Upper Esopus Creek

MANAGEMENT PLAN

VOLUME I · SUMMARY OF FINDINGS AND RECOMMENDATIONS

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Prepared by

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New York City Department of Environmental Protection

U.S. Army Engineer Research Development Center

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PREFACE

People and Catskill Mountain streams have had to adjust to each other for several centuries.We live with the beauty of streams while also learning to live with their powerful forces as they convey water and sediment out of the watershed. The streams that have helped carve these mountain valleys have adjusted their form to natural influences such as the regional climate, geology and ecosystem. Human development on the watershed landscape - roads, bridges, houses, and towns - are another influence on the stream's adjustment to its setting. Likewise, people adjust to the influences of the streams they live along. To sustain viable communities, we need to plan for the natural erosive and flooding forces that come with the steep slopes, melting snow and torrential rains common to the Catskills.

This planning process started in 2004 when a focus group representing diverse stream interests met to identify common issues concerning the Upper Esopus Creek (defined in this plan as above the Ashokan Reservoir). From these meetings, five long-term goal areas were identified, setting the scope of this Management Plan:

- Flooding and Erosion
- Water Quality
- Aquatic Ecology
- Recreation
- Management Coordination

With these goals in mind, the Project Team went to work on an "assessment" process that would inform recommendations for improvement in these goal areas. A physical assessment provided a baseline characterization of the Upper Esopus Creek corridor and assesses its physical and ecologic condition. We have also assessed people's opinions and needs about stream management as well as the history of human impacts on the stream.

This is not a manual on how to repair the Upper Esopus Creek. Given the constantly changing nature of streams and how

sensitive they are to human intervention, "repair" is not a practical objective. The site-specific "problems" identified today are not necessarily the problems that will be present tomorrow. As we who live and work along this stream know, the hammering floods of the last three years have shown how dynamic this stream is. Instead of looking at the stream as a fixed, stationary object, this Management Plan aims to create strategies that deal with the stream as a dynamic system.

General and specific recommendations for improving stream management are listed on page 23. Further findings on plan goals are detailed in subsequent chapters. (see "How to Use This Plan," p. 5). Some of the recommendations overlap or have some redundancy as this is a multi-objective planning effort. Also, because this Management Plan reflects the collaborative process of the Project Advisory Council (PAC) used to guide the planning process, we often use the words support, encourage, advocate when discussing many of the recommendations. Many entities will be responsible for the ultimate implementation of the plan recommendations.

This final draft of Volume I of the Upper Esopus Creek Management Plan was completed in November, 2008. Since the original draft in January 2007 several developments have taken place that require some content change from the original draft. Most notably, the Project Team has expanded to include Ulster County Soil and Water Conservation District ("District") and the Project Coordinator for Cornell Cooperative Extension is Elizabeth Higgins. In addition, New York City Department of Environmental Protection has committed new funding to support Management Plan recommendation implementation, as detailed below.

The Management Plan recommendations will be incorporated into Annual Ashokan Watershed Stream Management Program Action Plans ("Action Plans"). The Action Plans are developed annually by the Project Team and the Project Advisory Council. The Action Plans integrate the recommendations of all Ashokan Reservoir watershed stream management plans into annual work plans.

Successful implementation of the Management Plan requires a commitment to funding and stakeholder participation. In 2008, New York City Department of Environmental Protection ("DEP") committed a total of $8.15 million dollars in contracts for staffing an Ashokan Watershed Stream Management Program and implementation of prioritized recommendations for all Stream Management Plans in the Ashokan watershed (including Stony Clove and Broadstreet Hollow). $2 million dollars of that funding has been allocated to a grant-based program for local implementation of projects. An additional $2.1 million is specifically available for stream restoration/stabilization projects. Up to $400,000 dollars will be available to assist streamside landowners with restoring streamside vegetation for stream bank stability. Additional funding will be necessary as well. However, the current allocation of funding from the DEP and the commitment of the local community can help leverage needed grants from federal, state, and private foundation sources.

ACKNOWLEDGEMENTS

The Esopus Creek Project Team would like to appreciate the participation, support and patience of the residents of the Esopus Creek Watershed – particularly streamside residents who have allowed us to access their backyards in completing stream assessments. We also thank you for providing information through our surveys and various community activities and interviews.

Great appreciation is given to the following volunteers and agency staff for their support and generous assistance in developing the Draft Esopus Creek Stream Management Plan. We could not have completed the plan nor developed a collaborative effort without their participation. Many of these members assisted the process by serving on the Project Advisory Council and/or on Working Groups. Others contributed their historic photos, time, homes, and skills. We are grateful to the Town of Shandaken and Phoenicia Fish and Game Association for allowing use of their staff and facilities for meetings. We are also grateful to the entire staffs of the New York City Department of Environmental Protection (DEP) Stream Management Program, and Cornell Cooperative Extension of Ulster County who greatly assisted the project with their support.

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HOW TO USE THIS PLAN

The Esopus Creek Plan is divided into three volumes. Below is a description of each volume. From this description, the reader should be able to select the appropriate volume and review that volume's table of contents to find the information needed.

Volume I

Summary of Findings and Recommendations

Volume I is a summary document for the entire plan. It includes an overview of the project history, assessment findings and recommendations. This volume is intended to allow a wide range of readers to understand the main purpose behind this effort. For more details on a particular area, readers can refer to the appropriate section of Volumes II or III.

Volume II

Community and Stream Use Characterization

Volume II provides greater detail on social, geographic and policy issues of the Esopus Creek Watershed including the following sections: History and Demographics, Education and Outreach, the NYC Water Supply System, and Angling and Recreation - which includes detailed discussions on whitewater recreation and the Catskill Mountain Railroad. Appended in Volume II is the summary of results from the Esopus Creek Landowner Survey. Readers who wish to learn more detail about any of these particular issues may refer to their section of interest.

Volume III

Watershed and Stream Characterization

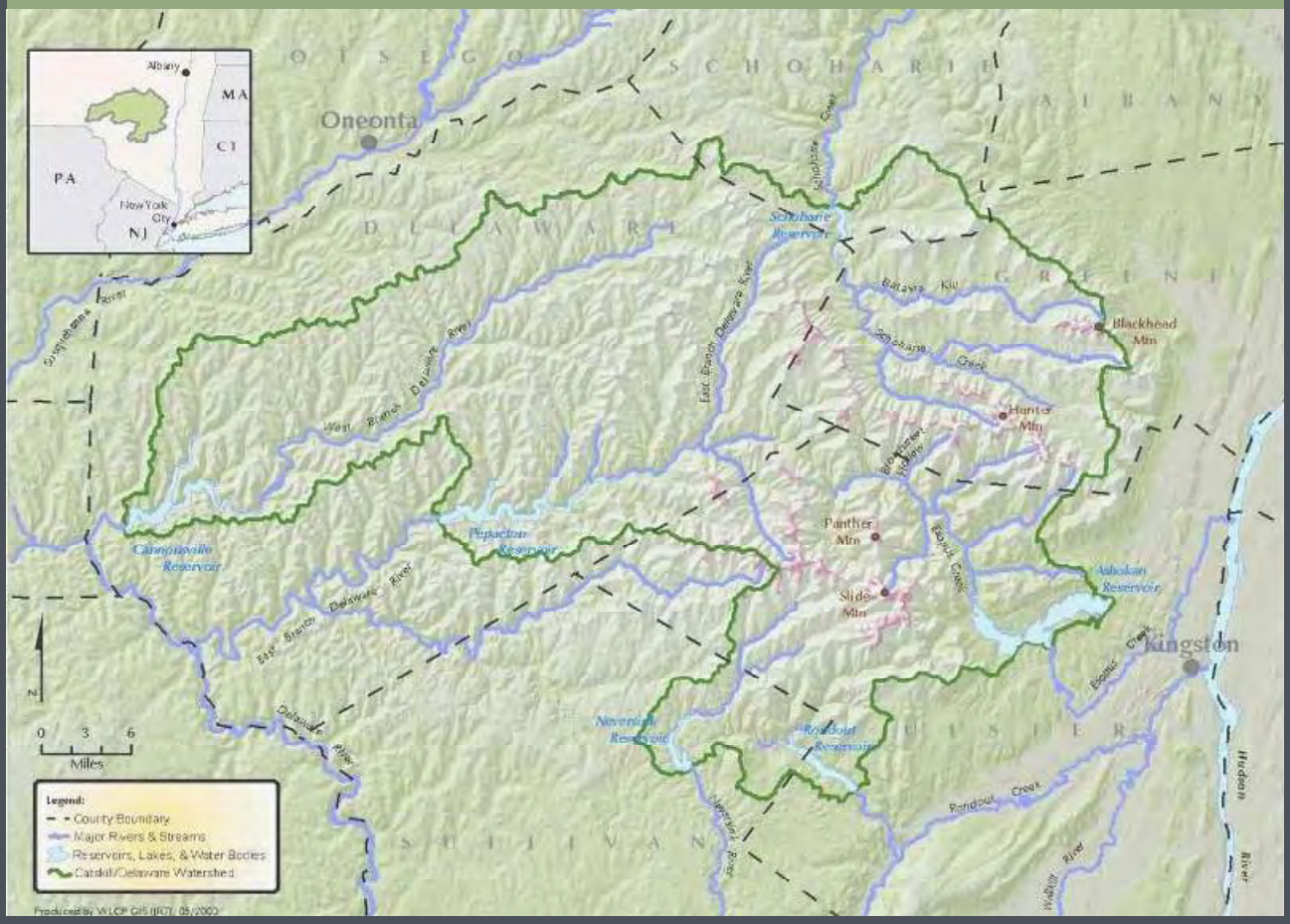
Volume III provides more detailed findings from the various physical assessments performed for this study. It includes a watershed description, characterization of geology, hydrology and water quality, geomorphic assessment and characterization of the Upper Esopus Creek corridor, the riparian vegetative buffer assessment, and the aquatic habitat assessments. There are numerous appendices in Volume III that provide data, maps, and additional information for many of the topics discussed therein. Readers seeking detailed technical information on assessment findings should refer to this volume.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

CATSKILL-DELAWARE WATERSHED



Project History

While this stream management plan has been primarily initiated by a federal drinking water quality mandate for the New York City Department of Environmental Protection ("DEP") – the project funder and a major stakeholder – it also has provided an opportunity to begin addressing issues beyond drinking water quality faced by local communities. The plan has provided a forum to bring together the complex and often conflicting user groups of the Esopus. The plan also has enhanced the ability to access additional funding sources through cost sharing or matching grants.

The history of this federal mandate starts with the Federal Safe Drinking Water Act. Under this law, DEP was granted a waiver from drinking water filtration by the U.S. Environmental Protection Agency in 1993, thus avoiding the need for a costly water filtration facility. The waiver, renewed every five years (including 2007), is known as the Filtration Avoidance Determination or "FAD," and it requires DEP to develop stream management plans in the New York City Watershed to maintain water quality. Other Stream management plans in the Esopus watershed previously were completed for the Stony Clove and Broadstreet Hollow Creeks (GCSWCD 2006 & 2007).

This project started in 2004 when the Consensus Building Institute (under contract with DEP) convened a focus group of stakeholders comprising municipal officials, county and state agencies, streamside landowners, DEP representatives, local non-profits and stream-reliant businesses to identify key

(ABOVE) PLANNING MEETING FOR ESOPUS CREEK RESTORATION DEMONSTRATION PROJECT

stream management issues. This focus group developed the primary goal areas of the Upper Esopus Creek Management Plan ("Management Plan") as below:

5 Goals of this Planning Process

1. **COORDINATION:** Provide a strategy for coordination of management activities among the various stakeholders to ensure none of the above goals is achieved at the expense of another.

