Local Flood Analysis

Town of Shandaken Along Esopus Creek
Hamlets of Phoenicia and Mt. Tremper
Ulster County, New York
June 2016

MILONE & MACBROOM
Engineering | Planning | Landscape Architecture | Environmental Science

Local Flood Analysis

Town of Shandaken Along Esopus Creek
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June 2016

Prepared for:
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MMI #4615-04-6

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ABBREVIATIONS/ACRONYMS

AWSMP	Ashokan Watershed Stream Management Program
BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
BFE	Base Flood Elevation
CCE	Cornell Cooperative Extension
CDBG	Community Development Block Grant
CFS	Cubic Feet per Second
CRS	Community Rating System
CWC	Catskill Watershed Corporation
CY	Cubic Yards
DEM	Digital Elevation Model
EWP	Emergency Watershed Protection
FEMA	Federal Emergency Management Agency
FHMIP	Flood Hazard Mitigation Implementation Program
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FMA	Flood Mitigation Assistance
FPMS	Floodplain Management Services Program
GCSWCD	Greene County Soil and Water Conservation District
GIS	Geographic Information System
HEC-HMS	Hydrologic Engineering Center – Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HMGP	Hazard Mitigation Grant Program
HMP	Hazard Mitigation Plan
LFA	Local Flood Analysis
LiDAR	Light Detection and Ranging
MMI	Milone & MacBroom, Inc.
NFIP	National Flood Insurance Program
NFIRA	National Flood Insurance Reform Act
NRCS	Natural Resources Conservation Service
NYCDEP	New York City Department of Environmental Protection
NYRCR	New York Rising Community Reconstruction
NYSDEC	New York State Department of Environmental Conservation
NYSDOS	New York State Department of State
PDM	Pre-Disaster Mitigation
RFC	Repetitive Flood Claims
SAFARI	Shandaken Area Flood Assessment and Remediation Initiative
SFHA	Special Flood Hazard Area
SMIP	Stream Management Implementation Program
SMP	Stream Management Plan
SRL	Severe Repetitive Loss
STA	River Station
TS	Trout Spawning
UCSWCD	Ulster County Soil and Water Conservation District
USACE	United States Army Corps of Engineers

USGS	United States Geological Survey
WI/PWL	Waterbody Inventory/Priority Waterbodies List

EXECUTIVE SUMMARY

Background

The subject Local Flood Analysis (LFA) was undertaken to evaluate potential flood mitigation within the town of Shandaken in the hamlets of Phoenicia and Mt. Tremper. Flooding has long been a problem in these communities, evidenced most recently by the extensive flooding and devastation during Tropical Storm Irene in 2011. The Shandaken Area Flood Assessment and Remediation Initiative (SAFARI) group provided guidance throughout the LFA process and was the primary pathway for community involvement, which included four public meetings and two Town Board meeting presentations. The LFA process began in fall 2014 and concluded in fall 2015.

The study areas are located along 6.2 miles of Esopus Creek and two of its tributaries, Stony Clove Creek and the Beaver Kill. These areas were selected to coincide with the majority of the developed area in the hamlets of Phoenicia and Mt. Tremper.

The intent of the LFA is to help municipalities to do the following:

- Confirm where significant flood hazards exist in the target area through engineering analysis.
- Use engineering analysis to develop a range of hazard mitigation alternatives; the primary focus of the analysis is to identify the potential for reducing flood elevations through channel and floodplain restoration as the first alternative to other hazard mitigation solutions.
- Evaluate both the technical effectiveness and the benefit-cost effectiveness of each solution and compare different solutions to each other for the most practical, sustainable outcome (New York City Department of Environmental Protection [NYCDEP], 2014).

Hydraulic analysis was conducted using the HEC-RAS program. The HEC-RAS software (*River Analysis System*) was written by the United States Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC) and is considered to be the industry standard for riverine flood analysis. The model is used to compute water surface profiles for one-dimensional, steady-state, or time-varied flow. For the area in the vicinity of the confluence of Stony Clove Creek and Esopus Creek and along Main Street in Phoenicia, a two-dimensional HEC-RAS model (Version 5.0, beta version) was set up and run to evaluate flood mitigation alternatives.

A wide range of flood mitigation alternatives were evaluated as part of this LFA, including the replacement of undersized bridges, floodplain enhancement, dredging of the channel, removal of sediment bars, enhancement and relocation of levees, and combinations of these approaches. Flood mitigation alternatives were evaluated using HEC-RAS modeling.

Alternatives that had flood reduction merit were evaluated using the Benefit-Cost Analysis (BCA) tool in order to determine whether they would be cost effective if implemented. A BCA is a method by which the future benefits of a project are estimated and compared to its cost. The end result is a benefit-cost ratio (BCR), which is derived from a project's total net benefits divided by its total project cost. The BCR is a numerical expression of the cost effectiveness of a project. A project is considered to be cost effective by the Federal Emergency Management Agency (FEMA) when the BCR is 1.0 or greater, indicating the benefits of the project are sufficient to justify the costs. A BCA was conducted for proposed alternatives that, based on evaluation of the HEC-RAS modeling, would result in reduced flooding and would not have an unacceptable impact on the community.

Resulting BCRs are summarized in Table ES-1 below.

TABLE ES-1
Benefit-Cost Ratios for Select Alternatives

Number	Scenario	Benefit-Cost Ratio (BCR)
	Phoenicia Study Area	
4a	Floodplain enhancement with Bridge Street bridge replacement	1.02
4b	Floodplain enhancement if Bridge Street bridge has been replaced	1.94
6	Dredging the Esopus Creek channel in Phoenicia	0.28
	Mt. Tremper Study Area	
9	Dredging the Esopus Creek channel in Mt. Tremper	0.27
11	Route 28 bridge replacement	0.08
14	Mt. Tremper floodplain enhancement on Esopus Creek	1.63
14a	Mt. Tremper floodplain enhancement on Esopus Creek combined with Route 28 bridge replacement	0.87
15	Floodplain bench on Beaver Kill	0.25
16	Plank Road bridge replacement	0.08

Alternatives that yielded a BCR of greater than 1.0 were as follows:

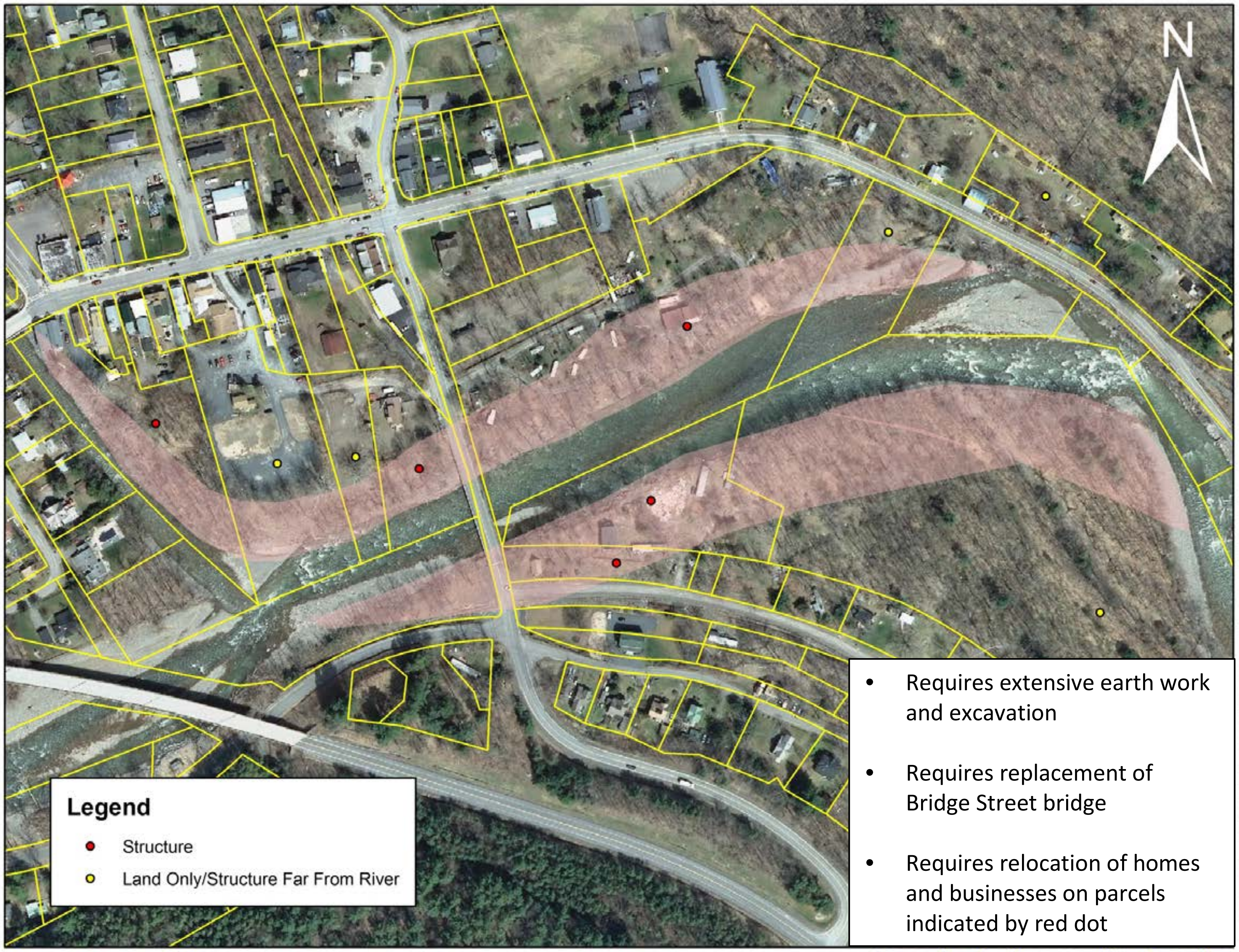
Floodplain Enhancement in Phoenicia (This scenario was evaluated both with and without the replacement of the Bridge Street bridge. The floodplain enhancement scenario without replacement of the Bridge Street bridge assumes that the bridge has already been replaced with a larger structure.)

- Floodplain Enhancement Along Esopus Creek in Mt. Tremper

These alternatives are described briefly below and in more detail later in this report.

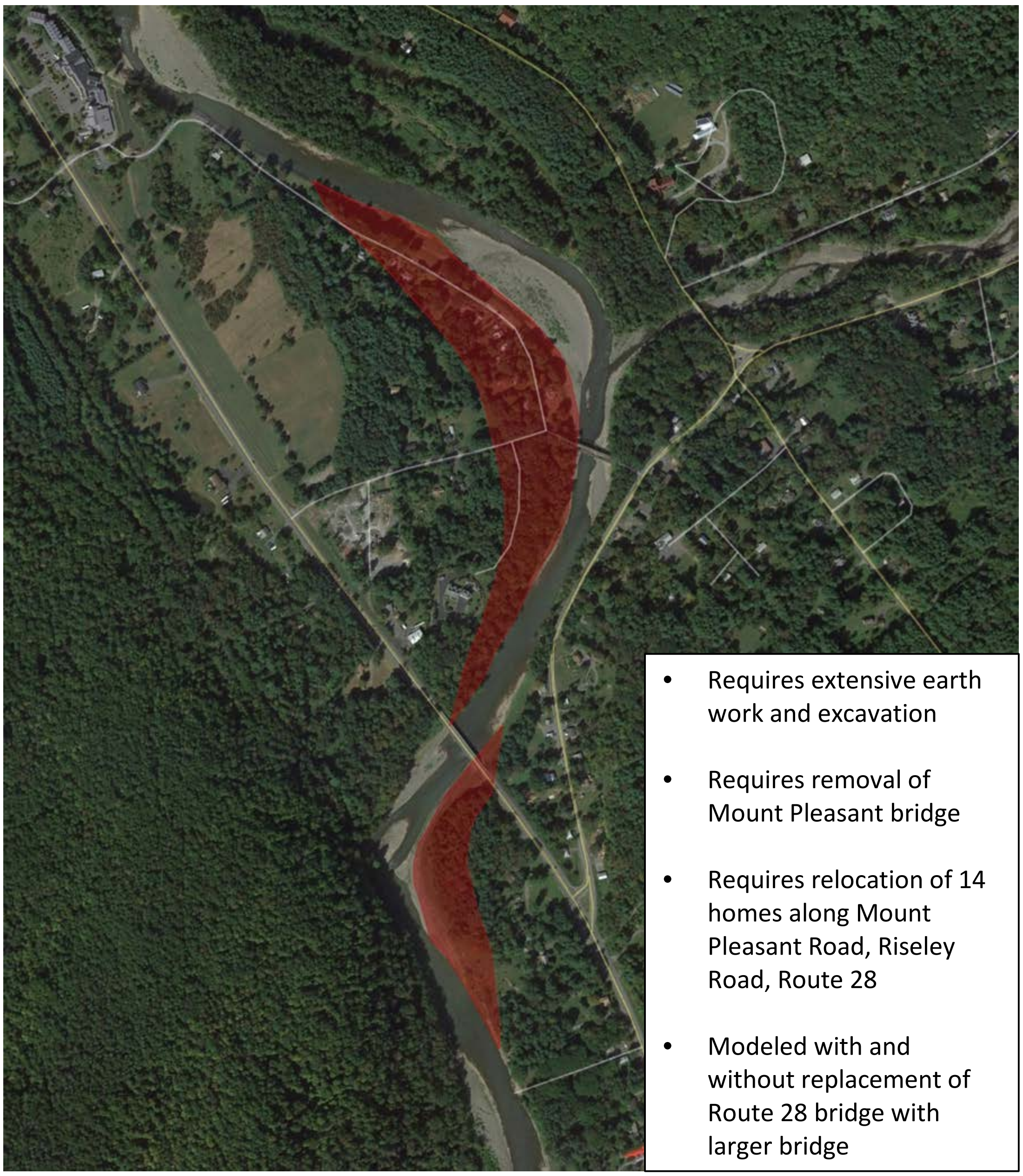
Floodplain enhancement involves excavation of the land area immediately adjacent to the creek in order to lower the elevation of the floodplain and increase its capacity to convey water during flood events. Floodplain enhancement in combination with the replacement of the Bridge Street bridge would reduce, but not eliminate, flooding along Main Street in Phoenicia during large flood events. If implemented, water surface elevations would be reduced by up to 1.2 feet along Main Street during a flood event similar in magnitude to Tropical Storm Irene. This flood mitigation scenario would require relocation of homes and businesses located along Esopus Creek and Stony Clove Creek. Specifically, this would include relocation of businesses on one parcel located to the east of and adjacent to the Main Street bridge over Stony Clove Creek, relocation of the structures located on two parcels along the right bank of Esopus Creek just east (downstream) of Bridge Street and north of Station Road, relocation of a portion of the Black Bear Campground, and potential relocation of one structure along Bridge Street. It is recommended that the town seek consensus from citizens and affected landowners on implementation of this floodplain enhancement scenario as funding allows.

FIGURE ES-1
Phoenicia Floodplain Enhancement/Bridge Street Bridge Replacement Scenario



Floodplain enhancement was also analyzed in Mt. Tremper along Esopus Creek near the bend just downstream of the Emerson Resort. This scenario involves lowering the elevation of the right bank and left bank floodplain and removal of the existing levee. Construction of this floodplain enhancement scenario would require removal of sections of Mount Pleasant Road and Riseley Road and relocation of some of the homes along these roads. A total of 14 homes would need to be relocated. This scenario would result in a water surface elevation reduction of up to 3.0 feet along 4,000 feet of channel during the 10-year flood event. Water surface elevation reductions under the floodplain enhancement scenario would be as much as 3.5 feet in the vicinity of the Route 28 bridge during the 100-year flood event and would extend approximately 4,000 feet upstream of the bridge.

Figure ES-2
Mt. Tremper Floodplain Enhancement Scenario



A variety of measures are available to protect existing public and private properties from flood damage. While the broader mitigation efforts described above are most desirable, they often take time and money to implement. On a case-by-case basis where structures are at risk in the hamlets, individual floodproofing should be explored. In areas where properties are vulnerable to flooding, improvements to individual properties and structures may be appropriate. Potential measures for property protection include elevation of structures, floodproofing, and home improvements to mitigate damage from flooding.

Several funding sources may be available to the Town of Shandaken for the implementation of recommendations made in this report. Table ES-2 lists potential funding sources. These are discussed in more detail later in this report.

TABLE ES-2
Potential Funding Sources for Flood Mitigation Alternatives with a Positive BCR

Mitigation Projects	Strategy	Federal	State	Other
Floodplain enhancement along Esopus Creek and Stony Clove, with Bridge Street bridge replacement	Acquire and relocate structures.	FEMA	NYSDOS	NYCDEP Buyout, CWC
	Replace Bridge Street bridge.	None	None	Ulster County, Ashokan SMP, CWC
	Create floodplain enhancement along Stony Clove Creek and Esopus Creek.	FEMA	NYSDOS, NYSDEC	Ashokan SMP, CWC
Mt. Tremper floodplain enhancement	Acquire and relocate structures.	FEMA	NYSDOS	NYCDEP Buyout, CWC
	Create floodplain enhancement along Esopus Creek.	FEMA	NYSDOS, NYSDEC	Ashokan SMP, CWC

FEMA = Federal Emergency Management Agency
NYSDOS = New York State Department of State
NYCDEP = New York City Department of Environmental Protection
CWC = Catskill Watershed Corporation
SMP = Stream Management Plan

1.0 INTRODUCTION

1.1 Project Background

The Town of Shandaken, utilizing funding provided by the New York City Department of Environmental Protection (NYCDEP) through the Ashokan Watershed Stream Management Program (AWSMP), retained Milone & MacBroom, Inc. (MMI) to complete a Local Flood Analysis (LFA) in the town of Shandaken, New York, in the hamlets of Phoenicia and Mt. Tremper. The LFA builds upon Federal Emergency Management Agency (FEMA) modeling to evaluate a variety of flooding issues in these communities and assess potential mitigation measures aimed at reducing flood inundation. The LFA is a program specific to the New York City water supply watersheds, initiated following Tropical Storm Irene to help communities identify long-term, cost-effective projects to mitigate flood hazards. The intent of the LFA is to help municipalities to do the following:

- Confirm where significant inundation flood hazards exist in the target area through engineering analysis.
- Use engineering analysis to develop a range of hazard mitigation alternatives; the primary focus of the analysis is to identify the potential for reducing flood elevations through channel and floodplain restoration as the first alternative to other hazard mitigation solutions.
- Evaluate both the technical effectiveness and the benefit-cost effectiveness of each solution and compare different solutions to each other for the most practical, sustainable outcome (NYCDEP, 2014).

Project recommendations generated through an approved LFA may be eligible for Flood Hazard Mitigation funding available through the county Soil and Water Conservation Districts and the Stream Management Implementation Program (SMIP) administered by Cornell Cooperative Extension (in Ulster County), the Catskill Watershed Corporation's (CWC) Flood Hazard Mitigation Implementation Program, or the NYCDEP-funded Buyout program.

1.2 Study Areas

The project has been divided into two study areas, the first including the hamlet of Phoenicia and the second including the hamlet of Mt. Tremper. The study areas are located along Esopus Creek and two of its tributaries, Stony Clove Creek and the Beaver Kill. Esopus Creek has its headwaters in the Catskill Mountains at Winnisook Lake and discharges to the Ashokan Reservoir, a drinking water supply source for the New York City water system. The region was settled around the time of the American Revolution and was established as a town in 1804. The hamlet of Phoenicia is the largest community within the town of Shandaken, with a population of 309.

In total, the study areas encompass 6.2 miles along Esopus Creek. Esopus Creek in this reach passes under Highway 28 twice: once near the upstream boundary of the Phoenicia project area and again near the downstream boundary of the Mt. Tremper project area. Figures 1-1 and 1-2 show the boundaries of the two study areas.

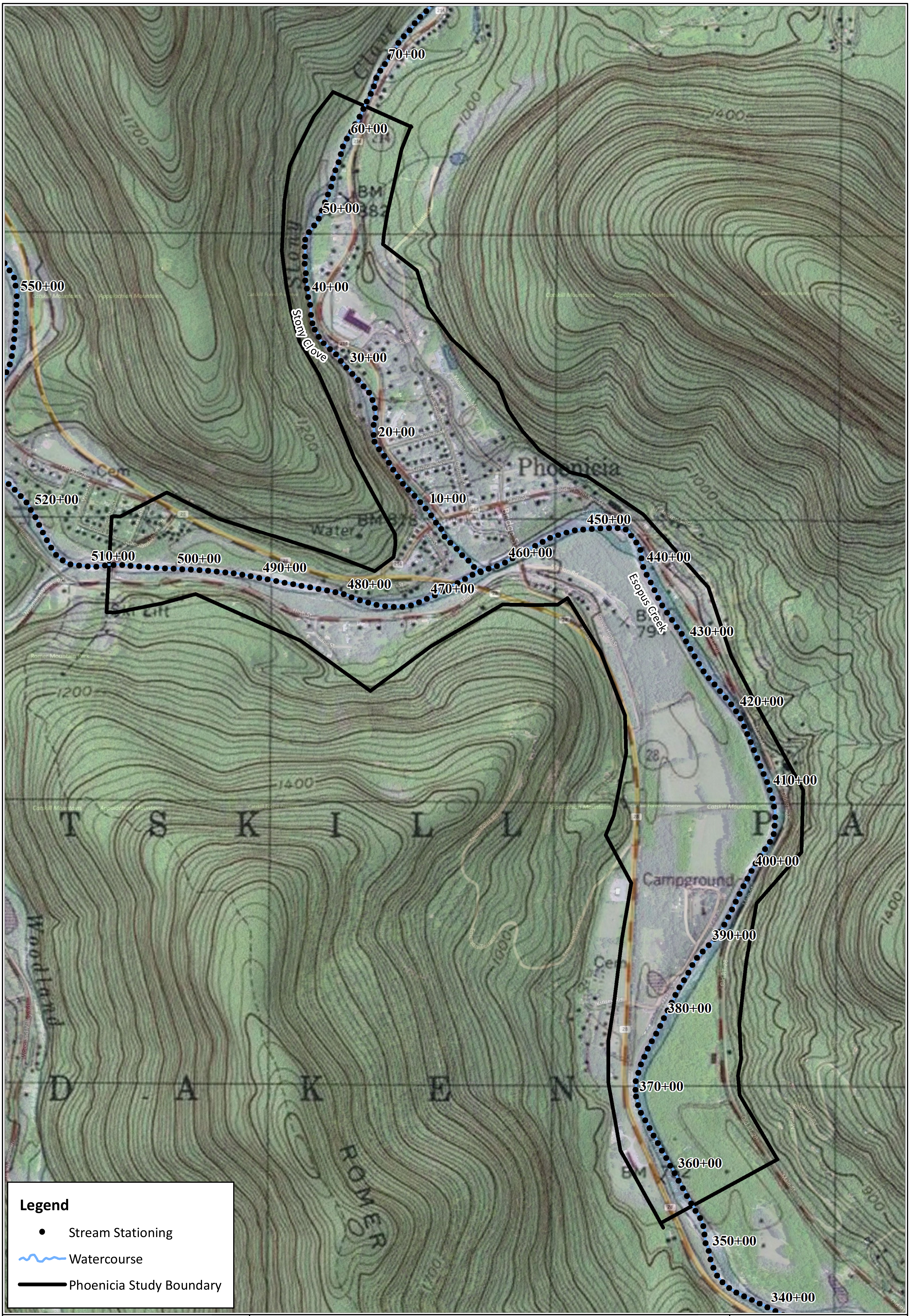


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Figure 1-1: Phoenicia Study Area

Location: **Phoenicia, NY**

N

Shandaken LFA

Map By: CMP
MMI#: 4615-04
MXD: Y:\4615-04\GIS\Maps\Report Maps\Phonecia Study Area.mxd
1st Version: 10/28/2015
Revision: 10/29/2015
Scale: 1 in = 1,000 ft

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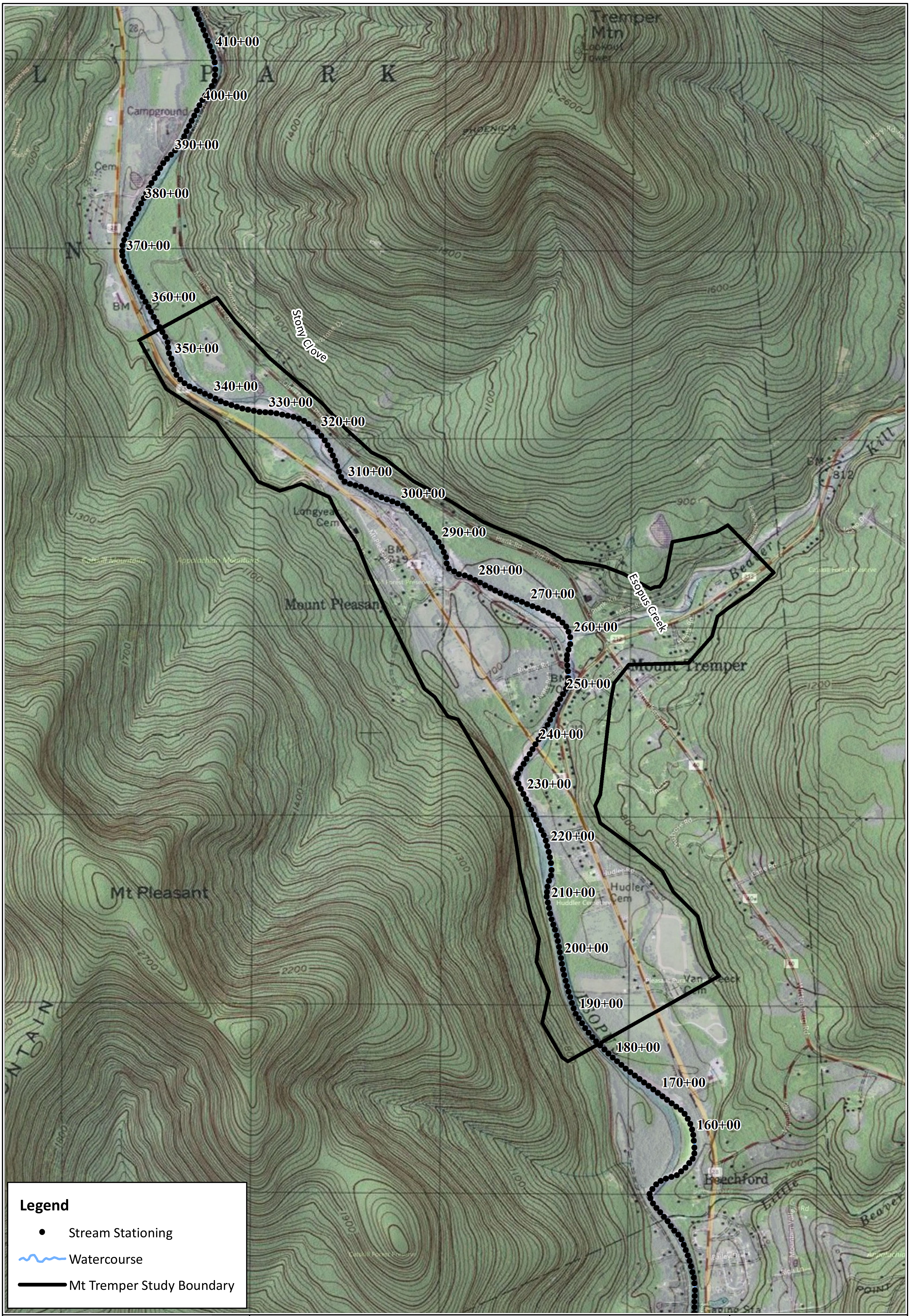

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Figure 1-2: Mount Tremper Study Area

Location:
Mount Tremper, NY

N

Shandaken LFA

Map By: CMP
MMI#: 4615-04
MXD: Y:\4615-04\GIS\Maps\Report Maps\Mt Tremper Study Area.mxd
1st Version: 10/28/2015
Revision: 10/29/2015
Scale: 1 in = 1,500 ft

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1.3 Community Involvement

The LFA was undertaken in close consultation with the Shandaken Area Flood Assessment and Remediation Initiative (SAFARI). SAFARI is comprised of individuals with technical and nontechnical backgrounds and is meant to represent various interests and stakeholders at the village, town, and county levels as well as the NYCDEP. SAFARI's mission is to reduce the flood hazard vulnerability in the planning area to ensure that residential and business communities can thrive within a healthy environment. The SAFARI team met regularly with MMI staff over the course of the LFA process to review results and provide input on flood mitigation alternatives. SAFARI members include representatives from the following organizations:

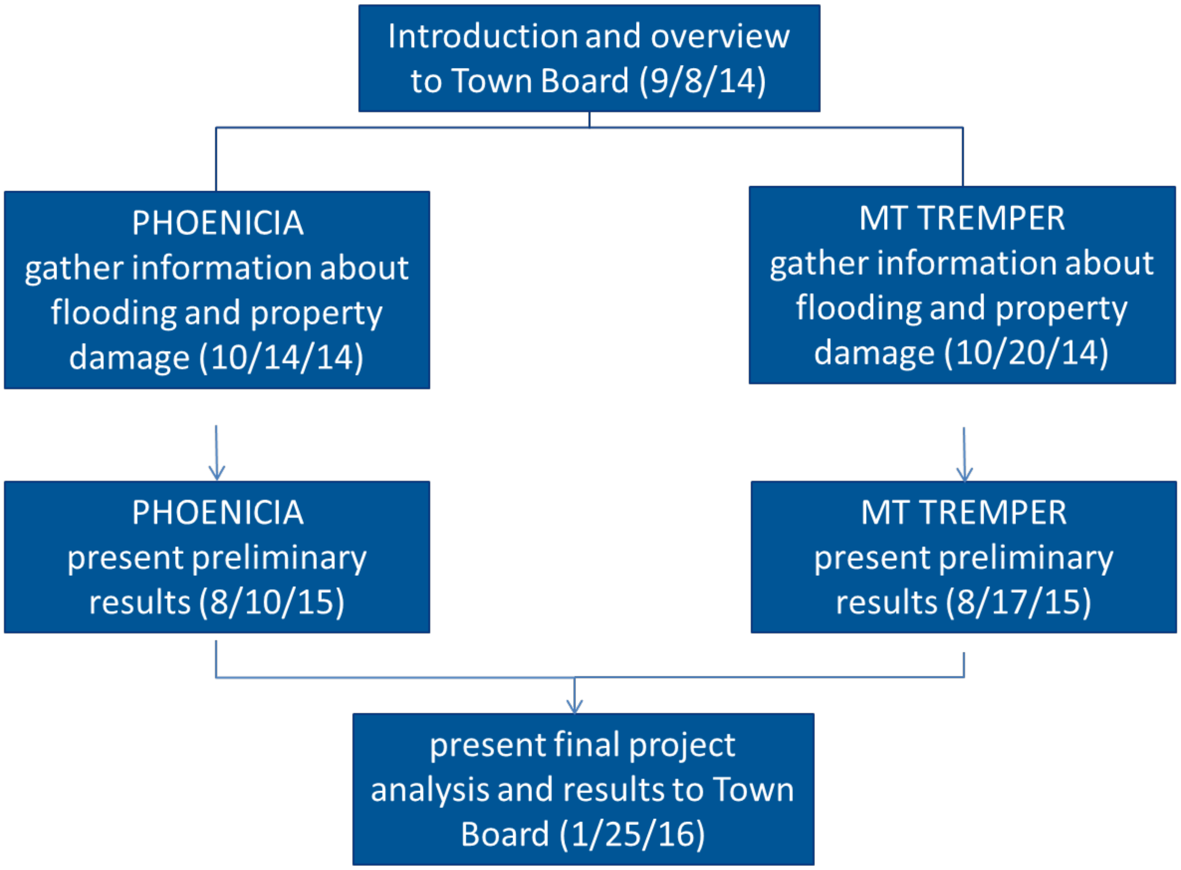
- Town of Shandaken
- Shandaken residents and business owners
- AWSMP (which includes representatives from the following three organizations):
    - Ulster County Soil & Water Conservation District (UCSWCD)
    - NYCDEP
    - Cornell Cooperative Extension of Ulster County
- Ulster County Department of the Environment
- MMI

SAFARI was also the primary pathway for community involvement in the planning process. The public was included and informed throughout the LFA process. The following public outreach events took place:

- On September 8, 2014, an initial presentation was made by MMI at a Shandaken Town Board meeting that took place at the Shandaken Town Hall. The purpose of this presentation was to kick off the LFA and provide Shandaken Town Board members and the public with an overview of the process and time line.
- The LFA process included two introductory public meetings that occurred near the beginning of the project. The first was held on October 14, 2014 at the Parish Hall on Main Street in Phoenicia. MMI provided attendees with an overview of the project, the LFA process, and hydraulic modeling techniques. Information was collected from attendees on flood damage and potential flood mitigation alternatives. On October 20, 2014, a second meeting was held at the Emerson Resort and Spa on Route 28 in Mt. Tremper.
- Toward the conclusion of the LFA process, when results of the analysis were available, public meetings were again held in the two communities, this time to present the LFA findings and conclusions. The first was held on August 10, 2015 at the Parish Hall in Phoenicia. On August 17, 2015, a second meeting was held at the Emerson Resort and Spa in Mt. Tremper.

Figure 1-3 graphically presents the community involvement efforts. *PowerPoint* presentations are included in Appendix B.

FIGURE 1-3
Community Involvement Meetings



1.4 Nomenclature

In this report and associated mapping, stream stationing is used as an address to identify specific points along the watercourse. Stationing is measured in feet, beginning at the point STA 0+00 where Esopus Creek enters the Ashokan Reservoir and continuing upstream to STA 1287+62 at its headwaters. As an example, STA 73+00 indicates a point in the Esopus Creek channel located 7,300 linear feet upstream from the point where it enters the Ashokan Reservoir. All references to right bank and left bank in this report refer to "river right" and "river left," meaning the orientation assumes that the reader is standing in the river looking downstream.

In order to provide a common standard, FEMA's National Flood Insurance Program (NFIP) has adopted a base line probability called the base flood. The base flood has a 1 percent (one in 100) chance of occurring in any given year, and the base flood elevation (BFE) is the elevation of this level. For the purpose of this report, the 1 percent annual chance flood is referred to as the ***100-year flood event***. Other reoccurrence probabilities used in this report include the ***2-year flood event*** (50 percent annual chance flood), the ***10-year flood event*** (10 percent annual chance flood), the ***25-year flood event*** (4 percent annual chance flood), the ***50-year flood event*** (2 percent annual chance flood), and the ***500-year flood event*** (0.2 percent annual chance flood). The Special Flood Hazard Area (SFHA) is the area inundated by flooding during the 100-year flood event.

2.0 WATERSHED INFORMATION

2.1 Initial Data Collection

Initial data collected for this study and analysis included publicly available data as well as input from SAFARI and from the public meetings held within the hamlets of Phoenicia and Mt. Tremper. A summary of key documents follows.

Flood Insurance Study (FIS)

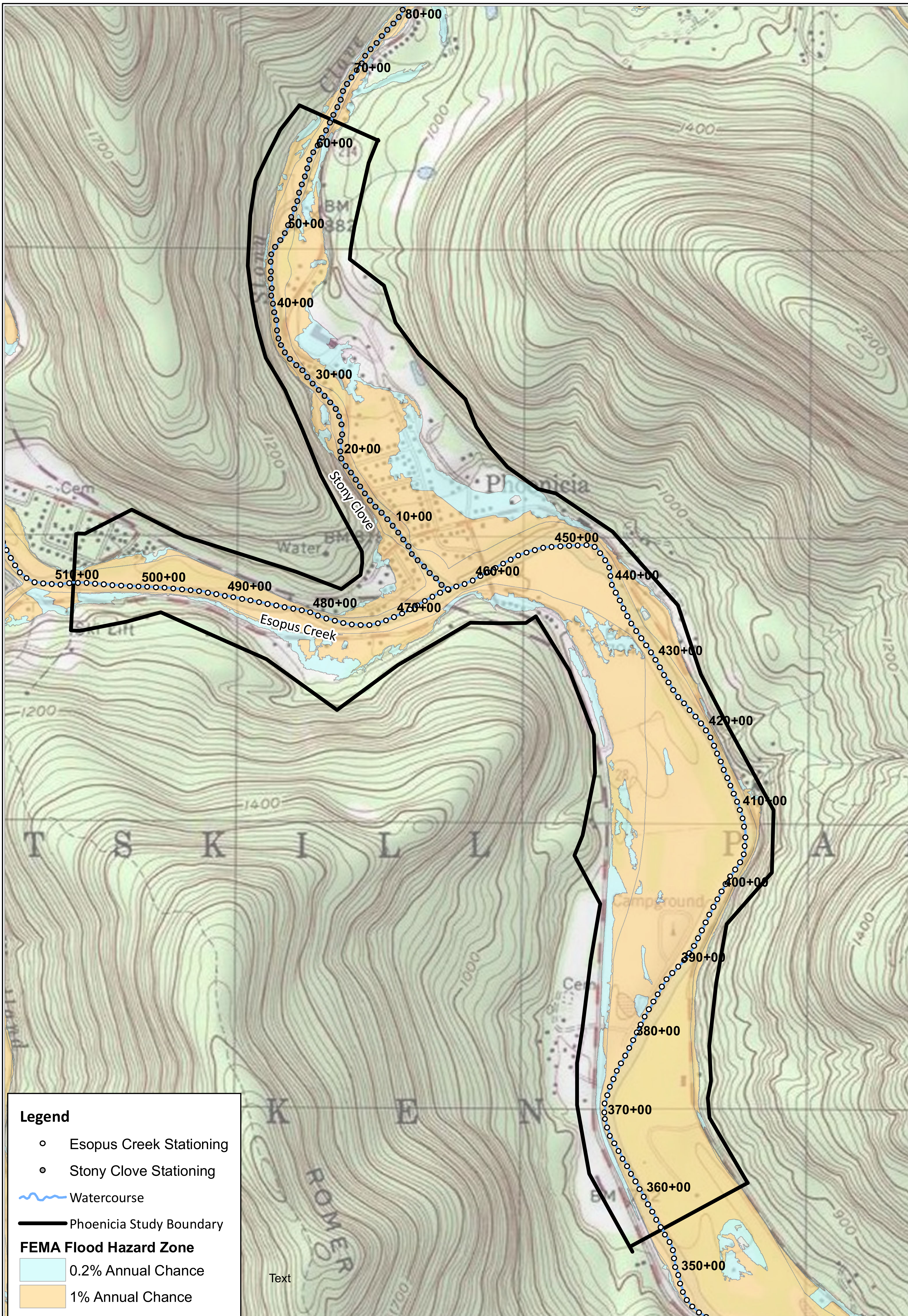
FEMA has produced a preliminary FIS dated May 24, 2013 for Ulster County that includes the upper Esopus, Stony Clove, and Beaver Kill watersheds. The purpose of the FEMA study was to determine potential floodwater elevations and delineate existing floodplains in order to identify flood hazards and establish insurance rates. MMI used the preliminary 2013 FIS from FEMA Contract No HSFEHQ-09-D-0369, task order HSFE02-10-J-0001. This work was based on 2009 Light Detection and Ranging (LiDAR) and field surveys conducted between 2011 and 2012.

An important byproduct of the FIS is a series of HEC-RAS computer models that are available for professional use and are a key component of the subject study. The area predicted to be flooded during the 100-year frequency event is known as the SFHA. FEMA's Flood Insurance Rate Mapping (FIRM) is shown in Figures 2-1 and 2-2.

Stream Management Plans

A detailed description of the Esopus Creek watershed and channel is contained in the 2007 Upper Esopus Creek Stream Management Plan (SMP) prepared by the NYCDEP with assistance from the U.S. Army Engineer Research Development Center and the Ulster County Cornell Cooperative Extension (CCE). An SMP was also prepared for Stony Clove Creek in 2005 by the Greene County Soil and Water Conservation District (GCSWCD) and the NYCDEP. Both reports present information on the regional setting, climate, physiography, hydrology and flood history, watershed geology, and land use/land cover.

The Upper Esopus Creek SMP consists of three volumes. The first is a summary of findings and recommendations. The second addresses the social and cultural aspects related to stream management, including a history of the watershed and its contribution to the New York City water supply system. The final volume provides a detailed physical description of the watershed. This volume also presents the results of the various assessments that were carried out for the study and used to formulate the recommendations in Volume 1 (NYCDEP, 2007). A digital copy of this document is available at http://ashokanstreams.org/publications-resources/resources-for-streamside-living/.



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FEMA Ulster County Special Flood Hazard Area

Figure 2-1: Phoenicia Study Area Flood Hazard Zones

Location: **Phoenicia, NY**

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Shandaken LFA

Map By: JCS
MMI#: 4615-04
MXD: Q:\Projects\Phoenicia_Mt_Tremper_LFA\GIS\Phonecia FEMA.mxd
1st Version: 10/28/2015
Revision: 1/15/2016
Scale: 1 in = 1,000 ft

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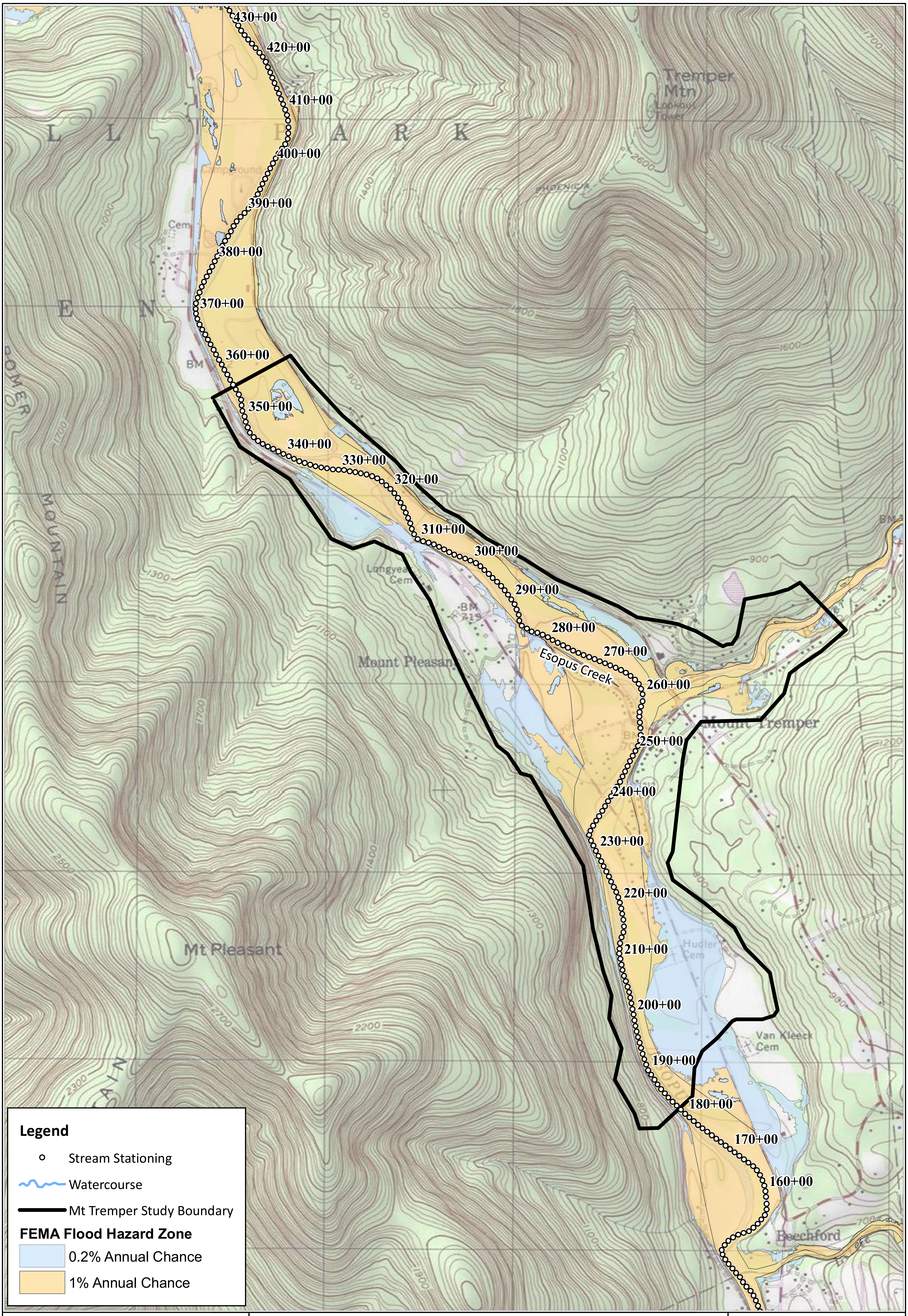

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FEMA Ulster County Special Flood Hazard Area

Figure 2-2: Mount Tremper Study Area Flood Hazard Zones

Location: **Mount Tremper, NY**

N

Shandaken LFA

Map By: JCS
MMI#: 4615-04
MXD: Q:\Projects\Phoenicia_Mt_Tremper_LFA\GIS\Mt Tremper FEMA.mxd
1st Version: 10/28/2015
Revision: 1/15/2016
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The Stony Clove SMP is divided into two volumes. The first volume provides background information while the second volume provides descriptions of the 21 management units spread along the length of the stream. This volume also provides reach-by-reach management recommendations. Additionally, it sets forth a series of management recommendations that are more effectively implemented at the watershed, community, or program scale (GCSWCD, 2005). A digital copy of this SMP is available at http://www.catskillstreams.org/stonyclovesmp.html.

