LOCAL FLOOD ANALYSIS

TOWN OF WINDHAM ALONG THE BATAVIA KILL IN THE HAMLETS OF WINDHAM, HENSONVILLE, AND MAPLECREST GREENE COUNTY, NEW YORK

August 2015

MMI #2884-05

Photo Source: Milone & MacBroom, Inc. (2014)

This document was prepared for the Town of Windham through the Stream Management Implementation Program of the Greene County Soil and Water Conservation District.

Prepared by:

MILONE & MACBROOM, INC.
231 Main Street, Suite 102
New Paltz, NY 12561
(845) 633-8153
www.miloneandmacbroom.com

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS/ACRONYMS

CFS	Cubic Feet per Second
CY	Cubic Yards
DFIRM	Digital Flood Insurance Rate Map
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FTP	File Transfer Protocol
GCSWCD	Green County Soil and Water Conservation District
GIS	Geographic Information System
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HMP	Hazard Mitigation Plan
LFA	Local Flood Analysis
LiDAR	Light Detection and Ranging
MMI	Milone & MacBroom, Inc.
NFIP	National Flood Insurance Program
NRCS	Natural Resource Conservation Service
NYCDEP	New York City Department of Environmental Protection
SFHA	Special Flood Hazard Area
SMP	Stream Management Plan
STA	River Station
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey

EXECUTIVE SUMMARY

Background

The subject Local Flood Analysis (LFA) was undertaken to evaluate potential flood mitigation within the Town of Windham in the hamlets of Windham, Hensonville, and Maplecrest. Flooding has long been a problem in these communities, evidenced most recently by the extensive flooding and devastation during Tropical Storm Irene in 2011.

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. Extensive bank erosion and flood-related damages to buildings and properties occurred along Route 56 and Route 40 through the hamlet of Maplecrest. A barn along Route 56 in Maplecrest was undermined by the high flows. Between Maplecrest and Hensonville, the channel appears to have avulsed (changed course) and homes were pushed off of their foundations along the right bank. In the hamlet of Hensonville, homes and other structures were damaged along Route 65A and Route 65.

Upstream of the hamlet of Windham, the channel avulsed, causing extensive damage to the Windham Country Club, and washing out two bridges. Extensive flooding occurred within the hamlet when as much as four feet of water flowed down Route 23, damaging homes and businesses and tipping over cars and a school bus. Floodwaters moved at a high velocity, carrying debris, dumpsters and propane tanks and sweeping structures off of their foundations. The Church Street bridge overtopped and extensive property damage occurred at the Windham Ashland Jewett Public School. Further downstream, the lumber yard was flooded and suffered extensive damage. Tropical Storm Irene was followed by precipitation from the remnants of Tropical Storm Lee, which caused additional flooding in the study area.

At the heart of the flood issue in these communities is that extensive development has occurred in the river's natural floodplain. Additionally, there appears to be some amount of encroachment (i.e. fill) within the floodplain, although the active flow channel is generally not undersized or lacking capacity.

The study area along the Batavia Kill was chosen to coincide with the majority of the population areas in the town of Windham. The Batavia Kill is a tributary to Schoharie Creek, which discharges into the Schoharie Reservoir, a drinking water supply source to the New York City water system. The study area extends 8.8 stream miles along the Batavia Kill through the hamlets of Windham, Hensonville, and Maplecrest.

Assessment Methodology

Like many communities in Greene County and throughout the Catskills, historic development has occurred along both banks of the river valley within the natural floodplain of the river and in some cases in the river's highly vulnerable floodway. The river intermittently becomes confined between valley walls and then widens, with a more expansive floodplain. It is in these wider floodplain areas where the majority of flood damages have occurred in developed areas.

Specific risk areas have been identified as being prone to flooding during severe rain events. 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. A benefit cost analysis was performed for a subset of the alternatives.

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 mouth of the Batavia Kill at STA 0+00 and continuing upstream to STA 1278+00 at its headwaters. A map showing the stream stationing for the study area is shown in Figure 1-2 in the body of the report.

For analysis purposes, the Batavia Kill corridor has been divided into High Risk Areas (HRAs) #1 through #4 from upstream to downstream as follows:

- High Risk Area #1 – Hamlet of Maplecrest (STA 975+00 to STA 925+00)
- High Risk Area #2 – Between Hensonville and Maplecrest (STA 890+00 to STA 837+00)
- High Risk Area #3 – Hamlet of Hensonville (STA 825+00 to STA 805+00)
- High Risk Area #4 – Hamlet of Windham (STA 680+00 to STA 625+00)

Various alternatives have been evaluated in each risk area to understand the potential for flood mitigation. Alternatives were initially assessed for a variety of flow events, with the goal of protection against the 100-year event, recognizing that the flows caused by Tropical Storm Irene were extremely rare and protection against such events is likely to be cost prohibitive. In some instances, there may be merit to undertaking flood mitigation measures that protect against lower frequency storm events to minimize frequent nuisance flooding.

Given the conditions within the Batavia Kill riparian corridor and floodplain, a limited number of flood mitigation opportunities are available to the communities through which it flows. A primary flood mitigation option lies in lowering the floodplain immediately adjacent to the Batavia Kill to create a classical compound channel that is capable of conveying normal river flows in the base channel, while creating an active, undeveloped floodplain bench for the conveyance of high flood flows. In this document, such alteration is referred to as floodplain enhancement.

Other options that have been evaluated include channel and bridge modifications, construction of levees, and dredging. Although these alternatives have not been assessed beyond a conceptual level, the order of magnitude costs that can be expected for each are an important consideration. For instance, implementing a flood mitigation project at a cost of $2M would not be warranted to protect two residential dwellings worth $200,000 each.

Mitigation Assessment and Recommendations

Table ES-1 presents a summary of all alternatives evaluated through the use of hydraulic modeling. Based on input received from the Windham Flood Advisory Committee, depth grid mapping was developed and a benefit-cost analysis was completed for a subset of the alternatives listed below, as indicated.

TABLE ES-1
Windham Flood Mitigation Alternatives

Alternative		Flood Mapping and Benefit-Cost Analysis Completed?	Cost Effective?	Recommended for Implementation?
HRA #1 – Hamlet of Maplecrest				
1.1A	Floodplain Enhancement D/S Slater Road	Y	N	N
1.1B	Dredging D/S Slater Road	N	N	N
1.2A	Bridge Replacement County Route 40	N	N	N
1.2B	Dredging U/S & D/S County Route 40	N	N	N
1.3	Strategic Acquisition of Properties[1]	N	Y	Y
HRA #2 – Between Hensonville and Maplecrest				
2.1	Channel Dredging Wedding Bells Ln to Rte 65A	N	N	N
2.2A	Floodplain Enhancement D/S Wedding Bells La	N	N	N
2.2B	Flood Control Levee D/S Wedding Bells La	N	N	N
2.3	Floodplain Enhancement Near Schaeffer Road	Y	N	N
2.4	Floodplain Enhancement U/S Route 40 Bridge	Y	N	N
2.5	Strategic Acquisition of Properties[1]	N	Y	Y
HRA #3 – Hamlet of Hensonville				
3.1	Floodplain Enhancement & Bridge Replacement[2]	Y	M	M
3.2	Strategic Acquisition of Properties[1]	N	Y	Y
HRA #4 – Hamlet of Windham				
4.1	Floodplain Enhancement U/S Church Street	Y	N	N
4.2	Bridge Replacement & Floodplain Bench	Y	Y	Y
4.3	Floodplain Enhancement D/S Church Street	Y	M	Y
4.4	Floodplain Enhancement D/S Windham	N	N	N
4.5	Strategic Acquisition of Properties[1]	N	Y	Y

1 – Strategic acquisition of floodprone buildings may be a viable alternative where property owner willingness exists, particularly those structures located in the FEMA floodway. Such properties could be converted to passive, non-intensive land uses.
2 – Alternative 3.1 is not cost effective but may be a viable option in the future if the bridge is scheduled for replacement.

Specific recommendations by community follow.

High Risk Area #1 – Hamlet of Maplecrest

Floodplain enhancement in the hamlet of Maplecrest will reduce flooding at residential properties, but based the benefic-cost analysis would not be cost effective. Dredging would provide mitigation benefits similar to floodplain enhancement, but at an order of magnitude higher cost and with potential streambed and bank instability as well as funding and permitting challenges. Bridge replacement along County Route 40 would provide little flood mitigation and at a cost that would be prohibitive.

In this community, the following actions are recommended:

1. Seek to acquire the most flood-vulnerable properties where there is owner interest and programmatic funding available either through FEMA or NYCDEP.

2. Move existing structures out of the floodway. Specifically, the rear building at 97 County Route 56 is located partially within the FEMA floodway and is recommended for relocation.

3. Disallow any new development in the floodway and require new construction to meet NFIP criteria.

4. Some of the homes in the floodplain are rarely flooded. Residents and businesses may benefit from minor individual property improvements. Providing land owners with information regarding individual property protection is recommended (see *Individual Property Flood Protection* measures described below).

High Risk Area #2 – Between Hensonville and Maplecrest

Within this high risk area, the Batavia Kill channel is confined upstream of Wedding Bells Lane and then opens up on the right bank, where properties are at risk of flooding. Wholesale channel dredging through this reach would reduce flooding of homes along Route 40, but at a cost that is prohibitive and at substantial risk of long-term channel instability. Dredging would leave the channel overly deep; would be difficult to construct and is not likely to be sustainable. Floodplain enhancements were evaluated as an alternative means of flood mitigation, but based on the benefit-cost analysis would not be cost effective. The following recommendations are offered for this reach:

1. Seek to acquire the most flood-vulnerable properties where there is owner interest and programmatic funding available either through FEMA or NYCDEP.

2. Disallow all new development in the floodway and require new construction to meet NFIP criteria.

3. Some of the homes in the floodplain are rarely flooded. Residents and businesses may benefit from minor individual property improvements. Providing land owners with information regarding individual property protection is recommended (see Individual Property Flood Protection measures described below).

High Risk Area #3 – Hamlet of Hensonville

Based on the benefit-cost analysis, the cost of floodplain enhancement and bridge replacement would surpass the aggregate value of the floodprone homes in this reach. In this reach of the Batavia Kill, the following actions are recommended:

1. Seek to acquire the most flood-vulnerable properties where there is owner interest and programmatic funding available either through FEMA or NYCDEP.

2. Remove existing structures out of the floodway. Specifically, homes located at 120 County Route 65 (currently abandoned), and at 109 County Route 65 (status unknown) are located in the FEMA floodway and should be removed.

3. Disallow all new development in the floodway and require new construction to meet NFIP criteria.

4. Some of the homes in the floodplain are rarely flooded. Residents and businesses may benefit from minor individual property improvements. Providing land owners with information regarding individual property protection is recommended (see *Individual Property Flood Protection* measures described below).

If funding allows, further consideration may be given to floodplain enhancement in this reach, particularly when the bridge is due to be replaced for structural reasons. The cost of such action (Alternative 3.1) may be feasible if the bridge is to be replaced under a separate funding source.

High Risk Area #4 – Hamlet of Windham

The hamlet of Windham hosts the largest number of properties affected by flooding. The Batavia Kill through the hamlet of Windham is confined on the left bank by a steep, wooded embankment. Its natural floodplain occurs on the right bank, where development is most dense, including Main Street. The Mitchell Hollow tributary enters the Batavia Kill in this area and contributes to flooding in the downtown area.

Floodplain enhancement upstream of Church Street (Alternative 4.1) would reduce water surface elevations in the upstream portion of the hamlet, but would not be cost effective and would not eliminate flooding of many properties currently located within the FEMA floodplain.

Implementation of Alternative 4.2 (replacement of Main Street bridge and floodplain bench on Mitchell Hollow Creek) would reduce flooding in the area of Main Street and Mill Street. It would require the acquisition and relocation of three commercial structures (5327, 5330 and 5331 County Route 23). Benefits would be derived from the acquisition and removal of the businesses from the flood prone area, and from the reduction of flooding at the remaining homes and businesses as a result of water surface elevation reductions. Nearly all of the acquisition benefits ($3,512,589 of the $3,512,640 in acquisition benefits) result from relocation of one commercial structure at 5330 County Route 23. This alternative has the potential to substantially reduce flooding and should be investigated more closely.

Implementation of Alternative 4.3 (floodplain enhancement downstream of Church Street) would be effective at reducing flooding along Main Street in Windham, especially if implemented in combination with Alternative 4.2, which reduces flooding associated with Mitchell Hollow Creek. Implementation of Alternative 4.3 would require the relocation of GNH Lumber. Based on the results of the benefit-cost analysis, the benefit-cost ratio for this alternative is 0.84. This alternative can be investigated more closely, costs and benefits can be refined, and potentially a benefit-cost ratio greater than 1.0 can be derived.

1. The lumber yard is located within the FEMA floodway and should be relocated. Its relocation would also be required in order to implement Alternative 4.3. Lumber yards are considered critical community facilities for the CWC program and relocation funding is available.

2. Disallow all new development in the floodway and require new construction to meet NFIP criteria.

3. Seek to acquire the most flood-vulnerable properties where there is owner interest and programmatic funding available either through FEMA or NYCDEP.

4. Some of the homes in the floodplain are rarely flooded. Residents and businesses may benefit from minor individual property improvements. Providing land owners with information regarding individual property protection is recommended (see *Individual Property Flood Protection* measures described below).

Individual Property Flood Protection

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, 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.

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 on piers to a height such that the first floor is located 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.

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 town 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 high water mark (if the ceiling permits). A wooden platform of pressure-treated wood can serve as the base.
- Anchor the fuel tank to the wall or floor with noncorrosive metal strapping and lag bolts.
- 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 National Flood Insurance Program (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.

Sediment Management

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.

2. Sediment management should be limited in volume to either a single flood's deposition or to the watershed's annual sediment yield in order to preclude downstream bed degradation from lack of sediment. Annual sediment yields vary, but one approach is to use a regional average of 50 cubic yards per square mile per year unless a detailed study is made.

3. Excavation of fine-grain sediment releases turbidity. Best available practices should be followed to control sedimentation and erosion.

4. 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.

5. 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 re-mobilization and re-deposition during the next large storm event.

6. No sediment excavation should be undertaken in areas where aquatic-based rare or endangered species are located.

1.0 INTRODUCTION

1.1 Project Background

The Town of Windham, utilizing stream management implementation funding through the Greene County Soil and Water Conservation District (GCSWCD), has retained Milone & MacBroom, Inc. (MMI) to complete a Local Flood Analysis (LFA) in the town of Windham, New York, along the Batavia Kill in the hamlets of Windham, Hensonville, and Maplecrest, located in the northwest part of the Catskill Mountains of New York. 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 within in 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 GCSWCD, through its Schoharie Watershed Program, is implementing the LFA program in the Schoharie watershed communities.

The subject LFA was undertaken separately from the New York Rising Community Reconstruction (NYRCR) program, which was underway during the same time period. The NYRCR program is intended to provide rebuilding and resiliency assistance to communities severely damaged by Hurricane Irene, Tropical Storm Lee, Superstorm Sandy, and the summer floods of 2013. The subject LFA is an engineering feasibility analysis that develops a range of flood hazard mitigation alternatives, with the primary focus of identifying options that reduce flood elevations and inundation. These LFA and NYRCR are separate but related efforts that are intended to complement and build upon one another.

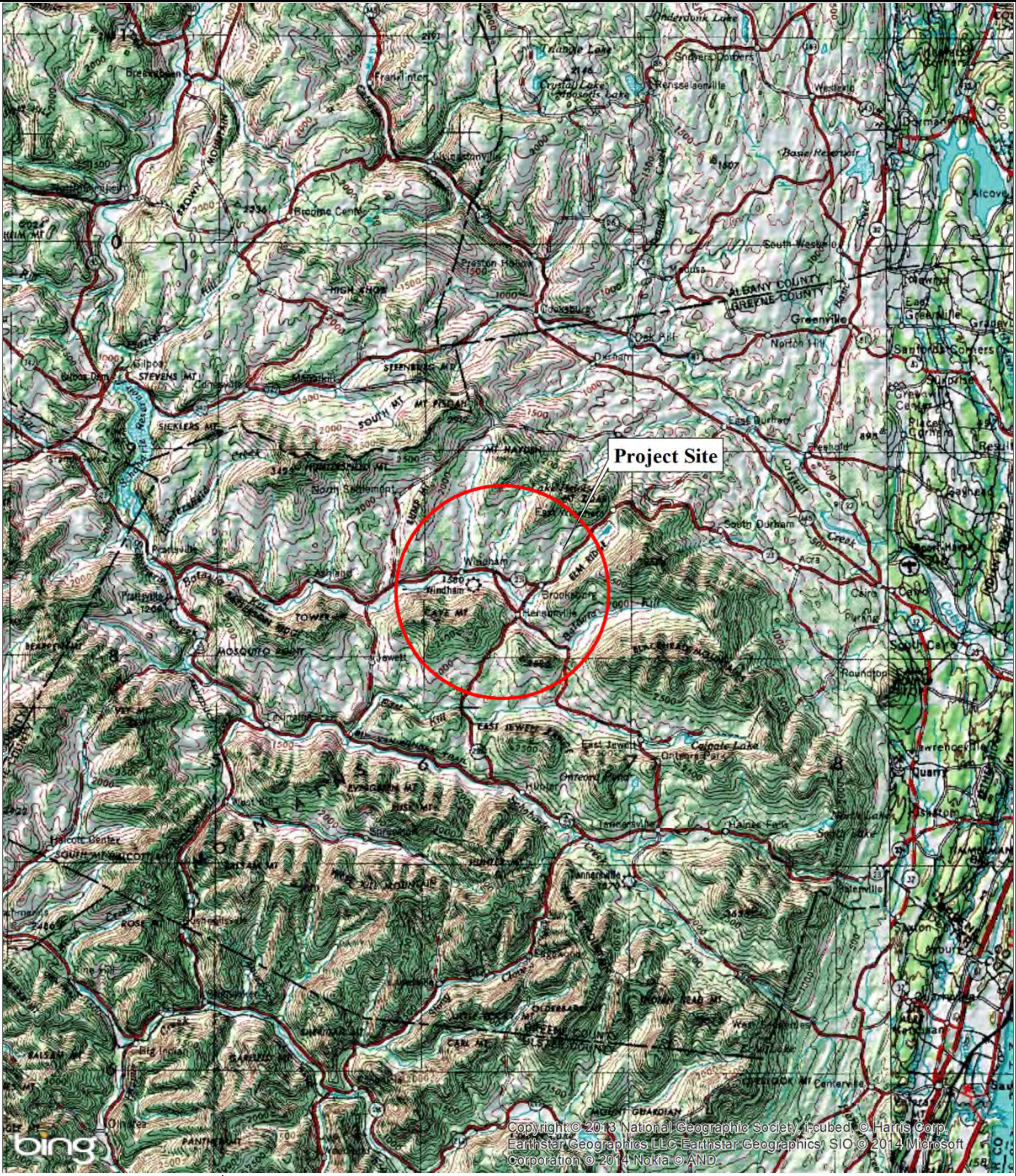
During the completion of this LFA, MMI worked closely with the Windham Flood Advisory Committee (FAC). The FAC is composed of Windham community members, business owners, and elected officials, as well as representatives from GCSWCD and the New York City Department of Environmental Protection. FAC members helped MMI to understand flood damages and impacts, vet flood mitigation alternatives, develop financial information for the benefit-cost analysis. The FAC will continue to plan an important role as the flood mitigation recommendations in this LFA are implemented.

A public meeting was convened in Windham on July 22, 2015, to share the results of this LFA and invite public feedback. A follow-up public meeting is scheduled for August 26, 2015.

1.2 Study Area

The study area along the Batavia Kill was chosen to coincide with the majority of the population areas in the town of Windham. The Batavia Kill is a tributary to Schoharie Creek, which discharges into the Schoharie Reservoir, a drinking water supply source of the New York City water system. The study area extends 8.8 stream miles along the Batavia Kill through the hamlets of Windham, Hensonville, and Maplecrest. The region was settled around 1780 and the town was formally established in 1798, originally as part of Ulster County before the formation of Greene County in 1800. The 2010 census reports a population of 1,703 in the town of Windham.

Figure 1-1 is a location plan of the study area. The upstream study area boundary is located at the CD Lane Park Dam. The downstream study area boundary is located downstream of the hamlet of Windham where the Batavia Kill flows past the Cave Mountain Motel. Flooding along the Batavia Kill was dramatically improved in terms of depths and velocities following construction of three upstream flood control dams in the 1960s and 1970s; however, flooding continues to occur during extreme events.



SOURCE(S):
USA Topo Maps
Copyright:© 2013
National Geographic Society, i-cubed

Figure 1-1: Location Plan

LOCATION:
Windham, NY

N

Local Flood Hazard Mitigation Analysis
Town of Windham along the Batavia Kill

MXD: Y:\2884-05\GIS\Maps\LocationMap.mxd

Map By: JEP
MMI#: 2884-05
Original: 8/7/2014
Revision: 9/15/2014
Scale: 1 inch = 20,000 feet

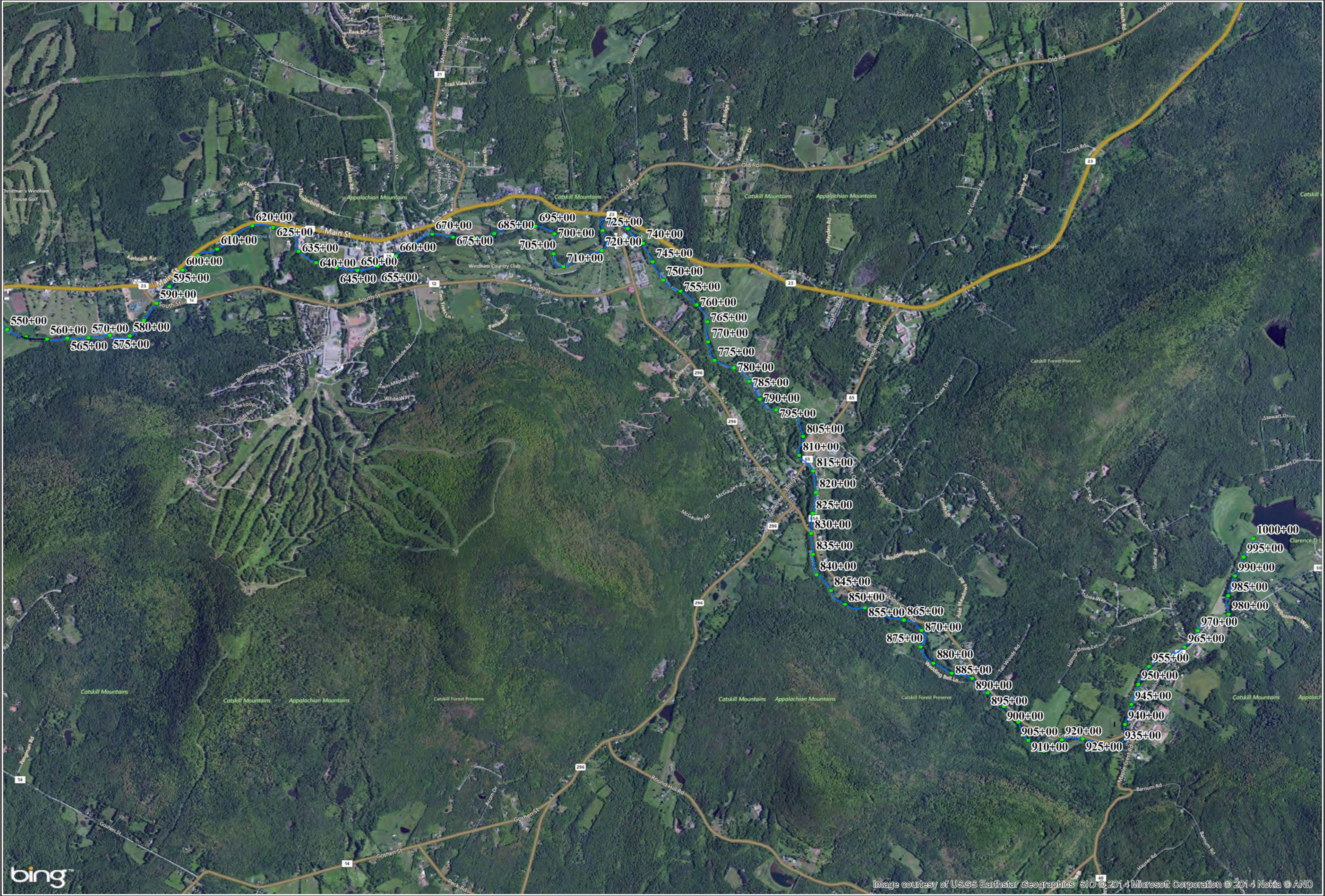
MILONE & MACBROOM
231 Main St, Suite 102
New Paltz, NY 12561 (845) 633-8153
www.miloneandmacbroom.com

1.3 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 mouth of the Batavia Kill at STA 0+00 (where it confluences with Schoharie Creek in Prattsville) and continuing upstream to STA 1278+00 at its headwaters. As an example, STA 73+00 indicates a point in the Batavia Kill channel located 7,300 linear feet upstream of its confluence with the Schoharie. A map showing the stream stationing for the study area is shown in Figure 1-2.