2. **FLOODING AND EROSION:** Document risks and outline strategies to reduce damage to private property and public infrastructure - roads, bridges and utility lines – from floodwaters and stream erosion.

3. **WATER QUALITY:** Summarize known information and outline strategies to protect and improve water quality.

4. **ECOSYSTEMS:** Document current conditions and outline strategies to protect and enhance the integrity of stream and floodplain ecosystems.

5. **RECREATION:** Document historic and present-day uses of the stream as a scenic and recreational resource including stakeholder concerns and outline strategies for enhancing opportunities for these activities.

In April, 2005, Cornell Cooperative Extension of Ulster County ("Extension") was contracted by DEP to provide coordination for the plan and provide education and outreach in the watershed. Extension established and facilitated a Project Advisory Council ("PAC") with working groups focused on specific goal areas. The PAC was based on the original Focus Group members and are identified in the preceding acknowledgements. The following section on Coordination details the accomplishments of these groups.

Coordination

Stream stewardship by nature involves a broad cross-section of community members and agencies. Coordinated stream stewardship requires greater communication, information and resource sharing, and collaboration among all stakeholders. Some of the issues related to coordination include:

- **MANAGEMENT STRATEGIES, ACTIVITIES, OR GOALS ARE SOMETIMES AT CROSS-PURPOSES.**
- **AGENCIES THAT HAVE A STREAM MANAGEMENT ROLE MAY NOT RECOGNIZE THAT ROLE, OR UNDERSTAND BEST MANAGEMENT PRACTICES.**
- **RESOURCE MANAGERS MAY NOT HAVE PROCEDURES FOR COORDINATING WITH OTHER RELEVANT AGENCIES.**
- **RECENT FLOOD DAMAGE FROM SEVERAL EVENTS COMBINED WITH THE EMERGENCY CONDITION OF THE OPEN PORTAL HAS MADE UNDERSTANDING CAUSES OF TURBIDITY AND EROSION DIFFICULT.**

The Upper Esopus Creek PAC and Working Groups have provided a natural structure and process for initial development of the Management Plan. These groups should continue to meet and develop longer-term structures and funding sources for sustainable stream management in the Upper Esopus Creek watershed. Additional tasks these groups should consider include developing and promoting an agreed-upon set of stream stewardship principles and ways for the plan recommendations to become incorporated into local policy. Annual action plans should be developed to update the Management Plan based on conditions and completed projects. Enhanced agency coordination can be accomplished through greater communication of stream management actions and agency adoption of common stream management principles and practices.

PAUL RUSH FROM NYC DEP PRESENTS TO ESOPUS ADVISORY COUNCIL ON SHANDAKEN TUNNEL OPERATIONS

Project Advisory Council

Throughout the development of this plan, the PAC has provided invaluable local knowledge of the Esopus Creek and has provided a forum for increased communication of stream management actions. The PAC has met eight times in less than two years, demonstrating their high level of commitment to the Esopus Creek and its future.

The PAC has also served as a vehicle for providing training and education to a broad set of community representatives. Activities of the PAC included regularly sharing information on stream management activities, increased understanding of the operations of the Shandaken Tunnel, broader understanding of user conflicts, and oversight on working group projects and plan development.

Education and Outreach Working Group

The Education and Outreach Working Group has been an outstanding group of committed volunteers and agency partners meeting monthly. Individual members have developed some of their own projects such as the youth watershed mural and stream cleanups. Other accomplishments have included: oversight on outreach materials and the landowner survey, producing knotweed awareness refrigerator magnets, assisting with community events, and initiating a volunteer stream stewards group.

Hazard Mitigation Working Group

This working group was formed to explore producing and adopting a Hazard Mitigation Plan (HMP) for the Towns of Olive and Shandaken. After several meetings with state and local authorities, this process was tabled until larger regional participation can be developed. Since the original draft of this Management Plan, the Ulster County Emergency Management Office has taken the lead on developing an Ulster County Hazard Mitigation Plan. The information presented in the Management Plan should be incorporated into that effort.

Watershed Assessment Working Group

The Watershed Assessment Working Group met once on July 11, 2005 to discuss and comment upon the geomorphic assessment planning approach proposed by Dan Davis (DEP) and Craig Fischenich, U.S. Army Engineer Research Development Center (ERDC). The group also developed a scope of work for assessing riparian and aquatic habitat in the Esopus Creek Management Plan. The assessment work presented in Volume III is the final product of that effort.

Aquatic Ecosystem Working Group

The Aquatic Ecosystem Working Group met several times to discuss and comment upon draft reports by Walt Keller on the current state-of-knowledge of the aquatic ecosystem. The work group assisted Keller in:

- **DELINEATING PHYSICAL STUDY BOUNDARIES;**
- **SIGNIFYING MAJOR HABITAT ZONES;**
- **SUPPLEMENTING FIELD OBSERVATIONS; AND,**
- **IDENTIFYING IMPORTANT AREAS FOR FURTHER STUDY.**

This work group consists of agency, non-profit and citizen investigators and has identified the need for further collaboration in developing standardized methodologies for future study to facilitate data sharing. It is anticipated that this group will remain active in developing an implementation plan, where many participants will have active roles going forward.

DAN DAVIS DISCUSSING THE DEMONSTRATION SITE ON WOODLAND VALLEY BRIDGE

What is Stream Management?

There are many "stream managers" – big and small - on Upper Esopus Creek. These stream managers include landowners who own and manage property alongside a stream; Town officials who guide land-use decisions and carry out town policies; Highway Departments who perform the routine and emergency repair work on roads and bridges; permitting and resource management agencies such as the New York State Department of Environmental Conservation (DEC) and DEP; angling and white-water recreation users; and non-profit organizations that serve the community through education or other means, among many others.

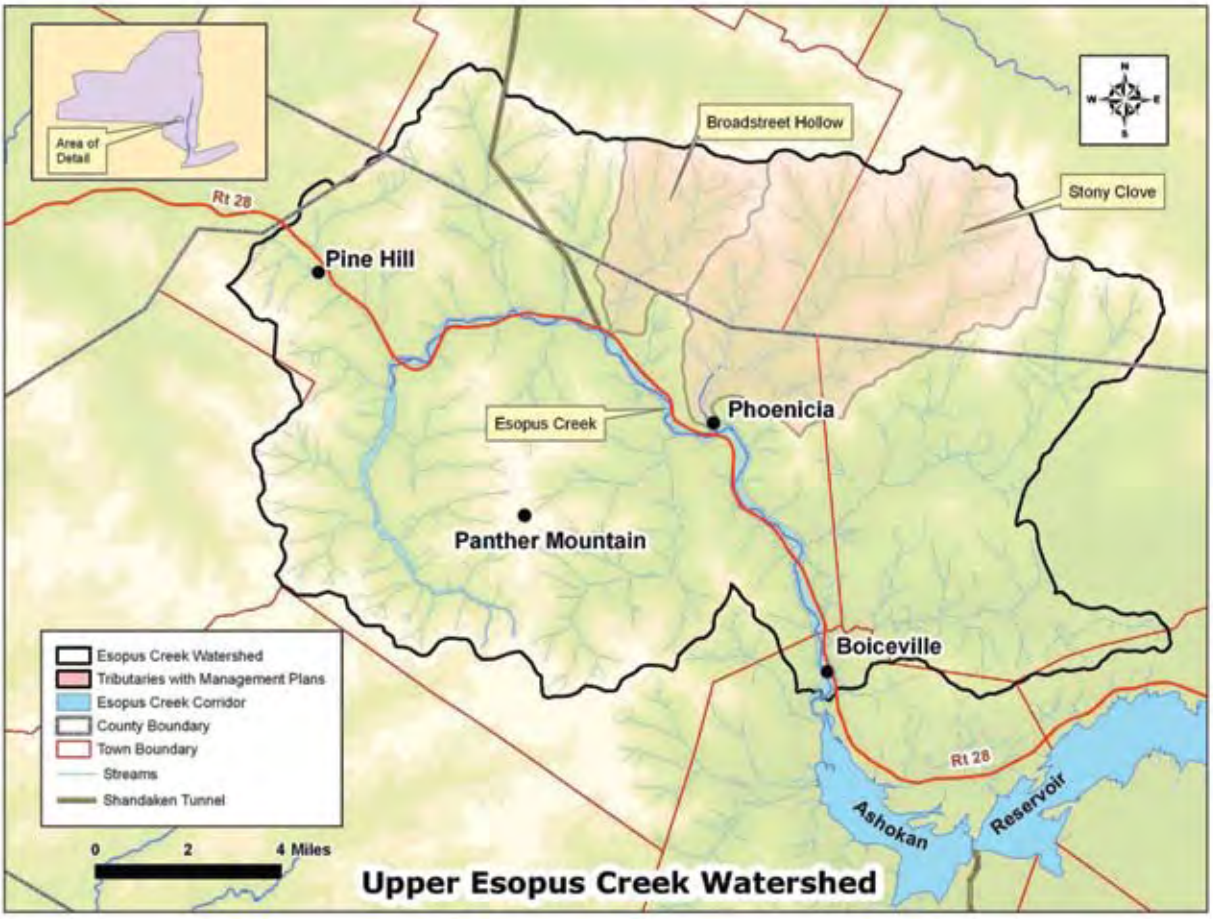
Whether aware or not of their role, the combined impact of these groups essentially becomes the community's "stream management" absent any other management framework. The purpose and challenge of stream management should be to plan and coordinate these actions for as much human and environmental benefit as possible.

Every action taken by a stream manager, whether it is reinforcing a private stream bank or constructing a public bridge, causes the stream to "react" or adjust to the changed condition. The adjustment from a single action may be so small as to escape notice by most and could take from minutes to decades for the stream to fully react. But the cumulative effect over time of many disparate management actions inexorably changes the character of the stream as well as the way we view and interact with it.

(LEFT) RIFFLE AND POOL ON THE ESOPUS

Figure 1

Upper Esopus Creek Corridor and Watershed



Stream Managemaent Planning Area

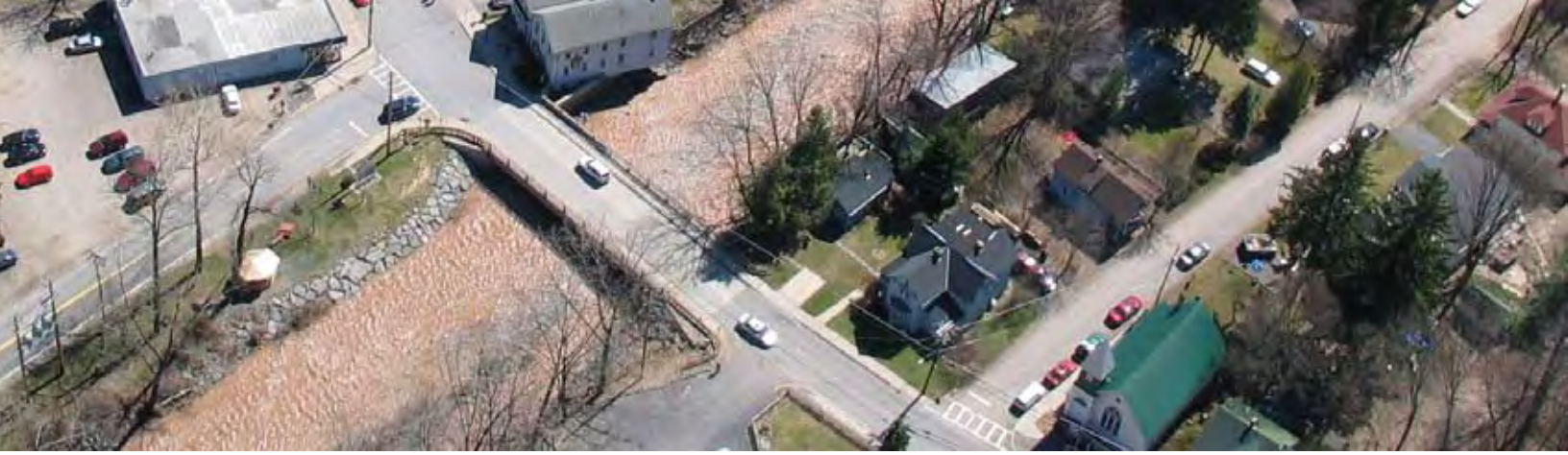
The scope of this planning effort is limited to the stream corridor of the Upper Esopus Creek, upstream of Ashokan Reservoir.