The SMP for the Beaver Kill was completed in April 2015 and is available at http://ashokanstreams.org/exploring-the-watershed/beaverkill-2/. The SMP for the Beaver Kill provides recommendations for each of the nine management units. Major issues identified in the SMP include excessive stream bank erosion, threats to transportation infrastructure, and geomorphic impacts from large woody debris.

United States Geological Survey (USGS) Stream Gauging Network

The USGS operates and maintains two stream flow gauges on the upper Esopus. One gauge is located upstream of the project boundary at Allaben, New York (1362200). A second gauge is located immediately downstream of the project area at Coldbrook, New York (1362500). A stream flow gauge is also located on Stony Clove Creek near the hamlet of Chichester, New York (1362370). The gauges record daily stream flow, including flood flows that are essential to understanding long-term runoff trends. Gauge data can be utilized to determine flood magnitudes and frequencies. Additionally, real time data is available to monitor water levels and provide flood alerts. Stream flow data and water levels are available at http://waterdata.usgs.gov/ny/nwis/sw.

Hazard Mitigation Plans

The purpose of hazard mitigation plans is to identify policies and actions that will reduce risk in order to limit losses to property and life. Flood hazard mitigation, in particular, seeks to implement long- and short-term strategies that will successfully limit loss of life, personal injury, and property damage that can occur due to flooding (URS, 2009). Flood mitigation strategies are most successful when private property owners; businesses; and local, state, and federal governments work together to identify hazards and develop strategies for mitigation (Tetra Tech, 2009).

Flood hazard mitigation planning is promoted by various state and federal programs. At the federal level, FEMA administers two programs that provide reduced flood insurance costs for communities meeting minimum requirements: the NFIP and the Community Rating System (CRS) (Tetra Tech, 2013). Flood hazard planning is a necessary step in acquiring eligibility to participate in these programs (URS, 2009).

Ulster County Multijurisdictional Natural Hazard Mitigation Plan

In 2009, Ulster County completed a multijurisdictional natural hazard mitigation plan (HMP). By participating in the plan, jurisdictions within the county comply with the Federal Disaster Mitigation Act of 2000. Compliance with this act allows jurisdictions to apply for federal aid for technical assistance and postdisaster mitigation project funding. An updated plan will be released in 2016. Recommended actions for Phoenicia and Mt. Tremper included in this LFA report will be considered for inclusion in the plan update.

The HMP identifies flooding as a significant natural hazard in Ulster County. The town of Shandaken was noted as being especially vulnerable as the majority of development is located in the valley of Esopus Creek and its tributaries, which were identified as high risk areas. High risk areas are defined as having a 1 percent chance of being flooded in any given year. In other words, a significant portion of the inhabited area of the town of Shandaken lies within the 100-year floodplain. Additionally, the Town of Shandaken and the City of Kingston both reported the second-highest number of repetitive property losses in the county.

Town of Shandaken Flood Mitigation Plan

The Town of Shandaken participated in the Ulster County Multijurisdictional Natural Hazard Mitigation Plan. However, based on its flood history, the town decided to develop a flood mitigation plan to more specifically address its needs and aid in reducing vulnerability to floods. The plan identifies hazards as well as resources, information, and strategies to reduce risk from flood hazards. Additionally, the plan helps guide and coordinate mitigation activities. The plan will also allow the Town of Shandaken to participate in the CRS with an improved classification, reducing flood insurance premiums for residents.

New York Rising Community Reconstruction Plan: NYRCR Towns of Shandaken and Hardenburgh

The New York Rising Community Reconstruction (NYRCR) program was developed to address significant impacts and establish long-term resiliency of the communities impacted by Tropical Storms Irene and Lee. A NYRCR Plan was developed jointly by the Towns of Shandaken and Hardenburgh for the NYRCR program. The plan provides a description of communities and the flood damage that occurred as a result of Tropical Storms Irene and Lee. The plan also provides a risk assessment of economic, health and social services; infrastructure; and cultural assets in the study area. It then explores a number of reconstruction and resiliency strategies. These strategies include the following:

1. Reducing the impact of flooding on critical facilities and infrastructure
2. Enhancing economic vitality by diversifying the business base and promoting economic growth and tourism
3. Ensuring continuity of critical services before, during, and after a disaster
4. Addressing housing issues related to flood risk, availability, and affordability
5. Protecting, preserving, and improving natural, cultural, and historic resources

The document concludes by presenting projects selected by the committee as candidates for Community Development Block Grant-Disaster Recovery funding.

Water Quality Reports

Throughout the project area, Esopus Creek is classified by the New York State Department of Environmental Conservation (NYSDEC) as a Class A (TS [trout spawning]) watercourse. The A classification indicates a best usage for a source of drinking water, swimming and other recreation, and fishing. Stony Clove Creek is classified as a Class B (TS) watercourse. Classification B indicates a best usage for swimming and other recreation and fishing. The Beaver Kill is classified as a Class C (TS) watercourse. Classification C indicates a best usage for fishing.

New York State's 2014 Section 303(d) inventory lists Esopus Creek (middle, main stem) as impaired due to turbidity from stream erosion. Stony Clove Creek and the Beaver Kill were not specifically listed in the inventory.

To fulfill requirements of the Federal Clean Water Act, the NYSDEC must provide periodic assessments of the quality of the water resources in the state and their ability to support specific uses. These assessments reflect monitoring and water quality information drawn from a number of programs and sources both within and outside the department. This information has been compiled by the NYSDEC Division of Water and merged into an inventory database of all water bodies in New York State. The database is used to record current water quality information, characterize known and/or suspected water quality problems and issues, and track progress toward their resolution.

The inventory of water quality information is the Division of Water's Waterbody Inventory/Priority Waterbodies List (WI/PWL). The 2008 WI/PWL categorizes Esopus Creek and its tributaries between Ashokan Reservoir and Allaben as an impaired segment. Impairment is due to high levels of turbidity from the Schoharie Reservoir as well as stream bank erosion along Esopus Creek and its tributaries, particularly Stony Clove and Broadstreet Hollow Creek. In spite of turbidity, water quality sampling found that conditions are fully supportive of aquatic life. The report lists both the Beaver Kill and Stony Clove as having "no known impact." However, Stony Clove is identified as a major source of turbidity for the Esopus and considered a high priority for stream restoration. The most recent WI/PWL, from 2014, identifies Woodland Creek, Beaver Kill, Broadstreet Hollow Creek, and Birch Creek as producing moderately high suspended sediment concentrations.

Local Flood Damage Prevention Codes

The Town of Shandaken has adopted a local code for flood damage prevention. The present code was adopted in 1993 to be consistent with the federal guidelines in order to participate in the NFIP.

The stated purposes of this local law are to do the following:

- Regulate uses that are dangerous to health, safety, and property due to water or erosion hazards or that result in damaging increases in erosion or in flood heights or velocities.
- Require that uses vulnerable to floods, including facilities that serve such uses, be protected against flood damage at the time of initial construction.
- Control the alteration of natural floodplains, stream channels, and natural protective barriers that are involved in the accommodation of floodwaters.
- Control filling, grading, dredging, and other development that may increase erosion or flood damages.
- Regulate the construction of flood barriers that will unnaturally divert floodwaters or that may increase flood hazards to other lands.
- Qualify for and maintain participation in the NFIP.

The stated objectives of the local law are as follows:

- Protect human life and health.
- Minimize the expenditure of public money for costly flood-control projects.

- Minimize the need for rescue and relief efforts associated with flooding and generally undertaken at the expense of the general public.
- Minimize prolonged business interruptions.
- Minimize damage to public facilities and utilities such as water and gas mains, electric, telephone and sewer lines, streets, and bridges located in areas of special flood hazard.
- Help maintain a stable tax base by providing for the sound use and development of areas of special flood hazard so as to minimize future flood blight areas.
- Provide that developers are notified that property is in an area of special flood hazard.
- Ensure that those who occupy the areas of special flood hazard assume responsibility for their actions.

The Office of the Building Inspector/Zoning and Code Enforcement is empowered as the local administrator for administering and implementing the local Flood Damage Prevention Code. It is the duty of the local administrator to grant or deny floodplain development permits in accordance with the code. The local administrator must conduct a permit application review prior to approval and must review the subdivision or new development to determine if the proposed site is relatively free from flooding. It is also their responsibility to determine if proposed development in an area of special flood hazard may result in physical damage to other property.

The local law identifies a series of Construction Standards for development in the floodplain, broken down into General Standards, Standards for All Structures, Residential Structures, Nonresidential Structures, and Manufactured Homes and Recreational Vehicles.

The General Standards section is broken down into standards for subdivision proposals and encroachments. All new subdivision proposals and other development proposed in a SFHA must be consistent with the need to minimize flood damage, minimize flood damage to utilities, and provide adequate drainage. When encroaching on zones A1-A30 and AE along streams without a regulatory floodway, development must not increase the BFE by more than 1 foot. Along streams with a regulatory floodway, development must not create any increase in the BFE.

Standards for all structures include provisions for anchoring, construction materials and methods, and utilities. New structures must be anchored so as to prevent flotation, collapse, or lateral movement during the base flood. Construction materials must be resistant to flood damage, and construction methods must minimize flood damage. Enclosed areas below the lowest floor in zones A1-A30; AE; AH; and, in some cases, Zone A must be designed to allow for the entry and exit of floodwaters. Utility equipment such as electrical, HVAC, and plumbing connections must be elevated to or above the base flood height. Water supply and sanitary sewage systems must be designed to minimize or eliminate the infiltration of floodwaters.

The elevation of residential and nonresidential structures is required in areas of special flood hazard. In zones A1-A30; AE; AH; and, in some cases, Zone A, new residential construction and substantial improvements must have their lowest habitable floor elevated at or above an elevation that is 2 feet above the BFE. In cases where BFE data is not known for Zone A, new residential construction and substantial improvements must have their lowest floor elevated at or above 3 feet above the highest adjacent grade.

For nonresidential structures in zones A1-A30; AE; AH; and, in some cases, Zone A, developers have the option of either elevating the structures or improvements to or above an elevation that is 2 feet above the BFE or floodproofing the structure so that it is watertight below an elevation that is 2 feet above the BFE. In cases where BFE data is not known for Zone A, new construction and substantial improvements must have their lowest floor elevated at or above 3 feet above the highest adjacent grade.

Recreational vehicles are only allowed in zones A1-A30, AE, and AH if they are on site fewer than 180 consecutive days and are licensed and ready for highway use or meet the construction standards for manufactured homes. Manufactured homes in the A1-A30, AE, and AH zones must be placed on a permanent foundation with the lowest floor elevated at or above an elevation that is 2 feet above the BFE. In Zone A, such structures must be placed on reinforced piers or similar elements that are at least 3 feet above the lowest adjacent grade.

2.2 Field Assessment

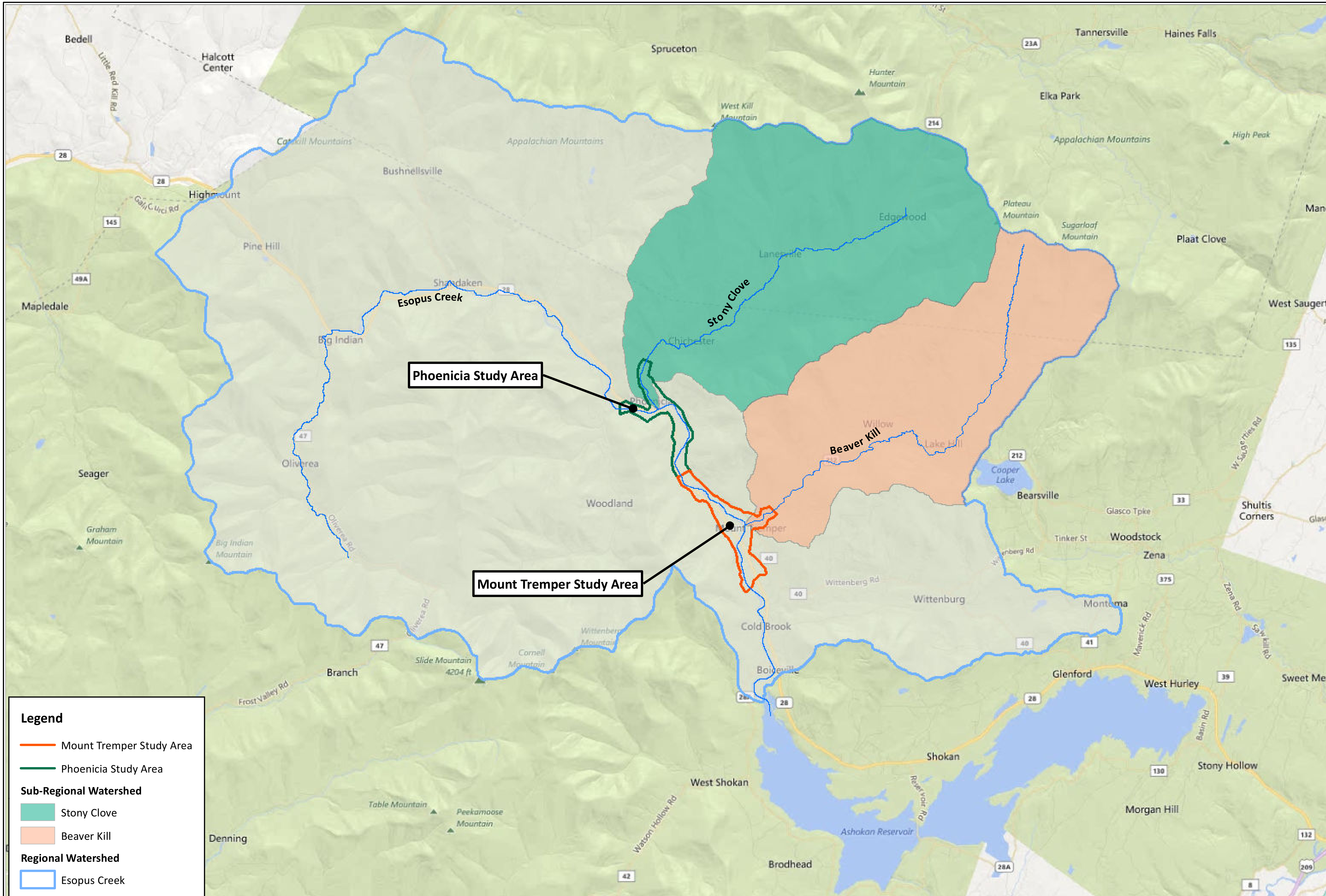
Following Tropical Storms Irene and Lee, MMI flood specialists and structural engineers conducted on-the-ground flood damage assessment and emergency response within Phoenicia and Mt. Tremper, working under contract to the NYCDEP. During the LFA process, MMI staff conducted numerous field visits to the project area. Field visits focused on two areas: (1) the river channel and its banks (bank and channel conditions, sediment bars, and vegetation along the stream corridor); (2) development in the floodplains.

A field survey of the Esopus Creek, Stony Clove, and Beaver Kill channels and their associated floodplains was conducted throughout fall 2014 in order to better understand site conditions and inform hydraulic modeling. Inspection was conducted on foot and by canoe down Esopus Creek. A visual "windshield survey" of the contributing watershed was also completed. Fieldwork included identification of low-lying structures, observation of bank and channel conditions, and characterization of vegetation along the stream corridor. Channel conditions were photodocumented and are included as a photo log in Appendix A.

2.3 Watershed Land Use

The Esopus flows through the hamlets of Phoenicia (near STA 460+00) and Mt. Tremper (near 259+00). The watershed of the Esopus pertaining to the project area is 172 square miles. The Esopus drains into the Ashokan Reservoir 3.5 miles downstream of the project area. The Stony Clove Creek and Beaver Kill drainages also contribute significantly to Esopus Creek in the project area. The watersheds are 32.4 square miles and 24.9 square miles, respectively. Figure 2-3 depicts the Esopus Creek, Stony Clove, and Beaver Kill watersheds as well as the project study areas.

Initial European settlement of the watershed occurred in the 1600s. Over the next 200 years, 80 percent to 90 percent of first growth forest was cleared primarily due to agriculture, tanneries, and forestry. In 1885, the Catskill Forest Preserve was created. In 1907, the Ashokan Reservoir was constructed and was entered into service in 1915. Since the early part of the 20th century, forest cover has increased with the decline in agriculture, forestry, and the disappearance of the tannery industry. Today forest cover in the watershed contributing to the Ashokan Reservoir exceeds 95 percent. Most residential and commercial areas that contribute impervious cover to the watershed are located along river valleys, with most development occurring along the Route 28 corridor (NYCDEP 2007). The SMPs should be consulted as a resource for detailed information on watershed history, land use and land cover, as well as watershed and stream characteristics.



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SOURCE(S):
BING Virtual Earth Roads
National Hydrography Dataset- Watercourses
StreamStats- Watersheds

Esopus Creek Watershed and Study Areas

Shandaken LFA

Phoenicia and Mount Tremper, New York

Map By: CMP
MMI#: 4615-04
MXD: Y:\4615-04\GIS\Maps\Report Maps\Esopus Watershed.mxd
1st Version: 1/15/2016
Revision: 1/22/2016
Scale: 1 in = 9,500 ft

Figure 2-3

2.4 Watershed and Stream Characteristics

This LFA considers three watercourses. The primary watercourse is Esopus Creek, which has its headwaters in the Catskill Mountains near Big Indian. Stony Clove Creek and the Beaver Kill were also analyzed as they are major tributaries to the Esopus. The portion of the Esopus Creek watershed that drains to the study area is 172 square miles, with an orientation from the northwest to the southeast. The watershed is characterized by steep slopes and a confined valley bottom.

The underlying bedrock geology of the project area consists of layers of sandstone and siltstone. Streambed particles are typically made up of eroded sedimentary bedrock (NYCDEP 2007). The surficial material overlying the bedrock consists of ice-age glacial deposits such as till, outwash and lake sediment, as well as more recent stream deposits. When exposed to the erosive action of the river, silts and clays can become mobilized, resulting in high turbidity and contributing to water quality impairment (NYCDEP 2007).

The total length of the Esopus from its headwaters to the end of the project area is 21 miles (MMI stationing). Within the project area, the length is 6.2 miles. In the upper watershed, the creek flows in a circular, clockwise manner from its headwaters to the upper boundary of the project area at the Woodland Valley Road bridge. The creek then flows in a southeasterly direction until it reaches the hamlet of Mt. Tremper. After this point, the Esopus flows in a more southerly direction until it reaches the Ashokan Reservoir. For much of its length, Esopus Creek can be characterized as an alluvial river, meaning its channel is located on sediment previously placed by the river. Alluvial rivers adjust their shape, size, and slope in response to flow rates and sediment loads.

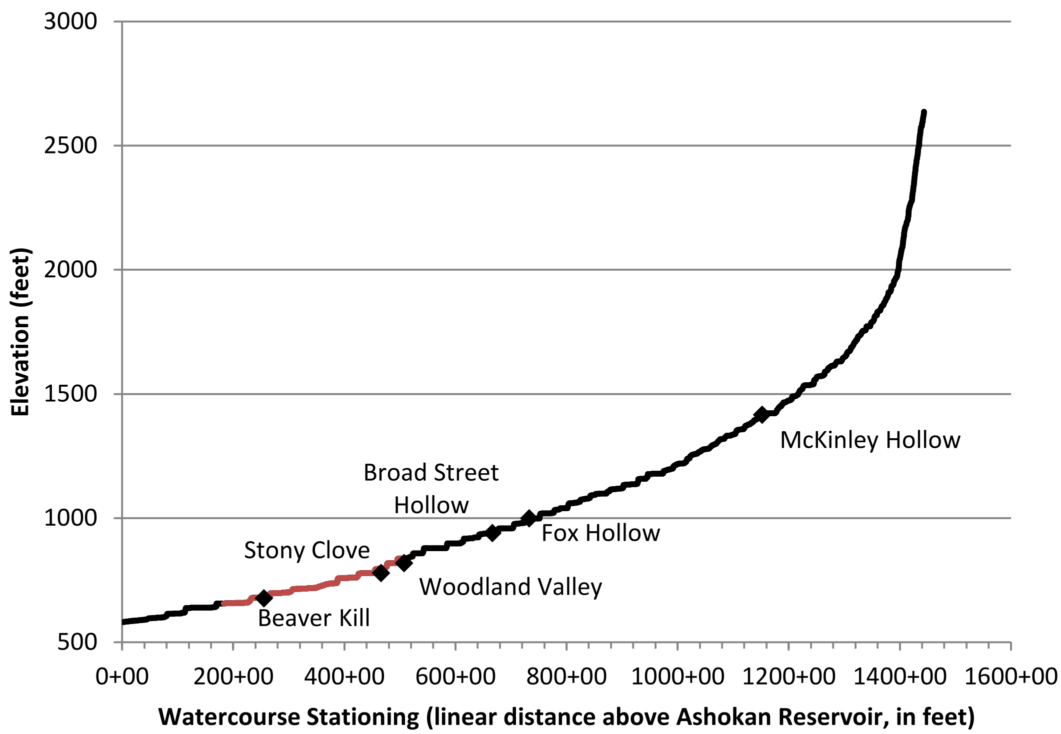
For descriptive purposes, Esopus Creek can be divided into four distinct sections. The first section extends from its headwaters near Winnisook Lake (STA 1443+55) to the hamlet of Oliverea (STA 1151+00). This section has a steep slope of 4.2 percent over a distance of 5.5 miles. This upper section of the watercourse is confined within the narrow, forested walls that rise steeply hundreds of feet above the channel along both banks. The watercourse consists of a single channel with low sinuosity. The confining valley walls limit lateral movement of the channel during major flood events.

The second section stretches from Oliverea (STA 1151+00) to immediately upstream of the Shandaken Tunnel (STA 682+00). The slope in this section is 1.0 percent over a distance of 8.9 miles. The valley bottom begins to broaden out, and the stream becomes braided between Oliverea and Big Indian. Between Big Indian and Allaben, the channel becomes more sinuous with the appearance of gravel point bars. As the creek passes through Allaben, the valley becomes more confined for the entirety of the section. Two notable tributaries entering the Esopus in this section are Birch Creek at Big Indian and Bushnellsville Creek in the hamlet of Shandaken. Two smaller tributaries, Fox Hollow Creek and Peck Hollow Creek, enter into Esopus Creek in the vicinity of Allaben.

The next section includes the length of stream from the Shandaken Tunnel (STA 682+00) to the upstream end of the project area (STA 507+00). Over a distance of 3.3 miles, the channel slope is 0.7 percent. This section is characterized by an interbasin transfer from the Schoharie Reservoir via the Shandaken Tunnel. The mean yearly flow rate delivered by the tunnel between 1998 and 2013 was 227 cubic feet per second (cfs). The channel in the upstream section is divided by two large islands in the vicinity of Broadstreet Hollow between STA 68+00 and STA 633+00. After this, the channel assumes a single thread with some occasional gravel point bars.

The final section begins at the Woodland Valley Road bridge (507+00), which defines the start of the project area, and continues to the Ashokan Reservoir (STA 0+00). The slope is much flatter in this region, with an average slope of 0.5 percent. The valley bottom continues to widen, and three major tributaries enter the Esopus including Stony Clove Creek, the Beaver Kill, and the Little Beaver Kill. The project area (STA 507+00 to STA 183+00) is one of the more densely populated regions in the upper Esopus, including the hamlets of Phoenicia and Mt. Tremper. Consequently, there are numerous residences and business located on the valley floor, many of which are in close proximity to the stream channel. Figure 2-4 presents a profile of Esopus Creek showing its elevation versus linear distance from its outlet to Ashokan Reservoir as well as the locations of several tributaries. The project area is indicated in red.

FIGURE 2-4
Esopus Creek Channel Profile



Stony Clove is one of two tributaries of the Esopus considered in the study. It is the largest tributary in the upper Esopus watershed, draining an area of 32.4 square miles. The bedrock geology is composed of a mixture of sandstone, siltstone, mudstone, and shale (GCSWCD, 2004). Surficial geology includes extensive amounts of glacial till and lake silts and clays. In one reach between the hamlets of Chichester and Phoenicia, the stream channel is subject to bedrock control.

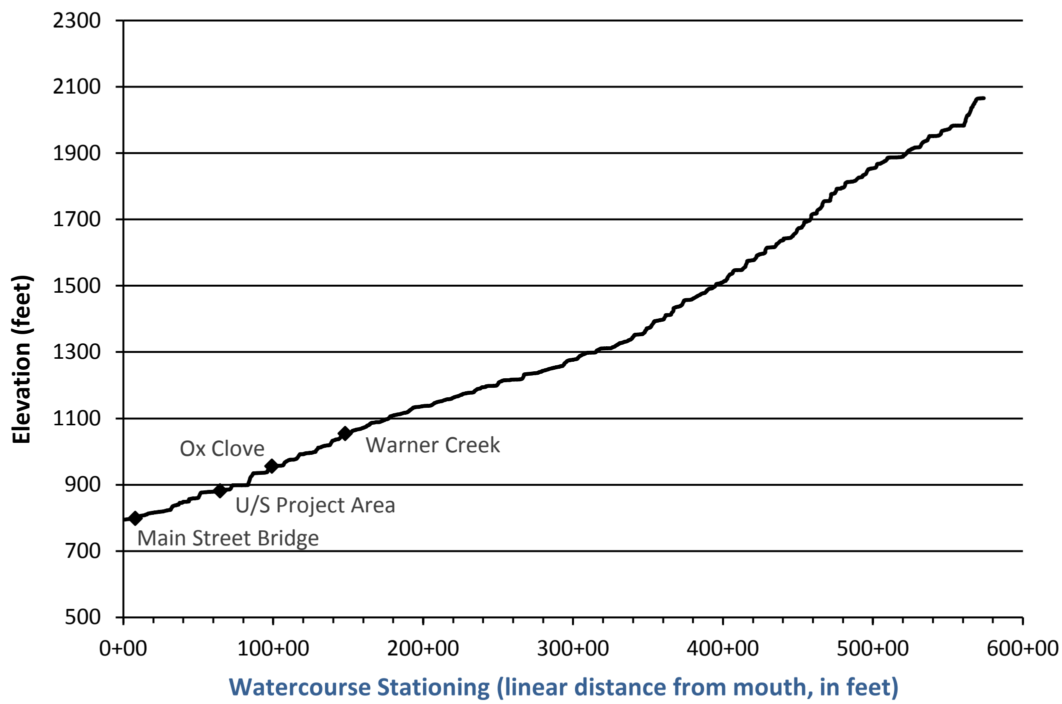
Stony Clove Creek and its main tributaries (Warner Creek, Hollow Tree Brook, Ox Clove, and Myrtle Brook) are primarily perennial streams. Precipitation ranges between 50 and 60 inches per year, which is high, even for the Catskills. In addition, the average slope of the watershed is 36.4 percent, making it one of the steepest of any subwatershed in the New York City water supply watershed (GCSWCD, 2004). As a result, Stony Clove stream levels rise and fall rapidly in response to storm events. Stony Clove

Creek is subject to high stream power due to its relatively high overall slope, which contributes to significant sediment load delivered into the study area.

The Stony Clove headwaters issue from Notch Lake, which lies in the valley between Plateau Mountain and Hunter Mountain. The creek is located in both Greene and Ulster counties and passes through the hamlets of Lanesville and Chichester before reaching the confluence with the Esopus at the hamlet of Phoenicia. Along its 10.2-mile course, NYS Route 214 crosses the Stony Clove three times, with many small bridges on private and side roads spanning the stream.

Figure 2-5 is a profile of Stony Clove Creek showing its elevation versus linear distance from its outlet at Esopus Creek in Phoenicia.

FIGURE 2-5
Stony Clove Creek Channel Profile



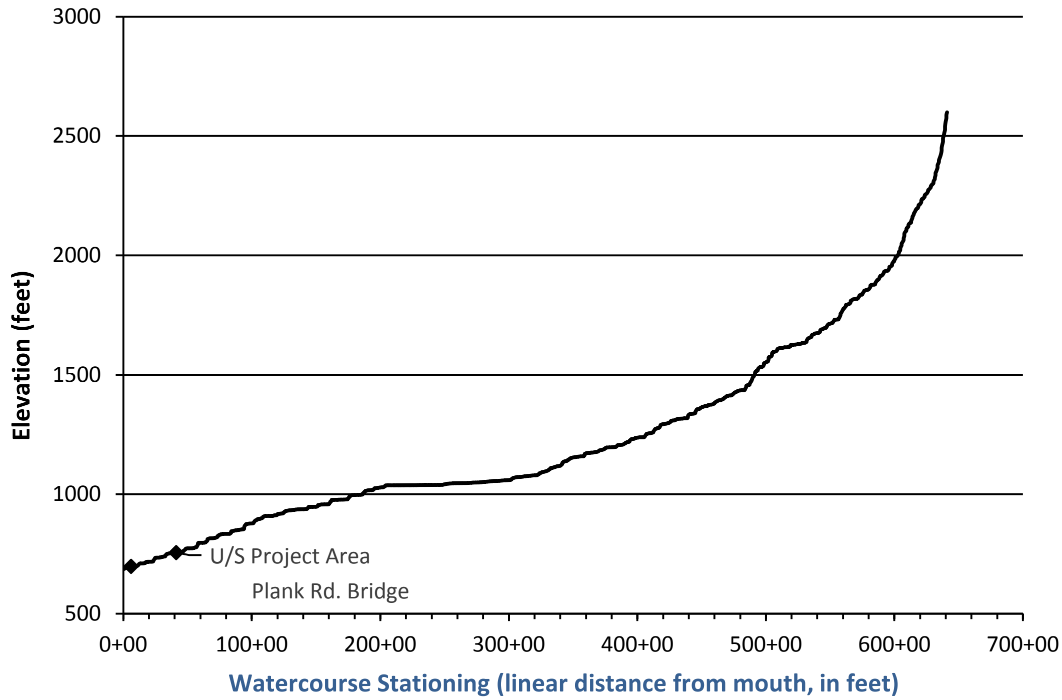
The Beaver Kill is the smaller of the two major tributaries that enter the upper Esopus within the project area. Its hydrology and geology are similar to Stony Clove Creek. The headwaters lie in the upper valley between Plateau and Sugarloaf mountains. The stream stretches approximately 13 miles between the headwaters and the confluence with the Esopus. Over its course, it is spanned by numerous small bridges.

From topographic maps and aerial imagery, three distinct sections of the Beaver Kill can be identified. The first section stretches from the headwaters to the hamlet of Lake Hill. This section is characterized by a narrow valley with steep slopes. Between the hamlets of Lake Hill and Willow, the valley broadens significantly, with the stream becoming wide and sinuous. Below Willow to the confluence with the

Esopus, the valley narrows again, and the channel slope steepens. A more detailed description of the Beaver Kill can be found in the SMP.

Figure 2-6 is a profile of the Beaver Kill showing its elevation versus linear distance from its outlet at Esopus Creek in Mt. Tremper.

FIGURE 2-6
Beaver Kill Channel Profile



2.5 Infrastructure

Seven bridges cross the Esopus, Stony Clove, and Beaver Kill within the study area: five across Esopus Creek, one across Stony Clove, and one across the Beaver Kill. Table 2-1 lists the bridges in the study area and the stream station location of each bridge.

TABLE 2-1
Bridges Crossing in the Study Area

Bridge Crossing	Stream	MMI Station
Woodland Valley Road	Esopus Creek	507+01
Route 28 in Phoenicia	Esopus Creek	466+00
Main Street (Route 214)	Stony Clove Creek	8+00
Bridge Street	Esopus Creek	458+39
Plank Road	Beaver Kill	6+25
Mt. Pleasant Road	Esopus Creek	254+83
Route 28 in Mt. Tremper	Esopus Creek	239+91

Esopus Creek is lined by a flood control levee as it flows through Mt. Tremper. According to information on the NYSDEC website and on signs placed on site, the levee project was authorized pursuant to Section 2 of the 1937 Flood Control Act as amended. The original project was operationally completed in 1952 and was modified in 1954 to provide for strengthening the riprapped toe of the spoil bank and for shoal removal. Emergency repairs of the flood-damaged spoil bank were made under authority of Public Law 84-99 in fall 1980 (NYSDEC website, 2015). The levee is not certified by FEMA, indicating that it does not meet FEMA's standards for design, operation, and maintenance. As a result, flood elevations indicated on the FIS and on FIRMs have been computed as if the levee did not exist.

Flood Control Levee Along Esopus Creek in Mt. Tremper

2.6 Hydrology

Hydrologic studies are conducted to understand historic and potential future river flow rates using data measured at stream gauging stations and those developed from predictive models. They inform communities of how much water flows in the river at a specific time and place.

The USGS operates and maintains stream flow gauges that record daily stream flow, including flood flows. This data is essential to understanding long-term trends. Gauge data can be utilized to determine flood magnitudes and frequencies. Table 2-2 is a list of USGS water surface stream gauging stations along Esopus Creek and Stony Clove Creek. There is also a USGS turbidity/stream flow site on the Beaver Kill, which the USGS updates monthly after the data are downloaded.

TABLE 2-2
Active USGS Gauging Stations

USGS Gauge Number	MMI River Station (Esopus Creek)	Location	Drainage Area (square miles)	Period of Record
1362200	731+00	Esopus Creek at Allaben	63.7	October 1963 to Present
1362230	681+00	Diversion from Schoharie Reservoir	NA	February 1924 to Present
1362500	123+50	Esopus Creek at Coldbrook	192	October 1934 to Present
1362370	99+00	Stony Clove below Ox Clove	30.9	February 1997 to Present
01362487	6+25	Beaver Kill at Mt. Tremper	25.0	Miscellaneous Measurements

The FIS for the town of Shandaken is preliminary and, at the time of this LFA report, has not been formally adopted. The purpose of the FEMA study is to determine potential floodwater elevations and delineate existing floodplains in order to identify flood hazards and establish insurance rates. Hydrologic analysis was employed by FEMA to estimate peak flows for the 10-, 25-, 50-, 100-, and 500-year flood events. Discharges in the Esopus Creek watershed were developed using Hydrologic Engineering Center – *Hydrologic Modeling System* (HEC-HMS) *3.5*, according to guidelines in Appendix C of the FEMA *Guidelines and Specifications*. The model was calibrated using Tropical Storm Irene (August 2011) and verified against Tropical Storm Lee (September 2011) and a second storm that occurred in October 2005. Table 2-3 lists peak discharges for the 10-, 25-, 50-, 100-, and 500-year flood events within the study area as determined by FEMA and reported in the FIS (FEMA, 2013).

TABLE 2-3
FEMA Peak Discharges (all flow values in cfs)

Location	Approximate MMI River Station	Drainage Area (square miles)	10-Year Flood Event	25-Year Flood Event	50-Year Flood Event	100-Year Flood Event	500-Year Flood Event
Esopus Creek upstream of Stony Clove Creek	464+00	105.3	18,209	27,904	38,121	51,036	97,916
Esopus Creek upstream of the Beaver Kill	259+00	144.23	24,183	36,677	50,173	68,362	134,869
Stony Clove Creek above confluence with Esopus Creek	464+00	32.44	6,966	11,226	15,463	20,895	38,759
Beaver Kill above confluence with Esopus Creek	259+00	25.06	4,613	7,087	9,583	12,764	23,147

Hydrologic data on peak flood flow rates along streams in the study area were also estimated using the USGS *StreamStats* program. *StreamStats* is a web-based geographic information system (GIS) application used to access stream flow statistics, drainage basin characteristics, and other information for selected sites on streams. However, the FEMA discharges were typically used because (a) they are more conservative and (b) they are the jurisdictional standard. The single exception is for bankfull flows as these discharges were not estimated by FEMA for their evaluations.

Bankfull discharge is defined as the flow that fills the channel to the top of the bank to the level where the water is just about to spill into the floodplain. Based upon flood frequency analysis, bankfull discharge occurs approximately every 1.5 years on average. It is considered important because it transports the greatest amount of sediment over time due to the frequency of occurrence. As a result, bankfull discharges are critical to channel maintenance and play a key role in determining the morphological characteristics of the channel (Rosgen, 1996).

Extensive data sets indicate the channel-forming or bankfull discharge in specific regions is primarily a function of watershed area and soil conditions. Bankfull dimensions including discharge, area, width, and depth represent long-term equilibrium conditions in alluvial channels and are important geomorphic criteria that are used for design.

Table 2-4 lists estimated bankfull discharge, width, and depth at several points within the study area as derived from the USGS *StreamStats* program.

TABLE 2-4
Estimated Bankfull Discharge, Width, and Depth
(Source: USGS *StreamStats*)

Location	Station	Watershed Area (square miles)	Discharge (cfs)	Bankfull Area (square feet)	Bankfull Width (feet)	Bankfull Depth (feet)
Esopus Creek, above confluence w/Stony Clove	465+00	105	4,010	610	137	4.45
Stony Clove Creek, above confluence w/Esopus	5+00	32	1,770	267	84.7	3.19
Esopus Creek, above confluence w/Beaver Kill	260+00	144	5,320	804	162	4.98
Beaver Kill, above confluence w/Esopus	3+00	24.9	1,440	218	75	2.94
Esopus Creek, downstream of project area	184+00	172	6,200	934	177	5.29

3.0 EXISTING FLOODING HAZARDS

3.1 Flooding History in Phoenicia and Mt. Tremper

The Catskill Mountains are subject to large storm events that are often unevenly distributed across watersheds. As a result, local flash floods can occur in one basin while an adjacent basin receives little rainfall. In addition to local flash floods, larger storm events can cause widespread flooding. Notable larger flood events occurred in 1996, 2005, and most recently during Tropical Storm Irene in August 2011.

An examination of flood history conducted for the 2007 Upper Esopus Creek Management Plan indicates that major floods have occurred periodically over the last century with at least 11 major floods occurring between 1933 and 2011 (NYCDEP 2007). Floods can take place any time of the year but are commonly divided into those occurring in winter and spring and those occurring in summer and fall. Floods that take place in summer and fall are typically due to extreme rainfall events caused by hurricanes and tropical storms. Floods in winter and spring are associated with rain on snow events and spring snowmelt (Tetra Tech 2013, NYCDEP 2007).

The largest flood of record occurred due to rainfall and was caused by Tropical Storm Irene in August 2011. The peak flow recorded on Esopus Creek at Coldbrook was 75,800 cfs. This surpassed the March 1980 flood, which had a flow rate of 65,300 cfs. Other notable flood events include the March 1980 flood, which resulted in an estimated $6 million of damage, and a flood of similar magnitude that occurred on March 30, 1951. Table 3-1 provides a summary of the 10 largest flood events on the Esopus as recorded at Coldbrook, New York (FEMA 2012).

Bridge Street Bridge in Phoenicia Being Overtopped by Floodwaters, August 28, 2011

Flooding Along Bridge Street near Intersection with Lower High Street, August 28, 2011

Flooding Along Route 212 in Mt. Tremper (looking toward Route 28), August 28, 2011

Aftermath of Flooding on Route 28 (near intersection with Route 212) in Mt. Tremper, August 28, 2011

TABLE 3-1
Historic Peak Discharges at Coldbrook, NY Gauge
(Source: FEMA 2012)

Rank	Date	Peak Discharge (cfs)
1	28-Aug-11	75,800
2	21-Mar-80	65,300
3	30-Mar-51	59,600
4	3-Apr-05	55,200
5	24-Aug-33	55,000
6	15-Oct-55	54,000
7	19-Jan-96	53,600
8	4-Apr-87	51,700
9	21-Dec-57	46,900
10	12-Mar-36	38,500

Over the past 2 decades, numerous smaller floods resulted in damage along Esopus Creek and its tributaries. During moderate to large floods, Route 214 and Main Street in Phoenicia were flooded, cars and other large debris were washed downstream, and the Main Street bridge was overtopped by flow in Stony Clove Creek. Flood events include Tropical Storm Floyd (September 1999) and a snowmelt event that occurred in January 1996 (FEMA 2013). A large rainfall event in April 2005 led to extensive flooding throughout the Esopus Creek watershed. The flooding forced thousands of residents to evacuate their homes and resulted in millions of dollars in damage. In October 2010, flooding occurred in Phoenicia as a result of Tropical Storm Nicole and again in December 2010, resulting in flooding on Main Street. On August 28, 2011, Tropical Storm Irene caused extensive flooding and devastation in the watershed (Tropical Storm Irene and associated damages are described in more detail in the section below). Shortly after Tropical Storm Irene, Tropical Storm Lee struck the region on September 6, 2011 resulting in further flooding. On October 30, 2012, rainfall from Hurricane Sandy resulted in localized flooding throughout the Esopus watershed.

3.2 Tropical Storm Irene

On August 28, 2011, Tropical Storm Irene caused extensive flooding and devastation in eastern New York. Discharge on Esopus Creek at the USGS gauge #01362200 at Allaben, located 4.2 miles upstream of the Phoenicia study area, peaked at 29,300 cfs. This discharge exceeded FEMA's projected 50-year flood event of 24,274 cfs but did not exceed the projected 100-year flood event of 31,925 cfs. Similarly, discharge on Esopus Creek at the USGS gauge #1362500 at Cold Brook, 1.1 miles downstream of the Mt. Tremper study area, exceeded FEMA's projected 50-year flood event at this location but did not exceed the projected 100-year flood event.

Figures 3-1 and 3-2 show annual peak flows recorded at the USGS gauges on Esopus Creek at Allaben and Cold Brook, respectively. These figures illustrate that Tropical Storm Irene produced the largest discharge ever recorded on Esopus Creek since the time that the gauges were first established (October 1963 at the Allaben gauge and October 1934 at the Cold Brook gauge).

FIGURE 3-1
Annual Peak Discharge
USGS Gauge, Esopus Creek at Allaben, at STA 731+00

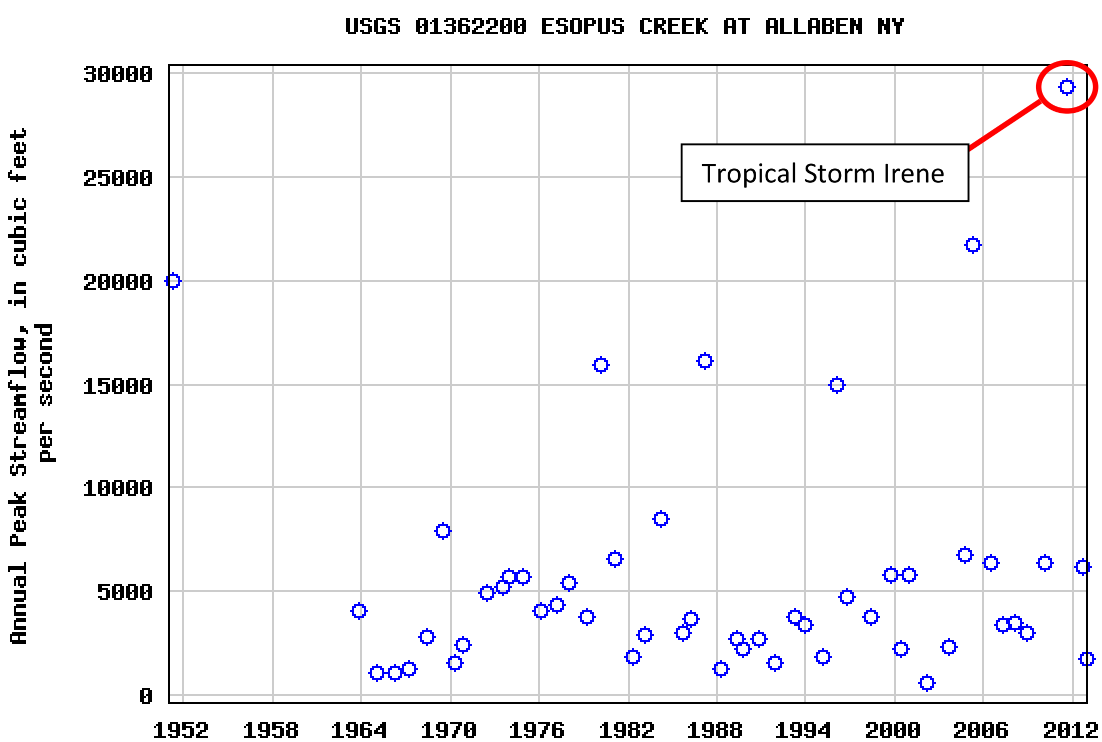
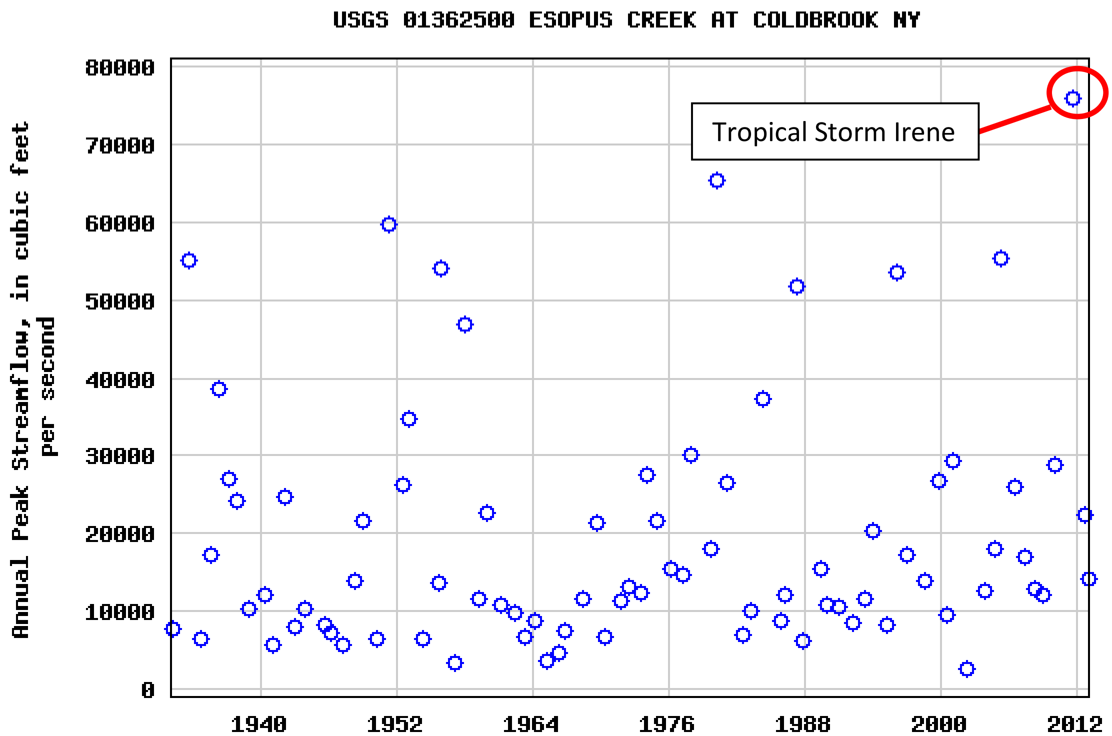


FIGURE 3-2
Annual Peak Discharge
USGS Gauge, Esopus Creek at Cold Brook, at STA 123+50



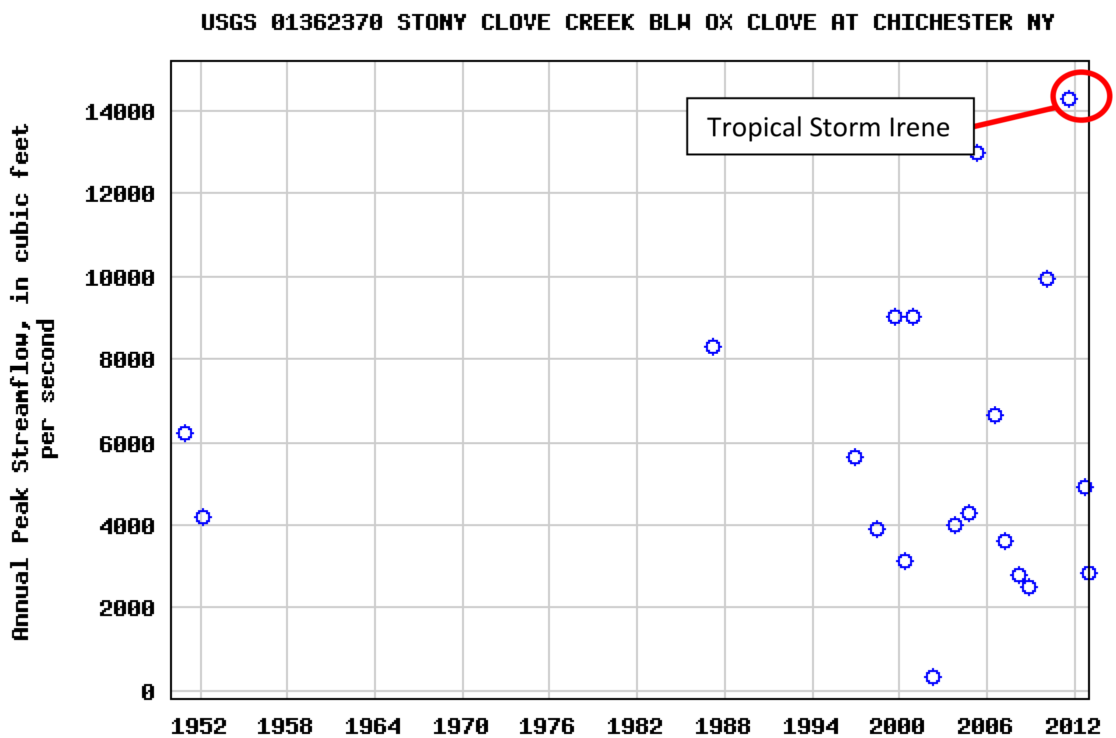
Discharge on Stony Clove Creek at USGS gauge #1362370 below Ox Clove in Chichester, 1.1 miles upstream of the Phoenicia study area, peaked at 14,300 cfs. This exceeded FEMA's projected 50-year flood event of 12,979 cfs but did not exceed the 100-year flood event of 17,606 cfs.

