearly 70 years of experience to work in assisting owners of America's private land with conserving their soil, water, and other natural resources. Local, state and federal agencies and policymakers also rely on our expertise. They deliver technical assistance based on sound science and suited to a customer's specific needs. Cost shares and financial incentives are available in some cases. Most work is done with local partners. NRCS's partnership with local conservation districts serves almost every county. For further information contact:

USDA NRCS
Walton Service Center
44 West Street, Suite 1
Walton, NY 13856
(607) 865-4005

United States Geological Society (USGS)
http://ny.water.usgs.gov/index.html (Verified 12-08-04)
The USGS provides the Nation with reliable information about the Earth to minimize the loss of lives and property from natural disasters, to manage biological, water, mineral, and energy resources, to enhance and protect the quality of life, and to contribute to wise economic and physical development. The USGS provides a variety of assistance related to the four main categories of biology, geography, geology, and water. The water division is broken down into ground water, surface water, and water quality. Individuals can find a multitude of data throughout the website, search various resource databases, and view a number of maps. For more information call the Troy office at (518) 285-5600.

Catskill Forest Association (CFA)
www.catskillforest.org/ (Verified 12-08-04)
The Catskill Forest Association is a non- profit organization dedicated to enhancing all aspects of the forest in New York's Catskill region. CFA offers educational programs at all levels, from one-on-one on-site visits at landowner properties to group woods-walks, workshops and seminars. School-based activities include classroom visits and teacher training such as the Watershed Forestry Institute. CFA is also active in advocating for proper forest management, as well as promoting the economic development of viable markets for a variety of forest products. For more information, email cfa@catskill.net or call (845) 586-3054.

Catskill Center for Conservation and Development (CCCD)
www.catskillcenter.org/ (Verified 12-08-04)
The Catskill Center is a non-profit organization working to protect the cultural, historic, and natural resources of the Catskill Mountains. The CCCD has a few integrated program areas:

Land Conservation & Natural Resource Protection: This program identifies, monitors, and engages in effective actions to protect and preserve sensitive, ecologically significant, aesthetically, or recreationally critical lands and waters.

Community Outreach and Planning Assistance: This program provides technical support to rural communities in the Catskills on grants-writing, planning, land use, zoning, subdivision, community empowerment, main street revitalization, regional forums, conferences and workshops, producing reports and publications, and public policy development.

Education: This program consists of a curriculum entitled The Catskills: A Sense of Place, which is a series of five modules on the water resources, geography and geology, ecosystems, human history, and culture and arts of the Catskills. A Sense of Place is designed to give children a better awareness, understanding, and appreciation of the distinctive features of our area. In addition, The Center has partnered with Hudson Basin River Watch to support advanced water quality monitoring efforts by adult volunteer groups. Lastly, we host a hike, lecture, and recreation series for our membership and the general public throughout the year.

Visit their website at www.catskillcenter.org or call (845) 586-2611.

Trout Unlimited (TU)

www.tu.org/index.asp (Verified 12-08-04)

Trout Unlimited's mission is to conserve, protect and restore North America's trout and salmon fisheries and their watersheds. TU accomplishes this mission on local, state and national levels with an extensive and dedicated volunteer network. Local TU members have been active in many aspects of stream management planning throughout the Catskill/ Delaware watershed. Not only do they participate in public meetings, legislative activities, and volunteer events, but TU has also funded research projects such as the "Economic Impact Assessment of the Beaverkill-Willowemoc Trout Fishery" to promote improved trout habitats and stream health. Please contact the following local chapters for further information:

Upper Susquehanna 210: (607) 432-8587

Ashokan-Pepacton 559: (845) 254-5904

ESRI Environmental Conservation Program (CSP)

This program provides donations and discounts of GIS software, data, books, and training. It offers free on-line live workshops. The overall goal of the ECP is to support conservation groups in acquiring, learning, and using GIS tools and methods. ECP has a particular focus on appropriate levels of technology for locally sustainable programs. Its goal is not to throw out one-off donations into a vacuum with no forethought, but to build permanent, locally based support structures that provide ongoing evolutionary growth in GIS skills. Email rcdgrant@esri.com for detailed information.

Name	Focus	Due Date	Contact	Award Example	Notes/Priority	on-the-ground	research	planning	<$20K	$20K to $100K	>$100K	Range
National Resources Conservation Service Conservation on Private Land http://www.nfwf.org/programs/nrcsnacd.htm	Projects that engage private landowners, primarily farmers, on-the-ground projects.	1/7/2005 9/16/2005	NE Regional Office, Tim Kelsch, 202-857-0166 or Lynn Dwyer, 631-312-4793		Partnerships with NRCS or local conservation districts, priority given to landscape, watershed scale projects integrating agriculture and forestry that benefit fish and wildlife	X			X	X		4K-100K
Emergency Watershed Protection http://www.nrcs.usda.gov/programs/ewp/factsheet.html	Projects support such work as clearing debris from clogged waterways, restoring vegetation, and stabilizing streambanks after major storm events	on-going	Walton Service Center 607-865-6713		The measures that are taken must be environmentally and economically sound and generally benefit more than one property owner,	X						
National Oceanic and Atmospheric Administration http://nmfs.noaa.gov/habitat/restoration	Provides funds for small-scale, locally driven habitat restoration projects that foster natural resource stewardship within communities.	9/14/2005	Robin Buchner 301-713-0174	Provides funding to implement on-the-ground habitat restoration projects to benefit marine, estuarine and riparian habitats		X				X	X	14K-8mil
Federal Emergency Management Association http://www.fema.gov	Program helps states and communities identify and implement measures to reduce or eliminate the long-term risk o flood damage to homes and other structures	established by states	26 Federal Plaza, New York, NY 10278 212-680-3600		Two types offered: planning and project grants for National Flood Insurance Program for participating communities	X		X				
U.S. Fish and Wildlife Service North American Wetlands Conservation Act Grants http://birdhabitat.fws.gov/NAWCA/grants.htm	Standard and small grants programs help deliver funding to on-the-ground projects through the protection, restoration or enhancement of an array of wetland habitats	3/04/2005 7/29/2005	Standard-David Buie 301-497-5870; Small Keith Morehouse 703-358-1888					X	X	X	X	small=<50K standard= 50K-1mil
Partners for Fish and Wildlife http://partners.fws.gov/	Focuses on restoring former and degraded wetlands, native grasslands, stream and riparian areas, and other habitats to conditions as natural as feasible.	on-going	Martha Naley 703-358-2201	The program has partnered landowners to restore wetlands in-stream aquatic and riparian habitat. Has reopened stream habitat for fish and other aquatic species by removing barriers to fish passage.	Provides technical and financial assistance to landowners interested in voluntarily restoring or otherwise improving native habitats for fish and wildlife on their lands.	X			X	X		<25K
State Emergency Management Office http://www.nysemo.state.ny.us/	Provides leadership, planning, education, and resources to protect lives, property and the environment.	on-going	Chief of Recovery 518-457-7082 postmaster@semo.state.ny.us			X		X	X	X	X	
Catskill Watershed Corporation Catskill Fund for the Future http://www.cwconline.org/econ_dev/ed_index.htm	Funds used to make loans and grants to businesses and organizations proposing environmentally responsible projects .	accepted on a rolling basis	Michael Triolo, triolo @cwconline.org or Phil Sireci, sireci@cwconline.org	Delhi received money for establishment of a Riverwalk Community Park (purchase of riparian property and development of a village riverfront area with canoe access).	This fund program includes a variety of grant and loan programs.	X		X	X	X	X	2K-100^{+}K
Septic System Rehabilitation and Replacement http://www.cwconline.org/programs/septic/septic.htm	This program reimburses homeowners for repairing or replacing damaged septic tanks	after completion of repair or replacement	Leo LaBuda, labuda@cwconline.org; John Jacobson, jacobson@cwconline.org or Kirsten Miller at kmiller@cwconline.org		Program limited to homeowners in areas highly sensitive to water quality, as identified by NYCDEP.	X			X			60% and 100% of eligible costs for non-primary and primary landowners, respectively
Stormwater Controls for New Construction http://www.cwconline.org/programs/strm_wtr/strmwtr_controls.htm	Program to design and construct runoff and erosion control measures.		Elizabeth Mastrianni, emastrianni@cwconline.org			X					X	
Stormwater Retrofits http://www.cwconline.org/programs/strm_wtr/strmwtr_retro.htm	Program to provide funds for stormwater management needed to correct or reduce existing erosion, polluted runoff or other problems associated with stormwater.		Elizabeth Mastrianni, emastrianni@cwconline.org	Town of Andes, $260,000 to install drainage along Tremperskill Road and its intersection with Main Street and Cabin Hill Road in the hamlet of Andes	Projects to implement stormwater BMPs that reduce erosion and/or pollutant loading associated with conditions existing on or before January 21, 1997 are eligible to apply.	X			X	X	X	up to 75% of project costs