The corridor includes a zone along the stream and a few hundred yards up some of the larger tributaries at their confluence with Upper Esopus Creek. Readers should note that stream management plans have previously been completed for Stony Clove Creek and Broadstreet Hollow Creek – both tributaries to Upper Esopus Creek. It is hoped that additional work in these and other tributaries will continue to provide more complete coverage of the entire watershed.

Because streams are a function of their watersheds, the social and physical watershed characteristics of Upper Esopus Creek are summarized briefly here.

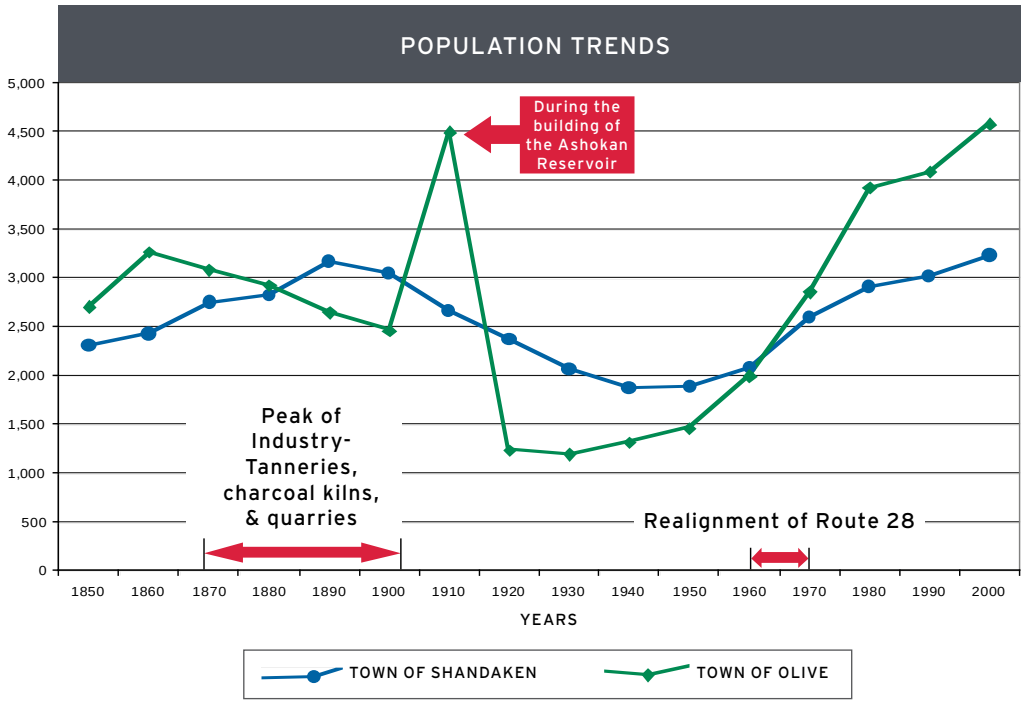
Social Characteristics

The Upper Esopus Creek runs mostly through the Town of Shandaken, NY, and crosses neighboring Olive, NY for about 1 mile before reaching Ashokan Reservoir. The Town of Shandaken has 2,666 housing units and a population of 3,235 (U.S. Census, 2000). Slightly more than half (55%) are full-time residents and about 45% are part-time residents, many of which have a primary residence in the NYC metropolitan area. According to the Shandaken Comprehensive Plan, Shandaken ranks last (20th) in Ulster County in household and family median income.



(ABOVE) MAIN ST. BRIDGE IN PHOENICIA OVER STONY CLOVE

Geographic Area	Population	Median Age	Average Household Size	Median Household Income
Shandaken (Town)	3,235	45.0	2.17	$31,566
Olive (Town)	4,579	42.2	2.43	$45,409
Ulster County	177,749	38.2	2.47	$42,551
New York State	18,976,457	35.9	2.61	$43,393



Shandaken differs from the County and state in age and income. Significant percentages of adults are distributed in the 40-55 and 65-75 year-old age ranges and median income is significantly lower.

Of all the households in the watershed, approximately 238 streamside residences lie along the Esopus Creek, and approximately 1,200 additional residences are adjacent to the major tributaries of the Esopus Creek Watershed.

PHYSICAL CHARACTERISTICS

The Upper Esopus Creek watershed covers 192 square miles in the south-central Catskill Mountain Region of southeast New York State. The entire 26-mile course of the creek flows "clockwise" in a sweeping arc from the headwaters at Winnisook Lake on Slide Mountain to the Ashokan Reservoir (see map on page 14). The stream and watershed all lie within the Catskill Park, a state designated park including a checkerboard of public and privately owned land. As of 2005, the New York State Department of Environmental Conservation owned 41% of the entire Park and can not sell or transfer its property without amending the state constitution.

Upper Esopus Creek and its tributary network of at least 330 stream miles drain some of the most rugged terrain in the Catskill Mountains, including 21 peaks higher than 3,000 feet above sea level (ft asl). Slide Mountain is the highest peak in the the Esopus watershed and the Catskills at 4,180 ft asl while the Ashokan Reservoir elevation is 633 ft asl. The resulting steep streams convey strong erosive forces as water and sediment make the quick descent from mountain top to the reservoir.

Climate and Hydrology

Mean annual precipitation for the Upper Esopus watershed ranges from ~52 inches at Ashokan Reservoir to ~63.5 inches at Slide Mountain (among the highest in the Northeast). Typical winters leave a snowpack in the mountains, causing most of the peak floods to occur with the combination of snow melt and spring rains. The region is also in the path of tropical storm events with consequent flooding in late summer and fall.

AERIAL VIEW OF ESOPUS CREEK VALLEY

While local impacts are more difficult to predict, current climate change models indicate that in the Catskills, storm events with rainfalls greater than 1" are likely to increase in frequency and magnitude (Frumhoff, et al., 2006). Paradoxically, drought periods are also likely to become more extreme. Snowpack amount and duration are also expected to decrease.

Land Use - Land Cover

Forested land exceeds 95% of the total watershed land cover. However, in the 1800's significant portions of the watershed were cleared of forest by logging and bark peeling activity. Consequently, streams were altered from

GLACIAL LAKE CLAY EXPOSED IN ESOPUS CREEK STREAM BANK

the increase in eroding sediment from the denuded landscape. Forest cover still tends to dominate the land cover in the valley bottom along most of the stream's course, however along the Route 28 corridor, development associated with roads, residences, businesses, and town centers increases the percentage of impervious surfaces. There are no large-scale agricultural land uses in the watershed.

Geology

Much of the current physical character of the watershed is a consequence of the most recent ice ages of 12,000 to 25,000 years ago when the Catskills were mostly occupied by glacial ice or the meltwater streams and lakes that followed the ice's retreat. These mountains are composed of sedimentary bedrock. The broken bits of this bedrock are the source of almost all of the stream sediment you see today - from clay to boulders. Cobbles and boulders found in the streams were eroded from the thick-bedded sandstones that shape the mountain cliffs. The reddish layered clays exposed in stream banks are ancient glacial lake sediments eroded from the red siltstones and shales that form many of the mountain slopes. The nature of the glacial lake deposits and the dense, clay-rich glacial till that can form some channel boundaries makes them susceptible to stream erosion and the main contributor to turbidity in the Catskill streams.

Water Supply and the Catskill District System

The Upper Esopus Creek is a regulated river by inter-basin transfer of water. The Shandaken Tunnel, and its outfall – often referred to as the "Portal," is a handmade 18 mile aqueduct that connects the Schoharie Reservoir to the Upper Esopus. The Catskill District of New York City's West-of-Hudson water supply system is one of three systems that supply water to New York City, and it includes the Schoharie Reservoir, Shandaken Tunnel, Ashokan Reservoir and the Catskill Aqueduct west of the Hudson River. Approximately 40% of the City's average water supply demand is provided by the Catskill System.

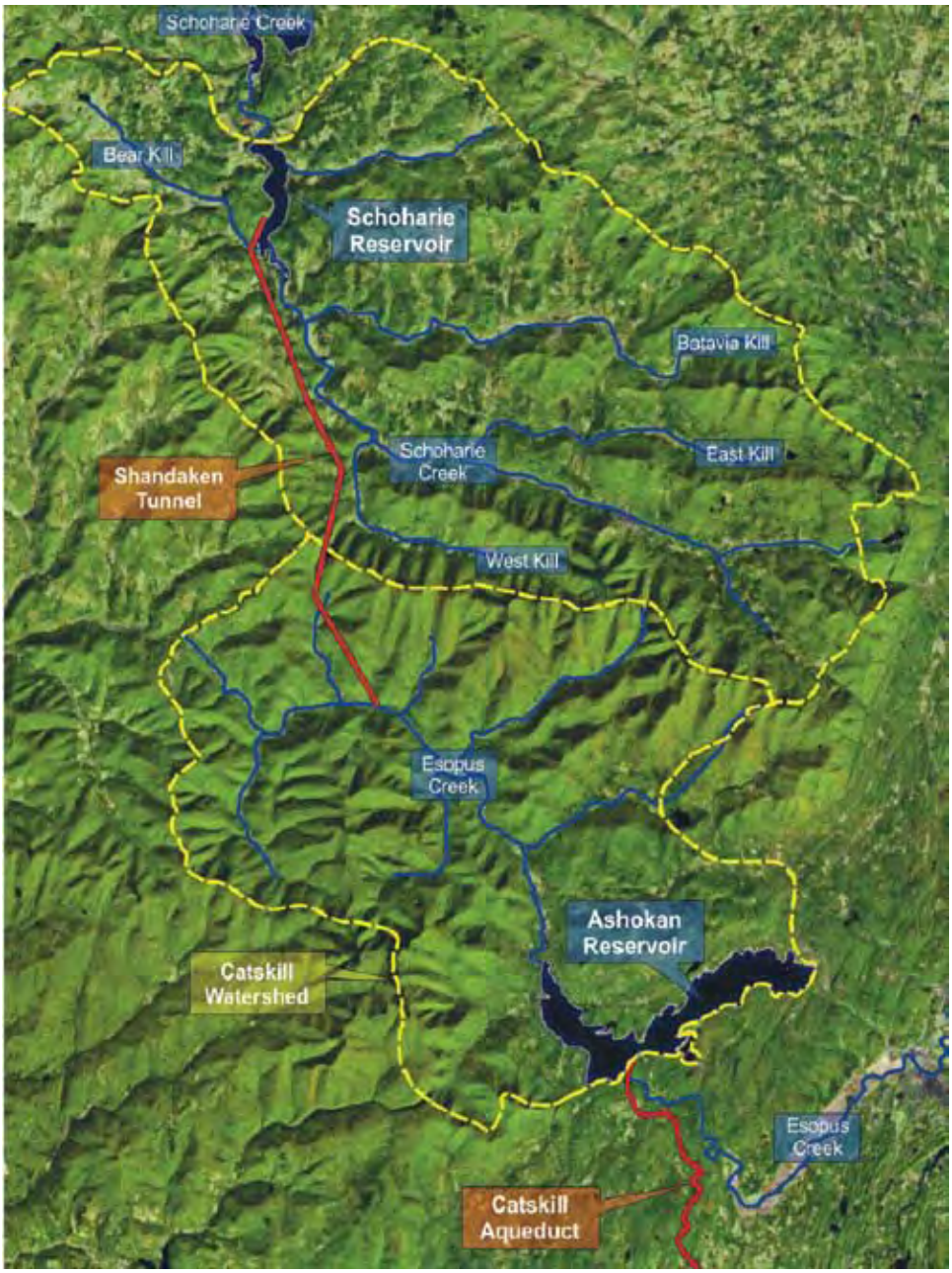
New York City must abide by two regulatory documents administered by the New York State Department of Environmental Conservation (DEC) when operating the Shandaken Tunnel: Title 6 NYCRR Part 670 "Reservoir Release Regulations: Schoharie Reservoir - Shandaken Tunnel – Esopus Creek" and a State Pollution Discharge Elimination System or "SPDES" permit. Together, these two regulations provide for flow, temperature, and turbidity thresholds to protect aquatic biota. Also, Part 670 allows up to four recreational releases

for whitewater recreation to be granted per year by the DEC (See Volume II for more detail on Part 670).