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 have a common standard, FEMA's National Flood Insurance Program has adopted a baseline probability called the base flood. The base flood has a one percent (one in 100) chance of occurring in any given year. For the purpose of this report, the one 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*** (0.5 percent annual chance flood).



Milone & MacBroom
231 Main St, Suite 102
New Paltz, NY 12561
(845) 633-8153
www.miloneandmacbroom.com

SOURCE(S):
Bing Maps Hybrid

Stream Stationing

Local Flood Hazard Mitigation Analysis
Town of Windham along the Batavia Kill

Windham, NY

Map By: JEP
MMI#: 2884-05
MXD: Y:\2884-05\GIS\Maps\Stationing.mxd
1st Version: 8/7/2014
Revision: 9/15/2014
Scale: 1 in = 2,000 ft

Figure 1-2

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 GCSWCD representatives. Appendix A includes a full listing of resource material gathered. A brief summary of key documents follows.

Flood Insurance Study (FIS)

Effective May 16, 2008, FEMA published a Flood Insurance Study (FIS) for all of Greene County that included the Batavia Kill watershed. 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. The county-wide study combines previous FISs of individual towns that were largely prepared during the 1980s, many of which had been prepared for FEMA by the U.S. Soil Conservation Service (now Natural Resource Conservation Service or NRCS).

FEMA's revised hydraulic analysis and floodplain mapping effective in May 2008 were completed several years earlier in 2004 using aerial topographic maps produced from 2001 photographs. 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 digital flood insurance rate map (DFIRM) depicts the entire length of Main Street in the hamlet of Windham as subject to flooding during the 100-year frequency event. The area predicted to be flooded during the 100-year frequency event is known as the special flood hazard area (SFHA).

Stream Management Plan

A detailed description of the Batavia Kill watershed and channel is contained in the 2003 Batavia Kill Stream Management Plan (SMP) prepared by GCSWCD, with the assistance of the New York City Department of Environmental Protection (NYCDEP). The report presents information on the watershed history, geography, flood history, floodplains, vegetation, land use, fisheries and wildlife, recreation, and water quality. The SMP also includes an inventory of five stream management segments that assess specific on-site conditions based upon field inspections and provide reach by reach recommendations. SMPs are also available for four major tributaries: West Kill, East Kill, Manor Kill, and Schoharie Creek. A digital copy of the Batavia Kill SMP is available at the website http://www.catskillstreams.org.

USGS Stream Gauging Network

The United States Geological Survey (USGS) operates and maintains stream flow gauges in the Batavia Kill watershed. 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 for Windham at *http://waterdata.usgs.gov/usa/nwis/uv?site_no=01349950*.

Multi-Jurisdictional Hazard Mitigation Plan

The Greene County Multi-Jurisdictional All-Hazard Mitigation Plan (HMP) provides a concise summary of the flood characteristics of Batavia Kill at Windham. The following recommendations for Windham are included in the HMP annex:

- Where appropriate, support retrofitting of structures located in hazard-prone areas to protect structures from future damage, with repetitive loss and severe repetitive loss properties as priority. Identify facilities that are viable candidates for retrofitting based on cost-effectiveness versus relocation. Where retrofitting is determined to be a viable option, consider implementation of that action based on available funding.

- Where appropriate, support purchase or relocation of structures located in hazard-prone areas to protect structures from future damage, with repetitive loss and severe repetitive loss properties as priority. Identify facilities that are viable candidates for relocation based on cost-effectiveness versus retrofitting. Where relocation is determined to be a viable option, consider implementation of that action based on available funding.

- As appropriate, support participation in incentive-based programs such as the Community Rating System (CRS).

- Continue to support the implementation, monitoring, maintenance, and updating of the HMP.

- Strive to maintain compliance with, and good standing in the National Flood Insurance Program (NFIP).

- Continue to develop, enhance, and implement existing emergency plans.

- Create/enhance/maintain mutual aid agreements with neighboring communities.

- Support County-wide initiatives.

- Continue to support the study of Mad (Pratt) Brook stream bank restoration alternatives.

- Perform a town-wide survey of road drainage and condition alternatives.

- Provide for emergency generators at Town of Windham emergency shelters. These shelters will be used in the event of evacuation of people within the inundation zone, associated with a flash flooding event resulting from a dam failure.

Water Quality Reports

New York State's 2012 Section 303(d) inventory lists Schoharie Reservoir as impaired and requiring a Total Maximum Daily Load (TMDL) assessment due to silt and sediment from streambank erosion. Batavia Kill was not specifically listed in the inventory. The Batavia Kill is, however, a source of silt and sediment to the Schoharie Reservoir.

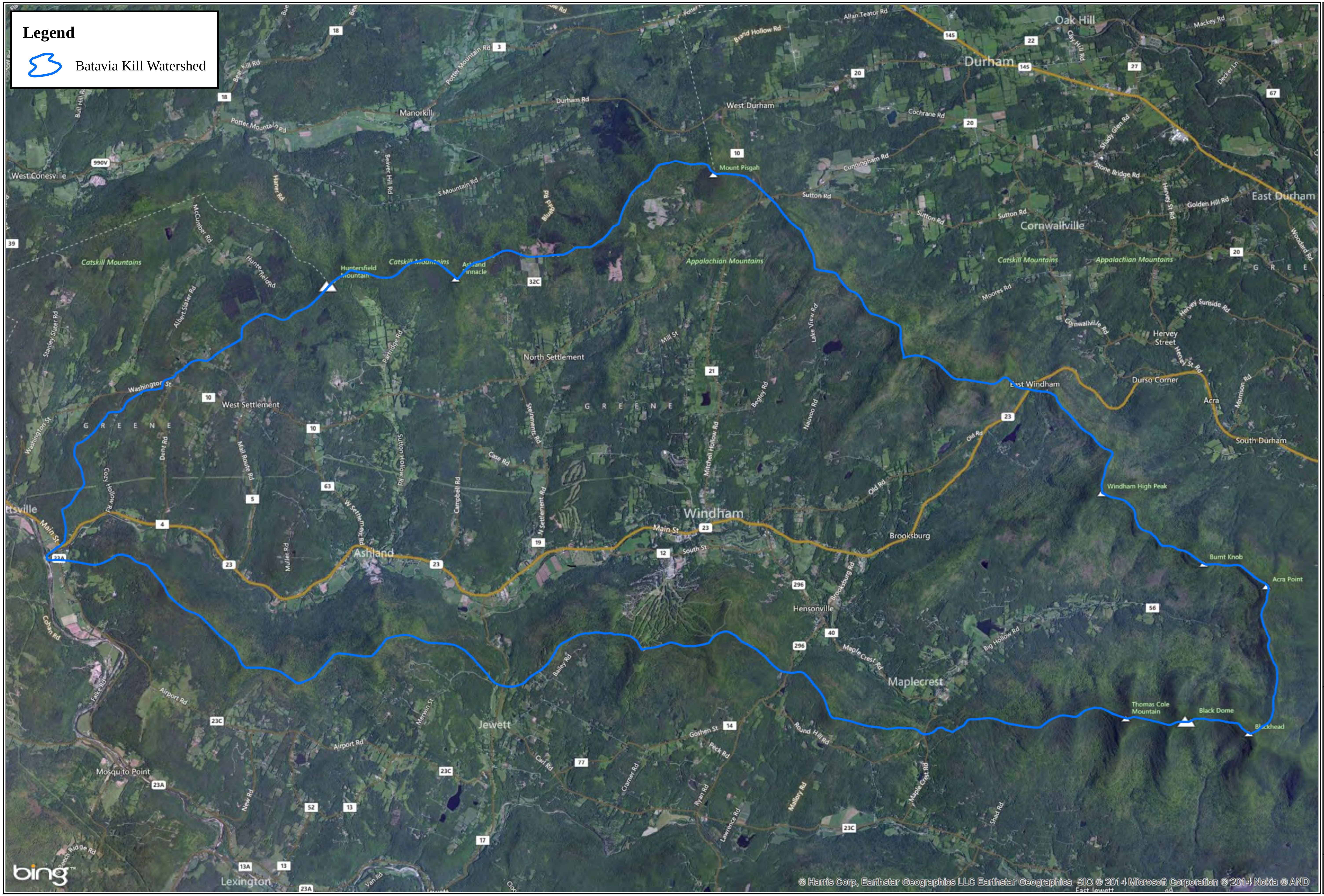
2.2 Field Assessment

Following Tropical Storms Irene and Lee, Milone & MacBroom, Inc. flood specialists and structural engineers conducted on-the-ground flood damage assessment and emergency response within the town of Windham, working under contract to the New York City Department of Environmental Protection. More recently, in June of 2014 and on subsequent visits to the watershed, MMI staff conducted visual inspections of the Batavia Kill channel and floodplain through the hamlets of Windham, Hensonville and Maplecrest, as well as a visual "windshield survey" of the contributing watershed and site conditions. The inspections included identification of low-lying structures, bank and channel conditions, and vegetation along the stream corridor. Channel reaches along the Batavia Kill were photo-documented. A photo log is included as Appendix B.

2.3 Watershed Land Use

Figure 2-1 is a watershed map of the Batavia Kill. The watercourse flows through the hamlets of Maplecrest (near STA 938+00), Hensonville (near STA 823+00), and Windham (near STA 662+00) within the town of Windham; through the hamlet of Ashland (near STA 369+00) within the town of Ashland; and through the hamlet of Red Falls (near STA 97+00) within the town of Prattsville. The Batavia Kill drains an area of 73.1 square miles and outlets into Schoharie Creek at a point 2.3 miles upstream of Schoharie Reservoir.

Since the early part of the 20th Century, the Batavia Kill drainage basin has undergone a gradual increase in forested land as agricultural lands were abandoned and open fields were encroached upon by woody vegetation (GCSWCD, 2003). The basin is now close to 90 percent forested (*StreamStats*, 2014) with a mix of residential and commercial land uses concentrated in and around the hamlets, rural residential uses outside of the hamlets, as well as agricultural uses located primarily in the river valley. Other land uses include golf courses and the Windham Ski Area. A portion of the watershed is located within the protected 700,000-acre Catskill State Park.



Milone & MacBroom
231 Main St, Suite 102
New Paltz, NY 12561
(845) 633-8153
www.miloneandmacbroom.com

SOURCE(S):
Bing Maps Hybrid

Watershed Map

Local Flood Hazard Mitigation Analysis
Town of Windham along the Batavia Kill

Windham, NY

Map By: JEP
MMI#: 2884-05
MXD: Y:\2884-05\GIS\Maps\Watershed.mxd
1st Version: 8/7/2014
Revision: 9/15/2014
Scale: 1 in = 6,000 ft

Figure 2-1

In the hamlet of Maplecrest, the Batavia Kill flows generally southwest from the CD Lane Park flood control project, then parallels Route 56 before crossing under Route 40. The watercourse bends sharply to the right and parallels Route 40, flowing in a northwesterly direction. The hamlet consists of residential homes, farms and small businesses, most of which are located along Route 56 and Route 40.

Downstream of Maplecrest, the Batavia Kill flows towards the hamlet of Hensonville, where it again passes under Route 40, then follows along Route 65A and crosses under Route 65. The hamlet of Hensonville is host to homes and small business concentrated around Route 296, Route 40 and Route 65.

Downstream of Hensonville, the Batavia Kill flows towards the hamlet of Windham, crossing under Route 296 before flowing across the Windham Country Club and entering the hamlet, where it parallels Route 23 flowing generally west and passing under Church Street and behind the Windham Ashland Jewett Public School. The hamlet of Windham includes commercial business concentrated along Route 23, with residential houses, farms and small business on the surrounding streets.

2.4 Watershed and Stream Characteristics

The watershed of the Batavia Kill is 73.1 square miles in size, asymmetrical in shape, with an east to west orientation. It has very steep, mountainous slopes, especially along its southern boundary where the watershed divide follows the summits of Patterson Ridge, Cave Mountain, and the Blackhead Mountains, which include some of the highest elevations in the Catskills. The Batavia Kill flows along the south side of the watershed, collecting the majority of its runoff from tributaries that originate in the northern part of the watershed, with only a few small watercourses entering from the south.

The watershed is underlain by unsorted glacial till with some areas of lacustrine clays along the valley floor. When exposed by the erosive action of the river, these lacustrine clays are mobilized, resulting in high turbidity and contributing to water quality issues. The underlying bedrock consists of grey sandstones and conglomerates underlain by red sandstone, red siltstone, red shale or mudstone (GCSWCD, 2003).

The total length of the Batavia Kill, from its headwaters on Blackhead Mountain to its outlet at Schoharie Creek, is 24.2 miles. The stream flows generally west with an average channel slope of 1.3 percent over its entire length. For much of its length the Batavia Kill 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. The Batavia Kill's channel bed sediments range in size from gravel to cobble. The river flows across exposed bedrock at several locations, for example at STA 909+00 in the hamlet of Maplecrest and at STA 100+00 at Red Falls.

For descriptive purposes, the Batavia Kill can be broken into three distinct sections. From its headwaters at STA 1278+00 downstream to the CD Lane Park Dam at STA 1000+00, the Batavia Kill flows through Big Hollow (shown on USGS maps as Black Dome Valley) and has a steep slope of 3.8 percent over a distance of 5.3 miles. This upper section of the watercourse is confined within the narrow, forested walls of Big Hollow, which rise steeply hundreds of feet above the channel along both banks. The watercourse here consists of a single channel with low sinuosity. The confining valley walls limit lateral movement of the channel during major flood events.

From the CD Lane Park Dam (STA 1000+00) downstream to the Ashland/Prattsville town line (STA 148+00), a distance of 16.1 stream miles that includes the study area, the Batavia Kill channel is much flatter, with an average slope of 0.6 percent. The valley bottom is generally broader through this section, leaving the channel less confined with wider areas of floodplain, and the channel is more sinuous with occasional lateral sediment bars. As the Batavia Kill approaches the hamlet of Windham, the channel is confined by very steep valley walls to the south (along the left bank) as it flows along the base of Cave Mountain in the area of the Windham Mountain Ski Area. Several tributaries enter the Batavia Kill from the more gently sloping northern part of the watershed, including the Lake Heloise tributary, Mitchell Hollow tributary, West Hollow Brook, Sutton Hollow tributary, and Lewis Creek.

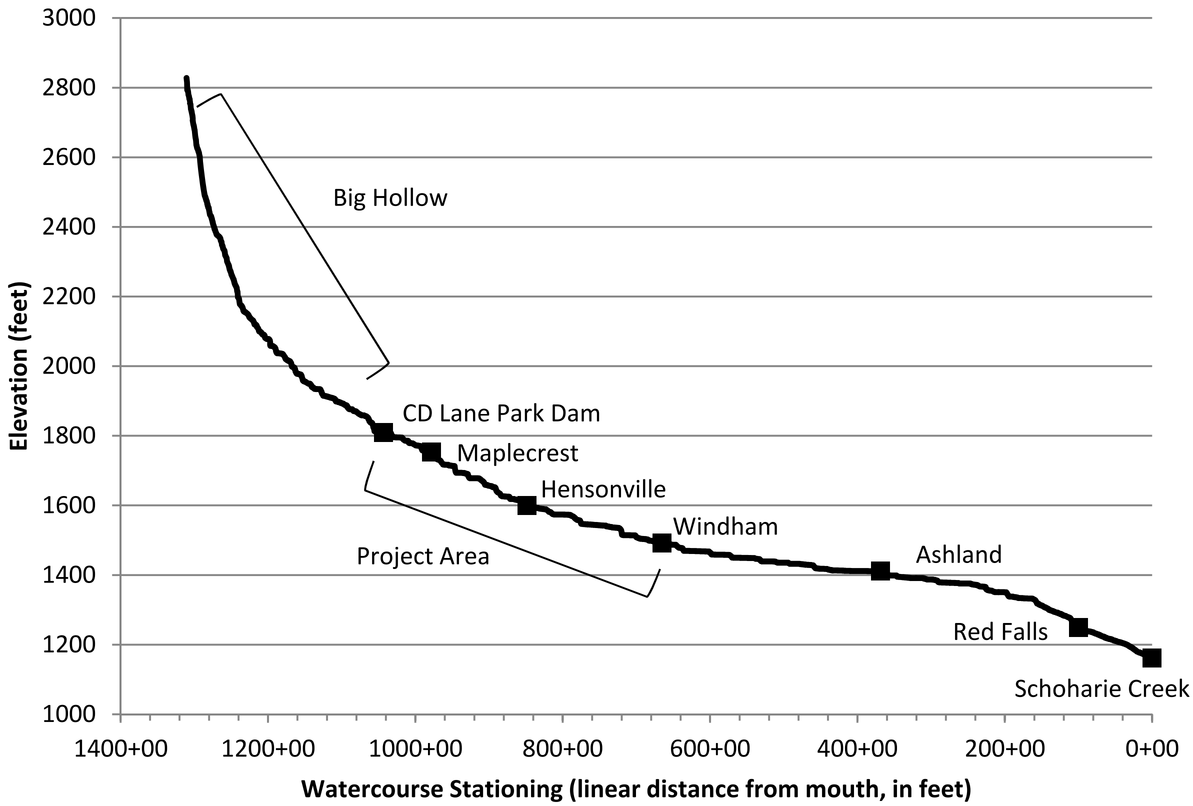
From the Ashland/Prattsville town line (STA 148+00) downstream to the outlet of the Batavia Kill at Schoharie Creek (STA 0+00), a distance of 2.8 miles, the channel steepens to a slope of 0.9 percent. Through this reach, the channel crosses exposed bedrock at Red Falls and is confined by the steep valley walls of Patterson Ridge on the left and Pratt Rocks on the right.

Figure 2-2 presents a profile of the Batavia Kill showing its elevation versus linear distance from its outlet at Schoharie Creek, as well as the locations of several hamlets, the CD Lane Park Dam, and Big Hollow. The watercourse drops a total of 1,667 vertical feet over its length, from an elevation of 2,828 feet above sea level at its headwaters on Blackhead Mountain to 1,161 feet at its outlet at Schoharie Creek.

2.5 Infrastructure

The Batavia Kill is crossed by nine bridges as it passes through the study area. While a number of these structures cannot pass 100-year flood flows, none of them appear to act as significant hydraulic constrictions in the 100-year event. This may be due to the fact that the channels are under-sized and/or the adjacent topography is so flat and low that the bridge is flanked or inundated rather than causing a backwater condition.

FIGURE 2-2
Batavia Kill Channel Profile



Flood profiles published in the FEMA FIS indicate that none of the bridges that span the Batavia Kill are inundated during the 100-year flood event. The 100-year flood event does bypass multiple bridges at the low lying areas on either side, including Slater Road (STA 967+00), Route 40 in Maplecrest (STA 937+50), Route 65 (STA 812+25), golf course bridge (STA 702+00), Route 79 (Church Street) (STA 658+25), and Route 12 (STA 590+00).

Table 2-1 lists the bridges and the stream station location of each. The bridges are listed from upstream to downstream. In all cases, the bridge deck is at a higher elevation than the FEMA 100-year flood elevation.

TABLE 2-1
Bridges Crossing the Batavia Kill in Study Area

Bridge Crossing	MMI Station	Predicted 100-Year WSEL	Bridge Deck Elevation
Slater Road	967+00	1782.69	1783.64
Route 40 in Maplecrest	937+50	1749.09	1752.87
Wedding Bell Lane*	894+00	1695.18	1701.32
Route 40 (Maplecrest Road)	829+50	1623.13	1625.82
Route 65	812+25	1606.75	1608.93
Route 296	733+00	1562.45	1581.27
Golf course bridge	721+00	1552.14	1561.03
Golf course bridge	702+00	1539.16	1543.24
Route 79 (Church Street)	658+25	1513.24	1519.78
Route 12	590+00	1480.24	1486.79

*Listed in FEMA study as Tall Woods Road

2.6 Hydrology

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 active and inactive (historic) USGS water surface stream gauging stations along the Batavia Kill. The only currently active gauge is USGS #01349950 at Red Falls, near STA 98+00, approximately 10.5 miles downstream of the study area.

TABLE 2-2
USGS Gauging Stations along the Batavia Kill

USGS Gauge Number	Location	Drainage Area (square miles)	Period of Record
01349840	Batavia Kill near Maplecrest	2.03	October 1997 to June 2009
01349850	Batavia Kill at Hensonville	13.5	August 1955 to July 2009
01349900	Batavia Kill near Ashland	51.2	April 1987 to June 2009
01349920	Batavia Kill at Ashland	62.0	October 1955 to December 1973
01349950	Batavia Kill at Red Falls*	68.6	January 1996 to present

* Currently active

The most current FEMA Flood Insurance Study that includes the town of Windham has an effective date of May 16, 2008, and covers all jurisdictions in Greene County.

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. The hydrologic analysis methods employed in the FEMA study followed the standardized regional regression equation procedure detailed by the USGS publication 90-4197, *Regionalization of Flood Discharges for Rural, Unregulated Streams in New York, Excluding Long Island*. This procedure relates runoff discharge to the mean annual precipitation and several other parameters based on watershed basin characteristics within a number of geographically distinct regions in New York State. The Greene County watersheds fall within USGS Region 4 for New York State. The parameters required for the Region 4 regression equations included mean annual precipitation, watershed area, and basin storage. Basin storage is defined by USGS as the percentage of the area within a watershed covered by lakes, ponds, or swamps (FEMA, 2008).

The Batavia Kill Flood Control District maintains and operates three large flood control dams in the Batavia Kill watershed. They were constructed by the U.S. Department of Agriculture NRCS following a 1960 flood. They are as follows:

- The largest of the three flood control dams is the CD Lane Park Dam (also known as the Batavia Kill Watershed Site 1 Dam), which was constructed in 1974 and is located on the Batavia Kill approximately 3.5 miles upstream of Hensonville at STA 1000+00.

- The Site 3 Dam was constructed in 1970 and is located on the Lake Heloise Tributary along Nauvoo Road, approximately one mile north of its confluence with the Batavia Kill at STA 727+00.

- The Site 4A Dam was constructed in 1967 and is located on Mitchell Hollow Creek at Siam Road, approximately 1.7 miles north of where it enters the Batavia Kill at STA 664+75.

The FEMA study accounted for the influence of the three flood control structures in its determination of the discharges reported in the FEMA Flood Insurance Study by using only the gauge data from 1975 and later (FEMA, 2008).

The pools created by the earth dams normally contain little water, providing "void" space that is used to temporarily detain floodwater. The dams each consist of an earth embankment, low level outlet pipe under the dam, and twin grass-lined emergency spillways for flows in excess of a 100-year flood event. All emergency spillways were active during Tropical Storm Irene, with variable levels of erosion.

Table 2-3 presents flood storage information on the three flood control dams. All three dams were inspected after Tropical Storm Irene and found to have been at full capacity, with active spillway usage. The dams performed as designed, storing 2.0 billion gallons of flood runoff. If this runoff had proceeded downstream over 12 hours during Tropical Storm Irene, it would have increased river flow rates by an estimated 6,150 cfs at the USGS stream gauge at Red Falls, a 13.9% increase over peak flows recorded at that gauge.

TABLE 2-3
Summary of Flood Control Dams in the Batavia Kill Watershed

Dam Site	Date Constructed	Height, ft.	Length, ft.	Total Storage Volume, Acre-Feet	Normal Storage, Acre-Feet	Drainage Basin, mi^2
#1 – CD Lane	1974	74	1,800	3,598	307	9.6
#3 – Nauvoo Road	1970	63	1,100	1,415	23	3.6
#4A – Siam Road	1967	57	1,400	2,928	43	6.8
			Totals	**7,941**	**373**	

The CD Lane Park dam has a small "normal" conservation pool used for fish, wildlife, and recreation. The total conservation storage at the three dams is reported to be 373 acre-feet, equal to 4.6 percent of the total storage. Had this additional volume been used for flood storage, it would have reduced peak flows at the USGS stream gauge at Red Falls by a potential 376 cfs, less than 1 percent of the total 44,200 cfs flood. Consequently, retaining the conservation pools at their normal storage levels does not have a significant effect on flood flows downstream. Table 2-4 lists peak discharges for the 10-, 50-, 100-, and 500-year flood events at various points along the Batavia Kill within the study area, as determined by FEMA and reported in the Flood Insurance Study (FEMA, 2008).