Name	Focus	Due Date	Contact	Award Example	Notes/Priority	on-the-ground	research	planning	<$20K	$20K to $100K	>$100K	Range
Public Education http://www.cwconline.org/programs/pub_edu/pe.htm	Projects that are intended to increase awareness, understanding and appreciation of clean water, the City's vast water delivery system, and the upstate Watershed which supplies 90 percent of the water consumed by nine million people		Diane Galusha, dgalusha@cwconline.org	South Kortright Central School (two grants); Delaware Academy and Central School, Delhi; Sidney Central School; Sidney Memorial Public Library; the Roxbury Arts Group, and the Catskill Forest Association.		X			X			1K-12K
Community Wastewater http://www.cwconline.org/programs/wastewater/wastewater.htm	Intended to address wastewater handling needs in five of the remaining 15 hamlets on the priority list			New Program for 2005 -06								
National Fish and Wildlife Foundation General Challenge http://www.nfwf.org/programs/guidelines.htm	Projects that address priority actions promoting fish and wildlife conservation and the habitats on which they depend, work proactively to involve other conservation and community interests.	year round, two decision cycles	NE Regional Office, Tim Kelsch, 202-857-0166 or Lynn Dwyer, 631-312-4793	Tioga County SWCD received $9,700 to restore 8 acres of former floodplain to benefit fish and wildlife habitat along the Catatonk Creek.	Goods and services that are exchanged for cash are ineligible.			X	X	X		10K-150K
Native Plant Conservation Initiative http://www.nps.gov/plants/nfwf/index.htm	Projects that protect, enhance and/or restore native plant communities on public and private land, including protection and restoration, information and education, and inventory and assessment.	twice/year, 12/1/2005 7/15/2005	Ellen Lippincott, 202-857-0166		Special emphasis is placed on larger projects that demonstrate a landscape-level approach and produce lasting broad based results on the ground.							
Five Star Grant Program http://www.nfwf.org/programs/5star-rfp.htm	Projects must include a strong on-the-ground wetland, riparian, or coastal habitat restoration component and should also include training, education, outreach, monitoring, and community stewardship components.	annually 3/01/2005	Sarah Ellgen, 202-857-0166			X			X			5K-20K
Watershed Agricultural Council NYC Watershed Forestry Program http://www.nycwatershed.org/	Provides cost-sharing incentives and technical assistance to watershed forest owners to promote forest management planning and help establish streamside buffers.	rolling assistance	607-865-7790		Assistance from this program could be used to establish additional grants from matching programs that require existing challenge funds and partnerships.			X	X			
Fish America Foundation http://www.fishamerica.org	Supports fisheries conservation and research in the best way by providing matching grants that empower citizen conservationists in their own communities nationwide.	7/31 each year	703-519-9691	Coldwater Fisheries Coalition & the New Hampshire Council of Trout Unlimited (2002: $8,000) To restore fisheries habitat and improve water quality along the Cold River by installing instream habitat structures, stabilizing streambanks and planting the riparian areas.		X	X					$500-10K
The Conservation Fund Kodak American Greenways Award http://www.conservationfund.org/?article=2372	Small grants to stimulate the planning and design of greenways in communities throughout America.	3/01 to 6/01 each year	greenways@conservationfund.org 703-525-6300		Grants used for appropriate expenses needed to complete greenway projects including planning, technical assistance, legal and other costs			X	X			up to $2,500
TechGrants http://www.techfoundation.org	TechFoundation is committed to bringing financial resources, technology solutions and management expertise to nonprofits to strengthen the social sector.	March each year	Kathleen Sherwin, 617-354-7595, grants@techfoundation.com	Colorado Environmental Coalition, www. ourcolorado.org	Awardees selected for focus on projects that will bring quality resources to nonprofits and show that effectively deployed technology can have a great impact on the ability of a nonprofit to achieve their mission.	X		X	X	X		5K-35K
Earthwatch Institute Research Program http://www.earthwatch.org/research/index.html	Supports scholarly field research worldwide in the biological, physical, social and cultural sciences.	on-going	978-461-0081 research@earthwatch.org	Projects monitor water quality in lakes, streams, wetlands and agricultural areas. Projects involve the inventory, monitoring or restoration of watershed environments.	Grants cover cost of maintaining volunteers and principal research staff in the field. Cannot be used for PI salaries, capital equipment or overhead costs.				X	X	X	7K-130K
Toshiba America Foundation http://www.toshiba.com/taf/apply.html	Contributes to the quality of science and mathematics in U.S. communities by investing in projects designed by classroom teachers to improve science and mathematics education.	accepted year round	212-596-0620 foundation@tai.toshiba.com	Chimacum Middle School received money for 7th and 8th grade earth science students to conduct a water quality study in their area.		X			X	X		2K-24K