Figure 3-3 shows annual peak flows recorded at the USGS gauge on Stony Clove Creek at Chichester. As on Esopus Creek, Tropical Storm Irene produced the largest discharges ever recorded on Stony Clove Creek since the time that the gauge was first established.

Tropical Storm Irene caused extensive flooding and devastation in the upper Esopus Creek watershed. A week later, on September 2, Tropical Storm Lee brought additional rainfall to the area resulting in further flooding. These two events produced the largest and most expensive natural disaster in the history of New York State at that time, with an estimated $1.5 billion in damages (FEMA 2013). (Hurricane Sandy in 2012 is now the most expensive, with estimated losses in New York of at least $18 billion.)

Photographs, aerial imagery, videos, and news accounts from Tropical Storm Irene paint a vivid picture of the extensive damages that occurred throughout the study area. Numerous roads were flooded or damaged. Within the Oliverea area, six bridges were washed out or compromised. The dam at Winnisook Lake, which is the source of Esopus Creek, began to erode provoking concerns that another heavy rainfall event could result in failure and lead to catastrophic flooding.

FIGURE 3-3
Annual Peak Discharge
USGS Gauge, Stony Clove Creek at Chichester, at STA 99+00



Phoenicia experienced extensive flood damage. Power lines were down throughout the village, Main Street was under water, and roads were washed out in several places. The bridge at Bridge Street became partially blocked by large woody debris, severely compromising the structure. Additionally, homes along the Esopus were devastated, and over 20 people trapped by floodwaters had to be rescued. Further downstream at Mount Pleasant, the floodwaters breached the flood control earthwork, resulting in damage to homes. There was also significant damage to homes in Mt. Tremper, and floodwaters pushed several cars off roads in the Mt. Tremper hamlet.

Flood damage also occurred along Stony Clove Creek. In the area of Chichester, a number of private bridges spanning Stony Clove Creek were washed away. High discharge also contributed to stream bank failures and channel instability, particularly at the confluence with Warner Creek.

3.3 FEMA Mapping

FEMA FIRMs are available for the study area and depict the SFHA, which is the area inundated by flooding during the statistical 100-year flood event. The maps also depict the FEMA designated floodway, which is the stream channel and that portion of the adjacent floodplain that must remain open to permit passage of the base flood. Floodwaters are typically deepest and swiftest in the floodway, and anything in this area is in the greatest danger during a flood (FEMA, 2008). The SFHAs described below are as depicted on the preliminary FIRM (see Figures 2-1 and 2-2), which at the time of this report had not yet been formally adopted. All appeals have reportedly been resolved in the town of Shandaken, and it is anticipated that formal adoption of the FIRMs will occur shortly.

On Esopus Creek near the upstream end of the Phoenicia project area, FEMA mapping indicates that Woodland Valley Road will be flooded during the 100-year flood event, but no structures are flooded in this area. High Street and Woodland Valley Road will be overtopped by Esopus Creek in the 500-year flood event between STA 508+00 and STA 503+00. One structure is located in the floodway near STA 504+00. The floodplain is confined between STA 498+00 and STA 483+00 by Route 28 and High Street, after which the 100-year and 500-year floodplains expand south across High Street and Lane Street inundating multiple homes.

Downstream of the confluence with Stony Clove Creek, Esopus Creek turns sharply south at STA 445+00. Between STA 445+00 and STA 388+00, FEMA maps indicate that flooding occurs primarily along the right bank between the channel and Route 28. Esopus Creek approaches Route 28 around STA 370+00 and flows southeast along Route 28 until STA 336+00. Although this portion of the creek is not densely developed, one home is located within the floodway, and several homes are located within the 500-year flood zone.

The 100-year floodplain narrows slightly between STA 336+00 and STA 285+00, after which the floodplain expands along the right bank overtopping Mount Pleasant Road and Riseley Road. Numerous homes along Riseley Road and Mount Pleasant Road are located within the floodway. Downstream of the confluence with Beaver Kill at STA 258+00, flooding inundates Route 28 on both sides of Esopus Creek. Multiple homes are predicted to flood in the vicinity of the Route 28 bridge over Esopus Creek at STA 241+00. Between STA 235+00 and STA 183+00, the floodplain extends primarily onto the left bank, flooding several homes. The 500-year floodplain extends further east after the junction of Route 212 and Route 28, overtopping Route 28 and Hudler Road.

On Stony Clove Creek downstream of STA 57+00, the FEMA mapping indicates that extensive flooding is predicted to occur along the left bank of Stony Clove Creek. Numerous homes and buildings are located within the 100- and 500-year floodplains, including the Phoenicia Elementary School, a pharmacy, and various businesses. The majority of downtown Phoenicia is within the 100-year floodplain at the confluence of Stony Clove Creek and Esopus Creek.

As the Beaver Kill flows west toward Esopus Creek, the floodplain widens near STA 20+00, crossing Route 212 and inundating numerous homes around Heintz Road. The floodplain expands north across Miller Road between STA 12+00 and STA 6+00, flooding a residential dwelling. Between STA 6+00 and the confluence with Esopus Creek, the 100-year event extends north and south of Beaver Kill, flooding several houses on Route 212.

3.4 Public Input

Two introductory public meetings were convened near the beginning of the LFA process. The first was held on October 14, 2014 at the Parish Hall on Main Street in Phoenicia. On October 20, 2014, a second meeting was held at the Emerson Resort and Spa on Route 28 in Mt. Tremper. MMI provided attendees with an overview of the project, the LFA process, and hydraulic modeling techniques. Information was collected from attendees on flood damage and potential flood mitigation alternatives. This information was then used throughout the LFA process to verify flood damages, calibrate hydraulic models, pinpoint problem areas, and develop flood mitigation alternatives.

Attendees were provided with large-format maps and asked to mark locations of flooding and flood damages during both Tropical Storm Irene and previous flood events. A summary of comments is listed below:

- Many individuals expressed a sentiment that dredging of the channel would alleviate flooding along Esopus Creek and should be pursued. The point was made that dredging and "gravel harvesting" was a common practice before environmental regulations were put in place.

- Residents noted that downed trees and other debris clogged bridge openings, which worsened flooding.

- Comments were received on the design of bridges within the study area and the tendency of newer-style bridges to be prone to debris jamming.

- Many residents pointed out their businesses and/or personal properties on the maps and noted flood damages, flood frequencies, flow paths, and high water marks during Tropical Storm Irene and prior floods.

- Individuals noted areas of bank erosion and areas of sediment deposition along Esopus Creek, Stony Clove Creek, and the Beaver Kill.

4.0 FLOOD MITIGATION ANALYSIS AND ALTERNATIVES

The purpose of a hydraulic assessment is to evaluate historic and predicted water surface elevations, identify flood-prone areas, and help develop mitigation strategies to minimize future flood damages and protect water quality. Hydraulic analysis techniques can also help predict flow velocities, sediment transport, scour, and deposition if these outcomes are desired.

Specific areas have been identified as being prone to flooding during severe rain events within the project area. Numerous alternatives were developed and assessed at each area where flooding is known to have caused extensive damage to homes and properties. Alternatives were assessed with hydraulic modeling to determine their effectiveness. The narrative below describes the alternatives and the results of modeling analysis.

4.1 Analysis Approach

Hydraulic analysis of Esopus Creek, Stony Clove Creek, and the Beaver Kill through the study area was conducted using the HEC-RAS program. The HEC-RAS software (*River Analysis System*) was written by the USACE Hydrologic Engineering Center (HEC) and is considered to be the industry standard for riverine flood analysis. The model is used to compute water surface profiles for one-dimensional, steady-state, or time-varied flow. The system can accommodate a full network of channels, a dendritic system, or a single river reach. HEC-RAS is capable of modeling water surface profiles under subcritical, supercritical, and mixed-flow conditions.

Water surface profiles are computed from one cross section to the next by solving the one-dimensional energy equation with an iterative procedure called the standard step method. Energy losses are evaluated by friction (Manning's Equation) and the contraction/expansion of flow through the channel. The momentum equation is used in situations where the water surface profile is rapidly varied such as hydraulic jumps, mixed-flow regime calculations, hydraulics of dams and bridges, and evaluating profiles at a river confluence.

4.2 Existing Conditions Analysis

The Duplicate Effective model was checked for correct Manning's n values, site conditions, and expansion/contraction coefficients to ensure that the information in the model accurately reflects river and floodplain conditions. Manning's n values within the Esopus Creek channel in Phoenicia (in the vicinity of STA 460+00) were increased from 0.03 to 0.04 due to high modeled flow velocities that exceeded 25 Feet per second, which is unlikely to occur in a natural channel setting. A "Corrected Effective Model" was created by copying the Duplicate Effective model and making necessary changes. Minor n-value changes were included in the Corrected Effective Model to more appropriately represent channel conditions.

A separate Corrected Effective Model was created for the 500-year flood event at the Route 28 bridge (River Station 239+91). Since this bridge overtops significantly during the 500-year flood event, the bridge modeling approach was changed from pressure flow to the standard step method.

An "Existing Conditions" model was created by saving a copy of the Corrected Effective Model and removing a scour hole downstream of Bridge Street. Based on field observations, there does not appear to be a scour hole in this location. Bankfull flows were added to the steady flow data based on USGS regression analysis.

The FEMA "Duplicate Effective" model for Beaver Kill Creek was created by importing the FEMA Effective model into HEC-RAS. The model was run in HEC-RAS with no changes to the received models.

The Duplicate Effective model was checked for correct Manning's n values, site conditions, and expansion/contraction coefficients to ensure that the information in the model accurately reflects river and floodplain conditions. No modifications to the Duplicate Effective Model were necessary; therefore, no Corrected Effective Model was created for the Beaver Kill.

The Existing Conditions model was created by copying the Duplicate Effective model and adding bankfull flows to the steady flow data based on USGS regression analysis. The effective Beaver Kill Creek model uses normal depth as the downstream boundary condition. This does not take into account backwater effects from Esopus Creek.

These new Existing Conditions models for Beaver Kill and Esopus Creeks were the base line models used to evaluate flood mitigation alternatives. For purposes of water surface elevation computations, the model was run in subcritical flow regime, which tends to use slower velocities but higher water surface elevations and also provides the worst-case scenario for flood surface elevations.

Model cross sections, Manning's "n" coefficients, site conditions, and expansion/contraction coefficients were reviewed to ensure they corresponded with conditions and values in the FEMA FIS.

The following revisions were made to the model to serve as the base line for existing conditions and for evaluation of the effectiveness of flood mitigation alternatives.

- Key nodes were labeled so the profile is easier to read.
- The bankfull flood event was added to the flow profiles for Esopus Creek and Beaver Kill Creek.
- A scour hole at the Bridge Street bridge was removed from the Esopus Creek model based on field observations.
- Manning's n roughness coefficients were changed from 0.03 to 0.04 in the Esopus Creek channel in Phoenicia (in the vicinity of STA 460+00).

The revised model was run and tested to validate the above changes.

For the area of the confluence of Stony Clove Creek and Esopus Creek and along Main Street in Phoenicia, a two-dimensional HEC-RAS model (Version 5.0, beta version) was set up and run to evaluate flood mitigation alternatives. One-dimensional FEMA models were combined to create a 1D multireach model with a junction joining the Stony Clove Creek to the Esopus Creek in Phoenicia. All n values, bridge modeling approaches, and ineffective flow areas were checked. The FEMA models were truncated to focus the model on the Phoenicia hamlet. Manning's roughness n values were determined from land uses and ground cover. Areas were delineated in GIS using aerial photography to assign roughness values based on specific site uses and conditions.

The two-dimensional flow area was used to represent flow in the left floodplain through the Phoenicia area. This two-dimensional area represents flow leaving the Stony Clove Creek main channel and flowing through the hamlet and into the Esopus Creek downstream of the confluence. The two-dimensional area begins upstream of the hamlet where water first flows out of Stony Clove Creek and over Route 214 near School Lane and ends downstream of the hamlet at the bend where Main Street is high on the valley wall. A computational mesh was created within the two-dimensional area at a grid spacing of 15 feet square, with nonsquare shapes created as necessary along the edges. The model algorithms solve equations at a finer detail than the mesh grid spacing, creating rating curves for flow and plotting output at the resolution of the digital elevation model (DEM).

The one-dimensional cross sections were truncated at the edge of the two-dimensional area, including bridge geometry and internal sections. The one-dimensional model cross sections were connected to the two-dimensional area using a lateral weir structure representing the area where water would transition from the channel into the hamlet area. Along Stony Clove Creek, this is the center of Route 214. Connection locations of the cross sections were measured and input to the model. The model automatically determined what mesh elements were connected to the weir. The elevation of the top of the weir was determined by sampling the DEM along the edge of the two-dimensional area. The elevation of the top of the weir was adjusted where necessary to be at a higher elevation than the mesh elements in the two-dimensional area that are attached to the weir at each location. Lateral weir coefficients were used as a calibration parameter to adjust the water transfer between the one- and two-dimensional elements.

The model was run in the unsteady computation mode. A flow hydrograph was used instead of using the peak flow run in steady state as FEMA inundation modeling uses. This means that a simulated storm peak is run through the model. The simulated storm was run for 48 hours with detailed output every 15 minutes. Hydrographs were based on USGS gauge data from Tropical Storm Irene. The USGS gauge at Allaben was used for Esopus Creek, and the USGS gauge on Stony Clove Creek below Ox Clove at Chichester was used for Stony Clove Creek. For the Irene model runs, the gauge data were scaled by drainage area to the upstream ends of the truncated model. For other recurrence intervals, the Irene hydrograph was converted to a unit hydrograph and multiplied by the FEMA peak flow at each recurrence interval to create an input hydrograph. The low flow at the ends of the hydrographs was raised to stabilize the model (minimum flow = 5 percent of peak for 100 year and 10 percent of peak for Irene). One-hundred-year and Irene-scenario unsteady flow files were compiled and executed for the existing conditions and alternatives.

The downstream boundary condition was set as normal depth (S=0.001). The energy balance method was used at the junction. The two-dimensional area was started with a dry initial condition. Diffusion wave equations were chosen to represent the flow through the two-dimensional area. Computations were calculated at 30-second intervals in the one-dimensional area and 5-second intervals in the two-dimensional area. Water surface and flow tolerances were set at 0.1.

4.3 Calibration/Validation

Photos of flooding during Irene were referenced as were online videos, photographs, and personal accounts. The area of active flooding during Irene was similar to the model output. The corner of Ave Maria Drive may have less flooding in the model than in a photograph. Model parameters were adjusted to increase water depths in the hamlet area after viewing available data. N values and weir coefficients were adjusted. Water depths in the one-dimensional portions of the model are similar to FEMA modeled levels. The water depth and extent in the two-dimensional area is less than shown in the FEMA mapping for the Stony Clove. The extent of flooding along the Esopus matches FEMA modeling well.

Example of Aerial Photographs Used for Hydraulic Model Calibration

Replacement of bridges and modifications of the channel may have occurred since the survey for the FEMA model was completed as a result of recent flood events. While the model is sufficiently accurate for evaluation of flood mitigation alternatives and development of design concepts in the study area, a more detailed, up-to-date survey would be required for permitting and engineering design of alternatives.

4.4 Mitigation Approaches

A number of flood mitigation approaches have been evaluated within the study area. A general overview of each follows.

Bridge removal/replacement – Undersized bridges can act as hydraulic constrictions, exacerbating flooding during high-flow events by increasing water surface elevations upstream of the bridge. Each bridge within the study area was evaluated. If the bridge appeared to be acting as a hydraulic constriction, it was removed from the model, which simulates the complete removal of the bridge from the channel. If bridge removal resulted in a significant reduction in water surface elevations and a resulting reduction of the flooding of structures and/or roads in the model, bridge replacement with a more hydraulically adequate structure was advanced for consideration.

Dredging – During the public meetings in Phoenicia and Mt. Tremper, residents expressed a sentiment that dredging and gravel bar removal would alleviate flooding along Esopus Creek and should be pursued. In response, numerous dredging alternatives were analyzed within the study area, ranging from the removal, or "skimming," of gravel bars to dredging the channel to a depth of 3 feet. These were reviewed relative to their effectiveness in mitigating flooding and inclusive of the risks associated with instability and sediment transport.

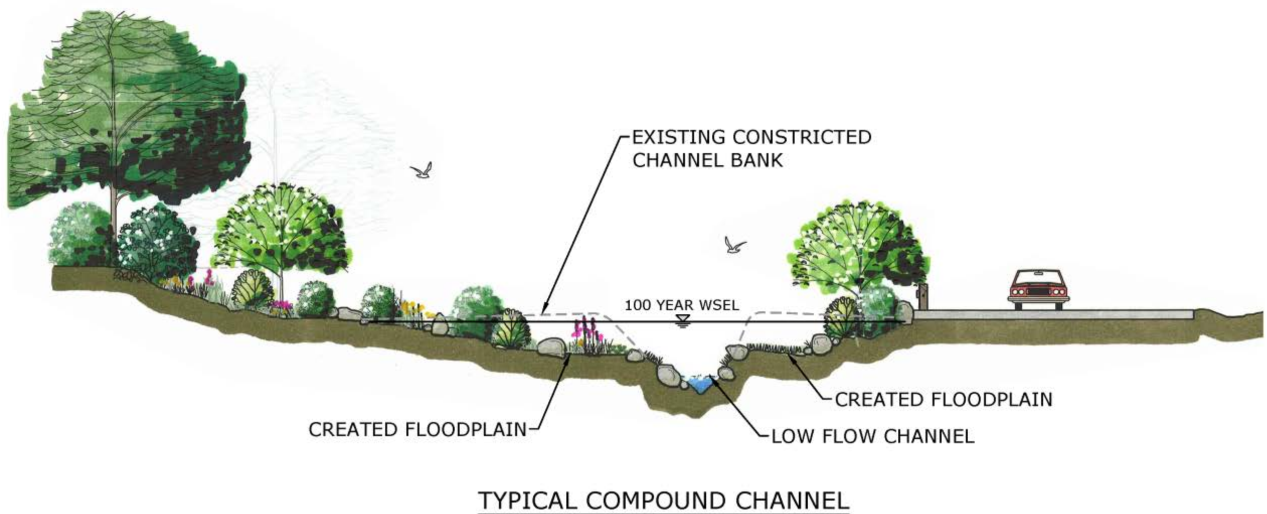
Levee enhancement and/or modification – Under certain circumstances, levees can be constructed for the purpose of protecting properties and structures from flood damage. Levees often require interior drainage pump stations, use of removable panels at road crossings, and considerable maintenance. Use of such measures requires careful consideration and risk assessment, engineering design, and ongoing monitoring and maintenance. Risks associated with levees include the potential to increase water surface elevations in the channel by cutting off the floodplain and the danger of a flood event that exceeds the design storm and overtops or breaches the levee. As an example, in Mt. Tremper during Tropical Storm Irene, floodwaters overtopped the levee system designed to protect structures and properties from flooding. Once a levee has been overtopped, floodwaters can become trapped behind the levee, exacerbating flooding problems. Additionally, levees need to be certified by FEMA and maintained according to FEMA requirements in order for any flood mitigation benefits to be recognized on the FIRM.

Natural channel design and floodplain enhancement – Historical settlement and human desire to build near water have led to centuries of development clustered along the banks of rivers all over the nation, including along Esopus Creek, Stony Clove, and the Beaver Kill. Dense development and placement of fill in the natural floodplain of a river can severely hinder a river's ability to convey flood flows without overtopping its banks and/or causing heavy flood damages. A river in flood stage must convey large amounts of water through a finite floodplain. When a channel is constricted or confined, velocities can become destructively high during a flood, with dramatic erosion and damage. When obstructions are placed in the floodplain, whether they are in the form of structures, infrastructure, or fill, they are vulnerable to flooding and damage.

In certain instances, an existing floodplain can be altered through reclamation, creation, or enhancement to increase flood conveyance capacity. Floodplain reclamation can be accomplished by excavating previously filled areas, removing berms or obstructions from the floodplain, or removal of structures. Floodplain creation can be accomplished by excavating land to create new floodplain where there is none today. Finally, floodplain enhancement can be accomplished by excavating within the existing floodplain adjacent to the river to increase flood flow conveyance. These excavated areas are sometimes referred to as floodplain benches.

Figure 4-1 shows a typical cross section of compound channel with excavated floodplain benches on both banks. The graphic shows flood benches on both banks; however, flood benches can occur on either or both banks of a river.

FIGURE 4-1
Typical Cross Section of a Compound Channel



4.5 Phoenicia Study Area

A number of specific flood mitigation scenarios were examined within the Phoenicia study area, including replacement of bridges, floodplain enhancement, dredging, removal of sediment bars, and combinations of these approaches. These scenarios are listed below.

1. Woodland Valley Bridge Replacement
2. Route 28 Bridge Replacement
3. Bridge Street Bridge Replacement
4a. Floodplain Enhancement with Replacement of Bridge Street Bridge
4b. Floodplain Enhancement if Bridge Street Bridge Has Been Replaced
5. Removal of Accumulated Sediment Bars in Esopus Creek
6. Dredging Esopus Creek Channel
7. Main Street Bridge Modifications

1. Woodland Valley Bridge Replacement

Woodland Valley Road bridge, which crosses Esopus Creek at STA 507+01, is a single-span truss-style bridge approximately 185 feet in length. Local residents have indicated that the bridge has washed out during past flood events. Initial hydraulic modeling indicated that the bridge acts as a hydraulic constriction during flood events and overtops during larger flood events, including the 50-, 100-, and 500-year flood events. In order to evaluate the influence of the bridge on water surface elevations, initially the bridge was completely removed from the hydraulic model. The results indicate that removal of the bridge would reduce water surface elevations during the 100-year flood event by approximately 4.8 feet immediately upstream of the bridge and by approximately 3 feet at a point 440 feet upstream of the bridge location. Backwater associated with the hydraulic constriction at the bridge contributes to the inundation of Woodland Valley Road along the right bank of Esopus Creek during the 100-year flood event. However, the hydraulic constriction does not contribute to the flooding of any structures in the vicinity. For these reasons, replacement of the Woodland Valley Road bridge was not advanced as a flood mitigation alternative at this time. It is recommended that the Woodland Valley Road bridge be replaced with a bridge with wider span when it is due for replacement.

<u>2. Route 28 Bridge Replacement</u>

Replacement of the Route 28 bridge in Phoenicia was evaluated. Hydraulic modeling demonstrated that this bridge does not act as a significant hydraulic constriction, and its replacement would not provide flood mitigation. As such, modification or replacement of this bridge was not advanced as a flood mitigation alternative.

<u>3. Bridge Street Bridge Replacement</u>

The Bridge Street (Ulster County Route 40) bridge, which crosses Esopus Creek at STA 458+39, is a concrete deck bridge with two piers. Residents of Phoenicia have reported that the bridge has overtopped during flood events in the past, including during Tropical Storm Irene, directing floodwaters into the floodplain along the right bank. The FEMA FIRM and the flood profiles in the FIS indicate that the bridge acts as a hydraulic constriction and overtops during larger flood events. SAFARI members shared that the bridge regularly becomes clogged with debris reducing the opening by 25 to 30 percent.

The HEC-RAS hydraulic model indicates that during the 100-year flood event removal of the Bridge Street bridge would reduce water surface elevations by 3.0 feet at the bridge and by 0.8 foot at the next HEC-RAS channel cross section located 340 feet upstream of the bridge. Additional modeling scenarios were run with a bridge blockage of 25 to 30 percent in place. This resulted in a greater water surface elevation at the bridge under existing conditions during the 100-year flood and a reduction in surface water elevation of 3.4 feet at the bridge and by 1 foot at a location channel 340 feet upstream of the bridge location when the bridge was removed. In both the original bridge removal run and the debris jam scenario, water surface reductions did not extend upstream to the next cross section located 691 feet upstream of the bridge.

While a reduction in water surface elevations of 3.4 feet in the channel is substantial (bridge removal under the debris jam scenario), the flood reduction benefit diminishes rapidly moving upstream of the bridge to a reduction of 1 foot at a point 340 feet upstream of the bridge and diminishing to zero prior to reaching 691 feet upstream of the bridge.

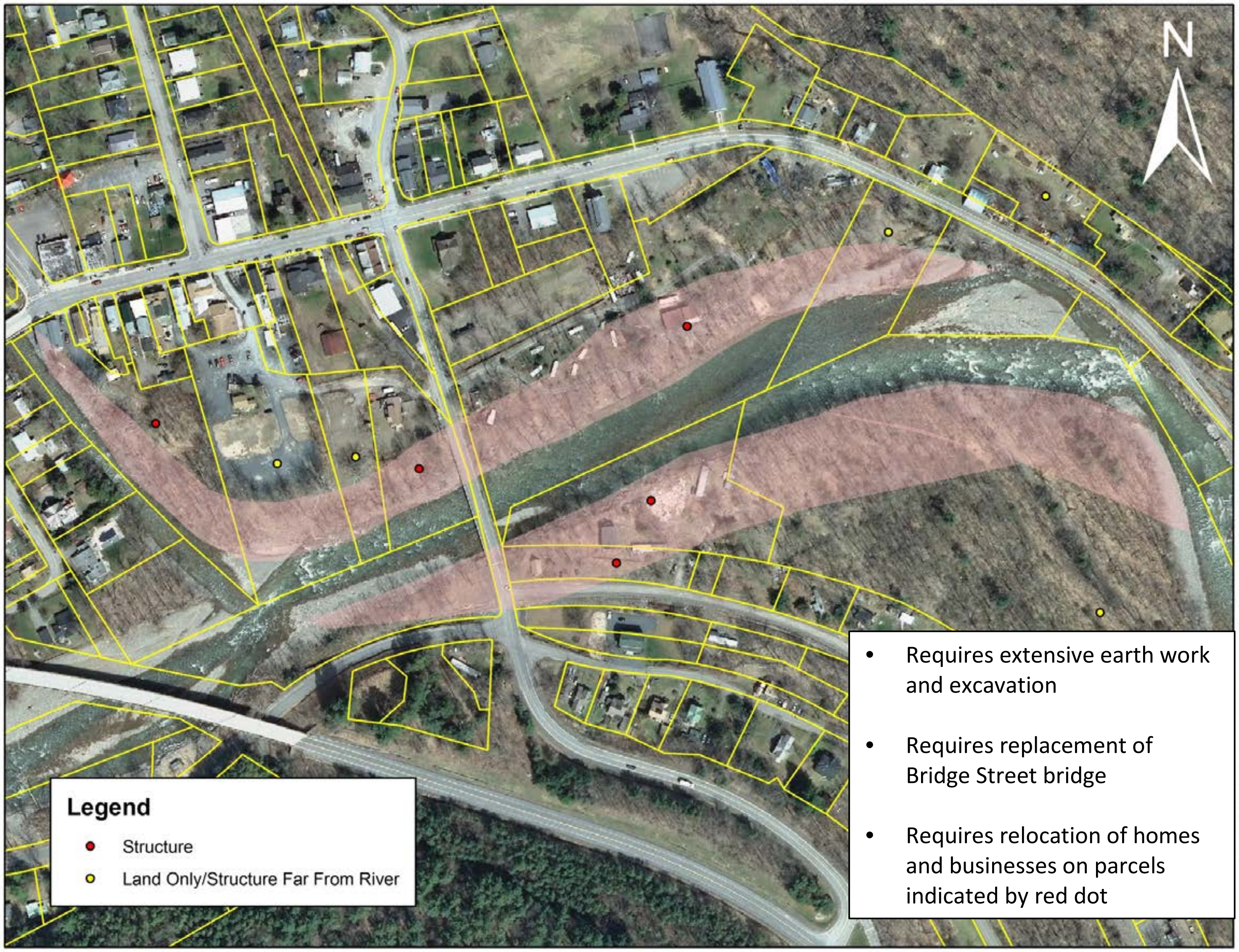
The passage of traffic over the Bridge Street bridge is economically important to the hamlet of Phoenicia, and removal of the bridge without replacement is not a feasible alternative. Replacing the bridge with a larger structure without enhancing the floodplain would have only moderate flood reduction benefits and is unlikely to be cost effective. Therefore, the scenario of replacing the bridge with a larger structure in combination with floodplain enhancement was examined under the Floodplain Enhancement scenario (Alternative 4 below). If bridge replacement under Alternative 4 is not pursued, it is recommended that the Bridge Street bridge be replaced with a higher, wider span when it is due for replacement.

4a. Floodplain Enhancement with Replacement of Bridge Street Bridge

Floodplain enhancement (i.e., excavating within the existing floodplain adjacent to the river to increase flood flow conveyance) was analyzed along both banks of Esopus Creek and Stony Clove Creek in several configurations. The configuration that yielded the greatest flood reduction benefit involves both sides of Esopus Creek and along the left (east) bank of Stony Clove Creek in combination with the replacement of the Bridge Street bridge with a larger structure. Specifically, this scenario would involve floodplain enhancement along 2,300 linear feet of channel extending from the Main Street (Route 214) bridge, along the left bank approximately 800 feet downstream to the confluence with Esopus Creek, then extending around the bend and along the left bank of Esopus Creek approximately 1,550 feet downstream of the confluence (see Figure 4-2).

Floodplain enhancement along the right bank of Esopus Creek would extend approximately 2,100 linear feet from just upstream of the Bridge Street bridge to downstream of Elmer's Bend. Several structures would need to be relocated under this scenario, and the Bridge Street bridge would need to be replaced with a larger structure that would span the entire width of the enhanced floodplain. Under this scenario, the bridge would be set at a higher elevation and increased from its current length of approximately 300 feet to a length of over 400 feet. The footprint of the floodplain enhancement scenario is shown in Figure 4-2. Property parcels from which structures would need to be relocated are marked with a red dot. Parcels that would be impacted by the floodplain enhancement but would not require relocation of structures are marked with a yellow dot.

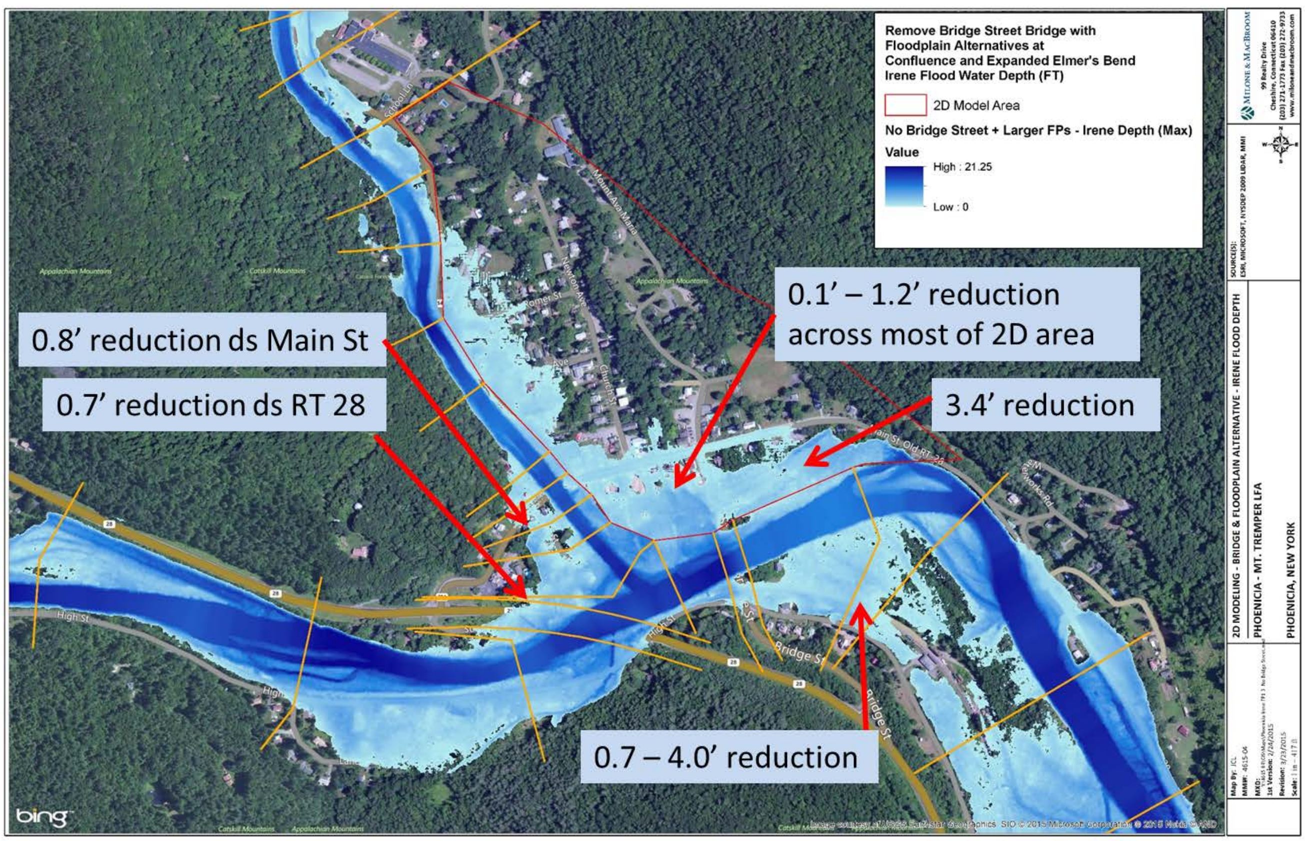
FIGURE 4-2
Phoenicia Floodplain Enhancement/Bridge Street Bridge Replacement Scenario



The floodplain enhancement scenario reduces but does not eliminate flooding along Main Street in Phoenicia. Water surface elevations are reduced by up to 1.2 feet on Main Street during an Irene-magnitude flood event. The scenario would require relocation of some homes and businesses. This floodplain enhancement scenario has potential for flood reduction and was, therefore, advanced as a flood mitigation alternative. Figure 4-3 is a flood inundation map showing water surface elevation reductions in Phoenicia if the floodplain enhancement scenario were to be implemented. The flows depicted in Figure 4-3 are the equivalent of peak flows that occurred in Phoenicia during Tropical Storm Irene.

Floodplain enhancement was also investigated further upstream on Stony Clove Creek. For most of its length within the project area, Stony Clove Creek is closely confined by a steep valley wall along its right bank and by Route 214 along its left, leaving little room for floodplain enhancement without major reworking of the roadway. This scenario was not investigated further.

FIGURE 4-3
Water Surface Elevation Reductions in Phoenicia Under the Floodplain Enhancement/Bridge Street Bridge Replacement Scenario



4b. Floodplain Enhancement if Bridge Street Bridge Has Been Replaced

For the purpose of the BCA, the floodplain enhancement scenario described under Scenario 4a above was evaluated, assuming that the Bridge Street bridge has already been replaced with a hydraulically adequate structure. This is described in more detail in Section 5 of this report.

5. Removal of Accumulated Sediment Bars in Esopus Creek

Removal of accumulated sediment bars at various locations along Esopus Creek was evaluated. Removal of sediment bars was modeled at the confluence of Esopus Creek and Stony Clove Creek, downstream of Phoenicia where Esopus Creek bends sharply to the right at a feature known as Elmer's Bend, downstream of Elmer's Bend between STA 439+00 and STA 435+00, and in the vicinity of the Sleepy Hollow Campground between STA 410+00 and STA 370+00. Simulated removal of accumulated sediment bars resulted in moderate reduction (typically less than 1 foot) in water surface elevation at a few locations during the bankfull event. Overall flood reduction was negligible, especially during large floods. There would be significant cost in accessing the channel and removing large volumes of material. Removal of sediment bars was not advanced for further analysis. Figures 4-4 and 4-5 illustrate the locations along Esopus Creek where the removal of sediment bars was modeled. Table 4-1 shows water surface elevation reductions, locations and volumes of sediment removal, and number of truckloads of sediment assuming a trucking capacity of 18 cubic yards per load of sediment.

Figure 4-4
Locations in Phoenicia Where the Removal of Sediment Bars Was Modeled

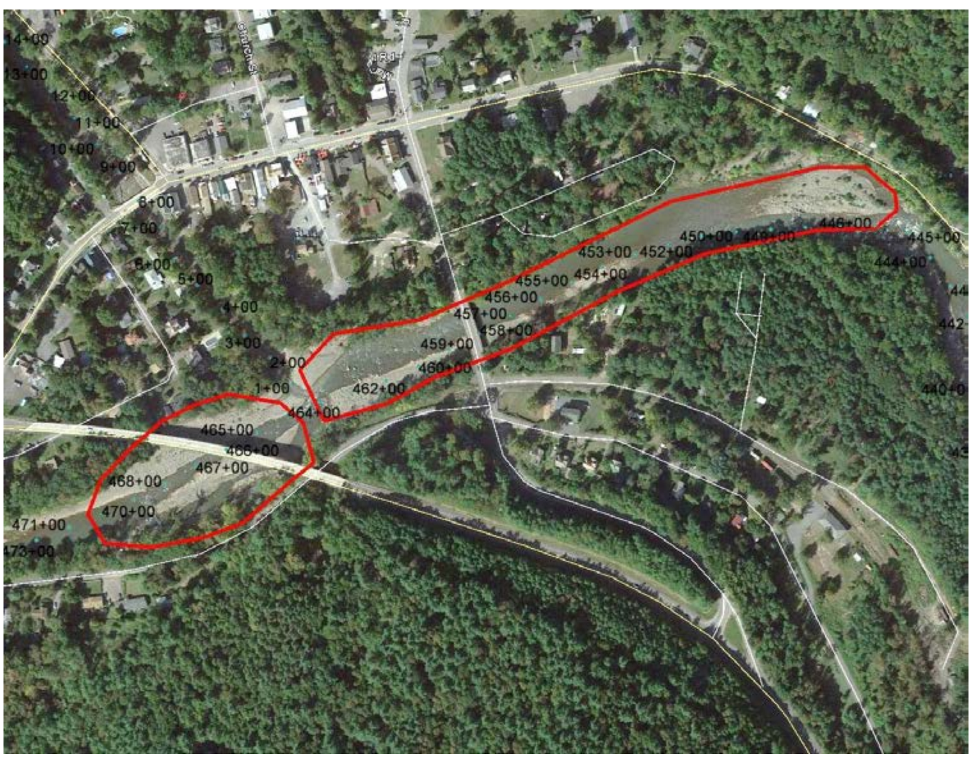


Figure 4-5
Location Adjacent to Sleepy Hollow Campground Where the Removal of Sediment Bars Was Modeled

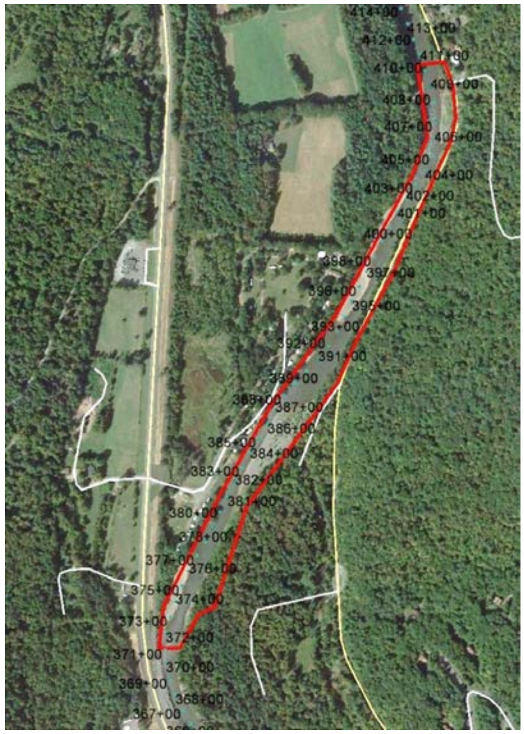


TABLE 4-1
Water Surface Elevation Reductions, Locations and Volumes of Sediment Removal, and Truckloads

Location	River STA	WSE Reduction (ft)				Sediment Volume	
		Bank Full	10-Year	100-Year	500-Year	CY	Truckloads*
Upstream Stony Clove Confluence	467+64	1	0.6	0.4	0.1		
	465+30	0.9	0.1	0	0	2,020	112
Near Bridge Street	461+82	-0.1	0.2	0	0		
	459+00	-0.1	-0.4	0	0		
	457+78	-0.2	-0.9	0	0		
	450+63	0.6	1.4	0.2	0.2		
	448+00	0.9	0.2	0.1	0	4,137	230
Near Sleepy Hollow Campground	409+00	0	0.4	0.1	0		
	404+54	0.5	0.2	0.1	0		
	396+86	0.1	0.2	0.1	0		
	390+15	0	0	0	0		
	379+97	-0.1	0	0	0		
	374+83	0.3	0.1	0	0		
	371+33	0.2	0.1	0.1	0.1	2,981	166

*Assumes truck capacity of 18 CY

6. Dredging the Esopus Creek Channel

A more aggressive sediment removal alternative was simulated in the hydraulic model. The bed of Esopus Creek within the bankfull channel was lowered in the hydraulic model by 3 vertical feet beginning at STA 469+00, upstream of the Route 28 bridge, to STA 457+00, 150 feet downstream of Bridge Street, as depicted in Figure 4-6 below. The channel walls were set at a 2:1 slope to mitigate bank instability caused by lowering of the bed. A typical channel cross section in the hydraulic model is shown in Figure 4-7. This scenario would result in the removal of approximately 11,291 cubic yards (CY) of material from 986 linear feet of the channel bed, which is the equivalent of 627 truckloads carrying 18 CY per load. The model indicates that the removal of this material would reduce water surface elevations, especially at the bankfull discharge. However, as flows increase to the 100-year event, the reduction in water surface elevations decreases. Recognizing that this alternative was of particular interest to the public who attended the outreach meetings, this alternative was advanced for further analysis.