It is important to note that a separate "Catskill Turbidity Control Study" has been conducted in parallel with this effort. The recently concluded Phase II of that study has outlined structural and operational modification options for controlling turbidity releases from the Shandaken Tunnel that are currently being considered by Federal, State, and local authorities.

Figure 2

Catskill District Water Supply System



Upper Esopus Creek Management Recommendations

Stream management recommendations have been developed through the physical and social assessments described above and detailed in volumes II and III. The recommendations are listed in this section by main goal areas of the plan. The Findings section further details some of the assessment results for each goal area.

Flooding and Erosion

1. Support funding and multi-objective incentives to assist streamside landowners and other stakeholders in the Esopus Creek watershed to address conflicts between stream erosion, flooding, and property use.

2. Support the completion of Flood Studies by FEMA to produce necessary revisions to the existing Flood Insurance Rate Maps (FIRMs) and support training for local floodplain managers.

3. Annually update and prioritize stream restoration projects identified in this management plan and support efforts to obtain funding to design and implement them.

4. Develop a document that describes appropriate best stream management practices to address stream bank erosion for use in the Esopus Creek watershed.

5. Encourage communities to adopt or amend local land use laws that prevent inappropriate development in areas of high flood or erosion risk and foster uses that are compatible with the anticipated flooding and erosion conditions.

(LEFT) 2005 FLOOD IMPACTS ON ROUTE 42 ON BUSHNELLSVILLE CREEK

6. Where existing communities, structures and facilities are in at-risk locations, encourage the application of flood-proofing measures or relocation.

7. Encourage Ulster County to develop a Hazard Mitigation Plan with emphasis on addressing flooding and stream erosion hazards.

8. Encourage collaboration between state and local highway departments to develop specifications for applying natural channel design concepts, as appropriate, to bridge rehabilitation and replacement as well as to streambank stabilization along roadsides.

9. Support development of preliminary recommendations for an emergency early flood warning system, and assist interested communities in obtaining funding for system implementation.

10. Advocate an active monitoring program for large woody debris (LWD) that focuses upon the identification and removal of debris that poses a flood hazard to infrastructure and a threat to human welfare.

11. Support continued characterization of flooding and erosion hazards in the tributary streams to the Esopus that have not been previously assessed.

12. Support an investigation of the geotechnical processes controlling coupled hill slope and stream bank erosion in order to evaluate management feasibility.

13. Support implementation of the stream physical monitoring program described in Volume III, Section 3.1.2.

Water Quality

1. Identify locations in the Upper Esopus watershed that are long-term chronic fine sediment sources and evaluate the potential efficacy of restoration practices.

2. Encourage the development and maintenance of best management practices that can reduce the loading of suspended sediment from roadside ditches and developed land and ensure that culverts, when replaced, are appropriately sized and sited to maintain up and downstream channel stability.

3. Support the development of operational and/or structural modifications at the Shandaken Tunnel intake chamber to reduce turbidity loading to Upper

Esopus Creek as outlined in the SPDES permit and Catskill Turbidity Control Study, Phase II.

4. Establish a program for the long-term monitoring of representative exposures of glacial deposits that contribute to turbidity (as described in Volume III, Section 3.1.3).

5. Support glacial geology mapping in the Upper Esopus Watershed to improve turbidity source characterization.

Education and Outreach

1. Develop and implement community education and outreach to support the riparian enhancement program (see below).

2. Disseminate stream education materials in the Upper Esopus Creek Watershed.

3. Provide community education on basic stream processes and functions.

4. Provide trainings in stream management for highway department staff and other resource managers.

5. Provide activities including youth programs and a volunteer monitoring program.

6. Provide a flood emergency preparedness program for watershed residents.

7. Provide a community education campaign for recreational safety on the Esopus Creek.

Riparian Enhancement

1. Develop a riparian enhancement program that assists landowners in (a) education on the role of riparian buffers in protecting their property and (b) establishing landowner riparian buffer management plans which include planting and monitoring support.

2. Encourage development and implementation of alternative management practices at US Army Corp flood control projects that enhance in-stream and streamside habitat conditions.

3. Continue use of the Upper Esopus Creek restoration project site as a Japanese knotweed control demonstration site.

4. Work with landowners and other partners to develop a Japanese knotweed eradication program that emphasizes starting in the headwaters and main tributary streams, then working the mainstem below Birch Creek.

5. Continue mapping and monitoring the presence of Japanese knotweed and other invasives in the Upper Esopus Creek watershed through multi-agency and public collaboration.

6. Support further riparian corridor assessment for the tributaries to Upper Esopus creek not previously investigated.

Aquatic Ecosystem

1. Explore opportunities for operational adjustments of the Shandaken Tunnel to accommodate the needs of biota along with other stakeholders.

2. Support identification and characterization of spring seeps and other cold water sources that provide critical cold-water habitat to trout and other biota.

3. Support further aquatic bio-monitoring and studies of other wildlife, their habitats, and interactions in the watershed by the multitude of public agencies and interest groups. Assist with coordination to make the sampling consistent and data reporting consistent, organized and accessible.

4. Further inventory and characterize wetlands along the main-stem Esopus Creek.

Recreation

1. Support the use of newly developed models to optimize operation of the Shandaken Tunnel to meet the flow requirements in Part 670, including recreational releases when requested, in balance with water supply and other stakeholder needs.

2. Enhance coordination between requestors of recreational releases, the NYS DEC, and NYC DEP.

3. Develop codes of conduct that are agreeable to all parties for stream activities (angling, tubing, boating) through an outreach and education program.

4. Address stream hydraulics and safety for whitewater recreation as part of any stream restoration or bank stabilization proposal.

5. Support continued exploration of stakeholder liability issues for large woody debris (LWD), as well as jurisdictional responsibility for removal of LWD.

6. Support the placement of information kiosks at common put-in and take-out locations as a means to share pertinent information about the location of in-stream hazards.

7. Explore opportunities for new access points or the enhancement of existing access points for tubing and whitewater recreation.

8. Stay abreast of opportunities and provide assistance to the Catskill Mountain Railroad and other pedestrian trail development activities as they relate to activity along the creek.

9. Study the economic impacts of recreation related activities on the local economy.

Coordination

1. The PAC and Work group members and other work groups should continue to meet and develop a locally sustained form of a watershed management organization.

2. Develop Annual Action Plans (consistent with the 2007 FAD) for updating stream management priorities each year.

3. Develop and promote a set of Stream Stewardship Principles for adoption by relevant entities.

4. Present the Upper Esopus Creek Management Plan to Towns and encourage adoption of the plan or appropriate policies.

5. Develop an information clearinghouse and coordinating process for stream management actions of relevant public.

6. Develop a coordinated post flood response streamwork protocol.

Plan Findings

The following section summarizes the findings, stakeholder issues and conclusions for four plan goal areas Flooding and Erosion Threats, Water Quality, Ecosystems, Recreation as well as Education and Outreach. Each section lists all of the major findings with some of the findings further detailed. This section is only meant to summarize each goal area of the plan Further details on the issues, assessment findings, and plan recommendations can be found in Volumes II and III.

(LEFT) RIFFLES LIKE THESE MAKE NICE TROUT HABITAT

Flooding & Erosion Threats

The Upper Esopus Creek is a mountain stream and all who live in its valley have witnessed its power during floods. Stream erosion is a natural process, but when the stream erodes into roads and bridges or developed property, this natural process needs to be addressed by appropriate management.

STAKEHOLDER ISSUES

- LOSS OF PRIVATE PROPERTY AND PUBLIC INFRASTRUCTURE FROM EROSION AND FLOOD INUNDATION.
- SEEMINGLY INCREASED RECURRENCE OF DAMAGING FLOOD EVENTS.
- PERCEIVED AND REAL FLOODING AND EROSION IMPACTS FROM SHANDAKEN TUNNEL FLOWS.
- PERCEIVED FLOODING IMPACTS FROM GRAVEL ACCUMULATION AND DEBRIS AT SPECIFIED LOCATIONS.
- WATER QUALITY IMPAIRMENTS FROM CLAY EXPOSURE IN STREAM BED AND BANK EROSION.
- EFFECTIVE MANAGEMENT OF SEDIMENT MOVEMENT IN THE STREAM.

(LEFT) WOODLAND VALLEY BRIDGE DURING APRIL, 2005 FLOOD

FINDINGS

The research, field, and analytical investigations conducted as part of the assessment phase of this planning project led to the following findings.

- Large Flood Events on Esopus Creek Have High Economic Costs
- Erosion of Stream Banks Is Localized, Not Systemic
- Flood Planning and Response Needs Improvement
- Five Locations Identified for Detailed Stream Management Evaluation
- No Evident Trend in Flood Frequency
- Models Developed to Assess Erosion and Flooding Potential and to Evaluate Management Options
- Large Woody Debris Contributes to Stream Bank and Channel Changes
- Impacts from Shandaken Tunnel Discharges Vary by Stream Flow

Large Flood Events on Esopus Creek Have High Economic Costs

The Town of Shandaken Highway Department spent almost twice its annual budget to respond to the April 3, 2005 flood before being reimbursed by the Federal Emergency Management Agency (FEMA).

Private property damage from the 1980 and 2005 floods was estimated at approximately $3.5 million (in 2005 dollars) for each event, according to local

Table 1

Town of Shandaken Highway Department Expenses from the April 3, 2005 Flood		
Original 2005 Budget	Total Flood Expenses	FEMA Reimbursement
$1,515,201	$2,172,109	$1,094,363

Table 2

SOURCE: STREAMSIDE LANDOWNER SURVEY ON ESOPUS CREEK

Private Landowner Money Spent to Protect/Repair Streambanks in Last 10 years	Streamside Landowners (%) of Respondents
Nothing	62%
Less than 1,000	15%
$1,000-$5,000	11%
Over $5,000 (responses up to $30,000)	12%

records. Twenty three percent of Esopus Creek landowners spent over $1,000 to protect or repair their streambanks in the last 10 years.

Erosion of Stream Banks Is Localized (Not Systemic)

Approximately 13% of the Esopus Creek banks were found to be actively eroding. This amount of erosion is relatively "normal," and coupled with other observations and analyses suggest that systemic instability is not presently occurring on this stream. In most cases, erosion was occurring in areas where it poses no threat to developed property and infrastructure. Several sections of eroding stream bank that threaten developed property and infrastructure include (1) Sleepy Hollow Campground, (2) just upstream of the Route 28 bridge at Phoenicia, (3) downstream of the confluence with Broadstreet Hollow - where at least 3 developed properties are experiencing rapid bank retreat, (4) the Brown Road area in Oliverea that has been washed out repeatedly, and (5) several locations where the abandoned railroad has been washed out. The upper reaches of Esopus Creek in Oliverea are largely in forested state and private land and are not close to developed property and infrastructure.