Appendix 9

Comments Compendium

Stream Corridor Stewardship Plan

Summary of Public Comments on Recommendations

A total of thirteen comments were received. The recommendations were generally accepted and supported by the public. The necessity of all agencies working together was important to achieving the common goal of healthy streams with respect to the Conservation Reserve Enhancement Program (CREP). There are some concerns about incentives for non-agricultural landowner's participation and it was suggested that there should be some sort of land tax easements for maintaining or improving stream characteristics. Another incentive suggestion was public recognition of good stewardship like a sign or plaque recognizing a family, town or village for maintaining their streambanks which would help get people interested in developing programs or partner groups such as watershed associations.

There was some controversy with streamlining the permitting systems. People generally thought it would be ideal to have all agencies work together to develop a simpler permitting process.

Gravel deposits were a big discussion during public meetings. People were concerned with gravel bar buildup in streams strongly felt they need to be addressed. A maintenance program was suggested to identify the problematic gravel bars and economically remove them to realistic stream channel dimensions. The public also feels that there should be funding for this program provided by New York City.

Financing stream projects is a big concern. One suggestion was that townships or municipalities could aid the process by budgeting for stream projects or to develop programs to make private citizens aware of situations near their homes and how they can help improve stream health with simple, inexpensive solutions.

Name	Recommendation #1
Ron Frisbee/Landowner	This integration is an absolute necessity. I would recommend that BMP's be developed locally to be applied to the Stream Stewardship Plans to maintain stability
Jerry Fraine/NYS DEC	Recommendation #1-4 are all good recommendation
Tom O'Brien/WAC Executive Director	We fully support the integration of the Stream Corridor Management Program (SCMP) and Watershed Agricultural Program (WAP) as follows: Establishment of a stream maintenance component in the Whole Farm Planning process supported by the Environmental Review/Problem Diagnosis process. Training for WAP staff to identify stream related issues.
Stub & Marian Ploutz/Landowners	The Draft presented has some good areas: working with the whole farm plan should have been done as early as 1996, Working with the CWC, Plans for non-ag. Land , Helping Municipalities, Flood hazard mitigation & flood recovery and Prioritizing of stream projects.
Shelly Johnson/ Chief Planner Delaware County Planning Dept.	The recommendation lists partners to assist in meeting the goals of this recommendation. However, the Delaware County Agriculture and Farmland Protection Board (DC AFPB) is not included. In addition this recommendation does not seem to take the Delaware County Agriculture and Farmland Protection Plan (DC AFPP) into consideration. The Plan should be evaluated to ensure the DC AFPP and the Stream Corridor Plan do not have contradictory goals. In addition the DC AFPB should be a partner to ensure the objectives of the Stream Corridor Plan are taken into consideration as they review actions on farmland in the county.

Name	Recommendation #2
Ron Frisbee/Landowner	Yes! CREP will only be successful on a basin-wide scale if the unstable sites are fixed. There are negative public opinions out there amongst the riparian shareholders, when CREP monies are available to be applied to only stable sites and the river is allowed to claim the unstable sites.
Tom O'Brien/WAC Executive Director	We fully support the concept of SCMP technical assistance to WAP to stabilize stream banks and facilitate the Conservation Reserve Enhancement Program (CREP) at sites currently ineligible for CREP.
Agricultural Meeting Delhi 3/24/2005	Any part of the program going to help already existing CREP ground that have been microburst or unavailable CREP grounds? Established a buffer/CREP area: How can we get assistance to areas that are not working before we lose the whole thing? Can't afford to repair it and it is required to do it. (Existing CREP that are damaged) Is there any funding available?

Name	Recommendation #3
Ron Frisbee/Landowner	A lot of potential here, especially in the area of funding.

Name	Recommendation #4
Ron Frisbee/Landowner	This is an excellent idea. Some sort of incentive program could be developed whereby membership in a West Branch Basin Streambank Owners Association would qualify the landowner for FREE Stream Corridor Management Plan similar to the Forestry management plans. The Streambank Owners Association will facilitate permitting under a Basin-wide permit (Army Corp) and educational and technical assistance to the landowners not eligible for the WAP.
Ed Stammel	Besides education what will encourage them to change... money! As a specific addition to Recommendation #4 tax easements by adding: Municipalities within the watershed should be encouraged to provide non-agricultural land owners with permanent tax easements for maintaining or improving stream characteristics. Similar easements should be granted to landowners who undertake activities which either enhance aquatic life or provide recreational access. Municipalities will resist any actions which reduce their tax dollars. If, on the other hand, they can be convinced that a well managed river with recreational opportunity will reduce flood damage to their roads and bridges and bring in the all-important tourist dollar. Why come to Delaware County if you are not allowed to enjoy the land? Government entities must be convinced that in the long run, the river is our best asset and any actions to enhance it will benefit all stakeholders in the valley.

Name	Recommendation #5
Ron Frisbee/Landowner	see above. Also recommend some sort of program to facilitate the removal of trees that have fallen in the channel and pose a threat to public safety and navigation AND/OR negatively effecting stream stability. NYC reimbursement to landowners with a Stream Corridor Management Plan?
Willard and Lucile Frisbee/Landowners	Must be a top priority for implementation. We heartily endorse all recommendations which allude to the permitting process. The current proposed (state) wetland legislation being discussed by the Board of Supervisors must be discouraged. Citizens should be alerted to be in touch with their Albany representatives! The State of New York has carried regulation much too far for too long, in our opinion. Good common sense in dealing with problems seems to elude officials in some of our agencies!
Lucinda C. Collins/Director Bureau of Program Resources and Flood Protection	The local communities should also be included in the working group, since they have jurisdiction over floodplain development in mapped special flood hard areas (SFHAs), as shown on their Flood Insurance Rat Maps (FIRMs). It is anticipated that new FIRMs will be developed for Delaware County over the next several years, which will include more detailed SFHAs especially in the West-of-Hustson watershed.
Stub & Marian Ploutz/Landowners	The recommendation to Streamline the Permit process does not go far enough. There are too many organizations with their fingers in the process and it will never work. There should be one agency as the lead agency with the others signing off to that agency with the Permit application being more general than specific and only a few pages long. The permitting process should be followed up with the technical and design help and the SWCD as a support agency in implementing the projects.
Public Meeting comments Walton 3/31/2005	Do you think we can get them to work together instead of going to one to another agency? Are you going to get Army Corps of Engineers to corporate?
Public Meeting Walton 3/31/2005	There are some private owners that would like to fund their own projects but the permitting is such a hassle. Is there going to be technical advice or help with permitting?
Shelly Johnson/ Chief Planner Delaware County Planning Dept.	This should be an ideal way to do permits. Would this include the permits that the Delaware County Department of Public Works (DPW) must get prior to doing bridge work and/or other road improvements along a stream? If this is the case DPW should be involved in this process and should be included in any committee that would be used to re-write the regulations allowing for a more direct permitting process.