TABLE 2-4
Batavia Kill FEMA Peak Discharges (all flow values in cfs)

Location	MMI River Station	Drainage Area (sq. mi.)	10-year flood event	50-year flood event	100-year flood event	500-year flood event
Upstream of confluence with West Hollow Brook	513+00	54.06	6,970	12,120	14,770	23,130
Windham downstream corporate limits	553+50	41.55	5,490	9,570	11,690	17,630
Upstream of Mitchell Hollow Tributary	667+00	29.11	4,020	7,060	8,650	13,190

Upstream of Lake Heloise Tributary	728+00	24.30	3,530	6,260	7,710	11,880
Hensonville Gage (#01349850)	829+50	13.38	1,680	2,880	3,570	5,680

Hydrologic data on peak flood flow rates along the Batavia Kill are also available from the USGS *StreamStats* program. *StreamStats* is a web-based geographic information system (GIS) that is used to access streamflow statistics, drainage basin characteristics, and other information for selected sites on streams. Streamflow statistics include the 100-year and 500-year floods. Basin characteristics include drainage area, stream slope, mean annual precipitation and percentage of forested area.

Peak discharges for the 2- and 25-year flood events were determined using the *StreamStats* program and are reported in Table 2-5. Peak discharges for the 10-, 50-, 100-, and 500-year flood events were also determined using the *StreamStats* program and compared to those reported by FEMA. Discharges reported by FEMA are slightly (in the range of a few percentage points) higher than those determined using *StreamStats*. The FEMA discharges were used in this analysis for the 10-, 50-, 100-, and 500-year flood events because (a) they are more conservative; and (b) they are the jurisdictional standard.

TABLE 2-5
Batavia Kill *StreamStats* Peak Discharges

Location	MMI River Station	Drainage Area (sq. mi.)	2-year flood event	25-year flood event
Upstream of confluence with West Hollow Brook	513+00	54.0	3,040	11,300
Windham downstream corporate limits	553+50	41.8	2,470	7,440
Upstream of Mitchell Hollow Tributary	667+00	29.1	1,790	5,340
Upstream of Lake Heloise Tributary	728+00	24.3	1,530	4,550
Hensonville Gage (#01349850)	829+50	13.3	873	2,590

3.0 EXISTING FLOODING HAZARDS

3.1 Flooding History Along the Batavia Kill

Reports from the early part of the eighteenth century indicate that flooding has been an historic and ongoing problem along the Batavia Kill. There are reports of the Church Street bridge in the hamlet of Windham being washed away during a flood in 1893. According to the FEMA FIS, flooding can occur in any month of the year in Greene County. The majority of the larger floods have occurred in either late winter or early spring when snowmelt adds to heavy spring rains to produce increased runoff. Summer and fall floods also occur due to hurricane activity (FEMA, 2008).

As described in the Hazard Mitigation Plan for Greene County (Tetra-Tech, 2009), floods in the vicinity of the Batavia Kill have occurred in the years 1869, 1874, 1885, 1893, 1926, 1933, 1938, 1950, 1955, 1960, 1980, 1996 and 1999. During these floods, at least two lives were lost and millions of dollars in damages have occurred in the hamlet of Windham and surrounding areas. The flood event of September 1960, associated with Hurricane Donna, was considered at that time to be the most damaging on record within the watershed. This event reportedly produced over $750,000 in damages (1960 U.S. Dollars) to over 75 residences, 27 businesses, and state, county, and town roads and bridges throughout the watershed (Tetra-Tech, 2009).

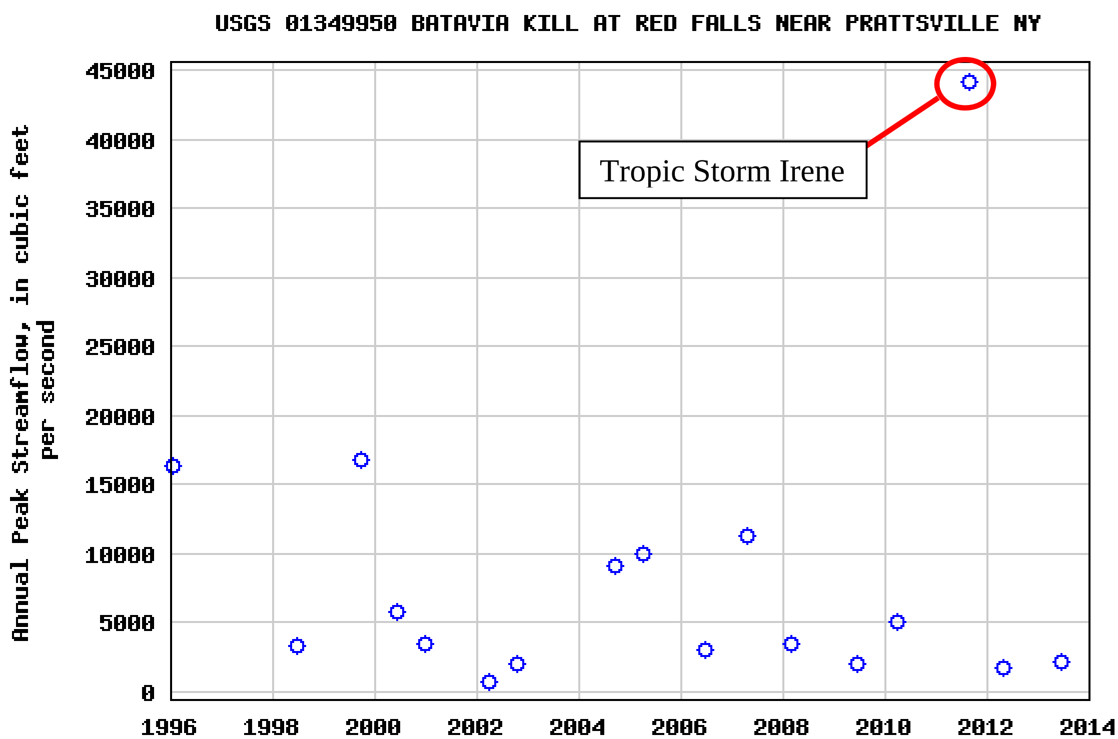
Flooding along the Batavia Kill was dramatically improved within the communities through which it flows following construction of the upstream flood control dams; however, flooding continues to occur during extreme events. According to municipal officials, residents, and published maps and reports, flooding and flood-related damages along the Batavia Kill have been most severe in the hamlet of Maplecrest parallel to Route 56 and Route 40; between the hamlets of Maplecrest and Hensonville along Route 40 downstream of Wedding Bells Lane; in the hamlet of Hensonville along Route 65A and Route 65; and in the downtown area of the hamlet of Windham along Route 23 (Main Street) and surrounding streets.

3.2 Tropical Storm Irene

In August 2011, Tropical Storm Irene caused extensive flooding and devastation in the eastern New York. The only active USGS gauge on the Batavia Kill during Tropical Storm Irene was gauge #01349950 at Red Falls, at STA 98+00, 10.5 miles downstream of the study area. Irene peaked at this location at 44,200 cfs. The FEMA Flood Insurance Study predicts the 100-year flood event at a point located 0.75 miles upstream of the Red Falls gauge to be 18,130 cfs, and the 500-year event to be 27,040 cfs. Therefore, peak flows at Red Falls during Tropical Storm Irene far surpassed FEMA's projected 500-year flood event and more than doubled the projected 100-year flood event.

Figure 3-1 presents annual peak flows recorded at USGS gauge #01349950 at Red Falls between 1996 and 2014.

FIGURE 3-1
Annual Peak Discharge
USGS Gauge #01349950 at Red Falls, at STA 98+00



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. The emergency spillways at each of the three flood control dams were active during the storm. Extensive bank erosion and flood-related damages to buildings and properties occurred along Route 56 and Route 40 through the hamlet of Maplecrest. A barn along Route 56 in Maplecrest near STA 974+00 was undermined by the high flows. In the vicinity of STA 886+00 downstream to STA 860+00, along Route 40 (Maple Crest Road) between Maplecrest and Hensonville, the channel appears to have avulsed (changed course) and homes were pushed off of their foundations along the right bank near STA 884+00. In the hamlet of Hensonville, homes and other structures were damaged along Route 65A and Route 65.

Upstream of the hamlet of Windham, the channel avulsed, causing extensive damage to the Windham Country Club, and washing out two bridges. Extensive flooding occurred within the hamlet when as much as four feet of water flowed down Route 23, damaging homes and businesses and tipping over cars and a school bus. Floodwaters moved at a high velocity, carrying debris, dumpsters and propane tanks and sweeping structures off of their foundations. The Church Street bridge overtopped and extensive property damage occurred at the Windham Ashland Jewett Public School. Further downstream, the lumber yard was flooded and suffered extensive damage and loss of inventory. Tropical Storm Irene was followed by precipitation from the remnants of Tropical Storm Lee, which caused additional flooding in the study area.

Table 3-1 presents estimated peak discharges at various locations along the Batavia Kill during Tropical Storm Irene.

TABLE 3-1
Estimated Peak Discharges
During Tropical Storm Irene (August 28, 2011)

Location	MMI River Station	Drainage Area (sq. mi.)	Tropical Storm Irene Discharge (cfs)
Upstream of confluence with West Hollow Brook	513+00	54.06	27,371
Windham downstream municipal limit	553+50	41.55	20,075
Upstream of Mitchell Hollow Tributary	667+00	29.11	17,611
Upstream of Lake Heloise Tributary	728+00	24.30	8,855
Hensonville Gauge (#01349850)	829+50	13.38	6,629

Note: Flows estimated based upon Red Falls USGS Gage data.

3.3 FEMA Mapping

FEMA Flood Insurance Rate Maps are available for the study area and depict the Special Flood Hazard Area, which is the area inundated by flooding during the 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).

FEMA mapping indicates that during a 100-year frequency event, waters from the Batavia Kill will overtop Route 56 (Big Hollow Road) near STA 965+00 and flood houses to the east of the Batavia Kill. Further downstream in the hamlet of Maplecrest, homes are predicted to flood in the vicinity of the intersection of Big Hollow Road and Maple Crest Road, near a bend in the watercourse at STA 935+00. Downstream of the bend in Maplecrest, the Batavia Kill flows generally northwest towards the hamlet of Hensonville. After flowing under Wedding Bells Lane at STA 894+00 the floodplain widens and floods an extensive area during the 100-year flood event. This flooding, which inundates multiple homes, occurs along the right bank between the Batavia Kill and Route 40 (Maple Crest Road) from STA 890+00 downstream to STA 837+00. The FEMA mapping indicates that during the 100-year flood event, waters overtop Route 40 in the vicinity of STA 856+00.

As the Batavia Kill flows to the east and north of the hamlet of Hensonville, FEMA mapping indicates that during the 100-year frequency event, floodwaters spread out extensively and flood several houses along the east side of Route 65A, and along Route 65 north to Elm Ridge Road (from STA 823+00 downstream to STA 808+00). This wide floodplain continues downstream of the Route 65 crossing to near the Route 296 crossing at STA 733+00, although land uses in this area consist primarily of forest and agricultural lands without structures. The Windham Country Club is also extensively flooded.

In the hamlet of Windham, FEMA mapping indicates that flooding during the 100-year event occurs from the confluence of the Lake Heloise Tributary at STA 727+00, downstream to the vicinity of Hickory Hill Road near STA 622+00. The 100-year flood event engulfs the entire downtown area of Windham to the north of Batavia Kill, including many homes, the fire station, churches and businesses along both sides of Route 23 (Main Street), Church Street, and several side streets. The Windham Ashland Jewett Public School (STA 649+00) is flooded, as well as a lumberyard (STA 632+00) and the country store (STA 628+00).

Downstream of the hamlet of Windham, flooding in the 100-year event occurs mostly to the south of Route 23 and includes several homes, the Chicken Run Restaurant and the wastewater treatment plant, all in the vicinity of the intersection of Route 23 and Route 12, near STA 590+00).

4.0 FLOOD MITIGATION ANALYSIS AND ALTERNATIVES

Specific risk areas along the Batavia Kill have been identified as being prone to flooding during severe rain events. 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 sections below describe these alternatives and their results. A benefit cost analysis was performed for those alternatives that showed the most merit for reducing flood levels. The results of the benefit cost analysis are summarized later in this report.

4.1 Analysis Approach

In order to develop hydraulic modeling to assess the alternatives, in June of 2014, MMI obtained the effective FEMA HEC-RAS model from NYCDEP. Hydraulic analysis of the Batavia Kill through the study area 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. 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.

HEC-RAS hydraulic modeling that was generated by FEMA in 2004 was used as a starting point for the current analysis. This “Duplicate Effective” model included the Batavia Kill from the CD Lane Park Dam downstream to its confluence with Schoharie Creek and is comprised of a total of 870 cross sections, including 27 lettered cross sections, A through AA. Table 4-1 presents a cross reference showing the FEMA lettered cross sections and their corresponding MMI stream station.

The FEMA model was truncated in order to focus on the relevant study area. The following revisions were made to the model to serve as the baseline for existing conditions and for evaluation of the effectiveness of flood mitigation alternatives.

- The model was truncated to extend only from the town of Windham municipal boundary upstream to the CD Lane Park Dam; beyond Windham was not simulated.

The model created for the study area comprised of 403 cross sections, including lettered cross sections M though AA.

- Key nodes were labeled so the profile is easier to read.
- The 2- and 25-year flood events were added to the flow profile.
- The Tropical Storm Irene discharge rate was added with flow files.

The HEC-RAS model was run and the resulting water surface elevations were compared to those published in the FEMA Flood Insurance Study and verified for accuracy. Model cross sections, Manning's 'n' coefficients, site conditions, and expansion/contraction coefficients were reviewed.

One important discrepancy was identified during the process of validating the FEMA model. The original model generated by FEMA contains two sets of hydrologic data. The two sets of tables contain the same flow rates for the 100-year flood event, but differ in their hydrologic change points (i.e., the locations along the watercourse at which flow rates increase as one moves downstream). MMI evaluated both sets of data and found that the hydrologic change points in one of the tables matched those described in the summary of discharges in Table 4 (on pages 13 and 14) of the Greene County, NY FEMA Flood Insurance Study (FIS). MMI used that table of hydrologic data in its hydraulic model. However, it appears that the version of the model used by FEMA to generate the Flood Insurance Rate Maps (FIRMs) and the water surface elevation tables and profiles in the FIS was run using the other table of hydrologic data, which do not match those described in the summary of discharges in the FIS. As a result, MMI's modeling results for existing conditions do not match the FEMA FIRMs and FIS.

As a result of this discrepancy, the FEMA FIRMs over-represent the area inundated during the 100-year flood event within the Town of Windham. MMI ran a Corrected Effective Model using the hydrologic data reported in Table 4 of the FIS.

TABLE 4-1
FEMA Cross Section Referenced to MMI Stream Stations

FEMA Lettered Cross Section	MMI Station	FEMA Lettered Cross Section	MMI Station
AA	991+66	T	734+37
Z	955+54	S	719+80
Y	924+96	R	656+55
X	890+35	Q	639+21
W	845+29	P	629+68
V	810+70	O	606+05
U	775+05	N	594+57

Replacement of bridges and modifications of the channel may have occurred subsequent to the survey for the FEMA model. While the model is sufficiently accurate for evaluation of flood mitigation alternatives and development of design concepts in the study area, more detailed, up-to-date survey will be required for permitting and engineering design of alternatives.

4.2 Existing Conditions Analysis

The HEC-RAS Corrected Effective Model was used as the existing conditions model to determine and evaluate a variety of high risk areas in the hamlets of Maplecrest, Hensonville, and Windham. Figures 4-1, 4-2, and 4-3 show the FEMA inundation areas, broken out by hamlet.

100-Year FEMA Floodplain Inundation Mapping - Maplecrest

Local Flood Hazard Mitigation Analysis
Town of Windham along the Batavia Kill

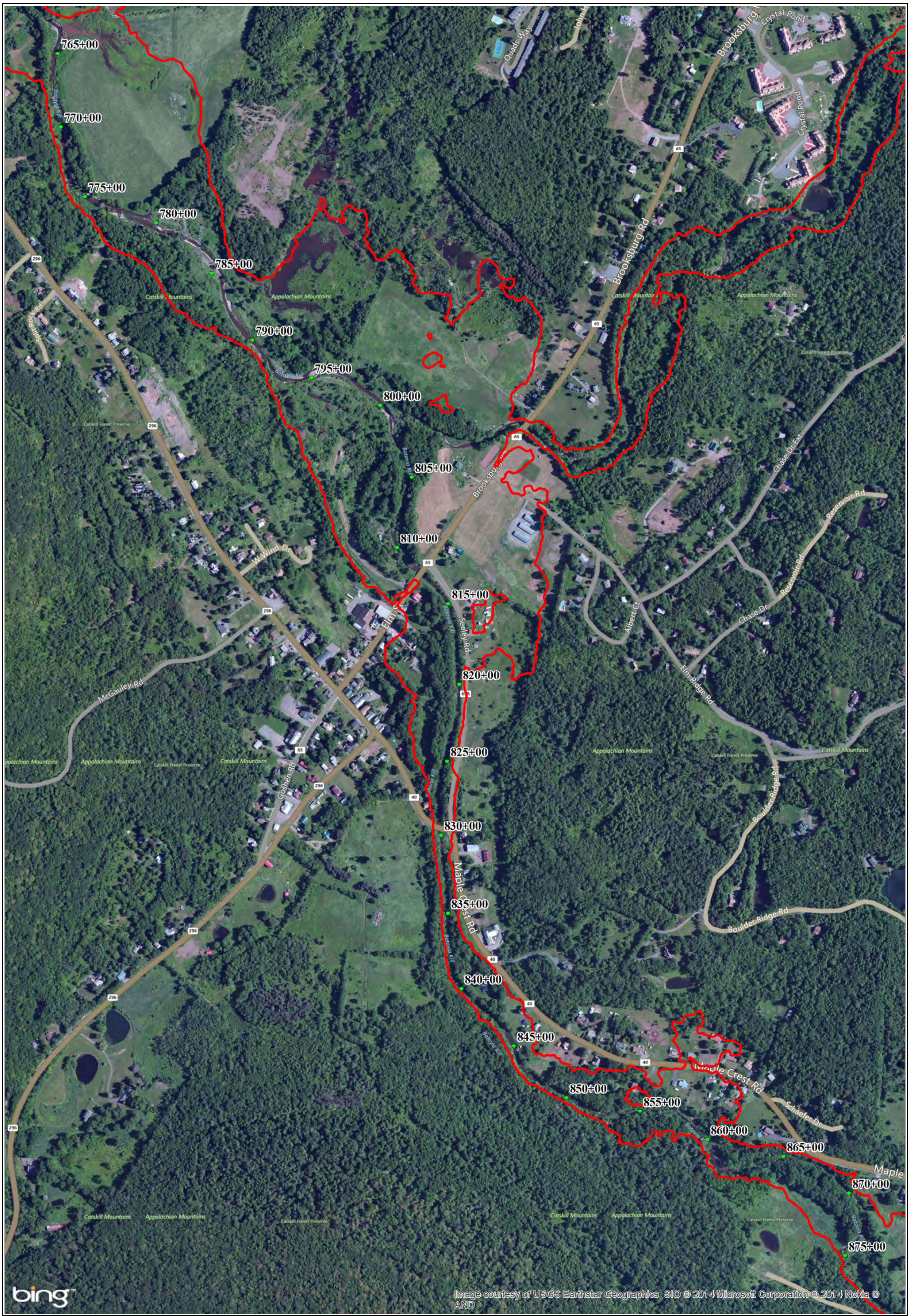
Windham, NY

SOURCE(S):
Bing Maps Hybrid
FEMA Flood Zones 2008

Milone & MacBroom
231 Main St, Suite 102
New Paltz, NY 12561
(845) 633-8153
www.miloneandmacbroom.com

Map By: JEP
MMI#: 2884-05
MXD: Y:\2884-05\GIS\Maps\FEMA Maplecrest.mxd
1st Version: 8/7/2014
Revision: 9/17/2014
Scale: 1 in = 600 ft

Figure 4-1



SOURCE(S):
Bing Maps Hybrid

FEMA Flood Zones 2008

Figure 4-2: 100-Year FEMA Floodplain Inundation Mapping - Hensonville

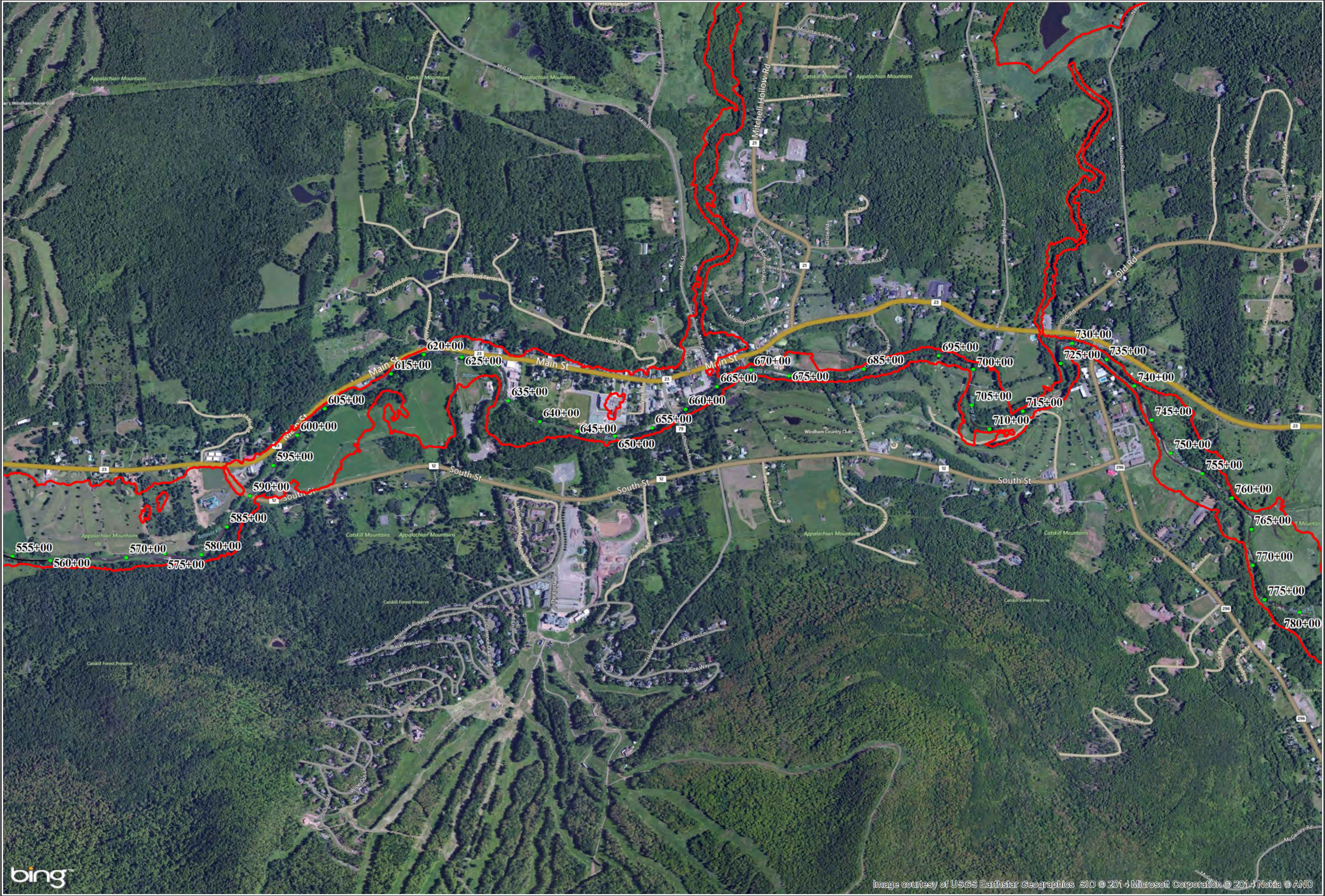
Location:
Windham, NY

N

Local Flood Hazard Mitigation Analysis
Town of Windham along the Batavia Kill

Map By: JEP
MMI#: 2884-05
MXD: Y:\2884-05\GIS\Maps\FEMA Hensonville.mxd
1st Version: 8/7/2014
Revision: 9/17/2014
Scale: 1 in = 550 ft

MILONE & MACBROOM
231 Main St, Suite 102
New Paltz, NY 12561 (845) 633-8153
www.miloneandmacbroom.com



MILONE & MACBROOM
231 Main St, Suite 102
New Paltz, NY 12561
(845) 633-8153
www.miloneandmacbroom.com

SOURCE(S):
Bing Maps Hybrid
FEMA Flood Zones 2008

100-Year FEMA Floodplain Inundation Mapping - Windham

Local Flood Hazard Mitigation Analysis
Town of Windham along the Batavia Kill

Windham, NY

Map By: JEP
MMI#: 2884-05
MXD: Y:\2884-05\GIS\Maps\FEMA Windham.mxd
1st Version: 8/7/2014
Revision: 9/17/2014
Scale: 1 in = 1,100 ft

Figure 4-3

For purposes of water surface elevation computations, the model was run in subcritical flow regime, which will tend to use slower velocities but higher water surface elevations, and also provides the worst case scenario for flood surface elevations.