Flood Planning and Response Needs Improvement

No formal flood preparedness mechanism currently exists in the Esopus Creek corridor, and unlike neighboring Delaware County, Ulster County has no All-Hazard Mitigation Plan. Conventional approaches to flood management stress the importance of:

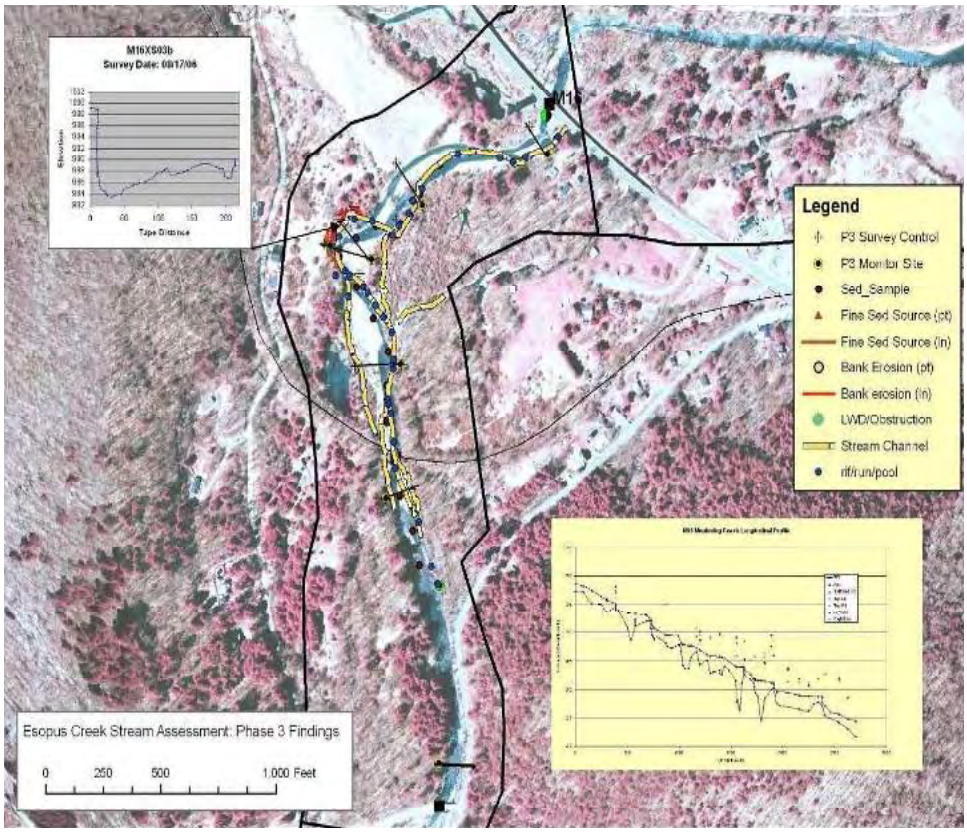
- **REDUCING RISKS BY LIMITING DEVELOPMENT IN FLOOD-PRONE AREAS,**
- **FLOOD-PROOFING STRUCTURES THAT MUST BE PLACED IN THESE AREAS,**
- **EMPLOYING FORMALIZED EARLY WARNING SYSTEMS TO ALERT POPULATIONS AT RISK FROM FLOODING, AND**
- **DEVELOPING FLOOD RESPONSE PLANS THAT CAN BE RAPIDLY IMPLEMENTED TO REDUCE FLOOD IMPACTS AND AID IN RECOVERY.**

The Management Plan also stresses these measures in lieu of large-scale flood control projects.

(BELOW) HOUSE IN BUSHNELLSVILLE CREEK AFTER THE CHANNEL MOVED IN 2005 FLOOD

Figure 3

Sample Phase 3 Geomorphic Assessment Upstream of Confluence with Birch Creek



Five Locations Were Identified for Detailed Stream Management Evaluation

During the stream assessments, several sites were identified that merited further study to develop mitigation measures for erosion or stability problems. These locations, otherwise known as the "Phase 3" sites on Esopus Creek include:

1. **FROM BROADSTREET HOLLOW DOWNSTREAM TO THE ALLABEN CEMETERY**
2. **SHANDAKEN TOWN HALL**
3. **BROWN ROAD (OLIVEREA)**
4. **JUST UPSTREAM OF BIRCH CREEK CONFLUENCE**
5. **CONFLUENCE OF STONY CLOVE CREEK WITH ESOPUS CREEK.**

For the Brown Road stream section, Ulster County Soil & Water Conservation District and the local USDA Natural Resource Conservation Service office have taken the lead in assessing and evaluating channel stabilization options.

Topographic surveys and hydraulic modeling are to be completed for the remainder of the sites by Summer, 2007. Volume III Section 3.1.3 discusses the conditions and evaluated options for each of the sites.

No Evident Trend in Flood Frequency

A trends analysis of USGS stream gage data failed to uncover any tendency that suggests that flooding has become more or less frequent in the past 75 years. The analyses do show that the most significant floods tend to occur in the early spring, generally involving rain on snow events.

Clustering of major floods have occurred on a ten year cycle throughout the last century. The top 10 floods of record are presented in the table below. Among recent events, the 2005 flood ranks 3rd and the 1996 flood ranks 6th in this time period at the Coldbrook gage. The March 1980 flood was the flood of record, with peak discharge of 65,300 cubic feet per second (cfs) and was found to have a return frequency of approximately 40 years (a "40-year flood").

Impacts from Shandaken Tunnel Discharges Vary by Stream Flow

Impacts from the Shandaken Tunnel releases on flooding were evaluated using computer models developed by ERDC. The model calculated the impacts of a full tunnel capacity release (at 900 cfs) for any flood flow on Esopus Creek. For example, during a 10 year flood, the model results show that a full Tunnel release would increase the water surface elevation by an average of about 3 inches in the first two miles downstream of the Tunnel, and about 2 inches thereafter. The impacts diminish with increased flow and distance downstream on the Esopus.

Under flood conditions, tunnel flows were found to have little, if any, impact upon erosion. Tunnel flows, even if operated at full capacity, were found to have virtually no effect on downstream velocities, shear stress and stream power (< 1 percent increase) during flows in excess of bankfull flow (floods). However, when the Creek level is less than bankfull or flood condition, a sustained, high release from the tunnel may contribute to eroding flows and bank loss within the first two miles downstream of the tunnel. Erosion thresholds would not generally be exceeded for well-vegetated or stable banks. On some disturbed banks with little protective vegetation, the increased duration of higher flows may contribute to the loss of bankline. Further investigation is necessary to evaluate this potential impact.

Table 3

Upper Esopus Creek - Top 10 Floods of Record as Measured at the USGS Stream Gage, ColdBrook, NY (near confluence with Ashokan Reservoir)					
Rank	Date	Peak Discharge (cfs)	Mean Daily Discharge (cfs)	Peak Stage (ft)	Approx. Return Frequency (years)
1	21-Mar-80	65300	22100	21.94	40
2	30-Mar-51	59600	15800	20.7	
3	3-Apr-05	55200	17400	20.57	25
4	24-Aug-33	55000	24400	20.4	
5	15-Oct-55	54000	22900	20	
6	19-Jan-96	53600	21800	20.33	
7	4-Apr-87	51700	17400	20.06	
8	21-Dec-57	46900	15900	18.98	
9	12-Mar-36	38500	17200	17.9	
10	5-Apr-84	37400	17900	17.75	10

CONCLUSION - FLOODING AND EROSION

Management recommendations for flooding center on three themes: 1) avoidance of future development in areas subject to flood damages, 2) flood proofing and other measures to reduce damages where existing infrastructure is at risk, and 3) formulation of an early-warning system and flood response plans for a more coordinated and timely response when flooding occurs. To facilitate the implementation of these recommendations, continued improvements to the hydrologic and hydraulic models for Upper Esopus Creek are warranted.

Giving the stream room for natural adjustment in adequate floodplains is the best option for the stream and often the most cost-effective management approach with respect to flooding and erosion concerns. However, there are 238 existing streamside landowners along its course, more than 9 miles of roads and many more miles of railroad within 300 feet of the channel, and 19 bridge crossings to consider – so natural adjustment is not an option in every location. Management needs to address protecting natural areas that currently require little management. In areas that require active management, solutions need to address both human and ecological objectives. This process had identified the need for a document that describes appropriate best stream management practices to address stream bank erosion for use in the Esopus Creek watershed.

Water Quality

In general, the water quality of Upper Esopus Creek is good. Water flowing in the Esopus Creek not only supports aquatic and terrestrial wildlife and plants, but also quenches the thirst of 9 million people in the greater NYC metropolitan area who drink it daily. The Ashokan Reservoir is part of the largest unfiltered water supply system in the United States.

STAKEHOLDER ISSUES

- **ESOPUS CREEK CONVEYS DRINKING WATER FOR ABOUT 9 MILLION PEOPLE, MOSTLY LOCATED IN THE GREATER NYC METROPOLITAN AREA AND IS PART OF THE LARGEST UNFILTERED WATER SUPPLY SYSTEM IN THE UNITED STATES.**
- **TURBIDITY IS A CONCERN FOR THE ECOLOGIC, RECREATIONAL AND AESTHETIC USE OF THE STREAM AS WELL.**

Turbidity, an index of water clarity, is a concern in this watershed because the suspended clay that creates turbidity can also prevent effective chlorination of drinking water. Turbidity is also a concern for the ecologic, recreational and aesthetic use of the stream. Turbidity resulting from flood events and/or from diversion of Schoharie Reservoir water into Esopus Creek via the Shandaken Tunnel continues to be the primary water quality issue.

Analysis of multiple years of water quality sampling by DEP reveals that dissolved phosphorous is not a problem in the Esopus Creek watershed at this time. Given the high forest coverage of the watershed, it is not anticipated

(LEFT) TURBID WATER FROM FOX HOLLOW ENTERING ESOPUS CREEK

CRAIG FISCHENICH SHOWS HOW EASILY SILT IS SUSPENDED FROM THE ESOPUS STREAMBED

THE SHANDAKEN TUNNEL EMPTIES WATER FROM THE SCHOHARIE RESERVOIR INTO THE ESOPUS

to change in the future. All other water quality parameters that are regularly sampled (pathogens, fecal coliform, specific conductance, dissolved oxygen, sulfur, pH, chloride) are not indicative of an impaired stream.

Two water quality regulations are relevant to turbidity in the Esopus: Safe Drinking Water Act oversight of NYC water supply and a NYS Department of Environmental Conservation "SPDES" Permit for the Shandaken Tunnel. A third regulation regulation on development also could be triggered if phosphorous concentrations in Ashokan Reservoir increase.

FINDINGS

- **Stream Bed and Banks are Dominant Sources of Suspended Sediment**
- **Glacial Lake Clay Exposures are Transient and Generally Resistant to Erosion – Except when Disturbed**
- **Ashokan Reservoir Design and Operation Addresses Most Drinking Water Impacts**

Stream Bed and Banks are Dominant Sources of Suspended Sediment

Turbidity in Catskill streams is from suspended sediment and is a product of geology (the source of suspended sediment) and hydrology (flooding). During and following flood events, all of the tributaries to Esopus Creek from Birch Creek downstream to Beaver Kill can be significant sources of turbidity to Esopus Creek. Stony Clove Creek is the most consistent, chronic, and acute tributary source of turbidity. The Shandaken Tunnel, which diverts water from Schoharie Reservoir to Esopus Creek just above the Broadstreet Hollow confluence, is a regulated chronic source of turbidity. Water from the tunnel can be turbid long after flood events in either the Esopus or Schoharie Creek watersheds. The suspended sediment is a combination of fine silt and clay originating from glacial deposits. It does not take much suspended sediment to cause turbidity values that significantly reduce water clarity. The suspended sediment gets in Upper Esopus Creek from 3 sources:

1. LANDSCAPE RUNOFF - WATERSHED SOURCES

Runoff from the landscape carries fine sediment (silt and clay) into the stream through ditches and culverts.