Name	Recommendation #6
Ron Frisbee/Landowner	#6-#14 all very good ideas and should be implemented.
Jerry Fraine/NYS DEC	This would be a tremendous asset to the municipalities and to DEC also. The problem would likely come down to cost. Typically, if a town wants to replace a culvert, and we request one with a larger diameter than they are proposing they resist on the basis of cost. However, if we can get some to put in larger diameter culverts, and bed them in the stream, I think we'll have less problems with aggradation above the culvert and erosion of bed and banks below the culvert.
Lucinda C. Collins/Director Bureau of Program Resources and Flood Protection	When considering culvert designs, the developer should review the effective FIRMs to see if the project falls within a mapped SFHA, and be aware of the requirements of the Local Law for Flood Damage Prevention in effect in that community. In general, development in the SFHA can have no adverse effects on adjoining properties, and if located within a regulatory floodway the project must not increase the base flood elevation (BFE).
Public Meeting Delhi 4/19/2005	How can people remove debris from culverts (regarding DEC permit issues)? Are SWCD permitting people to excavate gravel bars and remove debris?
Shelly Johnson/ Chief Planner Delaware County Planning Dept.	This technical assistance could be provided through recommendations made during the development of individual Town Highway Management Plans (HMPs). Then reconstruction can be incorporated with other highway maintenance programs. Therefore a more comprehensive look at the problem can be incorporated into the repairs, extending the life of the infrastructure. The Delaware County Planning Department (DCPD) along with DPW has committed significant time to the development of Town HMPs. The HMPs are intended to be a tool for municipalities to categorize and prioritize infrastructure improvements. DCPD has been very successful at getting funding to complete inventory and data collection for the HMPs. However, DCPD and DPW have struggled to get funding for the evaluation and assessment portions of the HMP development. This lack of funding has posed a significant hurdle to completing this task. The Management Plan appears to assume DPW can undertake this task, however, it has been our experience that the costs associated will require additional funding and there have been few funding streams available for this work.

Name	Recommendation #7
Jerry Fraine/NYS DEC	Good

Name	Recommendation #8
Jerry Fraine/NYS DEC	As I mentioned previously, I think this would be a very worthwhile endeavor.
Lucinda C. Collins/Director Bureau of Program Resources and Flood Protection	It is anticipated that various education and outreach activities will be developed and performed as part of the floodplain remapping effort in the County. We look forward to working with the County and the Stream Corridor Management Program on these items.
Public Meeting Walton 3/31/2005	Do you have staff to go out and tutor home owners on how to properly steward their stream? You don't have staff enough to do this?
Shelly Johnson/ Chief Planner Delaware County Planning Dept.	This education and outreach should start with the local planning boards. When a planning board conducts a review for subdivision or a site plan evaluation they should be aware of the concerns of the Soil and Water Conservation District in regards to the impacts on streams in light of additional growth and development. The planning boards could then be used as a local engine to distribute information and they could host workshops for private property owners that are current stakeholders or adjoining property owners. The Delaware County Planning Department's Town Planning Advisory Service (TPAS) may be a tool that could assist in education and outreach to the communities. It may also be useful to approach the town planning boards about the development of watershed associations.

Name	Recommendation #9
Jerry Fraine/NYS DEC	Good
Lucinda C. Collins/Director Bureau of Program Resources and Flood Protection	Where BFEs and floodways are shown on the effective FIRMs (so called studies"), information is often available from this office that may help document past conditions along the stream. This information generally consists of hydraulic models, commonly developed using HEC-2, which include channel cross-sections, n-values and estimated flows.
Public Meeting Walton 3/31/2005	What should you do in this situation? (Referring to Recommendation #9 photo of the bridge with a gravel problem.)
Shelly Johnson/ Chief Planner Delaware County Planning Dept.	Most projects require SEQRA and/or NEPA depending on the funding stream If that were the case those bridges are already being evaluated as to the impacts to the stream in order to get a negative declaration. In addition, NYS DOT may do similar reviews depending on the size of the project they are doing. Design reports and environmental assessments are completed for the larger bridges before they are reconstructed and as part of that work SEQRA and sometimes, NEPA are done. Therefore, the Soil and Water Conservation District geomorphic assessment should be done as part of the environmental review process conducted during the design phase of a project. Delaware County Planning and DPW should use Soil and Water expertise for this specific review and assessment.

Name	Recommendation #10
Jerry Fraine/NYS DEC	This is an excellent idea. Every year we get inquires from people that want to know what to do to stop their residences and out buildings from getting flooded. More often than not, when you visit the site they are in some small localized floodplain on a small tributary. Having these floodplains mapped would allow the towns to regulate development within these areas.
Public Meeting Walton 3/31/2005	Isn't the floodplain mapping a project that is a state initiative?
Shelly Johnson/ Chief Planner Delaware County Planning Dept.	This recommendation describes a process in which Soil and Water should work with all other partners to complete the County Hazard Mitigation Plan and the FEMA studies and maps. In the text it includes SEMO, however they should also be listed in the recommendation rather than just the description.

Name	Recommendation #11
Jerry Fraine/NYS DEC	Good

Name	Recommendation #12
Ron Frisbee/Landowner	Have FEMA by the property as they did in Schoharie and save us all a lot of money…apply those funds to the failing banks that are degrading water quality.
Phil Pierce/DPW	I am surprised to see the two sites in Walton identified as one of the "recommendations". This implies that they are considered much more important than any other identified sites. It seems odd that they are singled out in this manner.
Jerry Fraine/NYS DEC	Good.
Stub & Marian Ploutz/Landowners	Your plans to obtain funds one year, design the next year and the implementation the third year. If a business were run that way you would be out of business before you could get started.
Public Meeting Walton 3/31/2005	You should start dumping rock over the bank that is what you should be doing to stop the water from hitting the bank.