Based on the existing conditions model, water surface elevations from Tropical Storm Irene were from approximately one to eight feet higher than 100-year flood event. Table 4-2 presents maximum, minimum, and average differences in water surface elevation HEC-RAS results in the Maplecrest, Hensonville and Windham hamlets, as well as in the town of Windham.

TABLE 4-2
Water Surface Elevation Increase of Tropical Storm Irene
Over Water Surface Elevations of the 100-year Flood Event

	Maplecrest Hamlet	Hensonville Hamlet	Windham Hamlet	Town of Windham
Maximum (ft)	5.6	5.0	7.8	7.8
Minimum (ft)	1.7	1.0	2.4	1.0
Average (ft)	3.3	2.5	4.5	3.7

While it is not possible to eliminate all flood prone properties from damages associated with extraordinary-magnitude flood events such as Irene, it is possible to reduce the amount of damage associated with large-scale, infrequent flood events, such as the 50- or 100-year events. It is also possible to significantly reduce flooding depths and flood-related damages associated with smaller, more frequent events.

4.3 Mitigation Approaches

A number of mitigation approaches have been evaluated for the Batavia Kill within the study area. These are introduced in a more global manner in this section and are evaluated in specific instances in the subsequent analysis.

4.3.1 Sediment Management

While large-scale deposition of sediment in the Batavia Kill channel was not evident during field investigations, local representatives report a sentiment that dredging will alleviate flooding along the Batavia Kill and should be pursued. The need for dredging can be reduced by reducing the sediment load at its source and by improving sediment transport through reaches that are vulnerable to deposition. The three flood control structures located in the upper watershed reduce sediment loading to the remaining system; however, sediments are likely to continue to be transported downstream to some extent regardless of what actions are taken to control the source in the upper reaches.

Dredging is often the first response to flooding. However, over-widening or over-deepening through dredging can initiate instability (including bed and bank erosion), foster poor sediment transport, and not necessarily provide significant flood mitigation. Sediment removal can further isolate a stream from its natural floodplain, disrupt sediment transport, expose erodible sediments, cause upstream bank/channel scour, and encourage additional downstream sediment deposition. Improperly dredged stream channels often show signs of severe instability, which can cause larger problems after the work is complete. Such a condition is likely to exacerbate flooding on a long-term basis.

4.3.2 Levee Construction

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 the town of Windham, peak flows in the Batavia Kill were twice the 100-year storm flows during Tropical Storm Irene. Under this scenario, it is likely that floodwaters would have overtopped a levee designed to protect structures and properties from flooding during the 100-year flood event. 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 Flood Insurance Rate Maps.

4.3.3 Natural Channel Design and Floodplain Enhancement

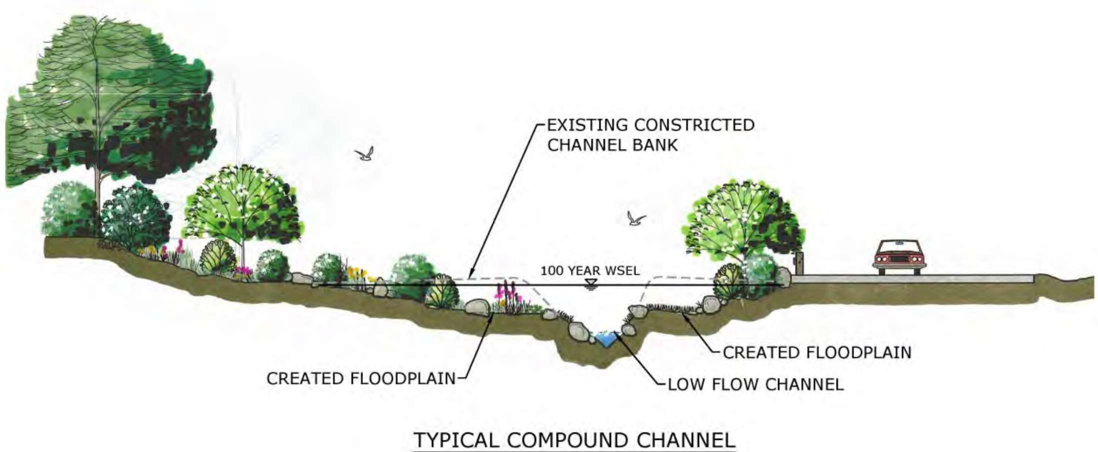
Historic settlement and human desire to build near water has led to centuries of development clustered along the banks of rivers all over the nation, including along the Batavia Kill. Dense development and placement of fill in the natural floodplain of a river can severely hinder a river's ability to 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.

Natural channels are typically comprised of a compound channel whereby normal flow is conveyed in a low flow channel that is flanked by active floodplain, which is ideally a vegetated, undeveloped corridor at a slightly higher elevation that is able to convey high flows. Although rivers in their natural setting seem to be at their low-flow stage most often, the entire flood-prone corridor is part of the river, and the importance of the floodplain only becomes evident on rare, but extreme occasions.

The natural floodplain along the Batavia Kill, in some locations, has been built upon and in other locations has been filled. 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 4-4 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 4-4
Typical Cross Section of a Compound Channel



4.4 High Risk Areas

For analysis purposes, the Batavia Kill corridor has been divided into High Risk Areas (HRAs) #1 through #4 from upstream to downstream as follows:

- High Risk Area #1 – Hamlet of Maplecrest (STA 975+00 to STA 925+00)
- High Risk Area #2 – Between Hensonville and Maplecrest (STA 890+00 to STA 837+00)
- High Risk Area #3 – Hamlet of Hensonville (STA 825+00 to STA 805+00)
- High Risk Area #4 – Hamlet of Windham (STA 680+00 to STA 625+00)

Various alternatives have been evaluated in each risk area to understand the potential for flood mitigation. These are presented in the sections that follow. Alternatives have been initially assessed for a variety of flow events, with the goal of protection against the 100-year event, recognizing that the flows caused by Tropical Storm Irene were extremely rare and protection against such events is likely to be cost prohibitive. In some instances, there may be merit to undertaking flood mitigation measures that protect against lower frequency storm events to minimize frequent nuisance flooding.

4.5 High Risk Area # 1 – Hamlet of Maplecrest (STA 975+00 to STA 925+00)

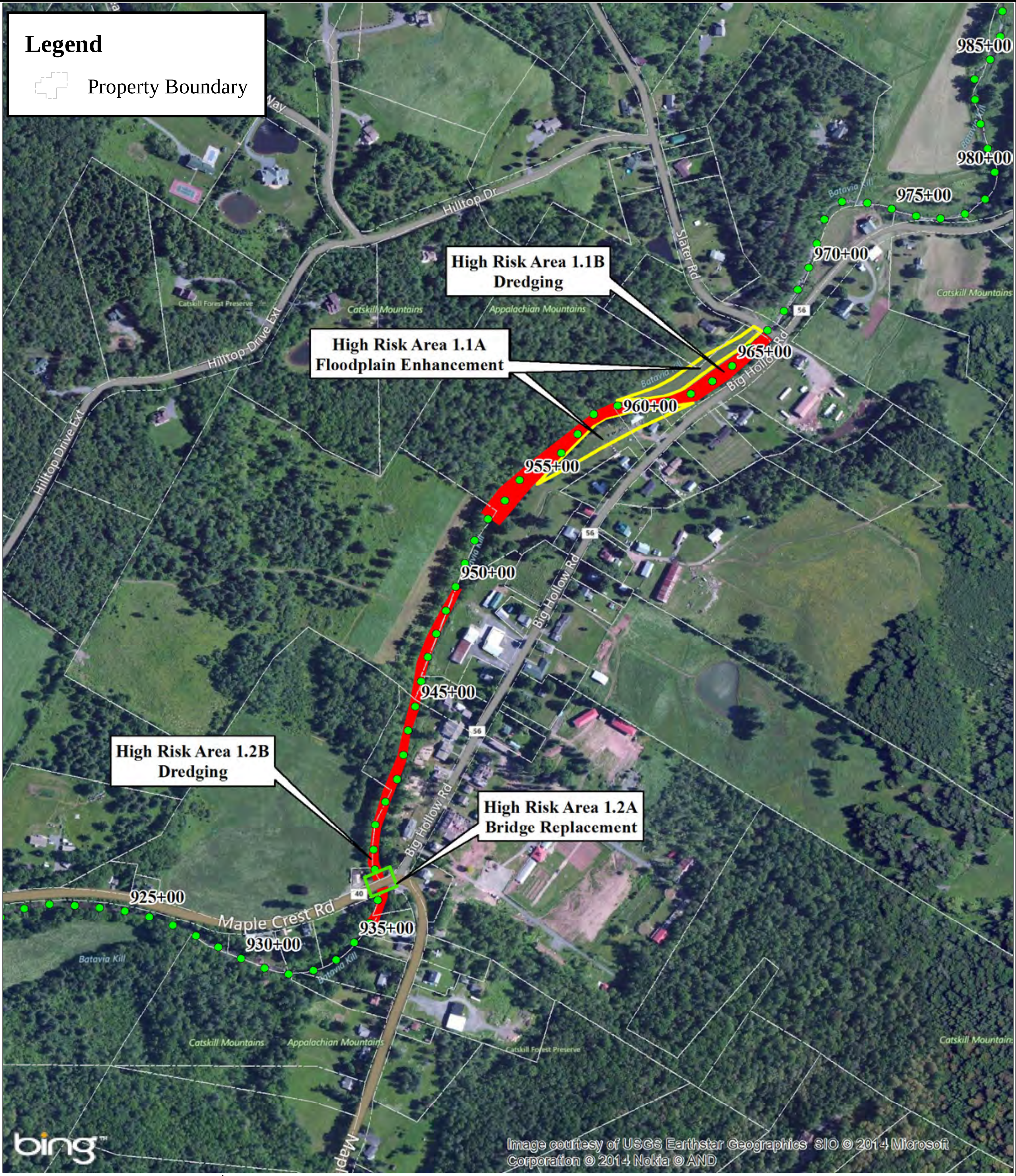
Figure 4-5 is a location plan of High Risk Area #1. During the 100-year frequency event, flooding in this reach occurs along Route 56 (Big Hollow Road) near STA 965+00. Structures are vulnerable to flooding along the left bank (east side) of the Batavia Kill. FEMA mapping indicates that the boundary of the 100-year floodplain runs closely behind several homes, the firehouse, and a building associated with the Maplecrest Church. Homes further downstream near the intersection of Big Hollow Road and Route 40 (Maple Crest Road) are flooded during the 100-year event. MMI's Corrected Effective Model shows a somewhat less expansive area of flooding during the 100-year event. Field investigations indicate that the channel and natural floodplain through this area are undersized due to encroachment and development, primarily along the left bank.

Table 4-3 lists flood prone properties within High Risk Area #1. All parcels with structures that are partially or entirely within the FEMA 100-year floodplain are included. A total of eight properties are included, some of which only have out-buildings located in the floodplain, as opposed to habitable structures. Using MMI's Corrected Effective Model, some of the homes listed below fall just outside of the 100-year floodplain but may still be subject to flooding during floods exceeding the 100-year event.

TABLE 4-3
Flood Prone Properties with Structures in High Risk Area #1

MMI Station	Parcel ID	Address	FEMA Flood Zone
974+00	114.00-1-42	128,136 & 141 County Rt 56	Barn is in 100-year floodplain
963+00	114.01-2-12	102 County Rt 56	Front of house in 100-year floodplain
961+00	114.01-2-13	96 County Rt 56	Edge of house in 100-year floodplain
961+00	114.01-2-6	97 County Rt 56	House in 100-year floodplain; rear structure in 100-year floodplain and partially in floodway
955+00	114.01-2-5	81 County Rt 56	Edge of house in 100-year floodplain
938+00	113.02-2-3	479 & 480 County Rt 40	Barn was in 100-year floodplain, now demolished
933+00	113.02-2-2	470 County Rt 40	Structures in 100-year floodplain

931+00	113.02-2-1	464 County Rt 40	Structures in 100-year floodplain



SOURCE(S):
Bing Maps Hybrid

Figure 4-5: Location Map - High Risk Area #1

LOCATION:
Windham, NY

N

Local Flood Hazard Mitigation Analysis
Town of Windham along the Batavia Kill

MXD: Y:\2884-05\GIS\Maps\Fig4-5.mxd

Map By: JEP
MMI#: 2884-05
Original: 9/15/2014
Revision: 9/17/2014
Scale: 1 inch = 500 feet

MILONE & MACBROOM
231 Main St, Suite 102
New Paltz, NY 12561 (845) 633-8153
www.miloneandmacbroom.com

Alternative 1.1A – Floodplain Enhancement – Downstream of Slater Road (STA 967+00 to STA 955+00)

In this alternative, left bank and right bank flood benches were analyzed along a 1,200 linear foot reach of channel. Flood benches are higher than the normal “wet” channel but are lower in elevation than the corresponding land to provide an active flow area during high stream flow events. The modeled flood benches occur from STA 963+00 to STA 955+00 on the left bank and from STA 967+00 to STA 960+00 on the right bank.

The floodplain excavation under this alternative would remove approximately 5,000 cubic yards of material. Two existing structures located near the left bank of the river near STA 961+00 would also need to be removed under this alternative. This includes a house that is located in the FEMA 100-year floodplain, and an associated outbuilding that is also in the 100-year floodplain and partially in the FEMA floodway. The close proximity of the Route 56 roadway embankment limits the extent of floodplain excavation along the left bank, where overtopping of the roadway is known to occur.

Model results indicate that this alternative reduces water surface elevations in the range of 1.0 to 1.5 feet, enough to contain the 100-year flood event within the newly created floodplain area and prevent water from flooding Route 56. However, it only minimally reduces flooding of homes along Route 56. This alternative does not reduce water surface elevations at homes and other structures in the vicinity of the intersection of Big Hollow Road and Maple Crest Road, near a bend in the watercourse at STA 935+00.

Modeled existing conditions water surface elevations during the 100-year flood event are shown in Figures 4-6. Proposed conditions water surface elevations for the 100-year flood event are shown in Figure 4-7, with Alternative 1.1A in place.

Alternative 1.1A 100-Yr Existing

TOWN OF WINDHAM LFA
HAMLET OF MAPLECREST
WINDHAM, NEW YORK

SOURCE(S):
NYS GIS Sever 2013 Aerial Imagery

MILONE & MACBROOM
231 Main Street, Suite 102
New Paltz, New York 12561
(845) 633-8153
www.miloneandmacbroom.com

Map By: V. Bevan
MMI#: 2884-5
MXD: Windham_HRA1_1.1
1st Version: 3/25/2015
Scale: 1 in = 167 ft

Fig. 4.6

MILONE & MACBROOM
231 Main Street, Suite 102
New Paltz, New York 12561
(845) 633-8153
www.miloneandmacbroom.com

SOURCE(S):
NYS GIS Sever 2013 Aerial Imagery

Alternative 1.1A 100-Yr Proposed

TOWN OF WINDHAM LFA
HAMLET OF MAPLECREST
WINDHAM, NEW YORK

Map By: V. Bevan
MMI#: 2884-5
MXD: Windham_HRA1_1.1
1st Version: 3/25/2015
Scale: 1 in = 167 ft

Fig. 4.7

Alternative 1.1B – Dredging Downstream of Slater Road (STA 970+00 to STA 953+00)

Dredging of this reach of river was also evaluated along 1,700 linear feet of channel by an average depth of three feet, starting at the downstream face of Slater Road. The total volume of excavation would be 7,704 cubic yards. Dredging would lower water surface elevations for the 100-year flood by approximately the same amount as the depth of bed lowering. It does not impact water surface elevations upstream of Slater Road. This alternative would provide mitigation benefits similar to Alternative 1.1A, but at an order of magnitude higher cost and with potential streambed and bank instability as well as funding and permitting challenges.

Alternative 1.2A – Bridge Replacement – County Route 40 (STA 937+50)

During the 100-year frequency event in the hamlet of Maplecrest, homes are flooded in the vicinity of the intersection of Big Hollow Road and Maple Crest Road near a bend in the watercourse at STA 935+00. Channel hydraulics were evaluated to determine whether the size or configuration of the bridge is contributing to flooding in this area.

Bridge widening on the eastern bank would involve the removal of a structure as well as the reconstruction of the intersection. Widening to the western bank would be intrusive to the neighboring properties.

To determine if the existing bridge is creating a hydraulic constriction, this alternative evaluated widening of the bridge from 44 feet to a 75 foot span. Modeling was conducted with the roadway raised along the right (western) bank from one to three feet higher for a length of several hundred feet in an attempt to cut off a low-lying area prone to flooding. The proposed changes had minimal impact on the flood prone areas, minimally reducing water surface elevations upstream by approximately 0.5 feet. This reduction does not successfully remove any flood prone structures from the floodplain, nor does it prevent the bridge from being flanked by floodwaters. Due to the close proximity of houses to the Batavia Kill in this area, any floodplain creation would require the removal of the same houses that are in need of protection and thus negates the merit of such an alternative.

Alternative 1.2B – Dredging Upstream and Downstream of Big Hollow Road and Maple Crest Road

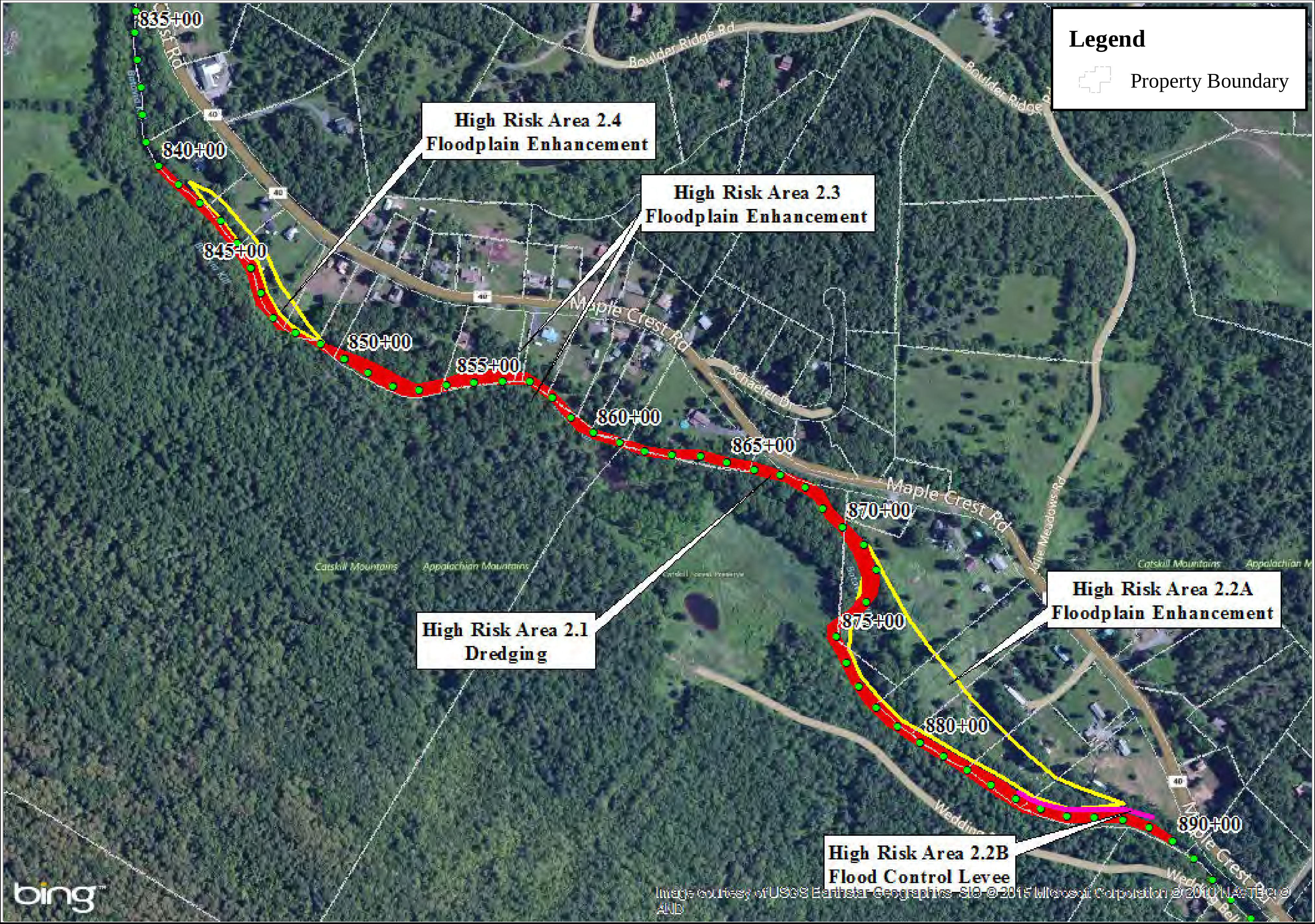
Dredging was considered for this 1,400-foot reach. The river slope along this reach is uniform and contiguous with the upstream and downstream reaches. As such, dredging would be akin to digging a bowl or a bathtub through this reach and is not a viable or sustainable flood mitigation option. Additionally, the bridge at County Route 40 would likely require replacement, in that dredging is likely to undermine its foundation.

Alternative 1.3 – Strategic Acquisition of Repetitive Loss Properties

For homes and associated structures listed in Table 4-3 that have been repeatedly subject to flooding damages, strategic acquisition, either through a FEMA or NYCDEP acquisition program or other governmental programs, may be a viable alternative where property owner interest exists. There are a number of grant programs that make funding available for property acquisition. Such properties could be converted to passive, non-intensive land uses.

4.6 High Risk Area #2 – Between Hensonville and Maplecrest (STA 890+00 – 837+00)

Figure 4-8 is a location plan of High Risk Area #2. After flowing under Wedding Bells Lane at STA 894+00, the floodplain of the Batavia Kill widens and floods an extensive area during the 100-year flood event, including homes located along the right bank between the Batavia Kill and Route 40 (Maple Crest Road) from STA 890+00 downstream to STA 837+00. Floodwaters overtop Route 40 in the vicinity of STA 856+00 and floods dwellings along the north side of the road. During Tropical Storm Irene, homes along the channel in this area suffered extensive damage. Field investigations indicate that development of homes has occurred within the low-lying, natural floodplain of the Batavia Kill.



SOURCE(S):
Bing Maps Hybrid

N

MXD: Y:\2884-05\GIS\Maps\Fig4-6.mxd

Figure 4-8: Location Map
High Risk Area #2

Local Flood Hazard Mitigation Analysis
Town of Windham along the Batavia Kill

LOCATION: Windham, NY

Map By:	JEP
MMI#:	2884-05
Original:	9/17/2014
Revision:	9/15/2014
Scale:	1 in = 450 ft

MILONE & MACBROOM
231 Main St, Suite 102
New Paltz, NY 12561 (845) 633-8153
www.miloneandmacbroom.com

Following Tropical Storm Irene, GCSWCD oversaw mitigation efforts along this reach of the Batavia Kill, as described in a report entitled *Hensonville Debris Removal Project on the Batavia Kill – Implementation Report* (GCSWCD, 2012). The work included the following components:

- Removal of flood-borne debris from the channel and floodplain.
- Excavation of deposited sediment in the active channel to restore a unified flow path.
- Grading of banks to achieve stable bank geometry.
- Repair of a nearby access road to the town of Windham Landfill.
- Application of seed and mulch to disturbed areas.

Table 4-4 lists flood prone properties within High Risk Area #2. The table includes all parcels that contain structures partially or entirely within the FEMA 100-year floodplain. A total of 13 properties are included in this reach, two of which only have out-buildings in the floodplain, as opposed to habitable structures. Using MMI's Corrected Effective Model, some of the homes listed below fall just outside of the 100-year floodplain but may still be subject to inundation during floods exceeding the 100-year event.