Figure 4-6
Location Along Esopus Creek Where Dredging of Channel Was Modeled

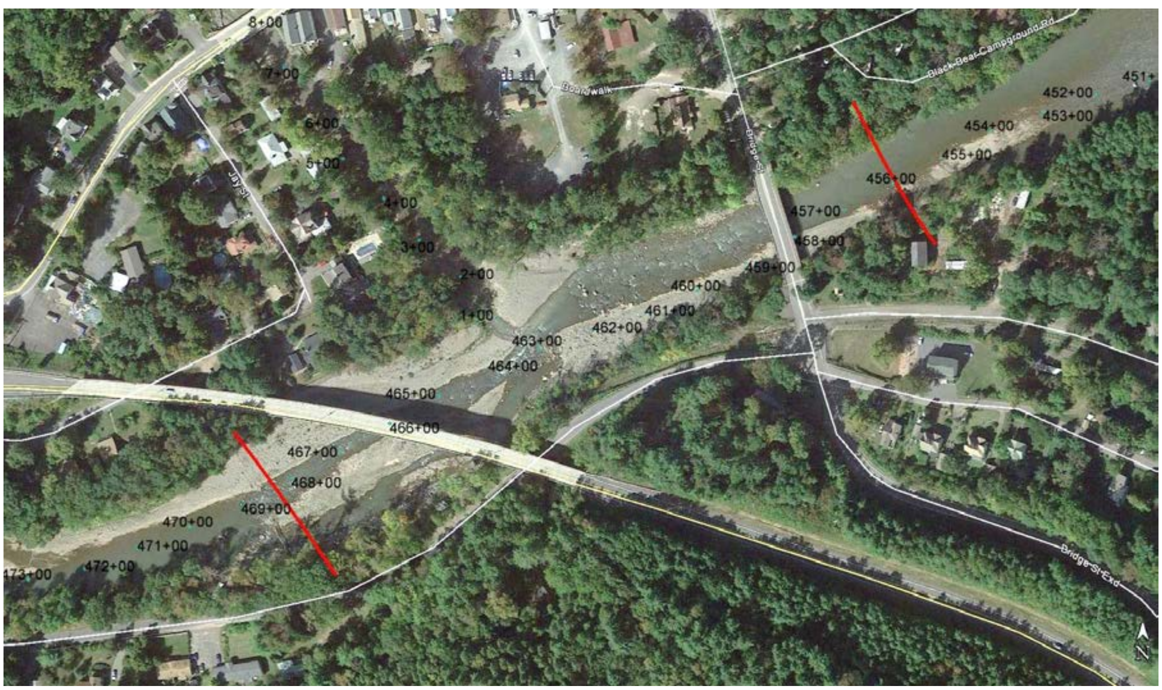


Figure 4-7
Typical Cross Section Along Esopus Creek Where Dredging of Channel Was Modeled

7. Main Street Bridge Modifications

A number of scenarios were evaluated at the Main Street bridge in Phoenicia, including modification of the bridge wingwalls and a thinner deck. These resulted in a negligible benefit with no flood reduction benefit to any commercial buildings. Bridge replacement would result in a substantial flood reduction benefit but would require raising and reconfiguration of the entire intersection and raising of the bridge. This was not judged to be cost effective and was not recommended for further analysis.

Conclusion

Based on the above analysis, two flood mitigation scenarios in Phoenicia were advanced to the BCA. These are as follows:

4a. Floodplain Enhancement with Bridge Street Bridge Replacement/Expansion
4b. Floodplain Enhancement if Bridge Street Bridge Has Been Replaced
6. Dredging of Esopus Creek

Both are discussed in more detail in Section 5.0 of this report (Benefit-Cost Analysis).

4.6 Mt. Tremper Study Area

A number of flood mitigation scenarios were examined within the Mt. Tremper study area. The individual flood mitigation scenarios are listed below.

- 8. Removal of Accumulated Sediment Bars Along Esopus Creek
- 9. Mt. Tremper Dredging of Esopus Creek
- 10. Mt. Pleasant Bridge Removal
- 11. Route 28 Bridge Replacement
- 12. Enhance Levee in Place by Increasing its Height
- 13. Levee Relocation Scenarios (13a through 13c)
- 14. Mt. Tremper Floodplain Enhancement on Esopus Creek
- 14a. Floodplain Enhancement on Esopus Creek Combined with Route 28 Bridge Replacement
- 15. Floodplain Bench on Beaver Kill
- 16. Plank Road Bridge Replacement

8. Removal of Accumulated Sediment Bars Along Esopus Creek

Similar to the analysis in Phoenicia, the removal of accumulated sediment bars through the Mt. Tremper study area was evaluated in the hydraulic model by modifying cross sections to simulate the removal of material. This was done in the Esopus Creek channel bed between STA 356+00 and STA 327+00 near Phoenicia Plaza; downstream of the Phoenicia Plaza between STA 356+00 and STA 327+00 near Uncle Pete's Campground; between STA 325+00 and STA 304+00, in the channel near Uncle Pete's Campground; and next to the Catskill Mountain Railroad Mt. Tremper Station between STA 325+00 and STA 304+00.

The modeling results indicate that while some moderate reduction in water surface elevation occurred near Phoenicia Plaza at STA 346+66 the overall result was negligible. Furthermore, decreases in water surface elevation were localized and came at a significant cost in removing large volumes of material. This scenario was not evaluated further.

9. Mt. Tremper Dredging of Esopus Creek

Dredging of Esopus Creek to a depth of 3 feet was modeled from adjacent to the Emerson Resort to downstream of the Route 28 bridge, a distance of 5,623 linear feet (just over 1 mile), as depicted in Figure 4-8. A typical channel cross section in the hydraulic model is shown in Figure 4-9. The estimated dredge volume is equal to 90,000 CY or about 5,000 18-CY-capacity truckloads. The model indicates that the dredging and removal of this material would reduce water surface elevations by as much as 2.6 feet during the bankfull discharge. However, as flows increase to the 100-year event, the reduction in water surface elevations decreases to a maximum of 0.7 feet. Modeling results are shown on the longitudinal profile depicted in Figure 4-10. The dredge scenario was evaluated further in the benefit-cost analysis in Section 5.0.

Figure 4-8
Location Along Esopus Creek Through Mt. Tremper Where Dredging of Channel Was Modeled

Figure 4-9
Typical Cross Section Along Esopus Creek Where Dredging of Channel Was Modeled

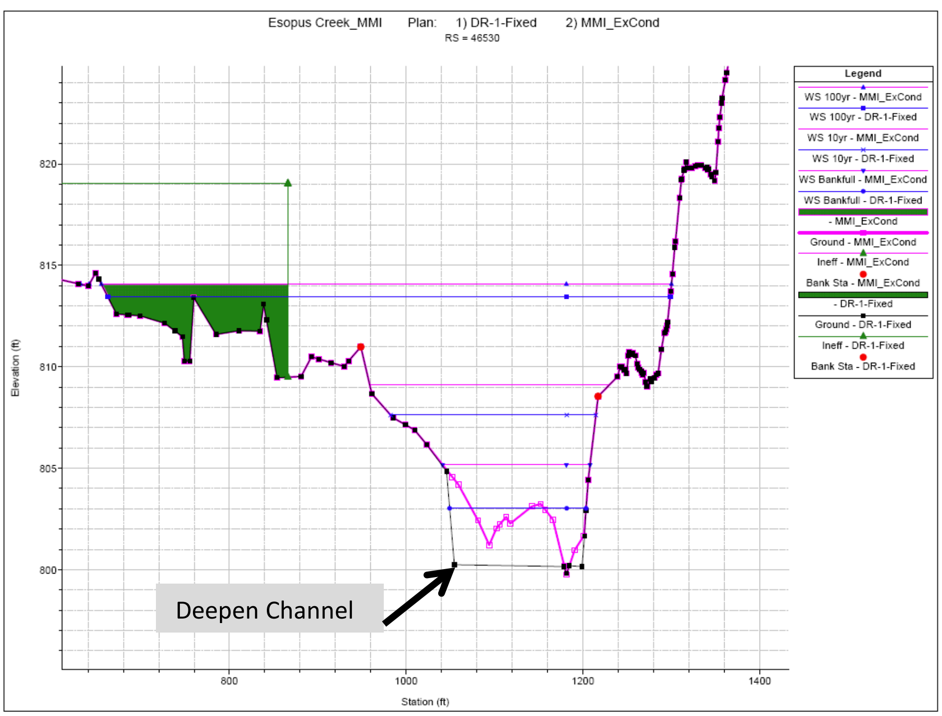
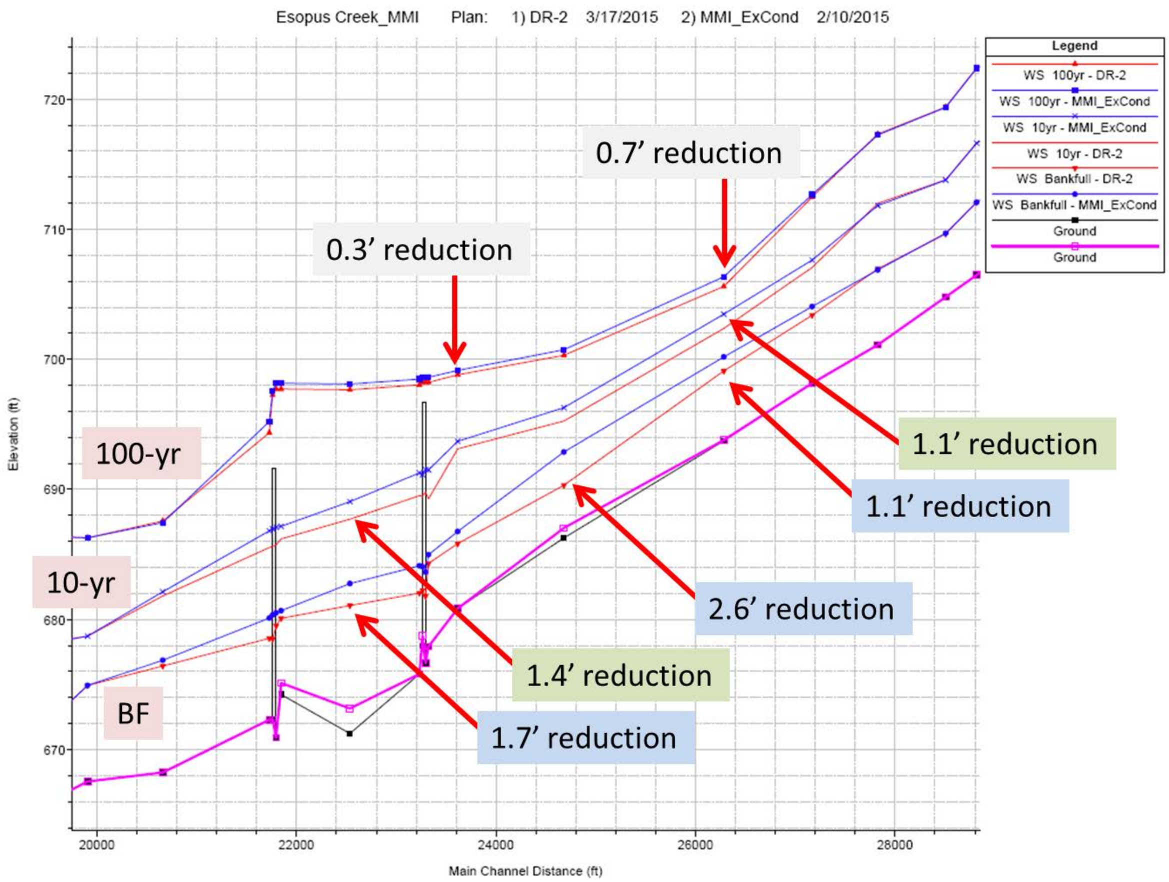


Figure 4-10
Water Surface Elevation Reductions Under the Dredging of Channel Scenario



Numbers indicate water surface elevation reductions during the bankfull, 10-year, and 100-year flood events. Note that flood reduction is greater during the smaller floods.

10. Mount Pleasant Bridge Removal

The Mount Pleasant bridge crosses Esopus Creek at STA 254+83, which is approximately 360 feet downstream of the Esopus/Beaver Kill confluence. The steel truss, concrete-decked bridge has a single pier in the bed of the stream. The bridge connects Mt. Pleasant Road on the right bank with New York State Highway 212 on the opposite bank. The bridge is currently closed to both vehicular and foot traffic. Hydraulic modeling was conducted to determine what effect removal of the bridge would have on water surface elevations. Results indicate that the backwater generated by the bridge is minimal and does not contribute to flooding of any structures in the vicinity. Therefore, its removal would not substantially reduce flooding. This scenario was not evaluated further; however, the removal of the Mount Pleasant bridge was included as part of the Mt. Tremper Floodplain Enhancement scenario (Scenario 14, described below). Removal of the Mount Pleasant bridge is advised if the floodplain enhancement scenario were to be undertaken.

11. Route 28 Bridge Replacement

The Route 28 bridge crosses over Esopus Creek at the downstream end of the hamlet of Mt. Tremper. The bridge is approximately 275 feet long with two piers. Residents of Mt. Tremper reported that the bridge overtopped during Tropical Storm Irene. They also indicated that the embankment associated with the Route 28 roadway further constricts flows, especially the roadway to the north of the bridge. The FEMA FIRM and the flood profiles in the FIS indicate that the bridge acts as a hydraulic constriction and overtops during larger flood events.

Three scenarios were modeled: (1) removal of the bridge only, (2) removal of the bridge and the road embankment on river right (looking downstream), and (3) removal of the bridge and the road embankment on river right and river left. The simulation included the 500-year flow, which was solved using the energy equation at the bridge to simulate submergence. The results of these scenarios indicate that the greatest flood reduction benefit would result from the removal of the bridge and road embankments on river right and river left and a larger replacement structure that would span the entire floodplain area. During the 10-year flood event, flood reduction benefits resulting from a larger bridge would be negligible. During the 100-year flood event, the water surface elevation reduction at the bridge would be 3.5 feet, with the reduction decreasing upstream of the bridge. Water surface elevation reductions are detailed in Table 4-2.

TABLE 4-2
Water Surface Elevation Reductions
Route 28 Bridge Replacement Scenario

Location in Channel	Station	Water Surface Elevation Reduction During 10-year Flood (feet)	Water Surface Elevation Reduction During 100-year Flood (feet)
1,126 feet downstream of Route 28 bridge	228+65	Negligible	Negligible
At Route 28 bridge	239+91	Negligible	3.5
1,850 feet upstream of Route 28 bridge	258+21	Negligible	0.8
2,895 feet upstream of Route 28 bridge	268+86	Negligible	0.7

Replacement of the Route 28 bridge with a larger structure was also modeled in combination with the floodplain enhancement scenario described below.

12. and 13. Levee Enhancement or Relocation

Under certain circumstances, levees can be constructed or enhanced for the purpose of protecting properties and structures from flood damage. Levees often require interior drainage pump stations, use of removable panels at road crossings, and considerable maintenance. Use of such structures requires careful consideration and risk assessment, engineering design, and ongoing monitoring and maintenance.

Risks associated with levees include the potential to increase water surface elevations in the channel by disconnecting the river from its floodplain and the danger of a flood event that exceeds the design storm and overtops or breaches the levee. Once a levee has been overtopped, floodwaters can become trapped behind the levee, exacerbating flooding problems. Additionally, levees need to be certified by FEMA and maintained according to FEMA requirements in order for any flood mitigation benefits to be recognized on the FIRM.

Esopus Creek is bordered by a flood control levee as it flows through Mt. Tremper, beginning on the right bank from the Emerson Resort downstream to the Mount Pleasant Road bridge and then on the left bank upstream and downstream of the Route 28 bridge. The levee is not certified by FEMA and does not successfully contain the 100-year flood event. During Tropical Storm Irene, waters overtopped the levee near the Emerson Resort and flooded residences along Mount Pleasant Road and Riseley Road.

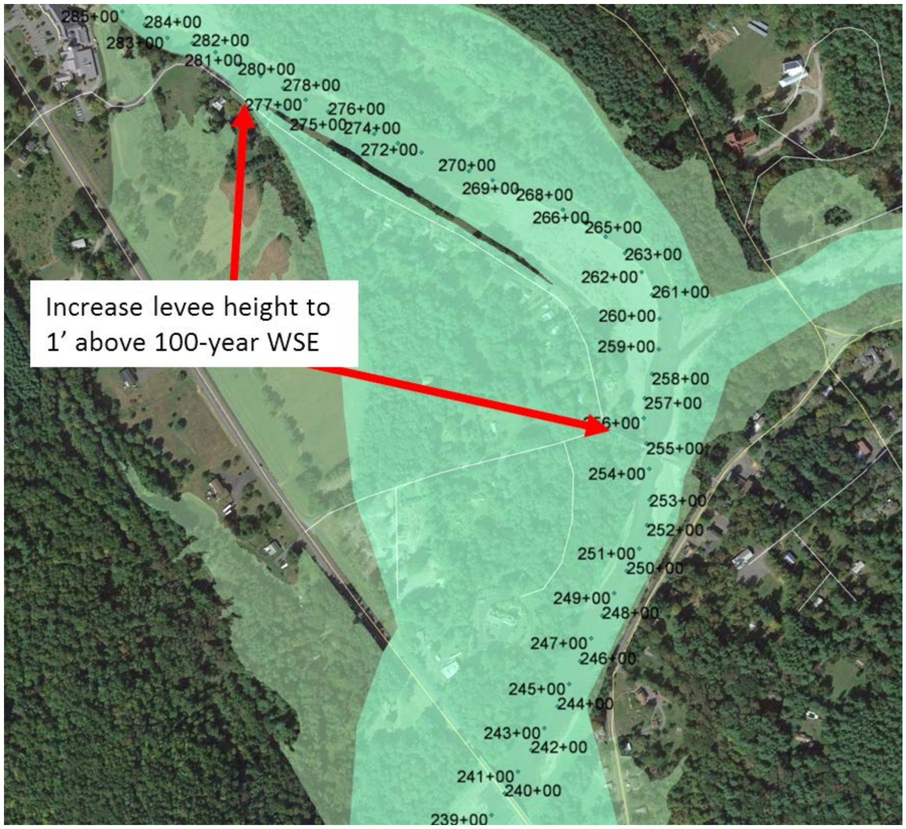
Four levee modification scenarios were investigated: (12.) Enhance the levee in place by increasing its height; (13a.) Relocate the levee to the other side of Mount Pleasant Road and replace Route 28 bridge and right embankment; (13b.) Relocate the levee out of the FEMA floodway; and (13c.) Create a flood relief chute that would convey waters across the inside of the bend in the river.

12. Enhance the levee in place by increasing its height.

Levee enhancement in place was modeled by increasing the height of the existing levee at its current location along the right bank between the Emerson Resort and the Mount Pleasant Road bridge. The height of the levee was increased to contain the 100-year flood event within the channel with 1 foot of freeboard. The existing levee would need to be raised by between 1.0 and 9.5 feet depending on the location along the levee. Levee enhancement is depicted schematically in Figure 4-11.

Enhancing the levee in place would require the placement of a substantial amount of fill within the FEMA floodway. Confining the 100-year flow within the channel would result in increases in water surface elevations ranging from 1 to 6 feet, resulting in increased flooding of structures along Plank Road and Route 212 on the left bank of Esopus Creek. The increases in water surface elevations on Esopus Creek at the confluence with the Beaver Kill would create a backwater condition that would extend up the Beaver Kill, exacerbating flooding problems there. Also, by concentrating flows within the channel, enhancing the levee in place would result in a substantial increase in flow velocities. Finally, because the levee would not be tied to a higher elevation at its downstream end at the Mount Pleasant bridge, floodwaters downstream of the bridge would continue to spill onto the floodplain and flood much of the area that is flooded under existing conditions. For these reasons, enhancing the levee in place is not recommended as a flood mitigation scenario.

Figure 4-11
Schematic Depiction of Levee Enhancement Scenario

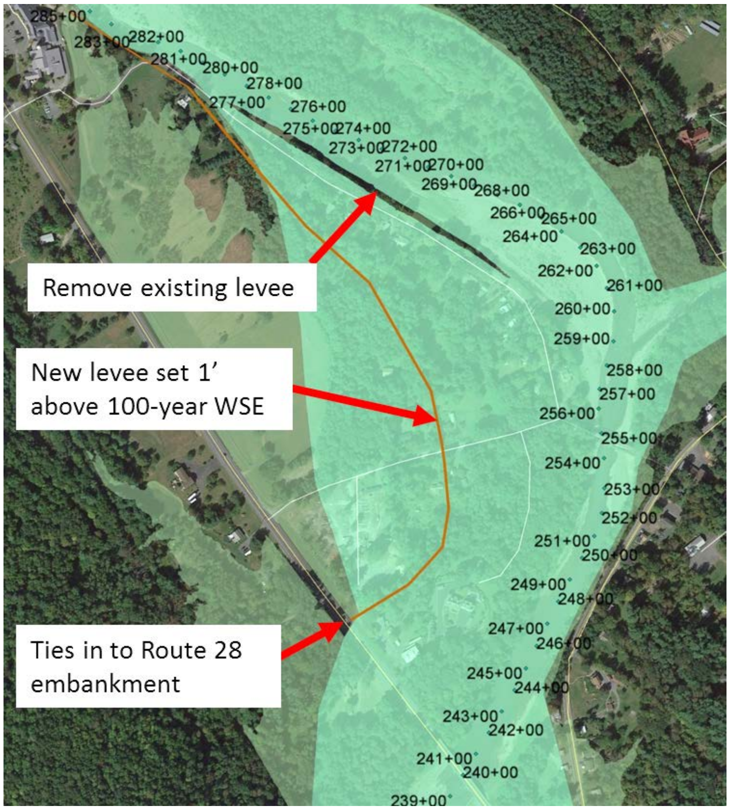


13a. Relocate the levee to the other side of Mount Pleasant Road and replace Route 28 bridge and right embankment.

Removing the levee from its current location and reconstructing an enhanced levee on the other side of Mount Pleasant Road would require the relocation of approximately 14 homes along Mount Pleasant Road and Riseley Road as well as one home and one business along Route 28. The new levee would need to be between 2.5 and 7.3 feet above existing grade in order to fully contain the 100-year flood event with 1 foot of freeboard and would require extensive placement of fill within the FEMA floodway. The levee would be designed to tie in to the Route 28 roadway embankment at its downstream end. The modeling of this scenario was paired with the removal of the Route 28 bridge and the roadway embankment to the right of the bridge. This levee relocation scenario is depicted schematically in Figure 4-12.

By confining the 100-year flow within the levee, water surface elevations would increase by approximately 1.4 feet in the channel upstream of the Mount Pleasant bridge. This would result in increased flooding of structures along Plank Road and Route 212 on the left bank. The increases in water surface elevations on Esopus Creek at the confluence with the Beaver Kill would create a backwater condition that would extend up the Beaver Kill. For these reasons, relocation of the levee as described above is not recommended as a flood mitigation scenario.

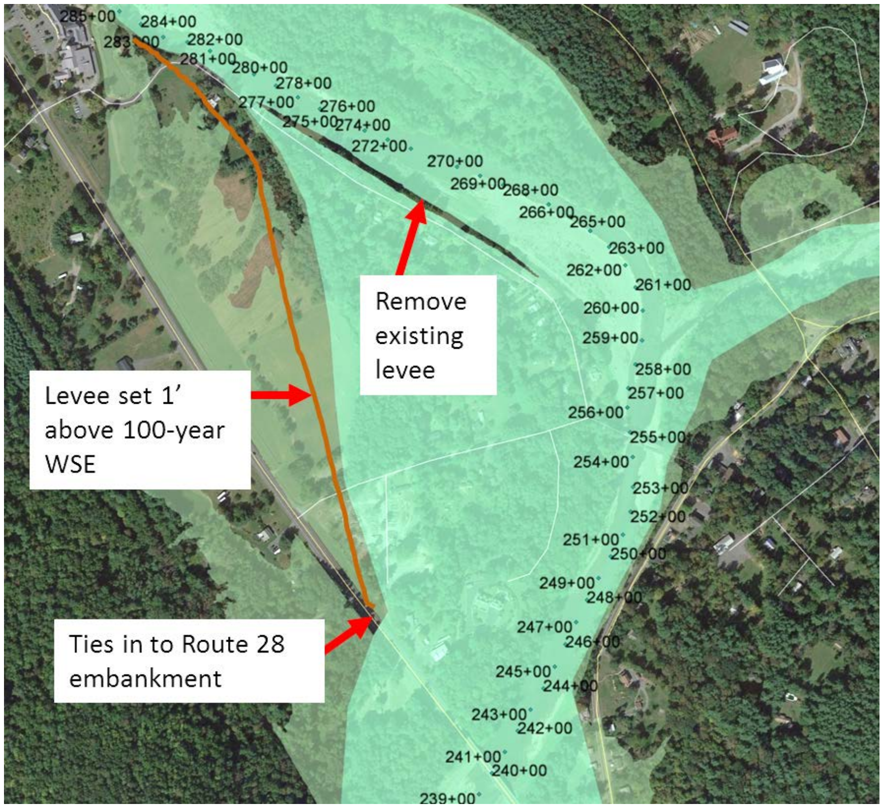
Figure 4-12
Schematic Depiction of Levee Relocation Scenario



13b. Relocate the levee out of the FEMA floodway.

The third levee modification involved moving the levee completely outside of the FEMA floodway (Figure 4-13). Upon close examination, this scenario would require the relocation of all of the homes and businesses along Mount Pleasant Road, Riseley Road, and along the east side of Route 28 just north of the Route 28 bridge and would result in the removal of a relatively small area from flooding during the 100-year flood event, mostly consisting of athletic fields. Therefore, this scenario is not recommended and was not investigated further.

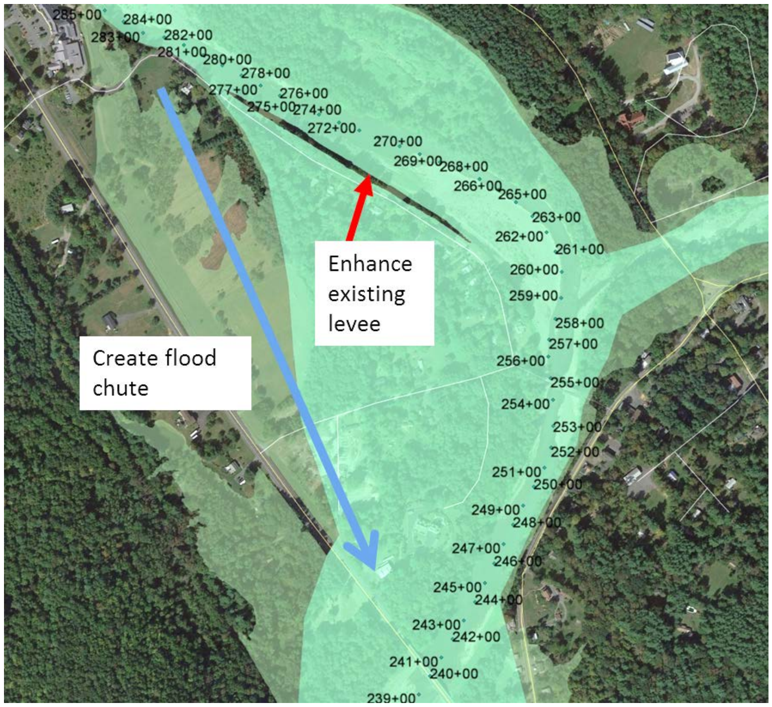
Figure 4-13
Schematic Depiction of Moving Levee Outside of Floodway Scenario



13c. Create flood relief chute that would convey waters across the inside of the bend in the river.

The fourth scenario would involve the creation of a flood relief chute that would convey waters across the inside of the bend in the river, approximately between STA 285+00 and STA 244+00. Floodwaters spilling over the left bank of Esopus Creek at STA 285+00 would be contained within a defined overflow channel that would run across the floodplain, reentering Esopus Creek at STA 244+00. This scenario is depicted schematically in Figure 4-14. Construction of the flood chute would require the relocation of at least one home and one business along Route 28. Under flood conditions, this scenario would result in approximately 14 homes along Mount Pleasant Road and Riseley Road being surrounded by floodwaters, which would prevent residents of these homes from safely evacuating the area and prevent emergency personnel from entering the area. Therefore, this scenario was not investigated further.

Figure 4-14
Schematic Depiction of Flood Chute Scenario

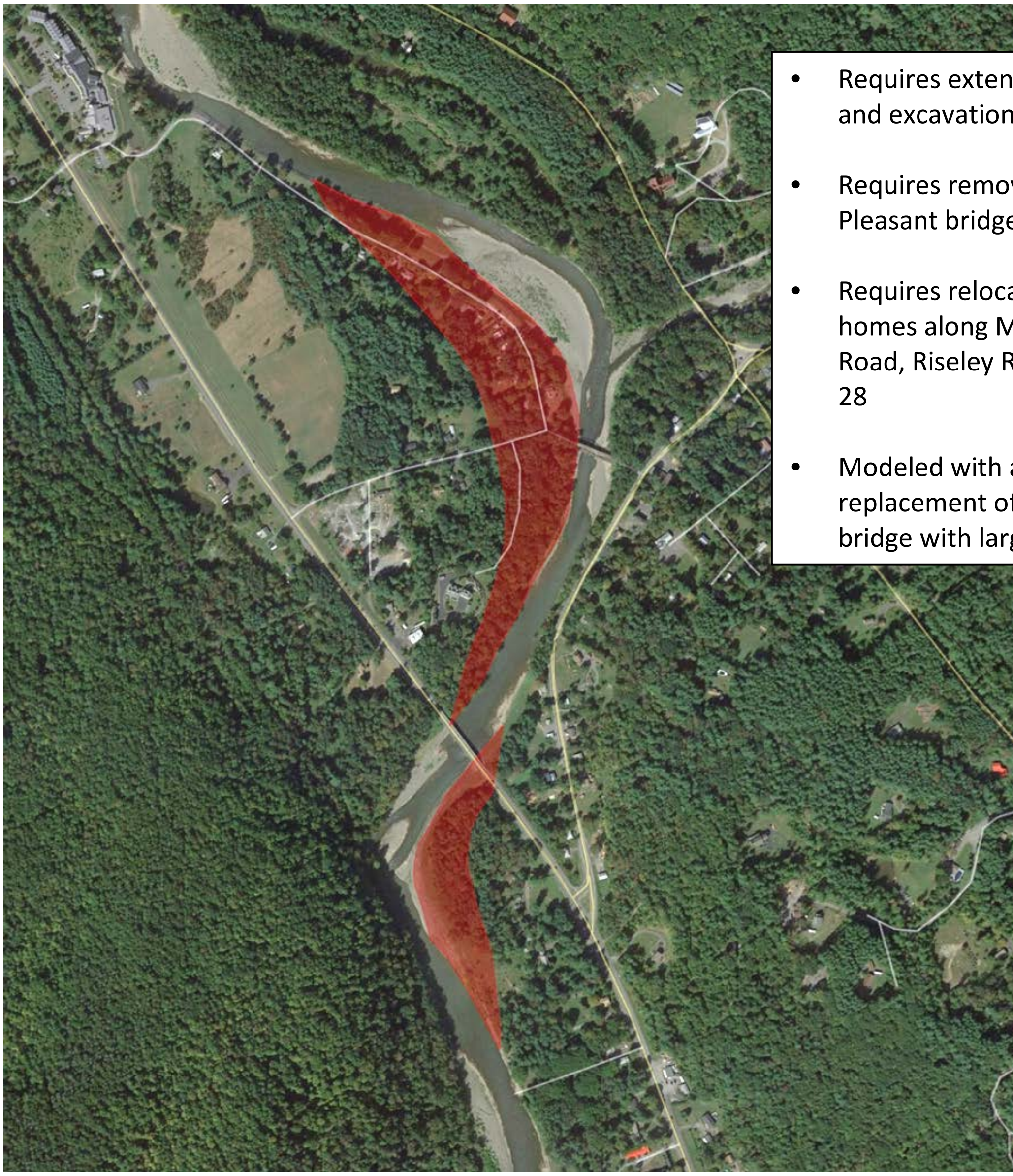


<u>14. Mt. Tremper Floodplain Enhancement on Esopus Creek</u>

Floodplain enhancement was analyzed along approximately 3,400 linear feet of Esopus Creek channel on the inside of the bend just downstream of the Emerson Resort along Mount Pleasant Road. This involved lowering the elevation of the right bank floodplain from STA 275+00 to STA 241+00 by a maximum of 9 feet and removal of the existing levee. Floodplain enhancement was also analyzed along approximately 1,800 linear feet of the channel on the inside of the bend just downstream of the Route 28 bridge. This involved lowering the elevation of the left bank floodplain from STA 242+00 to STA 224+00 by a maximum of approximately 10 feet and removal of the existing levee. Construction of the floodplain enhancement would require removal of sections of Mount Pleasant Road and Riseley Road and relocation of some of the homes along these roads. It would also require removal of the Mt. Pleasant bridge, which is in poor condition and closed to all traffic. The floodplain enhancement areas are shown on Figure 4-15.

This scenario results in a water surface elevation reduction of up to nearly 3.0 feet along approximately 4,000 feet of channel during the 10-year flood event. Water surface elevation reductions under the floodplain enhancement scenario would be as much as 3.5 feet in the vicinity of the Route 28 bridge during the 100-year flood event and would extend approximately 4,000 feet upstream of the bridge. Water surface elevation reductions under the Mt. Tremper floodplain enhancement scenario are detailed in Table 4-3. This floodplain enhancement scenario results in flood reduction and was, therefore, advanced as a flood mitigation alternative.

Figure 4-15
Mt. Tremper Floodplain Enhancement Scenario



- Requires extensive earthwork and excavation
- Requires removal of Mount Pleasant bridge
- Requires relocation of 14 homes along Mount Pleasant Road, Riseley Road, and Route 28
- Modeled with and without replacement of Route 28 bridge with larger bridge

TABLE 4-3
Water Surface Elevation Reductions
Mt. Tremper Floodplain Enhancement Scenario (14)

Location in Channel	Station	Water Surface Elevation Reduction During 10-year Flood (feet)	Water Surface Elevation Reduction During 100-year Flood (feet)
1,126 feet downstream of Route 28 bridge	228+65	Negligible	Negligible
At Route 28 bridge	239+91	1.6	3.5
At Mt. Pleasant Road bridge (would be removed)	254+83	Negligible	1.2
1,850 feet upstream of Route 28 bridge	258+21	2.8	1.2
2,895 feet upstream of Route 28 bridge	268+86	1.5	1.5
5,382 feet upstream of Route 28 bridge	293+73	0.2	1.8

The floodplain enhancement scenario described above (Scenario 14) was modeled in combination with the replacement of the Route 28 bridge (Scenario 11) in order to determine whether the combination resulted in greater flood reduction benefits. This combination is described below.

14a. Floodplain Enhancement on Esopus Creek Combined with Route 28 Bridge Replacement
The floodplain enhancement scenario described above was also modeled in combination with the replacement of the Route 28 bridge with a larger structure. This scenario combines the flood reduction benefits of floodplain enhancement, which results in substantially reduced water surface elevations under a range of flood events, with the benefits of the replacement of the Route 28 bridge, which results in substantial flood reduction during larger (i.e., 100-year) flood events. With a larger bridge and the enhanced floodplain in place, hydraulic modeling indicates that water surface elevations are reduced during both smaller (i.e., 10-year) and larger (i.e., 100-year) flood events. Water surface elevation reductions under the Mt. Tremper floodplain enhancement and Route 28 bridge replacement scenario are detailed in Table 4-4. These water surface elevation reductions are depicted graphically on a longitudinal profile on Figure 4-16 (for the 10-year flood event) and Figure 4-17 (for the 100-year flood event). This scenario results in flood reduction and was, therefore, advanced as a flood mitigation alternative.

TABLE 4-4
Water Surface Elevation Reductions
Mt. Tremper Floodplain Enhancement and Bridge Replacement Scenario

Location in Channel	Station	Water Surface Elevation Reduction During 10-year Flood (feet)	Water Surface Elevation Reduction During 100-year Flood (feet)
59 feet downstream of Route 28 bridge	239+32	2.0	3.7
At Route 28 bridge	239+91	2.9	6.8
At Mt. Pleasant Road bridge (would be removed)	254+83	1.6	5.2
1,850 feet upstream of Route 28 bridge	258+21	2.8	3.3
2,895 feet upstream of Route 28 bridge	268+86	1.5	3.1
5,382 feet upstream of Route 28 bridge	293+73	0.2	2.3

Figure 4-16
Water Surface Elevation Reductions – 10-Year Flood Event
Mt. Tremper Floodplain Enhancement and Bridge Replacement Scenario

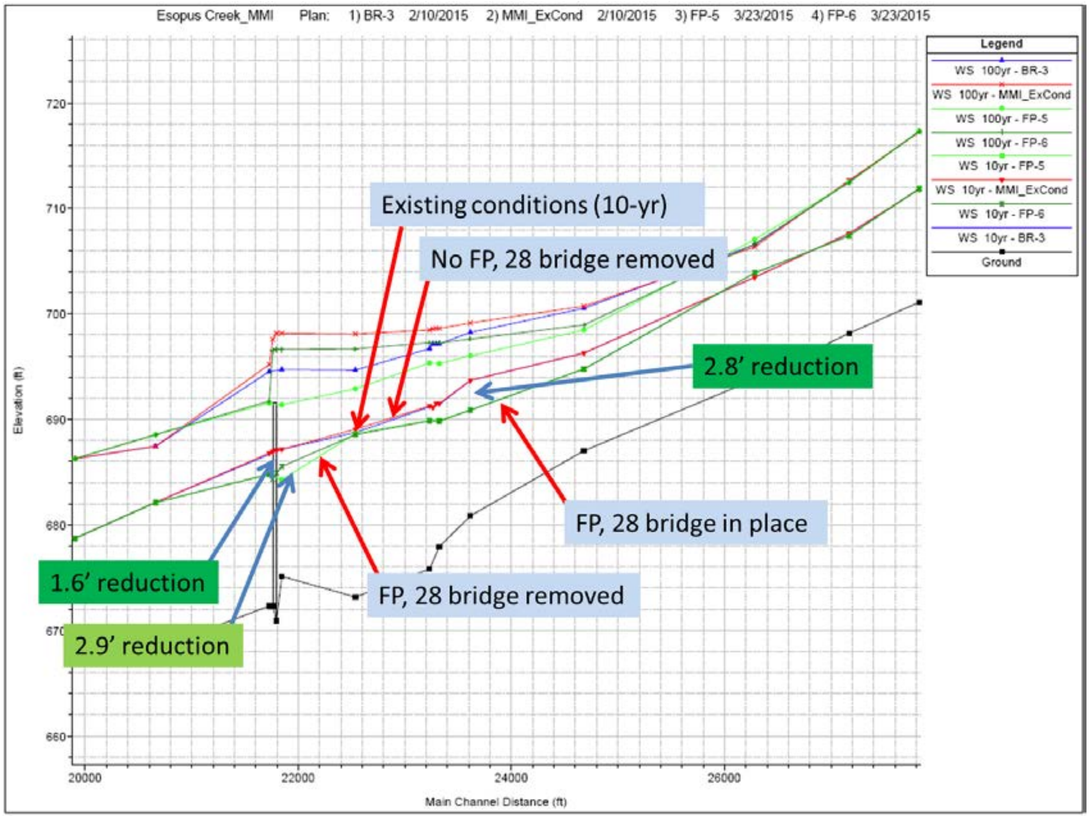
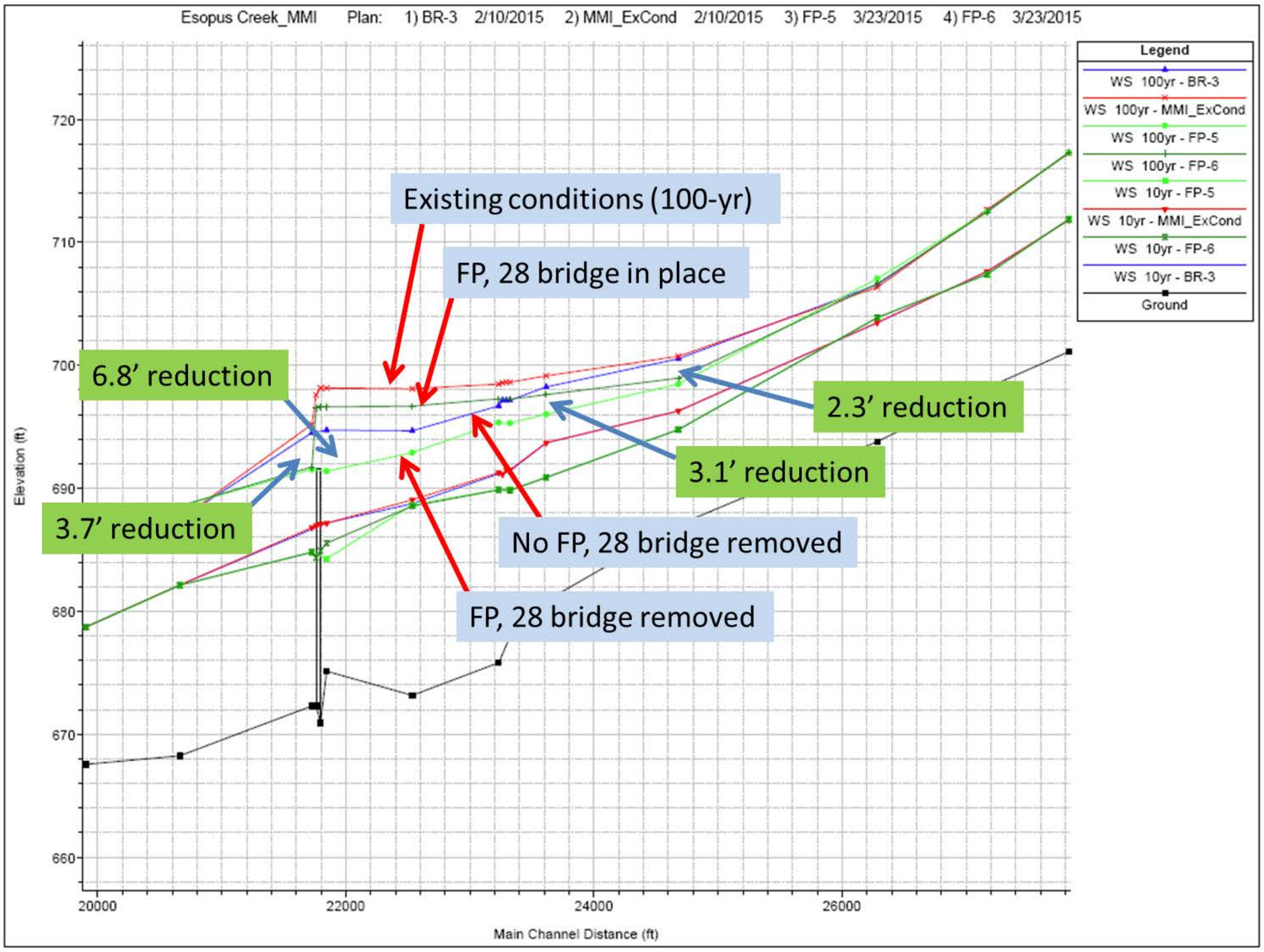


Figure 4-17
Water Surface Elevation Reductions – 100-Year Flood Event
Mt. Tremper Floodplain Enhancement and Bridge Replacement Scenario



15. Floodplain Enhancement on Beaver Kill

Floodplain enhancement was also analyzed along 700 feet of the channel on the Beaver Kill. This involved lowering the elevation of the left bank floodplain from STA 13+00 to STA 20+00 by a maximum of 5 feet to allow it to convey greater flow, as shown in Figure 4-18. This scenario results in an approximate 0.5-foot reduction over approximately 300 feet of channel in the 10-year flood event and a 1.6-foot reduction during the 100-year event (Figure 4-19). Flooding along Route 212 is reduced. This floodplain enhancement scenario has potential for flood reduction and was, therefore, advanced as a flood mitigation alternative.