Name	Recommendation #13
Jerry Fraine/NYS DEC	Good.
Shelly Johnson/ Chief Planner **Delaware County Planning Dept.**	None of the criteria discusses the needs of intervention based on surrounding land uses and future development pressure. This includes the potential for subdivision, the potential for development based on local zoning or other land use laws and the potential for development based on proximity to hamlet or village areas and their extension areas. All of these thanks have profound impact on the continued deterioration of stream banks and the potentials for contaminates into a stream. These should certainly be criteria for evaluating priority areas.

Name	Recommendation #14
Jerry Fraine/NYS DEC	This is of course a good idea. I thought it might be useful to include a time frame for the updates. Maybe every 5 years?

Name	Recommendation #15 Gravel Bar Removal
Tom O'Brien/WAC Executive Director	We suggest that SCMP explore a maintenance program to identify and economically remove problematic gravel bars and debris from stream channels. This process should also include a component to expedite regulatory permitting.
James Eisel/Delaware County Board of Supervisors Chairman	Gravel buildup in stream is a systemic problem that needs to be addressed. The Board and our constituents have strong feelings regarding this matter. Therefore, the Board moved that an additional recommendation be included in the Plan to implement a pilot program to scientifically remove problematic gravel bars to realistic stream channel dimensions and the New York City should assist with the funding this program as part of their Stream Management Program.
Willard and Lucile Frisbee/Landowners	gravel deposits also cause serious erosion and should not be ignored
Stub & Marian Ploutz/Landowners (Public meeting Walton, 3/31/2005)	What about gravel bar removal? The channel is not as deep as it used to be… I think it is flooding out faster because of the change in channel depth. What can we do about this? Should we get a drag line and dredge the stream out?
Public Meeting Walton 3/31/2005	We need to take out some of these gravel bars. Town roads clean out the ditch and the sediment builds gravel bars in the river where I used to swim is now filled in.
Agricultural Meeting Delhi 3/24/2005	Previous to 1996 storm, 5 feet of top soils is lost each year and we were allowed to go into the river to remove gravel bars. Why are we not allowed to continue to get into the rivers to remove gravel bars again? Gravel removal needs to be addressed! It is less money to remove gravel each year which is a temporary fix but it is the biggest bang for the buck.
Public Meeting Delhi 3/24/2005	Are SWCD permitting people to excavate gravel bars and remove debris?
Public Meeting Delhi 4/19/2005	How can people remove debris from culverts (regarding DEC permit issues)? Are SWCD permitting people to excavate gravel bars and remove debris?
Public Meeting Walton 3/31/2005	What should you do in this situation? (Referring to Recommendation #9 photo of the bridge with a gravel problem.)
Willard and Lucile Frisbee/Landowners	Removal of flood debris should be facilitate in a timely manner. (Our discussion concerns fallen trees, but gravel deposits also cause serious erosion and should not be ignored.) Dangerous blockage of the stream by trees can cause loss of life (canoeist/kayakers) plus the normal flow can be diverted to cause severe ongoing erosion and loss of cropland.

Name	General Comments
Ron Frisbee/Landowner	Not sure where this fits, but the same philosophy that has been utilized by New York City in their Watershed Agriculture and Forestry Programs needs to be applied to the Stream Corridor Management Program in terms of cost-sharing. The Riparian landowner should not be responsible for the costs involved in the implementation of stabilization methodologies. A concerted effort should be made by the shareholders within the NYC Watershed to receive permission to "work in the wet". To continue to be restricted to a "no noticeable change in turbidity" standard for water quality in New York State will be too expensive to implement effective stabilization of streambanks on a Basin-wide scale. What funding is available would go much farther if work could be done "in the wet" as in Pennsylvania and other states. The Army Corp and NYC should move to get an exemption for the permitted work under this Program. As Rosgen did out West, the SCMPr should gather turbidity data during natural events for comparison to turbidity generated by stabilization techniques. Overall, the recommendations are great. Keep up the good work!
Gail Hillriegel/Director of WAC	You asked me to send my comments on the Stream corridor Plan draft. I thought it was very good and covered considerable situations making it overall very useful and helpful. I know with any such work the next question is who is going to finance it? May I suggest that the townships of the county each give money toward implementing the plan. Possibly $10,000 to start to get the ball rolling. My reason for suggesting the townships get involved is they tend to wait until there is a flood and then expect FEMA to bail them out. Why not do prevention work to help avoid serious damage to roads and bridges. It seems that it would have to make a difference. Private citizens could also be made aware of situations near their homes and farms that could help prevent flooding by sometimes just some simple, inexpensive solutions. I would hope as many of these a possible could be done as soon as the problem was identified and a solution decided. I would hope that if everyone worked together, WAC, DEP, Townships, NRCS, Soil and Water and individual citizens as well as the counties in the
Dan Sanford/DPW	From what I read it looks good.
Paula O'Brien	Great vision! Great recommendations. The teaming of agencies in the CREP, Stream Permitting, and DCAP is exactly what is needed. If I were to suggest anything it would be to encourage and incentive program for maintaining & managing streambanks. A financial incentive (tax break, money) would be the best, but in lieu of money - recognition of good stewardship would be great. I was thinking along the lines of "Dairy of Distinction" - a sign or plaque recognizing a family, or town, or village for maintaining their streambanks would get people talking about it, get it in the paper every so often, and make it a source of pride.