TABLE 4-4
Flood Prone Properties with Structures in High Risk Area #2

MMI Station	Parcel ID	Address	FEMA Flood Zone
887+00	113.00-2-25	246 & 262 County Rt 40	Rear structure in 100-year floodplain
877+00	113.00-1-17	200,212-# 1&2 County Rt 40	Multiple structures in 100-year floodplain
860+50	113.00-1-6	152 County Rt 40	Dwelling and outbuildings in 100-year floodplain
859+50	113.00-1-5	146 County Rt 40	Dwelling and outbuildings in 100-year floodplain
858+50	96.18-2-23.1	140 County Rt 40	Dwelling and outbuildings in 100-year floodplain
857+00	96.18-2-23.2	136 County Rt 40	Dwelling and outbuildings in 100-year floodplain
859+50	96.18-2-21	147 County Rt 40	Dwelling in 100-year floodplain
858+50	96.18-2-20	143 County Rt 40	Dwelling in 100-year floodplain
857+50	96.18-2-19	135 County Rt 40	Dwelling in 100-year floodplain
856+50	96.18-2-18	131 County Rt 40	Dwelling in 100-year floodplain
854+00	96.18-2-25	126 County Rt 40	Dwellings in 100-year floodplain
845+00	96.18-2-11	92 County Rt 40	Dwelling in 100-year floodplain
843+50	96.18-2-10	86 County Rt 40	Dwellings in 100-year floodplain

Alternative 2.1 – Channel Dredging – Wedding Bells Lane Downstream to Route 65A (STA 890+00 to STA 840+00)

Downstream of Wedding Bells Lane, the floodplain of the Batavia Kill widens, especially on the right bank along Route 40 (Maple Crest Road). Flooding of structures occurs along the right bank. The hydraulic performance of the stream channel with the removal of 3 to

5 feet of bed material was assessed. The model included increased bed roughness and bank roughness to reflect bed and bank armoring, which would be required to protect against increased velocities. Construction of grade control structures to stabilize the steeper bed and prevent head cuts would also be required under this alternative.

Dredging 5,000 linear feet of channel by an additional 3 to 5 feet would generate approximately 27,000 cubic yards of sediment. Given the assumptions listed below, approximately 15 weeks of full time sediment hauling would result.

- each dump truck carries approximately 15 cubic yards of material
- approximately 20 minutes is required to load each truck
- one-way travel to a disposal site is 20 minutes
- three separate trucks can run simultaneously
- construction occurs 8 hours per day
- construction is active five days per week
- 24 loads per day at 15 CY each yields 360 CY per day

While this alternative would reduce flood elevations and inundation, it would result in a highly modified, unnatural reach of channel; would require large amounts of bank and bed armoring and grade control; would require periodic re-dredging; and is not considered to be long-term sustainable solution. Additionally, this alternative would be difficult to construct; would more than double flow velocities; and would leave the channel more vulnerable to erosion and instability. A compounding factor would be the potential undermining of the upstream Wedding Bells Lane bridge as a result of headcutting.

An alternative approach to dredging is to maintain existing channel depth and explore floodplain enhancement alternatives as discussed in subsequent alternatives.

Alternative 2.2A – Floodplain Enhancement – Downstream of Wedding Bells Lane (STA 888+00 to STA 870+00)

After flowing under the Wedding Bells Lane bridge at STA 894+00, the Batavia Kill floodplain valley widens, expanding to include an extensive area along the right bank during the 100-year flood event. Homes built in the floodplain along Route 40 are subject to inundation. Residential development is low-lying and located in the floodplain. These homes have as little as five feet grade change relative to the stream bed and are very vulnerable to flooding.

Floodplain enhancement was modeled for 1,700 linear feet of channel along the right bank of the Batavia Kill, between STA 888+00 and STA 870+00. Modeling of this alternative indicates that it would be effective in reducing the water surface elevations during a 100-year event by approximately 1.0 to 1.5 feet. During the 100-year flood event, this reduction would result in the elimination of flooding of structures on two properties that currently fall within the FEMA 100-year floodplain, including an outbuilding located on a property at STA 887+00, and multiple structures on a property at STA 877+00.

This alternative would require the removal of approximately 29,000 cubic yards of material, with a cost likely to be in excess of $500,000. The benefit would be removal of two homes and several outbuildings from the floodplain.

Alternative 2.2B – Flood Control Levee – Downstream of Wedding Bells Lane (STA 889+00 to STA 884+00)

Creation of a levee in the general vicinity of Alternative of 2.2A was also evaluated. Starting at STA 889+00, construction of 500 linear feet of levee along the right bank was assessed, beginning 500 feet downstream of Wedding Bells Lane.

The model indicates that a levee will increase water surface elevations and velocities, but would contain the 100-year flows to protect approximately two properties. This alternative would require raising the existing berm by three to four feet in height and constructing the entire structure to FEMA standards. The result would be the protection of two nearby structures.

There are a number of risks associated with levee construction, including most notably the risk of levee overtopping during a flood that exceeds the design storm, such as the case during Tropical Storm Irene. If areas upstream of the levee (i.e. Wedding Bells Lane bridge) were to overtop, flood waters could get behind the levee and flood the protected area. The cost of this alternative relative to the small number of structures that would benefit from it, coupled with the risk of levee overtopping, are not a desirable combination

Alternative 2.3 – Floodplain Enhancement – Near Schaeffer Road (STA 860+00 to STA 850+00)

This reach of channel has multiple flow paths through the left bank floodplain, showing signs of previous debris jams and avulsions. Homes that were constructed along the right bank in the floodplain on the south side of Route 40 are subject to inundation and flood damage.

This alternative involves floodplain benches on both banks of the river. In order to achieve appreciable flood mitigation in this reach, the water surface elevations immediately downstream must be lowered. Therefore, this alternative was assessed only in combination with Alternative 2.4.

The left bank contains mature woody vegetation but is not as steep or as high as in the next reach directly downstream. Therefore, this alternative considered floodplain enhancement along both banks over a 1,100 linear foot reach of channel, on the right bank between STA 860+00 and STA 850+00, and on the left bank between STA 859+00 and

STA 854+00. It would also require the removal of a structure located approximately 30 feet from the active flow of the Batavia Kill at STA 855+00, and another smaller outbuilding located 200 feet upstream. The removal of approximately 13,500 cubic yards of material would be required to implement this alternative.

Alternative 2.3, when implemented in combination with Alternative 2.4 below, would reduce water surface elevations during the 100-year flood event by approximately 1.0 to 2.0 feet. Despite this modest decrease, the surrounding topography is sufficiently flat such that during the 100-year flood event, there would be a reduction of flooding at structures and outbuildings along Route 40 between STA 860+50 and STA 843+50. Such results are only achievable when implemented in combination with Alternative 2.4 below.

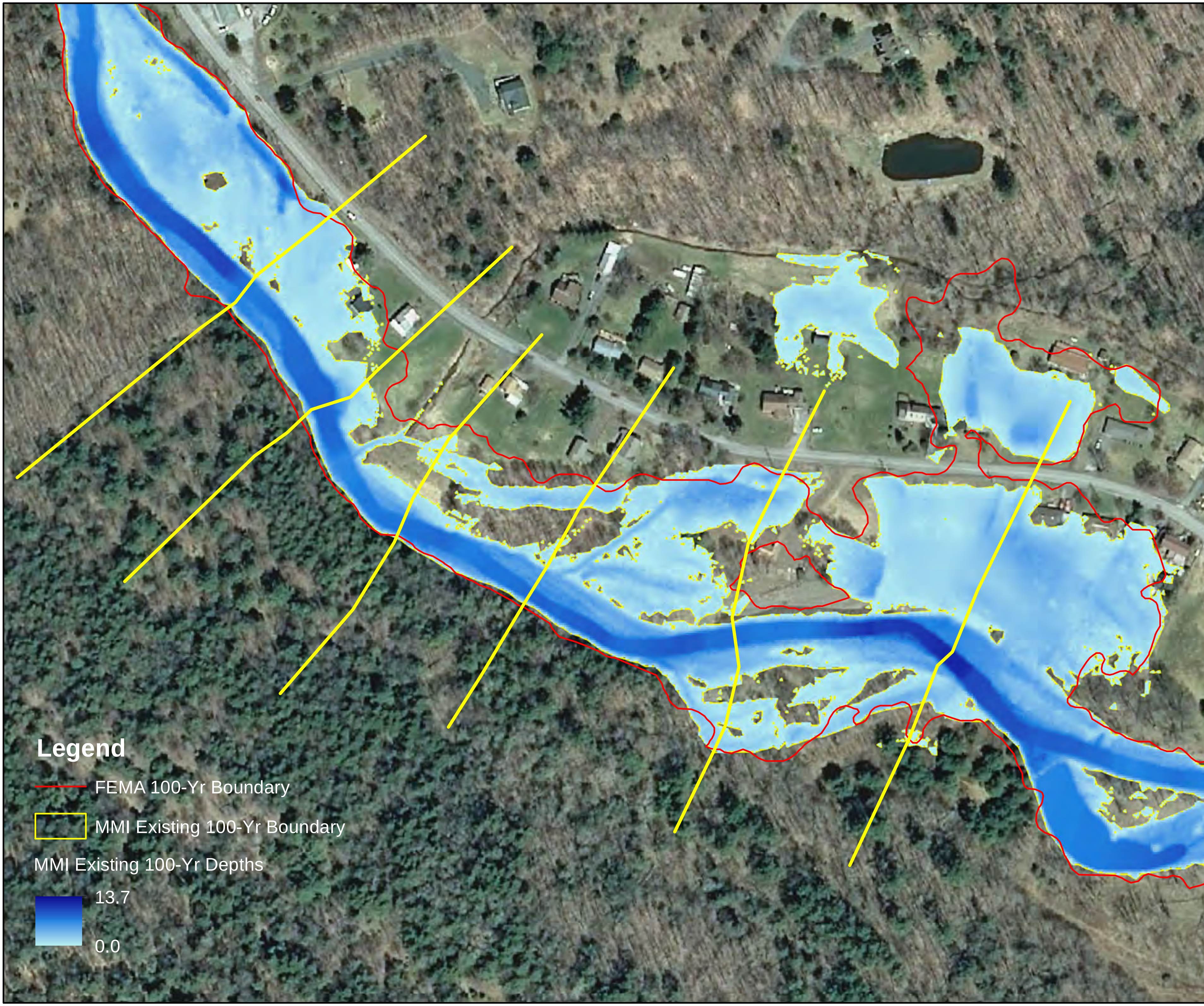
Alternative 2.4 – Floodplain Enhancement – Upstream of Route 40 Bridge (STA 849+00 to STA 841+00)

Homes built in the floodplain upstream of the intersection between Route 40 and Route 65 in the vicinity of STA 845+00 are subject to inundation along the right bank as the Batavia Kill becomes confined on the left by a steepening valley wall. The steep left bank has mature woody vegetation and would not be well suited for floodplain enhancement. Therefore this assessment considered locations along the right bank in existing yard areas along approximately 800 linear feet of stream channel, between STA 849+00 and STA 841+00.

Construction of a floodplain bench through this reach, combined with the floodplain benches associated with Alternative 2.3 predicted reduced water surface elevations by 1.0 to 2.0 feet, containing the 100-year flow entirely within the newly created floodplain. Modeling predicted that the new floodplain would not contain flows of a magnitude similar to Tropical Storm Irene. Approximately 4,000 cubic yards would need to be excavated under this alternative. Combined with Alternative 2.3, the total removal would be 17,500 cubic yards. Using the same assumptions as presented in Alternative 2.1, approximately 50 days or 10 weeks of hauling would be required for this alternative.

In addition to the 11 homes referenced in Alternative 2.3, this alternative would result in the elimination of flooding at two additional homes that currently fall within the FEMA 100-year floodplain, located at STA 845+00 and 843+50.

Existing conditions water surface elevations during the 100-year flood event are shown in Figure 4-9. Proposed conditions water surface elevations for the 100-year flood event are shown in Figure 4-10, with Alternatives 2.3 and 2.4 in place.



231 Main Street, Suite 102
New Paltz, New York 12561
(845) 633-8153
www.miloneandmacbroom.com

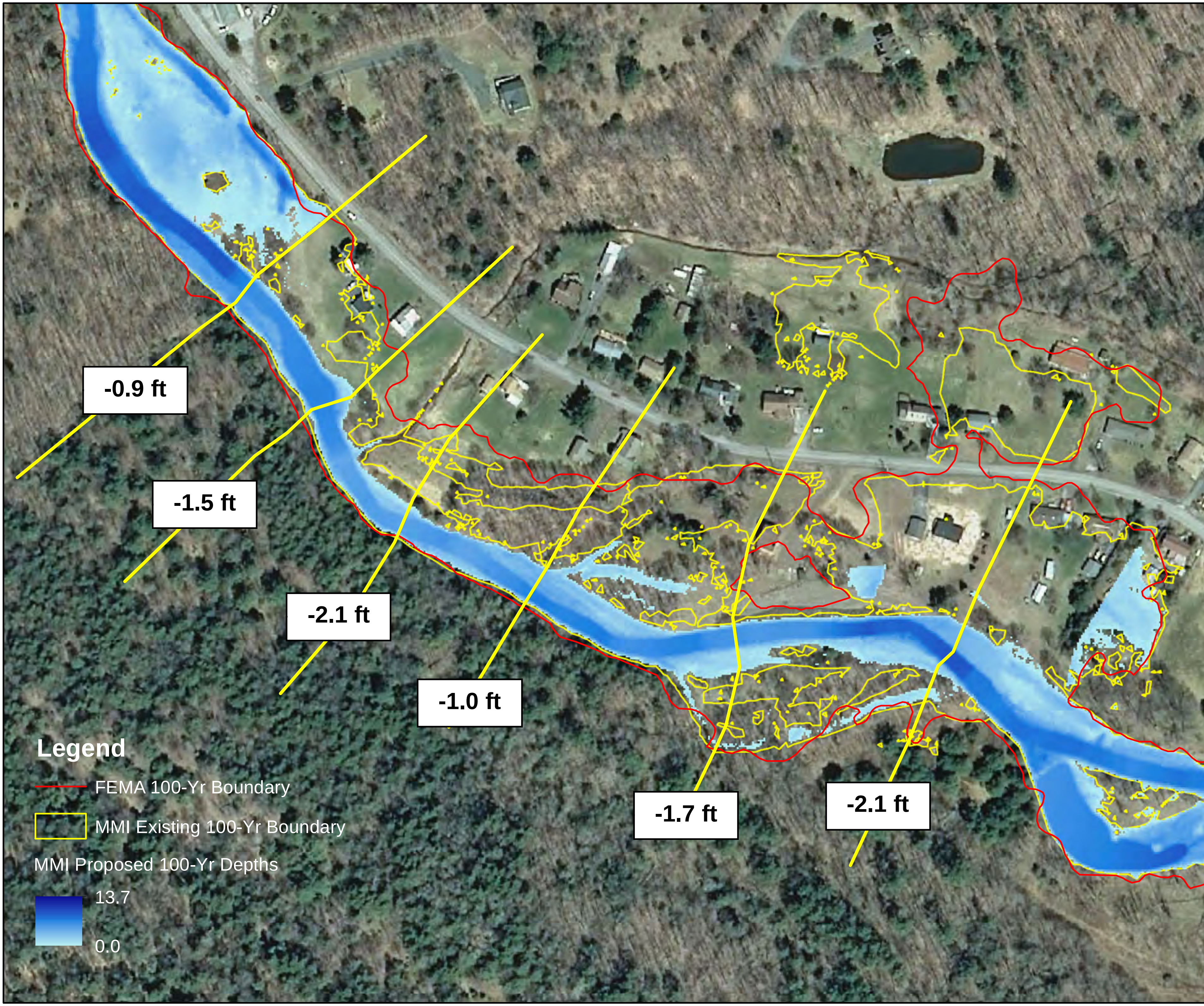
SOURCE(S):
NYS GIS Sever 2013 Aerial Imagery

Alternative 2.3 and 2.4 100-Yr Existing

TOWN OF WINDHAM LFA
HAMLET OF MAPLECREST
WINDHAM, NEW YORK

Map By: V. Bevan
MMI#: 2884-5
MXD: Windham_HRA2
1st Version: 3/25/2015
Scale: 1 in = 208 ft

Fig. 4-9



MILONE & MACBROOM
231 Main Street, Suite 102
New Paltz, New York 12561
(845) 633-8153
www.miloneandmacbroom.com

SOURCE(S):
NYS GIS Sever 2013 Aerial Imagery

Alternative 2.3 and 2.4 100-Yr Proposed

TOWN OF WINDHAM LFA
HAMLET OF MAPLECREST
WINDHAM, NEW YORK

Map By: V. Bevan
MMI#: 2884-5
MXD: Windham_HRA2
1st Version: 3/25/2015
Scale: 1 in = 208 ft

Fig. 4-10

Alternative 2.5 – Strategic Acquisition of Repetitive Loss Properties

For homes and associated structures listed in Table 4-4 that have been repeatedly subject to flooding damages, strategic acquisition, either through a FEMA or NYCDEP acquisition program or other governmental programs, may be a viable alternative where property owner interest exists. There are a number of grant programs that make funding available for property acquisition. Such properties could be converted to passive, non-intensive land uses.

4.7 High Risk Area # 3 – Hamlet of Hensonville (STA 825+00 to STA 805+00)

Figure 4-11 is a location plan of High Risk Area #3. In Hensonville during the 100-year event, flooding of structures is predicted to occur along the east side of Route 65A, along Route 65 north to Elm Ridge Road, and at the self-storage facility on Elm Ridge Road. Field investigations indicate that the channel of the Batavia Kill is constrained along its right bank as it flows along Route 65A, and that the channel and floodplain are undersized to convey the 100-year flood event.

Table 4-5 lists the flood prone properties within High Risk Area #3. All parcels with structures partially or entirely within the FEMA 100-year floodplain as well as two structures that are located within the FEMA floodway. A total of 12 properties are included in this reach. Using MMI's Corrected Effective Model, some of these homes fall just outside of the 100-year floodplain but may still be at risk during floods exceeding the 100-year event.

TABLE 4-5
Flood Prone Properties with Structures in High Risk Area #3

MMI Station	Parcel ID	Address	FEMA Flood Zone
818+00	96.14-1-9	48 County Rt 65A	Floodplain
817+00	96.14-1-8	52 County Rt 65A	Floodplain
815+00	96.00-5-51	60 County Rt 65A	Floodplain
813+00	96.00-5-52	120 County Rt 65	Floodway, Floodplain (abandoned)
819+00	96.14-1-5	87#1,2&91 &92 County Rt 65	Floodplain
818+00	96.14-1-13	84 County Rt 65	Floodplain
817+00	96.14-1-10.1	102 County Rt 65	Floodplain
813+00	96.14-1-10.2	98 County Rt 65	Floodplain
813+00	96.14-1-6	108 County Rt 65	Floodplain
816+00	96.00-5-87	8 Elm Ridge Rd	Floodplain (storage lockers)
805+00	96.00-5-3.2	139 County Rt 65	Floodplain
809+00	96.00-1-15	109 County Rt 65	Floodway, Floodplain

SOURCE(S):
Bing Maps Hybrid

Figure 4-11: Location Map - High Risk Area #3

LOCATION:
Windham, NY

N

Local Flood Hazard Mitigation Analysis
Town of Windham along the Batavia Kill

MXD: Y:\2884-05\GIS\Maps\Fig4-7.mxd

Map By: JEP
MMI#: 2884-05
Original: 9/15/2014
Revision: 9/17/2014
Scale: 1 inch = 250 feet

MILONE & MACBROOM
231 Main St, Suite 102
New Paltz, NY 12561 (845) 633-8153
www.miloneandmacbroom.com

Alternative 3.1 – Floodplain Enhancement and Bridge Replacement – Upstream of Route 65 (STA 825+00 to STA 805+00)

The natural channel profile becomes less steep in this reach (average slope is 0.75%, as compared to 1.2% upstream). Combined with a tributary entering just downstream of Route 65, this area is a natural sediment deposition zone that will be subject to aggradation and debris jams, and is likely to continue to adjust within the floodplain area during large magnitude flood events.

To add to the complicated hydraulics of this reach, while the Route 65 bridge deck is at a higher elevation than the predicted 100-year flood, the bridge has been flanked by floodwaters on both sides during large flood events and is vulnerable to overtopping during larger events, such as Irene. This alternative assesses increasing the bridge opening from 67 feet to 110 feet and widening the upstream floodplain. Replacement of the bridge without floodplain modification would have little effect.

Under this alternative, creation of a floodplain bench on the left bank along approximately 1,000 linear feet of channel (between STA 823+00 and 813+00) was assessed along with a near doubling in span of the Route 65 bridge. This alternative would require the acquisition and demolition of a structure at STA 813+00 on the left bank and removal of 14,000 cubic yards of overbank material.

Modeling predicts that implementation of this alternative would lower the 100-year water surface elevation throughout the reach by between 2 and 3 feet, and would contain the 100-year flood within the newly created flood bench. Implementation of this alternative would remove structures from the 100-year floodplain. This includes homes along Route 65A and Route 65, as well as the self-storage facility on Elm Ridge Road. The proposed floodplain bench would not eliminate flooding at the home upstream of the Route 65 bridge at STA 813+00 or the home located downstream of the Route 65 bridge at STA 809+00. The upstream dwelling would need to be removed to accommodate a larger bridge structure. The downstream dwelling is located in the vulnerable floodway.

Existing conditions water surface elevations during the 100-year flood event are shown in Figure 4-12. Proposed conditions under Alternative 3.1 for the 100-year flood event are shown in Figure 4-13.

Alternative 3.2 – Strategic Acquisition of Repetitive Loss Properties

For homes and associated structures listed in Table 4-5 that have been repeatedly subject to flooding damages, strategic acquisition may be a viable alternative where property owner interest exists, particularly those structures located in the FEMA floodway. Such properties could be converted to passive, non-intensive land uses.

4.8 High Risk Area # 4 – Hamlet of Windham (STA 680+00 – STA 625+00)

Figure 4-14 is a location plan of High Risk Area #4. Extensive flooding occurs in the hamlet of Windham, especially along the right bank of the Batavia Kill between the stream channel and Route 23 (Main Street). During the 100-year event, flood waters are predicted to flow onto Main Street, cross over to its north side and flood homes and businesses.