Figure 4-18
Floodplain Enhancement on Beaver Kill

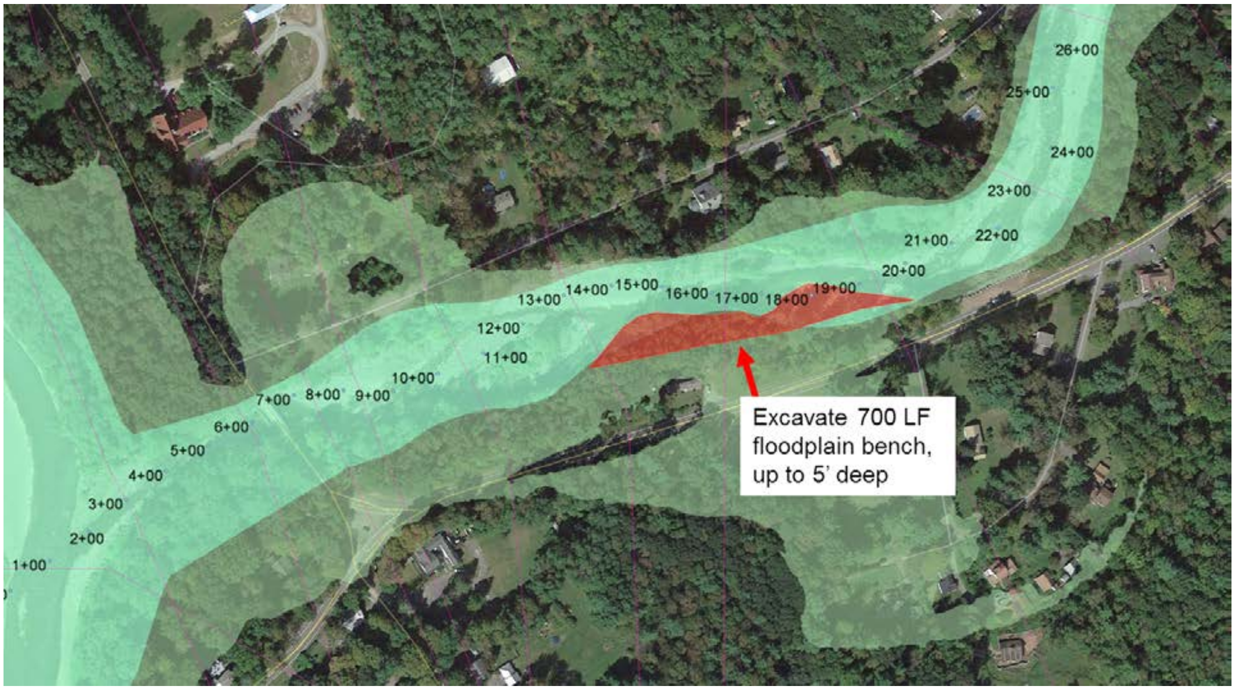
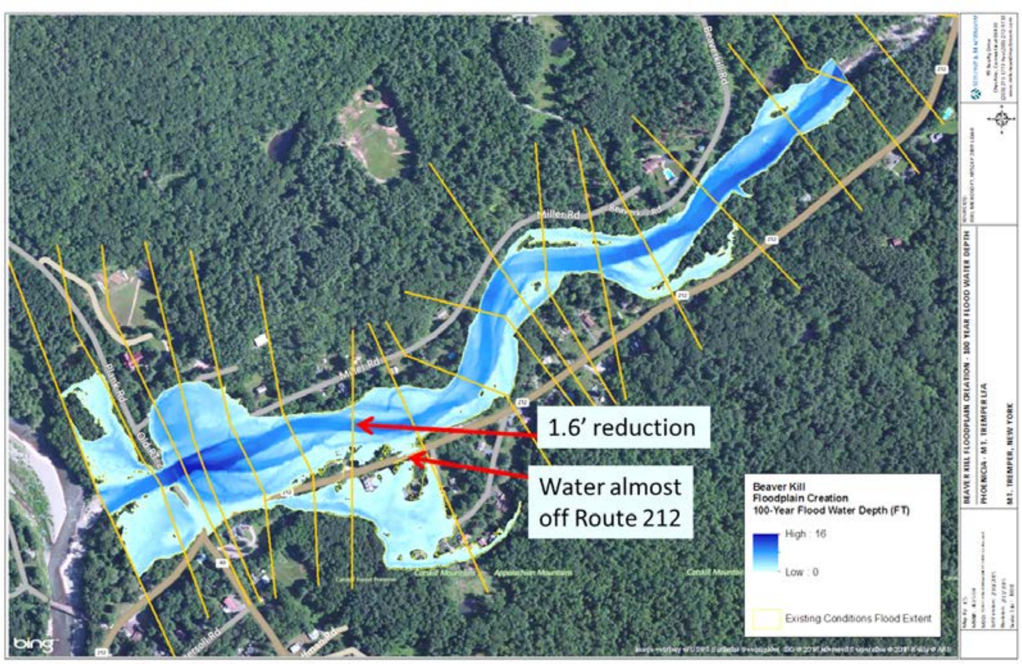


Figure 4-19
Water Surface Elevation Reductions Under the Floodplain Enhancement on Beaver Kill
100-Year Flood Event



16. Plank Road Bridge Replacement

The Plank Road bridge crosses the Beaver Kill at STA 6+25 (Figure 4-20). The bridge is a steel truss design with abutments on each bank and connects Plank Road with State Route 212. Hydraulic modeling was conducted to determine the effect replacement of the bridge with a larger structure would have on floodwater elevations. Modeling indicates that replacement of the bridge with a hydraulically adequate structure would reduce water surface elevations immediately upstream of the bridge but with only marginal benefit to homes and roads in the vicinity. Water surface elevation reductions are shown on Figure 4-21 (water surface profile) and Figure 4-22 (flooding depth map). Replacement of the bridge with a new bridge with a larger hydraulic opening has potential for flood reduction and was, therefore, advanced as a flood mitigation alternative.

Figure 4-20
Plank Road Bridge Over Beaver Kill

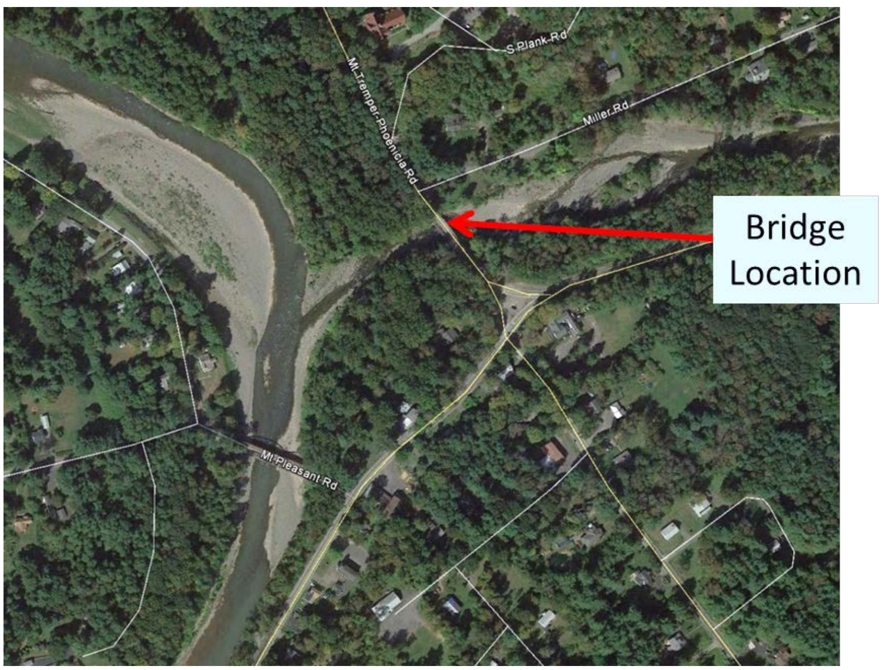


Figure 4-21
Water Surface Elevation Reduction Resulting From Replacement of Plank Road Bridge
10-Year and 100-Year Flood Events

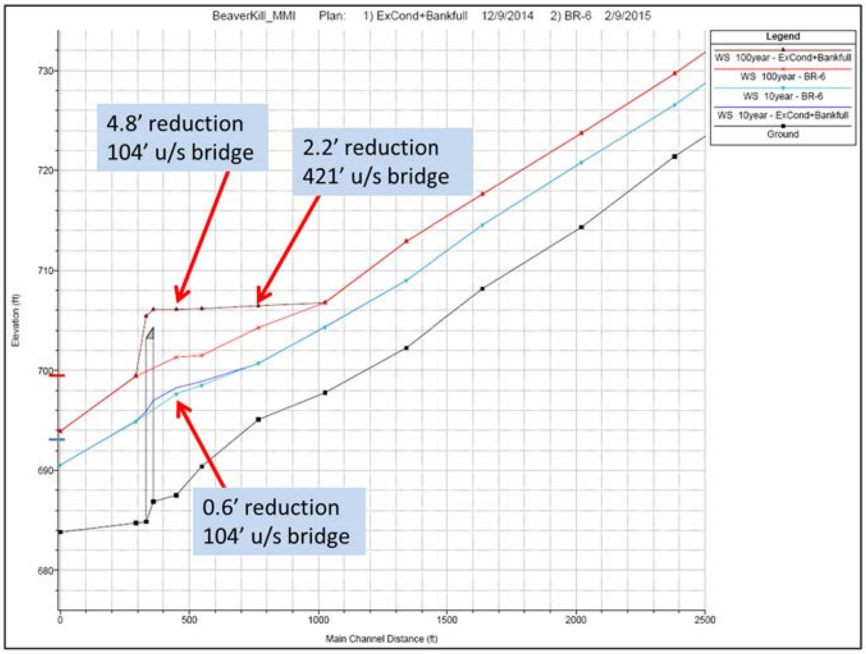
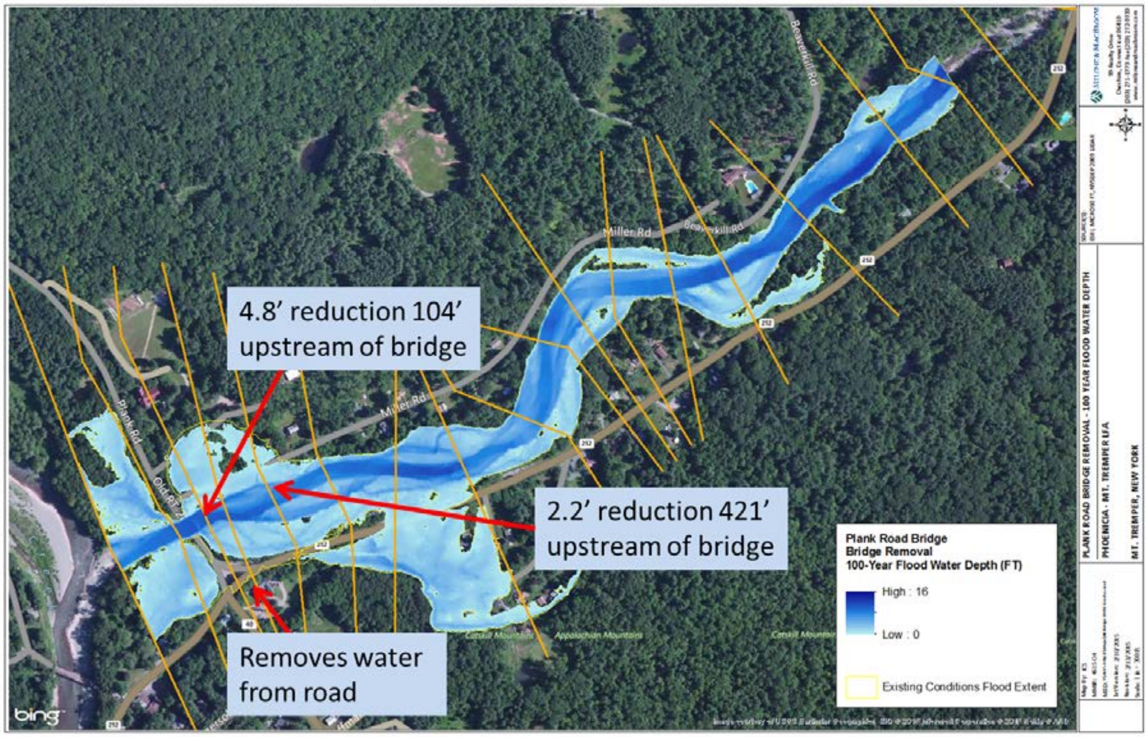


Figure 4-22
Water Surface Elevation Reduction Map Resulting From Replacement of Plank Road Bridge
100-Year Flood



<u>Conclusions</u>

Based on the above analysis, those flood mitigation scenarios in Mt. Tremper that had merit were advanced to the BCA. These are listed below and discussed in more detail in Section 5.0 of this report (Benefit-Cost Analysis).

9. Mt. Tremper Dredging of Esopus Creek
11. Mt. Tremper Route 28 Bridge Replacement
14. Mt. Tremper Floodplain Enhancement on Esopus Creek
14a. Mt. Tremper Floodplain Enhancement Combined With Route 28 Bridge Replacement
15. Floodplain Enhancement on Beaver Kill
16. Plank Road Bridge Replacement

5.0 BENEFIT-COST ANALYSIS

5.1 Overview of Benefit-Cost Analysis

A BCA is used to validate the cost effectiveness of a proposed hazard mitigation project. A BCA is a method by which the future benefits of a project are estimated and compared to its cost. The end result is a benefit-cost ratio (BCR) derived from a project's total net benefits divided by its total project cost. The BCR is a numerical expression of the cost effectiveness of a project. A project is considered to be cost effective by FEMA when the BCR is 1.0 or greater, indicating that the benefits of the project are sufficient to justify the costs. A BCA was conducted for proposed alternatives that, based on evaluation of the HEC-RAS modeling, would result in reduced flooding and would not have an unacceptable impact on the community.

A BCA was conducted for the following alternatives:

Phoenicia Study Area

- 4a. Floodplain Enhancement with Bridge Street Bridge Replacement/Expansion
- 4b. Floodplain Enhancement with Bridge Street Bridge Replacement/Expansion
- 6. Dredging of Esopus Creek

Mt. Tremper Study Area

- 9. Mt. Tremper Dredging of Esopus Creek
- 11. Mt. Tremper Route 28 Bridge Replacement
- 14. Mt. Tremper Floodplain Enhancement on Esopus Creek
- 14a. Mt. Tremper Floodplain Enhancement Combined with Route 28 Bridge Replacement
- 15. Floodplain Enhancement on Beaver Kill
- 16. Plank Road Bridge Replacement

To facilitate the BCA, a field survey of structures in the FEMA 100-year flood zone was carried out in the project area. The following features were noted:

- Is the structure commercial or residential?
- If the structure is commercial, is it a retail establishment, a warehouse, or vacant?
- Does the structure have a basement, crawlspace, or slab foundation?
- What is the number of stories?
- Is the structure split level?
- What is the elevation of the first floor in relation to the grade?

5.2 BCA Results – Phoenicia Study Area

4a. Phoenicia Floodplain Enhancement

As detailed in Section 4.5, the floodplain enhancement scenario in Phoenicia reduces (but does not eliminate) flooding in Phoenicia. Water surface elevations are reduced by up to 1.2 feet on Main Street during an Irene-magnitude flood event. The scenario would require relocation of some homes and businesses and would require the replacement of the Bridge Street bridge with a larger structure that would span the entire floodplain.

TABLE 5-1
Summary of Benefits – Floodplain Enhancement Scenario (4a)

Benefit Summary	
Benefits: Property Acquisition/Relocation	$6,864,796
Benefits: Water Surface Reductions at Buildings that Remain	$2,859,843
Benefits: Bridge Replacement	$456,943
Total Benefits	**$10,181,582**

TABLE 5-2
Summary of Costs – Floodplain Enhancement Scenario (4a)

Construction Task	Cost
Property Buyout	$3,079,937
Demolition	$190,000
Bridge Replacement	$5,000,000
Floodplain Bench	$1,752,701
Total	**$10,022,638**

For Scenario 4a, benefits of $2,859,843 were derived from reduced water surface elevations at homes and businesses in Phoenicia. This figure represents the reduced cost in flood cleanup and repair at numerous homes, projected over 50 years, if the project were implemented. The benefits of $6,864,796 were derived from completely avoided flood damages where homes were once located. The benefits of $456,943 represent reduced cost of bridge repairs resulting from flood damage.

BCR for Phoenicia Floodplain Enhancement (Scenario 4a): **1.02.**

A BCR was also determined for the floodplain enhancement scenario assuming that the Bridge Street bridge has already been replaced with a hydraulically adequate structure. Under this scenario (4b), the BCR for Phoenicia Floodplain Enhancement Scenario is **1.94.**

A compelling aspect of Scenario 4a and Scenario 4b is that the benefits are heavily weighted by the removal of buildings that are incidental to enhancement of the floodplain. The floodplain enhancement itself does not directly generate the larger portion of benefits. Nevertheless, the scenarios are a single project, and the BCA is valid if the total benefits are considered.

6. Phoenicia Dredge Scenario

The dredge scenario in Phoenicia would involve dredging to a depth of 3 feet and would result in the removal of approximately 11,291 CY of material from 986 linear feet of the channel bed. The model indicates that the removal of this material would reduce water surface elevations, especially at the bankfull discharge. However, as flows increase to the 100-year event, the reduction in water surface elevations decreases. The cost estimate for the dredge scenario assumes that the dredging would have to be repeated five times over a 50-year period as the channel fills with sediment, and the costs and benefits were based on this time frame.

TABLE 5-3
Summary of Benefits – Phoenicia Dredge Scenario (6)

Benefit Summary	
Benefits: Water Surface Reductions at Buildings That Remain	$ 314,784
Total Benefits	$ 314,784

TABLE 5-4
Summary of Costs – Phoenicia Dredge Scenario (6)

Construction Task	**Cost**
One-Time Sediment Removal	**$225,820**
10-Year Repeat Interval	X 5
Total	$1,129,100

BCR for Phoenicia Dredge Scenario (Scenario 6): **0.28**

5.3 BCA Results – Mt. Tremper Study Area

9. Mt. Tremper Dredging of Esopus Creek

Dredging of Esopus Creek to a depth of 3 feet was modeled from adjacent to the Emerson Resort to downstream of the Route 28 bridge, a distance of 5,623 linear feet (just over 1 mile). The model indicates that the dredging and removal of this material would reduce water surface elevations by as much as 2.6 feet during the bankfull discharge. However, as flows increase to the 100-year event, the reduction in water surface elevations decreases to a reduction of 0.7 feet or less. As with the Phoenicia dredge scenario, the cost estimate assumes that the dredging operation would need to be repeated five times over a 50-year period as the channel fills with sediment, and the costs and benefits were based on this time frame.

TABLE 5-5
Summary of Benefits – Mt. Tremper Dredge Scenario (9)

Benefit Summary	
Benefits: Water Surface Reductions at Buildings That Remain	$2,404,000
Total Benefits	$2,404,000

TABLE 5-6
Summary of Costs – Mt. Tremper Dredge Scenario (9)

Construction Task	**Cost**
One-Time Sediment Removal	$1,798,780
10-Year Repeat Interval	X 5
Total	$8,993,900

BCR for Mt. Tremper Dredge Scenario (Scenario 9): **0.27**

11. Mt. Tremper Route 28 Bridge Replacement

Of the various bridge configurations that were modeled, the greatest flood reduction benefit at the Route 28 bridge would result from the removal of the bridge and road embankments on river right and river left and a larger replacement structure that would span the entire floodplain area.

TABLE 5-7
Summary of Benefits – Mt. Tremper Route 28 Bridge Replacement (11)

Benefit Summary	
Benefits: Water Surface Reductions at Buildings That Remain	$1,241,392
Total Benefits	$1,241,392

TABLE 5-8
Summary of Costs – Mt. Tremper Route 28 Bridge Replacement (11)

Construction Task	**Cost**
Bridge Replacement	$15,000,000
Total	$15,000,000

BCR for Mt. Tremper Route 28 Bridge Replacement (Scenario 11): **0.08**

The bridge replacement was also evaluated in combination with the floodplain enhancement scenario.

14. Mt. Tremper Floodplain Enhancement on Esopus Creek

Floodplain enhancement would include 3,400 linear feet of the Esopus Creek channel on the inside of the bend just downstream of the Emerson Resort along Mount Pleasant Road as well as 1,800 linear feet of the channel on the inside of the bend just downstream of the Route 28 bridge. This scenario involved lowering the elevation of the floodplain and removal of the existing levee. Construction of the floodplain enhancement would require removal of sections of Mount Pleasant Road and Riseley Road and relocation of some of the homes along these roads. It would require removal of the Mt. Pleasant bridge.

TABLE 5-9
Summary of Benefits – Mt. Tremper Floodplain Enhancement Scenario (14)

Benefit Summary	
Benefits: Property Acquisition/Relocation	$21,821,090
Benefits: Water Surface Reductions at Buildings That Remain	$3,674,373
Total Benefits	$25,495,463

TABLE 5-10
Summary of Costs – Mt. Tremper Floodplain Enhancement Scenario (14)

Construction Task	**Cost**
Property Buyout	$8,843,133
Demolition	$590,000
Bridge Removal	$500,000[1]
Floodplain	$5,743,589
Total	**$15,676,722**

[1]An Ulster County estimate for removal and demolition of the bridge is $750,000.

BCR for Mt. Tremper Floodplain Enhancement Scenario (Scenario 14): **1.63.** This scenario was also modeled in combination with the replacement of the Route 28 bridge with a larger structure (Scenario 14a).

14a. Combination of Floodplain Enhancement on Esopus Creek and Route 28 Bridge Replacement

TABLE 5-11
Summary of Benefits – Bridge Replacement and Floodplain Enhancement Scenario (14a)

Benefit Summary	
Benefits: Property Acquisition/Relocation	$21,821,090
Benefits: Water Surface Reductions at Buildings That Remain	$4,865,055
Total Benefits	$26,686,145

TABLE 5-12
Summary of Costs – Bridge Replacement and Floodplain Enhancement Scenario (14a)

Construction Task	Cost
Property Buyout	$8,843,133
Demolition	$590,000
Bridge Replacement	$15,000,000
Remove Mt. Pleasant Bridge	$500,000
Floodplain	$5,743,589
Total	$30,676,722

BCR for Combination of Bridge Replacement and Floodplain Enhancement Scenario (Scenario 14a): **0.87**

15. Floodplain Enhancement on Beaver Kill

Floodplain enhancement was also analyzed along 700 feet of the channel on the Beaver Kill. This involved lowering the elevation of the left bank floodplain from STA 13+00 to STA 20+00 by a maximum of 5 feet to allow it to convey greater flow.

TABLE 5-13
Summary of Benefits – Floodplain Enhancement on Beaver Kill Scenario (15)

Benefit Summary	
Benefits: Water Surface Reductions at Buildings That Remain	$125,996
Total Benefits	$125,996

TABLE 5-14
Summary of Costs – Floodplain Enhancement on Beaver Kill Scenario (15)

Construction Task	Cost
Property Buyout and Demolition	$0
Floodplain Bench	$498,625
Total	$498,625

BCR for Beaver Kill Floodplain Bench (Scenario 15): **0.25**

16. Plank Road Bridge Replacement

The Plank Road bridge crosses the Beaver Kill at STA 6+25. The bridge is a steel truss design with abutments on each bank and connects Plank Road with State Route 212. The assessment below assumes that the bridge would be replaced with a similar truss-style bridge with a larger hydraulic capacity.

TABLE 5-15
Summary of Benefits – Plank Road Bridge Replacement Scenario (16)

Benefit Summary	
Benefits: Water Surface Reductions at Buildings That Remain	$141,451
Total Benefits	$141,451

TABLE 5-16
Summary of Costs – Plank Road Bridge Replacement Scenario (16)

Construction Task	Cost
Bridge Replacement	$1,750,000
Total	$1,750,000

BCR for Plank Road Bridge Replacement (Scenario 16): **0.08**

5.4 BCR Summary

Table 5-17 below provides a summary of BCRs for all flood mitigation scenarios for which a BCA was conducted. Within the Phoenicia study area, dredging of the Esopus Creek channel (Scenario 6) would not be cost effective while floodplain enhancement in combination with the replacement of the Bridge Street bridge (Scenario 4a) has a BCR of 1.02. A BCR was also determined for this floodplain enhancement scenario assuming that the Bridge Street bridge has already been replaced with a hydraulically adequate structure (Scenario 4b).

In the Mt. Tremper study area, the Esopus Creek dredge scenario (Scenario 9), replacement of the Route 28 bridge (Scenario 11), the Beaver Kill floodplain bench scenario (Scenario 15), and replacement of the Plank Road bridge (Scenario 16) all result in BCRs that are not cost effective. The Mt. Tremper floodplain enhancement scenario (Scenario 14) results in a positive BCR of 1.63. When combined with the Route 28 bridge replacement (Scenario 14a), the floodplain enhancement scenario results in a BCR of 0.87.

Files associated with the BCA analysis and estimates of cost are included in Appendix C.

TABLE 5-17
Summary of BCRs

Number	Scenario	Benefit-Cost Ratio (BCR)
	Phoenicia Study Area	
4a	Floodplain Enhancement With Bridge Street Bridge Replacement	1.02
4b	Floodplain Enhancement if Bridge Street Bridge Has Been Replaced	1.94
6	Dredging the Esopus Creek Channel in Phoenicia	0.28
	Mt. Tremper Study Area	
9	Dredging the Esopus Creek Channel in Mt Tremper	0.27
11	Route 28 Bridge Replacement	1.63
14	Mt. Tremper Floodplain Enhancement on Esopus Creek	0.08
14a	Mt. Tremper Floodplain Enhancement on Esopus Creek Combined With Route 28 Bridge Replacement	0.87
15	Floodplain Bench on Beaver Kill	0.25
16	Plank Road Bridge Replacement	0.08

6.0 FINDINGS AND RECOMMENDATIONS

The purpose of this LFA is to evaluate potential flood mitigation options within the town of Shandaken in the hamlets of Phoenicia and Mt. Tremper. Flooding has long been a problem in these communities as seen most recently by the extensive flooding and devastation during Tropical Storm Irene in 2011. A wide range of flood mitigation alternatives were evaluated, including the replacement of undersized bridges, floodplain enhancement, dredging, removal of sediment bars, enhancement and relocation of levees, and combinations of these approaches. Flood mitigation alternatives were evaluated using hydraulic modeling. Alternatives that had flood reduction merit were evaluated using a BCA tool in order to determine whether they would be cost effective if implemented.

6.1 Recommendations for Both Study Areas

A variety of measures are available to protect existing public and private properties from flood damage. While broader mitigation efforts are most desirable, they often take time and money to implement. On a case-by-case basis, where structures are at risk in the hamlets, individual floodproofing should be explored. Property owners within FEMA-delineated floodplains should also be encouraged to purchase flood insurance under the NFIP and to make claims when damage occurs.

The following actions are recommended:

1. Seek to relocate the most flood-vulnerable properties where there is owner interest and programmatic funding available through either FEMA, NYCDEP, or CWC flood buyout and relocation programs.
2. All habitable structures that receive 3 feet or more of floodwater against the structure are considered a high priority for "Property-Specific Mitigation." The flowchart in Figure 6-1 provides mitigation decision-making guidance for nonresidential properties. Figure 6-2 provides similar guidance for residential properties. Property owners are encouraged to seek town input on possible mitigation actions.
3. Move existing structures out of the floodway.
4. Disallow any new development in the floodway and require new construction to meet NFIP criteria.
5. Some of the homes in the floodplain are rarely flooded. Residents and businesses may benefit from minor individual property improvements. Providing landowners with information regarding individual property protection is recommended (see *Individual Property Flood Protection* measures described below).
6. During the public meeting process, flooding was reported throughout both study areas associated with undersized culverts and smaller drainageways that are not part of Esopus Creek, Stony Clove Creek, or the Beaver Kill. While these flooding sources were not evaluated as part of this LFA, they should be investigated and addressed.
7. Effort should be made to identify parcels that could benefit from securing or relocating fuel tanks to eliminate a potential source of man-made pollution and apply for funding through the CWC.

The town should work to identify and remove vacant and abandoned structures to prevent future hazards.

Individual Property Flood Protection Measures

In areas where properties are vulnerable to flooding, improvements to individual properties and structures may be appropriate. Potential measures for property protection include the following:

- Elevation of the Structure

  Home elevation involves the removal of the building structure from the basement and elevating it to a height such that the first floor is located at least 2 feet above the level of the 100-year flood event. The basement area is abandoned and filled to be no higher than the existing grade. All utilities and appliances located within the basement must be relocated to the first-floor level or installed from basement joists or similar mechanism at an elevation no less than 1 foot above the BFE. Elevation of homes can be implemented on a case-by-case basis as property owners approach the town about mitigation. Ensure that elevations are conducted in accordance with the effective BFEs at the time of the work.

- Construction of Property Improvements Such As Barriers, Floodwalls, and Earthen Berms

  Such structural projects can be used to prevent shallow flooding. There may be properties within the hamlets where implementation of such measures will serve to protect structures.

- Dry Floodproofing of the Structure to Keep Floodwaters from Entering

  Dry floodproofing refers to the act of making areas below the flood level watertight. Walls may be coated with compound or plastic sheathing. Openings such as windows and vents would be either permanently closed or covered with removable shields. Flood protection should extend only 2 to 3 feet above the top of the concrete foundation because building walls and floors cannot withstand the pressure of deeper water.

- Wet Floodproofing of the Structure to Allow Floodwaters to Pass Through the Lower Area of the Structure Unimpeded

  Wet floodproofing refers to intentionally letting floodwater into a building to equalize interior and exterior water pressures. Wet floodproofing should only be used as a last resort. If considered, furniture and electrical appliances should be moved away or elevated above the 100-year flood elevation.

- Performing Other Home Improvements to Mitigate Damage from Flooding

  The following measures can be undertaken to protect home utilities and belongings:

- Relocate valuable belongings above the 100-year flood elevation to reduce the amount of damage caused during a flood event.
- Relocate or elevate water heaters, heating systems, washers, and dryers to a higher floor or to at least 12 inches above the BFE (if the ceiling permits). A wooden platform of pressure-treated wood can serve as the base.
- Anchor fuel tanks to the wall or floor with noncorrosive metal strapping and lag bolts. The town and individuals are advised to seek funds from CWC to help anchor oil and propane tanks under the communitywide elimination of potential sources of pollution.
- Install a backflow valve to prevent sewer backup into the home.
- Install a floating floor drain plug at the lowest point of the lowest finished floor.
- Elevate the electrical box or relocate it to a higher floor and elevate electric outlets to at least 12 inches above the high water mark.

- Encouraging Property Owners to Purchase Flood Insurance Under the NFIP and to Make Claims When Damage Occurs

  While having flood insurance will not prevent flood damage, it will help a family or business put things back in order following a flood event. Property owners should be encouraged to submit claims under the NFIP whenever flooding damage occurs in order to increase the eligibility of the property for projects under the various mitigation grant programs.

- Pursue Relocations

  If property owners are interested, pursue relocations of homes and businesses. These may include critical facilities such as the Phoenicia fire district station on Route 214, the EMS medic building on Mt Ave Maria Drive, and key businesses in Phoenicia and Mt. Tremper. Businesses considered to be anchor businesses under the CWC program are eligible to apply for relocation assistance. Funding guidelines and other details are available on CWC's website, www.cwconline.org.

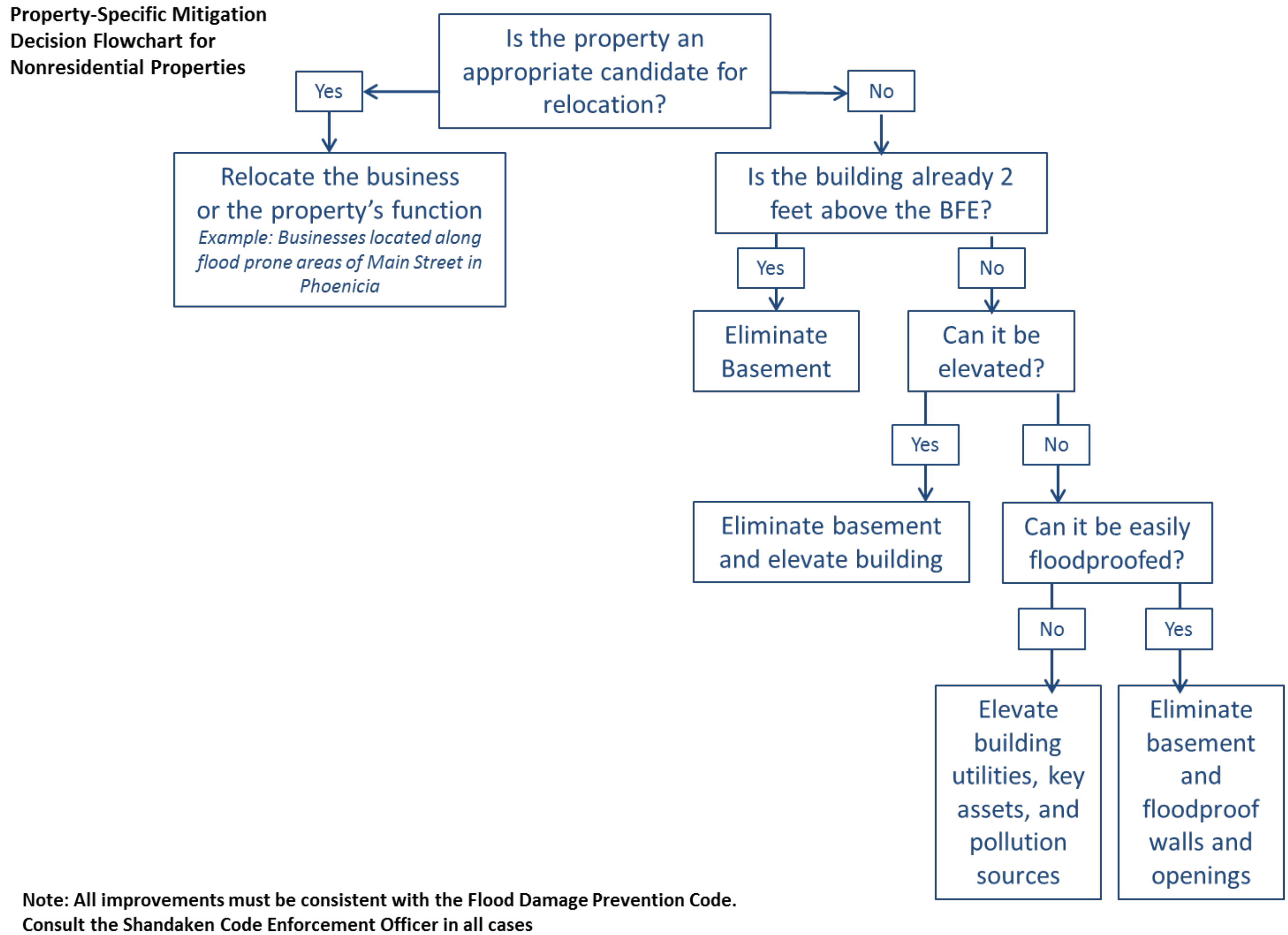
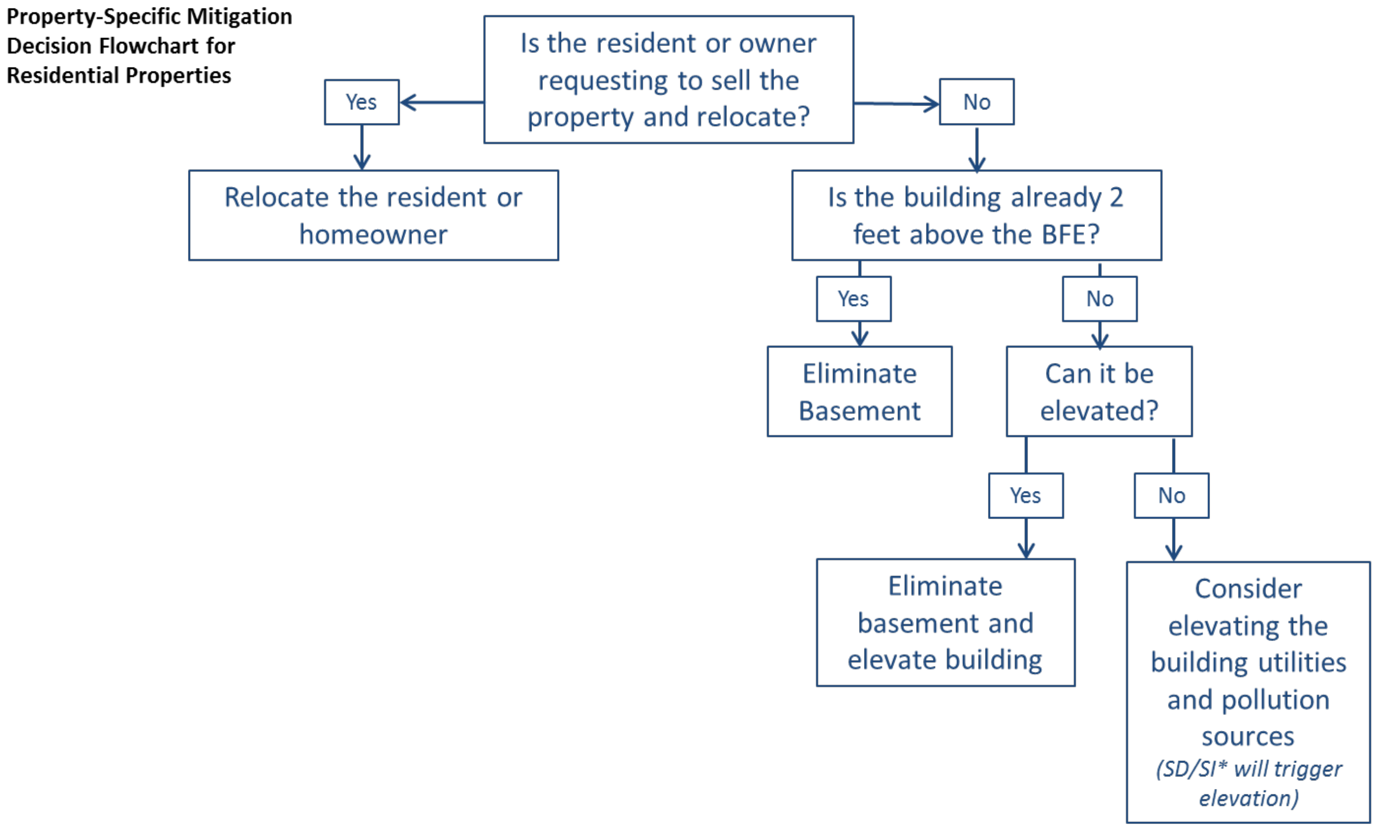

Property-Specific Mitigation Decision Flowchart for Nonresidential Properties
Is the property an appropriate candidate for relocation?
Yes
No
Relocate the business or the property's function
Example: Businesses located along flood prone areas of Main Street in Phoenicia
Is the building already 2 feet above the BFE?
Yes
No
Eliminate Basement
Can it be elevated?
Yes
No
Eliminate basement and elevate building
Can it be easily floodproofed?
No
Yes
Elevate building utilities, key assets, and pollution sources
Eliminate basement and floodproof walls and openings
Note: All improvements must be consistent with the Flood Damage Prevention Code.
Consult the Shandaken Code Enforcement Officer in all cases

Figure 6-1



*Substantial Damage/Substantial Improvement
Note: All improvements must be consistent with the Flood Damage Prevention Code. Consult the Shandaken Code Enforcement Officer in all cases

Figure 6-2

Figure 6-3 (provided by the NYSDEC) illustrates the relationship between depth of flooding in relation to the first floor and the percent damage to the structure.

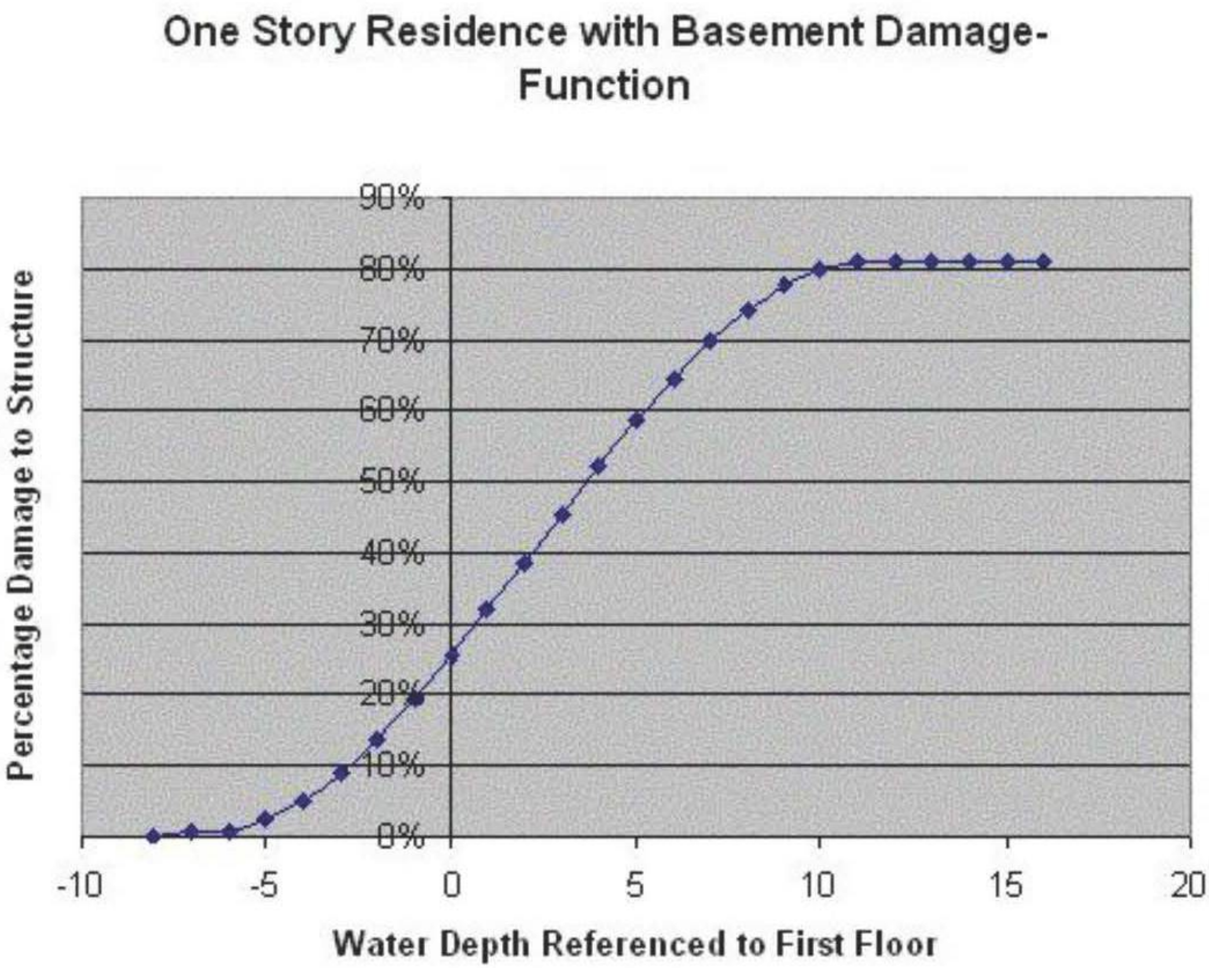


Figure 6-3
How Much Structural Damage Can you Expect?
(provided by NYSDEC)

Sediment Management

During the public meetings in Phoenicia and Mt. Tremper, residents expressed a sentiment that dredging would alleviate flooding along Esopus Creek and should be pursued. In response, dredging alternatives were analyzed as part of this LFA. These were reviewed relative to their effectiveness in mitigating flooding, project cost, and in light of the risks associated with instability and sediment transport.

Dredging often appears to be a simple and straightforward method of addressing flooding problems by increasing the size of the channel. Hydraulic analysis along Esopus Creek in Phoenicia and Mt. Tremper determined that dredging would result in very little flood reduction, especially during large-magnitude flood events. Also, there are often unanticipated consequences and continuing costs associated with dredging the channel. Sediment accumulates at particular locations in the stream channel because the conditions are such that sediments accumulate rather than being transported downstream. If sediment is removed without addressing the underlying reasons for sediment accumulation at that site, the sediment will return and fill in the channel. The problem can become more serious if dredging causes a head cut (a rapid, downward erosion of the channel), which often occurs when a section of channel is deepened. Upstream migration of the head cut often generates more sediment.

Development of a sediment management plan is recommended. A sound sediment management program sets forth standards to delineate how, when, and to what dimensions sediment excavation should be performed. Sediment excavation requires regulatory approvals as well as budgetary considerations to allow the work to be funded on an ongoing or as-needed basis as prescribed by the standards to be developed. Conditions in which active sediment management should be considered include:

- Situations where the channel is confined without space in which to laterally migrate
- For the purpose of infrastructure protection
- At bridge openings where hydraulic capacity has been compromised

In cases where sediment excavation in the stream channel is necessary, a methodology should be developed that would allow for proper channel sizing and slope. The following guidelines are recommended:

1. Maintain the original channel slope and do not overly deepen or widen the channel. Excavation should not extend beyond the channel's estimated bankfull width unless it is to match an even wider natural channel. Anyone proposing work in the channel is encouraged to work with the UCSWCD staff to identify the appropriate bankfull channel dimensions for the reach of stream.
2. Excavation of fine-grain sediment releases turbidity. Best available practices should be followed to control sedimentation and erosion.
3. Work with AWSMP to assess if treatment of upstream sediment sources can help alleviate downstream sediment accumulation.
4. If practicable, work with AWSMP to develop a sediment budget for the affected stream to determine what can actually be achieved in attempting to manage sediment accumulation in the affected stream segment.
5. Sediment excavation requires regulatory permits. Prior to initiation of any in-stream activities, NYSDEC and NYCDEP should be contacted and appropriate local, state, and federal permitting should be obtained.
6. Disposal of excavated sediments should always occur outside of the floodplain. If such materials are placed on the adjacent bank, they will be vulnerable to remobilization and redeposition during the next large storm event.
7. No sediment excavation should be undertaken in areas where aquatic-based rare or endangered species are located.

6.2 Recommendations for the Phoenicia Study Area

Floodplain enhancement in combination with the replacement of the Bridge Street bridge would reduce but not eliminate flooding along Main Street in Phoenicia. Water surface elevations would be reduced by up to 1.2 feet along Main Street during a flood event similar in magnitude to Tropical Storm Irene. The scenario would require relocation of some homes and businesses along both sides of Esopus Creek. It is recommended that the town seek input from citizens and affected landowners on implementation of the floodplain enhancement scenario as funding allows. This includes seeking funding for replacement of the Bridge Street bridge with a hydraulically larger structure.