Name	General Comments
Ed Stammel	As an increasing number of second-home owners displace dairy operations, the proportion of land in ag production is decreasing. Unlike a farmer who is protecting his fields and livestock by creating and maintaining stable waterways, the weekenders only want to enjoy his "country place". There is, at present, no financial incentive to practice conservation on their land. There are two areas which must be addressed: 1. Soil and water conservation along the river. The non-ag owner is interested primarily in the aesthetic and is prone to remove vegetation from the bank. In addition he tends to build structures on the bank for personal use. These activities have the potential to degrade the channel 2. Recreational quality and access. The non-ag owner does not like to share his "piece of heaven". Thinking with a city/suburban perspective, they tend to fence and protect their land from trespass. They bar hunting, discourage fishing, and consider passing canoes and intrusion.
Phil Pierce/DPW	It provides an excellent reference manual to help explain the relationships of the many and varied entities involved with this complex topic. Nice touch on the introductory quotation at the beginning of sections. Clearly there is relatively little text devoted directly to DPW issues - I think I found them. I suggest that work cited in Bovina Center and on Page Avenue (mentioned on Page 10 of 16, Section 4) be reworded to say it is nearing construction - not built yet. Nice job - you should be very proud of it. Hope money can be found to keep it a living document.
Tom Hutson/Landowner	It is real important that your program get everyone on board that is agencies, landowners, and public officials. We have gone far too long without a scientific based plan for the East and West branches of the Delaware River. As a lifetime resident & farmer I am affected by this daily. We need an acting plan that allows us to deal with problems that need to be addressed in a timely and economically viable manner which taking into consideration all of out regions resources. They would include people, wildlife and loss of fertile river bottom soils.
Tom O'Brien/WAC Executive Director	The plan as presented is a good starting document for the future of stream stewardship and management in the West Branch. Overall we support the plan recommendations and concepts for the future of integrated stream management in the West Branch Delaware River watershed.
James Eisel/Delaware County Board of Supervisors Chairman	The plan was well thought out and presented and your concept of the plan as a starting document for the future of integrated stream stewardship and management was well received. For these reasons the Board adopted the Plan. The Board of Supervisors is committed to sound reasonable stewardship for out stream corridor and is fully supportive of the recommendations presented.
Willard and Lucile Frisbee/Landowners	Removal of flood debris should be facilitate in a timely manner. (Our discussion concerns fallen trees, but gravel deposits also cause serious erosion and should not be ignored.) Dangerous blockage of the stream by trees can cause loss of life (canoeist/kayakers) plus the normal flow can be diverted to cause severe ongoing erosion and loss of cropland.

Name	General Comments
Public Meeting **Delhi 3/24/2005**	Do we have a practical plan for establishing Watershed Associations and for getting money? (Funds needed vs. funds available) Don't fight for money, become "fund-raisers". The Plan should suggest ways to get funding. Towns should give tax incentives to non-ag. landowners to encourage them to take over stewardship being all our money goes to ag. land.
Shelly Johnson/ Chief Planner **Delaware County Planning Dept.**	1.The commendations seemed difficult to understand until after reading the remainder of the document. By making them the first thing the reader sees, it is difficult to justify each recommendation and there is little understanding as to the importance of each recommendation. Often in planning documents an easy to read table or Action Plan can be a useful tool in assisting potential users of the plan by providing a quick reference which includes what the tasks are, who the responsible party for each task is, an anticipated time of completion for each task and potential funding sources for financing each task. 2.Are the recommendations in order of priority? If so, how was the prioritization calculated and what are the time frames for anticipated completion of each recommendation?

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10. Glossary

Note: where a word within a definition is italicized, it is defined elsewhere within the glossary

aggradation (aggrading) – A progressive build-up or raising of the channel bed and *floodplain* due to *sediment* deposition. The geologic process by which streambeds are raised in elevation and *floodplains* are formed. Aggradation indicates that stream *discharge* and/or *bedload* characteristics are changing.

aquatic habitat – Physical attributes of the stream channel and *riparian area* that are important to the health of all or some life stages of fish, aquatic insects and other stream organisms. Attributes include water quality (temperature, pH), *riparian* vegetation characteristics (shade, cover, density, species), stream bed *sediment* characteristics, and *pool*/*riffle* spacing**.**

Bank Erodibility Hazard Index (BEHI) – An index for predicting *erosion potential* on selected streambanks, usually associated with a *monitoring cross-section* for measurement of actual *erosion* rates over time (Rosgen, 1996).

bankfull depth – The depth from the elevation of water surface at the *bankfull discharge* to the deepest point in the channel.

bankfull discharge – The discharge (or flow) that occurs, on average, every 1.2 to 2.0 years. This discharge, from relatively frequent storms, is largely responsible for the shape of the stream channel within the *floodplain*.

bankfull width – The width of the water surface at the *bankfull discharge*.

base flood elevation – The height of the base flood, usually in feet, in relation to the National Geodetic Vertical Datum of 1929, the North American Vertical Datum of 1988, or other datum referenced in the Flood Insurance Study report, or average depth of the base flood, above the ground surface.

bedload – *Sediment* moving on or near the streambed and transported by jumping, rolling or sliding on the bed layer of a stream.

berm – A mound of earth or other materials, usually linear, constructed along streams, roads, *embankments* or other areas. Berms are often constructed to protect land from flooding or eroding, or to control water drainage (as along a road-side ditch). Some berms are constructed as a byproduct of a stream management practice whereby stream bed *sediment* is pushed out of the channel and mounded on (and along the length of) the stream bank - these berms may or may not be constructed for flood control purposes; some are simply piles of excess material. These berms often interfere with other stream processes such as *floodplain* function, and can exacerbate flood-related *erosion* or stream *instability*.

boulder – In the context of *stream assessment surveys*, a boulder is stream *sediment* that measures between 256 mm and 4096 mm (about 10 inches to 13.3 feet).

braided – A stream form in which the channel splits into 3 or more separate sub-channels, often criss-crossing to produce a "braided" pattern of connected channel with large or small islands between them. Islands formed between the channels can be either bare *gravel* or *cobble* materials, or contain mature forest vegetation.

channel-forming flow – see *bankfull discharge*

clay, clay exposure (see also glacial lake clay) – Clay is the smallest *sediment* size present in a stream, measuring less than 0.0039mm in size. Clay can be identified by its smooth and slippery texture. Clay deposits can be seen in sections of the stream, and can produce *turbidity* in stream water when it is disturbed either during floods or by activity in the stream. For a detailed description of '*glacial lake clay*,' see Chapter 3.1.1, Geology.

cobble – In the context of *stream assessment surveys*, cobble material is *sediment* that measures between 64 mm and 256 mm (about 2.5 inches to 10 inches).

cohesive - Soil types such as *clays* and *silts* that are held together owning to attraction between like molecules.

confluence – The location of the joining of two separate streams, each with its own *watershed*.

cross-section (see also monitoring cross-section) – In the context of *stream assessment surveys*, a *cross-section* is a location on a stream channel where stream *morphology* is measured perpendicular to the *stream flow* direction (as if taking a slice through the stream), including width, depth, height of banks and/or *terraces*, and area of flow.

culvert – A closed conduit for the free passage of surface drainage water[3]. Culverts are typically used by the Town and County to control water running along and under the road, and to provide a crossing point for water from road side drainage ditches to the stream, as well as for routing *tributary* streams under the roads. Culverts are also used by landowners to route roadside drainage ditch water under their driveways to reduce or prevent *erosion*.

degradation (degrading) – The process by which a stream *reach* or channel becomes deeper by eroding downward into its bed over time, also called "downcutting", either by periodic episodes of bed scouring without filling, or by longer term transport of *sediment* out of a *reach* without replacement.