2. STREAM BANK AND BED SOURCES

Streams contribute significantly to turbidity from the exposed "clays" that the stream has cut into and the mobilization of fine sediment mixed in the stream bed deposits. A preliminary sediment budget developed by ERDC indicates that under bankfull and greater flow conditions the sediment that is re-suspended from the stream bed is the principal source of turbidity in Esopus Creek. The significance of this finding is that turbidity from flood flows is a non-point source problem that cannot be mitigated by site-specific treatments. Below flood flows, or flows that don't mobilize the streambed, the exposed glacial deposits (lake clays and tills) in the bank and bed are the sources of suspended sediment.

3. DISCHARGE OF SUSPENDED SEDIMENT FROM SHANDAKEN TUNNEL

There is a perception that the Shandaken Tunnel carrying water from the Schoharie Reservoir is the major source of turbidity in the Esopus. Indeed, based on data collected routinely at a fixed frequency for the period 1987-

DIVIDING WEIR AT ASHOKAN RESERVOIR (JUNE, 2006)

GLACIAL LAKE CLAY, A SOURCE OF TURBIDITY, UNCOVERED BY BANK EROSION

2005, the Tunnel has the highest median turbidity value of the basin at 8.8 NTU. However, the Tunnel flows have been calculated to have a negligible impact on the total mass of sediment loading to Ashokan Reservoir. Nonetheless, Tunnel flows have been determined to impair the use of the creek for recreation through its visual impact. The perception that the portal is the dominant contributor of suspended sediment is likely due to visual observations made during periods of regional low flow. Especially during summer months, portal water can be visibly more turbid in contrast to the Esopus Creek flow upstream of the Tunnel.

Glacial Lake Clay Exposures are Transient and Generally Resistant to Erosion – Except when Disturbed

Glacial lake clay deposits are also difficult to characterize as point sources, since these exposures tend to change location over time. That is, each flood event can cover (or remove) previous exposures and uncover new exposures. Laboratory tests show that glacial lake deposits are generally resistant to erosion except when a disturbance (geologic or human) compromises its physical competency or when the layered clay deposit includes fine sand. Esopus Creek has far fewer exposures of glacial till, but these exposures tend to be longer-lasting than the glacial lake sediment exposures.

Ashokan Reservoir Design and Operation Addresses Most Drinking Water Impacts

The design of the Ashokan Reservoir includes a settling basin (the west basin) which "captures" much of the sediment from the more frequently recurring flood events and the Shandaken Tunnel discharge. The design and management of the water supply system can address this concern adequately. To date, the use of alum to remove suspended sediment from the water at Kensico Reservoir in Westchester has been limited to major flood events effecting the Ashokan Reservoir.

CONCLUSION – WATER QUALITY

In general, Upper Esopus Creek water quality is very good. Turbidity is the primary water quality concern for drinking water, recreation, and ecological conditions in the Esopus watershed, and is one of the primary focuses of New York City's filtration avoidance efforts. While we can manage some factors affecting water quality, other factors simply need to be accommodated in stream management. We do not have direct influence over the geology and hydrology that have the most impact on turbidity in this watershed. Given the presence of fine sediment incorporated in the stream bed, stream restorations may provide little benefit to turbidity reduction for drinking water purposes. The fact that the sources of suspended sediment (glacial till and glacial lake silt and clay) are widely distributed throughout most of the watershed means that effectively preventing the stream from carrying this material during high flood flows is impractical to consider. High levels of turbidity are expected in conjunction with future flood events.

However, turbidity at low to moderate flows from chronic long-term sources may be addressed by stream restoration. Water clarity during low flow conditions could be improved by addressing chronic turbidity sources such as clay exposures in stream bank/hill slope failures in the Esopus tributaries, thus benefiting recreation and ecological habitat. A prime example of this condition is along sections of the Stony Clove Creek between Silver Hollow Bridge and Chichester. There are four large hill slope failures directly adjacent to the stream that are significant sources of suspended sediment long after a flood. Targeted restoration in this reach of stream may reduce turbidity conditions following floods. The Shandaken Tunnel may be the most significant source of turbidity that can be affected by human control. Although turbidity in the Tunnel flows depend on Schoharie Reservoir turbidity levels, releases to the Esopus can be managed through modifications and operations of the Tunnel. Turbidity reduction alternatives at the Shandaken Tunnel intake are already being considered in a separate study.

Recommendations for water quality aim to improve our understanding of the locations of fine sediments in the tributaries as well as how it is eroded, transported and deposited. Likewise, the Catskill Turbidity Control Study, Phase II recently evaluated structural and operational methods to control turbid water discharged from the Shandaken Tunnel. That effort is highly supported by members of the Esopus Creek Project Advisory Council.

Ecosystem Condition

Upper Esopus Creek and its associated floodplain support an interrelated set of diverse plants and animals. Riparian buffers in a mountain river setting like the Catskills are necessary for maintaining a stable stream channel and maintaining ecologic integrity.

Several factors impact ecosystem conditions on the Esopus Creek. Upper Esopus Creek is located entirely within the Catskill Park, which includes the Catskill Forest Preserve, one of the largest expanses of protected land in the United States. The community perceives the health of the stream and associated wildlife as an important basis of the local sense of community and economy which is supported by fishing and whitewater recreation, among other activities.

Water from Schoharie Reservoir discharged into Esopus Creek via the Shandaken Tunnel may have both positive and negative ecological impacts. These flows must meet flow, temperature, and turbidity thresholds for aquatic habitat and other needs as outlined in two DEC regulatory documents.

STAKEHOLDER ISSUES

- **UPPER ESOPUS CREEK IS LOCATED ENTIRELY WITHIN THE CATSKILL PARK, IN WHICH LIES ONE OF THE LARGEST EXPANSES OF PROTECTED LAND IN THE UNITED STATES (THE CATSKILL FOREST PRESERVE) AND HOME TO A DIVERSE POPULATION OF PLANTS AND ANIMALS.**

(LEFT) SIDE CHANNEL ON ESOPUS AND HEALTHY STREAMSIDE VEGETATION

- **THE COMMUNITY PERCEIVES THE HEALTH OF THE STREAM AND ASSOCIATED WILDLIFE AS DIRECTLY RELATED TO THE SENSE OF COMMUNITY AND ITS WELL-BEING, AND THE LOCAL ECONOMY WHICH IS SUPPORTED BY FISHING AND WHITEWATER RECREATION, AMONG OTHER ACTIVITIES.**
- **THE SHANDAKEN TUNNEL DISCHARGES WATER FROM SCHOHARIE RESERVOIR INTO ESOPUS CREEK THAT MUST MEET DRINKING WATER SUPPLY NEEDS WHILE MEETING REGULATORY THRESHOLDS FOR FLOW, TEMPERATURE, AND TURBIDITY TO SUPPORT AQUATIC ECOSYSTEM FUNCTIONS.**
- **CONCERN OVER THREATS TO THE INTEGRITY OF THE ECOSYSTEM AND THE WILD CHARACTER OF THE WATERSHED FROM ATTEMPTS TO CONTROL FLOODING AND EROSION.**

Additionally, attempts to control flooding and erosion must be balanced with maintaining the integrity of the ecosystem and the wild character of the watershed.

For ease of reading, Riparian and Aquatic Ecosystem Findings are presented separately.

HEALTHY VEGETATION ON LEFT BANK, POOR VEGETATION ON RIGHT BANK

RIPARIAN BUFFERS

Vegetated riparian zones facilitate stream stability and function by providing rooted structure to protect against bank erosion and flood damage. Riparian buffers also offer protection against pollution, nutrient and sediment runoff, provide food and shelter for animals, and moderate fluctuations in stream temperature.

Approximately 63% of the total stream bank length along Esopus Creek has a vegetative buffer width greater than 100 feet. Intact riparian buffers of 25 feet or less protect approximately 22% of the total stream banks. Roads, railroads, and utility line rights-of-way, residential development, and invasive species were found to be the strongest influences on the continuity and integrity of riparian vegetative cover. Revetments (rock, rip-rap, walls) protect 6.25 miles of streambank or about 13% of the bank length. Most of this revetment is associated with the railroad and other transportation infrastructure.

(ABOVE) COLONY OF THE INVASIVE PLANT, JAPANESE KNOTWEED, CROWDS OUT NATIVE PLANTS.

FINDINGS - RIPARIAN BUFFERS

- Closed-Canopy Floodplain Forest is the Dominant Vegetation Class
- Japanese Knotweed and Other Invasive Species are Prolific

Closed-Canopy Floodplain Forest is the Dominant Vegetation Class

A total of 2,979 acres of riparian vegetation were mapped in the Esopus Creek corridor using aerial photography with ground-truthing. The vegetation classification with the most acreage was found to consist of a Closed-Canopy Floodplain Forest (798 acres, 27% of the river corridor) followed by Mowed Lawn with Trees (491 acres, 16% of the river corridor). A total of 40 different vegetation classifications were mapped and categorized. The complete study can be found in Volume III.

Japanese Knotweed and Other Invasive Species are Prolific

There is a systemic infestation of the exotic invasive species Japanese knotweed (Polygonum cuspidatum), sometimes referred to as "Japanese bamboo." Japanese knotweed spreads quickly to form dense thickets that exclude native vegetation and greatly alter natural ecosystems. It poses a significant threat to riparian areas, where it can survive severe floods and is able to rapidly colonize scoured shores and islands. Once established, populations are extremely persistent. The plant has extensively colonized the banks of Upper Esopus Creek from the confluence with Birch Creek to the Ashokan Reservoir. Interestingly (and fortunately) there are very few colonies above Birch Creek, though there are several known colonies in some of the tributaries that drain into the Big Indian Hollow. Though not mapped as part of this study, oriental bittersweet (Celastrus orbiculata) was also observed in many locations downstream of Birch Creek. Oriental bittersweet kills riparian trees by twining around tree trunks and branches.

CONCLUSION – RIPARIAN BUFFER

Riparian buffers in this mountain river setting are necessary for maintaining a stable channel form, water quality, and the ecologic integrity of the stream system. In general, channel stability and hence property protection increase as the riparian buffer increases. For example, a narrow 25 foot buffer zone may offer some bank stabilization while a buffer over 200 feet wide includes a diverse range of water quality and ecological benefits. Because 22% of the Esopus Creek's stream banks have a riparian buffer of 25 feet or less, increasing vegetation in these areas is of paramount importance as is a collaborative and systematic approach to invasive species management. Particular emphasis should be placed on areas with little or no riparian buffers to protect properties from erosion.

The composition of the buffer matters as well. The dominant and optimum riparian cover along Upper Esopus Creek is floodplain forest. This forest should be encouraged and protected. Although trees along the stream's edge can fall into the stream during floods, the mobilization of woody debris during storm events is typical of a forested mountain stream and management needs to account for this process. Trees eroded from upstream banks are frequently caught in the wooded areas downstream. Constructing bridges with wide spans so as to minimize debris jams and preventing the construction

of residential structures in the floodplain will reduce the damage and threat to property associated with woody debris. Flood hazard mitigation strategies should plan for removing debris where necessary following a flood event.