Flooding in Windham is exacerbated by flows entering from Mitchell Hollow Creek, which flows into the Batavia Kill upstream of the Church Street bridge (STA 665+00). The channel of Mitchell Hollow Creek is undersized as it passes between buildings and

MILONE & MACBROOM
231 Main Street, Suite 102
New Paltz, New York 12561
(845) 633-8153
www.miloneandmacbroom.com

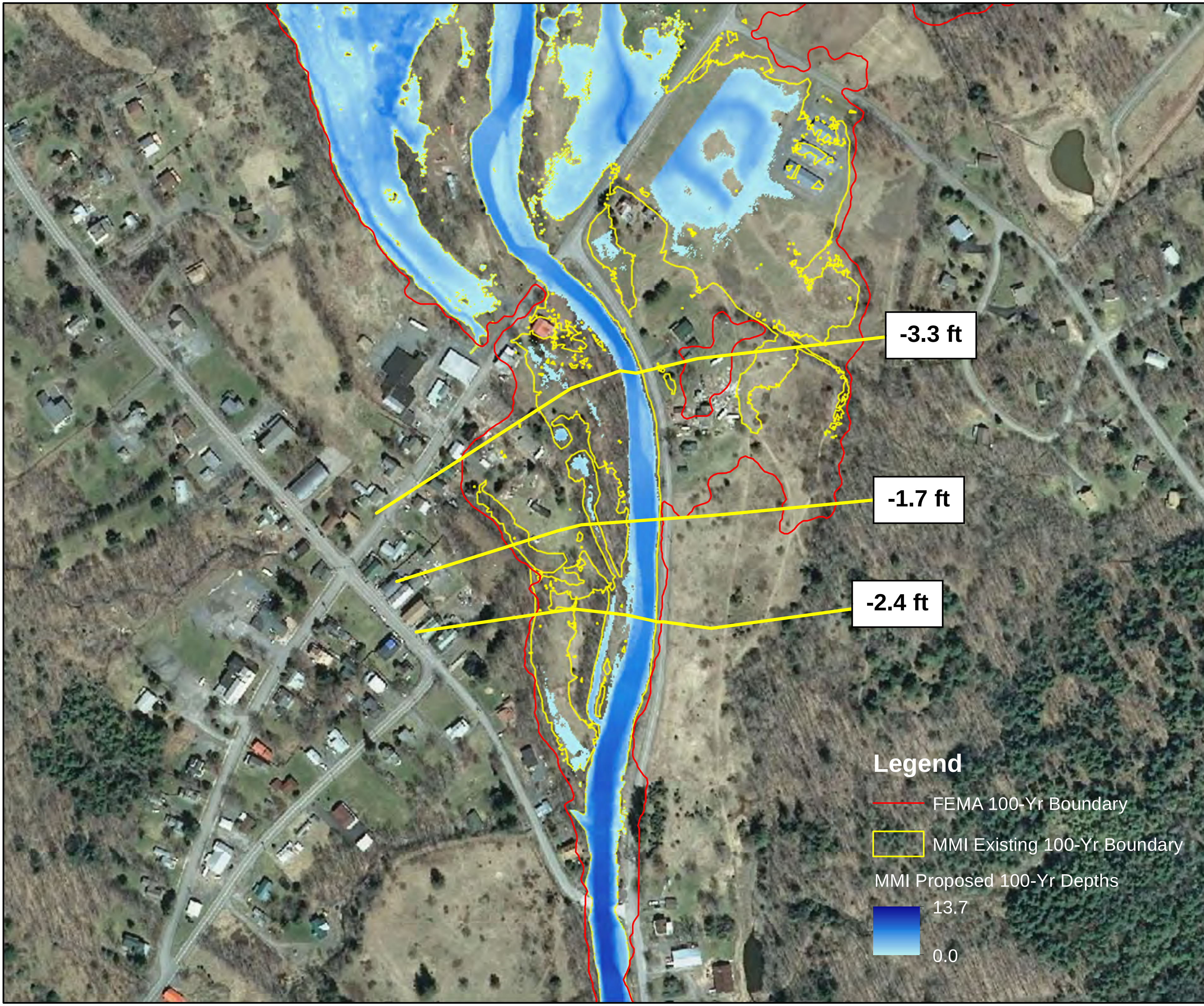
SOURCE(S):
NYS GIS Sever 2013 Aerial Imagery

Alternative 3.1 100-Yr Existing

TOWN OF WINDHAM LFA
HAMLET OF HENSONVILLE
WINDHAM, NEW YORK

Map By: V. Bevan
MMI#: 2884-5
MXD: Windham_HRA3
1st Version: 3/25/2015
Scale: 1 in = 208 ft

Fig. 4.12



Milone & MacBroom
231 Main Street, Suite 102
New Paltz, New York 12561
(845) 633-8153
www.miloneandmacbroom.com

SOURCE(S):
NYS GIS Sever 2013 Aerial Imagery

N
W
E
S

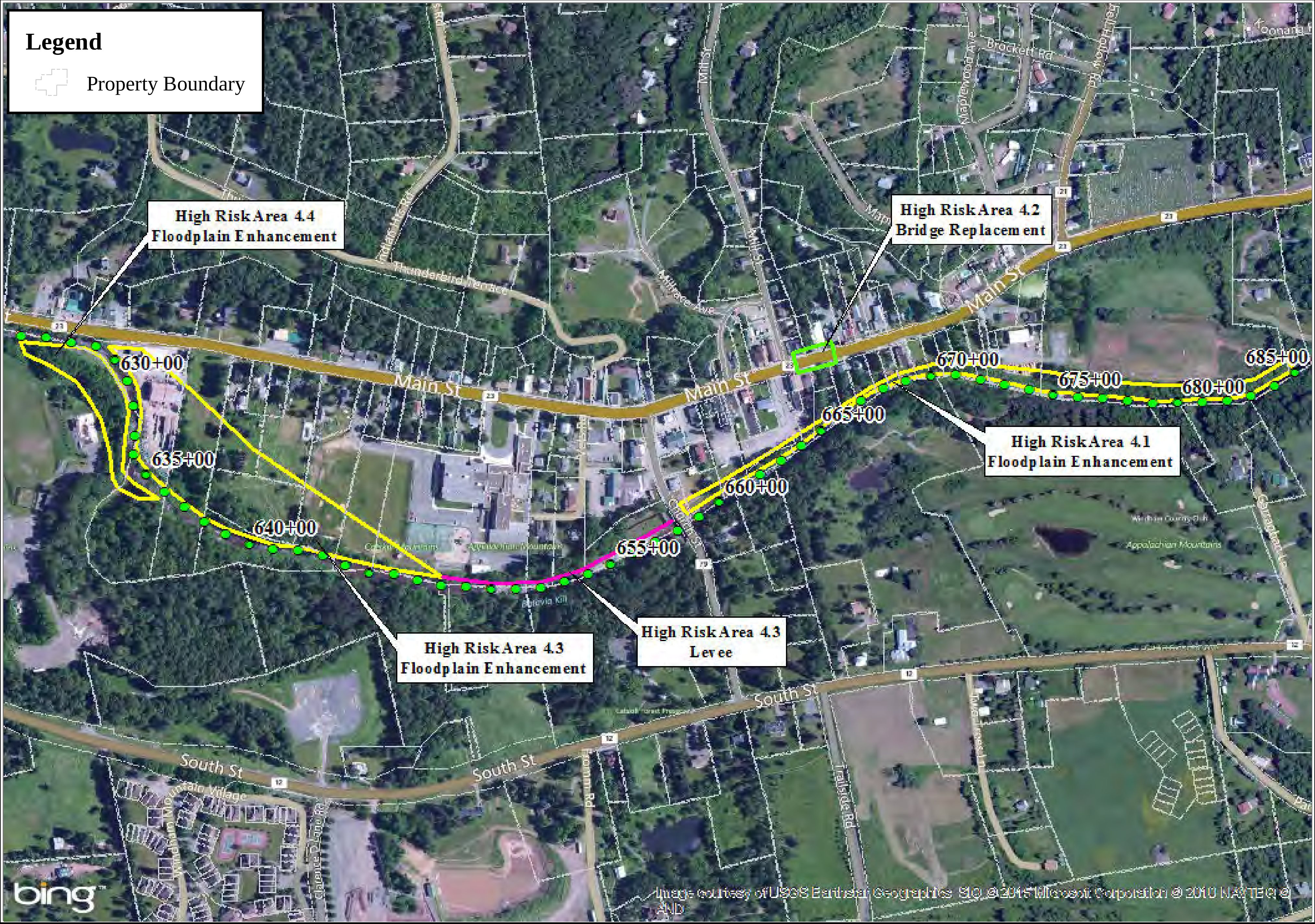
Alternative 3.1 100-Yr Proposed

TOWN OF WINDHAM LFA
HAMLET OF HENSONVILLE
WINDHAM, NEW YORK

Map By: V. Bevan
MMI#: 2884-5
MXD: Windham_HRA3
1st Version: 3/25/2015
Scale: 1 in = 208 ft

Fig. 4.13

vertical walls and flows under the Route 23 (Main Street) bridge, which acts as a hydraulic constriction, causing extensive flooding along Mill Street. Combined with high backwater conditions in the Batavia Kill, floodwaters from Mitchell Hollow flow onto Route 23 and begin flowing west through Windham.



SOURCE(S): Bing Maps Hybrid	Figure 4-14: Location Map High Risk Area #4 MXD: Y:\2884-05\GIS\Maps\Fig4-8.mxd	Local Flood Hazard Mitigation Analysis Town of Windham along the Batavia Kill LOCATION: Windham, NY	Map By: JEP MMI#: 2884-05 Original: 7/31/2015 Revision: 9/15/2014 Scale: 1 in = 500 ft	MILONE & MACBROOM 231 Main St, Suite 102 New Paltz, NY 12561 (845) 633-8153 www.miloneandmacbroom.com

Downstream of Church Street, the 100-year flood event engulfs the entire downtown area to the north of Batavia Kill, including many homes, the fire station, churches and businesses along both sides of Route 23, Church Street, and several side streets. The Windham Ashland Jewett Public School (STA 649+00) is flooded, as well as the country store (STA 628+00). The lumber yard (STA 632+00) is located not only in the 100-year floodplain but also in the FEMA-designated floodway.

Table 4-6 lists the flood prone properties within High Risk Area #4. All parcels with structures partially or entirely within the FEMA 100-year floodplain are included. Within High Risk Area #4, the 100-year floodplain generated by MMI's Corrected Effective Model is very similar to the 100-year floodplain shown on the FIRMS.

TABLE 4-6
Flood Prone Properties with Structures in High Risk Area #4

MMI Station	Parcel ID	Address	FEMA Flood Zone
674+00	78.19-3-25	5283-#2 State Rt 23	Floodplain
672+50	78.19-3-14	5283-#1 State Rt 23	Floodplain
672+00	78.19-2-20	State Rt 23	Floodplain
672+00	78.19-2-21	5287 State Rt 23	Floodplain
669+50	78.19-2-23.2	5299 State Rt 23	Floodplain
669+00	78.19-2-24	5305 State Rt 23	Floodplain
666+00	78.19-2-29	5331 State Rt 23	Floodplain
666+00	78.19-2-30	5327 State Rt 23	Floodway, Floodplain
664+50	78.19-1-18	5335 State Rt 23	Floodway, Floodplain
664+50	78.19-1-19	5339 State Rt 23	Floodplain
665+00	78.19-1-17	5338 State Rt 23	Floodway, Floodplain
665+00	78.19-1-16	6 & 8 Mill St	Floodway, Floodplain
665+00	78.19-1-15	12 Mill St	Floodway, Floodplain
665+00	78.19-1-7	18 Mill St	Floodway, Floodplain
665+50	78.19-2-31	5330 State Rt 23	Floodway, Floodplain
665+50	78.19-2-32	5326 State Rt 23	Floodplain
667+00	78.19-2-33	5320 State Rt 23	Floodplain
668+00	78.19-2-34	5316 State Rt 23	Floodplain
668+50	78.19-2-35	5312 State Rt 23	Floodplain
669+00	78.19-2-36	5308 State Rt 23	Floodplain
670+00	78.19-2-53	5296 & 5304 State Rt 23	Floodplain
665+00	78.19-1-6	19 Mill St	Floodway, Floodplain
665+00	78.19-1-5	26 Mill St	Floodway, Floodplain
664+00	78.19-1-12	5344 State Rt 23	Floodplain
664+00	78.19-1-13	Mill St	Floodplain
663+50	78.19-1-11	5348 State Rt 23	Floodplain
662+00	78.19-1-10.2	State Rt 23	Floodplain
662+00	78.19-1-10.1	5354 State Route 23 / #3-1 & 2 Library Rd	Floodplain
663+00	78.19-1-20	5345 State Rt 23	Floodplain
662+50	78.19-1-21	5351 State Rt 23	Floodplain
662+00	78.19-1-22	5355 State Rt 23	Floodplain
661+00	78.19-1-35	5359 State Route 23	Floodplain
661+50	78.19-1-29	5360 State Rt 23	Floodplain

661+00	78.19-1-30	5364 State Route 23/14 Library Rd	Floodplain

TABLE 4-6 (Cont.)
Flood Prone Properties with Structures in High Risk Area #4

MMI Station	Parcel ID	Address	FEMA Flood Zone
659+50	78.18-1-7	5370 State Rt 23	Floodplain
660+00	78.19-1-27	5369 State Rt 23	Floodplain
659+50	78.19-1-26	15-#2 Cty Rte 79	Floodway, Floodplain
658+50	78.19-1-25	15-#1 Cty Rte 79	Floodway, Floodplain
660+00	78.19-1-28	5365 State Rt 23	Floodplain
659+00	78.18-2-25	5373 State Rt 23	Floodplain
659+00	78.18-2-26	7 Cty Rte 79	Floodplain
658+00	78.18-1-8	5376 State Rt 23	Floodplain
657+00	78.18-1-9	5380 State Rt 23	Floodplain
656+00	78.18-1-13	5386 State Rt 23	Floodplain
655+00	78.18-1-11	5390 State Rt 23	Floodplain
654+00	78.18-1-12	5394 State Rt 23	Floodplain
656+00	78.18-2-29.2	11 Vets Rd	Floodplain
657+00	78.18-2-24	5379 State Rt 23	Floodplain
656+00	78.18-2-23	5383 State Rt 23	Floodplain
654+00	78.18-2-29.1	5387 State Rt 23	Floodplain
653+00	78.18-2-20	5393 State Rt 23	Floodplain
653+00	78.18-2-19	10 Vets Rd	Floodplain
653+00	78.18-2-18	14 Vets Rd	Floodplain
653+00	78.18-2-30	21/23 Vets Rd	Floodplain
652+00	78.18-2-31	25 Vets Rd	Floodplain
652+00	78.18-2-17	24 Vets Rd	Floodplain
652+00	78.18-2-16	5399 State Rt 23	Floodplain
649+00	78.18-2-32	5411 State Rt 23	Floodplain
653+00	78.18-1-10	5398 State Rt 23	Floodplain
652+00	78.18-1-14	5402 State Rt 23	Floodplain
651+00	78.18-1-15	5406 State Rt 23	Floodplain
650+00	78.18-1-16	5410 State Rt 23	Floodplain
649+00	78.18-1-17	5414 State Rt 23	Floodplain
648+00	78.18-1-19	5420 State Rt 23	Floodplain
647+50	78.18-1-20	5424 State Rt 23	Floodplain
647+00	78.18-1-21	5428 State Rt 23	Floodplain
646+00	78.18-1-22	5434 State Rt 23	Floodplain
644+50	78.18-1-23	5438 State Rt 23	Floodplain
643+00	78.18-1-24	5444/46&48 State Rt 23	Floodplain
642+00	78.18-1-25	5456 State Rt 23	Floodplain
640+00	78.18-1-26	5462 State Rt 23	Floodplain
637+00	78.18-1-28	5474 State Rt 23	Floodplain
648+50	78.18-2-15	5419 State Rt 23	Floodplain
648+00	78.18-2-14	5425 State Rt 23	Floodplain
646+50	78.18-2-13	5429 State Rt 23	Floodplain
646+00	78.18-2-12	5433 State Rt 23	Floodplain
645+00	78.18-2-11	5437 State Rt 23	Floodplain
644+00	78.18-2-10	5441 State Rt 23	Floodplain
642+50	78.18-2-9.1	5449 State Rt 23	Floodplain
641+00	78.18-2-8	5457 State Rt 23	Floodplain
640+00	78.18-2-7	5461 State Rt 23	Floodplain

TABLE 4-6 (Cont.)
Flood Prone Properties with Structures in High Risk Area #4

MMI Station	Parcel ID	Address	FEMA Flood Zone
639+50	78.18-2-6	5465 State Rt 23	Floodplain
639+00	78.18-2-5	5469-#2 State Rt 23	Floodplain
638+50	78.18-2-4	5469-#1 State Rt 23	Floodplain
631+00	78.18-2-2	5469-#1 State Rt 23	Floodway, Floodplain
629+00	78.18-1-47	5494 State Rt 23	Floodplain
628+00	78.18-1-32	5504 State Rt 23	Floodplain
628+00	78.18-1-38.2	State Rt 23	Floodplain
624+50	78.18-1-34	5522 State Rt 23	Floodplain

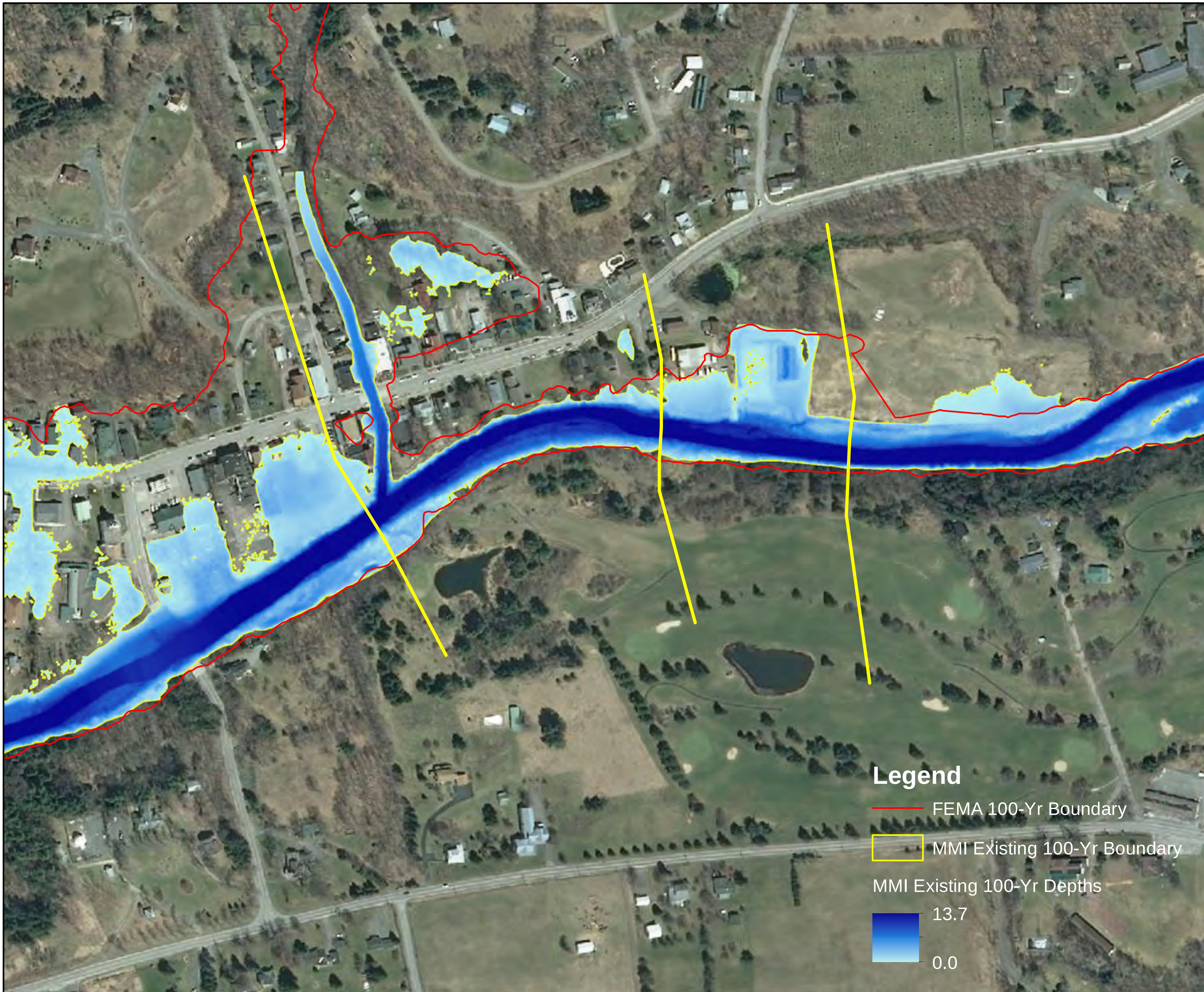
Alternative 4.1 – Floodplain Enhancement – Upstream of Church Street (STA 685+00 to STA 658+00)

Extensive flooding occurs along the right bank of the Batavia Kill upstream of Church Street between the channel and Route 23 (Main Street). Areas of the floodplain along the right bank are currently used for school bus parking (at STA 674+00), for accessory structures (STA 669+00 downstream to STA 666+00), and for parking (STA 664+00 downstream to STA 661+00). It appears that the floodplain has been historically filled in these areas.

This alternative evaluates the creation of a floodplain bench extending from 2,000 feet upstream of Church Street, downstream to the bridge (from STA 678+00 downstream to STA 658+00). The floodplain bench would be approximately 80 feet wide at its upstream end and would narrow gradually downstream to the Church Street bridge.

Floodplain enhancement alone would not prevent 100-year flooding along Main Street; however, flood depths are predicted to drop by 0.8 to 1.2 feet, on average. Although a flood bench will provide some benefit for smaller intensity storms, it could not be made wide enough to practically contain the 100-year flood elevations.

Existing conditions water surface elevations are shown in Figure 4-15. Proposed conditions under Alternative 4.1 are shown in Figure 4-16.



MILONE & MACBROOM
231 Main Street, Suite 102
New Paltz, New York 12561
(845) 633-8153
www.miloneandmacbroom.com

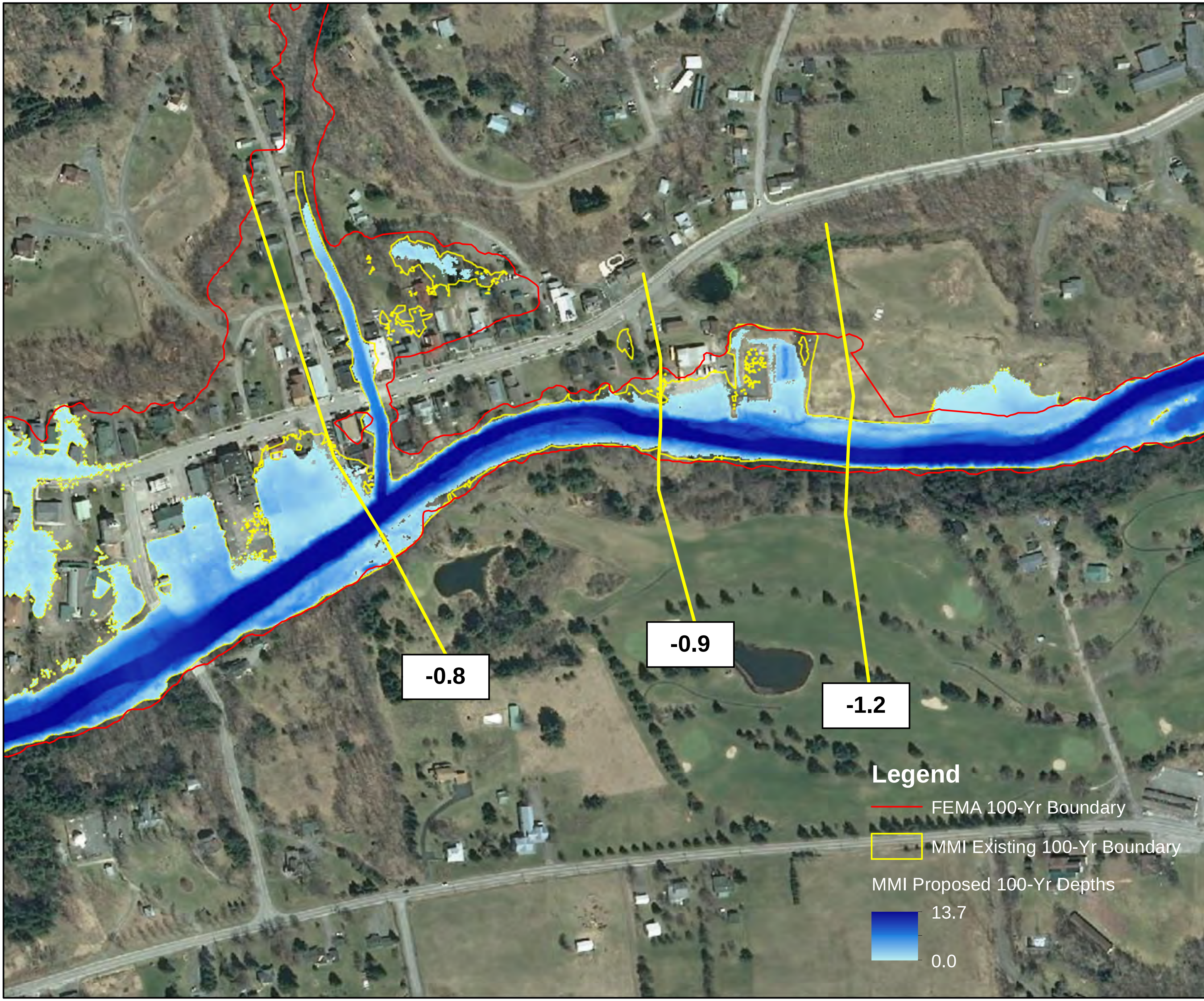
SOURCE(S):
NYS GIS Sever 2013 Aerial Imagery

Alternative 4.1 100-Yr Existing

TOWN OF WINDHAM LFA
VILLAGE OF WINDHAM
WINDHAM, NEW YORK

Map By: V. Bevan
MMI#: 2884-5
MXD: Windham_HRA4
1st Version: 3/25/2015
Scale:

Fig. 4.15



MILONE & MACBROOM
231 Main Street, Suite 102
New Paltz, New York 12561
(845) 633-8153
www.miloneandmacbroom.com

SOURCE(S):
NYS GIS Sever 2013 Aerial Imagery

Alternative 4.1 100-Yr Proposed

TOWN OF WINDHAM LFA
VILLAGE OF WINDHAM
WINDHAM, NEW YORK

Map By: V. Bevan
MMI#: 2884-5
MXD: Windham_HRA4
1st Version: 3/25/2015
Scale:

Fig. 4.16

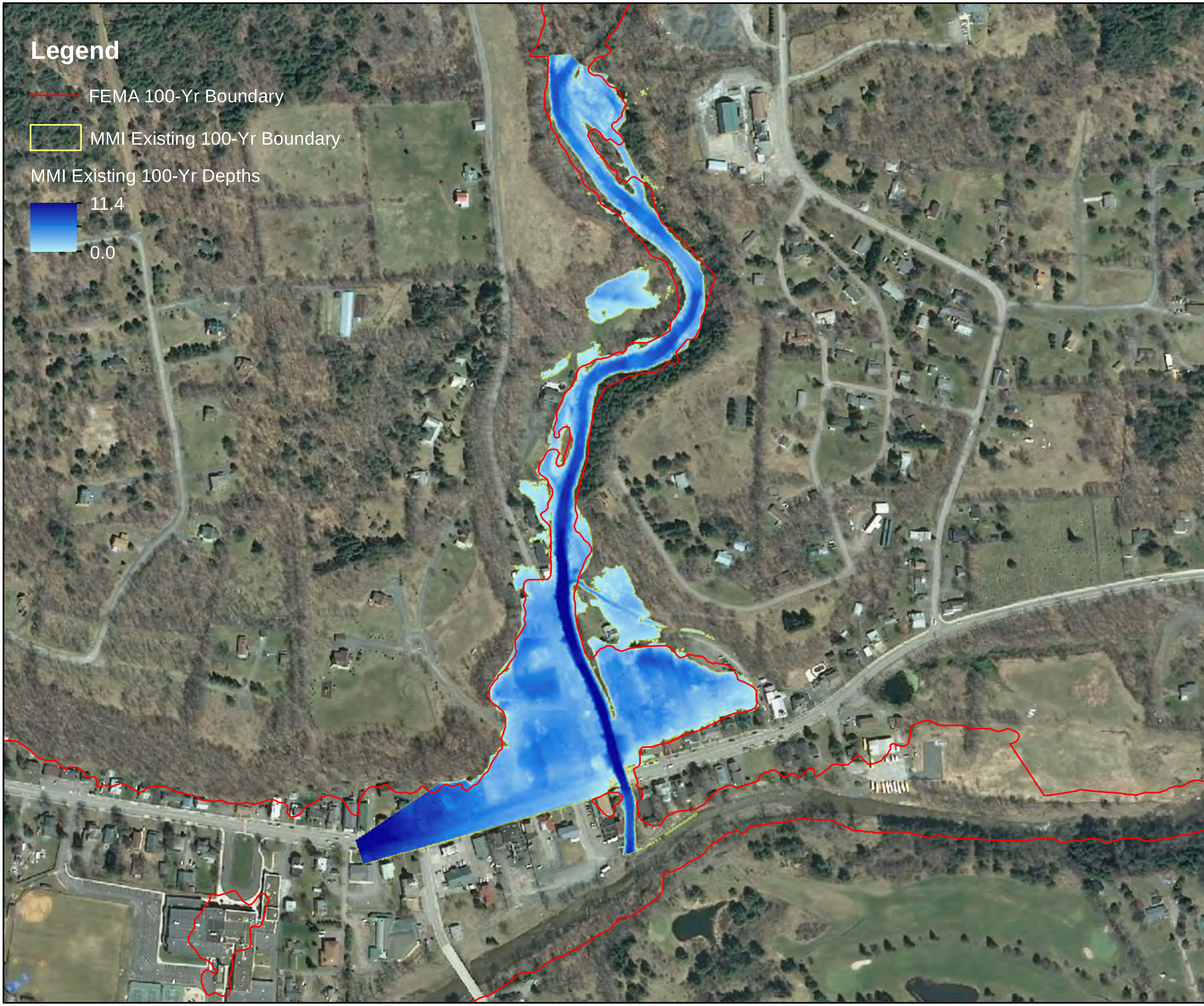
Alternative 4.2 – Route 23 (Main Street) Bridge Replacement and Floodplain Bench on Mitchell Hollow Creek (STA 665+00)

Mitchell Hollow Creek is a tributary to the Batavia Kill, entering 650 feet upstream of the Church Street bridge at STA 665+00. The Main Street bridge over Mitchell Hollow Creek is undersized and acts as a hydraulic constriction during large flood events. In addition, the channel upstream and downstream of the bridge is constrained on both sides by vertical walls, further exacerbating flooding. Combined with high backwater conditions in the Batavia Kill, flood waters flow onto Main Street at the bridge and begin flowing west along the roadway.

This alternative involves a larger bridge over Mitchell Hollow at Main Street as well as a wider floodplain bench upstream and downstream of the bridge. Dense development on the banks of Mitchell Hollow would necessitate the acquisition and removal of approximately three structures along the left bank in the vicinity of Main Street in order to accommodate channel and bridge widening. The left bank has fewer structures; therefore widening to this side would be easier to accommodate.

Under this alternative, a new Main Street bridge was modeled that lengthened the span to 65 feet. In addition, a flood bench was added along 900 feet of the left bank of Mitchell Hollow Creek. The results indicate a reduction in water surface elevations by as much as 3.6 feet in the channel upstream of the bridge, and that the new channel and crossing could fully contain the 100-year flood flows within the banks and beneath the bridge without overtopping. Flooding of structures during the 100-year event would be reduced within the area along Main Street in the vicinity of Mill Street, and extending north up Mill Street. This improvement would be a very important step in reducing flood waters that flow onto Main Street during large flood events.

Existing conditions water surface elevations are shown in Figure 4-17. Proposed conditions under Alternative 4.2 are shown in Figure 4-18.



MILONE & MACBROOM
231 Main Street, Suite 102
New Paltz, New York 12561
(845) 633-8153
www.miloneandmacbroom.com

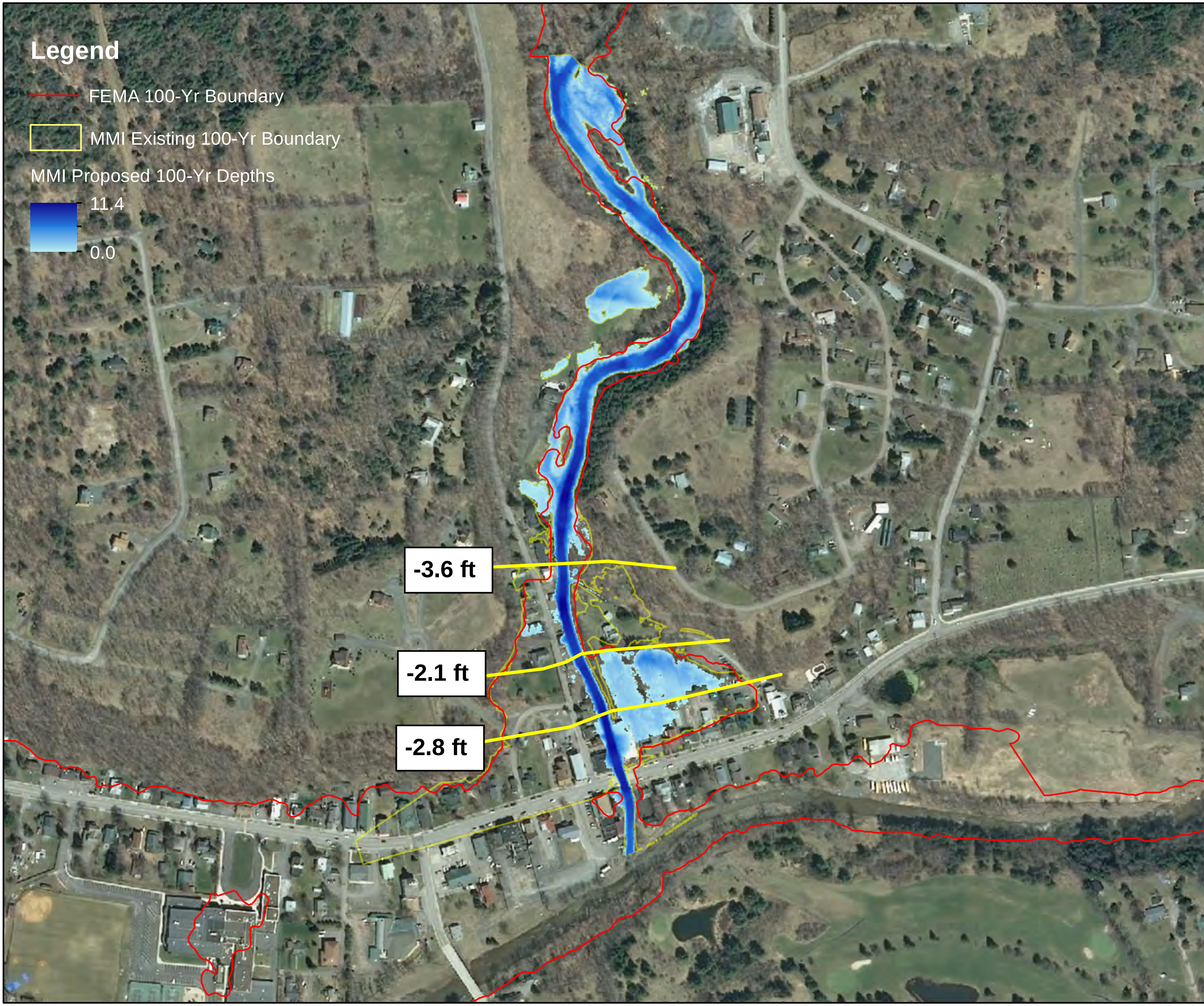
SOURCE(S):
NYS GIS Sever 2013 Aerial Imagery

Alternative 4.2 100-Yr Existing

TOWN OF WINDHAM LFA
VILLAGE OF WINDHAM
WINDHAM, NEW YORK

Map By: V. Bevan
MMI#: 2884-5
MXD: Windham_HRA4.2_Mitchell_Hollow
1st Version: 3/25/2015
Scale: 1 in = 277 ft

Fig. 4.17



Alternative 4.2 100-Yr Proposed

TOWN OF WINDHAM LFA
VILLAGE OF WINDHAM
WINDHAM, NEW YORK

SOURCE(S):
NYS GIS Sever 2013 Aerial Imagery

MILONE & MACBROOM
231 Main Street, Suite 102
New Paltz, New York 12561
(845) 633-8153
www.miloneandmacbroom.com

Map By: V. Bevan
MMI#: 2884-5
MXD: Windham_HRA4.2_Mitchell_Hollow
1st Version: 3/25/2015
Scale: 1 in = 1,106 ft

Fig. 4.18

Alternative 4.3 – Floodplain Enhancement –Downstream of Church Street (STA 658+00 to STA 630+00)

Downstream of Church Street, the 100-year flood event inundates the entire downtown Windham area to the north of Batavia Kill, including many homes, the fire station, churches and businesses along both sides of Main Street and several side streets. The Windham Ashland Jewett Public School is subject to flooding, as is GNH lumber yard and the Catskill Mountain Country Store.

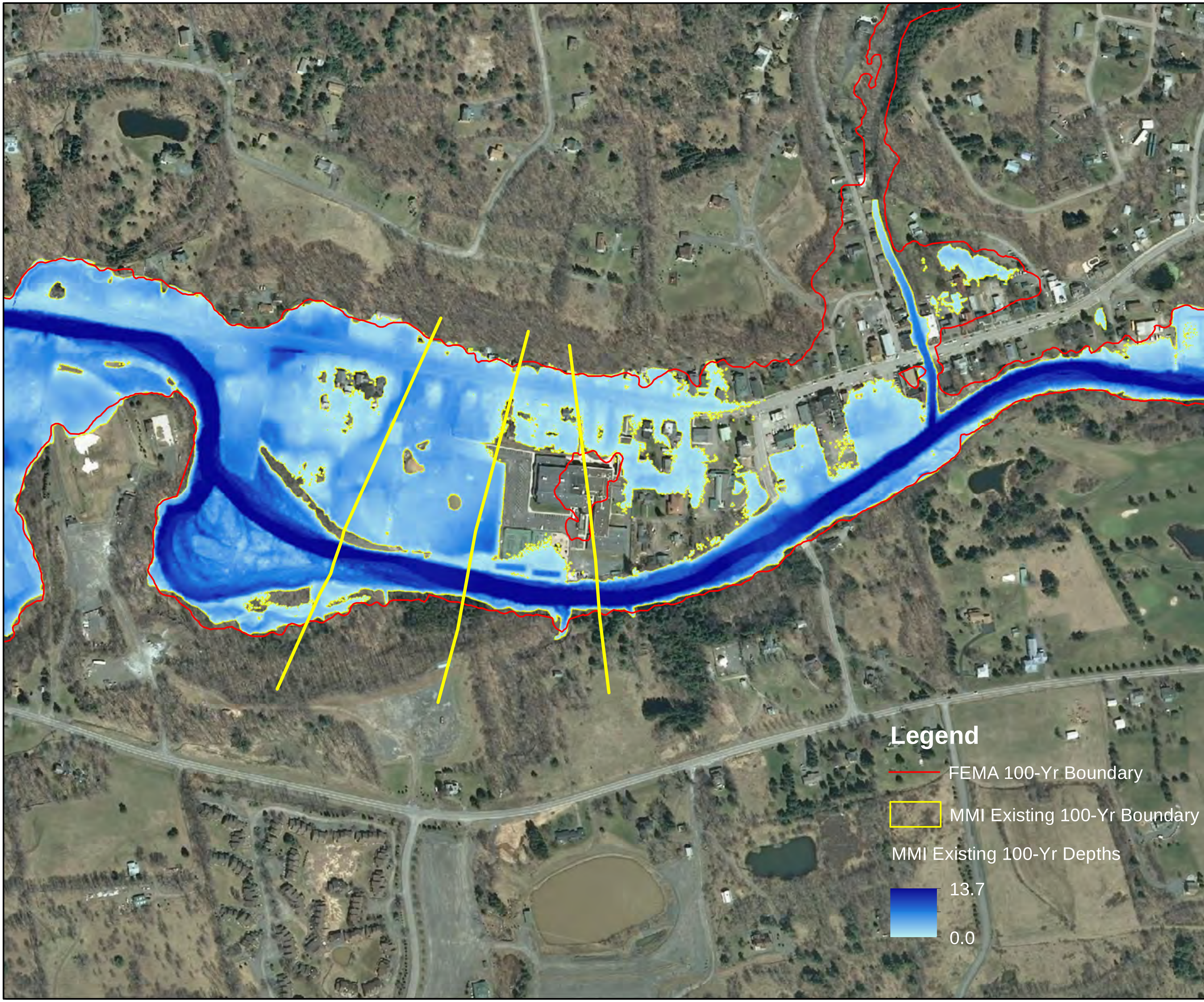
Fill and development in the natural floodplain have the effect of increasing flood levels and exposes Windham to significant flood hazards. Currently, shallow flooding (< 1 foot deep) occurs during the 100-year flood from Church Street to the school. Deeper flooding occurs downstream of the school, to the western end of the village, with flooding depths between one and three feet deep.

This alternative evaluates creation of a flood bench downstream of the school. The flood bench in combination with Alternative 4.2 on Mitchell Hollow Creek would significantly reduce flooding; however, it would not completely eliminate overtopping of the Batavia Kill during the 100-year event.

Creation of an open space floodplain in this area would not impact any residences. It would, however, require the relocation of the lumber yard from its current location in the floodway. The floodway is the area of a river that is required for flood conveyance, and encroachments on the floodway can cause damage not only to the encroaching building, but also to the floodplain upstream and downstream as well. Lumber yards are considered critical community facilities for the CWC program and relocation funding is available.

Model results indicate that this alternative can remove a portion of the village from the 100-year floodplain. Water surface elevation reductions of 2.2 feet would be seen during the 100-year flood event. Some areas may still be subject to flooding from the Mitchell Hollow Creek tributary upstream of Church Street. If both conditions were corrected, it is expected that flooding can be substantially reduced in the downtown Windham area.

Existing conditions water surface elevations are shown in Figure 4-19. Proposed conditions under Alternative 4.3 are shown in Figure 4-20.



MILONE & MACBROOM
231 Main Street, Suite 102
New Paltz, New York 12561
(845) 633-8153
www.miloneandmacbroom.com

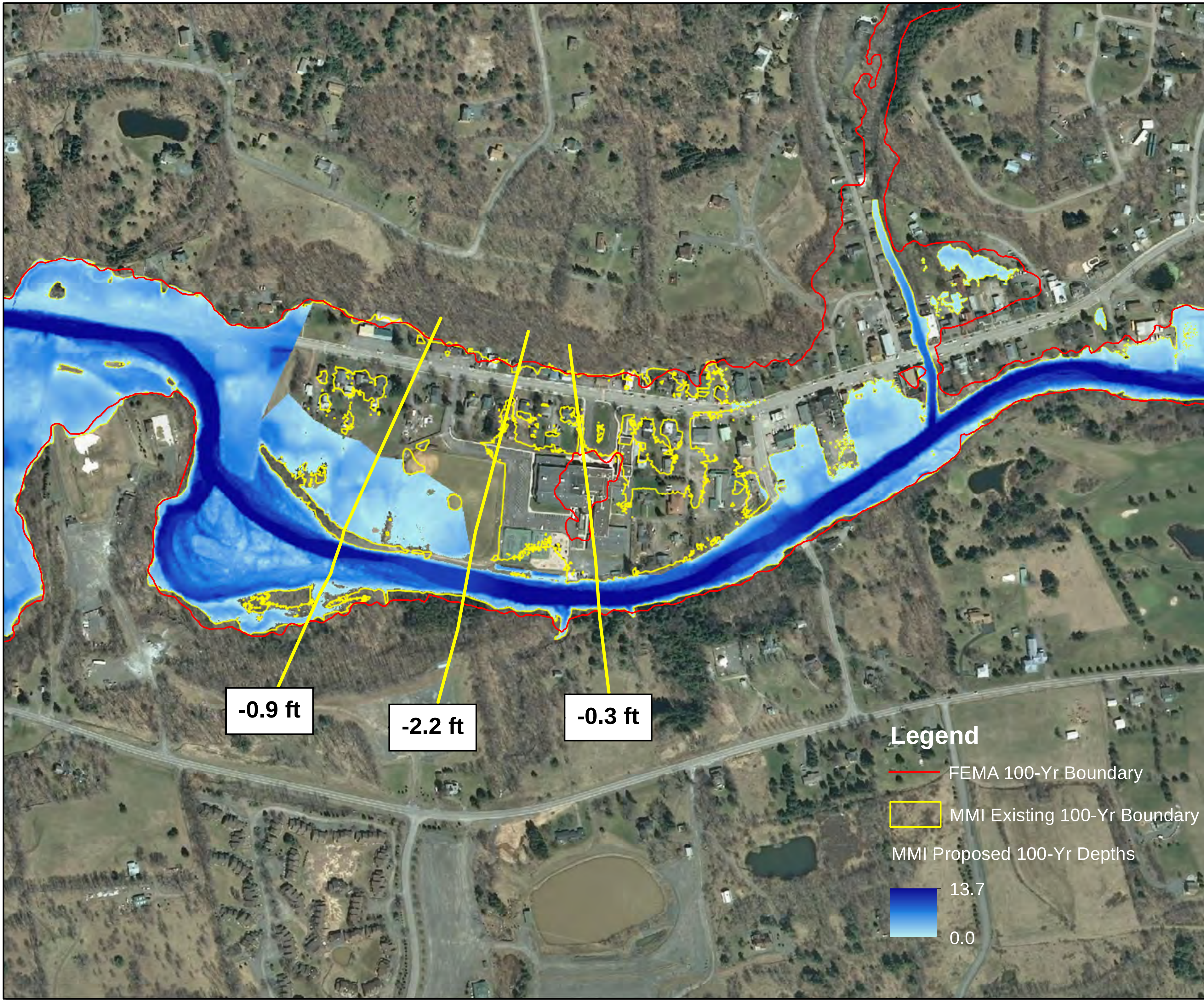
SOURCE(S):
NYS GIS Sever 2013 Aerial Imagery

Alternative 4.3 100-Yr Existing

TOWN OF WINDHAM LFA
VILLAGE OF WINDHAM
WINDHAM, NEW YORK

Map By: V. Bevan
MMI#: 2884-5
MXD: Windham_HRA3
1st Version: 3/25/2015
Scale: 1 in = 277 ft

Fig. 4.19



MILONE & MACBROOM
231 Main Street, Suite 102
New Paltz, New York 12561
(845) 633-8153
www.miloneandmacbroom.com

SOURCE(S):
NYS GIS Sever 2013 Aerial Imagery

Alternative 4.3 100-Yr Proposed

TOWN OF WINDHAM LFA
VILLAGE OF WINDHAM
WINDHAM, NEW YORK

Map By: V. Bevan
MMI#: 2884-5
MXD: Windham_HRA3
1st Version: 3/25/2015
Scale: 1 in = 277 ft

Fig. 4.20

Alternative 4.4 – Floodplain Enhancement – Downstream of Hamlet of Windham (STA 635+00 to STA 630+00)

Flooding occurs in the hamlet of Windham, most extensively between the Batavia Kill and Route 23 (Main Street). The open, flat floodplain valley is interrupted on left bank by a 50-foot high bluff. This alternative assess whether or not this bluff causes a backwater onto the hamlet of Windham.

The bluff is large, wooded, and likely to be cost prohibitive to remove/modify due to size. Also, a structure or parking area at STA 633+00 would have to be removed to accomplish this grading. The Route 23 roadway embankment prevents floodplain modification along the right bank.

Removal of approximately 10,000 cubic yards of material between STA 635+00 and STA 626+00 was assessed. This alternative did not seek to remove the entire bluff, only to "notch" out a floodplain and dispose of the material off site. The overall reduction in 100-year water surface elevations predicted from this work was approximately 0.2 feet. There was no resulting reduction in flooding of structures during the 100-year flood event.

Alternative 4.5 – Strategic Acquisition of Repetitive Loss Properties

For homes and businesses listed in Table 4-6 that have been repeatedly subject to flooding damages, strategic acquisition may be a viable alternative where property owner interest exists. Such properties could be converted to passive, non-intensive land uses.

5.0 BENEFIT COST ANALYSIS

5.1 Overview of Benefit-Cost Analysis

A Benefit-Cost Analysis (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), 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 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.

Benefit-cost analysis was conducted for the following alternatives and combinations of alternatives:

- Alternative 1.1A - Floodplain Enhancement downstream of Slater Road
- Combination of Alternative 2.3 and 2.4 - Floodplain Enhancement near Schaeffer Road and upstream of the Route 40 Bridge
- Alternative 3.1 - Floodplain Enhancement & Bridge Replacement
- Alternative 4.1 - Floodplain Enhancement upstream of Church Street
- Alternative 4.2 - Bridge Replacement & Floodplain Bench on Mitchell Hollow
- Alternative 4.3 – Floodplain Enhancement downstream of Church Street

Given the number of individual properties compared to the number of projects, the BCA methodology relied on the determination of sets of benefits for each property. The benefits were then summed outside of the BCA program and compared to the costs of the various alternatives. The weakness to this method is that it neglects the maintenance costs for mitigation projects, which are typically estimated (for example, $500 per year for floodplain bench "maintenance") and assigned a present value by the BCA program. However, the magnitude of the benefits and costs in Windham (discussed below) are so much greater than the present value of maintenance costs that they can be neglected for this analysis.

Other factors and assumption for the BCA include the following:

- Benefits for acquired/relocated properties were determined as acquisitions.
- Benefits for all other properties (the majority of those considered) were generated as local flood reduction projects.
- Lost revenue was included only for businesses that provided such information.
- Default depth-damage curves were used in the program.
- Existing and future water surface elevations were determined from the HEC-RAS output at cross sections. For any given building, the nearest cross section was used.

- First floor elevations were estimated using LiDAR topographic mapping.
- Adjustments to the LiDAR topography were made for buildings based on direct observations of first floors relative to adjacent grades.
- Building replacement values were based on the assessed values and square footages provided by the Greene County Planning Department's GIS database.

The BCA does not include benefits that could have been generated for avoiding future street cleanup, avoided detours, avoided emergency response, etc.

5.2 Benefit-Cost Analysis For Alternative 1.1A

A benefit cost ratio was determined for Alternative 1.1A - Floodplain enhancement downstream of Slater Road. Costs included the acquisition and demolition of one house and one associated commercial structure, and the construction of the floodplain enhancement project. Benefits were derived from the acquisition and relocation of the home and business from the flood prone area, and from the reduction of flooding at the properties that remain. For this alternative, most of the benefits were derived from the relocation of the home and business out of the floodplain. The results are summarized in Table 5-1.