The proposed floodplain enhancement project would be comprised of a compound channel whereby normal flow is conveyed in a bankfull channel that is flanked by active floodplain (see Figure 4-1). The active floodplain would be a vegetated, undeveloped corridor at a slightly higher elevation that is able to convey high flows. Design of the floodplain enhancement project would entail the proper sizing of the various components of the compound channel, including a low-flow channel, a bankfull channel, and a floodplain. During low-flow conditions, a low-flow channel would provide sufficient depths to support fish habitat. During bankfull flows, a bankfull channel is sized to maintain sediment transport and minimize the accumulation of sediments. During large flood events, a normally dry floodplain area would be inundated and would provide the capacity for flood flows to pass downstream.

All habitable structures that receive 3 feet or more of floodwater against the structure are considered a high priority for "Property-Specific Mitigation." See Section 6.1 for Decision Flowcharts and BCA information.

Additional recommendations for the Phoenicia study area include the following:

- Relocation of the High Street pump station out of the FEMA 100-year floodplain
- Relocate floodprone, town-critical facilities to town-owned parcel on Route 28, east of Phoenicia

6.3 Recommendations for the Mt. Tremper Study Area

Floodplain enhancement was analyzed in Mt. Tremper along the Esopus Creek channel near the bend just downstream of the Emerson Resort. This scenario would involve lowering the elevation of the right bank and left bank floodplain and removal of the existing levee. Construction of the floodplain enhancement would require removal of sections of Mount Pleasant Road and Riseley Road and relocation of some of the homes along these roads. This scenario would result in a water surface elevation reduction of up to 3.0 feet along 4,000 feet of channel during the 10-year flood event. Water surface elevation reductions under the floodplain enhancement scenario would be as much as 3.5 feet in the vicinity of the Route 28 bridge during the 100-year flood event and would extend approximately 4,000 feet upstream of the bridge. It is recommended that the town seek consensus from citizens and affected landowners on implementation of the floodplain enhancement scenario in Mt. Tremper as funding allows.

The scenario that combines the flood reduction benefits of floodplain enhancement that results in substantially reduced water surface elevations under a range of flood events with the benefits of the replacement of the Route 28 bridge that results in substantial flood reduction during larger (i.e., 100-year) flood events should also be investigated.

All habitable structures that receive 3 feet or more of floodwater against the structure are considered a high priority for "Property-Specific Mitigation." See Section 6.1 for Decision Flowcharts and BCA information.

6.4 Procedural Recommendations

The following procedural recommendations are offered:

- Gather and file flood-related lost revenue information as provided by businesses. This may help improve future BCA determinations.
- During and after future floods, record and compile municipal, county, and state costs related to cleanup and recovery in Phoenicia and Mt. Tremper. This may help improve future BCA determinations.
- During and after future floods, record high water marks throughout the hamlets. Track and record flood damage over time for anchor businesses and critical facilities.
- Identify opportunities to include water quality benefits in future BCA determinations. This may be particularly helpful when costs exceed standard flood mitigation benefits by narrow margins.

6.5 Funding Sources

Several funding sources may be available to the Town of Shandaken for the implementation of recommendations made in this report (see Table ES-2 for how funding sources apply to flood mitigation alternatives for Phoenicia and Mt. Tremper).

- Local Flood Analysis (LFA) and Stream Management Program (SMP)

  The LFA program that funded this study is one potential funding vehicle for some of the alternatives described in this report. As described in the LFA rules, "Stream Management Programs in the New York City water supply watersheds and the Catskill Watershed Corporation are supporting the analysis of flood conditions and the identification of hazard mitigation projects. The process consists of two steps: 1) an engineering analysis of flood conditions and identification of potential flood mitigation projects articulated in a plan and 2) project design and implementation. The engineering analysis and plan are termed 'Local Flood Analysis.' These program rules define the process for municipalities to apply for funding to complete a Local Flood Analysis (LFA). The program rules also define the process for municipalities to seek funding from the Stream Management Program to implement projects that involve streams, floodplains, and adjacent infrastructure to reduce flood hazards." LFA Program Rules can be viewed at: http://catskillstreams.org/wp-content/uploads/2015/01/LFA_Rules.pdf

- Buyout Programs

  Buyout programs are used to acquire individual flood-damaged properties that are associated with a mitigation project and have the potential for reducing future flood damages. Buyout programs are also a means of helping residents to relocate from properties that are repeatedly damaged by floods. Although large-scale buyouts are not recommended in this LFA, several properties have been identified for acquisition if the owners were willing to participate. The buyout program could potentially be used for some of these acquisitions. At the time of preparing this report, a NYCDEP-funded flood buyout program is proposed to assist communities with purchasing flood properties. Discussion of the program rules are ongoing.

- Catskill Watershed Corporation (CWC) Flood Hazard Mitigation Implementation Program (FHMIP)

  The CWC is a not-for-profit local development corporation established to protect the water resources of the New York City watershed west of the Hudson River, preserve and strengthen communities located in the region, and increase awareness and understanding of the importance of the New York City water system. CWC administers a number of programs under this mission such as the following:

  - Septic Repair and Maintenance – Funds residential septic system repairs, replacements, and maintenance
  - Stormwater Planning and Control – Funds planning, assessment, design, and implementation of stormwater and erosion controls for existing conditions as well as stormwater requirements for new construction
  - Education – Provides grants to schools and organizations
  - Community Wastewater Management – Funds a program to evaluate and build community-specific wastewater solutions, which may include septic maintenance districts, community septic systems, or wastewater treatment plants
  - Local Technical Assistance Program/Sustainable Communities Planning Program – Provides grants for planning updates for proposed relocations in communities that have completed an LFA
  - Economic Development – the Catskills Fund for the Future provides low-interest loans to businesses located within the New York City West of Hudson Watershed

  The FHMIP is intended to help fund projects such as property protection measures, floodplain reclamation, public infrastructure protection, communitywide elimination of potential sources of pollution, and property buyout/relocation. Most projects must be identified through a LFA conducted in watershed municipalities by consultants funded by NYCDEP's SMP or consultants engaged through other flood response programs.

  Municipalities with completed LFAs may apply to the CWC for funds to implement projects recommended in those analyses. Funding guidelines are described in the CWC's FHMIP rules and are available on CWC's website: www.cwconline.org.

  A related program was approved by the CWC Board of Directors in December 2014. The Sustainable Communities Planning Program, part of the Local Technical Assistance Program, is intended to fund revisions to local zoning codes or zoning maps or to upgrade comprehensive plans in order to identify areas within those municipalities that can serve as new locations for residences and/or businesses to be moved after purchase under the voluntary NYC Flood Buyout Program. Grants of up to $20,000 are available through this program. The Town of Shandaken should consider applying to identify such areas within its borders.

- Emergency Watershed Protection Program (EWP)

  Through the EWP program, the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) can help communities address watershed impairments that pose imminent threats to lives and property. Most EWP work is for the protection of threatened infrastructure from continued stream erosion. NRCS may pay up to 75 percent of the construction costs of emergency measures. The remaining costs must come from local sources and can be made in cash or in-kind services. EWP projects must reduce threats to lives and property; be economically, environmentally, and socially defensible; be designed and implemented according to sound technical standards; and conserve natural resources. These monies are not available at all times – only after Congressional allocations following federal disasters.

The projects described in this LFA report are not ideal matches for the NRCS EWP program. However, future use of the EWP program should be considered if the program rules change.

- FEMA Pre-Disaster Mitigation (PDM) Program

  The PDM Program was authorized by Part 203 of the Robert T. Stafford Disaster Assistance and Emergency Relief Act (Stafford Act), 42 U.S.C. 5133. The PDM program provides funds to states, territories, tribal governments, communities, and universities for hazard mitigation planning and implementation of mitigation projects prior to disasters, providing an opportunity to reduce the nation's disaster losses through pre-disaster mitigation planning and the implementation of feasible, effective, and cost-efficient mitigation measures. Funding of pre-disaster plans and projects is meant to reduce overall risks to populations and facilities. The amount, timing, and priorities for funding are determined by Congress on an annual basis.

  The PDM program is subject to the availability of appropriation funding as well as any program-specific directive or restriction made with respect to such funds. In 2014, funds were extremely limited, and FEMA provided strict constraints to the states on how many projects could be submitted for consideration. Although two projects described in this report could potentially be eligible for consideration under PDM – and meet or come close to meeting the BCA requirements – it is unlikely that PDM funding levels and the national competitiveness of the program will result in funding for the Alternative 4.2 and Alternative 4.3 projects.

- FEMA Hazard Mitigation Grant Program (HMGP)

  The HMGP is authorized under Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. The HMGP provides grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster. A key purpose of the HMGP is to ensure that any opportunities to take critical mitigation measures to protect life and property from future disasters are not "lost" during the recovery and reconstruction process following a disaster.

  The HMGP is one of the FEMA programs with the greatest potential fit to the two recommended projects in this LFA. However, it is available only in the months subsequent to a federal disaster declaration in the state of New York. Because the state administers the HMGP directly, application cycles will need to be closely monitored after disasters are declared in New York.

- FEMA Flood Mitigation Assistance (FMA) Program

The FMA program was created as part of the National Flood Insurance Reform Act (NFIRA) of 1994 (42 U.S.C. 4101) with the goal of reducing or eliminating claims under the NFIP. FEMA provides FMA funds to assist states and communities with implementing measures that reduce or eliminate the long-term risk of flood damage to buildings, homes, and other structures insurable under the NFIP. The long-term goal of FMA is to reduce or eliminate claims under the NFIP through mitigation activities.

The Biggert-Waters Flood Insurance Reform Act of 2012 eliminated the Repetitive Flood Claims (RFC) and Severe Repetitive Loss (SRL) programs and made the following significant changes to the FMA program:

  - The definitions of repetitive loss and severe repetitive loss properties have been modified.
  - Cost-share requirements have changed to allow more federal funds for properties with repetitive flood claims and severe repetitive loss properties.
  - There is no longer a limit on in-kind contributions for the nonfederal cost share.

One limitation of the FMA program is that it is used to provide mitigation for *structures* that are insured or located in SFHAs. Therefore, the individual property mitigation options described in this LFA are best suited for FMA funds. Like PDM, FMA programs are subject to the availability of appropriation funding as well as any program-specific directive or restriction made with respect to such funds.

- New York State Department of State (NYSDOS)

The NYSDOS may be able to fund some of the projects described in this report. In order to be eligible, a project should link water quality improvement to economic benefits. NYSDOS grant opportunities are available on the NYSDOS website at https://www.dos.ny.gov/funding/index.html.

- U.S. Army Corps of Engineers (USACE)

USACE provides 100% funding for floodplain management planning and technical assistance to states and local governments under several flood control acts and the Floodplain Management Services Program (FPMS). Specific programs used by the USACE for mitigation are listed below.

  - Section 205 – Small Flood Damage Reduction Projects: This section of the 1948 Flood Control Act authorizes USACE to study, design, and construct small flood control projects in partnership with nonfederal government agencies. Feasibility studies are 100 percent federally funded up to $100,000, with additional costs shared equally. Costs for preparation of plans and construction are funded 65 percent with a 35 percent nonfederal match. In certain cases, the nonfederal share for construction could be as high as 50 percent. The maximum federal expenditure for any project is $7 million.

- Section 14 – Emergency Streambank and Shoreline Protection: This section of the 1946 Flood Control Act authorizes USACE to construct emergency shoreline and stream bank protection works to protect public facilities such as bridges, roads, public buildings, sewage treatment plants, water wells, and nonprofit public facilities such as churches, hospitals, and schools. Cost sharing is similar to Section 205 projects above. The maximum federal expenditure for any project is $1.5 million.
- Section 208 – Clearing and Snagging Projects: This section of the 1954 Flood Control Act authorizes USACE to perform channel clearing and excavation with limited embankment construction to reduce nuisance flood damages caused by debris and minor shoaling of rivers. Cost sharing is similar to Section 205 projects above. The maximum federal expenditure for any project is $500,000.
- Section 206 – Floodplain Management Services: This section of the 1960 Flood Control Act, as amended, authorizes USACE to provide a full range of technical services and planning guidance necessary to support effective floodplain management. General technical assistance efforts include determining the following: site-specific data on obstructions to flood flows, flood formation, and timing; flood depths, stages, or floodwater velocities; the extent, duration, and frequency of flooding; information on natural and cultural floodplain resources; and flood loss potentials before and after the use of floodplain management measures. Types of studies conducted under FPMS include floodplain delineation, dam failure, hurricane evacuation, flood warning, floodway, flood damage reduction, stormwater management, floodproofing, and inventories of floodprone structures. When funding is available, this work is 100 percent federally funded.

In addition, USACE provides emergency flood assistance (under Public Law 84-99) after local and state funding has been used. This assistance can be used for both flood response and postflood response. USACE assistance is limited to the preservation of life and improved property; direct assistance to individual homeowners or businesses is not permitted. In addition, USACE can loan or issue supplies and equipment once local sources are exhausted during emergencies.

- <u>Other Potential Sources of Funding</u>

  - **Community Development Block Grant (CDBG)** – The Office of Community Renewal administers the CDBG program for the State of New York. The NYS CDBG program provides financial assistance to eligible cities, towns, and villages in order to develop viable communities by providing affordable housing and suitable living environments as well as expanding economic opportunities, principally for persons of low and moderate income. It is possible that CDBG funding program could be applicable for floodproofing and elevating residential and nonresidential buildings, depending on eligibility of those buildings relative to the program requirements.
  - **Empire State Development** – The state's Empire State Development program offers loans, grants, and tax credits as well as other financing and technical assistance to support businesses and encourage their growth. It is possible that the program could be applicable for floodproofing, elevating, or relocating nonresidential buildings, depending on the eligibility of those businesses relative to the program requirements.

- **Private Foundations** – Private entities such as foundations are potential funding sources in many communities. The Flood Advisory Commission will need to identify the foundations that are potentially appropriate for some of the actions proposed in this report.

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4615-04-6-jn616-rpt

APPENDIX A

PHOTO LOG

PROJECT PHOTOGRAPHS

PHOTO NO.:

1

DESCRIPTION:
Woodland Valley Road Bridge, STA 507+00

PHOTO NO.:

2

DESCRIPTION:
Route 28 Bridge in Phoenicia, STA 469+00

Engineering,
Landscape Architecture
and Environmental Science
MILONE & MACBROOM®
231 Main St, Suite 102
New Paltz, NY 12561
(845) 633-8153

PROJECT PHOTOGRAPHS

PHOTO NO.: **3** DESCRIPTION: Bridge Street Bridge viewed from Route 28 Bridge near STA 468+00	
PHOTO NO.: **4** DESCRIPTION: Stony Clove Creek view from confluence with Esopus Creek at STA 0+00	

Engineering,
Landscape Architecture
and Environmental Science
MILONE & MACBROOM®
231 Main St, Suite 102
New Paltz, NY 12561
(845) 633-8153

PROJECT SITE PHOTOGRAPHS

PHOTO NO.:

5

DESCRIPTION:
Bridge Street Bridge at STA 458+50

PHOTO NO.:

6

DESCRIPTION:
Esopus Creek near STA 426+00

PROJECT SITE PHOTOGRAPHS

PHOTO NO.:

7

DESCRIPTION:
Low-lying homes along Esopus Creek near STA 411+00

PHOTO NO.:

8

DESCRIPTION:
Sediment aggradation on Esopus Creek near Sleepy Hollow Camp Ground, at STA 387+00

PROJECT SITE PHOTOGRAPHS

PHOTO NO.:

9

DESCRIPTION:
Cobble bar in Mt Tremper, near STA 267+00

PHOTO NO.:

10

DESCRIPTION:
Mt Pleasant Bridge at STA 255+00

Engineering,
Landscape Architecture
and Environmental Science
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231 Main St, Suite 102
New Paltz, NY 12561
(845) 633-8153

PROJECT SITE PHOTOGRAPHS

PHOTO NO.:

11

DESCRIPTION:
Beaver Kill viewed from Esopus Creek. Plank Road bridge is visible.

PHOTO NO.:

12

DESCRIPTION:
Route 28 bridge in Mt Tremper viewed from upstream near STA 247+00

PROJECT SITE PHOTOGRAPHS

PHOTO NO.:

13

DESCRIPTION:
Route 28 bridge in Mt Tremper viewed from downstream near STA 236+00

PHOTO NO.:

14

DESCRIPTION:
Washed out railroad line at STA 207+00

PROJECT SITE PHOTOGRAPHS

PHOTO NO.:

15

DESCRIPTION:
Beaver Kill looking upstream

PHOTO NO.:

16

DESCRIPTION:
Route 212 in Mt Tremper

PROJECT SITE PHOTOGRAPHS

PHOTO NO.:

17

DESCRIPTION:
Homes along Mt Pleasant Road in MT Tremper

PHOTO NO.:

18

DESCRIPTION:
Looking upstream along flood control levee in Mt Tremper

PROJECT SITE PHOTOGRAPHS

PHOTO NO.:

19

DESCRIPTION:
Sign on levee

PHOTO NO.:

20

DESCRIPTION:
Main Street Bridge over Stony Clove Creek

PROJECT SITE PHOTOGRAPHS

PHOTO NO.:

21

DESCRIPTION:

Flooding along Route 28 (near intersection with Route 212) in Mount Tremper. Taken August 28, 2011.

PHOTO NO.:

22

DESCRIPTION:

Flooding along Route 212 in Mount Tremper (looking toward Route 28). Taken August 28, 2011.

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and Environmental Science
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New Paltz, NY 12561
(845) 633-8153

PHOTO NO.:

23

DESCRIPTION:
Bridge Street Bridge in Phoenicia being overtopped by floodwaters. Taken August 28, 2011.

PHOTO NO.:

24

DESCRIPTION:
Flooding along Bridge Street Bridge looking toward hamlet of Phoenicia. Taken August 28, 2011.

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Landscape Architecture
and Environmental Science
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231 Main St, Suite 102
New Paltz, NY 12561
(845) 633-8153

PHOTO NO.:

25

DESCRIPTION:
Bridge Street Bridge (looking toward hamlet of Phoenicia). Taken August 28, 2011.

PHOTO NO.:

26

DESCRIPTION:
Mt. Ava Maria Drive and Main Street during height of flood waters. Taken August 28, 2011.

APPENDIX B

***POWERPOINT* PRESENTATIONS**

MILONE & MACBROOM

Local Flood Analysis

Phoenicia and Mt. Tremper

Jeanine Gouin, P.E.
Mark Carabetta, CFM
Vernon Bevan, EIT

Town of Shandaken Board | September 8, 2014

Purpose of Tonight's Meeting

- Explain the Local Flood Analysis (LFA) process
- Introduce the project team
- Explain public meeting process
- Review the study areas
- Introduce modeling concepts
- Discuss potential flood mitigation strategies


The LFA Process

- Uniform across all communities yet able to be customized
- Collect input about flooding and flood damage from property owners, municipal officials and other stakeholders
- Build upon FEMA flood modeling efforts and the Shandaken and Ulster County hazard mitigation plans
- Identify and evaluate potential flood mitigation measures that protect water quality
- Through hydraulic modeling, assess potential magnitude of flood relief alternatives
- Refine alternatives through vetting of cost, feasibility, and public support
- Develop an implementation plan


Southbury plan could help flooded residents

Why Shandaken?

- Phoenicia and Mt Tremper have been devastated by flooding, resulting in extensive damage
- Critical infrastructure, businesses, and homes remain vulnerable
- Located within the New York City public water supply watershed
- LFA funding provides a unique opportunity to assess the watershed under current conditions and plan for the future


Main Street in Phoenicia


Along the Beaver Kill in Mt Tremper

Typical Water Quality Impacts of Flooding

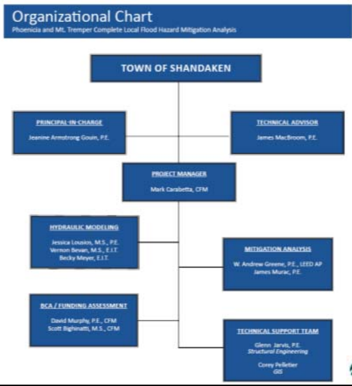
- Mobilization of sediment
- Mobilization of pollutants
  - Basements and basement utilities
  - Materials stored at commercial and industrial sites
  - Gasoline service stations
  - Fuel oil
  - Swimming pools
  - Waste storage sites
  - Septic Systems
  - Vehicles

Project Advisory Committee

Shandaken Area Flood Assessment and Remediation Initiative (SAFARI)

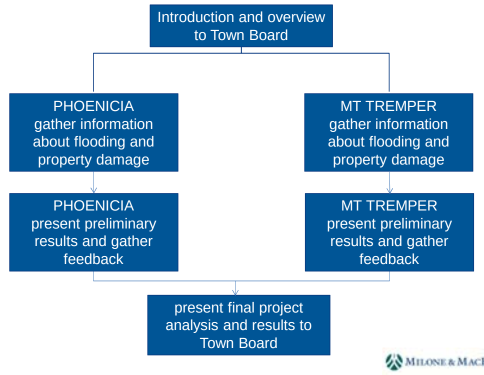
- Shandaken Residents and Business Owners
- Ashokan Watershed Stream Management Program
- Ulster County
- Ulster County Soil & Water Conservation District
- New York City Department of Environmental Protection
- Milone & MacBroom, Inc.

The MMI Team



MILONE & MACBROOM

Public Meeting Process



MILONE & MACBROOM

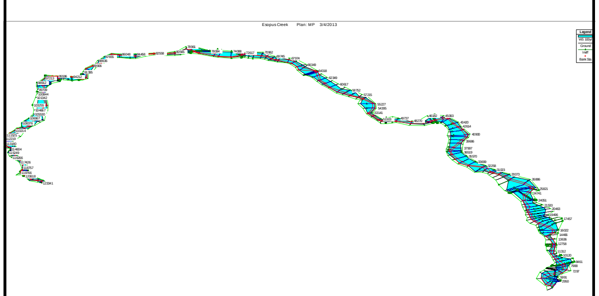
Project Area #1 - Phoenicia

- Esopus Creek
- Stony Clove Creek

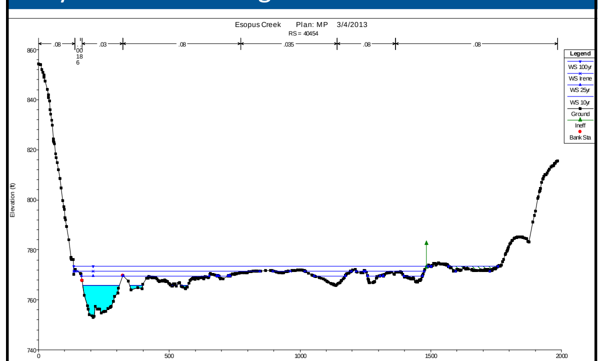
Project Area #2 – Mt Tremper

- Esopus Creek
- Beaver Kill

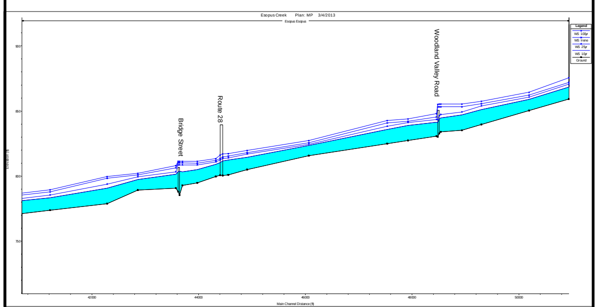
Hydraulic Modeling – Esopus Creek



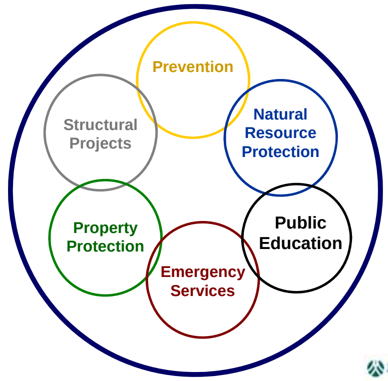
Hydraulic Modeling: Cross Section



Hydraulic Modeling: Water Surface Profile



Types of Flood Mitigation



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Flood Mitigation Strategies

Flood Mitigation

Structural Projects
- Replace Bridges and Culverts
- Remove In-Stream Dams
- Remove Obstructions
- Upstream Detention
- Install Stormwater Systems
- Create Floodways
- Enlarge Channels
- Reduce Flow Resistance
- Install Levees
- Install Flood Walls

Property Protection
- Wet Floodproofing
- Dry Floodproofing
- Elevate Buildings
- Relocate Buildings
- Secure Utilities
- Anchor Floatables
- Remove Hazardous Materials
- Re-Grade Properties
- Purchase Flood Insurance
- Join the Community Rating System (CRS)

Prevention
- Modify Zoning
- Modify Comp Plan
- Stormwater Management Regulations
- Increase Flood Damage Prevention Standards
- Low Impact Development
- Minimize Impervious Cover

Milone & MacBroom

Flood Mitigation Strategies

Flood Mitigation

Natural Resources
- Acquire or Preserve Floodplain Land
- Acquire and Remove Structures from Floodplains and Convert to Open Space
- Acquire or Preserve Other Lands
- Increase Wetland Storage
- Re-Connect Streams to Floodplains

Emergency Services
- Build Local Capacities to Respond
- Move Critical Facilities from Flood Risk Areas
- Establish Emergency Shelters
- Elevate Roads or Bridges to Ensure Egress
- Develop Community Evacuation Plans
- Develop Site-Specific Evacuation Plans
- Establish Satellite Facilities in Areas Subject to Isolation

Public Education
- Newsletters
- Community Meetings
- Information Kiosks
- Web Site with Flood Risk Maps
- Education of Municipal Staff
- Leverage State and FEMA Education Programs
- Establish a Standing Committee or Board to Oversee Outreach

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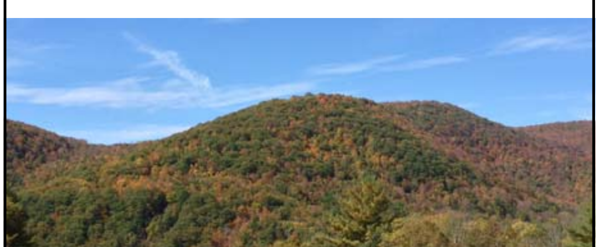


Questions and Comments?

MILONE & MACBROOM

Local Flood Analysis

Esopus Creek and Stony Clove Creek
Phoenicia

Jeanine Armstrong Gouin, P.E.
Mark Carabetta, CFM
Vernon Bevan, EIT

Phoenicia Public Meeting #1 | October 14, 2014

Purpose of Tonight's Meeting

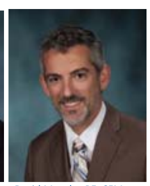
- Explain the Local Flood Analysis (LFA) process
- Introduce the project team
- Explain public meeting process
- Review the study area
- Introduce modeling concepts
- Collect information about flooding and flood damage
- Discuss potential flood mitigation strategies

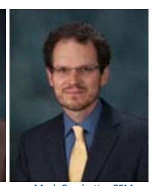
MILONE & MACBROOM

The LFA Team – Team Leaders


Jim MacBroom, P.E.


Jeanine Gouin, P.E.


David Murphy, PE, CFM


Mark Carabetta, CFM

MILONE & MACBROOM

The LFA Team - Modelers


Jessica Louisos, P.E.


Jim Murac, P.E.


Vernon Bevan, E.I.T.


Becky Meyer, E.I.T.

MILONE & MACBROOM

The LFA Team – Support Staff


Scott Bighinatti, CFM


Corey Pelletier


Jenabay Sezen, E.I.T.


Jessica Pica, E.I.T.

MILONE & MACBROOM

The LFA Process

- Evaluates the causes of flooding and options for mitigation
- Includes property owners, municipal officials and other stakeholders
- Builds upon FEMA flood modeling and the prior hazard mitigation plans
- Through hydraulic modeling, assesses the potential magnitude of flood relief alternatives
- Refines alternatives through vetting of cost, feasibility, and public support
- Develops an implementation plan


Southbury plan could help flooded residents

MILONE & MACBROOM

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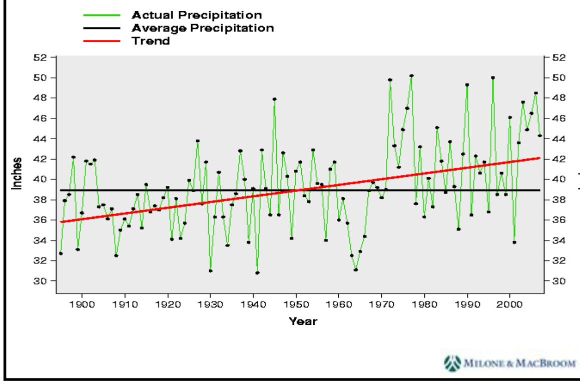
- Phoenicia has been devastated by flooding, resulting in extensive damage
- Critical infrastructure, businesses, and homes remain vulnerable
- LFA funding provides a unique opportunity to assess the watershed under current conditions and plan for the future
- Located within the New York City public water supply watershed and therefore eligible for funding by NYCDEP

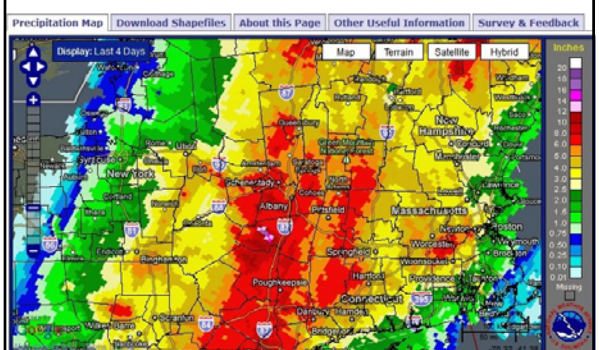
Flooding overtops Bridge Street, August 28, 2011.

From intersection of Mt. Ava Maria Drive and Main Street looking toward the Main Street Bridge, August 28, 2011.

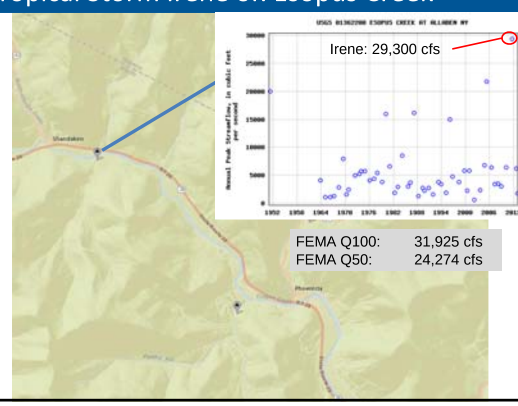
Precipitation in NY



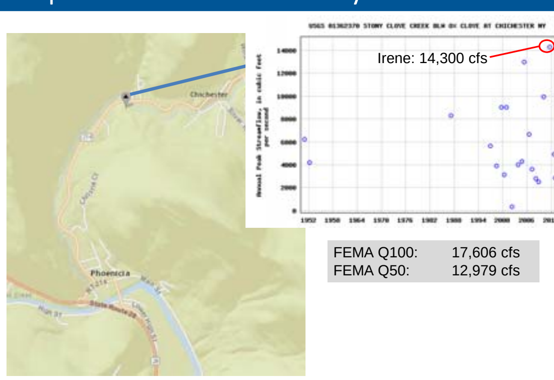
Tropical Storm Irene, August 2011



Tropical Storm Irene on Esopus Creek



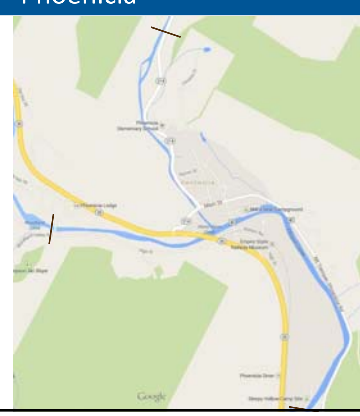
Tropical Storm Irene on Stony Clove Creek



Project Area #1 - Phoenicia

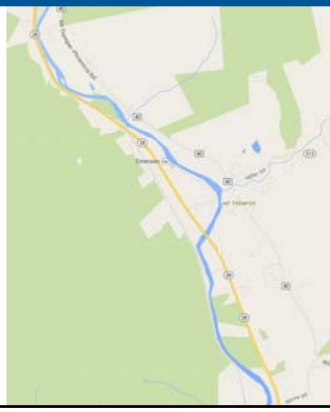
Esopus Creek
Woodland Valley Bridge to 2.75 miles downstream of Route 40 (Bridge Street) bridge.

Stony Clove Creek
From confluence to 1.25 miles upstream Main Street bridge



Project Area #2 – Mt Tremper

- Esopus Creek
- Beaver Kill



Flood Damage, Phoenicia

Phoenicia Pharmacy, August 29, 2011.

Large woody debris on Bridge Street bridge looking toward intersection with Route 28, August 29, 2011.

Phoenicia 2009

Phoenicia 2013

Typical Water Quality Impacts of Flooding

- Mobilization of sediment
- Mobilization of pollutants
  - Basements and basement utilities
  - Materials stored at commercial and industrial sites
  - Gasoline service stations
  - Fuel oil
  - Swimming pools
  - Waste storage sites
  - Septic Systems
  - Vehicles

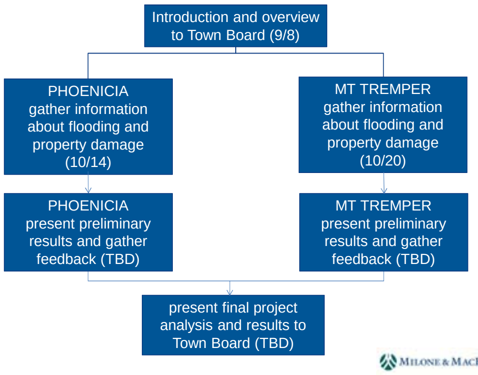
Project Advisory Committee

Shandaken Area Flood Assessment and Remediation Initiative (SAFARI)

- Ashokan Watershed Stream Management Program
  - Ulster County Soil & Water Conservation District
  - New York City Department of Environmental Protection
  - Cornell Cooperative Extension of Ulster County
- Town of Shandaken
- Shandaken Residents and Business Owners
- Ulster County Department of the Environment
- Milone & MacBroom, Inc.

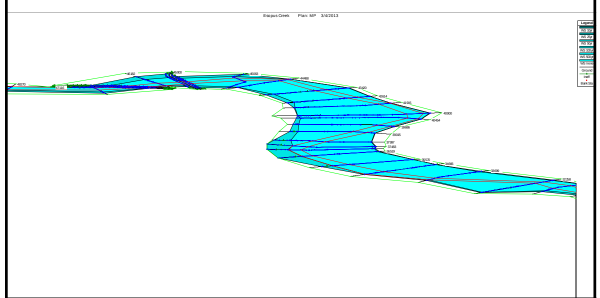
Milone & MacBroom

Public Meeting Process

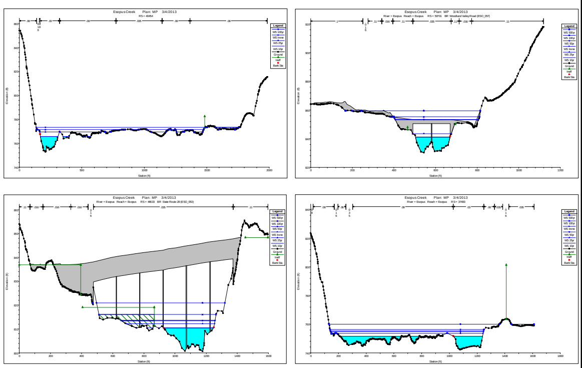


MILONE & MACBROOM

Hydraulic Modeling – Esopus Creek



Hydraulic Modeling: Cross Sections



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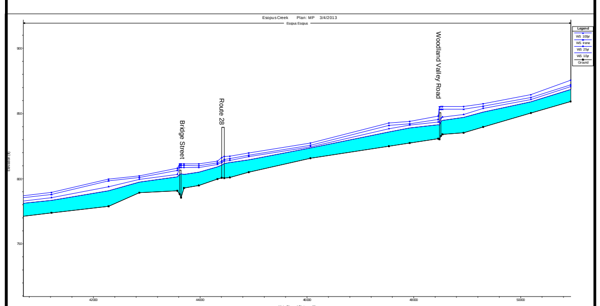
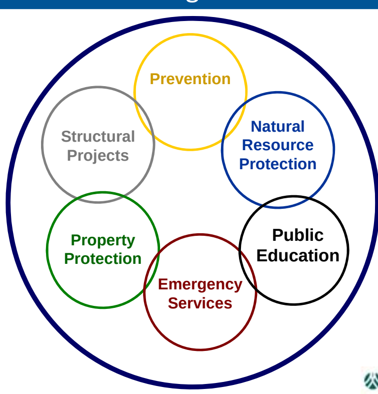


Types of Flood Mitigation



MILONE & MACBROOM

Flood Mitigation Strategies to be Modeled

- Channel Alteration – Widening, Realignment, Creation of Compound Channels
- Floodplain Alteration – Reclamation, Creation, Enhancement
- Bridge Replacement
- Sediment Management – Dredging, Sediment Management
- Individual Structure Treatment – Floodproofing, Elevation of Structures, Relocation, Voluntary Buy-Out

Final Outcomes

- Engineering Analysis – Scientifically Based
- Benefit Cost Analysis – To Understand Viability
- Sketches of Mitigation Options
- Preliminary Cost Estimates
- Identification of Potential Funding Sources
- A Blueprint for Near-Term and Long-Term Flood Mitigation
- A Better Understanding of What is Feasible, What is Cost Effective, and What is Desired by the Citizens of Phoenicia

Questions, Comments, or Thoughts?

MILONE & MACBROOM

Local Flood Analysis

Esopus Creek and Beaver Kill
Mt Tremper

Jeanine Armstrong Gouin, P.E.
Mark Carabetta, CFM
Vernon Bevan, EIT

Mt Tremper Public Meeting #1 | October 20, 2014

Purpose of Tonight's Meeting

- Introduce the project team
- Explain the Local Flood Analysis (LFA) process
- Explain public meeting process
- Review the study area
- Introduce modeling concepts
- Collect information about flooding and flood damage
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MILONE & MACBROOM

The LFA Team – Team Leaders


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David Murphy, PE, CFM


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MILONE & MACBROOM

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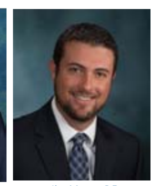
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MILONE & MACBROOM

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MILONE & MACBROOM

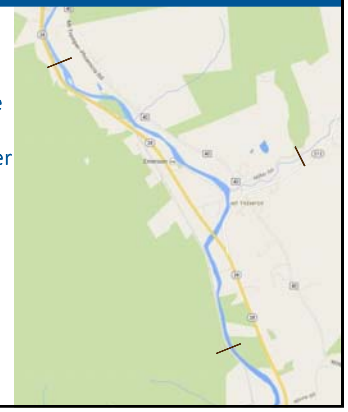
Project Area #2 – Mt Tremper

Esopus Creek

3.0 miles upstream of the Beaver Kill to 1.5 miles downstream of the Beaver Kill.

Beaver Kill

From Esopus Creek extending 0.75 miles upstream.



Project Area #1 - Phoenicia

Esopus Creek
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Stony Clove Creek
From confluence to 1.25 miles upstream Main Street bridge

Why here?

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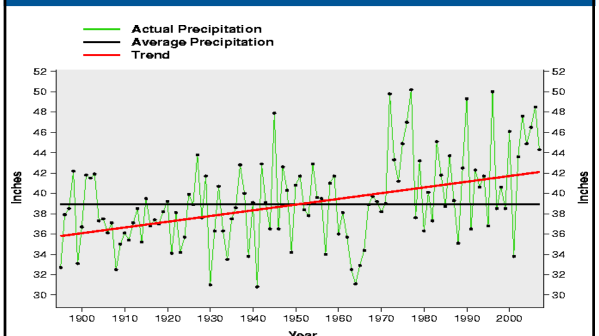
Flooding along Route 28 (near intersection with Route 212) in Mount Tremper, August 28, 2011.

Flooding along Route 212 in Mount Tremper (looking toward Route 28). Taken August 28, 2011.

Precipitation in NY



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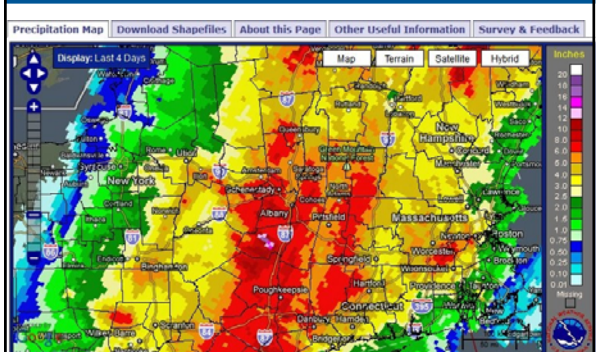
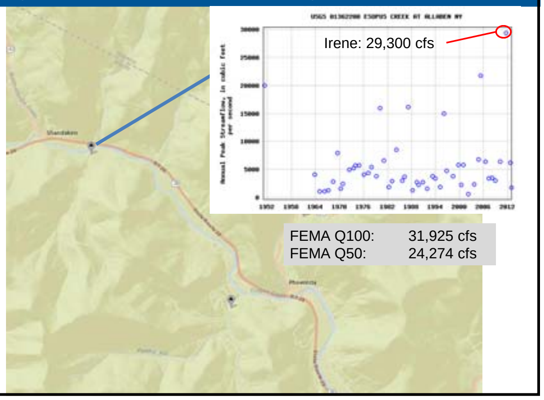
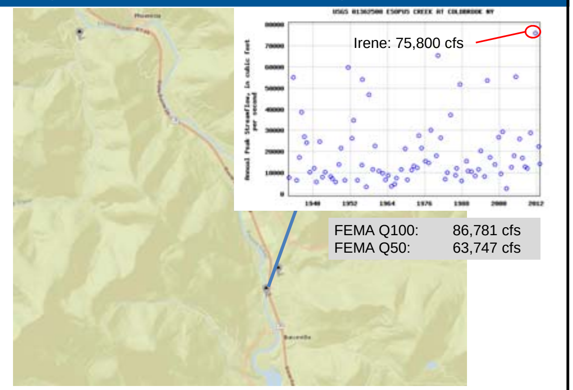
Tropical Storm Irene, August 2011



Tropical Storm Irene on Esopus Creek



Tropical Storm Irene on Esopus Creek



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  - Basements and basement utilities
  - Materials stored at commercial and industrial sites
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  - Fuel oil
  - Swimming pools
  - Waste storage sites
  - Septic Systems
  - Vehicles

Public Meeting Process

Introduction and overview to Town Board (9/8)

PHOENICIA gather information about flooding and property damage (10/14)

MT TREMPER gather information about flooding and property damage (10/20)

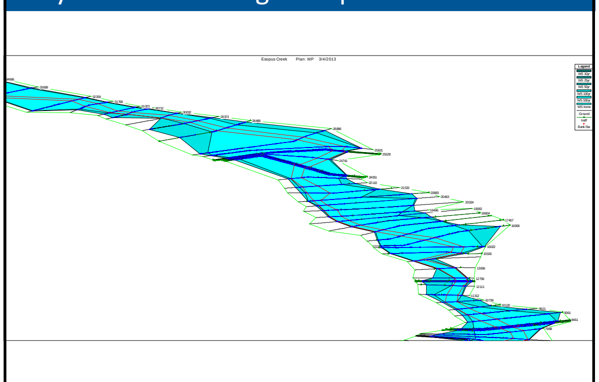
PHOENICIA present preliminary results and gather feedback (TBD)

MT TREMPER present preliminary results and gather feedback (TBD)

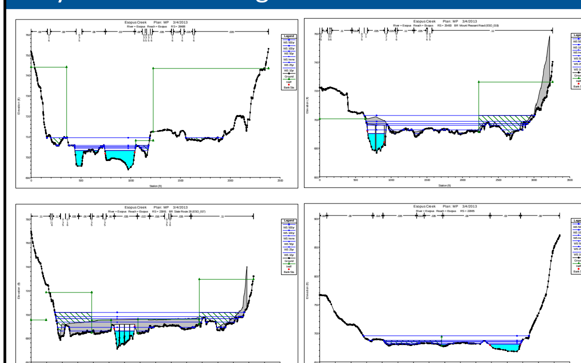
present final project analysis and results to Town Board (TBD)

MILONE & MACBROOM

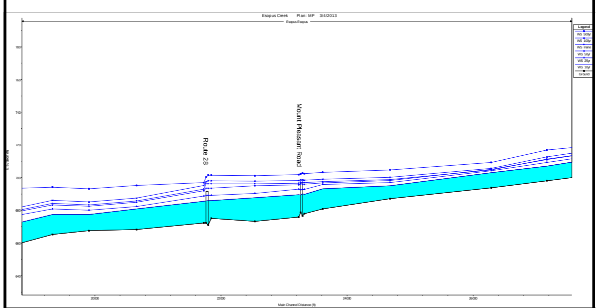
Hydraulic Modeling – Esopus Creek



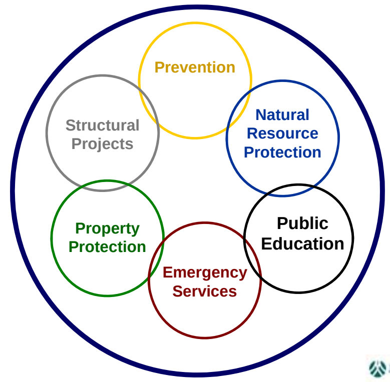
Hydraulic Modeling: Cross Sections



Hydraulic Modeling: Water Surface Profile



Types of Flood Mitigation

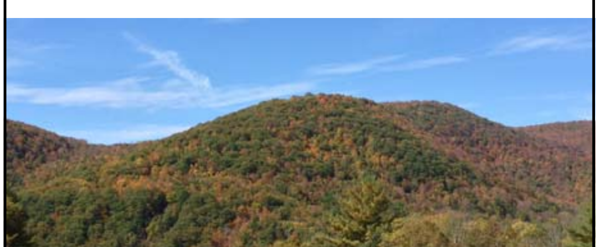


Flood Mitigation Strategies to be Modeled

- Channel Alteration – Widening, Realignment, Creation of Compound Channels
- Floodplain Alteration – Reclamation, Creation, Enhancement
- Bridge Replacement
- Sediment Management – Dredging, Sediment Management
- Individual Structure Treatment – Floodproofing, Elevation of Structures, Relocation, Voluntary Buy-Out

Final Outcomes

- Engineering Analysis – Scientifically Based
- Benefit Cost Analysis – To Understand Viability
- Sketches of Mitigation Options
- Preliminary Cost Estimates
- Identification of Potential Funding Sources
- A Blueprint for Near-Term and Long-Term Flood Mitigation
- A Better Understanding of What is Feasible, What is Cost Effective, and What is Desired by the Citizens of Phoenicia



Questions, Comments, or Thoughts?