From the analysis to date these are the following priority riparian management issues for consideration in this Plan:

- **PROTECTING AND ENHANCING THE EXISTING RIPARIAN BUFFER ALONG UPPER ESOPUS CREEK THROUGH PROGRAM DEVELOPMENT**
- **DEVELOPING AND IMPLEMENTING A JAPANESE KNOTWEED (OR OTHER EXOTIC INVASIVE) MANAGEMENT STRATEGY**
- **CONTINUED RIPARIAN BUFFER ASSESSMENT IS NEEDED IN THE TRIBUTARY VALLEYS**

FINDINGS - AQUATIC ECOSYSTEM CONDITION

- ### Habitat Values Generally Decreased with Distance Downstream
- ### Analysis of Esopus Creek Data, Literature, and Public Observations Identifies Four Key Management Issues

Habitat Values Generally Decreased with Distance Downstream

A visual assessment procedure performed by ERDC was used to qualitatively assess the environmental condition in each reach of Upper Esopus Creek. Five parameters were used for the assessment: aquatic habitat/ cover; flow and morphological diversity; vegetation diversity and condition above bankfull; stability; and turbidity. Cumulative scores for the environmental rating generally decreased with distance downstream. The highest scores were attained for the upper reaches of Esopus Creek – above the confluence of Birch Creek (Reaches 17-22, score = 76 out of 100), while the lowest was at the confluence of Ashokan Reservoir (Reach 1: score = 43). More detail can be found in Volume III, Appendix H.

A HEALTHY RAINBOW TROUT CAUGHT ON THE ESOPUS

Analysis of Esopus Creek Data, Literature, and Public Observations Identifies Four Key Management Issues

Despite frequent extreme changes in flows, either from natural events like floods or from changes in the quantity and quality of water released from the Shandaken Tunnel, the aquatic community appears to be doing well. It may be that most of the species studied to date are generally short lived (lifespan of 5 years or less), and their populations are able to rebound quickly after catastrophic changes in their respective habitats.

No studies have been conducted to determine the impacts of Esopus Creek turbidity on the fish population. The silt/clay sediments may cause some localized impacts on some macroinvertebrates and interstitial-dwelling fishes, but trout reproduction does not appear to be a management issue. Studies actually found a higher abundance and growth rate of trout, especially rainbow trout, downstream of the Portal than in the upstream section.

With regard to management actions that could benefit the aquatic ecosystem of waters in the Esopus Creek watershed, the following key issues are identified and recommendations proposed (in no particular order):

1. TURBIDITY IN ASHOKAN RESERVOIR MAY BE IMPACTING TROUT

In 2006, anglers observed Ashokan Reservoir-caught trout as skinny or slender, suggesting starvation. Such a condition is indicative of either an impaired feeding due to an inability to see - or to a low abundance of alewives (the trout's principal food source) or both. Chronic turbidity in Ashokan Reservoir following the April 3, 2005 flood most likely decreased alewives ability to feed and respire as they are mostly filter feeders and their gills have a lot of filaments. This impact may have caused their decline and a subsequent impact to the trout population.

2. DISCHARGES FROM THE SHANDAKEN TUNNEL PROVIDE ESSENTIAL COLD-WATER HABITAT

Water diversions from the Schoharie Reservoir through the Shandaken Tunnel vary by temperature, turbidity, velocity and volume, and very likely have a greater impact on the biota in this part of the watershed than any other watershed factor but flooding. The Shandaken Tunnel carries cold water, when available, from Schoharie Reservoir, which is critical to sustain the trout populations downstream of the Portal, and especially critical when normal flows of water from within the Esopus watershed are too warm. Current

management parameters are outlined in Part 670 and the SPDES permit for flow, temperature and turbidity.

Structural and operational alternatives currently being considered by New York City and the U.S. EPA in the Catskill Turbidity Control Study, Phase II may allow for the fine tuning of releases helping to optimize habitat for aquatic biota, particularly water temperature as it relates to the needs of trout. The habitat and environmental needs of biota, particularly the native fishes and macroinvetebrates, must first be better defined. Additionally, habitat suitability curves for certain target species, particularly trout, will have to be refined and considered.

3. COLD WATER FROM SPRING SEEPS PROVIDES ESSENTIAL HABITAT

Trout are more likely to spawn in Esopus Creek upstream of the Portal, and in tributaries, rather than downstream since flows are more moderate and the stream bed is likely not as embedded. Spring seeps are extremely critical for trout survival in the tributaries during the summer and early fall. Those same seeps may be important for trout spawning as the water temperatures there are warmer than the flowing stream during the winter (about 50-60 degrees F compared to about 32 or 33 degrees F). No comprehensive knowledge of spring seep locations currently exists. Any activity along the banks or in the main stem Esopus or its tributaries, for example placement of stormwater culverts, could compromise these cold-water refuges.

(BELOW) OUTFLOW FROM THE SHANDAKEN TUNNEL OR "PORTAL" ON THE ESOPUS

WETLANDS LIKE THIS ONE PROVIDE ESSENTIAL HABITAT AND ATTENUATE FLOODS ALONG THE ESOPUS

(RIGHT PAGE) WOODLAND VALLEY CREEK CONFLUENCE WITH THE ESOPUS

4. WETLANDS AND OTHER KEY HABITATS HAVE ONLY BEEN PARTIALLY CHARACTERIZED

Wetlands along the stream and within the stream floodplain provide important habitat and may play a role in maintaining cool water inflow to the Esopus. Only aerial inventory and no field inventory has been conducted to date. Further characterization could identify wetlands eligible for additional protection.

CONCLUSION - AQUATIC ECOSYSTEM

Environmental conditions on Upper Esopus Creek are generally good, but tend to diminish with distance downstream. The fish and wildlife resources are abundant throughout the system, and the trout fishery is sustained in part by the low temperature releases from the Shandaken Tunnel. These flows compensate somewhat for the degraded riparian conditions downstream. Many ecological interactions on the system remain poorly understood.

Management recommendations for fish, wildlife and other biota center on improving our knowledge and understanding of the stream and floodplain ecosystem. A biomonitoring program has been proposed, and efforts to document the wetland and spring resources along the creek are recommended.

The Shandaken Tunnel and Ashokan Reservoir produce different stream flow, water temperature, and water clarity (turbidity) conditions than would otherwise naturally occur. A study to better evaluate the effects of Tunnel releases on the aquatic resources of Upper Esopus Creek is needed. The results could be used to assess alternatives for optimizing diversion operations for water supply, recreation and environmental quality.

Recreation

Highly valued recreation activities on the Upper Esopus Creek such as angling, kayaking, canoeing, and tubing attract thousands of users annually playing an important role in the regional economy. Management of the Upper Esopus and its stream banks plays a large role in these recreational uses of the stream.

Upper Esopus Creek is a well managed fishery and is one of New York State's most prestigious fly fishing trout streams, with one of the longest open fishing seasons in New York State (April 1 – November 30th) and with relatively high access and fishing rights compared to other Catskill streams. Angler diary participant records indicate average to above average (1/2 fish/hour to 1 fish/hour) trout catch rates. The Upper Esopus Creek is also recognized over a wide region as a high quality recreational Class II/III whitewater recreation stream with ideal conditions for beginner and intermediate kayaking, good access and emergency takeout opportunities, and an idyllic setting in the Catskill Park. An average of 15,000 tubers per year visit one of two tubing outfitters to experience the float down Esopus Creek which provides a steady flow of visitors to the hamlet of Phoenicia during the typical summer vacation season. Two "tubing courses" an upper course and the lower course are utilized, each is approximately 2.5 miles in length. Tube rental businesses on Esopus Creek are self-regulated.

FISHING ON THE ESOPUS PHOTO (COURTESY OF ANGLER'S DEN IN PAWLING, NY)

(LEFT)
TUBING ON THE ESOPUS BY WOODLAND VALLEY BRIDGE

STAKEHOLDER ISSUES

- TURBID WATER SOMETIMES DISCHARGED FROM THE SHANDAKEN TUNNEL IMPACTS AESTHETICS AND RECREATIONAL USE OF THE STREAM.
- FLOWS FROM NORMAL OPERATION OF THE SHANDAKEN TUNNEL SUSTAIN THE TUBING INDUSTRY, WHILE THE KAYAKING AND CANOEING COMMUNITY REQUIRE RECREATIONAL RELEASES AS ALLOWED IN PART 670.
- LARGE WOODY DEBRIS AND UNNATURAL DEBRIS LIKE APPLIANCES AND METAL PROVIDE HABITAT FOR TROUT AND OTHER BIOTA BUT MAY PRESENT A NAVIGATIONAL HAZARD TO RECREATIONAL BOATERS AND TUBERS.
- STREAM PROJECTS HAVE THE POTENTIAL TO IMPACT USER- OPPORTUNITIES FOR ANGLING AND WATER-BASED RECREATION.
- ESOPUS CREEK ACCESS, INFORMATION, AND SERVICES (OR LACK THEREOF) COULD BE ENHANCED.
- CONFLICTS OCCUR BETWEEN STREAMSIDE PROPERTY OWNERS, ANGLERS, TUBERS, AND WHITEWATER BOATERS.

(BELOW) KAYAKERS TRAVEL FOR MILES TO PADDLE THE ESOPUS

FINDINGS

- Turbidity from Shandaken Tunnel Sometimes Impacts Recreation
- Compliance with Part 670 Sustains the Coldwater Fishery and Tubing Industry
- Recreational Releases from Shandaken Tunnel Sustain Whitewater Boating
- Large Woody Debris Provides Habitat but Poses a Navigational Hazard
- Access and Amenities Could be Enhanced
- Stream Restorations need Coordination with Outfitters
- User Conflicts Occur Among Various User-Groups

Turbidity from Shandaken Tunnel Sometimes Impacts Recreation

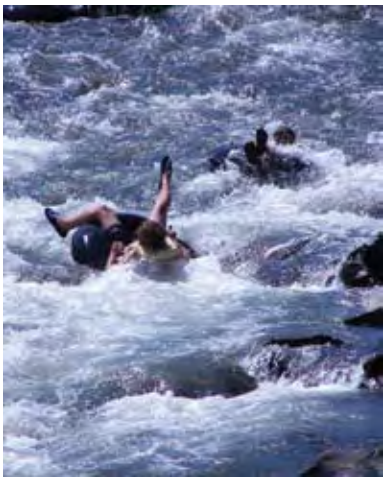
Research into human perceptions and Upper Esopus Creek-specific visual water clarity measurements indicates that as Esopus Creek turbidity values exceed 5 NTU, the measured thresholds for aesthetics, swimming, and wading in 1 meter of water are exceeded as well.

On September 1, 2006 discharges from the Tunnel became subject to meeting the conditions of a NYSDEC "SPDES" permit which limits the amount of additional turbidity the Tunnel can deliver to Esopus Creek to 15 NTU and requires the Tunnel to be shut off when water temperatures exceed 70 degrees Fahrenheit under most conditions. This 15 NTU limit was arrived at using "best professional judgment" to balance the Tunnel's need to deliver drinking water supply while sustaining aquatic flow and temperature conditions and other stakeholder needs. In addition, NYC is currently evaluating structural and operational modifications at the Shandaken Tunnel intake on Schoharie Reservoir to meet turbidity and temperature permit limits.

Compliance with Part 670 Sustains the Coldwater Fishery and Tubing Industry

Part 670 requires NYC to release waters into Upper Esopus Creek such that combined creek and Shandaken Tunnel flows measure 160 million gallons per day (MGD) which equals roughly 250 cubic feet per second during the months of June to October. Although this requirement was intended to meet minimum flows for aquatic habitat, the flows (250 cfs) also happen to provide minimum water needed to sustain tubing. Operations of the Shandaken Tunnel that are in compliance with this regulation sustain the tubing industry. Without the certainty of flows, tubing outfitters would likely not make investments in their businesses, advertise, and be able to deliver tubing conditions to customers throughout the summer with the predictability they do now.