Table 5-1
Estimated Costs, Benefits, and Benefit-Cost Ratio – Alternative 1.1A

Benefits: Property Acquisition/Relocation*	$51
Benefits: Water Surface Reductions at Buildings that Remain	$37,424
Total Benefits	$37,475
Total Costs	$1,220,000
Benefit Cost Ratio	**0.03**

*one house and one commercial structure

5.3 Benefit-Cost Analysis For Alternatives 2.3 and 2.4

A benefit cost ratio was determined for the combination of Alternatives 2.3 and 2.4 - Floodplain Enhancement near Schaeffer Road and upstream of the Route 40 Bridge. Costs included the acquisition and demolition of one house, and the construction of both floodplain enhancement projects. Benefits were derived from the removal of the home from the flood prone area, and from the reduction of flooding at the remaining properties as a result of water surface elevation reductions. The results are summarized in Table 5-2.

Table 5-2
Estimated Costs, Benefits, and Benefit-Cost Ratio – Alternatives 2.3 and 2.4

Benefits: Property Acquisition/Relocation*	$34,912
Benefits: Water Surface Reductions at Buildings that Remain	$83,942
Total Benefits	$118,854
Total Costs	$1,926,500
Benefit Cost Ratio	**0.06**

*one house

5.4 Benefit-Cost Analysis For Alternatives 3.1

A benefit cost ratio was determined for Alternative 3.1 - Floodplain Enhancement & Bridge Replacement within High Risk Area #3. Costs included the replacement of the bridge with a larger, hydraulically adequate structure, acquisition and demolition of one house, and the construction of the floodplain enhancement project. Benefits were derived from the removal of the home from the flood prone area, and from the reduction of flooding at the remaining properties as a result of water surface elevation reductions. The results are summarized in Table 5-3.

Table 5-3
Estimated Costs, Benefits, and Benefit-Cost Ratio – Alternative 3.1

Benefits: Property Acquisition/Relocation*	$10,708
Benefits: Water Surface Reductions at Buildings that Remain	$18,467
Total Benefits	$29,175
Total Costs	$1,608,000
Benefit Cost Ratio	**0.02**

*one house

5.5 Benefit-Cost Analysis For Alternative 4.1

A benefit cost ratio was determined for Alternative 4.1 - Floodplain Enhancement upstream of Church Street. No property acquisition or relocation of structures was required under this alternative. Costs included the construction of the floodplain enhancement project. Benefits were derived from the reduction of flooding at the properties along Main Street. The results are summarized in Table 5-4.

Table 5-4
Estimated Costs, Benefits, and Benefit-Cost Ratio – Alternative 4.1

Benefits: Property Acquisition/Relocation	$0
Benefits: Water Surface Reductions at Buildings that Remain	$211,098
Total Benefits	$211,098
Total Costs	$1,835,000
Benefit Cost Ratio	**0.12**

5.6 Benefit-Cost Analysis For Alternatives 4.2

A benefit cost ratio was determined for Alternative 4.2 - Bridge Replacement & Floodplain Bench along Mitchell Hollow Creek. Costs included the replacement of the bridge with a larger, hydraulically adequate structure, acquisition and relocation of three commercial structures (5327, 5330 and 5331 County Route 23). It also involves the construction of the floodplain bench along the left bank of Mitchell Hollow Creek. Benefits were derived from the acquisition and removal of the businesses from the flood prone area, and from the reduction of flooding at the remaining homes and businesses as a result of water surface elevation reductions. Nearly all of the acquisition benefits ($3,512,589) result from relocation of one commercial structure at 5330 County Route 23. The results are summarized in Table 5-5.

Table 5-5
Estimated Costs, Benefits, and Benefit-Cost Ratio – Alternative 4.2

Benefits: Property Acquisition/Relocation*	$3,512,640
Benefits: Water Surface Reductions at Buildings that Remain	$10,698,546
Total Benefits	$14,211,186
Total Costs	$3,723,000
Benefit Cost Ratio	**3.82**

*Involves three commercial structures on left bank of Mitchell Hollow Creek (5327, 5330 and 5331 CR 23)

5.7 Benefit-Cost Analysis For Alternatives 4.3

A benefit cost ratio was determined for Alternative 4.3 - Floodplain Enhancement downstream of Church Street. Costs included the acquisition and relocation of GNH Lumber, and the construction of the floodplain enhancement project. Benefits were derived from the acquisition and removal of the lumber yard from the flood prone area, and from the reduction of flooding at the remaining homes and businesses as a result of water surface elevation reductions. Because this alternative would result in a substantial riparian area being made available for public use and enjoyment, benefits also include a land use benefit. The results are summarized in Table 5-6.

Table 5-6
Estimated Costs, Benefits, and Benefit-Cost Ratio – Alternative 4.3

Benefits: Property Acquisition/Relocation[1]	$1,109,618
Benefits: Land Use[2]	$203,543
Benefits: Water Surface Reductions at Buildings that Remain	$303,543
Total Benefits	$1,616,506
Total Costs	$1,932,000
Benefit Cost Ratio	**0.84**

1 – GNH Lumber
2 - Riparian Area Benefit: $37,493/Acre

6.0 FINDINGS AND RECOMMENDATIONS

6.1 Summary of Findings

The communities along the Batavia Kill in the hamlets of Maplecrest, Hensonville, and Windham have experienced repeated damages from flooding, with devastating results following Tropical Storm Irene, during which peak flows at Red Falls surpassed the predicted 500-year flood. Like many communities in Greene County and throughout the Catskills, historic development has occurred along both banks of the river valley within the natural floodplain of the Batavia Kill and in some cases in the river's floodway. The Batavia Kill intermittently becomes confined between valley walls and then widens, with a more expansive floodplain. It is in these wider floodplain areas where the majority of flood damages have occurred in developed areas.

In the 1960s and 1970s, three flood control dams were constructed in the Batavia Kill watershed that act to moderate flood flows. These flood control dams were designed to store flood flows up to the 100-year flood event. Despite these controls, the communities within the study area remain vulnerable to flooding during large floods.

The nine bridges that cross the river through the study area do not, in and of themselves, cause flooding from backwater restrictions. Most of the bridge decks are several feet above the predicted 100-year water surface elevation.

At the heart of the flood issue in these communities is that extensive development has occurred in the river's natural floodplain. Additionally, there appears to be some amount of encroachment (i.e. fill) within the floodplain, although the active flow channel is generally not undersized or lacking capacity.

Given the conditions within the Batavia Kill riparian corridor and floodplain, a limited number of flood mitigation opportunities are available to the communities through which it flows. A primary flood mitigation option lies in lowering the floodplain immediately adjacent to the Batavia Kill to create a classical compound channel that is capable of conveying normal river flows in the base channel, while creating an active, undeveloped floodplain bench for the conveyance of high flood flows.

Other options that have been evaluated include construction of levees, channel and bridge modifications, and dredging. Although these alternatives have not been assessed beyond a conceptual level, the order of magnitude costs that can be expected for each are an important consideration. For instance, implementing a flood mitigation project at a cost of $2M would not be warranted to protect two residential dwellings worth $200,000 each.

6.2 Recommendations

The following conclusions and recommendations are offered:

6.2.1 High Risk Area #1 – Hamlet of Maplecrest

Floodplain enhancement in the hamlet of Maplecrest will reduce flooding at residential properties, but based the benefic-cost analysis would not be cost effective. Dredging would provide mitigation benefits similar to floodplain enhancement, but at an order of magnitude higher cost and with potential streambed and bank instability as well as funding and permitting challenges. Bridge replacement along County Route 40 would provide little flood mitigation and at a cost that would be prohibitive.

In this community, the following actions are recommended:

1. Seek to acquire the most flood-vulnerable properties where there is owner interest and programmatic funding available either through FEMA or NYCDEP.

2. Move existing structures out of the floodway. Specifically, the rear building at 97 County Route 56 is located partially within the FEMA floodway and is recommended for relocation.

3. Disallow any new development in the floodway and require new construction to meet NFIP criteria.

4. Some of the homes in the floodplain are rarely flooded. Residents and businesses may benefit from minor individual property improvements. Providing land owners with information regarding individual property protection is recommended (see *Individual Property Flood Protection* measures described below).

6.2.2 High Risk Area #2 – Between Hensonville and Maplecrest

Within this high risk area, the Batavia Kill channel is confined upstream of Wedding Bells Lane and then opens up on the right bank, where properties are at risk of flooding. Wholesale channel dredging through this reach would reduce and in some cases eliminate flooding of homes along Route 40, but at a cost that is prohibitive and at substantial risk of long-term channel instability. Dredging would leave the channel overly deep; would be difficult to construct and is not likely to be sustainable. Floodplain enhancements were evaluated as an alternative means of flood mitigation, but based on the benefit-cost analysis would not be cost effective. The following recommendations are offered for this reach:

1. Seek to acquire the most flood-vulnerable properties where there is owner interest and programmatic funding available either through FEMA or NYCDEP.

2. Disallow all new development in the floodway and require new construction to meet NFIP criteria.

3. Some of the homes in the floodplain are rarely flooded. Residents and businesses may benefit from minor individual property improvements. Providing land owners with information regarding individual property protection is recommended (see Individual Property Flood Protection measures described below).

6.2.3 <u>High Risk Area #3 – Hamlet of Hensonville</u>

Based on the benefit-cost analysis, the cost of floodplain enhancement and bridge replacement would surpass the aggregate value of the floodprone homes in this reach. In this reach of the Batavia Kill, the following actions are recommended:

1. Seek to acquire the most flood-vulnerable properties where there is owner interest and programmatic funding available either through FEMA or NYCDEP.

2. Remove existing structures out of the floodway. Specifically, homes located at 120 County Route 65 (currently abandoned), and at 109 County Route 65 (status unknown) are located in the FEMA floodway and should be removed.

3. Disallow all new development in the floodway and require new construction to meet NFIP criteria.

4. Some of the homes in the floodplain are rarely flooded. Residents and businesses may benefit from minor individual property improvements. Providing land owners with information regarding individual property protection is recommended (see *Individual Property Flood Protection* measures described below).

5. If funding allows, further consideration may be given to floodplain enhancement in this reach, particularly when the bridge is due to be replaced for structural reasons. The cost of such action (Alternative 3.1) may be feasible if the bridge is to be replaced under a separate funding source.

6.2.4 High Risk Area #4 – Hamlet of Windham

The hamlet of Windham hosts the largest number of properties affected by flooding. The Batavia Kill through the hamlet of Windham is confined on the left bank by a steep, wooded embankment. Its natural floodplain occurs on the right bank, where development is most dense, including Main Street. The Mitchell Hollow tributary enters the Batavia Kill in this area and contributes to flooding in the downtown area.

Floodplain enhancement upstream of Church Street (Alternative 4.1) would reduce water surface elevations in the upstream portion of the hamlet, but would not be cost effective and would not eliminate flooding of many properties currently located within the FEMA floodplain.

Implementation of Alternative 4.2 (replacement of Main Street bridge and floodplain bench on Mitchell Hollow Creek) would reduce flooding in the area of Main Street and Mill Street. It would require the acquisition and relocation of three commercial structures (5327, 5330 and 5331 County Route 23). Benefits would be derived from the acquisition and removal of the businesses from the flood prone area, and from the reduction of flooding at the remaining homes and businesses as a result of water surface elevation reductions. Nearly all of the acquisition benefits ($3,512,589 of the $3,512,640 in acquisition benefits) result from relocation of one commercial structure at 5330 County Route 23. This alternative has the potential to substantially reduce flooding and should be investigated more closely.

Implementation of Alternative 4.3 (floodplain enhancement downstream of Church Street) would be effective at reducing flooding along Main Street in Windham, especially if implemented in combination with Alternative 4.2, which reduces flooding associated with Mitchell Hollow Creek. Implementation of Alternative 4.3 would require the relocation of GNH Lumber. Based on the results of the benefit-cost analysis, the benefit-cost ratio for this alternative is 0.84. This alternative can be investigated more closely, costs and benefits can be refined, and potentially a benefit-cost ratio greater than 1.0 can be derived.

1. The lumber yard is located within the FEMA floodway and should be relocated. Its relocation would also be required in order to implement Alternative 4.3. Lumber yards are considered critical community facilities for the CWC program and relocation funding is available.

2. Disallow all new development in the floodway and require new construction to meet NFIP criteria.

3. Seek to acquire the most flood-vulnerable properties where there is owner interest and programmatic funding available either through FEMA or NYCDEP.

4. Some of the homes in the floodplain are rarely flooded. Residents and businesses may benefit from minor individual property improvements. Providing land owners with information regarding individual property protection is recommended (see *Individual Property Flood Protection* measures described below).

6.2.5 Individual Property Flood Protection

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, 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.

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 on piers to a height such that the first floor is located 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.

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 town 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 high water mark (if the ceiling permits). A wooden platform of pressure-treated wood can serve as the base.
- Anchor the fuel tank to the wall or floor with noncorrosive metal strapping and lag bolts.
- 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 National Flood Insurance Program (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.

6.2.6 Sediment Management

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:

7. 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. Regional bankfull channel dimensions were determined using *StreamStats* and are reported in Table 6-1.

8. Sediment management should be limited in volume to either a single flood's deposition or to the watershed's annual sediment yield in order to preclude downstream bed degradation from lack of sediment. Annual sediment yields vary, but one approach is to use a regional average of 50 cubic yards per square mile per year unless a detailed study is made. Table 6-2 presents a summary of estimated annual sediment yield in the Batavia Kill.

9. Excavation of fine-grain sediment releases turbidity. Best available practices should be followed to control sedimentation and erosion.

10. 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.

11. 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 re-mobilization and re-deposition during the next large storm event.

12. No sediment excavation should be undertaken in areas where aquatic-based rare or endangered species are located.

TABLE 6-1
Regional Bankfull Channel Dimensions

Location along Batavia Kill	Station	Bankfull Width (ft)	Bankfull Depth (ft)
Route 40 bridge, Maplecrest	937+00	52.0	2.28
Route 40 bridge, Hensonville	829+50	56.2	2.41
Church Street Bridge, Windham	658+25	91.1	3.35
Downstream end of study area	537+00	95.2	3.45

TABLE 6-2
Estimated Annual Sediment Yield

Location along Batavia Kill	Station	Watershed Area (sq. mi.)	Estimated Annual Sediment Yield* (cy/year)
Route 40 bridge, Maplecrest	937+00	11.2	560
Route 40 bridge, Hensonville	829+50	13.3	665

Church Street Bridge, Windham	658+25	38.0	1,900
Downstream end of study area	537+00	41.8	2,090

*This is the amount of sediment that naturally flows through a stream.

6.3 Funding Sources

Several funding sources may be available to the Town of Windham and Greene County Soil & Water Conservation District for the implementation of recommendations made in this report.

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

The LFA program that funded this study and report is likely to be the primary funding vehicle for some of the alternatives described in this report through the SMP. As described in the LFA rules, "Stream Management Programs in the NYC 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 (Section C) define the process for municipalities to apply for funding to complete a Local Flood Analysis (LFA). These program rules (Section D) also define the process for municipalities to seek funding from the Stream Management Program [managed by the GCSWCD] to implement projects that involve streams, floodplains and adjacent infrastructure to reduce flood hazards."

NYCDEP Buyout Program

The buyout program is used to acquire individual properties in the water supply watersheds and convert them to open space in order to reduce future flood damages. Although large-scale buyouts in Windham are not recommended in this LFA, several properties have been identified as targeted for acquisition. The buyout program could potentially be used for some of these acquisitions.

Catskills Watershed Corporation (CWC) Flood Hazard Mitigation Implementation Program (FHMIP)

The Catskill Watershed Corporation 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 (WOH); to preserve and strengthen communities located in the region; and to increase awareness and understanding of the importance of the NYC water system. CWC administers a number of programs under this mission, such as:

- 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 – Provides grants to communities conducting watershed protection and land use planning initiatives.

The FHMIP is a CWC program that is open for applications beginning in 2015. This program specifically allows funding of certain categories of projects identified in LFA reports, subject to various restrictions that are listed in the CWC's FHMIP rules.

Emergency Watershed Protection Program (EWP)

Through the EWP program, the U.S. Department of Agriculture's 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% 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.

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 Pre-Disaster Mitigation 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 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 are 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 non-federal 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.

NYS Department of State

The Department of State 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. An example from this plan would be flood mitigation of the GNH Lumber facility as this would reduce damages to an important local employer while reducing the potential for water quality impairments that could occur when the facility is flooded.

U.S. Army Corps of Engineers

The Corps 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 Corps for mitigation are listed below.

- Section 205 – Small Flood Damage Reduction Projects: This section of the 1948 Flood Control Act authorizes the Corps to study, design, and construct small flood control projects in partnership with non-Federal government agencies. Feasibility studies are 100% federally-funded up to $100,000, with additional costs shared equally. Costs for preparation of plans and construction are funded 65% with a 35% non-federal match. In certain cases, the non-Federal share for construction could be as high as 50%. 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 the Corps to construct emergency shoreline and streambank protection works to protect public facilities such as bridges, roads, public buildings, sewage treatment plants, water wells, and non-profit 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 the Corps 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 the Corps 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% federally funded.

In addition, the Corps 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 post-flood response. Corps assistance is limited to the preservation of life and improved property; direct assistance to individual homeowners or businesses is not permitted. In addition, the Corps can loan or issue supplies and equipment once local sources are exhausted during emergencies.

Other Potential Sources of Funding

- 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 non-residential 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 non-residential buildings, depending on 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.

REFERENCES

Brierley, Gary J. and Kristie A. Fryirs, 2005. Geomorphology and River Management. Blackwell Publishing.

FHWA, 2001. Stream Stability at Highway Structures (Hydraulic Engineering Circular No. 20). FHWA NHI 01-002. Federal Highway Administration, U.S. Department of Transportation, Washington, D.C.

FEMA, 2008. Flood Insurance Study, Greene County, New York (All Jurisdictions). Federal Emergency Management Agency Flood Insurance Study Number 36039CV001A. Effective May 16, 2008.

Greene County Soil & Water Conservation District, 2003. Batavia Kill Stream Management Plan.

Greene County Soil & Water Conservation District, 2012. Hensonville Debris Removal Project on the Batavia Kill - Implementation Report.

Lumia, R., Freehafer, D., and Smith, M., 2006. Magnitude and Frequency of Floods in New York. Scientific Investigations Report 2006–5112. U.S. Geological Survey, in Cooperation with the New York State Department of Transportation, Troy, NY

Miller, S. and Davis, D., 2003. Optimizing Catskill Mountain and Regional Bankfull Discharge and Hydraulic Geometry Relationships, NY. NYCDEP Technical Reports. NYCDEP

Milone & MacBroom Inc., 2007. Guidelines for Naturalized River Channel Design and Bank Stabilization. The New Hampshire Department of Environmental Services and the New Hampshire Department of Transportation (DES #B-04-SW-11), Concord, NH

Mulvihill, C., Baldigo, B., Miller, S., and DeKoskie, D., 2009. Bankfull Discharge and Channel Characteristics of Streams in New York State, U.S. Geological Survey, Reston, VA

Rosgen, D. and Silvey, L., 1996. Applied River Morphology, Wildland Hydrology, Pagosa Springs, CO

Tetra-Tech, 2009. Hazard Mitigation Plan for Greene County, New York.

USACE, 2010. Hydrologic Engineering Center River Analysis System (HEC-RAS) (V. 4.1). U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, CA

USGS, 1982. Guidelines for Determining Flood Flow Frequency (Bulletin #17b). Interagency Advisory Committee on Water Data, U.S. Geological Survey, Reston, VA

APPENDICES

APPENDIX A

LIST OF RESOURCE MATERIALS

LIST OF RESOURCE MATERIAL

LOCAL FLOOD HAZARD MITIGATION ANALYSIS

TOWN OF WINDHAM ALONG THE BATAVIA KILL IN THE HAMLETS OF WINDHAM, HENSONVILLE, AND MAPLECREST
GREENE COUNTY, NEW YORK

September 2014

MMI #2884-05

Study	Author	Date
Greene County Flood Insurance Study	FEMA	May 16, 2008
Batavia Kill Stream Management Plan	GCSWCD	January 2003
Multi-Jurisdictional Hazard Mitigation Plan	Greene County	2013
Summary Listing of Priority Waters	NYSDEC	
New York Rising Community Reconstruction Plan	Ulster County New York Rising Community Group Planning Committee	October 2013
DMA 2000 Hazard Mitigation Plan – Greene County, New York	URS	August 2009
Evaluation of the Concrete Wing Walls and Retaining Wall of Mad Brook	Delaware Engineerg, P.C.	July 23, 2009
Japanese Knotweed and Water Quality on the Batavia Kill in Greene County, New York: Background Information and Literature Review	Hudsonia Ltd.	December 6, 2002 REV November 4, 2003 REV November 21, 2004
Riparian Corridor Management Plan	GCSWCD	August 17, 2009
Public Fishing Rights Maps – Batavia Kill	NYSDEC	
Water Resources of the Batavia Kill Basin at Windham, Greene County, New York	USGS	1998

APPENDIX B

PHOTO LOG

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.: **1** DESCRIPTION: Hamlet of Maplecrest along Route 56, near STA 960+00	
PHOTO NO.: **2** DESCRIPTION: Hamlet of Maplecrest along Route 56, near STA 950+00	

PROJECT SITE PHOTOGRAPHS

PHOTO NO.:

3

DESCRIPTION:
Landowner berm at STA 888+00

PHOTO NO.:

4

DESCRIPTION:
Downstream of Route 40 in Hamlet of Hensonville near STA 828+00, looking downstream

PROJECT SITE PHOTOGRAPHS

PHOTO NO.: **5** DESCRIPTION: Batavia Kill along Route 65A in Hamlet of Hensonville, near STA 820+00	
PHOTO NO.: **6** DESCRIPTION: Route 40 between Hamlet of Maplecrest and Hensonville, near STA 840+00	

PROJECT SITE PHOTOGRAPHS

PHOTO NO.: **7** DESCRIPTION: Route 40 Bridge in Hamlet of Hensonville, STA 829+50	
PHOTO NO.: **8** DESCRIPTION: Looking upstream along Route 65A in Hamlet of Hensonville, near STA 818+00	

PROJECT SITE PHOTOGRAPHS

PHOTO NO.:

9

DESCRIPTION:
Storage units in Hamlet of Hensonville, adjacent to STA 815+00

PHOTO NO.:

10

DESCRIPTION:
Hamlet of Hensonville along Route 65, adjacent to STA 813+00

PROJECT SITE PHOTOGRAPHS

PHOTO NO.: **11** DESCRIPTION: Main Street Bridge over Mitchell Hollow Creek in Windham	
PHOTO NO.: **12** DESCRIPTION: Mitchell Hollow Creek at Main Street bridge, looking upstream	

PROJECT SITE PHOTOGRAPHS

PHOTO NO.: **13** DESCRIPTION: Route 23 (Main Street) in Hamlet of Windham, looking west	
PHOTO NO.: **14** DESCRIPTION: Route 23 (Main Street) in Hamlet of Windham, looking east	

PROJECT SITE PHOTOGRAPHS

PHOTO NO.:

15

DESCRIPTION:
Parking lot near STA 664+00, looking south towards Batavia Kill

PHOTO NO.:

16

DESCRIPTION:
Church Street Bridge STA 659+50, looking downstream

PROJECT SITE PHOTOGRAPHS

PHOTO NO.: **17** DESCRIPTION: Lumber Yard near STA 627+00, looking upstream	
PHOTO NO.: **18** DESCRIPTION: Along Route 23 at downstream end of Hamlet of Windham, near STA 627+00, looking downstream	

PROJECT SITE PHOTOGRAPHS

PHOTO NO.:

19

DESCRIPTION:
Church Street Bridge STA 659+50 after Tropical Storm Irene, looking downstream

PHOTO NO.:

20

DESCRIPTION:
Church Street Bridge STA 659+50 after Tropical Storm Irene, looking downstream

PROJECT SITE PHOTOGRAPHS

PHOTO NO.: **21** DESCRIPTION: Road damage in Hensonville after Tropical Storm Irene	
PHOTO NO.: **22** DESCRIPTION: Road damage in Hensonville after Tropical Storm Irene	

PHOTO NO.: **23** DESCRIPTION: Flooding in Maplecrest during Tropical Storm Irene (photo courtesy Jere Baker)	
PHOTO NO.: **24** DESCRIPTION: Flood damage in Maplecrest immediately following Tropical Storm Irene (photo courtesy Jere Baker)	

PHOTO NO.:

25

DESCRIPTION:
Flooding at Routes 40 and 56 in Maplecrest during Tropical Storm Irene (photo courtesy Jere Baker)

PHOTO NO.:

26

DESCRIPTION:
Debris jam at bridge following Tropical Storm Irene (photo courtesy Jere Baker)