demonstration stream restoration project, (demonstration project) – A *stream (stability) restoration* project that is designed and located to maximize opportunities for *monitoring* of project success, public and agency education about different *stream restoration* techniques, and interagency partnerships for funding and cooperation.

destabilized (see also instability, unstable) – Describing a section of stream that has been made *unstable*, by natural or human activity.

discharge (stream flow) – The amount of water flowing in a stream, measured as a volume per unit time, usually cubic feet per second (cfs).

embankment – A linear structure, usually of earth or *gravel*, constructed so as to extend above the natural ground surface[3]. Similar to a *berm*, but usually associated with *road fill* areas, and extending up the hillside from the road, or from the stream up to the road surface.

entrenched – In stream classification (see s*tream type*), entrenchment (or entrenchment ratio) is defined by stream *cross-sectional* shape in relation to its *floodplain* and valley shape, and has a specific numerical value that in part determines *stream type*. For example, if this number is less than 1.4, the stream is said to be highly entrenched, if between 1.4 and 2.2 it is mildly entrenched, and greater than 2.2 it is not entrenched. Entrenchment ratio is used with other stream shape data to determine *stream type*, and define baseline data for future *monitoring* (Rosgen, 1996).

equilibrium (see also "stable") – The degree to which a stream has achieved a balance in transporting its water and *sediment* loads over time without *aggrading* (building up), *degrading* (cutting down), or migrating laterally (eroding its banks and changing course).

erosion – The wearing away, detachment, and movement of the land surface (*sediment*), by running water, wind, ice, or other geological agents, including such processes as gravitational creep or *slumping*. [1] In streams, erosion is a natural process, but can be accelerated by poor stream management practices.

erosion potential – The amount of *erosion* that may be expected under given climatic, topographic, soil, and cultural conditions. [1]

exotic plant – see *invasive plants*

floodplain – The portion of a river valley, adjacent to river channel, which is covered with water when river overflows its banks at flood *stage*. The floodplain usually consists of *sediment* deposited by the stream, in addition to *riparian* vegetation. [4] The floodplain acts to reduce the *velocity* of floodwaters, increase infiltration (water sinking into the ground rather than running straight to the stream - this reduces the height of the flood for downstream areas), reduce stream bank *erosion* and encourage deposition of *sediment*. Vegetation on floodplains greatly improves their functions.

floodstage – The *stage* at which overflow of the natural banks of a stream occurs.

gabions – Large wire-mesh baskets filled with rock material used to *harden* or *stabilize* road *embankments* and sometimes stream banks.

Geographic Information System (GIS) – Desktop software with a graphical user interface that allows loading and querying, analysis and presentation of spatial and tabular data that can be displayed as maps, tables and charts.[5] The maps in the West Branch Delaware stream management plan were produced with a GIS, and can be updated as new information becomes available.

Global Positioning System (GPS) – A satellite–based positioning system operated by the U.S. Department of Defense (DoD). When fully deployed, GPS will provide all-weather, worldwide, 24-hour position and time information.[6] The *stream assessment survey* done for the West Branch Delaware stream management plan included the use of a GPS unit to document the locations of all mapped stream features. This information was added to the *GIS* to produce the maps.

gravel – In the context of *stream assessment survey*, *gravel* is *sediment* that measures between 2 mm and 64 mm (about 0.08 inches to 2.5 inches).

hardening – Any structural *revetment* that fixes in place an eroding stream bank, *embankment* or hillside by using "hard" materials, such as rock, sheet piling or concrete, that does not allow for re-vegetation or enhancement of *aquatic habitat*. *Rip-rap* and *stacked rock walls* are typically considered to be hardening measures, though some revegetation of these areas is possible.

head-cut – A marked change in stream bed slope, as in a "step" or waterfall, that is unprotected or of greater height than the stream can maintain. This location, also referred to as a "knick point", moves upstream, eventually reaching an *equilibrium* slope.

hydrologic delivery zone – An area where surface water runoff enters a watercourse, particularly on the down slope end of a crop field with its surface water runoff pattern parallel with an adjacent watercourse.

instability (see also "unstable") – An imbalance in a stream's capacity to transport *sediment* and maintain its channel shape, pattern and profile.

incised – *Erosion* of the channel by the process of *degradation* to a lower base level than existed previously or is consistent with the current hydrology.

invasive plants – Species that are not native to a region or country that have the ability to compete with and replace native species in natural habitats, also referred to as "exotic" plants. (Erich Haber, Impact of Invasive Plants, 2002).

Japanese Knotweed (see also invasive plants) – An *invasive plant*, not native to the Catskill region, that colonizes disturbed or wet areas, especially stream banks, road-side ditches and *floodplains*. This plant out-competes natives and other beneficial plants, and may contribute to *unstable* stream conditions.

left bank – The left stream bank as looking or navigating downstream. This is a standard used in *stream assessment surveys*.

matrix – The framework material within which other materials are lodged or included. For example, *cobbles* could be embedded in a matrix of *sand* and fine *gravel*.

meander – Refers both to a location on a stream channel that is curved (a "meander bend"), and to the process by which a stream curves as it passes through the landscape (a "meandering stream").

monitoring – The practice of taking similar measurements at the same site, or under the same conditions, to document changes over time.

monitoring cross-section – For the purposes of the West Branch Delaware stream management plan, this is a location where metal rebar rods have been used to permanently locate an actively eroding stream bank. At this site, detailed data have been gathered to document the stream condition. The site is permanently marked to enable future measurements that, when compared to the existing condition, provide information about the stream's change. Measuring change over time is considered '*monitoring*,' and this information provides early warning to stream managers about important but perhaps visually imperceptible changes in the stream.

monumented – Refers to a location, usually a *cross-section*, that is marked with a permanent or semi-permanent marker, or "monument", to enable future *monitoring* at the same place.

morphology, stream morphology – The physical shape, or form, of a landscape or stream channel, that can be measured and used to analyze stream or landscape condition, type or behavior.

nutrient – The term "nutrients" refers broadly to those chemical elements essential to life on earth, but more specifically to nitrogen and phosphorus in a water pollution context. In a water quality sense nutrients really deals with those elements that are necessary for plant growth, but are likely to be **limiting** -- that is, where used up or absent, plant growth stops.