Part 670 and the SPDES permit allow certain exceptions to the flow requirements however, in times of water supply need or during certain emergency conditions such as the recent repair of the Gilboa Dam – during which NYC has been operating under a waiver from the requirements and discharging flows at maximum capacity since November 2005 and lasted until December 2006. A full reconstruction of the dam is scheduled to take place between the years 2008 and 2011.



Recreational Releases from Shandaken Tunnel Sustain Whitewater Boating

The Upper Esopus Creek is used for whitewater boating primarily during requested recreational release flow dates. State Environmental Conservation Law Part 670 allows for up to four recreational releases per year between June and October. Aside from individual paddler trips, at least ten recreational clubs sponsor trips to the Esopus Creek annually, and four outfitters offer guided tours and instructional courses specifically on Esopus Creek. In addition, two whitewater races are held each year in June and October. The Upper Esopus, according to local paddlers, becomes too shallow in most reaches for paddling if the flow conditions are below 800 cubic feet per second (cfs) as measured at the Cold Brook USGS Stream Gage. Most paddlers preferred a stream height of 5'3" to 6'0 feet (between 800 cfs and 1100 cfs) measured at Cold Brook for paddling.

The KCCNY (Kayak and Canoe Club of New York), other boating organizations, and the Town of Shandaken make formal requests to the NYS DEC for summer recreational releases by April 15 of each year, as required. Historically these releases occur in early June, July, September, and October.

(ABOVE) LARGE WOODY DEBRIS ON ESOPUS CREEK

DEC measures the coldwater volume in Schoharie Reservoir in mid-June and assesses whether coldwater volume will be sufficient to safely make high water releases in late summer (July, August, or September) and not deplete cold-water in Schoharie Reservoir.

Further exploration revealed that out of a total of 56 requested releases between 1993 and 2006, 30 of the releases had sub-optimal (below 800 cfs) flow for kayaking and canoeing. Most of the low-flow days occurred in the late summer months when Esopus Creek baseflow (above Shandaken Tunnel) was below 100 cfs.

Large Woody Debris Provides Habitat but Poses a Navigational Hazard

Questions about landowner liability for large woody debris hazards on their properties were articulated as of paramount concern during this planning process. Two whitewater boating deaths (1 kayaker, 1 tuber) occurred in July 2002 from entanglement in large woody debris and resulted in lawsuits. The pivotal question remains: "who is responsible for large woody debris when it falls into the Esopus Creek?" Further detail can be accessed in Volume II.

(RIGHT PAGE) CATSKILL MOUNTAIN RAILROAD RUNNING WITH FALL FOLIAGE TOURISTS.

Currently along the stream course, outfitters and boaters work closely with private property owners to mitigate navigational hazards in high recreational boating areas, sometimes acquiring a DEC permit with an approved site plan, and a signed affidavit from the property owner. Government highway departments also remove debris from bridge piers when needed.

Continued exploration into liability questions may provide insight into how to effectively manage the debris to reduce recreational hazards and still maintain important aquatic habitat. The forthcoming legal decisions may also set state and national precedent on this complicated issue.

Access and Amenities Could be Enhanced

Kayakers voiced concern over lack of access to Esopus Creek below Phoenicia. Several boaters remarked that the quality of the experience would be enhanced through the creation of river pull-offs where boaters could picnic. Tubers and kayakers currently utilize the DEC angler access adjacent to the cemetery in Allaben which has resulted in some conflict with anglers. The absence of public restroom facilities in and around the creek was also noted

CONCLUSION

Angling, kayaking, canoeing, tubing, hiking, and swimming are all widely practiced on Upper Esopus Creek and provide significant benefits to the local economy. These user-groups sometime conflict with each others activities, presenting the need for collectively developed codes of conduct among the various parties. Exploring solutions for large woody debris management that provide multiple benefits is recommended, but has proven difficult because lawsuits arising from two recreational fatalities that occurred in 2002 are yet to be resolved.

Opportunities should be explored to optimize Shandaken Tunnel operations to meet water quality and habitat regulations while also providing water for recreational releases. New water management tools, developed for New York City reservoirs in a separate study, may provide regulators with an enhanced opportunity to meet requested recreational release flows, Local collaboration to enhance recreation services like restrooms and picnic areas, and creek access in certain locations is also recommended.

Education & Outreach

Stream stewardship involves a broad cross-section of community members and agencies. A shared understanding of stream stewardship principles in the community is essential for coordinated stewardship practices.

Three important audiences for education include: streamside landowners and general community; professionals and elected officials; and youth. Since most streamside property on the Esopus is privately owned in small parcels, landowners need the knowledge and technical assistance to be good streamside stewards. Professionals and elected officials such as highway superintendents and crews, town boards and supervisors make many decisions that impact streams. Contractors used by landowners to repair or protect streambanks also need to have the most up to date information and practices. Landowners may need more information on the roles and procedures of public agencies in relation to stream management or as available public resources.

Information from the community was gathered through a survey of streamside landowners, focus groups, site visits, office visits, community meetings and pilot educational events. These assessment tools gathered the community's opinions, knowledge and attitudes about stream stewardship to provide the findings below.

(LEFT) AARON BENNETT, FROM THE CATSKILL CENTER FOR CONSERVATION AND DEVELOPMENT, TEACHES A STREAM MONITORING WORKSHOP

STAKEHOLDER ISSUES

- STREAMSIDE LANDOWNER INVOLVEMENT IS IMPORTANT, AS MOST STREAMSIDE PROPERTY ON THE ESOPUS IS PRIVATELY OWNED.
- STAKEHOLDERS SUCH AS LANDOWNERS, HIGHWAY DEPARTMENTS AND CONTRACTORS MAY NEED MORE INFORMATION ON STREAM PROCESSES AND HOW TO IMPLEMENT BEST STREAM MANAGEMENT PRACTICES FOR MAINTAINING STREAMSIDE AREAS.
- COMMUNITY MEMBERS MAY NEED MORE INFORMATION ON THE ROLES AND PROCEDURES OF PUBLIC AGENCIES IN RELATION TO STREAM MANAGEMENT OR AS AVAILABLE PUBLIC RESOURCES.

FINDINGS

- Three Stream Management Issues Top the Community's Perception
- Streamside Landowners Prioritize Several Recommendations for Stream Stewardship
- Community Members Need More Stewardship Information and Resources
- Diversity of Audiences Requires Special Outreach Considerations
- A Majority of Streamside Landowners are Willing to Engage in Stream Stewardship

(BELOW) VOLUNTEERS PLANTING TREES ON THE ESOPUS

Three Stream Management Issues Top the Community's Perception

The top three issues most commonly raised in the Esopus Creek Watershed assessment include:

1. **EROSION AND FLOOD DAMAGE TO PROPERTY**
2. **FISH AND WILDLIFE HABITAT**
3. **TURBIDITY**

Additional issues also seen as important included (in no particular order of priority):

- **LARGE WOODY DEBRIS MANAGEMENT**
- **ASSISTANCE WITH FEMA FLOOD INSURANCE PROCESS**
- **EMERGENCY MANAGEMENT PLANNING**
- **WHITEWATER RECREATIONAL ACCESS**
- **SOCIO-ECONOMIC LOSSES**
- **WATER QUALITY**
- **LANDOWNER COOPERATION ALONG THE STREAM**

The Community Prioritizes Several Recommendations for Stream Stewardship

In general, community and streamside landowners prioritized the following recommendations:

- **IMPROVED COORDINATION OF LOCAL AGENCIES**
- **STABILIZING BANKS AND INCREASING STREAMSIDE VEGETATION**
- **DIRECT TECHNICAL ASSISTANCE FOR STREAMSIDE LANDOWNERS**
- **TAX INCENTIVES OR GRANT PROGRAMS FOR LANDOWNERS' USE OF BEST MANAGEMENT PRACTICES IN MANAGING BANKS AND STREAMSIDE VEGETATION.**

A Majority of Streamside Landowners are Willing to Engage in Stream Stewardship

Protection of personal property is clearly the largest motivating factor for streamside landowners based on where they would be willing to invest their time and money as shown below. Protecting fish and wildlife habitat are also significant motivating factors after private property protection.

Table 4

Items streamside land owners are willing to conserve or protect by acommitting time and/or money.	
Things to be conserved or protected	Percent willing to commit to conservation or protection*
My own property	75.2
Trout and other fish in the Creek	45.5
Streamside habitat, wildlife, trees, etc.	44.6
Clearer water—not muddy or brown	33.7
Water quality for drinking and other uses	22.8

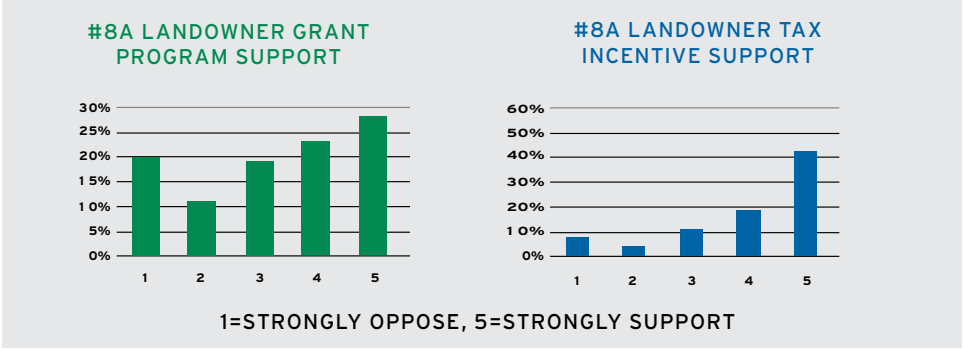
More than half (59%), of survey respondents were willing to do cleanups of stream trash. At least one-third to 40% of residents were willing to be involved in: planting streamside trees or shrubs, photo-monitoring, mapping and removing invasive plants, water quality surveys, or other mapping if trained.

Most (67%) indicated a willingness to attend an annual forum on the Esopus Creek. About half (52%) indicated they would join an Esopus Creek Landowners Association.

Survey question #8 asked respondents to indicate how much they would support or oppose different conservation incentives. The results show significant support for grant incentives as well as tax incentives to compliment the owner's investment.

Figure 4

Streamside Landowner Support for Conservation Incentives



Community Members Need More Stewardship Information and Resources

For just about any projects that would improve streamside buffers or banks, most streamside landowners indicated by survey that they would need considerable information before proceeding. Owners generally preferred local, "hands-on" information as opposed to information given on the radio or in a newspaper.

Audiences attending pilot education programs have requested more programs on basic stream functions and processes. Given the complex and often misunderstood nature of mountain streams, it has continued to be a challenge to build a shared understanding of why the Esopus erodes, deposits sediment and floods in particular ways.

CONCLUSION – EDUCATION AND OUTREACH

Erosion and flood damage are clearly the top perceived concern for streamside landowners, with protecting fish and wildlife habitat and reducing turbidity as second and third priorities. The majority of streamside landowners are very interested in doing what they can to protect and preserve streamside habitat but often feel that they need more information and resources to do so.

Further resources are needed to educate landowners on best management practices for streamside property. Important topics to cover include flooding and erosion, maintaining vegetative buffers, stream habitat, and water quality. A streamside assistance program would be most likely to help landowners implement best practices by providing one to one assistance coupled with grant incentives. Involving community members in volunteer-based stewardship projects could also have some success in developing local ownership of aspects of stream management. Youth programs would complement these programs in developing long-term stream stewardship ethics.

The fact that half of the residents in the watershed are part-time residents will make it challenging to schedule effective educational sessions or streamside work projects. Scheduling repeat events may help a wider group of people to attend educational activities. More needs to be learned about how to involve part-time residents that visit only occasionally or seasonally.

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