MILONE & MACBROOM

Local Flood Analysis

Esopus Creek and Stony Clove Creek
Phoenicia

Mark Carabetta, CFM

Phoenicia Public Meeting #2 | August 10, 2015

Purpose of Tonight's Meeting

- Recap - Local Flood Analysis (LFA)
- Explain flood mitigation options considered for Phoenicia
- Modeling results
- Results of Benefit-Cost Analysis
- Next steps

MILONE & MACBROOM

LFA Public Meetings

Introduction and overview to Town Board (9/8/14)

PHOENICIA gather information about flooding and property damage (10/14/14)

MT TREMPER gather information about flooding and property damage (10/20/14)

PHOENICIA present preliminary results (8/10/15)

MT TREMPER present preliminary results (8/17/15)

present final project analysis and results to Town Board (TBD)

MILONE & MACBROOM

What is an LFA?

- Engineering Analysis – Scientifically Based
- Develop Flood Mitigation Alternatives
- Evaluate Effectiveness using HEC-RAS Hydraulic Modeling
- Preliminary Cost Estimates
- Benefit-Cost Analysis – To Understand Viability
- Identification of Funding Sources
- A Blueprint for Near-Term and Long-Term Flood Mitigation
- A Better Understanding of What is Feasible, What is Cost Effective, and What is Desired by the Citizens of Phoenicia including Effected Landowners

Project Area #1 - Phoenicia

Esopus Creek
Woodland Valley Bridge to 2.75 miles downstream of Route 40 (Bridge Street) bridge.

Stony Clove Creek
From confluence to 1.25 miles upstream Main Street bridge

Project Area #1 - Phoenicia

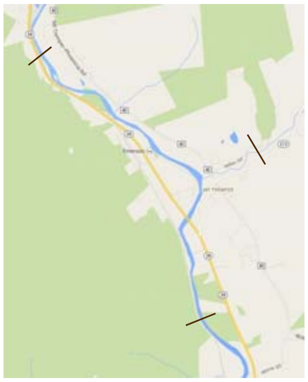
Project Area #2 – Mt Tremper

Esopus Creek

- From 3 miles upstream of Beaver Kill confluence, to 1.5 miles downstream of confluence.

Beaver Kill

- From 0.75 miles upstream of confluence, downstream to Esopus Creek.



Project Advisory Committee

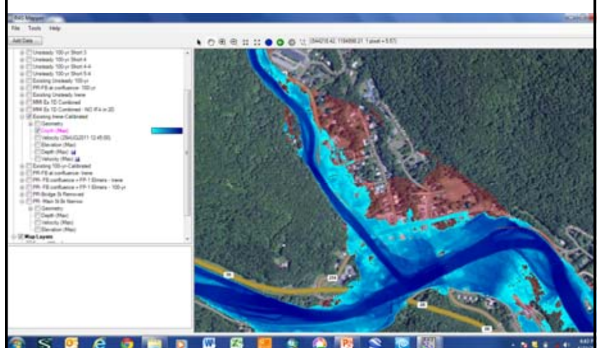
Shandaken Area Flood Assessment and Remediation Initiative (SAFARI)

- Town of Shandaken
- Shandaken Residents and Business Owners
- Ashokan Watershed Stream Management Program
  - Ulster County Soil & Water Conservation District
  - New York City Department of Environmental Protection
  - Cornell Cooperative Extension of Ulster County
- Ulster County Department of the Environment
- Milone & MacBroom, Inc.

Milone & MacBroom

2D Hydraulic Modeling: Calibration

Hydraulic Modeling: 2D Approaches



Phoenicia Study Area

Alternatives Evaluated

Esopus Creek

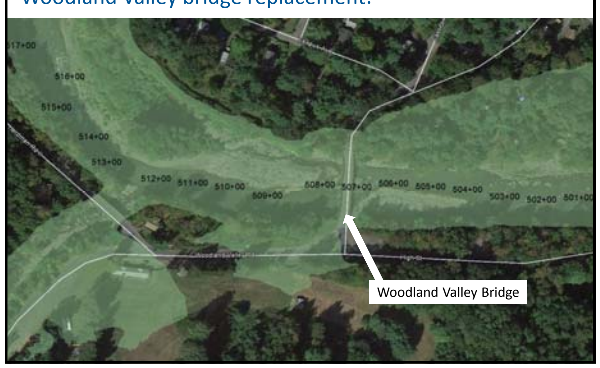
- Woodland Valley bridge replacement
- Bridge Street bridge replacement
- Floodplain enhancement
- Removal of accumulated sediment bars
- Dredging channel

Stony Clove

- Main Street bridge modifications
- Floodplain enhancement

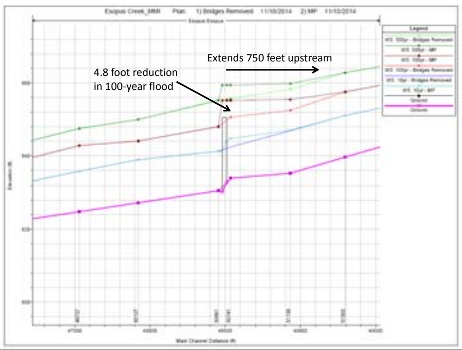
Phoenicia Study Area

Woodland Valley bridge replacement:



Phoenicia Study Area

Woodland Valley bridge replacement:



Phoenicia Study Area

Woodland Valley bridge replacement:

- Replacement with a larger bridge would reduce water surface elevations immediately upstream of bridge, and reduce flooding of Woodland Valley Road
- Would not reduce flooding of any homes
- Not recommended for further analysis
- When due for replacement, recommend larger bridge

Phoenicia Study Area

Bridge Street bridge replacement:

- Poor condition
- Prone to debris jams
- Damaged in Irene and prior floods
- Overtopped during Irene
- Required for traffic flow through Phoenicia

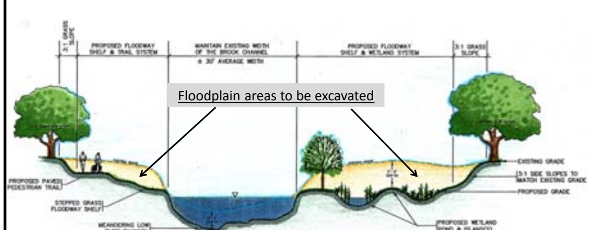
Phoenicia Study Area

Bridge Street bridge replacement:

- Replacement with a larger bridge results in a very localized benefit
- Would reduce water surface elevations by approximately 3 feet at the bridge, and by approximately 1 foot 350 feet upstream of the bridge
- Flood reduction benefits in Phoenicia would be minimal
- Replacement of bridge modeled in combination with floodplain enhancement scenarios

Phoenicia Study Area

Floodplain Enhancement



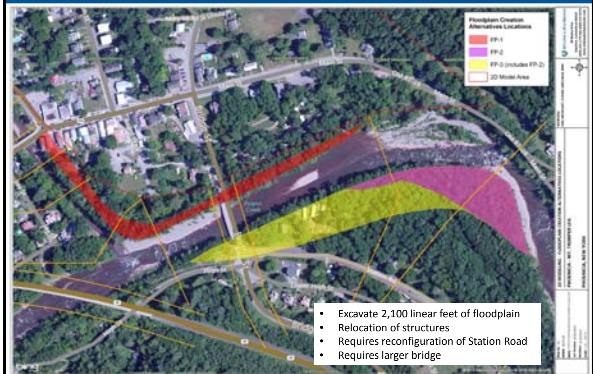
Phoenicia Study Area

Floodplain Enhancement - Left Bank

Phoenicia Study Area

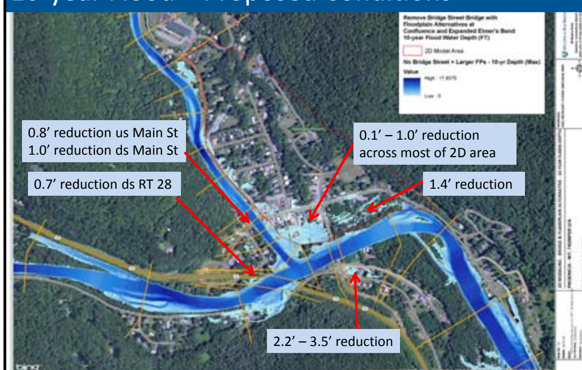
Floodplain Enhancement – Elmer’s Bend

Phoenicia Study Area



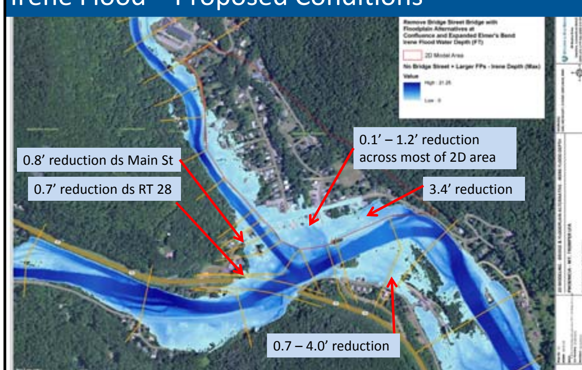
10-year Flood – Existing Conditions

10-year Flood – Proposed Conditions



Irene Flood – Existing Conditions

Irene Flood – Proposed Conditions



Phoenicia Study Area

Floodplain Enhancement and Bridge Street replacement

- Reduces (but does not eliminate) flooding in Phoenicia
- Water surface reduction of up to 1.2 feet on Main Street during Irene-magnitude flood event
- Would require relocation of some homes and businesses
- Requires larger Bridge Street bridge

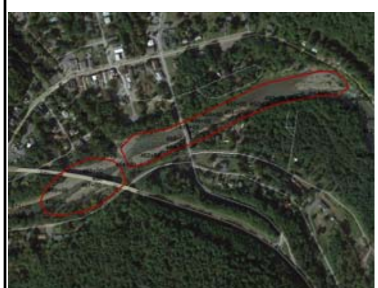
- Conduct Benefit Cost Analysis

Phoenicia Study Area

Removal of Accumulated Sediment Bars

Phoenicia Study Area

Removal of Accumulated Sediment Bars



Esopus Creek through Phoenicia

Esopus Creek along Sleepy Hollow Campground

Phoenicia Study Area

Removal of Accumulated Sediment Bars

Location	River STA	WSE Reduction (ft)				Sediment Volume	
		Bank Full	10-Year	100-Year	500-Year	CY	Truckloads*
Upstream Stony Clove Confluence	467+64	1	0.6	0.4	0.1		
	465+30	0.9	0.1	0	0	2,020	112
Near Bridge Street	461+82	-0.1	0.2	0	0		
	459+00	-0.1	-0.4	0	0		
	457+78	-0.2	-0.9	0	0		
	450+63	0.6	1.4	0.2	0.2		
	448+00	0.9	0.2	0.1	0	4,137	230
Near Sleepy Hollow Campground	409+00	0	0.4	0.1	0		
	404+54	0.5	0.2	0.1	0		
	396+86	0.1	0.2	0.1	0		
	390+15	0	0	0	0		
	379+97	-0.1	0	0	0		
	374+83	0.3	0.1	0	0		
	371+33	0.2	0.1	0.1	0.1	2,981	166

* Truckload = 25 CY

Phoenicia Study Area

Removal of Accumulated Sediment Bars

- Resulted in very moderate reduction in water surface elevation at a few locations during bankfull event
- Overall flood reduction was negligible, especially during large floods
- Significant cost in accessing channel and removing large volumes of material

- Not recommended for further analysis

Phoenicia Study Area

Dredging

Phoenicia Study Area

Dredging

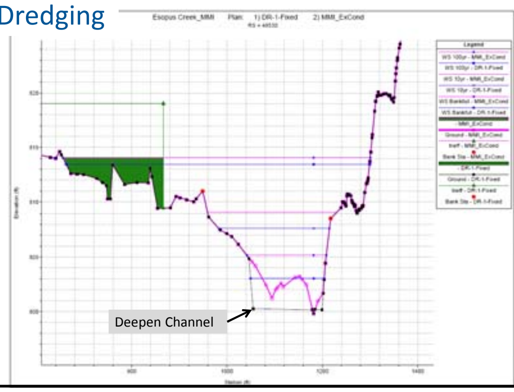
Phoenicia Study Area

Dredging

- Dredging Esopus Creek from upstream of Route 28 to downstream of Bridge Street, by 3 feet, maintaining 2:1 side slopes
- Estimated dredge volume = 11,291 Cubic Yards or 450 truckloads
- Distance of 986 linear feet of channel

Phoenicia Study Area

Dredging



Phoenicia Study Area

Dredging

- Reduces flooding at specific cross-sections under moderate (bankfull and 10-year) flood scenarios
- Negligible benefit during larger floods
- Requires repeat dredging
- Would lead to unstable channel conditions

- Conduct Benefit Cost Analysis

Phoenicia Study Area

Main Street Bridge over Stony Clove

- Modified wingwalls: negligible benefit
- Thinner deck: negligible benefit, no influence on commercial buildings
- Bridge removal: substantial benefit
- Would require raising intersection, raising bridge
- Not recommended for further analysis

Advance to BCA

Alternatives Evaluated

Esopus Creek

- Woodland Valley bridge replacement ✗
- Bridge Street bridge replacement ✓
- Floodplain enhancement ✓
- Removal of accumulated sediment bars ✗
- Dredging channel ✓

Stony Clove

- Main Street bridge modifications ✗
- Floodplain enhancement ✓

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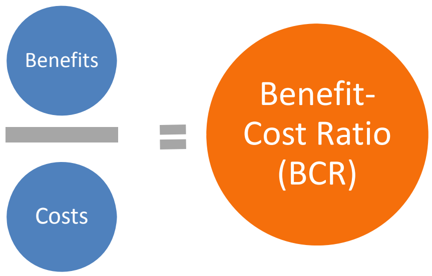
BCA Basics



All projects have a 50-year lifespan

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Approach to Cost Estimates

Dredge scenarios

- Cost of $10/CY to remove sediment
- Additional $10/CY for associated costs (e.g., permits, gaining access, water control, sediment control)
- Repeat 5 times over 50-year project lifespan
- May be some cost savings if material can be used locally

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Approach to Cost Estimates

Bridge replacement

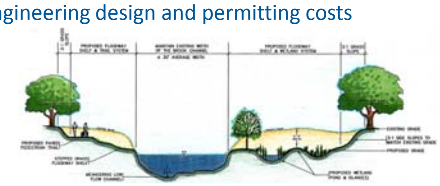
- Length and width of proposed bridge
- Bridge type
- Number of piers
- Subject to scour?
- Detour versus temporary bridge versus parallel bridge
- Engineering design costs

MILONE & MACBROOM

Approach to Cost Estimates

Floodplain enhancement

- Volume of material exported
- Linear footage of channel; one or both banks
- Area of floodplain (topsoil, seeding, plantings)
- Forested area to be cleared
- Engineering design and permitting costs



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Approach to Cost Estimates

Structure relocation for floodplain creation scenarios

- Assessed value of property (equalized value 25.5%)
- Demolition cost
- Assumes donated easements for properties where removal of structure is not required

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Approach to Benefits

Project benefits derived from:

- Property acquisition/relocation
- Benefits due to reduction of flooding at structures that remain
- Open space/riparian areas
- Damage avoidance for Bridge Street bridge
  - Detour length
  - Return interval of flood
  - Past damages ($) and length of closure (days)
  - Traffic counts

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Floodplain Creation and Bridge Replacement

Floodplain and Bridge Street

Benefits:

Benefit Summary	
Benefits: Property Acquisition/Relocation	$6,864,796
Benefits: Water Surface Reductions at Buildings that Remain	$2,859,843
Benefits: Bridge Replacement	$456,943
Total Benefits	$10,181,582

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Floodplain and Bridge Street

Cost Estimate:

Construction Task	Cost
Property buyout	$3,079,937
Demolition	$190,000
Bridge replacement	$5,000,000
Floodplain enhancement	$1,752,701
Total	$10,022,638

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Floodplain and Bridge Street

Cost/Benefit:

Benefit Cost Summary	
Total Benefits	$10,181,582
Total Costs	$10,022,638
Benefit Cost Ratio*	**1.02**

*using equalization adjustment of 25.5%

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Floodplain

Cost/Benefit:

Benefit Cost Summary	
Total Benefits[1]	$9,724,639
Total Costs	$5,022,638
Benefit Cost Ratio	**1.94**

1 – Assumes that Bridge Street bridge has been replaced with a hydraulically adequate structure

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Dredge Scenario

Benefit:

Benefit Summary	
Benefits: Water Surface Reductions	$314,784
Total Benefits	$314,784

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Dredge Scenario

Cost Estimate:

Construction Task	Cost
One-time sediment removal	$225,820
10-year repeat interval	X 5
Total	$1,129,100

Dredge Scenario

Cost/Benefit:

Benefit Cost Summary	
Total Benefits	$314,784
Total Costs	$1,129,100
Benefit Cost Ratio	**0.28**

Dredging in this area:
- reduces flooding under moderate flood scenarios;
- has negligible benefit during large floods;
- would lead to unstable channel conditions; and
- is not a sustainable solution to flooding problems.

Summary

BCRs:

Alternative	BCR
Phoenicia	
Floodplains and Bridge Street bridge replacement	1.02
Floodplains assuming Bridge Street bridge has been replaced	1.94
Phoenicia dredge scenario	0.28

Summary

Recovery from flood-related damages has been very costly. Without action, Phoenicia will continue to experience damaging and costly floods.

The following flood mitigation recommendations are offered:

- ✓ Seek consensus on implementation of the floodplain enhancement scenario as funding allows.
- ✓ Seek funding for replacement of Bridge Street bridge.
- ✓ Pursue floodproofing of commercial buildings in Phoenicia. Floodproofing should include sealing of lower portions of buildings including doors and other openings, and elevation of building utilities.
- ✓ Pursue elevation of homes on a case-by-case basis as property owners approach the Town about mitigation. Ensure that elevations are conducted in accordance with the effective BFE at the time of the work.
- ✓ Pursue relocations. These may include critical facilities, key businesses and homes.

Next Steps

- Mt Tremper Public Meeting on August 17
- Present LFA results to Town Board
- Produce Draft and Final LFA Reports
- Formal adoption of LFA by Town Board
- Pursue flood mitigation funding opportunities

MILONE & MACBROOM

Local Flood Analysis

Esopus Creek and Beaver Kill
Mt Tremper

Mark Carabetta, CFM

Mt Tremper Public Meeting #2 | August 17, 2015

Purpose of Tonight's Meeting

- Recap - Local Flood Analysis (LFA)
- Explain flood mitigation options considered for Mt Tremper
- Modeling results
- Results of Benefit-Cost Analysis
- Questions and Discussion
- Next steps

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MILONE & MACBROOM

What is an LFA?

- Engineering Analysis – Scientifically Based
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  - New York City Department of Environmental Protection
  - Cornell Cooperative Extension of Ulster County
- Ulster County Department of the Environment
- Milone & MacBroom, Inc.

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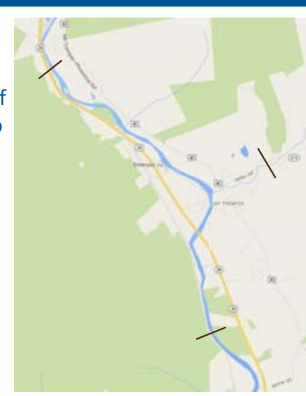
Project Area #2 – Mt Tremper

Esopus Creek

- From 3 miles upstream of Beaver Kill confluence, to 1.5 miles downstream of confluence.

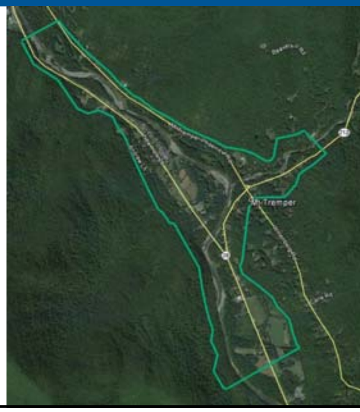
Beaver Kill

- From 0.75 miles upstream of confluence, downstream to Esopus Creek.



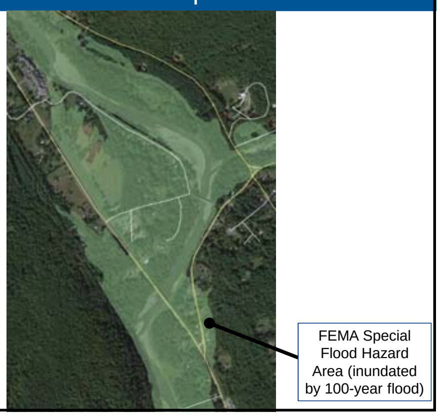
Project Area #2 – Mt Tremper

- Esopus Creek
- Beaver Kill

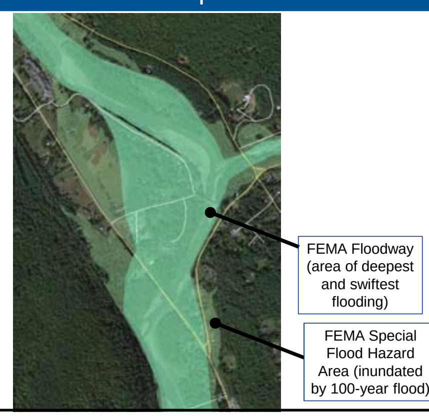


Project Area #2 – Mt Tremper

Project Area #2 – Mt Tremper



Project Area #2 – Mt Tremper



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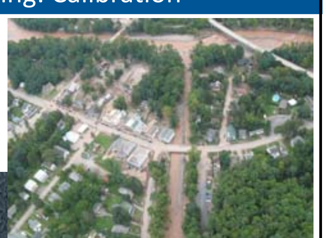


Mt Tremper Study Area - Alternatives Analysis

Esopus Creek

1. Removal of accumulated sediment bars
2. Dredge
3. Levee enhancement
4. Levee relocation A
5. Levee relocation B
6. Flood chute
7. Floodplain enhancement
8. Mt Pleasant bridge removal
9. Route 28 bridge replacement
10. Route 28 bridge replacement and floodplain enhancement

Beaver Kill

1. Floodplain bench on Beaver Kill
2. Plank Road bridge replacement

Removal of accumulated sediment bars

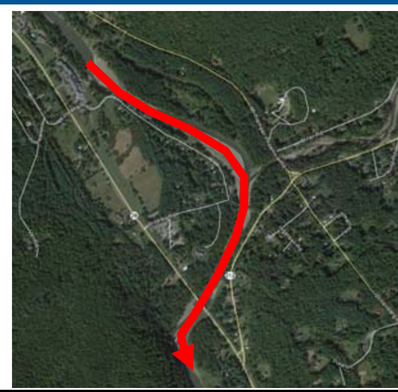
Removal of accumulated sediment bars

- Resulted in very moderate reduction in water surface elevation at a few locations during bankfull event
- Overall flood reduction was negligible, especially during larger floods
- Significant cost in accessing channel and removing large volumes of material

- Not recommended for further analysis
- Evaluate scenario where more significant sediment is removed from channel

Dredge Scenario

Dredge Scenario



Dredge Scenario

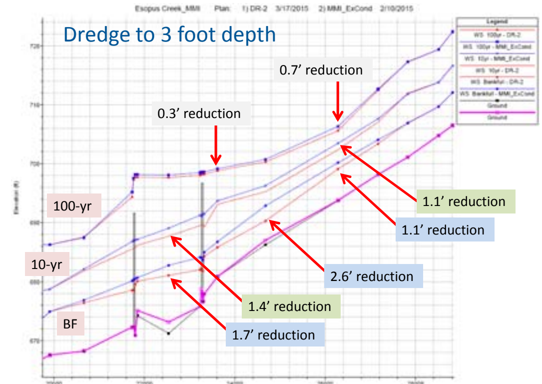
Dredge Scenario

Mt Tremper:

- Dredging Esopus Creek by 3 feet, from adjacent to Emerson Resort to downstream of Route 28 bridge, maintaining 2:1 side slopes
- Distance of 5,623 linear feet (just over 1 mile)
- Estimated dredge volume = 89,939 Cubic Yards (CY) or about 3,600 truckloads

Milone & MacBroom

Dredge Scenario



Dredge Scenario

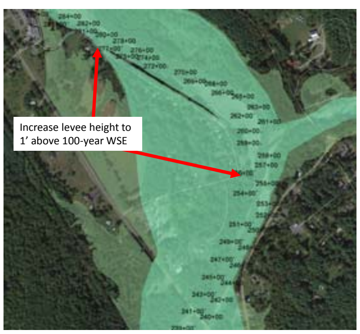
Results

- Reduces flooding at specific cross-sections under moderate (bankfull and 10-year) flood scenarios
- Smaller flood reduction during larger floods
- Requires repeat dredging as sediments accumulate
- Would lead to unstable channel conditions

- Conduct Benefit Cost Analysis

Mt Tremper Study Area

Levee enhancement in place



- 1.0' - 9.5' increase of levee height
- Substantial fill in FEMA Floodway
- Increase flood elevations by 1' – 6' in channel
- Increase flow velocities
- Increased flooding along Plank Road and Route 212
- Increase backwater condition up Beaver Kill
- Levee not tied in to grade at downstream end

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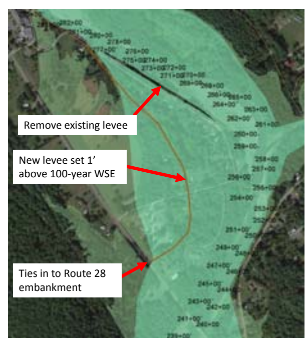
Mt Tremper Study Area

Move Levee



- Paired with Route 28 bridge improvement
- Requires relocation of homes along Mount Pleasant Road, Riseley Roads, Route 28.
- 2.5' – 7.3' height above grade
- Substantial fill in FEMA Floodway
- Increase flood elevations by 1.0' – 1.4'
- Increase flow velocities
- Increased flooding along Plank Road and Route 212
- Increase backwater condition up Beaver Kill

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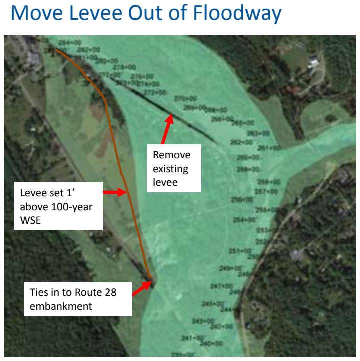
Mt Tremper Study Area

Move Levee Out of Floodway



- Requires relocation of homes along Mount Pleasant Road, Riseley Roads, Route 28.
- Provides only a small "dry" area for relocation
- Not cost effective

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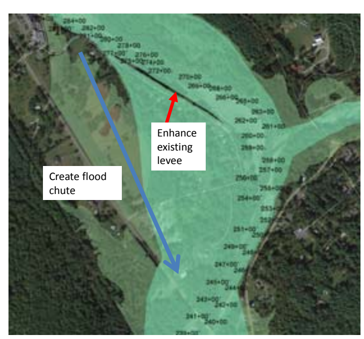
Mt Tremper Study Area

Create Flood Relief Chute



- Requires relocation of structures along Route 28.
- Isolates entire neighborhood and may prevent access by emergency vehicles during flood events

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Levee and Flood Chute Scenarios

Results

- Enhancement of existing levee or construction of new levee in FEMA Floodway would cause increase in flooding at properties along Plank Road and Route 212
- New levee outside of FEMA Floodway would have very minimal benefits, not cost effective
- Flood chute would help during small floods, but would put lives in danger during large floods

- No Further Analysis

Floodplain Enhancement Example

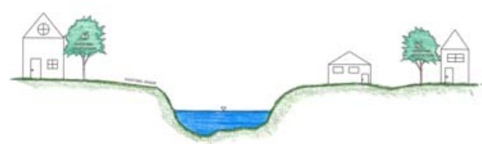
Existing conditions, normal flow

Floodplain Enhancement Example

Existing conditions, flood flow

Floodplain Enhancement Example

Existing conditions, normal flow

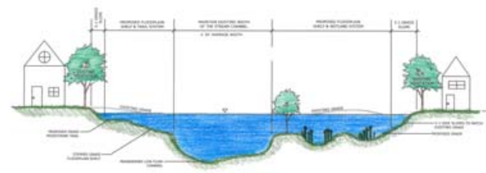


Floodplain Enhancement Example

Proposed conditions, normal flow

Floodplain Enhancement Example

Proposed conditions, flood flow

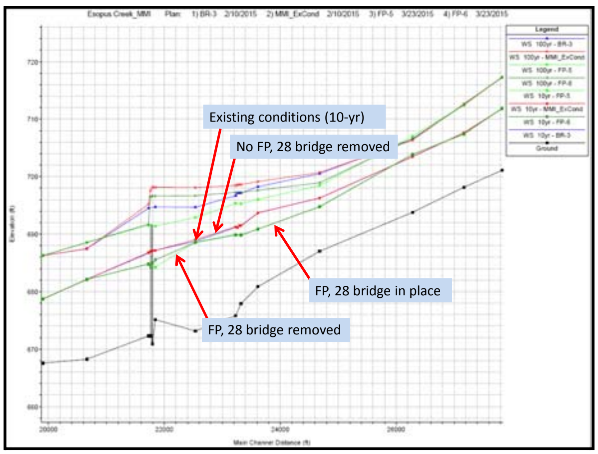


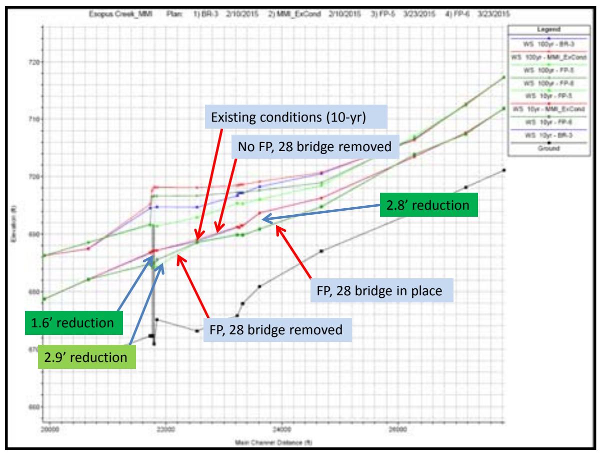
Mt Tremper Floodplain

- Requires extensive earth work and excavation
- Requires removal of Mount Pleasant Bridge
- Requires relocation of 14 homes along Mount Pleasant Road, Riseley Roads, Route 28.
- Modeled with and without replacement of Route 28 bridge with larger bridge

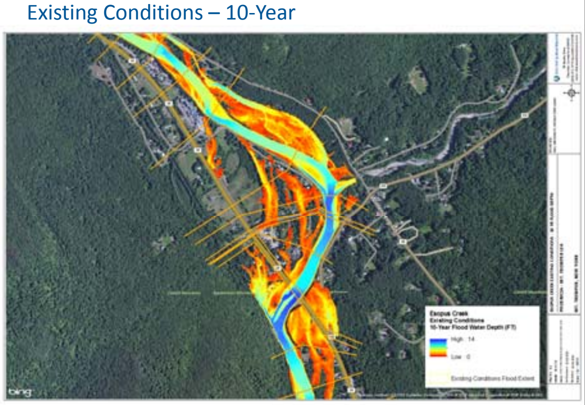
Replace Route 28 Bridge

MILONE & MACBROOM



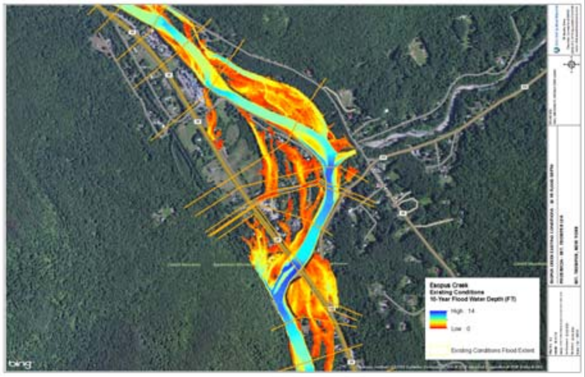


Existing Conditions – 10-Year

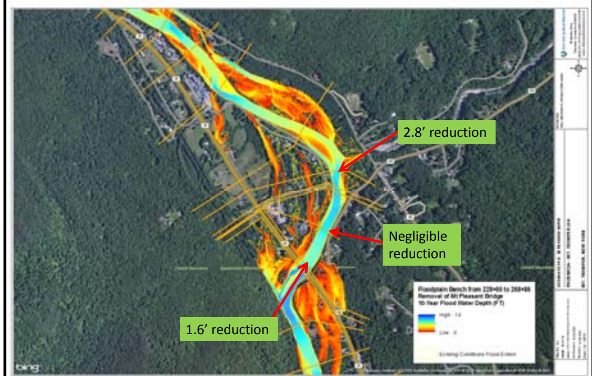


Route 28 Bridge Removal – 10-Year

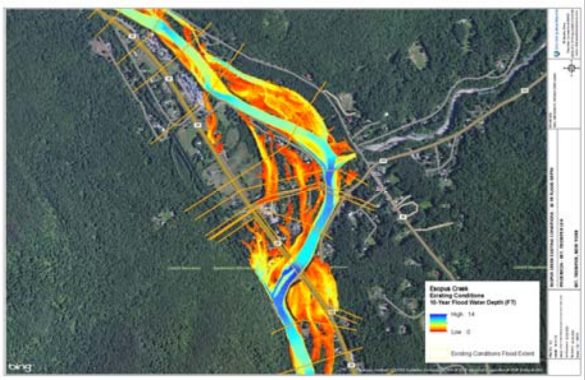
Existing Conditions – 10-Year



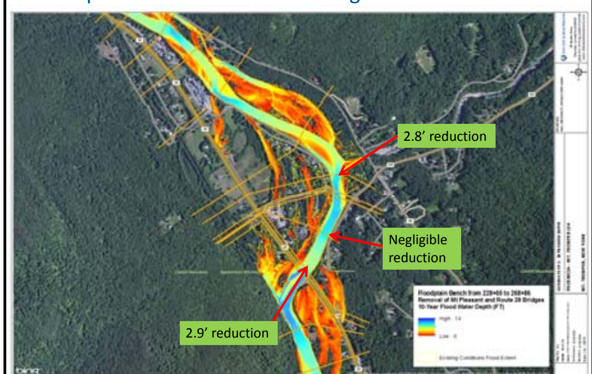
Floodplain Enhancement – 10-Year

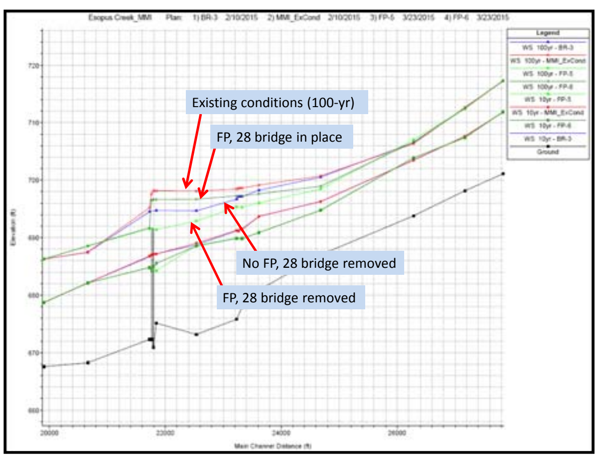


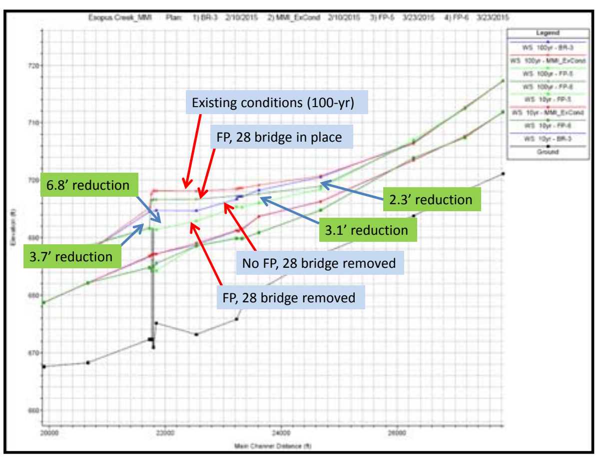
Existing Conditions – 10-Year



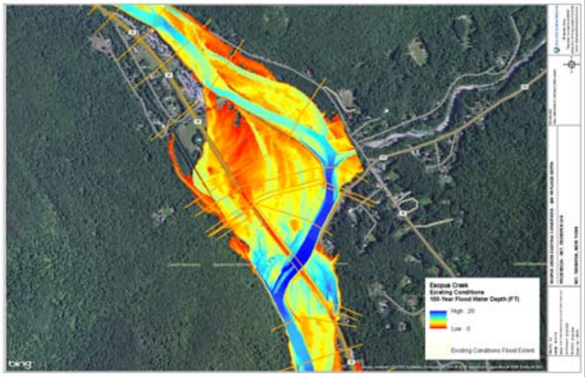
Floodplain Enhancement and Bridge Removal – 10-Year



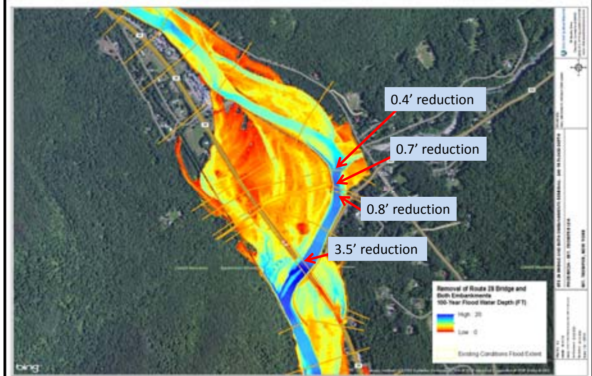




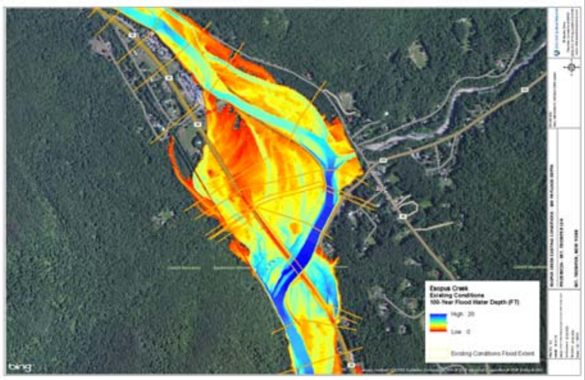
Existing Conditions – 100-Year



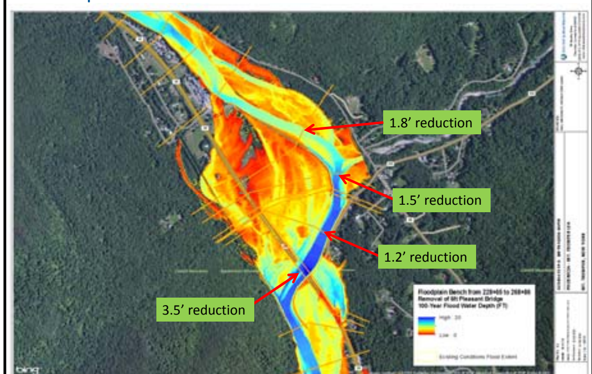
Route 28 Bridge Removal – 100-Year



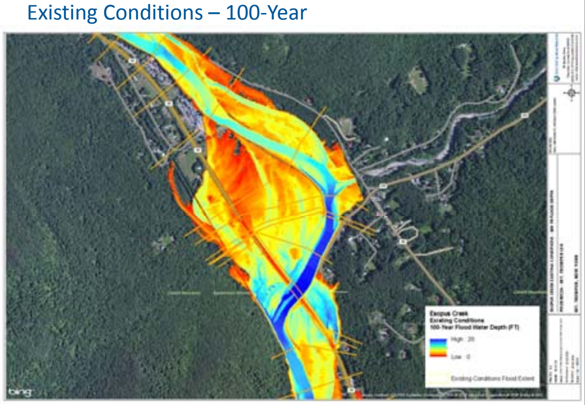
Existing Conditions – 100-Year



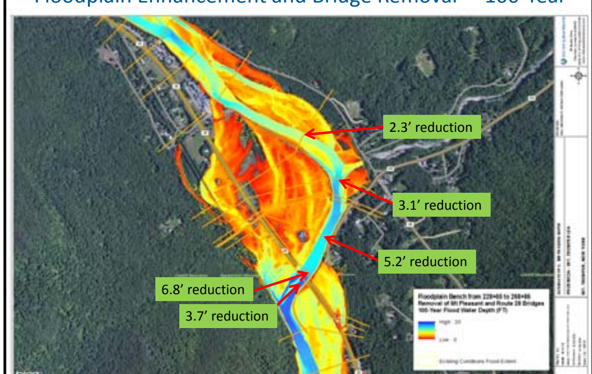
Floodplain Enhancement – 100-Year



Existing Conditions – 100-Year



Floodplain Enhancement and Bridge Removal – 100-Year



Floodplain Enhancement and Route 28 Bridge Replacement

Results

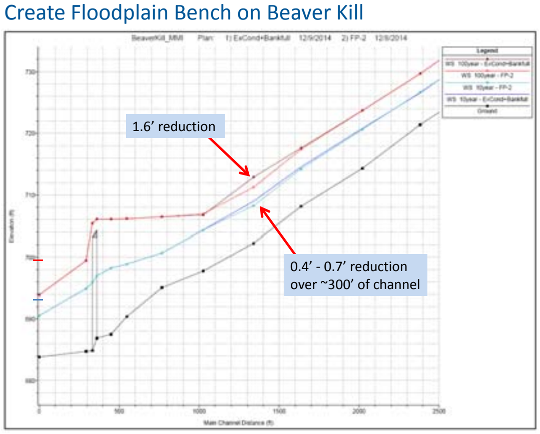
- During 10-year flood, substantial benefit from floodplain enhancement; negligible benefit from bridge replacement.
- During 100-year, best benefit from combination of floodplain enhancement and bridge replacement.
- Benefits from floodplain enhancement extend over 4,200 feet of channel, while benefits from bridge replacement extend over 3,000 feet.
- Reduces but does not eliminate flooding.