Pfankuch assessment – a stream channel *stability* evaluation procedure that assesses a number of stream channel and streambank conditions to derive a numerical rating for stream *reach* condition.

pool – A small section of stream characterized by having a flat or nearly flat water surface compared to the average *reach* slope (at low flow), and deep and often asymmetrical *cross-sectional* shape.

reach – A section of stream with consistent or distinctive *morphological* characteristics[1].

reference reach, stable reference reach – A *stable* portion of a stream that is used to model restoration on an *unstable* portion of stream. Stream *morphology* in the reference reach is documented in detail, and that *morphology* is used as a blueprint for design of a *stream stability restoration* project.

revetment – Any structural measure undertaken to stabilize a road *embankment*, stream bank or hillside.

riffle – A small section of stream characterized by having a steep water surface slope compared to the average *reach* slope (at low flow), and a shallow and often uniform *cross-sectional* shape.

right bank – The right stream bank as looking or navigating downstream. This is a standard used in *stream assessment surveys*.

riparian (area, buffer, vegetation, zone) – The area of land along stream channels, within the valley walls, where vegetation and other land uses directly influence stream processes, including flooding behavior, *erosion*, *aquatic habitat* condition, and certain water quality parameters.

rip-rap – Broken rock, *cobbles*, or *boulders* placed on earth surfaces, such as a road *embankment* or the bank of a stream, for protection against the action of water; materials used for soil *erosion* control. [1]

rotational failure (translational failure) – A geotechnical term referring to the shape and mechanism of a hillslope failure that results in a section of land surface that falls, or "fails", by rotating out of place along a curved plane surface (as opposed to sliding along a straight line or flat plane surface). This type of failure is common in the West Branch Delaware valley, easily recognized by "back leaning" trees on displaced sections of the slope, separated by fault scarps (cracks in the ground surface perpendicular to the failure direction, also often curved) as these blocks of land rotate downward and outward.

runoff – The portion of precipitation (i.e., rainfall) that reaches the stream channel over the land surface.

sand – In the context of *stream assessment surveys*, sand material is *sediment* that measures between 0.063 mm and 2 mm (up to 0.08 inches).

sediment, stream bed sediment – Material such as *clay*, *sand*, *gravel* and *cobble* that is transported by water from the place of origin (stream banks or hillsides) to the place of deposition (in the stream bed or on the *floodplain*).[3]

sediment discharge – The combination of *washload* plus *bedload* material.

silt – In the context of *stream assessment surveys*, silt material is *sediment* that measures between 0.0039 mm and 0.063 mm.

sinuosity – The ratio of channel length to direct down-valley distance. Also may be expressed as the ratio of down-valley slope to channel slope.

slump – The product or process of mass-wasting when a portion of hillslope slips or collapses downslope, with a backward rotation (also a rotational failure).

stable (see also equilibrium) – A stable stream is defined as maintaining the capacity to transport water and *sediment* loads over time without *aggrading* (building up), *degrading* (cutting down), or migrating laterally (eroding its banks and changing course). Stable streams resist flood damage and *erosion*, and provide beneficial *aquatic habitat* and good water quality for the particular setting.

stability – In stream channels, the relative condition of the stream on a continuum between *stable* (in *equilibrium* or balance) and *unstable* (out of *equilibrium* or balance). Stream stability assessment seeks to quantify the relative *stability* of stream *reaches*, and can be used to rank or prioritize sections of streams for management.

stacked rock wall – A *boulder revetment* used to line stream banks for stabilization. Stacked rock walls can be constructed on a steeper angle that *rip-rap*, so they take up less of the stream *cross-section*, provide a wider road surface, and provide less surface area for solar heating, allowing stream temperature to remain cooler relative to banks lined with *rip-rap*. These features can be augmented with bioengineering to enhance *aquatic habitat* and *stability* functions.

stage – In streams, stage refers to the level or height of the water surface, either at the current condition (i.e., current stage), or referring to another specific water level (i.e., flood stage).

stream assessment, stream assessment survey – The methods and summary information gathered in a stream *reach* or series of *reaches*, primarily focused on stream *morphology*. Stream assessment for the West Branch Delaware included detailed characterization and mapping of stream channel patterns, *cross-section* shapes and slope.

stream flow (*discharge*) – The amount of water flowing in a stream, measured as a volume per unit time, usually cubic feet per second (cfs).

stream stability restoration (design, project) – An *unstable* portion of stream that has been reconstructed, using *morphology* characteristics obtained from a *stable reference reach* in a similar valley setting, that returns the stream to a *stable* form (that is, to a shape that may allow the stream to transport its water and *sediment* load over time without dramatic changes in its overall shape).

stream type – As defined by Rosgen (1996), one of several categories defined in a stream classification system, based on a set of delineative criteria in which measurements of channel parameters are used to group similar *reaches*.

terrace – A level area in a stream valley, above the active *floodplain*, that was deposited by the stream but has been abandoned as the stream has cut downward into the landscape. These areas may be inundated (submerged) in higher floods, but are typically not at risk in more common floods.

thalweg – The line followed by the majority of the *stream flow*. [1] In *stream assessment*, this location is used as a reference location for surveys and other measurements, and is most often associated with the deepest point in the stream *cross-section* (i.e., the stream channel that would still have water flowing in it at even the lowest flow conditions).

toe – The bottom, or base, of a stream bank or *embankment*.

tributary – A stream that feeds into another stream; usually the tributary is smaller in size than the main stream (also called "mainstem"). The location of the joining of the two streams is the *confluence*.

turbidity – A measure of opacity of a substance; the degree to which light is scattered or absorbed by a fluid. Streams with high turbidity are often referred to as being "turbid".

unstable (see also instability) – Describing a stream that is out of balance in its capacity to transport *sediment* and maintain its channel shape, pattern and profile over time.

washload – The finest-grained fraction of the total *sediment* load, consisting of particles whose settling *velocity* are so low that they are transported in suspension at approximately the same speed as the flow and only settle out when flow *velocity* are much reduced.

watershed – A unit of land on which all the water that falls (or emanates from springs) collects by gravity and runs off via a common outlet (stream).[2]

wetland – An area that is saturated by surface water or ground water with vegetation adapted for life under those soil conditions, as in swamps, bogs, fens, and marshes.

velocity – In streams, the speed at which water is flowing, usually measured in feet per second.

[1]New York Guidelines for Urban Erosion and Sediment Control, USDA SCS, 1972

[2]Black, P., Watershed Hydrology, 1991, Prentice-Hall Inc., Englewood Cliffs, NJ

[3]Lo, S. 1992. Glossary of Hydrology. Water Resourced Publications, PO Box 2841, Littleton, CO. 80161

[4]Rosgen, D.L. 1996. Applied River Morphology.

[5]ArcView *GIS*: The Geographic Information System for Everyone. Environmental Systems Research Institute, Inc. 1996.

[6]GPS Pathfinder Office: Getting Started Guide. Trimble Navigation Limited. 1999.