- Conduct Benefit Cost Analysis for each scenario

Beaver Kill Floodplain Bench

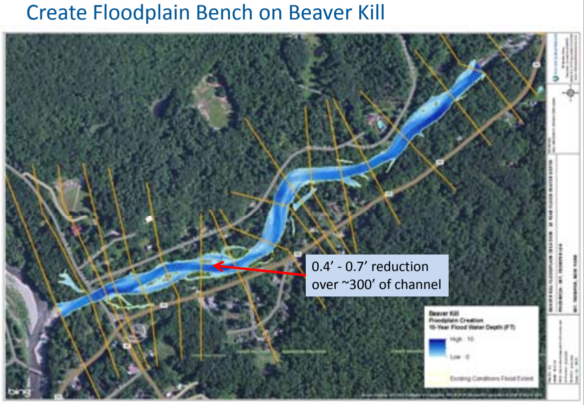
Milone & MacBroom

Create Floodplain Bench on Beaver Kill



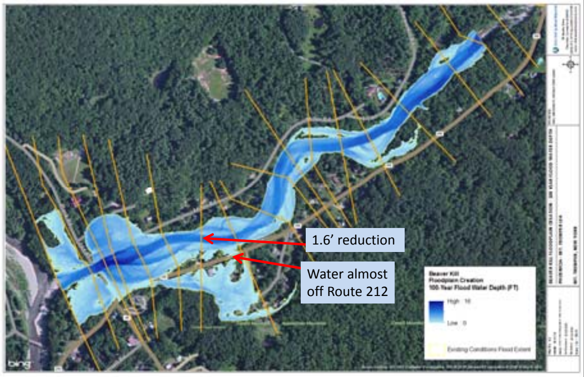
Create Floodplain Bench on Beaver Kill

Create Floodplain Bench on Beaver Kill

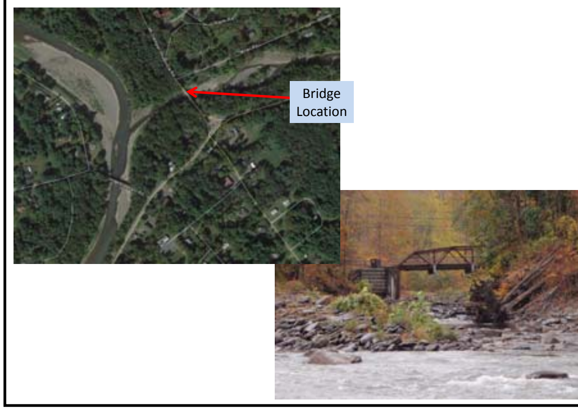


Create Floodplain Bench on Beaver Kill

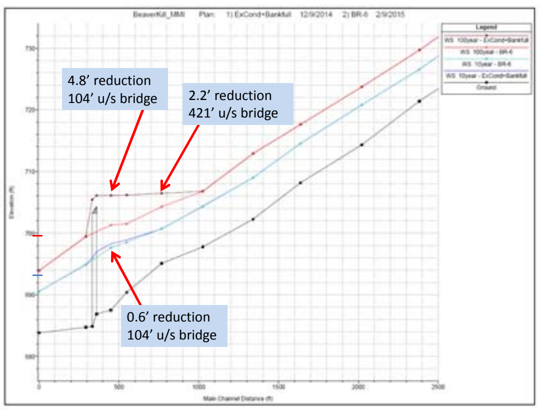
Create Floodplain Bench on Beaver Kill



Replace Plank Road Bridge

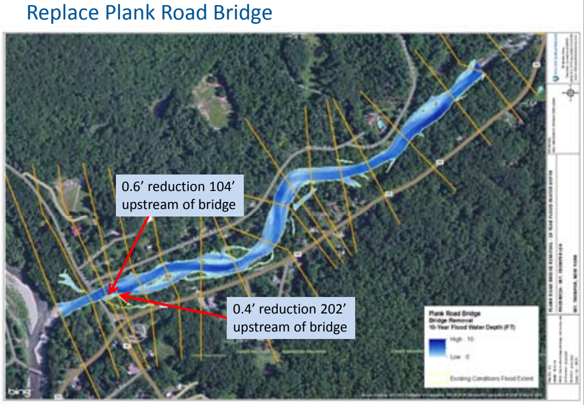


Replace Plank Road Bridge



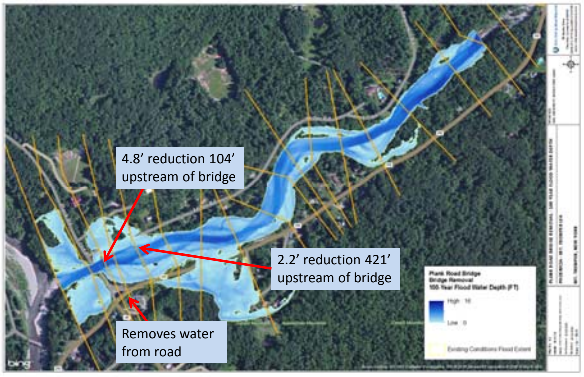
Replace Plank Road Bridge

Replace Plank Road Bridge



Replace Plank Road Bridge

Replace Plank Road Bridge



Mt Tremper Study Area

Esopus Creek

1. Removal of accumulated sediment bars ✗
2. Dredge ✓
3. Levee enhancement ✗
4. Levee relocation A ✗
5. Levee relocation B ✗
6. Flood chute ✗
7. Floodplain enhancement ✓
8. Mt Pleasant bridge removal (combined with other alternatives) ✓
9. Route 28 bridge replacement ✓
10. Route 28 bridge replacement and floodplain enhancement ✓

Beaver Kill

1. Floodplain bench on Beaver Kill ✓
2. Plank Road bridge replacement ✓

Milone & MacBroom

Benefit-Cost Analysis

Benefits / Costs = Benefit-Cost Ratio (BCR)

All projects have a 50-year lifespan

Milone & MacBroom

Dredge Scenario

Cost Estimate:

- Cost of $10/CY to remove sediment
- Additional $10/CY for associated costs (e.g., permits, gaining access, water control, sediment control)
- Repeat 5 times over 50-year project lifespan
- May be some cost savings if material can be used locally

Benefits:

- Benefits due to reduction of flooding at homes and businesses

Floodplain Enhancement

Cost

- Cost of homes or business relocation
- Volume of material exported
- Linear footage of channel; one or both banks
- Area of floodplain (topsoil, seeding, plantings)
- Forested area to be cleared
- Engineering design and permitting costs

Benefits

- Benefits from reduced flooding of relocated homes and businesses
- Benefits due to reduction of flooding at structures that remain
- Open space/riparian area benefit

Mt Tremper Dredge Scenario

Benefits:

Benefit Summary	
Benefits: Water Surface Reductions	$2,404,000
Total Benefits	$2,404,000

Milone & MacBroom

Mt Tremper Dredge Scenario

Cost Estimate:

Construction Task	Cost
One-time sediment removal	$1,798,780
10-year repeat interval	X 5
Total	$8,993,900

Mt Tremper Dredge Scenario

Cost/Benefit:

Benefit Cost Summary	
Total Benefits ÷	$2,404,000
Total Costs	$8,993,900
Benefit Cost Ratio	**0.27**

Dredging in this area:
- reduces flooding under moderate flood scenarios;
- has negligible benefit during large floods;
- would lead to unstable channel conditions; and
- is not a sustainable solution to flooding problems.

Mt Tremper Floodplain

Benefit:

Benefit Summary	
Benefits: Property Acquisition/Relocation[1]	$21,821,090
Benefits: Water Surface Reductions at Buildings that Remain	$3,674,373
Total Benefits[2]	$25,495,463

1 – Assumes relocation of fourteen structures
2 – Acquisition and relocation of structures is carrying the BCR

Mt Tremper Floodplain

Cost Estimate:

Construction Task	Cost
Property buyout[1]	$8,843,133
Demolition	$590,000
Remove Mt Pleasant Bridge	$500,000
Floodplain	$5,743,589
Total	$15,676,722

1 – Assumes relocation of fourteen structures

Mt Tremper Floodplain

Cost/Benefit:

Benefit Cost Summary	
Total Benefits[1] ÷	$25,495,463
Total Costs	$15,676,722
Benefit Cost Ratio[2]	**1.63**

1 – Assumes relocation of fourteen structures
2 – Acquisition and relocation of structures is carrying the BCR

Replace Route 28 Bridge

Benefit:

Benefit Summary	
Benefits: Water Surface Reductions	$1,241,392
Total Benefits	$1,241,392

Replace Route 28 Bridge

Cost Estimate:

Construction Task	Cost
Bridge replacement	$15,000,000
Total	$15,000,000

Replace Route 28 Bridge

Cost/Benefit:

Benefit Cost Summary	
Total Benefits	$1,241,392
Total Costs	÷ $15,000,000
Benefit Cost Ratio	**0.08**

Floodplain & Route 28 Bridge

Benefit:

Benefit Summary	
Benefits: Property Acquisition/Relocation[1]	$21,821,090
Benefits: Water Surface Reductions at Buildings that Remain	$4,865,055
Total Benefits	$26,686,145

1 – Assumes relocation of fourteen structures

Floodplain & Route 28 Bridge

Cost Estimate:

Construction Task	Cost
Property buyout	$8,843,133
Demolition	$590,000
Bridge replacement	$15,000,000
Remove Mt Pleasant Bridge	$500,000
Floodplain	$5,743,589
Total	$30,676,722

Floodplain & Route 28 Bridge

Cost/Benefit:

Benefit Cost Summary	
Benefits: Property Acquisition/Relocation[1]	$21,821,090
Benefits: Water Surface Reductions at Buildings that Remain	$4,865,055
Total Benefits	$26,686,145
Total Costs	$30,676,722
Benefit Cost Ratio	**0.87**

1 – Assumes relocation of fourteen structures

Replace Plank Road Bridge

Benefit:

Benefit Summary	
Benefits: Water Surface Reductions	$141,451
Total Benefits	$141,451

Replace Plank Road Bridge

Cost Estimate:

Construction Task	Cost
Bridge replacement[1]	$1,750,000
Total	$1,750,000

1 – assumes truss-style bridge

Replace Plank Road Bridge

Cost/Benefit:

Benefit Cost Summary	
Total Benefits	$141,451
Total Costs	÷ $1,750,000
Benefit Cost Ratio	**0.08**

Beaver Kill Floodplain Bench

Benefit:

Benefit Summary	
Benefits: Water Surface Reductions	$125,996
Total Benefits	$125,996

Beaver Kill Floodplain Bench

Cost Estimate:

Construction Task	Cost
Property buyout and demo	$0
Floodplain bench	$498,625
Total	$498,625

Beaver Kill Floodplain Bench

Cost/Benefit:

Benefit Cost Summary	
Total Benefits	$125,996
Total Costs	÷ $498,625
Benefit Cost Ratio	**0.25**

Discussion

Summary of BCRs:

Alternative	BCR
Esopus Creek	
Mt Tremper dredge scenario	0.27
Mt Tremper floodplain	1.63
Route 28 bridge replacement	0.08
Route 28 bridge replacement and floodplain	0.87
Beaver Kill	
Plank Road bridge replacement	0.08
Floodplain bench on Beaver Kill	0.25

Summary

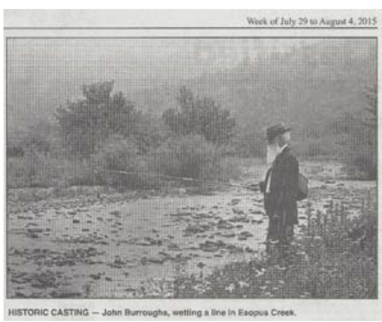
Recovery from flood-related damages has been very costly. Without action, Mt Tremper will continue to experience damaging and costly floods.

The following flood mitigation recommendations are offered:

- ✓ Seek community consensus on implementation of the floodplain enhancement scenario as funding allows.
- ✓ Investigate the possibility of Route 28 bridge replacement.
- ✓ Pursue floodproofing of commercial buildings. Floodproofing should include sealing of lower portions of buildings including doors and other openings, and elevation of building utilities.
- ✓ Pursue elevation of homes on a case-by-case basis as property owners approach the Town about mitigation. Ensure that elevations are conducted in accordance with the effective BFE at the time of the work.
- ✓ Pursue relocations, especially for structures in the FEMA floodway. These may include critical facilities, key businesses and homes.

Next Steps

- LFA results to be presented to Town Board
- Produce Draft and Final LFA Reports
- Formal adoption of LFA by Town Board
- Pursue flood mitigation funding opportunities



From the Catskill Mountain News
Photo circa 1900

Questions and Comments?

Mt Tremper Floodplain

Requires:

Relocation of 14 structures

Removal of Mt Pleasant bridge

APPENDIX C

BCA RESULTS

This spreadsheet contains the benefits for various scenarious for Phoenicia and Mt. Tremper.

These are the tabs in the spreadsheet:

Summary

Phoenicia DR1 Fixed: This looks at the Esopus within Phoenicia.

2D Model: This is the 2D model analysis that covers both the Esopus and Stony Clove.

MT BK FP2: This looks at the floodplain bench on Beaver Kill within Mt. Tremper.

MT BK BR6b: This looks at Plank Rd bridge on the Beaver Kill within Mt. Tremper.

MT E FP6: This looks at floodplain scenario on the Esopus in Mt. Tremper

MT E DR2: This looks at the dredge scenario on the Esopus in Mt. Tremper

MT E BR3B: This looks Rt 28 bridge at the Esopus in Mt. Tremper.

MT E FP5 BR3B: This looks at Route 28 bridge and floodplain enhancement on the Esopus in Mt. Tremper.

Phoenicia Acquisitions

Mt. Tremper Acquisitions

Bridge St. Bridge R&R: This sheet looks at the benefits of removing and replacing the Bridge Street bridge such that repairs and detours are not necessary as a result of any flood events.

Location	Alternative	Positive Benefits/Acquisition Costs	Adjusted for Equalized Assessments
Mt. Tremper/Beaver Kill	FP2	32,129	125,996
Mt. Tremper/Beaver Kill	BR6b	36,070	141,451
Mt. Tremper/Esopus	FP6	936,965	3,674,373
Mt. Tremper/Esopus	DR2	613,020	2,404,000
Mt. Tremper/Esopus	BR3b	316,555	1,241,392
Mt. Tremper/Esopus	FP5 + BR3b	1,240,589	4,865,055
Phoenicia/Esopus	DR1-Fixed	80,270	314,784
Phoenicia/Esopus and Stony Clove	2D	739,593	2,859,843
Acquisitions/Mt. Tremper		5,564,378	21,821,090
Acquisitions/Esopus		1,750,523	6,864,796

DR1 Fixed

Address Number	Street	Benefit	Business	Entered As
31	BOARD WALK	1,277		
10	BRIDGE ST	2,883	Town Tinker Tube Rental	Warehouse, Non-refrigerated
17 (Home)	BRIDGE ST	2,822		
17 (Office)	BRIDGE ST	50	Phoenicia Campground Office	Office One-Story
18	BRIDGE ST	4,831		
117	HIGH ST	72		
128	HIGH ST	143	Water District Bldg.	Industrial Light
151	HIGH ST	1,939		
159	HIGH ST	740		
161	HIGH ST	787		
7	JAY ST	154		
11	JAY ST	-236		
12	JAY ST	681		
14	JAY ST	393		
15	JAY ST	153		
18	JAY ST	482		
19	JAY ST	5,122		
8-10 (2 Family Res)	JAY ST	-234		
Associated w/11	JAY ST	17,484		
97	LOWER HIGH ST	285		
103	LOWER HIGH ST	189		
111	LOWER HIGH ST	318		
107-109 (House)	LOWER HIGH ST	564		
107-109 (Rear House)	LOWER HIGH ST	21		
110-112	LOWER HIGH ST	797		
38	MAIN ST	5,906	Retail Clothing/Realty	Retail Clothing
41	MAIN ST	126	Pharmacy	Convenience Store
42	MAIN ST	337	Liquor Store	Convenience Store
46	MAIN ST	147	Phoenicia Deli	Convenience Store
48	MAIN ST	41	Library	Office One-Story
49	MAIN ST	15	Sweet Sue's Restaurant	Non-Fast Food
52	MAIN ST	531	Morne Imports/Sporting Goods	Convenience Store
53	MAIN ST	Destroyed in Fire	Key Bank	
54	MAIN ST	530	Ricciardella's Restaurant	Non-Fast Food
58	MAIN ST	227	Ulster Savings Bank	Office One-Story
60	MAIN ST	1,532	Commercial Complex	Office One-Story
65	MAIN ST	520	Gas Station	Service Station
68	MAIN ST	5,811	Brio's	Non-Fast Food
70	MAIN ST	2,101	The Sportsman Bar and Grill	Non-Fast Food
73	MAIN ST	60	Spa and Salon	Office One-Story
79	MAIN ST	32		
80	MAIN ST	41	Hair Salon	Office One-Story
84	MAIN ST	356	The Nest Egg	Convenience Store
85	MAIN ST	3,418	Phoenicia Supermarket	Convenience Store
90	MAIN ST	29	Office Buildings	Office One-Story

104	MAIN ST	159	St. Francis Church	Religious Facilities
72-76	MAIN ST	383	Commercial Complex	Office One-Story
94-98	MAIN ST	147	Office Buildings	Office One-Story
9	MARY MOUNT DR	42		
22-24 (Church)	ROUTE 214	-217		
22-24 (Residence/Parsonage)	ROUTE 214	-184		
32-34 (Main House)	ROUTE 214	-200		
32-34 (Cottage)	ROUTE 214	367		
3	SOUTH ST	1,345		
6	SOUTH ST	5,883		
16	SOUTH ST	776		
23	SOUTH ST	3,243		
3	STATION RD	1,269		
17	STATION RD	2,709		
Total Benefits		79,199		
Positive Benefits Only		80,270		

2D model results

Address Number	Street	Benefit	Business	Entered As	Notes
31	BOARD WALK	4,926			
10	BRIDGE ST	17,349	Town Tinker Tube Rental	Warehouse, Non-refrigerated	
17	BRIDGE ST	4,414			MR. ROTELLA. Unlivable. (on Main St/Old 28)
17	BRIDGE ST	7,257			MS. OTIA (on Main St/Old 28)
18	BRIDGE ST	39,149			
17	BRIDGE ST (Home)	30,112			Home
17	BRIDGE ST (Office)	992	Phoenicia Campground Office	Office One-Story	
10	CHURCH ST	388	Shandaken Theater	Religious Facility	
117	HIGH ST	4,278	Mobile Home		
128	HIGH ST	-187	Water District Bldg.	Industrial Light	
151	HIGH ST	229			
159	HIGH ST	6,330			Mobile Home
161	HIGH ST	3,421			Mobile Home
167	HIGH ST	1,383			
175	HIGH ST	1,764			
187	HIGH ST	609			
189	HIGH ST	736			
201-205	HIGH ST	895			
7	JAY ST	2,093			
11	JAY ST	13,040			1 Residence and Apt. (2 Family home)
12	JAY ST	12,748			
14	JAY ST	9,916			
15	JAY ST	8,962			Residential Aprtments
18	JAY ST	5,079			
19	JAY ST	16,490			
8-10	JAY ST	7,122			2 Family residence
	JAY ST	-19,606			Has unlivable shed. Assoc. w/11 jay
25	LANE ST	809			
70	LOWER HIGH ST	668	Empire Railway: Station	Office One-Story	
94	LOWER HIGH ST	22,955			
97	LOWER HIGH ST	0			
103	LOWER HIGH ST	5,145			
111	LOWER HIGH ST	3,178			
107-109	LOWER HIGH ST	0			House
107-109	LOWER HIGH ST	2,105			Rear House
110-112	LOWER HIGH ST	0			
64-66	LOWER HIGH ST	1,886	Empire Railway	Office One-Story	
38	MAIN ST	77,942	Retail Clothing/Realty	Retail Clothing	
41	MAIN ST	1,279	Pharmacy	Convenience Store	
42	MAIN ST	60,410	Liquor Store	Convenience Store	
46	MAIN ST	21,634	Phoenicia Deli	Convenience Store	
48	MAIN ST	618	Library	Office One-Story	
49	MAIN ST	513	Sweet Sue's Restaurant	Non-Fast Food	
52	MAIN ST	16,077	Morne Imports/Sporting Goods	Convenience Store	
53	MAIN ST		Key Bank		
54	MAIN ST	12,795	Ricciardella's Restaurant	Non-Fast Food	
58	MAIN ST	3,879	Ulster Savings Bank	Office One-Story	
60	MAIN ST	10,182	Commercial Complex	Office One-Story	

65	MAIN ST	4,159	Gas Station	Service Station	
68	MAIN ST	9,585	Brio's	Non-Fast Food	
70	MAIN ST	21,739	The Sportsman Bar and Grill	Non-Fast Food	
73	MAIN ST	37	Spa and Salon	Office One-Story	
79	MAIN ST	-289,779			
80	MAIN ST	314	Hair Salon	Office One-Story	
84	MAIN ST	6,164	The Nest Egg	Convenience Store	
85	MAIN ST	7,637	Phoenicia Supermarket	Convenience Store	
87	MAIN ST	0	Funeral Home	Medical Office	
90	MAIN ST	2,834	Commercial Offices in House	Office One-Story	
91	MAIN ST	76,375			
93	MAIN ST	-49,238			
93	MAIN ST	6,609			Can't see structure from road
97	MAIN ST	15,796			
104	MAIN ST	7,411			No info at town
123	MAIN ST	0			
127	MAIN ST	0			
133	MAIN ST	4,961			
139	MAIN ST	221			Quonset Hut
141	MAIN ST	992			
141	MAIN ST				
170	MAIN ST	12,548			
175	MAIN ST	0			
181	MAIN ST	2,141			
	MAIN ST	0			
109-115	MAIN ST	-83,601	Church Hall	Religious Facility	Not measured yet
184-188	MAIN ST	163	Water District Bldg.	Industrial Light	
57-61	MAIN ST	507	Mama's Boy	Fast Food	
72-76	MAIN ST	6,917	Office Complex	Office One-Story	
94-98	MAIN ST	4,749	Offices in House	Office One-Story	
9	MARY MOUNT DR	-2,723			
8	MT. AVA MARIA DR	-27,509	Post Office	Office One-Story	
223	PLANK RD	-5,897			
319	PLANK RD	-124			
410	PLANK RD				
410	PLANK RD				Mobile Home
422	PLANK RD				Semi-livable shed
9	ROMER ST	1,044			
19	ROUTE 214	929			
20	ROUTE 214	4,989			
23	ROUTE 214	3,008			
25	ROUTE 214	6,738			Residential Aprtments
44	ROUTE 214	564			
46	ROUTE 214	876			Main House
72	ROUTE 214	85			
76	ROUTE 214	120	214 Tavern	Non-Fast Food	
86	ROUTE 214	-2,636			
22-24	ROUTE 214	6,091	Church	Religious Facility	
22-24	ROUTE 214	6,757			House

29-33	ROUTE 214	286			Cottage
29-33	ROUTE 214	5,785			House
29-33	ROUTE 214				Garage
32-34	ROUTE 214	6,688			Main House
32-34	ROUTE 214	8,765			Cottage
5636	ROUTE 28		Sleepy Hollow Campground		
5636	ROUTE 28				Mobile Home
3	SOUTH ST	8,486			
6	SOUTH ST	7,613			
16	SOUTH ST	0			
23	SOUTH ST	-4,904			
27	SOUTH ST	0			
35	SOUTH ST	-121			
3	STATION RD	7,119			
17	STATION RD	14,470			
20	STATION RD				Mobile home destroyed in flood
27	STATION RD				Mobile home destroyed in flood
31	STATION RD	15,345			
31	STATION RD				
71	STATION RD	219			Mobile Home

Total Benefits 253,268

Positive Benefits Only 739,593

MT BK FP2

Address Number	Street	Benefit	Business	Entered As
9	HEINTZ RD	797		
25	HEINTZ RD	6,452		
13-17 (House)	HEINTZ RD	1,776		
13-17 (Cottage)	HEINTZ RD	540		
13-17	HEINTZ RD	0		
103 (Cabin)	HEINTZ RD EXT	587		
103 (House)	HEINTZ RD EXT	7,298		
107	HEINTZ RD EXT	9,738		
5355 (Hotel)	ROUTE 212	2,233	Commercial Part/Hotel	Hotel
5355 (Home)	ROUTE 212	1,354	Residence/House	
5356	ROUTE 212	1,354		
Total Benefits		32,129		
Positive Benefits Only		32,129		

MT BK BR6b

Address Number	Street	Benefit	Business	Entered As
5	MILLER RD	32,820		
25	MILLER RD	1,994		
890	PLANK RD	1,256		
Total Benefits		36,070		
Positive Benefits Only		36,070		

MT E FP6

Address Number	Street	Benefit	Business	Entered As
13	MT PLEASANT RD	28,373		
16	MT PLEASANT RD	12,846		
19	MT PLEASANT RD	44,385		
23	MT PLEASANT RD	21,466		
27	MT PLEASANT RD	11,956		
27	MT PLEASANT RD	22,832		
31	MT PLEASANT RD	16,015		
35	MT PLEASANT RD	19,426		
37	MT PLEASANT RD	24,873		
41	MT PLEASANT RD	19,524		
55	MT PLEASANT RD	19,214		
59	MT PLEASANT RD	8,232		
65	MT PLEASANT RD	7,386		
81	MT PLEASANT RD	2,119		
89	MT PLEASANT RD	1,043		
22-24	MT PLEASANT RD	3,826		
22-24	MT PLEASANT RD	5,291		
45-49	MT PLEASANT RD	1,775		
45-49	MT PLEASANT RD	15,837		
45-49	MT PLEASANT RD	17,393		
744	PLANK RD	165		
746	PLANK RD	274		
755	PLANK RD	19		
762	PLANK RD	282		
763	PLANK RD	2		
804	PLANK RD	5,896	Zen Mt. Monastery	Reilgious Facility
890	PLANK RD	9,447		
764-766 (764)	PLANK RD	653		
764-766 (766)	PLANK RD	-112		
9	RISELEY RD	3,420		
13	RISELEY RD	15,527		
14	RISELEY RD	8,410		
14	RISELEY RD	14,391		

19	RISELEY RD	31,550		
22	RISELEY RD	14,411		
26	RISELEY RD	34,876		
27-29	RISELEY RD	873	Office	Office 1 Story
27-29	RISELEY RD	17,298		
5401	ROUTE 212	3,278	Recording Studio	Retail Electronics
5411	ROUTE 212	804	Church	Religious Facility
5415	ROUTE 212	122		
5415	ROUTE 212	504		
5449	ROUTE 212	1,682		
5463	ROUTE 212	6,415		
5464	ROUTE 212	4,498		
5467	ROUTE 212	13,852		
5468	ROUTE 212	4,543		
5472	ROUTE 212	5,859		
5474	ROUTE 212	4,401		
5485	ROUTE 212	24,829	Garage	Service Station
5392-5396	ROUTE 212	2,746		
5405-5407 (5405)	ROUTE 212	79		
5405-5407 (5407)	ROUTE 212	140		
5417-5419	ROUTE 212	96		
5446-5458	ROUTE 212	7,389	Post Office	Office 1 Story
5446-5458	ROUTE 212	7,969		
5453-5455 (5453)	ROUTE 212	8,677		
5453-5455 (5455)	ROUTE 212	18,997		
5259	ROUTE 28			
5260	ROUTE 28	37,276		
5262	ROUTE 28	18,450		
5267	ROUTE 28	24,344		
5283	ROUTE 28	3,856		
5295	ROUTE 28	74,444		
5307	ROUTE 28	23,607		
5317	ROUTE 28	2,695		
5321	ROUTE 28	1,280		
5239-5251 (5239)	ROUTE 28	19,832		

5239-5251 (5241)	ROUTE 28	26,839		
5239-5251 (5243)	ROUTE 28	18,701		
5239-5251 (5245)	ROUTE 28	20,372		
5239-5251 (5251)	ROUTE 28	87,083		
5360-5374 (Downstream)	ROUTE 28	0	Hotel	Hotel
5360-5374 (Most Downstream)	ROUTE 28			
Total Benefits		936,853		
Positive Benefits Only		936,965		

MT E FP6

Address Number	Street	Benefit	Business	Entered As
13	MT PLEASANT RD	17,986		
16	MT PLEASANT RD	6,641		
19	MT PLEASANT RD	12,677		
23	MT PLEASANT RD	9,605		
27	MT PLEASANT RD	10,149		
27	MT PLEASANT RD	5,177		
31	MT PLEASANT RD	7,267		
35	MT PLEASANT RD	9,348		
37	MT PLEASANT RD	12,154		
41	MT PLEASANT RD	9,974		
55	MT PLEASANT RD	13,976		
59	MT PLEASANT RD	5,527		
65	MT PLEASANT RD	5,553		
81	MT PLEASANT RD	2,009		
89	MT PLEASANT RD	1,337		
22-24	MT PLEASANT RD	3,457		
22-24	MT PLEASANT RD	2,082		
45-49	MT PLEASANT RD	8,815		
45-49	MT PLEASANT RD	11,377		
45-49	MT PLEASANT RD	1,049		
744	PLANK RD	1,182		
746	PLANK RD	559		
755	PLANK RD	-22		
762	PLANK RD	1,158		
763	PLANK RD	99		
804	PLANK RD	2,819	Zen Mt. Monastery	Reilgious Facility
890	PLANK RD	4,100		
764-766 (764)	PLANK RD	10,055		
764-766 (766)	PLANK RD	22,289		
774-776 (772)	PLANK RD	66		
774-776 (774)	PLANK RD	845		
774-776 (776)	PLANK RD	465		
9	RISELEY RD	3,594		
13	RISELEY RD	14,831		
14	RISELEY RD	12,270		
14	RISELEY RD	5,620		
19	RISELEY RD	34,634		

22	RISELEY RD	9,511		
26	RISELEY RD	14,833		
27-29	RISELEY RD	16,949	Office	Office 1 Story
27-29	RISELEY RD	888		
5401	ROUTE 212	1,036	Recording Studio	Retail Electronics
5411	ROUTE 212	541	Church	Religious Facility
5415	ROUTE 212	396		
5415	ROUTE 212	89		
5449	ROUTE 212	1,441		
5463	ROUTE 212	5,485		
5464	ROUTE 212	2,986		
5467	ROUTE 212	12,045		
5468	ROUTE 212	3,054		
5472	ROUTE 212	3,124		
5474	ROUTE 212	2,850		
5485	ROUTE 212	13,446	Garage	Service Station
5392-5396	ROUTE 212	2,137		
5405-5407 (5405)	ROUTE 212	42		
5405-5407 (5407)	ROUTE 212	116		
5417-5419	ROUTE 212	71		
5446-5458	ROUTE 212	7,065	Post Office	Office 1 Story
5446-5458	ROUTE 212	6,225		
5453-5455 (5453)	ROUTE 212	8,357		
5453-5455 (5455)	ROUTE 212	18,494		
5213	ROUTE 28	7		
5259	ROUTE 28			
5260	ROUTE 28	33,027		
5262	ROUTE 28	13,122		
5267	ROUTE 28	10,648		
5283	ROUTE 28	3,208		
5295	ROUTE 28	26,774		
5307	ROUTE 28	6,794		
5317	ROUTE 28	1,268		
5321	ROUTE 28	1,222		
5207-5209 (5209)	ROUTE 28	43		
5215-5219 (5217)	ROUTE 28	122		
5215-5219 (5219)	ROUTE 28	21		
5221-5223 (5223)	ROUTE 28	5,251		
5221-5223 (5221)	ROUTE 28	3,660		

5229-5235 (5229)	ROUTE 28	341		
5229-5235 (5231)	ROUTE 28	377		
5229-5235 (5233)	ROUTE 28	380		
5229-5235 (5235)	ROUTE 28	347		
5239-5251 (5239)	ROUTE 28	17,124		
5239-5251 (5241)	ROUTE 28	14,251		
5239-5251 (5243)	ROUTE 28	9,873		
5239-5251 (5245)	ROUTE 28	12,862		
5239-5251 (5251)	ROUTE 28	50,371		
5360-5374 (Downstream)	ROUTE 28	0	Hotel	Hotel
5360-5374 (Most Downstream)	ROUTE 28			
Total Benefits		612,998		
Positive Benefits Only		613,020		

MT E FP6

Address Number	Street	Benefit	Business	Entered As
13	MT PLEASANT RD	1,644		
16	MT PLEASANT RD	5,844		
19	MT PLEASANT RD	1,754		
23	MT PLEASANT RD	3,382		
27	MT PLEASANT RD	6,035		
27	MT PLEASANT RD	1,697		
31	MT PLEASANT RD	4,796		
35	MT PLEASANT RD	2,098		
37	MT PLEASANT RD	6,528		
41	MT PLEASANT RD	2,711		
55	MT PLEASANT RD	2,389		
59	MT PLEASANT RD	300		
65	MT PLEASANT RD	1,246		
81	MT PLEASANT RD	678		
89	MT PLEASANT RD	329		
22-24	MT PLEASANT RD	-626		
22-24	MT PLEASANT RD	738		
45-49	MT PLEASANT RD	3,299		
45-49	MT PLEASANT RD	262		
45-49	MT PLEASANT RD	416		
744	PLANK RD	30		
746	PLANK RD	43		
755	PLANK RD	26		
762	PLANK RD	51		
763	PLANK RD	6		
804	PLANK RD	3,645	Zen Mt. Monastery	Reilgious Facility
890	PLANK RD	3,064		
764-766 (764)	PLANK RD	2,217		
764-766 (766)	PLANK RD	-47		
774-776 (772)	PLANK RD			
774-776 (774)	PLANK RD			
774-776 (776)	PLANK RD			
9	RISELEY RD	4,705		
13	RISELEY RD	13,256		
14	RISELEY RD	7,509		
14	RISELEY RD	4,564		
19	RISELEY RD	17,634		

22	RISELEY RD	8,261		
26	RISELEY RD	9,171		
27-29	RISELEY RD	12,675	Office	Office 1 Story
27-29	RISELEY RD	1,493		
5401	ROUTE 212	5,936	Recording Studio	Retail Electronics
5411	ROUTE 212	1,416	Church	Religious Facility
5415	ROUTE 212	1,013		
5415	ROUTE 212	569		
5449	ROUTE 212	2,765		
5463	ROUTE 212	5,147		
5464	ROUTE 212	702		
5467	ROUTE 212	10,397		
5468	ROUTE 212	522		
5472	ROUTE 212	-2,698		
5474	ROUTE 212	271		
5485	ROUTE 212	3,547	Garage	Service Station
5392-5396	ROUTE 212	2,819		
5405-5407 (5405)	ROUTE 212	300		
5405-5407 (5407)	ROUTE 212	512		
5417-5419	ROUTE 212	140		
5446-5458	ROUTE 212	13,484	Post Office	Office 1 Story
5446-5458	ROUTE 212	5,309		
5453-5455 (5453)	ROUTE 212	8,745		
5453-5455 (5455)	ROUTE 212	18,189		
5213	ROUTE 28			
5259	ROUTE 28			
5260	ROUTE 28	53,141		
5262	ROUTE 28	24,649		
5267	ROUTE 28	995		
5283	ROUTE 28	3,528		
5295	ROUTE 28	5,264		
5307	ROUTE 28	1,443		
5317	ROUTE 28	1,559		
5321	ROUTE 28	376		
5207-5209 (5209)	ROUTE 28			
5215-5219 (5217)	ROUTE 28			
5215-5219 (5219)	ROUTE 28			
5221-5223 (5223)	ROUTE 28			
5221-5223 (5221)	ROUTE 28			

5229-5235 (5229)	ROUTE 28			
5229-5235 (5231)	ROUTE 28			
5229-5235 (5233)	ROUTE 28			
5229-5235 (5235)	ROUTE 28			
5239-5251 (5239)	ROUTE 28	720		
5239-5251 (5241)	ROUTE 28	388		
5239-5251 (5243)	ROUTE 28	641		
5239-5251 (5245)	ROUTE 28	913		
5239-5251 (5251)	ROUTE 28	6,659		
5360-5374 (Downstream)	ROUTE 28		Hotel	Hotel
5360-5374 (Most Downstream)	ROUTE 28			
Total Benefits		313,184		
Positive Benefits Only		316,555		

MT E FP5 BR3B

Address Number	Street	Benefit	Business	Entered As
13	MT PLEASANT RD	31,848		
16	MT PLEASANT RD	15,658		
19	MT PLEASANT RD	49,247		
23	MT PLEASANT RD	24,374		
27	MT PLEASANT RD	26,818		
27	MT PLEASANT RD	14,297		
31	MT PLEASANT RD	18,994		
35	MT PLEASANT RD	22,712		
37	MT PLEASANT RD	29,077		
41	MT PLEASANT RD	23,664		
55	MT PLEASANT RD	22,439		
59	MT PLEASANT RD	9,959		
65	MT PLEASANT RD	8,636		
81	MT PLEASANT RD	2,350		
89	MT PLEASANT RD	969		
22-24	MT PLEASANT RD	14,652		
22-24	MT PLEASANT RD	6,054		
45-49	MT PLEASANT RD	18,511		
45-49	MT PLEASANT RD	20,365		
45-49	MT PLEASANT RD	2,119		
744	PLANK RD	165		
746	PLANK RD	262		
755	PLANK RD	20		
762	PLANK RD	109		
763	PLANK RD	-43		
804	PLANK RD	7,479	Zen Mt. Monastery	Reilgious Facility
890	PLANK RD	11,285		
764-766 (764)	PLANK RD	-433		
764-766 (766)	PLANK RD	-2,430		
774-776 (772)	PLANK RD			
774-776 (774)	PLANK RD			
774-776 (776)	PLANK RD			
9	RISELEY RD	7,236		

13	RISELEY RD	22,649		
14	RISELEY RD	17,485		
14	RISELEY RD	9,988		
19	RISELEY RD	51,296		
22	RISELEY RD	17,851		
26	RISELEY RD	40,692		
27-29	RISELEY RD	27,273	Office	Office 1 Story
27-29	RISELEY RD	1,981		
5401	ROUTE 212	6,239	Recording Studio	Retail Electronics
5411	ROUTE 212	1,375	Church	Religious Facility
5415	ROUTE 212	1,342		
5415	ROUTE 212	619		
5449	ROUTE 212	3,338		
5463	ROUTE 212	15,906		
5464	ROUTE 212	9,825		
5467	ROUTE 212	40,329		
5468	ROUTE 212	10,444		
5472	ROUTE 212	14,053		
5474	ROUTE 212	9,530		
5485	ROUTE 212	51,139	Garage	Service Station
5392-5396	ROUTE 212	3,906		
5405-5407 (5405)	ROUTE 212	298		
5405-5407 (5407)	ROUTE 212	530		
5417-5419	ROUTE 212	208		
5446-5458	ROUTE 212	19,292	Post Office	Office 1 Story
5446-5458	ROUTE 212	19,052		
5453-5455 (5453)	ROUTE 212	21,347		
5453-5455 (5455)	ROUTE 212	46,454		
5213	ROUTE 28			
5259	ROUTE 28			
5260	ROUTE 28	75,138		
5262	ROUTE 28	54,714		
5267	ROUTE 28	19,115		
5283	ROUTE 28	5,209		
5295	ROUTE 28	83,276		

5307	ROUTE 28	27,155		
5317	ROUTE 28	3,385		
5321	ROUTE 28	1,329		
5207-5209 (5209)	ROUTE 28			
5215-5219 (5217)	ROUTE 28			
5215-5219 (5219)	ROUTE 28			
5221-5223 (5223)	ROUTE 28			
5221-5223 (5221)	ROUTE 28			
5229-5235 (5229)	ROUTE 28			
5229-5235 (5231)	ROUTE 28			
5229-5235 (5233)	ROUTE 28			
5229-5235 (5235)	ROUTE 28			
5239-5251 (5239)	ROUTE 28	16,815		
5239-5251 (5241)	ROUTE 28	15,296		
5239-5251 (5243)	ROUTE 28	13,814		
5239-5251 (5245)	ROUTE 28	14,718		
5239-5251 (5251)	ROUTE 28	56,885		
5360-5374 (Downstream)	ROUTE 28	0	Hotel	Hotel
5360-5374 (Most Downstream)	ROUTE 28	-29		
Total Benefits		1,237,654		
Positive Benefits Only		1,240,589		

Phoenicia Acquisitions

Address Number	Street	Parcel Value	Est. Demo.	Total	Benefit	Buy Out?	Notes
38	Main Street	192,308	50,000	242,308.00	135,251	No	
18	Bridge Street	121,154	30,000	151,154.00	50,487	No	
17	Bridge Street	334,615	50,000	384,615.00	19,721	No	Acquisition based on residential structure
17	Station Road	82,692	30,000	112,692.00	771,490	No	
3	Station Road	54,615	30,000	84,615.00	773,574	No	Commercial property based on "Retail Clothing"
Total Benefits		785,384	190,000		1,750,523		
Adjusted for Equalization		3,079,937					

Other properties in floodplain bench area with no structures or structures sufficiently far from river

Address Number	Street	Print Key
31	Boardwalk	
__	High Street	14.13-3-28
__	Bridge Street	14.13-3-34
133	Main Street	
141	Main Street	

Total Benefits	4,650,705
Positive Benefits Only	4,650,705

Mt. Tremper Acquisitions

Address Number	Street	Parcel Value	Est. Demo.	Total	Benefit	Buy Out?	Notes
65	Mt. Pleasant	139,231	30,000	169,231	21,603	No	
59	Mt. Pleasant	113,846	30,000	143,846	23,212	No	
55	Mt. Pleasant	102,692	30,000	132,692	42,098	No	
45-49	Mt. Pleasant	225,769	50,000	275,769	55,007	No	3 Structures. Based on largest building.
41	Mt. Pleasant	112,692	30,000	142,692	39,350	No	
37	Mt. Pleasant	154,615	30,000	184,615	47,781	No	
35	Mt. Pleasant	158,846	30,000	188,846	42,069	No	
31	Mt. Pleasant	95,000	30,000	125,000	31,999	No	
27	Mt. Pleasant	196,154	40,000	236,154	58,752	No	2 Structures. Based on largest building.
23	Mt. Pleasant	143,077	30,000	173,077	44,594	No	
19	Mt. Pleasant	157,308	30,000	187,308	84,952	No	
16	Mt. Pleasant	179,231	30,000	209,231	31,822	No	
13	Mt. Pleasant	101,923	30,000	131,923	63,850	No	
22-24	Mt. Pleasant	61,154	40,000	101,154	33,615	No	2 Structures. Based on largest building.
5239-5251	State Route 28	261,538	70,000	331,538	4,893,444	No	Associated with lower bench. May be land only. 5 Structure
5229-5235	State Route 28	51,923	60,000	111,923	50,230	Yes	Associated with lower bench. May be land only. 4 Structure
Total Benefits		2,254,999	590,000		5,564,378		
		8,843,133					

Other properties in floodplain bench area with no structures or structures sufficiently far from river

Address Number	Street	Print Key	Notes
__	State Route 28	25.10-4-24.2	
5256	State Route 28		
__	Riseley Road	25.10-4-23	Owned by Lee Delvecchio. May be land only
5260	State Route 28		
5446-5458	State Route 212		Associated with lower bench. May be land only. 2 Structure
5221-5223	State Route 28		Associated with lower bench. May be land only. 2 Structure
5340	State Route 28		
__	Mt. Pleasant	25.10-4-11	
__	Mt. Pleasant	25.10-2-22	
__	Mt. Pleasant	25.10-2-21	
__	Riseley Road	25.10-4-41	
5	Riseley Road		
3	Riseley Road		

Total Benefits	13,353,131
Positive Benefits Only	13,353,131

Benefits of Bridge Street Bridge Remove and Replace based on Allaben and Coldbrook gages.

Allaben

Date	Flow (cfs)	Return Interval (Year)	Annual Benefit ($)	50 Year Benefit ($)
28-Aug-11	29,300	82.9	33,110	456,943
2-Apr-05	21,700	42		

Coldbrook

Date	Flow (cfs)	Return Interval (Year)	Annual Benefit ($)	50 Year Benefit ($)
28-Aug-11	75,800	76.2	35,005	483,095
2-Apr-05	55,200	39.7		

		Traffic Count
Plank Road at bridge over Beaverkill		1147
From Aaron Bennett		detour is 8.0 miles
	June 27 and 28, 2006	repair cost $108,487.84 FEMA reimbursed
	2009	repair cost $25,000 County Budget

	Traffic Count		notes
Route 28 bridge in Mt Tremper		4827	west of Route 212
From Aaron Bennett	detour (via Plank Rd) is also only about 8.0 miles. This one is tricky though because the detour route is even more vulnerable than the bridge....as it is frequently washing out and gets ripped apart in more modest storms. If the Plank Rd (County Rte 40) is closed as well (which would almost certainly be the case), the detour would be approximately 42 miles. I want to say it was closed for 2 days after Irene and have no idea on the cost of repair.		
	Mt Tremper Rte 28 bridge (Irene) - under 50K in repairs; had some scour on east abutment, some concrete work was done and some boulders replaced. It was closed totally for 1 day. It was closed in one direction (for an additional 2 days). It has never been damaged enough to be closed from flooding previously. Bridge has never been over-topped		

		Traffic Count
Bridge Street Bridge		1512
From Aaron Bennett		Detour is 0.9 miles
	April 4 and 5, 2005	repair cost $508,604.92 FEMA reimbursed
		The bridge street bridge was closed from april 3 through September 29 2005
	August 28, 2011	repair cost $120,686.63 FEMA reimbursed
		Bridge Street Bridge was closed from 8/28/11 through 5/25/12

Cost Estimator for Beaver Kill Floodplain Bench: fill in pink cells only

Variable	Value	Cost	Notes
volume of material removed (CY)	31,900	$ 319,000	Determine cut volumes from HEC-RAS cross sections; assumes $10/CY to export
linear footage of bench (LF)	700	$ 70,000	Measure linear footage of project; assumes $100/linear foot; if FP bench on both banks, dc
Area of created floodplain (square feet)	0.8	$ 38,500	Measure area of disturbance; includes cost of topsoil, seeding and planting; assumes $2/sq
Area of forested land to be cleared (acres)	0.7	$ 7,000	Measure treed areas to be cleared; assumes $10,000/acre to clear land
Design and Permiting cost		$ 64,125	Assumes 15% of project cost
Total		**$ 498,625**	

Cost Estimator for Mt Tremper Floodplain Bench: fill in pink cells only

Variable	Value	Cost	Notes
volume of material removed (CY)	325,899	$ 3,258,990	Determine cut volumes from HEC-RAS cross sections; assumes $10/CY to export
linear footage of bench (LF)	5000	$ 500,000	Assumes $100/linear foot; if FP bench on both banks, double value
Area of created floodplain (acres)	22.1	$ 1,105,000	Cost of topsoil, seeding and planting; assumes $50,000/acre
Area of forested land to be cleared (acres)	15.0	$ 150,000	Measure treed areas to be cleared; assumes $10,000/acre to clear land
Design and Permiting cost		$ 729,599	Assumes 15% of project cost
Total		**$ 5,743,589**	

Cost Estimator for Phoenicia Floodplain Bench: fill in pink cells only

Variable	Value	Cost	Notes
volume of material removed (CY)	68,274	$ 682,740	Determine cut volumes from HEC-RAS cross sections; assumes $10/CY to export
linear footage of bench (LF)	3,670	$ 367,000	Assumes $100/linear foot; if FP bench on both banks, double value
Area of created floodplain (acres)	8.2	$ 410,000	Cost of topsoil, seeding and planting; assumes $50,000/acre
Area of forested land to be cleared (acres)	7.4	$ 74,000	Measure treed areas to be cleared; assumes $10,000/acre to clear land
Design and Permiting cost		$ 218,961	Assumes 15% of project cost
Total		**$ 1,752,701**	